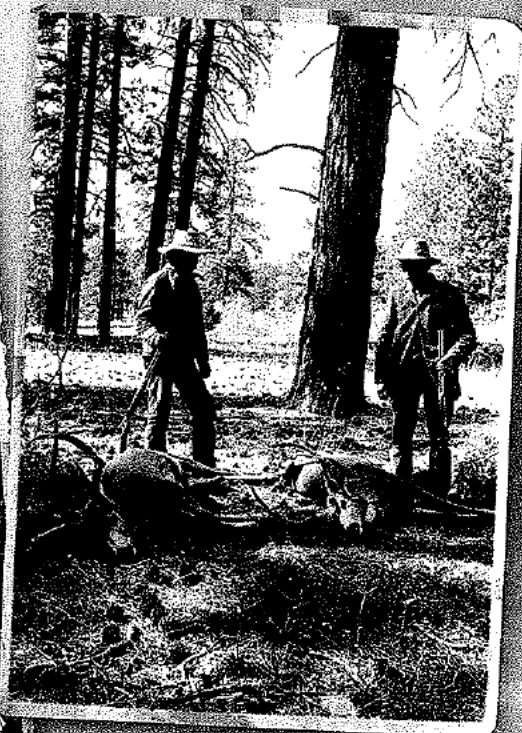


138



# Arizona Wildlife

THE TERRITORIAL YEARS | 1863-1912



David E. Brown, Editor

With Neil Carmony, Harley Shaw and W. L. Minckley

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FREDERIC MORTON CHAMBERLAIN'S  
1904 FISH SURVEY OF ARIZONA

*Edited and introduced by W. L. Minckley*

*A previous version of the following chapter was published in the Summer 1999 Journal of the Southwest [Volume 41, No. 2] and is reprinted here, as intended by the late Dr. Minckley, with permission of the editor, Joseph Wilder. The manuscript has been lightly edited and some passages rearranged for clarity. The serious student of Arizona's native fishes will want to check the original journal article to read all of Minckley's annotations and references.*

Although a number of fish had been collected on the various biological surveys in Arizona, it wasn't until 1904 that a bona fide aquatic biologist, Frederick Morton Chamberlain (1867-1921), conducted a systematic fish survey in Arizona Territory. Chamberlain was an assistant with the U.S. Fish Commission (after 1903 called the U.S. Bureau of Fisheries, evolving over time into the fish portion of the U.S. Fish and Wildlife Service) from 1897 to 1914. His assignments were diverse and geographically widespread (Jennings 1987). He surveyed freshwater fishes in rivers tributary to the Gulf of Mexico, studied salmon fisheries in California and Alaska, collected thousands of oceanographic records and biological specimens as a naturalist aboard the *U.S.S. Albatross* in the north and central Pacific, and assessed fur seal populations in the Pribilof Islands.

In 1904, Dr. Barton Warren Evermann, then director of the Division of Scientific Inquiry, U.S. Bureau of Fisheries, and Chamberlain's former mentor at Indiana State Normal School (now Indiana State University), commissioned Chamberlain to perform a survey of fishes in Arizona Territory. The resulting excursion from January 15 to April 28 included about thirty days in the field, concentrated in the Gila River basin. Most were in well-traveled parts of the territory, likely because of insufficient time to access more remote areas. Chamberlain nonetheless made collections and natural history observations at more than twenty locales, reported in a handwritten, fifty-two page manuscript housed in the Smithsonian Institution Archives. This manuscript was reproduced in toto in the summer 1999 issue of the *Journal of the Southwest* (41(2): 177-237) along with my annotations and comments. The following

passages, reprinted here with permission of the Arizona Historical Society, repeat Chamberlain's report nearly verbatim except for some detailed fish descriptions and a listing of Chamberlain's metal fish tags. Serious students of Southwest fishes will nonetheless want to consult the original journal article as it contains numerous detailed annotations regarding fish history and status.

Chamberlain's observations and reports of firsthand testimony on failing springs, declining water tables, and floodplain incision are pertinent, as are the numbers and species of fish recorded. His attribution of environmental deterioration from the collective abuses of overgrazing and other unwise agricultural practices, the over-cutting of forests and woodlands, the pumping of groundwater, mining spillages, and possible climatic change, was shared even then by the people he interviewed. Perhaps the most significant single contribution of his report, however, is to dramatize the magnitude of change. Many recognize the vastness of environmental alterations in Arizona, yet only a few specialists appreciate the disparate severity of these impacts on its original aquatic systems. More than half of the sites and stream reaches (fourteen of twenty-two) visited by Chamberlain in 1904 are now dry except in flood or are otherwise so drastically modified that native fishes are either significantly reduced in numbers and diversity, or extirpated. Of the sixteen native species caught by Chamberlain, one is extinct, and eight are listed as Threatened or Endangered by the U.S. Department of the Interior.

#### ITINERARY

- Reach Yuma, Ariz., Jan. 15.
- Work on Alaska Report to Feb. 26.
- Fish Colorado River at Yuma, Feb. 27.
- Reach Tucson, Feb. 29.
- Work on Alaska Report to March 26.
- Fish Santa Cruz River at San Xavier, March 27 and 29.
- Leave for Patagonia, Apr. 1.
- Fish Sonoita Creek and Monkey Spring, Apr. 2.
- Visit Monkey Spring, Apr. 3.
- Fish Santa Cruz River at Nogales, Apr. 4.
- Fish San Pedro [River] at Fairbank, Apr. 5.
- Fish San Pedro River at Charleston and Babocomari Creek, Apr. 6.

Reach Safford, Apr. 7.

Fish Ciënega and visit Gila River at Safford, Apr. 8.

Reach Clifton, Apr. 9.

Fish San Francisco River, Apr. 11.

Fish K.P. Creek, Apr. 12.

Fish Blue Creek [River], Apr. 13.

Fish Gila River above Duncan at the "box," Apr. 14.

Fish Gila above Duncan and at Coronado, Apr. 15.

Reach Globe, Apr. 16.

En route to Payson, Apr. 18 and 19.

Fish Tonto Creek at cañon, Apr. 20.

En route to Fossil Creek, Apr. 22.

Fish Pine Creek at Natural Bridge and East Verde River at Angora, Apr. 23.

En route to Cline, Apr. 24.

Fish Salt River at Roosevelt and Tonto Creek near mouth, Apr. 25.

Fish Pinal Creek, Apr. 26.

Reach Tucson, Apr. 27.

Leave for Alaska, Apr. 28.

### COLORADO RIVER [STATION I]

The Colorado was seined at the mouth of the Gila channel. Temperature in backwater was 65° F. This backwater extends from the Colorado up the Gila channel for nearly a mile. It is entirely from the Colorado water as the Gila is dry above at all but flood seasons. Water is 6 inches to 3 feet deep; mud about equally deep, apparently resting on a firmer bottom. The channel is somewhat trough shaped, deepest in the middle in most places.

Three [seine] hauls were made with a 45 ft. net, two hauls about 50 and 100 yds. [in length], respectively, above the Colorado in shallow water, perhaps not over two ft. at deepest, surface width about 100 ft. Results: mostly small carp and catfish, a few small bony-tail, and humpback sucker, the first two species very abundant and the carp in excess, about 100 of the latter in a haul, mostly 5 to 7 in. total length. Third haul made just inside on the island side, water deeper. In this haul the fish averaged much larger, in addition to the carp, cat, and

bonytail, about a dozen large humpbacks. A haul was attempted on the California side of the Colorado, about opposite, but the bag filled with mud and could not be landed. Only a few small carp were taken. A drift made opposite the penitentiary was a water haul [empty]. No "salmon" were taken. Water of river 62° F.

Carp are abundant in the Colorado and especially in backwater sloughs. They are taken sometimes with a hook mainly in fishing for salmon [*Ptychocheilus lucius*]. Not esteemed as food and eaten by few. Carp of about 1½ # taken in one haul was eaten by Dr. Leonard, who had assisted to draw the seine. He pronounced it very palatable.

Bonytail [chub] most abundantly taken of any fishes, mostly as in case of the carp, in fishing for salmon. It is eaten, but not valued on account of the many bones, though the flesh is fairly good. Average seen were 8 in. to 1 ft. total length.

Catfish [black bullhead], introduced, were not well known till comparatively recently. No record is obtainable of large sizes, most are below bonytail in average size. They are eaten and valued when sufficiently large.

Captain Mellon of the steamer line running on the Colorado was instrumental in making the early plants of catfishes under the auspices of the California Fish Commission. He states that for a number of years after plants were made no catfish were taken. Meanwhile they were observed in numbers in the Yaqui River of Mexico where they had previously been unknown. Sometime after this they became plentiful in the Colorado. His theory is that the stocked fish migrated to the Yaqui and later returned. It is probable that the Yaqui catfish are a different species. The fact that the Indians refuse to eat them, cited by Captain Mellon, may be due to a superstition. The theory is interesting as an example of local ideas.

Humpbacks [razorback suckers], rather abundant and often taken on the hook. They are preferred by the Indians to the preceding species.

Salmon, the only fish really sought. It is taken by hooks at all seasons and by the Indians with a sort of dip net on the falling water after rises. It is said to work in close along shore when the river rises, and to feed on the drift material. Ordinarily they lie in deep holes, especially just below riffles. I saw only one during

six weeks' stay in Yuma, though four or five were reported as taken. The one seen weighed 9 # and has the vent swollen as if about ready to spawn (Feb. 13). They will take almost any bait, are very slow to bite, but rather gamey when hooked. Capt. Mellon reports seeing a fish from the lower Colorado, which placed on a pole through the gill openings and the pole on the shoulders of two tall Indians, did not quite clear the ground. Such a fish would easily weigh 100 lb.

#### SANTA CRUZ RIVER [STATIONS II, III, AND IV]

The Santa Cruz rises in eastern Santa Cruz County, describes a short curve into old Mexico, and flows north by Nogales to Tucson, thence northwest only toward the Gila, reaching it in times of heavy rain.

At Tucson, or more strictly two mi. south of Tucson [Station II], the Santa Cruz was running about 100 in. [=2.5 cfs] of water during March and April. The channel was about 100 ft. wide and 10 ft. deep, stream 3 to 30 ft. wide, mostly about 10 or 15, and two to six inches deep, with no pools over 20 inches or two ft. deep. Bottom is mostly sand, sometimes gravel or adobe. Temperature of the water varies closely with that of the air, figures from 68° to 72° were obtained. Alkali is shown by incrustations in the banks.

No irrigating dams are now operative above Silver Lake; the channel is too deep. It was ditched within recent years, but the channel has deepened and the flow lessened till the ditches are no longer practicable. Irrigating is done by pumps in wells on the river bank. The water in these wells stands at about the river level, when the pumps are not working. It falls about 20 ft. when the pumps are operating moderately; at this point the inflow equals the output. The temperature is constant at 71° to 72°. The lower figure is shown by the well higher up the valley, no variation was noted during March. The water is in a gravel stratum under some 6 or 8 ft. of adobe and gravel, with sand above. A well some distance back from the river showed several degrees lower temperature.

The water supply is an interesting problem. The wells remain at a constant temperature and almost constant volume while the river varies in both—but especially in temperature. It was stated, with what accuracy I cannot judge, that small frogs are sometimes pumped from these wells in numbers.

It would seem that a large body of water must lie in the basin since beyond a certain level, perhaps governed by pressure required to force the water through the containing stratum, the pumps do not lower it, and their use, throwing a volume of water at least twice the amount running in the river, does not visibly affect that current. It would be of interest to find if the level of the wells when not being used is the same at the interval of about two miles which separates the extremes. The fact that the well at the foot of the mesa, only about 40 rods [=660 feet] farther from the river, shows a lower temperature, complicates the question materially. The conditions found there may be closely connected with the rising and sinking of the rivers throughout the region, or it may be an artesian well proposition. The subsurface water level at Tucson is said to have fallen some 6 ft. during the last two or three years, and complaint is made of the same condition in the San Pedro Valley.

Until a few years ago this part of the river contained pools; these were filled by a freshet and not again formed, nor can they again form owing to the large amount of sand now carried in floods and the absence of bed rock to produce currents. Silver Lake, mentioned above, was an artificial pool made in the channel about two mi. south of Tucson. At one time it was abundantly stocked with carp and native fishes. The dam was cut three years ago, and at that time it was reported carp were found abundantly as far down the valley as Sacaton.

As above San Xavier, water cress is abundant in suitable places along the margins of the stream. Another aquatic, not blooming and not identified, is also more or less abundant. Algae are everywhere in quantity: *Oedogonium*, *Vaucheria*, *Spirogyra*, and *Nitella* (Thornber). *Chara* is found in stagnant pools separated from the current. The willow (*Salix nigra*) is common on the banks, it reaches a diameter of over 2 ft.

*Agosia* [longfin dace] is very abundant both in the shallow pools and in the riffles, schools of six to thirty adults in every quiet reach, with smaller schools in the shallows. Fry of ½ in. up are abundant along the margins even in the more barren places, they are apparently feeding on the algae and are more abundant in the little pools. Adult females with eggs and males tuberculated indicate the spawning season, but no spawning was observed. . .

*Poecilia* [top-minnow] is equally or more abundant than *Agosia*. The females and smaller individuals are found more in standing pools at the side of, but connected with, the current, among plant growths, the males more in the main stream, but also found with sexes associated and perhaps copulating in the warmer marginal waters. The male in nuptial colors is almost wholly black, sometimes throat and breast pale, sides often with an emerald green iridescence. Caudal and base of anal and dorsal [fins] orange on membranes, paler distally. Females pale translucent green in life, marking unchanged in alcohol. They are not readily distinguished in the water from the minnows, but males are readily marked by color when black. These two are the only fishes found above Silver Lake and below San Xavier.

Few insect or crustacean forms were noted. There are few green frogs. One mass of frog spawn about  $\frac{1}{2}$  developed was noted March 28. One crane and one heron were the only water birds seen. A pair of small ducks [cinnamon teal?] were seen at San Xavier. Ducks are known to breed in small numbers throughout the region.

At San Xavier, 9 mi. from Tucson [Station III], the river was examined March 27 and 29. The main channel is here some 30 to 40 ft. wide with steep banks of 10 to 15 ft. height. The stream about  $\frac{1}{2}$  the width of the channel narrows in places to very few feet. The bottom is sand or adobe. In the course are a number of small pools two to four feet in depth. The water is said to rise about  $2\frac{1}{2}$  mi. above the mission. I examined it only about two-thirds of that distance. About a mile above the mission a dam diverts the entire current to an irrigation ditch and no water rises again in the channel until about three mi. below the mission. It flows over a rocky bed said to be impracticable to seine. It is entirely used for irrigating.

The river running for the most part over a shallow bottom varies in temperature as the atmosphere. It was 78° March 29. The water is alkaline to the extent of showing incrustations on the banks. In many cases the banks are springy. Water cress (*Roripa nasturtium*), identified by Prof. Thornber of the A. S. University [now University of Arizona] grows abundantly along the margins and in the current in suitable places. It was just beginning to flower the last of March. The growth of algae was less abundant than

nearer Tucson. About the same amount of water as at Nogales. The pool back of the dam varies up to 5 or 6 ft. deep, is about 300 yd. long, and 15 to 20 ft. wide. Logs and snags prevent seining in the lower pond, the upper 100 ft. was seined.

The most abundant species here is the dace, *Leuciscus intermedius* [now Gila chub, *Gila intermedia*], known locally as "red-finned chub" in allusion to the orange breeding colors. All I obtained were small, but occasional individuals of 12 to 14 in. have been seen in former years. The smaller individuals resemble *Agosia* in color very closely, but are readily distinguished by the decurved lateral line and by the black stippling of the lower sides.

*Agosia* much less abundant than near Tucson, the bronziness less marked, the bellies silvery rather than bronze, otherwise similar to the Tucson specimens; commonly confused with the dace [Gila chub].

*Poecilia* not so abundant as near Tucson. No males taken on account of large mesh of net, but some were seen. Females well developed; cheek apple green—no other effervescent markings.

Two species of suckers a *Pantosteus* [desert sucker] and a *Catostomus* [Sonora sucker] were taken in the pools in the upper part of the river. More in the pool back of dam. Six or 8 of each were taken in a haul, mostly small, the largest were saved for specimens.

The carp has been introduced by Mr J. M. Berger, Supt. Of the Mission, from Silver Lake near Tucson. I saw two about 14 in. long taken with a hook from the irrigating pool. They are said to be abundant in this pool, a statement which seems to me doubtful.

The hardshell turtle [Sonoran mud turtle] was abundant but was not taken with the seine. Several frogs were secured, their large tadpoles abundant.

The *Agosia* was found mainly in the shallower water, on or near the riffles. Killifish [Sonora topminnow] also was associated with these localities, but a good haul of them was made in the lower part of the irrigating pool. Dace [Gila chub] were found throughout the pool and above, suckers in deeper pools above. The *Agosia* was probably about ready to spawn, though none of them were noted with ripe ova.



This little pool or irrigating pond, poor as it is, is more or less frequented by citizens of Tucson and the neighboring region for sport. The catch of a half dozen dace [Gila chub] of 6 or 8 in. length repays for the drive, and the fortunate capture of a carp of a pound weight is master angler for the day. Mr. Berger is desirous of planting the catfish to satisfy this demand.

Silver Lake two miles south of Tucson at one time furnished much recreation for Tucson people, boats and fishing tackle were for rent and the carp taken were well appreciated. Were it not for the muddy floods it might be reestablished.

Another attempt at introducing game fishes was made in Rillito Creek by Mr. D. J. Holsinger, who in the fall of 1901 or 1902 had 400 rainbow trout planted in Sabino Cañon. So far as I could learn no results have come from this plant, possibly from poor judgement in choice of locality, or from the natural unfitness of the stream. I did not examine it as I was told the only water was a considerable distance back in the mountains.

The uppermost point examined is near Nogales [Station IV], about 6 mi. in a general easterly direction from the town, at the crossing of the Camp Washington road. At this point the channel is about 100 ft. average width and 6 to 8 ft. below the level of the banks. The water, April 4, about 100 to 150 miner's inches [2.5 to 3.75 cfs] in volume, occupied a width of four to 20 ft., and a depth of a few inches to two ft., the average 5 to 10 ft. wide and ankle deep. Temperature in afternoon is 62°. The bed is sandy or with fine gravel up to the size of a hen's egg—coarser than at Tucson. Little vegetation is present except algous, which is abundant in places, forming a blackish slime on the bottom; all other plants were doubtless trampled and eaten by cattle.

Most of the water is taken for irrigation. That in the ditch along side the river at this point was 68° in temperature. No dams were seen in the short extent examined, but the dams used are doubtless similar to those described [lower down].

There was a rather abundant growth of cottonwood along the banks. The surrounding country is hilly with a good deal of oak timber.

The seine was not operated, the fishes taken were caught with a dip-net. *Agosia* [long-fin dace] is abundant. Perhaps in consequence of the dark bottoms, they are darker than the

Tucson specimens, the bronze lateral band or stripe being quite indistinct. *Poecilia* [Sonora topminnow] is quite scarce, not over a half a dozen were seen, those scattered. One *Pantosteus* ? [desert sucker] was seen. Frogs plentiful.

The river appears to furnish water for irrigation at Calabasas near which point it is joined by Sonoita Creek. Immediately below this it is said to sink again. It rises a short distance above San Xavier.

#### SONOITA CREEK [STATION V]

Examined April 2 at Patagonia where the water first rises about ½ mile below the railroad station. From this point it continues at the surface most of the way to Calabasas. Where examined it was flowing 50 to 70 inches of water [1.25 to 1.75 cfs], was 16 in. to 10 ft. in width, mostly in the low sandy reaches similar to the Santa Cruz at Tucson. The channel is 60 to 100 ft. wide and 5 to 10 ft. deep. It is dammed at short intervals for irrigating. Small dams of sand and brush two to three ft. high were used.

Abundant growths of [water] cress and a yellow flowered plant (*Mimulus*) occur in the current and at the margins. The willow is common on the banks. Temperature of water 65° at 7:00 A.M. and showing the alkali inflorescence.

*Agosia* and *Poecilia* are very abundant, not so far advanced sexually as at Tucson, probably due to the greater elevation and consequent retardation of the season. Two small suckers, *Pantosteus* and *Catostomus*, were taken in a small pool, the only ones seen.

Frogs are not rare, some small black tadpoles seen, others had grown. Killdeer and woodcock [probably common snipe] were the only paludial birds noted.

#### MONKEY SPRING [STATION VI]

This spring is located on Richardson's Ranch, about 7 miles above Patagonia. It has an elevation of some 4,500 ft. It flows about 50 in. [1.25 cfs] of water at 80°, strongly impregnated with lime. The original waste ways show limy incrustations resembling lava streams. The water now enters a pond about 150 yds. long, 30 to 50 yds. wide and about 6 ft. deep at deepest point. This is an artificial pond supported by a dike upon which willows a foot in diameter are growing. There may have been

a small pool naturally formed before the dam was built, which furnished a habitation for the small native fish. The present pond is almost filled with a dense growth *Chara* and another plant not identified. It is bordered by a tall growth of sedges.

A second reservoir about 40 yds. square lies on the hillside a quarter of a mile farther down and perhaps at 75 ft. lower level, and the same height above the valley. The original spring flow was quite steep into the cañon below, which has a width of 30 to 100 ft., with rocky walls at intervals. The water is now conducted by a ditch around the hill.

The upper pond is abundantly inhabited by *Poecilia*, *Cyprinodon* [pupfish], and *Leuciscus* [*Gila intermedia*, Gila chub]. They were all native and have found lodgment here by natural means. In addition, a catfish has been introduced. A hardshell turtle was seen. The longest *Leuciscus* seen was about 8 inches, only small ones were taken in the seine. In second reservoir only the *Poecilia* and a few *Cyprinodons* were seined. A few frogs.

The catfish were planted July 8, 1899. Fourteen fish, 8 to 12 inches in length were put in. They were obtained from a creek near Casitas Mexico. Secured by sinking a hole in the bank about 8 ft. from the edge, through which a Mexican boy caught them by hand. It seems that this stream at Casitas becomes dry during the dry seasons and at these times the fish find refuge in pools back under the banks. The Mexican small boy had these reservoirs located.

In October and November following this plant large schools of fry about two in. in length were noted in the pond. In 1903 good catches of fish of two and three lb. were made. In 1904 two of total weight 9 lb. were taken. I was unable to secure specimens.

There are two or three small tributaries of the Sonoita not far from Patagonia. One three or four mi. to the southwestward is said to contain numerous small fish, perhaps *Agosia* and *Poecilia*. One about 9 mi. to the northward formerly had good fishing (*Leuciscus* [= Gila chub]), now none in it. A spring above Richardson's ranch [likely Cottonwood Spring] was also reported with small fish. None of these were visited.

The report, common everywhere, that some years ago good fishing for chubs and suckers existed, is universal here. The

recent dry years, increases of irrigation, and trampling out of herbage have combined to fill up and dry up streams, while the better fish are thought to have been washed out by flood. Some gentlemen in Patagonia are anxious to stock Sonoita Creek, but I cannot see how, under the conditions that obtain, a food fish of value could exist there.

#### SAN PEDRO RIVER [STATIONS VII, VIII, AND IX]

The San Pedro was visited only in the neighborhood of Fairbank [Station VII] and Charleston. Charleston is 6 mi. above Fairbank and about one mi. above the projected dam site for an irrigating reservoir [Station VIII]. Observations are now being made regarding volume and velocity, which data will be obtainable from the hydrographer in Phoenix. The river was examined at this point on April 6.

Just below Charleston it [San Pedro River] passes through a short cañon. The channel is 50 to 100 ft. wide with sand or gravel bottom and a few larger boulders in places. A few small pools are formed, greatest depth about three ft. The water is strongly impregnated with alkali, showing much more deposit than the Santa Cruz, temperature varies from 55° to 70° morning and evening. There is no vegetation along the river, but water cress is abundant in a spring near the dam below.

At Fairbank [Station VII] the channel is about 100 ft. wide and 15 ft. deep, the stream from 5 to 20 ft. wide and one in. to two ft. deep. A dam of 8 to 10 ft. height is placed across the river below the S. P. [Southern Pacific] railroad bridge forming a pool about 400 yd. and up to 8 ft. deep. I could not seine the pool. This dam has considerable overflow. A dam 1½ mi. above diverts the entire stream.

Good hauls were made below the lower dam, *Agosia* is the most abundant genus. *Pantosteus* [desert sucker] and *Leuciscus* [Gila chub] with two species of *Catostomus* [only the Sonora sucker is represented in the preserved collection]. *Meda* [spikedace], and *Tiaroga* [loach minnow] complete the list. A haul in the upper end of the backwater pool seined no *Meda* nor *Tiaroga* and but few *Agosia* or *Leuciscus*. The catch was almost entirely small suckers, which were rather numerous.

*Leuciscus* of 8 or 10 in. length are taken with a hook on either side of the dam. They are more or less esteemed for food. The

smaller minnows are mostly in swift water, perhaps because spawning.

All the *Tiaroga* were saved. It is most abundant on riffles. None was taken at Charleston, though places looked favorable. The ground color is greenish with mottling darker approaching black. Maxillary, corner of mouth, under and back part of opercle, axil of pectoral and marginal stripe on anal and caudal [fins] scarlet in breeding male. The red and green forming a very harmonious and handsome color scheme.

*Agosia* is more silvery than in Santa Cruz, none of the bronzy cast on lower parts, and bronze stripe more indistinct (but plain in the Babocomari specimens).

*Leuciscus* [Gila chub] about as in Santa Cruz. Known by the Mexicans as 'Lisa' (spelling ?, pronounced lees'a and meaning smooth). Smaller ones quite numerous, the largest ones saved for specimens.

Suckers are less abundant than *Leuciscus*—belly yellowish, more nearly white below, lower fins very slightly tinted. Smaller individuals, four or 5 in., with three dark blotches on median line of sides, one in front of caudal [fin], one between dorsal and anal [fins], one over pectoral [fin]. Not seen in very small ones nor in any over 6 in. Most of *Meda* saved.

In the pool above upper dam, about three ft. deep and 80 ft. wide, only *Leuciscus* and suckers were obtained. Also two turtles (sent in) and some frogs. One or two fish (*Agosia?*) were seen in the spring near by, but I could not secure any.

It is reported that carp are kept in ponds in this neighborhood and are at times taken in the river. *Xyrauchen* [razorback sucker] is said to have formerly been abundant and was marketed in Tombstone as "buffalo" called from the hump. All large fish are thought to have been killed by the cyanide in ore processing at Charleston when the mine was abandoned. While this might be true for a time, it does not account for the absence of fish several years after the works ceased to operate.

#### BABOCOMARI CREEK

This creek examined April 6 [Station IX] empties into the San Pedro opposite Fairbank. About three mi. above its mouth it passes through a short cañon 30 to 40 ft. wide. The stream is two to 8 ft. wide and up to two ft. deep. The numerous small

pools among these rocks were full of *Agosia* apparently trying to ascend. No other species were seen in the creek.

Below the cañon the channel expands and the stream becomes wider and shallow, seldom exceeding 6 or 8 in. in depth, over sandy bottom. About a mile down is an irrigation dam diverting all the water. The pond formed is 5 or 6 ft. deep and about 60 by 150 ft. in extent. I could not seine it. It is said to contain suckers but I could not see any. Water 70° at 4 P.M. clearer than San Pedro water and less alkali.

This entire region is subject to the causes of decline mentioned above. Aside from the backwater above the dams there are no pools of size for edible fish, the water passing over riffles and flats becomes very warm, cattle eat and tramp out the plants, while dams prevent migratory movements.

It is rumored that catfish are found in water holes below Benson. They are not known above. At Huachuca, above Fairbank, are some springs and marshes said to contain fair sized chubs (*Leuciscus*) in some numbers. I did not examine them.

#### GILA RIVER [STATIONS X, XI, XII, XIV, XV, XVI] AT SAFFORD

The cañon about 15 mi. above Duncan [Station XV] is the uppermost point at which the Gila River was examined. This cañon or "box," visited April 14, is said to be about 7 mi. long, with a farming (irrigated) district some 15 mi. in extent above it, which in turn is followed by another cañon.

The part of the cañon examined is 60 to 100 yd. wide with rocky walls in places perhaps 100 ft. high. The channel averages about 50 ft. in width, the stream 10 to 50 ft., and up to two feet in depth. The water somewhat alkaline and had a temperature of 78° F. at 2 P.M. The "Sunset" Dam at the lower end of the box takes practically all the water. No plants were noted except algae, which are plentiful in the stream and ditches. A few schools of *Agosia* were the only fish seen. Hauls in a good pool near the lower end of the cañon were water hauls, as was also a haul in main ditch. It is said that good fish formerly ran out with the ditches where they were caught by children. No seines were ever used. This may have helped to hasten the depletion of the stream.

A number of dams span the channel between the cañon and Duncan. These dams are built of brush and sand and go

out with the first rise. They are put in as early in the spring as practicable and stand during the rainless summer. The river is practically dry below each one, accumulating head enough by seepage to fill the next in succession. When the sand is deep over bed-rock the river "sinks" and is dry, the amount of water varies directly as the approach of bedrock to the surface. Near Sheldon [a former site in Greenlee County] the bed is of rock and there are likely looking pools. I did not examine them. Between there and Duncan the river is dry.

In pools above Duncan and below the box only *Agosia* was found. Suckers are said to have been plentiful up to two years ago, and salmon some years earlier. Catfish are also reported, they are said to have come from a broken pond on the ranch of Lyons and Campbell in New Mexico. Hardshell turtles [Sonoran mud turtle] were seen but could not be secured. A softshell was taken. These latter are said to be not rare. They may have been flooded over at the same time with the catfish.

In the shallow pools in the stretch above Duncan the current is so slight that the algae near the bottom decompose giving the water a foul odor. The growth is very copious.

At Coronado [a former site in Greenlee County], 20 miles below Duncan, examined April 15, the stream is larger, with a few fair looking pools [Station XVI]. I could not seine these but tried a small charge of powder in two of them with no result. There are doubtless no fish there with the exception of *Agosia*, the fry of which could be seen in places. A sort of *Myriophyllum* was growing there in small quantity. Children report having seen a few suckers in pools not far above toward Sheldon.

The river flows over a rocky or gravelly bed with pools of fair depth for a few miles below Coronado, where it is joined by the San Francisco [River]. I did not see it below this, but not far below, the Montezuma Dam [now called the San Jose diversion dam in Graham County] diverts nearly all if not quite all the water. When this ditch water reaches Solomonville it is thick with the concentration sediments. It is probable that fish would not live between the mouth of the San Francisco and a point below where the water had become purified, perhaps below Solomonville [now Solomon].

From the point of junction to above Sheldon native fishes

might survive under favorable conditions. A plant of black bass is said to have been made in this stretch in recent years (delivered to Wiley Jones at Solomonville perhaps). They probably did not survive the first flood.

At Safford, April 8, the river was examined [Station X]. The ? Dam lies two or three mi. below Safford. It was not examined, but is said to divert all the water. The "Central" dam about one mi. above Safford is of construction similar to those near Duncan described, except that boulders have been used in its construction leading to more or less permanency with the result that the channel above has been filled with sand and the bed thus raised to a level with the boulder substratum, about two ft. The entire dam is about four ft. high, diverting almost the entire stream into the ditch, about 80 in. of water [2.0 cfs]. The water here is clear, the Montezuma ditch removing all the concentration sediment [from upstream mines].

Below the dam the water again accumulates and a short distance below, perhaps  $\frac{1}{2}$  mi., the stream averages 20 ft. wide and three ft. deep, with a very slow current over a fine sandy bottom. A heavy growth of green algous slime lies on the bottom. The channel is 100 to 150 ft. wide and about 10 ft. below the general level, with heavy washes of sand banks in places. Water temperature at 3 P.M. 82° F. No sign of fish life visible. As there are no pools I did not seine.

Several years ago fish were abundant. Then pools of sufficient depth for men to swim in existed. Salmon reached a weight of 35 lb., humpbacks and other suckers were common. None of these fish has been taken in the last two years. It is believed that minerals and concentrate wash from the mines and works at Morenci and Clifton have killed the fish. In evidence of this is cited that fields irrigated with this wash will not grow certain plants as pumpkins and beans. I think it probably that these have had little or no causative influence in the matter as other causes are sufficient to account for the change.

The Gila as seen at San Carlos in crossing [April 16] shows the same characters as at Safford.

#### CIENÉGA SPRING

About 9 mi. south and west from Safford is a spring [Station XI] flowing about sufficient water to fill a two in. pipe under a

few in. head. Temperature 67°. This spring is said to be little subject to seasonal variation, and had been used as a watering place for many years. It is now boxed in, about 2½ ft. cube. Just below, the water flowing over a mucky blue clay forms a kind of marsh which gives name to the place. In this spring are a small number of Gila chubs.

They have been known there for years, but no one knows their origin. They are said to remain about the same in size and number, though I found young also. They differ from the species in other locations in their very dark color. About 7 or 8 adults were seen. . . . Young all of about the same size, probably only two sets or series; i.e., adult in two years. The young were found also in pools close to but outside of the spring box.

Flowing into this swamp is a small brook. In this was a large number of *Agosia*, very silvery with distinct dark stripe and caudal blotch, similar in appearance to those of Babocomari Creek. The water was very warm and of volume several times that of the spring. Duckweed is abundant near the spring, some pondweeds grow in the pools below.

Between Ciénega and Safford, lying a little farther north and west is a region of artesian wells. Some of these have given good flows for a time then gradually ceased. This stoppage is caused it is thought by the filling of the bore rather than failure of the water. These wells are said to vary slightly in temperature, the only one tested was 72°. They all carry more or less alkali. In several instances the owners have built ponds and are growing fish. A pond owned by Mr. J. H. Sparks was visited. It is about 2,000 sq. ft. in surface and four ft. in greatest depth. It is almost filled with a growth of *Chara*. The surface temperature was 67° April 8, the supply 72°. In boring he first struck water at 43 ft. At 180 ft. the flow about half fills a two in. pipe.

In August 1902 he put 29 catfish (*A. nebulosus?*), which had been taken from the Gila River, into the pond. These spawned in September, and again in May following. The young were very numerous, but later largely disappeared. The evening before my arrival he took three catfish of 9 lb. total weight from the pond.

In Nov. 1903, 300 black bass and about 150 crappies were put in. I saw some of the black bass about 12 in. in length. The crappies remain mostly out of sight. These fish are fed shelled

corn, wheat, and chubs, which Mr. Sparks finds are eaten by both catfish and bass. Occasionally a jackrabbit is cut up and fed to them, while entrails of poultry and such scraps are eagerly eaten. The fish are thrifty and the owner is well pleased with the results.

It is reported of another pond that has been stocked with bass obtained from the U.S. [Fish] Commission, that when subsequently drained a few years later owing to failure of the supply well, half a barrel of edible fish were taken out.

A pond visited at Duncan, which had been stocked with bass from the U.S. Commission, showed a very different result. It is surrounded by willows and approximately four or 5 ft. deep with supply from the irrigation ditch and a well. The water was roily and no vegetation could be seen in it. The owner had stocked also with catfish, but though both plants of fish were made several years ago no visible results have been obtained, and trials with the hook have never taken any fish. No feed has ever been given to them and apparently no thought.

#### SAN FRANCISCO RIVER [STATION XII]

The San Francisco was visited April 11 to 13. This stream at Clifton [Station XII] is as large or larger than the Gila at point of junction. It averages 12 to 40 ft. wide and from a few in. to a few ft. in depth. There are many good pools under the banks and among rocks. Some stretches are sandy bottom, but with many boulders. The river occupies a broken cañon of about 500 ft. average width, the channel varies from 50 to 100 ft., approximately. Temperature of water at 10 A.M. 62°.

The irrigating dams in this river only partially close the stream. The only effective dam seen is that of the Arizona Copper Company, a short distance above Clifton. It is of masonry and diverts the entire surface current, but below it the river soon gathers a new head. A mile or so above the dam is one belonging to the ? del Oro Company. It is also of masonry, but takes only part of the water. At Clifton, the wash from the concentrating machinery is rapidly filling the channel. Chase Creek, entering through the town, also carries a quantity of this debris from the works above. It is this material that is thought to kill the fish below and in the Gila.

The San Francisco is subject to heavy floods, as is all the region. During these high waters it is said the water becomes fairly thick with silt; ditches are sometimes filled with it in a night. During such times fish are seen in numbers swimming or floating at the surface, apparently gasping for breath, numbers may be picked up along the banks. Formerly the river is said to have carried numerous and valuable fish, primarily of the sucker family, now there is none. I saw no evidence of fish life and three hauls just below the mouth of Blue Creek [River] were water hauls. People living near by say there is none. A plant of black bass was made a few years ago a short distance above Clifton; they doubtless perished.

#### BLUE RIVER [STATION XIII]

Blue Creek enters the San Francisco about 18 mi. above Clifton. It is a small stream sinking in places during the summer. The channel is 20 to 50 ft. wide with a stream 5 to 20 ft. wide and 4 to 5 in. deep. It flows through a narrow valley, at no place over half a mile wide and narrowing in places to a cañon of 50 to 500 ft. width, often with high box walls mostly of stratified conglomerates. The stream bottom is mostly sand, but with some gravel and frequent boulders. There are no pools deep enough to seine as far up as the mouth of K.P. Creek [Station XIII]. There are said to be pools containing trout in a cañon a few miles above K.P. Creek. The stream is almost destitute of vegetable life except some algal growth in the upper part in the more quiet stretches. All else is trampled or eaten out by cattle and goats.

In the valleys of both San Francisco and Blue rivers is a sparse growth of cottonwoods and sycamores, with occasional individuals of some species of maple. A sort of small willow is abundant on some of the sandy beaches. Cedars grow on the rocky hillsides.

The only fish seen in Blue Creek was a small school of *Agosia* of which samples were obtained. They show no apparent differences from the *Agosia* in the Gila generally. Temperature of Blue Creek water 2 P.M. 72°.

#### K.P. CREEK [STATION XIV]

K.P. Creek is a small branch entering Blue Creek about 32 mi. above the latter's mouth. It is four to 6 ft. average width, and three in. to three ft. deep. It is said to be about 16 mi. in length, rising in the mountains. About 1½ mi. above its mouth is a short cañon of a half mile [Station XIV], and a mile above this another of two mi. in length. The intervening valleys are narrow and wooded with pine and deciduous trees. The stream bottom is gravelly, running over bedrock and boulders forming small pools. It is clear and apparently less subject to flood action, on account probably of the small drainage basin, than other streams examined. Temperature at 4 P.M. 60°. Few plants grown near the stream and no aquatics were noted; very little algal growth.

From the beginning of the first cañon up, this creek is inhabited by trout. No other fish is known in it. The only specimens obtained are small as are most of the fish taken in this creek, 12 in. being about a maximum. My largest specimen is about 9 in. They are golden on sides of head, body, and belly; pectorals golden, ventrals less so, ventrals and anal fin with white margin. About 10 roundish dark blotches on side, somewhat larger than eye; one or two supplementary rows of similar, but smaller blotches, all being below and independent of the regular black spots covering the upper parts, head, caudal, and dorsal fins. Rosy streak along side, along and under the lateral line about the breadth of the eye. The general golden color is said to increase with size, hence the larger ones are sometimes referred to as a different "kind." The "yellow trout."

These trout are said to be very abundant in the Black River and White, the Bonito Fork of the Salt River, and again in the upper tributaries of the Verde as Clear and Oak creeks. I did not reach any of these streams, they can only be attained on horseback over long and rough trails requiring several days.

Bonita and Eagle Creeks, entering the Gila below the mouth of the San Francisco River, were not examined on account of accessibility. They do not differ in character from the other creeks of the region. During the dry season they are said to sink in places and are affected by floods in the same damaging ways previously described.

San Carlos Creek [River] was noted in crossing. It contained



Two anglers on their way from Eagle Creek with stringers of "yellow trout" and chub, ca. 1907. Chamberlain did not examine Eagle Creek "on account of accessibility," but he wrote that the creek did not differ in character from other creeks in the region, where "these trout are said to be very abundant." PHOTO #47487 COURTESY OF ARIZONA HISTORICAL SOCIETY, TUCSON.

little water near its entrance into the Gila. The general character seemed to differ none from other streams in the region.

#### FOSSIL CREEK [STATION XVII]

This stream takes its name from the strong impregnation with lime salt that causes its waters to fossilize objects lying in it. It is tributary to the Verdi [Verde River] through Hardscrabble Creek. Its main origin is in a number of fine springs a short distance under the Mogollon "Rim." One of these springs tested had a temperature of 70°, which was that of the creek on April 22. The elevation of these springs is said to be about 4,200 ft. The stream is crystal clear, from three to 50 ft. in width, and from a few in. to 20 or 30 ft. depth. For the first half mile it is an ordinary rocky mountain brook. Below this lime salts deposit and build dams forming a series of pools and falls from a few in. to several ft. in height; the highest is said to be about 10 ft. This region is said to be about two mi. long, after which it again becomes an ordinary stream. The upper course only was examined [Station XVII]. The largest pools seen were 50 to 60 yd. long, 20 to 30 ft. wide, and approximately 20 ft. or more deep. At the dams are usually side currents that form natural fish ways so that it is improbable that the ascent of fish is hindered unless in cases of the 10 ft. fall which I did not see. The quieter pools are filled in places with a sort of pond weed. The rocks with dams and riffles are covered with liverwort, while *Chara* thrives in the stagnant side pools and apparently in deep bottoms. A moss is also quite abundant in floating masses, as well as a spongy sort of algae. *Mimulus* and Columbine adorn the banks. The flow of water is said to vary little during the summer, but the seasonal rains carry vast quantities of mud from the higher land the same as in other streams. Many old [tufa] dams at the sides mark variations in the channel.

Small [desert] suckers, *Leuciscus* [chubs], and *Tiaroga* [actually speckled dace, *Rhinichthys osculus*] are the only fish found. The nature of the bed made seining impossible and the collections were made with powder.

This is the only stream seen not in use for irrigation. There is the usual report of large fish formerly present, but I saw none. Some of the settlers believe that the good fish were swept out by the mud and floods some years ago and that the steam has

not recovered its value. It seems more probable that the close pasturing of the ranges above has subjected this stream as others to an unusual wash of mud and by that has made it more or less unfit for fish life.

#### **PINE CREEK [STATION XVIII]**

Pine Creek is tributary to the East Verde. It was examined at Natural Bridge, April 23 [Station XVIII]. At this season this is near the head, several fine springs here giving it a second origin. There is a small stream at the village of Pine some miles above, but that water is all used in irrigation and a dry space intervenes between its final consumption and the springs at Natural Bridge. At this latter place there is perhaps 15 in. of running water [0.38 cfs]. It occupies a very narrow and rough ravine and lies mostly in deep pools about large boulders. At other places are shallow stretches with mud bottoms. The stream is said to increase in size farther down, and perhaps has a supply of fish from the Verde.

The only fish known here is a [desert] sucker, *Pantosteus*, a few samples were secured with powder. The temperature of the water was 53° at noon. There is no vegetation about the creek except a little algae.

#### **EAST VERDE RIVER [STATION XIX]**

This stream was crossed at Angora [a former settlement] on the Payson Road [Station XIX]. At this point it runs through a sort of cañon or rough valley with very little bottom land. Though even here water is taken out for irrigating the little fields obtainable. The river channel is from 20 to 50 ft. wide and the stream 6 to 20, with occasional pools of three or four ft. depth. The bottom is sand or gravel in the riffles and mud in the pools. Very large boulders are abundant. At the road crossing the river is joined by Sycamore Creek, a small rocky creek with 10 or 15 in. [0.25 to 0.38 cfs] of water. It was not examined. The temperature of the East Verde was 60° at 6 P.M. April 23.

Three hauls were made. *Leuciscus* [a chub] and *Catostomus* [Sonora sucker] of small size were plentiful, some good specimens of *Tiaroga* [Chamberlain here misidentified speckled dace as loach minnow due to the bright breeding colors, WLM] were secured—all of this genus were saved. There was no

vegetation in the stream and little on the banks except for a scrub growth of cottonwood and willow.

#### **TONTO CREEK [STATION XX]**

This creek flowing into Salt River near Roosevelt drains a large region of mesas and valleys. The low valley land, as usual in the region, is narrow, seldom exceeding a mile in width. The water rises a short distance above the mouth of the creek [Station XXa]. At this point it is 10 to 20 ft. wide and 6 to 18 in. deep. The channel is some 50 ft. wide and about 8 ft. below the general level. No plants in evidence about the stream except algae, these fill the pools. *Agosia* is very abundant with *Poecilia* and a few suckers, but they may run up from the Salt River.

From this point to the cañon or box 24 mi. above the only water at this season is obtained by sinking holes in the bed. Minnows are said to be sometimes found in the holes thus made. In the upper part the channel of the creek will average perhaps 80 ft. in width and is a few feet, 6 or 8, below the level. The water apparently covers much of the valley in flood times. Some cottonwood and smaller growth is found along the banks. At one time, ranches were irrigated from the creek, but this season the supply has failed for all but the uppermost ranches at the cañon. This takes all the water in a single ditch with prospect of it drying up before June.

The "box" averages about 150 ft. in width with high broken walls [Station XXb]. The channel is 20 to 75 ft. in width, with the stream of one-third that breadth. In its course are a number of good pools, some too deep to wade. The creek bottom is gravelly to sandy, and occasional large boulders form good shelters for fish. *Chara* and algae abound, but there are few plants above the margins. Mesquite and paloverde grow on the hillsides (blooming April 19 and on). Of fish, *Agosia* is the most plentiful. Two stages of the fry were numerous, about ½ in. and 1¼ in. respectively in length. *Catostomus* also is comparatively common, *Pantosteus* and *Leuciscus* rare. The creek was at one time, even as recently as two years ago, noted for the number of suckers of edible size. Their disappearance is accounted for, as in other places, by the muddy floods. At Gisela above the cañon there is said to be yet a few fish of eatable size. I could not examine it.



Leaving Tonto Cañon the road passes across Gold Creek, Hands [?] Creek, Deer Creek, and Wild Rye Creek, all of which at one time contained small fish; now all are dry. The same is true of such branches as Sally May [Salome] Creek, Greenback Wash, or lower down the valley. All of these, at least the larger, probably have water near the sources in which small fishes may yet survive.

#### SALT RIVER MAINSTREAM [STATION XXI]

Salt River was examined in the region between Livingstone [an abandoned settlement near the mouth of Pine Creek] and Roosevelt, April 19 and 25. Here it traverses a valley of  $\frac{1}{2}$  mi. to one mi. in width with mesas on either side. It is a shallow, rather broad stream, 10 to 50 ft. or more in width, and from a few inches to a foot or more in average depth. The bottom is sand or gravel with larger boulders in places. The water is roily and slightly saline, the latter due, it is said, to a small branch flowing into Black River over a bed of rock salt. The greater number of wells in this region are salt, and ranchers draw their drinking water from springs or an occasional fresh well. The salinity is slight, the water serving very well for stock and irrigation. It does not apparently affect fish life. At 4:30 P.M. the temperature was 72°. Throughout this stretch are small pools of enough depth to protect fish, and in this river were found the only fish of eatable size taken during the work.

Just below Roosevelt [townsite on the eastside of Roosevelt Dam] the Salt River enters a cañon and there forms good size pools. In this region, protected by its inaccessibility, it is said salmon of marketable size can still be taken. I did not investigate it. At the entrance to this box the Tonto is building a dam [Roosevelt] that is to convert this part of the valley into a reservoir.

Eight hauls were made in the neighborhood of Roosevelt on April 25 [Station XXI]. One humpback [razorback] sucker and a small salmon [*Ptychocheilus lucius*] were obtained in the first haul, *Meda* [spikedace], Gila [roundtail chub], and three or more other species of suckers [desert, Sonora, and flannelmouth] made up the catch. One carp was taken, as well as a number of carp fry, which were taken in a sort of back water, mud bottomed eddy, off from the main current. They were associated with *Poecilia*

[Sonora topminnow]. Bonytail [chub] was more abundant in the pools, *Agosia* shallower places. All the *Meda* and "bonytail" suckers [flannelmouth suckers] were saved. *Poecilia* were found to be with well developed young almost ready to deposit. This species was remarkably abundant in the outlet of a warm spring near the town. [This spring still flows from cliff faces on the west side of the river immediately downstream from the dam.] The water at the outlet of this spring was 108°, but somewhat cooler where the fish were. There is also a small frog and a great number of tadpoles of large size in this warm water.

#### PINAL CREEK [STATION XXII]

This stream flows into Salt River from the south. It is a small stream, dry in its upper course, but rising just above the crossing of the Payson road [Station XXI], a few miles above its mouth. It carries only about 25 to 40 in. of water [0.63 to 1.9 cfs] over a fine gravelly bed at the point examined. The only fish found was *Tiaroga* [actually speckled dace, *Rhinichthys osculus*], which was taken with a hand dipnet. There is no vegetation in the stream. Below the road the creek enters a rough cañon and probably increases more or less in size.

To complete this examination it had been my intention to visit such streams as could be reached from the connecting road through Phoenix, getting topographic data at Phoenix for the whole region. The upper waters of the Verde are accessible from Jerome. A further study of the White Mountain region should also be included.

#### DISCUSSION AND SUMMARY

The general causes of extinction of fish life now operative in this region may be outlined in this manner:

1. Destruction of vegetation (cattle ranching, etc.).
  - a. Increased Floods
    - 1' Diminished volume of streams during dry seasons
    - 2' Increased erosion
  - b. Increased Erosion
    - 1' Filling in of pools
      - a. Destruction of places of refuge
      - b. Destruction of food, plant life

- c. Increase in range of temperature
  - 2' Rendering water unfit for respiration
  - 3' Change of climate—?
  - 2. Irrigating operations
    - a. Use of water
    - b. Prevention of migration by dams
    - c. Destruction of fish in ditches
  - 3. Mining operations
    - a. Use of powder in destroying fish
    - b. Drainage of sediment from mills
- Injurious chemicals in ores or processing

1. Ranging [Ranching] has destroyed the herbage. Primitively the mesas were covered by a protective growth of grass and herbage. This during the rains reached a height of two ft. or more. Upon return of the dry season it died but formed with the roots a mulch and a barrier to erosion. Since the introduction of herds this growth is not only eaten short but trampled out of existence to a greater or less extent over all that region within a radius of daily movement from water. Only at considerable distance from any source of water is the growth undisturbed. Cattle range 10 or 12 miles, horses and burros further. This denudation leads to - 1st, increased floods, 2nd, increased erosion, and 3rd, perhaps to climatic change.

The water falling on bare ground is not taken up by the soil but runs off rapidly causing more rapid and greater rises in the streams and proportionately longer periods of drought since what would be the permanent water has drained away all at once, hence there is a greater and a longer depression of value to the streams. This increased flow causes greater erosion on account of the greater velocity of the wash. 2nd, the bareness of the ground allows vast quantities of material to be carried off. This sediment affects fish life detrimentally in two ways: 1st by filling up the channels and obliterating the pools, 2nd by rendering the water unfit for respiration at the time of its complete saturation.

The filling up of pools destroys the places of refuge of the larger fish—their habitation, allowing them to become prey of all animals that desire them. It induces them to run out into

ditches where they are lost, and to leave the stream by its regular channel. It destroys the natural vegetation by destroying the habitat of species that require cooler, deeper, and quieter water, by covering and killing plants growing at the margins of the stream, by making all parts of the channel subject to the trampling and feeding of cattle.

It increases the range of temperatures by spreading the waters in a thin sheet and subjecting it thus to rapid augmentation and loss of heat from the sun and atmosphere. This renders the water uninhabitable by its high temperature, perhaps increasing disease, and also increases the amount of evaporation.

The destruction of trees for lumber and wood has added to the effect of loss of smaller plant growth. The growth of cottonwood and other timber has been cut for lumber, mining fuels, and in some instances for the feed afforded by the foliage. For fuel it is carried out of the more inaccessible places by burros.

The water of the streams is said to become almost thick with silt during the floods. Fish in numbers are seen floating in the turbid areas, apparently gasping for breath. Even if not killed by this excess of suspended matter, they may be stupefied to loss of control and drift out on the banks to die, or are carried to the lower courses where in a less rapid current the water clears up to a living condition, and whence they may not return over the dams. Or previous times the distastefulness of such waters may lead the larger and more powerful fish to seek more agreeable regions.

Climatic changes seem to be following this denudation of the country. The last three or four years are spoken of as years of increasing drought. Ranchers everywhere insist that 'Arizona is drying up.' In many places, as the Tonto Valley, once prosperous farms have been abandoned.

2. Irrigation operations affect the fish life primarily by the consumption of the water. Once diverted from the river it is expended on land and lost by evaporation. Only the depth of bedrock prevents the extinction of the smaller streams in their upper courses, but in the sand lying above, a seepage occurs that renews the stream successively above each dam, until the

amount of water remaining is within the capacity of the sand layer to carry it beneath the surface. At this point the stream is dry and water can be obtained only by digging. In these 'wells' fish are sometimes found, but I could not determine whether they were surface refugees from the gradual seasonal drying up or whether they might be able to exist in the sand in cavities and find liberty—later—in pools formed by the 'well.' This absorption of water sometimes leads to the curious reversal of natural conditions and streams may be larger nearer their source.

Irrigation dams are for the most part temporary structures put in year by year after the rains. In almost all cases they present a barrier to the ascent of all fish thus shutting off any increase of supply from the permanent waters below or above. Those from below can not climb over the dam, those from above follow out into the unscreened ditches and are lost in the fields.

3. Mining operations are perhaps accountable for the depletion to some extent. 1st because the almost universal familiarity with powder has led to more or less destruction in that way. (In my experience not one-twentieth of the number of fish killed by powder can ordinarily be obtained. A general belief obtains that they rise after such death. This is true only of such fish as have life enough remaining to struggle as when the drift of the current 'boils' them up. Hence in collecting it is best to use powder in pools with strong bottom currents, as beneath falls, or when by subsequent clearing of the water one can see his results on the bottom. The sediment from concentrating mills, as at Clifton, rapidly fills up river channels. It has the effects in a much less degree already noted under the heads of floods and erosion.

Perhaps the most remote effect is the action of poisonous compounds. Enough poisonous material might escape at times to have an appreciable effect either in the normal operation of roasting copper ores, or from abandoned cyanide processes. I saw no instances when I thought this cause operative.

So long as the present climatic conditions remain, and the existing industries are prosecuted, I can see no means of restocking these streams. The execution, if it were possible, of limiting laws for the trout streams might save them. The

streams of the White Mountain region are beginning to attract the attention of anglers from towns like Clifton and Safford, who may perfect this sport. The usual method of catching trout, as pursued by residents, is by the means of the eye as bait. The first fish is taken in any possible manner, the eye is then extracted for the next so that each fish furnishes means for capture of his fellows. Catches of 200 are reported for a single line. Of course they cannot long survive such vigorous onslaughts in the little streams which they inhabit.

Plants of various kinds have been made in the streams at times, but I could hear of no results. The planting is sometimes left to an uninterested person who is anxious to avoid the long and tedious drive with its attendant cans to a proper point for depositing the fish, and the trips are thought to have been in some cases unduly shortened. The Aravaipa has been suggested to me by Mr. Holsinger as a stream worth stocking. I had no opportunity to see it, but from description of a recent visitor I suspect it of doubtful value.

The only hope for fish in this region lies in pond culture. Not infrequently, springs, wells, mountain brooks or such supplies furnish opportunity to grow fish. In a few cases it is being done, but otherwise intelligent men seem often—if not usually—to think a pool of water, a small fish, and a brief time the only conditions for a good catch. Ponds are usually overstocked both in numbers of individuals and number of species. If the recipients of stock fish could be given a few plain rules for the preparation of their ponds and care of the fish, especially if they could be made to understand that not only does the growth of fish depend on food supply to an even greater extent than in the case of other stock, but that their survival is a question of abundant food, they should perhaps attempt fewer fish in small ponds or arrange for feeding. With a more general knowledge of pond culture the necessary natural depletion of Arizona streams may be viewed with equanimity.

Respectfully submitted

[signed] F. W. Chamberlain

Asst. Bur. Fish.