

**PARIA RIVER NATIVE FISH MONITORING  
1996 ANNUAL REPORT**

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Bureau of Reclamation  
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## Introduction

Use of the Paria River, Arizona, by spawning flannelmouth sucker (*Catostomus latipinnis*) has been well documented. Suttkus and Clemmer (1976), Carothers and Minckley (1981), Maddux et al. (1987) and Thieme (*in preparation*) reported ripe flannelmouth suckers near the confluence of the Paria and Colorado Rivers, and spawning in the Paria River. Weiss (1993) reported flannelmouth sucker spawning activity and young-of-year (YOY) in the lower 10 kilometers (km) of the Paria River. Sampling by Arizona Game and Fish Department (AGFD) during 13 May and 15 June 1994 resulted in 44 larval flannelmouth suckers caught, verifying successful spawning. On 15 June 1994, 297 juvenile flannelmouth suckers were captured, ranging in length from 30 - 50 mm total length (TL). In 1996, AGFD, in conjunction with the University of Arizona, continued to monitor use of the Paria River by native fishes.

## Study Site

Ten standardized AGFD sites in the Paria River were sampled in the lower 4.8 km of the Paria River (Table 1; Figure 1). Of these, nine were classified as runs (Bisson et al. 1982). Site 10, located at the confluence of the Paria and Colorado Rivers, was classified as pool habitat. Locations of sampling sites are noted as river kilometer (RK) upstream from the mouth.

Table 1. Site, river kilometer and description of sampling locations in the Paria River, Arizona, 1996.

Site	River Kilometer	Description
1	4.8	"Devil's Diving Board"
2	4.2	0.6 km downstream from "Devil's Diving Board"
3	3.2	0.3 km upstream from Site 4
4	2.9	Near abandoned ranch/corral site
5	2.4	~ 35 m upstream from old water pump
6	1.9	USGS gauging station
7	1.6	Bedrock site, ~ 0.3 km upstream from Site 8
8	1.3	~ 90 m upstream from water pipeline
9	0.8	Bridge
10	0.0	Mouth of Paria River

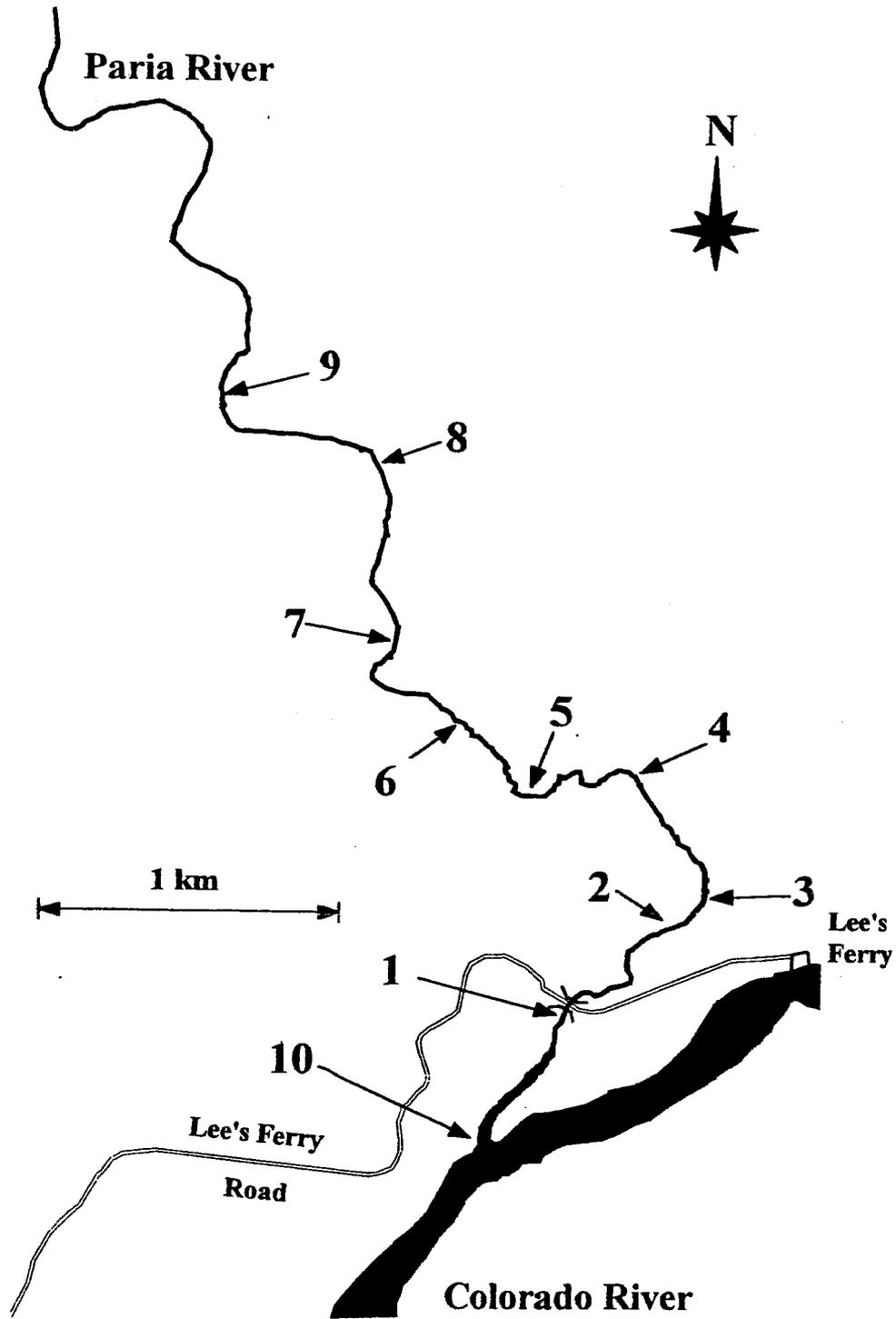


Figure 1. Sampling sites used by AGFD on the lower Paria River, Arizona, 1996.

## Methods

### Fish

Seine hauls were conducted using a 4.6 x 1.8 m straight seine with a 4.8 mm nylon mesh at Sites 1 - 9. Site 10 was sampled using a 10.0 x 1.8 m bag seine with a 1.8 x 1.8 x 1.8 m bag with 6.4 mm mesh. Only one seine haul was made at each site, with the exception of Site 10, at which from 1-5 hauls were made.

Fish were identified to species, measured for total length (TL; mm), weighed (0.0 g) and released alive at site of capture. All native fish  $\geq 150$  mm TL were scanned for the presence of a PIT tag. If no tag was present, one was inserted into the fish. PIT tag numbers were recorded for all fish.

### Habitat

Habitat data were collected at a representative location within each sampling site. Depth (cm; maximum and representative), velocity (cm/s) and temperature ( $^{\circ}$ C) were recorded at all sites sampled.

## Results

### Fish Collections

A total of 859 fish of four species was caught in the Paria River in 1996. Speckled dace (*Rhinichthys osculus*) was the most common species caught, comprising 59.9 % (515) of the catch. Flannemouth sucker comprised 39.7 % (341) of the catch. Two golden shiner (*Notemigonus crysoleucas*) and one rainbow trout (*Onchorynchus mykiss*) were also caught, comprising < 1% each. The majority (336; 98.2 %) of flannemouth suckers were caught at RK 0.0 (the mouth), whereas only five were caught upstream: three at RK 2.6 and two at RK 3.0. Speckled dace were caught in substantial numbers throughout the entire river reach sampled, with the highest catch at RK 0.0 (284) and lowest at RK 1.0 (9).

### *Flannemouth Sucker*

The majority of flannemouth suckers caught were young-of-year (YOY), with only 17 adults being caught. Mean length of flannemouth suckers caught was 57.2 mm TL and mean weight was 81.4 g (Table 2).

Table 2. Mean, minimum and maximum total length and weight for all species caught in the Paria River, Arizona, 1996.

Species	N	Total Length (mm)			Weight (g)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
Flannemouth sucker	341	57.2	19	515	81.4	0.2	1334.0
Speckled dace	515	67.1	28	112	3.8	0.3	97.0
Golden shiner	2	92.5	91	94	7.4	7.0	7.8
Rainbow trout	1	305.0	305	305	97.0	97.0	97.0

Flannemouth sucker catch was low early in the year and all fish caught were adults (Figure 2). However, beginning in May, catches of larval and juveniles increased the catch dramatically. Flannemouth sucker catch peaked on 30 May 1996, with a CPUE of 48.7 fish/100 m<sup>2</sup> seined. Catch rates then decreased through the summer and early fall.

Flannemouth suckers caught in the spring of 1996 were of the 3 cm modal length class (Figure 3). Two sub-adult (151 mm; 191 mm) and two adult (264 mm; 437 mm) flannemouth suckers were also caught during this period. During the summer, YOY dominated the catch and the modal length class of YOY increased over the summer from 3 - 9 cm. Also, four sub-adult (174 - 188 mm) and nine adult (240 - 515 mm) flannemouth suckers were caught during the summer. Young-of-year flannemouth suckers continued to be caught in late summer/early fall, and were 8 - 10 cm in length. One adult (215 mm) was also caught during this period.

A total of 32 flannemouth suckers were scanned for PIT tags. Eighteen of these scanned fish were found dead along the shoreline on 16 April and five had PIT tags (Table 3). Three of 14 live flannemouth suckers scanned were recaptures. Information regarding initial mark of two of the three live fish indicates that one flannemouth sucker grew 20 mm TL and gained 14.8 g in 57 days while the other grew 43 mm TL and 39.5 g in 75 days. Fourteen flannemouth suckers (>150 mm TL) were implanted with PIT tags (Table 4).

### *Speckled Dace*

Speckled dace had a mean length of 67.1 mm TL and mean weight of 3.8 g. Speckled dace catch also fluctuated with summer reproduction (Figure 2). Catch-per-unit-effort remained steady through the spring, decreased in early summer then increased in late summer. Speckled

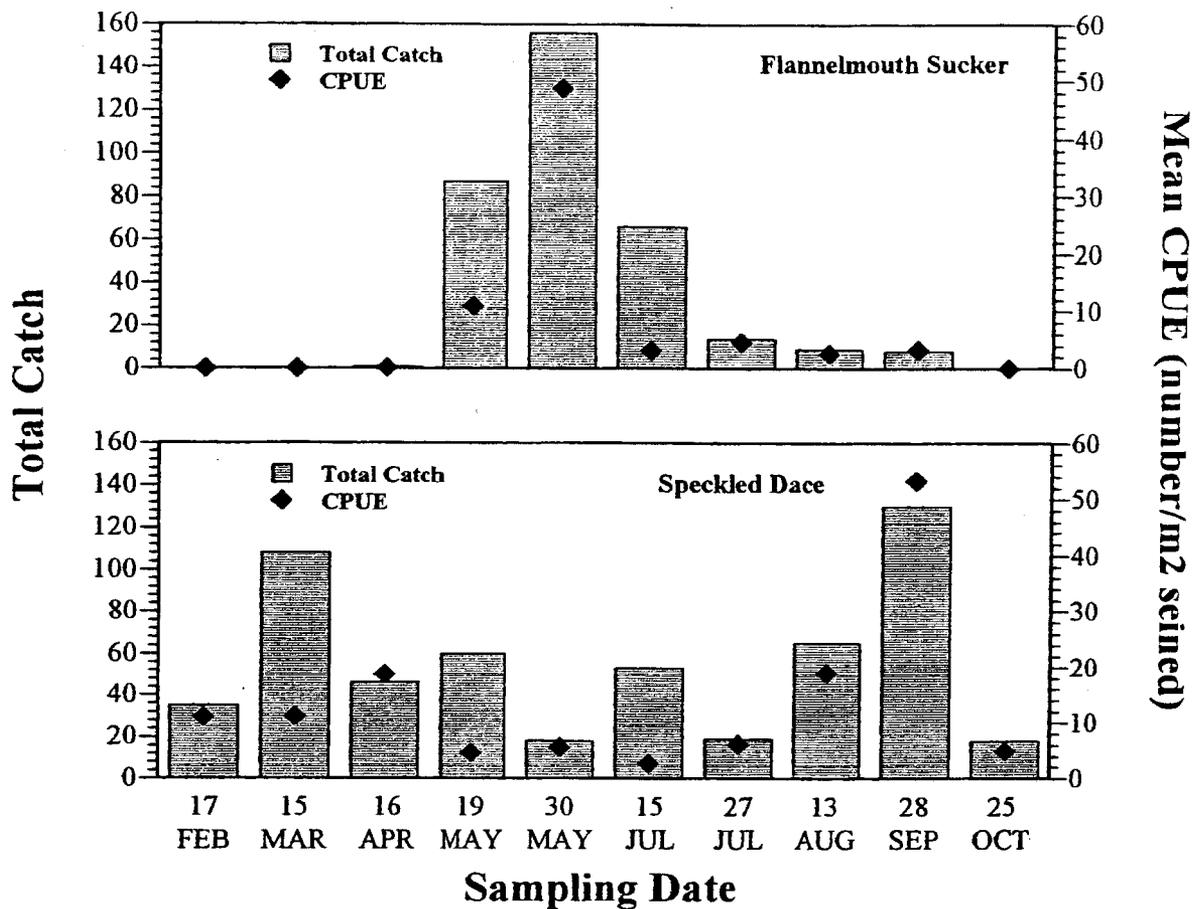


Figure 2. Total catch and catch-per-unit-effort (CPUE; number/100 m<sup>2</sup> seined) of flannelmouth sucker and speckled dace caught in the Paria River, 1996.

dace CPUE peaked at 53.2 fish/100 m<sup>2</sup> seined on 28 September 1996

Several size classes of speckled dace were caught in 1996 (Figure 4). In the spring, speckled dace ranged from 3 - 12 cm with a modal length class of 7 cm. During the summer, speckled dace were of the 5 cm modal class and ranged from 3 - 12 cm length classes, whereas fish in the late summer/early fall averaged 7 cm and ranged from 3 - 11 cm.

#### *Other Species*

Only flannelmouth sucker and speckled dace were captured upstream in the Paria River, proper. Three fish of two other species were caught in the mouth of the Paria River in addition to flannelmouth sucker and speckled dace. Two golden shiners (91 and 94 mm TL) and one rainbow trout (305 mm TL) were also caught in the mouth of the Paria River.

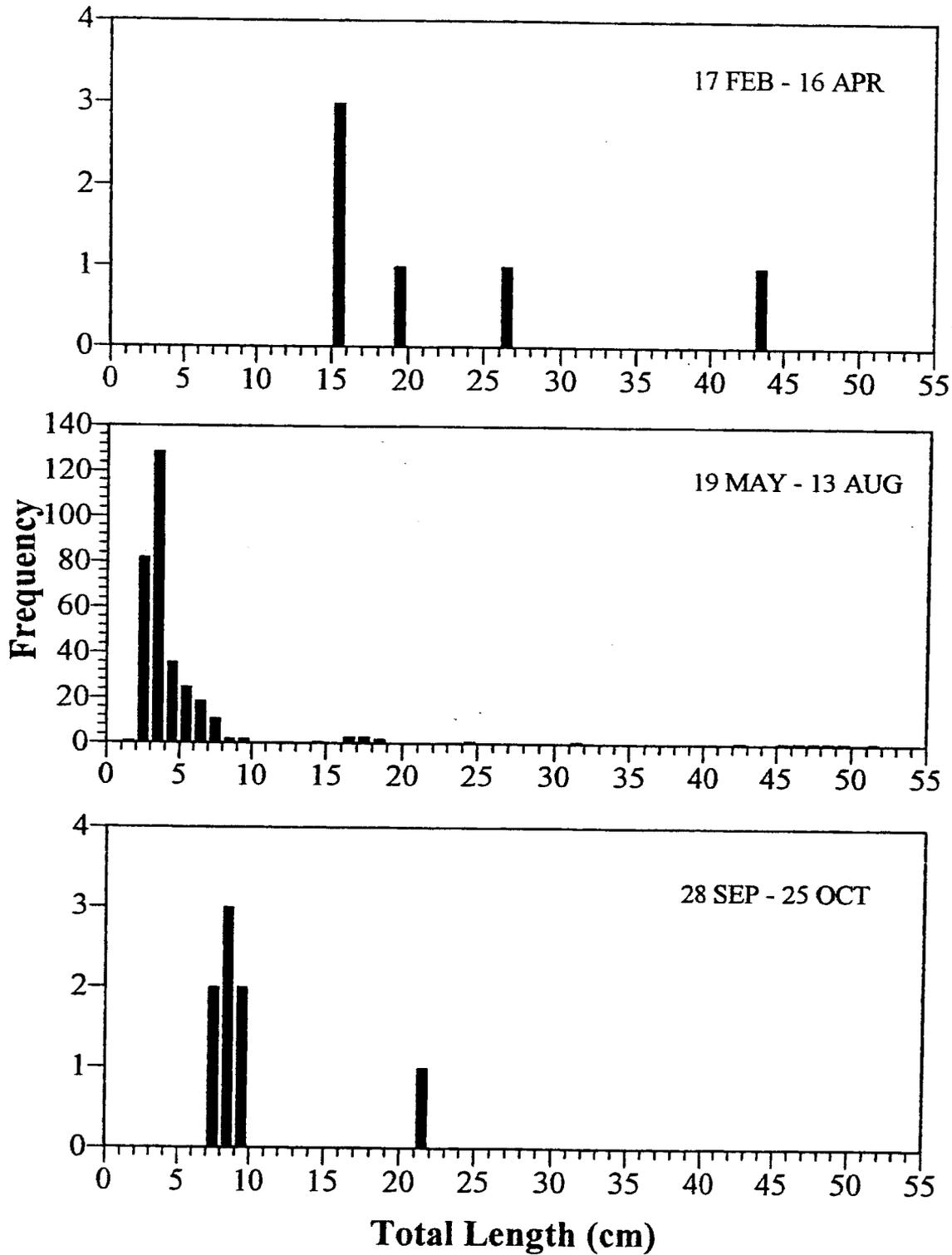


Figure 3. Length frequency histogram of flannelmouth suckers caught during spring (top), summer (middle) and fall (bottom) in the Paria River, Arizona, 1996.

Table 3. Capture location, length, weight and sex as well as location, length, weight and date of original marking and previous recapture of fish recaptured with a PIT tag in the Paria River, Arizona, 1996.

Species	PIT Tag Number	Recapture				Mark				
		Date	Capture Location	Total Length	Weight	Sex	Date	Capture Location	Total Length	Weight
Flannemouth Sucker	1F201AC1B	16 APR 96	PAR	437	848.0	M	-	-	-	-
Flannemouth Sucker*	7F7B016E47	16 APR 96	PAR	-	-	-	14 MAR 93	PAR	-	-
Flannemouth Sucker*	7F7D3C501D	16 APR 96	PAR	-	-	-	03 MAR 93	PAR	-	-
Flannemouth Sucker*	7F7F284637	16 APR 96	PAR	-	-	-	-	-	-	-
		14 MAR 93	PAR	404	680	U	14 OCT 92	LCR	390	602
Flannemouth Sucker*	7F7F3C0446	16 APR 96	PAR	-	-	-	-	-	-	-
Flannemouth Sucker*	1F2043532B	16 APR 96	PAR	-	-	-	-	-	-	-
Flannemouth Sucker	1F78265C67	15 JUL 96	PAR	176	43.8	U	19 MAY 96	PAR	156	29
Flannemouth Sucker	1F7A757A78	28 SEP 96	PAR	215	81.5	U	15 JUL 96	PAR	172	42

\* Indicates fish that were found as mortalities along shoreline at RK 2.6 - RK 4.2.

Table 4. Capture location, total length, weight and sex of fish implanted with a PIT tag from the Paria River, Arizona, 1996.

Study	Total Length	Weight	Sex	PIT Tag Number
5964010	156	29.0	U	1F78265C67
5964010	158	32.0	U	1F7B49732A
5966010	420	741.0	U	1F78106673
5966010	462	1028.0	U	1F7A29417D
5966011	480	968.0	M	1F78100158
5966011	165	34.9	U	1F7B060A56
5967010	172	42.0	U	1F7A757A78
5967010	166	44.0	U	1F7A21695D
5967010	174	46.9	U	1F7B4D0118
5967010	188	59.8	U	1F7B191835
5967010	240	121.0	U	1F78095C04
5967010	316	266.0	U	1F7B6C1664
5967010	459	974.0	U	1F7A201037
5967010	475	1032.0	U	1F78057F65

### Habitat

Mean temperatures in the Paria River during 1996 ranged from 9.8 - 26.9° C (Table 5). Highest temperature was recorded on 19 May at Site 8 (32.0° C). Lowest temperature recorded was 7.0° C on 17 February at Site 1.

Maximum and representative depths were relatively constant throughout 1996 (Table 5). Representative depths ranged from 9.5 - 19.5 cm. Velocity was highly variable at sampling sites in 1996. Mean velocities ranged from 44.3 cm/s on 13 August to 61.6 cm/s on 15 March. The lowest velocity was recorded on 16 April (2 cm/s) and the highest on 27 July (106 cm/s).

Paria River discharge in 1996 was relatively stable with few spates (Figure 5). The highest discharge in the Paria River was 510.3 cfs on 22 February and the lowest was 2.8 cfs on 19 May. All spates occurred at times when YOY prevalence was low.

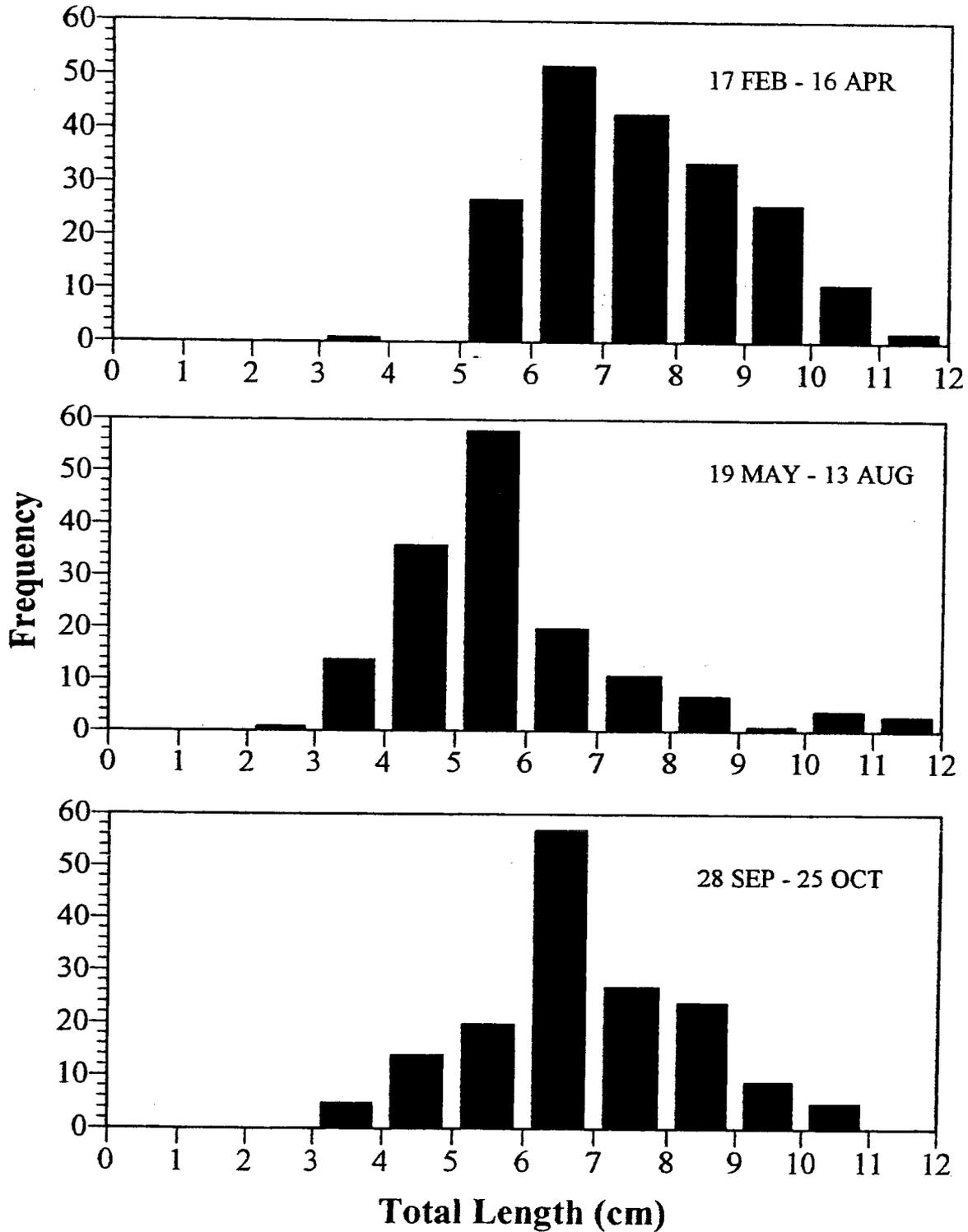


Figure 4. Length frequency histogram of speckled dace caught during spring (top), summer (middle) and fall (bottom) in the Paria River, Arizona, 1996.

Table 5. Mean and range of temperature, velocity and representative depth at sampling sites in the Paria River, Arizona, 1996.

Date (Trip)	Temperature (°C)			Velocity (cm/s)			Representative Depth (cm)		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
17 Feb (1)	11.07	7.0	14.7	50.9	7	68	17.4	11	19
15 Mar (2)	147.8	8.8	10.7	61.6	27	97	18.3	10	21
16 Apr (3)	20.8	13.2	24.0	45.6	2	79	18.1	7	22
19 May (4)	22.5	25.8	32.0	-	-	-	-	-	-
30 May (5)	26.5	26.5	26.5	-	-	-	-	-	-
15 Jul (6)	23.6	18.0	31.4	46.0	34	58	15.7	10	18
27 Jul (7)	25.3	24.0	27.0	88.5	77	106	19.5	14	20
13 Aug (8)	26.9	24.0	28.0	44.3	15	74	9.5	6	11
28 Sep (9)	16.0	14.0	19.0	-	-	-	-	-	-
25 Oct (10)	9.8	8.8	10.7	53.4	6	103	17.2	9.0	20

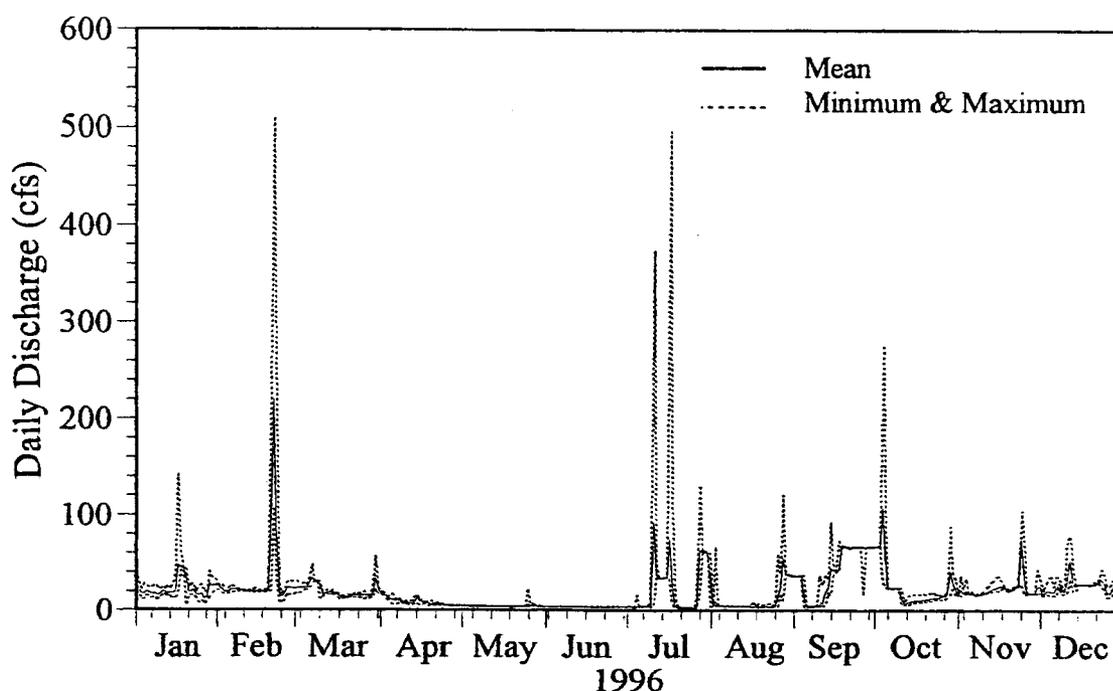


Figure 5. Mean, minimum and maximum daily discharge in the Paria River, 1996.

### Discussion

Results of fish sampling emphasize the importance of the Paria River for spawning adult flannelmouth suckers and rearing of larval and YOY fish during periods of low Paria River discharge. During 1996, the most abundant species was speckled dace, accounting for 59.9 % of the total number of fish collected. Flannelmouth sucker comprised 39.7 % of the catch and the majority were < 75 mm TL, indicating that spawning had occurred in the Paria River. These data support findings by Weiss (1993), who captured eight YOY flannelmouth suckers in the Paria River during 1992. Further support was provided by AGFD in 1994, when 44 larval flannelmouth suckers were collected on 13 May and 297 juveniles on 15 June (AGFD unpublished data). However, no YOY had previously been captured later in the summer, indicating a lack of recruitment.

Large numbers of YOY flannelmouth suckers were captured throughout the 1996 growing season and young fish grew quickly throughout the summer. The unusually high numbers of flannelmouth sucker YOY in 1996 may be attributed to a lack of significant flooding in the Paria River and/or high mainstem Colorado River flows which ponded the Paria River mouth. Michele Thieme (*in preparation*) suggests that this slackwater pool acted as a

refuge/rearing area for YOY flannelmouth suckers. Larval flannelmouth suckers are prone to drifting out of spawning tributaries upon reaching swim-up stage (Robinson et al. 1996). The slackwater pool, acting as a rearing area for larvae and YOY, allowed flannelmouth sucker to grow to 90 mm TL by the fall. The slackwater pool provided suitable rearing habitat for long periods of time, increasing their survivability upon entering the cold mainstem Colorado River (Thieme et al. 1996). The lack of flooding from April - early July allowed YOY flannelmouth suckers to remain in this rearing area through the summer. By July, fish were large enough to withstand the small spates that occurred during this period. See Thieme (*in preparation*) for a more thorough description of flannelmouth sucker population dynamics in the Paria River in 1996.

The presence of adult flannelmouth sucker mortalities upstream in the Paria River are indicative of an upstream spawning run followed by post-spawning mortality. These data support findings of Suttkus and Clemmer (1976), Carothers and Minckley (1981) and Maddux et al. (1987), who documented spawning runs up the Paria River. Weiss (1993) also reported that spawning occurred in 1992 and 1993 throughout the lower 10 km of the Paria River. However, no previous record of post-spawn mortality has been recorded. Weiss (1993) also noted an increase in the mean length of adult fish between 1992 and 1993, indicating that the Paria River population of flannelmouth sucker may be becoming senescent. Our results showing adult post-spawning mortality may be further evidence of an aging population. Excellent rearing conditions in the Paria River in 1996 may provide some recruitment into the adult population.

Catches of speckled dace through the year appeared to show a die-off of adults, replaced by YOY later in the summer. The life span of speckled dace is only 2 - 3 years (Minckley 1973) and decreased catches in mid-summer 1996 may reflect adult mortality. This was followed by the appearance of YOY being recruited into the population in late July through September. Decreased catches in late October may reflect fish leaving the Paria River as temperatures dropped below that of the Colorado River.

We feel that continued monitoring of the Paria River and its use by all life stages of flannelmouth sucker and speckled dace is necessary. With low levels of recruitment having been reported by past studies, efforts to quantify post-spawn mortality of an aging adult population of flannelmouth suckers should be continued. Lastly, variables such as Paria and Colorado River discharges should be taken into account when examining factors affecting successful recruitment.

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This report summarizes results of monitoring the use of the Paria River by native fishes in 1997. Based on findings in 1996, we continued to examine post-spawn mortality of spawning adult flannelmouth suckers, recruitment of flannelmouth sucker and speckled dace and factors affecting recruitment (e.g., Paria River discharge, Colorado River discharge and rearing habitat availability).

## Study Site

Ten standardized AGFD sites were sampled in the lower 4.8 km of the Paria River (Table 1; Figure 1). Of these, nine were classified as runs, while Site 10, located at the confluence of the Paria and Colorado Rivers, was classified as pool habitat. Locations of sampling sites are noted as river kilometer (RK) upstream from the mouth.

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3	3.2	0.3 km upstream from Site 4
4	2.9	Near abandoned ranch/corral site
5	2.4	~ 35 m upstream from old water pump
6	1.9	USGS gauging station
7	1.6	Bedrock site, ~ 0.3 km upstream from Site 8
8	1.3	~ 90 m upstream from water pipeline
9	0.8	Bridge
10	0.0	Mouth of Paria River

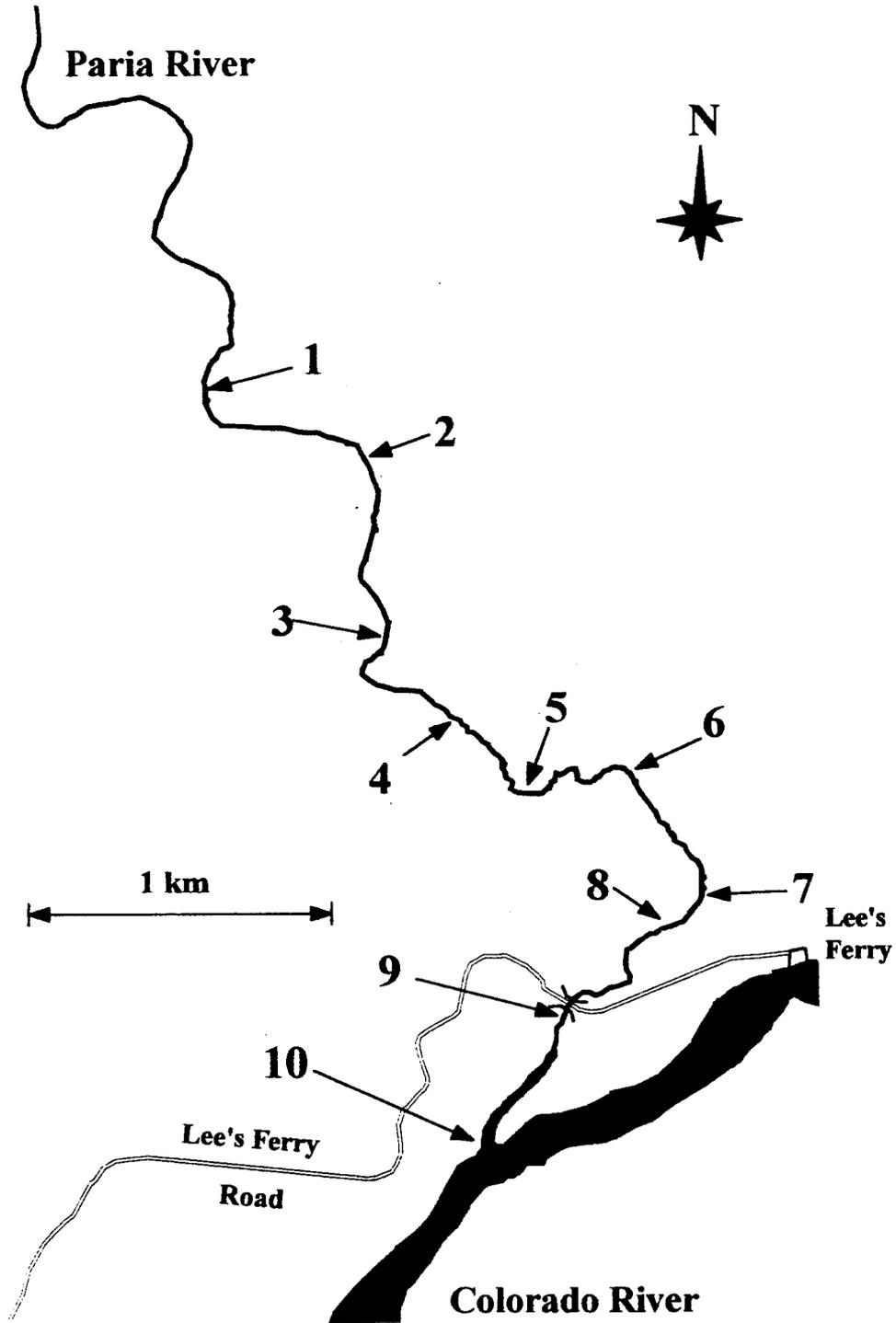


Figure 1. Sampling sites used by AGFD on the lower Paria River, Arizona, 1997.

## Methods

### Fish

Seine hauls were conducted using a 4.6 x 1.8 m straight seine with a 4.8 mm nylon mesh at Sites 1 - 9. Site 10 was sampled using a 10.0 x 1.8 m bag seine with a 1.8 x 1.8 x 1.8 m bag with 6.4 mm mesh. Only one seine haul was made at each site, with the exception of Site 10, at which as many as five hauls were made.

Fish were identified to species, measured for total length (TL; mm), weighed (0.0 g) and released alive at site of capture. All native fish  $\geq 150$  mm TL were scanned for the presence of a PIT tag. If no tag was present, one was inserted into the fish. PIT tag numbers were recorded for all fish.

### Habitat

Depth (cm), velocity (cm/s) and temperature ( $^{\circ}$ C) were recorded from a representative location within each sampling site. Maximum depth within the seined area was also recorded.

## Results

### Fish Collections

A total of 587 fish of four species was caught in the Paria River in 1997. Speckled dace was the most common species caught, comprising 62.2 % (365) of the catch. Flannelmouth sucker comprised 34.4 % (202) of the catch. Of special note, two bluehead suckers (*Catostomus discobolus*), comprising < 1% and 18 (3.1 %) redbreast shiners (*Richardsonius balteatus*) were also caught.

### *Flannelmouth Sucker*

The majority (190; 94.1 %) of flannelmouth suckers were caught at RK 0.0 (the mouth), whereas only 12 were caught upstream: one at RK 0.5, RK 1.0 and RK 3.0, two at RK 1.8 and RK 2.0 and five at RK 1.5. The majority of flannelmouth suckers caught were young-of-year (YOY), with only 16 adults being caught. Mean length of flannelmouth suckers was 65.6 mm TL and mean weight was 384.5 g (Table 2).

Table 2. Number caught and mean, minimum and maximum total length and weight for all species caught in the Paria River, Arizona, 1997.

Species	N	Total Length (mm)			Weight (g)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
Flannelmouth sucker	202	65.6	10	490	384.5	0.3	1194.0
Bluehead sucker	2	200.0	146	254	-	-	-
Speckled dace	365	70.7	22	121	3.7	0.0	19.5
Redside shiner	2	51.5	46	56	1.2	0.3	1.7

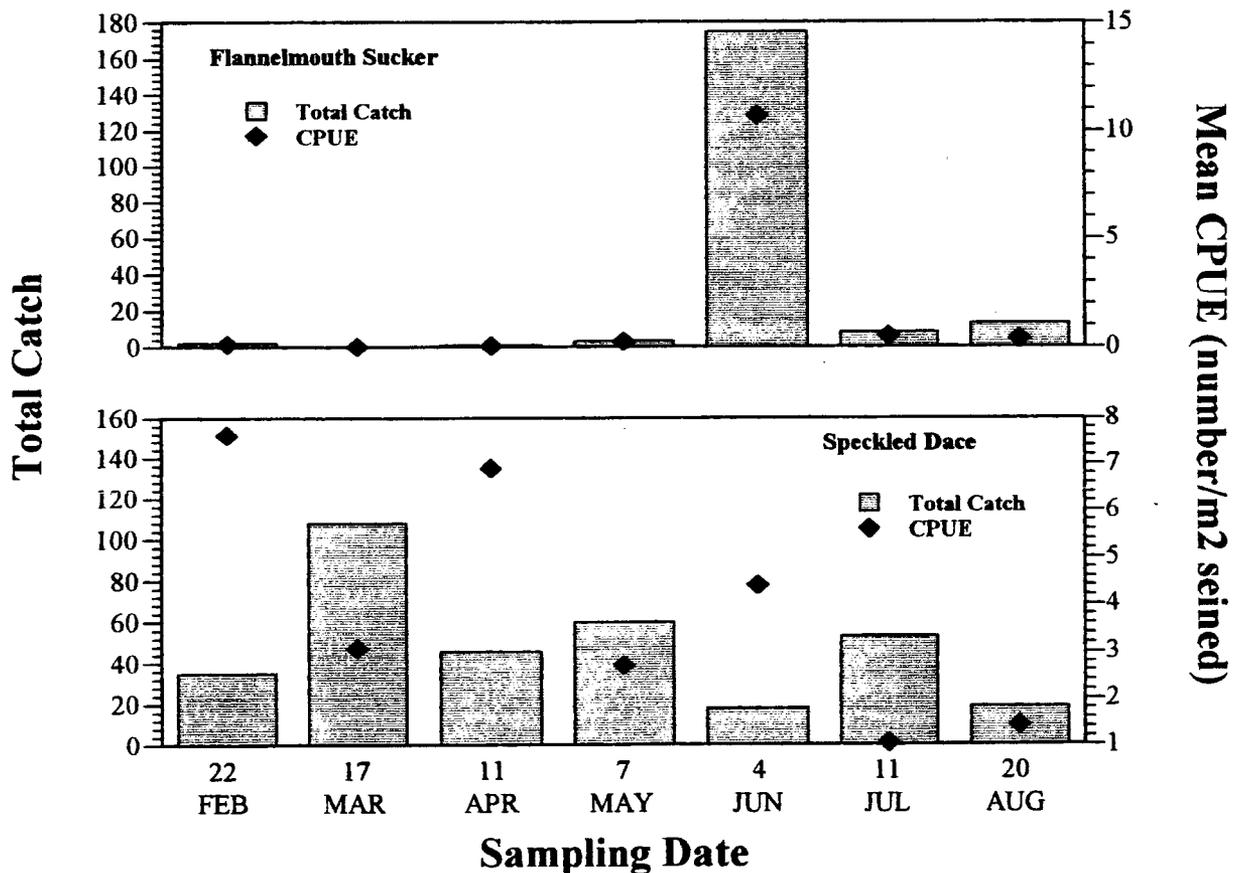


Figure 2. Total catch and catch-per-unit effort (CPUE; number/100 m<sup>2</sup> seined) of flannelmouth sucker and speckled dace during each sampling period in the Paria River, Arizona, 1997.

Flannelmouth sucker catch was low early in the year; however, four age 1 fish and one adult were caught in the spring (Figure 2). Beginning in May, catches of larvae and juveniles increased dramatically with a peak on 4 June 1997 (CPUE 10.7 fish / 100 m<sup>2</sup> seined). No sub-adults were caught and YOY were no longer collected after 11 July.

Four age 1 flannelmouth suckers (85 - 113 mm TL) were caught in the spring of 1997 (Figure 3). One adult (472 mm) flannelmouth sucker was also caught during this period. During the summer, YOY were of the 3 cm modal length class and 14 (292 - 493 mm TL) adult flannelmouth suckers were also caught during this period.

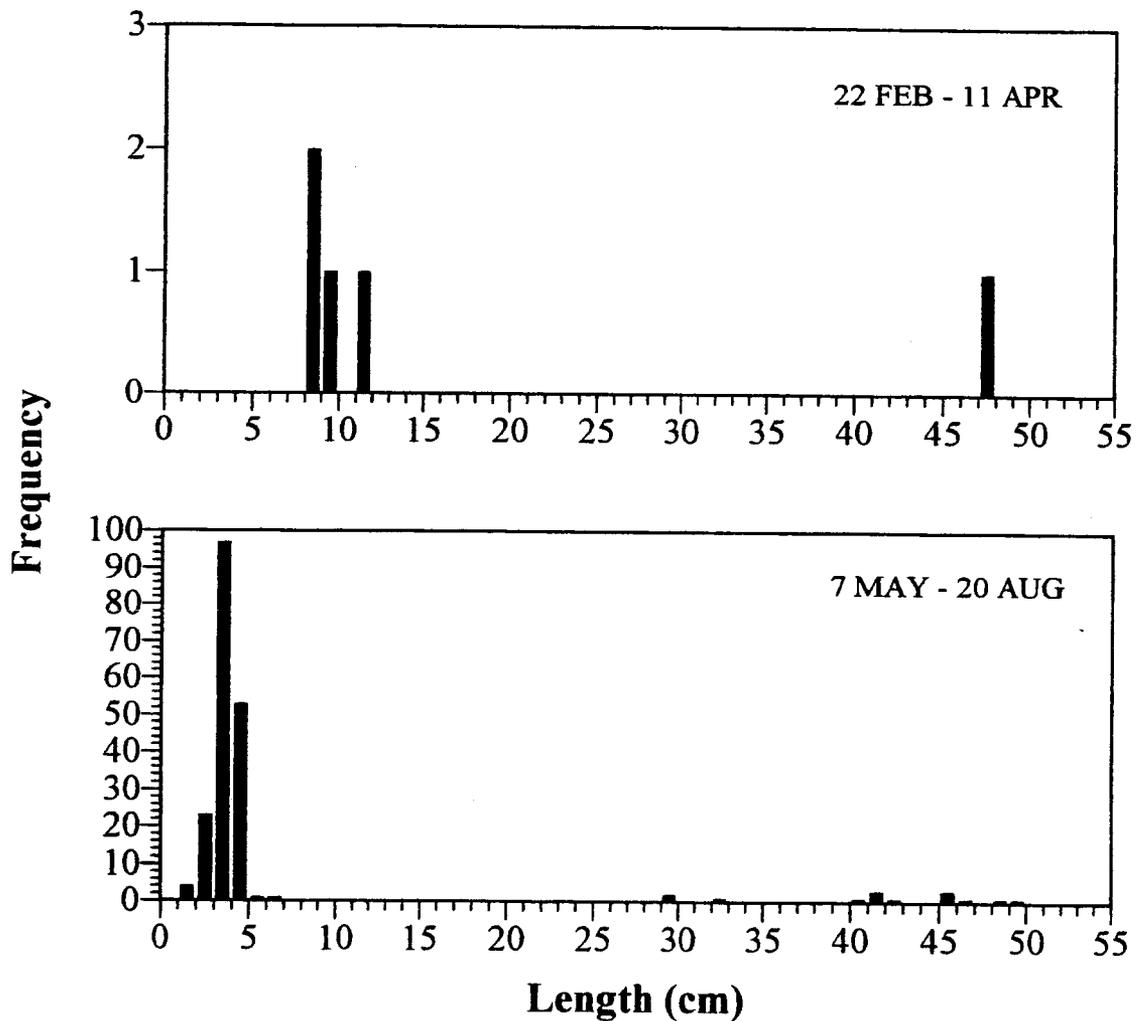


Figure 3. Length frequency histogram of flannelmouth suckers caught during the spring (top) and summer (bottom) in the Paria River, 1997.

Table 3. Capture location, length, weight and sex, as well as location, length, weight and date of original marking and previous recapture of fish recaptured with a PIT tag in the Paria River, Arizona, 1997.

PIT Tag Number	Recapture					Mark				
	Date	Capture Location	Total Length	Weight	Sex	Date	Capture Location	Total Length	Weight	
1F7B5F7F08	7 MAY 97	PAR	411	-	U	23 JUN 95	KAN	330	296	
	29 APR 96	LCR	380	-						
1F3E6C7641	20 AUG 97	PAR	451	753	U	-	-	-	-	
1F78095C04	20 AUG 97	PAR	329	278	U	27 JUL 96	PAR	240	121	
1F7B693746	20 AUG 97	PAR	419	726	U	29 APR 96	KAN	375	577	
1F7B575738	20 AUG 97	PAR	415	715	U	26 APR 96	LCR	387	531	
1F77785B17	20 AUG 97	PAR	461	1050	U	18 MAR 97	PAR	476	1192	

A total of 14 flannelmouth suckers were scanned for PIT tags. Six of these scanned fish were recaptures (Table 3). Information regarding initial mark of five of the six fish indicates that flannelmouth sucker growth, depending on size, ranged from 1.7 - 6.8 mm/30 days and 21.3 - 83.9 mm/year (Table 4). One adult flannelmouth sucker (PIT tag # 1F77785B17) lost weight and length since being marked. This fish may have been a female that lost length due to spawning (e.g, frayed fins) and weight to expression of gametes. Eight flannelmouth suckers (>150 mm TL) were implanted with PIT tags (Table 5).

Table 4. Growth rates of flannelmouth sucker caught in the Paria River, 1997.

Tag Number	Days at Large	Total Length (mm)		Growth Rate (mm/30days)	Annual Growth Rate (mm/year)
		Mark	Recapture		
1F78095C04	389	240	329	6.8	83.9
1F7B5F7F08	684	330	411	2.5	30.5
1F7B693746	478	375	419	2.7	31.6
1F7B575738	475	387	415	1.7	21.3
1F77785B17	155	476	461	-	-

Table 5. Capture location, total length, weight and sex of fish implanted with a PIT tag from the Paria River, Arizona, 1997.

Location	Total	Weight	Sex	PIT Tag Number
Site 10	294	233	U	1F787D0765
Site 10	290	193	U	1F7A337A3A
Site 10	453	810	U	1F7836446F
Site 10	490	1194	U	1F7A1B321A
Site 10	405	578	U	1F78154B09
Site 10	429	667	U	1F7A232A1A
Site 10	456	950	U	1F1E4F5E16
Site 10	485	1050	U	1F1F5E6202

*Speckled Dace*

Speckled dace were caught in substantial numbers throughout the entire river reach sampled, with the highest catch at RK 0.0 (98) and lowest at RK 1.0 (11). Speckled dace had a mean length of 67.1 mm TL and mean weight of 3.8 g (Table 2). Speckled dace catch and CPUE fluctuated with summer reproduction (Figure 2). Speckled dace CPUE peaked at 7.6 fish / 100 m<sup>2</sup> seined on 22 February 1997.

Several size classes of speckled dace were caught in 1997 (Figure 4). In the spring, speckled dace ranged from 11 - 13 cm. During the summer, two age classes of speckled dace were present. During the summer, YOY fish ranged from 2 - 4 cm and age 1 from 4 - 11 cm.

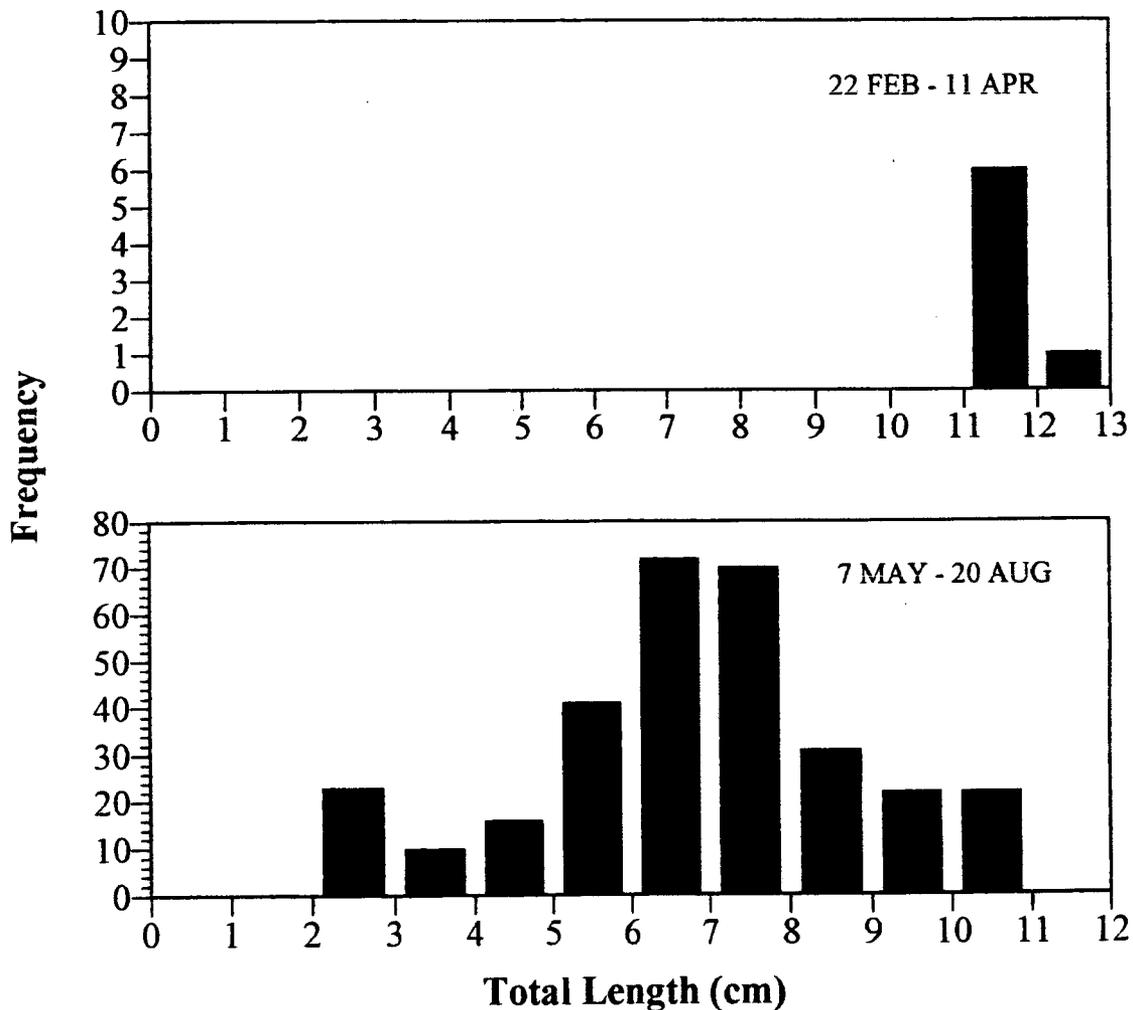


Figure 4. Length frequency histogram of speckled dace caught during spring (top) and summer (bottom) in the Paria River, Arizona, 1997.

### *Other Species*

Two bluehead suckers were caught in the Paria River at RK 0.8. These fish were 146 and 254 mm TL.

Eighteen redbreast shiners were caught, all in the mouth of the Paria River (RK 0.0). These fish ranged in total length from 46 - 56 mm and in weight from 0.3 - 1.7 g. All fish were preserved.

### Habitat

Mean Paria River temperatures in 1997 ranged from 9.8 - 26.9° C (Table 6). Highest temperature was recorded on 19 May at Site 8 (32.0° C). Lowest temperature recorded was 7.0° C on 17 February at Site 1.

Representative depths were relatively constant throughout 1997 (Table 6). Mean representative depths at each sampling period ranged from 12.0 - 22.5 cm.

Velocity was highly variable at sampling sites in 1997 (Table 6). Mean velocities ranged from 44.3 cm/s on 13 August to 61.6 cm/s on 15 March. The lowest velocity was recorded on 16 April (2 cm/s) and the highest on 27 July (106 cm/s). Sampling was only conducted during periods of base flow for safety reasons. Depth and velocity would be greater during flood events.

Paria River discharge in 1997 was relatively stable with few spring spates but frequent and large monsoon flooding from August - early October (Figure 5). The highest discharge in the Paria River was 4,090 cfs on 10 August and the lowest was 1.3 cfs on 5 August.

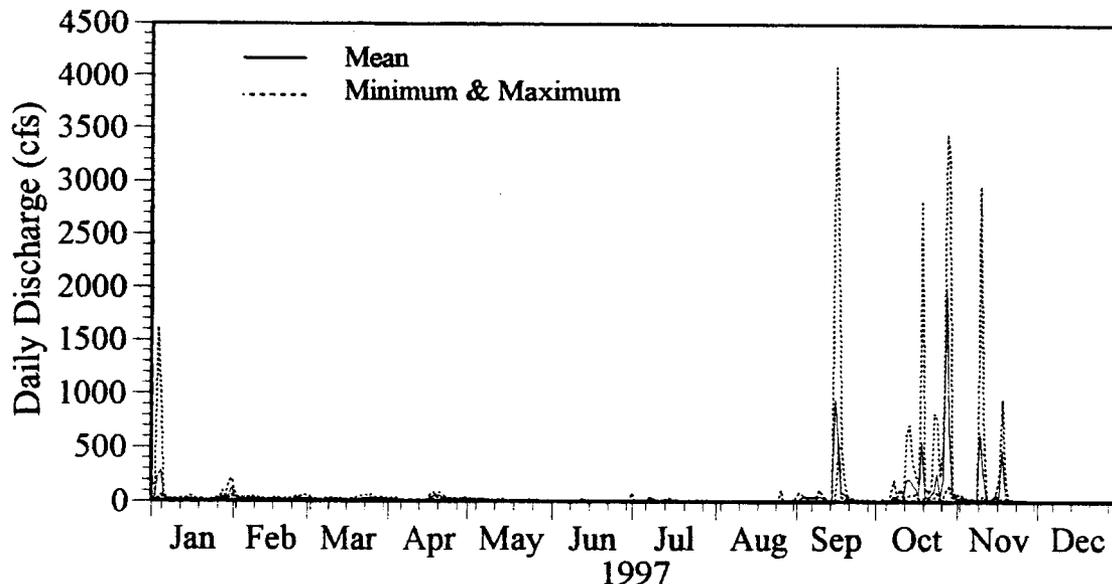


Figure 5. Mean, minimum and maximum daily discharge in the Paria River, 1997.

Table 6. Mean, minimum and maximum temperature, velocity and representative depth at sampling sites in the Paria River, Arizona, 1997.

Date (Trip)	Temperature (°C)			Velocity (cm/s)			Representative Depth (cm)		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
22 Feb (1)	7.8	4	10	-	-	-	16.6	10	28
17 Mar (2)	15.1	13	18	27.3	14	68	21.4	14	40
11 Apr (3)	17.8	16	19	90	50	125	22.5	15	30
7 May (4)	17.7	17	18	-	-	-	-	-	-
4 Jun (5)	30.6	27	34	6	1	21	12	12	12
11 Jul (6)	28.3	22	32	35.5	27	46	10.4	7	15
20 Aug (7)	24.8	13.4	31	29.4	0	55	21.1	0	106

## Discussion

Results of continued efforts to monitor use of the Paria River by spawning adult flannelmouth suckers and rearing of larvae and YOY further reinforce this tributary's importance to native fishes. During 1997, the most abundant species was speckled dace, accounting for 62.2 % of the total number of fish collected. Flannelmouth sucker comprised 34.4 % of the catch and the majority were < 70 mm TL, indicating that spawning had occurred in the Paria River.

As in 1996, large numbers of YOY flannelmouth suckers were captured during the 1997 growing season. However, YOY were no longer collected after 4 June. The unusually high numbers of flannelmouth sucker YOY in 1996 were attributed to a lack of significant flooding in the Paria River and/or high mainstem Colorado River flows which ponded the Paria River mouth (Thieme *in preparation*). Thieme (*in preparation*) suggests that the ponded Paria River mouth acted as a refuge/rearing area for YOY flannelmouth suckers. No significant flooding, when YOY prevalence was high, occurred in the Paria River from 1 January to 10 November 1997. Also, Colorado River discharges in the spring (~20,000 cfs) and early summer (~26,000 cfs) of 1997 were relatively high and similar to those of 1996. However, the Paria River mouth was not ponded during Colorado River discharges of ~ 20,000 cfs on 13 - 14 May 1997 (M. Thieme, University of Arizona, personal communication), as it was under similar flows in 1996. Thieme (*in preparation*) attributes the lack of a ponded tributary mouth in 1997 to prolonged periods of steady high mainstem Colorado River flows backing up the Paria River mouth, causing suspended sediments in the Paria River to be deposited in the mouth. On 4 June, a "back-eddy" was present near the mouth of the Paria River, caused by high Colorado River discharge, which scoured sediments and created a small pool where large numbers of YOY were caught. Young-of-year may not have been caught after this period due to a small spate of 90 cfs on 5 June in the Paria River.

In 1996, we observed post-spawning mortality of adult flannelmouth sucker (Brouder and Hoffnagle 1997). No evidence of this was observed in 1997. We hypothesized that adult post-spawning mortality may be further evidence of an aging population as theorized by Weiss (1993). This may still be the case, however, post-spawn mortality may be a sporadic event.

As in 1996, catches of speckled dace throughout 1997 appeared to show a die-off of adults, replaced by YOY later in the summer. The life span of speckled dace is only 2 - 3 years (Minckley 1973) and decreased catches in mid-summer 1996 may reflect adult mortality. This

was followed by the appearance of YOY being recruited into the population through August.

Of special note is the capture of two large bluehead suckers at RK 0.8 in the Paria River in 1997. Weiss (1993) reported the capture of three bluehead suckers in the Paria River. A total of 111 juvenile bluehead suckers were captured by AGFD (unpublished data) on 15 June 1994, mostly in the mouth, but as far upstream as Site 1 (RK 4.8). Carothers and Minckley (1981) reported the presence of bluehead suckers in the Paria River during the summer of 1978. It is possible that small numbers of bluehead suckers use and may even spawn in the Paria River. However, recruitment for this species is also low, since no bluehead suckers were captured by AGFD in the Colorado River below the Paria (AGFD 1996).

Of special concern is the catch of 18 redbreasted shiners in the mouth of the Paria River on 11 July. Redbreasted shiner is an exotic species which may compete with or prey on YOY flannelmouth sucker for habitat and/or food. Minckley (1973) reports that redbreasted shiner are piscivorous and are a particular threat to native fishes. With low levels of recruitment having been reported in past studies, the presence of this exotic species may have negative effects on recruitment and ultimately survival of native fishes. In addition, two bluehead suckers were caught at RK 0.8 in 1997. Although not the first time this species has been caught in the Paria River (Weiss 1993; AGFD unpublished data), numbers of bluehead sucker have been low.

The excellent rearing conditions present in 1996 were not observed in 1997; however, catches of YOY flannelmouth sucker were relatively high early in the summer. These results and those of Thieme (*in preparation*) show that successful recruitment of flannelmouth sucker is dependent on more than just Paria and Colorado River discharge. The timing of events such as high and low flows in the Paria and Colorado Rivers are just as important as the magnitude of these flows. Continued monitoring of the Paria River and its use by all life stages of flannelmouth sucker and speckled dace is necessary to understand the relationship of Paria River discharge and Glen Canyon Dam operations to recruitment of flannelmouth sucker. With low levels of recruitment having been reported in past studies, monitoring the abundance and distribution of redbreasted shiners and other exotics in and around the Paria River is also important. Lastly, the capture of bluehead suckers in the Paria River in 1997 means that YOY sucker species must be accurately identified so that any changes in abundance and/or distribution of bluehead suckers may also be detected.

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**PARIA RIVER NATIVE FISH MONITORING  
1998 ANNUAL REPORT**

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Submitted to:

Grand Canyon Monitoring and Research Center  
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## Introduction

The lower Paria River, Arizona, is an interesting stream because of its depauperate ichthyofauna. Despite the myriad of non-native fishes that have been captured in or near its confluence with the Colorado River, it commonly contains only two species of fish, both of which are native to the stream: flannelmouth sucker *Catostomus latipinnis* and speckled dace *Rhinichthys osculus*. This is probably due to the wide range of temperatures that it experiences and the severe flooding that it experiences nearly every year. Despite this, the Paria River is an important spawning stream for these two Colorado River native fishes (Arizona Game and Fish Department 1996a). Flannelmouth sucker use the Paria only seasonally for spawning and early rearing (Weiss 1993; Brouder and Hoffnagle 1997a; Thieme 1997; Weiss et al. 1998). Juvenile flannelmouth suckers will stay in the Paria as long as possible - usually until a flood flushes them out. Speckled dace may be the only year-round residents of the stream, but their numbers are also susceptible to reduction, at least temporarily, by severe flooding.

Spawning of flannelmouth sucker in the Paria River has been documented since the 1970's (Suttkus and Clemmer 1976; Carothers and Minckley 1981; Maddux et al. 1987; Weiss 1993; Thieme 1997). Although eggs and/or larvae have been regularly observed in the Paria River since 1993, no indication of recruitment of these fish into the population had been found prior to the 1996 year class (Weiss 1993; Arizona Game and Fish Department 1996a), which has survived longer than any other recent year class (Brouder and Hoffnagle 1997a; b; Thieme 1997). This was probably due to a drought-induced lack of flooding in the Paria River, which allowed larvae to remain in the warmer Paria, instead of being displaced into the colder Colorado River. In addition, unusually high flows in the mainstem Colorado River created a large, warm pool in the mouth of the Paria which may have provided rearing habitat for young-of-the-year (YOY) fishes (Thieme et al. 1997). In 1997, 80 - 120 mm total length (TL) flannelmouth suckers were captured in the mouth of the Paria River - probably fish from the 1996 Paria River cohort (Brouder and Hoffnagle 1997b). In 1998, a few flannelmouth suckers 200 - 250 mm were caught in the mouth of the Paria, indicating that the 1996 year class may be

recruiting into the adult population (S. Rogers, Arizona Game and Fish Department, personal communication).

Monitoring the Paria River fish population, particularly flannelmouth sucker, is an important component of monitoring the abundance and cohort size of native fishes in Grand Canyon. This report documents the results of Arizona Game and Fish Department Paria River fish monitoring for 1998.

### Study Site

Ten standardized Arizona Game and Fish Department sites in the Paria River were sampled in the lower 4.8 km of the Paria River (Figure 1; Table 1) (Arizona Game and Fish Department 1996a). Length of the sites ranged from 15 - 85 m and usually spanned the entire stream. These sites have been sampled by Arizona Game and Fish Department since 1994 and previously by Weiss (1993). Of these, nine were classified as runs, while sites located at the confluence of the Paria and Colorado rivers, were classified as pool habitat (Bisson et al. 1982). This pool is created by the ponding of the Paria River by the mainstem Colorado River. Size (area and volume) of the pool depends largely on Colorado River discharge and antecedent flows of the Paria River which may scour or deposit sediments in the mouth. Locations of sampling sites are noted as distance (m) upstream from the confluence of the Paria and Colorado rivers.

### Methods

Samples were collected monthly beginning in June 1998. My plan was to sample beginning with the onset of the spawning run (usually April or May), but there was no observed spawning aggregation at the mouth of the Paria River nor a run upstream (S. Rogers, Arizona Game and Fish Department, personal communication). However, spawning did occur in the Paria River, since young suckers were observed there on 17 May 1998 (P. Sponholtz, Arizona Game and Fish Department, personal communication) and I began sampling on 4 June 1998. Sampling dates within each month were chosen based on availability of volunteer help (see

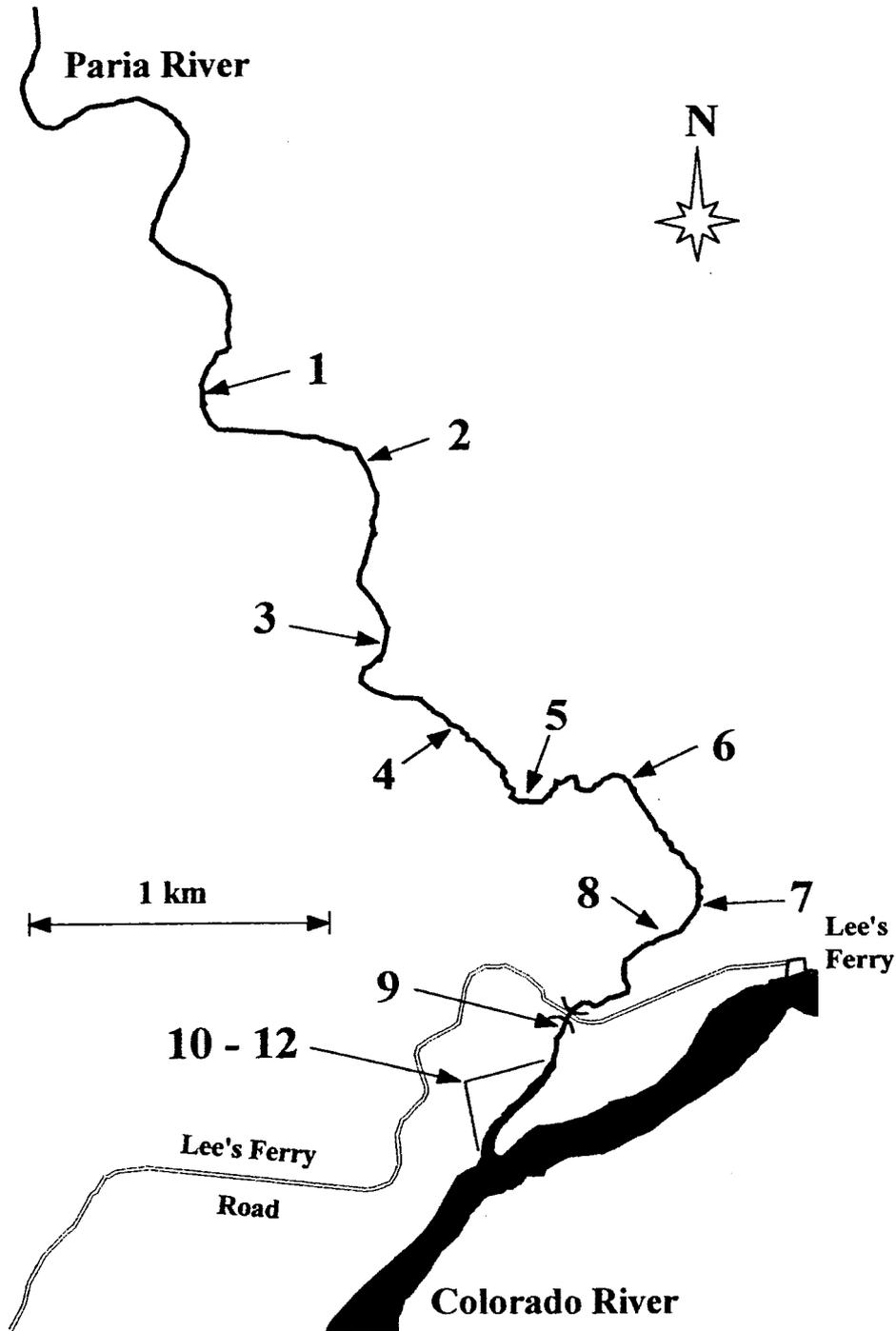


Figure 1. Sampling sites used by Arizona Game and Fish Department in the lower Paria River, Arizona (see Table 1 for description of sites).

Table 1. Site, location [distance (m) above the mouth] and description of sampling locations in the Paria River, Arizona.

Site	Location	Description
1	4.8	“Devil’s Diving Board”
2	4.2	0.6 km downstream from “Devil’s Diving Board”
3	3.2	0.3 km upstream from Site 4
4	2.9	Near abandoned ranch/corral site
5	2.4	~ 35 m upstream from old water pump
6	1.9	USGS gauging station
7	1.6	Bedrock site, ~ 0.3 km upstream from Site 8
8	1.3	~ 90 m upstream from water pipeline
9	0.8	Bridge
10-12	0 - 0.2	Mouth of Paria River

Appendix 1 for list of participants) and Paria River discharge: i.e., if the Paria River discharge exceeded approximately 40 cfs, it was deemed unsafe and infeasible to sample.

Habitat

Habitat data were recorded at each sampling site. Representative depth (cm), turbidity (NTU) and temperature (°C) were recorded from a representative location near the middle of each site. Maximum depth (cm) was recorded from the deepest point sampled within each site. Sediment was characterized (i.e., clay, silt, sand, gravel, pebble, cobble, boulder or bedrock) and primary and secondary sediment types were recorded for each sampling site. Stream velocity (cm/s) was also measured, when the instrument was available (November). Stream discharge data were obtained from the U.S. Geological Survey, Flagstaff, Arizona.

Fish

Fish were collected using one of two bag seines. The primary seine was 4.6 m long x 1.8 m high with a 3.2 mm nylon mesh on the wings and 1.6 mm mesh in the 1.8 x 1.8 m bag. This seine was used at all upstream sites (Sites 1-9) and occasionally at sites in the mouth of the

Paria River. We usually used a larger bag seine when sampling the ponded mouth. This seine was 10 m long x 1.8 m high with 6.4 mm mesh on the wings and 3.2 mm mesh in the 1.8 x 1.8 m bag. The total surface area seined was estimated and recorded for each seine haul. Only one seine haul was made at each of Sites 1 - 9. In the mouth of the Paria River, three hauls were made at Sites 10 - 12, ranging from the mixing zone to 200 m upstream.

All fish captured were identified to species, measured for total length (mm), weighed (0.0 g) and released alive at the site of capture. Catch-per-unit-effort was calculated as the number of fish captured / 100 m<sup>2</sup> seined.

## Results and Discussion

### Habitat

#### *Discharge*

The Paria River has a base flow of approximately 4 cfs, but is prone to severe flooding to over three orders of magnitude higher, particularly as a result of monsoon rain storms. Spring discharge was relatively low and even, due to the prolonged, cool spring that we experienced (Figure 2). However, the monsoon season brought several spates, six exceeding 300 cfs and one that reached 5360 cfs.

Dramatic floods are probably the key to the ichthyofauna of the Paria River. Only species which evolved in such a dynamic system could withstand such conditions. Speckled dace appear to be particularly capable of withstanding these floods and/or quickly recolonizing the stream after being displaced. Flannelmouth suckers only use the Paria for spawning and early rearing. YOY suckers will stay in the Paria as long as possible (Thieme 1997; Brouder and Hoffnagle 1997a; b), but do not quickly recolonize after being flushed out.

#### *Temperature*

Temperature varied seasonally in the Paria River from a maximum of 32.2° C in July (Trip 98-2) to a minimum of 0.2° C in December (Trip 98-7) (Table 2). Temperature also varied daily with cooler temperatures being recorded in the morning and rapid warming through the

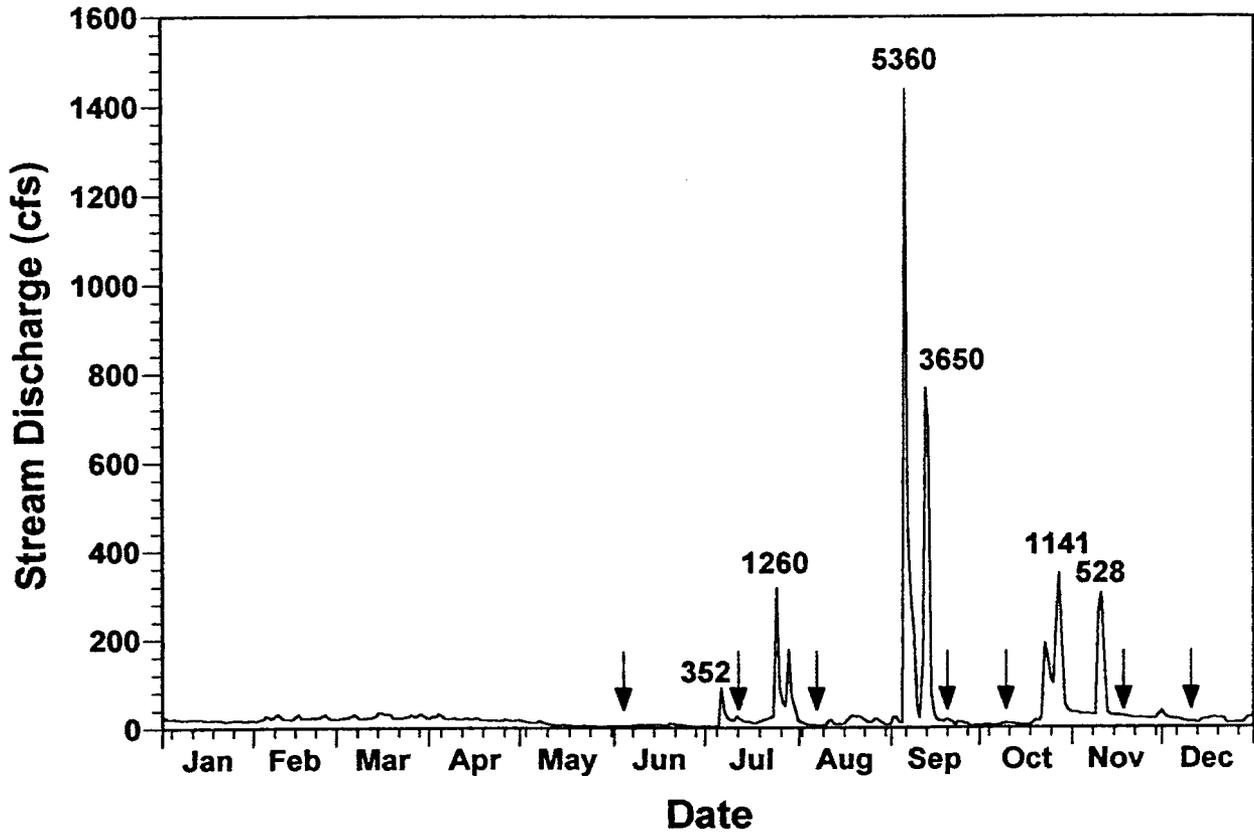


Figure 2. Mean daily discharge in the Paria River, 1998. Maximum discharge of flooding events is given above the peak. Arrows indicate sampling dates.

Table 2. Mean, minimum and maximum temperature ( $^{\circ}$  C) at sites sampled on each trip during Arizona Game and Fish Department Paria River fish monitoring, 1998.

Trip	Mean	Minimum	Maximum
June	19.93	16.6	23.8
July	29.19	15.3	32.2
August	27.49	16.0	31.0
September	23.11	18.6	25.8
October	21.07	16.8	23.8
November	9.64	6.9	11.5
December	3.33	0.2	5.4

day. The daily range of temperatures among trips ranged from 16.2° C in July to 4.6° C in November (Trip 98-6).

The wide, shallow character of the Paria and the open canyon in which it flows are conducive to wide fluctuations in water temperature. In the summer, the Paria River warms rapidly during the day, as evidenced by a 16.2° C temperature change over the approximately four hours that it took to sample all sites. Since we conclude our sampling by 15:00, the maximum temperature and temperature range of the Paria River is undoubtedly higher. The converse is true during winter, when the stream cools rapidly at night. During the December sample, there was ice (2-3 mm thick) along shore and surrounding exposed rocks and frazil ice floating downstream. However, the ice melted by approximately 11:30 and water temperature increased from 0.2° C at 10:40 to 4.9° C at 13:50. Warmer temperatures (5.4° C) were later recorded in the mouth as water from the Paria and Colorado rivers mixed.

#### *Turbidity*

In 1998, turbidity in the Paria River ranged from 22.9 NTU in June to 105,500 NTU in July (Table 3). Turbidity tends to be less in the ponded mouth of the Paria River, where the clear water of the Colorado River dilutes the sediment in the Paria and reduced velocity causes the fine sediment to precipitate.

Turbidity in the Paria River is mostly dependent upon flooding. At base flow, the Paria is a slightly turbid river, measuring approximately 30 NTU. The Paria River is an alluvial stream and drains 3730 km<sup>2</sup> of southern Utah and northern Arizona (Topping 1997). The Paria River is the second largest contributor of sediment to the Colorado River, delivering 23,000 tons of sediment / year (Andrews 1991). Turbidity appears to be used by native fishes as a form of cover - fish are more likely to be captured in shallow water at a turbidity of >30 NTU (Valdez and Ryel 1995; Arizona Game and Fish Department 1996a). Its characteristic high turbidity and high summer temperature may be a large factor in limiting the species diversity of the Paria River.

#### *Velocity*

Velocity was only measured during November. Mean velocity for the 12 sites samples

Table 3. Mean, minimum and maximum turbidity (NTU) at sites sampled on each trip during Arizona Game and Fish Department Paria River fish monitoring, 1998.

Trip	Mean	Minimum	Maximum
June	36.52	22.9	81.0
July	96,630.00	16,800.0	105,500.0
August	161.39	67.1	186.0
September	469.78	217.0	645.0
October	109.93	85.1	142.0
November	1,371.67	1,270.0	1,448.0
December	327.42	195.0	442.0

was 50.9 cm/s and velocity ranged from 12 - 75 cm/s. Velocity in the Paria River is swift for larval fishes. However, it has a low base flow and, in places, a cobble/boulder substrate, making it easy for larvae to find slow water along shore or behind rocks.

#### Depth

Representative and maximum depth of the sampling sites varied on each trip, largely due to variation in river discharge during the sampling period (Table 4). However, antecedent

Table 4. Mean, minimum and maximum representative depth (cm) and maximum depth (cm) at sites sampled on each trip during Arizona Game and Fish Department Paria River fish monitoring, 1998.

Trip	Representative Depth (cm)			Maximum Depth (cm)		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
June	34.5	5	120	62.3	9	134
July	21.8	18	28	56.1	32	96
August	21.5	11	52	57.7	19	98
September	22.0	11	52	41.9	23	72
October	22.3	10	52	38.5	18	74
November	23.0	8	40	51.8	24	84
December	19.2	9	37	29.3	16	45

Table 5. Number of the sampled sites in which each sediment type was the primary or secondary sediment during each Arizona Game and Fish Department Paria River fish monitoring trip, 1998.

Trip	Sediment Type								
	T	Clay	Silt	Sand	Gravel	Pebble	Cobble	Boulder	Bedrock
June		0	10	11	1	0	0	0	0
July		0	7	10	2	0	1	0	0
August		2	6	9	4	2	0	0	1
September		2	7	10	3	2	0	0	0
October		3	6	9	5	0	1	0	0
November		2	7	10	2	1	1	0	1
December		2	5	10	5	1	1	0	0

discharge also affects depth due to scouring and aggradation of sites. Spring floods tend to be of lower volume and carry less sediment per volume of water than monsoon floods (Topping 1997). Mean representative and maximum depth of the sampling sites was greatest in June (Trip 98-1), following the spring floods. Conversely, the large monsoon flood in September changed the course of the stream in several sites and deposited loose sand in areas where there had been deep scour holes along bedrock banks.

*Sediment Characteristics*

Sediment in the Paria River is primarily sand and silt (Table 5). In the ponded mouth, the sediment is primarily silt with clay and sand as secondary sediment types. Coarser sediment types, such as gravel and pebble sediments, tend to be found after flood events scour the finer sediments. The fine sediments return soon afterwards, with the return of lower flows.

Fish Collections

Six species of fish were captured during seven sampling trips in 1998 (Table 6). Three native species were captured: the common flannelmouth sucker and speckled dace, and

Table 6. Total catch and mean, minimum and maximum catch-per-unit-effort (CPUE; number caught / 100 m<sup>2</sup> seined) for each species caught on each trip during Arizona Game and Fish Department Paria River fish monitoring, 1998.

Species	Total Catch	CPUE (number / m <sup>2</sup> seined)		
		Mean	Minimum	Maximum
<u>Trip 98-1: 4 June 1998</u>				
Flannelmouth Sucker	53	3.643	0	18.421
<u>Trip 98-2: 9 July 1998</u>				
Flannelmouth Sucker	2	0.148	0	1.042
Speckled Dace	22	1.284	0	6.14
<u>Trip 98-3: 7 August 1998</u>				
Flannelmouth Sucker	5	0.792	0	6.25
Speckled Dace	6	0.601	0	4.412
Golden Shiner	1	0.149	0	1.786
<u>Trip 98-4: 19 September 1998</u>				
Bluehead Sucker	1	0.139	0	1.667
Flannelmouth Sucker	1	0.139	0	1.667
Speckled Dace	39	3.653	0	16.667
Redside Shiner	1	0.163	0	1.961
<u>Trip 98-5: 9 October 1998</u>				
Flannelmouth Sucker	3	0.313	0	3.75
Speckled Dace	21	1.605	0	5.556
<u>Trip 98-6: 19 November 1998</u>				
Speckled Dace	12	0.726	0	5.128
Rainbow Trout	1	0.103	0	1.235
<u>Trip 98-7: 11 December 1998</u>				
Speckled Dace	1	0.066	0	0.794
Redside Shiner	2	0.043	0	0.517

bluehead sucker *C. discobolus* which is very rare in the Paria River. Three species of non-native fish were also captured: rainbow trout *Oncorhynchus mykiss*, golden shiner *Notemigonus crysoleucas* and redside shiner *Richardsonius balteatus*.

Flannelmouth sucker and speckled dace were commonly captured in all sampling sites

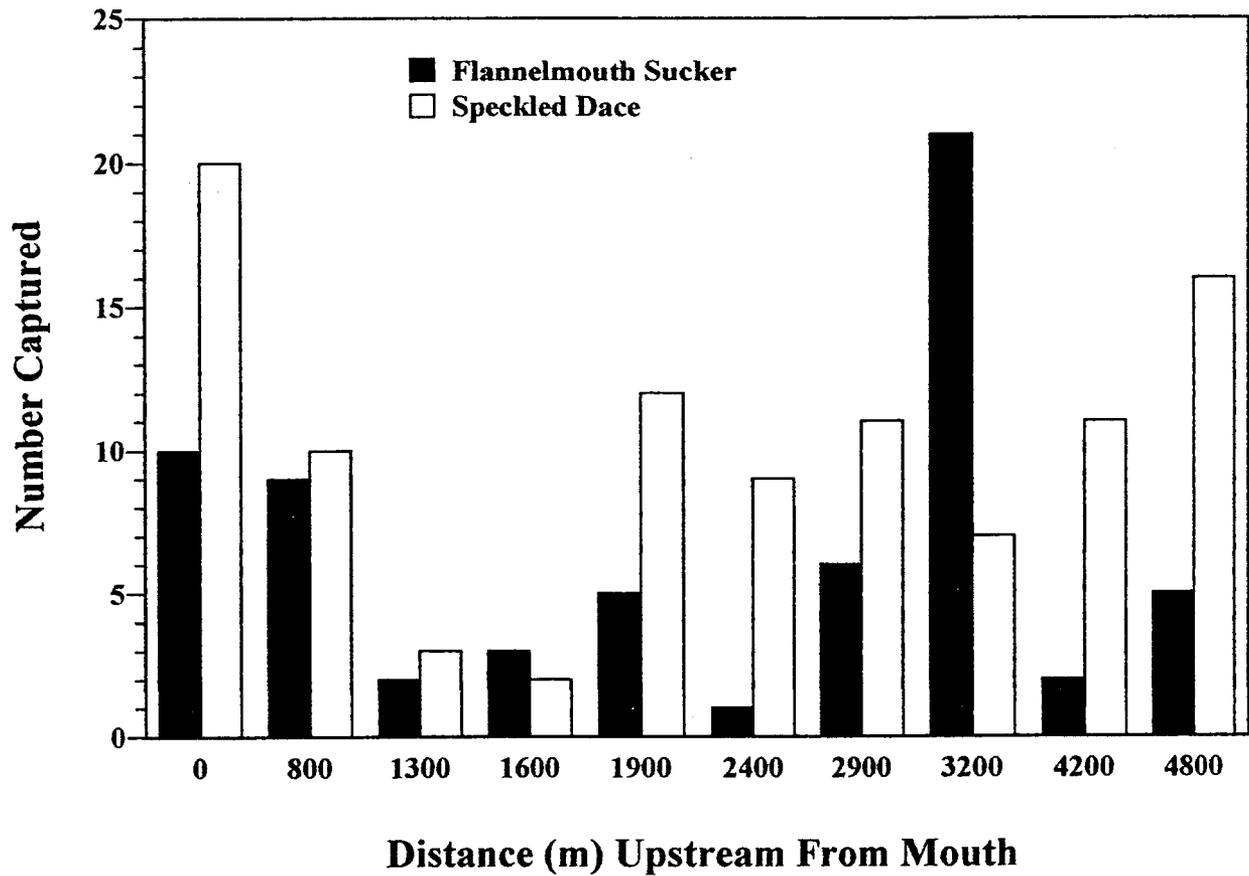


Figure 3. Number of flannelmouth sucker and speckled dace captured at each of the ten standard sampling sites during Arizona Game and Fish Department Paria River fish monitoring, 1998.

(Figure 3). Rainbow trout was captured only from Site 9 (800 m upstream from the mouth). Bluehead sucker, golden shiner and redbside shiner were only caught in the mouth of the Paria River. It is likely that high temperature, high turbidity and/or flash flooding keep numbers of non-native fish low in this stream.

*Bluehead Sucker*

One bluehead sucker was captured in the Paria River in 1998. This adult (265 mm; 244 g) was captured in the mouth of the Paria River in September (Trip 98-4). This species is very rare in this region of the Colorado River. Another subadult/adult (146 mm; 30 g) bluehead sucker was captured 800 m upstream in the Paria River in February 1997 (Brouder and

Hoffnagle 1997b). One hundred eleven juvenile (33 - 61 mm) bluehead suckers were captured in June 1994 (Figure 4). Bluehead suckers are common in the Colorado River downstream from the Little Colorado River (60.6 river miles below the Paria River) where they spawn in all of the major tributaries and most of the smaller ones (Arizona Game and Fish Department 1996a). It is unknown why they are rare above the Little Colorado River. In the Paria River, it may be due to the fine, shifting sediments of this tributary. However, Nankoweap Creek (51.3 river miles below the Paria River) would appear ideal for bluehead suckers.

### *Flannelmouth Sucker*

Young-of-the-year flannelmouth suckers were captured at all sampling sites (Figure 3). Flannelmouth sucker catch was greatest in June, when 53 YOY were captured at a rate of 3.6 fish / 100 m<sup>2</sup> seined and many additional fish were observed in small sides channels and pockets of low velocity water (Table 6; Figure 5). These fish ranged in length from 18 - 36 mm and weighed from 0.1 - 0.4 g. (Tables 7 and 8). In July, three days after the first monsoon flood of the summer, only two YOY were captured and no more YOY were captured the remainder of the year. The lack of flannelmouth suckers in the Paria River in November and December may be due to the Paria being colder than the Colorado River at this time of year.

Adult flannelmouth suckers were captured in the mouth of the Paria River in August, September and October (Figures 3 and 5; Table 6). These fish ranged in length from 430 - 550 mm and in weight from 694 - 1614 g (Tables 7 and 8) and included several that were tuberculate, indicating the possibility of a fall spawning period for these fish. Tuberculate flannelmouth suckers were also captured in Havasu Creek in October (M. Douglas, Arizona State University, personal communication). Arizona Game and Fish Department (1996a) has documented fall spawning by bluehead suckers in Crystal Creek and I observed larval suckers in Crystal Creek in September and October 1998. It appears that some flannelmouth suckers may be induced to spawn in the fall, as well. In all of these cases, the spawning fish have come from the mainstem Colorado River to spawn in a tributary. It may be that monsoon flooding induces this behavior, but this certainly warrants more investigation.

Thieme (1997) estimated that growth of YOY flannelmouth sucker in the Paria River was 0.52 mm / day. However, estimates based on wild fish can be misleading due to death of

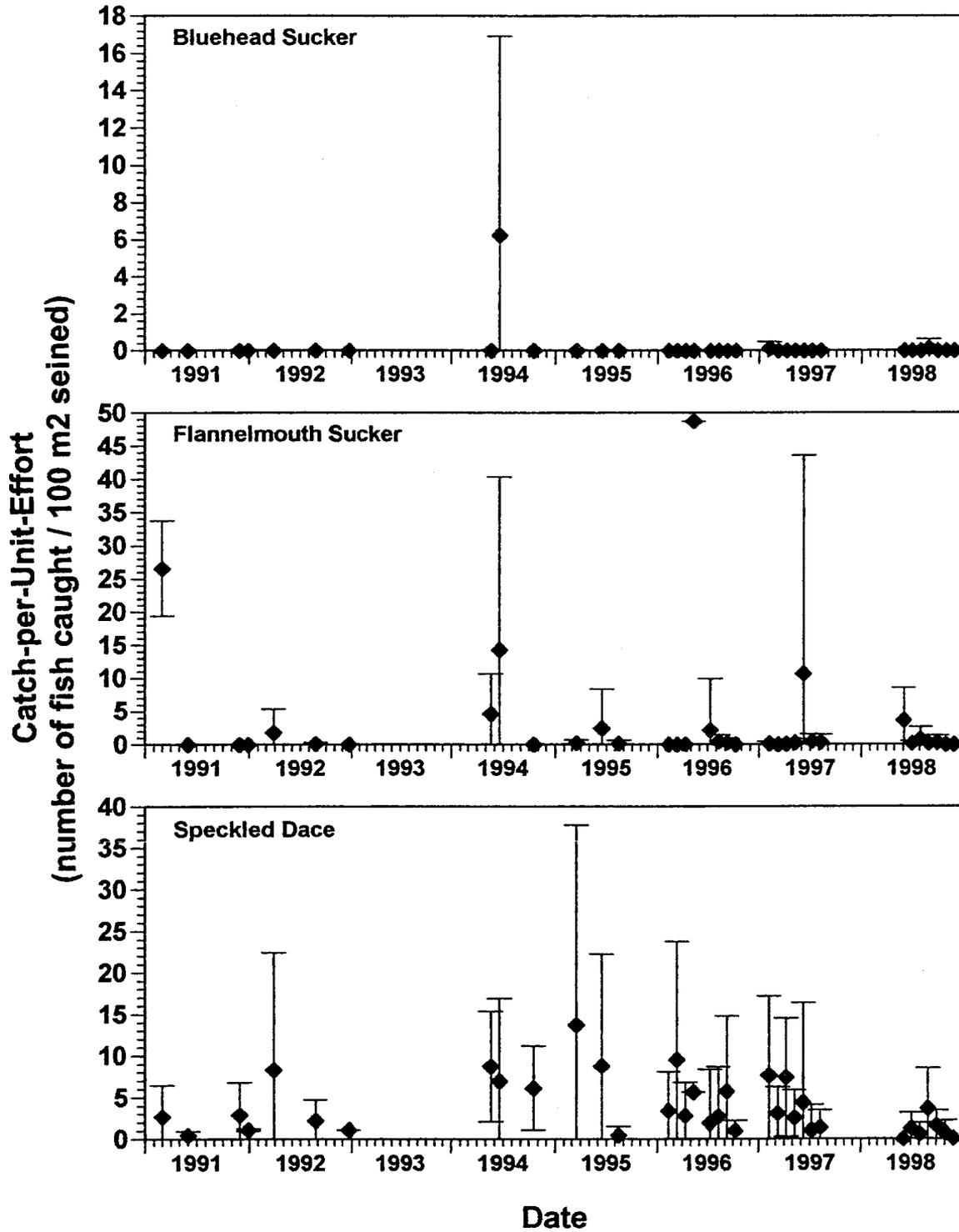


Figure 4. Mean ( $\pm 1$  SD) CPUE of native fishes (bluehead sucker, flannemouth sucker and speckled dace) caught on each sampling trip in the Paria River, Arizona, 1991-1998.

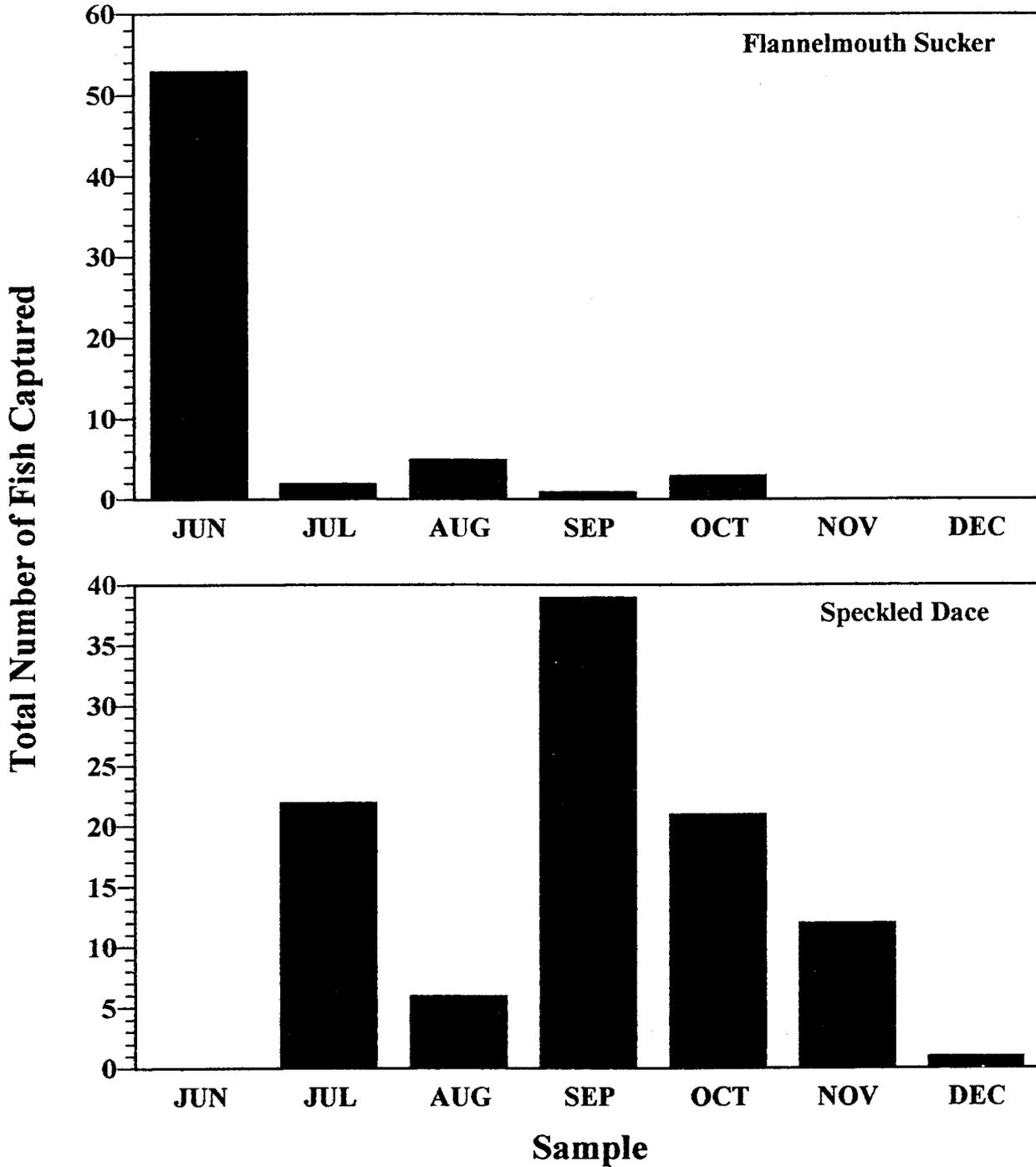


Figure 5. Number of flannemouth suckers and speckled dace captured during each Arizona Game and Fish Department Paria River fish monitoring trip, 1998.

Table 7. Mean, minimum and maximum total length and weight of all species caught on each trip during Arizona Game and Fish Department Paria River fish monitoring, 1998.

Trip/Species	Length (mm)			Weight (g)		
	Mean	Min	Max	Mean	Min	Max
<u>Trip 98-1: 4 June 1998</u>						
Flannelmouth Sucker	26.2	18	36	0.15	0.1	0.4
<u>Trip 98-2: 9 July 1998</u>						
Flannelmouth Sucker	35.0	32	38	0.35	0.2	0.5
Speckled Dace	36.4	20	82	0.70	0.1	4.1
<u>Trip 98-3: 7 August 1998</u>						
Flannelmouth Sucker	467.0	430	550	994.30	694.0	1614.0
Golden Shiner	65.0	65	65	2.40	2.4	2.4
Speckled Dace	67.3	37	96	3.67	0.3	7.3
<u>Trip 98-4: 19 September 1998</u>						
Bluehead Sucker	265.0	265	265	244.00	244.0	244.0
Flannelmouth Sucker	431.0	431	431	950.00	950.0	950.0
Redside Shiner	40.0	40	40	0.40	0.4	0.4
Speckled Dace	80.7	52	123	5.64	1.0	21.1
<u>Trip 98-5: 9 October 1998</u>						
Flannelmouth Sucker	479.0	433	519	1120.30	905.0	1310.0
Speckled Dace	82.6	46	120	2.60	2.6	2.6
<u>Trip 98-6: 19 November 1998</u>						
Rainbow Trout	112.0	112	112	13.00	13.0	13.0
Speckled Dace	93.1	61	116	6.67	2.0	13.0
<u>Trip 98-7: 11 December 1998</u>						
Speckled Dace	95.0	95	95	6.00	6.0	6.0
Redside Shiner	82.5	75	90	4.75	4.2	5.3

Table 8. Number of flannemouth sucker and speckled dace of each length class captured on each trip during Arizona Game and Fish Department Paria River fish monitoring, 1998.

Length Class (cm)	Flannemouth Sucker							Speckled Dace						
	98-1	98-2	98-3	98-4	98-5	98-6	98-7	98-1	98-2	98-3	98-4	98-5	98-6	98-7
1	1													
2	37							8						
3	15	2						10	1					
4								1	2			1		
5										5	2			
6										3	4	1		
7								1		10	4			
8								2		9	2	5		
9									3	6	3	2	2	1
10										3	2	2		
11										2	2	2		
12										1	1	1		
43				2	1	1								
44														
45														
46				2										
47														
48														
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smaller fish, making growth seem faster than it really is. In the lab, flannelmouth sucker eggs hatched in 5-7 days at 18.5° C, the larvae were approximately 11 mm TL at hatching and grew at a rate of 0.31 mm / day at 20° C (Mike Childs, AGFD, personal communication). However, lab fish may not grow as fast as wild fish due to the ability of wild fish to feed at any time, whereas in the lab, fish can only feed when they are fed. Therefore, I estimated date of hatching based on a growth rate of 0.4 mm / day, which gave an estimated date of hatching between 2 April and 17 May 1998 and an estimated spawning date of 26 March - 10 May. This means that flannelmouth suckers probably spawned throughout the period of descending discharge in the Paria River. It appears from these data that the main spawning period occurred around 28 April based on the peak length class of 23 mm.

In 1996, the last year in which they were abundant, YOY flannelmouth suckers first appeared in samples during May (CPUE = 48.7 flannelmouth sucker / 100 m<sup>2</sup> seined; Brouder and Hoffnagle 1997a). In 1998, we awaited word of spawning activity before beginning sampling. However, there was no observed spawning aggregation at the mouth of the Paria River nor a run upstream (S. Rogers, AGFD, personal communication). Discharge in the Paria River from 1 January through early June was typical of previous years (Graf et al 1991): spring 1998 air temperature was cool and mean daily discharge ranged from 20 - 35 cfs through early April, then steadily declined to base flow by the end of May (Figure 2). It is unknown why no spawning aggregation was observed this year. In the Little Colorado River, the cool spring and an extended runoff period extended the 1998 spawning period for all native fishes (Hoffnagle 1998). However, flannelmouth suckers may not require flooding or increasing water temperature for induction of spawning. Each spring flannelmouth suckers spawn on a gravel bar in the Colorado River approximately 5.4 miles upstream from the Paria (approximately 10.5 miles below Glen Canyon Dam). Due to the dam, there is little annual change in flow regime nor a change in water temperature in this area. Therefore, it is likely that photoperiod is a strong cue for spawning of flannelmouth suckers.

Flannelmouth sucker catch is highest in the spring, with the capture of spawning adults and later YOY (Figure 4). All flannelmouth suckers captured after July 1998 were adults. The loss of the YOY suckers from the Paria River is likely due to monsoon floods which flush young fish into the Colorado River. High catches (4 - 50 fish / 100 m<sup>2</sup> seined) of YOY flannelmouth

suckers occurred throughout 1996, when there were no floods until late in the summer (Brouder and Hoffnagle 1997a). Brouder and Hoffnagle (1997a) and Thieme et al. (1997) hypothesized that a lack of flooding and the presence of a ponded mouth permitted YOY flannelmouth suckers to rear in the Paria River throughout the summer of 1996 and Thieme (1997) later attributed this primarily to the presence of a ponded mouth. Results from 1998 sampling suggest that the lack of flooding may have been the primary factor. The Colorado River discharge has been higher than normal throughout 1998, significantly ponding the mouth of the Paria River. Flooding occurred in the Paria River this year and catches of YOY flannelmouth suckers were greatly reduced or absent after these events, even in the ponded mouth. At a minimum, it appears that this year's pool was an insufficient buffer to prevent young fish from being flushed into the Colorado River by late spring floods.

### *Speckled Dace*

Speckled dace were captured in the Paria River on all 1998 sampling trips, except in June (Figure 5; Table 6) and at all sampling sites (Figure 3). Mean CPUE for this species ranged from 0.1 - 3.7 fish / 100 m<sup>2</sup> seined, in December and September, respectively. Speckled dace ranged in length from 20 - 123 mm and in weight from 0.1 - 21.1 g (Table 7). Both YOY and adult speckled dace were captured (Table 8).

Speckled dace are the most abundant fish in the Paria River and they use the river, at least throughout the period in which it is warmer than the Colorado River. Only one speckled dace was captured during December and that was caught in the mouth. Surprisingly, no speckled dace were captured in June. This was likely due to one, or both, of two reasons. First, larger speckled dace were probably able to evade the net in the clear, shallow water, and several larger fish were observed darting ahead of the net. Secondly, it was probably too early in the season for larval speckled dace to be present. In 1996 and 1997, YOY speckled dace appeared in the catches by late May (Brouder and Hoffnagle 1997a; b). However, it is likely that speckled dace also spawned later than usual in 1998, due to a late and prolonged spring flood, which is a spawning cue for this species (John 1963). Most of the speckled dace captured during July were YOY, indicating a successful spawn after or just prior to the June sampling period. John (1963) also noted spawning cued by monsoon floods in the Chiricahua Mountains, Arizona, which has

not been noted in the Paria River.

Speckled dace also appear to be affected by flooding. Catches tend to be highest from late spring through summer (Figure 4). The August sample occurred in the middle of the monsoon flood period and only 6 speckled dace were captured (only two came from above the mouth). However, in contrast to flannelmouth sucker, speckled dace recolonized the Paria soon after flooding. By the September trip (13 days following the largest flood of the year; approximately 6,000 cfs), the speckled dace abundance reached its highest of the year (39 fish; 3.7 fish / 100 m<sup>2</sup> seined). It is unknown whether these fish withstood the flood, recolonized from the Colorado river or were flushed downstream from upper reaches of the Paria.

Speckled dace may not occupy the Paria River year-round, as was previously thought. During December, no dace were caught above the mouth and only one was caught in the mouth. Ice was present in the Paria as sampling began and water temperature was 0.2° C at the first site. The Colorado River is a nearly constant 8 - 10° C year-round. It would seem sensible for the fish to leave the colder Paria for the relatively warmer Colorado when temperatures drop below their thermal preference.

#### *Golden Shiner*

One golden shiner was caught in August (Table 6). This fish was 65 mm long and weighed 2.4 g (Table 7). Golden shiners have also been caught in 1996 in the mouth of the Paria (Figure 6).

The golden shiner is native to the Mississippi and Atlantic coast drainages (Sigler and Sigler 1996). It is rare in the Colorado River and its tributaries between Glen Canyon Dam and Diamond Creek - one was caught in the mouth of the Paria River in 1996 (Brouder and Hoffnagle 1997a) and another in a backwater of the Colorado River just above its confluence with the Little Colorado River in 1997 (Arizona Game and Fish Department 1996a). The golden shiner captured in the Paria in 1998 was probably an age 1 fish, based on growth data compiled by Carlander (1969). Since this species has been captured here before, it is possible that this fish was spawned in the mouth of the Paria, survived a trip through the Glen Canyon Dam turbines or is a released bait fish. Golden shiners prefer quiet pools and backwater habitat and is tolerant of moderate turbidity (Pflieger 1975), similar to that found in the ponded Paria River mouth.

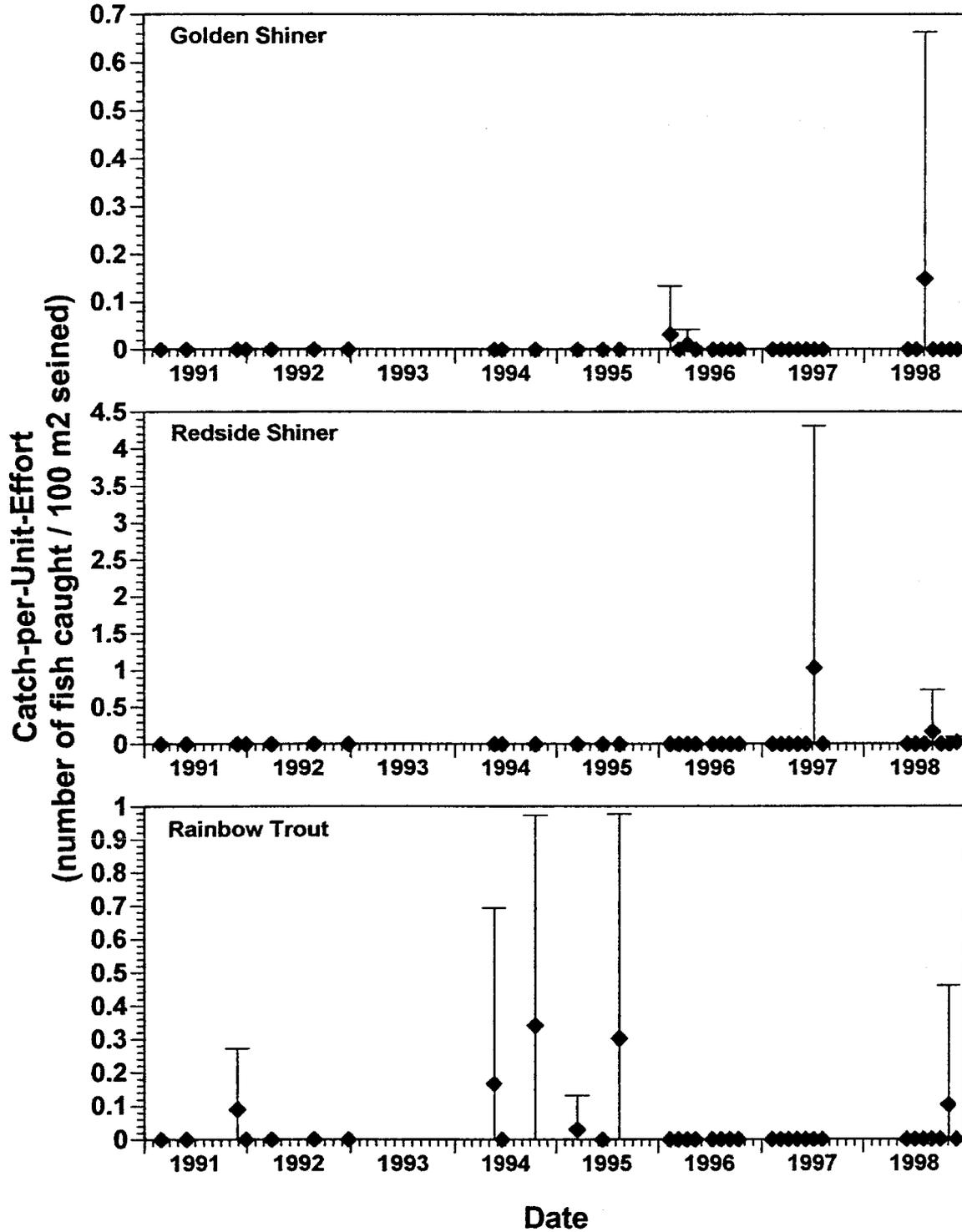


Figure 6. Mean ( $\pm 1$  SD) CPUE of non-native fishes (golden shiner, redside shiner and rainbow trout) caught on each sampling trip in the Paria River, Arizona, 1991-1998.

Golden shiners feed on algae, invertebrates and small fish (Minckley 1973; Pflieger 1975) and may compete with flannelmouth suckers and speckled dace for invertebrates (Arizona Game and Fish Department 1996a). Because of interactions with native fish, golden shiner has been implicated in the demise of the Little Colorado River spinedace *Lepidomeda vittata* in Chevalon Creek, Arizona (Minckley and Carufel 1967). It appears unlikely that golden shiners will colonize the Paria River upstream of its mouth and frequent flooding will probably keep their abundance low in the generally small ponded area. However, it is possible that long-term ponding of the mouth may allow this species to increase their numbers and impact the native flannelmouth suckers and speckled dace.

#### *Redside Shiner*

One redside shiner was captured in September and another two were captured in December (Table 6). These fish ranged in size from 40 - 90 mm and 0.4 - 5.3 g (Table 7). Redside shiners were also caught in 1997, when 18 were caught in the mouth of the Paria in July (Figure 6).

The redside shiner is native to the Columbia River and Bonneville Basin drainages. It is also rare in the Colorado River and tributaries in Grand Canyon. They are occasionally caught in the Paria River mouth (Brouder and Hoffnagle 1997b) and they have been caught in the Colorado and lower Little Colorado rivers (Kaeding and Zimmerman 1983; Arizona Game and Fish Department 1996b). This fish is omnivorous and may compete with or prey on larval native species (Minckley 1973; Sigler and Sigler 1996). However, it is rarely captured in the Paria and Colorado rivers, probably due to the Colorado River being too cold and the Paria River being too warm (Sigler and Sigler 1996). Therefore, this species is unlikely to be detrimental to native fishes under the current environmental conditions in these streams.

#### *Rainbow Trout*

One rainbow trout was captured at Site 9 (800 m upstream from the mouth) in November (Table 6). This fish was 112 mm long and weighed 13 g (Table 7). Rainbow trout are the most common species of fish in this reach of the Colorado River and they are occasionally captured in the mouth of the Paria River and a short distance upstream (Figure 6). However, the high

summer temperature and year round high turbidity keep this species from invading the Paria. Rainbow trout are predators of larval fishes (Marsh and Douglas 1997) and no small flannelmouth suckers have been captured in the Colorado River below the Paria (Arizona Game and Fish Department 1996a). It is hypothesized that this is because cold-shocked larvae are being consumed by rainbow trout, although no data has substantiated this.

### **Conclusion**

The Paria River fish community remains limited to flannelmouth sucker, speckled dace and the few uncommon species that are captured only in or near its mouth. Both flannelmouth sucker and speckled dace continue to spawn in the Paria, with only speckled dace successfully recruiting in 1998. However, flannelmouth sucker are a long-lived species (Minckley 1991) that probably does not require annual recruitment to maintain a healthy population. Continued monitoring and, possibly, management actions will be necessary to ensure that the fishes of this dynamic stream are maintaining themselves.

### **Recommendations**

I believe that the protocols used in this monitoring/research should be evaluated to ensure that the data are being effectively and efficiently collected. For example, Data collected prior to 1998 was collected whenever time permitted. The monthly sampling scheme implemented in 1998 is an effort to ensure that sampling is conducted during all periods of the year. It is expected that following the 1999 field season, the monitoring schedule will be reduced to spring, summer and fall, with more intensive sampling to be continued during the spring spawning period. However, any changes made to this protocol must be comparable with data collected from previous years. The following are some suggested changes for 1999 that will provide additional information, but will be compatible with previous data.

1 - Continue sampling the Paria River monthly, except from 1 April through 3 June, when trips should be conducted at least biweekly to better document spawning time and presence of YOY

flannelmouth sucker and speckled dace.

2 - Since a spawning bar has been identified close upstream from Site 1 (M. Brouder, Arizona Game and Fish Department, personal communication) an additional sampling site should be located at there and another between the spawning bar and the present Site 1.

3 - Past seine sampling has been habitat-selective in favor of smooth-bottomed runs, which may have biased the catch. Therefore, additional samples should be taken from other areas. For example, rocky areas (e.g., riffles) may be sampled by using personnel to chase fish into a seine.

4 - Velocity was only measured on one trip in 1998 due to equipment not being available. Temperature, turbidity and velocity are known to be the factors primarily influencing habitat selection by small fishes (Arizona Game and fish Department 1996a). Therefore, these factors should be measured consistently on each trip.

5 - Use of the Paria River by adult flannelmouth suckers and speckled dace appears to be influenced by Colorado River temperature. Colorado River turbidity and discharge may also influence fish behavior. Therefore, these variables should be recorded from the Colorado River near the mouth of the Paria River on each sampling trip.

6 - Use night sampling with a winged hoop net to capture fishes, particularly adult flannelmouth sucker, entering the mouth of the Paria after dark.

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**Appendix**

Appendix 1. List of personnel for Arizona Game and Fish Department Paria River Fish Monitoring, 1998.

<u>Trip/Participant</u>	<u>Agency</u>
<u>Trip 98-1: 4 June 1998</u>	
Tim Hoffnagle	Arizona Game and Fish Department
Pam Sponholtz	Arizona Game and Fish Department
Kirsten Rowell	Grand Canyon Monitoring and Research Center
Paul Bagdonas	Arizona Game and Fish Department volunteer
<u>Trip 98-2: 9 July 1998</u>	
Tim Hoffnagle	Arizona Game and Fish Department
Mark Brouder	Arizona Game and Fish Department
<u>Trip 98-3: 7 August 1998</u>	
Tim Hoffnagle	Arizona Game and Fish Department
Dave Baker	Arizona Game and Fish Department
Brian Hoffnagle	Arizona Game and Fish Department volunteer
<u>Trip 98-4: 19 September 1998</u>	
Tim Hoffnagle	Arizona Game and Fish Department
Pam Sponholtz	Arizona Game and Fish Department
Brian Hoffnagle	Arizona Game and Fish Department volunteer
<u>Trip 98-5: 9 October 1998</u>	
Tim Hoffnagle	Arizona Game and Fish Department
Mike Rabe	Arizona Game and Fish Department
Debbie Brown	Arizona Game and Fish Department
<u>Trip 98-6: 19 November 1998</u>	
Tim Hoffnagle	Arizona Game and Fish Department
Debbie Brown	Arizona Game and Fish Department
Bob Bramblett	U.S. Fish and Wildlife Service
Randy Van Haverbeke	U.S. Fish and Wildlife Service
<u>Trip 98-7: 11 December 1998</u>	
Tim Hoffnagle	Arizona Game and Fish Department
Pam Sponholtz	Arizona Game and Fish Department
Dan Redondo	U.S. Forest Service/Northern Arizona University