Extinctions of North American Fishes During the Past Century

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ABSTRACT

Extinctions of 3 genera, 27 species, and 13 subspecies of fishes from North America are documented during the past 100 years. Extinctions are recorded from all areas except northern Canada and Alaska. Regions suffering the greatest loss are the Great Lakes, Great Basin, Rio Grande, Valley of Mexico, and Parras Valley in Mexico. More than one factor contributed to the decline and extinction of 82% of the fishes. Physical habitat alteration was the most frequently cited causal factor (73%). Detrimental effects of introduced species also were cited in 68% of the extinctions. Chemical habitat alteration (including pollution) and hybridization each were cited in 38% of the extinctions, and overharvesting adversely affected 15% of the fishes. This unfortunate and unprecedented rate of loss of the fishery resource is expected to increase as more of the native fauna of North America becomes endangered or threatened.

RESUMEN

Durante los 100 años pasados se registraron extinciones de tres generos, 27 especies, y 13 subespecies de peces en Norte America. Extinciones fueron registrados de todas partes fuera de la parte norte de Canada y Alaska. Las regiones que sufrieron las pérdidas mas grandes fueron los Lagos Grandes (E.U. y Canada), el Bolsón Grande, Rio Bravo, Valle de México, y el Valle de Parras de México. Mas de un factor contribuyó a 82% de las extinciones. Alteración física del habitat fue el factor causal citada con mayor frecuencia (73%). Efectos dañosos de introducciones de especies exóticas tambien fueron citados como factores contribuyentes en una mayoría de las extinciones (68%). Ambas alteración quimica del habitat (incluyendo la contaminación) e hibridación fueron citadas en 38% de las extinciones, y sobre explotación afectó adversamente a 15% de las especies extinctas. Se espera que esta desafortunada, y anteriormente desconocida, tasa de extinción se aumentará aún mas mientras mayor parte de la fauna nativa de Norte America llega a encontrarse en peligro, o en amenaza, de extinción.

Many rivers, lakes, and springs in North America have been fragmented, polluted, or destroyed. These losses have been documented through growing lists of endangered fishes (Deacon et al. 1979; Campbell 1985, 1988; USDI 1989) and endangered ecosystems (Williams et al. 1985). The American Fisheries Society now lists 103 fish taxa as endangered, 114 as threatened, and 147 others as of special concern in North America (Williams et al. 1989, this issue).

Despite the increasing threat to the aquatic resources, extinctions have been poorly documented. Part of the problem is the difficulty in determining when a species is extinct (Diamond 1987). Should a species be considered extinct when it is not found in a single survey, or are many more negative searches required before extinction should be considered confirmed? Extinctions are particularly hard to document for small fishes or species that easily evade casual observation or occupy habitats that are difficult to sample.

Some taxa may persist at perilously low numbers for many years, only to be rediscovered in remote corners of their habitats or after populations have recovered sufficiently to again be noticed. There are several examples of fishes that were considered to be extinct only to be rediscovered by [illegible] scientists. The Owens pupfish (*Cyprinodon radiosus*) was rediscovered in a remote corner of Fish Slough, California, in 1964 (Miller and Pister 1971) after being presumed extinct by [illegible] (1961) and others. Similarly, the Shoshone pupfish (*C. nevadensis shoshone*) was rediscovered in 1986 after previous surveys failed to find a population that had dwindled to such a small size that the remaining individuals experienced a genetic bottleneck (Taylor et al. 1988). For such endangered taxa, where remnant populations survive, much of the original genetic variation has been lost (Wilson 1988). Unfortunately, chances of rediscovery are slim for an increasing number of fishes.

Our purposes here are to provide a comprehensive list of recently extinct fishes of the North American continent and detailed accounts of each extinction. We include fishes whose extinctions are presumed on the basis of numerous negative surveys and taxa that are poorly known but whose extinction is presumed and rediscovery [illegible] impossible. All fish extinctions [illegible] to have occurred during the [illegible] years are included.

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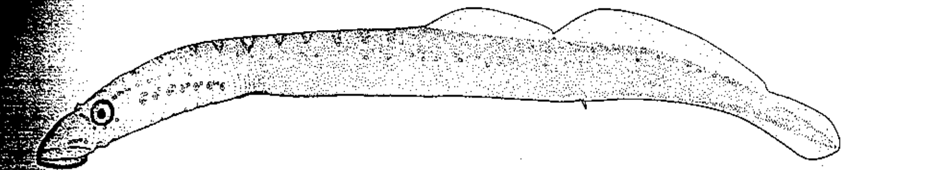


Figure 1. Miller Lake lamprey, *Lampetra minima*. An adult male collected near the northern shore of Miller Lake, Klamath County, Oregon, 17 July 1952. *Drawing by Sara V. Fink.*

The Extinct Fishes

Miller Lake Lamprey
Lampetra minima Bond and Kan

Figure 1

This dwarf species of parasitic lamprey was endemic to Miller Lake, Klamath County, Oregon (Bond and Kan 1973). It is thought to have evolved from a stock of the Pacific lamprey (*L. tridentata*) isolated in Miller Lake after the explosion of Mt. Mazama (now Crater Lake), which probably destroyed virtually all aquatic life in the lake 6,600 years ago. Kan and Bond (1981) attributed evolution of this dwarf species to a reduced food supply, short generation time, and the small numbers of lampreys surviving in the area after the mountain's eruption.

Forty-five adult specimens examined by Bond and Kan (1973) ranged from 71 to 129 mm TL, making this the smallest species of parasitic lamprey known. In addition to its small size, the species was notable in having relatively high fecundity, indicating a greater use of energy for gamete production than for spawning migrations (Kan and Bond 1981).

Because it preyed on introduced trout, the Miller Lake lamprey was purposely poisoned with ichthyocides during the 1950s by the state of Oregon. The last collection of the species was made from Miller Lake on 17 July 1952. Subsequent investigations have confirmed the extinction of this species.

Longjaw Cisco
Coregonus alpenae (Koelz)

The longjaw cisco, described from Lake Michigan off Charlevoix, Michigan, was most abundant in Lakes Michigan and Huron. The species was rare in Lake Erie, where the last record of capture was in November 1957 (Scott and Smith 1962). It was one of the largest ciscoes in the Great Lakes; adults often attained a length of 38 cm and a weight of 1 kg (Koelz 1929).

Stocks of this large and commercially valuable species were severely depleted by overfishing in Lakes Michigan and Huron by the turn of the century (Smith 1968). As the catches began to decrease, the fishery became more intense and selective. The severe decline caused by commercial overexploitation probably was aided in its later stages by predation from the exotic sea lamprey (*Petromyzon marinus*), which became established in the 1940s. As the longjaw cisco became increasingly rare, it is believed to have become extinct through hybridization with more common ciscoes (G. R. Smith, University of Michigan, personal communication). The last known record of capture in Lake Michigan was from Grand Traverse Bay in 1967 and in Lake Huron from Georgian Bay, Ontario, on 12 June 1975 (T. N. Todd, Fish and Wildlife Service, Ann Arbor, MI, personal communication).

Deepwater Cisco
Coregonus johannae (Wagner)

The deepwater cisco was one of the two most important species in the early cisco fisheries of the Great Lakes. The deepwater cisco occurred in the deeper parts of Lakes Michigan and Huron, at depths of 55 to 183 m (Koelz 1929). The last known record of capture for the species in Lake Michigan was from Grand Traverse Bay in June 1951, and in Lake Huron from Wolfsell, Ontario, on 4 August 1952 (T. N. Todd, Fish and Wildlife Service, Ann Arbor, MI, personal communication).

Heavy exploitation from the commercial fishery produced a marked decline in deepwater cisco populations during the early 1900s (Smith 1970). Continued intensive fishing for all larger ciscoes, coupled with predation by exotic sea lampreys, led to dwindling stocks of this species (Smith 1964). As populations of the deepwater cisco were diminished, introgressive hybridization with more common ciscoes may have contributed to final extinction.

Lake Ontario Kiyi
Coregonus kiyi orientalis Koelz

In his monograph on coregonid fishes of the Great Lakes, Koelz (1929) recognized the kiyi of Lake Ontario as a distinct subspecies (*Coregonus kiyi orientalis*). It was one of the smallest ciscoes in the Great Lakes and occurred throughout Lake Ontario at depths of 37 to 137 m (Koelz 1929).

Along with other ciscoes, the Lake Ontario kiyi supported an important commercial fishery from the 1800s through the 1930s. Although fishery statistics did not distinguish among the species, the Lake Ontario kiyi was probably the most important species in the Lake Ontario fishery (Pritchard 1931).

The last known collection of this fish was made on 19 September 1964 near Oswego, New York (T. N. Todd, Fish and Wildlife Service, Ann Arbor, MI, personal communication). Like the other extinct coregonid fishes of the Great Lakes, the decline and ultimate disappearance of the Lake Ontario kiyi was caused by a combination of events. Overfishing was a major factor. Establishment of exotic and non-native fishes and deterioration of water quality from eutrophication and release of toxic chemicals also were contributing factors.

Blackfin Cisco
Coregonus nigripinnis (Gill)

The blackfin cisco was one of the largest and most commercially valuable of the coregonid fishes in the Great Lakes. It occurred in the deeper waters (110 to 146 m) of Lakes Michigan and Huron (Koelz 1929).

The decline and eventual extinction of the blackfin cisco were caused by the same factors (overfishing, sea lamprey predation, and introgressive hybridization) as those described for the longjaw cisco. The last blackfin cisco known from Lake Huron was taken at Wiarton, Ontario, on 26 June 1923 (Koelz 1929). The last record of the species from Lake Michigan was on 26 November 1969 at Marinette, Wisconsin (T. N. Todd, Fish and Wildlife Service, Ann Arbor, MI, personal communication).

Yellowfin Cutthroat Trout
Oncorhynchus clarki macdonaldi (Jordan and Evermann)

The yellowfin cutthroat trout was known only from Twin Lakes on Lake Creek, a tributary to the Arkansas River in Lake County, Colorado. The presence of the greenback cutthroat trout (*O. clarki stomias*) in Twin Lakes and its early extinction clouded the taxonomic history of the yellowfin cutthroat trout. Behnke (1979) examined yellowfin and greenback cutthroat trouts of the same size from Twin Lakes and concluded that *macdonaldi* was a valid taxon, probably most closely related to the Colorado cutthroat trout (*O. c. pleuriticus*).

Apparently a favorite of local anglers during the late 1800s, the yellowfin cutthroat attained a weight of at least 5 kg (Jordan 1922). Yellowfin cutthroat trout were propagated at Leadville National Fish Hatchery and may have been introduced into Colorado's Grand Mesa (Behnke 1979) and even into France (Jordan 1922). Attempts at establishment and long-term propagation failed.

Non-native trouts were extensively introduced into Twin Lakes and landlocked salmon (*Salmo salar sebago*), rainbow trout (*Oncorhynchus mykiss*), lake trout (*Salvelinus namaycush*), and brook trout (*S. fontinalis*) all were established in the lakes by the turn of the century (Juday 1907). Introgressive hybridization with rainbow trout and competition from deep-water lake trout apparently eliminated yellowfin cutthroat trout as well as the local population of greenback cutthroat trout from Twin Lakes around 1910. The Forest Service apparently propagated a silvery "yellowfin" trout from Island Lake, Colorado, during the early 1930s, but their genetic purity was doubtful.

Alvord Cutthroat Trout
Oncorhynchus clarki ssp.
Figure 2

The Alvord cutthroat trout was endemic to streams in the Alvord Basin of southeastern Oregon and northwestern Nevada. It was known only from Trout Creek in Oregon and Virgin Creek in Nevada, although it may have lived in several of the larger Alvord Basin streams during recent times (Hubbs and Miller 1948). The Alvord cutthroat's nearest relative appears to be another undescribed subspecies of cutthroat trout from V... Whitehorse creeks in Orego... of the Alvord Basin.

Hybridization and introg... introduced rainbow trout... caused extinction of the A... throat trout. Rainbow tr... teristics were already no... the first collection of trout f... Creek made by Carl L. H... family in 1934. Cutthroat... mentation was present in... fish collected by Carl E. Bo... and 1957, but no basibran... (typically present in O. cl...) found (C. E. Bond, Oregon... versity, personal communic... liams and Bond 1983). All... collections of trout from Vir... are known from 1957 to 197... mens collected in 1971, 1978... showed typical rainbow tro... teristics or appeared to be... cutthroat hybrids (Williams... 1983). Electrophoretic analyse... collected from isolated portio... gin Creek in 1984 to 1986 show... portions of rainbow trout alle... samples (Tol and French 1988)... ically pure Alvord cutthroat... pear to be extinct, and may ha... extirpated soon after stocking... bow trout during the early 19...

Silver Trout
Salvelinus agassizi (Garm...)
Figure 3

The silver trout from Dublin... New Hampshire, was recogniz... unique, distinctive trout as ea... 1849 (Bigelow 1850), althoug... not formally described as a new... 1885. In addition to Dublin Pond... Center Pond or Monadnock... silver trout occurred in Christine... (Warfel et al. 1939). Both were in... Connecticut River drainage. Mor... logically, silver trout are similar to... trout, but the two are distinctly... in coloration. Both species... sympatrically, and the silver... was relegated by many early... to subspecific status, *Salvelinus* ... *agassizi* (Jordan 1885).

...silver trout typically weighed ... 1 and 2 kg, but individuals ... 3 kg were known (Kendall 1914). ... were taken by fishermen using a ... of baits, including worms, min..., grasshoppers, and artificial flies. The species began to decline in abundance during the late 1800s. This decline appears to be attributable to ... harvesting during spring and autumn, when silver trout were in shallow water. Although populations were reduced by excessive fishing, it was the introduction of non-native fishes that caused extinction of the species. Warfel et al. (1939) reported the following introduced fishes in Dublin Pond: Atlantic salmon, rainbow trout, lake trout, chinook salmon, rainbow smelt (*Osmerus mordax*), brown bullhead (*Ictalurus nebulosus*), yellow perch (*Perca flavescens*), and white perch (*Morone americana*). Both Dublin Pond and Christine Lake received hatchery stocks of brown trout in addition to the native form. Hybridization with hatchery-reared brook trout may have contributed to extinction of the silver trout. The last record of silver trout from Christine Lake was in 1926 (Warfel et al. 1939) and from Dublin Pond in 1930 (Behnke 1980).

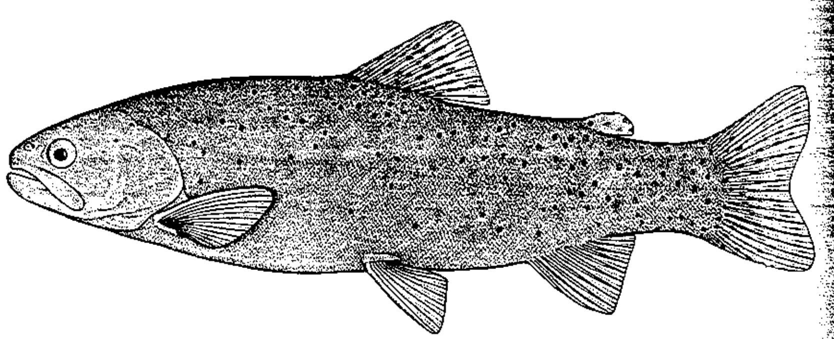
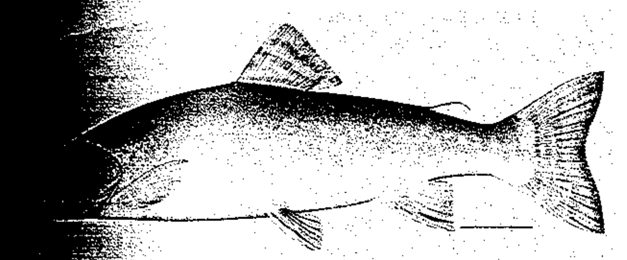


Figure 2. Alvord cutthroat trout, *Oncorhynchus clarki* ssp. An adult female, 106.5 mm SL, collected from Virgin Creek, Humboldt County, Nevada. *Drawing by Sara V. Fink.*



...Silver trout, *Salvelinus agassizi*. A specimen 21.6 cm TL collected from ... Lake, Cheshire County, New Hampshire, 2 December 1887. *Drawing by* ... *Denton.*

Maravillas Red Shiner
Cyprinella lutrensis blairi (Hubbs)

Hubbs (1940) described the Maravillas red shiner from two localities in the Big Bend region of Texas. The type series consists of two collections of 41 specimens taken from Garden Springs on 16 April 1937 and 19 July 1938, and one collection of 10 specimens from Peña Colorado Creek taken on 16 April 1937. Both localities are in the Maravillas Creek drainage, tributary to the Rio Grande. The last known collection of this subspecies was apparently made by Clark Hubbs in 1954, when red shiners were collected from upper Maravillas Creek at its confluence with Peña Colorado Creek.

By 1954, Garden Springs was dominated by an introduced population of plains killifish (*Fundulus zebrinus*) and no red shiners could be found (Matthews 1987). Matthews (1987) suggested that the subspecies was extinct because of loss of the Garden Springs population and unsuccessful efforts to collect the shiner from Peña Colorado Creek in 1978.

Mexican Dace
Evarra spp.

The Mexican cyprinid genus *Evarra* was described by Woolman (1895) from canals in the endorheic Valley of Mexico, where Mexico City and its suburbs now stand. The genus *Evarra*, an Indian name meaning "maker of gods in lands beyond the sea" (Jordan and Evermann 1896–1900), includes three species: *E. eigenmanni* Woolman, *E. tlahuacensis* Meek, and *E. bustamantei* Navarro.

Unfortunately, relatively few museum specimens of these small (maximum SL = 80 mm) minnows still exist. Alvarez and Navarro (1957) had large series of two of the species, but these have largely disappeared. *Evarra* is presumed to be derived from the Mexican genus *Algansea* (Barbour and Miller 1978).

Alvarez and Navarro (1957) believed all three species to be nearing extinction three decades ago, and all were believed to be extinct by 1983 (E. Diaz-Pardo, Instituto Politecnico Nacional, Mexico City, personal communication). The extinctions coincided with drying of the lakes, spring-fed ponds, and canals of the valley floor, due to agricultural practices, persistent groundwater removal, and the development of Mexico City and suburbs.

Independence Valley Tui Chub
Gila bicolor isolata Hubbs and Miller

Gila bicolor isolata was endemic to Warm Springs of Independence Valley in Elko County, Nevada. It was quite possibly extinct by the time it was originally diagnosed as a new subspecies by Hubbs and Miller (1972). In the first collection of the subspecies on 25 August 1965, Hubbs et al. (1974) described the fish as abundant in the spring complex. They greatly outnumbered another endemic, the Independence Valley speckled dace (*Rhinichthys osculus lethoporus*). A second collection of the tui chub was made on 3 April 1966 by S. H. Berwick and others. Since 1966, no collections of the Independence Valley tui chub are known. Recent surveys of the Warm Springs system conducted by Vinyard (1984) yielded a few speckled dace but no tui chub.

Between 1960 and 1966, largemouth bass (*Micropterus salmoides*) and bluegills (*Lepomis macrochirus*) were introduced into the Warm Springs system and the largemouth bass is now abundant (Vinyard 1984). Hubbs et al. (1974) reported the introduced bullfrog (*Rana catesbeiana*), common carp (*Cyprinus carpio*), and largemouth bass in the springs in 1965 and expressed concern for survival of the native fishes. Vinyard (1984) speculated that the introduced centrarchids were responsible for elimination of the tui chub. This appears to be a logical hypothesis, as *G. b. isolata* preferred midwater habitats that were easily invaded by largemouth bass, whereas the speckled dace may have largely escaped extirpation by finding refuge in shallow water with dense aquatic vegetation.

Extinction of the Independence Valley tui chub probably occurred during the late 1960s or early 1970s. Surveys of other springs in the valley for fishes have been unsuccessful (Vinyard 1984).

Thicktail Chub
Gila crassicauda
Baird and Girard

At one time the thicktail chub, which attained lengths of 250 mm, was one of the most common fishes in California's Central Valley and at the turn of the century was sold in markets in San Francisco. Examination of fish remains from historic Indian middens revealed the abundance of the chub. In one midden approximately 1 km west of the Sacramento River in Colusa County, thicktail chub was the most abundant species, contributing 41% of the 1,497 fish recovered (Schulz 1979). Museum records for the species during the late 1800s and early 1900s indicated a broad distribution throughout lower-elevation streams and rivers of the Central Valley, tributary streams of San Francisco Bay, central California coastal rivers, and Clear Lake (Rutter 1908; Miller 1963; Mills and Mamika 1980). In periods of heavy runoff, the species also inhabited fresh surface waters of San Francisco Bay (Ayres 1862). Preferred habitats consisted of rivers, marshes, sloughs, lakes, and slow-flowing reaches of rivers.

Primary causes of the decline of thicktail chub can be traced to conversion of much of the Central Valley to intensive agricultural production. Many of the sloughs and marshes were drained during the late 1800s, and the remaining streams and rivers were largely dredged or channelized for navigation or flood control. Of the 34 museum lots of thicktail chub with collection dates, only 11 (32%) were collected after 1900. Habitat loss, combined with competition and predation pressures from a myriad of introduced nonnative fishes, probably combined to cause extinction of the thicktail chub. It was last collected from Clear Lake in 1938 and from the Sacramento River in 1950. The last known collection of the species was made from Steamboat Slough along the San Joaquin River, Solano County, on 16 April 1957. Repeated efforts to find the species since that time have failed.

Pahranagat Spinedace
Lepidomeda altivelis
Miller and Hubbs

The Pahranagat spinedace was known from only two localities, the outflow of Ash Springs and Upper Pahranagat Lake, in Pahranagat Valley, Nevada. Miller and Hubbs (1960) reported collecting the spinedace in abundance at the two sites during 1938. It was not present in Crystal or Hiko springs or Ash Springs proper, indicating an avoidance of constant, warm water.

Extinction of the Pahranagat spinedace is most likely attributable to competition or predation by introduced species. In 1938, only a few common carp were collected with the spinedace from the outflow of Ash Springs, whereas this exotic was plentiful in Upper Pahranagat Lake. Common carp and another introduced species, the mosquitofish (*Gambusia affinis*), were abundant during a 1959 survey that yielded no Pahranagat spinedace (Miller and Hubbs 1960). The introduction of bullfrogs also may have contributed to the decline of the native fish by predation. The 1938 collection of Pahranagat spinedace is the last known, as numerous attempts to collect the species by Miller and Hubbs, and J. E. Deacon from the University of Nevada at Las Vegas, have failed.

Ameca Shiner
Notropis amecae
Chernoff and Miller

The Ameca shiner was described from upper parts of the Río Ameca drainage in Jalisco, Mexico (Chernoff and Miller 1986). The Río Teuchitlán, from which the type specimens were collected, lies about 75 km west of Guadalajara. Its waters are heavily utilized for drinking, irrigation, and other domestic uses and have been heavily polluted by humans and livestock.

The species was not common during the early 1900s, as only 46 of 2,875 fishes collected from the upper Río Ameca basin between 1939 and 1969 were *Notropis amecae*. The last known capture of the Ameca shiner was on 21 April 1969. Intensive collecting in the drainage during th... uncovered no shi... formerly occupied b... now populated by... such as shortfin m... *cana*), platyfish (X... lapia (*Tilapia*). Thu... Río Ameca endemic...

Durang...
Notropis...
Chernoff...

The Durango s... the Río Tunal, wh... waters of the Río... slope river rising... Durango, Mexico (C... 1986). It was take... and 1961. All spec... were collected in... ervoir on the Río T... of 1,865 m. Like it... of which occur sou... species evidently p... Collections farther... Tunal (where the... failed to yield any...

Since the mid-19... has grown conside... that streamflows h... and domestic and... have adversely affe... In addition, introd... seriously impacted... competition and pre... that only 6 of the... known from the... there. None of the... Introduced largem... ular, have seriously... biota. Attempts to... shiner as recently... and we therefore do... survives.

Phantom...
Notropis orc...

The phantom sh... fused with the bl... *tropis simus* (Cope... recognized as a... endemic to the R... mouth of the river... Texas, to central N... ing the mouth of th... noff et al. 1982)... the biology of th... been collected onl... years—a single ad... the Mexican side...

...of the Rio Grande ...a result of water ...their impound... ...tion and an in... ...correlated with ...these factors, along ...of introduced ...a significant de... ...both the phantom ...especially after ...Rio Grande was ...and droughts, ...stable flow re... ...fauna may well ...these long-term ...introduced fishes, ...diminished dur... ...flourished in

...are known ...the upper Rio ...as long ago ...1982). By 1939, ...*simus* taken in ...Valencia (New ...exhibited intro... ...The precise ...unknown, but ...by the reduction ...sites and/or ...species. What role ...in the decline of ...known because we ...their biology.

...ntnose Shiner
...simus Cope

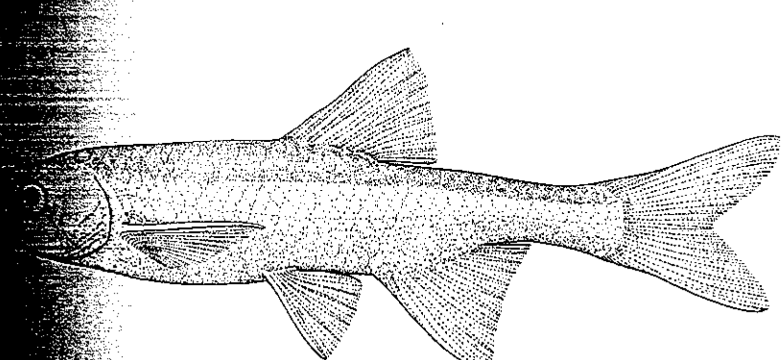
...was recently ...two subspecies, *N. s. simus* from the upper Rio Grande between the Chama River and El Paso, Texas; and *N. s. pecosensis* from the Pecos River in New Mexico (Chernoff et al. 1982). Adult Rio Grande bluntnose shiners inhabited the swift, relatively deep, main river channel, but were occasionally taken from irrigation ditches or shallow riffles.

The last known Rio Grande bluntnose shiner was caught in the Rio Grande north of Peña Blanca, Sandoval County, New Mexico, on 28 July 1964 by R. D. Suttkus and class. As discussed above for the phantom shiner, a number of factors may have contributed to the extinction of the Rio Grande bluntnose shiner, including modifications of the river by dams and their impoundments, irrigation practices, and channelization. Loss of spawning sites by desiccation, perhaps in conjunction with competition from introduced species, may have been especially critical.

Clear Lake Splittail
Pogonichthys ciscoides Hopkirk

Pogonichthys ciscoides was restricted to Clear Lake and its tributary streams in Lake County, California. This lacustrine cyprinid once formed large schools in Clear Lake, especially in the littoral zones. During April and May, the splittail ascended streams tributary to the lake to spawn (Moyle 1976). Hopkirk (1973) reported the species from several localities in Clear Lake during the early and mid-1960s, and a single specimen that apparently was washed downstream into Cache Creek, 0.6 km upstream from State Highway 16 (1965).

The decline of the once abundant splittail parallels the drastic change in Clear Lake itself. Prior to the 1880s, the lake was a cool, clear habitat with a fishery dominated by rainbow trout and Sacramento perch (*Archoplites interruptus*) (Murphy 1951); by the early 1940s, it had been transformed into a warm, turbid lake dominated by centrarchids, common carp, and other introduced fishes. Goldman and Wetzel (1963) documented the "extreme eutrophication" of Clear Lake by the late 1950s and attributed the change to rapid and poorly planned development of the watershed for agriculture, which washed sediment, fertilizers, and sewage into the lake. The Clear Lake splittail was abundant until 1942 or 1943, but during three summers of intensive seining from 1946 to 1950, Murphy (1951) collected only a few juveniles. Murphy (1951) concluded that the low rainfall years of the early 1940s, coupled with diversion of tributary streams for agriculture, eliminated most of the habitat for the remaining splittails. The demise of the species may have been hastened by the application of large quantities of chlorinated hydrocarbon pesticides used to control swarms of Clear Lake gnats (*Chaoborus astictopus*). During the 1940s and 1950s, increasing use of DDD (dichloro-diphenyl-dichloroethane) resulted in the appearance of this toxin in fishes and piscivorous birds (Hunt and Bischoff 1960) and massive die-offs of western grebes (*Aechmophorus occidentalis*). Also, the abundance of introduced littoral fishes, such as bluegills and inland



...Grande bluntnose shiner, *Notropis s. simus*. A specimen 65.2 mm SL, collected from Rio Grande 7 km ...Blanca, Sandoval County, New Mexico. *Drawing by Sara V. Fink.*

silverside (*Menidia beryllina*) probably was detrimental. The last specimen of Clear Lake splittail was taken from Clear Lake in 1970. Recent collection efforts have failed and the species is presumed to be extinct (Moyle 1976).

Banff Longnose Dace
Rhinichthys cataractae smithi Nichols

The Banff longnose dace was endemic to the marsh created by Cave and Basin Hotsprings 1.7 km southwest of Banff, Alberta, Canada. Based on collection records during the late 1800s and early 1900s, the Banff longnose dace was quite abundant in its restricted habitat (Lanteigne 1988). After the early 1900s, surveys revealed few specimens. In May 1971, 16 individuals were collected at the inflows, and 7 more from the same site in May 1981 (Lanteigne 1988). A September 1981 trip yielded only two specimens from a pool at the outlet of the marsh into the Bow River, but others were sighted in the same locality. Decreasing population size by 1981 indicated that the Banff longnose dace was endangered at that time, and more recent unsuccessful collection efforts indicate the subspecies to be extinct (Lanteigne 1988).

Initial decline of the Banff longnose dace can be attributed to introductions of numerous exotic and non-native fishes, including mosquitofish, which were stocked as early as 1924 (McAllister et al. 1985), and various tropical fishes such as sailfin mollies, guppies (*Poecilia reticulata*), convict cichlids (*Cichlasoma nigrofasciatum*), and green swordtails (*Xiphophorus helleri*), (Lanteigne 1988). Other factors contributing to the decline of the longnose dace are periodic cessation of flows related to use of the hotsprings as public baths, and the periodic spillage of sewage from the public facilities. Once the Banff longnose dace declined in numbers, it was susceptible to introgressive hybridization with the eastern subspecies of longnose dace (*R. c. cataractae*), which apparently caused its final extinction (Renaud and McAllister 1988).

Las Vegas Dace
Rhinichthys deaconi Miller

Between 1891 and 1940, several collections of a small minnow were made from Las Vegas Creek, near Las Vegas, Nevada. This dace was described by Miller (1984) and distinguished from its closest relative, the speckled dace (*R. osculus*).

In May 1844, John Fremont described Las Vegas Creek as "a delightful bathing place." In 1891, Vernon Bailey mentioned the numerous little fish in the springs and stream. Cottonwoods and willows grew along the banks. In high water, flow from Las Vegas Creek reached the Colorado River, some 40 km distant, but by 1947, flow down the creek had already been reduced by development of the Las Vegas community. Nothing is left of the spring and creek complex today, except a hole in the ground with stagnant water at the bottom. At one time, this creek and marsh also supported the endemic Vegas Valley leopard frog (*Rana fisheri*), which is also extinct. Both species were extirpated as the system was converted for agricultural and urban development.

The last known collection of the Las Vegas dace was made on 30 July 1940, at Lorenzi Ranch in Las Vegas. The species probably survived in one of the springs and its outflow until about 1955, when there was a marked increase in the amount of water withdrawn from the artesian basin beneath Las Vegas. No fish were found 10 years later when the area was searched by J. E. Deacon and colleagues from the University of Nevada, Las Vegas.

Grass Valley Speckled Dace
Rhinichthys osculus reliquus Hubbs and Miller

The Grass Valley speckled dace is known only from a single collection made by C. L. Hub[illegible] on 9 August 1938. [illegible] was given by Hubb[illegible] as a "spring-fed [illegible] meadow in the [illegible] western arm of [illegible] east of Mt. Callagh[illegible] Callaghan (Woodw[illegible] eastern Lander Co[illegible]

The speckled dace [illegible] collected in 1938. [illegible] sisted of 474 specim[illegible] one trout was seen [illegible] second collecting [illegible] Miller in 1969 produ[illegible] trout and brook tro[illegible] (Hubbs et al. 1974) [illegible] versity of Nevada, R[illegible] munication, to Hubb[illegible] finding no speckled [illegible] stream "full of tro[illegible] to Grass Valley in [illegible] to collect this speckle[illegible] Valley during the 19[illegible] the fish appears [illegible] introduction of tro[illegible] primary cause of ex[illegible] the water for agric[illegible] contributed to the lo[illegible]

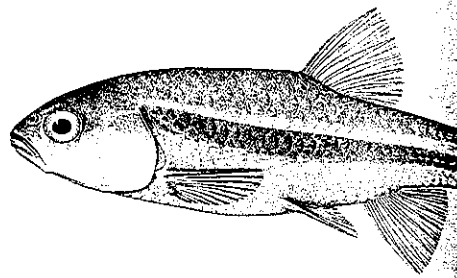


Figure 5. Stumptooth minnow, *Stypodon signifer*. The syntype, [illegible] from a spring near Parras, Coahuila. *Drawing by Sara V. Fink.*

Stumptooth [illegible]
Stypodon signi[illegible]
Figure [illegible]

This species repre[illegible] genus known only [illegible] mens—two collected [illegible] in 1903. All specim[illegible] spring or spring co[illegible] in southern Coahuila [illegible] cies was named fo[illegible] form pharyngeal [illegible] dently were special[illegible] the abundant mollus[illegible]

[illegible] Parras Valley in [illegible] C. Hubbs, re[illegible] surviving native [illegible] by Contreras- [illegible] modification [illegible]/or water pol[illegible] practices that car[illegible] fields were [illegible] factors in the de[illegible] were the food of [illegible] may have [illegible] to changes [illegible] deteriorating water

[illegible] Sucker
[illegible] *liorus* Jordan

[illegible] (*Chasmistes liorus*), [illegible] *ardens*), and [illegible] occurred in [illegible] Utah Lake [illegible] as the "greatest [illegible] universe" (Jordan [illegible] suckers were [illegible] except during [illegible] June—hence [illegible] when they as[illegible] for spawning. [illegible] harvested the [illegible] spawning runs in [illegible] Forks rivers as [illegible] during winter. [illegible] streams for [illegible] the lake's com[illegible] the sucker and [illegible] as early as 1860 [illegible] communication, in [illegible] Diversion dams [illegible] also blocked spawn[illegible] hybridization be[illegible] species as they [illegible] the dam's tail[illegible] of 25 exotic and [illegible] also contributed to decline of the native fishes. Eleven of these were established in Utah Lake or its tributaries prior to 1930 (Heckmann et al. 1981).

The final collapse of the June sucker appeared to result from the severe drought of the mid-1930s. Tanner (1936) succinctly described the final demise of genetically pure June suckers as follows: "At this writing Jan. 1936, practically all the suckers as well as other fish in Utah Lake have been killed by the severe drought of the past four years. . . During the winter of 1934–35 the water was so shallow that hundreds of tons of suckers and carp were killed due to freezing and crowding in the few deep holes. . . In the spring of 1935 there were no suckers to run up Provo River, something that has never happened before in the history of Utah Lake."

A *Chasmistes* now exists in Utah Lake, but it differs significantly from type specimens of *C. liorus*. The true-breeding population of *Chasmistes* from Utah Lake was described as a new subspecies, *C. liorus mictus*, that resulted from hybridization between the June and Utah suckers (Miller and Smith 1981). Unlike previous hybrids in the lake, this subspecies of June sucker comprised a large breeding population with consistent, distinguishable characters. The original form of June sucker, *C. l. liorus*, is extinct (Miller and Smith 1981).

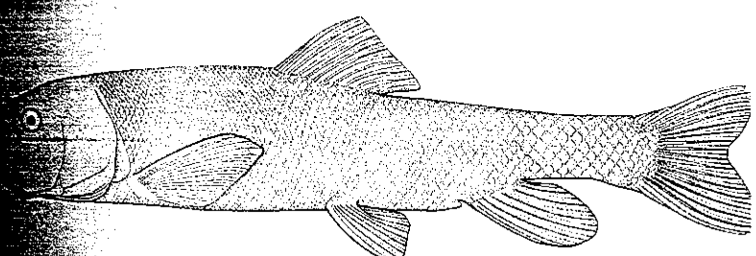
Snake River Sucker
Chasmistes muriei Miller and Smith
Figure 6

The Snake River sucker is known only from a single specimen collected by Dr. Olaus J. Murie from the Snake River below Jackson Lake Dam, Wyoming, on 13 October 1927 (Miller and Smith 1981). The species is presumed to have occupied Jackson Lake and perhaps other lakes on the upper Snake River. Like other members of the genus *Chasmistes*, the Snake River sucker was a lacustrine species with numerous dendritic gill rakers for feeding on plankton.

Chasmistes muriei may have been extinct in genetically pure form when the only specimen was collected in 1927. By this time, introgression of the Utah sucker with the Snake River sucker was evident. A rock-filled dam was constructed on the outflow of Jackson Lake in 1905–1906. After this dam was washed out in 1910, construction began the next year on a concrete dam that would eventually almost double the surface area of Jackson Lake (J. Daugherty, National Park Service, personal communication). Hybridization with the Utah sucker probably occurred because such dams on the upper Snake River blocked spawning migrations and forced remaining suckers to spawn in the dams' tailwaters. Had it not been for the diligence of wilderness advocate Dr. Murie, who collected the only specimen, the passage of this species into extinction would have gone unnoticed.

Harelip Sucker
Lagochila lacera Jordan and Brayton
Figure 7

During the late 1800s, the harelip sucker was widespread in the eastern United States, where it occurred in at least eight states. Museum records exist for the Chickamanga River (GA), Elk River (TN), Scioto River and Maumee



[illegible] River sucker, *Chasmistes muriei*. An adult female, 371 mm SL, collected from the Snake River below [illegible] Dam, Teton County, Wyoming, 13 October 1927. *Drawing by Sara V. Fink.*

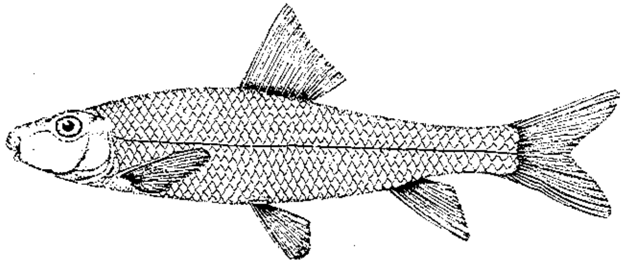


Figure 7. Harelip sucker, *Lagochila lacera*. Specimen collected at Fairview, Williamson County, Tennessee, sometime before May 1880. ***Drawing by H. L. Todd.***

River (OH), Tennessee River drainage (AI, TN, VA), Cumberland River drainage (KY, TN), and Tippecanoe River (IN) (Jordan 1882, 1890; Evermann and Jenkins 1889; Woolman 1892; Kirsch 1896). Although the distribution of the harelip sucker was widespread, its habitat appears to have been restricted to deep pools between shoal areas with clear water over a bedrock or rocky bottom in moderate to large streams. Most collectors reported the species as "abundant," "common," or "not rare."

Some life history data are available from studies of catostomid brain and lips (Miller and Evans 1965) that noted the large optic brain lobes of the harelip sucker and its highly modified lips with few taste buds. These characteristics indicate visual location of foods. Examination of stomach contents of nine harelip suckers revealed that about 90% of the food items were mollusks (R. E. Jenkins, Roanoke College, personal communication).

The decline and ultimate extinction of the species may be attributable to increased turbidity and siltation of its clearwater pool habitats as a result of agricultural practices. Siltation and pollution could have greatly reduced mollusk populations and impaired the ability of the sucker to visually locate foods. The species was last collected in 1893, but it probably did not become extinct until the early 1900s based on reports of the harelip sucker as "common" in the 1880s and 1890s.

Parras Pupfish

Cyprinodon latifasciatus Garman

The Parras pupfish is known only from two collections made in 1880 and 1903, from a spring or spring complex near Parras in southern Coahuila, Mexico. The species was collected at the same time as the stumptooth minnow, now also extinct. Until the early 1930s, Parras Valley contained magnificent spring systems. Subsequent development of extensive wine factories, a flour mill, rubber mill, and textile factory (Imlay 1936) seriously reduced and greatly modified available surface water. By 1953, when an extensive attempt was made to collect or observe this species again, no trace of it was found. The extinction of the Parras pupfish, like that of the stumptooth minnow, was probably caused primarily by the failure of spring flows. Industrial and domestic pollution also likely contributed to the decline.

Tecopa Pupfish

Cyprinodon nevadensis calidae Miller

The Tecopa pupfish was known from outflows of two hot springs near Tecopa, Inyo County, California (Miller 1948). The species was fairly common in water of 36.5°C and abundant in water of 32 to 36°C.

Modification of North and South Tecopa Hot Springs for use as bathhouses resulted in the decline and eventual extinction of the Tecopa pupfish. Pools were enlarged and outflow creeks were ditched and diverted. Channelization of the outflow allowed the Amargosa pupfish (*Cyprinodon n. amargosae*) from the nearby Amargosa River to gain access to habitat of the Tecopa pupfish. This resulted in hybridization and continued loss of the *calidae* genome by introgression. The introduction of mosquitofish also contributed to the de…

Extinction of the … curred in late 197… Six pupfish collec… on 28 March 195… Springs Well" … cies. A more rece… same place by R… 2 February 1970 co… that are clearly re… three that are pro… *n. calidae*, and … gressed with C… the last known col… pupfish. Surveys i… and in 1977 by D… extinction of the s… fish was the first … officially extinc… the Endangered S…

Monkey Spr…

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This undescribed … was restricted to … tributary to the Sant… in Santa Cruz Count… ley 1973). The spec… dance in the spring… ciénega formed by …

Attempts to imp… the ciénega apparen… which resulted in dr… (Minckley 1973). The … abundant in the … mouth bass were … and 1969. Minckley (1… a few pupfish esca… largemouth bass unt… the species was extir… habitat. Introductio… extirpated the local … (*Gila intermedia*), wh… different from other … cies (Minckley 1973)… Monkey Spring pup… thus eliminating an… of Arizona's only … demic fish species.

Raycraft Ranc…

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Figur…

Miller (1948) desc… *latos* from Pahrump… and recognized thr… springs located alon… the valley. The Rayc… occurred only in one…