PARIA RIVER NATIVE FISH MONITORING
1998 ANNUAL REPORT

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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

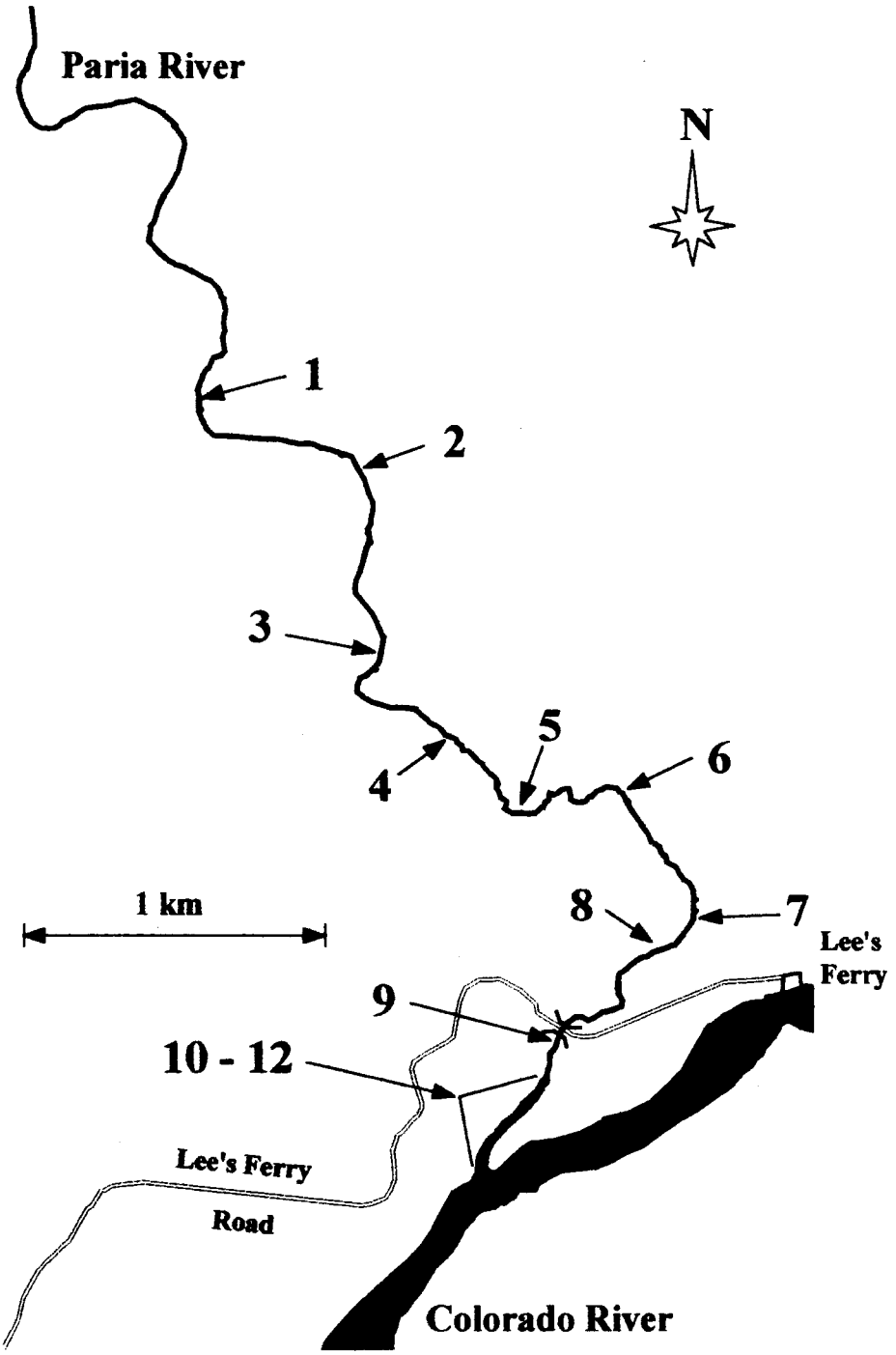

Figure 1. Sampling sites used by Arizona Game and Fish Department in the lower Paria River, Arizona (see Table 1 for description of sites).

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^2 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

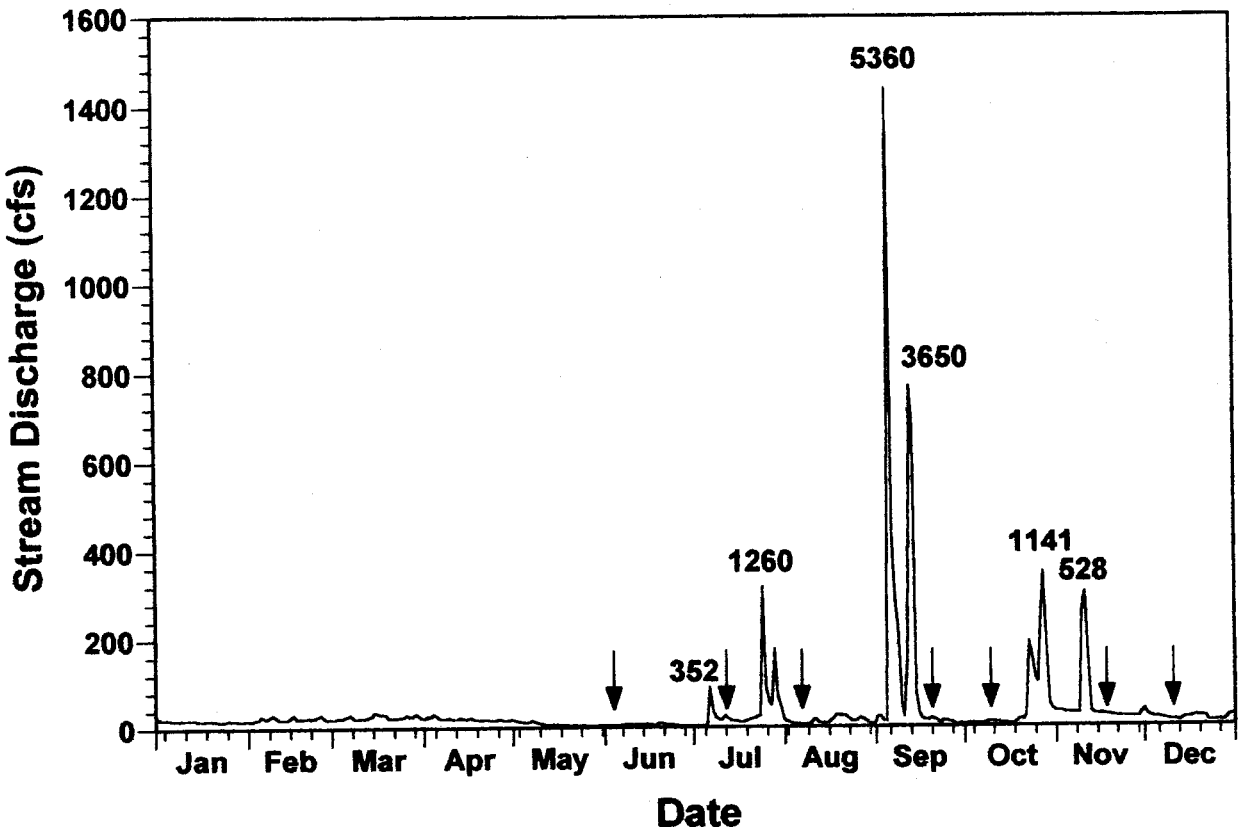

Figure 2. Mean daily discharge in the Paria River, 1998. Maximum discharge of flooding events is given above the peak. Arrows indicate sampling dates.

Table 2. Mean, minimum and maximum temperature (° 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^2 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.

	Representative Depth (cm)			Maximum Depth (cm)		
Trip	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.

	Sediment Type							
Trip	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 agradation 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^2 seined) for each species caught on each trip during Arizona Game and Fish Department Paria River fish monitoring, 1998.

		CPUE (number / m^2 seined)		
Species	Total Catch	Mean	Minimum	Maximum
Trip 98-1: 4 June 1998				
Flannelmouth Sucker	53	3.643	0	18.421
Trip 98-2: 9 July 1998				
Flannelmouth Sucker	2	0.148	0	1.042
Speckled Dace	22	1.284	0	6.14
Trip 98-3: 7 August 1998				
Flannelmouth Sucker	5	0.792	0	6.25
Speckled Dace	6	0.601	0	4.412
Golden Shiner	1	0.149	0	1.786
Trip 98-4: 19 September 1998				
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
Trip 98-5: 9 October 1998				
Flannelmouth Sucker	3	0.313	0	3.75
Speckled Dace	21	1.605	0	5.556
Trip 98-6: 19 November 1998				
Speckled Dace	12	0.726	0	5.128
Rainbow Trout	1	0.103	0	1.235
Trip 98-7: 11 December 1998				
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

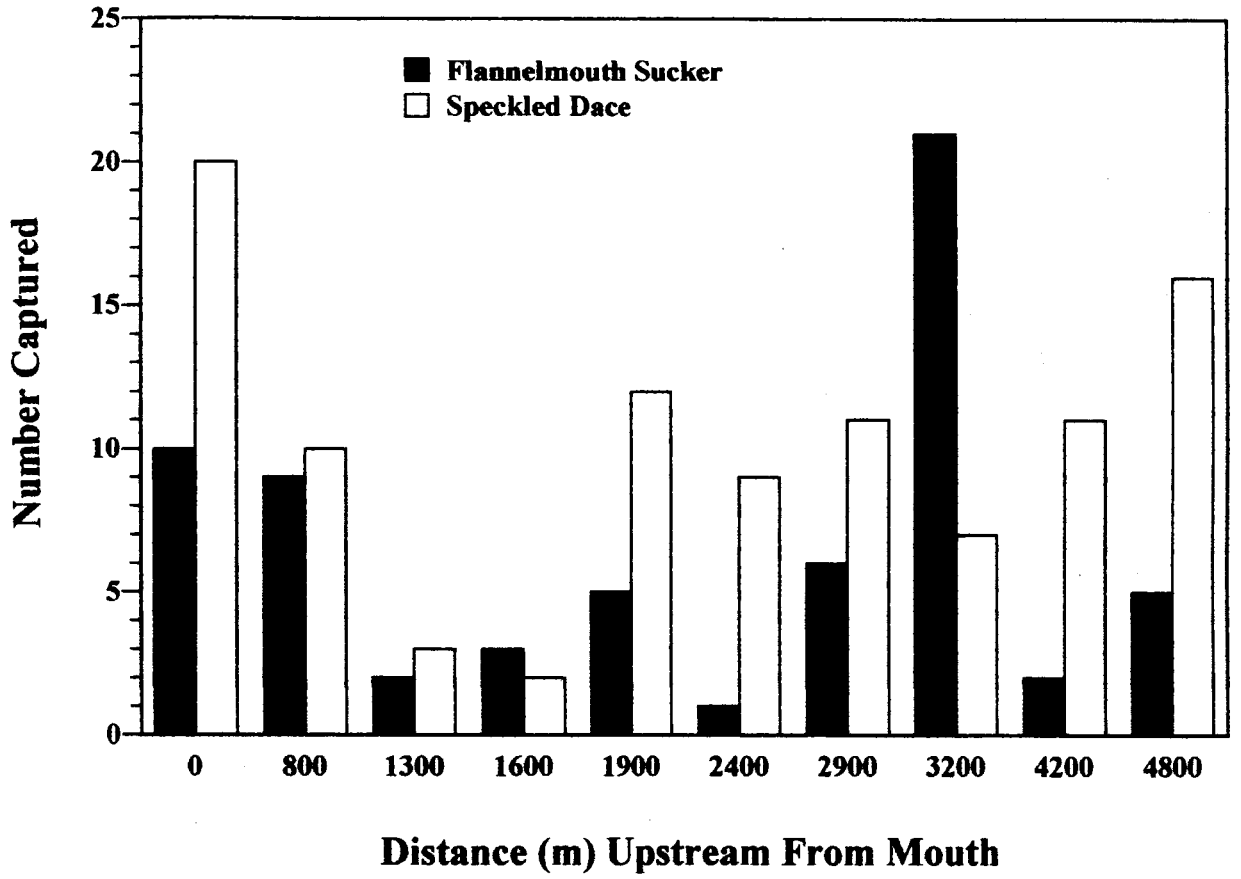

Figure 3. Number of flannelmouth sucker and speckled dace captured at each of the ten standard sampling sites during Arizona Game and Fish Department Paria River fish monitoring, 1998.

(Figure 3). Rainbow trout was captured only from Site 9 (800 m upstream from the mouth). Bluehead sucker, golden shiner and redside 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^2 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

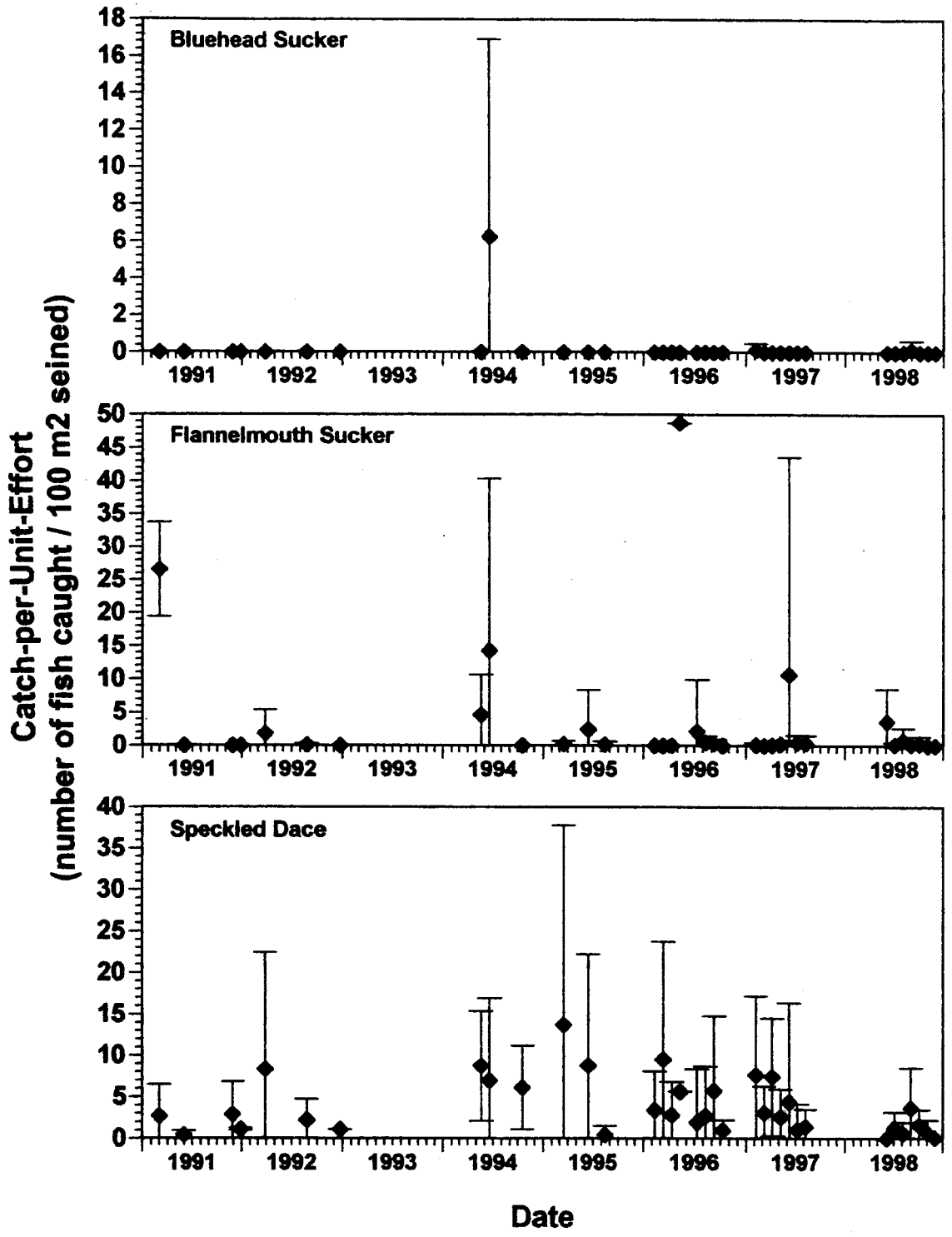

Figure 4. Mean (± 1 SD) CPUE of native fishes (bluehead sucker, flannelmouth sucker and speckled dace) caught on each sampling trip in the Paria River, Arizona, 1991-1998.

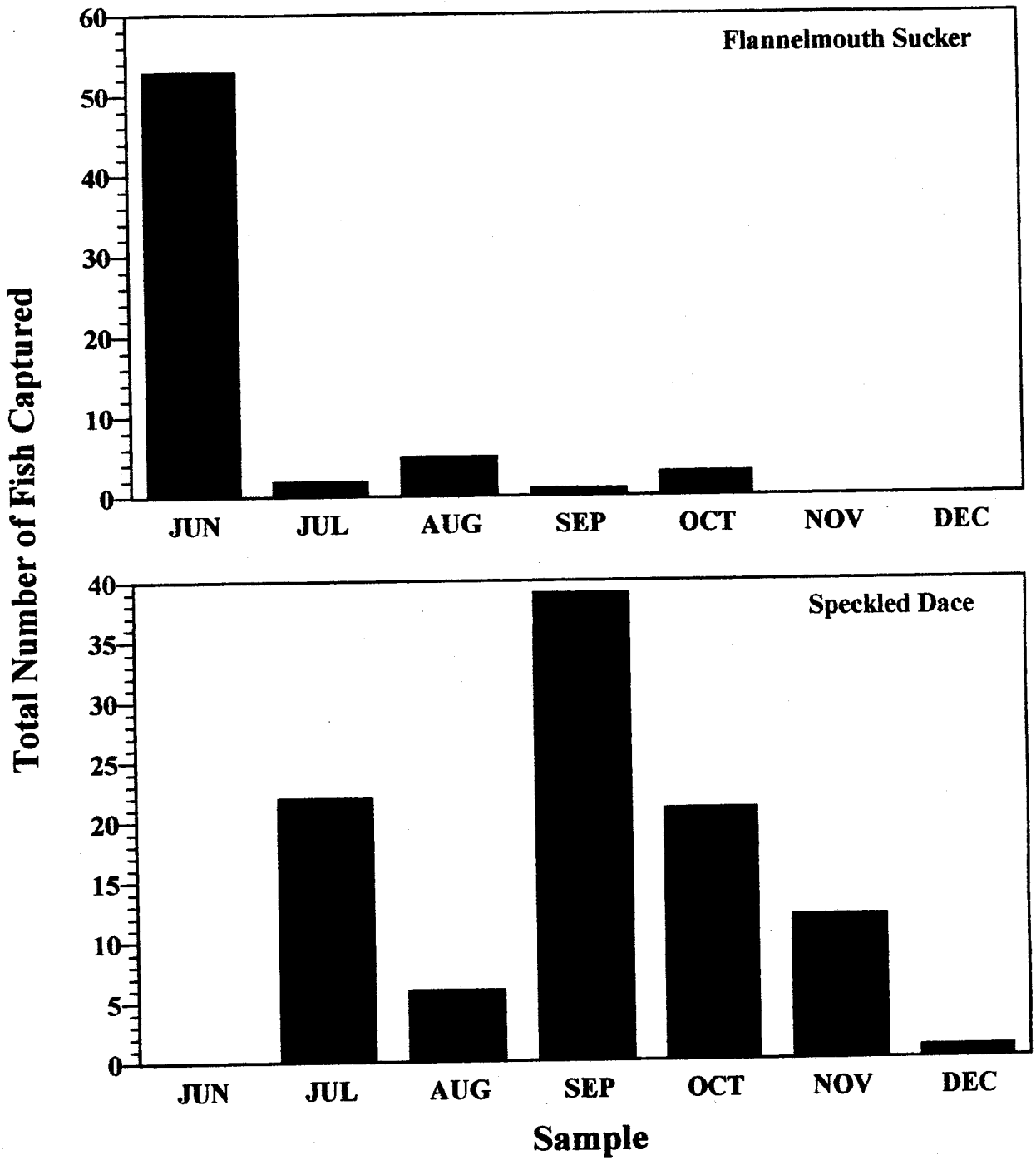

Figure 5. Number of flannelmouth suckers and speckled dace captured during each Arizona Game and Fish Department Paria River fish monitoring trip, 1998.

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.

	Length (mm)			Weight (g)		
Trip/Species	Mean	Min	Max	Mean	Min	Max
Trip 98-1: 4 June 1998						
Flannelmouth Sucker	26.2	18	36	0.15	0.1	0.4
Trip 98-2: 9 July 1998						
Flannelmouth Sucker	35.0	32	38	0.35	0.2	0.5
Speckled Dace	36.4	20	82	0.70	0.1	4.1
Trip 98-3: 7 August 1998						
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
Trip 98-4: 19 September 1998						
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
Trip 98-5: 9 October 1998						
Flannelmouth Sucker	479.0	433	519	1120.30	905.0	1310.0
Speckled Dace	82.6	46	120	2.60	2.6	2.6
Trip 98-6: 19 November 1998						
Rainbow Trout	112.0	112	112	13.00	13.0	13.0
Speckled Dace	93.1	61	116	6.67	2.0	13.0
Trip 98-7: 11 December 1998						
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 flannelmouth 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)	Flannelmouth 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	1
10											3	2	2	
11											2	2	2	
12											1	1		
43			2	1	1									
44														
45														
46			2											
47														
48					1									
49														
50														
51					1									
52														
53														
54														
55			1											

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 m2 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^2 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^2 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^2 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.

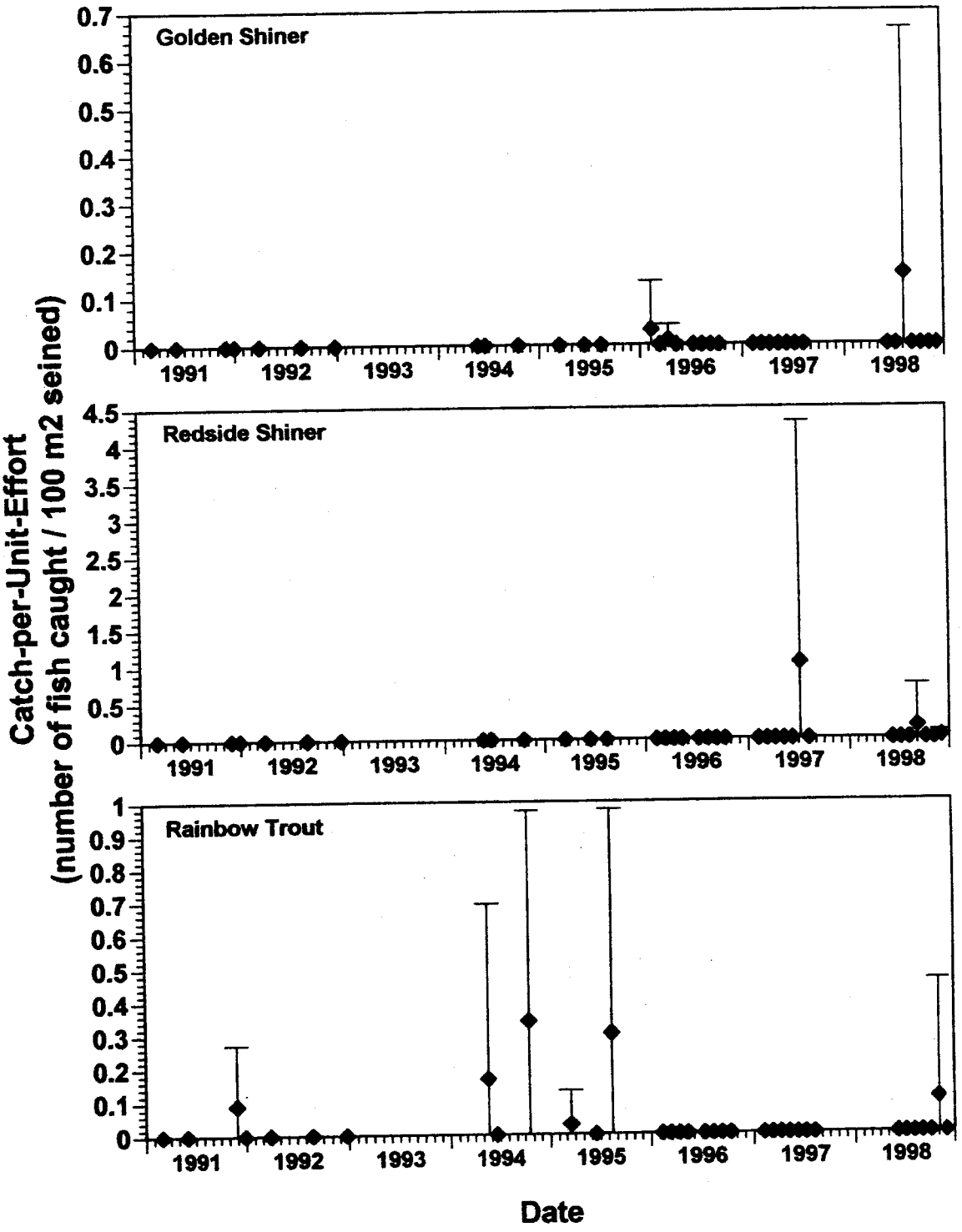

Figure 6. Mean (± 1 SD) CPUE of non-native fishes (golden shiner, redside shiner and rainbow trout) caught on each sampling trip in the Paria River, Arizona, 1991-1998.

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

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February 10, 1999

Dr. Owen Gorman, Project Leader
Grand Canyon Fishery Resources Office
U. S. Fish and Wildlife Service
P. O. Box 338
Flagstaff, Arizona 86002-0338

Re: Paria River Native Fish Monitoring: 1998 Annual Report

Dear Owen,

Enclosed is the above referenced report, submitted in partial fulfillment of our Cooperative Agreement 1448-20181-98-J805. It presents results of Paria River sampling during 1998. Please let Tim Hoffnagle or me know if you have any questions about the report.

Sincerely,

Bill Persons

Bill Persons
Research Program Supervisor

Cc: Barry Gold, Grand Canyon Monitoring and Research Center
Barbara Ralston, Grand Canyon Monitoring and Research Center
Kirk Young, AGFD Nongame Branch
Pam Sponholtz, AGFD Habitat Branch
Larry Riley, AGFD Fisheries Branch
Scott Reger, AGFD Region II
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Tim Hoffnagle, AGFD Research Branch