RESULTS OF FISH MONITORING OF SELECTED WATERS OF THE GILA RIVER BASIN, 1995-1996

Prepared For

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INTRODUCTION

The Central Arizona Project (CAP) is a series of aqueducts and pipelines that transports Colorado River water from Lake Havasu, Arizona-California, to central and southern Arizona for agricultural, municipal, and industrial uses. The CAP was authorized by Congress in the Colorado River Basin Project Act of 1968, and construction was largely completed by the U.S. Bureau of Reclamation (Reclamation) in 1993. A U.S. Fish and Wildlife Service (FWS) Biological Opinion (BO) on transportation and delivery of CAP water to the Gila River Basin (FWS 1994) determined that the project would jeopardize the continued existence of four threatened or endangered fishes: Gila topminnow *Poeciliopsis occidentalis*, spikedace *Meda fulgida*, loach minnow *Tiaroga cobitis*, and razorback sucker *Xyrauchen texanus*. FWS (1994) also determined that the project would adversely modify designated critical habitat of the latter three species. The primary justification for the jeopardy opinion was the potential for transfers of nonindigenous fishes and other aquatic organisms from the Lower Colorado River to various drainages in the Gila River Basin via the CAP, where they could negatively impact threatened or endangered fishes.

A Reasonable and Prudent Alternative (RPA) of the BO directed that Reclamation, in cooperation with the Arizona Game and Fish Department (AGFD) and FWS, "...develop and implement a baseline study and long-term monitoring of the presence and distribution of non-native fish..." in the CAP aqueduct and selected river and canal reaches in Arizona. The goal of the monitoring plan as stated in the BO is "...to establish baseline data on the presence and distribution of non-native fishes in the target reaches and to detect changes in the species composition or distribution."

Target reaches to be monitored include: 1) the CAP aqueduct; 2) Salt River Project (SRP) canals; 3) Florence-Casa Grande (FCG) Canal; 4) Salt River between Stewart Mountain Dam and Granite Reef Dam; 5) Gila River between Coolidge and Ashurst-Hayden dams; and 6) San Pedro River downstream from the U.S.-Mexico border.

The BO, completed in April 1994, directed Reclamation to begin monitoring by October 1994. That monitoring was mostly completed without benefit of a monitoring plan, and the data were partially reported in memoranda to files that were distributed to FWS and AGFD (Jakle 1995b, c). An amendment to the BO dated June 22, 1995, further established dates for development of draft and final monitoring plans by June 1, 1995, and August 1, 1995, respectively. The draft plan was submitted for review on July 2, 1995, and was revised on June 7, 1996. The most recent revision was completed in October, 1996. Because methodologies, at least in early years of implementation, may evolve somewhat as experience, testing, and refinements accumulate, the monitoring plan may be updated periodically and therefore may never become "final."

This report presents results of Reclamation and subcontractor/cooperator monitoring of target streams and canals for the years 1995 and 1996. In addition, comparisons with other published and unpublished sampling data within target reaches are made, and in some cases those data have been retabulated herein to facilitate those comparisons. Habitat data that were collected under the monitoring plan methodologies will be reported in the 5-year comprehensive report required under the 1994 BO.

METHODS

Detailed sampling methodologies were presented in the 1996 monitoring plan and appendices (Clarkson 1996), and will not be reiterated in detail here. In general, streams were stratified according to geomorphology or flow characteristics, and replicate "quantitative" sampling stations were established as the source for distribution and assemblage structure data. The plan calls for electrofishing as the primary gear for this purpose, but use of other methods is encouraged if electrofishing is deemed inadequate. In practice, only the relatively small habitats of the San Pedro River rely upon electrofishing for the bulk of data collection. During sampling in 1995 and 1996, other gear types including gill nets, trammel nets, drift nets, hoop nets, minnow traps, seines, dip nets, trot lines, and angling have been deployed to varying extent. Attempts are made to sample all available habitat, but that is only practical in the San Pedro River and certain reaches with "small" habitats in the Gila and Salt rivers. Following collection of "quantitative" data from fixed stream stations, qualitative sampling is to be performed upstream and/or downstream of each station for the purpose of collecting rare species for additions to species richness estimates.

In canals, sampling is more opportunistic, and is conducted during low flow or "dry-up" conditions. Sampling reaches are fixed, but only in the CAP canal are fixed stations sampled. For logistical reasons, pumping plant forebays are the primary source of CAP canal fishery data, and sampling there requires the use of a large array of sampling gears to be effective. Sampling in the SRP and FCG canals requires searches for available water and fish concentrations during flow outages, and primarily relies upon seines, dip nets, and entanglement gears for collection of fishes.

Reclamation has sought help from various sources to conduct this work. The Boulder City Regional Office of Reclamation has had primary responsibility for CAP sampling. Reclamation's Phoenix Area Office, with considerable help from the AGFD, conducted much of the sampling of the remaining sites in 1995. AGFD has overseen a multi-agency sampling of the SRP canals above the electrical fish barriers since 1990. In 1996, AGFD took over primary sampling of the Gila, Salt, and San Pedro rivers, and Arizona State University (ASU) contracted the SRP and FCG canals in 1995-1996 and 1996, respectively.

Note that 1995 sampling preceded development of the most recent version of the monitoring plan. The only major differences between 1995 and 1996 sampling methods were that two stations on the San Pedro River quantitatively sampled 400 m of stream in 1995 (the figure was dropped to 200 m by Clarkson [1996]; see Results and Discussion section), and that field data forms differed. Sampling in 1995 required some collection of fish length-weight data, but did not otherwise attempt to distinguish between age-0 and older fish, i.e. many individuals were simply enumerated without regard to age or size class. Other more specific methodological notes are discussed under individual stream/canal sections below.

RESULTS AND DISCUSSION

General failures to adhere to detailed methods in Clarkson (1996) include occasional or routine omissions of: measurement and recording of electrofishing electrical settings, stream conductance, and temperature; recording of detailed field notes and stream station maps, and; preservation of adequate samples for voucher. These deficiencies will be rectified in future sampling efforts.

Complete standardization of sampling methodologies within and across sampling stations in these early years of the monitoring program has not yet occurred. This deficiency introduces bias when attempting to compare assemblage structure variations. In addition, the statistical approach to presentation of assemblage structure data under the monitoring program is still undergoing review and analysis (Clarkson 1996). For these reasons, percentage relative abundance was not computed, and quantitative and qualitative fish collection data were pooled for purposes of tabular presentation. Therefore, only very general conclusions regarding assemblage structure are presented in this report. Future reports will present more complete data analyses in this regard, reflecting recommendations arising from the statistical review of sampling design and data analysis that should be completed this calendar year.

Another notable exception to methods specified by Clarkson (1996) includes delays in fully implementing quality control/quality assurance procedures. All data were entered and verified (double entry) using the Key Entry III data entry software system (Southern Computer Systems, Inc.; not the custom dBASE V program identified in the plan), but the post-processing data verification steps have not yet been fully developed and implemented. Finally, a management action plan to direct responses to field contingencies has not been developed.

Table 1 lists sampling dates of all stream and canal monitoring conducted during 1995 and 1996. Table 2 provides a list of common and scientific species names, and their acronyms used in subsequent tabulation.

Central Arizona Project Canal

Sampling Notes and Deviations From Protocol--CAP sampling has generally adhered to methods of Mueller (1990, 1996), i.e., primary reliance upon electrofishing, gill netting, and angling. Lack of easy access to the surface waters of the canal (i.e. no boat ramps) has dictated use of a truck-operated crane to place and retrieve boats into the canal, a logistically-challenging practice that has been historically performed by Reclamation's Boulder City, Nevada, office. Based on experiences accumulated and reported on by Mueller (1990, 1996) and the Boulder City office, sampling areas have been restricted to pumping plant forebays and canal reaches immediately above and occasionally below. For efficiency of sampling, monitoring occurs during periods of reduced flows (approximately 400 cfs or less), which now (since 1996) apparently routinely occur during mid-winter in the Fannin-McFarland (middle) and Tucson (lower) aqueducts, and during mid-summer in the Hayden-Rhodes Aqueduct (upper). The deep habitats and swift flows in the CAP render monitoring data largely qualitative in nature, depending greatly on gear selectivity and amount of sampling effort.

All CAP stations with the exception of the Hassayampa pumping plant were sampled in 1995, but no stations were sampled during 1996. The forebay and canal upstream of the Hassayampa pumping plant were dried during summer 1995 for silt removal, obviating the need for fish sampling of this station during our autumn sampling window. Failure to obtain advanced schedules for the new pumping patterns associated with use of Lake Pleasant for CAP storage resulted in missing the low-flow sampling period for the Hayden-Rhodes Aqueduct in 1996. Breakdown of the boat shocker pulsator immediately prior to scheduled winter sampling prevented sampling of the lower canal during the 1996-97 low-flow period.

Species Richness and Distribution--We caught relatively few species in the upper reaches (Fannin-McFarland and Hayden-Rhodes aqueducts) of the canal during 1995. Six species were taken from the Bouse Hills, four from the Little Harquahala, and seven from the Salt-Gila pumping plants (Table 3). Eight species in total were taken from these reaches. Low numbers of fish (except threadfin shad at Bouse Hills) were coincident with low species richness.

In contrast, although we captured a maximum of only eight species from a single station in the lower reach (Tucson Aqueduct) in 1995, 13 species in total were taken from this reach (Table 3). Species we captured that are unique to the lower reach included goldfish, grass carp, green sunfish, black bullhead, and yellow bullhead. Black bullhead is a new record from the canal (captured at San Xavier), as is white bass, which was captured from the Salt-Gila and Brady pumping plants and was presumably derived from Lake Pleasant. Grass carp, a species intentionally and now routinely (since 1990) stocked for weed control, is also a new record from the canal. Goldfish was observed from the canal in the late 1980s by Mueller (1990, 1996), but was not collected. We captured six goldfish from the San Xavier pumping plant in 1995.

Of note when comparing species composition in 1995 with the years 1986-1989 reported by Mueller (1990, 1996) is absence of collections from 1995 of razorback sucker, desert sucker, Sonora sucker, black crappie, flathead catfish, and mosquitofish. These species were all considered rare in 1986-1989. Lack of capture of some of these species (e.g. mosquitofish) may reflect reduced sampling effort in 1995 compared to the Mueller (1990, 1996) study, but also may indicate their real disappearance from the system due to changes in the way the system is operated.

Aside from the previously-noted concentration of *Lepomis* species in the lower canal, the other conspicuous trends in distribution of fish species in the CAP based on 1995 data is apparent rareness of channel catfish in the lower reach, and the general restriction of several other uncommonly-encountered species to the lower reach. Striped and white basses have not yet established in the lowermost segments of the canal, but are expected to do so in the future as conveyance rates increase and summer temperature maxima decrease (due to hypolimnial release from Lake Pleasant). White crappie (*Pomoxis annularis*) and tilapia are species that are expected to be encountered in future surveys, as both are common in Lake Pleasant.

Assemblage Structure--Given the considerable bias of sampling efficiencies for different species among gear types and the generally low catches per unit effort from the canal in 1995, only general statements can be made regarding relative abundance of species. In the upper canal, channel catfish and striped bass, both predicted by Mueller (1990) to increase in relative abundance as conveyance rates increased, were caught most commonly (Table 3). Threadfin shad was numerically dominant at Bouse Hills, but the schooling tendencies of this species may bias their true abundance. Mueller (1990, 1996) noted population crashes of threadfin shad from the Bouse Hills segment (and others) during the latter part of his study, but it is apparent that interactions among canal operations, periodic immigration from Lake Havasu, in-reach production, and predator population dynamics can result in reversal of such trends.

With certain exceptions, *Lepomis* species and largemouth bass populations dominated the assemblage structure of the lower CAP canal in 1995 (Table 3). Bullhead catfishes (sporadically) and red shiner were also encountered in relatively large numbers in the lower canal. Threadfin shad, one of the most common species found in 1986-1989 from this reach (Mueller 1990), was virtually absent from collections from 1995 (Table 3).

Gila River Between Coolidge and Ashurst-Hayden Dams

Sampling Notes and Deviations From Protocol--Gila River monitoring stations are sampled annually in the autumn during the Florence-Casa Grande Canal dry-up period, when flows from Coolidge Dam cease. Upper stations during this period are characterized by shallow, steep riffles and large, often deep, rocky pools. With increasing tributary sediment and water inputs in downstream reaches, finer substrates accumulate and flows, stream widths and maximum depths increase. Backpack shockers work acceptably in smaller, shallow areas, but need to be supplemented with nets of various sorts and other gears to effectively sample the array of habitats available. The relatively large sizes of habitats in the Gila River in this reach render sampling largely qualitative in nature and dependent on gear effectiveness and sampling effort; it is likely that large portions of fish populations are never sampled in certain habitats.

Some Gila River monitoring stations have been routinely sampled by Reclamation since 1991, although those activities were not conducted under auspices of a standardized monitoring plan. Those data have been reported previously through memoranda to files (Jakle 1992, 1993a, 1995a, b). This report provides a summary of these data (1991-1994) for comparisons to 1995-1996 samples.

The middle station of the upper reach identified in the monitoring plan (Clarkson 1996) has no vehicle access and has been dropped from the sampling design. The decision to conduct monitoring during autumn months and dam outages (which usually coincide) created logistical difficulties in quickly acquiring human resources sufficient to monitor all stations during this brief sampling window. Assistance of AGFD in this regard was secured in 1995, but inability to resolve right-of-entry issues in a timely manner resulted in failure to sample four of the 11 Gila River stations in 1995. In 1996, AGFD committed to lead the sampling effort for the Gila River, but scheduling and other factors resulted in failure to sample all but one of the identified stations. Qualitative fish sampling was not undertaken at the single Gila River site monitored in 1996 (Girmendonk and Young 1997).

High water conductivities (near 3000 µS/cm) in the uppermost sampling reach (resulting from contribution from a warm spring just below Coolidge Dam) burned out an electrical component of Reclamation's Smith-Root, Inc. Type VII backpack shocker during 1995 sampling, so reliance upon other sampling methods was necessary. Use of other sampling gears in addition to backpack shocker by AGFD in high discharge conditions in the lowermost Gila River reach in 1995 should have been undertaken, but was not.

Species Richness and Distribution--Ten identified species were collected from the Gila River during 1995, with a maximum of seven taken at any one station (Table 3). The fewest number of species encountered at any station was four. Fathead minnow, common carp, largemouth bass, and mosquitofish were encountered only in the uppermost sampling reach, and usually from disconnected habitats (unconnected to the mainchannel). The native species longfin dace, Sonora sucker, and desert sucker were found throughout most of the study reach, as was the non-native red shiner (Table 3). Species recorded from various sources from the Gila River since 1970 (Clarkson 1996) but not taken during 1995 include spikedace (*Meda fulgida*), bluegill, and green sunfish.

A total of eight species were taken from the single station (Cochran) sampled in 1996 (Table 4). Green sunfish was the only species sampled in 1996 that was not encountered during 1995 monitoring. Fathead minnow and largemouth bass, collected in 1995, were not found in 1996.

Samples from 1991-1994 (Table 5) contained a total of 13 species, and showed a more widespread distribution of mosquitofish, common carp, and yellow bullhead than indicated by 1995-1996 samples (Tables 3-4). Channel catfish was consistently common at the Coolidge Dam site in 1991-1994. Red shiner was the species most consistently encountered across the study reach (Table 5).

Assemblage Structure--Red shiner numerically dominated the fish assemblage when viewing the entire study reach in 1995 (Table 3), but the native suckers and longfin dace followed closely, with the sucker species accounting for the majority of biomass in the river. A similar pattern of assemblage structure was evident from the single station sampled in 1996, but channel catfish and yellow bullhead appeared more common (Table 4).

Collections from 1991-1994 also showed red shiner the numerically-dominant species throughout most of the Gila River (Table 5). Longfin dace consistently was a major component of the assemblage at the San Pedro River and Box O Wash sites, and also to a large extent at the Christmas and Cochran sites. Native suckers were relatively poorly represented except at the mouth of the San Pedro River in some years. Large numbers of carp, largemouth bass, green sunfish, and channel catfish were taken immediately below Coolidge Dam, but were rare or absent in other reaches (Table 5). Mosquitofish numbers were much greater in 1991-1994 than in 1995-1996 samples.

San Pedro River

Sampling Notes and Deviations From Protocol--Habitats in the San Pedro River are the most conducive among the target streams sampled under the monitoring program to obtaining good assemblage structure estimates. Stream width, depth, and flow characteristics of this stream are sampled very effectively for the most part by backpack shocker with a single pass. Only rarely are seines and other gears needed to supplement electrofishing collections.

Four San Pedro River sampling stations have been monitored annually by Reclamation since 1991 and prior to development of standardized monitoring in 1995 and 1996 (Jakle 1992, 1993a, 1995a, b). Two coincide with permanent stations identified by Clarkson (1996), and one (Dudleyville) is very near the Swingle Wash site. The fourth, located at the San Manuel road crossing, has not been sampled since 1994. This report presents summaries of those data for comparisons to 1995 and 1996 samples.

Inability to obtain right of entry to the lower sampling station of the middle reach (Cascabel to Redington) identified in the monitoring plan (Clarkson 1996) precluded sampling there, and the site has been dropped from the study design. Qualitative fish sampling was not undertaken at the five lower sampling stations in 1996 (Girmendonk and Young 1997). Quantitative fish sampling was halted at approximately 100 m at the Dudleyville site in the lower reach in 1995 after a landowner informed the crew they were on private property and did not have a valid right of entry. Miscommunication with another landowner was responsible for this problem, which was corrected in 1996 by moving the sampling station to a new site. The site was moved downstream several hundred meters to Swingle Wash in the recently-acquired Nature Conservancy property downstream from Dudleyville. Finally, fish monitoring at the mouth and Aravaipa Creek stations consisted of 400 m samples in 1995.

Species Richness and Distribution--A total of nine species were collected from the San Pedro River among the eight stations sampled in 1995, with a maximum of seven from each of two stations in the upper reach (Table 3). The sandy-bottomed, braided channel representative of the lowermost two stations supported only three species. Largemouth bass was taken exclusively from the upper reach in 1995, and fathead minnow was nearly exclusively taken there (a single specimen was recorded from the lower reach). Green sunfish and black bullhead were restricted to the upper four stations, and yellow bullhead to the lower three stations. Longfin dace and mosquitofish were the only two species captured at all eight sampling stations in 1995 (Table 3). Sonora sucker, thought absent from the mainstem San Pedro River by Jackson et al. (1987), were collected downstream from the mouth of Aravaipa Creek in 1995. They were likely emigrants from that tributary, where they remain common.

A similar pattern of species richness and distribution was found in 1996 in the San Pedro River (Table 4). Significant exceptions included absence of largemouth bass, capture of a single specimen each of common carp, channel catfish, and green sunfish from the Swingle Wash site, increase in distribution of Sonora and desert suckers in the lower reach, and invasion of red shiner in the lower reach. The latter observation is especially noteworthy in light of the red shiner invasion into Aravaipa Creek in 1997, which is discussed further, below.

The difficulty in finding any fish at all at the Hughes Ranch site in 1996 (only a few longfin dace were captured outside of the quantitative 200 m reach; Table 4) was apparently due to drying of the site that summer, based upon discussions with local landowners. Overall, although native species seemed to improve their situation in the San Pedro River in 1996 (through range expansion in the lower reach), the downside was that nonnative species increased their presence in the river by two, increasing total species richness to 11 (Table 4).

San Pedro River sampling conducted during 1991-1994 (four stations; Table 6) found the same 11 species total taken during 1995-1996 sampling. The most species (seven in 3 of 4 years) were taken at the Aravaipa confluence station. Sonora sucker, common carp and largemouth bass were species found only at that station. Only longfin dace and mosquitofish were distributed throughout the stream (Table 6).

The pattern of red shiner occurrence in the lower San Pedro River in conjunction with the 1990 and 1997 invasions into Aravaipa Creek appears correlated with long periods (years) of absence of major flood events on the San Pedro River. Although pre-1991 data for San Pedro River red shiner occurrence have not been accumulated here, the species was collected from the lower river in 1988 (W.L. Minckley, ASU, personal communication), and undoubtedly persisted there through the 1990 Aravaipa Creek invasion. U.S. Geological Survey (USGS) discharge records for the San Pedro River (Figure 1) and Aravaipa Creek (Figure 2) show the period between 1986 and 1991 without flood magnitudes exceeding approximately 1500 cfs (note the San Pedro River gage data shown in Figure 1 are from upstream of Aravaipa Creek, and thus must be added to Aravaipa Creek data to provide a minimum estimate of San Pedro River discharge downstream from Aravaipa Creek). The last collection of red shiner from Aravaipa Creek prior to the 1997 invasion was in February 1991 (Sally Stefferud, FWS, personal communication), immediately prior to a 3000+ cfs flood, the largest one (by far) since 1983 (Figure 2).

Red shiner remained in the San Pedro River through 1991 and 1992, but was absent in 1993, the year an 11,000+ cfs flood occurred (Figures 1 and 2). Red shiner did not appear in collections from the lower San Pedro River again until 1996 (Table 4), again coinciding with a long period absent significant flood events (Figures 1-2; unpublished USGS data). The species again appeared in collections from Aravaipa Creek in October 1997 (Jeff Simms, BLM, personal communication).

Assemblage Structure--Longfin dace was by far the numerically-dominant species in the greater San Pedro River in both 1995 and 1996, but the species was rare or absent at some upstream stations (Tables 3-4). Phenomenal densities of this species were found in lower stations, especially in 1995. Mosquitofish was next highest in abundance in 1995, but fell below desert sucker numbers in 1996. Black bullhead and green sunfish were conspicuous in upper sampling stations in both years, especially in biomass. Red shiner and Sonora sucker comprised a moderate component of the fish assemblage in lower reaches in 1996.

Assemblage structure of fishes in the lower San Pedro River during 1991-1994 generally agreed with 1995 and 1996 results, showing longfin dace as the dominant species, followed by mosquitofish and sporadic occurrences of other species (Table 6).

Florence-Casa Grande Canal

Sampling Notes and Deviations From Protocol--Sampling in the FCG Canal during dry-up is opportunistic. Drying pools are extremely ephemeral in this unlined, mostly sand-bottomed canal. Sampling in 1995 was conducted three days following the closure of the headgates at Ashurst-Hayden Dam, and only a few pools associated with hard structures remained. In contrast, 1996 sampling was done the day after initiation of dry-up, and more surface water was available. Therefore, although sampling techniques were similar across both years, effort was more extensive in 1996.

The reach of the FCG that is sampled annually extends from the Ashurst-Hayden diversion dam to just downstream of the Pima Lateral turnout. The reach above the China Wash fish barrier is approximately 4 km long, while the reach below the barrier is approximately 19 km. These reaches have been sampled annually since 1991, for which data have been partially reported by Jakle (1991, 1993b). These collections and other previously unreported collections from the FCG Canal are presented here for comparisons to 1995-1996 samples. No significant deviations from written protocol were noted.

Species Richness and Distribution--Five species were collected from the FCG Canal in 1995 (Table 3). Of the three taken above the China Wash electrical fish barrier, surprisingly only one was collected from the Gila River immediately upstream. Two additional species (red shiner, Sonora sucker) were collected from below the electrical barrier in 1995; Sonora sucker is a new record for the canal.

A total of 12 species were collected from the canal in 1996 (Table 4; Marsh 1997). These collections represent a greater species richness than that found in all of the collections from the Gila River upstream in 1995 and 1996. The collections contain three new records for the canal: bluegill, green sunfish, and threadfin shad. Seven species were taken above the electrical barrier, and 11 were found below the barrier. Longfin dace, red shiner, green sunfish, bluegill, and threadfin shad were taken only below the barrier, while channel catfish was taken only above the barrier. Comparison of the FCG Canal "sink" fauna to that of the upstream Gila River "source" fauna in 1996 was not possible due to a dearth of 1996 Gila River collections.

Sampling of the FCG Canal during 1991-1994 found a total of nine species, with all taken above the barrier, but only eight from below (Table 7). The greatest richness in any year was 1993 (seven above and eight below). Longfin dace was consistently found (but in low numbers) below the barrier, but only a single specimen was taken in one year from above the barrier. Channel catfish collections displayed the opposite pattern. Red shiner and mosquitofish were taken in all years from sites both above and below the barrier (Table 7). A single largemouth bass taken from above the barrier in 1993 represents a new species record for the canal.

Assemblage Structure--The relatively small numbers and species of fishes collected in 1995 preclude detailed analysis of assemblage structure for that year, other than to note that native sucker numbers were numerically dominant (Table 3). In 1996, suckers were relatively rare, and the nonnatives red shiner, mosquitofish, and fathead minnow numerically dominated the fish community (Table 4). Many of the species taken in 1996 that were not found in 1995 consisted of only a few individuals.

Samples from 1991-1994 showed that red shiner and mosquitofish nearly consistently represented the greatest proportion of fish numbers in the canal, but that channel catfish also comprised a large component of the fauna from the reach above the electrical barrier (Table 7). Desert sucker and fathead minnow were only minor, sporadic components of the assemblage during 1991-1994.

Salt River Between Stewart Mountain and Granite Reef Dams

Sampling Notes and Deviations From Protocol--The variety of aquatic habitats represented among the three sampling stations for the Salt River dictated a diversity of sampling approaches. Backpack shockers were used in shallow riffles at the upper site, but a canoe shocker and/or entanglement nets were used in deeper pool habitats there and at downstream sites. The lowermost site is essentially a shallow reservoir habitat impounded by Granite Reef Dam.

A shocker was not available for sampling at the Blue Point site in 1995, and sampling consisted solely of entanglement gears. The Granite Reef Dam station was not sampled at all in 1996 (Girmendonk and Young 1997; Table 4).

Species Richness and Distribution--The Salt River between Stewart Mountain and Granite Reef dams is one of the more species-rich reaches of water monitored under Reclamation's program. Thirteen species were captured in 1995 (Table 3) and 11 in 1996 (Table 4). A maximum of 11 species were found at a single (upper) station in 1995, and a site-maximum of eight species was taken in 1996. Two new species were recorded for this reach of the Salt River during 1995 (black crappie and mosquitofish), and a third during 1996 (smallmouth bass).

Most species collected in relatively large numbers were distributed throughout the study reach in 1995, while rarer species were often taken only at one or two stations (Table 3). The lower species richness observed at the middle station in 1995 (only five species captured compared to 11 and 9 at the upper and lower stations, respectively) likely represented the sampling limitation of only using entanglement devices. Three species were unique to upper station samples in 1996, and four were unique to middle station samples in 1996 (Table 4). Age-0 desert sucker was captured only in riffles below Stewart Mountain Dam (Tables 3-4); density of the 1995 cohort was impressively high.

Assemblage Structure--Native suckers, especially desert sucker, were the most abundant species overall in the Salt River during 1995-1996 (Tables 3-4). Largemouth bass was the next most numerous species, with low numbers and often sporadic captures of most other species across stations.

Salt River Project Canals

Sampling Notes and Deviations From Protocol--Sampling of the concrete-lined SRP canals typically occurs in October of each year for the South Canal, and in January for the Arizona (north) Canal. Because the January Arizona Canal sampling falls immediately following the bulk of sampling for other target streams and canals under the monitoring program, for reporting purposes, data are considered part of the previous year's sample (e.g., a January 1997 sample becomes part of the 1996 sample year).

Introduction of grass carp into the SRP canals, beginning in 1989, has begun to affect the manner in which the canals are managed. Historically, the north and south side canals were essentially completely dried for approximately one month each year for maintenance purposes. These actions assured near complete destruction of fishes in the canals each year (Marsh and Minckley 1982). Canal "dry-ups" now increasingly maintain pooled areas to maintain grass carp populations, thereby allowing at least some across-year survival of other resident fishes. These actions, first fully apparent in 1996, now also introduce additional sampling variance to fish collections.

Sampling methods for the canals downstream from the electrical fish barriers typically consist of driving the canal bank and looking for areas with concentrations of fish suitable for sampling. Collections are usually by seine and dip net in shallow areas, with entanglement nets set for varying periods in deeper areas. Sampling occurs the day immediately following start of the dry-up period. Sampling in the Arizona Canal extends to the Indian Bend Wash siphon, a reach of approximately 22 km. The reach sampled in the South Canal includes the entire reach to the junction of the Tempe and Consolidated canals, which is approximately 16 km long.

Fish sampling in the canal reaches between the electrical fish barriers and Granite Reef Dam consists exclusively of multiple seine hauls and dip netting. The broad-crested weir upon which the electrical barrier apparatus is situated impounds water from 1-2 m deep following closure of the headgates. Following diminishment of flows over the weir, the electrical barrier is turned off, and usually several days later the reach between the weir and the gates is drained and sampled for fishes. Use of long seines and multiple passes in combination with diminishing water volumes effectively samples nearly all of the fishes in the reach, and is thus a near "census" of fishes there.

It is important to note that the author observed what was estimated to be several thousand fish descend over the South Canal weir immediately following electrical cutoff to the barrier in 1997. This was possible due to incomplete closure of the ageing headgates, which created an approximately 1-2 cm deep flow of water over the weir. The fish transport appeared to be limited to a single species, *Tilapia* sp. Thus, although the electrical barrier samples on the SRP canals sample nearly all fishes present, they do not account for the unknown number of fishes that emigrate from the reach immediately following the start of dry-up.

Also, the author observed a small desert sucker transgress the South Canal electrical barrier in an upstream direction during this same time, and attempts to swim up the weir by what appeared to be red shiner were also noted. Reclamation is working with SRP to determine ways to eliminate the possibility of such fish movements.

No major deviations from established sampling protocol were noted during 1995 and 1996.

Species Richness and Distribution--Probably due to the increased sampling effectiveness of the canals during dry-up, considerably more species are routinely collected from the canals than the Salt River immediately upstream, which is presumably the predominant source of canal fishes. In the electrical barrier reaches, 13 and 15 species were collected from the Arizona Canal in 1995 and 1996, respectively, and 13 and 10 were captured from the South Canal during those years (Tables 3-4). Samples from the downstream canal reaches (below the electrical barriers) contained 15 and 11 from the Arizona Canal in 1995 and 1996, and 9 and 17 from the South Canal in those years. Species taken from the canals but not the Salt River included longfin dace, red shiner, grass carp, redear sunfish, flathead catfish, threadfin shad, bigmouth buffalo, and smallmouth bass (Tables 3-4). Mosquitofish was the only species collected from the Salt River that was not taken from the canals.

A total of 19 species have been recorded from the Arizona and South canals from samples taken in 1990-1994; 17 from each (Table 8). Species unique to the South Canal during these years include goldfish and longfin dace, while bigmouth buffalo and grass carp were taken only from the Arizona Canal during that time.

Grass carp was detected above the South Canal electrical fish barrier in 1995 (Table 3), and above the Arizona Canal fish barrier in 1996 (Table 4). Smith-Root, Inc. reports for the South Canal barrier between annual sampling periods (October 1993-October 1995; note the South Canal barrier reach was not sampled in 1994; Table 8) were reviewed to assess their operational status. It was noted in those reports that there was a power failure on December 23, 1993, during which time the backup generator failed to start. In addition, lightning strikes on September 2-3, 1994, damaged several pulsers (the electrical devices that meter electricity to the barrier rails), but the report stated that the barrier remained "mostly operational" during that period. The damaged pulser boards were replaced on October 27, 1994. It is likely that the grass carp moved above the South Canal barrier during one or both of these events. There is also a possibility that human-aided transfer of fish occurred.

Electrical barrier reports for the Arizona Canal between the January 1996 and January 1997 sampling periods were reviewed, but no barrier failures were noted. Discussions with Smith-Root, Inc., personnel revealed the possibility that fishes can ascend the weir and electrified barrier rails during periods when water levels are shallow (•8 cm or less). These conditions are present during dry-up operations and occasionally during other times. Attempts to visually monitor this condition during the 1997 dry-up period failed when the dry-up schedule was changed without warning. This avenue of potential barrier transgression will be investigated further prior to the next scheduled canal dry-up period.

One other instance of grass carp transgression of the SRP electrical barriers was noted during the 1993 (January 1994) Arizona Canal sample (Table 8). The power outage previously noted for the South Canal on December 23, 1993, also affected the Arizona Canal for several hours, and presumably was responsible for the capture of two grass carp above the barrier that year.

Assemblage Structure--Native suckers, common carp, channel catfish, and red shiner were the most numerous components of the fish assemblages in the SRP canals in 1995 and 1996 (Tables 3-4), as well as in certain years during earlier sampling (Table 8). Depending on stocking times and locations, rainbow trout was a numerically-conspicuous element of the canal fish communities above the electrical barriers, especially in 1991-1994 (Table 8). Tilapia also is an important component of canal samples above the fish barriers, and its numbers are likely underestimated considerably if observations of downstream movements following electrical cutoff to the barriers noted above occur consistently.

The native roundtail chub retains an important presence in the canal system, although its capture in the upstream Salt River is rare. Largemouth bass is also captured consistently in the canals. Most other species are sporadically collected, but almost certainly reflect omnipresent populations in the Salt and Verde rivers upstream. Rare captures of the native longfin dace sustain hope that their populations are maintained in the Salt or Verde rivers upstream.

As in many of the target reaches sampled under the monitoring plan, especially canals, considerable instability of assemblage structure across years was evident in the SRP canals. For example, "censuses" above the electrical barriers on the South Canal show shifts in dominance from red shiner and tilapia in 1990, to suckers, rainbow trout, and channel catfish in 1991, to suckers, red shiner, and channel catfish in 1992, to common carp and desert sucker in 1993, to red shiner, suckers and channel catfish in 1995, and to desert sucker, channel catfish, and tilapia in 1996 (Tables 3-4, 8). In the Arizona Canal, these shifts in numerical dominance moved among tilapia, suckers, and channel catfish in 1990, suckers, channel catfish, and rainbow trout in 1991, suckers, channel catfish, and tilapia in 1992, common carp, suckers, and rainbow trout in 1993, common carp, suckers, channel catfish and rainbow trout in 1994, red shiner, suckers, channel catfish, and rainbow trout in 1995, and suckers and channel catfish in 1996 (Tables 3-4, 8).

CONCLUSIONS

Although there have been several glaring deficiencies in fully implementing the monitoring plan described by Clarkson (1996) (most that are attributable to normal start-up problems associated with any large, complex project), major benefits of monitoring have become apparent. New species records for the CAP (black bullhead, white bass), Florence-Casa Grande Canal (Sonora sucker, bluegill, green sunfish, threadfin shad), and Salt River (black crappie, mosquitofish, smallmouth bass) were found during sampling of target reaches in 1995-1996. The wealth of ecological data accrued from such a long-term undertaking has already begun to manifest itself, e.g., in distribution patterns of red shiner in the San Pedro River associated with invasions of Aravaipa Creek, and in large inter-annual variation in assemblage structure in many systems. Finally, collaboration among state and federal agencies and academia (AGFD, FWS, Reclamation, ASU) in implementing the monitoring plan has enhanced interagency communication and advanced awareness of native fish conservation needs and the management problems created by nonnative species.

In the larger picture, undoubtedly the most serious deficiency in implementation of the monitoring plan to satisfy conditions of the biological opinion is failure to date to develop a management action plan. This plan, as described by Clarkson (1996), is intended to (1) define threshold criteria for fish species richness, distribution, and assemblage structure indices in target streams and canals, and (2) develop management action contingencies to return monitored parameters within an acceptable range. The early warning system that is monitoring will be wasted if there is no plan to remedy new species incursions or other detrimental changes to community stability. Native fish populations will continue to diminish in the face of new nonindigenous forms. In reality, there is little utility to monitoring if there is never any intention of action should monitored parameters deteriorate; the monitoring exercise becomes mere surveillance and recording of events. Management agencies must be willing to confront this issue directly if conservation and recovery of native fishes in the Gila River Basin is to proceed.

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Table 1. Dates of sampling of target reaches and stations monitored for fish populations in 1995-1996. Note that 1996 samples for the Salt River Project Arizona Canal were collected in 1997, but are considered part of 1996 samples.

		DATES SAMPLED	
STREAM OR CANAL REACH	STATION NAME	1995	1996
San Pedro River			
Hereford to Fairbank	Hereford	November 29	December 10
	Lewis Springs	November 29	December 11
	Charleston	November 28	December 11
Cascabel to Redington	Hughes Ranch	December 20	December 4
	Soza Wash	December 19	December 2
Aravaipa Creek to Gila River	Aravaipa Creek	October 17	December 2
	Dudleyville (1995); Swingle Wash (1996)	October 17	December 3
	Gila River	October 16	December 3
Gila River			
Coolidge Dam to Needles Eye	Coolidge Dam	November 20	
	Hook & Line Ranch	November 20	
Little Ash Creek to Hayden	Dripping Spring Wash		
	Christmas	November 20-21	
	O'Carroll Canyon		
Hayden to Mineral Creek	San Pedro River		
	Kearney		
	Kelvin		
Mineral Creek to Ashurst-Hayden Dam	Diamond A Ranch	November 21	
	Cochran	November 20	November 4
	Box O Wash	November 21	
Salt River			
Stewart Mtn. Dam to Granite Reef Dam	Stewart Mtn. Dam	November 2	November 12
	Blue Point	November 1-2	November 13
	Granite Reef Dam	November 1-2	
CAP canal			
Hayden-Rhodes Aqueduct	Bouse Hills	September 27-28	
	Little Harquahala	September 26-27	
	Hassayampa		
Fannin-McFarland Aqueduct	Salt-Gila	November 9-10	
Tucson Aqueduct	Brady	November 8-9	
	Red Rock	November 7-8	
	San Xavier	November 6-7	
Florence-Casa Grande canal	above barrier	October 30	October 27-28
	below barrier	October 30	
SRP canals	Arizona Canal	November 25-26	January 18
	South Canal	October 21-22	October 26
	AZ Canal above barrier	November 27	January 20
	SO Canal above barrier	October 23	October 28

Table 2. Common names, scientific names, and acronyms for species of fish collected during monitoring of streams and canals in the Gila River Basin. Acronyms formed by combining the first two letters of the genus name and specific epithet.

ACRONYM	SCIENTIFIC NAME	COMMON NAME
GIRO	*Gila robusta*	Gila chub
PIPR	*Pimephales promelas*	Fathead minnow
CAAU	*Carassius auratus*	Goldfish
AGCH	*Agosia chrysogaster*	Longfin dace
CYCA	*Cyprinus carpio*	Common carp
CYLU	*Cyprinella lutrensis*	Red shiner
CTID	*Ctenopharngodon idellus*	Grass carp
CAIN	*Catostomus insignis*	Sonora sucker
PACL	*Pantosteus clarki*	Desert sucker
MISA	*Micropterus salmoides*	Largemouth bass
LEMI	*Lepomis microlophus*	Redear sunfish
LECY	*Lepomis cyanellus*	Green sunfish
LEMA	*Lepomis macrochirus*	Bluegill sunfish
MIDO	*Micropterus dolomieu*	Smallmouth bass
PONI	*Pomoxis nigromaculatus*	Black crappie
AMME	*Ameirus melas*	Black bullhead
PYOL	*Pylodictis olivaris*	Flathead catfish
ICPU	*Ictalurus punctatus*	Channel catfish
AMNA	*Ameirus natalis*	Yellow bullhead
GAAF	*Gambusia affinis*	Mosquitofish
ONMY	*Oncorhynchus mykiss*	Rainbow trout
STVI	*Stizostedion vitreum*	Walleye
TILA	*Tilapia sp.*	Tilapia species
MOMI	*Morone mississippiensis*	Yellow bass
MOCH	*Morone chrysops*	White bass
MOSA	*Morone saxatilis*	Striped bass
DOPE	*Dorosoma petenense*	Threadfin shad

Table 3. Numbers of fish captured at each sampling station (including qualitative samples) in target reaches during 1995. See Table 1 for species acronyms. OTHR denotes an unidentified species, hybrid, or rare species (see footnotes). Single numbers refer to totals of small-bodied fishes where age was not estimated; paired numbers refer to totals of putative age-0 fish, followed by totals of putative age-1+ fish; numbers in parentheses denote totals of large-bodied species where age was not estimated. Dashes denote no captures of a species at a particular site.

SAMPLING STATION	GIRO	PIPR	CAAU	AGCH	CYCA	CYLU	CTID	CAIN	PACL
CAP Canal-Upper									
Bouse Hills PP	-	-	-	-	-	-	-	-	-
Little Harquahala PP	-	-	-	-	0-1	-	-	-	-
Hassayampa PP[a]	-	-	-	-	-	-	-	-	-
CAP Canal-Middle									
Salt-Gila PP	-	-	-	-	0-5	1	-	-	-
CAP Canal-Lower									
Brady PP	-	-	-	-	0-5	14	0-2	-	-
Red Rock PP	-	-	-	-	0-5	2	-	-	-
San Xavier PP	-	-	0-6	-	-	10	0-14	-	-
Gila River-Upper									
Coolidge Dam	-	2	-	4	0-13	3	-	-	0-6
Hook & Line Ranch	-	10	-	-	0-2	-	-	1-0	35-4
Gila River-Middle Upper									
Dripping Spring Wash	-	-	-	79	-	72	-	6-17(3)	0-31
Christmas[a]	-	-	-	-	-	-	-	-	-
O'Carrol Canyon	-	-	-	11	-	44	-	1-2	1-3
Gila River-Middle Lower[a]									
San Pedro River	-	-	-	-	-	-	-	-	-
Kearny	-	-	-	-	-	-	-	-	-
Kelvin	-	-	-	-	-	-	-	-	-
Gile River-Lower									
Diamond A Ranch	-	-	-	-	-	11	-	6-3	11-1
Cochran	-	-	-	6	-	105	-	0-1	19-53
Box O Wash	-	-	-	68	-	152	-	1-0	13-15
San Pedro River-Upper									
Hereford	-	-	-	186	-	-	-	-	21-0(1)
Lewis Springs	-	2	-	2	-	-	-	-	21-4
Charleston	-	92	-	30	-	-	-	-	55-13
San Pedro River-Middle									
Hughes Ranch	-	-	-	1390	-	-	-	-	-
Soza Ranch	-	-	-	344	-	-	-	-	2-0
San Pedro River-Lower									
Aravaipa Creek	-	1	-	5505	-	-	-	3-1	87-1
Swingle Wash	-	-	-	513	-	-	-	-	-
Mouth	-	-	-	2184	-	-	-	-	-
Florence-Casa Grande Canal									
Above barrier	-	-	-	-	0-3	-	-	-	(3)
Below barrier	-	-	-	-	0-5	6	-	3-23 (1)	2-43 (175)
Salt River									
Stewart Mtn. Dam	-	-	-	-	0-2	-	-	0-23	198-19
Blue Point	-	-	-	-	-	-	-	0-7	0-80
Granite Reef Dam	-	-	-	-	0-1	-	-	0-18	0-4
Salt River Project Canals									
Arizona Canal	1-0	-	0-1	-	0-1	1250	0-5	0-24	3-68
South Canal	2-1	-	-	-	-	543	0-10	27-53	69-66
AZ Canal above barrier	(1)	-	-	-	(155)	15	-	(288)	(601)
SO Canal above barrier	(22)	-	-	-	(327)	-	(2)	(150)	(276)

Table 3. Extended.

SAMPLING STATION	MISA	LEMI	LECY	LEMA	PONI	AMME	PYOL	ICPU	AMNA
CAP Canal-Upper									
Bouse Hills PP	0-1	0-1	-	1-0	-	-	-	0-6	-
Little Harquahala PP	0-7	-	-	-	-	-	-	0-10	-
Hassayampa PP[a]	-	-	-	-	-	-	-	-	-
CAP Canal-Middle									
Salt-Gila PP	0-31	-	-	0-4	-	-	-	0-2	-
CAP Canal-Lower									
Brady PP	0-6	-	-	1-0	-	-	-	-	-
Red Rock PP	0-26	1-0	0-59	7-14	-	-	-	-	0-5
San Xavier PP	0-1	0-10	0-76	22-34	-	1-15	-	-	-
		(1)	(251)	(262)					
Gila River-Upper									
Coolidge Dam	1-4	-	-	-	-	-	-	0-1	-
Hook & Line Ranch	2-0	-	-	-	-	-	-	-	-
Gila River-Middle Upper									
Dripping Spring Wash	-	-	-	-	-	-	-	0-1	0-2
Christmas[a]	-	-	-	-	-	-	-	-	-
O'Carrol Canyon	-	-	-	-	-	-	-	-	-
Gila River-Middle Lower[a]									
San Pedro River	-	-	-	-	-	-	-	-	-
Kearny	-	-	-	-	-	-	-	-	-
Kelvin	-	-	-	-	-	-	-	-	-
Gile River-Lower									
Diamond A Ranch	-	-	-	-	-	-	-	-	0-1
Cochran	-	-	-	-	-	-	-	1-0	0-5
Box O Wash	-	-	-	-	-	-	-	-	-
San Pedro River-Upper									
Hereford	-	-	4-5	-	-	3-12	-	-	-
Lewis Springs	4-0	-	14-8	-	-	0-4	-	-	-
Charleston	2-0	-	6-7	-	-	6-7	-	-	-
San Pedro River-Middle									
Hughes Ranch	-	-	3-0	-	-	1-0	-	-	-
Soza Ranch	-	-	-	-	-	-	-	-	-
San Pedro River-Lower									
Aravaipa Creek	-	-	-	-	-	-	-	-	7-1
Swingle Wash	-	-	-	-	-	-	-	-	2-0
Mouth	-	-	-	-	-	-	-	-	3-0
Florence-Casa Grande Canal									
Above barrier	-	-	-	-	-	-	-	3-0	-
Below barrier	-	-	-	-	-	-	-	1-2	-
Salt River									
Stewart Mtn. Dam	6-9	-	4-1	2-1	0-1	-	-	-	0-1
Blue Point	0-6	-	-	-		-	-	-	0-3
Granite Reef Dam	30-7	-	4-0	0-2		-	-	0-1	1-3
Salt River Project Canals									
Arizona Canal	0-5	-	0-1	0-1	-	-	1-0	0-1	-
South Canal	1-0	-	-	6-0	-	-	-	-	-
AZ Canal above barrier	(30)	-	-	(2)	-	-	(23)	(274)	-
SO Canal above barrier	(3)	-	-	(8)	-	-	(4)	(155)	-

Table 3. Extended.

SAMPLING STATION	GAAF	ONMY	STVI	TILA	MOMI	MOCH	MOSA	DOPE	OTHR
CAP Canal-Upper									
Bouse Hills PP	-	-	-	-	-	-	0-17	126	-
Little Harquahala PP	-	-	-	-	-	-	0-3	-	-
Hassayampa PP[a]	-	-	-	-	-	-	-	-	-
CAP Canal-Middle									
Salt-Gila PP	-	-	-	-	-	0-9	0-2	-	-
CAP Canal-Lower									
Brady PP	-	-	-	-	-	0-1	0-5	2	3-0[b]
Red Rock PP	-	-	-	-	-	-	-	-	-
San Xavier PP	-	-	-	-	-	-	-	-	(5)[b]
Gila River-Upper									
Coolidge Dam	-	-	-	-	-	-	-	-	-
Hook & Line Ranch	2	-	-	-	-	-	-	-	-
Gila River-Middle Upper									
Dripping Spring Wash	-	-	-	-	-	-	-	-	1[c]
Christmas[a]	-	-	-	-	-	-	-	-	-
O'Carrol Canyon	-	-	-	-	-	-	-	-	-
Gila River-Middle Lower[a]									
San Pedro River	-	-	-	-	-	-	-	-	-
Kearny	-	-	-	-	-	-	-	-	-
Kelvin	-	-	-	-	-	-	-	-	-
Gile River-Lower									
Diamond A Ranch	-	-	-	-	-	-	-	-	-
Cochran	-	-	-	-	-	-	-	-	-
Box O Wash	-	-	-	-	-	-	-	-	-
San Pedro River-Upper									
Hereford	112	-	-	-	-	-	-	-	-
Lewis Springs	65	-	-	-	-	-	-	-	-
Charleston	35	-	-	-	-	-	-	-	-
San Pedro River-Middle									
Hughes Ranch	422	-	-	-	-	-	-	-	-
Soza Ranch	187	-	-	-	-	-	-	-	-
San Pedro River-Lower									
Aravaipa Creek	326	-	-	-	-	-	-	-	1-0[d]
Swingle Wash	27	-	-	-	-	-	-	-	-
Mouth	324	-	-	-	-	-	-	-	-
Florence-Casa Grande Canal									
Above barrier	-	-	-	-	-	-	-	-	-
Below barrier	-	-	-	-	-	-	-	-	-
Salt River									
Stewart Mtn. Dam	3	0-2	0-3	-	-	-	-	-	-
Blue Point	-	-	0-1	-	-	-	-	-	-
Granite Reef Dam	-	-	-	-	0-1	-	-	-	-
Salt River Project Canals									
Arizona Canal	18	0-1	-	0-2	-	-	-	-	-
South Canal	-	0-1	-	-	-	-	-	4	-
AZ Canal above barrier	-	(167)	-	-	(37)	-	-	17	(1)[e]
SO Canal above barrier	-	-	(17)	(16)	(10)	-	-	-	(1)[f]

[a] Reach or station not sampled in 1995
[b] Unidentified species (or hybrids) of *Lepomis*
[c] *Cyprinella lutrensis* or *Pimephales promelas*
[d] *Catostomus insignis* X *Pantosteus clarki* hybrid
[e] *Ictiobus cyprinellus*
[f] *Micropterus dolomieu*

Table 4. Numbers of fish captured at each sampling station (including qualitative samples) in target reaches during 1996. See Table 1 for species acronyms. OTHR denotes an unidentified species, hybrid, or rare species (see footnotes). Single numbers refer to totals of small-bodied fishes where age was not estimated; paired numbers refer to totals of putative age-0 fish, followed by totals of putative age-1+ fish; numbers in parentheses denote totals of large-bodied species where age was not estimated. Dashes denote no captures of a species at a particular site. Salt River Project Arizona Canal data shown here were collected in January 1997.

SAMPLING STATION	GIRO	PIPR	CAAU	AGCH	CYCA	CYLU	CTID	CAIN	PACL
CAP Canal-Upper[a]									
Bouse Hills PP	-	-	-	-	-	-	-	-	-
Little Harquahala PP	-	-	-	-	-	-	-	-	-
Hassayampa PP	-	-	-	-	-	-	-	-	-
CAP Canal-Middle[a]									
Salt-Gila PP	-	-	-	-	-	-	-	-	-
CAP Canal-Lower[a]									
Brady PP	-	-	-	-	-	-	-	-	-
Red Rock PP	-	-	-	-	-	-	-	-	-
San Xavier PP	-	-	-	-	-	-	-	-	-
Gila River-Upper[a]									
Coolidge Dam	-	-	-	-	-	-	-	-	-
Hook & Line Ranch	-	-	-	-	-	-	-	-	-
Gila River-Middle Upper[a]									
Dripping Spring Wash	-	-	-	-	-	-	-	-	-
Christmas[a]	-	-	-	-	-	-	-	-	-
O'Carrol Canyon	-	-	-	-	-	-	-	-	-
Gila River-Middle Lower[aa]									
San Pedro River	-	-	-	-	-	-	-	-	-
Kearny	-	-	-	-	-	-	-	-	-
Kelvin	-	-	-	-	-	-	-	-	-
Gile River-Lower									
Diamond A Ranch[a]	-	-	-	-	-	-	-	-	-
Cochran	-	-	-	2	0-4	183	-	3-24	4-40
Box O Wash[a]	-	-	-	-	-	-	-	-	-
San Pedro River-Upper									
Hereford	-	-	-	21	-	-	-	-	0-19
Lewis Springs	-	6	-	-	-	-	-	-	3-9
Charleston	-	33	-	8	-	-	-	-	67-66
San Pedro River-Middle									
Hughes Ranch	-	-	-	148	-	-	-	-	-
Soza Ranch[b]	-	-	-	7	-	-	-	-	-
San Pedro River-Lower									
Aravaipa Creek	-	-	-	524	-	6	-	2-2	26-56
Swingle Wash	-	-	-	179	1-0	32	-	2-1	18-9
Mouth	-	-	-	1136	-	61	-	11-15	164-182
Florence-Casa Grande Canal									
Above barrier	-	2	-	-	-	28	-	0-1	0-12
Below barrier	-	19	-	5	0-1	251	-	0-1	0-3
Salt River									
Stewart Mtn. Dam	-	-	-	-	-	-	-	0-34	11-140
Blue Point	0-4	-	-	-	-	-	-	1-14	0-47
Granite Reef Dam[a]	-	-	-	-	-	-	-	-	-
Salt River Project Canals									
Arizona Canal	0-2	-	-	-	0-1	3	0-11	0-52 (43)	0-30 (240)
South Canal	0-6	-	-	6	0-4	1078	0-8	0-31	43-108
AZ Canal above barrier	0-31	-	-	-	0-8	18	0-1	206-164	1546-180
SO Canal above barrier	0-18	-	-	-	0-16	358	-	8-51	11-311

Table 4. Extended.

SAMPLING STATION	MISA	LEMI	LECY	LEMA	PONI	AMME	PYOL	ICPU	AMNA
CAP Canal-Upper[a]									
Bouse Hills PP	-	-	-	-	-	-	-	-	-
Little Harquahala PP	-	-	-	-	-	-	-	-	-
Hassayampa PP	-	-	-	-	-	-	-	-	-
CAP Canal-Middle[a]									
Salt-Gila PP	-	-	-	-	-	-	-	-	-
CAP Canal-Lower[a]									
Brady PP	-	-	-	-	-	-	-	-	-
Red Rock PP	-	-	-	-	-	-	-	-	-
San Xavier PP	-	-	-	-	-	-	-	-	-
Gila River-Upper[a]									
Coolidge Dam	-	-	-	-	-	-	-	-	-
Hook & Line Ranch	-	-	-	-	-	-	-	-	-
Gila River-Middle Upper[a]									
Dripping Spring Wash	-	-	-	-	-	-	-	-	-
Christmas[a]	-	-	-	-	-	-	-	-	-
O'Carrol Canyon	-	-	-	-	-	-	-	-	-
Gila River-Middle Lower[aa]									
San Pedro River	-	-	-	-	-	-	-	-	-
Kearny	-	-	-	-	-	-	-	-	-
Kelvin	-	-	-	-	-	-	-	-	-
Gile River-Lower									
Diamond A Ranch[a]	-	-	-	-	-	-	-	-	-
Cochran	-	-	0-1	-	-	-	-	5-1	6-5
Box O Wash[a]	-	-	-	-	-	-	-	-	-
San Pedro River-Upper									
Hereford	-	-	0-9	-	-	5-15	-	-	-
Lewis Springs	-	-	1-15	-	-	0-17	-	-	-
Charleston	-	-	0-1	-	-	0-10(2)	-	-	-
San Pedro River-Middle									
Hughes Ranch	-	-	-	-	-	0-1	-	-	-
Soza Ranch[b]	-	-	-	-	-	-	-	-	-
San Pedro River-Lower									
Aravaipa Creek	-	-	-	-	-	-	-	-	0-2
Swingle Wash	-	-	(1)	-	-	-	-	1-0	-
Mouth	-	-	-	-	-	-	-	-	0-1
Florence-Casa Grande Canal									
Above barrier	-	-	-	-	-	-	-	10-0	0-1
Below barrier	-	-	1-0	2-0	-	-	-	-	0-1
Salt River									
Stewart Mtn. Dam	7-8	-	9-0	-	-	-	-	-	-
Blue Point	30-3	-	-	3-0	-	-	-	1-3	-
Granite Reef Dam[a]	-	-	-	-	-	-	-	-	-
Salt River Project Canals									
Arizona Canal	0-3	0-1	-	-	-	-	-	1-1	-
South Canal	0-12	-	-	0-1	0-1	-	0-1	0-7	-
AZ Canal above barrier	2-83	-	0-1	0-7	0-4	-	0-19	1946-82	-
SO Canal above barrier	0-17	-	-	0-4	-	-	-	207-71	-

Table 4. Extended.

SAMPLING STATION	GAAF	ONMY	STVI	TILA	MOMI	MOCH	MOSA	DOPE	OTHR
CAP Canal-Upper[a]									
Bouse Hills PP	-	-	-	-	-	-	-	-	-
Little Harquahala PP	-	-	-	-	-	-	-	-	-
Hassayampa PP	-	-	-	-	-	-	-	-	-
CAP Canal-Middle[a]									
Salt-Gila PP	-	-	-	-	-	-	-	-	-
CAP Canal-Lower[a]									
Brady PP	-	-	-	-	-	-	-	-	-
Red Rock PP	-	-	-	-	-	-	-	-	-
San Xavier PP	-	-	-	-	-	-	-	-	-
Gila River-Upper[a]									
Coolidge Dam	-	-	-	-	-	-	-	-	-
Hook & Line Ranch	-	-	-	-	-	-	-	-	-
Gila River-Middle Upper[a]									
Dripping Spring Wash	-	-	-	-	-	-	-	-	-
Christmas[a]	-	-	-	-	-	-	-	-	-
O'Carrol Canyon	-	-	-	-	-	-	-	-	-
Gila River-Middle Lower[aa]									
San Pedro River	-	-	-	-	-	-	-	-	-
Kearny	-	-	-	-	-	-	-	-	-
Kelvin	-	-	-	-	-	-	-	-	-
Gile River-Lower									
Diamond A Ranch[a]	-	-	-	-	-	-	-	-	-
Cochran	-	-	-	-	-	-	-	-	-
Box O Wash[a]	-	-	-	-	-	-	-	-	-
San Pedro River-Upper									
Hereford	155	-	-	-	-	-	-	-	-
Lewis Springs	31	-	-	-	-	-	-	-	-
Charleston	76	-	-	-	-	-	-	-	-
San Pedro River-Middle									
Hughes Ranch	22	-	-	-	-	-	-	-	-
Soza Ranch[b]	-	-	-	-	-	-	-	-	-
San Pedro River-Lower									
Aravaipa Creek	6	-	-	-	-	-	-	-	-
Swingle Wash	14	-	-	-	-	-	-	-	-
Mouth	10	-	-	-	-	-	-	-	-
Florence-Casa Grande Canal									
Above barrier	55	-	-	-	-	-	-	-	-
Below barrier	34	-	-	-	-	-	-	13	-
Salt River									
Stewart Mtn. Dam	-	-	0-1	1-0	-	-	-	-	1-0[b]
Blue Point	24	-	-	5-0	-	-	-	-	-
Granite Reef Dam[a]	-	-	-	-	-	-	-	-	-
Salt River Project Canals									
Arizona Canal	-	0-1	-	0-2(3)	-	-	-	-	-
South Canal	49	-	0-1	0-3	-	-	-	22	0-1[b]
AZ Canal above barrier	-	10-65	0-2	2-57	-	-	-	-	-
SO Canal above barrier	-	-	0-8	22-93	-	-	-	-	-

[a] Reach or station not sampled in 1996
[b] *Micropterus dolomieu*

Table 5. Numbers of fish captured at sampling stations on the Gila River between Coolidge and Ashurst-Hayden dams, 1991-1994 by Reclamation under Fall Fish Count sampling (modified from Jakle 1992, 1993a, 1995a, b). See Table 1 for species acronyms. Ages not estimated. Dashes denote no captures of that species at a particular site.

COOLIDGE DAM	PIPR	AGCH	CYCA	CYLU	MEFU	CAIN	PACL	MISA	LEMA	LECY	ICPU	AMNA	GAAF
1991	-	-	22	178	-	-	-	2	1	37	9	-	31
1992	-	3	14	20	-	-	-	5	2	17	9	-	-
1993[a]	1	5	65	227	-	-	1	10	-	2	27	-	-
1994[b]	-	-	19	373		-	-	14		11	3	5	-
CHRISTMAS													
1991	-	-	3	213	-	-	-	-	-	2	-	2	14
1992	-	5	-	1	-	-	-	-	-	3	-	6	2
1993	-	368	10	16	-	9	14	5	-	1	-	10	-
1994	-	44	4	43		9	15	2		5	-	11	80
SAN PEDRO RIVER													
1991	6	136	5	32	-	-	1	-	-	-	-	-	10
1992	-	22	-	24	-	3	-	-	-	-	-	-	68
1993	-	265	4	29	-	-	69	3	-	27	-	3	3
1994	-	17	2	216		8	55	1		2	-	3	183
RIVERSIDE													
1991	2	-	-	105	-	-	-	-	-	-	-	1	-
1992	1	1	2	194	-	-	-	-	-	-	-	-	34
1993	-	3	-	30	-	-	2	-	-	-	-	-	3
1994	-	4	1	24		1	24	-		4	-	3	-
DIAMOND A RANCH													
1991	-	1	-	5	-	-	1	-	-	-	3	1	-
1992	-	-	-	37	-	-	-	-	-	-	-	6	2
1993	-	1	-	-	-	-	13	-	-	-	-	2	1
1994	4	23	4	182		5	19	1		-	-	7	20
COCHRAN													
1991	1	43	-	198	1	-	1	-	-	-	-	-	1
1992	3	32	-	365	-	-	-	-	-	-	-	1	123
1993	-	6	1	267	-	-	-	-	-	-	-	10	-
1994	2	-	-	144		4	9	-		-	1	17	239
BOX O WASH													
1991	-	41	-	49	-	-	-	-	-	-	-	19	42
1992	4	42	-	168	-	-	-	-	-	-	-	3	11
1993	1	112	7	202	-	3	59	-	-	-	1	12	26
1994	1	38	1	13		-	2	-		-	-	7	18

[a] Also includes 2 *Lepomis cyanellus* X *L. macrochirus* hybrids
[b] Also includes 1 *Lepomis cyanellus* X *L. macrochirus* hybrid

Table 6. Numbers of fish captured at sampling stations on the San Pedro River 1991-1995 by Reclamation under Fall Fish Count sampling (modified from Jakle 1992, 1993a, 1995a, b). See Table 1 for species acronyms. Ages not estimated. Dashes denote no captures of that species at a particular site.

DUDLEYVILLE CROSSING	PIPR	AGCH	CYCA	CYLU	CAIN	PACL	MISA	LECY	AMM E	AMNA	GAAF
1991	-	114	-	-	-	-	-	-	-	-	1
1992	-	196	-	-	-	-	-	1	-	6	2
1993	-	563	-	-	-	10	-	-	-	-	-
1994	-	103	-	10	-	3	-	-	-	5	15
ARAVAIPA CONFLUENCE											
1991	-	659	1	2	-	-	1	12	-	14	182
1992	-	567	-	9	1	6	-	1	-	11	33
1993	-	622	2	-	14	12	-	1	3	7	-
1994	-	110	-	-	-	9	-	-	8	6	14
SAN MANUEL CROSSING											
1991	-	69	-	-	-	-	-	-	-	-	6
1992	-	115	-	-	-	-	-	-	2	-	210
1993	-	410	-	-	-	-	-	1	-	-	-
1994	-	399	-	-	-	-	-	-	3	-	16
HUGHES RANCH											
1991	-	165	-	-	-	-	-	-	-	-	-
1992	-	378	-	-	-	-	-	5	-	-	3
1993	29	152	-	-	-	14	-	12	2	-	-
1994	-	152	-	-	-	-	-	-	5	-	27

Table 7. Numbers of fish captured at sampling stations on the Florence-Casa Grande canal 1991-1995 by Reclamation (modified from Jakle 1991, 1993b, unpubl. data). See Table 1 for species acronyms. Ages not estimated. Dashes denote no captures of that species at a particular site.

ABOVE BARRIER	PIPR	AGCH	CYCA	CYLU	PACL	MISA	ICPU	AMNA	GAAF
1991	-	-	-	6	-	-	4	5	73
1992	-	-	-	32	-	-	35	-	19
1993	3	-	14	120	2	1	5	-	71
1994	-	1	-	14	1	-	51	-	11
BELOW BARRIER									
1991	2	1	-	1	-	-	-	2	52
1992	4	15	-	88	-	-	-	9	16
1993	3	3	2	282	11	-	1	4	10
1994	-	3	-	27	-	-	-	-	63

Table 8. Numbers of fishes captured in the Salt River Project Arizona and South canals between the electrical fish barriers and Granite Reef Dam, 1990-1994. See Table 1 for species acronyms. Ages were not estimated. Dashes denote no captures of a species. The South Canal was not sampled in 1994.

SOUTH CANAL	GIRO	ICCY	CAAU	AGCH	CYCA	CYLU	CTID	CAIN	PACL	MISA	LEMA	PYOL	ICPU	AMNA	ONMY	STVI	TILA	MOMI	DOPE
1990	-	-	-	-	-	210	-	7	30	2	1	-	1	-	-	-	262	-	21
1991	13	-	1	-	28	10	-	261	136	10	3	12	121	-	111	4	39	1	1
1992	2	-	-	1	4	146	-	134	112	18	2	2	208	-	-	-	23	16	-
1993	25	-	-	-	772	8	-	61	207	11	4	2	92	1	-	5	4	34	-
ARIZONA CANAL[a]																			
1990	-	-	-	-	2	4	-	21	51	2	-	13	66	-	1	-	748	-	-
1991	7	-	-	-	17	33	-	163	459	32	4	11	196	-	113	10	68	-	1
1992	21	-	-	-	-	5	-	218	97	21	-	2	134	1	21	-	109	9	1
1993	1	-	-	-	526	-	2	105	470	42	-	12	66	-	103	9	5	39	-
1994	1	1	-	-	155	15	-	288	601	30	2	23	274	-	167	-	-	37	17

[a] Except in 1990, Arizona Canal samples were taken in January of the following year, but are listed under the previous year's sample.

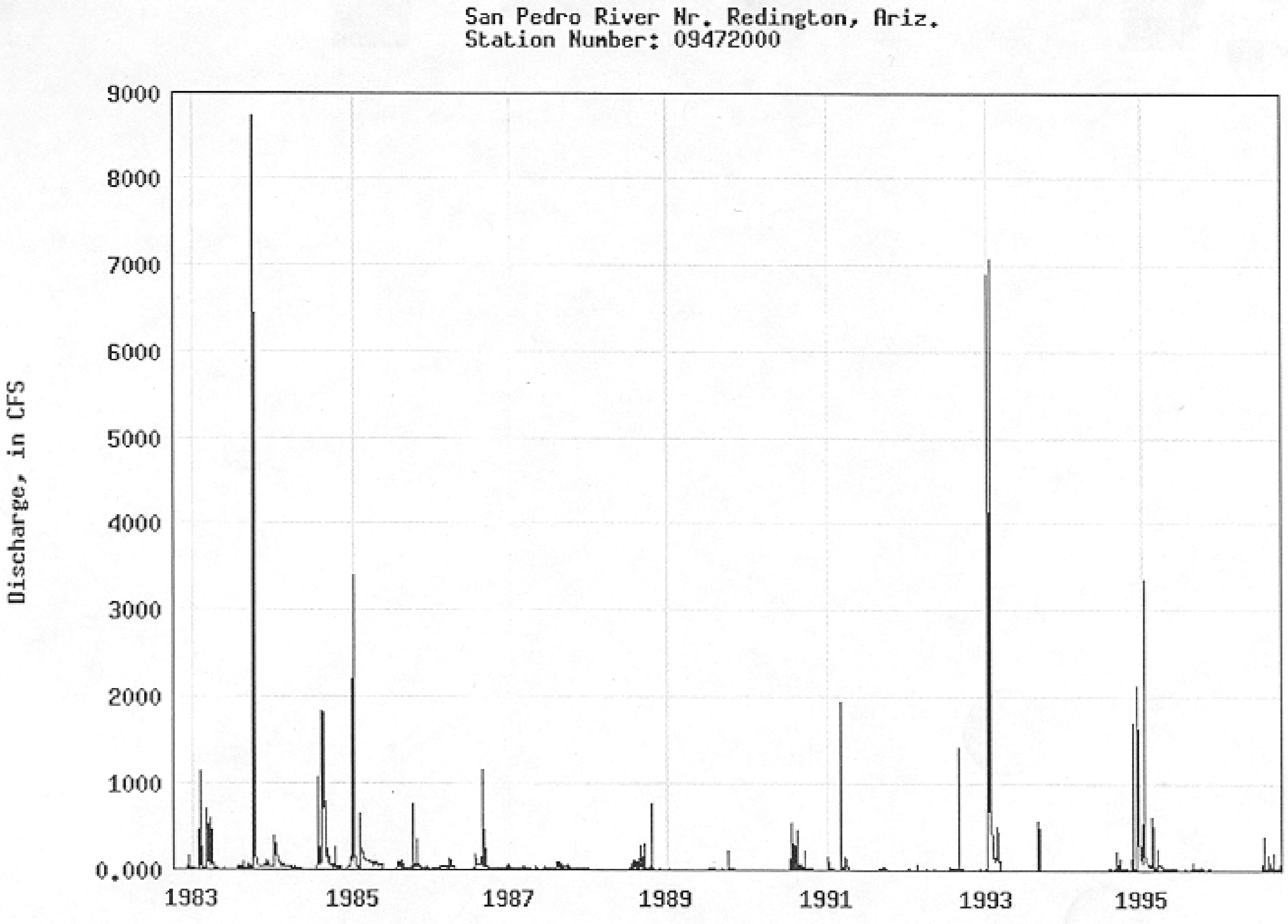

Figure 1. Discharge in cubic feet per second (cfs) at the San Pedro River Near Redington, Arizona, gage for the period October 1, 1982-September 30, 1996.

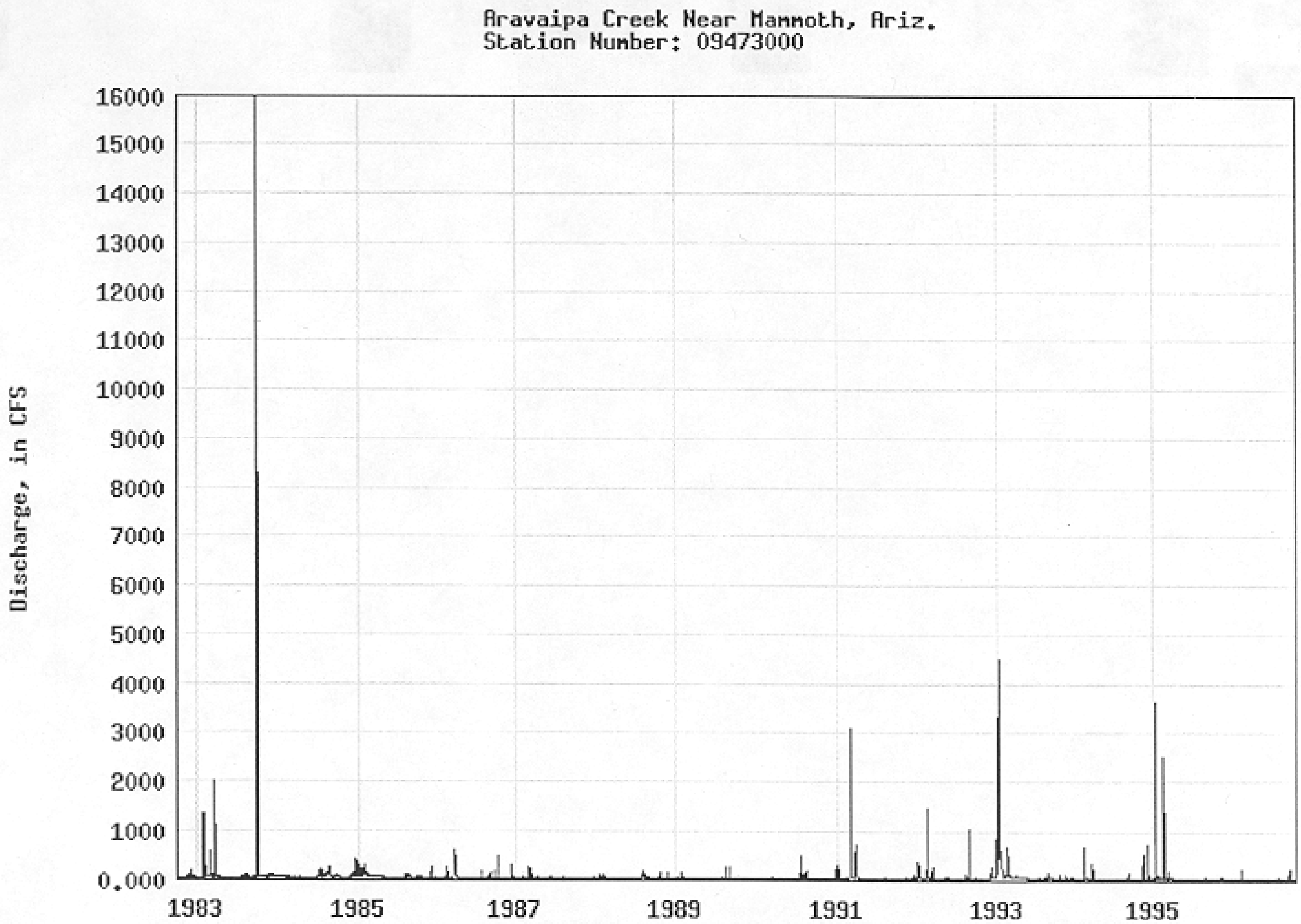

Figure 2. Discharge in cubic feet per second (cfs) at the Arizona Creek Near Mammoth, Arizona, gage for the period October 1, 1982-September 30, 1996.