Analysis of Fish Population Monitoring Data for Selected Waters of the Gila River Basin, Arizona, for the Five-year Period 2000-2004

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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. 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 2000 to 2004, 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 (Central Arizona Project [CAP], Florence-Casa Grande [FGC], and Salt River Project [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. 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.

Three, fixed sample stations (upper, middle, and lower) 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 Canal.

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 and merged in Microsoft Access, and young-of-year (age 0) and adult (age 1) data were combined before analysis.

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 (Table 2). Not all stations were sampled every year, 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 electrofishing for the Salt River. This resulted in a total of 79 station samples from 2000 to 2004 (Table 3). Combining these station samples into their associated reaches resulted in six out of 40 reach samples (8 reaches and 5 years of data) having no station samples, and leaving 34 reach-year combinations to analyze (Table 4). All 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 comprehensive raw 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. The CAP Canal was represented by three reaches (upper, middle and lower) and the FCG, SRP-Arizona and SRP-South canals each were represented by two reaches, one upstream of the electrical fish barrier and one downstream (Clarkson 1996). There are no electrical fish barriers on the CAP Canal. Not all stations were sampled every year on each canal: the single station middle reach on the CAP Canal was not sampled in 2001 or 2003, the SRP-South Canal was not sampled in 2001 (no outage), and the FCG Canal was not sampled in 2003 (canal was dry) (Tables 5-8).

Analysis for the CAP Canal was restricted to quantitative data because the vast majority of the data were collected quantitatively and the qualitative data were restricted to one reach and one year in which quantitative data were also available. All data were used for the SRP-South, SRP-North and FCG canals. Data above the electric fish barriers on the SRP-South and SRP-North canals are quantitative and complete (near census)

samples, data elsewhere are qualitative. Stacked bar graphs accommodate interpretation of temporal changes in species composition through the five-year sample period, and allow within-canal comparison of reaches (CAP Canal) and above/below electrical fish barriers (FCG, SRP-South and SRP-North canals).

Data Analysis. To analyze the emergence 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 the ten-year period 1995-2004. The data were then tabulated for each reach and system and the apparent emergence of a species was verified by review of survey reports previous 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. Species that made up more than 3% of catch for any year for a given reach or stream were individually discriminated in the bar graph. Species that contributed 3% or less were combined into a single "other" group.

Results and Discussion

New Species Records. There were 29 previously unreported species records for specific waters of the Gila River basin during the ten-year sample period 1995-2004 (Tables 9-15); 22 of these records were during 1995-1999 and seven were during 2000-2004. These first-records are summarized below by system, reach, and sample year (note that sample year may not always be the same as the calendar year in which the record occurred; see tables).

San Pedro River – 2 system records

Lepomis macrochirus bluegill. Reach 1, 1997

Ictalurus punctatus channel catfish. Reach 3, 1996.

Gila River – 5 system records
Ameiurus melas black bullhead. Reach 2, 1999
Pomoxis nigromaculatus black crappie. Reaches 1 & 2, 1997
Pylodictis olivaris flathead catfish. Reach 1, 1997
Micropterus dolomieu smallmouth bass. Reach 1, 1997
Dorosoma petenense threadfin shad. Reaches 1, 2, & 3. 1997

Salt River – 8 system records
Agosia chrysogaster longfin dace. Reach 1, 2000.
Pomoxis nigromaculatus black crappie. Reach 1, 1998
Oreochromis aureus blue tilapia. Reach 1, 1996.
Gambusia affinis Mosquitofish. Reach 1, 1995
Cyprinella lutrensis red shiner. Reach 1, 2000.
Tilapia zilli redbelly tilapia. Reach 1, 1997
Lepomis microlophus redear sunfish. Reach 1, 1997.
Micropterus dolomieu smallmouth bass. Reach 1, 1996

CAP Canal – 4 system records
Ameiurus melas black bullhead. Reach 3, 1995
Ctenopharyngodon idella grass carp. Reach 3, 1995
Micropterus dolomieu smallmouth bass. Reach 1, 2004
Morone mississippiensis white bass. Reaches 2 & 3, 1995.

SRP Arizona (North) Canal – 3 system record
Ictiobus cyprinellus bigmouth buffalo. Reach 1, 1995
Ictiobus niger black buffalo. Reach 1, 2000
Perca flavescens yellow perch. Reach 1, 2001

SRP South Canal – 1 system record
Morone saxatilis striped bass, Reach 2, 1999.

FCG Canal – 6 system records
Catostomus insignis Sonora sucker. Reach 2, 1995
Lepomis macrochirus bluegill. Reach 2, 1996
Pylodictis olivaris flathead catfish. Reach 1, 2001
Lepomis cyanellus green sunfish. Reach 2, 1996.
Micropterus salmoides largemouth bass. Reach 2, 2002.
Dorosoma petenense threadfin shad. Reach 2, 1996.

In addition to new records, the ten-year monitoring program has documented the disappearance, at least temporarily, of some native fish from collections in the Gila River. *Agosia chrysogaster*, *Pantosteus clarki*, and *Catostomus insignis* were encountered in every year from 1995 to 1999 and captured at least once in all reaches sampled in the same time period. In contrast, in 2002 only *Catostomus insignis* was encountered and none of the three species was collected in 2003 or 2004. Drought is one possible factor in native species catch declines; for example, only four of the 11

possible collection stations were sampled in 2004 because there was no water at the sample station.

Stream Data. Correlation between catch and effort was weak for the San Pedro and Gila rivers, but was strong for the Salt River (Figures 1-4). The collection method and/or stream characteristics may help explain this result because the San Pedro and Gila rivers were sampled with a backpack electrofisher and the Salt River was sampled using a boat electrofisher. The backpack electrofisher was used because the streams are shallow and actual flow from year to year can vary dramatically, changing the concentration of fish, ease of capture, and catch per unit effort. The boat electrofisher was used on the Salt River because of larger flows, and concentration and availability of fish from year to year may be more similar.

Twenty fish taxa were encountered among the three natural streams sampled, including undetermined tilapia but excluding hybrid or unidentified sunfishes, which were assumed to be represented within the three species of the genus *Lepomis* listed (Table 4). Ten taxa were taken from San Pedro River, 13 from Gila River and 15 from Salt River. Four taxa are native in the Gila River basin, *Agosia chrysogaster, Gila robusta, Catostomus insignis,* and *Pantosteus clarki*; the remainder are species introduced from Africa, Asia, and eastern and northwestern United States. Although there was much variation among streams, reaches, and stations, non-native *Cyprinella lutrensis* overall was the most abundant species, followed by *Gambusia affinis* and native *Agosia chrysogaster.*

Five of ten species collected in San Pedro River were found in all five sample years, two in four years, one in two years and two in one year. Four of the ten species were taken from all three reaches, four were in two reaches, and two were from one reach. There was much variation in abundance among years. *Agosia chrysogaster* was the most abundant taxon in three of five years, and *Pantosteus clarki* and *Gambusia affinis* were most abundant in one year each. *Lepomis cyanellus*, *Ameiurus melas*, *Cyprinus carpio* and *Pimephales promelas* were captured in most years, while other taxa were sporadic in occurrence.

Three of 13 species collected in Gila River were found in all five sample years, three were found in four years, three in two years, three in two years, and one in only one

year. Five of 13 taxa were taken from all four reaches, three were in three reaches, three were in two reaches and two were in one reach. There was substantial variation in abundance among years. *Cyprinella lutrensis* was the most abundant species in three of five years, and *Gambusia affinis* predominated the other two. *Gambusia affinis* or *Cyprinella lutrensis* was the second most abundant species in years they did not predominate, except in 2000 when *Lepomis cyanellus* followed *Cyprinella lutrensis*. *Ameiurus natalis, Cyprinus carpio*, *Ictalurus punctatus*, *Micropterus salmoides* and *Pylodictis olivaris* were common in some years, uncommon or absent in others. The remaining species generally were sporadic in occurrence and few in number.

Three of 15 species collected in Salt River were found in all five sample years, three were found in four years, three in three years, and six were taken only in one year each. There were no assemblage comparisons among reaches because there was only one reach. Total catch generally was small, likely a reflection of the gears deployed in this stream, which favored capture of large-bodied fishes. *Catostomus insignis* was the most abundant taxon overall, but predominated in only one year. *Catostomus insignis* and *Micropterus salmoides* were nearly equal in abundance for all other years. *Lepomis macrochirus* was captured in all five years and was common-to-uncommon. Unknown *Tilapia* was common for two of the five years. Other species were sporadic in occurrence and generally were uncommon-to-rare.

Overall species composition in the San Pedro River changed little over the course of the five year period (Figure 5). Native *Agosia chrysogaster* apparently has been in general decline and native *Pantosteus clarki* on the increase. As noted above for the Gila River, stream drying may be responsible in part for this result. Relative abundance of *Pantosteus clarki* and *Agosia chrysogaster* were cyclical (no trend) in the upstream reach of the San Pedro (Figure 6). This was the only reach in which three stations were sampled for all five years. *Agosia chrysogaster* made up the entire collection of fish for the middle reach in 2000 (Figure 7), but non-native *Ameiurus melas*, *Pimephales promelas*, and *Lepomis cyanellus* reemerged the following year and continued through 2003. The 2004 collection consisted of a single specimen of *Ameiurus melas*. There was an apparent decline of *Agosia chrysogaster* and overwhelming predominance of *Gambusia affinis* in the downstream reach (Figure 8). However, the lower most reach

sample sites have been affected by drought. The seven fish in 2002 were caught in one pool at one site. Since then all sites for the lower reach have been generally dry.

Overall, relative abundance from Gila River collections was cyclical for G*ambusia affinis* and *Cyprinella lutrensis* (Figure 9), the two species shifting back and forth in dominance across the five years. The fauna was more diverse in 2000 and 2001, and these were the only two years when all available stations were sampled. Few changes were evident in three years of collection data for the upstream reach on the Gila River (Figure 10). A slight decline in relative abundance for *Cyprinella lutrensis* coincided with a slight increase in relative abundance for *Gambusia affinis*. A similar shift in relative abundance occurred in the upper middle reach of the Gila River with a decrease in *Cyprinella lutrensis* and a subsequent increase in *Gambusia affinis* (Figure 11). Relative abundance was inconsistent for most species in the Gila River lower middle reach (Figure 12). Catch in 2001 was the most diverse, resulting in a reduction in relative abundance of the two predominant species, *Gambusia affinis* and *Cyprinella lutrensis*. Dominance shifted in 2002 and 2004 from *Gambusia affinis* to *Cyprinella lutrensis*. However, both of these samples were represented by a single station, each year corresponding to a different station. The lower reach was typically dominated by *Cyprinella lutrensis*, followed by *Gambusia affinis* or *Ameiurus natalis* (Figure 13). In 2002, 1,998 *Gambusia affinis* were captured at one station in the lower reach, and this was the only station sampled that year. *Ameiurus natalis* and *Cyprinus carpio* were also caught, but together made up less than one percent of the total catch. In 2004, all three stations were sampled and *Cyprinella lutrensis* returned to prominence.

Salt River maintained a species composition dominated by native *Catostomus insignis* and non-native *Micropterus salmoides* (Figure 14). Undetermined *Tilapia* and *Ameiurus natalis* were captured sporadically, and each made up nearly 20% of the catch when present.

Canal Data. Eight of 15 species (excluding undetermined *Lepomis*) encountered in the CAP Canal were found in all years, two species were found in four years, one species was found in three years, one was found in two years, and three were found only once (Table 5). Nine of the 15 species were taken from all three reaches, two were in two reaches, and four were from one reach each. The most abundant taxon was

undetermined *Lepomis,* followed respectively by *Lepomis macrochirus, L. microlophus*, *Cyprinella lutrensis*, *Cyprinus carpio*, *Ctenopharyngodon idellus*, *Ictalurus punctatus, Micropterus salmoides*, and *Morone saxatilis.*

The CAP Canal overall was consistently dominated by sunfishes (undetermined *Lepomis*, *Lepomis macrochirus, Lepomis cyanellus* and *Lepomis microlophus*) until 2004 when *Cyprinella lutrensis* was also abundant (Figure 15). Sunfishes in general trended downward in relative abundance over the five year period. Diversity of catch was high with eleven species contributing more than 3% of the catch in at least one year.

Diversity was similar for the upstream reach of the CAP Canal where ten species each contributed more than 3% of the catch (Figure 16). No trends were evident with dominant species shifting from year to year between four species (*Ctenopharyngodon idellus*, *Cyprinella lutrensis*, *Cyprinus carpio*, and *Ictalurus punctatus*). Catch was low (average 28 fish per year) for the middle reach on the CAP Canal and each of the three years of collection data was dominated by a different species (Figure 17); *Cyprinus carpio*, *Morone saxatilis*, and *Ctenopharyngodon idellus*. The downstream reach on the CAP Canal was dominated by sunfishes (undetermined *Lepomis*, *Lepomis macrochirus, Lepomis cyanellus* and *Lepomis microlophus*; Figure 18). However, relative abundance of sunfishes declined markedly from 2003 to 2004 with a coincident increase in relative abundances of *Ictalurus punctatus* and *Cyprinella lutrensis*.

Eleven of 24 species encountered (including undetermined *Tilapia*) in the SRP South Canal were found in all years sampled, three species were found in three years, five species were found in two years, and five species were found only once each (Table 6). A majority of species (13) was found both above and below the electric fish barrier. Three taxa, *Oncorhynchus mykiss*, *Pomoxis nigromaculatus* and *Sander vitreus* were only in the reach above the barrier, while eight others, *Ameiurus natalis, Carassius auratus*, *Dorosoma petenense, Gambusia affinis, Morone mississippiensis*, *Morone saxatilis, Oreochromis aureus*, and *Oreochromis mossambicus* were found only below the barrier. Undetermined *Tilapia* was the most abundant taxon, followed respectively by *Ictalurus punctatus, Micropterus salmoides*, *Catostomus insignis*, *Cyprinella lutrensis*, *Lepomis macrochirus*, *Pantosteus clarki, Cyprinus carpio*, *Ctenopharngodon idellus*, and *Gila robusta*.

Large above barrier samples in SRPs canal for 2000 and 2003 resulted in a dominant influence on the overall relative species abundances for those years (Figures 19 and 20). The majority of the catch above the barrier and subsequently overall in 2000 and 2003 was undetermined *Tilapia*. Other species increased in relative abundance in years without undetermined *Tilapia*, but no trends were evident for the overall or above barrier catch.

Below the barrier, relative abundance of *Cyprinella lutrensis* declined through 2003, then dominated the catch in 2004 (Figure 21). *Pantosteus clarki* was prominent in 2000 and all but disappeared afterward, and *Catostomus insignis* increased in relative abundance through 2003 then declined in 2004.

Nine of 23 species encountered in the SRP Arizona (North) Canal were found in all years, three species were found in four years, three species were found in three years, two species were found in two years, and six species were found only once each (Table 7). Most species (14) were found both above and below the electric fish barrier. Six fishes, *Ameiurus natalis*, *Ictiobus cyprinellus, Ictiobus niger, Micropterus dolomieu, Pomoxis nigromaculatus* and *Sander vitreus* were only in the reach above the barrier and three others, *Cyprinella lutrensis*, *Gambusia affinis* and *Perca flavescens were* found only below the barrier. *Ictalurus punctatus* was the most abundant taxon, followed respectively by *Catostomus insignis*, *Pylodictis olivaris*, *Micropterus salmoides*, *Ctenopharngodon idellus*, *Cyprinella lutrensis*, undetermined *Tilapia*, *Lepomis macrochirus*, *Pantosteus clarki*, *Gambusia affinis*, *Cyprinus carpio*, *Oncorhynchus mykiss*, *Lepomis cyanellus* and *Morone mississippiensis*.

Overall the SRPn Canal was dominated by *Ictalurus punctatus* and *Catostomus insignis* (Figure 22)*;* these species individually dominated the above barrier and below barrier catch respectively (Figures 23 and 24). There was also a slight increase in relative abundance of *Micropterus salmoides* from above barrier samples.

Three of 12 species encountered in the FGC Canal were found in all years, four species were found in three years, one species was found in two years, and four species were found only once each (Table 8). Eight species were found both above and below the

electric fish barrier; *Pylodictis olivaris* and *Catostomus insignis* were encountered only above the barrier, and one individual each of *Agosia chrysogaster* and *Micropterus salmoides* were captured in the reach below the barrier. The three most abundant species, *Cyprinella lutrensis, Gambusia affinis*, and *Ictalurus punctatus* (in order of abundance) were collected in all years. *Cyprinus carpio* and *Ameiurus natalis* were the next two most abundant fishes, respectively, while other species were less common by an order of magnitude.

In the FCG canal, *Gambusia affinis* dominated the catch in 2000 and 2002 above and below the barrier and subsequently in overall abundance (Figures 25-27). A large catch of *Ictalurus punctatus* in 2001 predominated overall below the barrier, and *Cyprinella lutrensis* dominated the catch above, below, and overall in 2004. There was a general increase in relative abundance for *Cyprinella lutrensis* across the four years of above barrier samples.

Conclusion and Recommendations

The Gila River Basin fish monitoring program has detected the presence of a number new species within the waters sampled, and has documented the decline and potential disappearance of native species from some 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 failure to detect three native species from samples in four different reaches on the Gila River could be cause for alarm. The proximate cause of this decline is unknown, but in other systems such disappearances have been attributed largely to habitat loss or establishment of non-native species (Desert Fishes Team 2003, 2004). Because other species persist where these losses have occurred, we indict presence of non-native fishes as the most likely reason these three native species have been seemingly extirpated, at least locally.

We make the following recommendations to improve implementation of the CAP fish monitoring program:

1. A more concerted effort should be made to sample all stations each year. Failure to sample a station or reach reduces an already-small sample size and compromises the ability to make reliable assessment, especially as regards species presence.

2. There seems to be a correlation between use of auxiliary sample gears and number of species detected. In addition to use of backpack electrofishing as the standard gear for stream samples, we recommend collectors use seines or other gears to more thoroughly explore habitats up- and downstream from the designated station, and perhaps to re-sample any in-station areas, a deeper pool, for example, that might not be adequately represented by backpack shocking alone. Such protocol is within the standardized monitoring plan of Clarkson (1996), but greater effort at undertaking this sampling is necessary.

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Table 1. Four-letter species codes in alphabetic order, scientific names, and common names of fishes used throughout this paper. Native species indicated by an asterisk (*).

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

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) 2000 through 2004. Gear codes, by category are Entrapment/Entanglement: gill net (G), trammel net (T), shock/trammel net (STN); Seining: straight seine (SS), dip net (D); Electrofishing: backpack shocker (Bp), boat shocker (Ef); tote barge shocker (TB).

		Station 1		Station 2		Station 3	
Reach	SY	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative
San Pedro River							
1	2000	Bp	Bp	Bp	Bp	Bp	Bp
	2001	SS	Bp	SS	Bp	SS	Bp, SS
	2002	SS	Bp	SS	Bp	SS	Bp
	2003	-	Bp	-	Bp	-	Bp
	2004	SS	Bp	SS	Bp	SS	Bp
2	2000	Bp	Bp	Bp	Bp		
	2001	Bp	Bp	Bp	Bp		
	2002	Bp	Bp	Bp	Bp		
	2003	-	Bp	-	Bp		
	2004	Bp	Bp	-	-		
3	2000	Bp	Bp	Bp	Bp	-	-
	2001	Bp	Bp	Bp	Bp	Bp	Bp
	2002	-	SS	Bp	Bp	-	-
	2003	-	-	-	-	-	-
	2004	-	Bp	-	-	-	-
Gila River							
1	2000	Bp	Bp,Ef,D,SS,T			Bp	Bp,STN,TB,T
	2001	-	Bp,Ef			-	Bp,Ef
	2002	-	Bp,BS,TB,T			-	Bp,SS,TB,T
	2003	-	-			-	-
	2004	-	-			-	-
2	2000	Bp	Bp,BS	Bp	Bp	Bp	Bp,SS,T
	2001	Bp	Bp,Ef,T	-	Bp,SS	Bp	Bp,T
	2002	SS	Bp,SS	SS	Bp	SS	Bp,T
	2003	-	Bp	-	Bp	-	Bp
	2004	-	-	-	-	-	-
3	2000	Bp	Bp,SS	SS	Bp	Bp	Bp,SS
	2001	Bp	Bp	Bp	Bp	Bp	Bp
	2002	-	Bp	-	-	-	SS
	2003	-	-	-	-	D	-
	2004	-	-	-	-	-	Bp
4	2000	Ef	Ef,D,SS	Bp	Bp,SS	Bp	Bp
	2001	Bp	Bp	Bp	Bp	Bp	Bp
	2002	-	Bp,SS,T	-	-	-	-
	2003	-	D	-	-	Bp	-
	2004	-	Bp	-	Bp	-	Bp
Salt River							
1	2000	T	Bp,Ef,STN,T	Bp,Ef	Ef,T	Ef	Ef,T
	2001	T	Ef,T	-	-	Ef	Ef,T
	2002	Bp,Ef	Ef,G,T	Bp	Ef,T	Ef	Ef
	2003	Ef	Ef	Bp	Ef	Ef	Ef
	2004	Ef	Ef	-	-	-	-

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 2000 through 2004.

Stations Sampled

	San Pedro River			Gila River				Salt River
Year	upstream	middle	downstream	upstream	upper middle	lower middle	downstream	downstream
2000	1,2,3	1,2	1,2	1,3	1,2,3	1,2,3	1,2,3	1,2,3
2001	1,2,3	1,2	1,2,3	1,3	1,2,3	1,2,3	1,2,3	1,3
2002	1,2,3	1,2	1(ne),2	1,3	1,2,3	1,3(ne)	1	1,2,3
2003	1,2,3	1,2	none	none	1,2,3	3(nq)	1(ne)	1,2,3
2004	1,2,3	1	1*	none	none	3	1,2,3	1

nq = nonquantitative sample

ne = nonelectrofishing sample

# of Stations for Analysis

	San Pedro River			Gila River				Salt River
Year	upstream	middle	downstream	upstream	upper middle	lower middle	downstream	downstream
2000	3	2	2	2	3	3	3	3
2001	3	2	3	2	3	3	3	2
2002	3	2	1	2	3	1	1	3
2003	3	2	0	0	3	0	0	3
2004	3	1	1*	0	0	1	3	1

* Station 1 was sampled but no fish were captured.

Table 4. Total numbers of fishes captured during sampling in behalf a long-term monitoring plan for fish populations in selected waters of the Gila River basin, Arizona, during sample years 2000 through 2004. Abbreviations as in Clarkson (1996). Totals include young of year and adult individuals. Reaches are labelled as upper, middle, and lower to indicate relative position upstream to downstream. Reaches that were not sampled or non-quantitatively sampled are excluded from this table.

			Species																				
Year	**Stream**	**Reach**	**AGCH**	**AMME**	**AMNA**	**CAIN**	**CYCA**	**CYLU**	**DOPE**	**GAAF**	**ICPU**	**LECY**	**LEMA**	**LEMI**	**LEPO**	**MIDO**	**MISA**	**MOMI**	**ONMY**	**PACL**	**PIPR**	**PYOL**	**TILA**	**Total**
2000	**SanP**	upper	30	3						58		2								17	2			112
		middle	99																					99
		lower	12							8														20
	Gila	upper						235		126	15	160			15		20					1		572
		upper middle	1		13	9	14	1729		114	46	276	2				3					1		2208
		lower middle						56		53	1	4												114
		downstream			1			87		13	10													111
	Salt	downstream			3	155	9	1		1		9	8	2			88	1	1	14			48	340
2001	**SanP**	upper	71	12	1					35		20					1			128	24			292
		middle	688	32								26									35			781
		lower	83		4		41	29		19		8								1	1			186
	Gila	upper					10	68		39	4	17										5		143
		upper middle			8	9		96		5	16	22					2					6		164
		lower middle	26		22	7		12		30	9	4					1				4			115
		downstream			40	3		140		45	5													233
	Salt	downstream				24	1					3	12				26		1					67
2002	**SanP**	upper	48		2		1			86		16								51	1			205
		middle	33	4								3												40
		lower								7														7
	Gila	upper			1			46		112		37					11							207
		upper middle			13	1	54	260		157	5	33					28					17		568
		lower middle					7	7		31														45
		downstream			1		4			1998														2003
	Salt	downstream			3	31	3		1			8	6		2	3	33			1			22	113
2003	**SanP**	upper	34	6			1			8		1								9	5			64
		middle	23	11						2											6			42
	Gila	upper middle			1		8	161		193	5	32	8								3			411
	Salt	downstream			3	43	5					1	5				41		1	6			1	106
2004	**SanP**	upper	38	4			1			20		1								75				139
		middle		1																				1
		downstream																						0
	Gila	lower middle			1			33		8														42
		downstream		1	9			230		75														315
	Salt	downstream			13	16							5				22							56
		Total	1186	74	139	298	159	3190	1	3243	116	683	46	2	17	3	276	1	3	302	81	30	71	

Table 5. Total numbers of fishes captured during sampling in behalf a long-term monitoring plan in Central Arizona Project (CAP) Canal, Arizona, during sample years 2000 through 2004. Abbreviations as in Clarkson (1996). Totals include young of year and adult individuals.

		Species																
Year	Reach	AMME	AMNA	CAAU	CTID	CYCA	CYLU	DOPE	ICPU	LECY	LEMA	LEMI	LEPO	MIDO	MISA	MOSA	PYOL	Total
2000	upstream				7	16	58	23	9	11	47		54		3	1		229
	middle				6	9	4	2	2						1			24
	downstream	1			8	12	6	1		7	87	12	204		3	3		344
2001	upstream				7	5	4		15				5		6	3		45
	downstream			3	3	1			3	6	25	35	13		3	1		93
2002	upstream				9	5	2		3		5	1			4	5		34
	middle				1						1				3	12		17
	downstream	16		4	13	4			1	9	23	79	67		12	8		236
2003	upstream				14	32			17	12			6		9	6	1	97
	downstream	8			6	9	6		5	12	102	136	18		33	13		348
2004	upstream				6	13	10		2		5			4	2	2		44
	middle				23	1	5		1		2	1			2	7		42
	downstream	7	2	2	2	7	28		40		20	28	2		13	8	1	160
	Total	32	2	9	105	114	123	26	98	57	317	292	369	4	94	69	2	

Table 6. Total numbers of fishes captured above and below the electrical barrier during sampling in behalf a long-term monitoring plan in Salt River Project South (SRPs) Canal, Arizona, during sample years 2000 through 2004. Abbreviations as in Clarkson (1996). Totals include young of year and adult individuals.

		Species																							
Year	Reach	AMNA	CAAU	CAIN	CTID	CYCA	CYLU	DOPE	GAAF	GIRO	ICPU	LECY	LEMA	MIDO	MISA	MOMI	MOSA	ONMY	PACL	PONI	PYOL	STVI	TIAU	TILA	TIMO	Total
2000	above			39		13				11	145				10				17	1	27	1		3754		4018
	below		1	14			26	7		2	24	2	6		11	2	1		29		5			5		135
2002	above			8	22	17				2	69		3		21			1			44			34		221
	below			50	1		26		2	4	121		10	1	112		2		4		111		1			445
2003	above			8		2					113		4		28			3	4		64			1129		1355
	below	1		127	4		10			6	102		14	1	84		1		6		10				2	368
2004	above				1	8	27				26	4	56	1	96			1		1	8	1		24		254
	below	1		52	6	2	105		3	8	34				3		1		2		9					226
	Total	2	1	298	34	42	194	7	5	33	634	6	93	3	365	2	5	5	62	2	278	2	1	4946	2	

Table 7. Total numbers of fishes captured above and below the electrical barrier during sampling in behalf a long-term monitoring plan in Salt River Project North (SRPn) Canal, Arizona, during sample years 2000 through 2004. Abbreviations as in Clarkson (1996). Totals include young of year and adult individuals.

		Species																							
Year	Reach	AMNA	CAIN	CTID	CYCA	CYLU	DOPE	GAAF	GIRO	HYBR	ICCY	ICNI	ICPU	LECY	LEMA	MIDO	MISA	MOMI	ONMY	PACL	PEFL	PONI	PYOL	STVI	TILA	Total
2000	above		15	7	5				1			1	264		1		7		2	4			99		7	413
	below		46	14	1	24	1			1			4	2	8		8	2	2	10					2	125
2001	above		13	3	5								314		3	1	18	11	8	9		3	33	2	10	433
	below		121	6	1	26	6						7				7		1	11	1		1			188
2002	above		35		15				3				166		7		44		1			1	75		37	384
	below		275	35		1			2				3	7	7		16								1	347
2003	above	1	12		1								325		2		17		4	1			57		5	425
	below		160	50					1				4	3	10		21						1		3	253
2004	above	2	10	1	4		1				1		75	5	6		43		5	1		1	13		3	171
	below		65	17	2	47		34					10		4		1		1				2		1	184
	Total	3	752	133	34	98	8	34	7	1	1	1	1172	17	48	1	182	13	24	36	1	5	281	2	69	

Table 8. Total numbers of fishes captured above and below the electrical barrier during sampling in behalf a long-term monitoring plan in Florence-Casa Grande (FCG) Canal, Arizona, during sample years 2000 through 2004. Abbreviations as in Clarkson (1996). Totals include young of year and adult individuals.

		Species												
Year	Reach	AGCH	AMNA	CAIN	CYCA	CYLU	DOPE	GAAF	ICPU	LECY	LEMA	MISA	PYOL	Total
2000	above				13	20	2	262	92		1			390
	below	1	1		8	103		795	55					963
2001	above		47	1	54	47		19	28				3	199
	below		5		8	35	1		222	1				272
2002	above					12		17						29
	below		1		5	6		103	1		1	1		118
2004	above					471		269	6	1	1			748
	below					2375	1	516	3	1				2896
	Total	1	54	1	88	3069	4	1981	407	3	3	1	3	

Table 9. Fish species presence (+) or absence (-) from ten 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 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.

	95	96	97	98	99	00	01	02	03	04
*Desert sucker	+ + +	+ - +	+ - +	+ + +	+ - +	+ - -	+ - +	+ - -	+ - o	+ - -
*Longfin dace	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + -	+ + o	+ + -
*Sonora sucker	- - +	- - +	- - +	- - +	- - +	- - -	- - -	- - -	- - o	- - -
Black bullhead	+ + -	+ + -	+ - -	+ + -	- + -	+ - -	+ + +	- + -	+ + o	+ + -
Bluegill	- - -	- - -	+ - -	- - -	- - -	- - -	- - -	- - -	- - o	- - -
Channel catfish	- - -	- - +	- - -	- - +	- - +	- - -	- - -	- - -	- - o	- - -
Common carp	- - -	- - +	- - -	- - +	- - -	- - -	- - +	+ - -	+ - o	+ - -
Fathead minnow	+ - +	+ - -	+ + +	+ + -	- - -	+ - -	+ + +	+ - -	+ + o	+ - -
Green sunfish	+ + -	+ - +	+ + +	+ + +	- - +	+ - -	+ + +	+ + -	+ - o	+ - -
Hybrid sucker	- - +	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - o	- - -
Largemouth bass	+ - -	- - -	+ - -	+ - -	- - -	- - -	+ - -	- - -	- - o	- - -
Mosquitofish	+ + +	+ + +	+ + +	+ - +	+ - +	+ - +	+ - +	+ + +	+ + o	+ - -
Red shiner	- - -	- - +	- - +	- - +	- - +	- - -	- - +	- - -	- - o	- - -
Yellow bullhead	- - +	- - +	+ + +	- - +	+ + +	- - +	+ - +	+ - -	- - o	- - -

Table 10. Fish species presence (+) or absence (-) from ten 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.

	95	96	97	98	99	00	01	02	03	04
*Desert sucker	+ + o +	o o o +	+ + + +	+ + + +	- + - +	- - - -	- - - -	- - - -	o - - -	o o - -
*Longfin dace	+ + o +	o o o +	- + + -	- + + -	- + + +	- + - -	- - + -	- - - -	o - - -	o o - -
*Sonora sucker	+ + o +	o o o +	+ + + +	+ + + +	+ + - +	+ - - -	+ + + +	- + - +	o - - -	o o - -
Black bullhead	- - o -	o o o -	- - - -	- - - -	- + - -	- - - -	- - - -	- - - -	o - - -	o o - +
Black crappie	- - o -	o o o -	+ + - -	+ + - -	+ - - -	+ - - -	- - - -	+ - - -	o - - -	o o - -
Bluegill	- - o -	o o o -	- - - -	- - + -	+ + - -	+ + - -	- - - -	+ - - -	o + - -	o o - -
Channel catfish	+ + o +	o o o +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + - +	o + - -	o o - -
Common carp	+ - o -	o o o +	+ + + +	+ + + +	+ + + +	+ + - +	+ + + +	+ + + +	o + - -	o o - -
Fathead minnow	+ - o -	o o o -	- - + -	- - - -	- - - -	- - - -	- - + -	- - - -	o + - -	o o - -
Flathead catfish	- - o -	o o o -	+ - - -	+ + + -	+ - - -	+ + - -	+ + - -	+ + - -	o - - -	o o - -
Green sunfish	- - o -	o o o +	+ + + +	+ + + +	+ + - -	+ + - -	+ + - -	+ + - +	o + - -	o o - -
Hybrid sucker	- - o -	o o o -	- - - -	- - - -	- - - +	- - - -	- - - -	- - - -	o - - -	o o - -
Largemouth bass	+ - o -	o o o -	+ + - -	+ + + -	+ + - -	+ + - -	+ + + -	+ + - -	o - - -	o o - -
Mosquitofish	+ - o -	o o o -	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	o + + +	o o + +
Red shiner	+ + o +	o o o +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	+ + + +	o + + -	o o + +
Smallmouth bass	- - o -	o o o -	+ - - -	- - - -	- - - -	- - - -	- - - -	- - - -	o - - -	o o - -
Threadfin shad	- - o -	o o o -	+ + + -	+ - + +	+ - - -	+ - - -	- - - -	- - - -	o - - -	o o - -
Undetermined or hybrid sunfish	- - o -	o o o -	- - - -	+ - - -	+ - - -	+ - - -	+ - - -	- - - -	o - - -	o o - -
Yellow bullhead	- + o +	o o o +	+ + + +	+ + + +	+ + + +	- + - +	+ + + +	+ + - +	o + - -	o o + +

Table 11. Fish species presence (+) or absence (-) from ten 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.

	95	96	97	98	99	00	01	02	03	04
*Desert sucker	+	+	+	+	+	+	-	+	+	-
*Longfin dace	-	-	-	-	-	+	-	+	+	-
*Sonora sucker	+	+	+	+	+	+	+	+	+	+
Black crappie	-	-	-	+	-	-	+	-	-	-
Blue tilapia	-	+	-	-	-	-	-	-	-	-
Bluegill	+	+	-	-	+	+	+	+	+	+
Channel catfish	+	+	+	+	+	+	-	-	+	-
Common carp	+	-	+	+	+	+	+	+	+	+
Flathead catfish	-	-	-	+	+	+	-	-	-	-
Green sunfish	+	+	+	+	+	+	+	+	+	-
Hybrid sucker	-	-	-	-	+	+	-	-	-	-
Largemouth bass	+	+	+	+	+	+	+	+	+	+
Mosquitofish	+	+	+	+	+	+	-	+	+	-
Rainbow trout	+	-	-	-	+	+	+	-	+	-
Red shiner	-	-	-	-	-	+	-	+	+	-
Redbelly tilapia	-	-	+	-	-	-	-	-	-	-
Redear sunfish	-	-	+	+	-	+	-	-	-	-
Roundtail chub	-	+	-	+	+	+	-	-	-	-
Sailfin molly	-	-	-	-	+	+	-	+	+	-
Smallmouth bass	-	+	-	-	+	-	-	+	-	-
Threadfin shad	-	-	-	-	-	+	-	+	-	-
Undetermined Cichlid	-	-	-	+	+	+	-	+	+	-
Undetermined or hybrid sunfish	-	-	-	-	+	-	-	+	-	-
Walleye	+	+	-	-	-	-	-	-	-	-
Yellow bass	+	-	+	+	-	+	+	-	-	-
Yellow bullhead	+	-	+	+	+	+	-	+	+	+

Table 12. Fish species presence (+) or absence (-) from ten 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.

	95	97	98	99	00	01	02	03	04
Black bullhead	- - +	- - +	- - -	- - +	- - +	- - -	- - +	- - +	- - +
Bluegill	+ + +	+ + +	+ + +	+ - +	+ - +	- - +	+ + +	- - +	+ + +
Channel catfish	+ + -	+ + -	+ + +	+ + -	+ + -	+ - +	+ - +	+ - +	+ + +
Common carp	+ + +	+ + -	+ + +	+ + +	+ + +	+ - +	+ - +	+ - +	+ + +
Flathead catfish	- - -	- - -	- - -	- - -	- - -	- - -	- - -	+ - -	- - +
Goldfish	- - +	- - -	- - +	- - +	- - -	- - +	- - +	- - -	- - +
Grass carp	- - +	+ - -	+ + +	+ + +	+ + +	+ - +	+ + +	+ - +	+ + +
Green sunfish	- - +	- - +	+ - -	+ - -	+ - +	- - +	- - +	+ - +	- - -
Largemouth bass	+ + +	+ - +	+ + +	+ + +	+ + +	+ - +	+ + +	+ - +	+ + +
Red shiner	- + +	+ - +	- + +	+ - +	+ + +	+ - -	+ - -	- - +	+ + +
Redear sunfish	+ - +	- - +	+ - +	- - +	- - +	- - +	+ - +	- - +	- + +
Smallmouth bass	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	+ - -
Striped bass	+ + +	+ + +	+ + +	+ + +	+ - +	+ - +	+ + +	+ - +	+ + +
Threadfin shad	+ - +	- - +	- - +	- - +	+ + +	- - -	- - -	- - -	- - -
Undetermined or hybrid sunfish	- - +	- - -	+ - -	+ - +	+ - +	+ - +	- - +	+ - +	- - +
White bass	- + +	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Yellow bullhead	- - +	- - +	- - -	- - -	- - -	- - -	- - -	- - -	- - +

Table 13. Fish species presence (+) or absence (-) from ten 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.

	95	96	97	98	99	00	02	03	04
*Desert sucker	+ +	+ +	+ +	+ +	+ +	+ +	- +	+ +	- +
*Longfin dace	- -	- +	- -	- -	- -	- -	- -	- -	- -
*Sonora sucker	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	- +
Black crappie	- -	- +	- -	- -	- -	+ -	- -	- -	+ -
Blue tilapia	- -	+ +	- -	- -	- -	- -	- +	- -	- -
Bluegill	+ +	+ +	+ -	+ +	+ +	- +	+ +	+ +	+ -
Channel catfish	+ -	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Common carp	+ -	+ +	+ +	+ +	+ -	+ -	+ -	+ -	+ +
Flathead catfish	+ -	+ +	- +	+ +	+ +	+ +	+ +	+ +	+ +
Goldfish	- -	- -	- -	- -	- -	- +	- -	- -	- -
Grass carp	+ +	- +	- +	- +	- +	- -	+ +	- +	+ +
Green sunfish	- -	- -	- -	- +	- +	- +	- -	- -	+ -
Largemouth bass	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Mosquitofish	- -	- +	- -	- +	- -	- -	- +	- -	- +
Mozambique tilapia	- -	- -	- -	- -	- -	- -	- -	- +	- -
Rainbow trout	- +	- -	- +	- -	+ -	- -	+ -	+ -	+ -
Red shiner	- +	+ +	+ +	+ +	- +	- +	- +	- +	+ +
Redbelly tilapia	- -	- -	- +	- +	- -	- -	- -	- -	- -
Roundtail chub	+ +	+ +	+ +	+ +	+ +	+ +	+ +	- +	- +
Smallmouth bass	+ -	+ +	- -	- -	+ -	- -	- +	- +	+ -
Striped bass	- -	- -	- -	- -	- +	- +	- +	- +	- +
Threadfin shad	- +	- +	- -	+ -	- +	- +	- -	- -	- -
Undetermined Cichlid	+ -	- -	+ -	+ -	+ +	+ +	+ -	+ -	+ -
Undetermined or hybrid sunfish	- -	- -	- -	- -	+ -	- -	- -	- -	- -
Walleye	+ -	+ +	+ -	- -	- -	+ -	- -	- -	+ -
Yellow bass	+ -	+ -	- -	+ -	- -	- +	- -	- -	- -
Yellow bullhead	- -	- -	- -	- -	- +	- -	- -	- +	- +

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	95	96	97	98	99	00	01	02	03	04
*Desert sucker	+ +	+ +	+ +	+ +	+ +	+ +	+ +	- -	+ -	+ -
*Longfin dace	- -	- -	- +	- -	- -	- -	- -	- -	- -	- -
*Sonora sucker	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Black crappie	- +	+ -	+ -	- -	+ -	- -	+ -	+ -	- -	+ -
Blue tilapia	- +	+ +	- +	- -	- -	- -	- -	- -	- -	- -
Bluegill	+ +	+ -	+ +	+ -	+ -	+ +	+ -	+ +	+ +	+ +
Bigmouth buffalo	+ -	- -	- -	+ -	- -	- -	- -	- -	- -	+ -
Black buffalo	- -	- -	- -	- -	- -	+ -	- -	- -	- -	- -
Channel catfish	+ +	+ +	+ +	+ -	+ +	+ +	+ +	+ +	+ +	+ +
Common carp	+ +	+ +	+ +	+ -	+ +	+ +	+ +	+ -	+ -	+ +
Flathead catfish	+ +	+ -	+ +	+ -	+ -	+ -	+ +	+ -	+ +	+ +
Goldfish	- +	- -	- +	- -	- -	- -	- -	- -	- -	- -
Grass carp	- +	+ +	- +	+ +	+ +	+ +	+ +	- +	- +	+ +
Green sunfish	- +	+ -	- +	+ -	+ +	- +	- -	- +	- +	+ -
Hybrid sucker	- -	- -	- -	- -	- -	- +	- -	- -	- -	- -
Largemouth bass	+ +	+ +	+ +	+ -	+ +	+ +	+ +	+ +	+ +	+ +
Mosquitofish	- +	- -	- -	- -	- -	- -	- -	- -	- -	- +
Rainbow trout	+ +	+ +	+ +	+ -	+ +	+ +	+ +	+ -	+ -	+ +
Red shiner	+ +	+ +	- +	+ +	- +	- +	- +	- +	- -	- +
Redbelly tilapia	- -	- +	- +	+ -	- -	- -	- -	- -	- -	- -
Redear sunfish	- -	- +	- -	- -	- -	- -	- -	- -	- -	- -
Roundtail chub	+ +	+ +	+ +	+ -	+ -	+ -	- -	+ +	- +	- -
Smallmouth bass	- -	+ -	- -	- -	+ -	- -	+ -	- -	- -	- -
Threadfin shad	+ -	- -	- -	+ -	+ +	- +	- +	- -	- -	+ -
Undetermined cichlid	- -	- -	+ -	+ -	+ +	+ +	+ -	+ +	+ +	+ +
Walleye	- -	+ -	+ -	- -	- -	- -	+ -	- -	- -	- -
Yellow bass	+ -	- -	+ +	+ -	+ -	- +	+ -	- -	- -	- -
Yellow bullhead	- -	- -	- -	- -	- -	- -	- -	- -	+ -	+ -
Yellow perch	- -	- -	- -	- -	- -	- -	+ -	- -	- -	- -

Table 15. Fish species presence (+) or absence (-) from ten 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.

	95	96	97	98	99	00	01	02	04
*Desert sucker	+ +	+ +	- +	- -	- -	- -	- -	- -	- -
*Longfin dace	- -	- +	+ -	- +	- -	- +	- -	- -	- -
*Sonora sucker	- +	+ +	+ -	+ +	- -	- -	+ -	- -	- -
Bluegill	- -	- +	- -	- -	- -	+ -	- -	- +	+ -
Channel catfish	+ +	+ -	+ +	+ +	+ +	+ +	+ +	- +	+ +
Common carp	+ +	- +	- -	+ +	- -	+ +	+ +	- +	- -
Fathead minnow	- -	+ +	- -	- -	- -	- -	- -	- -	- -
Flathead catfish	- -	- -	- -	- -	- -	- -	+ -	- -	- -
Green sunfish	- -	- +	- -	- -	- -	- -	- +	- -	+ +
Largemouth bass	- -	- -	- -	- -	- -	- -	- -	- +	- -
Mosquitofish	- -	+ +	+ +	+ +	+ +	+ +	+ -	+ +	+ +
Red shiner	- +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Threadfin shad	- -	- +	- -	+ +	- -	+ -	- +	- -	- +
Yellow bullhead	- -	+ +	+ +	+ +	- -	- +	+ +	- +	- -

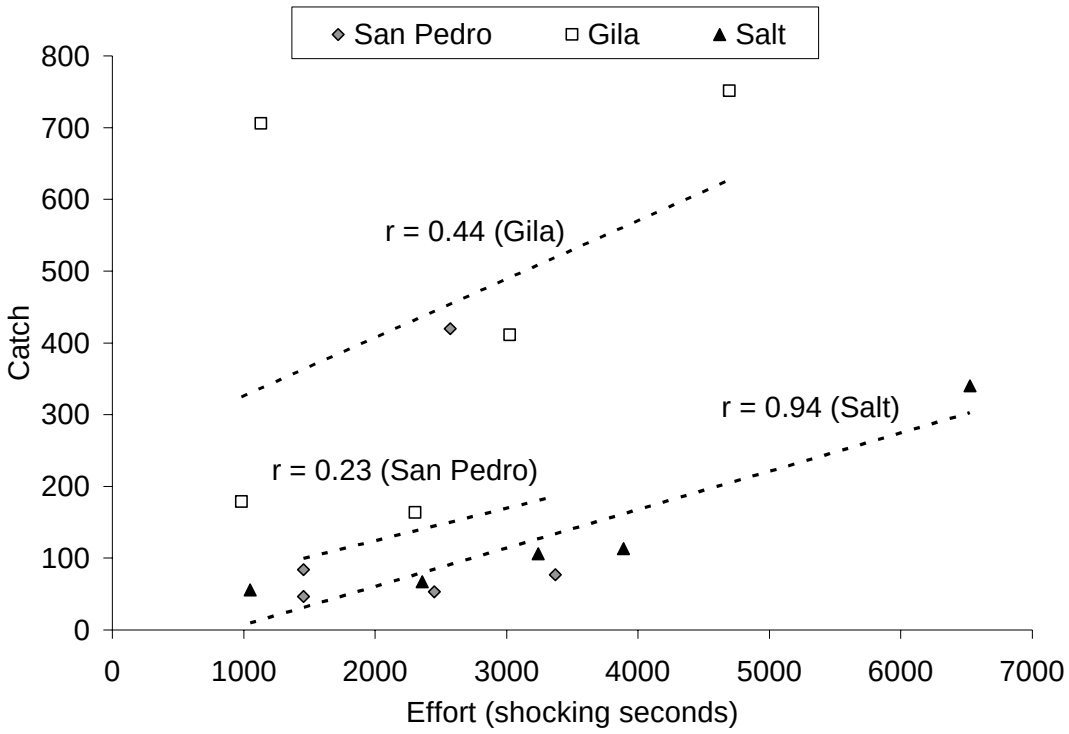

Figure 1. The correlation of catch and effort as calculated by summing electrofishing catch and effort for each sample year and river system. Effort is backpack electrofishing seconds for San Pedro and Gila rivers, and boat electrofishing seconds for the Salt River.

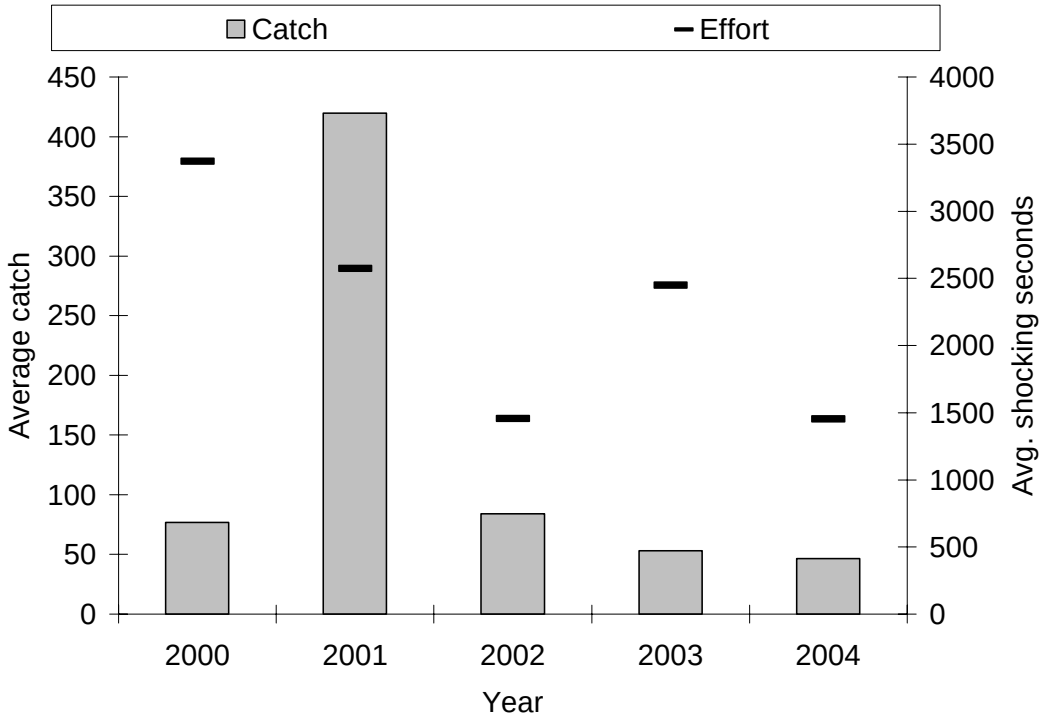

Figure 2. The average across reaches of catch and effort for San Pedro River, sample years 2000 to 2004. Effort is backpack electrofishing seconds.

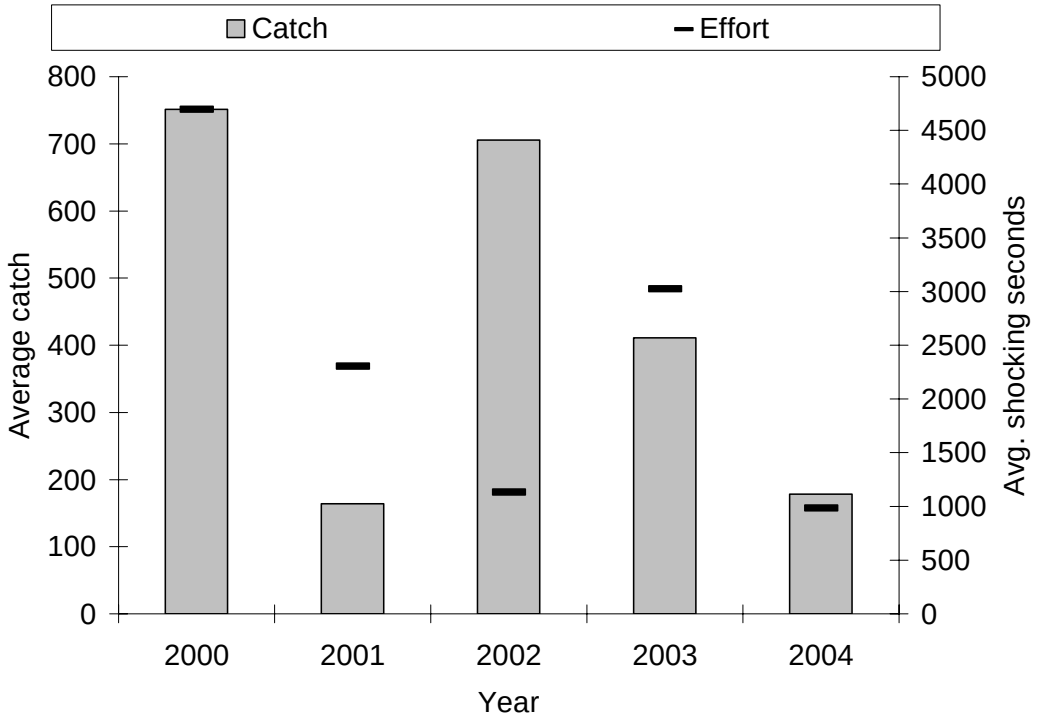

Figure 3. The average across reaches of catch and effort for Gila River, sample years 2000 to 2004. Effort is backpack electrofishing seconds.

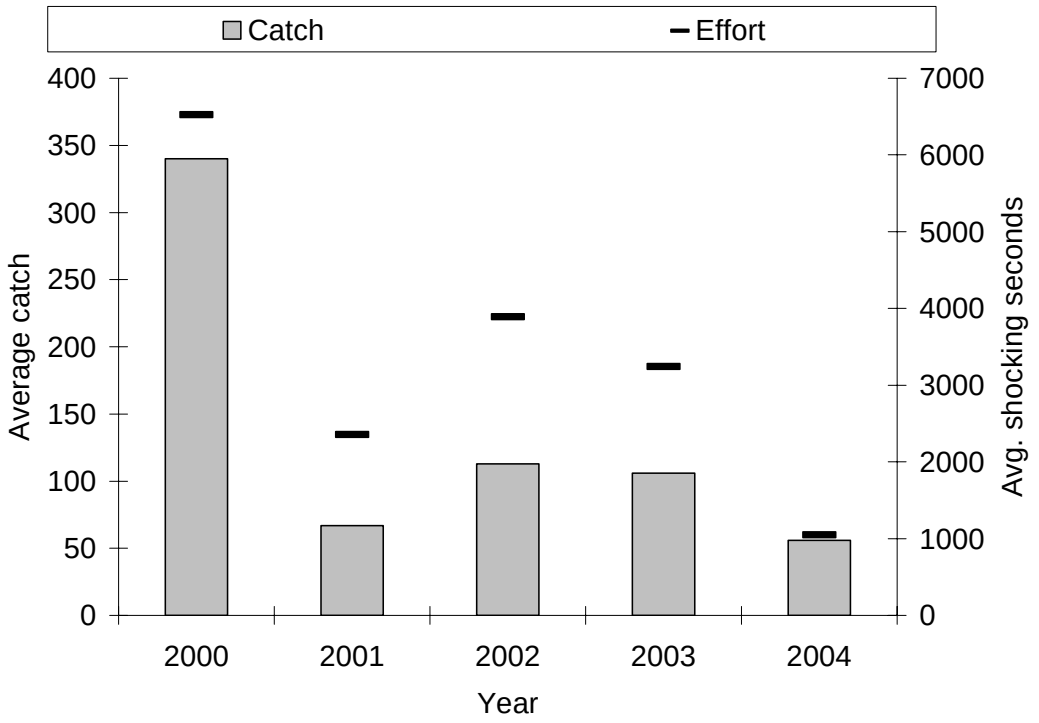

Figure 4. The average across reaches of catch and effort for Salt River, sample years 2000 to 2004. Effort is boat electrofishing seconds.

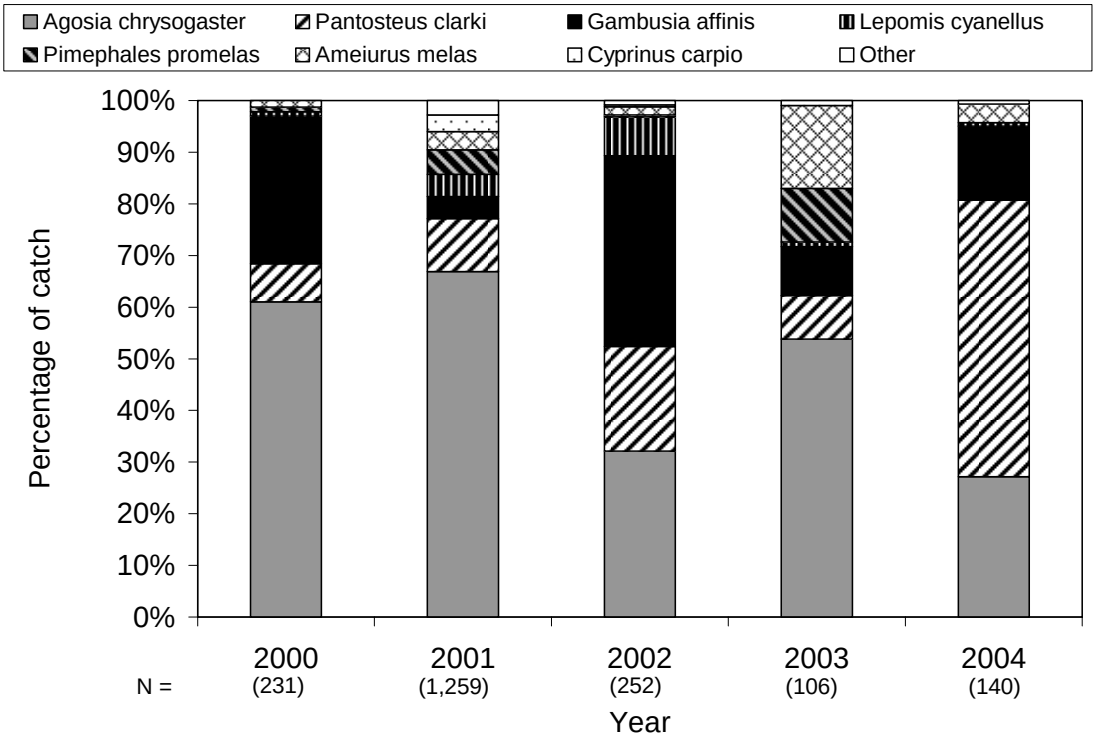

Figure 5. Relative abundance of fishes captured in San Pedro River during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

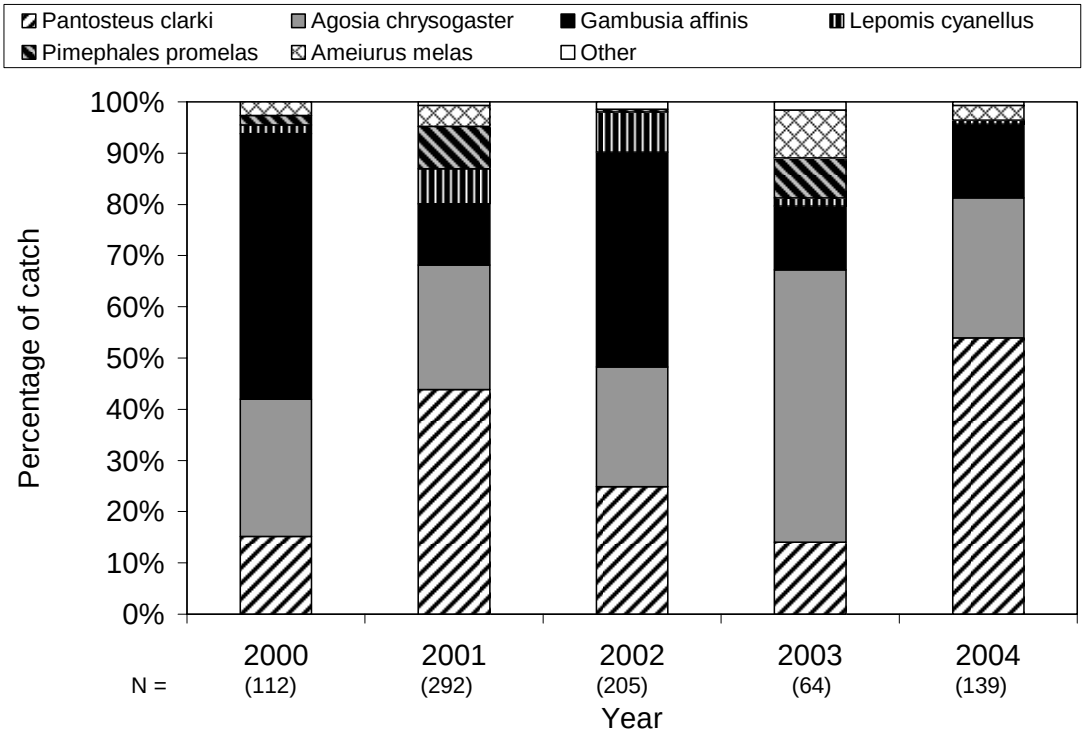

Figure 6. Relative abundance of fishes captured in San Pedro River upstream reach during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

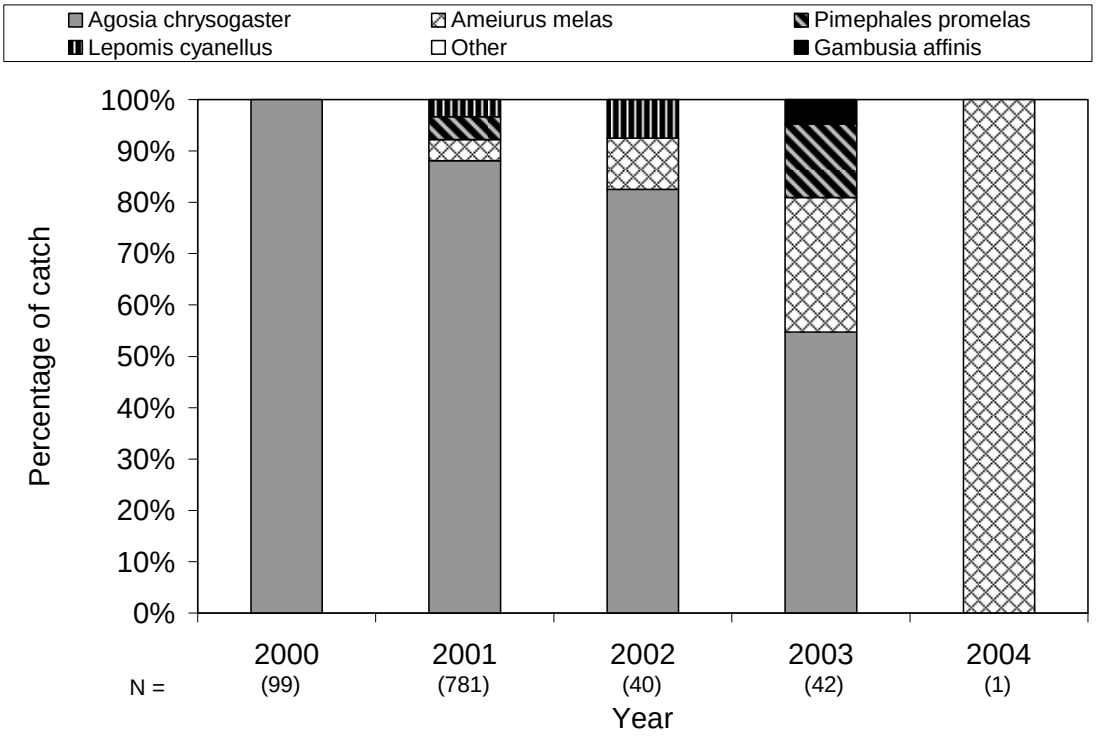

Figure 7. Relative abundance of fishes captured in San Pedro River middle reach during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

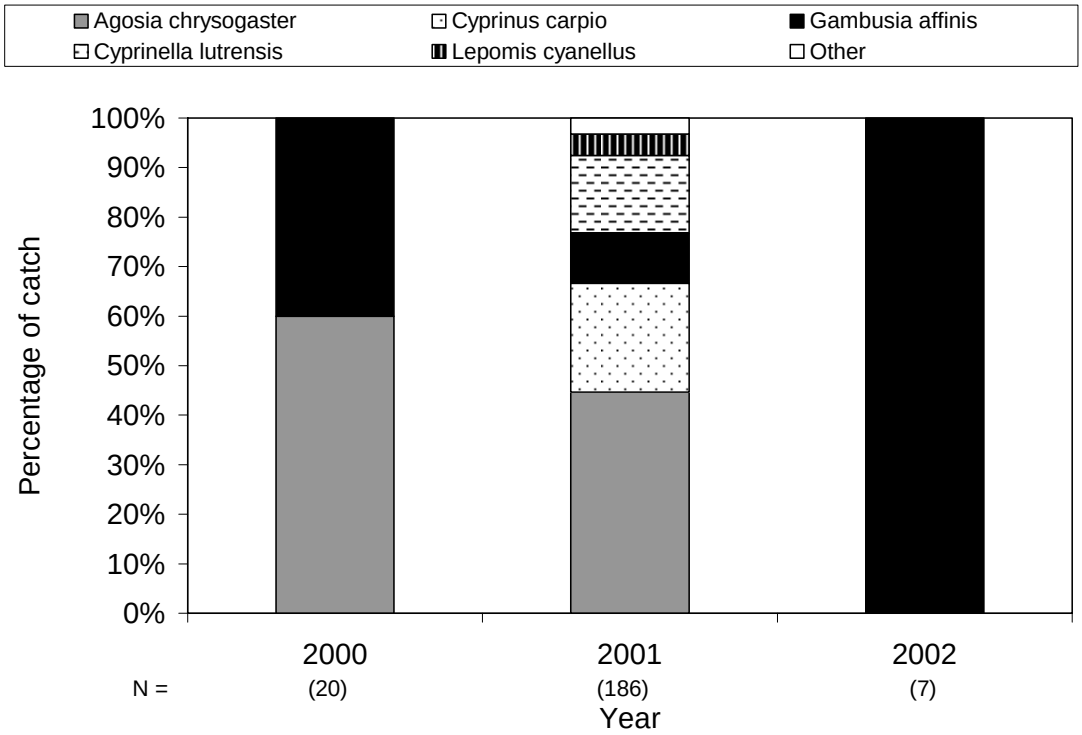

Figure 8. Relative abundance of fishes captured in San Pedro River downstream reach during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

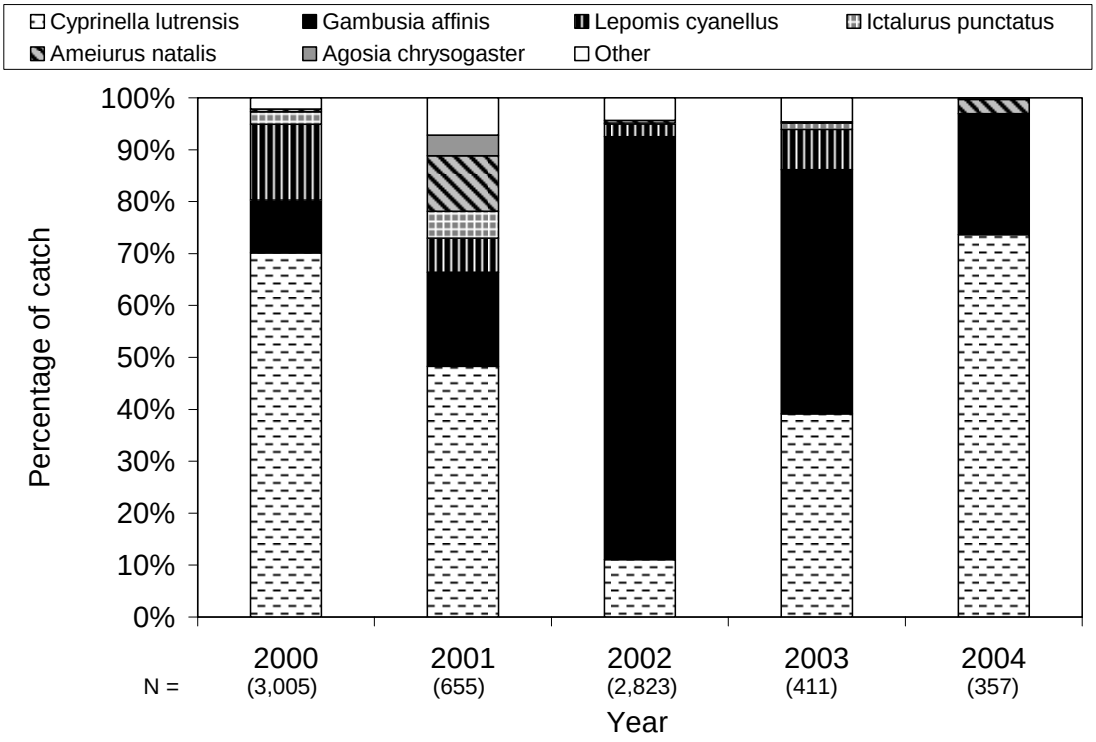

Figure 9. Relative abundance of fishes captured in Gila River during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

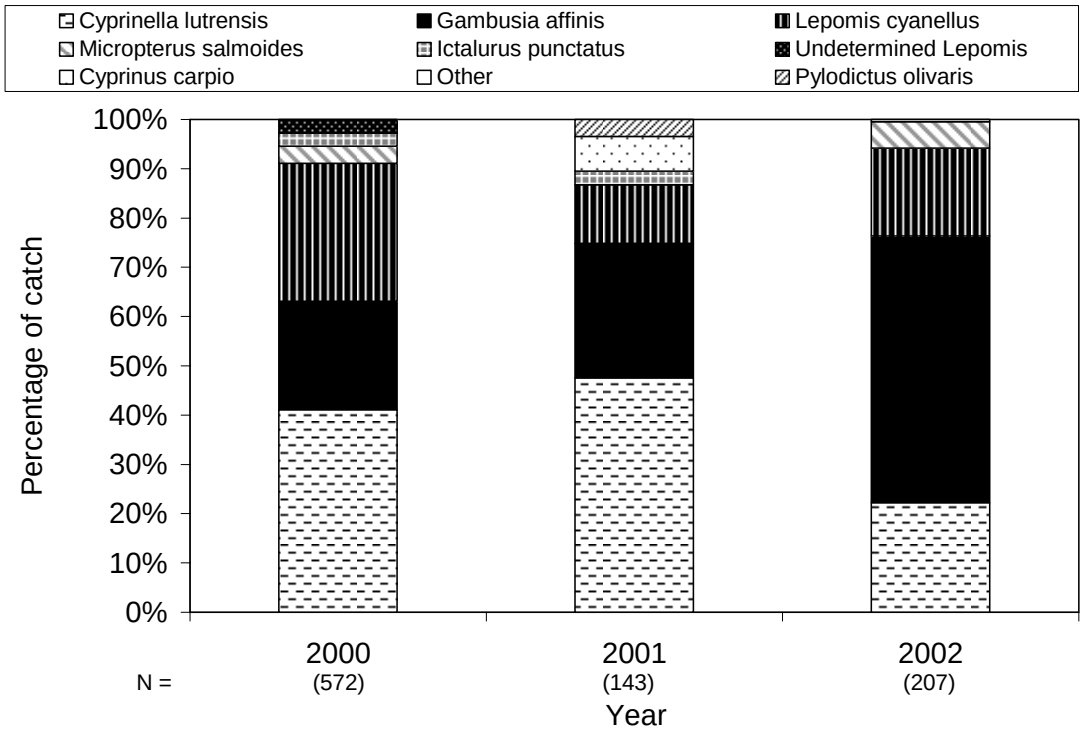

Figure 10. Relative abundance of fishes captured in Gila River upstream reach during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

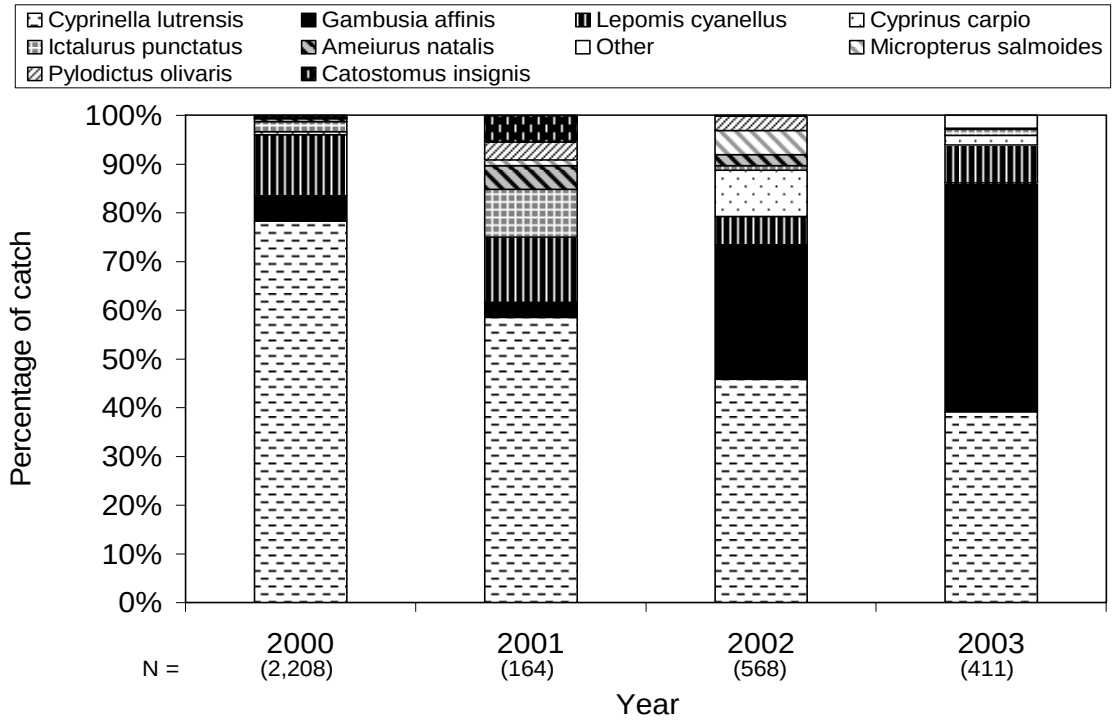

Figure 11. Relative abundance of fishes captured in Gila River upper middle reach during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

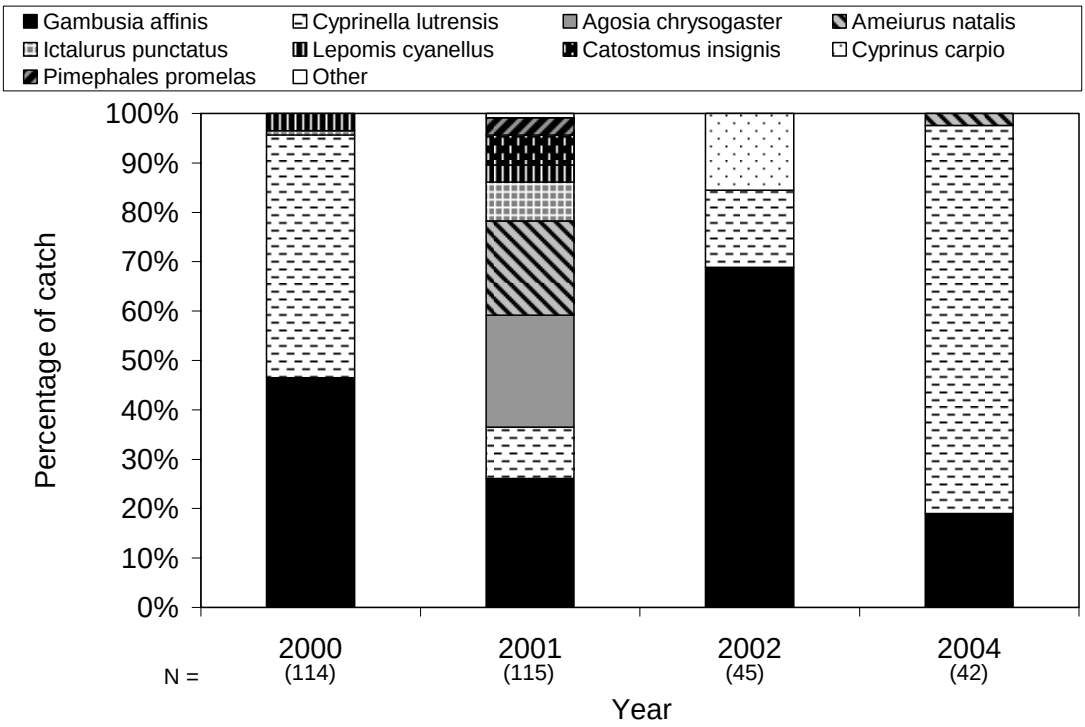

Figure 12. Relative abundance of fishes captured in Gila River lower middle reach during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

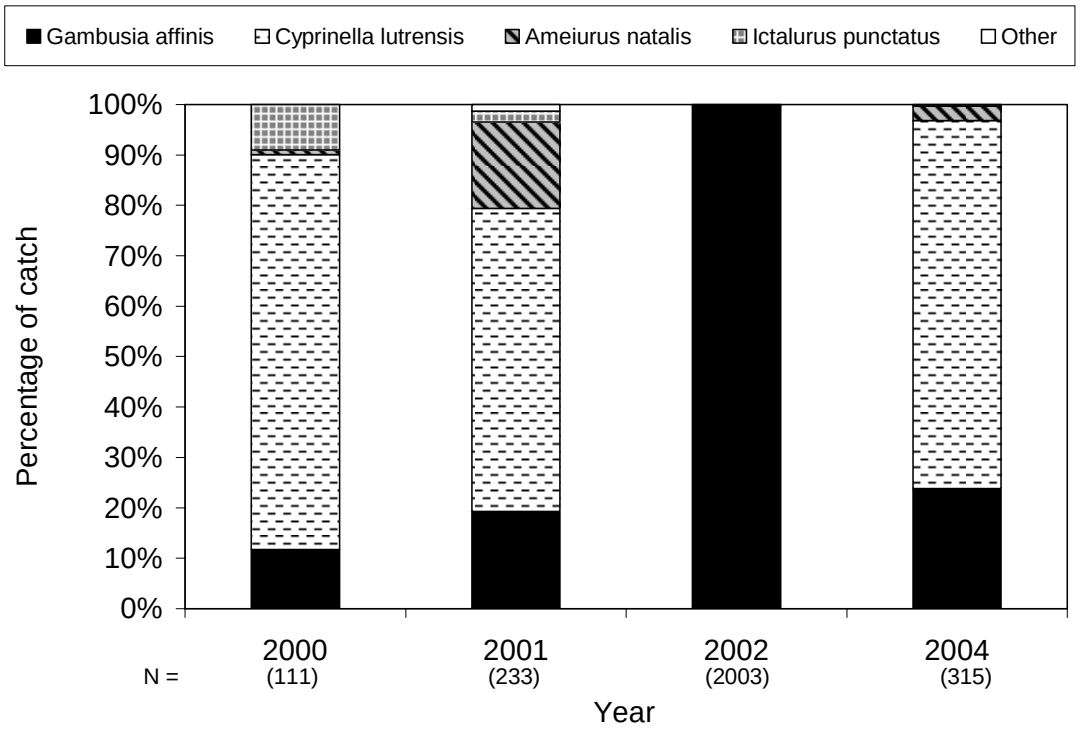

Figure 13. Relative abundance of fishes captured in Gila River downstream reach during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

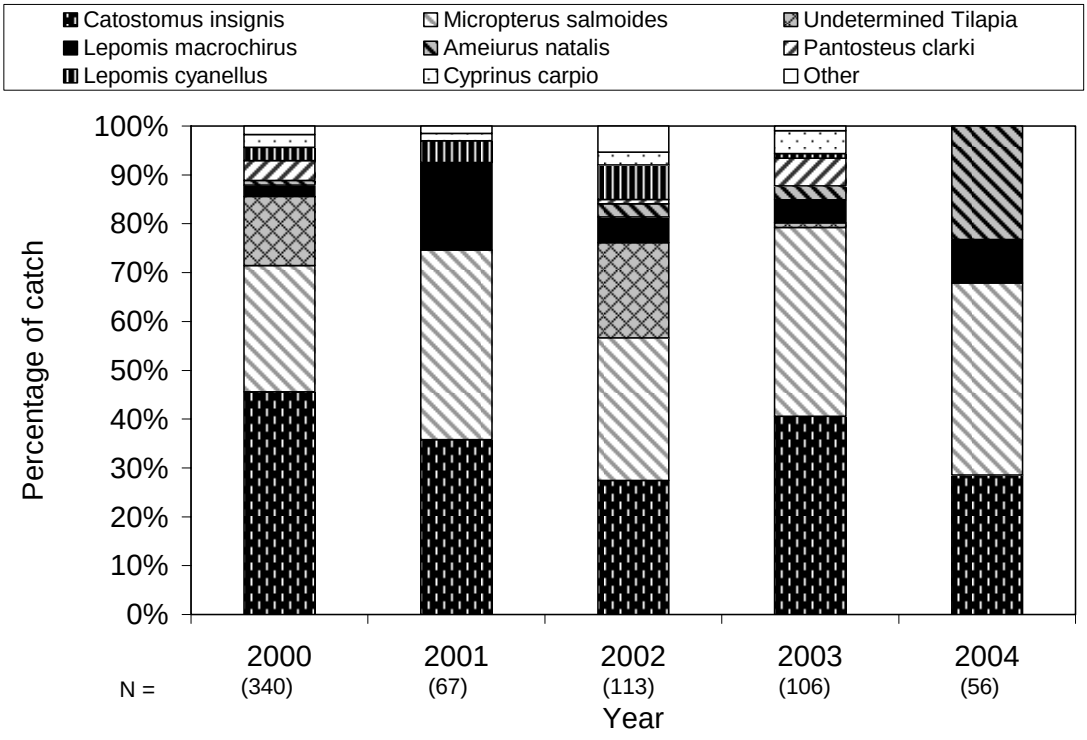

Figure 14. Relative abundance of fishes captured in Salt River during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

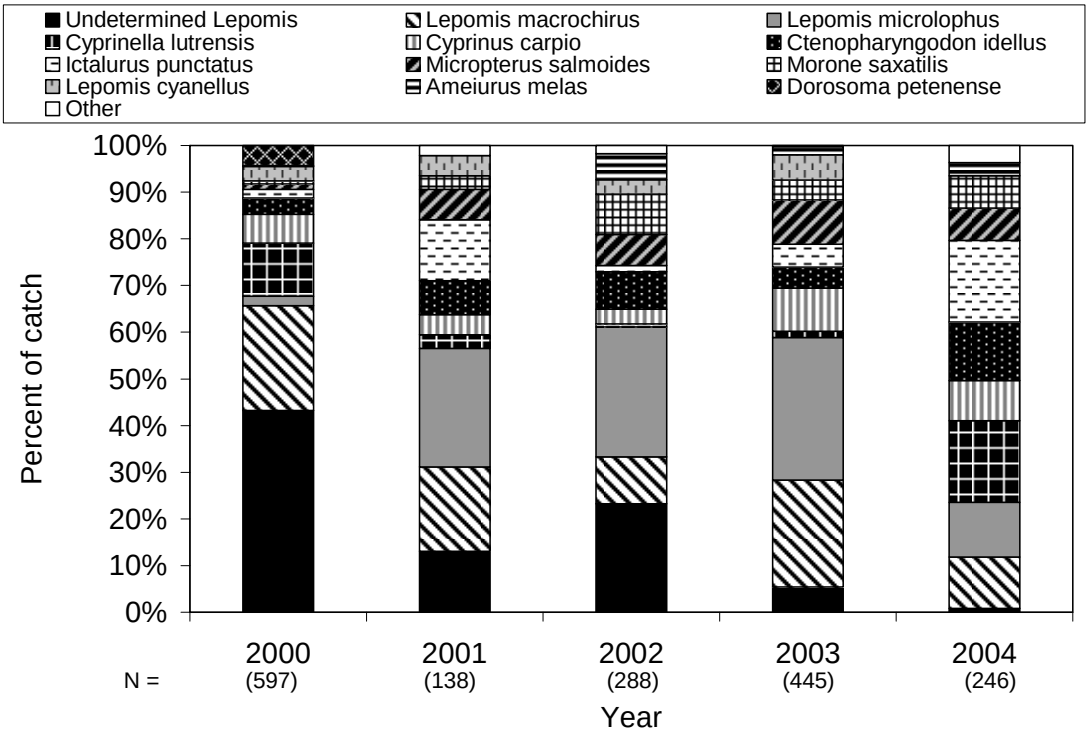

Figure 15. Relative abundance of fishes captured in CAP Canal during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

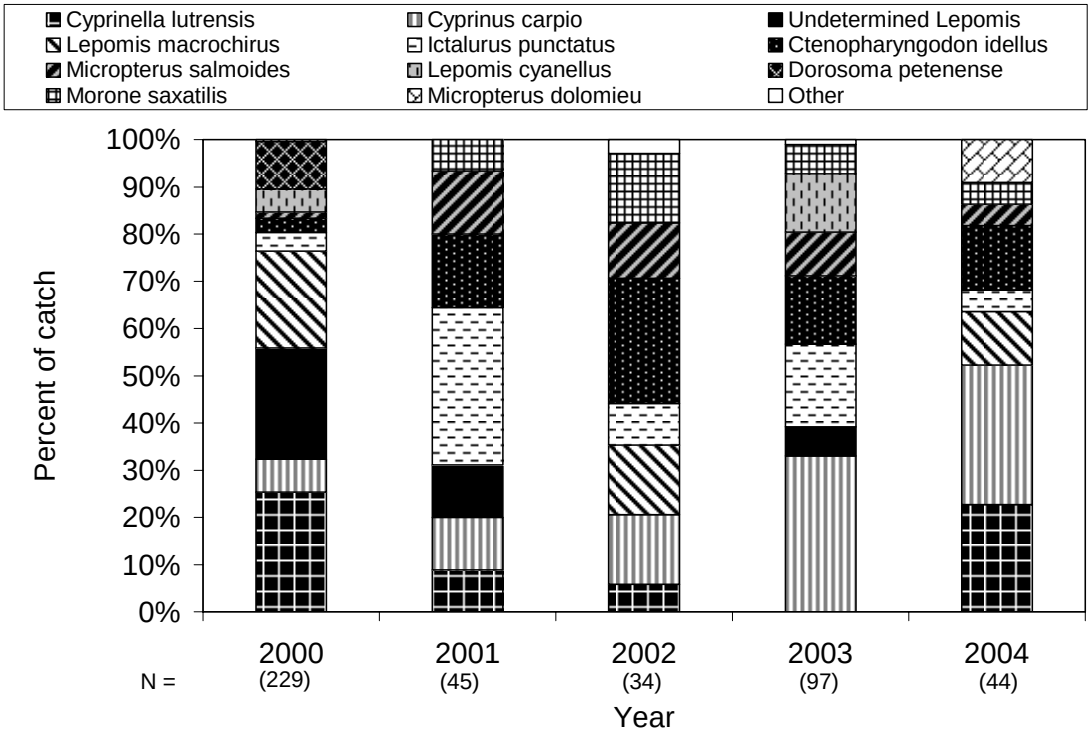

Figure 16. Relative abundance of fishes captured in CAP Canal upstream reach during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

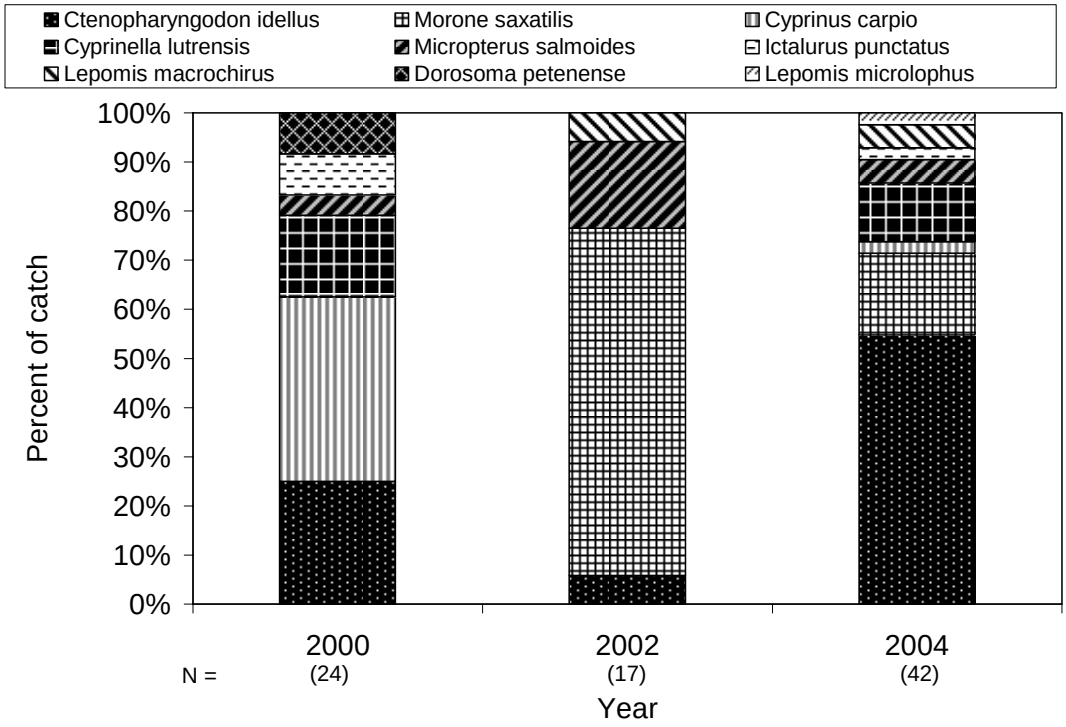

Figure 17. Relative abundance of fishes captured in CAP Canal middle reach during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

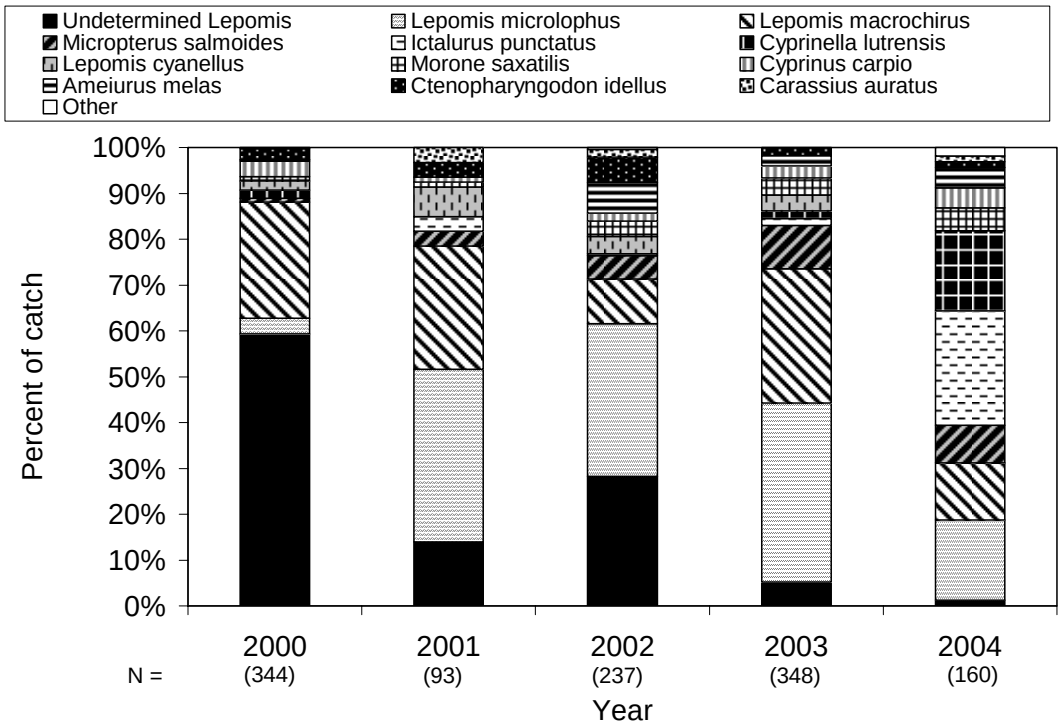

Figure 18. Relative abundance of fishes captured in CAP Canal downstream reach during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

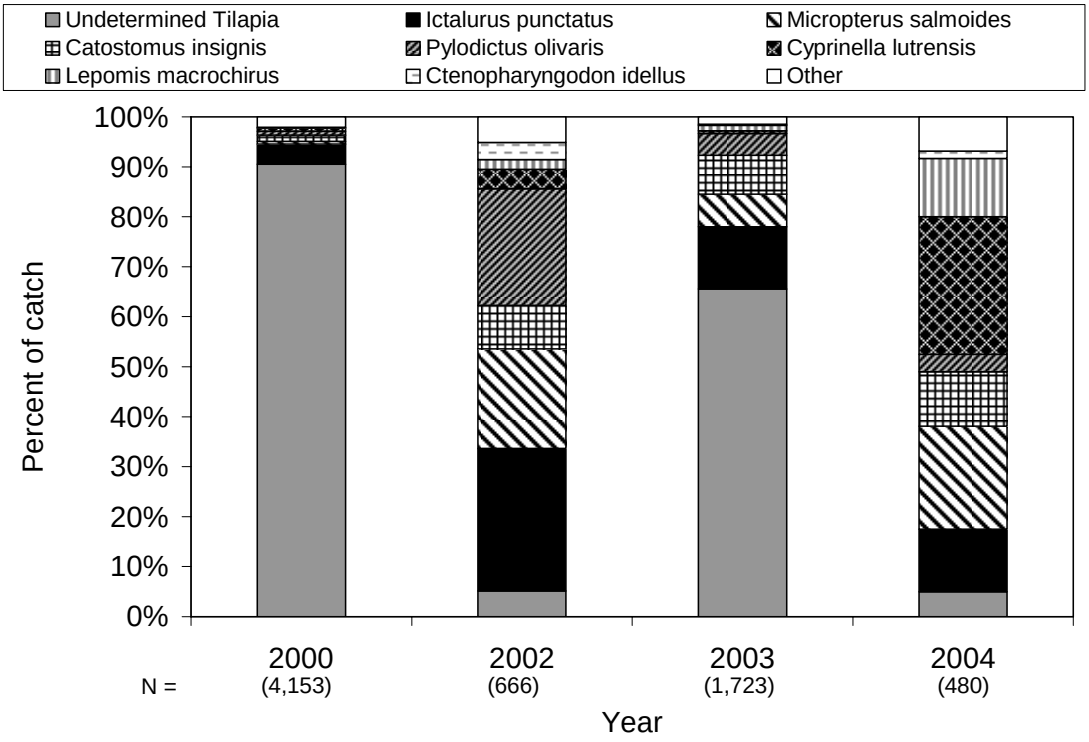

Figure 19. Relative abundance of fishes captured in SRPs Canal during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

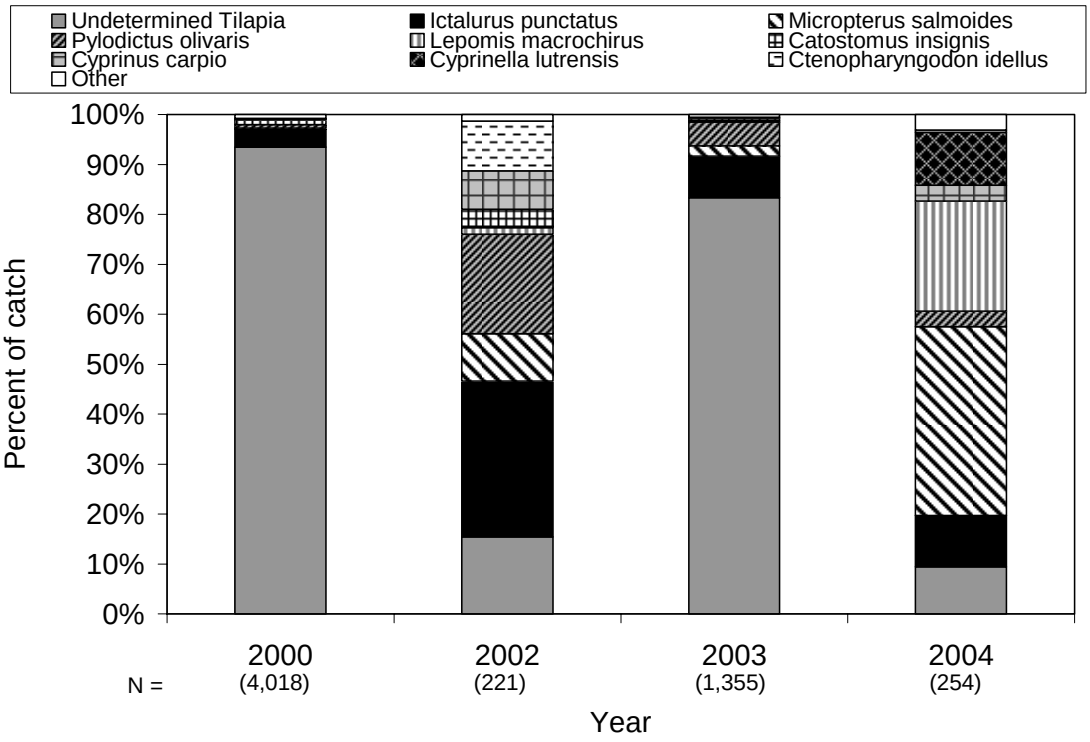

Figure 20. Relative abundance of fishes captured in SRPs Canal above the electrical fish barrier during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

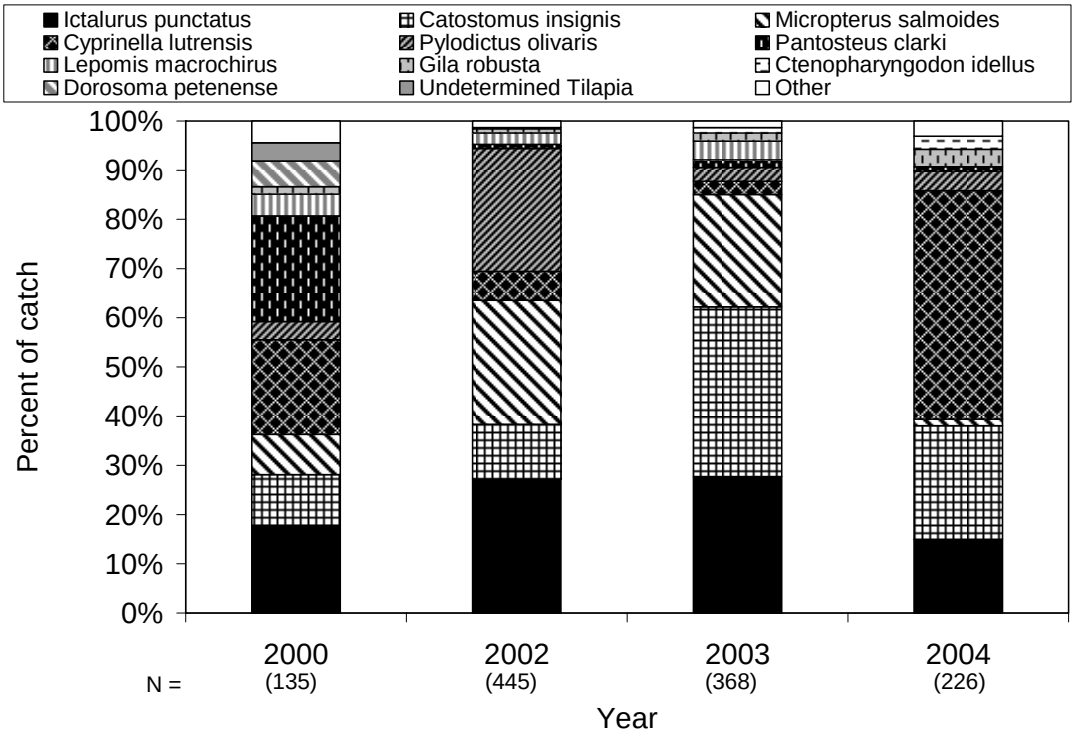

Figure 21. Relative abundance of fishes captured in SRPs Canal below the electrical fish barrier during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

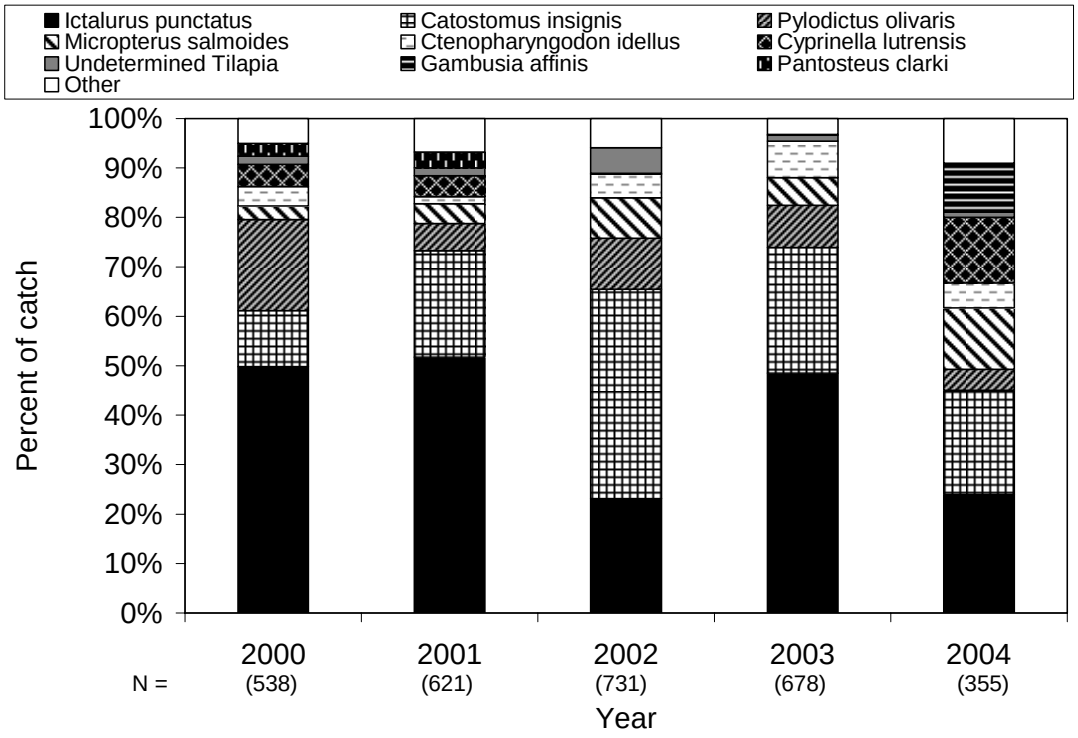

Figure 22. Relative abundance of fishes captured in SRPn Canal during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

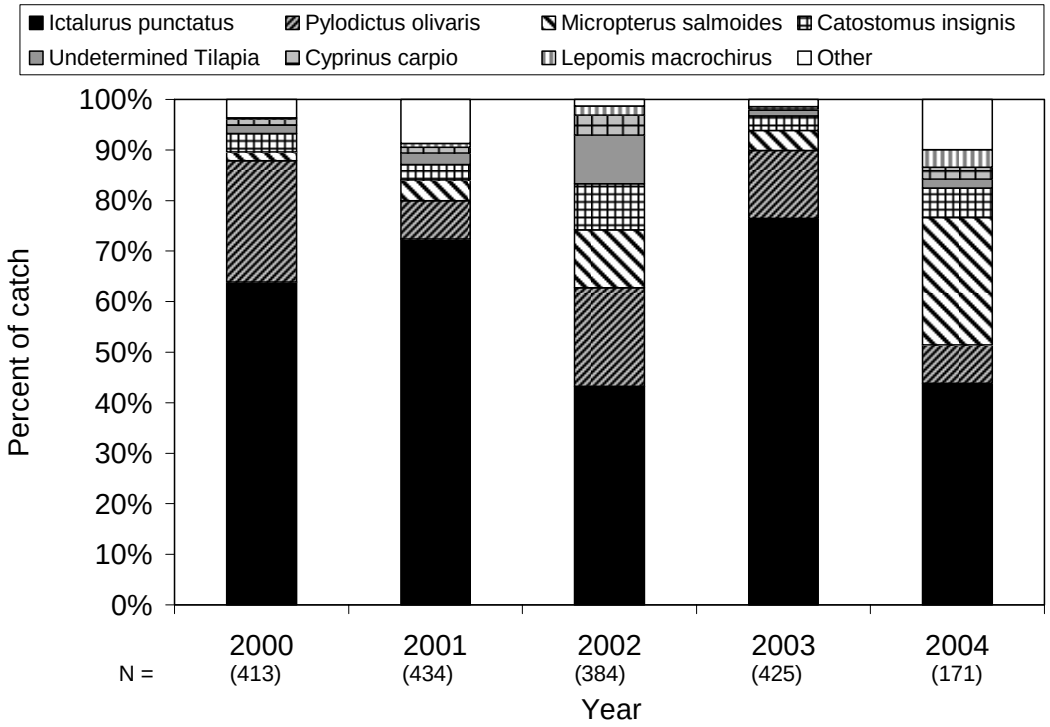

Figure 23. Relative abundance of fishes captured in SRPn Canal above the electrical fish barrier during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

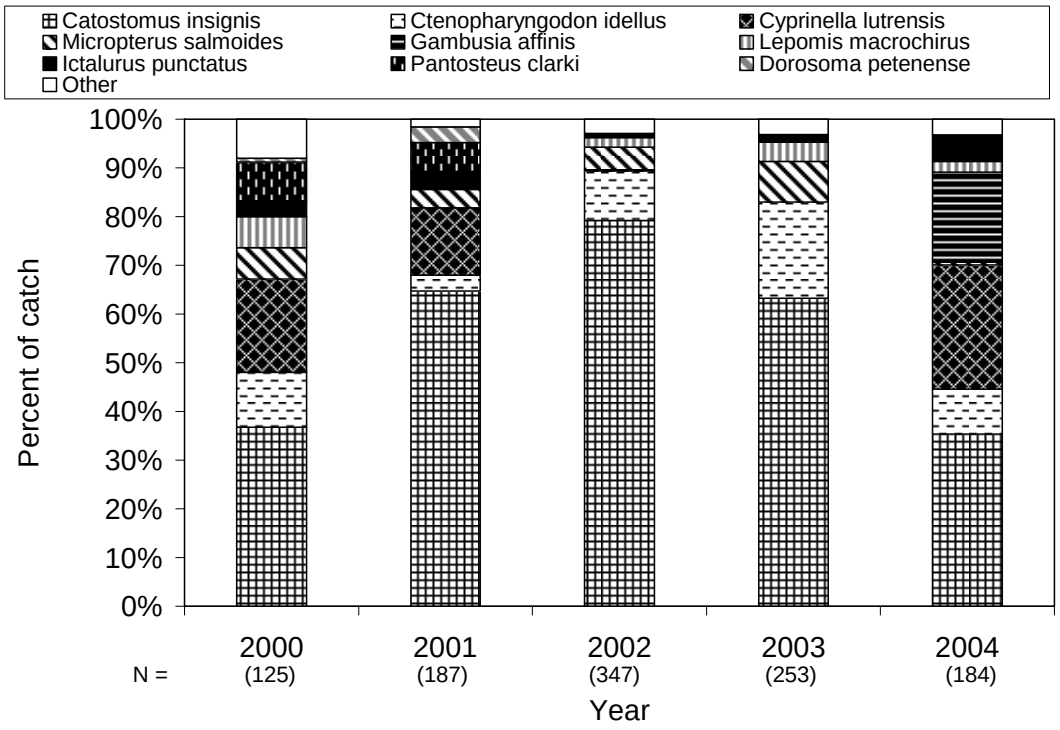

Figure 24. Relative abundance of fishes captured in SRPn Canal below the electrical fish barrier during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

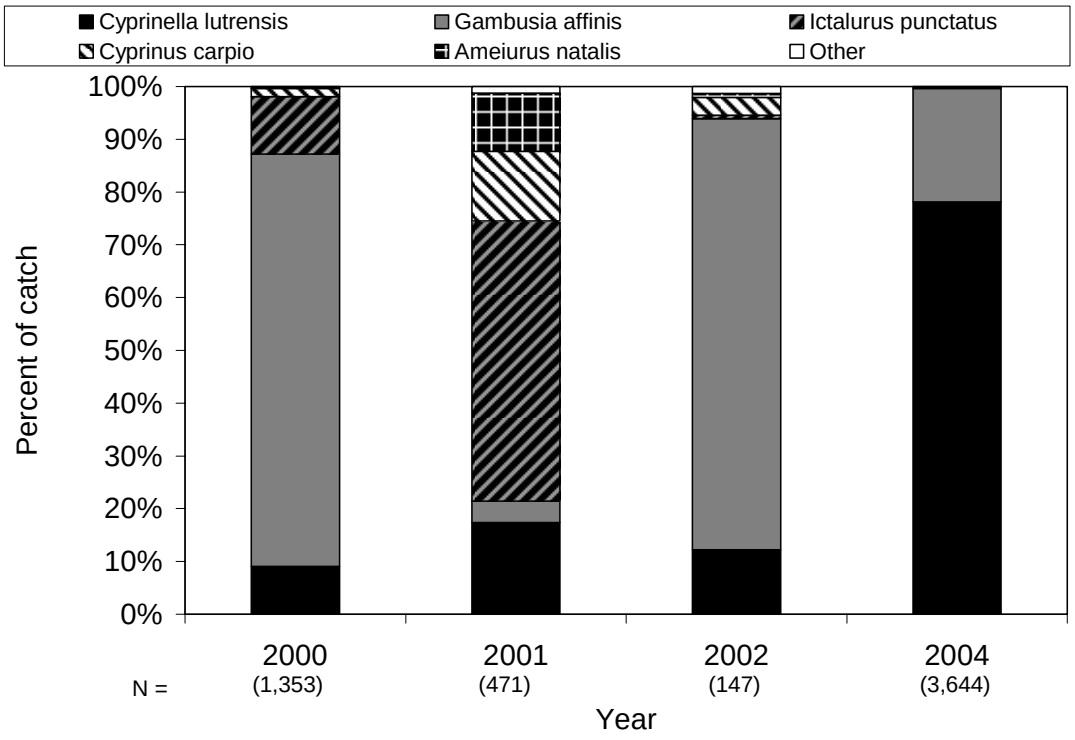

Figure 25. Relative abundance of fishes captured in FCG Canal during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

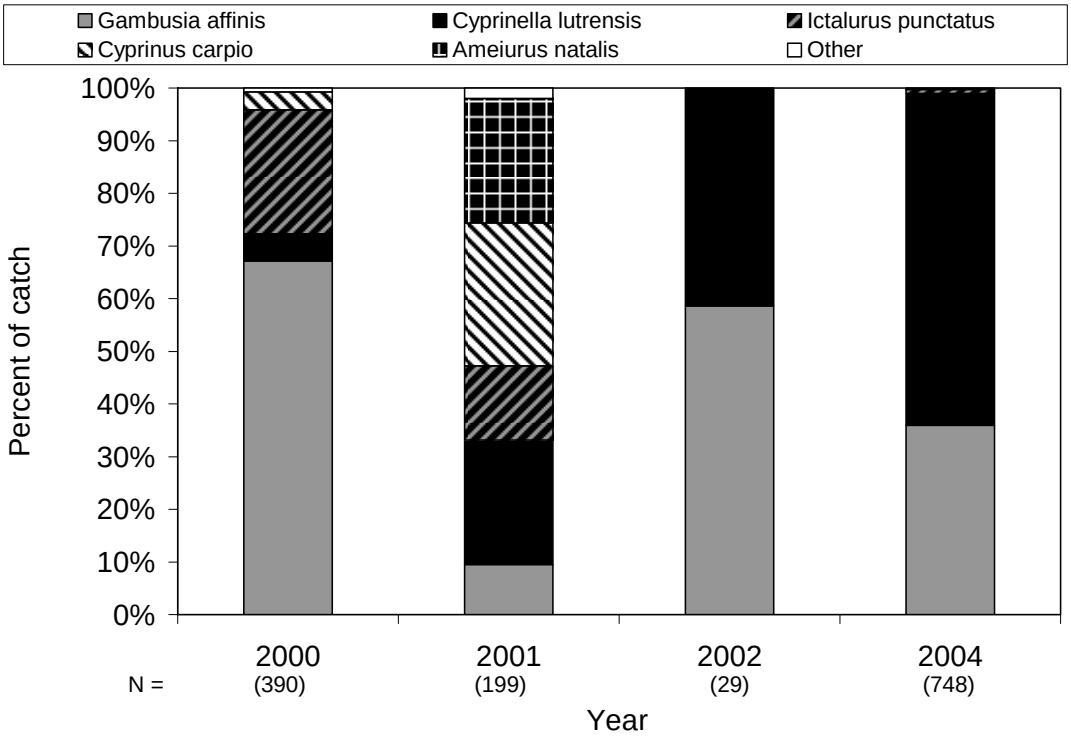

Figure 26. Relative abundance of fishes captured in FCG Canal above the electrical fish barrier during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.

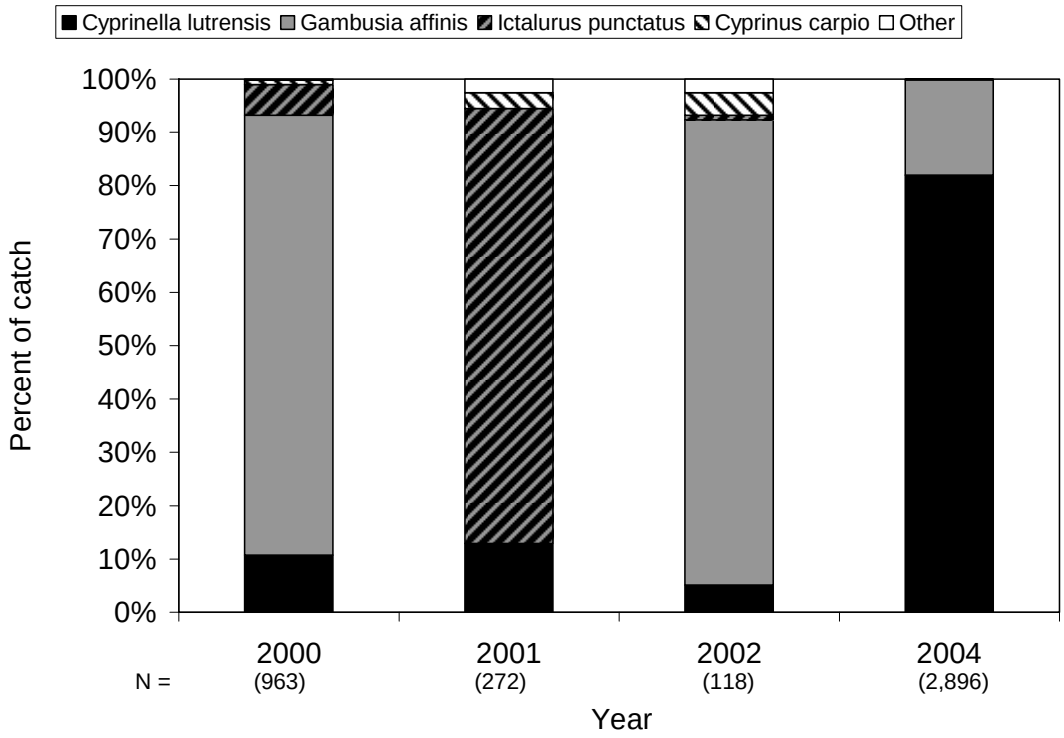

Figure 27. Relative abundance of fishes captured in FCG Canal below the electrical fish barrier during sample years 2000 through 2004. Totals include young of year and adult individuals. Sample size is in parentheses.