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Colorado River Fishes of Lake Cahuilla, Salton Basin, Southern California: A Cautionary Tale for Zooarchaeologists

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Abstract.—Since the late Pleistocene the Colorado River has periodically filled the Salton Basin of southern California to form a huge lake, Lake Cahuilla. Fish remains recovered from archaeological sites occupied about 500 years B.P. along the shores of the last highstand of this lake have been identified as razorback sucker, *Xyrauchen texanus*, Colorado squawfish, *Ptychocheilus lucius*, striped mullet, *Mugil cephalus*, machete, *Elops affinis*, and bonytail, *Gila elegans*. For a number of reasons some of these identifications are considered tentative; the zoogeographic basis is doubtful (*G. robusta, G. cypha*, and the sucker *Catostomus latipinnis* may also have been present), taxonomic imprecision makes early range determinations unreliable, the remains are fragmentary, and individual variation and potential hybridization make definitive determinations challenging. Zooarchaeologists need to be aware of and address these types of difficulties when they are encountered.

Since at least the late Pleistocene the Salton Basin of southern California has periodically filled and desiccated as the Colorado River altered its course en route to the Gulf of California (Hubbs and Miller 1948; Wilke 1978; Waters 1983; Sutton and Wilke 1988). When the basin filled, a productive freshwater lake, Lake Cahuilla, was formed. It reached a maximum size of 185 km long, 56 km wide, and over 91 m deep. The most recent cycle of filling followed by desiccation took place approximately A.D. 900 to A.D. 1500 (Sutton and Wilke 1988). The basin partially filled during 1905–1906 due to an accidental course change of the Colorado River and remained fresh until about 1930. Today the Salton Sea is the saline remnant of this overflow and is maintained by agricultural run-off. Its fish fauna consists of introduced marine sport fishes (Walker et al. 1961; Moyle 1976).

Fish remains recovered during the excavation of archaeological sites on the former shores of Lake Cahuilla provide a rare opportunity to identify the fishes that inhabited this ancient lake. These remains are important not only for their archaeological value, but also because they provide clues to the ecology of a fish fauna that is largely extinct or endangered (Williams et al. 1989).

Fish remains recovered from archaeological sites have provided information on the zoogeography and associations of native freshwater fishes (Miller 1955; Gehlbach and Miller 1961; Minckley and Alger 1968; Schulz and Simons 1973; Casteel 1976; Schulz 1979; Gobalet 1990). It is the objective of this study to record the ichthyofauna of Lake Cahuilla based on archaeological studies and to discuss difficulties inherent in establishing definitive identifications.

The frequent lack of rigor in the discipline of zooarchaeology is troubling. Data are presented in the poorly circulated gray literature that is not subjected to peer review. Little more than species lists often appear in cultural resource management reports and they generally do not consider the biology of the species identified. This does not promote confidence in the findings. Fish remains recovered from the former shores of Lake Cahuilla provide an opportunity to discuss problems that may arise from limited familiarity with the species present.

Zoogeographic Context

Identification of faunal remains often is initially based on expectations resulting from knowledge of the present distribution of fishes. Miller (1961) and Minckley et al. (1986) have comprehensively reviewed the native fish faunas of the Colorado River drainage. Early records of the fishes are few because early surveys were not thorough and major habitat alterations, species introductions and extirpations had already occurred. As a result, species lumping may have occurred which would have excluded certain recognized species.

Miller (1961) reported the following species from the lower Colorado River near Yuma, Arizona: bonytail (*Gila elegans*), razorback sucker (*Xyrauchen texanus*), Colorado squawfish (*Ptychocheilus lucius*), striped mullet (*Mugil cephalus*), machete (*Elops affinis*), woundfish (*Plagopterus argentissimus*), desert pupfish (*Cyprinodon macularius*), and Gila topminnow (*Poeciliopsis occidentalis*). Evermann (1916), Hubbs and Miller (1948) and Miller (1961) each reported only a single *Gila*, the bonytail, from either the Salton Basin or the lower Colorado River. Other records suggest that more than one chub occupied the lower Colorado and potentially Lake Cahuilla. Minckley (1973, 1983) reported *Gila robusta*, roundtail chub, from the lower Colorado River and Sigler and Miller (1963) report observations of its spawning in Lake Mohave, Nevada. Miller (1955) extended the range of *Gila cypha*, at least prehistorically, into the lower Colorado River and D. G. Buth (pers. comm. 1990) identified one captured in the 1950's from the lower Colorado River. Since *G. cypha* was not recognized as a separate species from *G. elegans* until 1946 (Miller 1946), the prior records of distribution and abundance of these species are tenuous (Valdez and Clemmer 1982).

Potentially there were three large chubs in the lower Colorado River that may have inhabited Lake Cahuilla: *G. cypha*, *G. elegans*, and *G. robusta*. Flannelmouth sucker, *Catostomus latipinnis*, would also be expected from the lower Colorado River (Miller 1961; Minckley 1973).

Methods

Fish remains have been recovered during excavations of archaeological sites in the La Quinta region of Riverside County, California (Fig. 1). Ten archaeological sites (CA-RIV-1182, -1769, -2196, -2936, -3143, -3144, -3681, -3682, -3683, and -3793) have been excavated by the Archaeological Research Unit of the University of California, Riverside and the findings have been recorded in a series of unpublished reports (UCRARU #970, #977, #1014, #1023, #1027, #1044). These sites bordered Lake Cahuilla and were occupied during the later stages of its last stand, A.D. 1300–1500. Fish remains recovered during these excavations have been identified and compared with findings of other investigators.

Identifications were determined by comparisons with skeletons listed in the

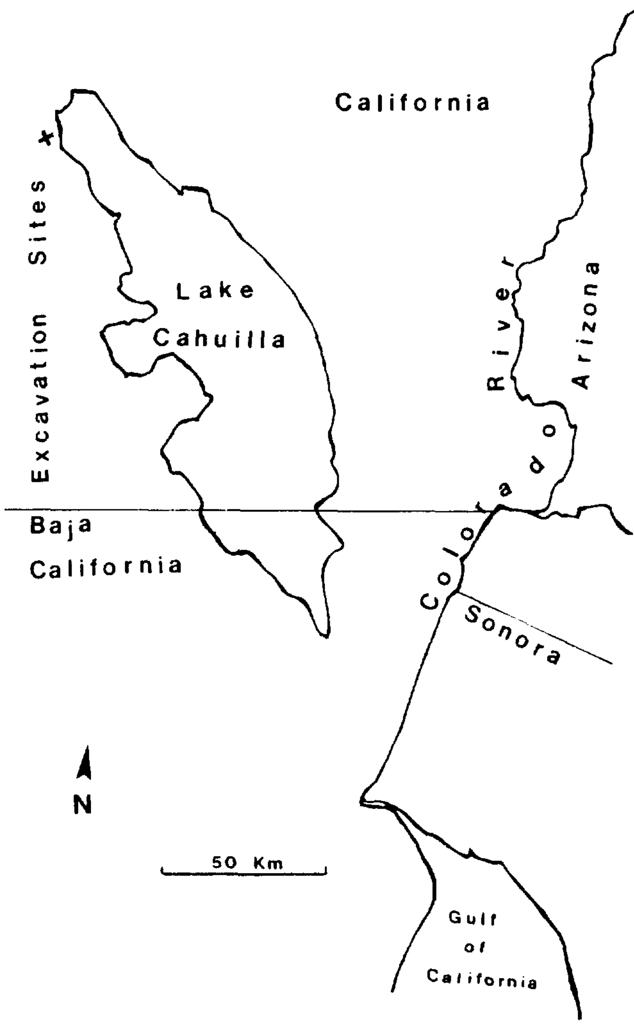

Fig. 1. Location of archaeological sites relative to highstand of Lake Cahuilla, A.D. 900–1500.

materials examined section. Plates in Miller (1955), Gehlbach and Miller (1961) and Miller and Smith (1984) were useful as were photographs of the spinal columns of razorback sucker, bonytail (CAS, Accession No. 1962-II:23) and Colorado squawfish (CAS 26210) (taken under the direction of W. I. Follett). Pharyngeals, teeth, basioccipitals, asterisci, and interneurals were particularly closely examined. Fish names follow Robins et al. (1980).

Results and Discussion

All five of the fishes identified from these ten sites (Table 1), razorback sucker, bonytail, Colorado squawfish, machete (*Elops affinis*) and striped mullet (*Mugil cephalus*) have previously been identified at archaeological sites in the Salton Basin. Though the identifications of bonytail and razorback sucker at these ten sites were made with confidence, they are subject to the qualifications that follow.

Table 1. Number of fish remains recovered from archaeological sites in the Salton Basin of southern California.

	RIV-1182	RIV-1769	RIV-1179[a]	RIV-2196	RIV-2827[a]	RIV-2936	RIV-3143	RIV-3144	RIV-3681	RIV-3682	RIV-3683	RIV-3793	JM-1[b]	Anza-Borrego[c]	Total
Bonytail	142	469	1043	38	82	2	6	7	—	472	3	1	295	106	2666
Razorback Sucker	239	431	276	52	60	3	3	9	1	366	3	78	48	12	1581
Colorado Squawfish	—	17	78	—	—	—	—	—	—	11	—	4	—	—	110
Striped Mullet	5	—	—	—	1	1	—	—	—	35	1	1	18	—	62
Machete	—	—	—	—	—	—	—	—	—	1	—	—	1	—	2

[a] Follett 1988.
[b] Salls unpublished data.
[c] Yohe et al. 1986.

Follett (1988) found all of these fishes except the machete at RIV-1179 and only bonytail and razorback sucker at RIV-2827. In the La Quinta dune area (JM-1) Salls (unpub. data) reported all but the Colorado squawfish. Yohe et al. (1986) found remains of bonytail and razorback suckers at Indian Hill Rockshelter, Anza-Borrego Desert State Park. L. T. Findley (pers. comm. 1991) identified these species at sites in the southern portion of the Salton Basin. At the Magma sites in Imperial County, Follett (1979) reported the fish remains by percent of total weight of remains: .62% bonytail, 44.64% razorback sucker, 20.02% probable razorback sucker, .74% striped mullet, and 33.98% unidentified fragments. Follett, Salls and Yohe et al. have not described the basis for their faunal identifications, making verification difficult.

Gila sp.

There are numerous problems in the systematics of minnows of the genus *Gila* (Uyeno 1960; Hopkirk 1973; Hubbs et al. 1974; Moyle 1976; Bills 1978). Holden and Stalnaker (1970), Minckley (1973), Smith et al. (1979), Kaeding et al. (1986, 1990), Douglas et al. (1989, 1991), and Buth et al. (1990) have addressed taxonomic problems of the *Gila robusta* complex of the Colorado River drainage. Because the systematics of these forms is controversial even when whole animals are considered and because fragmentary elements are the basis for these identifications, caution is necessary in identifying these remains as bonytail. A nearly complete pharyngeal might confidently be identified as bonytail, but a fragmentary pharyngeal is problematic since members of the *Gila robusta* complex are so anatomically similar (Fig. 2).

Holden and Stalnaker (1970) and Smith et al. (1979) recognized three separate *Gila* species despite the existence of intermediate forms between *G. robusta* and *G. elegans* and between *G. cypha* and *G. elegans*. Large numbers of these (hybrids?) were found in Lake Powell possibly resulting from habitat changes following the construction of Glen Canyon Dam (Holden and Stalnaker 1970). Kaeding et al. (1986) found considerable intergradation between *G. cypha* and *G. robusta* in western Colorado and Kaeding et al. (1990) suggested that offspring of this cross would be viable.

Since today intergrades exist between all three species of *Gila* potentially present in Lake Cahuilla, it is possible that such intergrades existed there. The rapid initial flooding of the Salton Basin to form Lake Cahuilla could have been a catastrophic event creating a disturbed habitat leading to hybridization. Weisel (1955) illustrated how single bones of an intergeneric cyprinid hybrid have a form intermediate between those of the parents. Single elements from such a hybrid would be difficult to impossible to identify to species, particularly if fragmentary, the most common condition.

A *Gila* sp. pharyngeal found at RIV-3682 shows evidence of an unusual third tooth in its inner row (Fig. 2C). A third tooth is found only in the inner row of three of thirty-two roundtail chub pharyngeals (AMNH 47091, AMNH 47096) suggesting roundtail chub were present. There is considerable variation in pharyngeal tooth number and position in members of the *Gila robusta* complex. One of twelve pharyngeals of bonytail has two teeth in its highly unusual intermediate row and one of four pharyngeals of humpback chub lacks an inner row. Roundtail chub pharyngeals also occasionally have an unusual single tooth in a middle row

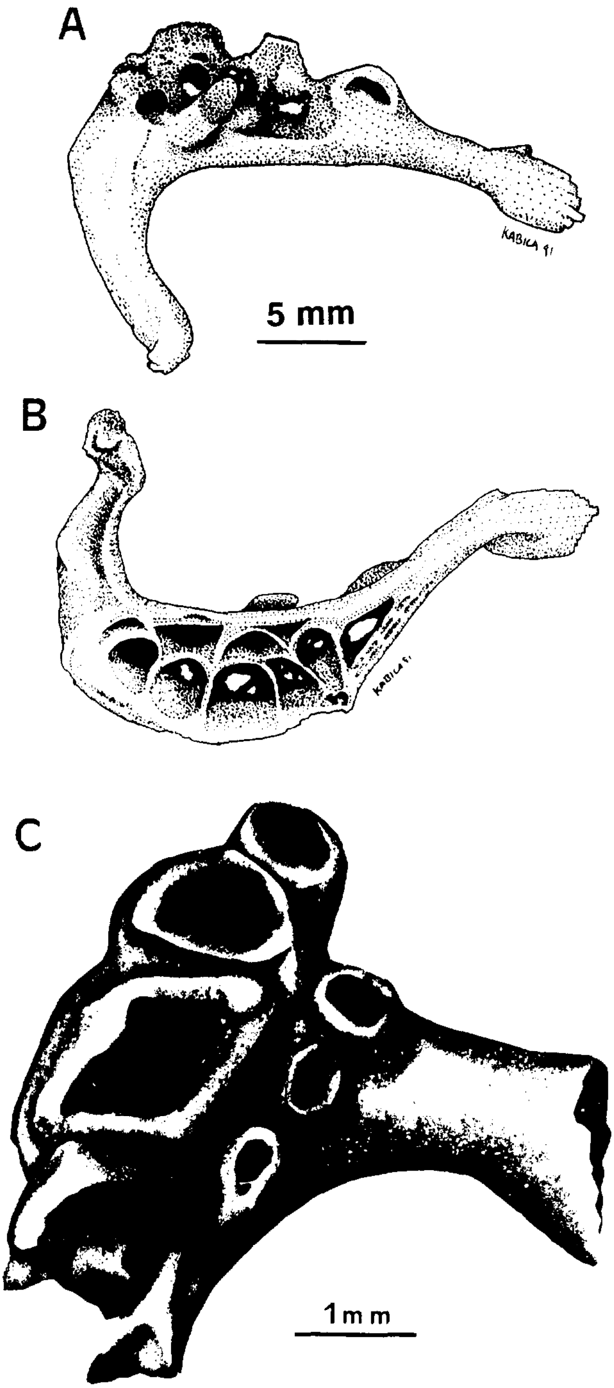

Fig. 2. *Gila elegans* from CA-RIV-1182. Right pharyngeal missing most teeth: A, dorsal view; B, ventral view. C, *Gila* sp. from CA-RIV-3682. Left pharyngeal fragment with unusual third tooth in the inner row.

(UMMZ 179580, CAS 25851). The shape of the more complete recovered pharyngeals however are the most like bonytail. The tui chub, *Gila bicolor*, of the *Siphateles*-type within the genus, however, have great uniformity of dentition with a single pharyngeal of 157 examined possessing a supernumerary tooth in its single row.

The 25 *Gila* sp. basioccipitals examined from these archaeological sites however show extraordinary homogeneity in the shape and degree of concavity of their masticatory plates. Sixty-four basioccipitals of comparative tui chubs, on the other hand, show considerable variation in the shape, thickness and degree of concavity of their plates. The homogeneity of the Lake Cahuilla specimens may in fact result from the lack of genetic diversity of a few founders. Even greater variation in tooth count in the recovered pharyngeals would be expected based on the variation among the comparative specimens. Considering the potential for hybridization, the range of individual variation, and with questionable zoogeography, identification to species in the genus *Gila* should be cautiously made.

Bonytail and humpback chub have a characteristic humpbacked form and narrow caudal peduncular morphology that are convergent with those of the razorback sucker. Though these specializations are associated with survival in strong currents resulting from periodic flooding of the Colorado River (Minckley and Mefee 1987), bonytail, like the razorback sucker, breed in (Sigler and Miller 1963) and spend much time in pools and eddies (Moyle 1976). The fingerling bonytail found in coprolites by Wilke (1978) suggest spawning and recruitment in Lake Cahuilla, though Wilke does not indicate the basis for this identification. Much like the congeneric tui chub of Eagle Lake, California (Kimsey 1954), and Lake Tahoe, and Pyramid Lake, Nevada, the omnivorous bonytail (or other *Gila* sp.) probably thrived in Lake Cahuilla. A filter feeding lacustrine form comparable to *G. bicolor pectinifer* bearing numerous gill rakers (see Kimsey 1954; Hubbs 1961; Cooper 1985) might even have become abundant.

Razorback Sucker

Razorback suckers apparently were quite abundant in Lake Cahuilla (Table 1). Diagnostic interneurals helped confirm razorback sucker identification but the considerable variation in morphology of its asterisci (Fig. 3) leads one to caution in identification.

Though Dill (1944) reported that the razorback sucker is a bottom feeder, Minckley (1973), Marsh (1987), and Papoulias and Minckley (1990) have confirmed that it is primarily a planktivore. Its fimbriate gill rakers (Miller and Smith 1981) suggest that it is a "pump filter-feeder," a feeding method by which the broad gill rakers "guide" particles to the pharyngeal jaws (Sanderson et al. 1991). It is probably the riverine equivalent of the lacustrine suckers of the genus *Chasmistes* (tribe Catotostomine; Hubbs and Miller 1953). Razorback suckers probably thrived in a plankton rich Lake Cahuilla.

Since razorback suckers breed in the shallow waters of reservoirs (Sigler and Miller 1963), it is likely that they spawned along the shore of Lake Cahuilla and thus avoided migratory runs, though Hubbs (1960) reported evidence of successful prehistoric spawning in Fish Creek, a tributary of Lake Cahuilla. The tendency of razorback suckers to feed inshore in small schools (Moyle 1976) and their spawning in shallow water made them the easy prey of Native American fishermen

Fig. 3. *Xyrauchen texanus*: Individual variation in asterisci from archaeological sites; A, CA-RIV-3682; B, CA-RIV-3793; C, CA-RIV-2196; D, CA-RIV-3793.

along the lower Colorado River (Castetter and Bell 1951; Miller 1955; La Rivers 1962). Razorback suckers which reached a meter and 6 kg (Minckley 1973) were easily snared by pulling grab hooks through a school (Sigler and Miller 1963). "Old timers" in Phoenix considered them an excellent food (Minckley 1973). The cui-ui, *Chasmistes cujus*, another planktivorous sucker, was very popular with the Northern Paiute of Pyramid Lake, Nevada (Follett 1982). Despite attaining a greater size in the more sluggish parts of the Colorado River than in its headwaters (La Rivers 1962), razorback suckers have suffered greatly as a result of the reservoir system installed along the Colorado River. Though its larvae have been found in Lake Havasu on the Colorado River for the first time since the 1950's (Marsh and Papoulias 1989), the lack of planktonic food during the critical post hatching period between 19 and 28 days may explain the general lack of recruitment throughout its range (Papoulias and Minckley 1990). Predation by exotic fishes also limits its recruitment (Minckley 1983). Lake Cahuilla probably had the warmer temperatures reported by Tyus and Karp (1990) preferred by razorback suckers, as well as abundant plankton, and no exotic predators.

Colorado Squawfish

The Colorado squawfish (identified here by vertebrae, a basioccipital and a pharyngeal tooth) is the largest North American minnow and one time reached almost two meters and 45 kg (Holden and Wick 1982). It is the chief native piscivore of the Colorado River (Minckley 1973). It is now threatened and very rare due to human alteration of the Colorado River (Miller 1961) which, among other things, has interfered with its spawning runs up tributary streams (Sigler and Miller 1963). Its larvae seem to be more temperature sensitive than those of other species (Marsh 1985) and the backwater habitats necessary for fry development described by Karp and Tyus (1990) were presumably lacking in the Salton Basin and may have contributed to its apparent rarity in Lake Cahuilla. It migrates great distances (Holden and Wick 1982) and the few individuals represented in the remains probably came from up-river. Sigler and Miller (1963) reported that Indians along the lower Colorado River formerly caught them using dip-nets in waters that receded rapidly, or by shooting them with bow and arrow. All these large fishes could have been taken near shore and captured after their escape was limited by inshore stone weirs described by Wilke (1980).

Striped Mullet

Striped mullet, rare among these remains, were quite abundant in the Salton Sea earlier this century (Dill 1944). Follett (1988) reported finding large numbers of striped mullet otoliths in the Salton Basin. It is a marine species that breeds in offshore waters (Fitch and Lavenberg 1971) and has sporadic appearance in the Colorado River (Follett 1960). Despite reports that it is a bottom feeder (Minckley 1973), its thin and elongate gill rakers are suggestive of filter feeding. Filamentous algae might have been readily available to this herbivore in Lake Cahuilla.

Machete

Only two elements (one a vertebra) of the machete were identified at any of the sites studied. It normally schools in the Gulf of California (Thomson et al. 1979) but has had sporadic appearance in the Colorado River (Follett 1960) and earlier in the Salton Sea, where Dill (1944) found it consumed desert pupfish. It may have consumed the fry and fingerlings of bonytail and razorback suckers over 500 years ago in Lake Cahuilla.

Expected, Unrecorded Species

A large species of the lower Colorado River unrepresented in these studies but potentially a resident of Lake Cahuilla was the flannelmouth sucker. It was an important food fish for Indians (La Rivers 1962). Since flannelmouth suckers do poorly in calm waters of impoundments (Minckley 1973), it would be unlikely to thrive in a calm Lake Cahuilla. Since flannelmouth and razorback suckers hybridize (Hubbs and Miller 1953; Suttkus and Clemmer 1979; Minckley 1983; Buth et al. 1987; Tyus and Karp 1990), distinguishing between their remains could present a considerable challenge. Fertile hybrids, presumably between flannelmouth and razorback sucker, found by Tyus and Karp (1990), provide evidence of the possibility of an introgressive gene pool.

Small fishes (under 9 cm SL) reported by Miller (1961) in the lower Colorado River that do not appear among these remains include three endangered species: the woundfin, desert pupfish, and Gila topminnow. Screens of ⅛ in. were used in these excavations creating a possible sampling bias because screens with ⅛ in. and larger mesh miss the remains of small fishes (Fitch 1972; Casteel 1972; Gobalet 1989). Had these small fishes been utilized by Native Americans, they might have been found in coprolites microscopically examined by Wilke (1978) and Farrell (1988).

Summary

Ninety-six percent of the 4421 fish elements identified from 14 archaeological sites along Lake Cahuilla are probably from bonytail and razorback sucker which suggests that Lake Cahuilla was a plankton rich habitat. The razorback sucker probably thrived in the lake and fed upon a plankton bloom resulting from the slow flow and increased surface temperatures of the nutrient rich waters of the Colorado River. Omnivorous bonytail may have extensively exploited the plankton as well. Rare in the lake were piscivorous Colorado squawfish and the euryhaline striped mullet and machete. Small species were undoubtedly present, but not represented among these remains.

Literature review suggests that other large chubs, *G. cypha* and *G. robusta*, as well as the flannelmouth sucker, may have also been present in Lake Cahuilla. Therefore, identifications based on such fragmentary remains should be considered unconfirmed in part because hybridization may have occurred among the chubs and between flannelmouth sucker and razorback sucker. Unfortunately, it is now resources such as these from archaeological sites that are the only ones available for studying the ranges of these vanishing species.

Recommendations to Zooarchaeologists

In reporting the species recovered from an archaeological site be certain to include the zoogeographical and anatomical evidence for identifications and a list of specimens examined in making determinations. It is also advisable to consider the tenuous nature of basing identification on fragmentary remains that may come from species subject to considerable individual variation and possibly hybridization. Qualifying work based on these considerations will enhance the confidence in the identifications. Submit the papers based on the identifications to peer-reviewed journals.

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Materials Examined

Institutional abbreviations are as listed by Leviton et al. (1985) except that unnumbered specimens and those designated KWG are in the collection at California State University, Bakersfield. *Gila bicolor*: OS 7752, OS 7757, CAS 25815, CAS 26302, UMMZ 174438-s(2), KWG 8 skeletons, 136 pharyngeals, 54 basioccipitals; *G. crassicauda*: CAS 18378, KWG 14 partial pharyngeals; *G. cypha*: UMMZ 179577-5, 178667; *G. elegans*: AMNH 46106, CAS 25865, CAS 66037, CAS 66038; *G. robusta*: AMNH 46113, AMNH 47091, AMNH 47092, AMNH 47093, AMNH 47094, AMNH 47095, AMNH 47096, AMNH 47097, AMNH 47098, AMNH 47099, CAS 25850, CAS 25851, UMMZ 179580, UMMZ 182502; *Ptychocheilus lucius*: CAS 66217; *P. grandis*: KWG 243, skeleton; *P. oregonensis*: KWG 347, KWG 404, KWG 454; *Xyrauchen texanus*: AMNH 30848, CAS 66229, CAS 66231, LACM 43613-1; *Catostomus catostomus*: KWG 453, one skeleton; *C. fumeiventris*: 2 skeletons; *C. latipinnis*: UMMZ 178628, UMMZ 178690, UMMZ 179567; *C. macrocheilus*: KWG 349, KWG 353, KWG 366, one skeleton; *C. occidentalis*: KWG 277, KWG 240; *C. tahoensis*: KWG 350, KWG 363, 7 skeletons; *Chasmistes cujus*: KWG 346, KWG 399, KWG 351; *Erimyzon tenuis*: 2 skeletons; *Ictiobus bubalus*: KWG 364, KWG 361; *Elops affinis*: KWG 205, KWG 294; *Mugil cephalus*: KWG 360, KWG 347.

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