FISHES, AMPHIBIANS, AND REPTILES

of the

LOWER MAJOAVE RIVER SYSTEM

by:

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INTRODUCTION

The Mojave Desert, like all portions of the Basin and Range Province, is characterized by internal drainage. The Mojave River follows this pattern. From it's headwater tributaries, Deep Creek and West Fork,the river drops steeply within 10 miles from 5114 ft. at Lake Arrowhead to about 3000 ft. at Mojave Forks. From Mojave Forks the river curves northeast across the Mojave Desert for about 100 miles along a very gentle gradient, and eventually empties into Soda Lake Playa at 922 ft.

Most of the time there is very little surface water in the Mojave River except in the headwater region. On the higher mountain slopes, annual precipitation ranges up to 35 inches, and there are a number of permanent cool water streams. However, in the lowlands precipitation drops to about 5 inches at Victorville and to less than 2 inches at Afton Canyon (Thompson, 1929). Thus the headwater tributaries account for about 90% of the total flow within the Mojave River. Below Mojave Forks there are only four areas of permanent surface water flow: a 7-mile stretch near Victorville, another about 20 miles east of Barstow at Camp Cady Ranch, a 6-mile portion in Afton Canyon, and some pools at Soda Springs on the west side of Soda Dry Lake (Hubbs and Miller, 1943). Except at these sites located on impervious surface bedrock, water flow along most of the lower river is subsurface beneath deep sands and gravels.

During occasional heavy storms, rapid runoff from the mountains may produce a rushing torrent causing sudden drastic changes in downstream conditions and the distribution of organisms living along the river. At such times many times the normal flow may be experienced within a very short period. For example, in 1932 the U.S. Geological Survey gauge at Barstow recorded no measurable flow until February 9th,when a sudden storm produced a flow of 3090 $ft.^3/sec.$ Four days later the reading was 358 $ft.^3/sec.$, but by May 15th there was once again no measureable flow.

Within the past eight years, two major dams have been constructed near the confluence of the Mojave River headwaters. Cedar Springs Dam across the West Fork at 3355 ft. has impounded 78,000 acre feet of water to form Lake Silverwood. This lake has become an important public

recreation site, is regularly stocked with game fishes, and also serves as a storage reservoir for the Feather River Aquaduct. Mojave River Forks Dam lies across the mouth of Deep Creek. Normally no water is impounded behind this dam, but is allowed to flow directly into the Mojave River.

These dams have not materially changed the characteristics of water flow in the Mojave River. Whenever storms or snow melt fill Lake Silverwood beyond its normal storage capacity, the excess is immediately released downstream. During below-capacity periods no water is released. For example in 1977, a "typical" year, the total water released amounted to only 1,723 acre feet. By contrast 1978 has had record winter rains. 27,888 acre feet were released in March alone, and by June a total of 89,992 acre feet or 52 times the normal flow had passed downstream, (1 acre foot = 325,851.43 gal. or 43,560 ft^3) (pers, comm. Mr. Chester Burtch, Water Operations, California Dept. of Water Resources, Castaic).

During peak flood years water sometimes fills Soda Lake and overflows into Silver Dry Lake just to the north. The result was disastrous flooding of the town of Baker which lies right between Soda and Silver Lakes. After particularly severe flooding in 1967, the Union Pacific Railroad built a diversion levee at Basin Siding to channel the greater flow of floodwater into East Cronese Lake, thus preventing the overflow of Soda Lake and flooding of Baker. The floods of this year filled East Cronese Playa with a large lake, and this water was still present by July 8 at the end of this study. Thus the Mojave River still has the characteristics of a true desert wash subject to infrequent but catastrophic flash floods.

From above Victorville to Afton Canyon 40 miles east of Barstow, there are extensive interrupted stretches of riparian forest along the river flood plain. At several places sloughs and ponds of permanent water provide suitable habitat for fishes, amphibians, and aquatic reptiles. Thus the river provides a dispersal corridor far into the desert for animals normally tied to more mesic environments.

Beyond Afton Canyon the river becomes a dry wash with only subsurface flow to Soda Lake except during infrequent floods. At Soda Springs there is a pond of permanent water which houses the only known pure population of the Mojave chub (Gila bicolor mojavensis), a Pleistocene relict and the only fish native to the entire river system.

From April 14 to July 8, 1978 a field study was made to determine the status of all fishes, amphibians, and reptiles now occurring in the lower Mojave River System from Hesperia to Soda Lake. In addition an assessment was made of the natural and human ecological factors affecting these organisms. This report summarizes these findings. All common and scientific names follow Moyle (1976) for fishes and Stebbins (1966) for amphibians and reptiles.

I wish to thank Dr. Patricia Brown, Mr. Lloyd Findley, and Mr. Gary Keasler who ably assisted me in the field. Mr. and Mrs. Stanford Shaw very generously permitted me the use of their property near Camp Cady as a study site. Mr. Ken Wilhelm, Mr. Wes Mongee, Mr. Dennis McClane, Mr. L. M. Froley, and Mr. Chester Burtch all provided much useful information concerning the biology and hydrology of the area.

METHODS AND MATERIALS

Fishes

Any water along the course of the Mojave River from the vicinity of Hesperia to Soda Springs was sampled using 6 foot and 8 foot two-man "Common Sense" minnow seines and/or dip nets, wherever appropriate. Bodies of water included the main channel of the river, side channels, riffles and eddy pools, and sloughs, ponds, or isolated pools on the flood plain. 22 sites were sampled in all, with fishes being caught at only eight of these. All specimens were killed and fixed in the field using 10% formalin and later washed and transferred to a 40 % isopropanol solution as a permanent preservative.

Additional information was obtained regarding the occurrence of various species, introductions, and patterns of water flow from three main sources: interviews with private persons living along the river, interviews with officials of California Fish and Game and State Park Rangers, interviews with State Water Resources, San Bernadino County Flood Control, and U.S. Geological Survey officials, and a review of literature on the hydrology and fish distribution along the Mojave River.

Amphibians and Reptiles

Three principal methods were used for sampling amphibians and reptiles. The first was on-foot reconnaissance using noose, hand-capture, and nets or seines (for tadpoles). Second was the use of 5-gallon pitfall can traps buried flush with the soil, each with a one ft^2 masonite cover elevated over the mouth of the can by 4 stones. A total of 52 cans were buried at 10 sites along the river. These were checked every two weeks throughout the three months of the study (April 21 - July 9, 1978). Sites were chosen on the basis of habitat variety, spacing along the river course, accessibility, and freedom from the likelihood of vandalism or disturbance. The third method of sampling was nighttime road-riding in the vicinity of the river. One specimen of each species taken at each site was killed and fixed in 10% formalin, then washed and transferred to a 40% isopropanol solution for permanent preservation. Other specimens were recorded, then released where captured.

Tadpoles from each site were kept until metamorphosis to insure correct identification. All collecting of fishes, amphibians, and reptiles was done under provisions of a Scientific Collector's Permit (No. 1181) issued by the California Department of Fish and Game to Timothy W. Brown.

RESULTS - Species are listed in order of abundance at each site.

1) Hesperia Site - 3½ miles east southeast of Hesperia on east side of Mojave River at the right angle bend of Deep Creek Road (Lake Arrowhead Quadrangle T-4N, R-3W, S-31, ¼S-¼NW; elevation 2910 feet). This was a broad flat sandy flood plain with clumps of Chrysothamnus, Lepidospartum, Ceanothus, a variety of forbs, a few scattered logs and other flood debris, and much open sandy ground. A low terrace immediately above this site supported an open stand of Joshua Trees (Yucca brevifolia). Five cans were buried about 10 yards from one another at this site. No fishes were found in the broad shallow river channel near this site. The river itself was devoid of vegetation and was clear and fast-flowing in May, but had become a dry sandy wash by June 23.

Reptiles:

Cnemidophorus tigris	-	19
Sceloporus magister	-	4
Uta stansburiana	-	2
Phrynosoma coronatum	-	2
Xantusia vigilis	-	2
Masticophis flagellum	-	2

2) Bear Valley Cutoff Site - Flood plain on east side of Mojave River immediately north and south of Bear Valley Cutoff bridge (Hesperia Quadrangle T-5N, R-4W, S-36; elevation 2825 feet). Shallow sloughs on either side of the bridge were sampled with an 8 foot seine. Thousands of Hyla regilla tadpoles were found in the north slough on 15 May 1978 among flooded grasses and forbs in about 6 inches of water. No fishes or other amphibians or reptiles were found.

Amphibians:

Hyla regilla	-	> 1000 tadpoles

3) Oro Grande Site - 1¼ miles south of Oro Grande on east side of river (Victorville Quadrangle T-6N, R-4W, S-30; elevation 2668 feet). This was a cutover riparian forest on an elevated flood plain with scattered stands of Populus fremontii and Salix sp., and many open sandy areas with Chrysothamnus nauseosus, Artemisia tridentata, and Eriodictyon trichocalyx.

Numerous brush piles, log heaps, old boards, and other debris lay about. The river bank was steep and about 7 feet high.
mesh. Water was swift and shallow over the bare sand river bed in April and May, but had become just a broad trickle by July 8. No fishes or amphibians were obtained here.

Reptiles:

Sceloporus occidentalis	-	34
Cnemidophorus tigris	-	7
Uta stansburiana	-	3
Xantusia vigilis	-	2
Eumeces gilberti	-	1

4) Helendale Site - ½ mile west of Helendale on the west side of the river just north of the Harper Lake Road bridge (Victorville Quadrangle T-7N, R-4W, S-32; elevation 2420 feet). This site was on a flood plain island cut off from a development known as Silver Lakes Estates by a muddy slough. The island was somewhat elevated above the river (5 feet) on sandy soil and supported a riparian forest of Populus fremontii and Salix sp.. Chrysothamnus nauseosus, Brassica nigra, and Lepidium sp. occupied the open areas. Much brush and dead wood lay around on the ground. Five can traps were buried here about 10 yards apart. A small trickle joined the slough to the river itself, which had a shallow rapid flow of water. By July 8 the river bed was entirely dry.

Fishes:

Gasterosteus aculeatus	-	32

Amphibians:

Bufo boreas	-	23
Hyla regilla	-	10

Reptiles:

Sceloporus occidentalis	-	56
Uta stansburiana	-	5
Xantusia vigilis	-	3
Cnemidophorus tigris	-	1

5) Helendale Slough Site - Small one-acre slough just north of Harper Lake Road on east bank of Mojave River at Helendale (Victorville Quadrangle T-8N, R-4W, S-32; elevation 2420 feet). This was a shallow (~ 2 feet deep) pond of clear water on a low silty flood plain. Juncus, Baccharis, and small Populus and Salix grew in the water. The margins were grassy. This looked excellent for garter snakes, however no reptiles or fishes were found here. The only vertebrates seen were a large number of Hyla regilla tadpoles and adults.

Amphibians:

Hyla regilla	-	200

6) De Vries Farm Site - 5.4 miles northeast of Helendale. This site lay on low sand hummocks at the edge of a broad flat flood plain on the east side of the river. It was reached by a dirt road which ran north for about one mile from Holcome Ranch Road past some farm buildings and alfalfa fields to the edge of the Mojave River flood plain (Barstow Quadrangle T-8N, R-4W, S-12; elevation 2320 feet). This site was quite open in April and May, but by late June it was almost covered by a dense growth of Salsola kali. Other scattered shrubs included Tamarix gallica and Baccharis viminea. A few bits of wood lay around here and there. Five can traps were buried here. Immediately east of this site was an irrigated alfalfa field.

Amphibians:

Bufo boreas	-	12	

Reptiles:

Uta stansburiana	-	5	
Callisaurus draconoides	-	4	
Sceloporus occidentalis	-	3	(by farm building)
Cnemidophorus tigris	-	2	
Gambelia wislizenii	-	1	(by railroad)
Sceloporus magister	-	1	
Masticophis flagellum	-	1	(on highway)
Gopherus agassizi	-	1	(on highway)

7) Flood Plain Site - 4½ miles northeast of Helendale (Hawes Quadrangle T-8N, R-4W, S-12; elevation 2280 feet). Here the flat sandy flood plain on the south side of the river was nearly ¼ mile wide. The recent flood had scoured off all but a few bent Tamarix gallica bushes, and the river was wide and flowed rapidly until late June. Tadpoles and adult Hyla regilla were found in an isolated pool below a sand bank. An eddy pool behind the roots of a fallen tamarisk at the edge of the river channel yielded 2 species of fishes. Callisaurus were seen on the open sandy flood plain.

Fishes:

Gasterosteus aculeatus	-	1
Lepomis cyanellus	-	1

Amphibians:

Hyla regilla	-	10

Reptiles:

Callisaurus draconoides	-	2

8) Stanford Shaw's near Camp Cady Site - Private property belonging to Mr. Stanford Shaw situated on the south flood plain of the Mojave River one mile southwest of Camp Cady Ranch (Newberry Quadrangle T-10N, R-3E, S-26; elevation 1730 feet). 8 can traps were buried on the flood plain on ridges and in dry stream channels in a dense riparian forest of Populus fremontii, Salix sp., Prosopis pubescens and P. juliflora, and Tamarix gallica. By April no water still flowed here, but flooding had been severe a few weeks before. Many pools and wet mud were still in evidence, but all had dried up by late May. Fishes and tadpoles were taken from isolated pools. An artificial pond was seined behind Mr. Shaw's house on the river terrace 5 feet above the flood plain. One end of the pond had a dense growth of Typha, and mats of Potamogeton were present in the water.

Fishes:

Gambusia affinis	-	34	(seined from pond)
Ictalurus melas	-	2	(flood plain pool)

Amphibians:

Rana catesbeiana	-	18	(tadpoles and adults in pond)
Hyla regilla	-	15	(tadpoles)
Bufo boreas	-	5	(tadpoles and adults)

Reptiles:

Sceloporus occidentalis	-	28
Sceloporus magister	-	12
Uta stansburiana	-	4
Masticophis flagellum	-	2
Cnemidophorus tigris	-	1
Crotalus cerastes	-	1

9) Afton Canyon West Site - River flood plain south of Union Pacific Railroad tracks on the north side of river about ½ mile west of BLM campground (Cave Mountain Quadrangle T-11N, R-6E, S-18; elevation 1420 feet). The river here was severely changed by the floods of March. Several large ponds were washed out, and a 5 foot waterfall had formed just downstream from sampling area. Water flow was moderate in April and was barely a wide trickle by June. 5 can traps were buried on the flood plain among scattered Tamarix gallica and Prosopis pubescens. Stony sand of flood plain was covered by stands of Scirpus sp.

Amphibians:

Hyla regilla	-	25

Reptiles:

Leptotyphlops humilis	-	13
Uta stansburiana	-	3
Cnemidophorus tigris	-	3
Coleonyx variegatus	-	1
Xantusia vigilis	-	1

10) Afton Canyon East Site - Deep sloughs and low sandy ridges on north side of Mojave River about ½ mile east of BLM campground (Cave Mountain Quadrangle T-11N, R-6E, S-17; elevation 1390 feet). The sloughs were filled with stagnant muddy water, the deepest being about 5 feet. Dense stands of Typha stood in deeper water, with Scirpus, Juncus, and Anemopsis in the shallows. Banks and dry ridges were grown to thickets of Pluchea sericea, Atriplex lentiformis and A. canescens, Tamarix gallica, and Prosopis pubescens. 8 can traps were buried along the edges of sloughs and on the ridges. Sloughs were nearly dry by July. A small pool nearby in the river bed was seined, and 2 species of fishes

were obtained. This pool was lined with Scirpus and fed by a trickle of water over a 1 foot embankment.

Fishes:

Gila bicolor mojavensis x Gila orcutti		30
Ictalurus melas	-	7

Amphibians:

Hyla regilla	-	10
Rana catesbeiana	-	5

Reptiles:

Uta stansburiana	-	32
Cnemidophorus tigris	-	16
Callisaurus draconoides	-	5
Sceloporus magister	-	3
Xantusia vigilis	-	3
Coleonyx variegatus	-	1
Sauromalus obesus	-	1

11) Afton Canyon-Horseshoe Bend Site. About one mile southeast of Afton Siding the Mojave River makes a sharp curve to the southwest around a ridge of resistant rock (Cave Mountain Quadrangle T-11N, R-6E, S-20; elevation 1360 feet). By mid-May, the river here was a shallow rivulet in the wide sandy flood plain with isolated side channels and pools. A fringe of Tamarix gallica, Prosopis, and Chilopsis linearis grew along the banks. Here a number of tadpoles and several drowned Leptotyphlops were found in isolated pools, but no fishes were seen.

Amphibians:

Hyla regilla	-	50

Reptiles:

Leptotyphlops humilis	-	7

12) East Cronese Lake Site - East Cronese Dry Lake lies in a valley just north of Highway 15 about 15 miles southwest of Baker (Cave Mountain Quadrangle T-12N, R-7E, S-20; elevation 1080 feet). Normally this is a dry playa. This year, however, floodwaters diverted north from the Mojave River at Basin Siding had completely filled East Cronese Playa

to a depth of several feet. In March water was still flowing rapidly through the wash under Highway 15. However, this inflow had completely ceased by mid-April. Tamarix gallica, Prosopis juliflora, and Chilopsis linearis clumps stood in several feet of water around the lake margins, and a powerline maintenance road along the southern edge of the lake was completely flooded. Beyond the water's edge the valley consisted of sand hummocks and low dunes crowned with Larrea and Prosopis. 4 can traps were buried along the southeast edge of the lake. By mid-May the water had receded considerably leaving acres of mud-cracked shoreline strewn with stranded flotsam. The remaining water was quite warm, stagnant, and covered with a scum of algae. 7 seine hauls yielded nothing, but two dead and decomposing Ictalurus melas were found and preserved.

Fishes:

Ictalurus melas	-	2

Reptiles:

Gnemidophorus tigris	-	4
Callisaurus draconoides	-	3
Coleonyx variegatus	-	2
Uta stansburiana	-	2
Chionactis occipitalis	-	2
Dipsosaurus dorsalis	-	1
Phyllorhynchus decurtatus	-	1

13) Mojave River Sink-Crucero Siding to Soda Springs - This seven-mile stretch marks the end of the Mojave River where it disappears into Soda Dry Lake. The ruins of Rasor Ranch lie at about 980 feet (T-12N, R-8E, S-27) midway along a poorly-defined sand road between Crucero and Soda Springs. No can traps were located in this area, but it was reconnoitered on 29 April 1978. This is a region of windblown dunes capped with Prosopis juliflora, Chilopsis linearis, and Larrea divaricata. Some Tamarix aphylla have been planted along the Union Pacific tracks and a few still persist around the ruins of Rasor Ranch and the old Tonopah and Tidewater Railroad bed. The Mojave River is here a broad expanse of windblown sand, which showed no signs of flooding even this year. It is doubtful whether there is ever much surface water here, all flow being by slow percolation under the deep sands.

Due to the total lack of surface water, no fishes or amphibians are to be expected here. Uma, Callisaurus, Cnemidophorus, Urosaurus, Uta, Coleonyx, Chionactis, and Crotalus cerastes are probably the dominant forms of reptile life. Only one Callisaurus was collected, though, this having been just run over by a dune buggy. ORV's were in evidence everywhere in this otherwise picturesque and lonely region.

Reptiles:

Callisaurus draconoides - 1

14) South Soda Springs Site - About ¼ mile south of the buildings at Soda Springs, 6 can traps were buried in an alkaline marsh at the foot of a rugged rocky hill about 15 yards to the north (T-12N, R-8E, S-11; elevation 930 feet). The alkaline marsh vegetation consisted of Anemopsis californica, Distichlis spicata, Scirpus spp., Frankenia grandiflora, and Juncus sp. The soil here was a heavy black mud. The limestone slope consisted of jagged outcrops and loose fragments with a few Prosopis pubescens and P. juliflora, Haplopappus spp., Baccharis sarothroides, and Perityle emoryi. Although the soil in the marsh was wet, there was no open water. About ¼ mile to the southwest there was a series of low sand hummocks with Larrea, Haplopappus, and Ambrosia. This represented a northwest extension of the vast dune area just to the south of Soda Lake. These sand hummocks were reconnoitered several times on foot.

Reptiles:

Uta stansburiana	-	16	
Cnemidophorus tigris	-	11	
Dipsosaurus dorsalis	-	3	(sand hummocks)
Leptotyphlops humilis	-	3	
Uma scoparia	-	2	(sand hummocks)
Sauromalus obesus	-	1	
Gambelia wislizenii	-	1	(sand hummocks)
Urosaurus graciosus	-	1	(sand hummocks)
Phrynosoma platyrhinos	-	1	
Hypsiglena torquata	-	1	

15) Soda Springs Site - A group of buildings and a shallow 1-acre pond at the edge of Soda Dry Lake (T-12N, R-8E, S-11; elevation 930 feet). This pond is elevated about 3 feet above the level of the lake bed, so it never receives floodwaters from the Mojave River (Hubbs and Miller, 1943). It is fed by underground springs which also supply water to the Desert Consortium Facility at a fairly constant rate of a million gallons per day. The banks are covered with mats of Distichlis spicata and clumps of Juncus sp. The north end supports a rather dense growth of Typha. This pond is noteworthy for being the only place where a pure population of Gila bicolor mojavensis can be found. Also in the pond are introduced Cyprinodon nevadensis. The Mojave chub is fully protected by law, so no collecting was done, although individuals of both species were seen. Amphibians in the pond were Hyla regilla and introduced Rana catesbeiana. Fortunately none of these other inhabitants of the pond seems to be having any adverse effect on the Mojave chub population.

Fishes:

Gila bicolor mojavensis	-	11
Cyprinodon nevadensis	-	30

Amphibians:

Hyla regilla	-	3
Rana catesbeiana	-	3

Reptiles:

Callisaurus draconoides	-	6
Uta stansburiana	-	3
Cnemidophorus tigris	-	1

16) North Soda Springs Site - An access road runs from Highway 15 to Soda Springs between the edge of Soda Lake Playa and the base of the Soda Mountains. About a mile north of Soda Springs there are some shallow alkaline ponds in the marsh at the edge of the playa (T-12N, R-8E, S-2; elevation 930 feet). One can trap was buried at the base of the rocky slope in a mat of Distichlis, and another was buried in the alkaline marsh in a bed of Anemopsis and Scirpus. Dense stands of Scirpus surrounded the ponds, which were sampled by seining. Although likely-looking, no fishes were found here, but many Hyla regilla tadpoles and

adults were obtained. By early July these ponds had dried up, but natural seeps from the base of the hill kept feeding the marsh with rivulets of water.

Amphibians:

Hyla regilla	-	80

Reptiles:

Crotaphytus insularis	-	6
Sauromalus obesus	-	4
Hypsiglena torquata	-	3
Uta stansburiana	-	1
Leptotyphlops humilis	-	1
Masticophis flagellum	-	1

Fishes of the Mojave River System

Common Name	Scientific Name	Status	Observed During Stu
Threadfin Shad	(Dorosoma petenense)	Introduced	
Sockeye Salmon	(Oncorhynchus nerka)	Introduced	
Brook Trout	(Salvelinus fontinalis)	Introduced	
Brown Trout	(Salmo trutta)	Introduced	
Rainbow Trout	(Salmo gairdneri)	Introduced	
Carp	(Cyprinus carpio)	Introduced	
Goldfish	(Carassius auratus)	Introduced	
Mojave Chub	(Gila bicolor mohavensis)	Native	X
Arroyo Chub	(Gila orcutti)	Introduced	X (hybrid
Channel Catfish	(Ictalurus punctatus)	Introduced	
Yellow Bullhead	(Ictalurus natalis)	Introduced	
Black Bullhead	(Ictalurus melas)	Introduced	X
Amargosa Pupfish	(Cyprinodon nevadensis)	Introduced	
Mosquitofish	(Gambusia affinis)	Introduced	X
Threespine Stickleback	(Gasterosteus aculeatus)	Introduced	X
Striped Bass	(Morone saxatilis)	Introduced	
Sacramento Perch	(Archoalites interruptus)	Introduced	
Green Sunfish	(Lepomis cyanellus)	Introduced	X
Bluegill	(Lepomis macrochirus)	Introduced	
Redear Sunfish	(Lepomis microlophus)	Introduced	
White Crappie	(Pomoxis annularis)	Introduced	
Largemouth Bass	(Micropterus salmoides)	Introduced	
Riffle Sculpin	(Cottus gulosus)	Introduced	

Number of Native Species	1
Number of Introduced Species	22
Total Number of Species	23

DISCUSSION

Fishes

According to Hubbs and Miller (1943), the Mojave chub (Gila bicolor mojavensis) evolved in a chain of three large Pleistocene lakes, Manix, Little Mojave, and Mojave, connected by the then constantly flowing Mojave River. They believed that the arroyo chub (Gila orcutti) was also native to the Mojave drainage, but inhabited the river itself rather than the lakes, thereby keeping the two species allopatric. Later when these large lakes dried up, both the Mojave and arroyo chubs were crowded into the few remaining permanent pools along the river and produced a hybrid swarm. The only population not so affected was the one at Soda Springs, which remained isolated above the level of the Soda Lake Playa, and was therefore never brought into contact with Gila orcutti.

Later workers essentially agree with Hubbs' and Miller's account of Gila bicolor mojavensis, but believe that Gila orcutti was later introduced to the Mojave drainage from coastal streams by European man, and has produced the hybrid swarm within the past 80 years or so (Moyle, 1976). Whatever the case may be, there are now at least 22 species of introduced fishes in the Mojave River drainage (see Results section of this report). Even the one remaining population of "pure" Gila bicolor mojavensis shares the pond at Soda Springs with the introduced Amargosa pupfish Cyprinodon nevadensis.

Despite periodic flushing of the lower Mojave system by flash floods, a few habitable pockets and backwaters retain enough survivors to start up breeding populations again. Then, too, fish introductions are still occurring, for some species at an almost constant rate. For example, Mr. Wes Mongee, Ranger-naturalist for the State Park at Lake Silverwood, has informed me of several types of ongoing fish introductions at Lake Silverwood:

1. Game Fishes - These include introductions of rainbow trout (Salmo gairdneri) every two weeks from the hatchery at Mammoth Lakes; channel catfish (Ictalurus punctatus) on a catch basis, from the Imperial County Hatchery; brown trout (Salmo trutta) introduced two years ago as fry and now being caught up to 5 pounds;

Sacramento perch (Archoplites interruptus) introduced from Lake Crowley a year ago as food for the introduced largemouth bass (Micropterus salmoides) from Lake Mathews; white crappie (Lepomis microlophus) planted occasionally as broodfish to keep up the population level.

2. Bait Fishes - Although it is illegal to sell or use any non-native forms of live bait at Lake Silverwood, anglers surreptitiously bring in such species as three-spine sticklebacks (Gasterosteus aculeatus), and arroyo chub (Gila orcutti), both of which have escaped into the lower Mojave River system.

3. Accidentals - Lake Silverwood is connected by the Feather River Aquaduct to natural waters all the way into Northern California. Occasionally fishes or their eggs have survived this arduous journey and have become established at Lake Silverwood. These include the threadfin shad (Dorosoma petenense), riffle sculpin (Cottus gulosus), and green sunfish (Lepomis cyanellus).

Except for the various species of trout and the riffle sculpin, all of the above are warm water fishes and are potential colonizers of the lower Mojave River system. Some of them already have done so (see Results section of this report).

Another source of fishes comes from direct introductions along the lower Mojave River system. Mr. Ken Wilhelm, a long-time resident at the Camp Cady Ranch some 20 miles east of Barstow, has periodically stocked several ponds on the ranch and has released the following species into the river itself: channel catfish (Ictalurus punctatus), blue catfish (Ictalurus furcatus), white crappie (Pomoxis annularis), largemouth bass (Micropterus salmoides), and bluegill (Lepomis macrochirus). Interestingly, all of the ponds at Camp Cady Ranch were swept away by this year's floods, so that anything not intentionally introduced was sure to get into the river by this means. Mosquitofish (Gambusia affini were present in Stanford Shaw's pond about a mile southwest of Camp Cady Ranch. While this pond remained intact during the flood, mosquitof are, as the name implies, commonly introduced into natural and artificia waters as a mosquito control measure. They probably have entered the

Mojave River system as a result of this. Carp (Cyprinus carpio) and goldfish (Carassus auratus) are popular ornamental pond fish and are also sometimes released by pet owners who tire of them.

No one seems to know the exact source of the now abundant black bullhead (Ictalurus melas). I suspect that it may have inadvertantly come in with a planting of other types of catfish, but whatever the source, it is now firmly established in the lower Mojave River and is doing very well.

Amphibians

Five amphibian species are known to occur along the lower Mojave River. Three of these, the Pacific treefrog (Hyla regilla), the California toad (Bufo boreas halophilus), and the bullfrog (Rana catesbeiana), were recorded during this study. Of these, only the bullfrog has been introduced. A fourth species, the red-spotted toad (Bufo punctatus) is locally common around isolated water sources throughout the Mojave Desert, but surprisingly was not seen along the river. The fifth species, the arroyo toad (Bufo microscaphus californicus), was reported by Stebbins (1954) from larvae taken in the vicinity of Victorville. The arroyo toad was not seen during this study. Either this population is extremely local and was simply not sampled, or it may now be extinct.

The Pacific treefrog is the most successful West Coast amphibian and occurs in a wide variety of habitats from Canada to southern Baja California. Unlike the California toad, whose successful colonization of the lower Mojave River has been restricted to stretches of riparian forest or irrigated farmland, the Pacific treefrog has readily adapted to all habitats from shaded woodlands to the alkaline marshes at Soda Lake Playa. All it seems to require is semi-permanent surface water and a minimum of cover. The arroyo toad, California toad, and Pacific treefrog may well have inhabited the entire lower river system during the Pleistocene. Even now gene flow between populations probably is not interrupted for very long due to the periodic flash floods.

The bullfrog represents a rather ominous element in the fauna. A large voracious predator, it obviously adapts well to any permanent

body of quiet water, and may often succeed in reducing or eliminating other amphibian species. This species has been intentionally introduced by Mr. Ken Wilhelm of Camp Cady Ranch who told me that he had released bullfrogs from Louisiana into the Mojave River in 1927 and again in 1969. Whetherhe is solely responsible for their being there is unknown, but others also may have introduced this species for the sport of frog-gigging or under the mistaken impression that they control insects effectively.

Since all of the lowland salamanders of Southern California are found on the coastal side of the San Bernadino mountains, it is unlikely that any would occur along the Mojave. However, should the non-native waterdog or larval tiger salamander (Ambystoma tigrinum)ever be released as illegal live bait at Lake Silverwood, this species could conceiveably become established on the lower Mojave River.

Reptiles

The reptiles of the Mojave River system may be divided into four broad categories: 1) Upland species which have folowed the mesic riparian habitat into the desert, 2) Aquatic species, 3) Desert species which concentrate along the river for various reasons, and 4) Desert specieswhose preferred habitat merely happens to be contacted by the river. Unlike fishes and amphibians, there are no man-introduced reptile species known along the Mojave River.

1. Upland Species - Most notable in this category is the Great Basin fence lizard (Sceloporus occidentalis biseriatus), which was also the reptile most frequently trapped during this study. This species is common throughout the Upper Sonoran and Transition Life Zones of the San Bernardino mountains from grassland and rocky slopes, through chaparral, and into yellow pine forest. However, in the Lower Sonoran Life Zone from the Joshua tree woodland on down to the desert floor, it is replaced by the yellow-backed spiny lizard (Sceloporus magister uniformis). Wherever there is good riparian forest of cottonwoods and willows, though, the Great Basin fence lizard has followed the river well into the desert, even as far as Camp Cady Ranch 20 miles east of Barstow. A little beyond here, though, the cottonwoods yield dominance to mesquite

and tamarisk. The tall shady forest canopy gives way to a low tangled thicket of thorny branches. This change marks the easternmost boundary of the Great Basin fence lizard along the Mojave. It's range is by no means continuous westward, though. Gaps in the riparian forest are also gaps in it's range. A good example was the Hesperia site, near the lower edge of the chaparral but devoid of riparian forest. No fence lizards were taken here at all, although they were abundant a few miles downstream in the cottonwood forest near Victorville. Interestingly Sceloporus magister also occurred in the riparian cottonwood forests, but in far lesser numbers.

Two reptile species are common in the chaparral and were expected along the lower river, but were not found during this study. These were the San Diego alligator lizard (Gerrhonotus multicarinatus webbi) and the San Bernardino ringneck snake (Diadophis punctatus modestus). Both are partial to mesic situations and dense cover.

The California horned lizard (Phrynosoma coronatum blainvillei) would appear to be another chaparral species which has followed the river, but it is not. It's capture at the Hesperia site merely reflects it's occurrence over the entire ecotone between chaparral and Joshua tree and/or juniper woodland. The presence of the river makes no difference in the distribution of this species. Also in this same category would be the southern Pacific rattlesnake (Crotalus viridis helleri) and the San Diego gopher snake (Pituophis melanoleucus annectens), both of which might be expected down as far as the Hesperia site but no further.

2. Aquatic Species - Foremost among these is the southwestern pond turtle (Clemmys marmorata pallida). There are records of this species as far downriver as Afton Canyon, although no specimens were seen during this study. These downriver records undoubtedly represent breeding populations rather than merely flood-borne waifs, at least in the Camp Cady region where both Ken Wilhelm and Stanford Shaw have observed egg laying and newly hatched young of this species on several occasions. The sloughs at Afton Canyon probably also support a permanent population of these turtles, since children of the railroad workers living at Afton frequently find them there. Beyond Afton, though, there is no permanent surface water except at Soda Springs. Tough as these turtles are, they apparently have never made it across the Mojave River Sink to the pond

at Soda Springs, although once there, they could probably survive with little trouble.

The other aquatic reptile, expected, but not found along the river, was the two-striped garter snake (Thamnophis couchi hammondi). State Park rangers have recorded this species at Silverwood Lake, and ample food and good habitat exist at various places downriver all the way to Afton Canyon. The shallow pond full of Hyla regilla near Helendale seemed most likely for garter snakes, yet none was found there even during seining operations. Neither Mr. Shaw and Mr. Wilhelm near Camp Cady, nor Mrs. Helen Romero of Afton (Union Pacific Railroad) had ever seen them, although they were all quite familiar with other snakes of the area. The presence of this species along the lower Mojave River still remains to be confirmed.

3. Desert species concentrated along the river - Included among these are the yellow-backed spiny lizard (Sceloporus magister uniformis), the desert night lizard (Xantusia vigilis vigilis), western red-tailed (Gilbert's) skink (Eumeces gilberti rubricaudatus), western blind snake (Leptotyphlops humilis), and the California kingsnake (Lampropeltis getulus californiae).

The yellow-backed spiny lizard is partial to climbing and is especially common in rocky areas and stands of Joshua trees (Yucca brevifolia) or Mojave yuccas (Yucca schidigera). Probably for this reason, as well as the abundance of insect food, spiny lizards have invaded the riparian forests. However, this habitat may not be quite as suitable for spiny lizards as for the Great Basin fence lizard which far outnumbers it in this situation.

Desert night lizards are commonest wherever fallen logs, bark, rock flakes, and other debris provide cover and small arthropods for food. The riparian woodland does all of this and has more moderate temperatures and plenty of termites in the moister soil under rotting wood.

The Gilbert's skink has a spotty distribution at somewhat higher elevations in the Mojave Desert, especially around seeps and springs and in rocky areas with fairly dense cover. The riparian woodland certainly provides the cover, moisture, and abundant insect food which seems to suit this species.

The western blind snake has a widespread but spotty distribution in the Mojave Desert. It apparently favors rocky areas with deep loose soil and plenty of rotting wood with termites. It spends nearly all of it's time burrowing, only occassionally coming to the surface at night. Conditions along the river below rocky slopes seem especially favorable for these snakes,as evidenced by their numbers in the can traps at Afton Canyon and Soda Springs. Floods take their toll, however, as seen by the drowned specimens found in the river at Afton Canyon, where there appears to be a very high population density of blind snakes.

California kingsnakes were not found during this study. However they do occur widely in the Mojave Desert, especially around rocky areas and places where dense brush and debris provide good cover. Sites such as the one at Oro Grande seemed ideal for this species, and Stanford Shaw has seen them in the riparian forest near Camp Cady. Our failure to encounter king snakes at any of the study sites was probably a function of their nocturnal habits and large size unsuitable for can trapping, rather than their absence from these areas.

4. Desert species not concentrated along the river - At first glance the desert side-blotched lizard (Uta stansburiana stejnegeri) would appear to have been densely concentrated along the river, but this is not so. This lizard is the most abundant reptile in almost every habitat in the Mojave Desert. It's high numbers on the study sites simply reflect this widespread general abundance rather than any concentrating factor peculiar to riparian situations.

All of the other reptile species not discussed in the three other categories belong in this group. Some like the Great Basin gopher snake (Pituophis melanoleucus deserticola), reported by Stanford Shaw and Ken Wilhelm from the Camp Cady area, and the red racer (Masticophis flagellum piceus) are widespread in the desert. Others like the Mojave fringe-toed lizard (Uma scoparia) and western chuckwalla (Sauromalus obesus obesus) are very habitat-specific, but not to riparian situations per se.

It should be noted that failure to record many of the snake species known to occur along the lower Mojave River was most probably due to their nocturnal habits. Also their relatively large sizes preclude the use of can traps as an effective means of catching them. Road driving at night usually works well, but not many roads closely follow the lower Mojave River for long distances.

CONCLUSIONS

The Mojave River represents a dispersal corridor into the arid Mojave Desert for fishes, amphibians, and mesic or aquatic reptiles. Stretches of riparian forest and places where there is permanent surface water provide refugia for breeding populations of these species.

In addition some species of true desert reptiles also appear to concentrate along the river, where they coexist with more mesic forms. The great majority of reptiles, however, are found along the river, merely because it happens to cross their preferred desert habitat, and not because they are especially attracted to a riparian situation.

Populations of truly aquatic forms along the river are inherently unstable. Catastrophic flash floods periodically scour the entire lower river system producing drastic changes in the environment. Organisms are swept into unsuitable locations where they die, while others are brought downstream into new locations where they may survive. Thus true long-term isolation along the river is virtually impossible.

Only one species is truly endemic to the lower Mojave River. This is the Mojave chub (Gila bicolor mojavensis), a Pleistocene relict existing now as a pure populations only in an isolated pond at Soda Springs. Twenty two other species of fishes plus the bullfrog (Rana catesbeiana) have been introduced to the Mojave River, and many of these are now well-established. There are no introduced reptile species.

Although it is hopeless to try to restore the river to its original state, no new species of any kind should be introduced. In addition the riparian environment should be left natural, undeveloped, and unmodified wherever possible with a minimum of human impact. This also includes channelization, damming, and excessive drawdown of permanent surface waters by well pumping and irrigation. Under no circumstances should any form of pollution be allowed to enter the river system. The riparian biota has had a long period of evolution with natural catastrophes, but the short term drastic changes man can impose could destroy this modified but still intact ecosystem.

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