Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

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Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

TWENTIETH ANNUAL SYMPOSIUM

Death Valley National Monument Headquarters

Furnace Creek, California

November 16-19, 1988

PREFACE

The Twentieth Annual Symposium was a nostalgic event for most members, as we recounted the Council's origin and evolution and the role it has played in protection and preservation of desert aquatic ecosystems. Nearly 200 attended the three-day meeting, representing 13 offices of the U.S. Fish and Wildlife Service, 6 offices of the Bureau of Land Management, 4 units of the National Park Service, 4 national forests, 3 offices of the Bureau of Reclamation, 2 offices of the Geological Survey, the fish and wildlife agencies of 7 western states, the Sierra Club, Naval Weapons Center at China Lake, two offices of The Nature Conservancy, 36 universities and colleges from throughout North America, and several private consulting firms (an attendance list is included in the appendix). In addition to reports of activities of government agencies, 40 research papers were presented relating to desert aquatic communities.

In commemoration of the twentieth anniversary, an extra day was added to the usual three-day symposium devoted to the general subject of "Battle Against Extinction: Native Fish Management in the American West." Twenty papers were presented in this special session, which will be published as a book by University of Arizona Press, edited by W. L. Minckley and J. E. Deacon. Publication date is scheduled for late 1989. The general program for the special symposium is included in the appendix.

Following the Thursday paper sessions, the Council held its usual barbecue. Because of extremely stormy conditions in Death Valley, National Park Service personnel allowed us to move into the sheltered area next to the auditorium. As has been their practice throughout the Council's history, the National Park Service extended every courtesy to us. For this we remain very grateful.

At the November 16 business meeting it was decided that the 1989 symposium would be held during the period of November 16-18 at Albuquerque, New Mexico, hosted by the University of New Mexico, U.S. Fish and Wildlife Service, and New Mexico Department of Game and Fish, with Steve Platania serving as general coordinator. It is currently planned that the 1990 symposium will be held in Mexico, with the exact location to be determined in 1989.

Progress Report: A comparison of morphology, thermal tolerances, and biochemical genetics of the Kendall Warm Springs dace (Rhinichthys osculus thermalis) and speckled dace (R. osculus yarrowi) of the upper Green River drainage in Wyoming.

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Abstract

Comparisons of morphology, thermal tolerance, and biochemical genetics between Kendall Warm Springs dace (Rhinichthys osculus thermalis), listed as an endangered fish by the U.S. Fish and Wildlife Service, and speckled dace (R. o. yarrowi) of the upper Green River drainage have demonstrated both similarities and differences. Tolerances for high temperatures (critical thermal maxima) do not differ significantly. Electrophoretic examination of 26 loci have shown no variants at any locus in either population, and both populations are fixed at all loci. However, five of eight restriction enzymes reveal polymorphic mitochondrial DNA (mtDNA) in R. o. yarrowi, and only one enzyme revealed a polymorphic mtDNA in R. o. thermalis. The most important morphological difference measured is in pharyngeal tooth formulas, with 86% of R. o. thermalis lacking pharyngeal teeth in at least one secondary row, compared with less than 1% of R. o. yarrowi. R. o. yarrowi have been spawned, incubated, and are being reared at 18, 24, and 28 C to determine thermal lability of meristic features, and whether those at the highest temperature will remain differentiable from R. o. thermalis.

Introduction

The purpose of this study is to determine differences or similarities between the Kendall Warm Springs dace (Rhinichthys osculus thermalis) and speckled dace (R. osculus, also known as R. o. yarrowi) of the upper Green River drainage through comparisons of several categories of characteristics: morphology and meristics, physiological thermal tolerances, and biochemical genetics. These comparisons are intended to evaluate the validity of the present subspecific designation of the Kendall Warm Springs dace, which is listed as an endangered fish by the U. S. Fish and Wildlife Service. These dace were first designated as a separate subspecies by Hubbs and Kuhne (1937), on the basis of morphological differences from other R. osculus and on their isolation in a small, thermal spring creek. Since it is possible that some of these morphological differences could be environmentally induced by elevated temperatures during early development of the young, as recognized by Hubbs and Kuhne (1937), the validity of the subspecific designation has remained in question.

Methods

Specimens of _R. osculus thermalis_ were collected from Kendall Warm Springs and _R. o. yarrowi_ from three sources: the Green River upstream from the mouth of Kendall Warm Springs; Boulder Creek, a tributary downstream from its mouth, and Duck Creek, a tributary to the Green River near Pinedale, Wyoming. Collections were made in accordance with permits issued by the U. S. Fish and Wildlife Service (FA/SE/Blanket Permit, Subpermit 86-16) and the Wyoming Game and Fish Department (Permit No. 91). Collection dates were October 3, 1987 and September 6, 1988 in Kendall Warm Springs and Duck Creek, and September 7, 1988 in the Green River and Boulder Creek. Dace were taken with dip nets in Kendall Warm Springs and with a backpack electrofisher in the other waters. A total of about 50 dace from each source were preserved in formalin for morphologic measurements. About 150 from Kendall Warm Springs, 75 each in 1987 and 1988, and about 350 from Duck Creek, 250 in 19877 and 100 in 1988, were transported live to Montana State University in Bozeman. All references to live specimens of speckled dace (_R. o. yarrowi_) in this report refer to those taken from Duck Creek.

Morphologic and meristic measurements followed standard procedures and concentrated on numbers of fin rays, lateral line scales, and pharyngeal teeth.

For tests on thermal tolerances, Kendall Warm Springs dace and speckled dace were acclimated to 27 C, and speckled dace also to 24 C, before being subjected to standard measurements (Paladino et al. 1980) of their critical thermal maxima (CTM). Dace were tested individually in 14.5 liter tanks. Temperature started at the acclimation level and was raised at a rate of .45 C per minute until the endpoint was reached of first loss of equilibrium by the fish.

Electrophoretic analyses of protein variation and mitochondrial DNA were conducted both on specimens sacrificed from among those maintained live, and specimens frozen after dying in captivity. Protein variation of both liver and muscle tissue was studied through methods similar to that described in Brussard et al. (1981), while techniques for comparisons of mitochondrial DNA (mtDNA) restriction endonuclease cleavage sites were similar to that described by Avise et al. (1984).

For attempts at captive breeding, speckled dace were maintained at temperatures of 15 to 24 C, and Kendall Warm Springs dace at 24 and 28 C, under 14 hour photoperiod, until specimens appeared to become gravid. Specimens tentatively identified to sex by external appearance were placed in 75-liter spawning tanks in groups of three, two males and a female, or five, three males and three females. Spawning substrates were either gravel, small rocks, or a contoured, woven, plastic material (Tensar Mat, Tensar Corporation, Morrow, Georgia) held down with rocks and gravel.

Results and Discussion

Morphology

Selected morphological features are presented in Table 1. The number of lateral line scales is significantly lower in Kendall Warm springs dace than in speckled dace from the other three sources, and the number of pectoral fin rays is significantly different from those of speckled dace

Table 1. Selected morphological features of Rhinichthys osculus thermalis and three nearby populations of R. o. yarrowi. Mean counts and (standard deviations) are given for lateral line (LL) scales and pectoral fin (PF) rays. Number of individuals and (% of total) are given for fish lacking pharyngeal teeth in at least one secondary row.

	R. o. thermalis	R. o. yarrowi		
	Kendall Warm Spr.	Duck Creek	Green River	Boulder Cr.
Number	50	50	21	40
LL scales	56.0 (4.7)*	64.8 (3.9)	68.6 (3.5)	68.0 (4.2)
PF rays	13.3 (0.7)	13.4 (0.8)	14.2 (0.9)	13.3 (0.7)
No. without teeth in one secondary row	43* (86%)	0	0	1 (3%)

* Significantly different ($P<.05$) from all R. o. yarrowi populations

from the Green River, but not from Duck Creek or Boulder Creek. These results are in general agreement with the earlier descriptions by Hubbs and Kuhns (1937), except that the present pectoral fin ray counts are higher, and the Kendall Warm Springs dace are not significantly different from speckled dace of all sources. The most important finding is the difference in pharyngeal tooth formulas, which have not previously been studied for Kendall Warm Springs dace. Of 50 specimens examined, 43 (86%) lacked pharyngeal teeth in at least one of the secondary rows, whereas this condition was extremely rare (1 out of a total of 111) in speckled dace from the three sources. Since pharyngeal tooth counts appear not to be thermally labile during early development, this suggests a genetically based morphological differentiation of the Kendall Warm Springs dace.

Critical Thermal Maxima

There was no significant difference in critical thermal maxima between Kendall Warm Springs dace and speckled dace from Duck Creek, with both acclimated to 27 C (Table 2). For the Kendall dace, this acclimation

Table 2. Critical thermal maxima of Rhinichthys osculus thermalis and R. o. yarrowi.

Source and Acclimation	N	Mean length in mm	Mean CTM
Kendall, 27 C	14	43.1	34.8 (a)*
Speckled, 27 C	13	48.4 (a)	34.3 (a,b)
Speckled, 24 C	7	48.8 (a)	33.9 (b)

* Common letter indicates $P>.05$ (Newman-Keuls)

temperature approximates the lower limit that might be experienced at any time in the thermal spring creek. The CTM values for these dace acclimated to 27 C are about 2 C lower than measured by Deacon et al. (1987) for speckled dace from the Virgin River in Utah acclimated to 25 C. This difference may be related in part to the much larger specimens (average of 72.2 mm) used in that study. Speckled dace used in the present trials were deliberately selected for small size so that they would be similar to the Kendall Warm Springs dace, however, they were still significantly larger.

Electrophoretic Studies

The 26 loci examined for 12 specimens each from Kendall Warm Springs and Duck Creek are listed in Table 3. No differences were discernable at

Table 3. Enzymes examined for comparisons of *R. o. thermalis* and *R. o. yarrowi*.

Locus	Enzyme	Buffer*
AAT-1,2	Aspartate aminotransferase	R
AGP	Alpha-glycerophosphate dehydrogenase	4
EST-1,2	Esterase	R
GAPDH	Glyceraldehyde-3-phosphate dehydrogenase	C
GDH	Glutamic dehydrogenase	C
GP-1,2,3	General protein	C
GPI-1,2	Glucosephosphate isomerase	C
G6PDH	Glucose-6-phosphate dehydrogenase	R
HBDH	Hydroxybuteric dehydrogenase	C
IDH-1,2	Isocitrate dehydrogenase	C
LDH	Lactate dehydrogenase	4
MDH-1,2	Malate dehydrogenase	C
ME	Malic enzyme	R
MPI	Mannosephosphate dehydrogenase	R
PGD	Phosphogluconate dehydrogenase	4
PGM	Phosphoglucomutase	C
SOD-1,2	Superoxide dismutase	R
XDH	Xanthine dehydrogenase	C

* R = Ridgeway, G. J. et al., 1970, Trans. Am. Fish. Soc. 99:147-151;
4 = Selander, R. K. et al., 1971, Univ. Texas Publ. 7103:49-90;
C = Clayton, J. W. and D. N. Tretiak, 1972, J. Fish Res. Bd. Can. 29:1169-1172.

these loci between Kendall Warm Springs and speckled dace. No variants were observed at any locus in either population, and both populations were fixed for the same electromorphs at all loci.

Mitochondrial DNA Studies

Initial results from four Kendall Warm Springs dace and seven speckled dace from Duck Creek are depicted in Fig. 1. Five of the eight restriction enzymes reveal polymorphic mtDNA in fish from Duck Creek, and one enzyme revealed a polymorphic mtDNA in fish from Kendall Warm Springs. On the basis of this small sample analyzed to date, Kendall Warm Springs dace appear to have inherited only one form of the mtDNA found in speckled dace in this nearby tributary of the Green River.

Captive Breeding and Rearing

Speckled dace have spawned repeatedly in our laboratory tanks, but

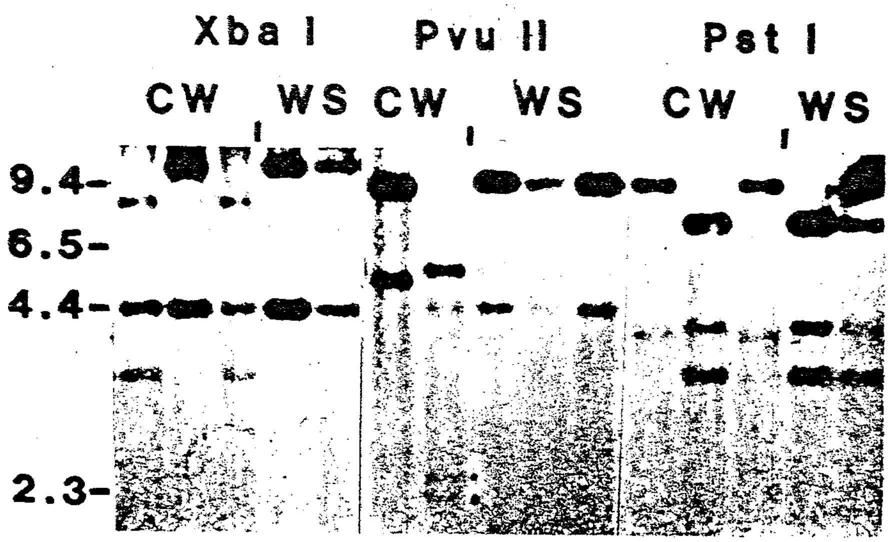

Figure 1. Mitochondrial DNA polymorphisms in Kendall Warm Springs (WS) and speckled dace (CW). Restriction endonuclease Xba I and Pst I show a polymorphism in speckled dace (CW), one form of which is also found in the Kendall Warm Springs dace (WS). Pvu II polymorphisms found in speckled dace (CW) have not been found in Kendall Warm Springs dace (WS).

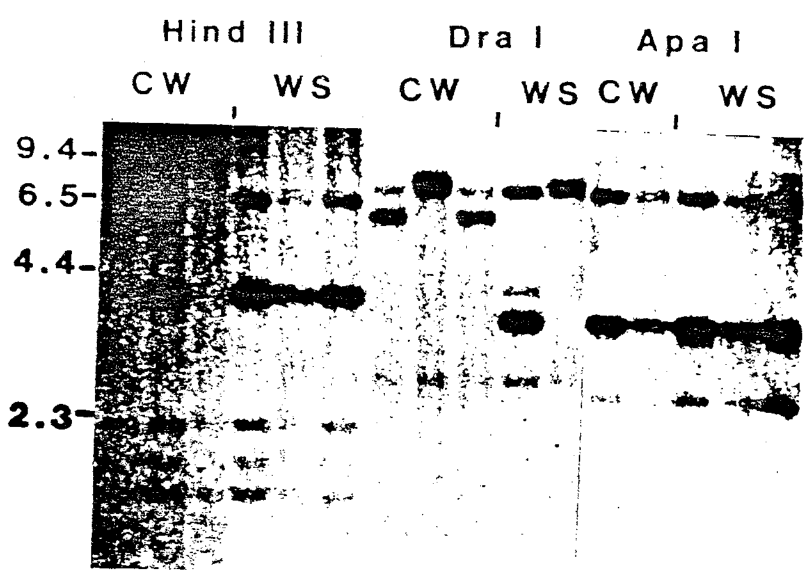

Figure 2. Mitochondrial DNA polymorphisms in Kendall Warm Springs (WS) and speckled dace (CW). Restriction endonuclease Apa I is monomorphic in all fish tested. Hind III and Dra I are both polymorphic in speckled dace (CW) but only one of the forms for each enzyme is found in the Kendall Warm Springs dace (WS).

most eggs from earlier spawnings, over a gravel substrate, were eaten by the adults. Eggs from later spawnings were saved from predation by lining the bottom of the tanks with the artificial plastic substrate, through which the eggs would sink beyond the reach of the adults. Young were produced from spawnings of four separate groups of two females and three males each which spawned between 30 August and 9 September 1988, one group at 18 and three at 24 C. Temperature for one batch of eggs spawned at 24 C was increased to 28 C. Fry are thus presently being raised that have been incubated, hatched, and reared at 18, 24, and 28 C. The young speckled dace will be maintained at these three temperatures until they are large enough for morphologic measurements. This could determine the extent to which meristic features of R. osculus yarrowi are affected by temperature during development, and whether specimens developing at a level (28 C) similar to those experienced by R. o. thermalis will remain differentiable from the latter.

Despite the relative ease with which we have been able to induce spawning in speckled dace, we have not yet been able to do so with Kendall Warm Springs dace. Various combinations of conditions in the spawning tanks, including flowing vs. static water, different substrates, and presence or absence of vegetation, have not yet produced results.

Summary

Results to date provide new evidence in support of the differentiation of Kendall Warm Springs dace, R. o. thermalis, from speckled dace of the upper Green River drainage, R. o. yarrowi. The most important differences have come from pharyngeal tooth counts and mitochondrial DNA analyses, neither of which have been compared previously in these fish. Mitochondrial DNA analyses are continuing with additional specimens. Further morphologic comparisons will be conducted on young speckled dace presently being reared at 18, 24, and 28 C, the latter similar to temperatures within Kendall Warm Springs. If results of these ongoing investigations continue to show differences between Kendall Warm Springs dace and speckled dace, this would provide important evidence to support the original description of R. o. thermalis by Hubbs and Kuhne (1937) as an identifiable variant of R. osculus.

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Microhabitat Selection of the Owens Tui Chub, *Gila bicolor snyderi*, in the Hot Creek Headsprings, Mono County, California.

by

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Abstract

Microhabitat selection of the Owens tui chub, an endangered cyprinid inhabiting the Hot Creek headsprings, was investigated from June 1986 to February 1988. The purpose of the study was to elucidate the relationship of the chub and aquatic vegetation for management (recovery) purposes and to identify potential impacts from operations of the Hot Creek Fish Hatchery which diverts water from the headsprings. Test specimens were placed in an artificial stream chamber containing two microhabitat types: an 'open' cell with no cover and a 'vegetation' cell containing ample amounts of vegetative cover. After an acclimation period the number of individuals in each microhabitat type was recorded. Sixty-four observations were made over different diel and seasonal periods. Chi-square analysis showed that the chubs overwhelmingly selected for the vegetation cell. Distribution experiments using minnow traps support these findings. The chubs' close affinity for aquatic vegetation is due mainly to four factors: spawning, water velocity displacement, predator avoidance, and feeding behavior.

Abstracto

Introduction

The Owens tui chub (Gila bicolor snyderi) is very similar in form, ecology, and behavior to other subspecies of tui chub inhabiting many Great Basin drainages. This subspecies is found in the Owens River drainage in east-central California, a subsystem of the Death Valley hydrographic basin (Fig. 1). During pluvial periods of the Pleistocene this drainage was continuous with the Death Valley system and other systems to the north and south, and hence shows many close ichthyofaunal relationships to these presently isolated drainage basins (Miller 1946; Hubbs and Miller 1948). The present distribution of this fish is the result of the invasion and subsequent isolation of the Lahontan form (G. b. obesa) during the Pleistocene (Miller 1946). The Owens tui chub shows close taxonomic affinities to this subspecies (Miller 1946).

The Owens tui chub is both state and federally listed as endangered and is presently restricted to five locations: the Owens River immediately downstream from Crowley Lake; the Owens Valley Native Fish Sanctuary; Little Hot Creek; springs and ditches along the west shore of Owens Lake; and the Hot Creek headsprings, where this study took place (Fig. 1). Factors contributing to their endangered status are predation by exotic species, water development, and, most importantly, hybridization with the Lahontan tui chub, which was introduced into Crowley Lake and has rapidly spread throughout the lower reaches of the drainage. Only those populations that are isolated by barriers have escaped introgression.

The Hot Creek headsprings are located in the Long Valley Caldera which erupted approximately 700,000 years ago, forming the Bishop Tuff and the present geomorphology of Long Valley (Bailey et al. 1976) (Fig. 1). The two headsprings which comprise the habitat for this population, known as the CD and AB headsprings, are part of a complex of springs which emanate from the edge of a basalt flow and coalesce to form Hot Creek, which flows into the Owens River just above Crowley Lake. These two springs and three others supply water to the Hot Creek State Fish Hatchery (Fig. 2).

The CD headspring discharges into a small reservoir then flows approximately 200 m to its terminus. It flows at about 0.35 m^3/s, which varies only slightly throughout the year, and has a constant temperature of about 14.5 C. It ranges in depth from 0.1 m to 0.7 m. The AB headspring is approximately 130 m in length, has a flow about the same as the CD headspring, and has a fairly constant temperature of about 15.0 C. Depth ranges from 0.1 m to 0.75 m. Populations of rainbow trout (Oncorhynchus mykiss) and cutthroat trout (O. clarki) coexist with the chubs in the headsprings and no other fish species are present. Both headsprings are designated critical habitat and they both support a lush growth of emergent and submergent aquatic plants, which include: water-cress (Nasturtium officinale), water fern (Azolla

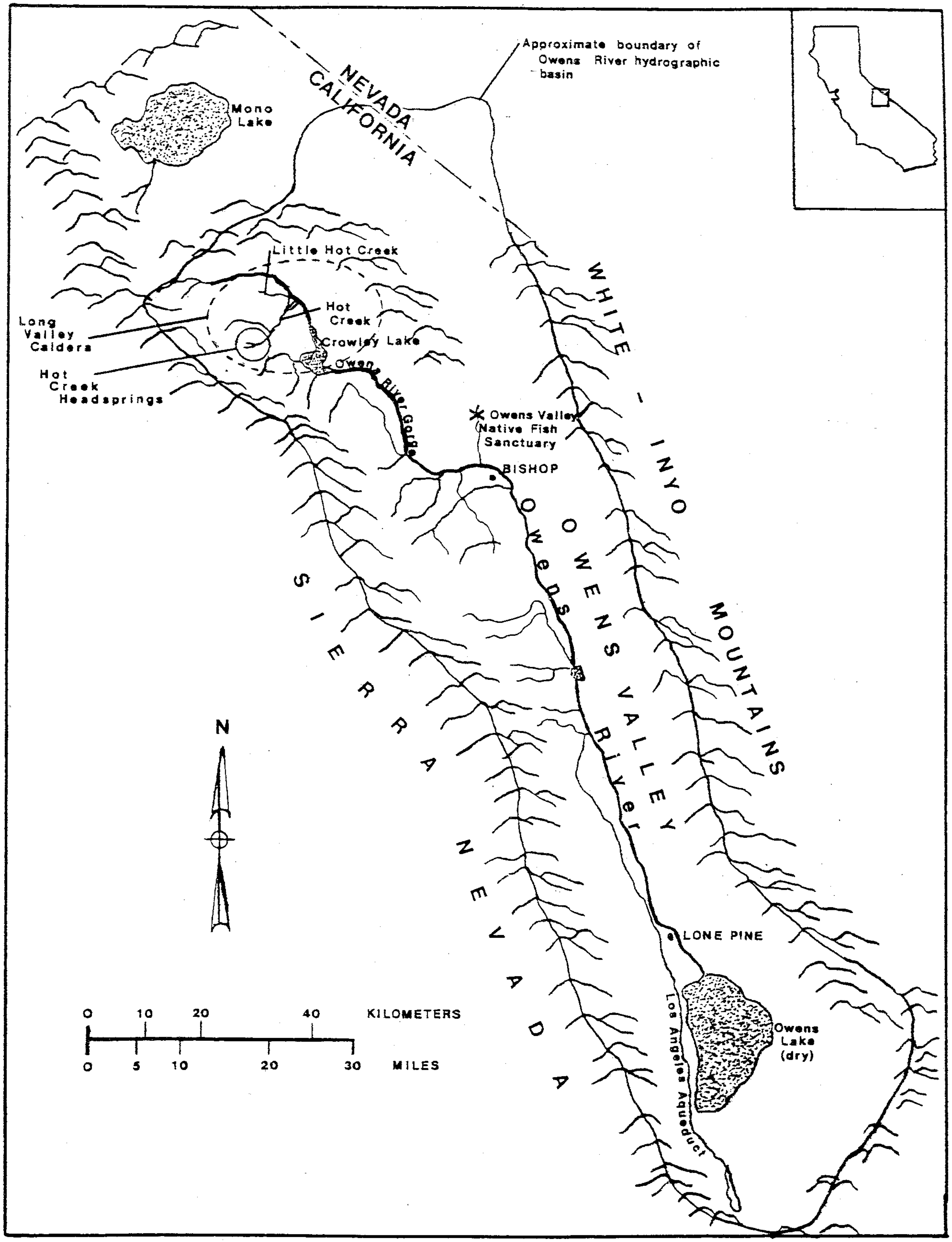


Figure 1. General features of the Owens River drainage.

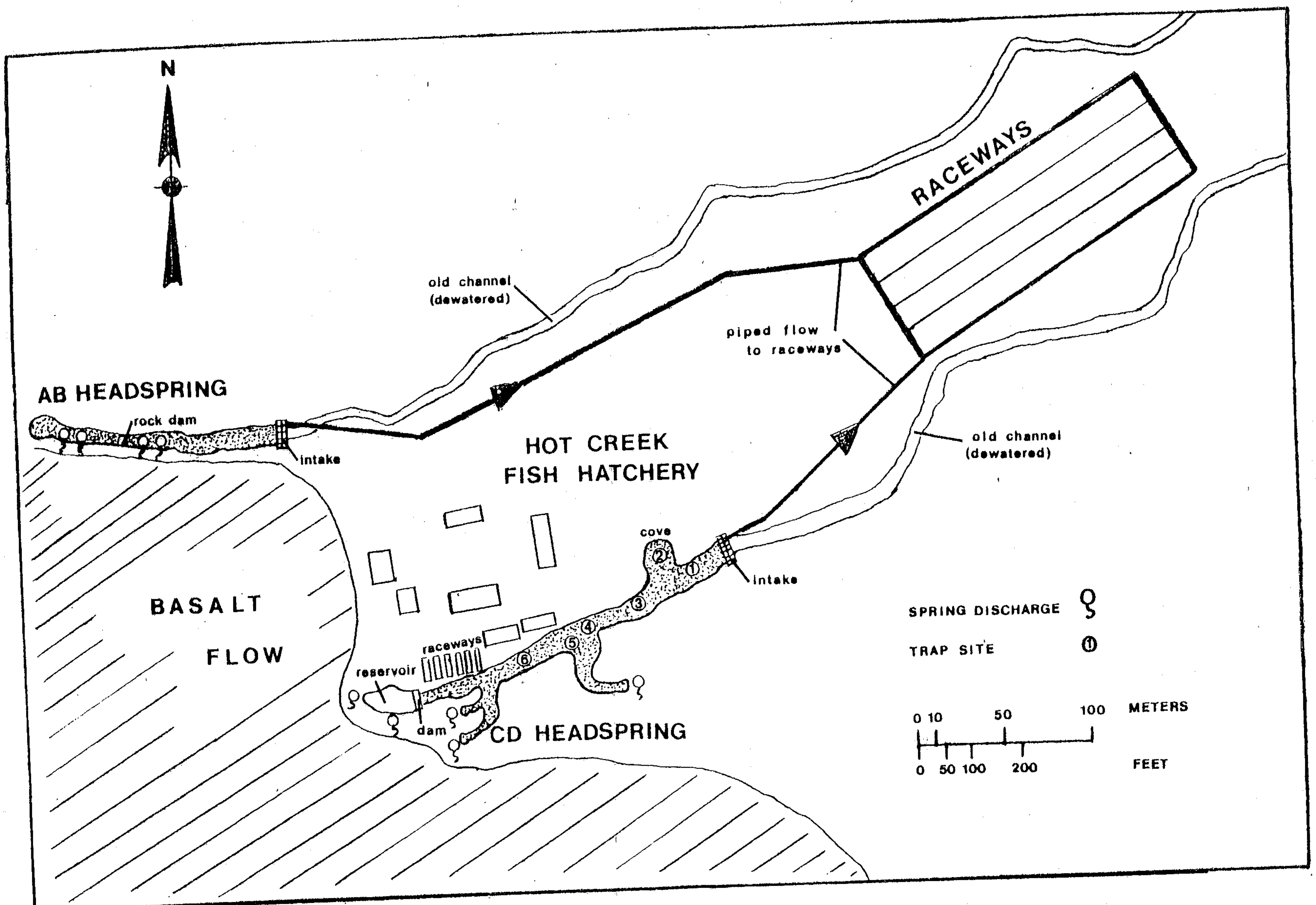


Figure 2. Map of the Hot Creek headsprings vicinity.

filiculoides), duckweed (Lemna sp.), pondweed (Potamogeton sp.), aquatic buttercup (Ranunculus aquatilis), and elodea (Elodea canadensis).

Under natural conditions, these plants cover approximately 50% to 75% of the stream surface area. The plants typically grow out from the sides in the main channel, forming dense beds along the stream margins which delineate a small chute of swift flowing water in the center of the channel. In the backwater areas with zero water velocities, vegetation covers nearly 100% of the surface area. There is a limited die-off of vegetation beds during the winter, but most of the beds persist due to the thermal characteristic of the headsprings.

The hatchery has a continuing problem with impingement and entrainment of aquatic vegetation which obstructs their water intake and raceway screens. The water intakes divert the entire flow for hatchery operations and constitute the barriers which isolate the Owens tui chubs from hybrids that exist downstream (Fig. 2). To remedy this problem, hatchery personnel, until recently, had been periodically removing nearly 100% of the vegetation from both springs. This consequently rendered the entire habitat devoid of aquatic vegetation for several weeks after removal.

The purpose of this study was to investigate the nature of the relationship between the Owens tui chub and aquatic vegetation so that recovery actions could be identified and implemented, and to identify impacts caused by hatchery procedures so that these procedures could be modified.

Although life history information has been documented for other subspecies of tui chub inhabiting similar environments (Cooper 1978; Kimsey 1954; Vicker 1973; Bird 1975; Kucera 1978) and for the tui chub as a species (Burns 1966; Moyle 1976), life history and ecological requirements of the Owens tui chub have not been investigated. Life history and population data from limited California Department of Fish and Game observations are primarily in the form of unpublished memoranda and correspondence. Most of what is known of this fish concerns taxonomy and distribution (Gilbert 1893; Snyder 1917; Miller 1969, 1973).

Aquatic vegetation is an important habitat component for several subspecies of tui chub (Moyle 1976). Lahontan tui chub are opportunistic generalist feeders and an integral part of their diet consists of aquatic plants and invertebrates associated with aquatic plants (Kimsey 1954). Both Mohave tui chub (G. b. mohavensis) and the Lahontan tui chub utilize aquatic vegetation as a spawning substrate. (Kimsey 1954; Vicker 1973; Cooper 1978).

Methods and Materials

Microhabitat selection experiments were conducted from fall, 1986 through summer, 1987 with an artificial stream chamber measuring 1.8 m by 1.2 m by 0.9 m. Water was conveyed into the chamber via siphons, and baffles were placed at each end to reduce the flow through the chamber to zero. The habitat portion of the chamber was constructed so that it could be separated into two cells of equal size by raising a flexible nylon mesh attached to the bottom. In one cell clumps of vegetation were fixed and the other cell was left open with no cover.

Chubs were introduced into the chamber and allowed to acclimate and distribute themselves, after which the partition was quickly raised from a distance. The number of chubs in each cell was recorded and the partition was lowered to allow free access once again.

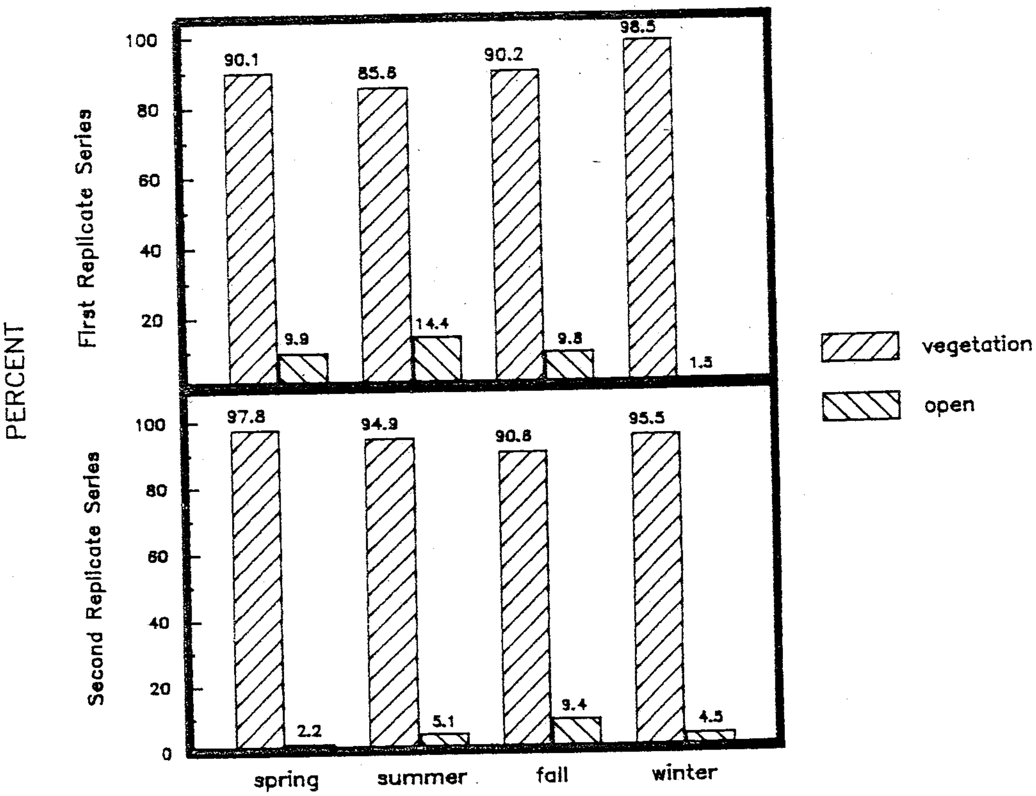
This experiment was done at dawn, noon, near sunset, and at midnight, and then replicated the following day. At the end of the second day the positions of the vegetation and open cells were reversed and the experiments were repeated for two more days. One experimental treatment consisted of 16 tests over a four day period and the treatments were repeated during each season. A total of 64 tests was made. Chi square analysis was used to test the null hypothesis that cell selection was random.

Distribution of chubs in the CD headspring was examined by placing minnow traps (122 cm by 43 cm diameter with a 12.7 mm by 12.7 mm mesh) at locations in the headspring on several occasions during the course of the study. The locations represented different habitat types with different abundances of vegetation (Fig. 2). The traps were set after sunset, fished overnight, and inspected after sunrise the following day.

Gut contents from 35 chubs taken from the CD headspring on four seasonal samplings were examined. Food categories were identified, counted, and weighed, and an index of relative importance (I.R.I) was derived by adding the percent number and percent weight, then multiplying the result by the frequency of occurrence (Pinkas et al. 1971).

Results

The chubs used in the 64 tests overwhelmingly selected for the vegetation cell (Fig. 3). Chi square analysis supported this observation: in 59 of the 64 cases, the null hypothesis was rejected ($p = 0.05$) and a significant majority of the chubs in each case selected for the vegetation cell. Of the remaining five cases, the chubs selected for the open cell in one case, and selection was random in four cases ($p = 0.05$). These five cases were all tests conducted during the midnight period where the chubs showed a higher incidence of open cell selection (Fig. 4).



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9/20/87	not fished	0.35	0.09	0.09	0	8.0
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2/27/88	0.35	4.49	0	0.04	0	282.4

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This might also be due to the species and size of trout present in the headsprings. The population of trout is almost entirely domestic rainbow trout which have escaped from nearby raceways. The mean fork length in the four samples was 265, 221, 209, and 195 mm, and, based on observations while electrofishing, these sizes are representative of the trout in both headsprings. According to some studies, rainbow trout do not become piscivorous until they reach a size of 300 to 350 mm (McAfee 1966). Their potential as a predator probably influences chub behavior however, and predation probably occurs to some degree, given the piscivorous nature of trout.

Trout are not the only predators on the chubs. Flocks of black crowned night herons, Nycticorax nycticorax, and great blue herons, Ardea herodias, are common in the vicinity of the hatchery and have been observed in the headsprings on several occasions. In addition, many of the chubs captured in the traps and by electrofishing had large scars across their dorsal and lateral surfaces, which were probably caused by herons.

Feeding Behavior. The results of the gut content analysis indicate that Owens tui chub are generalist feeders that utilize a wide variety of food items. Twelve different food categories were identified (five categories of aquatic invertebrates were combined into one to facilitate graphing) (Fig. 6). Some items, such as detritus and plant material, are underrepresented however, because the percent number values were arbitrarily assigned a value of zero.

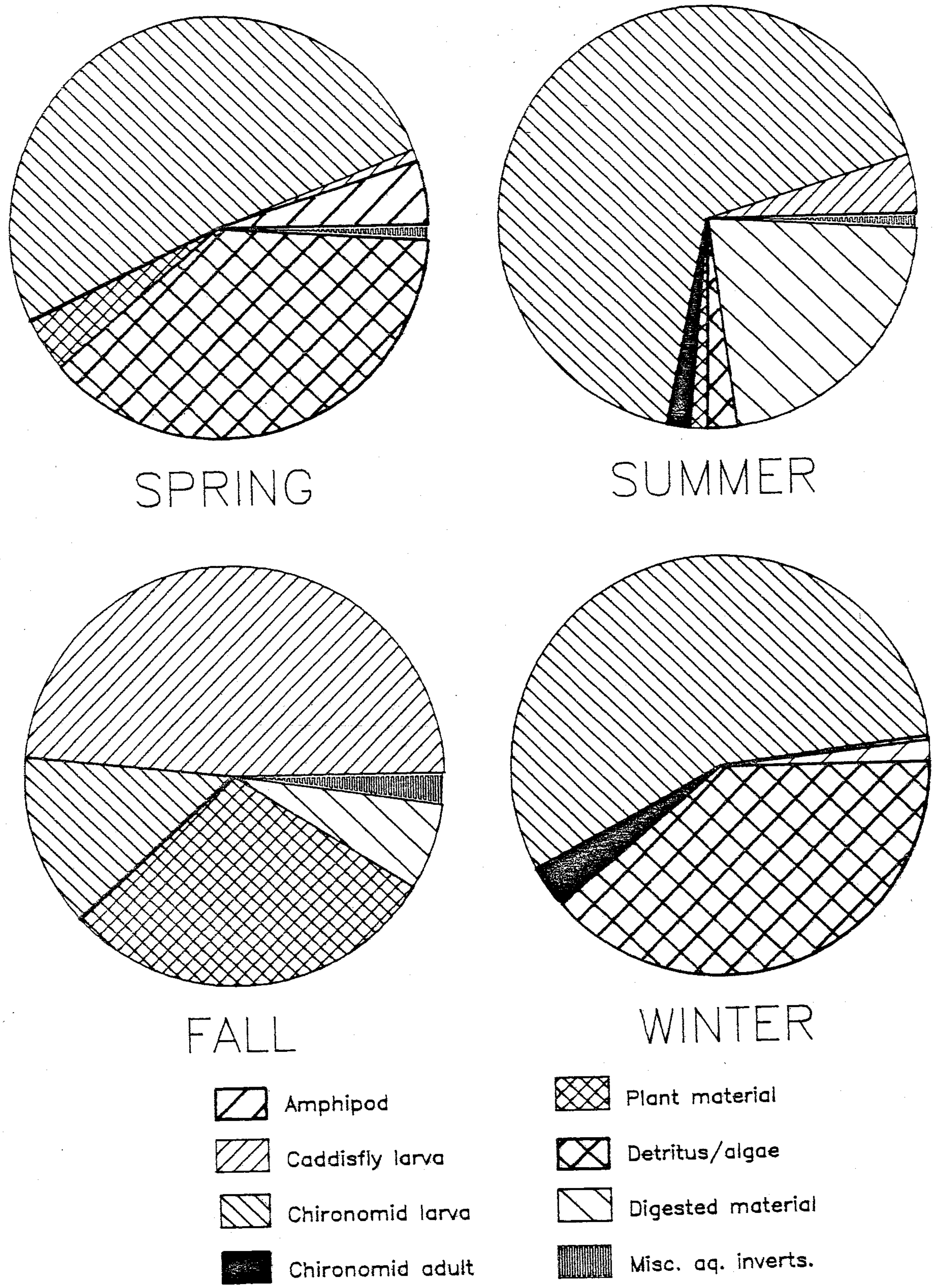

Figure 6. Relative percentage of IRI values of food items found in Owens tui chubs from the CD Hot Creek headspring.

Chironomid larvae appear to be the most important food item. They were present in all four samples and in 27 of the 35 digestive tracts examined. They had the highest I.R.I. value in three of the four samples and third highest in one. Other items of importance include: larvae of two species of hydroptillid caddisfly, other aquatic invertebrates, plant material, and detritus. Chironomid larvae, caddisfly larvae, and detritus were present in all four samples, indicating that they are available year-round (Fig. 6).

An examination of plant material collected from the CD headspring showed that most of the invertebrate food items were present in the vegetation, chironomid larvae being the most abundant and profuse. This finding indicates that aquatic vegetation is not only an important food source, but also provides an important substrate which supports the aquatic invertebrate fauna of the headsprings.

These experiments and observations suggest that aquatic vegetation is an important ecological component of the headsprings. Another outstanding component, and one that is highly interrelated, is the constancy of this environment, primarily flow and temperature. Environmental constancy, among other things, allows for the persistence of the vegetation through the winter, as well as a year-round production of the aquatic invertebrate fauna. Any management or recovery plan for the Owens tui chub in these headsprings should recognize the importance of these two ecological components.

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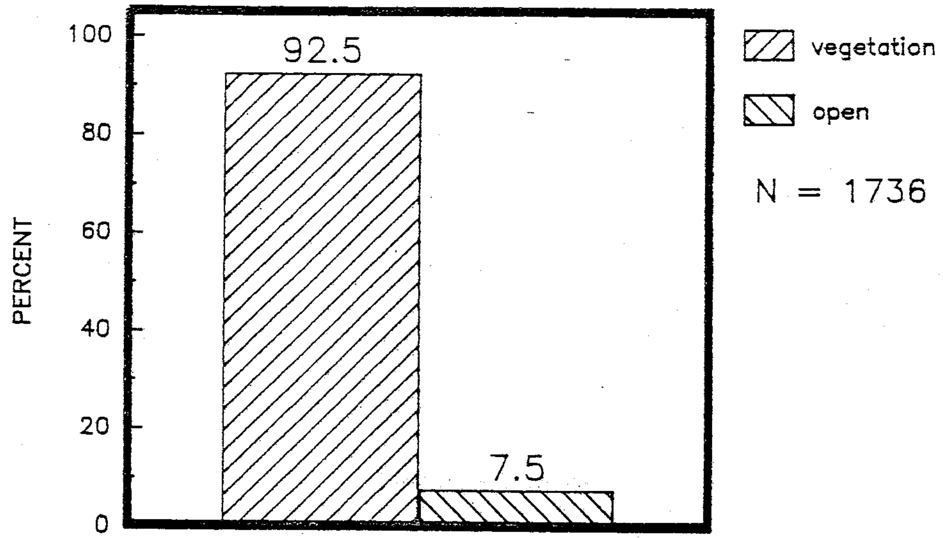


Figure 3. Relative frequency of Owens tui chub microhabitat selection. Values are percentages of all chubs used in 64 tests.

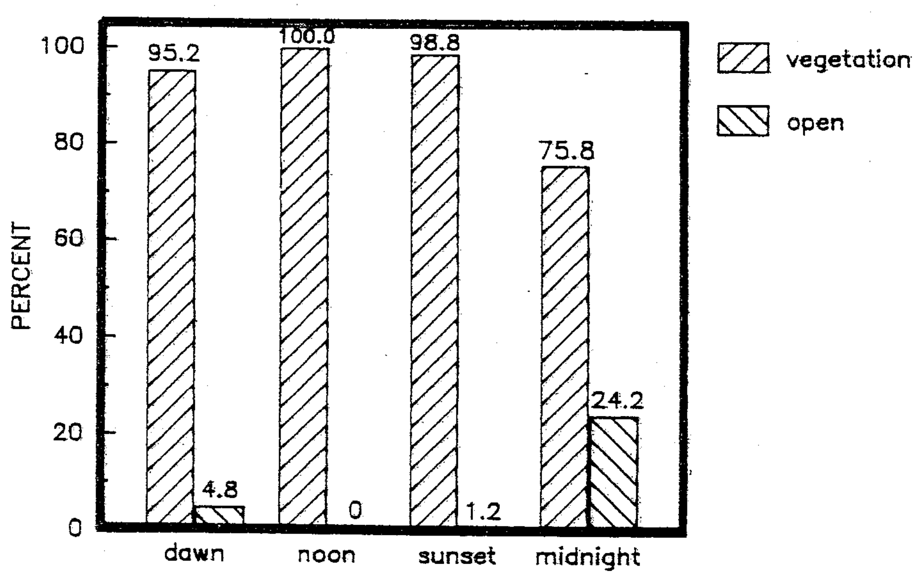


Figure 4. Relative frequency of Owens tui chub microhabitat selection by diel period.

There did not appear to be a significant difference in selection between the tests when the position of the cells was reversed (Fig. 5). This was of particular concern during the noon observations because the south cell was almost entirely in shadow and the north cell almost entirely in sunlight.

The distribution studies in the CD headspring support this finding that the chubs tend to remain in close proximity to the vegetation. The collections indicated that chub densities were greatest in the cove (trap site 2), which had the densest vegetation in the headspring, and decreased farther upstream, where the vegetation beds were less distinct (Table 1). Trap site 6, which was farthest upstream and had the least amount of vegetation, yielded the least number of chubs (Table 1).

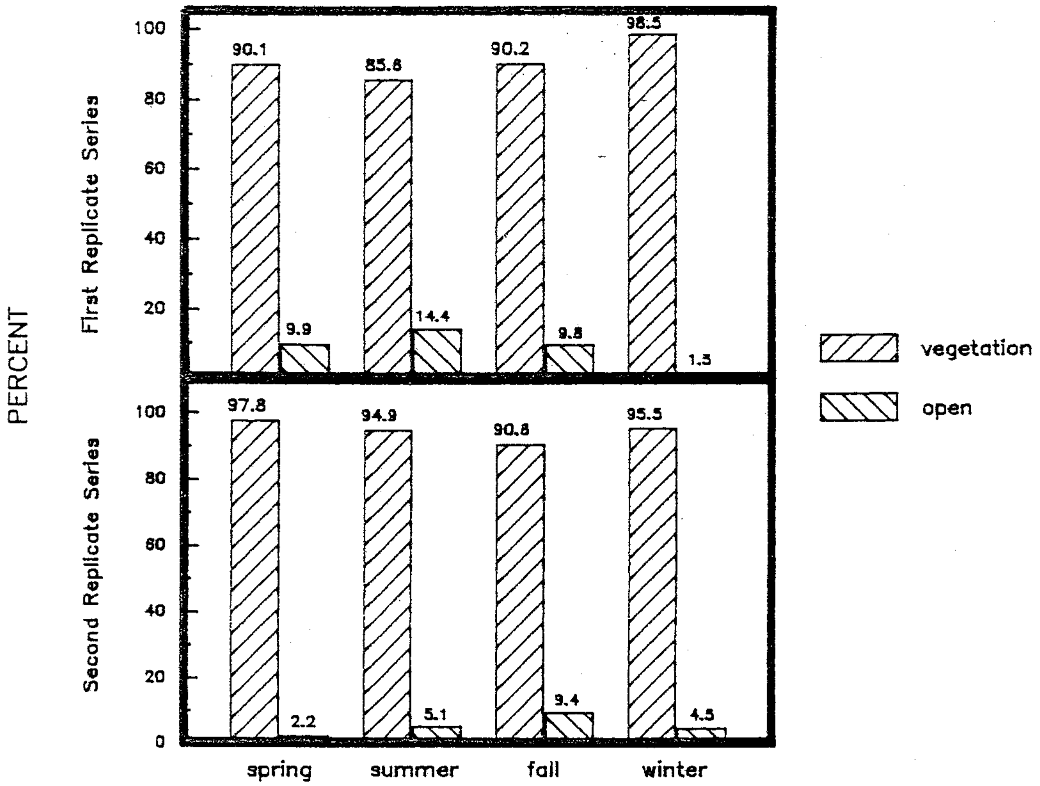
Discussion

These observations and experiments support the assertion that aquatic vegetation is an important habitat component of Owens tui chub and that they tend to remain in close association with it. Other researchers have found this to be true of the tui chub as a species and for other subspecies of tui chub (Moyle 1976; Vicker 1973; Kimsey 1954; Cooper 1978; Williams and Bond 1981). The question remains as to why this relationship exists. Although a detailed study of this relationship was not undertaken, observations made in the laboratory and field during the course of the study indicate that it is due mainly to four factors: spawning, water velocity displacement, predator avoidance, and feeding behavior. These are discussed briefly below.

Spawning. The use of aquatic vegetation by tui chubs as a spawning substrate is well documented. Kimsey (1954) found that eggs from Lahontan tui chubs were adhesive and developed only if they were attached to plants or otherwise kept off of the bottom. Cooper (1982) found that Lahontan tui chub eggs from Pyramid Lake, Nevada were adhesive. Cooper (1978) and Vicker (1973) observed that Lahontan and Mohave tui chub, respectively, spawn over aquatic vegetation.

Although I did not find eggs attached to the aquatic vegetation in either headspring, I found that newly extruded eggs are similar in description to those of Lahontan and Mohave tui chubs and are quite adhesive. The adhesiveness of Owens tui chub eggs and the preponderance of aquatic plants in their habitat would suggest that they also utilize aquatic vegetation as a spawning substrate.

Water Velocity Displacement. Measurements of water velocities were taken in the CD headspring using a Marsh - McBirney velocity meter on several occasions in the fall of 1987. Zero velocities were recorded in vegetation beds which were surrounded by open water that had velocities of 0.15 m/s and higher. Chubs were seen darting across these areas of relatively high velocity, usually to move from one vegetation bed to



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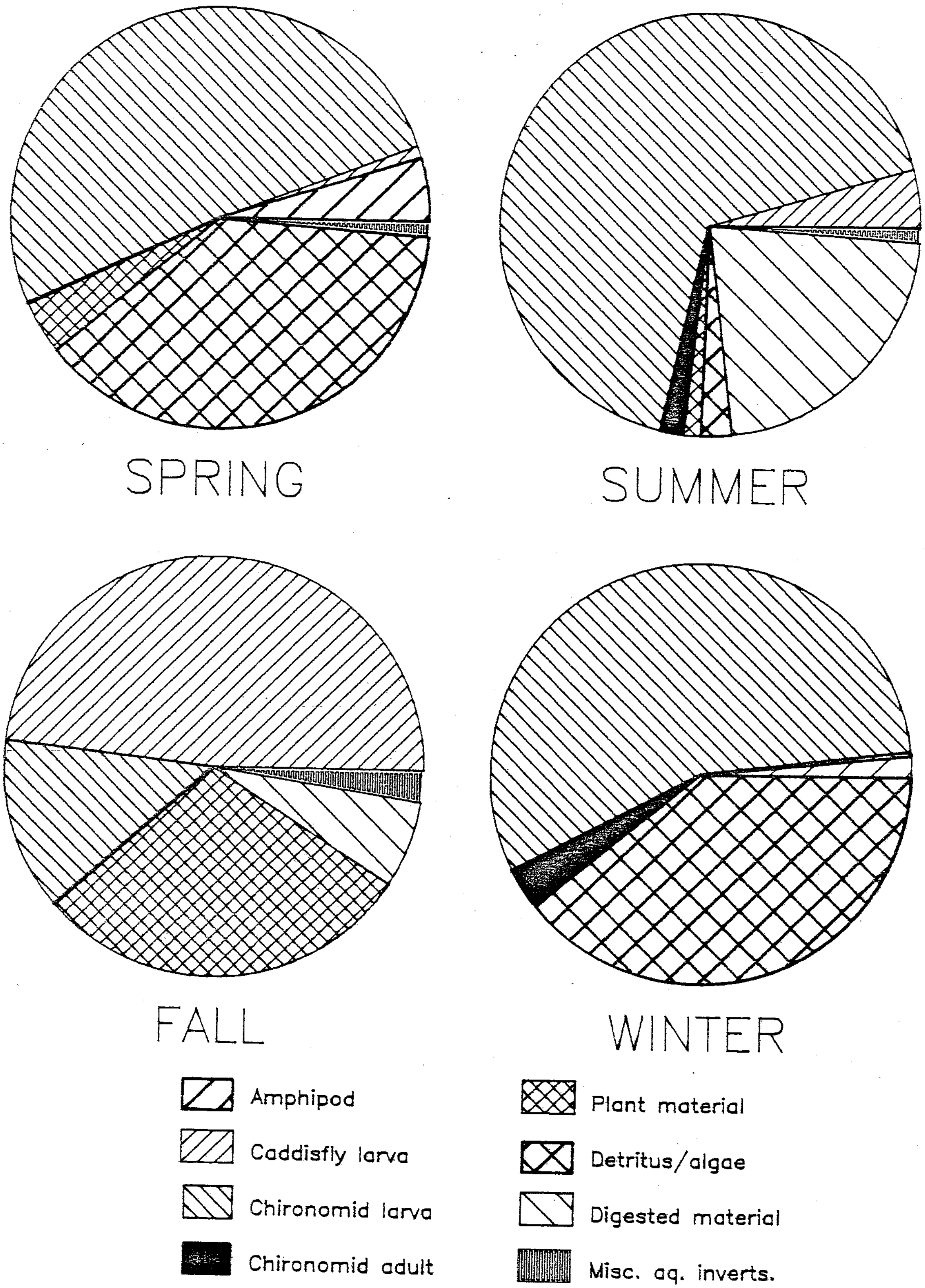

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ENDANGERED FISHES OF CATARACT CANYON

by

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ABSTRACT

A 3-year investigation of the fishes of Cataract Canyon has just been completed. The Final Report on this project will be submitted in early 1989.

Cataract Canyon is a 16-mile whitewater region of the Colorado River below the confluence of the Green River and above the inlet to Lake Powell. It is characterized by a steep gradient with a predominantly boulder and cobble substrate and talus shorelines. Low summer flows are about 5,000 cfs, runoff flows are about 70,000 cfs, with a record flow of 120,000 cfs.

A total of 28 species of fish, representing 10 families, were found in Cataract Canyon. This includes 20 non-native and 8 native species. The most common species are red shiners (Notropis lutrensis), channel catfish (Ictalurus punctatus), common carp (Cyprinus carpio), sand shiners (Notropis stramineus), and fathead minnows (Pimephales promelas). These five non-native species make up over 85% of the catch. The native species, according to abundance, include the Colorado squawfish (Ptychocheilus lucius), speckled dace (Rhinichthyes osculus), flannelmouth sucker (Catostomus latipinnis), bluehead sucker (Catostomus discobolus), roundtail chub (Gila robusta), humpback chub (Gila cypha), bonytail chub (Gila elegans), and razorback sucker (Xyrauchen texanus).

This investigation has contributed information to the Rare and Endangered Colorado River Fishes Sensitive Areas document. It confirms the presence of adult Colorado squawfish in Cataract Canyon, but fails to document any evidence of spawning adults, although deep pools and cobble/riffle habitat are present, and larval fish less than 25 mm were found. The investigation also upgrades the lower 50 miles of the Green River to a high density nursery area, and extends the YOY nursery area through Cataract Canyon to upper Lake Powell.

A concentration of humpback chub is confirmed in Cataract Canyon with the capture of five or more adults in one year. It also can be designated a suspected spawning area because of the presence of larvae, young-of-year, and tubercled adults. However, spawning activity was not confirmed because of a failure to capture ripe females with strippable eggs. This has been shown to be a formible task in Cataract because of high flows during spawning.

The Cataract Canyon Study also revealed a possible enclave of bonytail. Several adults and juveniles, as well as one suspected YOY were captured, but the definitive taxonomic status of this enclave remains undetermined. Specimens from Cataract possess many bonytail characters but lack the extreme features associated with the species. We urge inclusion of these specimens in a proposed taxonomic investigation of the Colorado River Gila. If this enclave is confirmed, it can provide a source of genetic material from the upper basin.

PECES AMENAZADOS DEL CAÑON DE CATARACT

por

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RESUMEN

Una investigacion ictiológica de 3 años en el Cañon de Cataract se ha completado. El Reporte Final en este proyecto se somete el el año 1989.

El Cañon de Cataract es una region de 16 millas de aqua turbuliente en el Rio Colorado entre la confluencia con el Rio Verde y la presa Lake Powell. Se caracterisa por grado escarpado con fondo y orillas rocosas. Flujo minimo del verano es aproximadamente 5,000 cfs, los maximos son de 70,000 a 120,000 cfs.

Un total de 28 especies de peces, representando 10 familias, fueron descubridas en el Cañon de Cataract. Esto incluye 20 especies introducidas y 8 nativas. Los mas comunes especies son red shiners (*Notropis lutrensis*), channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), sand shiners (*Notropis stramineus*), y fathead minnows (*Pimephales promelas*). Estas cinco especies introducidas son mas que 85% de los peces cogidos. Las especies nativas, por abundancia, incluyen Colorado squawfish (*Ptychocheilus lucius*), speckled dace (*Rhinichthyes osculus*), flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*Catostomus discobolus*), roundtail chub (*Gila robusta*), humpback chub (*Gila cypha*), bonytail chub (*Gila elegans*), y razorback sucker (*Xyrauchen texanus*).

Esta investigacion ha contribuido informacion al documento "Rare and Endangered Colorado River Fishes Sensitive Areas". Confirma la presencia de adultos del Colorado squawfish en el Cañon, pero falla documentar evidencia de adultos en el acto de reproduccion, aunque ocurren charcos profundos y habitats rocosas, y larvas de menos de 25 mm longitud. La investigacion tambien revisa designar las 50 millas bajas del Rio Verde a region de crecimiento con densidad maxima, y extende la region de crecimiento a traves del Cañon a la presa Lake Powell.

Una concentracion de humpback chub se confirmó en el Cañon de Cataract con la captura de cinco o mas adultos en un año. Tambien se designó una area sospechosa de reproduccion por la presencia de larvas, jovenes, y adultos con tubercles. Sin embargo, activididad de reproduction no fue confirmada por falta de capturar hembras con huevecillos. Es dificil documentar el acto de reproduccion en este Cañon por los flujos altos y turbulientes.

Este estudio tambien reveladó la posibilidad de una poblacion de bonytail. Varios adultos y juveniles se han capturado, pero su estado taxonómico no se ha determinado. Especimenes de Cataract poseen muchas de las características del bonytail pero faltan las facciones extremas asociadas con el especie. Urgimos incluyir estos especimenes en la investigacion taxonómica proponida sobre el genero *Gila* del Rio Colorado. Si se confirma esta poblacion, puede proveer material genético de la cuenca superior.

WINTERTIME MOVEMENT AND HABITAT OF ADULT COLORADO SQUAWFISH AND RAZORBACK SUCKERS IN THE GREEN RIVER

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ABSTRACT

Wintertime movement and habitat of adult Colorado squawfish (Ptychocheilus lucius) and razorback suckers (Xyrauchen texanus) were assessed for the first time in the Green River with the aid of radiotelemetry. Twenty individuals of each of these rare, endemic species were tracked and monitored from December 1 to March 31, 1986-87 and 1987-88, in a 97-mile reach from Echo Park, CO downstream to Ouray, UT. This investigation revealed that adult Colorado squawfish and razorback suckers overwinter in specific river regions, generally less than 3 miles long. Although one Colorado squawfish ranged 25.9 miles, and one razorback sucker ranged 10.5 miles, 72% of all the radiotagged fish remained within a 3-mile reach during the 4 winter months. This study also showed that these fishes may remain for days in a 100-m diameter area within slackwaters, slow runs, eddies, or backwaters. The fish move periodically to one of several "favorite spots" or microhabitats, characterized by greater than average depth and low velocity. The position of each fish is often associated with underwater structure such as sand shoals, sand ridges, or cobble jetties.

RESUMEN

Movimiento y habitat de adultos del Colorado squawfish (Ptychocheilus lucius) y razorback sucker (Xyrauchen texanus) fueron avaluado durante el invierno por la primera vez en le Rio Verde con uso de radiotelemetria. Veinte individos de cada de estos especies raros y endemicos fueron rastreados de Deciembre 1 a Marzo 31, el los anos 1986-87 y 1987-88, en una region de 97 millas de Echo Park, CO a Ouray, UT. Esta investigacion revelado que los adultos del Colorado squawfish y razorback sucker pasan el invierno en regiones especificas, generalmente menos de 3 millas distancia. Aunque un Colorado squawfish tuvo un alcance de 25.9 millas, y un razorback sucker de 10.5 millas, 72% de todos los peces de radiotelemtria se quedaron dentro de una region de 3 millas durante los 4 meses del invierno. Este estudio tambien ensenio que estos peces pueden quedarse por dias en un area de 100 m en diametro entre habitats especificas; "slackwaters, slow runs, eddies, o backwaters". Los peces se mueven periodicamente a una de varias localidades o microhabitats, caracterizadas por mas que promedio de profundidad y velocidad minima. La posicion de cada pez frecuentemente fue asociada con estructura, como bajos y espinazos de arena, o puntas rocosas.

INTRODUCTION

This paper is part of a Final Report submitted to the Bureau of Reclamation (BOR) in fulfillment of Contract No. 6-CS-40-04490, entitled "Winter Habitat Study of Endangered Fish - Green River." It integrates the results of a 2-year investigation (1986-87 and 1987-88) of wintertime movement and habitat of adults of the rare and endemic Colorado squawfish (Ptychocheilus lucius) and razorback sucker (Xyrauchen texanus) in the Green River. The investigation was conducted from December 1 to March 31 of each year in the 100-mile reach from Echo Park, CO to Ouray, UT.

The objectives of this investigation were to:

1. Determine if adult Colorado squawfish and razorback suckers overwinter in specific river regions.

2. Describe microhabitat (water column depth, velocity, substrate, cover and temperature) used by overwintering adult Colorado squawfish and razorback suckers.

3. Evaluate fish movement and changes in habitat with changes in flow of the Green River during the winter months.

STUDY AREA

This investigation was conducted on the Green River from Echo Park, CO to Ouray, UT (Figure 1). This 97-mile reach of river has three flatwater sections; Echo Park (2 miles), Island and Rainbow Parks (7 miles), and Split Mountain to Ouray (72 miles). It also has two whitewater sections; Whirlpool Canyon (9 miles) and Split Mountain Canyon (7 miles). For the purposes of this investigation, the study area was divided into upper, middle and lower regions according to stream gradient and river morphology. The upper region from Echo Park to lower Split Mountain Canyon (25.3 miles) has a relatively steep gradient with primarily a gravel-boulder-bedrock substrate. The middle region from lower Split Mountain Canyon to Jensen Bridge (18.3 miles) has a moderate gradient with a gravel-cobble substrate in the upper reaches and a sand substrate in the lower reaches, and the lower region from Jensen Bridge to Ouray Bridge (53.5 miles) is a low-gradient, meandering river with primarily a sand substrate.

METHODOLOGY

This investigation consisted of two phases. Phase I involved capturing 10 adult Colorado squawfish and 10 adult razorback suckers in mid to late October and surgically implanting each with a radiotransmitter. Phase II consisted of six 10-day tracking and monitoring trips over a 4-month winter period from December 1 to March 31. The same general approach was used for both years of the investigation; year 1 = 1986-87; and year 2 = 1987-88. Twenty different fish of each species were radiotagged over the 2-year period.

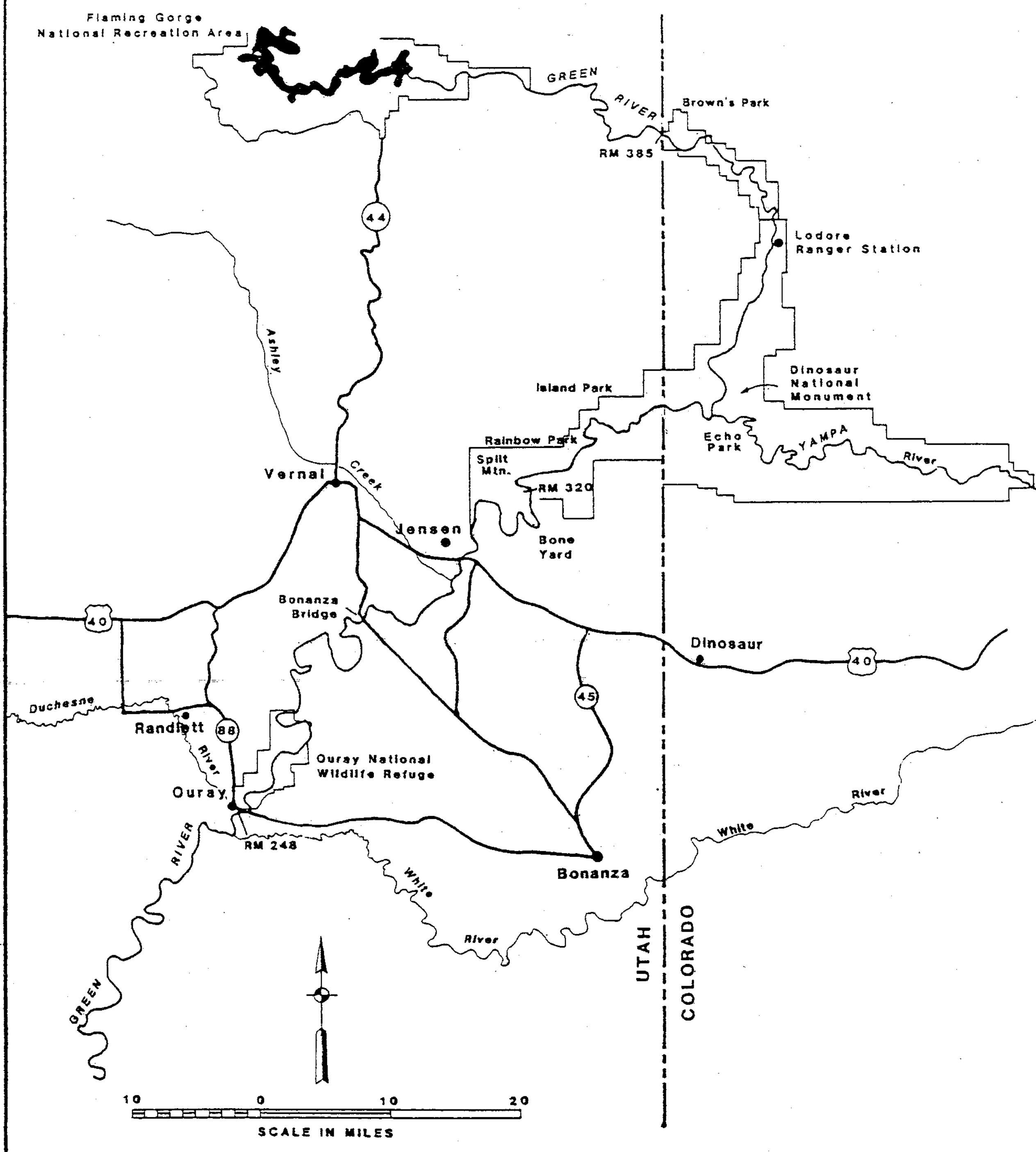

Figure 1. Study Area for Winter Habitat Needs of Colorado Squawfish and Razorback Suckers.

All data on fish movement and habitat use were based on these 40 radiotagged fish, although 1 Colorado squawfish and 3 razorback suckers were excluded from the database for various reasons. None of the data associated with Colorado squawfish OR-3237 were used, since the fate of the fish was unknown; only the radiotransmitter was found on a dry sand bar. Of the three razorback suckers excluded, no data were collected on GR-6110, since the partially decomposed carcass with transmitter were found shortly after release; the data associated with GR-129 were also not used, since this fish was suspected of being a hybrid of a razorback and flannelmouth sucker (such crosses have been reported, McAda 1978); OR-3230 was not contacted following release, for the only suspected case of transmitter failure during this investigation.

In year 2, we also recontacted 3 razorback suckers (GR-2417, GR-6117, OR-3266) and 1 Colorado squawfish (GR-6104), which had been tagged during year 1; all four fish were equipped with AVM transmitters that had surpassed their 12 to 14-month life expectancy. We no longer received signals from the four transmitters in March of year 2, and we concluded that these had functioned for about 17 months. During monitoring, these fish appeared to behave normally, and the data from razorback sucker GR-2417 and Colorado squawfish GR-6104 were included in the year 2 database. Razorback sucker GR-6117 was contacted only by aerial tracking, and was not monitored because the fish was located in a relatively inaccessible area near Mitten Park, while razorback sucker OR-3266 was contacted too infrequently to monitor.

Capturing The Fish

All fish used in this investigation were captured with a 220-volt DC electrofinding system, controlled by a Coffelt VVP-15 variable voltage pulsator. The normal operating level was 90-200 volts and 4-10 amps, at 80 pulses per second with a 40 percent pulse width. A 16-foot jonboat and an 18-foot Havasu raft were equipped with electrofishing systems which were removed during tracking.

Electrofishing was conducted primarily along shorelines and other suitable habitat accessible by boat. All adult Colorado squawfish and razorback suckers were held in live wells for transport to a nearby mobile surgery station for implanting the radiotransmitters. Other endangered fishes were weighed, measured, tagged and released, including Colorado squawfish and razorback suckers considered too small for surgical implant. No endangered humpback chub (Gila cypha) or bonytail (Gila elegans) were captured during this study.

Radiotelmetry Equipment and Techniques

Radiotransmitters And Receivers

Of the 20 radiotransmitters used in year 1, 10 were manufactured by Smith-Root (model P-40) and 10 by AVM (model SM-1). These transmitters were powered by lithium and mercury batteries, respectively, each with a 12 to 14-month life expectancy. For year 2, 20 Smith-Root (P-40) radiotransmitters were used. These transmitters operated within the 40.660 to 40.700 MHz range, with transmission rates of 40 to 80 pulses per minute. All transmitters were tested for pulse and frequency upon receipt from the factory, and each was dipped in melted beeswax prior to implantation to minimize negative reaction by the peritoneum and internal organs of the recipient fish. Pulse and frequency were rechecked prior to and immediately following implantation to record any variation in frequency or pulse from factory specifications, and to minimize the difficulty in locating transmitter signals during tracking.

Smith-Root search (SR-40) and standard tracking (RF-40) receivers, as well as an Advanced Telemetry Systems (ATS) programable scanning receiver were used for tracking and monitoring. These were equipped with Larsen Kulrod NMO-40 whip omnidirectional antennas or Smith-Root loop directional antennas.

Surgical Implant Procedures

The radiotransmitters were implanted surgically according to the techniques described by Tyus (1982, 1988). Fish were anesthetized with tricaine methanosulfate (MS-222) in a 40-gallon plastic bucket used as a portable live well. A fish was determined to be sufficiently anesthetized when, within 1-2 minutes, it could no longer maintain equilibrium.

Surgery was performed by placing the fish on a measuring board or a specially designed cradle placed atop the live well. One person held the fish firmly in position while another continuously bathed the gills with water using a baster. Water with anesthesia was used to a point about midway through the surgery at which time fresh water was used to minimize the effect of the anesthesia and to speed recovery of the fish. Fish exposed the least amount of time to the anesthesia recovered quicker and were more alert for an earlier release.

To implant the transmitter, a small incision (2.5 - 3.0 cm long) was made anterior and slightly dorsal to the insertion of the left pelvic fin. The transmitter was inserted toward the posterior end of the abdominal cavity so it came to rest on the pelvic girdle. The incision was closed with four to eight sutures using 3-0 Ethilon™ black monofilament nylon with an FS-1 cutting needle. Each fish was then observed in a live well or recovery pen in the river for periods of up to 1 hour, until it was alert and actively swimming, before release.

All adult Colorado squawfish and razorback suckers were weighed, measured, and tagged with a uniquely-numbered orange Carlin dangler tag attached to the base of the dorsal fin (Valdez et al. 1980). Previously tagged fish were recorded as recaptures and the tag replaced only if the original attachment thread appeared frayed. Only Colorado squawfish 530 mm total length (TL) or larger were equipped with radiotransmitters, although some slightly smaller fish were used that were judged sufficiently robust to accept a transmitter. No size restriction was placed on adult razorback suckers.

Radiotracking

Six 10-day tracking trips were conducted during each of the 2 years of this investigation. The fish were located on the first day of each trip by aerial tracking with fixed-wing aircraft. The location of each fish was provided to ground crews to facilitate locating the fish for subsequent monitoring and habitat analyses. Aerial tracking was conducted from a Cessna 182 RG fixed-wing aircraft owned by BIO/WEST. The same pilot and observer conducted most of the tracking using uniform procedures to maximize the number of fish contacted. Locations provided through aerial telemetry were generally within 0.1 mile of the point subsequently located by ground crews. Generally, aerial telemetry was conducted at ground speeds of 70-160 mph at above-ground elevations of 50-1000 feet.

Radiotracking on the river was done primarily from jonboats, although ice cover during January and February, 1988, prevented their use through most of the study area. During this time, access was by vehicle along shoreline roads and on cross-country skis over the frozen and snow-covered river channel. Snowmobiles and quadratracks were found to be impractical because of the unstable and rough nature of the river ice and the heavy shoreline vegetation.

Once a signal was received, the RF-40 receiver with loop antenna was used to pinpoint the fish location. As soon as the signal source was located, the boat was taken to the nearest shore or island, with care to not disturb the fish. From land, the RF-40 receiver was used exclusively; first to identify the fish by determining the transmitter frequency and pulse, and then to locate the fish using triangulation. Triangulating the location of a fish involved using the directional capabilities of the loop antenna to establish two or three bearings at different places along the shore. Each bearing was marked with two flagged metal rods driven into the ground 3 to 5 m apart and in line with the sighting.

Each fish was determined to be alive by intentionally disturbing and causing the fish to move at the end of the monitoring period, although some movement was recorded for nearly all fish during the monitoring period. If no movement was detected or could be caused, a concerted effort was made to locate the fish carcass or radiotransmitter. All fish were accounted for during this investigation, except for razorback sucker OR-3230, which was not contacted following release; transmitter failure is suspected.

Monitoring Fish Movement And Habitat Use

Monitoring

The fish and their associated habitats were monitored under three modes; 2-hour, 24-hour, and crepuscular. Only 2-hour and 24-hour monitoring were conducted during year 1. In year 2, 2-hour and crepuscular monitoring were conducted. The selection and order of fish to be observed for 24-hour and crepuscular monitoring was determined within each of the three study regions using a random numbers table.

Two-hour monitoring was performed on as many fish as possible during each field trip of both years. Its primary purpose was to locate each fish, observe it over a short daylight period, and record physical habitat measurements. Once a fish was contacted, its location was monitored continuously for 2 hours. During this time, movement and habitat utilized were recorded. A map of the river reach occupied by the fish (about 250 m) was hand-drawn on the back of each data sheet, to include habitats, prominent features of the channel, as well as fish locations and movements. At the end of the 2-hour monitoring period, habitat measurements were taken only at sites used by the fish continuously for 15 minutes or longer. Each fish that had not moved during the monitoring period was intentionally disturbed following habitat measurements to insure that it was alive.

Twenty-four hour monitoring was done to describe diel movement patterns and habitat use, and to determine if the 2-hour daylight monitoring represented diel fish activity. Each fish during year 1 was monitored once for 24 hours, in randomly selected order. During that time, locations and movements were checked and recorded at intervals generally not exceeding 2 hours. If a fish moved to a different location during the 24-hour period and remained stationary for a substantial time, additional habitat measurements were taken at the new location. Maps of the river reach occupied by the fish were also completed for each 24-hour monitoring period, and at least one 2-hour monitoring period was conducted as described above.

Crepuscular monitoring was conducted to determine if behavior, movement, or habitat use were different for dawn and dusk as compared to daytime. The observation period extended from 1 hour before to 1 hour after sunrise or sunset. Movement and habitat use by each fish was recorded and mapped, and as with the 2-hour monitoring, habitat measurements were taken at sites occupied by a fish for longer than 15 minutes. The fish were observed in randomly selected order within each of the three study regions.

<u>Movement</u>

Movement by the radiotagged fish is classified as either long-range or local. **Long-range movement** is associated with fish that changed position in the river significantly. It is considered transitory because it occurred between habitats located some distance apart. Long-range movement is classified as total or net. Total movement is the sum of fish movement in both up and downstream directions, based on locations during tracking trips. Net movement is the resultant distance from the original tracking location in early December to the final location in late March. Long-range movement is expressed to the nearest 0.1 mile.

Local movement describes the activity of a fish within a localized area, with no significant change in location. This pattern often involved movement between two to eight closely-spaced "favorite spots", or microhabitats, within a single habitat type. Local movement is also classified as gross or net. Gross movement is the sum of fish movement during a monitoring period. Net movement is the linear distance between the first and last tracking points. Local movement is expressed as meters per hour.

<u>Habitat Measurements</u>

Habitat parameters were measured to evaluate habitat use and to relate it to changes in water surface elevation. These measurement were taken at the end of the 2-hour, 24-hour, or crepuscular monitoring periods. The following measurements were taken at each location where a fish was stationary for 15 minutes or longer: water depth; water velocity; water temperature; instream, bank, and overhead cover; dominant and secondary substrate; ice thickness; and frazil ice depth.

Measurements were taken from either a boat, by wading, or through a hole in the ice at three points relative to the fish; the point of triangulation ('point' measurement), one meter toward the river channel ('out' measurement), and one meter toward the shore ('in' measurement). Measurements were taken at the three points described to characterize the microhabitat occupied by the fish as well as the adjacent associated habitat parameters.

Habitat measurements taken at all three points were the same, except for velocity. The point measurement included water velocity at 5 cm off the river bottom, and at two-tenths, six-tenths, and eight-tenths of the water depth. Velocity measurements at one meter on either side of the fish ('in' and 'out') were recorded only at six-tenths of the depth. Velocities were measured using a Marsh-McBirney current meter and a 2 or 4-m wading rod. Where the measurement was taken in a countercurrent (i.e. an eddy) greater than 90 degrees from the main directional flow, velocity was recorded as negative.

Substrate was categorized as silt, sand, gravel, cobble, boulder, or bedrock by probing with the hand, foot, or wading rod, depending on water depth. Features providing cover (i.e. large boulders, overhanging banks, sand ridges) at each fish location were also recorded.

RESULTS AND DISCUSSION

Movement

No significant differences were found in movement by adult Colorado squawfish or razorback suckers among the diurnal, nocturnal, and crepuscular periods. Movement data were therefore pooled for the respective species.

Colorado Squawfish

Long-range movement of overwintering adult Colorado squawfish was not considered extensive during this investigation. In year 1, maximum net movement by a fish was 22.2 miles upstream (Figure 2). Although two other fish moved 13.9 and 13.1 miles downstream, 7 of the 10 radiotagged fish were found less than 3 miles from their initial tracking locations. The average net movement of these 10 fish during year 1 was 5.6 miles. In year 2, one fish moved 25.9 miles downstream from its initial tracking location, but the other 8 radiotagged fish remained within 2 miles of their initial respective locations. The average net movement of these 9 fish was 3.6 miles.

Total long-range movement by these fish was not very different from net movement. In year 1, maximum total movement by a fish was 22.8 miles, and average total movement by all 10 fish was 6.0 miles. In year 2, maximum total movement was 25.9 miles, and average was 5.3 miles. The similarity between average total and net movement for the two winters (6.0 and 5.6 miles in year 1; 5.3 and 3.6 miles in year 2) indicates little random movement by the fish in the wintertime, outside of their immediate habitat. We conclude from this analysis that the majority of adult Colorado squawfish in the Green River probably overwinter within a 2 to 3-mile reach of river.

Local movement by Colorado squawfish was generally restricted to a specific habitat usually with little net movement. Under nonfluctuating, ice-free flows, 4 overwintering adult Colorado squawfish in year 1 moved an average of 15.23 m/h, while 9 fish in year 2 moved 23.03 m/h. This movement was usually between favorite spots, which the fish occupied for extended periods of time. This amount of movement is considered normal, although we hypothesize

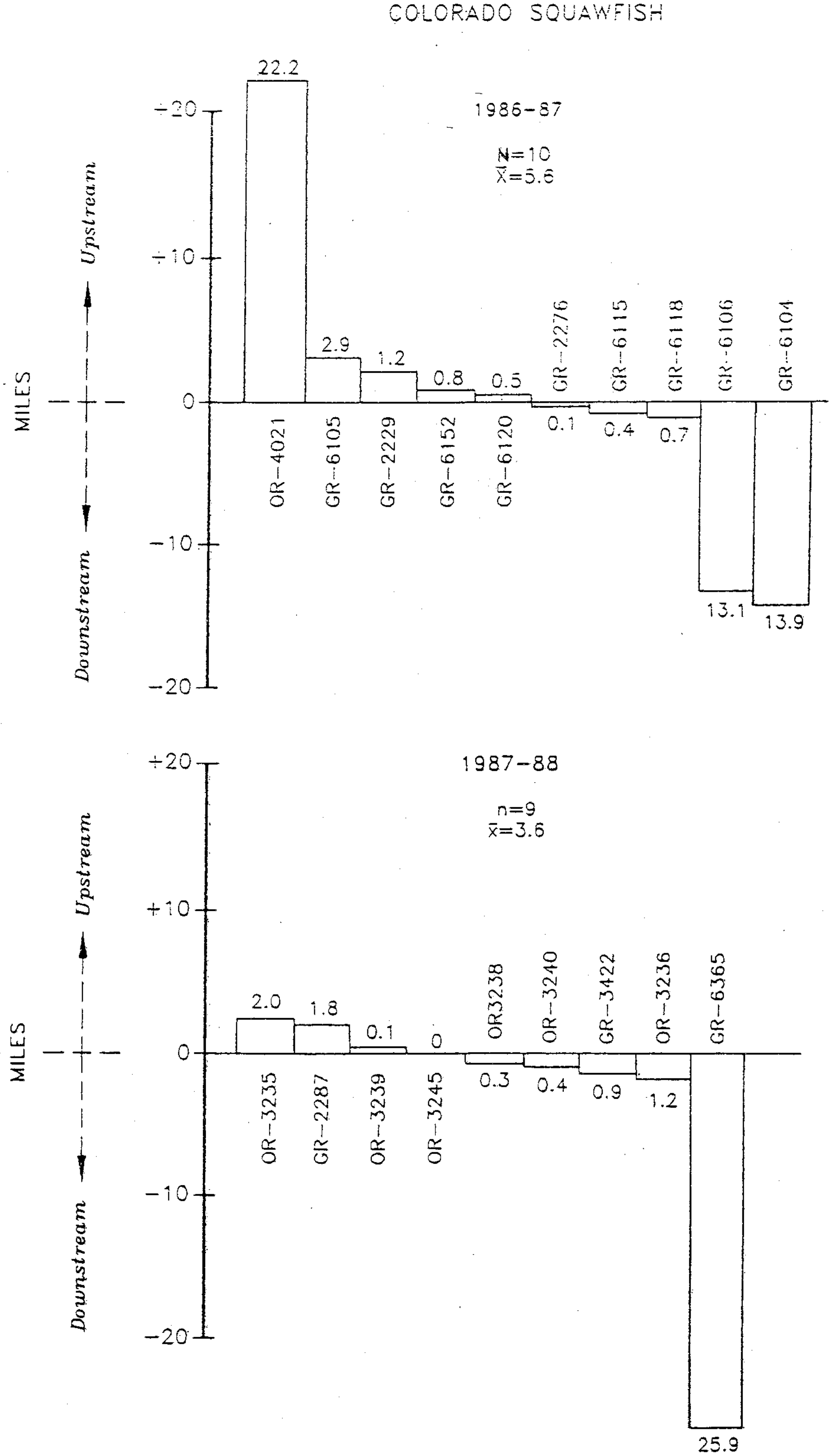

Figure 2. Net upstream and downstream movement of adult radiotagged Colorado squawfish in 1986-87 and 1987-88.

that it differs with habitat type to reflect a resting mode in slow runs and slackwaters and a feeding mode in eddies and backwaters. We attribute the relatively greater movement during year 2 to lower flow regimes that may have created more marginal conditions in fish habitat.

Figure 3 illustrates the local movement of 2 of the 10 radiotagged fish monitored in year 1. Colorado squawfish OR-4021 occupied four favorite spots within the same slackwater during a 24-hour period. The fish moved a total of 50 m during this time, but ended up only 10 m from its original location. This fish occupied the four spots five times for periods of 2, 1, 4, 8 and 9 hours. A second Colorado squawfish, GR-6106, in the same vicinity, visited eight favorite spots for periods of 1 to 9 hours, all within a 50-m diameter area in the same slackwater habitat. Gross movement by this fish was 118 m while net movement was 10 m.

We conclude from these observations that local movement rates of 15 to 23 m/h are normal for overwintering adult Colorado squawfish in the absence of fluctuating flows. This movement is not continuous, but occurs between favorite spots or microhabitats in which the fish is sedentary for several hours before moving to another spot.

Local movement was also analyzed under stable ice and nonfluctuating flows in year 2 to determine if ice cover affects this aspect of fish behavior. The average local movement by 5 Colorado squawfish under stable ice conditions was 29.16 m/h. This figure did not differ significantly from average movement of 23.03 m/h under ice-free nonfluctuating flows. Although their movement is not significantly greater under ice, we believe Colorado squawfish use ice as a cover element.

Local movement by an adult Colorado squawfish under stable ice is illustrated in Figure 4. Fish GR-3422 occupied three favorite spots during a 2 hour period; gross movement was 30 m and net movement was 7 m. We conclude from these observations that local movement by adult Colorado squawfish under stable ice is not significantly greater than in ice-free conditions. We noted that all fish monitored in areas characterized by a mosaic of solid surface ice and jam ice remained beneath the former more stable form.

Razorback Sucker

Long-range movement by overwintering adult razorback suckers was not considered extensive. In the first winter of the investigation, maximum net movement by a fish was 10.5 miles downstream (Figure 5). Although one other fish moved 4.4 miles downstream, 6 of the 8 radiotagged fish were found less than 1 mile from their initial tracking locations. The average net movement of these 8 fish during year 1 was 2.1 miles. In the second winter, maximum net movement by a fish was 7.3 miles upstream, while two other fish moved 5.9 and 3.2 miles downstream. Six of the 9 radiotagged fish in year 2 remained within 3 miles of their initial tracking locations. The average net movement of these 9 fish was 2.9 miles.

As with adult Colorado squawfish, total movement by adult razorback suckers was not very different from their net movement. In year 1, maximum total movement by a razorback sucker was 10.5 miles, and average total movement by the 8 fish was 2.3 miles. In year 2, maximum total movement was 10.4 miles, LOWER REGION - Colorado Squawfish in ice-free water

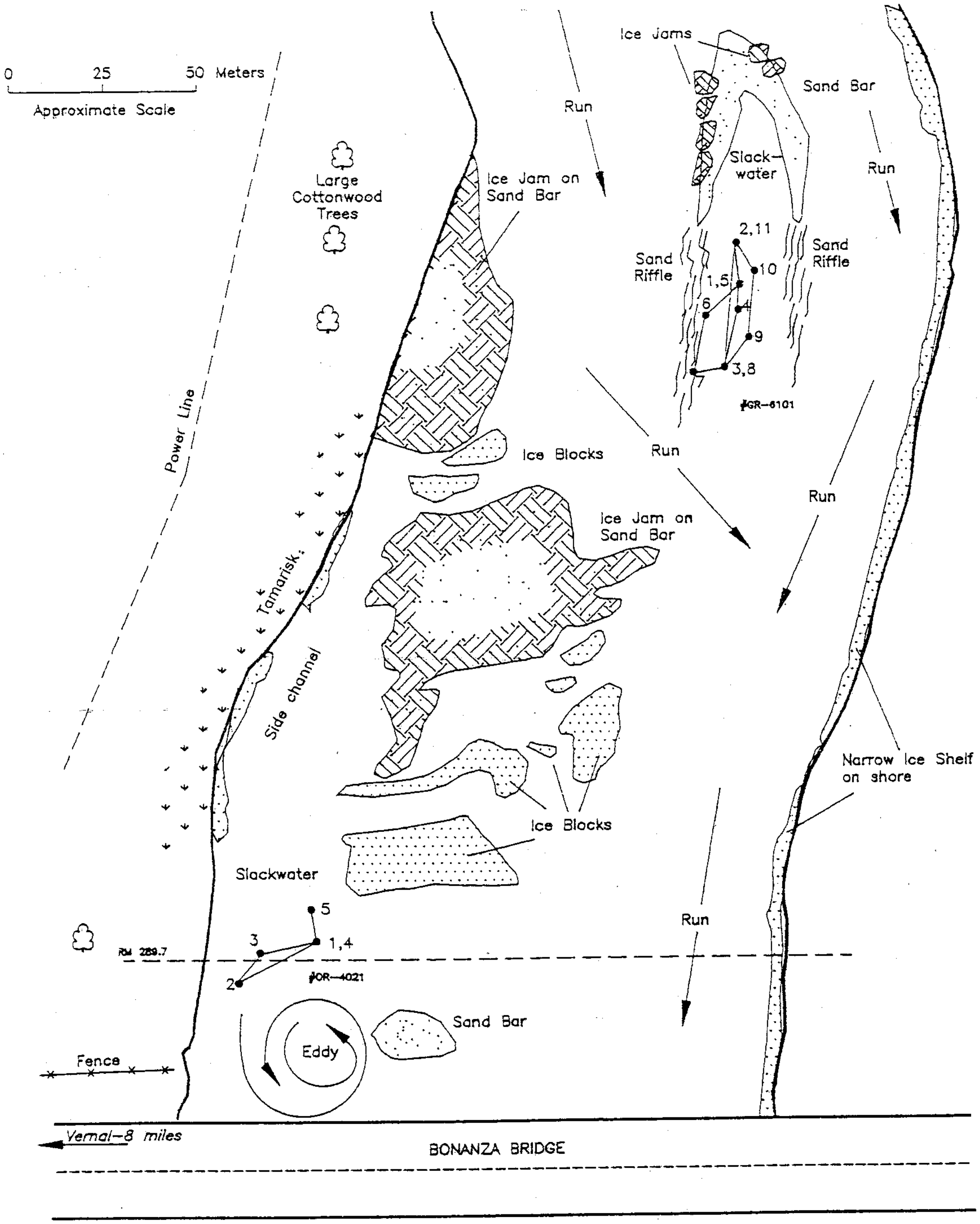

Figure 3. Local movement of two radiotagged Colorado Squawfish OR-4021 and GR-6106 during a 24 hour period (1428h on 2/2/87 to 1425h on 2/3/87) at RM 289.7-289.8, above Bonanza Bridge, on the Green River.

LOWER REGION – Colorado Squawfish under stable ice

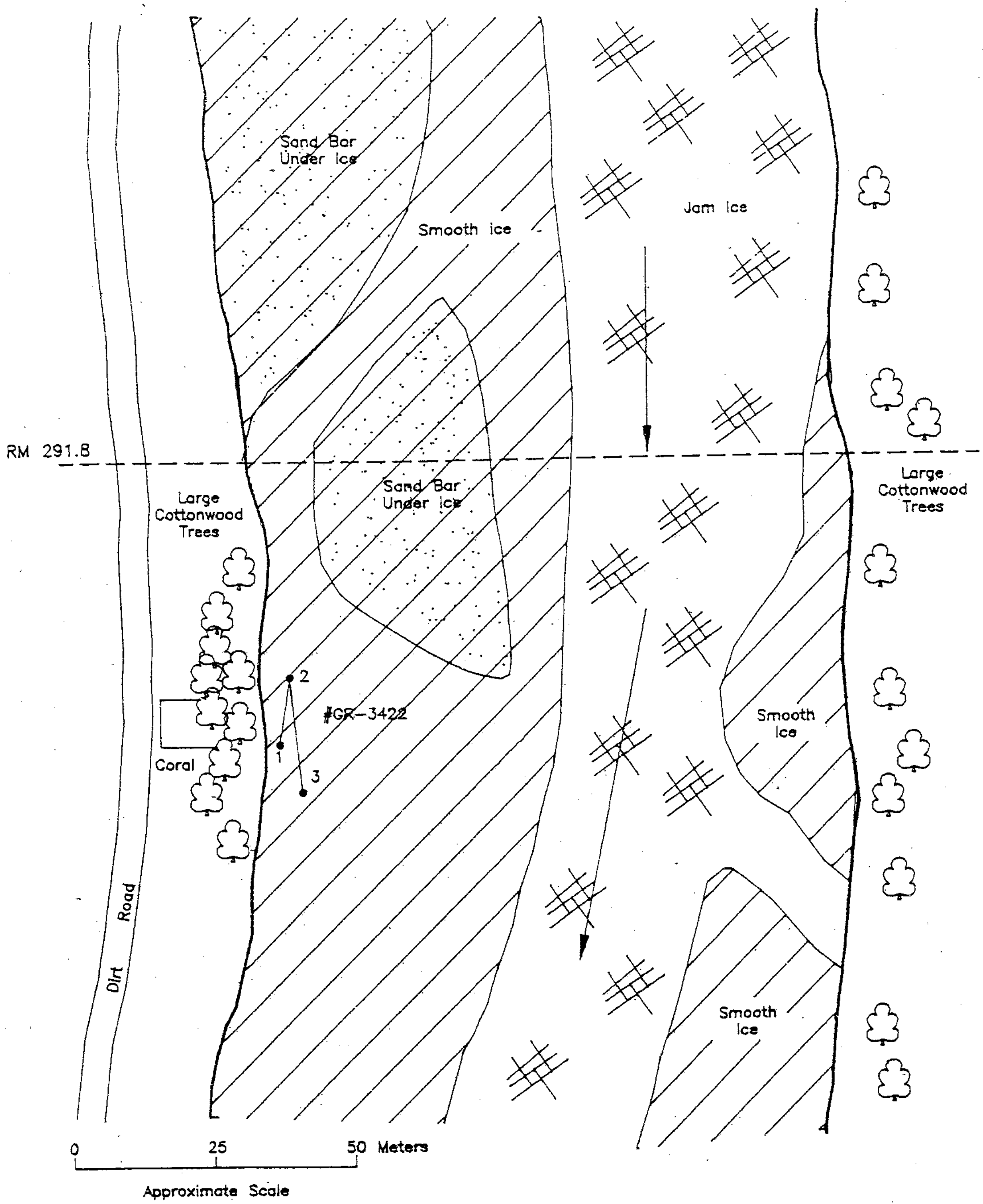

Figure 4. Movement of radiotagged Colorado Squawfish GR–3422 during a 2 hour period (0900–1058h) at RM 291.8, near Alhandra Ferry Site, of the Green River, January 11, 1988.

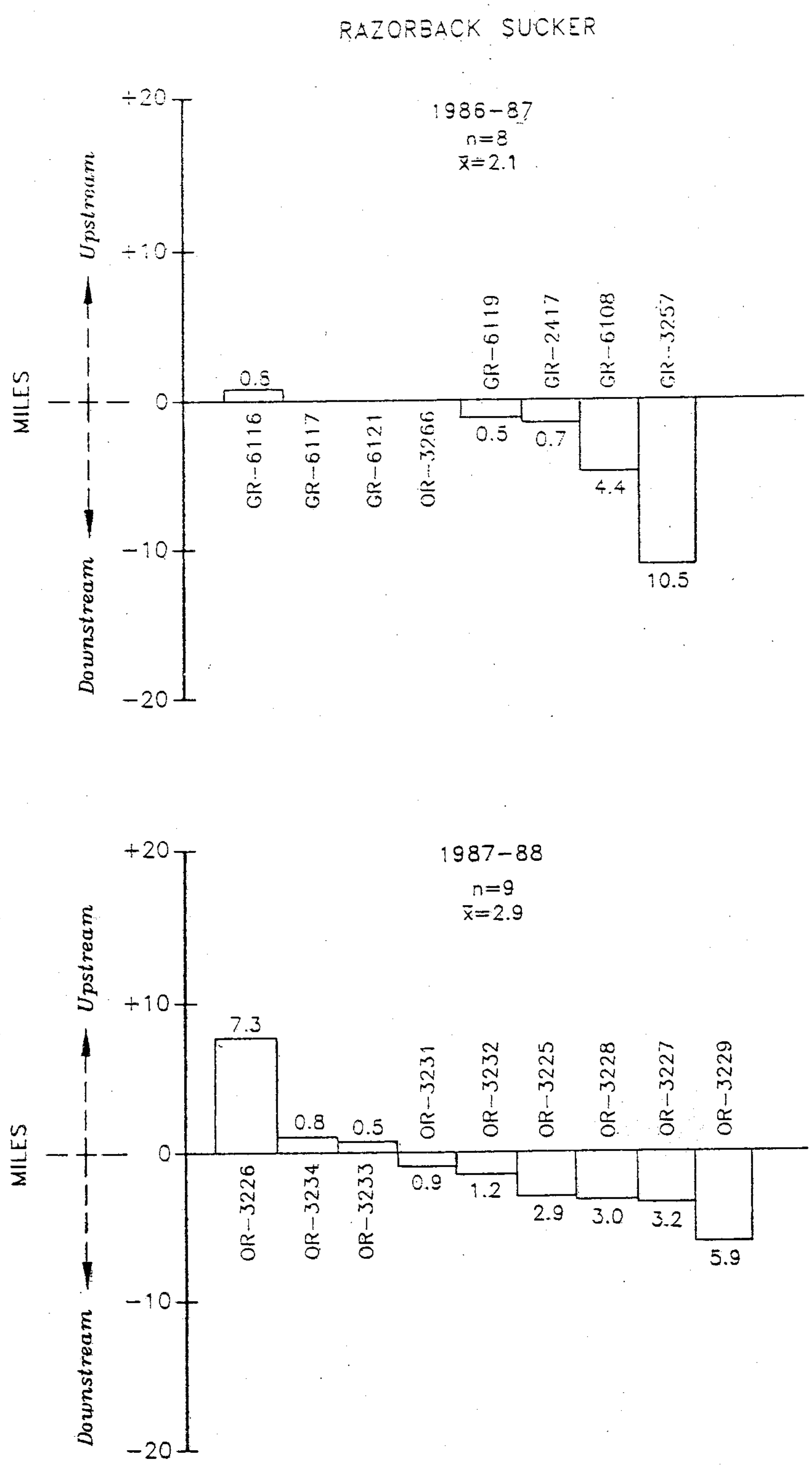

Figure 5. Net upstream and downstream movement of adult radiotagged razorback sucker in 1986-87 and 1987-88.

and average was 5.2 miles. The similarity between average total and net movement for the two winters (2.3 and 2.1 miles in year 1; 5.2 and 2.9 miles in year 2) indicates little random movement by the fish outside of their immediate habitat. We conclude from this analysis that the majority of adult razorback suckers in the Green River overwinter within a 1 to 3-mile reach of river.

Local movement by these overwintering fish was generally restricted to a specific habitat with little net movement. Under nonfluctuating, ice-free flows, 3 overwintering adult razorback suckers in year 1 moved an average of 24.54 m/h, while 8 fish in year 2 moved 30.93 m/h. This movement was usually between favorite spots, which the fish occupied for extended periods of time. This amount of movement is considered normal, and did not differ with habitat types as was seen with Colorado squawfish. We attribute the relatively greater movement during year 2 to lower flow regimes that may have created more marginal conditions in fish habitat.

Figure 6 illustrates the local movement of a radiotagged fish monitored in year 1. Razorback sucker OR-3257 occupied three favorite spots, two within the same slow run and one in a nearby slackwater in a sand trough, during a 24-hour period. This fish occupied these spots for periods of 15, 4, and 5 hours. The fish moved a total of 103 m during this time, but ended up only 20 m from its original location.

We conclude from these observations that local movement rates of 24 to 31 m/h are normal for overwintering adult razorback suckers. This movement is not continuous, but occurs between favorite spots used by the fish for up to several hours before moving to another spot. Local movement of adult razorback suckers under ice and nonfluctuating flows could not be analyzed because of insufficient sample size. Only 1 radiotagged fish was located in these conditions; movement rate of this fish was 19.71 m/h, in a pattern similar to that of Colorado squawfish.

Habitat Use

No significant differences were found in habitat used by adult Colorado squawfish or razorback suckers among the diurnal, nocturnal, and crepuscular periods. Habitat data were therefore pooled for the respective species.

Colorado Squawfish

During the first winter of this investigation, the 10 radiotagged Colorado squawfish were observed in four habitat types; runs, slackwaters, eddies, and backwaters. The fish occupied these habitats 43, 39, 12 and 6% of the total observation time, respectively (Figure 7). All of these observations were made during ice-free conditions.

The 9 radiotagged fish monitored the second winter, under ice-free conditions, used runs, slackwaters, backwaters, and eddies 64, 29, 5, and 2% of the time, respectively (Figure 7). The same 9 fish monitored under ice-covered conditions during year 2 occupied runs, backwaters, and slackwaters 69, 17, and 14% of the time, respectively. Their use of ice-covered backwaters and relatively shallow areas is believed a behavioral response to surface ice as a cover element that may be associated with feeding.

LOWER REGION – Razorback Sucker in ice-free water

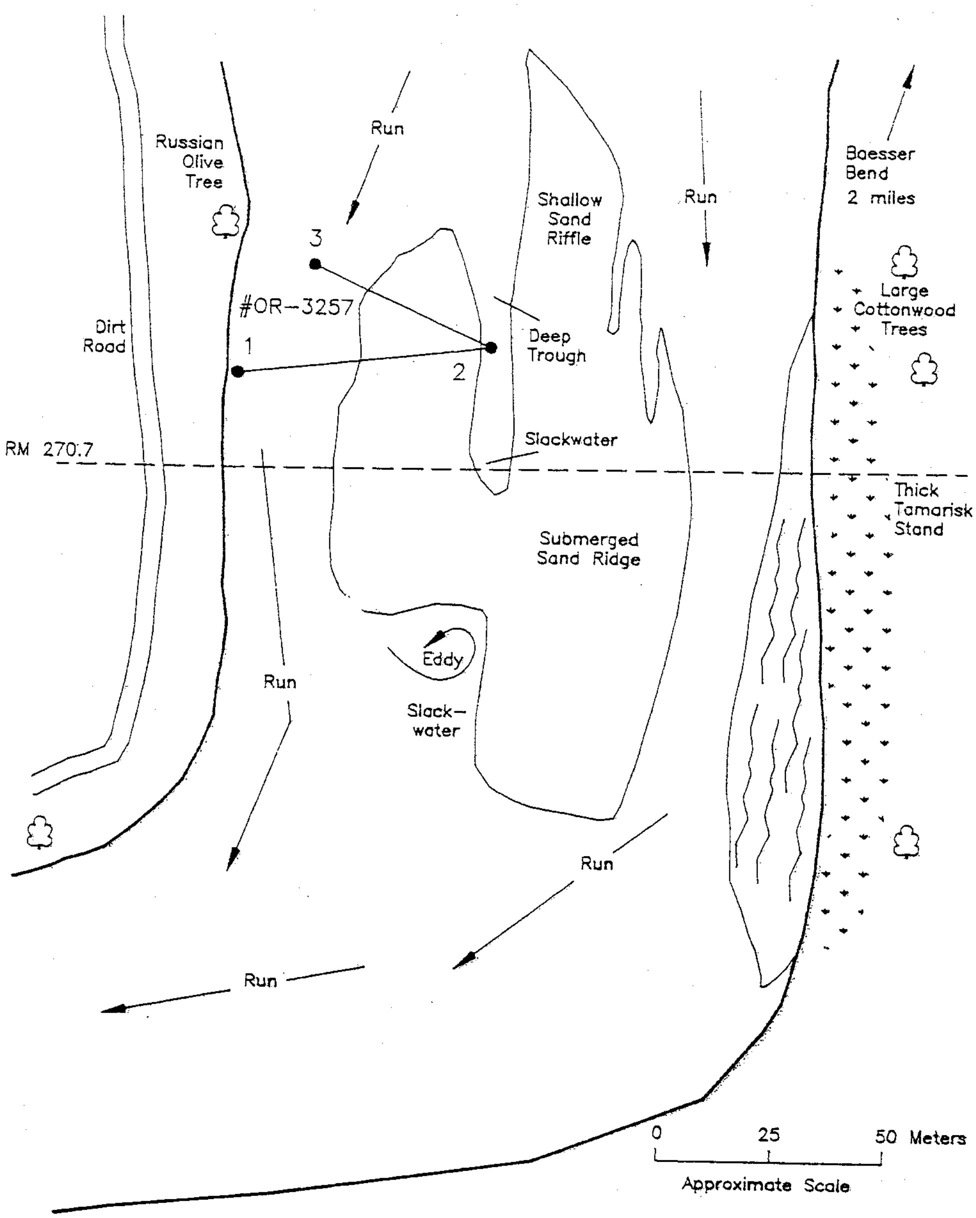

Figure 6. Movement of Radiotagged Razorback Sucker OR-3257 during a 24 hour period (1030h on 3/11/87 to 1030h on 3/12/87) at RM 270.7, below Baesser Bend, of the Green River.

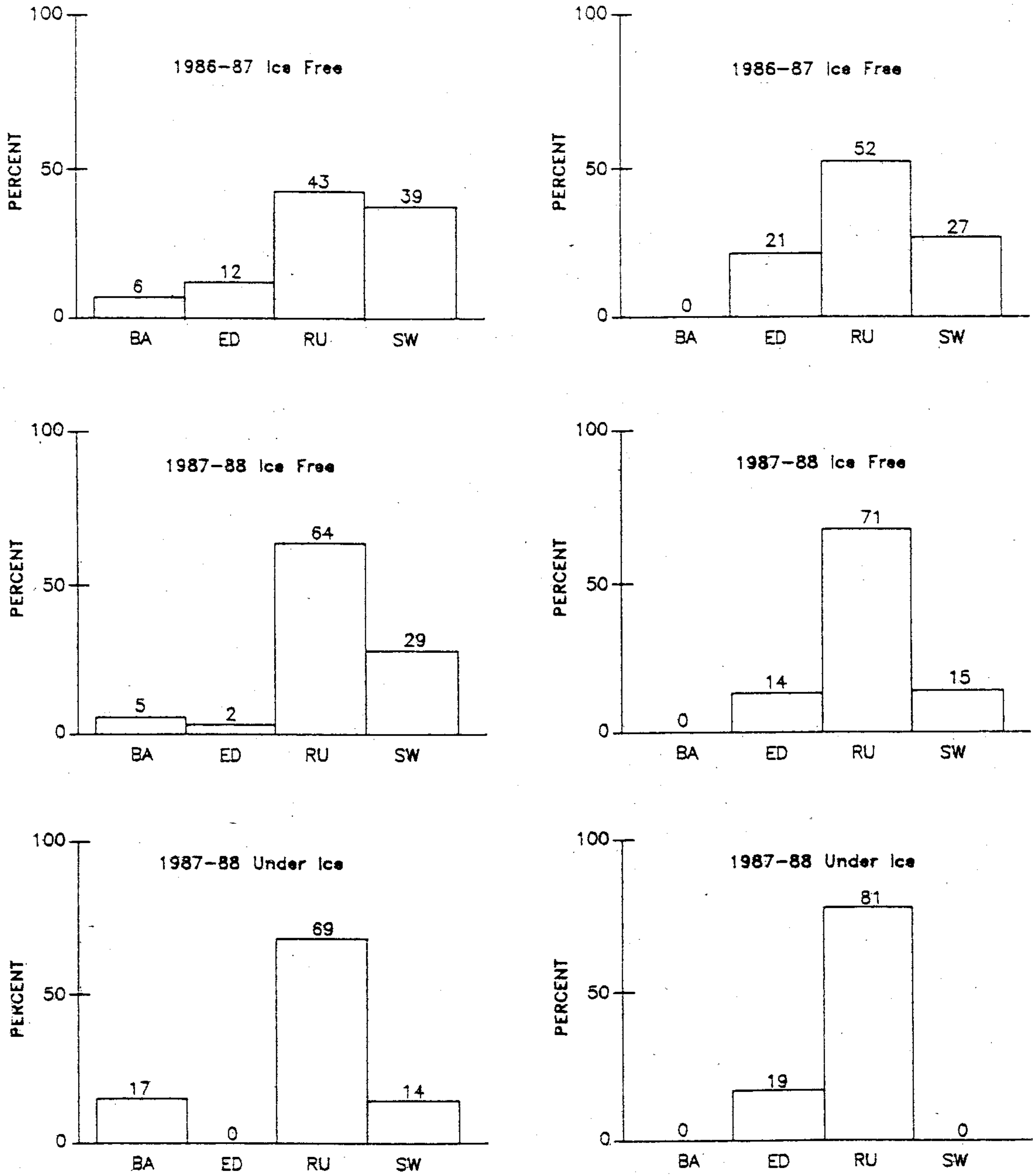

Figure 7. Habitat used by overwintering adult radiotagged Colorado squawfish and razorback suckers in the Green River under ice and ice-free conditions, BA= backwater, ED = eddy, RU = slow run, SW = slackwater.

We believe the use of these four habitat types reflects as least two behaviors; resting and feeding. Overwintering adult Colorado squawfish appear to rest in slow midchannel runs and slackwaters, and feed in eddies and backwaters. This hypothesis is based on the relatively sedentary nature of the radiotagged fish while in slow runs and slackwaters and a greater amount of local movement while in eddies and backwaters. Colorado squawfish in year 2 exhibited different degrees of movement in the two habitat categories identified above. Movement of 9 fish in slow runs and slackwaters ($n = 12$; mean = 21.71 m/h; SD = 22.92) differed significantly (Student's $t = 1.70$; $P > 0.90$) from their movement in eddies and backwaters ($n = 10$; mean = 48.20 m/h; SD = 49.27). The greater degree of movement in eddies and backwaters is attributed to foraging for prey species which are probably more abundant in these habitats than in midchannel runs and slackwaters.

Selection of wintertime microhabitat by adult Colorado squawfish appears driven by low average (at 0.6 depth) and near-bottom velocity and an average minimum depth requirement of about 3.5 feet (Table 1). Fish were observed in three separate habitat categories in similar watercolumn depths and velocities under ice and ice-free conditions. These areas were not necessarily the deepest parts of the river channel, and we believe the fish were positioned near the bottom where velocities were low, although river turbidity did not allow us to observe them directly. We also recognized that the fish were commonly associated with an instream cover element. Adult Colorado squawfish were frequently seen resting in slow runs and slackwaters immediately downstream of a sand shoal that appeared to slow water velocity at the fish location. Often the fish were located in a small depression or trough created by sand waves, as is reflected by the dominant run/slackwater substrate.

Although the fish frequented shallow water under ice, the depth measurements do not reflect this because the fish were too mobile to meet the minimum 15-minute criterion for habitat measurements. Thus, depth and velocity measurements collected in this investigation probably reflect primarily resting habitat. Measurements were not taken on fish that were continually active. The relatively greater number of observations (measurements) in runs and slackwaters (Table 1) supports the hypothesis that adult Colorado squawfish rest principally in these habitat types.

Razorback Sucker

During the first winter of this investigation, 8 radiotagged razorback suckers were observed in three habitat types; runs, slackwaters, and eddies. The fish occupied these ice-free habitats 46, 24, and 30% of the total observation time, respectively (Figure 7).

The 9 radiotagged fish monitored the second winter, under ice-free conditions, used runs, slackwaters, and eddies 71, 15, and 14% of the time, respectively (Figure 7). The same 9 fish monitored under ice-covered conditions during year 2 occupied runs and eddies 81 and 19% of the time, respectively.

Unlike adult Colorado squawfish, adult razorback suckers not exposed to fluctuating flows in year 2 did not exhibit different degrees of movement in the two habitat categories identified above. Movement of 8 fish in slow runs and slackwaters ($n = 19$; mean = 31.94 m/h; SD = 35.92) was no different

Table 1. Mean depth and velocity (range in parenthesis) used by overwintering adult radiotagged Colorado squawfish in the Green River under ice (1987-88) and ice-free conditions (1986-87 and 1987-88).

HABITAT	NO. OBSERVATIONS	NO. FISH	DEPTH	VELOCITY 0.6	VELOCITY BOTTOM	SUBSTRATE[a] 1	SUBSTRATE[a] 2
1986-87: ICE-FREE							
BA	6	3	3.6 (2.7-4.9)	0.1 (0-0.3)	0	SA	SI
ED	10	5	3.8 (1.4-8.0)	0.1 (-0.2-0.5)	0.1 (-0.1-0.3)	SI	SA
RU + SW	45	8	3.8 (0.9-7.5)	0.7 (0-2.2)	0.1 (0-1.1)	SA	SA
ALL	61	10	3.8 (0.9-8.0)	0.6 (-0.3-2.2)	0.2 (-0.1-1.1)	SA	SA
1987-88: ICE-FREE							
BA	2	2	2.5 (1.2-3.8)	0.9 (0.2-1.6)	0.3 (0-0.3)	SA	SA
ED	5	3	4.5 (1.7-10.0)	0.4 (-0.2-2.3)	0.0 (-0.2-0)	SI	SA
RU + SW	21	9	4.2 (1.3-7.7)	0.6 (0-1.5)	0.1 (-0.1-0.5)	SA	SA
ALL	28	9	4.2 (1.2-10.0)	0.6 (-0.2-2.3)	0.1 (-0.2-0.5)	SA	SA
1987-88: UNDER ICE							
BA	6	2	3.3 (1.1-6.6)	0.0 (-0.1-0.1)	0.0 (0.0)	SI	SI
ED	0	0	-	-	-	-	-
RU + SW	15	9	2.8 (0.3-7.0)	0.7 (0-1.3)	0.2 (0-0.4)	SA	SA
ALL	21	9	2.9 (0.3-7.0)	0.5 (-0.1-1.5)	0.2 (0-0.4)	-	-

a 1 = dominant substrate, 2 = secondary substrate

Table 2. Mean depth and velocity (range in parenthesis) used by overwintering adult radiotagged razorback suckers in the Green River under ice (1987-88) and ice-free conditions (1986-87 and 1987-88).

HABITAT	NO. OBSERVATIONS	NO. FISH	DEPTH	VELOCITY 0.6	VELOCITY BOTTOM	SUBSTRATE[a] 1	SUBSTRATE[a] 2
1986-87: ICE-FREE							
BA	0	0	-	-	-	-	-
ED	13	6	4.5 (2.0-7.9)	0.1 (-0.2-1.0)	0.1 (-0.2-0.6)	SI	SA
RU + SW	37	8	4.5 (1.3-9.8)	1.1 (0.1-3.0)	0.2 (0-0.9)	SA	SA
ALL	50	8	4.5 (1.3-9.8)	0.9 (-0.1-3.0)	0.2 (0-0.9)	SA	SA
1987-88: ICE-FREE							
BA	0	0	-	-	-	-	-
ED	15	5	4.2 (1.4-6.3)	0.2 (-0.4-3.3)	0.4 (-0.2-1.4)	SA	CO
RU + SW	34	9	3.9 (1.3-8.5)	0.9 (0.1-2.0)	0.3 (0-0.8)	SA	SA
ALL	49	9	4.0 (1.3-8.5)	0.7 (-0.4-3.3)	0.3 (-0.2-1.4)	SA	SA
1987-88: UNDER ICE							
BA	0	0	-	-	-	-	-
ED	2	2	2.0 (1.8-2.2)	0.8 (0.3-1.2)	-0.1 (-0.6-0.3)	SA	CO
RU + SW	6	4	3.4 (0.5-6.9)	0.1 (0.1-0.2)	0.1 (0-0.3)	SA	SA
ALL	8	6	3.0 (0.5-6.9)	0.3 (0.1-1.2)	0.1 (-0.6-0.3)	-	-

[a] 1 = dominant substrate, 2 = secondary substrate

(Student's t = 0.01; P < 0.55) than their movement in eddies and backwaters (n = 14; mean = 32.05 m/h; SD = 28.85). This similarity in movement between the two habitat categories does not allow us to hypothesize on wintertime resting and feeding habitat for adult razorback suckers.

Selection of wintertime microhabitat by adult razorback suckers also appears driven by low average and near-bottom velocities, but the depth requirement does not seem as critical as for adult Colorado squawfish; minimum average depth used by razorback suckers was 2.0 feet. These fish used similar watercolumn depths and velocities in three habitat categories under ice and ice-free conditions (Table 2). The fish consistently used areas of low bottom velocity which were not necessarily the deepest parts of the river channel. Webelieve both adult razorback suckers and Colorado squawfish were frequently positioned near the river bottom where velocities were low, although river turbidity did not allow us to observe them directly. Although the dominant and secondary substrates associated with both species was usually sand or silt, adult razorback suckers appeared to use cobble areas more frequently than adult Colorado squawfish, although this is reflected only as a secondary substrate in eddies.

We also recognized that these fish were commonly associated with an instream cover element. Adult razorback suckers, like adult Colorado squawfish, were frequently seen in slow runs and slackwaters immediately downstream of sand shoals that appeared to slow water velocity at the fish location. Razorback suckers were often located in small depressions or troughs created by either sand waves or cobble piles.

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GEOHYDROLOGIC EVIDENCE FOR THE DEVELOPMENT OF DEVILS HOLE, SOUTHERN NEVADA AS AN AQUATIC ENVIRONMENT

by Alan C. Riggs

ABSTRACT

Devils Hole apparently results from the tectonic pull-apart of a small fault in Paleozoic carbonate bedrock. It presently extends from ground surface, through the water table 16 m down, to a depth of at least 100 m. The fault started to open at depth at least 750 Ka ago, but did not reach the surface until later. The early water table was high, filling the spreading fissure with ground water supersaturated with respect to calcite. Travertine, a distinctive morph of calcite, precipitated on all underwater surfaces. Over time, as water table fluctuated and slowly fell to its present level, a different calcite morph precipitated at water level. The distinctiveness of the two morphs and their suitability for Uranium-series dating allow us to begin interpreting the history of Devils Hole in terms of its suitability for habitation by the Devils Hole pupfish, *Cyprinodon diabolis*.

There is probably no evidence of initial habitation of Devils Hole by *C. diabolis*; the best we can do is to fix the time when Devils Hole first became an isolated habitat suitable for pupfish. Two possible scenarios are: 1) roof collapse prior to the last excursion of water table above

Devils Hole lip level, and 2) roof collapse after the last excursion of water table above Devils Hole lip level. In the first scenario, organisms migrating up a surface stream from Ash Meadows would colonize Devils Hole pool, and isolation would start with the last fall of water table below the lip. According to Winograd and Szabo (these Proceedings) that probably would have occurred between 180 and 800 Ka ago. In the second scenario, Devils Hole pool forms after water levels became low enough that no surface stream would ever connect Devils Hole with Ash Meadows, and above ground colonization would take place over dry intervening countryside. In this case, the time of isolation would begin with introduction of the pupfish, sometime after roof collapse. At the present time there is insufficient evidence to choose between these alternatives, however several observations may be significant: 1) on the basis of two samples only, travertine precipitation on the walls of the main chamber stopped about 50 Ka ago, after operating essentially uninterruptedly for the prior 700 Ka, and 2) ceiling collapse floored the main chamber with bedrock breakdown that is uncoated by travertine, and was therefore emplaced 50 Ka or less ago, and 3) scanning electron micrographs show a layer of what appears to be organic material coating travertine surfaces in the main chamber. This coating may be what stops travertine precipitation even though the water remains supersaturated. Together, these observations suggest that surface collapse took place about 50 Ka ago, fostering the development of a photosynthetically based, surface bound community that prevented further travertine precipitation and produced an environment favorable for pupfish colonization.

TIME OF ISOLATION OF CYPRINODON DIABOLIS IN DEVILS HOLE: GEOLOGIC EVIDENCE

by Isaac J. Winograd and Barney J. Szabo

ABSTRACT

The modern water table in Devils Hole is about 16 m below land surface. It is commonly believed that Cyprinodon diabolis became isolated in this cavern at the close of the Pleistocene Epoch, 12,000 to 15,000 years ago, as a direct result of increasing aridity accompanied by a cessation of spring discharge from Devils Hole. Uranium-series dating of speleothems from Brown's Room in Devils Hole indicates, however, that the water table stood only about 9 m above the modern level between 44,000 ± 1,000 and 27,000 ± 1,000 years ago, and declined thereafter. Thus, if we assume that C. diabolis became isolated due to a decline of water table then this species has been isolated a minimum of 44,000 years.

What might be the maximum time of isolation of C. diabolis? The distribution of vein calcite, tufa, and other evidence indicative of paleo-ground water discharge, indicates that during the early-to-middle Pleistocene (1.6 million to 700,000 years ago) the water table in the central Amargosa Desert, Nevada was tens of meters higher than the modern water table, and that ground-water discharge occurred as far as 14 km upstream from modern discharge areas. The apparent water-table decline in this part of the Great Basin since the early-to-middle Pleistocene probably reflects a combination of: a) tectonic uplift of vein calcite and tufa, unaccompanied by a change in water-table altitude; b) lowering of ground water base-level in response to tectonism or erosion; and; c) decline in water-table altitude in response to increasing aridity caused by major uplift of the Sierra Nevada and Transverse Ranges during the Pleistocene. Uranium-series dating of the calcitic veins permits calculation of rates of apparent water-table decline in the past million years; rates of 0.02 to 0.09 $m/10^3$ yr are indicated.

A synthesis of hydrogeologic, neotectonic, and paleoclimatologic information with the vein-calcite data permits the inference that the water table in the central Amargosa Desert, progressively lowered throughout the Pleistocene. If we assume that C. diabolis was isolated due to this progressive lowering of the water table at a proto-Devils Hole, then -- using the water-

table decline rates cited above and the 16 m depth to modern water table -- this species would have been isolated for 180,000 to possibly as much as 800,000 years. That isolation times in excess of 100,000 years are credible is supported by the absence, at Devils Hole, of geologic evidence for late Pleistocene ground-water discharge, as well as by the dated paleo-water levels in Brown's Room.

Introduction of C. diabolis into Devils Hole within the past 44,000 years, by mechanisms that are independent of regional water-table decline, is also possible, and should not be completely discounted; three such mechanisms are discussed.

Management for Recovery of Colorado Squawfish

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ABSTRACT

The Colorado squawfish, Ptychocheilus lucius, once widespread and abundant in mainstream rivers of the Colorado River Basin, has been extirpated from about 75% of its historic range. It is most common in the Green River Basin of Colorado and Utah in habitats that have been little affected by water resources alterations. Intensive research and management efforts by federal, state, and other institutions, have provided a basis for conservation of this species only recently - largely persuant to passage of the Endangered Species Act of 1973. This study demonstrated that conservation and management for recovery of Colorado squawfish can only be accomplished with a full understanding of the complex life cycle and ecological relationships of this fish. A major factor in the conservation effort is provision of a proper hydrologic regimen. Flows identified as providing suitable nursery habitats have resulted in successful recruitment, and shown that water management, not water quantity alone, is most important for future recovery of the fish. Although the endemic Colorado River fauna may never be restored to its former composition and abundance, even in smaller subbasins, conservation and recovery of this species is possible in the remaining habitat if preferred habitats are optimized and life history needs are met.

RESUMEN

El Colorado squawfish, Ptychocheilus lucius, a una vez muy extensivo y abundante en los ríos mayores de la cuenca del Río Colorado, ha sido eliminado de aproximadamente 75% de su alcance histórico. Es mas común en la cuenca del Río Verde de los estados de Colorado y Utah en la habitat que no se ha afectado mucho por alteraciones de recursos actuáticos. Investigaciones intensivas y enfuerzos de manejo por instituciones de gobiernos federal, estatal, y varios otros, han proveido una base para conservación de este expecie solamente recientemente - mas bien después de adopción de la ley para protección de especies amenazados, "Endangered Species Act of 1973'. Este estudio demonstró que conservación y manejo para recobre del Colorado squawfish se puede cumplir solamente con comprensión completa del ciclo complejo de vivencia y relaciones ecológicas de este pez. Un factor mayor en la efuerza de conservación es la provisión de un propio regimen hidrológico. Flujos identificados que proveen la propia habitat para criadero han resultado con éxito del crecimiento de la poblacion, y han muestrado que el manejo acuático, no solamente la calidad de aqua, es lo mas importante para el recobro futuro del pez. Aunque la fauna endémica del Río Colorado no se pueda restablecer a su composición y abundancia anterior, hasta en las cuencas mas pequeñas, conservación y recobro de este especie es posible en la habitat disponible si se puede proveer mas de la habitat que se prefiere y se satisfechan los requerimientos de vivencia.

NATIVE FRESHWATER AND ANADROMOUS FISHES OF COASTAL SOUTHERN CALIFORNIA

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The coastal drainages of southern California have a small native freshwater fish fauna consisting of 27 taxa (six freshwater, six anadromous, four freshwater/brackish and eleven marine taxa that frequently enter freshwater). Six of the sixteen nonmarine forms are endemic to southern California. The southern terminus of the distribution for all the anadromous and freshwater/brackish taxa occurs in this area. Only a limited number of historical records exist for several of the marine invaders. The species restricted to bays and lagoons which spend part of their life cycle in freshwater and the other in brackish water live in a habitat which has been severely reduced. In fact, the habitat for all native taxa has been reduced. One taxa, *Lampetra* sp., has already been extirpated; one is endangered, *Gasterosteus aculeatus williamsoni*, and a third is a species of special concern, *Eucyclogobius newberryi*. Human modification of habitat and continuing introduction of non-native fishes continue to be the major threats to native species. This paper will compare the historical distributions of the southern California native freshwater fishes with the most current information on their present distributions.

ABSTRACT

Status of the native fish fauna of California. Peter B. Moyle, Jack E. Williams, and Eric D. Wikramanayake. Department of Wildlife and Fisheries Biology, University of California, Davis, Davis CA 95616. The native fishes of California can be placed, conservatively, into 115 taxa. 67% of these taxa are endemic to the state. Of the 115 taxa, 4 (3%) are extinct and 16 (14%) are formally recognized by state and/or federal agencies as threatened or endangered. Our analysis of the remaining taxa indicates that 4 need immediate recognition as threatened or endangered. Another 21 taxa (18% of the fauna) have declined considerably in abundance in recent years or have such naturally restricted ranges that management measures are needed to keep them from becoming endangered in the near future. Two additional species would be considered threatened or endangered if they had not been widely planted outside their native range as sport fish. In total, 41 % (47 taxa) of the native fish fauna is extinct, in serious trouble, declining in abundance, or very restricted in distribution. In addition, all wild populations (runs) of spring and winter run chinook salmon (Oncorhynchus tshawytscha) and of summer steelhead (O. mykiss) need immediate protection.

LONG-TERM CHANGES IN THE FISH COMMUNITY OF LOWER SAGEHEN CREEK, CALIFORNIA

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A long-term study was made of impacts of a new reservoir on upstream fish populations. The fish populations of Sagehen Creek, California have been under study since 1951. In 1969, the lowest section of the creek was flooded by Stampede Reservoir. Soon after, populations of nine species, six of them native, began to undergo changes. Large fluctuations in relative abundance and simplification of the fish community have occurred. Brook trout (Salvelinus fontinalis), speckled dace (Rhinichthys osculus), mountain sucker (Catostomus platyrhynchus), and mountain whitefish (Prosopium williamsoni) have become rare. Lahontan redside (Richardsonius egregius), Tahoe sucker (Catostomus tahoensis), brown trout (Salmo trutta), rainbow trout (Salmo gairdneri), and Paiute sculpin (Cottus beldingi) remain common with Lahontan redside predominant. Thus, the fish community has been reduced from nine consistently occurring species to five. Reservoir levels have fluctuated greatly, eliminating the riparian zone in the lower stream section. In 13 of the past 19 years, Stampede Reservoir has fallen below 50% capacity and had an average annual change in volume of 32.1%. These changes in the reservoir appear to have restructured the upstream populations of fish. Two nearby streams similarly influenced by a reservoir, have populations much like those in Sagehen Creek.

CAMBIOS DE LARGO PLAZO EN LA COMUNIDAD DE PECES EN LA PARTE INFERIOR DEL ARROYO SAGEHEN EN CALIFORNIA

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Se realizó una investigación de largo plazo sobre el impacto de un nuevo depósito acuífero sobre la ictiofauna del arroyo Sagehen en California. La ictiofauna de este arroyo ha sido estudiada desde 1951. La parte más baja del arroyo fue inundada en 1969 por el deposito "Stampede". Al poco tiempo se observaron cambios en la densidad de población de nueve especies, seis de ellas nativas. Sus densidades relativas han sufrido grandes fluctuaciones y la estructura de la comunidad se ha simplificado. La densidad de Salvelinus fontinalis (brook trout), Rhinichthys osculus (speckled dace), Catostomus platyrhynchus (mountain sucker) y Prosopium williamsoni (mountain whitefish) se ha vuelto escasa. Catostomus tahoensis (Tahoe sucker), Salmo trutta (brown trout), Salmo gairdneri (rainbow trout), Cottus beldingi (Paiute sculpin) y Richardsonius egregius (Lahontan redside) permanecen abundantes siendo esta última la especie predominante. Por consiguiente, la comunidad íctica ha sido reducida de nueve especies normalmente presentes a sólo cinco. Grandes fluctuaciones en el nivel del deposito han eliminado la zona ribereña en la parte baja del arroyo. Durante 13 de los 19 años pasados, el depósito ha bajado a menos del 50% de su capacidad y ha tenido una fluctuación anual promedio en su volumen del 32.1%. Estos cambios en los niveles del depósito parecen haber reestructurado las poblaciones en la parte superior del arroyo. Dos arroyos cercanos que han sido afectados en forma similar por la presencia de depósitos tienen poblaciones similares a las de Sagehen.

IMPACT AND ABUNDANCE OF AN INTRODUCED CICHLID IN THE LOWER RIO GRANDE (RIO BRAVO DEL NORTE), TEXAS AND MEXICO

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The blue tilapia (*Oreochromis aureus*) was not recorded from the lower Rio Grande prior to the mid-1970's. The species has since extensively colonized the lower river and has become one of the dominant members of the fish community. Studies conducted since 1980 show extensive ecological overlap between blue tilapia and native fishes. A severe winter cold period in late 1983 drastically reduced the blue tilapia population; however, the species rapidly rebounded and reestablished former levels of abundance. In the past 30 years, the fish community of the lower Rio Grande has extensively changed. The success of the blue tilapia and the similarity of its ecology to those of the existing fishes, especially the native Rio Grande cichlid (*Cichlasoma cyanoguattatum*) suggest that such characteristics as generalized food habits, good colonizing ability and adaptability to often stressful environments are important factors in determining the species composition of the fish community.

IMPACTO Y ABUNDANCIA DE UNA ESPECIE DE CICLIDAS INTRODUCIDA EN EL BAJO RIO GRANDE (RIO BRAVO DEL NORTE) DE TEXAS Y MEXICO.

La tilapia azúl (*Oreochromis aureus*) no ha sido registrada entre las especies del bajo Río Grande antes de la década de 1970. Desde entonces, ésta especie ha colonizado extensivamente la parte baja del Río y se ha convertido en una de las especies dominantes en el área. Los estudios que se han llevado a cabo desde 1980 indican una extensa interación ecológica entre la tilapia azúl y las especies nativas. El invierno de 1983 fué severo en la región y la población de tilapia azúl fué reducida drásticamente; sin embargo, la especie ha vuelto a reestablecerse a su nivél anterior de abundancia. En los últimos 30 años, la comunidad piscícola del bajo Río Grande ha cambiado extensivamente. El éxito de la tilapia azúl y la similaridad de su ecología a las especies locales, especialmente la ciclida nativa del Río Grande (*Cichlasoma cyanoguttatum*) sugieren que algunas caracteristicas como los hábitos generales de alimentación, la habilidad colonizadora y la adaptabilidad a un medio ambiente a menudo difícil, son factores importantes que determinan la composición de la comunidad piscícola.

STATUS OF LEOPARD FROGS (*Rana pipiens* COMPLEX; RANIDAE) IN ARIZONA AND SOUTHEASTERN CALIFORNIA: AN UPDATE

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Abstract -- A sample of literature and museum localities of leopard frogs (*Rana pipiens* complex), was surveyed in Arizona and Imperial Valley, California, during 1983-1987. We found *R. chiricahuensis* at only two of 36 localities which previously supported the species in the 1960s and 1970s; two new localities are reported. Of 13 of 28 literature localities surveyed for *R. pipiens*, none were found to be inhabited, although one previously unreported population was discovered. *Rana blairi* was found at two of six literature localities surveyed, and a new population was reported. *Rana yavapaiensis* could not be found in Imperial Valley and the lower Colorado River, Arizona-California, but upland Arizona populations are relatively intact. Introduced *R. berlandieri* has replaced *R. yavapaiensis* along the Colorado and Gila rivers, Arizona. These apparent losses represent additional decimation of an increasingly endangered North American ranid fauna.

ESTATUS DE LAS RANAS LEOPARDO (*Rana pipiens* COMPLEJO; RANIDAE) EN ARIZONA Y SURESTE DE CALIFORNIA: UNA ACTUALIZACION

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Resumen - Se tomaron muestras de localidades revisadas en la literatura existente y de colectas depositadas en museos de las ranas leopardo (Complejo *Rana pipiens*), en Arizona y Valle Imperial, California durante 1939 a 1987. Se encontró a *R. chiricahuensis* en solo dos de las 36 localidades en donde anteriormente habitaba la especie entre las décadas de los sesentas y setentas; además se registran dos localidades nuevas. Trece de las 28 localidades citadas en la literaatura que registraron a *Rana pipiens*, en otro tiempo, ya no se les encuentra actualmente. Sin embargo, una población no registrada previamente fué descubierta en este estudio. *Rana blairi* fué encontrada en 2 de 6 localidades registradas en la literatura y se encontró una población nueva. *Rana yavapaiensis* no se registró en el Valle Imperial y la parte baja del Río Colorado. En cambio, en Arizona - California las poblaciones a elevaciones mayores están relativamente intactas. La *R.* introducida *R. berlandieri* ha reemplazado a *R. yavapaiensis* a lo largo de los ríos Colorado y Gila en Arizona. Estas pérdidas aparentes representan un decline adicional a la constantemente en aumento fauna de ránidos de Norte América en Peligro de Extinción.

SAN BERNARDINO NATIONAL WILDLIFE REFUGE, A CASE STUDY OF ACID RAIN IN THE SOUTHWEST

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Abstract -- The San Bernardino National Wildlife Refuge was established in 1982 for the protection and management of endangered desert fishes which are indigenous to the Rio Yaqui drainage. The 2,309-acre refuge is located on the United States-Mexico border 16 miles east of Douglas, Arizona. Collectively, copper smelter emissions in southern Arizona and northern Sonora have created a regional atmospheric condition where mean annual precipitation pH is 4.7 to 5.0. Background chemistries are largely unavailable and influence of both nonferrous smelter emissions and current agriculture practices and pesticide use remain unexplored. During May through June 1987, water chemistry was determined on-site at each of 13 locations within the refuge (including Leslie Creek) and sediment and selected tissue samples were collected for trace metals and pesticide analysis. Overall, refuge waters were virtually absent of dissolved trace metals and spring chemistries were relatively consistent due to their presumable origin from a common aquifer. Alkalinity exceeded the EPA recommended minimum of 20 mg/l for freshwater aquatic life by a factor of 10 to 18 and appears to be the mitigating factor which disallows acidic deposition to adversely manifest itself in the aquatic ecosystem. Biota are probably the best integrative indicator of watershed quality, and its ability to neutralize acid. Trace metal residues in tissue matrices were mixed in their occurrence, especially for frogs. However, no evidence of acid-stress in resident organisms on the refuge was observed. Native fish populations exhibited no symptoms of lack of recruitment, incident of morphological abnormalities, or subnormal growth. Likewise, bullfrogs flourish through the refuge and exhibited little in regard to trace metal body burdens. Periodic biological and chemical monitoring is the recommended course of action to evaluate refuge condition and trend relative to environmental quality.

SAN BERNARDINO NATIONAL WILDLIFE REFUGE, UN CASO DE ESTUDIO DE LLUVIA ACIDA EN EL SUROESTE

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Resumen - El San Bernardino National Wildlife Refuge fué establecido en 1982 para la protección y manejo de los peces del desierto en Peligro de Extinctión que son nativos a la cuenca del Río Yaqui. El refugio, con una extensión de 2,309 acres está localizado en la frontera México - Estados Unidos, 16 millas al este de Douglas, Arizona. Emisiones de la fundición de cobre provenientes del sur de Arizona y norte de Sonora han creado una situación atmosférica regional donde el pH de la precipitación media anual es de 4.7 a 5.0. No se cuenta con antecedentes de análisis químicos y la influencia de las emisiones de las fundiciones no ferrosas y de las prácticas agrícolas y el uso de pesticidas, permanecen sin examinar. De Mayo a Junio de 1987, la calidad del agua fué determinada "in situ" en cada una de las 13 localidades dentro del Refugio (incluyendo Leslie Creek) y muestras de tejido seleccionado y de sedimento fueron colectados para análisis de metales traza y pesticidas. En síntesis, las aguas del Refugio estuvieron libres de metales traza disueltos y los análisis de la calidad del agua de los arroyos fueron consistentes debido a su probable origen de un acuífero común. La alcalinidad excedió el mínimo recomendado por EPA de 20 mg/l para la vida acuática por unfactor de 10 a 18 y esto pareciera ser el factor mitigante que anula el depósito ácido que podría manifestarse adversamente en el ecosistema acuático. La biota es probablemente el mejor integrante indicador de la calidad de las aguas de la cuenca y su habildad para neutralizar los ácidos. La presencia de residuos de metales traza en los tejidos fueron variados, especialmente en las ranas. Sin embargo, no se observó evidencia de estres por ácidos en los organismos residentes del Refugio. Las poblaciones de peces nativos no mostraron síntomas de falta de reclutamiento, incidencia de anormalidades morfológicas o crecimiento anormal. Del mismo modo, las rana-toro abundaron en todo el Refugio a pesar de las cargas corporales de metales traza. La línea de acción recomendada son las evaluaciones biológicas y químicas periódicas para estimar la situación del Refugio y la tendencia relativa de la calidad ambiental.

DESERT FISH HABITAT PROTECTION THROUGH FEDERAL ACQUISITION

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U.S. Fish and Wildlife Service
Albuquerque, New Mexico

Annually, the United States Fish and Wildlife Service obtains property for the conservation of wildlife. Most acquisition is directed towards migratory birds. Within the past five years increased emphasis has been given to obtaining property for recovery of threatened or endangered species, including fishes. The Service has numerous ways of acquiring and managing land. For lands which are part of the public domain, cooperative management agreements or direct transfer of jurisdiction can be used to give the Service management responsibility. Private lands are usually acquired in fee title. Land and Water Conservation funds, Migratory Bird funds or construction funds can all be used to purchase private lands. Direct donation, easements, and leasing can also be used to protect these habitats.

Observations on the Little Colorado River population of the humpback chubs, during May 1987, 1988.

C.O. Minckley
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During May of 1987 and 1988 research was conducted on the population of humpback chubs occurring in the Little Colorado River from it's confluence upsteam 10 km. Native fishes dominated the catch, with the humpback chub being the most common fish taken.

Reproduction was confirmed in this species by the presence of fish exhibiting secondary sexual characteristics, expression of gametes, breeding colors and larval fish. Reproduction was not observed.

In 1987, 82.5% of the humpback chubs captured were tagged and 11.9% were recaptured. Movement of recaptured 1988 fish was within the lower 1,200 m of the Little Colorado. Six fish previously tagged by Arizona Game and Fish were also recaptured. These later fish had grown from 2-46 mm in total length. In 1988, 60.5% of the chubs taken were tagged. Of that number, 21.3% were recaptured. Maximum upstream movement in 1988 was 9.2 km, maximum downstream movement was 2.9 km. The mean number of days at large during 1987 was 3.4; in 1988 it was 4.4 days.

In 1988, 20 fish tagged in 1987 were recaptured. Also, 31 fish tagged by other agencies were recaptured. Fish tagged in 1987 had grown from 0-42 mm. The other older recaptures had grown from 1-69 mm and one fish had been at large almost eight years. Based on preliminary examination of otoliths, it appears likely this species lives at least 34 years (W.L. Minckley pers. comm.).

The population estimate for 1987 was 5,783 ± 679 humpback chubs. In 1988 it was estimated that 7,060 ± 574 humpback chubs were present. Both of these estimates are for the lower 1200 m of the Little Colorado.

This study was funded by the Arizona Game and Fish Department, nongame branch. Additional logistic support was provided by the Glen Canyon Ecological Survey and numerous river companies.

SPRINGSNAILS OF THE DEATH VALLEY SYSTEM, CA-NV: DESCRIPTION AND PRELIMINARY ZOOGEOGRAPHIC ANALYSIS.

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Twenty-two species of springsnails (Gastropoda: Hydrobiidae) are known from permanent waters of Death Valley System, CA-NV. Most of these snails are very narrowly distributed, and local endemics are concentrated in Owens Valley, northern Death Valley, and Ash Meadows. Zoogeographic patterns exhibited by these organisms do not strongly support the hypothesis that inter-connected Pleistocene lakes within the area facilitated dispersal between currently isolated drainages. Alternative explanations for observed patterns are discussed.

HETEROZYGOSITY AND FITNESS DIFFERENCES AMONG POPULATIONS OF THE ENDANGERED SONORAN TOPMINNOW (*Poeciliopsis occidentalis*)

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Abstract

Remnant populations of the Sonoran topminnow (*Poeciliopsis occidentalis*) from Arizona contain significantly lower levels of genetic variability than their counterparts in Sonora, Mexico. Three of five Arizona populations surveyed were genetically invariant at 25 protein-determining loci. The purpose of this study was to test the prediction that low genetic variability in remnant populations of an endangered species is associated with a reduction in fitness.

Gravid *P. occidentalis* females were collected from three Arizona populations differing in mean levels of genic heterozygosity (H): Monkey Spring (H = 0.0%), Tule Spring (H = 1.5%), and Sharp Spring (H = 3.7%). First generation laboratory progeny were isolated in a recirculating aquatic incubator and raised to sexual maturity (12 weeks) under conditions of constant temperature, diet, and photoperiod. Four components of fitness were measured at the end of the 12 week experimental period: survivorship, growth, fecundity, and developmental stability. All four fitness components increased with an increase in mean heterozygosity across populations. Monkey Spring topminnows invariably ranked lowest in estimates of survivorship, growth, fecundity, and developmental stability; whereas, the most heterozygous population studied, Sharp Spring, consistently ranked highest. Tule Spring topminnows, intermediate in mean heterozygosity, ranked intermediate to Monkey Spring and Sharp Spring for two characters (growth and fecundity), but performed similarly to Sharp Spring in survivorship and to Monkey Spring in developmental stability. The more variable Sharp Springs fish would serve as the best native population for restocking and reclamation efforts in Arizona. The results emphasize the necessity of genetic as well as demographic information in the formulation of sound conservation and recovery practices.

DIFERENCIAS EN HETEROCIGOCIDAD Y FITNESS ENTRE POBLACIONES DEL "SONORAN TOPMINNOW" (*Poeciliopsis occidentalis*) EN PELIGRO DE EXTINCION

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Resumen

Poblaciones remanentes del "Sonoran topminnow" (*Poeciliopsis occidentalis*) de Arizona contienen niveles de variabilidad genética significativamente menores que sus contrapartes de Sonora, México. Tres de las cinco poblaciones Mexicanas estudiadas no presentaron variación genética en 25 loci determinantes de proteinas. El propósito de este estudio fue testear la predicción de que la baja variabilidad genética de las problaciones de Arizona esta asociado con una reducción en fitness.

Las hembras grávidas de *P. occidentalis* provienen de tres problaciones de Arizona que difieren en los niveles de heterocigocidad promedio (H): Monkey Spring (H = 0.0%), Tule Spring (H = 1.5%), and Sharp Spring (H = 3.7%). La primer progenie originada en laboratorio fue aislada en un incubador acuático y criada hasta la madurez sexual (12 semanas) bajo condiciones constantes de temperatura, dieta, y fotoperíodo. Cuatro componenetes del fitness fueron medidos al final del período experimental de 12 semanas: supervivencia, crecimento, fecundidad, y estabilidad en el desarrollo. Los cuatro componentes del fitness aumentaron con un incremento en la heterocigocidad media entre poblaciones. Los "topminnows" de Monkey Spring ocuparon invariablemente el nivél mas bajo en las estimaciones de supervivencia, crecimiento, fecundidad y estabilidad en el crecimiento; mientras que la población mas heterocigotica estudiada, es decir la de Sharp Spring, ocupó consistentemente el mayor nivel. Los "topminnows de Tule Spring, con una heterocigocidad intermedia, ocuparon el nivel intermedio entre Monkey Spring y Sharp Spring para dos caracteres (crecimiento y fecundidad), pero obtuvieron una perfomance semejante a los de Sharp Spring en supervivencia, y a los de Monkey Spring en estabilidad en el desarrollo. La población de Sharp Spring, mas variable, seria la mejor poblacion nativa para los esfuerzos de repoblación y recuperación en Arizona. de El resultado enfatiza la necesidad de información tanto genética como demográfica en la formulación de las prácticas de saneamiento y recuperación.

Status of Populations of Threespine Sticklebacks, *Gasterosteus aculeatus*, at the Southernmost Portion of their Pacific Coastal Range

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The original range of the circumboreal threespine stickleback, *Gasterosteus aculeatus*, included the coastal streams of southern California and Baja California del Norte as far south as El Rosario. This species was subsequently introduced into areas of California's transverse range and into a few inland drainages. However, during historical times, many of these populations have been extirpated and the rate of population extinction appears to be accelerating. In this paper we discuss the current status of these southernmost populations of *G. aculeatus*, including their distribution and the pattern of recent extirpations.

Sampling Theory, Genetic Characterization of Populations, & Loss of Alleles in Populations of Low Effective Number.

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ABSTRACT

A probabilistic model relating sample size, ploidy number, acceptable error rate and minimum detectable allele frequency answers the question, "How many individuals do I need for allozyme studies?" In a diploid population, sample sizes of 30 and 150 yield 95% probability of detecting all uncommon alleles, $q = 0.05$, and rare alleles, $q = 0.01$, respectively. Confidence in comparative studies (i.e., systematics) may be restricted by the smallest sample size. By substituting effective population number for sample size, estimates of retained allelic diversity (one component of genetic variability) may be obtained. The relationship of effective population size to generation length in years required to retain 90% of initial quantitative genetic variation in diploid species over 200 years is given.

A RECENT SURVEY OF FISHES FROM THE INTERIOR RIO YAQUI DRAINAGE WITH A RECORD OF FLATHEAD CATFISH, *Pylodictis olivaris*, FROM THE RIO AROS

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Abstract -- During winter and spring of 1988 fishes were surveyed in the remote reaches of the Rio Yaqui drainage, Sonora, Mexico. These reaches consisted of the Rios Papagochic, Aros, Bavispe and Yaqui. Fishes were surveyed as part of an ecological and monitoring study of bald eagles, *Haliaeetus leucocephalus*, in Sonora. Native fishes accounted for 64% of the fishes surveyed in the Rio Papagochic and upper Rio Aros. *Ictalurus pricei*, the Yaqui catfish, the *Gila robusta*, the roundtail chub, were dominant with *Catostomus bernardini*, the Yaqui sucker, being rare. Introduced fishes (mostly *Carpiodes carpio*, river carpsucker) were dominant in the Rio Bavispe and Bacadehuachi. Other exotic fishes surveyed were: *Cyprinus carpio*, common carp, *Micropterus salmoides*, largemouth bass, and *Ictalurus punctatus*, channel catfish. An important but unfortunate occurrence of flathead catfish, *Pylodictis olivaris* was documented in the Rio Aros 1 km above the confluence with the Rio Bavispe and Rio Yaqui.

UN ESTUDIO RECIENTE DE LOS PECES DEL INTERIOR DE LA CUENCA DEL RIO YAQUI CON UN REGISTRO DEL BAGRE CABEZA PLANA, *Pylodictis olivaris* DEL RIO AROS

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Resumen - Durante el invierno y la primavera de 1988 se colectaron peces de arroyos de la cuenca del Río Yaqui, Sonora, México. Estos arroyos pertenecen a los ríos Papigochic, Aros, Bavispe y Yaqui. Los peces fueron muestreados como parte de un estudio ecológico sistemático del Aguila Calva, *Haliaeetus leucocephalus*, en Sonora. Los peces nativos sumaron el 64% de los peces colectados en el Río Papigochic y la parte alta del Río Aros. El Bagre Yaqui *Ictalurus pricei* y el Charal Aleta Redonda *Gila robusta*, fueron las especies dominantes y, el Matalote Yaqui *Catostomus bernardini* fue una especie rara. Los peces exóticos, principalmente el Bocachiquita *Carpioides carpio*, fueron dominantes en el Río Bavispe y Bacadéhuachi. Otros peces exóticos colectados fueron; la Carpa Común *Cyprinus carpio*; la lobina negra *Micropterus salmoides*; y el Bagre de Canal *Ictalurus punctatus*. Fué registrada la presencia desafortunada pero importante del Bagre Cabeza Plana *Pylodictis olivaris*, en el Río Aros a 1 km arriba de la confluencia con el Río Bavispe y el Río Yaqui.

ECOLOGICAL OBSERVATIONS OF NATIVE FISHES FROM THE LOWER RIO YAQUI, SONORA, MEXICO.

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Alejandro Varela-Romero
José Campoy-Favela

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A B S T R A C T

The Ichthyofauna from the lower Río Yaqui sub-basin; Ríos Sahuaripa and Bacanora (Ríos Papigochic, Sirupa and Aros sub-basin) was surveyed from 24 collections made in Agoust 1988. A total of 20 species were recorded corresponding 50% to the natives, 45% exotics and 5% euryhaline. Most native species ocurred (78.5%) in the uppermost effluents, not same with the exotics which are present preferably in Río Yaqui main bed. The native species Ictalurus pricei, Chichlasoma beani and Poeciliopsis prolifica ocurred in very small number and Dorosoma smithi previously recorded was not found in our suvery. Gambusia affinis and Tilapia were observed widely distributed in most parts of the basin, the latter shares most native species habitats in the river bed and small streams. Dorosoma petenese was recorded in the main river bed near its mouth near Cd. Obregón. Parasites as Lernaea sp. and Digenetic Trematodes cercaria were present mainly on native species with highest infestation levels ocurred on Poeciliopsis spp., Campostoma ornatum, Catostomus bernardini and Agosia chrysogaster at Rio Sahuaripa. We could not detect alteration on river and streams, the native species seem threaten by the penetration of exotics into their natural habitats (river bed), given them problems relating with competence for habitats, food resources, predation and hybridization.

OBSERVACIONES ECOLOGICAS DE LOS PECES NATIVOS DEL BAJO RIO YAQUI,SONORA,MEXICO.

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José Rafael Campoy-Favela

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R E S U M E N

La ictiofauna de la subcuenca del Bajo Río Yaqui y los Ríos Sahuaripa y Bacanora (subcuenca de los Ríos Papigochic,Sirupa y Aros) se estudió en base a 24 colectas realizadas del 18 al 23 de agosto de 1988. Un total de 20 especies fueron registradas correspondiendo el 50% a las nativas, 45% introducidas y 5% eurihalinas. Los mayores porcentajes de especies nativas (78.5) se observaron en los afluentes más apartados, a diferencia de las introducidas, encontrandose preferentemente en el cauce principal del Río Yaqui. Las especies nativas, *Ictalurus pricei*, *Chiclasoma beani* y *Poeciliopsis prolifica* resultaron escasos en las colectas y *Dorosoma smithi* reportada anteriormente, no fue detectada en nuestras colectas. *Gambusia affinis* y Tilapia se observaron más ampliamente distribuidas en la mayoría de la cuenca, ocupando esta última, habitats compartidos con especies nativas en los ríos y arroyos.*Dorosoma petenense* se registró en el cauce principal del río cerca de su desembocadura. *Lernaea* sp. y cercarias de Trematodos Digéneos fueron detectados principalmente en las especies nativas. Las mayores tasas de parasitismo se registraron en el Río Sahuaripa sobre *Poeciliopsis* sp., *Campostoma ornatum*, *Catostomus bernardini* y *Agosia chrysogaster*. No se observaron alteraciones físicas sobre los cauces de los ríos y arroyos. Las especies nativas se ven amenazadas por la penetración de las introducidas en los habitats naturales (cauces de los ríos), propiciandose problemas de competencia por habitats y recursos alimenticios, depredación e hibridación.

IMPACT OF CATTLE ON TWO ENDEMIC FISH POPULATIONS IN PAHRANAGAT VALLEY, NEVADA

Frances R. Taylor
Leah Gillman
John W. Pedretti
James E. Deacon

ABSTRACT

Little information is available assessing the impact that cattle have on endemic fish populations. Cattle have been found to have a significant impact on fish populations in Brownie and Ash Springs in Pahranagat Valley, Nevada. Between Feb 1986 and Sept 1986, the population of Rhinichthys osculus in Brownie Spring was significantly decreased due to the presence of high ammonia and nitrite concentrations because of the presence of cattle. During the Summer and Fall of 1986 cattle were present at the headpool of Ash Springs. Population data for Ash Springs showed a significant population decrease in springfish, mollies, Gambusia, and cichlids while cattle were present and an increase after the cattle were removed. High concentrations of ammonia and nitrites were found when the cattle were present at Ash Springs.

SUCCESSFUL REPRODUCTION OF *CYPRINODON DIABOLIS* IN AQUARIA

Frances R. Taylor
John W. Pedretti
James E. Deacon

ABSTRACT

Past attempts at reproducing *Cyprinodon diabolis* in the lab have yielded little published success. Devil's Hole pupfish were successfully spawned and a fry reared in the lab at the University of Nevada, Las Vegas. Several aspects of the habits and habitat were taken into consideration with an attempt to utilize as many of these parameters as possible.

COLORADO SQUAWFISH WINTER HABITAT STUDY, YAMPA RIVER: A DESERT FISH UNDER ICE

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and

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ABSTRACT

Radiotracking of adult Colorado squawfish (Ptychocheilus lucius) was conducted on the upper Yampa River, Colorado, over two winters (December 1986-March 1988) under conditions historically found in the upper portions of the Colorado River System. During Winter 1, 10 squawfish were radiotracked for 553 total observation hours, from which 118 hours were used to develop habitat utilization criteria. Long-term, 24-hour observations during Winter 1 showed that habitat use and behavior was similar for morning, afternoon, evening, and night. In Winter 2, 74 observation hours were accumulated on 10 squawfish. Of these, 34 hours were used to develop habitat utilization criteria on depth, velocity and substrate. Squawfish were often active within a particular habitat but they did not move outside the river reach they selected for over-wintering. Squawfish showed fidelity to very specfic habitat areas by remaining in either one or a few favorite habitats throughout the winter. During the ice covered period, total range of movement of all fish averaged only 0.3 miles each year. Several squawfish demonstrated fidelity to specific fall and winter habitats and river reaches over one or more years. During Winter 1, embayment, backwater, and run habitats were most frequently used. Pool and run habitat were used most often in Winter 2. Habitat use also differed between the three study areas. This appeared related to habitat availability and diversity. A backwater habitat was used almost exclusively by three fish in the Government Bridge study area, river mile (RMI) 95-100, during Winter 1. Run habitat was used most frequently the next year probably because channel bed changes prevented access to the area used most frequently in Winter 1. Embayment and run habitat appeared to be preferred over pool habitat in the Maybell study area (RMI 70-82) which had diverse habitat availability. Pool habitat was used almost exclusively in the Lily Park study area (RMI 51-54), in Winter 2, where pool habitat was dominant. Effective depth (ice free water under packed frazil and/or solid ice cover) and velocity utilization for each trip were averaged over the winter period for three habitat catagories. Shallowest mean effective depths (2 feet) and velocities (0.1 fps) were from backwater and embayment habitats. Eddys and pools had the deepest average effective depth utilization (3.3 feet) with an average mean velocity of 0.2 fps. The run and shoreline habitat catagory had the highest average velocity (0.5 fps) with an average effective depth of 2.4 feet. Naturally stable flow conditions allowed ice cover to exist throughout the majority of the winter period both years. Flows and air temperatures were above normal in Winter 1 and below normal in Winter 2.

Formation of different types of ice on the Yampa River changed hydraulic conditions. During early winter, water surface elevations were maintained in spite of reductions in discharge. During Winter 2, changes in effective depths used by squawfish were examined at the Maybell study site by comparing elevation changes of water surface, ice surface, and ice thickness in response to changes in discharge. Discharge increased throughout most of Winter 2, a relatively low water year, ranging from 142 cfs on December 15, 1987 to 340 cfs on March 3, 1988. Ice thickness increased from 0.85 feet December 15, 1987 to 2.12 feet March 15, 1988. Increasing water surface elevations compensated for increasing ice thickness resulting in relatively stable effective depth. Effective depths measured biweekly in embayment habitat between December 15 and February 17 varied only 0.1 feet. Regression analysis of discharge on water surface elevation was used to predict the effect of hypothetical reductions in flow below the lowest measured discharge of 142 cfs. For each 20 cfs loss in discharge, water surface elevation was predicted to decrease approximatly 0.2 feet during mid-winter, ice-covered conditions. Overall productivity of the winter ecosystem appeared to be maintained by natural flows which provided diverse low velocity habitats (embayments, backwaters, pools, and runs). During Winter 2, this diversity appeared to be best maintained in the 200-300 cfs flow range in mid-winter during ice cover. Flows below this range result in less than optimum depth in prefered embayment habitat while higher flows flood and eliminate these habitats. Alterations in flow during winter due to water project impacts must be analyzed with respect to the portion of the winter in which they may occur. Effects will be different due to current ice conditions, air temperature, precipitation, and discharge. Reductions below natural baseflow at initial ice formation should be avoided. At this time actual discharge is already decreasing because water is being tied up in ice formation. Maintaining natural flows during the initial freeze period in late November or early December would insure that ice cover forms over the maximum amount of usable winter habitat. A key flow consideration during mid-winter is maintaining the natural conditions of steady discharge with little fluctuation. Flows normally do not fluctuate more than 140 cfs above or below the annual mean during the period from mid-December through February. It is important to avoid unnatural discharge fluctuations that could remove natural ice cover. The ice-out period, which usually occurs in March, can be the most critical part of winter. During this time, water surface elevations and effective depth decrease even though discharge is maintained. Therefore, any reductions in flow should be avoided until ice is completely out.

WINTER HABITAT OF ADULT COLORADO SQUAWFISH AND RAZORBACK SUCKER IN THE GREEN RIVER, UTAH

by

R.A. Valdez and W.J. Masslich

Wintertime movement and habitat use of adult Colorado squawfish and razorback sucker was assessed for the first time in the Green River, Utah, with the aid of radiotelemetry. A total of 20 squawfish and 20 razorbacks were tracked and monitored during two winters, 1986-87 and 1987-88.

This investigation revealed that adult squawfish and razorbacks have a high wintertime fidelity for given habitats and reaches of river. The fish often remained for days within a 100 m diameter area in a defined habitat, moving periodically to one of several "favorite spots". The habitats most commonly used were slackwaters, slow runs and eddies, all characterized by greater than average depth and low near-bottom velocity. The position of each fish was often associated with underwater structure such as sand shoals, sand ridges, or cobble jetties. Only the razorbacks seemed to select areas with cobble, boulder or gravel substrate.

Although the fish remained in these areas for long periods of time, they sometimes moved several miles to relocate in similar habitats. This long-range movement was not extensive and confirmed the high wintertime fidelity of these fishes for specific river reaches. Over 60% of all fish radiotagged remained within 5 miles of their original capture site during each of the two 5-month winter periods. The maximum net movement by squawfish was 25.6 miles upstream and 5.2 miles downstream. The maximum net movement by razorbacks was 39.9 miles downstream and 0.8 miles upstream.

Missing Pages 89-90

Plains minnow, *Hybognathus placitus*

River darter, *Percina shumardi*

River redhorse, *Moxostoma carinatum*

River shiner, *Notropis blennius*

Slough darter, *Etheostoma gracile*

Speckled darter, *Etheostoma stigmaeum*

Spotfin shiner, *Notropis spilopterus*

Spotted sucker, *Minytrema melanops*

Stippled darter, *Etheostoma punctulatum*

Tadpole madtom, ~~*Notropis*~~ *Noturus* *gyrinus*

Topeka shiner, *Notropis topeka*

(3) **Amphibians**

Red-spotted toad, *Bufo punctatus*

(4) **Reptiles**

Alligator snapping turtle, *Macroclemys temmincki*

Rough earth snake, *Virginia striatula*

Western hognose snake, *Heterodon nasicus*

(5) **Birds**

Bobolink, *Dolichonyx oryzivorus*

Cerulean warbler, *Dendroica cerulea*

Curve-billed thrasher, *Toxostoma curvirostre*

Ferruginous hawk, *Buteo regalis*

Golden eagle, *Aquila chrysaetos*

Henslow's sparrow, *Ammodramus henslowii*

Ladder-backed woodpecker, *Picoides scalaris*

Long-billed curlew, *Numenius americanus*

Resistance of high desert fish assemblages to flash flooding

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U.S. Fish and Wildlife Service,
Oregon Department of Fish and Wildlife,
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The impact of a flash flood on high desert fish assemblages was examined in the John Day Basin of northeastern Oregon. Assessment of impact was made by comparing assemblage composition of the same habitats approximately 1 month before and 1 month after the date of the flash flood. Possible seasonal changes in fish assemblage composition was determined by comparing fish assemblages during the same time period in two streams that were not effected by the flash flood. The influence of water retention times, within stream reaches, on the ability of assemblages to resist change will be discussed.

KANSAS THREATENED AND ENDANGERED SPECIES

(1) **INVERTEBRATES**

Amphibious snail, *Pomatiopsis lapidaria* (E)

Heel-splitter mussel, *Anodonta suborbiculata* (E)

Scott riffle beetle, *Optioservus phaeus* (T)

(2) **FISH**

Arkansas darter, *Etheostoma cragini* (T)

Arkansas river shiner, *Notropis girardi* (E)

Chestnut lamprey, *Ichthyomyzon castaneus* (T)

Flathead chub, *Hybopsis gracilis* (T)

Hornyhead chub, *Nocomis biguttatus* (T)

Neosho madtom, *Noturus placidus* (T)

Pallid sturgeon, *Scaphirhynchus albus* (E)

Redspot chub, *Nocomis asper* (T)

Sicklefin chub, *Hybopsis meeki* (E)

Silverband shiner, *Notropis shumardi* (T)

Speckled chub, *Hybopsis aestivalis tetranemus* (E)

(3) **AMPHIBIANS**

Cave salamander, *Eurycea lucifuga* (E)

Central newt, *Notophthalmus viridescens louisianensis* (T)

Dark-sided salamander, *Eurycea longicauda melanopleura* (T)

Eastern narrowmouth toad, *Gastrophryne carolinensis* (T)

Graybelly salamander, *Eurycea multiplicata griseogaster* (E)

Green frog, *Rana clamitans melanota* (T)

Grotto salamander, *Typhlotriton spelaeus*, (E)

Northern crawfish frog, *Rana areolata circulosa* (T)

Northern spring peeper, *Hyla crucifer crucifer* (T)

Strecker's chorus frog, *Pseudacris streckeri streckeri* (T)

Western green toad, *Bufo debilis insidior* (T)

KANSAS THREATENED AND ENDANGERED SPECIES

(4) **REPTILES**

Broadhead skink, *Eumeces laticeps* (T)
Checkered garter snake, *Thamophis marcianus marcianus* (T)
Eastern hognose snake, *Heterodon platyrhinos* (T)
Kansas glossy snake, *Arizona elegans elegans* (T)
New Mexico blind snake, *Leptotyphlops dulcis dissectus* (T)
Northern redbelly snake, *Storeria occipitomaculata occipitomaculata* (T)
Texas longnose snake, *Rhinocheilus lecontei tessellatus* (T)
Texas night snake, *Hypsiglena torquata jani* (T)
Western earth snake, *Virginia valeriae elegans* (T)

(5) **BIRDS**

Bald eagle, *Haliaeetus leucocephalus* (E) Endangered nationally
Eskimo curlew, *Numenius borealis* (E) Endangered nationally
Least tern, *Sterna antillarum* (E) Endangered nationally
Peregrine falcon, *Falco peregrinus* (E) Endangered nationally
Piping plover, *Charadrius melodus* (T) Threatened nationally
Snowy plover, *Charadrius alexandrinus* (T)
White-faced ibis, *Plegadis chihi* (T)
Whooping crane, *Grus americana* (E) Endangered nationally

(6) **MAMMALS**

Black-footed ferret, *Mustela nigripes* (E) Endangered nationally
Eastern spotted skunk, *Spilogale putorius interrupta* (T)
Gray myotis, *Myotis grisescens* (E) Endangered nationally

Species in Need of Conservation list:

(1) Invertebrates

Butterfly mussel, *Ellipsaria lineolata*

Cylindrical paper-shell mussel, *Anodontoides ferussacianus*

Elk-toe mussel, *Alasmidonta marginata*

Fluted shell mussel, *Lasmigona costata*

Kidney-shell mussel, *Ptychobranchus occidentalis*

Neosho pearly mussel, *Lampsilis rafinesqueana*

Regal fritillary butterfly, *Speyeria idalia*

Snuffbox mussel, *Epioblasma triquetra*

Spectacle-case mussel, *Quadrula cylindrica cylindrica*

Warty-backed mussel, *Quadrula nodulata*

Western fan-shell mussel, *Cyprogenia aberti*

(2) Fishes

Banded darter, *Etheostoma zonale*

Banded sculpin, *Cottus carolinae*

Black redhorse, *Moxostoma duquesnei*

Blue sucker, *Cycleptus elongatus*

Bluntnose darter, *Etheostoma chlorosomum*

Brassy minnow, *Hybognathus hankinsoni*

Gravel chub, *Hybopsis x-punctata*

Greenside darter, *Etheostoma blennioides*

Highfin carpsucker, *Carpiodes velifer*

Northern hog sucker, *Hypentelium nigricans*

Ozark minnow, *Notropis nubilus*

Mountain plover, *Charadrius montanus*

Prairie falcon, *Falco mexicanus*

Red-shouldered hawk, *Buteo lineatus*

Whip-poor-will, *Caprimulgus vociferus*

Yellow-throated warbler, *Dendroica dominica*

(6) Mammals

Eastern chipmunk, *Tamias striatus*

Franklin's ground squirrel, *Spermophilus franklinii*

Pallid bat, *Antrozous pallidus bunkerii*

Southern bog lemming, *Synaptomys cooperi*

Southern flying squirrel, *Glaucomys volans volans*

Texas mouse, *Peromyscus attwateri*

Townsend's big-eared bat, *Plecotus townsendii*

Nevada Department of Wildlife
Report to
Desert Fishes Council
November 16-19, 1988

1. Devil's Hole pupfish *Cyprinodon diabolis*

Population counts were conducted at Devil's Hole twice in 1988. In April, 225 pupfish were observed. By September the population had expanded to 525. Following the September count, 30 pupfish were collected from Devil's Hole and transplanted into the Hoover Dam refugium, where the pupfish had died out. During observations following the release, a maximum of six pupfish, three pair, were seen. These fish were active and apparently healthy. The actual success or failure of this transplant will not be known until next spring.

The Amargosa Ash Meadows refugium maintains a population of approximately 100 pupfish.

Population counts at Devil's Hole will continue in 1989. The two refugia will also be monitored. The process will be initiated to begin the yearly replacement of ten refugium fish with 10 Devil's Hole fish. This project has been identified since the refugia were built, but has never been accomplished.

2. Pahrump poolfish *Empetrichthys latos*

Again this year all three refugia were inventoried. Mark and recapture population estimates were made. At Corn Creek, only the middle pond was inventoried. Dense cattail growth in the upper and lower ponds made trapping these ponds difficult. In June 1988, the middle pond population was 4266 ± 668. Traps set in the other two ponds did produce fish. The population of Pahrump poolfish at Corn Creek continues to do well.

At Spring Mountain State Park a mark and recapture estimate was conducted for the first time since fish were released into the pond in 1983. This population was estimated at 25,343 ± 2938 in June 1988. In a couple of years, the Nevada Division of State Parks will have to dredge out this reservoir pond to remove accumulated silt and regain the original depth of the reservoir. They have been informed of the need to consult with the Nevada Department of Wildlife and the U.S. Fish and Wildlife Service prior to the work.

The Shoshone ponds population is the only one of the three having problems. The actual designated refugium pond only contained 185 ± 45 in July 1988. This is down from 1987 (325 fish). The stock pond just to the north, however, continues to support a large poolfish population, estimated at 8109 ± 3478. The cause of the decline in the refugium pond is unknown.

3. Ash Meadow fishes

No monitoring was accomplished in Ash Meadows during 1988. We plan to begin an intensive inventory and distribution study of all fish, native and introduced, on the Ash Meadows refuge. This project will he headed up by U.S. Fish & Wildlife Service's Seattle Fisheries Research Center.

4. White River springfishes

The White River springfish, *Crenichthys baileyi baileyi*, continues to hold its own at Ash Spring. This summer approximately 200 springfish were released into the upper portion of the spring system. These fish were raised by Dr. Deacon at the University of Nevada, Las Vegas. It appears, however, that supplementing this population in this manner may not be necessary. The swimming/camping facility at Ash Spring has become a resort for members only. The membership fees appear to have reduced the number of people using the spring, lessening the impacts. The exotic fish in the system continue to pose the most serious threat to the natives.

The Hiko White River springfish, *Crenichthys baileyi grandis*, population at Hiko Spring dropped slightly in 1988. Population estimate was 4048 $\pm$ 237 in April and 4686 $\pm$ 447 in July. In April 1987, the population was 5479 $\pm$ 400. The Crystal Springs population was estimated at 350.

5. Pahranagat roundtail chub *Gila robusta jordani*

The two year study conducted by the U.S. Fish & Wildlife Service Seattle Fisheries Research Center concludes this year. Along with gaining information on the population dynamics of this chub, data collected on life history requirements will aid in developing a program to eradicate the exotics from the Ash Creek system with the least impact on the natives.

6. Railroad Valley springfish *Crenichthys nevadae*

This past year exclosure fences were constructed around the two springs at Lockes Station, which are on public land. Since elimination of grazing at North Spring, the wire grass has released and has grown over most of the spring outflow. Springfish numbers appeared unaffected in July. This vegetative growth and its affect on the springfish will be monitored. At the Reynolds Springs, no vegetative release has occurred. Population data was collected from all four spring systems at Lockes to allow for comparison between the grazed and ungrazed springs.

The introduced population at Chimney Spring was lost this summer following severe trampling by livestock. The three pools became too shallow to allow the extremely hot water from the spring source to cool to a temperature the springfish could tolerate. The Bureau of Land Management has agreed to remove the gate from this exclosure and to reconstruct the ponds. To date this work has not been done.

Presented by: David Buck, Supervising Biologist

Submitted by: Donna Withers, Biologist
Date: November 9, 1988

DW:jln

AGENCY REPORT OF THE TEXAS PARKS AND WILDLIFE DEPARTMENT

Gary P. Garrett

Texas Parks and Wildlife Department
HOH Research Station
Junction Star Route, Box 62
Ingram, Texas 78025

The Texas Parks and Wildlife Department (TPWD) has been very active this year in the realm of native fishes. As may be expected, some of these actions were controversial, yet they have all had a common goal: To protect and enhance one of our state's valuable resources, our native fishes.

Tilapia

We have had a proclamation in effect since 1974 that restricts importation, possession, sale or release of several exotic species. All species of *Tilapia* were on this original list.

In 1979, *Tilapia aurea* and *T. mossambica* were removed from the list. It was through they had spread as far as they could in nature, were uncontrollable in these locations, yet may be of some value as bait and human food.

A recent report issued by TPWD (Muoneke 1988) showed *T. aurea* has continued to spread. Prior to 1979 they were found in 14 reservoirs and three rivers in Texas; by 1988 they had been reported in 27 reservoirs and five rivers. Although many of these systems are spring-fed or heated by power plants, some are ambient temperature waters. *Tilapia* were also implicated in spawning suppression of sport fishes and competition with other native fishes. The report concluded *Tilapia* represent a threat to the state's fisheries resources and should be restricted.

Adaptation, through mutation or hybridization, to non-heated environments would create an even greater problem. The extreme winter die-offs in some systems creates a strong selective advantage to any individuals with this trait. In addition, some aquaculturists artificially select for increased cold tolerance in order to be able to maintain their stocks outdoors in the winter.

As a result of this report and requests from the public, the Texas Parks and Wildlife Commission recently adopted a revision to the state Restricted Fishes List putting all *Tilapia* back on the list. Culture and transport of only *T. aurea*, *T. mossambica* and their hybrids will be allowed under a set of very specific guidelines. These species can be possessed if eviscerated or with a permit. Some of the requirements of the permit include closed culture systems above the 100-year flood plain, inspections by TPWD and an annual reporting system. It also is required that species purity be certified electrophoretically.

Tilapia aurea may be sold to the public only in an eviscerated state. Because *T. mossambica* were not shown to be spreading at this time, they will be allowed for use as forage in private waters. They are, however, subject to the same restrictions on culture, transport, species certification, etc.

This new regulation has been very controversial with aquaculturists, aquarists and bait dealers. As an example, a meeting held to discuss the proposed regulation and to consider compromises submitted by affected parties was attended by 35 culture industry representatives and 11 state legislators. The potential for further discussion in court and in the State Legislature is high.

Land Acquisition

Texas has recently purchased two large tracts of land that will likely be beneficial to some of our fishes. These are the Big Bend Ranch and Dolan Creek Ranch. Both of these are slated to become State Natural Areas. The Big Bend Ranch encompasses portions of the Rio Grande and Alamito Creek. Three species (*Notropis chihuahua*, *Campostoma ornatum*, *Cyprinodon eximius*) listed by Texas as Threatened are found in this area (Hubbs et al. 1977). The Dolan Creek Ranch contains portions of the Devil's River and its tributary, Dolan Creek. Species listed as Threatened by Texas that occur here are *Notropis proserpinus*, *Dionda diaboli*, *Cyprinodon eximius* and *Etheostoma grahami* (Davis 1980; Garrett 1980; Williams et al. 1985). The population of *C. eximius* in Dolan Creek was extirpated in the 1950's, but was apparently reestablished through stocking efforts in 1979 (Garrett 1980; Williams et al. 1985).

Monitoring/Recovery

For Threatened and Endangered fishes we are developing a monitoring program that will be an "early warning" system for problems that may arise. We will first define essential criteria for each species. The next step is to design a check-off procedure for monitoring these defined criteria. Various Department personnel will be assigned species to monitor and a sampling schedule. Data will be analyzed by Research staff and remedial action recommended when needed.

In a related activity, we are currently developing recovery plans for all Threatened and Endangered fishes listed by Texas. With these we will seek to define the problems that have led to each species present status. These plans will outline the methods necessary to preserve and protect these species and, in some cases, provide recommendations for measures that will lead to population recovery and ultimate delisting.

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Garrett, G.P. 1980. Update on some of the protected and endangered fishes of Texas. Proceedings of the Desert Fishes Council 11:34-46.

Hubbs, C., R.R. Miller, R.J. Edwards, K.W. Thompson, E. Marsh, G.P. Garrett, G.L. Powell, D.J. Morris, and R.W. Zerr. 1977. Fishes inhabiting the Rio Grande, Texas and Mexico, between El Paso and the Pecos confluence. Pages 91-97 *in* R.R. Johnson and D.A. Jones, eds., Importance, Preservation and Management of Riparian Habitat: A Symposium. USDA Forest Service, General Technical Report RM-43.

Muoneke, M.I. 1988. Tilapia in Texas waters. Inland Fisheries Data Series Number 9. Texas Parks and Wildlife Department, Austin, Texas.

Williams, J.E., D.B. Bowman, J.E. Brooks, A.A. Echelle, R.J. Edwards, D.A. Hendrickson, J.L. Landye. 1985. Endangered aquatic ecosystems in North American deserts with a list of vanishing fishes of the region. Journal of the Arizona-Nevada Academy of Science 20:1-62.

REPORTE DEL DEPARTAMENTO DE LOS PARQUES DE TEXAS Y VIDA SALVAJE

Gary P. Garrett

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En este ano hemos estado muy activos con los peces naturales. Como era de esperarse, algunas de nuestras acciones han despertado controversias a pesar de que todas ellas tienen un objetivo en comun: la protecion y el realce de uno de los recursos naturales mas valiosos del estado, los peces.

Tilapia

Se ha mantenido un edicto desde 1974 en el que se restringe la importacion, la posesion, la venta o la liberauon de varias esperies exoticas, entre las cuales se encontraban incluidas todas las del genero *Tilapia*.

En 1979 *T. aurea* y *T. mossambica* fueron excluidas de la lista, ya que se creyo que por su naturaleza no podian extenderse mas alla de su localizacion y si podrian ser de utilidad como alimento humano o como anzuelo.

Un reporte reciente publicado por TPWD (Muoneke 1988) demostro que la *T. aurea* continua diseminandose. Antes de 1979 se le encontro en 14 reservorios y tres rios de Texas y para 1988 se habia reportado en 27 reservorios y cinco rios; Aunque la mayoria de estos sitios son manantiales o se calientan con instalaciones apropiadas, algunos tienen el agua a temperatura ambiente. Tambien se encontro que la *Tilapia* estaba implicada en la inhibicion de la reproduccion de otros peces y en la competencia con algunos otros. Este articulo concluye que la *Tilapia* representa una amenaza para los recursos pesqueros del estado y deberia ser restringida.

Un problema mayor es el que resulta de la adaptacion a temperaturas mas bajas durante el invierno por mutacion o hibridismo de los deseendrentes. Aunado a esto, algunos aquaculturistas los someten a medios artificiales para incrementar tolerancia a las temperaturas bajas con el fin de mantenerlos en el exterior durante el invierno, con ello se aumenta la resistencia del pez y se favorece, de ese modo, su proliferacion.

Como resultado de este articulo y por peticiones recibidas, recientemente el departamento ha aceptado una revision a la lista de los peces controlados del estado pontendo nuevamente a todas las especies del genero *Tilapia* en ella. El cultivo y el transporte de *T. aurea* y *T. mossambica*, solo se permitara bajo una serie de lineamientos. Solo podran poseerse evisceradas o bien con un permiso. Para este ultimo, se requiere un sistema de cultivo cerrado en el que se incluya un aditamento que sea suficiente para impedir el derrame del agua interior que pudiera acomularse en 100 anos de lluvia e inspecciones por TPWD, ademas de un reporte anual. Por otro lado, sera necesario corroborar la pureza de la especie por medio de electroforesis.

La _T._ _aurea_ podra ser vendida a el publico salamente eviscerada. Hasta la actualidad no se ha demostrado que la _T._ _mossambica_ se disemine. Por este motivo se permitira su uso como alimento en aguas privadas. Sin embargo se sometera a las mismas restricciones en lo referente a cultivo, transporte, certificacion de la especie, etc.

Esta nueva disposicion ha sido muy controversial entre los aquaculturistas, aquaristas y la gente que comercia el pez como anzuelo. Hubo una reunion para discutir nuestro reglamento as como para considerar los compromisos a los que se someten las grupos afectaddos. Asistieron 35 representantes de la industria y 11 Legisladores del estado. El potencial para una discusion adicional en la corte y en la legislatura del estado es alto.

Adquisicion de Tierra

Texas ha comprado recientemente a grades terronos que posiblemente seran de beneficio a algunos de nuestros peces. Estos son el Big Bend Ranch y el Dolan Creek Ranch que estan destinados para convertirse en areas naturales del estado. El primero comprende porciones del Rio Grande y el Arroyo del Alamito. En esta area se encuentran 3 especies de las protegidas (_Notropis chihuahua_, _Campostoma ornatum_, _Cyprinodon eximius_) (Hubbs et al. 1977). El Dolan Creek Ranch contiene segmentos del Rio de Devil y su tributario, Arroyo Dolan. De las especies protegidas situadas en este lugar figuran _Notropis proserpinus_, _Dionda diaboli_, _Cyprinodon eximius_ y _Etheostoma grahami_ (Davis 1980; Garrett 1980; Williams et al. 1985). El _C._ _eximius_ fue extirpado en 1950's, pero fue aparentemente reestablecido en 1979 (Garrett 1980; Williams 1985).

Recuperacion

Para los peces en programa de proteccion, estamos desarrollando un proyecto que seva un sistema de "auiso temprano" para problemas que puedan surgir. Primero definiremos criterios esenciales para cada especie y posteriormente disenaremos un procedimiento para verificar el control de estos criterios. Se asignaran las especies a el personal del departamento para su monitoreo y un programa de muestreo. Los datos seran analizados por el staff y se recomendaran acciones encaminadas a remediar en caso necesario.

En una actividad relacionada, estamos desarrollando proyectos de recuperacion para los peces protegidos, con las que trataremos de definir los problemas que han conducido a cada especie a su estado actual. De este modo tambien se delinearan los metodos necesarios para preservar y proteger estas especies y en algunos casos dar recomendaciones para los lineamientos necesarios que conduciran a la repoblacion y de este modo excluirlos de la lista.

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Davis, J.R. 1980. Rediscovery, distribution, and populational status of Cyprinodon eximius (Cyprinodontidae) in Devil's River, Texas. The Southwestern Naturalist 25:81-88.

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Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

TWENTIETH ANNUAL SYMPOSIUM

APPENDIX

Death Valley National Monument Headquarters

Furnace Creek, California

November 16-19, 1988

Wednesday, November 16.

0800-1200 Registration

0900 Welcome to Death Valley.

Ed Rothfuss, Superintendent, Death Valley National Monument.

Announcements and introductions.

Phil Pister, Executive Secretary, Desert Fishes Council.

SESSION I - AGENCY REPORTS AND MISCELLANEOUS PRESENTATIONS.

México

United States

Bureau of Land Management	Arizona
National Park Service	California
Bureau of Reclamation	Colorado
Forest Service	Kansas
Fish and Wildlife Service	Nevada
Agency overview	New Mexico
Virgin River	Texas
	Utah

MISCELLANEOUS PRESENTATIONS

- Society for Conservation Biology - Peter Brussard
- The Annual Desert Fishes Council Fish Count - Steve Platania
- Sociedad Ictiológica Mexicana, A.C. - Salvador Contreras-Balderas

SESSION II - GENERAL RESEARCH AND MANAGEMENT PAPERS 1-13. 1330

Chairman: Walter R. Courtenay, Jr., Florida Atlantic University, Boca Raton.

SESSION III - BUSINESS MEETING. 2030

Thursday, November 17. 0800

SESSION IV - GENERAL RESEARCH AND MANAGEMENT PAPERS 14-24.

Chairman: Gary K. Meffe, Savannah River Ecology Lab. (University of Georgia), Aiken, S.C.

SESSION V - BATTLE AGAINST EXTINCTION: NATIVE FISH MANAGEMENT IN THE AMERICAN WEST. 1330. Refer to special agenda.

Chairmen: James E. Deacon, University of Nevada, Las Vegas; and W.L. Minckley, Arizona State University, Tempe.

SESSION VI - BARBECUE AND RANDOM DISCUSSIONS. 1900

Friday, November 18. 0800

SESSION VII - CONCLUSION OF "BATTLE AGAINST EXTINCTION" SYMPOSIUM.

SESSION VIII - GENERAL RESEARCH AND MANAGEMENT PAPERS 25-37. 1330

Chairman: Gail C. Kobetich, Chairman, Desert Fishes Council.

SESSION IX - SPECIAL DEVILS HOLE PRESENTATIONS. 2030

- Time of isolation of Cyprinodon diabolis in Devils Hole: geologic evidence.

  Isaac Winograd and Barney J. Szabo, U.S. Geological Survey, Reston, VA and Denver, CO.

- Geohydrologic evidence for the development of Devils Hole, southern Nevada, as an aquatic environment.

  Alan C. Riggs, U.S. Geological Survey, Denver, CO.

Saturday, November 19. 0800

SESSION X - GENERAL RESEARCH AND MANAGEMENT PAPERS 38-40.

Chairman: Francisco Abarca, Arizona State University, Tempe.

SESSION XI - FIELD TRIP TO ASH MEADOWS. 0930

Chairmen: Bob Love, The Nature Conservancy, Ash Meadows; and Dave Brown, U.S. Fish and Wildlife Service, Las Vegas.

General Research and Management Papers

1. Status of the native fish fauna of California. Peter B. Moyle, Jack E. Williams, and Eric Wikramanayake, University of California, Davis.

2. Native freshwater and anadromous fishes of coastal southern California. Camm C. Swift, Natural History Museum of Los Angeles; and Thomas R. Haglund, University of California, Los Angeles.

3. After nearly 100 years: a remarkable find. Robert Rush Miller, University of Michigan, Ann Arbor.

4. Status and evolutionary relationships of the Kendall Warm Springs dace. Peter F. Brussard, Montana State University, Bozeman.

5. Long-term trends of the fish community in lower Sagehen Creek, California. Don C. Erman, University of California, Berkeley.

6. Impact and abundance of an introduced cichlid in the lower Rio Grande (Río Bravo del Norte), Texas and Mexico. Robert J. Edwards, Pan American University, Edinburg, Texas; and Michael G. Wood, Del Mar College, Corpus Christi, Texas.

7. Role of diet in cannibalism by Gambusia adults. Clark Hubbs and Kirk Winemiller, University of Texas, Austin.

8. Status of leopard frogs (Rana pipiens Complex; Ranidae) in Arizona and southeastern California: an update. Robert W. Clarkson, Arizona Game and Fish Department, Pine Top; and James C. Rorabaugh, U.S. Bureau of Reclamation, Yuma, AZ.

9. San Bernardino National Wildlife Refuge, a case study of acid rain in the Southwest. William G. Kepner, U.S. Fish and Wildlife Service, Phoenix.

10. Desert fish habitat protection through Federal acquisition. Gerald L. Burton, U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

11. Managing for "worthless" species: a role for State Parks. Thomas L. Taylor, California Department of Parks and Recreation, Sacramento.

12. Observations on the Little Colorado River population of humpback chub, 1988. C. O. Minckley, Northern Arizona University, Flagstaff.

13. Springsnails of the Death Valley System, California and Nevada: description and preliminary zoogeographic analysis. Robert Hershler, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

14. Genetic status of the Pecos pupfish. Gene R. Wilde, Oklahoma State University, Stillwater.

15. Genotypic components of survival under stress in desert streams. Robert C. Vrijenhoek, Center for Theoretical and Applied Genetics, Rutgers University, New Brunswick, New Jersey.

16. Heterozygosity and fitness differences among populations of the Sonora topminnow, Poeciliopsis occidentalis. Joe Quattro, Center for Theoretical and Applied Genetics, Rutgers University, New Brunswick, New Jersey.

17. Mitochondrial DNA analysis of cutthroat trout subspecies: evolutionary relationships and genetic structure. Rick Williams, Portland State University, Portland, Oregon.

18. Conservation genetics of Pecos gambusia. Alice F. Echelle, A.A. Echelle, and D.R. Edds, Oklahoma State University, Stillwater.

19. Sampling theory, genetic characterization of populations, and loss of alleles in populations of low effective number. William J. Berg, University of California, Davis.

20. Analysis of genomic DNA from cutthroat trout. R.P. Evans, Brigham Young University, Provo, Utah.

21. Cutthroat trout spotting: can it be quantified? Dennis K. Shiozawa, Brigham Young University, Provo, Utah.

22. Status of populations of threespine sticklebacks, Gasterosteus aculeatus, at the southernmost portion of their Pacific Coastal range. Thomas R. Haglund and Donald G. Buth, University of California, Los Angeles.

23. A recent survey of fishes from the interior Río Yaqui drainage, with a record of flathead catfish, Pylodictis olivaris from the Río Aros. William Leibfried, Northern Arizona University, Flagstaff.

24. Ecological observations of native fishes from the lower Río Yaqui, Sonora, México. Lourdes Juárez-Romero, Alejandro Varela-Romero, and Jose Campoy-Favela, Centro Ecológico de Sonora, Hermosillo.

25. Update on the Colorado River endangered fishes recovery program. John Hamill, U.S. Fish and Wildife Service, Denver.

26. The Bureau of Land Management's threatened and endangered fish team - a foundation for the future. Mike Crouse, Bureau of Land Management, Washington, D.C.

27. Impact of cattle on two endemic fish populations in Pahranagat Valley, Nevada. Frances R. Taylor, Leah Gillman, John W. Pedretti, and James E. Deacon, University of Nevada, Las Vegas.

28. Successful reproduction of Cyprinodon diabolis in aquaria. Frances R. Taylor, John W. Pedretti, and James E. Deacon, University of Nevada, Las Vegas.

29. Microhabitat selection of the Owens tui chub, Gila bicolor snyderi. Dennis McEwan, California State University, Sacramento.

30. A day in the Swartkops drainage, South Africa. Walter R. Courtenay, Jr., Florida Atlantic University, Boca Raton; and Paul H. Skelton, J L B Smith Institute of Ichthyology, Grahamstown, South Africa.

31. Natural repopulation of a native subpopulation of rainbow trout (Oncorhynchus mykiss nelsoni) in a segment of Arroyo San Rafael, northwest Sierra San Pedro Mártir, Baja California Norte, México. Gorgonio Ruiz-Campos, Universidad Autónoma de Baja California, Ensenada.

32. Seasonal diet and utilization of prey resources of San Pedro Mártir trout (Oncorhynchus mykiss nelsoni). Patricia Cota-Serrano and Gorgonio Ruiz-Campos, Universidad Autónoma de Baja California, Ensenada.

33. Colorado squawfish winter habitat study: a desert fish under ice. Edmund J. Wick and John A. Hawkins, Colorado State University, Fort Collins.

34. Winter habitat of adult Colorado squawfish and razorback sucker in the Green River, Utah. R.A. Valdez and W.J. Masslich, BIO/WEST, Inc., Logan, Utah.

35. Endangered fishes of Cataract Canyon (Colorado River, Utah). R.A. Valdez and R.G. Williams, BIO/WEST, Inc., Logan, Utah.

36. The need for quantitative habitat information in the management of endangered species: leopard darter - a case study. P. James, O.E. Maughan, and S. Leon, University of Arizona, Tucson.

37. Resistance of a high desert fish assemblage to flash flooding. Todd Pearsons, Oregon State University, Corvallis.

38. Research on the fishes of Yucatan: a progress report. Miguel Navarro M., Centro de Investigaciónes de Quintana Roo, Puerto Morelos, Quintana Roo, México.

39. Fish faunal survey of the Samalayuca complex in northern Chihuahua, México. Anabella Espinosa-Aguilar, Lourdes Lozano-Vilano, and Salvador Contreras-Balderas, Universidad Autónoma de Nuevo León, Monterrey, N.L., México.

40. Fish faunal survey of the Río San Juan sub-basin, Río Salado, northern Coahuila, México. Graciela Patricia Arrocha-Gomez, Salvador Contreras-Balderas, and Lourdes Lozano-Vilano, Universidad Autónoma de Nuevo León, Monterrey, N.L., México.

BATTLE AGAINST EXTINCTION: NATIVE FISH MANAGEMENT IN THE AMERICAN WEST

A Symposium

Commemorating the 20th Annual Meeting of the Desert Fishes Council
Death Valley National Monument, California, USA

17-18 November 1988

1:30 pm Introduction to the Symposium
W. L. Minckley

SESSION I -- WHERE, HOW, AND WHY IT ALL BEGAN

1:40 The Period of Discovery
Michael E. Douglas and W. L. Minckley

2:00 Exploration of the American West: The Hubbs-Miller Era, 1915-50
Robert Rush Miller, Clark Hubbs, and Frances Hubbs Miller

2:20 Ghosts of the Green River: Impact of the Green River Poisoning on Native Fishes and Their Management
Paul B. Holden

2:40 Fishes in the Desert: Paradox and Responsibility
Holmes Rolston, III

3:00 Break

3:20 Desert Fishes Council: Catalyst for Change
E. Phillip Pister

3:50 Public Awareness, Legislation, Litigation, and Conservation of Native Fishes
James E. Deacon and Cindy Deacon Williams

4:10 Legacy of the Devil's Hole Pupfish
James E. Deacon and Cindy Deacon Williams

4:30 Evolution of Recovery Programs for Upper Colorado River Fishes
Richard S. Wydoski and John Hamill

4:50 Conservation Status of Freshwater Fishes in Mexico
Salvador Contreras Balderas

SESSION II, 18 November 1988 -- RESEARCH AND MANAGEMENT

8:00 am	Conservation Genetics and Genic Diversity in Threatened Fishes of Western North America Anthony A. Echelle
8:20	Lake Sucker Life History and Management G. Gary Scoppettone and Gary Vinyard
8:40	Management toward Recovery of Colorado Squawfish Harold M. Tyus
9:00	Razorback Sucker Management, with a Review of Reintroduction as a Management Tool for Long-lived Fishes W. L. Minckley, Paul C. Marsh, and James E. Brooks
9:30	Conservation of Short-Lived Species: Research and Management on Western Cyprinodontids and Poeciliids Gary K. Meffe and David L. Soltz
9:50	Reintroductions as a Management Tool for Short-lived Species Dean A. Hendrickson and James E. Brooks
10:10	Break
10:30	History and Operation of Endangered Species Hatcheries James E. Johnson and Buddy Lee Jensen
10:50	Reclamation and Alteration of Habitat as Management Tools for Native Fishes John N. Rinne and Paul R. Turner
11:10	On the Design of Preserves to Protect Native Fishes Peter B. Moyle and Georgina M. Sato
11:30	Progress Toward Refuges Jack Williams
11:50	Summary of the Symposium (Where do we go from here?) James E. Deacon

The UNM
University of New Mexico
DEPARTMENT OF BIOLOGY
Albuquerque, NM 87131
Telephone 505: 277-3411

16 May 1988

Dear Colleague,

At the 1987 Desert Fishes Council meeting in Hermosillo, Mexico, Dean Hendrickson chaired a special symposium on monitoring of fish populations. The main reoccurring theme throughout that session was the need for annual systematic monitoring of fish populations in the southwest.

It was suggested that one possible way to conduct such a program was to initiate a census similar to the ornithologists' Christmas Bird Count. This idea has received the support of the Desert Fishes Council and we plan to try to initiate it in 1988. We envision a "fish count" as relatively simple but effective means of monitoring populations and believe that it could go a long way towards eliminating some of the problems we constantly encounter when trying to detect ichthyofaunal changes in our southwestern systems.

While initially this program will initially be conducted on a small scale, in only a few years the benefits should become obvious and hopefully the program could expand. However, it is important that the two major underlying themes of our fish count not be lost in a maze of bureaucracy. The primary goal is to monitor fish populations and look for long term patterns and the second goal is to get out and have some fun.

Each participant should select one or two sites, preferably close to where they live or work, for sampling. Remember, the idea is that this/these same site/sites will be collected each of the following years during the census period. Keep it simple and close to home. Don't get bogged down trying to come up with a location which will provide the most or sexiest species. The value of your work will be in its repeatability.

I know that to some, this might not seem like enough of an effort. Remember, the Christmas Bird Counts also started out small and have now reached a point where almost 40,000 people pay to participate. Think of the amount of data we would now have if we started doing this 20 years ago when the Desert Fishes Council was founded. A lot of the questions raised at the 1987 DFC monitoring symposium would have been answered.

Our goal for the first year of this fish count is to have at least two different individuals sampling in different sections of each of the states covered by the Desert Fishes Council (hopefully more). We too will use a holiday as the focal point of our count and at several peoples suggestions, have picked the 4th of July. In order to allow plenty of time for collections to be made you will have at least three weekends around which sampling could be performed (June 25-July 10).

What we need from you now (ASAP) is to know whether you are interested in participating in this program and (not as important), where you might be sampling. When I have received this information from everyone, I will get back in touch with you so that we can proceed.

There are certainly a number of questions which we have not addressed but don't let that bother you. I hope to do that in the next letter. In the meantime, give this project some thought as we are open to any and all suggestions. Also, if you have a suggestion for what we should call this endeavor, let me know.

I can be reached at the above address and following telephone numbers: (505) 277-5340 (work), (505) 889-9536 (home). Hope to hear from you soon.

Sincerely yours,

Steven P. Platania

Steven P. Platania

The University of New Mexico

Department of Biology
Albuquerque, NM 87131
Telephone 505: 277-3411

TO: Participants in the Desert Fishes Council October Fish Count

FROM: Steven Platania

DATE: 15 September 1988

Sorry that I waited this long before getting back in touch with each of you but replies are still coming in to our Desert Fishes Council October Fish Count request for participation. The response has been greater than I anticipated and represents an excellent start to what we envision as a long-term program to be conducted by the Desert Fishes Council.

Our initial letter was sent to a select few individuals and at present, we have approximately 20 people who (cumulatively) will make almost 50 collections in six states. This does not include those who will be participating in the Gila River Basin survey being conducted by Dean Hendrickson (even though those data will be incorporated into this project).

A few of you have inquired about the type and amount of data to be taken. As I said in a previous letter, I want to leave the amount of peripheral information gathered up to the individual. I assume that general field notes will be available and that those can be referred to at a later date. In the meantime, I have enclosed copies of two different field data forms. The longer version is that which is going to be used by Dean for the Gila River survey. You do not need to use these. Let them serve as a guide for those of you that had questions.

I am going to try to get individual letters to each of you over the next two weeks but in the meantime, I wanted to thank you for your willingness to participate in this project. Good luck with you October collections.

STATE ________ COUNTY ________________ DATE ___________ FIELD # ________

LOCATION ____
____

QUADRANGLE ______________________________ T.R.S. ______________________

WEATHER ___________________ TIME _____________ CREW ___________________

HABITAT (sinkhole, spring, stream, marsh, pond, modified, unmodified,
other ____)

SUBSTRATE (est. to nearest 10%)
- sapropel ________
- silt ________
- sand ________
- gravel ________
- cobble ________
- boulder ________
- bedrock ________
- other ________
- (______________________)

COVER (est. to nearest 10%)
- none ________
- aquatic em. ________
- aquatic sub. ________
- terrestial ________
- abiotic ________
- (______________________)
- other ________
- (______________________)

DEPTH ________, ________, ________
________, ________, ________
________, ________, ________

VELOCITY ________, ________, ________

SECCHI DEPTH ________, ________, ________

TEMP ________ D.O. ________ pH ________ COND ___________ SALINITY ________

CHANNEL CONFIGURATION width (min/max) _______________
adjacent slope _______________________________

AQUATIC PLANTS ____

RIPARIAN PLANTS ______________________________ CANOPY (none, moderate, dense)

COLLECTION METHOD ____

COLLECTION EFFORT ____

TAXA COLLECTED	NUMBER	TAXA COLLECTED	NUMBER

SAMPLE PRESERVED yes/no
all/part ________

(OVER)

ACCESS TO OTHER WATER BODY ______________________________

ACCESS TO SITE ______________________________

COMMENTS ______________________________

SITE DIAGRAM:

FORM NO. ____________________

PHOTO NO. ____________________

DATE ____________ STREAM ______________________ COLLECTORS ______________

LOCATION ____

COUNTY ______________ T ______ R ______ S ______ ORDER ________ GRADIENT (m/km) ________

TIME: B. ______ E. ____ ____ METHOD seine snorkel visual shock: 5 7 11 ELEV (ft) ______ COMPASS ______

DESCRIPTION ____

____

INVERTEBRATES ____

NON-AQUATIC VERTEBRATES ______________________ NOTES ON BACK? ______________

______ TEMP. (AIR)	______ pH	______ SILT %	FLOW METER #: ____
______ TEMP. (SURFACE)	______ REDOX (mV)	______ MUD %	WIDTH (m): ______
______ TEMP. (____ cm)	______ CONDUCTIVITY (mho)	______ SAND %	D ______ V ______
....	______ TDS	______ GRAVEL %	______ ______
______ SEC. LENGTH (m)	....	______ COBBLE %	______ ______
______ AVG. DEPTH (cm)	______ EMERGENT VEG. %	______ BOULDER %	______ ______
______ MAX. DEPTH (cm)	______ ROOTED VEG. %	______ BEDROCK %	______ ______
______ AVG. WIDTH (m)	______ ALGAL MATS & DUCKWEED %	....	______ ______
....	______ FILAMENTOUS ALGAE %	______ POOLS %	______ ______
______ FLOW	______ ATTACHED ALGAE %	______ RIFFLES %	______ ______
______ TURBIDITY (1clear-5)	....	______ RUNS %	______ ______
______ SHADE % (noon)			______ ______

RIPARIAN VEGETATION (% of area)	COVER (% of area)	MAN MOD. (1=PRISTINE TO 5=CONCRETE)
WIDTH OF RIPARIAN STRIP: ______	______ NO COVER	______ OVERALL (1-5)
______ WETLAND VEG.	______ OBJECTS <150mm diam.	______ LOGGING (1-5)
______ GRASS	______ OBJECTS 150-300mm diam.	______ GRAZING (1-5)
______ BRUSH	______ OBJECTS >300mm diam.	______ ROADS (1-5)
______ WOODLAND	______ OVERHANGING VEG.	______ BUILDINGS/STRUCTURES (1-5)
______ MINOR CONIFERS	______ ROOT WADS	______ CHANNELIZATION (1-5)
______ PINE-FIR	______ UNDERCUT BANKS (% edge)	______ OTHER (1-5): ______
SPECIFIC PLANTS: ______________	______ SURFACE TURBULENCE	
______________	______ ROOTED VEG.	

FORM NO. ____________

POTENTIAL SPAWNING AREAS (at least 600mm^2; circle if currently exposed):

SAND PATCHES: (AREAS) ____________

GRAVEL PATCHES: (AREAS) ____________

COBBLE PATCHES: (AREAS) ____________

HABITAT TYPE (% area):

alcove ____	corner scour ____	side channel ____	run ____
plunge ____	under scour ____	backwater ____	glide ____
dammed pool ____	lateral scour ____	flat ____	riffle ____
trench ____	pocket water ____		rapids ____

OVERALL FISH (1=POOR TO 5=FISH MARKET): ____________

0-5		No.	0-5		No.	0-5		No.	0-5		No.	0-5		No.	0-5		No.
___	TFS	___	___	SB	___	___	SP	___	___	HCH	___	___	LMP	___	___		___
___	RT	___	___	SMB	___	___	TP	___	___	HH	___	___		___	___		___
___	BN	___	___	LMB	___	___	SCP¹	___	___	SQ	___	___		___	___		___
___	EB	___	___	GSF	___	___	SCP²	___	___	RCH	___	___		___	___	RLF	___
___	CS	___	___	RSF	___	___	STB	___	___	SD	___	___		___	___	YLF	___
___	WCF	___	___	BG	___	___	GAM	___	___	BF	___	___		___	___	BF	___
___	BB	___	___	BCR	___	___	CP	___	___	FHM	___	___		___	___	SAL	___
___	CCF	___	___	WCR	___	___	GF	___	___	SKR	___	___		___	___	TUR	___

GENERAL DRAWING OF STREAM SECTION:

(mark deep runs, riffles, spawning patches (S=sand, G=gravel, C=cobble))

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

407 West Line Street
Bishop, California 93514

December 1, 1988

RESOLUTION 88-1

RELATIVE TO THE PLACEMENT OF TILAPIA SPECIES
ON THE TEXAS RESTRICTED FISHES LIST

WHEREAS Tilapia aurea and Tilapia mossambica are increasing their ranges in Texas, and

WHEREAS Tilapia aurea now comprises a major fraction of the fish biomass in the lower Rio Grande, and

WHEREAS other species of Tilapia may be released into the natural waters of Texas, and

WHEREAS the Texas Parks and Wildlife Department has placed Tilapia species on the Texas Restricted Fishes list, now therefore be it

RESOLVED that the Desert Fishes Council, an international organization numbering more than 500 individuals representing the general public, government and university scientists and resource managers, and private conservation organizations, meeting at its Twentieth Annual Symposium in Death Valley, California from November 16-19, 1988, does hereby commend the Commissioners of the Texas Parks and Wildlife Department for their thoughtful action, and be it further

RESOLVED that copies of this resolution be forwarded to the Executive Director and Inland Fisheries Branch Chief of the Texas Parks and Wildlife Department.

PASSED WITHOUT DISSENTING VOTE

ATTEST:

Edwin P. Pister
Executive Secretary

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

407 West Line Street
Bishop, California 93514
January 23, 1989

Mr. F. Dale Robertson, Chief
USDA Forest Service
P.O. Box 96090
Washington, D.C. 20013-6090

Dear Mr. Robertson:

The Desert Fishes Council is an international organization numbering more than 500 individuals representing the general public, government and university scientists and resource managers, and private conservation organizations, all concerned with maintaining the integrity of desert aquatic ecosystems and their related fauna and flora. The accompanying resolution was passed at the Council's Twentieth Annual Symposium, held at Death Valley National Monument on November 16-19, 1988.

E. P. Pister
Executive Secretary

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

407 West Line Street
Bishop, California 93514
December 1, 1988

RESOLUTION 88-2

RELATIVE TO FISH HABITAT PROTECTION, RESTORATION, AND IMPROVEMENT ON THE NATIONAL FORESTS

WHEREAS the USDA Forest Service is responsible for the management of over 128,000 miles of streams and 2.2 million acres of lakes, reservoirs, and ponds on this Nation's 191 million acres of National Forests, and

WHEREAS these waters are habitats for 39 Endangered or Threatened species of fishes, such as the Kendall Warm Springs dace, Gila topminnow, Paiute and Lahontan cutthroat trouts, and others, and

WHEREAS the Forest Service has implemented a renewed and aggressive fisheries program called RISE TO THE FUTURE, intended

1. to protect, restore, and improve fish habitats on National Forest System lands, and
2. to elevate fisheries resource management to a level equal to other resources in the National Forests, and
3. to increase partnerships with States, other Federal agencies, tribal governments, and conservation groups, and
4. to increase dollar and people resources directly involved in managing National Forest fisheries, now therefore be it

RESOLVED that the Desert Fishes Council supports the RISE TO THE FUTURE program, and be it further

RESOLVED that the Forest Service recognize the value of proper management of fragile arid land aquatic ecosystems as integral in achieving these overall objectives for enhancing biodiversity as well as recreational values, and be it further

RESOLVED that the Forest Service be congratulated for its leadership in the protection, restoration, and improvement of fish and their habitats nationwide, including endangered and threatened species, and be it further

RESOLVED that copies of this resolution be forwarded to the Chief of the Forest Service, the Regional Foresters, Forest Supervisors, and District Rangers and their staffs.

PASSED WITHOUT DISSENTING VOTE

ATTEST: [signature]
Edwin P. Pister, Exec. Secty

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

407 West Line Street
Bishop, California 93514
December 2, 1988

RESOLUTION 88-3

RELATIVE TO THE CONSTRUCTION OF A FISH BARRIER IN ARAVAIPA CREEK TO PREVENT THE INVASION OF EXOTIC FISHES FROM THE DOWNSTREAM REACH

WHEREAS Aravaipa Canyon, as of August 1984, is included in the National Wilderness Preservation System, and

WHEREAS Aravaipa Creek harbors a unique assenblage of seven indigenous Gila River basin fishes, two of which, spikedace (Meda fulgida) and loachminnow (Tiaroga cobitis), are Federally Listed as Threatened, and

WHEREAS there is a long history of valuable scientific research from Aravaipa Creek, and

WHEREAS only recently have exotic fishes been detected in the Aravaipa Creek mainstream, and

WHEREAS red shiner (Notropis lutrensis), an exotic fish that is a documented threat to most native fishes in the creek, have been found just one mile below the Aravaipa Creek-San Pedro River confluence, and unless immediate steps are taken, will gain access to Aravaipa Creek, and

WHEREAS The Arizona Nature Conservancy supports building a fish barrier to prevent movement of red shiner upstream into Aravaipa Creek and is currently negotiating the acquisition of land appropriate for such a structure, now therefore be it

RESOLVED that the Desert Fishes Council, an organization comprising a nationwide and international representation of federal, state, and university scientists and resource specialists, members of conservation organizations, and individuals concerned with long-term environmental values, assembled at the Council's Twentieth Annual Symposium on November 16-19, 1988 at Death Valley National Monument, does hereby express its deepest concern for the native fishes of Aravaipa Creek and supports the efforts of The Nature Conservancy and other potential agencies to construct a fish barrier in Aravaipa Creek, and be it further

RESOLVED that copies of this resolution be forwarded to the Director of The Arizona Nature Conservancy; the Manager of Safford District, Bureau of Land Management; the Director of the Arizona State Game and Fish Department; the Chief Biologist of the Phoenix Office, Bureau of Reclamation; and to other agencies and individuals as appropriate.

PASSED WITHOUT DISSENTING VOTE

ATTEST: [signature]
Edwin P. Pister, Exec. Secty

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

407 West Line Street
Bishop, California 93514
December 2, 1988

RESOLUTION 88-4

RELATIVE TO THE EXECUTIVE SECRETARY

WHEREAS Edwin Philip Pister has been Executive Secretary of the Desert Fishes Council since its inception in 1969, and

WHEREAS the Desert Fishes Council has become a major influence in the conservation of desert fishes and their associated habitats and life forms, and

WHEREAS the Desert Fishes Council has developed in large measure because of the untiring enthusiasm and competence of our Executive Secretary, and

WHEREAS the conservation ethic Phil has imparted to the Council through his support of students in Mexico and the United States typifies the highest ideals of conservationists throughout North America, now therefore be it

RESOLVED that the Desert Fishes Council expresses its appreciation to our Executive Secretary by establishing the Edwin Philip Pister Student Travel Award, to be granted annually to two deserving students, one from Mexico and the other from the United States, by a consensus of the Executive Committee, to assist in defraying travel expenses to the annual symposia, and be it further

RESOLVED that the Desert Fishes Council expresses its deepest appreciation to Edwin Philip Pister for his dedication and accomplishments in the conservation of our natural resources.

PASSED WITHOUT DISSENTING VOTE

ATTEST:

Edwin P. Pister
Executive Secretary

ATTENDEES, SYMPOSIUM XX
Aardahl, Jeff
Abarca, Francisco
Abell, Dana
Archer, Don
Armantrout, Neil
Bagley, Brian
Barrett, Paul
Baucom, Frank
Bestgen, Kevin
Bisson, Henri
Bolster, Betsy
Bowen, Mark
Bowler, Peter
Bransfield, Ray
Brittan, Marty
Brooks, Jim
Brown, Dave
Brussard, Pete
Burke, Tom
Burton, Jerry
Busdosh, M & L
Buth, Don
Casey, Os
Castleberry,Dan
Clarkson, Rob
Clemmer, Glen
Coffey, Michael
Coffin, Pat
Cordery, Ted
Courtenay, Walter
Crouse, Mike
Deacon, Jim & Mary Dale
DeMarais,Bruce&Alice
Douglas, Mike
East, Mike
Echelle, T & A
Edmiston, Tasker and Beula
Edwards, Bob
Ellis, Susan
Eng, Larry
Erman, Don
Evans, Paul
Feldmeth, Bob
Fisher, Leon
Garrett, Gary
Goldberg, Jan
Groschupf, Kathy
Gustafson, E & L
Haglund, Tom
Hall, Bob
Hamill, John
Hendrickson, Dean
Herbst, Dave
Hershler, Bob
Hoffman, Walt
Hoover, Frank
Horn, Mike
Hubbs, Clark
Hutchings, John

Jakle, Marty
Jenkins, Tom
Jerry & Sally Stefferud
Johnson, James E.
Jones, Tom
Kahl, Joe
Karp, Cathy
Kepner, B & L
Kimsey, Diann
King, Jennifer
Kinney, Ed
Knight, Denise
Kobetich, Gail
Kohfield, Beverly
Krausman, Mike
Landye, Jerry
Langhorst,Dan
Langlois, Dave
Lanigan, Steve
Launer, Alan
Leibfried, Bill
Lorentzen, Ed
Love, Bob
Lucas, Lauren
Marsh, Paul
Martin, Larry
Mazeroll, Anthony
McAda, Chuck
McCready, Alan
McEwan, Dennis
McGriff, Darlene
Meffe, Gary.
Meral, Jerry
Meyer, Curt
Miller, Robert R.
Milliron, Curtis
Minckley, W.L.
Minckley, Chuck
Mire, June
Mohr, Mike
Montgomery, Linn
Moyle, Peter
Mueller, Gordon
Muirhead, Neal
Nicol, Kim
Norton, Nancy
N. Kanim,M. Parker
Olech, Lillian Andris
Osmundson, Douglas
Parmenter, Steve
Pease, Chris
Pister, Phil
Platania, Steve
Propst, Dave
Quattro, Joseph
Ray, John
Riggs, Alan
Ring, Everett
Rinne, John
Rolston, Holmes

Rothfuss, Ed
Russi, Terry
Sada, Don
Vande Sande, Ted
Scherba, Gerry
Schoenherr, Al
Scoppettone, Gary
Shiozawa, Dennis
Shumway-Moskovitz, Mignon
Smith, Gary
Soltz, Dave
Swift, Camm
Taylor, Tom
Thompson, Rosie
Tiernan, Don
Tonopah, USFS
Tully, Sharon
Tyus, Harold
Ulmer, Linda
Valdez, Rich
Wales, Joe
Wasowicz, Tony
Whitney, Jeff
Wick, Ed
Wilde, Gene
Wilke, Phil
Williams, Bob
Williams, Caryl
Williams, Jack and Cindy
Williams, Rick
Winograd, Ike
Wong, Darrell
Yess, Scott
Young, Kirk
Zuckerman, Larry

Desert Fishes Council

CONSEJO DE LOS PECES DEL DESIERTO

"Dedicated to the Preservation of America's Desert Fishes"

21st Annual Desert Fishes Council Meeting

VIGESIMOPRIMER SIMPOSIO ANUAL

ALBUQUERQUE HILTON HOTEL

ALBUQUERQUE, NEW MEXICO

16-18 NOVIEMBRE, 1989

PREFACE TO VOLUME XXI

The twenty-first annual symposium was held on November 15-18, 1989 at the Albuquerque Hilton Hotel, with the University of New Mexico's Department of Biology serving admirably as our primary hosts, beginning with a social gathering held at the University on Wednesday evening (November 15). The symposium started on the following morning with a special session concerning permits and collecting within Mexico (refer to agenda for participants). Scientists and public officials from both nations participated in this valuable exchange, which is almost certain to promote understanding, facilitate scientific endeavor, and work in the long-term best interest of the aquatic biota

The usual excellent research and management papers were then given, ending with a superb Mexican banquet on Friday night. The final event of the symposium was a bus trip to the Dexter National Fish Hatchery, topped off by an excellent barbecue staged by the hatchery staff.

The Council expresses its deep gratitude for the kindness of the following groups and individuals: Museum of Southwestern Biology (University of New Mexico), New Mexico Game and Fish Department, U.S. Fish and Wildlife Service (especially Jim Brooks, Buddy Jensen, and the Dexter National Fish Hatchery staff), U.S. Bureau of Reclamation, Albuquerque Hilton Hotel, the Anheuser-Busch Companies, Inc. (Premier Distributing), and the New Mexico Museum of Natural History. Instrumental in planning the entire symposium was long-time Council member Steve Platania (a graduate student at the University of New Mexico), assisted by his lovely wife, Marta. To them, and to all involved, a hearty thanks!!

Phil Pister
Bishop, California
December 14, 1990

AGE AND GROWTH OF SAN PEDRO MARTIR RAINBOW TROUT, *Oncorhynchus mykiss nelsoni* EVERMANN, FROM ARROYO SAN RAFAEL, BAJA CALIFORNIA, MEXICO

GORGONIO RUIZ-CAMPOS[1/] AND JAVIER GOMEZ-RAMIREZ [2/]

ABSTRACT

Age structure and growth of *Oncorhynchus mykiss nelsoni*, an endemic rainbow trout subspecies from the Sierra San Pedro Mártir, Baja California, México, was studied in a section of Arroyo San Rafael from January to December 1987. Four age groups (0-III) were recognized from scale and body measurement of 196 specimens. Age group-0 was the most dominant in the population (49 %). Juvenile recruitment occurred in late spring (June). The linear relation between scale radius and fish length was Y= 13.0 + 14.4X, and allometry equation of length-weight regression was $W= 6.225 * 10^{-5} L^{2.744}$; von Bertalanffy and Gompertz growth function models described well the growth for the first three years. The highest condition factor (Fulton's modified) was found in age-0 fish. In late summer and middle winter the highest condition was correlated with the period of highest gonadic development of older trout.

RESUMEN

La estructura de edad y crecimiento de *Oncorhynchus mykiss nelsoni*, una subespecie endémica de trucha arcoiris de la Sierra San Pedro Mártir, Baja California, México, fue estudiada en una sección del Arroyo San Rafael de Enero a Diciembre de 1987. Se reconocieron cuatro grupos edad (0-III) a partir de la interpretación en escamas y mediciones corporales de 196 especímenes. El grupo edad-0 fue el más dominante en la población (49 %). El reclutamiento de juveniles ocurrió en primavera tardía (Junio). La relación lineal del radio de la escama y la longitud del pez fue Y= 13.0 + 14.4X, y la ecuación alométrica de la relación longitud-peso fue $W= 6.225 * 10^{-5} L^{2.744}$, los modelos de función de crecimiento de von Bertalanffy y de Gompertz describieron adecuadamente el crecimiento de la trucha durante los primeros tres años. El mayor factor de condición (Fulton modificado) fue registrado en el grupo edad-0. Los valores más altos del factor de condición fueron registrados en verano tardío y a mediados de invierno, y en correlación con el período de mayor desarrollo gonádico de las truchas adultas.

[1/]Escuela Superior de Ciencias y [2/]Facultad de Ciencias Marinas, Universidad Autónoma de Baja California, A.P.1653, Ensenada, B.C. 22800, México.

INTRODUCTION

Endemic populations of rainbow trout of the subspecies O. *mykiss nelsoni* Evermann, inhabit the western slope of the Sierra San Pedro Mártir, Baja California, México, at elevations between 600 to 2,000 m. This subspecies distinguishes from other subspecies of the rainbow trout complex in that it does not migrate and is eurythermic in its natural habitat (Needham 1938). Furthermore it is considered to be purer than the North American rainbow trout populations (E.P. Pister[1], pers. comm.).

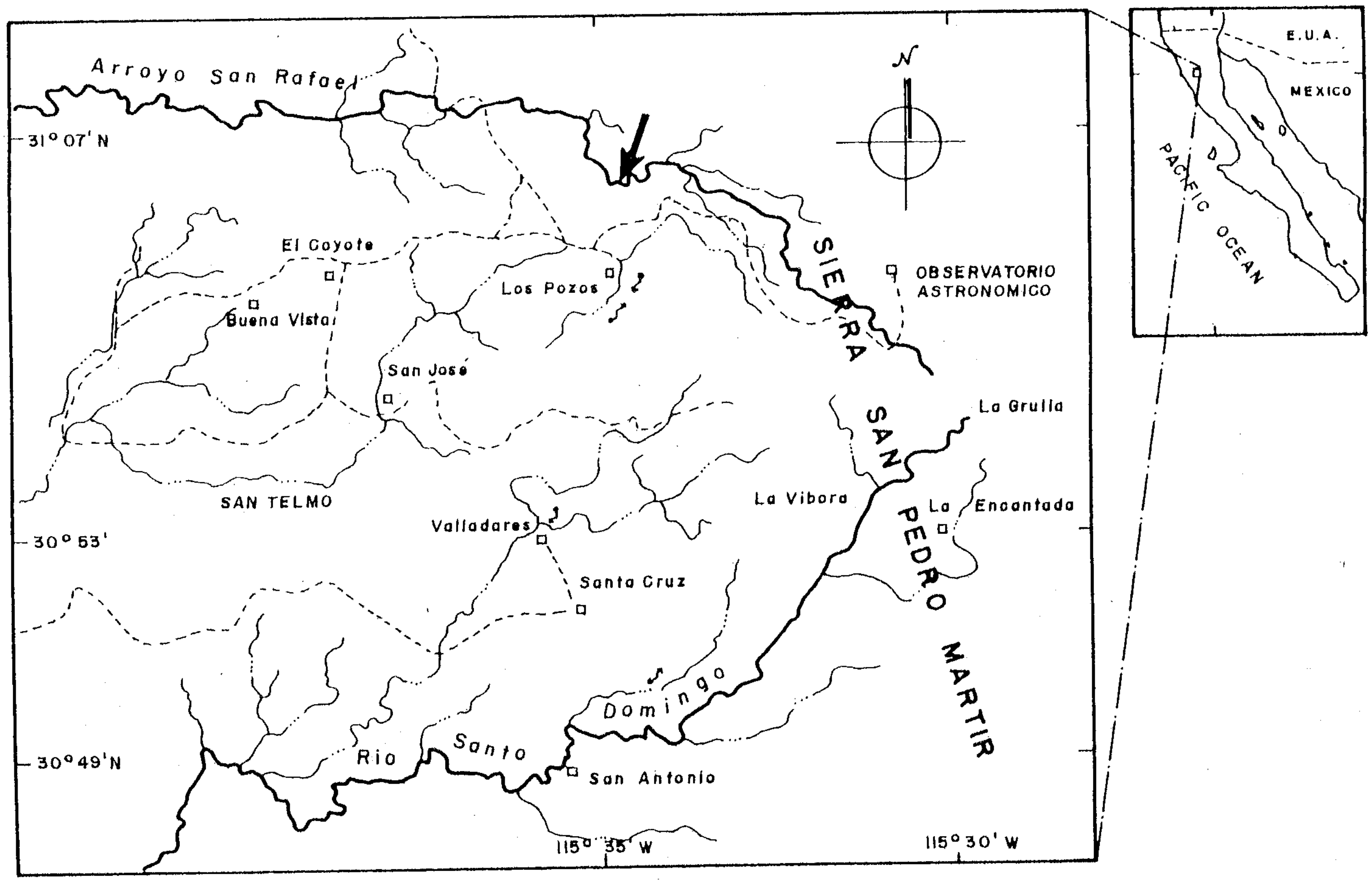
Age structure and growth characteristics of this endemic rainbow trout subspecies have not been well documented, in contrast with the other subspecies of North America (Carlander 1969). Snyder (1926) aged 56 specimens of *Salmo nelsoni* Evermann (now refered as *O. m. nelsoni*, Smith and Stearley 1989) of Arroyo San Antonio (a tributary of Río Santo Domingo) at Sierra San Pedro Mártir, and found four age groups (I-IV), with the two and three year old groups dominating, but, his analysis was based on only one collection.

This paper reports the age structure and growth of *O. m. nelsoni*, of a locality from Arroyo San Rafael, Northwest of the Sierra San Pedro Mártir, Baja California, México.

Study Site

The collection site is at an altitude of 1,219 m, Northwest of the Sierra San Pedro Mártir (Fig. 1). Average stream width and depth are 4.0 and 0.4 m, respectively.

[1]California Department of Fish and Game, Bishop, Ca 93514.



SCALE 1: 250 000

Fig. 1. Map of study area. An arrow indicates the exact site of trout sampling.

The bottom is composed mostly of sand-gravel (granite) and few aquatic macrophytes exist. High water transparency is typical of streams in this area. The benthic invertebrates most common are trichopterans, simuliids and odonats larvaes (Cota-Serrano 1989). Furthermore, *O. m. nelsoni* is the only fish species inhabiting the Arroyo San Rafael (Ruiz-Campos 1989).

METHODS

Trout were collected in January, March, June, September and December 1987, by electrofishing 100 m transects with AC electrofishing equipment (110 V) (Vincent 1971). All collections were made at approximately 1100 hours, where all available habitat types (e.g. pools. riffles, etc.) were considered.

The water temperature was taken with a digital thermometer (0.1 °C) at several points of the sampling transect to obtain the mean temperature.

Trout were measured (standard length in mm) and weighed (0.1 g) in the field. All specimens were fixed with a 10 % formaldehyde solution (buffered with sodium borate) and preserved in 50 % isopropanol.

Ages were determinated by counting scale annuli, because they correspond well with those of otoliths (Cooper 1951; Alvord 1953; Reimers *et al.* 1955). The scales were taken from the axilary region and were cleaned in a potassium hydroxide solution (5 %) for three hours to eliminate tissue material; they were then washed in water. Five scales were selected from each fish and placed between glass slides. Their image was examined on a microvideo system adapted to a dissecting microscope. The radius of each annulus was measured with a calibrated ocular micrometer (micrometer coeff.= 25).

To describe the somatic growth of the sampled trout, three differents models were considered: (1) Fraser-Lee or direct porportion model (Bagenal 1978), (2) von Bertalanffy growth function (Moreau 1987), and (3) Gompertz growth function (Ricker 1979). The growth parameters of models (2) and (3) were calculated using Fishparm, an iterative program for IBM computers (Saila *et al.* 1988).

The length-weight relationship of the sampled trout was determinated using the non-linear technique (Ricker 1975): $W = a L^b$, again with Fishparm.

The condition factor was computed for all trout collected using a modified Fulton's index as described in Bagenal (1978): $H' = \text{Weight (g)} * 10^5 / SL^b$ (mm).

An ANCOVA test (Sokal and Rohlf 1981) for condition was performed, using length and weight as covariates for each age.

The mean calculated length and weight for each age group were compared to empirical (observed) values, and tested using a Chi-square test.

RESULTS

The highest water temperature (16.8 °C) was registered during late summer (September 17 1987), and the lowest (7.2 °C), was found in early spring (March 22 1987). when light snow was registered.

A total of 196 rainbow trout were collected during this study (range =49-198 mm SL, $\bar{X}$ = 93.2 ± 33.9 mm).

<u>Age Composition</u>. Four age groups (0, I, II, and III) were recognized for the Arroyo San Rafael rainbow trout population by counting scale annuli. Age group-0 was the most dominant in the population (49 %), followed by age group I (23 %), II (22 %) and III (6 %).

The mean length by age group for each collection date is shown in Figure 2. During mid-winter (January 27 1987), only the age groups I and II were detected (Fig. 3); in early spring (March 22 1987) three age groups (I, II and III) were found, and group I was the most abundant. By late spring (June 9 1987) the age composition of the trout population was composed of four age-groups (0-III), with a clear dominance of age-0 fish. In late summer (September 17 1987), the age structure was represented by four age-groups, with a predominance of individuals from groups 0 and II. However, by late autumm (December 6 1987) the trout population was composed of four age groups, where age-0 fish were again very conspicuous (Fig. 3).

<u>Growth</u>. The linear relation between scale radius (x) and fish length is Y = 13.0 + 14.4 (x), r^2 = 0.87. The

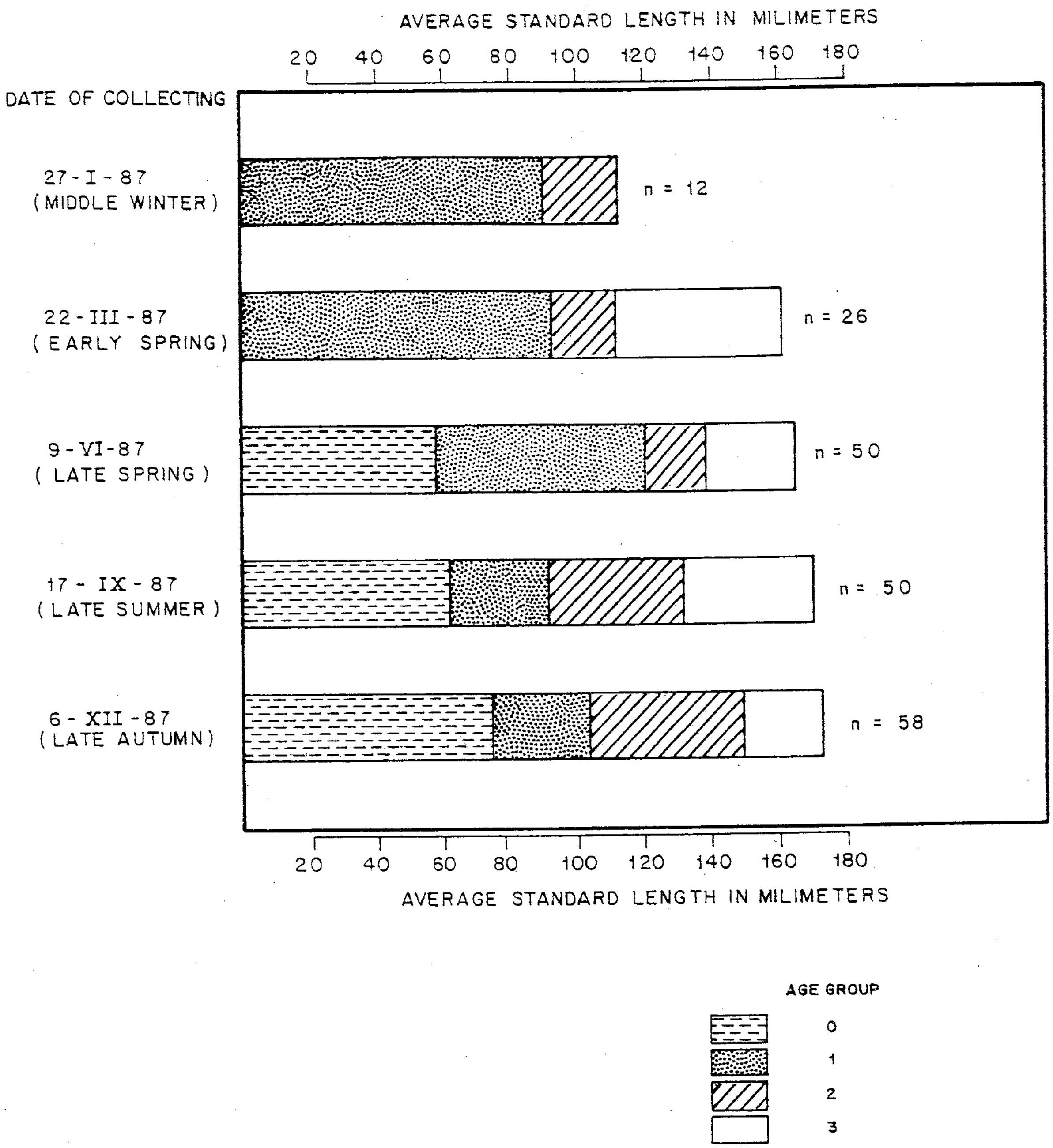


Fig. 2. Average standard length by age group of rainbow trout <u>Oncorhynchus</u> <u>mykiss</u> <u>nelsoni</u> from Arroyo San Rafael, Baja California, México. The vertical lines within bars indicates the average standard lengths in each age group.

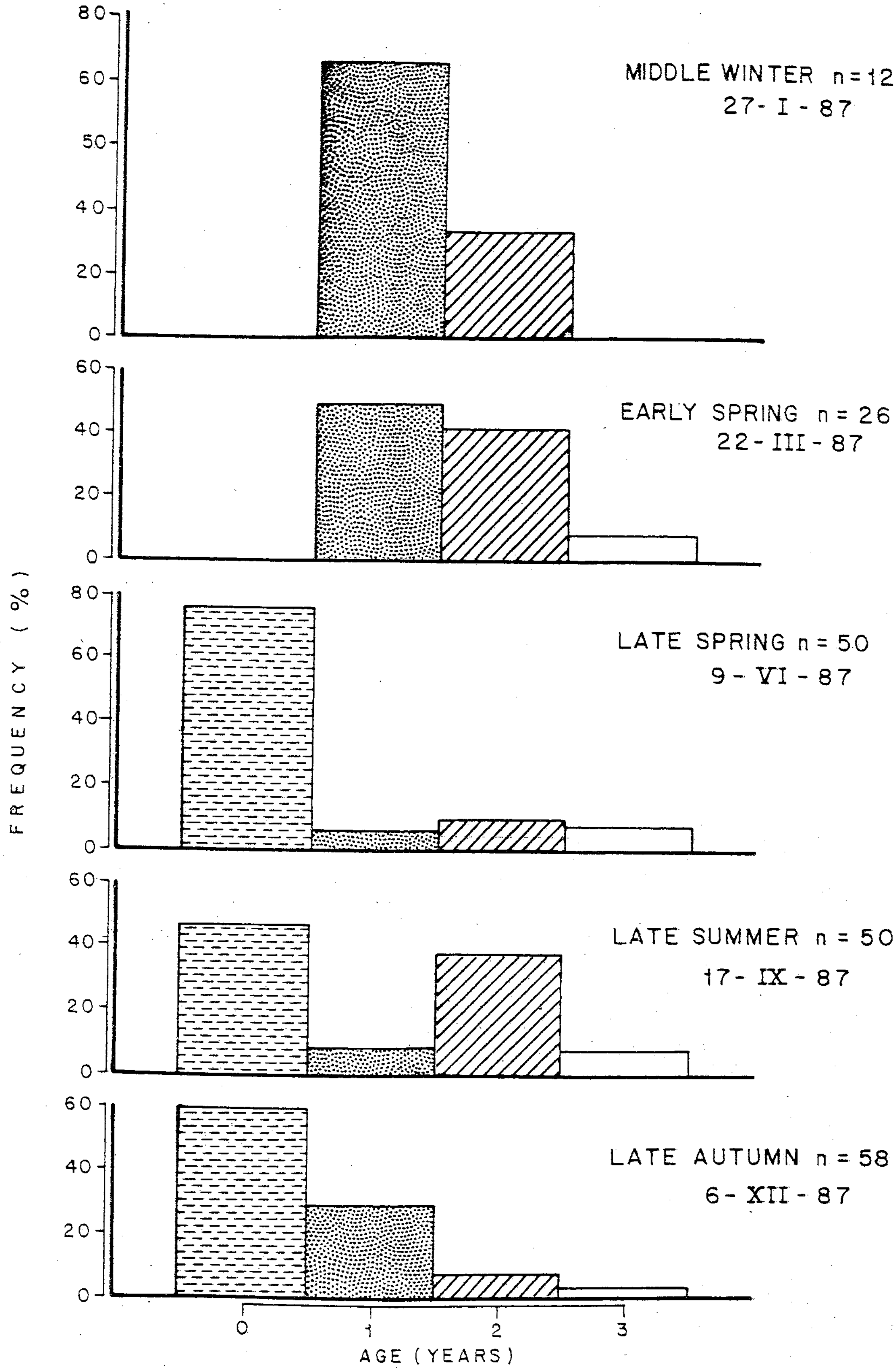


Fig. 3. Seasonal age-structure of rainbow trout population, from Arroyo San Rafael, Baja California, México, as determined by analysis of scales.

length-weight relation for the San Rafael trout population is, $W = 6.225 * 10^{-5} L^{2.744}$ (Fig. 4).

Annual growth rates, in terms of fish length, estimated to each formed annulus, whether by indirect techniques or by counting scale annuli are shown on Table 1. In all three methods, the largest increases in length occurred during the first year of life.

Fish lengths obtained by back-calculation (Fraser-Lee's methods) were statistically different ($X^2 = 13.58$, $p < 0.05$) from empirical lengths. However, they were not statistically different at 0.05 ($X^2 = 0.25$) than length calculated by von Bertalanffy model (Fig. 5a). Also, weights calculated by the Gompertz model (Fig. 5b) for each age were not statistically different at 0.05 ($X^2 = 0.05$) than empirical weights (Table 1).

The average condition factor by age-group (all months combined) was variable; the 0-group showed the highest condition and the I-group the lowest (Fig. 6a). Furthermore the average condition factor (all age groups combined) changed during the year, the highest condition being during late summer and lowest in early spring (Fig. 6b). This variation of condition with age and month was statistically significant (ANCOVA, p = 0.0004 and 0.0132, age and month respectively).

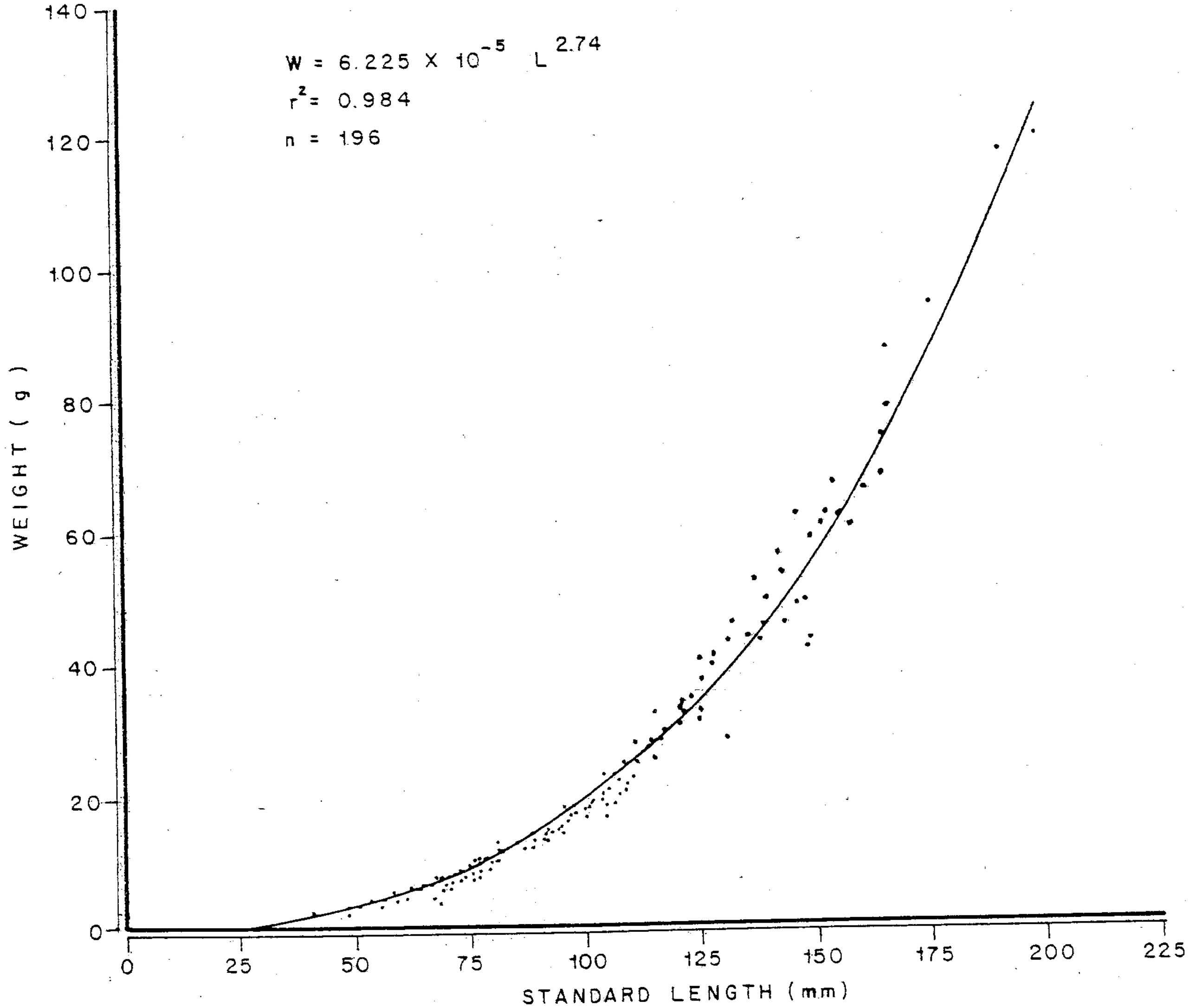


Fig. 4. Length-weight relationship of <u>Oncorhynchus mykiss nelsoni</u> from Arroyo San Rafael, Sierra San Pedro Mártir, Baja California, México.

Table 1. Mean values of growth rates (length and weight) for the rainbow trout, *Oncorhynchus mykiss nelsoni*, from Arroyo San Rafael, Sierra San Pedro Mártir, B.C., México.

Mean Standard Length (mm) * = Increase in Growth

Age (years)	SL (empirical)	*	SL (back-calculated)	*	SL (von Bertalanffy)	*
0	66.16	---	---	---	65.85	---
1	98.17	32.01	74.70	---	97.96	32.11
2	127.56	29.39	101.82	27.12	130.08	32.12
3	167.94	40.38	146.35	44.53	162.18	32.10

Mean Weight (g)

Age (years)	W (empirical)	*	$W_{(t)}$ (Gompertz)	*
0	6.84	---	7.11	---
1	18.40	11.56	17.65	10.54
2	39.11	20.71	39.49	21.84
3	80.88	41.77	80.63	41.14

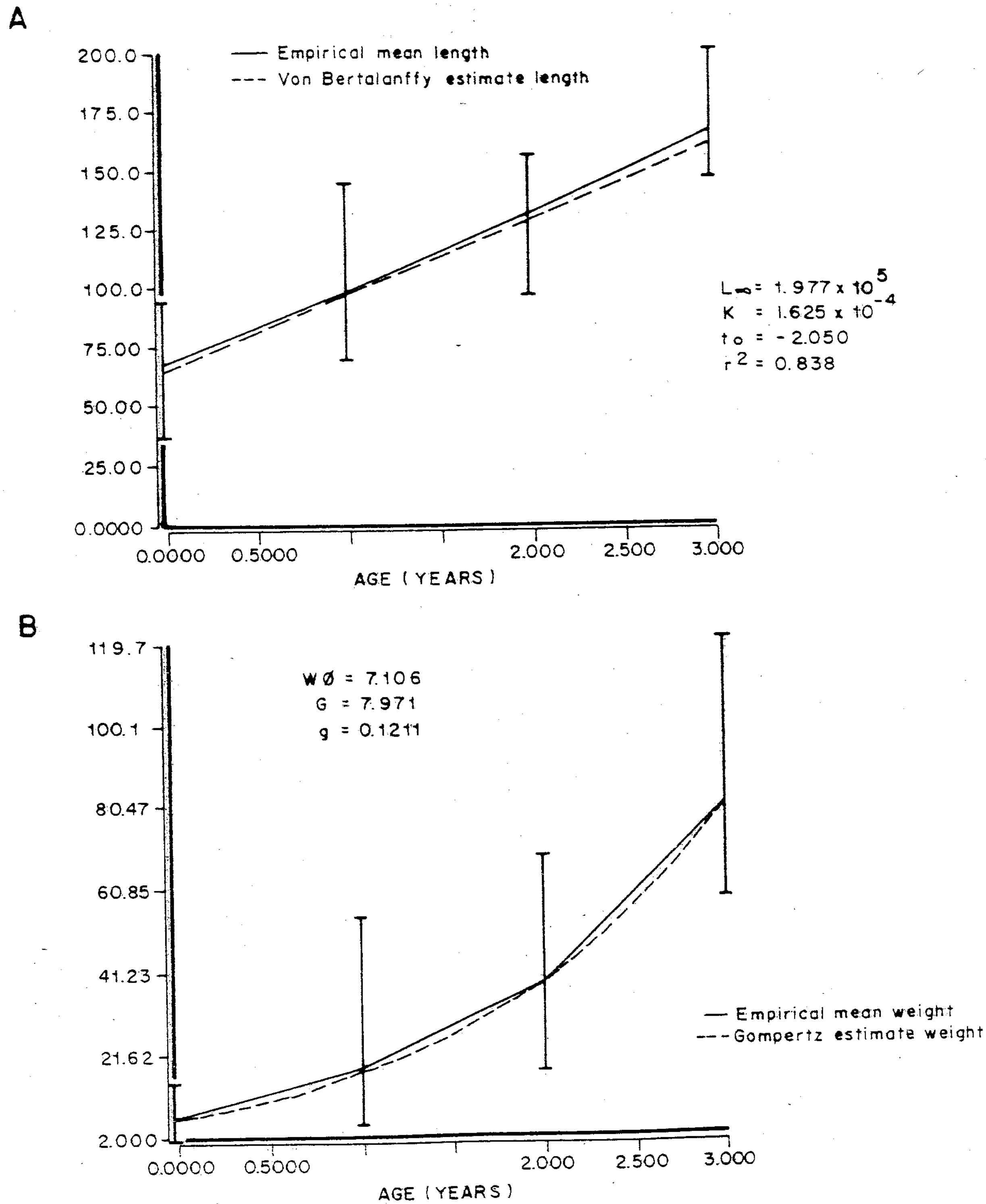


Fig. 5. Von Bertalanffy and Gompertz growth functions for San Pedro Mártir rainbow trout.

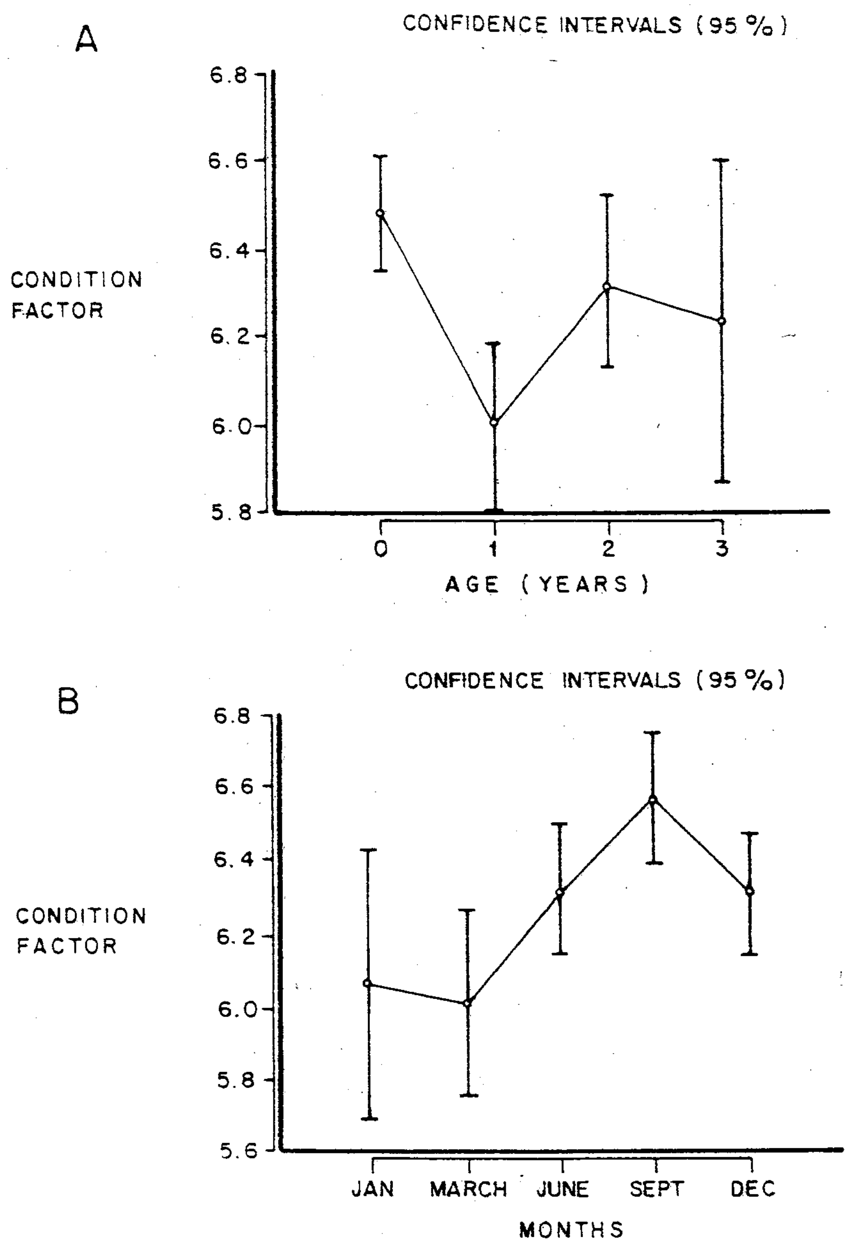


Fig. 6. Condition factor (Fulton's modified) of San Pedro Mártir rainbow trout by age class and month. A.- Age (all months combined), B.- Month (all age groups combined).

DISCUSSION

Snyder (1926) reported four age classes (I-IV) for the rainbow trout population in Río Santo Domingo, but in Arroyo San Rafael, although we also found four age classes, they were younger (0-III). This differences might be due to Snyder used selective angle fishing, while in our study, we used non-selective electrofishing. Also, the trout specimens caught by Snyder came from a single area sampled over 4 days (April 24 to 27 1925), which corresponded to early spring conditions before recruitment; in our study collections were made year-round. Furthermore the juvenile recruitment occurred in late spring (June).

The age structure found for the San Rafael trout population is younger than that noted for several rainbow trout subspecies in California (Carlander 1969). This might be a consequence of several effects of population regulation; for example, high mortality principally of young of-the-year due to predation (Alexander 1979). The piscivorous snake (two-striped garter, *Thamnophis couchi hammondi*) was commonly seen to prey on young rainbow trout in the study site, and it is possible that raccoon (*Procyon lotor*) consumes older trout; their prints were frequently seen on the edges of stream. Short longevity of trouts, may also be an ecological strategy of population regulation (Beverton 1987) in response to low productivity and food supply that are characteristic of the region (Cirilo-Sánchez and Ruiz-Campos 1987). Although it has been mentioned for other species (e.g. walleye, *Stizostedion v. vitreum*), that a much greater longevity of fish may be expected in the more northerly locations where the food supply is more limited (Colby and Nepszy 1981); this concept might not be applicable for southern rainbow trout populations for reasons cited above.

A high mortality in the first year was observed. Similar results have been found for juvenile rainbow trout in many localities of North America (see Alexander 1979 for a review). LeCren (1973) attributed the mortality rate of juvenile brown trout (*Salmo trutta*) to density-dependence, indicating that each particular habitat only supports a certain number fish. Thus, the habitat seems to be a bottle-neck for population size (Heraldstad and Jonsson 1983). Newman (1956) and Stuart (1957) mentioned that juvenile trout exhibit a less agonistic territory defense behavior than older trouts; an important factor in the survival and recruitment rates of young trout.

The growth rate obtained for the *nelsoni* subspecies is lower than those observed in other rainbow trout subspecies in California (Carlander 1969); allusive to this, Thorpe *et al.* (1982) mentioned that the salmonids are especially remarkable for the wide variation or plasticity of their growth, maturation and longevity within the same gene pool.

The von Bertalanffy and Gompertz growth function models, typically overestimate the parameters $L\infty$ and $W\infty$ (Yamaguchi 1975; Pauly 1979). Nevertheless, they describe well the growth for the first three years (Fig. 5a-b). Pauly (1979) claimed that L∞ is often overstimated, when slow-growing, old fishes are not sampled, or for those short-lived species which show an inflection point in their growth rate and are exploited early in life (Yamaguchi 1975). This last explanation can be discarded for the trout population we studied, because there is no fishing mortality.

Lengths obtained by counting scale annuli were higer than those estimated by back-calculation (23.9 % higher for age-I,, 20.2 % age-II and 12.9 % age III), because the former are the average length of trouts with the nth annulus completely formed plus the last annulus partially formed, while the back-calculated lengths are the average lengths of individuals with the nth annulus completely formed.

The highest condition factor for this subspecies was found in age-0 fish, which showed a high rate of increase in lenght, but not in weight during their first year. In late summer and middle winter the highest condition of all fish combined was found concomitant with the period of highest gonadic development of older trout. This obviously influenced the weight. The spawning time for this subspecies is reported to be during January or February (Needham 1938), where we found a high frequency of trout with flaccid and empty gonads, mainly in those individuals of two and three old years.

Concluding Remarks

This study shows that the endemic rainbow trout subspecies inhabiting the small streams of the Sierra San Pedro Mártir, Baja California, México, is characterized by a short life and slow growth adapted to extreme environmental and habitat conditions, such as wide fluctuations of temperature, often low-water flows, low productivity and food supply, typical of this southerly habitat.

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RADIOTELEMETRY OF RAZORBACK SUCKERS IN THE GILA RIVER, EASTERN ARIZONA

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Introduction

Wild populations of razorback sucker, *Xyrauchen texanus* (Abbott), were extirpated from the Gila River basin in the late 1950s (Minckley 1973, 1983; Minckley *et al*., 1990), before studies of its life history and ecology could be performed. A reintroduction program in behalf of the species' recovery began in 1981 (Johnson 1985), which will ultimately encompass 10 years of propagation, stocking, monitoring, and research. Initial studies documented substantial losses of newly planted fish to introduced predators (Marsh and Brooks 1989), and stockings of larvae and small juveniles were abandoned in favor of larger, more predator-immune fish. Based on known growth rates of both wild and captive razorback suckers (McCarthy and Minckley 1987; Papoulias 1988; Marsh in press, unpubl.), reintroduced fish could have attained adult sizes >50 cm total length in 3 to 5 years (Hamman 1985; Marsh and Langhorst 1988).

Although it was demonstrated early that juvenile razorback suckers <20 cm long moved downstream *en masse* after stocking (Brooks 1985; Marsh and Brooks 1989), behavior of larger fish in the Gila River was unknown. A radiotelemetry pilot study was thus conceived and implemented by Arizona State University, with support and cooperation of the U. S. Fish and Wildlife Service (USFWS), U. S. Bureau of Land Management, and San Carlos Apache Indian Tribe. G. Divine, USFWS, expedited partial funding and H. M. Tyus, USFWS, trained us in technique, loaned equipment, assisted with transmitter implantation, and provided enthusiastic counsel; B. L. Jensen and crew, USFWS Dexter National Fish Hatchery (DNFH) supplied fish and other assistance; C. Williams, R. Timmons, K. Young, and D. Langhorst helped in the field; S. P. Vives reviewed the manuscript.

Methods

Transmitters were Smith-Root, Inc. (SR) or AVM Co.[1/] internal units coated with bee's wax to preclude extrusion (Tyus 1988) and surgically implanted into the body cavities of anaesthestized (MS-222) fish following protocols outlined by Tyus and McAda (1984). Individuals were also marked with unique external dangler or spaghetti tags. Radiotracking and location with Smith-Root SR-40 and RF-40 receivers fitted with whip or bi-directional loop antennas was performed on foot,

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[1/] Reference to trade names does not imply endorsement of commercial products. Modules weighed 11-18 gm in air, transmitted in the 40-MHz range, and had battery life expectancies of 6-9 (SR) or 12-14 (AVM) mo.

by canoe, raft, all-terrain vehicle (ATV), or truck, depending on channel accessibility, stream discharge, and area searched. Intensive tracking was weekly or bi-weekly from the Arizona-New Mexico state line downstream 55 stream-km to the stocking site, and thence downstream another 38 stream-km to the San Jose Diversion. At low flow most of the river is diverted into irrigation delivery canals at the latter point, only to rise again from subsurface underflow a few hundred meters to a kilometer or more downstream. On two occasions, canals and the river channel below San Jose were searched by motorized vehicle to the delta of San Carlos Reservoir, 90 stream-km downstream. One, 3-day search in San Carlos Reservoir was by motor-driven boat.

Ten, 4-, 6-, or 7-year-old, hatchery-reared razorback suckers (DNFH), plus four wild adults trammel netted 20-23 May 1988 from Lake Mohave, Arizona-Nevada, received internal radiotags on 24 May 1988 (Group I). Fish were released immediately after surgery into the Gila River at the Old Safford Bridge, Greenlee County, Arizona (discharge 1.64 m^3/sec), and tracking began thereafter.

Surgery was next performed on nine, 4-year-old hatchery-reared fish (Group II) under controlled conditions at DNFH. After implantation on 30 August 1988, fish were placed in an outdoor pond to recover from trauma associated with handling and surgery. One died the following day, and a second a month later. Both transmitters were recovered and successfully implanted into healthy fish by DNFH personnel. Nine implanted fish, all in apparently good condition, were transported and released at the Old Safford Bridge on 12 October 1988 (discharge 6.23 m^3/sec).

Habitat data were collected for each fish contacted. Most razorback suckers remained stationary for the 10- to 30-minute period required to pinpoint their location by triangulation. The fish were then visually contacted if in clear water, or if in turbid water forced to move by a wading investigator, and stream width, depth, substrate, and current velocity were estimated at the specific point of occurrence. In some instances where data were not initially recorded, localities were revisited within a few days at similar river discharge, and habitat relations were reconstructed.

Results

All Group I fish remained within 0.8 km of the release site during the first 12 hours. Movements were primarily during darkenss, and over the next several days, three of the original 14 fish moved upstream an average of 7.2 km (0.2 to 23.7); these remained at large an average of 10 days (1 to 32). Eleven fish moved downstream an average of 11.9 km (1.6 to 32.0) and contact was maintained for 19 days (4 to 32).

There were no significant differences ($\underline{t}$-test, $n = 39$, $p>0.05$) among habitats occupied by fish that moved upstream <u>versus</u> downstream. Occupied habitats (Table 1; Fig. 1) averaged 10 ± 5 (S.D.) m wide, 0.4 ± 0.3 m deep, and 0.21 ± 0.17 m/second current velocity ($n = 30$ contacts).

Subsequent mortality was high. There was clear evidence of attacks by terrestrial or aerial predators or scavengers, although it is unknown whether fish died and were then eaten, or were killed. Low flow in September reduced depths of riffles to a few cm in places, enhancing probabilities that fish might become stranded and thereby gain attention of roving animals. By late June (32 days after release), 8 of 14 fish were dead and their transmitters recovered (some with evident tooth marks). Contact was maintained with two other transmitters (one of which was in an apparent raptor nest on a cliff high above the river), but neither fish nor transmitter could be recovered. Contact was lost with two other fish, and only two with functional transmitters remained alive.

Because the fate of several fish remained unknown, radiotracking was conducted twice by truck along 128 km of water-delivery canals in the Safford Valley, and once through the 90 km reach of river from San Jose Diversion to the delta at San Carlos Reservoir. Confidence was high that implanted fish would be detected because depths were relatively shallow (rarely exceeding 50 cm) and equipment was deployed either directly on or in close proximity to the water. Straight-line detection distances for different transmitters in air varied from ca. 50 to more than 150 m. No contacts were established.

Seven of the Group II fish moved downstream an average of 8.1 km (limits 0.1 to 37.2), and were tracked for an average of 39 days (1 to 144). Contact was lost with the other two fish shortly after release. Occupied habitats averaged 10±3 m wide, 0.5±0.4 m deep, and 0.30±0.20 m/second current velocity (n = 11 contacts). Although velocity at contact points was greater than for Group I fish (0.21±0.17 m/sec), the difference was not significant (*t*-test, n = 39, p>0.05).

Radiotracking was again conducted along all major canals by truck, and through the Gila River reach from San Jose Diversion downstream onto the delta at San Carlos Reservoir by ATV. No contacts were recorded.

In further attempts to locate fish, San Carlos Reservoir was visited in April. Radio-signal transmission distance was reduced as a function of water depth, *i.e.*, a transmitter suspended >3.0 m below the surface could not be detected, and reception range at 1.0 m depth was about 5.0 m. Diminution of reception range may also have been due to high conductance (>1000 umhos/cm at 25° C), which effectively attenuates radio signals (Winter 1983), characteristics of transmitters (*e.g.*, age and battery condition), condition of receivers, unknown factors, or a combination of these. Nonetheless, shallow shorelines and deltaic areas of both the Gila and San Carlos arms of the reservoir, plus coves in the vicinity of Coolidge Dam were thoroughly searched for signals for 3 days; none was recorded.

The relatively short periods of contact for most Group II fish may have been due to failure of transmitter batteries, most of which had been activated for periods approaching their rated lifetimes.

Conclusions

Radiotagged razorback suckers stocked into the Gila River exhibited significantly more movements downstream than upstream (chi-square = 13.50, df=1, $p<0.01$). Similar results were obtained from earlier studies of smaller, juvenile fish reintroduced in the Gila River (Brooks 1985; Jensen et al., 1987). Habitats occupied by radiotagged fish were primarily in wide, sandy, mid-channel runs of modest depth and current velocity, which constitute the most common habitat type in the Gila River reach under study. Eddies, quiet backwaters, or deep pools were available, yet only a few individuals used them. Similar habitat relations were reported for radiotagged adult razorback suckers in the Green River, Utah (Tyus 1987), even though that stream is substantially larger in size than the Gila River.

The ultimate fate of 9 of 23 radiotagged fish remains unknown. If dead, their transmitters could have been buried so deeply in stream substrates as to render signal detection impossible, but this seems unlikely since areas were checked frequently and other transmitters were successfully recovered when interred to depths of >0.3 m. We suspect some fish were removed from the river by predators, or they may have moved through canals to expire on distant irrigated fields. Alternatively, some or all may have attained San Carlos Reservoir, and thus been effectively lost to further contact.

This study nonetheless demonstrated the feasibility of razorback sucker radiotelemetry in the Gila River, and provided opportunities to solve a suite of logistical problems. Measures to reduce or eliminate short-term mortality of fish include hatchery implantation of radios with time allowed for recovery from surgery and handling, and stocking during relatively high flow periods (e.g., late autumn-winter) to avoid apparent predation by terrestrial or aerial animals.

Evaluation of the 10-year razorback sucker re-introduction program cannot be accomplished unless the fate of stocked fish is known. To date, recaptures have generally been inadequate in this regard (Minckley et al. 1990). We believe additional radiotelemetry can provide valuable guidance to monitoring activities by pinpointing specific habitats and waters in which radiotagged fish reside, which may then be sampled by conventional methods. We also recommend tracking of fish in more confined habitats such as backwaters to quantify apparent diel movement patterns, and intense sampling of fishes in the major receiving reservoirs downstream of reintroduction sites.

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Table 1. Distances moved (0 km is stocking location, + indicates upstream, - downstream) and physical characteristics of habitats occupied by radio-implanted razorback suckers released into the Gila River, eastern Arizona, May and October 1988.

Fish No.	Distance (km)	Width (m)	Depth (m)	Velocity (m/sec)	Dominant substrate	Habitat type	Days at large
Group I (released 24 May 1988):							
700	- 1.6	--	--	--	--	--	1, dead
701	+ 0.1	--	--	--	--	--	1, dead
702	- 0.8	12	0.2	0.15	sand	run	1
	+ 0.1	22	0.4	0.05	sand	pool	2
	+ 0.1	7	0.2	0.30	sand/gravel	run	3
	0.0	13	1.2	0.10	sand/silt	pool	7
704	---	--	--	--	--	--	n.d.[1/]
705	- 2.4	12	0.6	0.25	sand	run	1
	7.2	--	--	--	--	--	7, dead
706	- 0.8	5	0.3	0.20	sand	run	1
	-10.4	12	0.6	0.05	gravel/sand	run	8
707	- 0.8	8	0.5	0.30	sand	run	1
	0.0	8	0.1	0.25	sand	run	2
	- 2.5	14	0.2	0.35	sand	run	2
	- 6.4	12	<0.1	<0.05	sand/gravel	run	7
	- 9.6	12	1.0	0.00	gravel	eddy	15
708	-21.6	6	0.75	0.50	various	eddy	3
	-22.4	2	0.25	0.30	gravel/cobble	run	3
709	-32.0	18	0.25	0.80	sand/gravel	riffle	28
710	- 0.8	9	0.4	0.40	sand	run	1
	0.0	12	0.4	0.25	sand	pool	2
	- 6.0	9	0.4	0.25	sand	run	3
711	- 0.8	9	0.4	0.40	sand	run	1
	0.0	8	0.1	0.25	sand	run	2
	+ 0.1	22	0.4	0.05	sand	pool	3
	- 0.1	9	0.2	0.15	sand	run	3
	- 3.7	6	0.4	0.05	sand/gravel	pool	28
714	- 0.8	12	0.2	0.15	sand	run	1
	-23.7	12	0.75	0.00	various	eddy	8
715	- 0.8	5	0.3	0.20	sand	run	1
	+ 3.5	7	0.4	0.20	sand	run	22
716	- 0.3	15	0.25	0.20	sand	run	1
	+20.0	4	0.1	0.05	sand	run	21
	+18.1	4	0.5	0.05	sand	pool	29
718	- 9.6	--	--	--	--	--	7, dead

(continued).

TABLE 1. (concluded).

Fish No.	Distance (km)	Width (m)	Depth (m)	Velocity (m/sec)	Dominant substrate	Habitat type	Days at large
Group II (released 12 October 1988):							
700-2	- 0.1	9	0.2	0.15	sand	run	0
	- 1.5	12	0.25	0.15	sand	run	3
702-2	- 0.2	10	1.2	0.40	sand	eddy	0
	- 2.0	12	0.15	0.20	sand	run	3
	- 7.5	14	0.4	0.15	sand	run	9
705-2	- 0.1	9	1.1	0.70	sand	run	0
706-2	- 7.2	14	0.15	0.15	gravel/sand	run	144
707-2	---	--	--	--	--	--	n.d.
709-2	-37.2	5	0.5	0.60	sand/gravel	run	144
714-2	---	--	--	--	--	--	n.d.
715-2	- 1.5	6	1.2	0.35	sand	run	0
718-2	- 1.0	7	0.2	0.15	sand	run	3
	- 1.5	9	0.15	0.25	sand	run	9

1/ n.d. = no data; no contact achieved at any time after initial release.

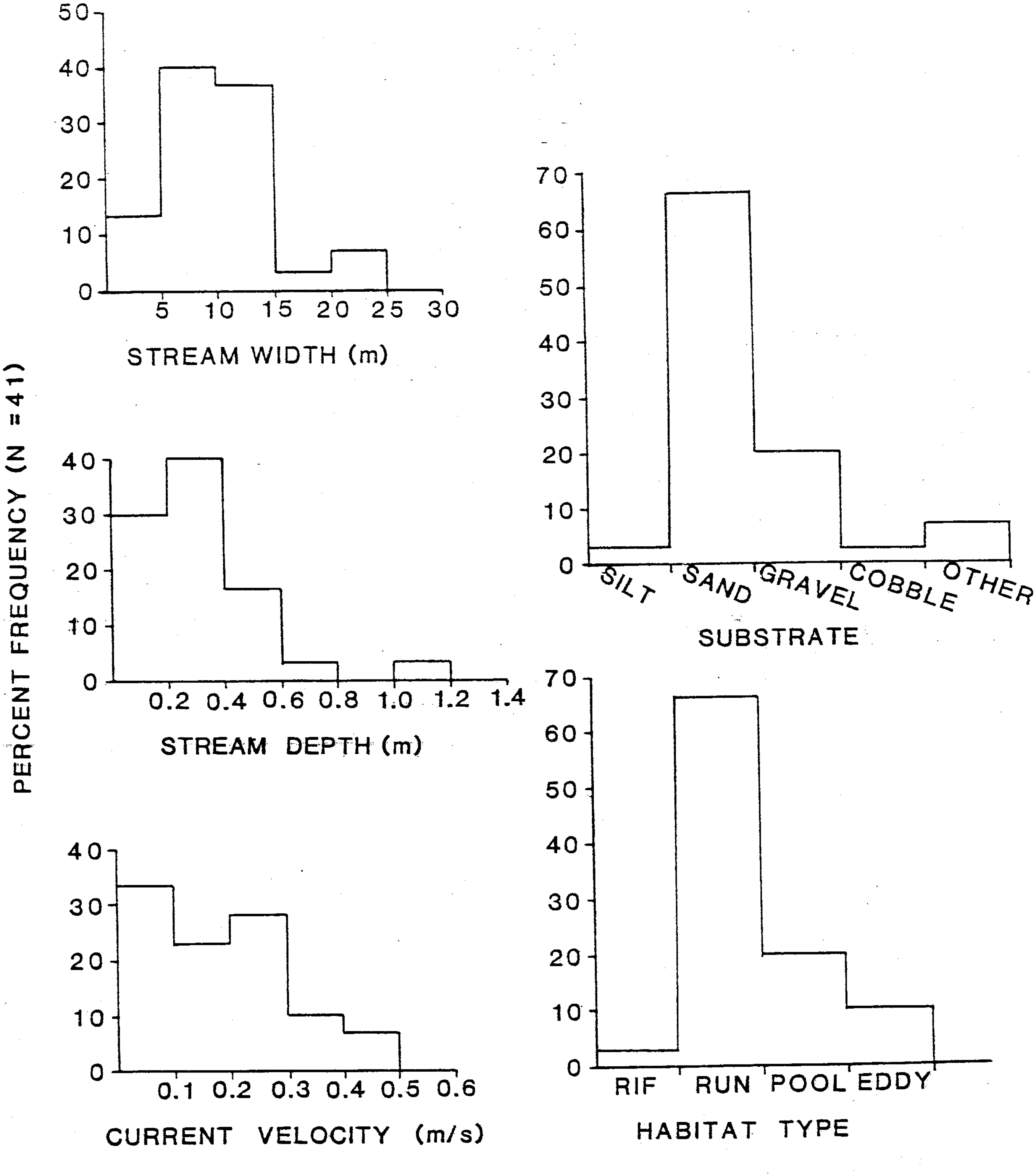

FIGURE 1. Physical characteristics (width, depth, current velocity, substrate, and type) of habitats occupied by radiotagged razorback suckers (expressed as percent frequency of occurrance; n = 41 contacts) in the Gila River, eastern Arizona, May 1988 to May 1989.

The Rapid Spread of the Freshwater Hydrobiid Snail Potamopyrgus antipodarum (Gray) In the Middle Snake River, Southern Idaho[1]

La Rapida Dispersión de el Caracol Hydróbiido de Agua Dulce Potamopyrgus antipodarum (Gray) en la Parte Media del Río Snake, en el Sur de Idaho

Peter A. Bowler[2]

Abstract. From Shoshone Falls to the C.J. Strike Reservoir the Snake River supports a remnant community of the molluscan fauna which was once widespread throughout the upper area of the Middle Snake River. This suite of roughly 30 species includes six candidate endangered species: the Bliss Rapids Snail (an undescribed monotypic hydrobiid genus) and Fontelicella idahoensis (Pilsbry), which are relics from Blancan Lake Idaho (late Pliocene); an undescribed Lanx which was recently petitioned for Emergency Listing; the Pleistocene lake and river relic Physa natricina Taylor; Valvata utahensis Call; Fluminicola columbiana Hemphill in Pilsbry, and the limpet Fisherola nuttalli (Haldeman). These and other native molluscs such as Fluminicola hindsi (Baird) and Vorticifex effusus (Lea) are experiencing competition for habitat from the exotic Potamopyrgus antipodarum (Gray), native to New Zealand but widely introduced in Australia and Europe. This species was first observed in the Middle Snake River by D.W. Taylor in 1987. Since that time this parthenogenetic hydrobiid has built large populations in the mainstem Snake River and its "Thousand Springs" tributaries. Potamopyrgus is spottily though broadly distributed in this area with highly variable population numbers, being especially variable in the springs. Its Snake River populations are enormous, and in places it comprises >85% of the snails present in non-impounded sites and probably far exceeds that in impoundments and at some other localities. Potamopyrgus is the dominant species on filamentous green algae and attached macrophytes in the Snake River, and has become the dominant species on rocks in riffle sections of various unimpounded river sections. It does well in impoundment habitats, and apparently can withstand the impacts of hydroelectric peakloading which artificially raises and lowers water levels by a meter or more on a daily basis. This practice is devastating to the native fauna, but Potamopyrgus forms thick mats covering the bottoms of rocks where the native species retreat during water fluctuation episodes. Potamopyrgus is not photophobic, as are the Bliss Rapids Snail and some of the other native species, and could form a threat through simply occupying space with vast populations under rocks formerly inhabited by the natives. This exotic appears to be in a phase of range expansion and population building in the Middle Snake River at present. This area of the Snake River is a last refuge for the native mollusc fauna since the river is relatively sterile above and below this reach due to impoundments, water diversion and water quality problems.

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Resumen. Desde las cascadas de Shoshone hasta el depósito de C.J. Strike, el río Snake mantiene una comunidad de fauna molusca remanente, la cual fue una vez ampliamente distribuida a traveés del área superior en la parte media del río Snake. Esta serie de aproximadamente 30 especies incluye seis especies candidatas a peligro: el caracol Bliss Rapids (un género hydrobiido monotípico no descrito) y Fontelicella idahoensis (Pilsbry), estos son relictos del lago Blancan Idaho (Plioceno tardio); un Lanx no descrito que fue recientemente solicitado para la Lista de Emergencia; el relicto del rí y lago Pleistoceno, Physa natricina Taylor; Valvata utahensis Call; Fluminicola columbiana Hemphill in Pilsbry y la lapa Fisherola nuttalli (Haldeman). Estos y otros molluscos nativos tales como Fluminicola hindsi (Baird) y Vorticifex effusus (Lea) estan compitiendo por habitat con el exótico Potamopyrgus antipodarum (Gray), nativo de Nueva Zelanda y ampliamente naturalizado en Australia y Europa. Esta especie fue observada por primera vez en la parte media del río Snake por D.W. Taylor en 1987. Desde entonces, este hydróbiido partenogenético ha formado poblaciones grandes en el río Snake y sus tributarios "mil nacimientos de agua". Potamopyrgus esta localizado en manchas aunque esta ampliamente distribuido en esta área, con números poblacionales altamente variables, siendo especialmente variable en los nacimientos de agua. La población de el río Snake es enorme y en algunos lugares abarca el >85% de los caracoles presentes en sitios donde no son cazados y probablemente sobrepasa a aquellos de lugares donde son cazados y de algunas otras localidades. Potamopyrgus es la especie dominante en algas verdes filamentosas y macrofitas adheridas en el río Snake y ha llegado a ser la especie dominante en las rocas de las secciones robadas, de varias secciones de río que han sido cazadas. Vive bien en hábitats que han sido cazados y aparentemente puede resistir los impactos de las cargas hidroeléctricas pico las cuales suben y bajan los niveles de agua en un metro o mas cada dia. Esta práctica es devastante para la fauna nativa, pero Potamopyrgus forma gruesos tapetes que cubren el fondo rocoso donde las especies nativas se refugian durante los episodios de fluctuación de agua. Potamopyrgus no es fotobóbico como el caracol Bliss Rapids y algunas otras especies nativas, y puede formar una amenaza simplemente a través de la ocupación del espacio con poblaciones inmensas debajo de las rocas anteriormente inhabitadas por los nativos. Actualmente, este exótico parece estar en una fase de expansión y crecimiento poblacional en la parte media del río Snake. Esta área del rio Snake es un ultimo refugio para la fauna nativa de moluscos ya que el río es relativamente esteril arriba y abajo de esta extensión debido a la cacería, desviación de agua y problemas con la calidad de agua.

From Shoshone Falls to the head of the C.J. Strike Reservoir, the Snake River in southern Idaho supports a remnant of the rich molluscan fauna which was once widespread throughout the upper Middle Snake River. This fauna comprises approximately thirty species, with some being broadly distributed and others occurring primarily in springs. Molluscs characteristic of the this section of the Snake River (Table I) include six candidate endangered species, another species which was recently petitioned for Emergency Listing, and other large river snails, such as Fluminicola (= Lithoglyphus sensu Taylor) hindsi (Baird), Stagnicola hinkleyi (Baker), and Vorticifex effusus (Lea), as well as a number of clams (Anodonta californiensis Lea, Gonidea angulata (Lea), Sphaerium striatinum (Lamarck), Pisidium compressum Prime and P.pauperculum Sterki).

Taylor (1985a; see also Taylor, 1966) summarized the biogeographic distributions and histories of many of these species, and cited their fossil record appearances. The Bliss Rapids Snail is an undescribed hydrobiid endemic to this area of the Snake River and some of its spring tributaries, such as Box Canyon, where it primarily inhabits fast water habitat under rocks. Fontelicella (or Pyrgulopsis fide Hershler and Thompson, 1987) idahoensis (Pilsbry) is another hydrobiid now restricted to a river segment between dams where it lives primarily in sand or littoral silt. An undescribed Lanx which was recently petitioned for Emergency Listing as an endangered species is known from Box Canyon Creek and another nearby spring where it lives in fast water habitat in a patchy distribution within the springs. The Bliss Rapids Snail and F. idahoensis are relics of the late Pliocene Lake Idaho which covered much of southern Idaho 3.5 million years ago. Physa natricina Taylor, otherwise known from Pleistocene lakes and rivers, was recently described by Taylor (1988), and is now restricted to two tailwater segments in the Snake River. This is a rare species which is apparently extremely sensitive to water quality. Valvata utahensis Call is a sediment inhabiting species now restricted to a few sites along the Snake River, a few spring alcove sites and with a disjunct population far upstream on the Snake River near American Falls. Fisherola nuttalli (Haldeman), the Giant Columbia River Limpet, invaded the Snake River after the draining of Lake Idaho and the cutting of Hells Canyon, and has a population which still survives in this region of the Snake River (Taylor, 1985a; Nietzal and Frest, 1989). Fisherola is primarily a fast water species in this area, occurring on the undersides of rocks. Fluminicola columbiana Hemphill in Pilsbry occurs in the Hagerman Reach (= L.Salm.Falls tailwaters; Nietzal and Frest, 1989), and is otherwise disjunct to the lower Columbia River and its tributaries.

This section of the Snake River has supported these relics and other now endangered species because it has a steep gradient (Figure I), with morraine-like gravel bars of lava boulders, themselves remnants of the catastrophic Bonneville Flood (Malde, 1968; Malde, 1987; Jarrett and Malde, 1987) about 15,000 years ago, which provide superior habitat in the well-oxygenated water, and is thus somewhat analogous to the surf zones of the large Pliocene and Pleistocene lakes that supported many of these species in former times. The Snake River in southern Idaho has continually shifted its course to the south as Pleistocene and earlier lavas from the north filled older canyons, forcing the river to entrench new canyons in the lakebed deposits (primarily the 1,200 foot deep Lake Idaho or "Glenns Ferry Formation" deposits) to the south. Sometimes lava dams would force the Snake River to overflow on the north side, and would entrench small canyons in the lava - which would then be abandoned by the river when the lava dam was eventually breached. Box Canyon, Blind Canyon and Blueheart Springs alcove are examples of this phenomenon. In this process of canyon filling and canyon cutting, the Snake River's modern canyon exposed the Snake River Plain aquifer as it was entrenched, so that nearly 5,500 cfs of spring water are contributed to the Snake River in a forty mile spring system from Shoshone Falls to Bliss. This high quality water falling through the Snake River gradient allowed this suite of species persist. Above Shoshone Falls at Milner Dam, the Snake River is entirely diverted during the summer irrigation season and below C.J. Strike Reservoir, the Snake River is sterile until it reaches the free-flowing reaches of Hells Canyon. Thus, water quality problems, water diversions, hydroelectric dams and impoundments (or direct habitat loss), and peakloading (Irving and Cuplin, 1956) have been the historic threats which reduced the pre-development populations to endangered status in the case of a half dozen species and has made this reach an isolated refuge.

Potamopyrgus antipodarum (Gray) (= P. jenkinsi (Smith); see Ponder, 1988) is a hydrobiid snail native to New Zealand which has colonized eastern Australia and Tasmania (see Ponder, 1988 for a summary of the species' spread since its introduction to Australia in the mid-1800s), Europe (Roth, 1987, reviews the expansions of the species' range in Europe), and more recently North America. It was first reported in the Snake River system in south-central Idaho in 1987, when D.W. Taylor found Potamopyrgus antipodarum during a survey of molluscs in The Nature Conservancy's Thousand Springs Preserve adjacent the Upper Salmon Falls Dam impoundment. At that time Taylor (1987) expressed concern that this exotic might pose problems for the native species. The rapid colonization of this species is due to its reproductive biology, the ease and diversity of means of introduction once the species is present in a watershed, its ability to successfully exploit both eutrophic and non-polluted waters (Dorgelo, 1988), and its tenacity in a variety of micro-habitat types ranging from sand or silt littoral sediments, to rocky bottoms, to aquatic vegetation (especially algae). Potamopyrgus is parthenogenetic and ovoviparous (Dorgelo, 1988). This life history strategy has contributed to the ability to build large populations rapidly and to readily recover from population crashes. For example, at a site in the Netherlands in 1982 the sand inhabiting population level was 25,000 individuals per square meter, but was reduced to nearly zero by an unexplained population crash (Dorgelo, 1988). Soon thereafter the species had a recovery to levels of up to 2,000/sq. meter, and has had populations ranging between 13,000 and 300/sq. meter ever since.

Potamopyrgus colonized all of the 40 km. long Lake Zurich, Switzerland, in a period of a few years (Ribi and Arter, 1986), where population levels surpassed 100,000/sq. meter. Under normal conditions, P. antipodarum reproduces parthenogenetically, with unfertilized eggs giving rise only to females. Laboratory studies of growth rates suggests that there is more rapid growth within eutrophic environments (Dorgelo, 1988), although growth and reproduction was significantly greater in an experimental stream of 25% treated sewage effluent than in a more concentrated 50% effluent solution (Watton and Hawkes, 1984). In the Thousand Springs (Snake River Plain aquifer) tributaries of the Snake River Potamopyrgus has variable populations, ranging from rare individuals to dense aggregations among large Fluminicola hindsi populations, especially in stream segments below aquaculture facilities. In general the native snails, especially Fluminicola which is otherwise the most common spring snail, have depressed populations below fish hatcheries. Relative abundance and selected population densities are presented in Table 2.

Potamopyrgus is easily dispersed, and its parthenogenetic reproductive mode allows even a single individual to begin a new population. Within-lake dispersal in Lake Zurich, Switzerland, was thought to have been enhanced through passive dispersal by birds, fish or floating algae (Ribi, 1986). Potamopyrgus antipodarum orients upstream, can climb vertically, and can survive a six hour passage through the gut of a trout and give birth immediately afterward (Haynes, Taylor and Varley, 1985). In Idaho it was observed that on flat, vertical surfaces in springs, such as hydroelectric weirs, Potamopyrgus forms a dense black band from the surface of the water to perhaps 10 cm below the surface, where the exotic grazes on algal films with all of the individuals oriented upstream like a design. In an area such as the Hagerman Valley in southern Idaho, colonization could occur from many mechanisms, ranging from commercial movement of aquaculture products such as trout eggs or live fish, floating downstream or rafting on dead vegetation, motorboats, passive dispersal through migratory waterfowl, transport through the guts of fish, commercial harvesting, cleaning and sale of watercress or the transport of agricultural products requiring moisture during transport, and even through pump irrigation from the Snake River. In the Snake River this species is most abundant on green algae, attached macrophytes and on or under rocks. It is not as frequent on sand or silt, though it is present in these micro-habitats. After a few more years of building populations it may be easier to understand habitat preferences in southern Idaho.

There appears to have been little study of potential competition between Potamopyrgus and native species. Siegismund and Hylleberg (1987) noted that Potamopyrgus co-exists with several other hydrobiid mud inhabiting snails in Kysing Fjord, Denmark, however, there were differences in preferred micro-habitats within the estuary along a salinity gradient (and Potamopyrgus had severe winter kills not experienced by the other species). In the Snake River and its tributaries in southern Idaho competition for preferred habitat space occurs at least in rocky riffle habitats and in littoral sand habitats; there could be competition for forage on rocks, but there is no indication that this is limited (nothing is known about the algal forage preferences of any of the native species, much less how Potamopyrgus could impact native species' feeding success.).

Potamopyrgus antipodarum was first observed in the Snake River near Hagerman, Idaho during the summer of 1987. At that time it was common, particularly on filamentous green algae and attached aquatic macrophytes in the Upper Salmon Falls and Lower Salmon Falls impoundments and the Lower Salmon Falls Dam tailwaters (the Hagerman Reach). The species was also present on rocky boulder habitats in the Hagerman Reach. Although it may have been present, it was not observed in the Thousand Springs tributaries. By December, 1988, Potamopyrgus was the dominant species in the riffle-rapid habitat of the Hagerman Reach and the Bliss Dam Tailwaters (Glenns Ferry Reach), forming dark mats of hundreds of individuals in habitat normally preferred by native species such as Fluminicola hindsi, Vorticifex effusus, the Bliss Rapids Snail, Physa natricina, and Fisherola nuttalli. By the summer of 1989 this species was clearly the most dominant in this entire section of the Snake River. Potamopyrgus was much more common and dominant in the mainstem Snake River than in the springs. In the Snake River it was abundant on filamentous green algae, as well as being common upon sand environments and under rocks. The phenomenon of the thick mats of hundreds of Potamopyrgus individuals on the undersides of boulders in riffles was not observed during the summer of 1987. The native fauna suffers from the impacts of peakloading in the summer, which raises and lowers the water up to a meter on a daily basis, wetting and drying the rocky bars and shallow riffle areas. Potamopyrgus seems to be able to withstand this temporary desiccation far better than the native species, and forms black rings around the exposed rocks, as well as dense aggregations beneath them. This is potentially particularly hard on photophobic native species, such as the Bliss Rapids Snail and Fontelicella idahoensis (Pilsbry) (which may also be photophobic based on limited phototaxis observations). These species are essentially trapped under the rocks during the day, yet cannot effectively graze at night if the water is low or if there are masses of Potamopyrgus surrounding them. Potamopyrgus is extremely abundant in the Bliss Dam tailwaters to C.J. Strike Reservoir and inhabits the same micro-habitat as Fontelicella idahoensis (Pilsbry) in littoral sand or silt. In addition to Fontelicella, Valvata utahensis Call also is a sediment dweller, and the exotic should be carefully watched in areas where they co-exist and potentially compete. Similarly, Potamopyrgus is now present in thick mats on the sites which Physa natricina Taylor, Fisherola nuttalli (Haldeman), and the Bliss Rapids Snail prefer- as well as the sites in which most of the native snail species lay their eggs. The relatively constant temperatures of the Thousand Springs tributaries and moderate variation in temperature of the Snake River in this reach make winter kills of Potamopyrgus unlikely. In those streams which do freeze, such as lower Clover Creek, re-colonization can be expected each spring. Potamopyrgus could support increased populations of molluscivorous predators, such as leeches, which could increase predator caused mortality among native species of snails. Bottom feeding fishes, such as suckers, could begin foraging more extensively in habitats in which Potamopyrgus co-exists with Fontelicella or other native species. Potamopyrgus needs to be carefully watched in this ecosystem, although there is little that can be done to control its continued proliferation - which can be anticipated to extend down the Snake River system and up its downstream tributaries.

Potential threats to native species and particularly candidate endangered species (i.e., Physa natricina, Bliss Rapids Snail, Fisherola nuttalli, Frest's new Lanx species, the Bliss Rapids Snail, Fisherola nuttalli, Fontelicella idahoensis, Fluminicola columbiana Hemphill in Pilsbry and Valvata utahensis) include domination of preferred habitat for adults and juveniles, physical covering of egg sites and egg masses, potential harboring and support of molluscivorous predators and attraction of fish predators. It is possible under certain specific circumstances (where boulder substrate is limited, for example) that competition for forage areas could occur, though foraging among these species is unstudied and food base flora doesn't superficially appear to be a restricting parameter. There may be other unanticipated effects this exotic could have upon the native fauna in the Snake River below Shoshone Falls.

In conclusion, this species is proliferating and expanding its range very rapidly in the upper Middle Snake River. It is competing for micro-habitat space with a number of candidate endangered species, and more subtle competition and interaction could be occurring. It should be expected to expand its range beyond the immediate Snake River canyon, to which it is now temporarily confined, in the near future.

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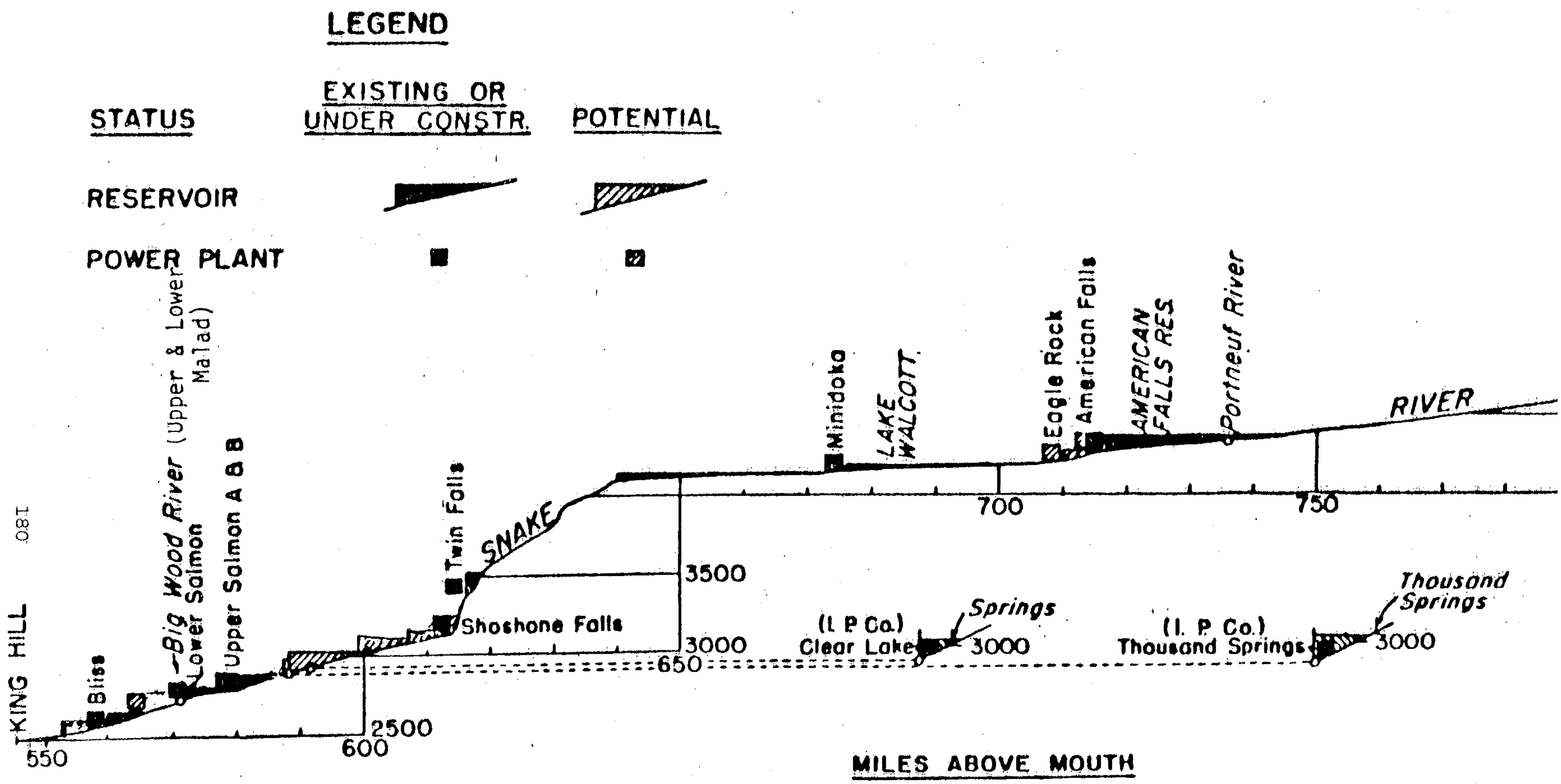

Figure 1. Profile of the Snake River gradient showing existing and a number of proposed hydroelectric projects. (Adapted from Figure 4-3 in Federal Energy Regulatory Commission, 1982; the profile originally was developed by the Federal Power Commission in 1967.) The gradient in the area from Shoshone Falls to King Hill averages approximately 3 meters or more per 1.6 km. at sites such as the Lower Salmon Falls Dam tailwater which are of the highest habitat quality.

Table 1. A summary of the modern mollusc fauna of the upper area of the Middle Snake River. The Box Canyon records are based upon Taylor (1985b) with subsequent additions incorporated. The mainstem Snake River listings represent free-flowing sites, and the complement of species present varies from locality to locality. The best and most complete examples are the Lower Salmon Falls Dam tailwaters (the "Hagerman Reach") and the Bliss Dam tailwaters (the "Glenns Ferry Reach"). Margaritifera is locally extirpated, though shells killed in place can still be found in the dry river channel formed by the Upper Salmon Falls Dam diversionary canal. This is not a comprehensive species list as there are undoubtedly a few additional species at one site or another, but it does present the species characteristic of the areas cited. Taxonomic nomenclature for the most part follows Burch (1989), except when superceded in my view by Taylor (1985a and 1985b, especially).

	Box Canyon/ Blueheart Springs (BLM ACEC)	Mainstream Snake River	Malad River	Dry/Clover Creeks
Class Gastropoda (snails)				
Valvatidae				
Valvata humeralis Say		+		
Valvata utahensis Call	+	+		
Hydrobiidae				
Fulminicola columbiana Hemphill in Pilsbry		+		
Fluminicola hindsi (Baird)	+	+	+	
Fontelicella (or Pyrgulopsis) idahoensis (Pilsbry)		+		
Potamopyrgus antipodarum (Gray) (introduced)	+	+	+	
Bliss Rapids Snail	+	+		
Physidae				
Physella gyrina (Say)	+	+	+	+
Physa natricina Taylor		+		
Lymnaeidae				
Fossaria exiqua Lea			+	+
Fossaria parva (Lea)	+			
Stagnicola caperata (Say)	+			
Stagnicola hinkleyi (Baker)	+	+		
Stagnicola modicella (Say)	+			
Stagnicola nuttalliana (Lea)	+			
Radix auricularia (Linn.) (introduced)	+	+	+	
Lancidae				
Fisherola nuttalli (Halderman)	+	+		
Frest's Lanx	+	+		
Ancylidae				
Ferrissia rivuleris (Say)				+
Planorbidae				
Gyraulus parva (Say)	+	+		+
Bulinidae				
Planorbella subcrenata (Carpenter)	+			
Vorticifex effusus (Lea)	+	+	+	
Landsnails (Adjacent Streams)				
Succineidae				
Oxyloma haydeni (W.G. Binney)	+	+	+	
Valloniidae				
Vallonia cyclophorella (Sterki)		+		
Class Pelecypoda (clams)				
Unionidae				
Anodonta californiensis Lea	+	+	+	
Gonidea angulata (Lea)	+	+	+	
Margaritiferidae				
Margaritifera margaritifera falcata (Gould) (locally extirpated = E)		E		
Sphaeriidae				
Sphaerium striatinum (Lamarck)		+		
Sphaerium truncatum (Gould)	+			
Pisidium casertanum (Poli)	+			
Pisidium compressum Prime	+	+		
Pisidium insigne Gabb	+	+		
Pisidium pauperculum Sterki	+			
Pisidium punctatum Sterki	+			
Corbiculidae				
Corbicula sp. (introduced)		+		

Table 2. Selected examples from the Snake River and several springs showing the variation in relative densities of snail species.

Mainstem Snake River, Bancroft Springs, August 31, 1989. Count of all snails on eight river cobbles (river-rounded basalt pebbles) ranging in size from 6 x 6 to 11.5 to 6.5 cm from the same depth (when peakloading flows are released, approximately 1.1 meters; around 20 cm when flows are held back).

N = 520 snails

Potamopyrgus antipodarum	89%
Vorticifex effusus	7%
Fontelicella idahoensis	3%
Fluminicola hindsi	<1%
Bliss Rapids Snail	<1%

Mainstem Snake River at the mouth of Clover Creek, August 2, 1989. Count of all snails on eight river cobbles ranging in size from 10 x 8 to 6 x 4.5 cm. Depth could not be determined because the water was in the process of rising with a hydroelectric release, but all were under shallow water at the lowest cycle of water levels.

N= 758

Fluminicola hindsi	60%
Potamopyrgus antipodarum	31%
Vorticifex effusus	8%
Bliss Rapids Snail	<1%
Fontelicella idahoensis	<1%
Physella gyrina	<1%

Alcove of an unnamed spring on the Bliss Grade along Highway 30. Rocky ledge 0 - 5 cm deep. Samples were made with a 10 x 10 cm quadrat frame.

N = 3 quadrats; Total snails = 89

Fluminicola hindsi	12.4%
Potamopyrgus antipodarum	87.6%

Shallow riffle area below the bridge at the first impoundment on Malad River. Samples taken with a 10 x 10 cm quadrat frame in water 7 - 14 cm deep (on lava talus). A total of six quadrats were counted on three rocks.

N = 6 quadrats; Total snails = 232

Fluminicola hindsi	99%
Potamopyrgus antipodarum	1%

On-going Macroinvertebrate Analysis Using The Biotic Condition Index and the Appearance of Potamopyrgus antipodarum (Gray) in Box Canyon Creek, Southern Idaho[1]

Análisis de Macroinvertebrados en Progreso Usando El Indice de Condición Biológica y la Aparición de Potamopyrgus antipodarum (Gray) en el Arroyo de Box Canyon, en el Sur de Idaho

Stephen Langenstein[2] and **Peter Bowler**[3]

Abstract. Box Canyon Creek is the eleventh largest spring in the United States and is an Area of Critical Environmental Concern (ACEC) managed by the Bureau of Land Management (BLM). The creek contains a number of Federal (U.S. Fish and Wildlife Service) Candidate Species (mollusks and an endemic sculpin) which were considered in the design of the ACEC Management Plan. A proposal by a private developer to divert water from the creek instigated BLM efforts to monitor this unique ecosystem using a complex and ongoing sampling scheme which was initiated in 1987. Along with the Biotic Condition Index, (BCI, used to develop baseline data to better understand the impacts of an historic diversion in 1973 and provide a data-based record of the potential impacts of future diversions) other monitoring includes underwater observation using snorkeling, photographic transects, visual examination of special habitat sites, and sediment/vegetative sampling. One significant result of the monitoring was the documentation of the appearance of the exotic snail Potamopyrgus antipodarum (Gray) in Box Canyon Creek over two years after this introduced hydrobiid was known to occur in the adjacent Snake River. From the preliminary results of the BCI analysis and the mollusc inventories it seems probable that Box Canyon Creek received a significant adverse ecological impact from past developments (in or out of the canyon) which has reduced flows and that the ACEC portion of the creek is in an ecological condition reflecting stress as indicated by a poor BCI level, compared to its calculated potential. The Diversity Index and Standing Crop values are good to fair, but the Biotic Condition Index value is in the "poor condition" range. This is likely due to pollution laden water entering the spring system, as indicated by the presence of a number of pollution tolerant macroinvertebrate species. Because the studies began as a result of the Proposed Project, the low BCI values are concerning because the existing ACEC management plan was designed to assure protection of Federal Candidate species populations and because the proposed diversion would likely further increase existing instream flow reduction impacts and could reduce current dilution of the nutrient-rich water being detected through BCI indicator species. Results of the monitoring program, the sampling techniques employed by the BLM in this ongoing survey, and water quality data from the Environmental Protection Agency (EPA) are presented. Ultimately this data is expected to be used for an impact analysis of the proposed project. Although similar monitoring could be established in the headwaters of this stream no data is currently being collected as comparative data for the lower (BLM ACEC) portion of the creek.

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[1] Presented at the Twenty-first Annual Symposium of the Desert Fishes Council at the University of New Mexico, Albuquerque, New Mexico on November 16, 1989.

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Resumen. El arroyo Box Canyon es el décimo primer nacimiento de agua más grande en los Estados Unidos y es un Area Crítica de Interes Ambiental (ACIA) administrada por el Bureau of Land Management (BLM). El arroyo presenta varias Especies (moluscos y un pez endémico) Federales Candidatas (U.S. Fish and Wildlife Service), las cuales fueron consideradas en el diseño del Plan de Manejo de la ACIA. Un proyecto realizado por un constructor para desviar agua del arroyo, fomentó los esfuerzos de la BLM para monitorear este ecosistema único utilizando un esquema de muestreo progresivo y complejo, el cual se inició en 1987. Con el Indice de Condición Biológica (ICB), se usaron técnicas de monitoreo 1) para desarrollar una base inicial de datos, 2) para permitir un mejor entendimiento del impacto de una desviación de agua ocurrida en 1973 y 3) para proveer un registro basado en datos sobre el potencial de impacto de futuras desviaciones; estos monitoreos han incluido observaciones bajo el agua usando buceo libre, transectos fotográficos, examinación visual de sitios especiales de hábitat y muestreos de sedimento y vegetación. Un resultado significativo del programa de monitoreo fue la documentación de la apariencia del caracol exótico Potamopyrgus antipodarum (Gray) en el arroyo de Box Canyon, dos anos despues de que se conoció que este hydrobiido introducido existia en el rio adjacente Snake. De los resultados del inventario de moluscos y de la investigación del ICB es probable que el arroyo Box Canyon recibió un significativo impacto ecológico negativo debido a la reducción histórica en el flujo del arroyo y que la porción ACIA del arroyo esta en una condición ecológica que la porción ACIA del arroyo refleja estres reflejandose en un pobre nivel de ICB, comparado con su potencial calculado. El Indice de Diversidad y la Cosecha en Pie van de valores promedio a bueno, pero el valor de el Indice de Condición Biológica esta en el rango de una "condición pobre". Probablemente esto se deba a el agua cargada de contaminación que entra al sistema de nacimiento de agua, como indica la presencia de varias especies de macroinvertebrados tolerantes a la contaminación. Los valores bajos de ICB son preocupantes porque el plan de manejo existente para el ACIA fue diseñado para asegurar la protección de las poblaciones de especies Candidatas Federales a peligro y porque la desviación propuesta probablemente incrementara el existente impacto en la reducción del flujo y podria reducir la actual dilución de aguas ricas en nutrientes que ha sido detectada a traves del indicador de especies ICB. Se presentan los resultados del programa de monitoreo, las técnicas empleadas por el BLM para este reconocimiento en progreso y los datos de calidad de agua de la Agencia de Protección Ambiental (EPA). Finalmente se espera usar estos datos para un análisis de impacto de el proyecto propuesto. Aun cuando un monitoreo similar podria esta blecerse aguas arriba en este arroyo, no se estan colectando datos actualments para ser comparados con la porción baja del arroyo (ACIA BLM).

Box Canyon Creek is a tributary of the Snake River in south central Idaho at river mile 588.3 (948.9 km) and is the eleventh largest spring in the United States (Figure 1). Numerous springs emerge from the creek bed throughout the 2.41 km (1.4 mile) water course. In the 1950s the creek flowed at 24.08 cms (850 cfs) at its confluence with the Snake River. Currently with one 8.5 cms (300 cfs) water diversion from the creek and extensive deep well pumping of the Snake River Plain Aquifer for agricultural irrigation, stream flow at the mouth is approximately 11.3 cms (400 cfs), which has reduced the natural dilution and instream flow values of the lower stream as well as the adjacent habitat in the Snake River. Seasonal variations in flow, recorded at the U. S. Geological Survey water measuring station in the upper third of the creek, show a predictable fluctuation in flow between 13 and 16 percent through the water year between October to September. This spring system is part of a larger group of springs known as the "Thousand Springs" tributaries which emerge from the Snake River Plain Aquifer along the north bank of the Snake River canyon.

The 45.7 m (150 ft.) deep canyon was caused by a Pleistocene volcanic eruption which formed a temporary lava dam across the Snake River, forcing the river around the dam on the north bank. The diverted Snake River flow entrenched Box Canyon before the dam failed. Several other sites in the area, notably Blue Heart Spring and Blind Canyon, represent similar but less completely formed alcove ecosystems that either historically have or continue to provide natural remnant biological habitats for several uncommon or rare species. This reach of the Snake River was formed by extensive canyon-cutting activity which exposed many springs in the porous pillow lava underlying the flows of capping basalts (see Covington, Whitehead and Weaver, 1985). For these and other reasons Box Canyon was nominated as a Candidate National Natural Landmark (National Park Service; Bowler, 1981), and has been identified as a unique aquatic and geologic resource in statewide surveys (Rabe and Savage, 1976), was recommended as a potential Research Natural Area (Rabe and Savage, 1976), is included in inventories of the Idaho Natural Area Coordinating Committee (INACC, 1976; Rabe and Savage, 1976; 1977), was recognized as one of the foremost threatened sites in Idaho in the U.S. Fish and Wildlife Service's "Inventory of Fish and Wildlife Habitats in Idaho" (Boccard, 1980), and is regarded as an exceptional native trout fishery by the Idaho Department of Fish and Game. In 1989 this nomination was rejected by the private landowner and hence it is no longer a formal Candidate National Natural Landmark. Box Canyon is still considered a protected stream by the NW Power Planning Council.

The head of Box Canyon contains a large alcove pool (est. 1/2 hectare) where the initial springs emerge. Below this pool, the creek rapidly descends approximately 804.6 meters (1/2 mile) to a large waterfall approximately 12.2 m (40 ft.) across and 3.7 m (12 ft.) high. This waterfall is sufficiently high to be a barrier to some fish species, but it is estimated that salmon and steelhead from the Snake River could have historically passed this mark. This barrier creates an unexamined natural experiment because it blocks upper canyon access for a number of fishes and at least one endemic species, the Shoshone Sculpin (Cottus greenei), which occurs in the lower canyon, while its congener the Mottled Sculpin (Cottus bairdi) is found both above and below the waterfall. From the waterfall the stream continues at about the same gradient until it is interrupted by the slackwater pool of a 8.5 cms (300 cfs) diversion which provides water for a fish propagation facility on the opposite bank of the Snake River (Box Canyon water is diverted and piped under the Snake River for the hatchery on the other side). The upper two-thirds of the canyon, including the existing diversion structure, is privately owned, as is the mouth of the creek. The portion of the creek just below the diversion is included in a specific Area of Critical Environmental Concern (ACEC) Management Plan prepared by the Bureau of Land Management (BLM) in 1986. The Plan's objectives include the management of habitats for four Federal Candidate Species (U.S. Fish and Wildlife Service), the Bliss Rapids Rapid Snail (an undescribed, monotypic hydrobiid genus), the Utah or Desert Valvata Snail (Valvata utahensis Call), the Giant Columbia River Limpet (Fisherola nuttalli (Haldeman), and the Shoshone Sculpin (Cottus greenei) within the ACEC. Some of these Candidate Species have been designated "Warranted" by the U.S. Fish and Wildlife Service for listing as either Threatened or Endangered. Recent partial inventories reported as affidavits in pending litigation have contributed greatly to the understanding of the distribution and abundance of these species in Box Canyon, and have indicated that there is an undescribed Lanx species (Frest, 1989) in the stream as well. These species are not uniformly distributed throughout the canyon and each occupy unique habitats and may be affected by the barrier presented by the falls.

An additional Box Canyon Creek diversion has been proposed on the public land for the development of a fish propagation facility in the adjacent Blind Canyon. The applicant, a private developer, has been granted the needed State permits to extract up to 17 cms (600 cfs) at a point in the stream where only about 9.3 cms (330 cfs) occur. This is one example of how the stream has been over appropriated by more than twice the water which was historically in the channel prior to the existing diversion (Figure 1). In addition, during the past two decades agricultural expansion encouraged deep well pumping from the Snake River Plain Aquifer for irrigation which seemingly has effected the volumes of the spring flows. However, there is no quanitative record establishing the extent of stream flow diminishment due to wells and groundwater pumping.

During the last BLM land use planning effort in 1985, D.W. Taylor was contracted to conduct a survey of Box Canyon Creek for molluscs (Taylor, 1985), and the BLM and the U.S. Fish and Wildlife Service contracted J. Griffith, *et al.* (Griffith, 1981; Wallace and Griffith, 1982) to survey Shoshone Sculpin in the ACEC and along the Snake River. Taylor (1985) reported that "*Box Canyon has a richer fauna of molluscs than any other alcove spring along the Snake River, even though it has less flow than some.*" He reported several populations of living Bliss Rapids Snails and Utah Valvata Snails along with shell deposits containing numerous specimens of the Bliss Rapids Snail and several shells of the Giant Columbia River Limpet. Many of the shells were heavily eroded, indicating that these animals had once experienced heavy sediment load exposure, an unusual occurrence in this canyon-enclosed, spring-fed watershed with virtually no turbidity or suspended solids and little natural sediment load. The surveys showed that a recent extensive deposit area in a natural pool on public land supported a healthy population of Utah Valvata Snails, and drift material in the pool included a few Limpet shells, abundant Bliss Rapids Snail shells, as well as the shells of other snails and clams. Taylor concluded that sediments deposited in the natural pool from the construction of the earthen diversion dam upstream in 1973 had increased the habitat for the Utah Valvata Snail, while causing a severely adverse impact to the Bliss Rapids Snail by reducing its habitat and also probably that of the Giant Columbia River Limpet. Samples from a sediment delta at the mouth revealed no living molluscs or large populations of other macroinvertebrates. It was concluded that the sediment delta at the mouth, a deposit from a breach of the diversion canal, caused mass loading of the stream in about 1980. This distributed site contained few shells of any snails or clams and had not yet been recolonized by the native fauna.

Wallace and Griffith (1982) described the relative abundance, life history and habitat preferences of Shoshone Sculpin at 49 locations in 25 springs and streams in the Hagerman Valley along the Snake River. The study included Box Canyon, Blue Heart Spring and Blind Canyon and examined abundance, spawning behavior, food preferences and desired habitats. Habitat parameters measured included depths, velocities, cover, temperatures and water chemistry. A Shoshone Sculpin survey was contracted to examine the distribution of this endemic fish in Box Canyon Creek and formed some of the basis of Management Plan protective measures in the ACEC.

On November 7, 1986, a right-of-way was issued to a private developer allowing the construction of a water diversion facility within the ACEC, provided the applicant agree to some 29 stipulations including paying for snail, sculpin and macroinvertebrete habitat monitoring, and preserving the upper third of the canyon as offsite mitigation (private land). In October, 1989 litigation began against the BLM and the U.S. Army Corps of Engineers regarding this proposed diversion for allegedly violating the Federal Land Policy and Management Act, the Administrative Procedures Act and the National Environmental Policy Act. The initial monitoring schedule included but was not limited to the following (Figure 1):

1. Annual fisheries monitoring would include an evaluation of the presence or absence of Bliss Rapids Snails at three or more permanent locations on public land and on three sites on private land including the mouth and the upper canyon. Three other random samples would also be collected from sites throughout the canyon.

2. At least three sediment samples would be taken to evaluate the Utah Valvata Snail status. Live specimens would be counted and released.

3. A visual inspection of the Shoshone Sculpin populations at the large pool would be made to provide estimates of fish per square meter for each year monitored.

4. Sediment and vegetative material would be sampled for the Giant Columbia River Limpet. Additional studies would be developed as more information on the species was collected.

5. A photographic transect would be established to show the entire riparian area of the public and private lands during the spring and summer seasons.

6. Water quality measurements of dissolved oxygen, temperature, pH, and conductivity would be taken every 4 to 6 weeks at permanent monitoring stations. These tests should be conducted at the time when the water volume measurements were made to check compliance with minimum stream flows requirements.

7. To establish a baseline of data, invertebrate analyses would be conducted each season of the year, beginning in the year prior to construction. The accepted technique for this monitoring is the Biotic Condition Index (BCI).

It should be noted that at the time these monitoring parameters were identified, the endemic Lanx was not known to occur at the site. A total of $2,925.00 per year for four years was to be contributed by the applicant to support this monitoring regime. The remainder of the costs for monitoring would be paid for through BLM funding opportunities.

Methods & Discussion

Since 1987, monitoring has occurred at various levels of intensity. Initially the BCI transects were established as permanent stations by cabling rock baskets containing lava talus to boulders along the waterway on public land. Each 30.48 cm x 30.48 cm x 10.16 cm basket is framed by steel rod and covered by 1.27 cm (1/2 in.) hardware cloth and contains a permanent set of native lava rocks. Two sets of four baskets (total 8 baskets) were placed in the stream and the current velocities above each basket were recorded. Four baskets were placed below the proposed diversion and four above, some within the expected pool area. The objective of the monitoring was to establish a four season baseline of invertebrate data prior to construction activities to be followed by three years of post construction data to examine the effects of the facilities. Typically, baskets were placed in the stream and the habitat cages were allowed to be colonized by macroinvertebrates for 35 to 45 days (Table 1). The first sample was colonized for 60 days because of other work schedules and sampling inexperience. At the end of the colonization period each rock was removed from the basket, and macroinvertebrates were systematically collected with forceps and preserved for later analysis. Rocks were returned to the cages and placed on the bank out of the water until the next recolonization period. Field collections were preserved in 70% ethyl alcohol and submitted to the Intermountain Region Aquatic Ecosystem Analysis Laboratory, Provo, Utah for analysis. Data has been analyzed and is reported for collections which represent one year (four seasons of sampling).

Other monitoring is more qualitative than quantitative, except for the EPA Storet information. When BCI samples were set or collected, visual inspections of the closest pools were made, and the species, size classification and relative number of fish were noted. Photographic transects have been established in the canyon on both public and private land above the canyon rim and within the canyon. Additional underwater transects were delineated in the summer of 1989. Historic water quality equipment has been completely refitted and is now functional and dependable. The first BLM water quality samples were recorded early this fall (1989) for this data base. Water quality data was extracted from the EPA Storet system providing a long term data base of sampling parameters at the USGS gauging station just downstream from the falls in the upper third of the canyon.

In the fall of 1988 several water level marks were scribed onto rocks in the large natural pool ("Sculpin pool") and water levels were recorded this past summer and fall. One additional rock was marked during the fall of 1989. This rock is located on the southwest portion of the Sculpin pool where water flows into an area of subsurface talus. This site will be used to determine if the backwater pool of the project affects groundwater movement through the talus and results in upsetting flow-through or water levels in the pool.

Cursory surveys were conducted by snorkeling in various areas of the Sculpin pool during the summer of 1989 to identify sample sites for permanent Shoshone Sculpin population counts. Actual counts have not yet been conducted because a counting frame (Griffith, 1981) must be built, and sampling periods were missed again this year. This technique was extremely helpful in learning the profile of the pool and understanding the behavior and habitats of several species of interest.

TABLE 1. The dates and duration of the first year of BCI sampling in the Box Canyon ACEC. In each case the first date of collection is the lower and the second date the upper sample site.

Dates Set	Dates Collected	Number of Days Colonized
April 1, 1987	June 1, 1987	60
	June 2, 1987	61
August 8, 1988	October 4, 1988	42
	October 7, 1988	45
March 15, 1989	April 20, 1989	36
	April 21, 1989	37
May 8, 1989	June 13, 1989	35
	June 14, 1989	36

Conclusion

The BCI report through four seasons of data indicates that the stream is in fair to poor condition. Our analyses (Table 2) focused upon three major parameters: Diversity Index or DAT (mean), Standing Crop g/m2 (mean), and Biotic Condition Index (BCI).

DAT is an index of diversity combining a measure of dominance and the number of taxa; habit, habitat and feeding preferences of taxa; tolerances of taxa; and community composition (Winget and Mangum, 1979). In this stream the DAT varied a great deal between readings. In the first sample station (L, the lower portion of the stream below the proposed diversion in the ACEC) the DAT is fair, at station U (for upper or above the proposed diversion) there is a good rating; second sample - L = fair, U = fair; third sample - L = poor, U = fair; and the fourth sample - L = fair; U = good. With this variation in results there is no clear trend, and sampling should be continued for several more years to establish a longer term pattern - or its absence - through additional baseline data. Current litigation and BLM funding may restrict this effort.

Standing crop is a description of the community in dry weight biomass expressed in grams/m2. This information was more consistent than other BCI parameters. All stations except one were in the good category; however, they were generally near its lower limits. Sample three, Upper station, had a fair rating. The data indicates a good biomass production, but in lower numbers than one would expect from this stream. Total numbers of specimens at each site for each sample are presented in Table 3, and a species list (excluding molluscs, which are listed in Taylor, 1985 and Bowler, 1990) is provided in Table 4.

The BCI results are the most important data our sampling produced. The BCI data indicate that three of the four samples at both stations are in the "poor" range. Sample three, with a poor category standing crop value, had a fair BCI condition. The sample period was during the early stage of the irrigation season which corresponds with some of the lowest annual streamflows. Lower streamflows could be expected to have an opposite effect on the invertebrate populations and stream condition because lower stream flows reduce spring water dilution of nutrients appearing in the lower ACEC area potentially causing higher concentrations of enrichment. It is evident from this data that the biotic condition of Box Canyon Creek is not good to excellent as one might assume when looking at this clear, cold stream. Sampling in the upper canyon reach is needed to explore the possibility that the existing diversion has caused a water quality impact in the lower canyon which does not occur in the undiverted waters of the upper stream. Upstream sampling might also clarify where nutrient laden springs are arising. If they are situated in the lower area of the ACEC, as suspected, the upper stream would provide an unpolluted site for comparison.

Table 3. A summary of the data for the Upper and Lower sample stations for each of colonization sample periods arranged in chronological order (adapted from Mangum, 1987 and 1989).

REPL	TOTAL NO. SPECIES	MEAN /SQM	CONFIDENCE LIMITS (80 PERCENT) LL	UL	STANDARD DEVIATION	PERCENT SE OF MEAN	COEFF. OF VARIATION	DBAR	R	CTQA	CTQD
											DATE: 06/02/87
STATION: U											
* NUMBERS DATA											
4	22	27266.	20804.	33728.	7889.79	14.47	28.94	3.1955	0.2836	85.	85.
											DATE: 06/01/87
STATION: L											
* NUMBERS DATA											
4	24	13853.	7903.	19804.	7266.12	26.22	52.45	3.054	0.3346	86.	85.
											DATE: 10/07/88
STATION: U											
* NUMBERS DATA											
4	27	11987.	7519.	16454.	5455.25	22.76	45.51	3.3418	0.2979	78.	85.
											DATE: 10/04/88
STATION: L											
* NUMBERS DATA											
4	23	11699.	7601.	15797.	5003.40	21.38	42.77	2.8000	0.3817	83.	85.
											DATE: 04/21/89
STATION: U											
* NUMBERS DATA											
4	21	10375.	5078.	15672.	6467.46	31.17	62.33	2.8423	0.3533	90.	92.
											DATE: 04/21/89
STATION: L											
* NUMBERS DATA											
4	20	14577.	7228.	21926.	8972.96	30.78	61.56	2.3096	0.4661	85.	89.
											DATE: 06/14/89
STATION: U											
* NUMBERS DATA											
4	26	5950.	4251.	7650.	2075.41	17.44	34.88	2.7513	0.4158	76.	79.
											DATE: 06/13/89
STATION: L											
* NUMBERS DATA											
4	20	5068.	3602.	6534.	1790.54	17.67	35.33	2.4779	0.4280	80.	79.

Table 4. A list of the taxa, excluding mollusks, found in the experimental colonization baskets. The species tolerance codes are as follows: CW = clean water species; O = organic enrichment tolerant; MT = moderantly tolerant species; ChR = resistant to adverse chemistry; S = sediment tolerant (adapted from Mangum, 1987 and 1989).

CLASS	ORDER	FAMILY	GENUS	SPECIES	
ARACHNIDA	HYDRACARINA				S,0
CRUSTACEA	AMPHIPODA	GAMMARIDAE	GAMMARUS		0
CRUSTACEA	AMPHIPODA	TALITRIDAE	HYALLA	AZTECA	0
CRUSTACEA	COPEPODA				
CRUSTACEA	DECAPODA				S
INSECTA	COLEOPTERA	ELMIDAE			S
INSECTA	DIPTERA				
INSECTA	DIPTERA	CHIRONOMIDAE			S,0
INSECTA	DIPTERA	EMPIDIDAE			S
INSECTA	DIPTERA	PSYCHODIDAE	PERICOMA		S,ChR
INSECTA	DIPTERA	SIMULIIDAE			0
INSECTA	DIPTERA	TIPULIDAE	ANTOCHA	MONTICOLA	MT
INSECTA	EPHEMEROPTERA	BAETIDAE	BAETIS		S,0
INSECTA	EPHEMEROPTERA	HEPTAGENIIDAE	EPEORUS		CW
INSECTA	EPHEMEROPTERA	EPHEMERELLIDAE	EPHEMERELLA	INERMIS	S
INSECTA	EPHEMEROPTERA	EPHEMERELLIDAE	EPHEMERELLA	MARGARITA	MT
INSECTA	EPHEMEROPTERA	TRICORYTHIDAE	TRICORYTHODES	MINUTUS	S
INSECTA	LEPIDOPTERA	PYRALIDAE	PARPGYRACTIS		S
INSECTA	LEPIDOPTERA	PYRALIDAE	PETROPHILA		S
INSECTA	ODONATA	COENAGRIONIDAE			S
INSECTA	ODONATA	COENAGRIONIDAE	ARGIA		S
INSECTA	PLECOPTERA	LEUCTRIDAE			CW
INSECTA	PLECOPTERA	NEMOURIDAE	AMPHINEMURA		CW
INSECTA	PLECOPTERA	NEMOURIDAE	ZAPADA		CW
INSECTA	PLECOPTERA	PERLODIDAE	CULTUS		CW
INSECTA	TRICHOPTERA				
INSECTA	TRICHOPTERA	BRACHYCENTRIDAE	BRACHYCENTRUS		S
INSECTA	TRICHOPTERA	BRACHYCENTRIDAE	MICRASEMA		MT
INSECTA	TRICHOPTERA	GLOSSOSOMATIDAE	GLOSSOSOMA		MT
INSECTA	TRICHOPTERA	HYDROPSYCHIDAE	ARCTOPSYCHE		CW
INSECTA	TRICHOPTERA	HYDROPSYCHIDAE	CHEUMATOPSYCHE		S
INSECTA	TRICHOPTERA	HYDROPSYCHIDAE	HYDROPSYCHE		S
INSECTA	TRICHOPTERA	HYDROPTILIDAE	ALISOTRICHIA		S
INSECTA	TRICHOPTERA	HYDROPTILIDAE	HYDROPTILA		S
INSECTA	TRICHOPTERA	HYDROPTILIDAE	LEUCOTRICHIA		S
INSECTA	TRICHOPTERA	LEPTOCERIDAE	NECTOPSYCHE		S
INSECTA	TRICHOPTERA	POLYCENTROPODIDAE			S
INSECTA	TRICHOPTERA	RHYACOPHILIDAE	ATOPSYCHE		MT
INSECTA	TRICHOPTERA	RHYACOPHILIDAE	HIMALOPSYCHE	SPECIES 1	MT
INSECTA	TRICHOPTERA	RHYACOPHILIDAE	HIMALOPSYCHE	SPECIES 2	S
INSECTA	TRICHOPTERA	RHYACOPHILIDAE	RHYACOPHILA		MT
INSECTA	TRICHOPTERA	RHYACOPHILIDAE	RHYACOPHILA	BIFILA	MT
NEMATODA					S,0
OLIGOCHAETA					0,S
TURBELLARIA	TRICLADIDA	PLANARIIDAE	PLANARIA		0

The EPA STORET data provided longitudinal views of water quality parameters used for the BCI analysis. Along with a variety of other data, sulfate (total) and alkalinity (CaCO3) were measured periodically at the USGS gauging station in the upper third of the stream. These two measurements more than others are directly related to the number and species of taxa found in any water source. As the concentration of each of these parameters increases, the number and diversity generally decreases (after a certain point). The reverse occurs when these concentrations decline. The data indicates that in this stream both of these parameters are very stable over time. Sulfate concentration (SO4) in fourteen water samples taken between 1974 and 1985 had an average of 35.5 mg/l (maximum 38 and minimum 33 mg/l). Alkalinity (total CaCO3) in twelve water samples taken between 1973 and 1988 had a mean of 142.55 mg/l, varying between 170 and 130 mg/l. To compare this data with the current water quality at the actual sampling sites, the stream sections where the BCI stations were placed were recently sampled for these parameters. The recent samples provided the following information: Sulfate - U = 34.5 mg/l, L = 34.5 mg/l, Alkalinity - U = 130mg/l , L = 131mg/l. This information indicates that the upper and lower sampling stations on the stream have similar sulfate and alkalinity levels and thus should display similar BCI ratings if they are tested.

Two additional parameters, water temperature, and streamflow volumes, were examined from the EPA STORET data base. Because the numerous samples were taken during random months over the years makes it is difficult to minimize variables associated with specific monthly conditions. Several trends are apparent on the basis of this data.

Water temperature variation throughout the year is about that which would be anticipated for a spring-fed stream system. In 63 temperature readings between 1949 and 1988, the mean was 14.23oC, with a maximum record of 16oC and a minimum of 11.5oC. (all but seven readings were between 13.5 and 15oC). The warmest temperature recorded (16 degrees C) occurred twice in 39 years; in the spring of 1970 and in the spring of 1986. The coldest temperature record (11.5 degrees C) also occurred twice in 39 years; in the early fall of 1976 and in the late fall of the same year. Generally the stability in temperature year after year and month after month indicates that temperature should not be a significant factor in BCI result variations in this stream, and adds to the habitat value for the sensitive endemic biota.

Streamflow is also relatively consistent (flow only varies from 13% to 16%) over time for this part of the stream. In the lower reach a major water diversion was established in 1973. That diversion is licensed to extract 8.49 cms (300 cfs) and has been alleged to extract up to an additional 1.69 cms (60 cfs), thereby on occasion drying up a short section of the stream below the diversion. Today the diversion is regulated through automated devices attached to small hydroelectric facilities on the system. For the past 3 - 5 years it is assumed that the lower portion of the stream has maintained a flow regime which correlates with that of the upper stream. Historically the stream would have flowed at about twice the volume at the lowest BCI station as is flowing today because of the diversion. The lower portion of the stream where the macroinvertebrate data was collected has experienced sixteen years of this reduced flow condition. It is likely that over time it has stabilized and provides the lower condition rating shown in the BCI on a persistent bases. Although the flows are consistent, the current flow levels possibly affect the degree to which enrichment sources arising in the lower stream system are diluted. There is no overland tributary entering the main creek (except one small spring providing less than .01 cms) along the private land portion of the stream. However, that section contains many springs which have reduced their flows since deep well pumping for agriculture started some twenty or more years ago. The fact that the stream increases in volume as it flows to the mouth suggests that there could be biotic differences between the two stations based on water volumes. There is a known difference in volume of 2.46 cms (87 cfs) between the proposed point of diversion and the mouth of the creek. A similar increase would be expected between the upper and lower BCI stations. This may ba partial explanation of the difference between the BCI results at the two sample sites. The dilution hypothesis has not been explored in detail through specific water quality analysis, and a closer look is needed to explain the presence of pollution tolerant indicator species and habitat parameters in the stream.

The results of the visual inspections provided additional ecological information which is qualitative but is reported for future reference. Each time the BCI experiment was set or read, visual inspections of the closest pool were made to observe the number, species and size class of fish. Typically, each spring a few large and a few juvenile rainbow trout, Oncorhynchus mykiss (formerly Salmo gairdneri), were observed. Large suckers (Catostomus macrocheilus, Catostomus columbianus, or both) and northern squawfish (Ptychocheilus oregonensis) were common in the pools, and especially in the large Sculpin pool. In the summer the number of rainbow trout seemed to increase slightly with little change in the size class. Generally the suckers decreased toward the end of summer and the squawfish were absent by the beginning of summer. Shoshone Sculpin (Cottus greenei) were obvious in some areas of the Sculpin pool and Mottled Sculpin were present year-round. The sculpin species were not observed to be more abundant any particular time of the year. A specific monitoring regime is required in the stipulations of the proposed project right-of-way, but is scheduled to be conducted in June to compare current population demography with the initial studies of Griffith's group. Although no BLM studies of the Shoshone Sculpin have been completed, initial snorkeling has identified specific areas where the required monitoring will be done. During the fall a spawning population of large rainbow trout enter Box Canyon Creek from the Snake River. During the fall and winter suckers are rarely observed in the stream.

Snail sampling consisted of re-examining sites where the Bliss Rapids Snail had been previously observed. There is no known method of conducting population estimates on this species and, therefore, only the presence or absence of the species was documented during monitoring. Occasionally Bliss Rapids Snails occurred in the BCI samples. A few Bliss Rapids Snails were found at other sites in the lower part of the stream in recent checks. At known sites, the snail is absent more often than present by a 3:1 ratio in four checks. Fluminicola (or Lithoglyphus sensu Taylor) hindsi (Baird), the most abundant snail in the creek, frequently colonized the baskets. In the summer of 1989 Potamopyrgus antipodarum (Gray), a species not previously observed in Box Canyon Creek, was found in the BCI samples. During the fall of I989 samples were taken from the vegetation in the Sculpin pool which were taxonomically verified by Robert Hershler (U.S. National Museum).
At the time of this collection P. antipodarum was nearly as common as the native Fluminicola hindsi.

The photographic transects, although only undertaken for two years, have already illustrated change within the canyon. The private landowner (applicant for the proposed project) has constructed a small vehicle bridge on his property above the existing water diversion structure. A connecting road (approx. 1/10 mile) has also been built but does not extend upstream from the bridge. There has been geologic exploration activity on the public land which can be seen in the photos. The exploration activity consisted of establishing test pits and drill hole sites using rubber tired equipment to minimize surface disturbance. No instream drilling or stream crossing occurred in this testing process. Some video footage was taken of the access development to show the care and minimum disturbance approach used by the applicant under the direct supervision of the BLM manager.

Water levels were marked on several large boulders in the Sculpin pool to monitor the levels through the year before and after the project construction. During the summer of 1989 there was an 18.41 cm (7.25 in) drop in water in the Sculpin pool. It is assumed this is a normal reduction due to the deep well irrigation pumping on the Snake River Plain Aquifer. An additional scribe was placed on a rock at the south and west end of the Sculpin pool late in 1989, to monitor the project's impoundment affect on the flow and level of this area.

In summary, the studies reported are only a beginning in the understanding of this ecosystem. It is anticipated that research will continue and that additional, and more intensive investigations may be conducted because of the pending litigation. Copies of the raw data presented in Mangum (1987; 1989), Taylor's (1985) mollusc survey report, and the STORET data are available upon request from the first author.

ACKNOWLEDGEMENTS

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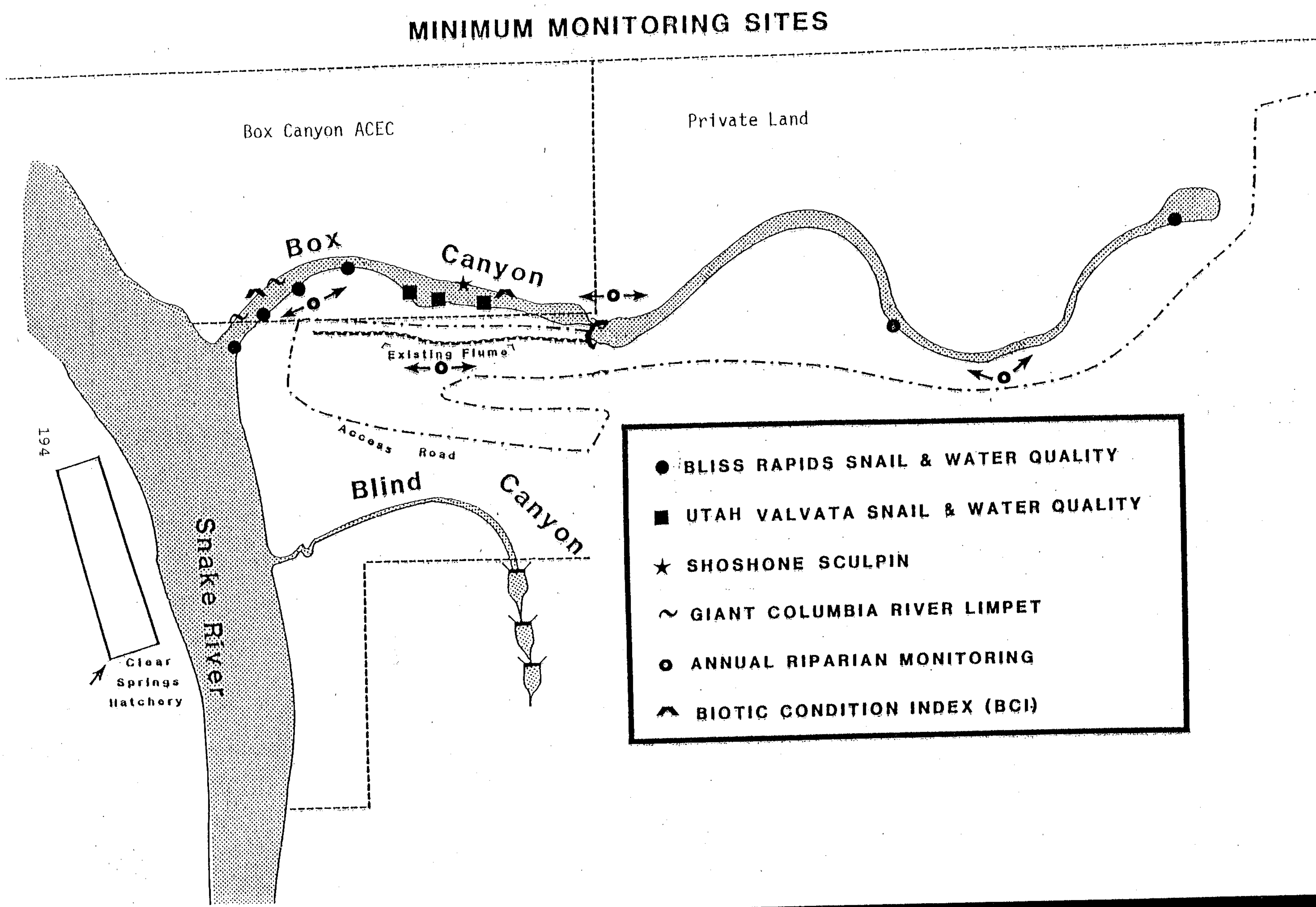
Figure 1. Monitoring sites for biological parameters in the Box Canyon ACEC including riparian monitoring sites in the upper area of the canyon.



The Current Status of the Bruneau Hot Springs Snail, an Undescribed Monotypic Genus of Freshwater Hydrobiid Snail, and Its Declining Habitat[1]

El Estado Actual del Caracol de Agua Dulce Bruneau de Hot Springs y la Decadencia de su Habitat: Un Género Monotípico no Descrito de la Familia Hydrobiidae[1]

Peter A. Bowler[2]
and Pat Olmstead[3]

Abstract. The Bruneau Hot Springs Snail is an undescribed monotypic genus in the Hydrobiidae which is endemic to Hot Creek and a number of adajcent thermal seeps along the Bruneau River in Owyhee County, southern Idaho. The "Indian Bathtub," formerly by far the largest site at the head of Hot Creek which historically supported the greatest population (an estimated 75,000 animals in 1982), is now dry. This site had a former surface flow of 2,500 gallons per minute. Surface seep and spring water levels have tracked drawdown from pumping and diminishing seasonal recharge for years, and it is estimated that approximately half of the elevational lens in which surface water appears is now dry. Dramatic aquifer drawdown is occurring throughout the Bruneau-Grandview area, and the upper seep springs at Hot Creek appear to be 3 to 6 degrees C cooler than historic measurements. A cloudburst caused a severe flashflood in 1985 which filled the Hot Creek channel with several feet of coarse sediment, and lower Hot Creek is still vulnerable to impacts from flash floods. In the field the snail appears to prefer a thermal range of between 30 and 32.8 degrees C. In an aquarium setting the snails are not photophobic and have two annual reproductive cycles, with young appearing in June and in November. A recent estimate by Minshall's group (September, 1989) suggested that there may be as little as 52.4 square meters of seep habitat remaining and as few as 64,683 snails inhabiting these sites, though there is a little additional habitat among vegetation along Hot Creek. In addition to the endemic snail, an ambrysid, Ambrysus mormon minor, is also restricted to this site, though it was found at one other thermal spring at which it no longer occurs. This is the northernmost and one of a few Idaho localities for Hydroscaphis natans, and the state-listed Threatened orchid, Epicactis gigantea (Giant Helleborne) has been recorded from the site, though it is now apparantly extirpated at this locality. A large wild population of guppies, Poecilia reticulata, inhabits Hot Creek and the thermal plume in the Bruneau River. The guppies occur in waters between 35.5 and 30 degrees C. The molluscan fauna of Hot Creek includes the landsnail Oxyloma haydeni (W.G. Binney) (Succineidae), Physella gyrina (Say) (Physidae), Fossaria exigua Lea (Lymnaeidae), Gyraulus vermicularis Lea (Planorbidae), and the undescribed Bruneau Hot Springs Snail (Hydrobiidae). The fauna of the adjacent Bruneau River consists of those listed for Hot Creek (excluding the Bruneau Hot Springs Snail), Fluminicola hindsi (Baird) and Fontelicella sp. (Hydrobiidae), Anodonta californiensis Lea and Gonidea angulata (Lea) (Unionidae), and Psidium sp. (Sphaeridae). The Bruneau River fauna is a species poor derivative of the Snake River fauna. The exotic Potamopyrgus antipodarum (Gray) which has recently invaded the Middle Snake River has not yet appeared at this site. There is no question that Critical Groundwater Area designation is needed immediately to curtail further new pumping, and that a series of triage measures are required if this site and these thermally restricted species are to survive.

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[1] Presented at the Twenty-first Annual Symposium of the Desert Fishes Council at the University of New Mexico, Albuquerque, New Mexico on November 16, 1989.

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Resumen. El caracol Bruneau de Hot Springs es un género monotípico no descrito de la Familia Hydrobiidae, el cual es endémico de Hot Creek y de varios escurrimientos termales adyacentes a lo largo del rio Bruneau en el condado de Owyhee en la porción Sur del estado de Idaho. En el sitio "Indian Bathtub" localizado en la parte superior de Hot Creek, que históricamente se caracterizó por presentar la población más grande (75,000 animales en 1982) actualmente se encuentra seco. Este sitio presentó un flujo de 2,500 galones por minuto. Los niveles de agua han disminuido debido al bombeo y reducción de la recarga estacional durante años y se ha estimado que la columna de agua se ha reducido aproximadamente a la mitad. Una dramática reducción de los mantos acuíferos esta ocurriendo en el área de Bruneau-Grandview y la parte superior del arroyo Hot Creek parece ser de 3-6° C más frio que los registros anteriores. En 1985 una tormenta causó una avenida que llenó el canal del Hot Creek con varios pies de grava y la porción inferior de Hot Creek es aún vulnerable a el impacto de avenidas. En el campo el caracol parece preferir un rango termal entre los 30 y 32.8° C. En el acuario los caracoles no son fotofóbicos y presentan dos ciclos reproductivos anuales, los juveniles aparecen en junio y noviembre. Una estimación reciente realizada por el grupo de Minshall (septiembre de 1989) sugiere que actualmente quedan 52.4 metros cuadrados de escurrimientos termales y tan solo 64,683 caracoles viviendo en estos sitios, a pesar de que aún existe una parte adicional de hábitat en la vegetación a lo largo del arroyo Hot Creek. Además de este caracol endémico, existe un ambrysido, Ambrysus mormon minor, que tambien esta restringido a este sitio y que anteriormente se encontraba en otra fuente termal. Este es el límite Norte y una de las pocas localidades en Idaho para Hydroscaphis natans y la orquidea Threatened listada para el estado Epicactis gigantea (Giant Helleborne) ha sido registrada para este sitio, aún cuando actualmente es extraida de esta localidad. Una población muy grande de guppies silvestres Poecilia reticulata vive en Hot Creek y la pluma termal en el rio Bruneau. Los guppies existen en aguas entre 35.5 y 30° C. La fuana molusca de Hot Creek incluye el caracol terrestre Oxyloma haydeni (W.G. Binney) (Succineidae), Physella gyrina (Say) (Physidae), Fossaria exigua Lea (Lymnaeidae), Gyraulus vermicularis Lea (Planorbidae), y el caracol no descrito de Bruneau Hot Springs (Hydrobiidae). La fauna adyacente del rio Bruneau consiste de aquellas especies listadas para Hot Creek (excluyendo el caracol de Bruneau Hot Springs), Fluminicola hindsi (Baird) y Fontelicella sp. (Hydrobiidade), Anodonta californiensis Lea, Gonidea angulata (Lea) (Unionidae) y Psidium sp. (Sphaeridae). La fauna del rio de Bruneau es pobre en especies derivadas de la fauna del rio Snake. El exótico Potamopyrgus antipodarum (Gray) el cual recientemente invadio la porción media del rio Sanke aún no ha aparecido en este sitio. No existe duda que es necesaria la designación inmediata de un nivel de agua y area crítica para reducir el bombeo así como una serie de medidas para que este sitio y las especies restringidas térmicamente puedan sobrevivir.

The "Indian Bathtub," the locality from which the Bruneau Hot Springs Snail was first collected from enormous historic populations on seeps in the Bathtub walls, is one of a number of thermal springs near the Bruneau River approximately 17.8 km from the town of Bruneau in south central Idaho. The Indian Bathtub is a well known historic site in southern Idaho and is culturally significant in having petroglyphs and buried archeological resources adjacent a hot springs, an unusual occurrence. During this fiscal year the site is slated for listing on the Register of Historic Places (T. Greene, pers. comm., 1989). This site is mentioned in most Idaho guidebooks, and is marked on many state highway maps. It is located in U. S. Geological Survey Hot Spring Quadrangle (1949) (N.E. 1/4 sec. 3, T. 8 S., R. 6 E.).

As its name implies, the Indian Bathtub was an area heavily used by Indians and was a popular bathing site from the days of the early settlers. Historic photographs from the 1880s show Indians bathing in a full Bathtub, and photographs into the 1960s similarly capture bathers enjoying ample water from sources both above the Bathtub flowing over the lip of the falls into the plunge pool (the Bathtub) and from sources emanating from seeps and springs in the Bathtub and its porous walls. Abundant petroglyphs, including an interesting depiction of a deer, adorned the walls of the Bathtub and were clearly exposed, well above the water level of the tub. The Indian Bathtub is located on Bureau of Land Management Land, and Hot Creek into which it flows descends some 12 to 15 meters in elevation along a half a kilometer to its confluence with the Bruneau River. In addition to Hot Creek, there are a number of other thermal springs on both the east, but most abundantly on the west, bank of the Bruneau River for at least a half mile downriver.

As far is known, the Bruneau Hot Springs Snail was first collected by Borys Malkin in 1952, and in 1953 W.F. Barr, an Associate Entomologist at the University of Idaho's Agricultural Experiment Station in the College of Agriculture, sent material he had collected to J.P. Morrison at the U.S. National Museum (Barr, letter to J.P. Morrison, July 14, 1953). Having seen the material in the U.S. National Museum, D.W. Taylor visited the site in 1959, and in a series of subsequent trips in 1963, 1975, 1979, 1981 and 1982 (Taylor, 1982). Since the early 1980s, the second author has visited the site several times a year, and in 1988 Terrence Frest (The Burke Museum, University of Washington) went to the site, and again in 1989, as did Robert Hershler (National Museum of Natural History). On July 17, 1985, the first aquarium population was established in the BLM Boise District Office by Pat Olmstead. This small population fluctuates greatly but usually is stabilized between 40 and 60 snails. It is the only surviving remnant of the Bathtub population, though the entire species likely represents one population genetically. Malkin (Barr, 1953) and Morrison (Hershler, pers. comm.) apparently recognized that this was an undescribed taxon, as did Taylor, who has had the most extensive experience with the site and species prior to the 1980s. Taylor considered the undescribed taxon of generic level distinction, and included it in references to endemism in freshwater molluscs of the Snake River Plain (Taylor, 1985).

By the early 1980s, it was graphically apparent that habitat loss was extensive and progressing at an alarming rate, and in 1981 Taylor was contracted by the U.S. Fish and Wildlife Service to conduct a status review of the species. Taylor's (1982) status review was the first comprehensive compilation of information about this undescribed taxon, and included a review of early collections, the status of the species, a description (though no name was formally applied, and, in any event, an unpublished status review would not constitute a valid nomenclatural or descriptive work), its significance, the geographic distribution, a discussion of habitat requirements, notes on population biology and ecology, land ownership at the time, threats, and the recommendation that the species be listed as a Federal Endangered Species with the protection afforded by the Endangered Species Act of 1973.

Taylor's status review was the basis of the U.S. Fish and Wildlife Service's placing the Bruneau Hot Springs Snail on the list of species under review in 1980 and on the list of candidate Endangered Species as a Category I species (data on hand to support the appropriateness of a proposal for endangered or threatened status) on May 22, 1984 (49 FR 21664-21675) in the Service's review of invertebrate candidate species. On August 21, 1985, a proposal to list the Bruneau Hot Springs Snail was published in the Federal Register (50 FR 33803-33805). In December, 1985, and January, 1986, hearings were conducted to solicit public comment on the proposed listing action. As might be anticipated by those familiar with the attitudes of special interests such as the cattle grazing community and other agricultural interests in Owyhee County and southern Idaho, controversy arose around the prospect of listing the species as Endangered, and there were extended exchanges in local newspapers between those opposing listing and those favoring the preservation of the species. An anthology of selected newspaper articles, editorials, and letters to the editor are referenced at the end of this paper. The species was not listed, nor was it continued on the list of Candidate Endangered or Proposed (for listing) organisms. In 1989 funding was provided to begin implementing a management plan (see below) under the direction of Dr. Wayne Minshall (Stream Ecology Center, Idaho State University), which included the immediate establishment of aquarium populations as well as a number of habitat conservation measures (fencing the critical habitat area to prevent cattle intrusion into the streambed, and so forth). The specific measures are cited below (Table 1), but few have actually been accomplished or initiated. Regrettably, efforts to purchase critical habitat on lower Hot Creek were not successful. In a letter to the U.S. Fish and Wildlife Service, Frest (1989) stated, "Information was sufficient for listing (the Bruneau snail) as Endangered in 1981....Continued drop in seasonal (thermal water) flow through 1988 places the main population in serious jeopardy, and the downward trend in flow at this site has been documented for decades. Emergency listing as Endangered.....is justified on present information." This view is universally shared by professional biologists familiar with the situation.

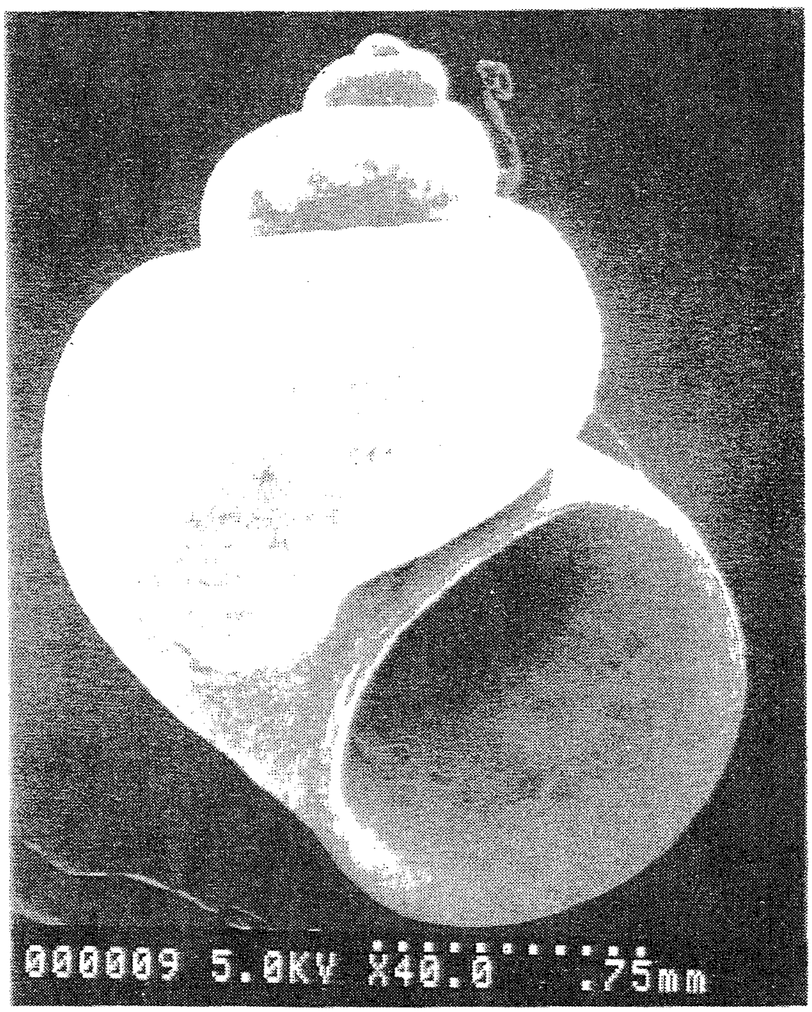

Figure 1. The Bruneau Hot Springs Snail. Scanning electgron micrograph at 40X magnification (see scale). Photograph by Robert Hershler, National Museum of Natural History.

The Bruneau Hot Springs Snail has not been found in fossil form, but has a relatively simple shell morphology (see Figure 1). As Taylor (1982) described, "The snails have a globular ovoid shell generally 3 - 3 1/2 mm long in adults, with up to 2 1/2 whorls. In life the snails appear black or dark gray, with an eroded shell apex contrasting white. A pale tan to brown operculum closes when the animal is withdrawn." Dead shells turn white over time and can be found at the base of some of the seeps supporting living populations. Although Taylor considers the taxon a new genus, he did not clarify the distinguishing generic level characters in his Status Review paper in 1982. Taylor noted, "As is commonly the case in the Hydrobiidae, the shell and external features of the animal do not indicate it distinctiveness or relationships. The more characteristic features of the genus are in the reproductive system....The penis bears a small process containing apocrine glands on the left side. Distal to this process the penis is heavily pigmented, longer than the broad base, and blunt with no conspicuous taper....(in the female system) the gonopore is relatively large. Proximal to the bursa copulatrix, the oviduct bears a single receptaculum seminis on the posterior end of a loop appressed to the bursa; this receptaculum is minute, and relatively far from the junction of bursa and oviduct." Taylor (1982) figured both reproductive systems, and presumably a thorough taxonomic description and discussion of generic placement will be published by Taylor or others in the future. The species is easily distinguished from the other local hydrobiids on shell morphology alone because it is much smaller than Fluminicola hindsi (Baird) and very different in shell shape from Fontelicella species, both of which occur in the adjacent Bruneau River.

Few details are known about the life history of this species, which are being researched by Minshall's group at Idaho State University. Observations of the BLM aquarium population indicate that the species does not appear to be photophobic, and is active under exposure to bright light. Young have been observed in the aquarium in June and in November, suggesting two reproductive cycles per year under aquarium conditions. The young develop rapidly to sub-adults, and within a month or so after their appearance they are in the second tier of size classes in an aquarium setting.

In the field this species appears to prefer thermal water between approximately 30 and 32.78 degrees C (86 and 91 degrees F) and Taylor found the snails in water ranging between 23 and 36 degrees C (Taylor, 1982). The precise thermal tolerance and preference of the species are being further researched by Minshall. As Barr (1953) described in his letter to J.P. Morrison, "Mr. Borys Malkin has written me about a new species of Fluminicola that he collected at Hot Creek Falls, Owyhee County last summer. He asked that I attempt to gather some ecological data for you on my next visit to that area....The snails were most commonly encountered on a sheer rock wall about ten feet high, out of which trickled and oozed warm water. The rocks were covered with a yellowish-slime, algal-like plant and the snails were present in and on this. The temperature of the water at the time of the collection was 35 degrees C. The water from this small cliff, which is located near the main falls, ran in a small trickle into the main creek. Many of the snails were found on and under rocks in this small trickle, which also had a temperature of 35 degrees C. I could not find any snails in the main creek, which is a very fast stream and had a temperature of 36 degrees C." These are the first ecological observations of the Bruneau Hot Springs Snail. Taylor described tens of thousands of snails with up to 60 snails per square inch on the Bathtub walls in the 1960s. The species now occurs among low grass and sedge vegetation along Hot Creek, as well as in a number of seeps along the west and east bank of the Bruneau River.

There is a second species endemic to this thermal spring sequence, though it is not as well known as the Bruneau snail and has not been considered for endangered listing up to this point. Ambrysus mormon minor La Rivers (La Rivers, 1963) in the Hemiptera, Family Naurcoridae, was described from the "Hot Creek Falls" (the Indian Bathtub) by Ira La Rivers in 1963. This subspecies was subsequently collected at another warm spring east of Boise by Russ Biggam. Unfortunately, a revisitation of this site in 1983 (Biggam, pers. comm.) revealed that the subspecies no longer inhabits this second spring locality, and is now apparently restricted to Hot Creek and a few of the adjacent small thermal springs. This subspecies may in a sense be even more habitat restricted than the snail because it requires more than a seep (i.e., at least trickling water) for sustenance, and the standing population levels observed seem relatively small, as only a few individuals were seen on our August 13, 1989 site reconnaissance trip. Ambrysus is extremely predaceous (see Usinger, 1946, and La Rivers, 1956) and could feed upon the Bruneau snail, although the common Physella gyrina (Say) which has no operculum would seem an easier prey. Hydrobiids such as the Bruneau snail often retract into their shell and retreat behind the protection of their operculum when they are disturbed or sense danger.

Pat Olmstead has observed this reaction in his aquarium population when the snails are touched by cladocerans, far smaller than the aggressive Ambrysus. Considering the gravity of the progression of habitat loss, a status survey and aquarium culture efforts for Ambrysus mormon minor would seem prudent.

Another interesting invertebrate occurrence in Hot Creek and the smaller seeps nearby is that of the skiff beetle Hydroscapha natans (Hydroscaphidae), for which this location is one of the northernmost and one of the few Idaho records (Reichardt and Hinton, 1976, cite only "Hot Creek Falls," or the Indian Bathtub, for Idaho, though the species occurs at a few other Idaho localities). This species is otherwise known from sites in Nevada, Arizona, Texas and southern California (Leech and Chandler, 1956; Reichardt and Hinton, 1976).

Giant Helleborine, Epicpactis gigantea (Orchidaceae), a species on the State of Idaho List of Threatened Plants, historically occurred at this site, but it is now extirpated in the Hot Creek Canyon. It is otherwise known from nine localities.

Hot Creek and several of the other small thermal springs immediately adjacent and downstream along the west bank of the Bruneau River support a large wild population of guppies, Poecilia reticulata (Poecilidae). Pat Olmstead recalls the guppies being present throughout Hot Creek, including the Bathtub when it had water in it, and the now dry stretch just below the Bathtub. It seems probable that the original release of the guppies was into the Bathtub, from which they spread downstream and into the other springs. Some are even able to survive in the thermal plume at the spring confluence with the Bruneau River along the west bank. A similar situation exists in the Snake River where the thermal plume from Banbury's Natatorium enters the river, supporting a population of Tilapia escapees from an upstream aquaculture facility (not reported by Simpson and Wallace, 1978). There is an analogous population of wild Tilapia in a thermal plume in the Bruneau River near the town of Bruneau. It is interesting to note that the only other reported wild population of guppies in Idaho is in a warm spring in the Little Lost River area near Howe, and that the Hot Creek population represents a new high in thermal tolerance for wild Idaho populations. The Hot Creek population occurs in water ranging between 35.5 degrees C in the creek to 30 degrees C in the thermal plume along the Bruneau River, whereas the Howe population occurs in water ranging between 21.1 and 25 degrees C (70 and 77 degrees F; Simpson and Wallace, 1978). This record appears to be a new high in thermal tolerance for wild populations of guppies (data is not listed in Carlander, 1969; a review of North American wild guppy populations is presented in Courteneay, et. al., 1986).

The history of habitat loss for this species is dramatic. The elevation lens in which thermal springs occur on the surface at this site lies approximately within a 23 meter elevational zone, between the highest spring (now dry, at approximately 823 meters or 2,700 feet) in the bed of Hot Creek above the Indian Bathtub, to the level of the adjacent Bruneau River high water mark (roughly 800 meters or 2,625 feet). The springs arise from Banbury Basalt - Tuff Idaho Group overlain by various Chalk Hills formation lavas and lake and stream deposits (see Fig. 4 in Young and Whitehead, 1975). Taylor (1982), in a review of hydrological and geological papers (which we cite in our reference list), summarized the decline in surface water flow in Hot Creek from a high measurement of 2,200 gallons per minute in 1954, through a steady descent in streamflow measurements through 1978, when the site had been reduced to a surface flow of 130 gpm. As Taylor (1982) notes, "At the mouth of Hot Creek Canyon the flow was estimated at 100 gpm (by him in 1982); in contrast, values cited by the U.S. Geological Survey (1970) for years from 1922 to 1966 range from 1,667 to 2,513 gpm." As a groundwater resource summary states (Anon., date not known), "The discharge of the Indian Bathtubs Hot Springs (8S-6E-3BDD1S) has declined significantly due to ground-water development. Littleton and Crosthwaite (1957) reported a discharge of 2,200 gal/min in 1954; subsequent measurements by Young and Mitchell (1973), and Young, Lewis, and Backsen (1979) indicated that discharges were 458 gal/min in 1972 and 140 gal/min in 1978, respectively." This year there was no surface flow in the Bathtub in August, thus by far the largest thermal spring in the area with surface flow measurements of between 4 and 5 cfs, had become dry. In the past 25 years the thermal spring surface flow has dried up in approximately half of this elevation zone. In a groundwater analysis of the Bruneau - Grandview area, Gemperle and Ralston (1989) observed, "Ground water resources within the Bruneau-Grand View area are believed to be over appropriated. The region has experienced water level declines of 0.5 to 2 feet per year. Based on previous estimates, pumpage exceeds recharge by a factor of seven....Natural ground water discharge has been reduced from a predevelopment annual rate of 25,000 acre-feet to a current rate of about 4,000 feet. Decreased natural discharge is directly related to ground water development and has occurred mainly as reduction in spring discharge rates and loss of bottomland vegetation..." More about the thermal aquifer will be known when current U.S. Geological Survey investigations are completed.

For a number of years there was a marked seasonal diminishment in seep surface exposure at the Bathtub, but this year there was only a small patch of perhaps a decimeter or less of seep just above ground level, and no snails were observed where Taylor reported the remarkably large populations of only 25 years ago. The rapid recession of the aquifer is alarming because the snails occur in relatively few of the tiny thermal springs, the majority being well above their thermal tolerance (the snails are found primarily in thermal water between 30 degrees C or 86 degrees F in lower Hot Creek and 32.78 degrees C or 91 degrees F in the seeps, though Barr (1953) reported snail occupied Bathtub seep temperatures of 35 degrees C, while most of these springs below the Hot Creek confluence arise at 41.1 degrees C or 106 degrees F). Young and Whitehead (1975) report the Indian Bathtub springs as being 39 degrees C (102.2 degrees F) and the largest of the downstream springs nearby (34dcbls) as being 41 degrees C (105.8 degrees F). There is some evidence to suggest that the the seeps below the Bathtub and Hot Creek when it appears on the surface are cooler than in the past. Barr and others have reported the Bathtub seeps and Hot Creek at 35 and 36 degrees C, respectively. However, the temperature of the Bathtub seeps (before they dried up), the uppermost seeps below the Bathtub along Hot Creek, and Hot Creek itself, is now below 33.5 degrees (at some seeps below 33 degrees), which might suggest that as the aquifer receeds the highest surface flows are for some reason somewhat cooler than historic, pre-drawdown temperatures. While these temperatures are well within the snail's range of thermal tolerance, there is the possibility that the forage base, especially algal sheaths covering the seep areas, could be reduced. Detailed information about water chemistry and other aquifer features are presented in Figs. 9, 10 and Tables 2, 3 of Young and Whitehead (1975). While the depth, subterranean capacity and morphology of the thermal aquifer is not known, the surface flows have clearly tracked the irrigation season for the past 25 years, and drawdown is now occurring at a rapid rate. There is no question that continued aquifer drawdown would terminate the seep exposures and eventually Hot Creek. Since over half the elevation depth of the surface flow origins are already no longer flowing, this is a serious situation.

In addition to habitat loss through the drying of spring sources, the Hot Creek and the Bathtub are susceptible to flash flood and attendant inundation of habitat. In 1985 a flash flood caused by a cloudburst event four to five miles upstreamed conveyed an enormous load of sediment, filling the Bathtub perhaps as much as 101 meters and similarly filling the Hot Creek streambed to the confluence. This undoubtedly smothered thousands of snails, but it also raised the level of the creekbed. Tributary seeps were partially covered and their habitat was reduced. Today there is a re-established population in certain areas of Hot Creek, but cattle "grazing" and the attendant devastation to riparian and instream habitat, a diminishment in historic riparian habitat along upper Hot Creek, and the drying up of perennial water sources which supported the vegetation makes this area very vulnerable to a repeat and compounding of the past flash flood damage. Were this to occur, only seep surfaces which escaped inundation would persist.

The present status of the species is clearly precarious and declining. Minshall's group, which has just begun its research, recently surveyed Hot Creek and most of the seeps along Hot Creek and the west bank of the Bruneau River (Minshall, Sept. 15, 1989). This group estimated that the eleven micro-sites they examined comprised only 52.4 square meters of habitat and that the current population within this area was 64,683 snails. A number of small seeps and the minor sites below the Bruneau River flood line on the east bank weren't included in this sample, but they would not add much habitat or numbers of individuals to the overall picture. Sixty percent of the living population was estimated to occupy three small sites that constitute 55% of the habitat surface area (28.75 sq. meters). In September, 1989, Minshall's group established aquarium populations to examine life history and population dynamics (Minshall, Sept. 15, 1989). These and the Boise BLM's modest aquarium population offer a small triage of protection against the advancing diminishment of habitat. It is depressing to read Taylor's statement in his status review (1982) that "As of May, 1982, total population (of snails) at the Indian Bathtub was estimated at about 75,000 individuals." Thus, the elimination of the Bathtub habitat and its population represented a loss of over 12,000 more snails than are estimated living today. It should be noted that Taylor (1982) also observed a large population within Hot Creek, but because of the vulnerability to flash flooding and scouring he viewed the population as "a transient phenomena" and "liable to extinction." The subsequent filling of the Hot Creek channel by flash flood borne sediment reduced the kind of gravel habitat he had observed and demonstrated the sensitivity of the creek to flooding. Snails still occur in vegetation along the lower section of the creek.

On an August 13, 1989, field trip the authors collected molluscs from Hot Creek and the adjacent Bruneau River, since there was no list of species for either site. In addition to the hydrobiid Bruneau Hot Springs Snail, the freshwater snail fauna of Hot Creek includes Physella gyrina (Say), Fossaria exigua Lea, and the planorbid Gyralus vermicularis Lea. Physella gyrina is very abundant in the upper and middle sections of Hot Creek, and nearly all adult individuals are eroded and whitened, appearing as if they are dead. Fossaria exigua occurred on the seeps. The succineid landsnail Oxyloma haydeni (W.G. Binney) occurred on sedges growing in Hot Creek. This species is common along the Snake River and its Snake River Plain Aquifer tributaries (it has been verified from Bancroft Springs, an unnamed spring at Snake River Pottery in the Lower Salmon Falls Dam tailwaters, and Box Canyon). The molluscan fauna of the adjacent Bruneau River includes these species, with the exception of the thermally restricted Bruneau Hot Springs Snail, the hydrobiids Fluminicola (= Lithoglyphus sensu Taylor) hindsi (Baird) and Fontelicella sp., the unionid clams Anodonta californiensis Lea and Gonidea angulata (Lea), and the sphaeriid clam Psidium sp. The Fluminicola all had a whitened, eroded apex, and were abundant on boulders and cobbles. Only a single, dead shell of an immature Fontelicella species was found, and the Bruneau River with its large sediment load and raging runoff would be a poor habitat for this sand or silt burrowing species. Both the Anodonta and Gonidea appeared to be stream ecotypes, not reaching the size these species achieve in the Snake River.

The molluscan fauna of the Bruneau River appears to be a species poor derivative of the Snake River into which it flows. Characteristic Snake River species such as Vorticifex effusus (Lea), Fisherola nuttalli (Haldeman), and the local Snake River endemics, Fontelicella idahoensis (Pilsbry), the Bliss Rapids Snail, and Physa natricina Taylor were not found. It was with relief that the absence of the exotic Potamopyrgus antipodarum (Gray), a prolific introduced hydrobiid snail, was confirmed. A more detailed discussion of the site is presented in the attached field trip report.

In conclusion, the current status of the Bruneau Hot Springs Snail is precarious and continuing to decline as incremental habitat loss occurs. The primary locality which had the largest surface flow and most favorable habitat, and which supported more snails in 1982 than are estimated to be alive today, is now dry. There is no question that the situation is critical and that the management and recovery efforts proposed by the U.S. Fish and Wildlife Service must be implemented immediately (Table I). The situation for the Bruneau Hot Springs Snail, Ambrysus mormon minor, and the unique thermal springs ecosystem this site represents has gotten much more grim than it was in 1981 when Armantrout first reported the status of the snail to the Desert Fishes Council. The public domain portion of this site is neither a BLM Area of Critical Environmental Concern nor a Research Natural Area, and as of the date of this meeting, neither the ambrysid nor the snail are Candidate or Proposed Endangered species. Cattle still have access to the riparian corridor in Hot Creek and are not fenced from either the public or privately owned critical habitat. As Gemperle and Ralston (1988) observed for the entire Bruneau - Grandview area "pumpage exceeds reharge by a factor of seven...under Idaho water law this condition warrants a Critical Ground Water Area designation, which essentially stops all future development of ground water." However, it has not been so designated. It can only be hoped that the triage measures now required will keep this area and these clearly endangered species alive until some real solutions with a more permanent basis and a more positive prognosis can be achieved. Time and action are of the essence for rescuing this site.

Acknowledgements

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Mountain Home News, Mountain Home, Idaho. (Date unknown, prior to Jan. 15, 1986.) Endangered Species List Grows at "Snail's Pace;" Hearing Set.

Mountain Home News, Mountain Home, Idaho. January 15, 1986. Editorial Section. Reader Refutes Snail Editorial. By Randy Morris.

The Idaho Statesman, Boise, Idaho. January 16, 1986. Foes Steamed Over Hot Springs Snail Plan. By Randy Stapilus.

Slides and Historic Photographs

Sets of standard slides of historic photographs of the Indian Bathtub from the early 1920's through 1989 are available on a loan basis from either author.

Table I. A summary of the approaches proposed by the U.F.W.S. and others to gain information about the Bruneau Hot Springs Snail and the geothermal springs upon which its ecosystem depends, though only a few of these actions are underway. These tasks are to be completed by 1992. Regrettably, some of the most critical actions, such as purchasing critical habitat have failed in recent months, and others, such as fencing Hot Creek to exclude cattle have not been accomplished to date. Other agency actions, such as listing the species as Endangered (U.S.F.W.S.), designating the area an ACEC and RNA (BLM), and placing Critical Groundwater Area restrictions on pumping remain clear options not cited below.

U.S.F.W.S. Bruneau Hot Spring Snail Action Plan (Summarized from the February 6, 1989 document):

1. BLM: Pursue land acquisition; fence spring to control cattle access

2. FWS/BLM: Conduct biological/ecological investigations at the Indian Bathtub Spring, in Hot Creek, at small springs in the Bruneau River near the confluence of Hot Creek, at spring seeps along the cliff north of the Hot Creek confluence, and develop and document a sampling/counting technique.

   Develop answers to basic questions such as: How do snails survive a drought, i.e., do adults burrow in moist soil? How deep? Do immature snails seek out moist cracks in the wetted rock surfaces? Can eggs lie dormant for a long period, and so forth?

   Identify fundamental life history traits, such as: How long do individuals live? How many generations are produced each year? What is the breeding season(s)? Number of offspring produced per female (sex ratio)? Are they preyed upon by other species?

   Identify limiting factors/agents, such as predators, restrictions of food (algae), lack of water/moist substrate, pollution of water (i.e., cattle feces, urine, or other factors), water quality problems (i.e., reproductive activity at various water temperatures, and so forth).

   If the snails are gone from Indian Bathtub Spring, then plant a group from the lower springs and monitor/document survival, growth, demise (stability of the population). Investigate other sites for transplant. Assess the general impact of beaver activity (dams) located on lower Hot Creek on the snail.

   Conduct a literature search on the biology and ecology of hydrodiid snails. Implement laboratory studies to elucidate substrate preference, reproductive and water chemistry influences on the biology of the organism. Review the taxonomic status of the species, and publish a formal taxonomic description and name for the species.

3. U.S. Geological Survey: Initiate hydrologic, geologic and water-chemistry studies, determine the cause or causes of rapidly declining Hot Spring discharges along Hot Creek, and assess long-term effects of continued use of hot water resources in valley lowlands on spring discharge along Hot Creek.

4. Idaho Department of Water Resources: Review historical agricultural impacts upon the Bruneau Valley to define in detail, within a geographic infomration system, the historical changes that have occurred in the Bruneau-Grandview area to provide information for future management of the area (GIS databases), and produce a report reflecting the changes in ground water usage. Complete a geologic mapping of the Bruneau-Grandview area (in conjunction with the U.S.G.S.), and locate and map faults and other structural features that would influence ground water flows in the area.

Notes on a Site Visit to the Indian Bathtub, Hot Creek and the Adjacent Bruneau River on August 13, 1989

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On August 13, 1989, I visited the Indian Bathtub, Hot Creek and the adjacent Bruneau River with Pat Olmstead (Aquatic Ecologist, Boise District BLM) who kindly spent his Sunday showing me the situation, which was shocking when compared with historic photographs of the site. This site is one of the most dramatic examples of habitat destruction due to aquifer drawdown I have seen and is comparable to any of our other endangered species tragedies. The Indian Bathtub had no flowing surface water and snail habitat was restricted to a very small wedge of a few inches of wetted rock from a seep source perhaps three inches above ground level. I was unable to find any snails on this tiny patch of habitat, but there may have been a few. Excavation for bathing at the head of the bathtub had produced a small pool less than a foot deep, however, this did not produce habitat which could support snails. Pat had photographs from the early 1960s which graphically illustrated what the site had been like when the surface flow was 2,200 gallons per minute (between four and five cfs). Interestingly, a substantial quantity of this surface flow originated upstream of the Bathtub, a source now entirely dry. It is very possible that a population of the Bruneau Hot Springs Snail could have existed in this upstream hot water spring and the creekbed segment between the spring and the Bathtub. Former inhabitance by snails might be determined by excavating around the now dry source less than half mile above the Bathtub. The historic seep surfaces at the Bathtub where Taylor reported tens of thousands of snails in the early 1960s are now dry, with peeling patches of dead algal sheath and rock surface exfoliating due to desiccation characterizing the once wet seep surfaces. In addition to the loss of snail habitat this is significant because it could threaten the petroglyphs at the Bathtub. The primary petroglyphs appear to be buried by sandy sediment which is now many feet (perhaps as many as four feet) deeper than the surface level of soil in photographs taken twenty five years ago.

The site had no surface flow below the remnant Bathtub seep for some distance. The former creekbed is now buried under the sandy sediment which filled the Bathtub. It may be that snails once were able to occupy the streambed prior to its inundation with sediment in relatively recent years (early photographs indicate a rocky stream below the Bathtub). In addition to direct habitat loss at the Bathtub, the small seeps along Hot Creek are also probably somewhat less extensive because of this sedimentation. I was unable to find the Bruneau snail in the upper area of trickling water, though it did occur in poison oak shrouded seeps not far downgradient from the point at which water began to appear on the surface. Physella gyrina (Say) was abundant in all sections except the confluence area of Hot Creek. The shells of nearly all living individuals of P. gyrina had lost their external coloration and were white and eroded, looking as if they had been dead for some time (though they were living). A few individuals of the amphibious Fossaria exigua Lea were found at the seeps along Hot Creek, and the planorbid Gyraulus vermicularis Lea was abundant in Hot Creek itself. The landsnail Oxyloma haydeni (W.G. Binney) was found on aquatic vegetation growing in Hot Creek. The now dry Bathtub is the type locality for Ambrysus mormon minor (Hemiptera: Family Naucoridae; Rivers, 1963), which was seen in both Hot Creek and a few of the springs below the Hot Creek confluence with the Bruneau River. This subspecies has only been collected at one other site to the best of my knowledge (Russ Biggam at the University of Idaho has a record of it in a different warm spring, however, collection efforts in 1983 at the second site revealed none of the taxon). This is another taxon (besides the endemic snail) now known only from the springs near the Bathtub. Sadly this subspecies may be as endangered or more endangered than the snail because of smaller population numbers and what appear to be more restrictive micro-habitat requirements, and, of course, it is threatened by the same incremental habitat loss as the snail. The skiff beetle (Hydroscaphidae) Hydroscapha natans was also observed in lower Hot Creek and one of the lower springs. This site is the northernmost locality for this species, and the only Idaho record. Clearly this distributional outpost is also jeopardized by the creeping habitat loss caused by the retreating springs and dropping hot water aquifer.

I was disturbed to see cattle grazing along Hot Creek, as it was my understanding that this sensitive area was excluded from grazing. The animals had ear tags and what looked like an "O" brand; we later saw cattle wading across the Bruneau River just below the confluence with Hot Creek. I was also concerned to observe that tamarisk has begun to appear along Hot Creek, and hope that it can be curtailed and eliminated. Russian olive, similarly, should be removed. There was considerable evidence of wildlife along Hot Creek, where I saw deer tracks, porcupine tracks (a waddling tail drag trail that was fresh) - as well as several well barked Russian olive trees (one of which was dead, probably from porcupine predation). There was abundant evidence of beaver, and we heard chukars calling as we waded down the Bruneau River. We also saw a large Thamnophis elegans along the river.

There is a manmade ditch above Hot Creek, which is purportedly a product of Chinese laborers and may be of cultural significance. I noted that it appears to be on an elevation that would preclude use of the Bathtub water, suggesting that water for the ditch might have been piped from Hot Creek at the elevation of the falls at the head of the Bathtub. If federal ownership of the critical habitat area is accomplished it would also preserve in public domain a number of cultural resources besides the ditch, including an early homestead site. The Idaho State Historic Preservation Officer, Tom Greene, has placed the site on the state list of sites to be evaluated for potential Register of Historic Places listing, and concurs that it qualifies. The elements of potential cultural significance on land currently privately owned could be included along with the rich petroglyph and archeological resources on BLM land when the site is listed - or added to the site description when critical habitat passes into protective federal ownership.

We crossed the Bruneau River at its confluence with Hot Creek and examined a series of small hot water seeps on the east side of the river below the Bruneau River high water line. At this point the Bruneau River was clear and thigh deep, with boulders and cobbles of local lava as well as rocks of upgradient (non-lava) sources. The sediment was primarily coarse. There were perhaps fifteen tiny hot springs or seeps in a few hundred feet along the eastern or right bank of the river. Some of these seeps were at river level, while others were slightly above river level, which was low even for this time of year according to Pat. There were small numbers of Bruneau hot springs snails at several of these sites, but for the most part they drained onto rocks and not into the vegetation which seemed to be preferred by the snails. These small seeps appear to be very restricted and vulnerable to high water; I was surprised that snails could hang on at them at all (few have).

Returning to the west (left) bank of the Bruneau, we visited a series of seeps and small springs downstream of Hot Creek. Nearly all of these springs, including Hot Creek, had abundant wild populations of guppies, Poecilia reticulata (Poecilidae). A sample of these fish were captured using my hat in the spring immediately below Hot Creek, and their identity was established by Dr. A. Schoenherr (Fullerton College). It is interesting to note that the only reported locality for a wild population of this species in Idaho is a warm spring in the Little Lost River area near Howe, and that the Hot Creek population may represent a new high in thermal tolerance for Idaho wild populations (otherwise known from water 70 - 77 degrees F; Simpson and Wallace, 1978). Several of the small hot springs had substantial Bruneau snail populations, though we didn't penetrate the poison oak to expose the seep surfaces beyond those where the seeps flowed down into the river. There is a substantial but sterile (for snails at any rate) spring which flows over a broad rock ledge into the Bruneau River, but apparently it is above the thermal tolerance of Bruneau snails (it has been measured at 106 degrees F, while lower Hot Creek is 86 degrees). Just below this relatively large spring outflow is fairly deep hole in the Bruneau River in which we saw a pair of catostomid fish of about a foot in length. Although private land begins shortly below this spring (which is a site where rafters bath), I examined the continuing line of springs downstream for perhaps another third of a mile (at least a half mile below the Hot Creek confluence). Regrettably my thermometer was broken so I was unable to measure their temperatures, but they felt as warm as the 106 degree spring upriver. Although I only cursorily surveyed these seeps and springs as they cascaded from the underbrush over rock faces to the river, I was not able to find snails in any of them. It seems probable that they are too warm to sustain snails, as snails were abundant on the cooler seeps upstream. Because these springs were on private property I stayed in the Bruneau River through this section and was not accompanied by Pat, who stayed in the middle of the river.

Pat and I collected snails in the Bruneau River and I picked up drift material as well (see table below). It is interesting to note that while a number of common Snake River species are present - Fluminicola hindsi (Baird), Anodonta californiensis Lea, Gonidea angulata (Lea), Psidium sp. - the absence of other species is striking. Species such as Vorticifex effusus (Lea), Fisherola nuttalli (Haldeman), a number of big river Lymnaeids, and the local endemics (Physa natricina Taylor, Fontelicella idahoensis (Pilsbry), and the Bliss Rapids Snail are not present. Widespread species such as the ubiquitous Physella gyrina, Fossaria exigua (common in this area of southern Idaho), and the landsnail Oxyloma haydeni (common in southern Idaho along Snake River tributaries) are not surprising occurrences in the Bruneau River. Only a single dead immature shell of the Fontelicella was found despite considerable searching. This section of the Bruneau River was very marginal as Fontelicella habitat and the heavy flushing flows with high sediment load during runoff would be difficult for species such as sand-dwelling Fontelicellae to survive. The Bruneau River appears to have a depauperate fauna derived from the Snake River, and doesn't support a number of species characterizing the fauna of the adjacent Snake River. The species recorded from Hot Creek, including the Bruneau Hot Springs Snail, occur in the some of the hot seeps and springs nearby along the adjacent section of the Bruneau River. It was a relief to note that the introduced New Zealand hydrobiid snail, Potomapyrgus antipodarum (Gray), now widespread in the Snake River and its tributaries above Indian Cove Bridge, was not found either in the Bruneau River nor in Hot Creek.

The Hot Creek molluscan fauna as collected on this fieldtrip comprises the following species:

Freshwater Snails

Hydrobiidae
Bruneau Hot Springs Snail

Physidae
Physella gyrina (Say)

Lymnaeidae
Fossaria exigua Lea

Planorbidae
Gyraulus vermicularis Lea

Land Snails

Succineidae
Oxyloma haydeni (W.G. Binney)

The mollsucan fauna of the Bruneau River in the area of its confluence with Hot Creek includes:

Freshwater Molluscs

Class Gastropoda (snails)

Hydrobiidae
Fluminicola hindsi (Baird)
Fontelicella sp.

Lymnaeidae
Fossaria exigua Lea

Planorbidae
Gyraulus vermicularis Lea

Class Pelecypoda (clams)

Unionidae
Anodonta californiensis Lea
Gonidea angulata (Lea)

Sphaeriidae
Pisidium sp.

I thank Allan Schoenherr for identifying the wild guppies, Terry Frest for identifying or verifying my identifications of the molluscs and Pat Olmstead for taking the time to show me the site. Collections of the molluscan species were donated to Terry Frest's collection at the Burke Museum, University of Washington. Identified specimens of some of the snails were given to Pat Olmstead.

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Habitat Monitoring and Management Implications at Ash Springs and Condor Canyon, Nevada, for the White River springfish and Big Spring spinedace

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ABSTRACT

Ash Springs NV. is a spring source which provides habitat for the Federally Endangered White River springfish. Recent findings by the University of Nevada at Las Vegas have required the Bureau of Land Management to implement management actions to assure the well being of the endemic fish species.

Condor Canyon NV. is 4 miles of critical habitat for the Federally Threatened Big Spring spinedace. The Union Pacific Railroad removed its' railroad tracks in 1984 making the canyon accessible to the public.

In 1989 the Ash Springs Coordinated Resource Management Plan and the Condor Canyon Habitat Management Plan analyzed the existing situation including impacts to these two ecosystems and implemented monitoring methods to measure the intensity of those impacts. Objectives were also developed to maintain certain habitat features and improve others.

Ash Springs Nevada is a perennial spring source located in Lincoln County Nevada, which provides habitat for the White River springfish, *Crenichthys baileyi baileyi*. This fish is presently listed as endangered by the U.S. Fish and Wildlife Service (49 CFR 19360).

The pond associated with Ash Spring is approximately two thirds of an acre and is private land. Of the two thirds acre, approximately one eighth is on public lands administered by the Bureau of Land Management. Admission is charged to the public for access into the private portion. There is no charge for the public to use the public lands portion of Ash Springs.

In 1989 the Ash Spring Coordinated Resource Management Plan was implemented. This plan identified actions which have recently occurred or are presently occurring and impacts resulting from those actions which were or have the potential of affecting the well being of the springfish. This plan also identified monitoring required to quantify those impacts and objectives designed to maintain certain habitat features and improve others.

Recent data (1987) collected by the University of Nevada at

Las Vegas identified high ammonia and nitrite levels as well as lowered oxygen levels at the spring source. This situation was resulting in physiological stress to the fish and probably contributed to the infection of the White River springfish by pathogenic bacteria. The report (UNLV, July 1987) identified livestock bodily excretions as the source of the elevated nitrite and ammonia levels as well as lowered oxygen levels. This deterioration of aquatic habitat was resulting in an increased jeopardy to the well being of the springfish. In 1988 the livestock permittee developed water on his private land and the Bureau built a protective fence to exclude livestock from Ash Springs.

There is a lack of control of certain public activities, such as washing of horses and vehicles in - and in the vicinity of the spring source and unruly night time parties. There is no formal periodic collection of trash at the site. There are also periodic uncontrolled and unplanned developments of the site by individuals other than the Bureau.

There is a millsite (serial # NMC-56039), which encumbers the public portion of Ash Springs. There has not been any recent work done at the millsite.

Tamarix, an introduced vegetative species has dramatically increased since 1976.

Monitoring, objectives and planned actions developed to rectify the above mentioned conditions: 1) stabilize stream banks by maintaining 80 percent canopycover of native vegetation along the banks of the public land portion of Ash Spring, 2) eradicate tamarix at the site, 3) maintain ammonia levels of not to exceed 0 ppm. and oxygen levels of no less than 2.25 ppm., 4) continue to implement a monthly water sampling and analysis which will test for nutrients, physical properties and microbiological components, 5) replace the existing barbed wire exclosure with a more permanent type fence, 6) install vehicle barriers and parking areas to keep vehicles at least 30 feet from the waters edge, 7) implement contract for the periodic collection of trash receptacles, 8) install interpretive signs to inform the public of prohibited actions at the site, 9) designate the site as a day use area, 10) withdraw the Ash Springs site from all forms of mineral and agricultural entry.

Condor Canyon is located in Lincoln County Nevada within the Meadow Valley Wash drainage. The aquatic and riparian zone make up the critical habitat for the Federally Threatened Big Spring spinedace, *Lepidomeda mollispinis pratensis.*

Elevation varies from 4,740 feet at the lower end of the canyon to 5,160 feet at the upper mouth of the canyon. Average width and average depth of the creek is 9.2 feet and 0.6 feet respectively. Average stream velocity is 1.2 feet/second. Average stream discharge is 5 cubic feet/second. Average stream gradient is 1.6%. The creek is well confined within steeply rising rock and soil formations, moderately to deeply entrenched by a combination of 10 foot sandy soil - high flow walls and a man made railroad bed. The meander of the creek is restricted due to past construction activities by the railroad.

The "draft" Condor Canyon Habitat Management Plan was written in 1989 and is currently being reviewed by involved Federal, State and public entities. The plan includes objectives designed to enhance quality and quantity of the habitat elements food, water, cover, and space.

Issues and related actions for which the Bureau has authoritive responsibilities and have potential to impact the critical habitat of the spinedace are:

In 1984, the historical Union Pacific Railroad tracks which ran through the canyon were removed. This action left behind the old railroad bed which opened up the canyon to recreationists and vehicle travel. There is a concern due to the potential for impacts resulting from recreationists due to off road vehicle travel and a concern for public safety because of the existing and deteriorating railroad trestles.

There are three mining claims and two oil and gas leases which overlap or are in the vicinity of the critical habitat.

There are four grazing allotments which contain the critical habitat for the Big Spring spinedace.

Objectives and planned actions developed to mitigate any impacts which may occur due to the above mentioned conditions: 1) installation of an educational sign system intended to inform the public of the potential danger associated with the existing railroad trestles and the significance and sensitivity of the Big Spring spinedace and associated habitat, 2) implementation of a "limited" off road vehicle (ORV) designation - organized competitive and non competitive ORV events are not allowed within Condor Canyon and critical habitat. Limit all casual use to existing railroad bed. Limit all organized competitive and non competitive ORV events to existing roads and trails within the surrounding watershed (outside of Condor Canyon), 3) potential impacts resulting from mining and oil/gas activities can be mitigated through the planning stages in consultation with the U.S. Fish and Wildlife Service, 4) allow no more than 20% bank trampling or 50% vegetative utilization, whichever occurs first, on an annual basis and averaged between all stations (key areas) per allotment within the critical habitat, 5) allow no more than 35% bank trampling or 50% vegetative utilization whichever occurs first, on an annual basis per any one station, per allotment within the critical habitat, 6) fence allotment boundaries, 7) prohibit livestock grazing from March 15 through November 15. The 20% bank trampling objective will help to maintain stable stream banks, protect overhanging banks, increase the herbaceous vegetative component which will help to filter out sediment and nutrient (related to livestock and agricultural activities) loading. The restriction to allow grazing to occur only from March 15 through November 15 will help to meet overall habitat objectives in that livestock grazing would occur when aquatic and stream banks are typically frozen and can withstand the presence of livestock.

The implementation of the above two management plans will serve to assure the recovery and continued existence of the Federally listed species and the values related to all living organisms. The continued existence of these species will preserve the niche that they maintain in the ecosystem and perpetuate the ecological balance in that same ecosystem.

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PRESENT STATUS AND CONSERVATION EFFORTS FOR THE HIKO WHITE RIVER SPRINGFISH (*Crenichthys baileyi grandis*)

by

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Abstract

At the time of its proposed listing as an endangered species in 1985, the Hiko White River springfish was restricted, as a confirmed, viable wild population, to a single location at Crystal Spring, Lincoln County, Nevada, numbering probably less than 100 individuals. Since 1985, two additional wild populations have been successfully established, one in historic habitat. In 1989, Blue Link Spring, Nevada, had an estimated population of 8918 springfish, and Hiko Spring, Nevada, 5174 springfish. A population of springfish remain at Crystal Spring, although their exact status is undetermined. Both Hiko and Blue Link Springs have demonstrated the Viability of using laboratory reared fish to re-establish wild populations.

EL ESTADO ACTUAL Y LOS ESFUERZOS PARA PRESERVAR EL SPRINGFISH DEL RIO HIKO BLANCO

Resumen

En el momento de su inscripción propuesta de especie empeligrado en 1.985, el springfish del rio hiko blanco se limitó, como población salvaje confirmado y viable, a un soló sitio llamado Crystal Spring, condado de Lincoln, estado de Nevada. Se contó menos de cién individuos. Desde 1.985, se estableció dos poblaciónes salvajes adicionales, uno en habitat historio. En 1989, el manantial Blue Link, Nevada tuvo población estimada a 8,918 springfish y el manantial Hiko, Nevada una población estimada a 5,174 springfish. Todavía queda una población de springfish en el Manantial Crystal, aunque el estado exacto está indeterminado. Ambos manantiales han demonstrado la viabilidad de usar peces criados en laboratorios para reestablecer poblaciónes salvajes.

PROTECTING NATURAL ECOSYSTEMS: THE STATUS OF THE SAN MARCOS RIVER THREATENED AND ENDANGERED SPECIES

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ABSTRACT

Four species (Gambusia georgei, Etheostoma fonticola, Eurycea nana and Zizania texana) comprise the listed endangered and threatened species inhabiting the upper San Marcos River of central Texas. Eurycea nana and Etheostoma fonticola also inhabit the Comal River headsprings area, although the original Comal River population of E. fonticola was extirpated when the springs at Comal failed during a mid-1950's drought. Although some gains have been made in securing habitat, modifying disruptive land and water-use patterns, and increasing public awareness of the importance of the San Marcos and Comal springs and their unique biota, the problem of maintaining dependable springflows, especially during periods of drought, appears nearly insurmountable given the present nature of Texas water laws and the excessive and uncontrolled use of underground water sources. The populations of two (E. fonticola and E. nana) of the four listed species appear stable, at present. Zizania texana continues to decline in areal coverage. Gambusia georgei, an extremely rare species whose presence has always been difficult to document, may be extinct.

RESUMEN

Cuatro especies (Gambusia georgei, Etheostoma fonticola, Eurycea nana y Zizania texana) en peligro de extinción, habitan la parte alta del Río San Marcos en la parte central de Texas. Eurycea nana y Etheostoma fonticola también habitan el nacimiento del Río Comal, aunque la población original de E. fonticola se acabó al secarse el Río Comal durante la sequía de la década de 1950. Aunque algún progreso se ha hecho en la recuperación del habitat, el uso de la tierra y del agua, el reconocimiento público de la importancia de los Ríos San Marcos y Comal y sus especies, el problema del mantenimiento de corrientes permanentes en esos Ríos, especialmente durante periodos de sequía, parece casi sin solución, debido a las leyes actuales de Texas y al uso exesivo y sin control de las fuentes subterráneas del agua. Las poblaciones de dos de las especies mencionadas (E. fonticola y E. nana) parecen ser estables en el presente. Zizania texana continúa declinando en esta área. Gambusia georgei, una specie extremadamente rara y cuya presencia ha sido siempre difícil de comprobar, puede estar ya extinta.

FISHES OF NORTH AMERICA ENDANGERED, THREATENED, OR OF SPECIAL CONCERN: 1989

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ABSTRACT

We update the American Fisheries Society now decade-old list of rare North American fishes (Deacon et al. 1979). The 1989 list adds 124 new taxa to the list of 251 fishes and removes 26 taxa for an updated total of 349 fishes in Canada, United States and Mexico that warrant protection because of their rarity. The 26 taxa removed from the 1979 list include 15 that now have better information on their taxonomy or status and 11 because they have become extinct. Not a single fish warranted removal from the list because of successful recovery efforts. In addition, 48 fishes have changed in status but remain on the list: seven have improved in status, 22 have declined, and 19 have been reclassified because new information revealed that they were either more common or rarer than was earlier believed and therefore were incorrectly classified in 1979.

Comparison of the 1979 and 1989 lists indicates recovery efforts have been locally effective for some species, but are clearly lagging behind deterioration of the overall continental fish fauna. The health of aquatic habitats continues to decay. A major commitment to conservation of entire ecosystems, rather than the inconsistent recovery efforts for individual species, is needed to reverse this trend.

TROPHIC ECOLOGY OF *Oncorhynchus mykiss nelsoni* EVERMANN, FROM THE SIERRA SAN PEDRO MARTIR, B.C., MEXICO (PISCES, SALMONIDAE)

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ABSTRACT

The trophic ecology of *Oncorhynchus mykiss nelsoni* was studied during an annual cycle (January to December, 1987), in the Arroyo San Rafael, Northwestern from the Sierra San Pedro Mártir, Baja California, México.

A total of 50 food items were systematically recognized for all seasons of the year, which the larvae and pupae of Simuliidae dipterans (24.5 %), and larvaes of trichopterans: Hydropsychidae (24.1 %), Sericostomatidae (22.5 %) and Hydroptilidae (18.6 %) were the most importants prey items according to the Index of Relative Importance.

Significant trophic similarity was found between the autumm and winter trout diet (63.4 %), and also between spring and summer diet (92.6 %). The greater difference was registered for spring and winter trout diet.

The diet composition among size class of trout was different, principally for the $\leq$ 55 and $\geq$126 mm SL size class.

Seasonaly, the relationship between trout mouth size and average prey size consumed were significant for those preys most importants, such as: Hydroptilidae, Simuliidae, Hydropsychidae, Leptophlebiidae, Chironomidae, and Stratiomyidae.

ECOLOGIA ALIMENTICIA DE *Oncorhynchus mykiss nelsoni* EVERMANN, EN LA SIERRA SAN PEDRO MARTIR, B.C., MEXICO (PISCES, SALMONIDAE)

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RESUMEN

Se analizó la ecología trófica de *Oncorhynchus mykiss nelsoni*, durante un ciclo anual (Enero-Diciembre de 1987) en el Arroyo San Rafael, Noroeste de la Sierra San Pedro Mártir, Baja California.

Se reconocieron sistematicamente un total de 50 rubros alimenticios para las cuatro estaciones del año, siendo las presas más importantes de acuerdo al índice de importancia relativa, las larvas y pupas del díptero Simuliidae (24.5%) y larvas de los tricópteros: Hydropsychidae (24.1 %), Sericostomatidae (22.5 %) e Hydroptilidae (18.6 %).

Una significativa similitud trófica fue encontrada para esta trucha en las estaciones de Otoño e Invierno (63.4 %), asimismo entre Primavera y Verano (92.6 %). La mayor disimilitud trófica (22.5 %) fue encontrada durante las estaciones de Primavera e Invierno.

Una marcada diferencia alimenticia a nivel de grupos tallas, fue encontrada para esta subespecie de trucha, siendo más evidente entre los grupos extremos ($\leqslant$55 y $\geqslant$126 mm LP).

A nivel estacional la relación entre tamaño de boca de la trucha, y tamaño promedio de presa consumida fue significativa para aquellos rubros alimenticios más importantes: Hydroptilidae, Simuliidae, Hydropsychidae, Leptophlebiidae, Chironomidae, y Stratiomyidae.

USE OF THE LITTLE SNAKE RIVER IN COLORADO BY ENDANGERED COLORADO SQUAWFISH AND HUMPBACK CHUB.

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ABSTRACT

Colorado squawfish *Ptychocheilus lucius* and suspected humpback chub *Gila cypha*, were collected in the Little Snake River, a tributary of the Yampa River during spring 1988. Two radiotagged Colorado squawfish were located in the Little Snake River during spring runoff in late May and early June. As discharge decreased in June, these fish left the Little Snake River. One large 12 pound fish was later located by the U.S. Fish and Wildlife Service on July 6, 51.8 km downstream in the Yampa River at a spawning area in Dinosaur National Monument. Seven suspected humpback chub and one large, radiotagged Colorado squawfish were captured in trammel nets during May and June; two humpback chub displayed spawning tuberculation. Humpback chub collected in the Little Snake River were morphologically similar to humpback chub collected nearby in Cross Mountain Canyon and Deerlodge Park on the Yampa River in 1980 and 1981 respectively, and "cypha-like" chubs collected in Debeque Canyon on the Colorado River in 1980. Humpback chub from the Little Snake River and those collected from the above areas representing their upstream range did not have the abrupt nuchal hump and fleshy snout found on larger specimens collected from more typical, centrally located habitats like Blackrocks and Westwater Canyon on the Colorado River and Yampa Canyon. This difference in appearance could be due to their relatively small size, phenotypic variation, or hybridization with roundtail chub. Colorado squawfish and humpback chub probably left the Little Snake River as flows decreased since no endangered fishes were collected during baseflow conditions. Therefore, use of the Little Snake River by endangered fishes appeared restricted to the runoff period when higher flows provided habitat suitable for them. However, other large, native fish species , flannelmouth sucker *Catostomus latipinnus*, bluehead sucker *Catostomus discobolus*, and Colorado roundtail chub *Gila robusta robusta* remained in the Little Snake River year-round and used it for spawning and a nursery area. It is recommended that the Little Snake River and other tributaries in the Upper Colorado River Basin be studied to further document the ecology of their fish populations.

ALARM REACTIONS OF SOME SOUTHWESTERN FISHES

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Population reductions and replacements of native by non-native fishes have been frequently recorded. Predation by non-native fishes on the native fishes is a factor in some of these cases. The objective of this study was to examine if native fishes reacted to the odor from injured conspecifics in a similar manner as non-native fishes. This "alarm reaction" is known in a variety of cyprinids and catostomids, but a paucity of information exists for western species. A group of four to six subjects was placed into an aquarium. Horizontal activity of the fish was monitored for 15 minutes and then either a distilled water control or conspecific skin extract was injected into the aquarium. After the injection, horizontal activity was measured for an additional 15 minutes. The red shiner (*Notropis lutrensis*) a non-native cyprinid, showed an alarm reaction as did the native bonytail chub (*Gila elegans*), Colorado squawfish (*Ptychocheilus lucius*), and the razorback sucker (*Xyrauchen texanus*). An alarm reaction was confirmed in the non-native mosquitofish, *Gambusia affinis*, however, preliminary data failed to show an alarm reaction in the Sonoran topminnow, *Poeciliopsis occidentalis*. The possibility of this being a contributing factor in the replacement of Sonoran topminnow by mosquitofish was discussed.

Desert Pond and Marsh Environments Which Minimize Water Demand[1]

T. W. Bilhorn

Abstract

Results of three habitat studies in the Mohave desert at Fort Soda, China Lake and Camp Cady are reviewed with illustrations, displaying the source of water which supplies small ponds, a marsh and a riparian habitat. The areas have some unusual hydrologic conditions which explain their existence and their vulnerability. Expectations of enhancement and permanence are discussed. These examples are presented to aid those involved in resource management to recognize water supply types and the actions which critically effect longevity and water quality.

[1] Studies performed under contracts with the U.S. Department of Interior, Bureau of Land Management, U.S. Navy, China Lake, and the California Department of Fish and Game.

October 16, 1989

The updated status of the Sonoran topminnow (*Poeciliopsis occidentalis*) and desert pupfish (*Cyprinodon macularius*) in Arizona

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ABSTRACT

Sonoran topminnow and desert pupfish, listed as endangered in 1967 and 1986 respectfully, have been the focus of one of the largest reintroduction programs in southwest. While these fish were once considered among the most abundant fish in southern Arizona, they were listed as Endangered Species as a result of population declines related to habitat loss, habitat modifications and predation by non-native fish. Quitobaquito pupfish (*Cyprinodon macularius eremus*) have been stocked into over 15 sites. None of these sites contained fish representing pure Quitobaquito pupfish. The Gila river form of the desert pupfish (*Cyprinodon macularius macularius*) has been stocked into over 18 sites; 4 reintroduced populations remain. 13 sites have been stocked with Yaqui topminnow (*Poeciliopsis occidentalis sonoriensis*), 9 of which were successful. With over 210 sites having been stocked with Gila topminnow (*Poeciliopsis occidentalis occidentalis*), 44 remained in 1987. In 1989 30 of these 44 reintroduced populations remained. However, many of these populations are not likely to persist. Over half of the unsuccessful reintroduction sites were dry. 3 of 11 natural Gila topminnow sites were unsuccessful while 5 of the remaining populations are coexisting with non-native mosquitofish. Future efforts need to focus on renovating non-native fish from natural sites and reintroducing fish into more permanent waters.

Shoshone Pupfish (<u>Cyprinodon</u> <u>nevadensis</u> <u>shoshone</u>)

Propagation Project Final Report

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Shoshone Pupfish (*Cyprinodon nevadensis shoshone*)

Propagation Project Final Report

Thought at one time to be extinct, Shoshone Pupfish (*Cyprinodon nevadensis shoshone*) were rediscovered (Taylor et al. 1988). On May 27 1988, nine of the last remaining Shoshone pupfish were salvaged from altered habitat at Shoshone Spring, Shoshone, California. These pupfish were transferred to our laboratory at the University of California, Davis for propagation and eventual reintroduction (Castleberry et al. [In press]).

We started with nine fish. Three were thought to be females, however, since then one of these three has proven to be male. Another female was collected on November 19, 1988. All fish were large adults. Six of the original ten have died, four males remain. We successfully spawned one of these females and are currently holding over 150 progeny in facilities on the UC Davis campus (see attached appendix, Shoshone Pupfish Population Update at UC Davis).

Our first spawning attempts were modeled after prior success spawning Amargosa pupfish (*C.n. amargosae*). One male and female fish were placed together in an outdoor tank and another pair in an indoor aquarium, fed, and checked for fry daily. These attempts proved fruitless, probably due to the low number of spawning individuals we started with. We switched to a more intensive approach, including attempts to induce spawning.

The first steps taken to induce spawning were to change photoperiod and water temperature. Photoperiod was increased to

16 hours light:8 hours dark and water temperature was increased to 28°C (Shrode and Gerking 1977).

A breeding pair was maintained in a large aquarium (approximately 30 gallons) and were separated by a divider. A yarn mop was put in the aquarium to act as a spawning substrate and the divider removed for approximately 1-2 hours each day to allow spawning to occur. At the end of each spawning period the mop was removed and examined for eggs. If eggs were present the mop was placed into a separate aquarium and the eggs were observed for hatching.

The female pupfish began to spawn almost immediately after the changes in water temperature and photoperiod occurred. She spawned approximately 30 eggs on the yarn mop each day (these numbers may not be absolute because eggs were difficult to find). None of the eggs on the mop hatched and in time they became overgrown with fungus.

A variety of steps were taken to control fungus and determine if eggs were fertilized. The breeding pair was moved to a ten gallon aquarium, where spawning could be closely observed. A divider separated them except during spawning periods. During spawning, the female laid her eggs on the spawning grass and on the bottom of the aquarium. Eggs were transferred to a beaker and maintained at 28°C and kept in suspension by bubbling air. Eggs were treated with methylene blue (2 mg/L) for 12-24 hours to reduce fungus growth (Shrode 1975). We examined eggs several times a day for development and removed dead eggs. Hatching typically occurred four days after spawning.

At the present time we have been able to hatch 173 fry and have had few post-hatch mortalities. However, a large number of eggs are never fertilized. For example, in three spawnings the female spawned 249 eggs, of those only 59 were fertilized. We noticed some improvement after supplementing diets with krill, cladocerans and mosquito larvae. One male (male V) in particular seemed to increase both number of eggs spawned and the fertility rate.

At the present time we have no adult females from the wild. We do have two female progeny (females II and III) that are ready to spawn, but the anal fins on these fish extend to and are joined with their caudal fins. This morphological anomaly causes us to question the wisdom of attempting to spawn these females. We have noticed no similar anomalies on any of the other progeny, although one fish has an extended lower lobe on its caudal fin, giving it a reverse "splittail-like" appearance.

We will need more female pupfish, more fish holding space, and money to support fish care personnel if we are to continue spawning Shoshone pupfish. We suggest that progeny currently held at our facilities be reintroduced to Shoshone Spring at the earliest possible date.

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Shoshone Pupfish Population Update at UC Davis

August 1989

Adults: 4 Males

Juveniles: 173 Progeny

Collections.

5-27-88: Six males and three females were collected by Jack Williams of the United States Fish and Wildlife Service and Betsy Bolster of the California Department of Fish and Game. One female was later recognized as a male when it developed spawning coloration.

11-19-88: One female was collected by Jack Williams of USFWS and Dan Castleberry, Georgina Sato, Larry Brown, and Eric Wikramanayake of the University of California at Davis.

Deaths.

8-3-88: One female and two males died shortly after 5-27-88 collection date.

10-4-88: Female died.

5-25-89: Female I died.

7-21-89: Male IV died.

Spawnings: Female I - Male II: (1 Fry)

4-10-89 2 eggs collected. 1 egg hatched on 4-14-89.

Spawnings: Female I - Male V: (85 Fry)

4-20-89 2 eggs collected. 0 fertilized.

4-21-89 3 eggs collected. 0 fertilized.

4-24-89 9 eggs collected. 4 eggs hatched on 4-28-89. One fry was lost while transfering to a new tank on 5-2-89. 3 fry surviving on 5-15-89.

4-27-89 145 eggs collected. 15 eggs hatched on 5-3-89. 15 fry surviving on 5-15-89.

5-1-89 96 eggs collected. 45 fertilized. 40 eggs hatched on 5-6-89. 38 fry surviving on 5-19-89.

5-3-89 48 eggs collected. 43 fertilized. 31 eggs hatched on 5-8-89 the other 12 eggs were lost. 29 fry surviving on 5-19-89.

Spawnings: Female I - Male I: (0 Fry)

5-4-89 44 eggs collected. 0 fertilized.

5-8-89 58 eggs collected. 0 fertilized.

Spawnings: Female I - Male III: (1 Fry)

5-10-89 11 eggs collected. 0 fertilized.

5-13-89 52 eggs collected. 0 fertilized.

5-15-89 26 eggs collected. 0 fertilized.

5-16-89 23 eggs collected. 0 fertilized.

5-17-89 22 eggs collected. 1 fertilized.

Spawning: Female I - Male V: (43 Fry)

5-19-89: 86 eggs collected. 61 fertilized. 44 hatched on 5-23-89. 5-28-89: 41 surviving fry. 6-1-89: 35 surviving fry.

5-21-89: 23 eggs collected. 20 fertilized. 8 fry surviving.

Spawning: Female II & III - Male I: (0 Fry)

5-18-89: 5 eggs collected. 0 fertilized.

5-19-89: 13 eggs collected. 0 fertilized.

5-21-89: 6 eggs collected. 0 fertilized.

Spawnings: Female I - Male II: (0 fry)

5-24-89: 12 eggs collected. 0 fertilized.

5-25-89: Female I found dead in her tank.

Spawnings: Female II & III - Male V: (41 Fry)

5-24-89: 4 eggs collected. 3 fertilized.

5-25-89: 25 eggs collected. 15 fertilized. 10 eggs hatched on 5-31-89.

5-28-89: 3 eggs collected. 3 fertilized. 3 eggs hatched on 6-3-89.

6-5-89: 55 eggs collected. 40 fertilized. 20 eggs hatch on 6-9-89.

6-8-89: 0 eggs were collected.

6-14-89: 19 eggs were collected. 11 fertilized. Several eggs lost, only 4 remain on 6-16-89. 4 hatch on 6-19-89.

6-21-89: 7 eggs collected. 6 fertilized. 2 eggs developing on 6-26-89.

6-21-89: 12 eggs collected. 0 fertilized.

7-1-89: 0 eggs collected.

7-3-89: 27 eggs collected. 10 fertilized. 1 egg hatches on 7-8-89.

7-12-89: 0 eggs collected.

8-5-89: 3 eggs collected. 3 fertilized. 0 eggs hatch.

NEVADA DEPARTMENT OF WILDLIFE
ENDEMIC FISH PROGRAM

STATUS REPORT - 1989

The Nevada Department of Wildlife's Endemic Fish Program has responsibility for the monitoring, status evaluation, and program coordination for 75 species and sub-species of endemic, non-game fish within the geographic boundaries of the state of Nevada. Currently the program is staffed with one full-time biologist stationed in Las Vegas. The primary concentration of effort at this time has been on the implementation and coordination of Section 6 funded projects for federally listed species, with inventory and evaluation of state-listed sensitive species being conducted on a time-available basis.

Major activities during calendar year 1989 have been as follows, listed by species:

1. Devil's Hole pupfish, _Cyprinodon diabolis_.

Population counts were conducted at Devil's Hole in April and September of 1989. The combined spring dive/surface counts on April 2, 1989, averaged 203 fish. This compares favorably with previous spring counts of 239 (1988), 151 (1987), and 152 (1985). Population counts conducted on 23 September, 1989 generated a combined dive/surface count average of 452. This is comparable to previous fall counts of 525 in 1988 and 441 in 1986.

With the stabilization of the water level in Devil's Hole, numbers of the Devil's Hole pupfish seems to have also stabilized at an annual peak of around 500 fish. Monitoring will be continued twice annually in the spring and fall to minimize disturbance unless evidence is found of increased fluctuation in the population level.

Surface and dive counts were also conducted in spring and fall of 1989 at the Amargosa pupfish refugium in Ash Meadows. 1989 counts were 115 fish on 2 April and 118 fish on 23 September. These are within the range of previous counts over the past two years.

Currently, the Hoover Dam pupfish refugium contains no fish. The existing population of _Cyprinodon diabolis_ was extirpated sometime during the spring of 1989 due to unknown causes. As no trace of the fish were found it is assumed that they expired and were removed from the tank accidentally along with debris. Routine maintenance and repair work has been conducted on the refugium in the interim; as yet no decision has been made as to when and with what species the refugium will be restocked.

2. Pahrump killifish, Empetrychthys latos latos.

Census work was conducted on the three populations of Pahrump killifish at Corn Creek, Spring Mountain Ranch State Park, and Shoshone Ponds Refugium. All populations are stable or increasing. The combined population estimate of killifish at the three sites is approximately 24,800 fish. At the Corn Creek refugium, dense growth of Typhus sp. in the three ponds had completely eliminated open water areas. In September and October of this year USF&WS and NDOW personnel treated the cattails with spray applications of Rodeo herbicide, as previous mechanical treatments had not been effective in controlling the spread of cattails in the ponds. No adverse effects on the killifish were detected from the herbicide treatment. The standing organic material will be burned later this year, hopefully creating a vegetative mosaic in the ponds which will be more conducive to the killifish than the dense stands of Typhus sp., as well as facilitating management activities.

3. Hiko White River springfish, Crenichthys baileyi grandis

Populations were monitored at Hiko, Crystal, and Blue Link Springs. The Hiko and Blue Link populations are stable or expanding; combined population estimates for the two sites are 14,600 springfish. The springfish at Crystal Spring remain at a severely depressed level due primarily to the numbers of exotic fish present in the spring source pools and outflows. Methodology needs to be developed to control numbers of exotics at this site to effect a recovery of the springfish population.

The final report on the study of potential pathogenic bacteria of springfish at Crystal and Hiko Springs by Dr. Richard Heckmann of BYU was completed in April. No known bacterial fish pathogens were detected from sample fish taken at these sites, and only one case of parasitism was detected at Crystal Spring (Anchor Worm). Springfish from these springs evaluated during the study appeared to be in excellent condition.

4. White River springfish, Crenichthys baileyi baileyi

Census work at Ash Spring indicates that the White River springfish population remains at a significantly depressed level due to the presence of exotic species and disturbance by public use. The spring source and head pool area are on public land and recent improvements by the BLM have been effective in eliminating livestock use from the area, reducing exposure of the fish to potential impacts caused by water quality and habitat degradation. Until such a time as the land management agency implements an effective plan to regulate public use at this site, however, impacts will continue due to the high level of public use in the spring source pool.

The outflow from Ash Spring, listed as critical habitat for both the springfish and the Pahranagat roundtail chub Gila robusta jordani, is located on private lands. The segment immediately below the spring source pool is within the boundaries of a resort development which is currently for sale. Depending on the disposition of these lands, significant impacts could occur to this portion of the habitat.

Final recommendations are pending from the Pahranagat River Ecosystem Study, conducted under a NDOW contract by personnel of the US Fish & Wildlife Service, National Fisheries Research Center and NDOW. Efforts to eradicate exotic species from both the spring source and outflows of Ash Spring are anticipated to begin within the next few months upon implementation of the recommendations of this study.

5. Big Springs spinedace, Lepidomeda mollispinis pratensis

Fieldwork began in October of this year on a study to delineate habitat requirements and life history information on the Big Springs spinedace in Condor Canyon, Lincoln County, Nevada. Depending on both initial findings and the continuation of funding, it is hoped that this study will be expanded to allow delineation of additional sites for reintroduction of the spinedace outside of its existing restricted range within the four mile confines of Condor Canyon.

6. Railroad Valley springfish, Crenichthys nevadae

All known populations of Railroad Valley springfish were censused or evaluated during 1989. Populations in Railroad Valley, at Lockes Ranch and Chimney Spring, are stable or expanding. Total estimated numbers at the springs in the Lockes Ranch complex are approximately. 13,000 springfish; A census at Chimney Spring by USF&WS personnel in June gave a population estimate at that site of 836 +- 147 fish. Reconstruction of U.S. Highway 6 through the Big Spring site at Lockes Ranch during the summer of 1989 had the potential to seriously affect the population of springfish at that location. A high degree of cooperation by the Nevada DOT and relevant contractors resulted in the construction project having no adverse impact on the Big Spring springfish population. Recent efforts by the BLM at Chimney Spring to control livestock trespass have had a significant favorable impact on habitat quality at this site.

The population at Big Warm Spring in Duckwater Valley continues to be significantly depressed due to the impacts of public use and development of the commercial catfish farming operation at the site. Isolated introduced populations in Hot Creek Valley and at Sodaville in Mineral County remain at stable levels and have not shown any adverse impacts from development.

7. Ash Meadows System populations

A coordinated study of the Ash Meadows System populations is anticipated to begin in December of this year, implemented under contract with the USF&WS National Fisheries Research Center. In addition to assistance on this project, NDOW personnel will be assisting Ash Meadows NWR personnel in restoration of historic endemic fish habitats within the refuge.

FISH SPECIES OF SPECIAL CONCERN OF CALIFORNIA

by

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Final Report Submitted to
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Department of Fish and Game
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INTRODUCTION

The fish fauna of California is characterized by a high degree of endemism. Sixty-five of the 113 species and subspecies are found only in the state, and many of the remainder are shared only with a few other western states (Moyle et al. 1989). This endemism is the result of long isolation of California's drainage basins, coupled with aquatic environments requiring special adaptations for long-term persistence of fish populations (Moyle 1976). Fish are found in habitats ranging from tiny desert springs, to rivers that have huge fluctuations in flow, to shallow alkaline lakes and sloughs. Although the native fishes are admirably suited for surviving the vagaries of nature, they have done poorly when forced to compete with humans for the water in which they live. In California, most streams have been dammed, diverted, or otherwise altered; many lakes and marshes have been drained; much of the water has been polluted; and numerous fish species have been introduced into both altered and unaltered waters. As a result, five species or subspecies have become extinct in recent years and 16 others have been recognized as threatened or endangered by state or federal governments (Table 1).

Unfortunately, the forms that are formally recognized as extinct, endangered, or threatened are only the most obvious part of the picture. In this report, we describe four species or subspecies and two major runs of salmonids that deserve immediate recognition as threatened or endangered. Forty-four other taxa are described that need special protection because they appear to have seriously declining populations, because they have very limited ranges, or because we know so little about their status. In the latter case, we listed them on the assumption that the lack of information is at least partially a reflection of rarity. Three other taxa described in this report, Sacramento perch, arroyo chub, and Volcano Creek golden trout, would probably deserve listing as threatened or endangered if they had not been widely planted outside their native ranges; we list them because their native populations are still in trouble. Altogether, counting taxa that are extinct, taxa that are already listed as threatened or endangered, and taxa covered in this report, there are 721 species, subspecies, or salmon runs that need special protection or management, 64% of the native freshwater fish taxa! The decline of the native fishes should also be regarded as indicative of the decline of native aquatic habitats and ecosystems, which no doubt contain many poorly known endemic invertebrates and plants as well.

The decline of California's native aquatic organisms will continue and many extinctions will occur unless the widespread nature of the problem is recognized and a systematic effort is made to protect aquatic habitats in all drainages. The task of protecting the native fauna is going to be extraordinarily difficult because California's human population is growing rapidly and the demand for the state's limited water is growing with it. It is nonetheless a task well worth undertaking.

METHODS

The first step in creating this report was compiling the list of California fishes based on Moyle (1976) and more recent literature and knowledge of the authors. For the freshwater fishes the biggest problem faced was the inclusion of forms of uncertain taxonomic status; there are many isolated populations of undescribed fishes around the state whose relationship to described forms is poorly known yet seem to have distinctive morphological or ecological characteristics. Usually,

TABLE 1. Status of native freshwater fishes within the state of California. Fish classified as C1-C4 are species of special concern treated in this report. FE and FT are federally listed endangered and threatened species, respectively. SE and ST are state listed endangered and threatened species, respectively. Extinct species may be either globally extinct or extinct in California.

Petromyzontidae

Kern brook lamprey, *Lampetra hubbsi* (C2)
Pacific lamprey, *Lampetra tridentata*
  Sea-run Pacific lamprey, *L. t. tridentata* (C5)
  Goose Lake lamprey, *L. t.* subsp. (C2)
Pit-Klamath brook lamprey, *Lampetra lethophaga* (C5)
Klamath river lamprey, *Lampetra similis* (C3)
Modoc brook lamprey, *Lampetra folletti* (C3)
River lamprey, *Lampetra ayresi* (C3)
Pacific brook lamprey, *Lampetra pacifica* (C5)

Acipenseridae

White sturgeon, *Acipenser transmontanus* (C5)
Green sturgeon, *Acipenser medirostris* (C5)

Salmonidae

Mountain whitefish, *Prosopium williamsoni* (C5)
Chinook salmon, *Oncorhynchus tshawytscha*[2]
  Spring chinook salmon (C2)
  Winter chinook salmon (C1)
  Fall chinook salmon (C5)
  Late-fall chinook salmon (C5)
Coho salmon, *Oncorhynchus kisutch* (C3)
Pink salmon, *Oncorhynchus gorbuscha* (C2)
Chum salmon, *Oncorhynchus keta* (C5)[3]
Sockeye salmon, *Oncorhynchus nerkes* (C5)[3]
Rainbow trout, *Oncorhynchus mykiss*
  Coastal rainbow trout
    Resident rainbow trout *O. m. gairdneri*[4] (C5)
    Summer steelhead (C1)
    Winter steelhead (C5)
  Eagle Lake rainbow trout, *O. m. aquilarum* (C3)
  Kern River rainbow trout, *O. m. gilberti* (C2)
  Little Kern golden trout, *O. m. whitei* (FT)
  Volcano Creek golden trout, *O. m. aguabonita* (C4)
  Goose Lake redband trout, *O. m.* subsp. (C2)
  McCloud River redband trout, *O. m.* subsp. (C3)
Cutthroat trout, *Oncorhynchus clarki*
  Coastal cutthroat, *O. c. clarki* (C3)
  Lahontan cutthroat, *O. c. henshawi* (FT)
  Paiute cutthroat, *O. c. seleniris* (FT)

Bull trout, *Salvelinus confluentus* (EXTINCT)[4]

Osmeridae

Delta smelt, *Hypomesus transpacificus* (C1)
Longfin smelt, *Spirinchus thaleichthys* (C5)
Eulachon, *Thaleichthys pacificus* (C5)

Cyprinidae

Tui chub, *Gila bicolor*
- Lahontan creek tui chub, *G. b. obesa* (C5)
- Lahontan lake tui chub, *G. b. pectinifer* (C2)
- Mohave tui chub, *G. b. mohavensis* (SE, FE)
- Owens tui chub, *G. b. snyderi* (SE, FE)
- Cowhead Lake tui chub, *G. b. vaccaceps* (C2)
- Goose Lake tui chub, *G. b. thalassina* (C3)
- Eagle Lake tui chub, *G. b.* subsp. (C3)
- High Rock Springs tui chub, *G. b.* subsp. (C2)
- Klamath River tui chub, *G. b. bicolor* (C5)
- Pit River tui chub, *G. b.* subsp. (C5)

Blue chub, *Gila coerulea* (C5)
Arroyo chub, *Gila orcutti* (C4)
Thicktail chub, *Gila crassicauda* (EXTINCT)
Bonytail chub, *Gila elegans* (SE, FE)
Lahontan redside, *Richardsonius egregius* (C5)
Hitch, *Lavinia exilicauda*
- Sacramento hitch, *L. e. exilicauda* (C5)
- Clear Lake hitch, *L. e. chi* (C3)
- Monterey hitch, *L. e. harengus* (C5?)

California roach, *Lavinia symmetricus*
- Sacramento roach, *L. s. symmetricus* (C5)
- San Joaquin roach, *L. s.* subsp. (C3)
- Monterey roach, *L. s. subditus* (C3)
- Navarro roach, *L. s. navarroensis* (C3)
- Tomales roach, *L. s.* subsp. (C3)
- Gualala roach, *L. s. parvipinnis* (C2?)
- Pit roach, *L. s. mitrulus* (C2)

Sacramento blackfish, *Orthodon microlepidotus* (C5)
Sacramento splittail, *Pogonichthys macrolepidotus* (C2)
Clear Lake splittail, *Pogonichthys ciscoides* (EXTINCT)
Hardhead, *Mylopharodon conocephalus* (C3)
Sacramento squawfish, *Ptychocheilus grandis* (C5)
Colorado squawfish, *Ptychocheilus lucius* (SE, FE, EXTINCT)
Speckled dace, *Rhinichthys osculus*
- Amargosa Canyon speckled dace, *R. o.* subsp. (C2)
- Klamath speckled dace, *R. o. klamathensis* (C5)
- Lahontan speckled dace, *R. o. robustus* (C5)

Owens speckled dace, *R. o.* subsp. (C2)
Sacramento speckled dace, *R. o.* subsp. (C5)
Santa Ana speckled dace, *R. o.* subsp. (C1)

Catostomidae
Flannelmouth sucker, *Catostomus latipinnis* (EXTINCT)
Sacramento sucker, *Catostomus occidentalis*
Sacramento sucker, *C. o. occidentalis* (C5)
Goose Lake sucker, *C. o. lacusanserinus* (C3)
Tahoe sucker, *Catostomus tahoensis* (C5)
Owens sucker, *Catostomus fumeiventris* (C3)
Modoc sucker, *Catostomus microps* (SE, FE)
Klamath smallscale sucker, *Catostomus rimiculus* (C5)
Klamath largescale sucker, *Catostomus snyderi* (C2)
Lost River sucker, *Deltistes luxatus* (SE, FE)
Mountain sucker, *Catostomus platyrhynchus* (C3)
Santa Ana sucker, *Catostomus santaanae* (C2)
Razorback sucker, *Xyrauchen texanus* (SE)
Shortnose sucker, *Chasmistes brevirostris* (SE,FE)

Cyprinodontidae
Desert pupfish, *Cyprinodon macularius* (SE,FE)
Amargosa pupfish, *Cyprinodon nevadensis*
Saratoga Springs pupfish, *C. n. nevadensis* (C3)
Amargosa pupfish, *C. n. amargosae* (C3)
Shoshone pupfish, *C. n. shoshone* (C1)
Tecopa pupfish, *C. n. calidae* (EXTINCT)
Owens pupfish, *Cyprinodon radiosus* (SE,FE)
Salt Creek pupfish, *Cyprinodon salinus*
Salt Creek pupfish, *C. s. salinus* (C3)
Cottonball Marsh pupfish, *C. s. milleri* (ST)
California killifish, *Fundulus parvipinnis* (C5)

Atherinidae
Topsmelt, *Atherinops affinis* (C5)[6]

Gasterosteidae
Threespine stickleback, *Gasterosteus aculeatus*
Unarmored threespine stickleback, *G. a. williamsoni* (SE,FE)
Santa Ana threespine stickleback, *G. a. santannae* (C1)
Partially plated threespine stickleback, *G. a. microcephalus* (C5)[7]
Fully plated threespine stickleback, *G. a. aculeatus* (C5)[7]

Centrarchidae
Sacramento perch, *Archoplites interruptus* (C4)

Embiotocidae

Tule perch, *Hysterocarpus traski*
  Sacramento tule perch, *H. t. traski* (C5)
  Russian River tule perch, *H. t. pomo* (C2)
  Clear Lake tule perch, *H. t. lagunae* (C5)
Shiner perch, *Cymatogaster aggregata* (C5)[6]

Mugilidae

Striped mullet, *Mugil cephalus* (C5)[6]

Gobiidae

Tidewater goby, *Eucyclogobius newberryi* (C2)
Longjaw mudsucker, *Gillichthys mirabilis* (C5)[6]

Cottidae

Prickly sculpin, *Cottus asper*[8]
  Coastal prickly sculpin, *C. a.* subsp. (C5)
  Sacramento prickly sculpin, *C. a.* subsp. (C5)
  Clear Lake prickly sculpin, *C. a.* subsp. (C5)
Riffle sculpin, *Cottus gulosus* (C5)
Pit sculpin, *Cottus pitensis* (C5)
Reticulate sculpin, *Cottus perplexus* (C3)
Marbled sculpin, *Cottus klamathensis*
  Upper Klamath marbled sculpin, *C. k. klamathensis* (C5)
  Bigeye marbled sculpin, *C. k. macrops* (C3)
  Lower Klamath marbled sculpin, *C. k. polyporus* (C5)
Paiute sculpin, *Cottus beldingi* (C5)
Coastrange sculpin, *Cottus aleuticus* (C5)
Rough sculpin, *Cottus asperrimus* (ST)
Pacific staghorn sculpin, *Leptocottus armatus* (C5)[6]

Pleuronectidae

Starry flounder, *Platichthys stellatus* (C5)[6]

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[1]*The population of "L. pacifica" from Los Angeles Basin probably represent a distinct species, now extinct (C. Swift, pers. comm.).*

[2]*Chinook salmon have genetically distinct populations (runs) in each major drainage. Probably all wild populations have declined in recent years, but we only list spring run and winter run chinook salmon as Class 1 species.*

[3]*Only strays into California freshwater; probably have never had established populations in California.*

[4]*Like chinook salmon, steelhead have a number of genetically distinct runs in each drainage.*

[5]*Listed as "state endangered," but recent surveys indicate that the bull trout is extinct in California.*

[6]*Marine species common in lower reaches of coastal streams.*

[7]*See Bakker and Svenster (1988) for alternate "subspecies" terminology for sticklebacks. Copeia 1988(2):569-571.*

[8]*Hopkirk (1973) suggested at least three subspecies of prickly sculpin exist in California. The Clear Lake population especially may deserve recognition as it is distinctive ecologically.*

we included undescribed or poorly described forms if they were listed in Hubbs et al. (1979) and one or more other sources, or we had some personal experience in working with them that indicated their distinctness. The poor descriptions and lack of life history information for many subspecies indicate the need for more work on the systematics and biology of widely distributed species with many isolated populations such as tui chub (*Gila bicolor*) and California roach (*Lavinia symmetricus*). The extensive work done on one such species, rainbow trout (*Oncorhynchus mykiss*), demonstrates that many of these populations probably do deserve recognition as distinct taxa (e.g., Berg 1987). The ones listed as undescribed subspecies in this report are only the most obvious of these populations. All taxa described in this report, however, fit the definition of species in the Federal Endangered Species Act of 1973 as "any species, subspecies, or distinct population that interbreeds when mature."

Unless otherwise indicated, descriptions of species are based on Moyle (1976). Fish lengths are reported as total length (TL), fork length (FL), or standard length (SL), although the latter is used wherever possible.

The status of each species described in this report is based solely on the condition of the species within California. Taxa were excluded that were already extinct or listed as endangered or threatened by state or federal agencies. After evaluating the evidence available, the remaining species were placed in five classes according to the likelihood of their becoming extinct in the near future. Class 5 species were considered secure and not included in this report. The classes are as follows:

<u>Class 1 Species (C1)</u>.

These are taxa that seem to conform to the state definitions of the threatened or endangered species and should be added to the official list.

<u>Class 2 Species (C2)</u>.

These taxa have populations that are low, scattered, or highly localized. Their populations have declined in abundance in recent years and so require management to prevent them from becoming threatened species.

<u>Class 3 Species (C3)</u>.

These are uncommon taxa occupying much of their natural range, formerly more abundant, but still with pockets of abundance within their range. These species should be periodically monitored to see if their decline is accelerating. Taxa with very restricted distributions but stable populations are also included here.

<u>Class 4 Species (C4)</u>.

These fishes have declined in abundance within their native range but have been introduced and established in greater numbers outside their native range. Special management is required to prevent loss of native populations.

<u>Class 5 Species (C5)</u>.

These are common or widespread taxa whose populations appear stable or increasing in the face of habitat alterations. However, at least four species in this category need investigation to see if our designation is accurate: green sturgeon, blue chub, Lahontan speckled dace, and mountain whitefish.

The following agency and institution abbreviations are used in this report: AFS (American Fisheries Society), BLM (Bureau of Land Management), CDFG (California Department of Fish and Game), PG&E (Pacific Gas and Electric Company), UCD (University of California, Davis), USFS (United States Forest Service), and USFWS (United States Fish and Wildlife Service).

Species accounts in this report were initially assembled from the literature and files of Moyle and Williams by Wikramanayake. Moyle and Williams determined the status of each taxon, wrote the status and management sections, and revised the species accounts.

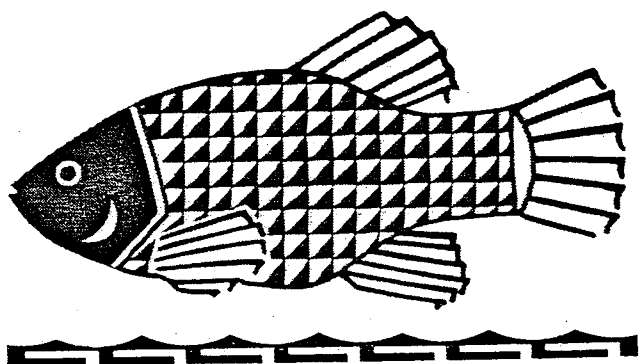
ACKNOWLEDGMENTS

Preparation of this report was aided greatly by the use of unpublished data from various scientists throughout California. In particular we would like to think Donald G. Buth, Tom R. Haglund, and Camm C. Swift for information on southern California fishes; Donald W. Sada for data on speckled dace in the Owens Valley; Don C. Erman on Lahontan fishes; and Eric R. Gerstung for material on numerous salmonids. The following employees of CDFG improved quality of this document through their careful reviews: Betsy C. Bolster, Almo Cordone, Paul P. Chappell, Susan Ellis, Eric R. Gerstung, John M. Hayes, Terry Healey, Frederick Meyer, Edwin P. Pister, Forrest Reynolds, Mike Rode, Donald E. Stevens, and Don W. Weidlein. Financial support was provided by the CDFG through the Endangered and Rare Fish, Wildlife, and plant Species Conservation and Enhancement Account (Income Tax Check-Off). We especially appreciate the assistance of our contracting officer, Betsy C. Bolster. This report was prepared while Jack E. Williams was participating in an Intergovernmental Personnel Act appointment from the U.S. Fish and Wildlife Service. Final editing and manuscript preparation was completed by Shirley H. Cable; illustrations are by T. J. Roehrig.

Desert Fishes Council

CONSEJO DE LOS PECES DEL DESIERTO

"Dedicated to the Preservation of America's Desert Fishes"



21st Annual Desert Fishes Council Meeting

VIGESIMOPRIMER SIMPOSIO ANUAL

APPENDIX

ALBUQUERQUE HILTON HOTEL

ALBUQUERQUE, NEW MEXICO

16-18 NOVIEMBRE, 1989

AGENDA

THURSDAY, NOVEMBER 16.

0700-1200 Registration.

0800 Announcements and introductions.

SESSION I - AGENCY REPORTS. 0810.

SESSION II - PERMITS AND COLLECTING IN MEXICO. 0940.

Chair: Francisco Abarca-Gonzalez, Arizona State University, Tempe.

Secretaría de Relaciónes Exteriores: Monica Belicia and Angelica Narvaez.

Centro Ecológico de Sonora: Lourdes Juárez-Romero.

Universidad Autónoma de Nuevo León: Salvador Contreras-Balderas.

The University of Michigan: Robert Rush Miller.

U.S. Fish and Wildlife Service: Jack Woody.

Arizona Game and Fish Department: Dean Hendrickson.

BREAK FOR LUNCH. 1140-1300.

SESSION III - GENERAL RESEARCH AND MANAGEMENT PAPERS. 1300. (13 papers)

Chair: Linn Montgomery, Northern Arizona University, Flagstaff.

BREAK FOR DINNER. 1730-1900.

SESSION IV - GENERAL RESEARCH AND MANAGEMENT PAPERS. 1900. (5 papers)

Chair: Denise Knight, Utah Division of Wildlife Resources, Salt Lake City.

SESSION V - BUSINESS MEETING. 2040.

FRIDAY, NOVEMBER 17.

SESSION VI - GENERAL RESEARCH AND MANAGEMENT PAPERS. 0800. (11 papers)

Chair: Donna Withers, U.S. Fish and Wildlife Service, Reno, NV.

BREAK FOR LUNCH. 1140-1300.

SESSION VII - GENERAL RESEARCH AND MANAGEMENT PAPERS. 1300. (14 papers)

Chair: Rich Valdez, Bio/West, Inc., Logan, UT

SESSION VIII - BANQUET. 1900.

SATURDAY, NOVEMBER 18.

SESSION IX. FIELD TRIP TO DEXTER NATIONAL FISH HATCHERY. 0630.

1. Management of Truckee River storage to enhance cui-ui spawning. Tom Strekal, Bureau of Reclamation, Carson City, Nevada.

2. Monitoring report on the Little Colorado River population of the humpback chub, 1989. Chuck Minckley, Northern Arizona University, Flagstaff.

3. How many catfishes inhabited the pristine Rio Grande Basin? Robert Rush Miller, University of Michigan, Ann Arbor.

4. The rapid spread of the freshwater hydrobiid snail, Potamopyrgus antipodarum, and its impacts on the native snail fauna of the Middle Snake River, southern Idaho. P.A. Bowler, University of California, Irvine.

   Results of the on-going macroinvertebrate analysis using the biotic condition index in Box Canyon Creek, a large spring in southern Idaho, and the appearance of Potamopyrgus antipodarum in 1989. S. Langenstein and P.A. Bowler, University of California, Irvine.

   The current status of the Bruneau Hot Springs Snail (an undescribed monotypic genus of freshwater hydrobiid snail) and its habitat. P.A. Bowler and P. Olmstead, University of California, Irvine.

5. Mitochondrial DNA assessment of phylogenetic relationships and population status of Gila trout (Oncorhynchus gilae). Brett R. Riddle and Terry L. Yates, University of New Mexico, Albuquerque; and David L. Propst, New Mexico Department of Game and Fish, Santa Fe.

6. Diel food utilization by Virgin River spinedace (Lepidomeda mollispinis mollispinis) and speckled dace (Rhinichthys osculus), in Beaver Dam Wash, Utah. Ted Angradi, Scott Spaulding, and Edward Koch, Idaho State University, Pocatello.

7. Habitat use by Virgin River spinedace (Lepidomeda mollispinis mollispinis), speckled dace (Rhinichthys osculus), and desert suckers (Catostomus clarki) in Beaver Dam Wash, Utah. Scott Spaulding, Edward Koch, and Ted Angradi, Idaho State University, Pocatello.

8. Potential overlap in food habits between spikedace (Meda fulgida) and red shiner (Cyprinella lutrensis). Francisco J. Albarca-Gonzalez, Arizona State University, Tempe.

9. Trophic ecology of Oncorhynchus mykiss nelsoni Evermann, from the Sierra San Pedro Mártir, B.C., México (Pisces, Salmonidae). Patricia Cota-Serrano and Gorgonio Ruiz-Campos, Universidad Autónoma de Baja California, Ensenada.

10.The Pleistocene history of desert climates of Hispaniola. Michael L. Smith, American Museum of Natural History, New York City.

11.The systematics and distribution of *Poecilia sulphurophila*. Carlos M. Rodriguez and Michael L. Smith, American Museum of Natural History, New York City.

12.Management of special status fishes and their ecosystems on public lands--a strategy for the future. Jack E. Williams and Ted E. Cordery, Bureau of Land Management, Washington, D.C. and Phoenix, AZ.

13.Impact of natural perturbations on the recovery of the Gila trout: implications for other southwestern lotic habitats. Paul R. Turner, New Mexico State University, Las Cruces, and David L. Propst, New Mexico Department of Game and Fish, Santa Fe.

14.The updated status of the Sonoran topminnow (*Poeciliopsis occidentalis*) and desert pupfish (*Cyprinodon macularius*) in Arizona. Brian Bagley, Arizona Game and Fish Department, Phoenix.

15.Variation in ribosomal DNA restriction fragments of the cutthroat, redband, and brown trout. Rob Sorenson, Dennis K. Shiozawa, and R. Paul Evans, Brigham Young University, Provo, UT.

16.Alarm reactions of some Southwestern fishes. Stephen P. Vives, Arizona State University, Tempe.

17.Status of Idaho sockeye. Scott Spaulding and Mike Rowe, The Shoshone-Bannock Tribes-Fisheries Department, Fort Hall, Idaho.

18.Protecting natural ecosystems: the status of the San Marcos River threatened and endangered species. Robert J. Edwards, Pan American University, Edinburg, Texas.

19.Hydrology of the Río Santo Domingo, Baja California. Carlos Yruretagoyena, Ensenada, B.C., México.

20.El cariotipo de la trucha Archoiris *Oncorhynchus mykiss nelsoni* de San Pedro Mártir, B.C., México y datos preliminares sobre su variabilidad cromosómica. Carlos Marquez-B. and Ramon Perez-A., Universidad Autónoma de Baja California, Ensenada, B.C., México. Poster presentation.

Biología de la trucha de San Pedro Mártir, B.C. y lineamientos sobre su manejo y conservación. Gorgonio Ruiz-Campos and Carlos Marquez, Universidad Autónoma de Baja California, Ensenada, B.C., México.

21. Fishes of North America endangered, threatened, or of special concern: 1989. James E. Johnson, Jack E. Williams, Dean A. Hendrickson, Salvador Contreras-Balderas, James D. Williams, Miguel Navarro-Mendoza, Don E. McAllister, and James E. Deacon.

22. Morphometric comparisons of *Cyprinodon nevadensis shoshone* and *Cyprinodon nevadensis amargosae*. Fran Taylor, University of Nevada, Las Vegas.

23. Conservation status of threatened fishes in Warner Basin, Oregon. Jack E. Williams, Bureau of Land Management, Washington, D.C.

24. Habitat monitoring and management implications at Ash Springs and Condor Canyon, Nevada, for the White River springfish and Big Spring spinedace. Eddie Guerrero, Bureau of Land Management, Caliente, NV.

25. Systematic relationships of native cutthroat trout (*Oncorhynchus clarki*) of the southern Rocky Mountains. Dwight W. Moore, Emporia State University, Emporia, KS; David J. Hafner, New Mexico Museum Natural History, Albuquerque; Terry L. Yates, University of New Mexico, Albuquerque; and David W. Reduker, Colorado State University, Fort Collins.

26. Block'n shock: sampling spring backwaters for Colorado squawfish. Thomas Nesler, Colorado Division of Wildlife, Fort Collins.

27. Virtual extinction of two undescribed species of *Cyprinodon* from Sandia, Nuevo León, México. Lourdes Lozano-Vilano and Salvador Contreras-Balderas, Universidad Autónoma de Nuevo León, Monterrey, N.L., México.

28. Recovery of Apodaca and Mesquital platyfish, *Xiphophorus* sp., in Nuevo León. Salvador Contreras-Balderas, Universidad Autónoma de Nuevo León, Monterrey, N.L., México.

29. Radiotelemetry of razorback suckers in the Gila River, eastern Arizona. Paul C. Marsh and W.L. Minckley, Arizona State University, Tempe.

30. The effect of biotic interaction on structure of a Great Basin stream fish assemblage: an experimental approach. D.W. Sada and G.L. Vinyard, University of Nevada, Reno.

31. Genetic diversity in subdivided populations. Bill Berg and D.K. Duncan, University of California, Davis.

32. Potential impact of a fish barrier on native fishes. Caryl Mary Williams, Arizona State University, Tempe.

33. Culturing the natives. Arcadio Valdez-Gonzales, Universidad Autónoma de Nuevo León, Monterrey, N.L., México.

34. Exotic fishes data base: monitoring the status and distribution of alien fishes. Jim Williams and Dawn Jennings, U.S. Fish and Wildlife Service, Gainesville, FL.

35. Genetic diversity and competitive interaction among sexually and clonally reproducing forms of Poeciliopsis. Robert C. Vrijenhoek, Center for Theoretical and Applied Genetics, Rutgers University, New Brunswick, New Jersey.

36. Use of video image analysis in endangered species research, and analysis of sexual dimorphism in Gila cypha. Michael Douglas, Arizona State University, Tempe.

37. Use of Little Snake River in Colorado by endangered Colorado squawfish and humpback chub: a range extension. Ed Wick, John Hawkins, and Tom Nesler, Colorado State University, Fort Collins.

38. Population estimates of razorback suckers in Lake Mohave. Paul C. Marsh and W.L. Minckley, Arizona State University, Tempe.

39. Present status and conservation efforts for the Hiko White River springfish, Crenichthys baileyi grandis. Jon C. Sjoberg, Nevada Department of Wildlife, Las Vegas.

40. Preliminary biochemical analysis of hybridization among native and nonnative trout in Arizona. Tom Dowling and Mike Childs, Arizona State University, Tempe.

41. Wetland use by fishes in the arid Southwest. Gary K. Meffe, Savannah River Ecology Lab. (Univ. Georgia), Aiken, SC.

42. Fishes of the Ríos Mayo and Fuerte Basins, Sonora and Sinaloa, Mexico. Alejandro Varela-Romero, José Campoy-Favela, and Lourdes Juárez-Romero, Centro Ecológico de Sonora, Hermosillo, Sonora, México.

43. Relationships in the Gila robusta complex. Don Buth, University of California, Los Angeles; W.L. Minckley, Arizona State University, Tempe; and Rick L. Mayden, University of Alabama, Tuscaloosa.

44. Population structure in Catostomus plebeius: are there two or three species in this complex? Don Buth, T.R. Haglund, and D.H. Moon, University of California, Los Angeles.

45. Evaluación de la calidad del agua del Río Sonora, México, a través del estudio de macroinvertebrados bentónicos y peces. Carlos Chávez-Toledo, Julio C. Rodríquez, and Elvira Rojero-Díaz, Escuela Superior de Ecología, Hermosillo, Sonora, México.

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. Box 337
Bishop, CA 93514
(619) 872-8751

May 2, 1990

TO: All interested parties

FROM: Executive Committee, Desert Fishes Council

SUBJECT: Items of deep concern to the Desert Fishes Council and the preservation of biodiversity in the Southwest

The Desert Fishes Council is an international organization of more than 500 aquatic scientists and resource managers dedicated to the preservation of North America's desert aquatic ecosystems.

At the Council's 21st Annual Symposium, held in 1989 in Albuquerque, New Mexico, discussion was held concerning a variety of issues of environmental concern throughout North America, with an emphasis on the Southwest. Resolution were drafted concerning several issues, and copies are enclosed as appropriate.

We trust that you will give serious attention to these matters, as we have.

Sincerely,

Edwin P. Pister
Executive Secretary

NOTE

These resolutions were formulated and passed at the Council's November 16, 1989 business meeting. However, an administrative error resulted in a delay in their dissemination. We trust that this will not decrease the attention given them.

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

Desert Fishes Council
P. O. Box 337
Bishop, California 93514
(619) 872-8751

89-1

RESOLUTION REGARDING THE INTRODUCTION OF RAINBOW SMELT

WHEREAS The Colorado River is occupied by a suite of unique native fishes, many of which are imperiled and thus recognized as endangered, threatened, or of special concern, and

WHEREAS Interaction(s) with introduced, non-native fishes is(are) widely regarded as contributory to declines of native kinds, and

WHEREAS Recovery plans for big-river fishes of the Colorado River system (bonytail chub, humpback chub, and Colorado squawfish) all itemize curtailment or elimination of stockings of non-native fishes among recovery activities, and

WHEREAS The State of Utah proposes introduction of non-native rainbow smelt as forage in an attempt to enhance a population of non-native striped bass in Lake Powell, a Colorado River reservoir, and

WHEREAS Rainbow smelt would pose a serious potential threat to native fishes known to dwell there and in confluent waters of Arizona, California, Colorado, New Mexico, Nevada, and Utah, and to recovery of these fishes, and

WHEREAS Potential effects of non-native rainbow smelt on the non-native striped bass fishery in Lake Powell are unknown and speculative, now therefore

BE IT RESOLVED

by the Desert Fishes Council at its twenty-first annual meeting on 16 November 1989 at Albuquerque, New Mexico, that

The State of Utah forgo the stocking of rainbow smelt into waters of the Colorado RIver system, and

BE IT FURTHER RESOLVED that

The State of Utah be encouraged to design and implement fisheries management strategies consistent with conservation of native fish resources of the Region, and

BE IT FURTHER RESOLVED that

copies of this resolution be sent to Regional Directors of the U.S. Fish and Wildlife Service in Denver, Albuquerque, and Portland; Regional Directors of the U.S. Bureau of Reclamation in Boulder City and Salt Lake City; Regional Director of the U.S. National Park Service; Directors of Arizona, California, Colorado, New Mexico, Nevada, and Utah departments of wildlife; Bonytail chub, Humpback chub, and Colorado squawfish Recovery teams; and participants in the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin.

Passed without dissenting vote.

Attest:

Edwin P. Pister
Executive Secretary

6 April 1990

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. Box 337
Bishop, CA 93514
(619) 872-8751

May 2, 1990

89-2

Resolution Requesting Recovery Plan Update and Approval

WHEREAS the 1973 Endangered Species Act, as amended, requires the Secretary of the Interior to prepare Recovery Plans which quantify requirements necessary to enhance and protect threatened and endangered species so they may be removed from the U.S. Fish and Wildlife Service List of Threatened and Endangered Species, and

WHEREAS State and Federal management, habitat acquisition, and research for recovery of threatened and endangered species cannot be implemented without guidance from Recovery Plans, and

WHEREAS Recovery Plans for at least 16 species of fishes in North American Deserts (including Lahontan cutthroat trout, spikedace, Yaqui catfish, Big Spring spinedace, Sonoran chub, Owens tui chub, Warner sucker, White River spinedace, Railroad Valley springfish, Devils Hole pupfish, Ash Meadows pupfish, Ash Meadows Amargosa pupfish, Ash Meadows speckled dace, Yaqui chub, and loach minnow) have been drafted but not approved by the U.S. Fish and Wildlife Service, and

WHEREAS many of these drafted and other approved plans must be revised or updated in order to accurately describe management accomplishments and changing priorities in recovery efforts,

NOW THEREFORE BE IT RESOLVED that the Desert Fishes Council at its 21st annual meeting in Albuquerque New Mexico on November 16, 1989 requests the U.S. Fish and Wildlife Service to give highest priority to revision, update, approval, and printing and distribution of Recovery Plans, and

BE IT FURTHER RESOLVED that the Desert Fishes Council be provided a schedule showing when currently drafted plans for fishes in North American Deserts will be approved and/or revised.

Copies of this resoulution be sent to:

Director
U.S. Fish and Wildlife Service
U.S. Department of the Interior
Washington, D.C. 20240

Regional Director
U.S. Fish and Wildlife Service
500 NE Multnomah St., Suite 1692
Portland, OR 97232

Michael Spear, Regional Director
U.S. Fish and Wildlife Service
500 Gold Ave., SW
P.O. Box 1306
Albuquerque, NM 87103

Galen Buterbaugh, Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486, Denver Federal Center
Denver, CO 80225

Passed without dissenting vote.

Attest:

Edwin P. Pister
Executive Secretary
2 May 1990

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"
P.O. Box 337
Bishop, CA 93514 (619) 872-8751
May 2, 1990

89-3

Resolution Regarding The Ash Meadows National Wildlife Refuge

Whereas The Desert Fishes Council played a major role in the establishment of The Ash Meadows National Wildlife Refuge and has a continuing interest in promoting the development of management policies compatible with the purposes for which it was established, and

Whereas The Nature Conservancy purchased Ash Meadows, and later sold the area to the U. S Fish and Wildlife Service as a means of providing protection for the unique ecosystem so that it could continue to sustain the numerous endemic species occuring there, and

Whereas The management and staff of the Ash Meadows National Wildlife Refuge, in the face of considerable local misunderstanding, have consistently demonstrated their understanding of the primary purposes for which the refuge was created, and

Whereas The U. S. Fish and Wildlife Service negotiated an agreement with Nye County to develop a paved, primary County road along the south border of the Refuge, recognizing that through traffic across the refuge would be incompatible with the primary purposes of the refuge and would jeopordize the continued existence of some endangered species living there, and

Whereas Largemouth bass are known to jeopardize survival of endangered pupfish and speckled dace living on the Refuge, and

Whereas Interconnected springs, streams and marshes must be maintained on the Ash Meadows National Wildlife Refuge to provide for the continued survival and evolution of the endemic species, now therefore, BE IT RESOLVED by the Desert Fishes Council at its twenty first annual meeting at Albuquerque, New Mexico on 16 November 1989 that:

the Desert Fishes Council considers the following to be inconsistent with the purposes for which the Refuge was established, and to jeopardize the continued existence and adversely modify Critical Habitat of many listed endangered and threatened species in Ash Meadows:

1. construction or maintainance of roads on the Refuge for purposes other than refuge management (specifically in the present instance, of a road to accomodate through traffic between the communities of Amargosa and Pahrump).
2. maintainence of largemouth bass or any other sport fish on the Refuge
3. grazing by domestic livestock or by feral horses or burros, and

BE IT FURTHER RESOLVED that
the U. S. Fish and Wildlife Service is urged to immediately begin the process of eliminating all sport fish from the Refuge, to enforce a no-fishing policy on the refuge, to act on the draft recovery plan that has been available to the Portland Regional Office for about two years, to take all steps necessary to insure that paved roads or "improved" roads are not built on the refuge, and to inform the Desert Fishes Council at the earliest opportunity of the steps being taken to accomplish these goals, and

BE IT FURTHER RESOLVED that
the Desert Fishes Council continues to believe that, unless evidence begins to suggest otherwise, hunting and other limited recreational uses can be conducted in ways that do not jeopardize the continued existence and evolutionary development of the unique biota on the Ash Meadows National Wildlife Refuge, and

BE IT FURTHER RESOLVED that
copies of this resolution be forwarded to:
The Ash Meadows National Wildlife Refuge,
The Portland Regional Office of the U.S. Fish and Wildlife Service,
The Director of the U.S. Fish and Wildlife Service,
The Director of the Nevada Department of Wildlife,
The Great Basin Office of The Nature Conservancy,
The Sierra Club Legal Defense Fund,
The Environmental Defense Fund,
The Natural Resources Defense Council,
The National Wildlife Federation,
The Nye County Commission,
The Pahrump Valley Times,
The Death Valley Gateway Gazette
The Director, Bureau of Land Management,
The Nevada State Director, Bureau of Land Management,
The Las Vegas District Manager, Bureau of Land Management.

Passed without dissenting vote.

Attest:

Edwin P. Pister
Executive Secretary

2 May, 1990

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. Box 337
Bishop, CA 93514
(619) 872-8751

May 2, 1990

89-4

RESOLUTION REGARDING THE VIRGIN RIVER ECOSYSTEM

Whereas The survival probabilities of the endangered woundfin and Virgin roundtail chub have been dramatically reduced over the past few years and continue to deteriorate, and

Whereas Responses by the Woundfin Recovery Team to the complex and difficult problems on the Virgin River appear unable to reverse the trend toward extinction of these two species and deterioration of the ecosystem, and

Whereas An attempt to remove the red shiner from a portion of the Virgin River resulted instead in near extirpation of woundfin, Virgin roundtail, and other native fishes in the Arizona and Nevada reaches of Virgin River, and

Whereas Plans were made to stock hatchery-produced Virgin roundtail without following American Fisheries Society Guidelines for introductions of native fishes or examining the genetic integrity of the fish to be planted, and

Whereas The U. S. Fish and Wildlife Service is responsible for establishing programs for preventing extinction of freshwater fishes in the United States, now therefore

BE IT RESOLVED

by the Desert Fishes Council at its twenty-first annual meeting on 16 November 1989 at Albuquerque, New Mexico, that

the U. S. Fish and Wildlife Service be asked to immediately allocate time and funding for a Virgin River Ecosystem Recovery Team, and

BE IT FURTHER RESOLVED that

a newly constituted Virgin River Ecosystem Recovery Team be directed to immediately develop and promote implementation of a recovery plan for the ecosystem, and

BE IT FURTHER RESOLVED that

copies of this resolution be sent to the Director of the U.S. Fish and Wildlife Service, Regional Directors of the U.S. Fish and Wildlife Service in Denver, Albuquerque and Portland, Directors of Utah, Arizona and Nevada Departments of Wildlife, the Washington County Water Conservancy District, and to the Woundfin Recovery Team.

Passed without dissenting vote.

Attest:

Edwin P. Pister
Executive Secretary
2 May 1990

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. Box 337
Bishop, CA 93514 (619) 872-8751

May 2, 1990

89-5

Relative to the Protection of the Bruneau Hot Springs Snail and the Hot Creek Ecosystem

WHEREAS The Bruneau Hot Springs Snail is a species endemic to Hot Creek and adjacent thermal seeps along the Bruneau River in southern Idaho, and

WHEREAS water levels in the aquifer fed spring source of Hot Creek and the seeps has been declining dramatically such that the primary seep habitat in the Indian Bathtub is now dry during hot summer months, thus rendering it unusable as snail habitat, and the Hot Creek streambed has been filled with sediment from a flash flood, so that habitat is rapidly being lost and snail population numbers are dwindling, and

WHEREAS urgent action is needed to prevent any further losses of habitat for the snail and other species dependent upon this site, such as the endemic _Ambrysus mormon minor_, now therefore be it

RESOLVED that the Desert Fishes Council urges the Idaho Water Resources Board to immediately designate the area as Critical Groundwater Management Area and afford the site the protection that designation conveys, and be it further

RESOLVED that the U.S. Fish and Wildlife Service be urged to do _everything_ in its power to prevent any further habitat loss or the extinction of the clearly endangered species at this site, and that the funding for research and preservation be clearly explained, including what is hoped to be gained from the expenditures, and be it further

RESOLVED that copies of this resolution be forwarded to the Regional Director of the U.S. Fish and Wildlife Service; Idaho State Director of the Bureau of Land Management to the Idaho Water Resources Board; to the Governor of the State of Idaho; to the Idaho Department of Fish and Game; and to the Idaho Natural Heritage Program.

PASSED WITHOUT DISSENTING VOTE

Attest

Edwin P. Pister
Executive Secretary

LIBRARY

UNIVERSITY OF NEVADA, LAS VEGAS
4505 MARYLAND PARKWAY • LAS VEGAS, NEVADA 89154 • (702) 739-3286

November 14, 1989

TO: Phil Pister, Executive Secretary, Desert Fishes Council

FROM: Mary Dale Deacon, Dean of Libraries MDD

RE: Proposal to Create a Desert Fishes Council Archive at the James R. Dickinson Library, University of Nevada, Las Vegas

Now that the Desert Fishes Council has reached the age of consent (21 years in most places), I am respectfully requesting that this august organization consider placing its records under the auspices of the James R. Dickinson Library where these materials will be preserved for posterity. Specifically, the Desert Fishes Council archive would be housed in the Special Collections Department of the library. While the records would not circulate outside of the library, they would be available to anyone who might have use of them. Portions of the collection could be copied in our Copy Service for patrons who need the material for extended research.

Our library already has extensive collections of materials pertaining to arid environments, endangered species and water rights. The holdings are especially strong for the Great Basin and Mojave desert regions. While we know that the work of the Desert Fishes Council also encompasses the arid regions of Mexico, Arizona, and New Mexico, we believe that our facility would be a logical place for the archive because of the early (and ongoing) work done by the Council.

For your consideration, our Head of Special Collections has developed general archival guidelines which I am listing below:

> RE: Archival Guidelines for the Desert Fishes Council
>
> Generally speaking, archives are non-current records of permanent value. Value is determined by considerations such as their administrative, legal, fiscal, and historical research potential. Materials selected for permanent retention should be those which best document the growth, development, and activities of the organization. Such materials would include correspondence, reports, accounts, photographs, publications, and administrative records such as membership lists and minutes.

The major group of records desired for the archive would be those which document the "big picture," such as annual reports and runs of official publications. Correspondence is a gray area since much in a file may not be of permanent value, but standard archival practice is to retain all correspondence. Scrap books and such compilations, while not official documents, do record the activities of the organization and are retained.

Permanent retention is the goal of an archive. To limit the amount of material retained, standard practice is to weed out intermediate paperwork and items which contain information which is summarized at a higher level. An example of the first principle would be rough drafts and intermediate reports used to compile a final report. In this case only the final report would be retained. Similarly, if an annual membership list is compiled it is not necessary to keep every individual membership application.

After having been told this, members of an organization inevitably have many questions on specific doucments. The library staff would like to have the Council agree to let us recommend what should be retained for the archive. Otherwise the Council might decide that an item is not worthy of being kept which we would see as having research potential. On the other hand, there may be instances in which the Council will want something retained which we see no use for. In the interests of diplomacy we would keep it, of course.

Should the Desert Fishes Council decide to accept this proposal, David Robrock, Head of Special Collections would be the contact person. He can be reached at (702)739-3252.

MDD:dne

cc: David Robrock

SUCCESSION OF CHAIR, DESERT FISHES COUNCIL

	Nominated in	Assumed office in
Phil Pister	November, 1969	November, 1969
J. A. St. Amant	November, 1970	November, 1972
Robert Rush Miller	November, 1972	November, 1974
James E. Deacon	November, 1974	November, 1976
Peter G. Sanchez	November, 1976	November, 1978
James E. Johnson	November, 1978	November, 1980
Salvador Contreras-Balderas	November, 1980	November, 1982
W. L. Minckley	November, 1982	November, 1984
Gail C. Kobetich	November, 1984	November, 1986
Paul B. Holden	November, 1986	November, 1988
Jack E. Williams	November, 1988	November, 1990
John Rinne	1991	1992
[illegible]	1993	1994
Mike Douglas	1995	1996
Gary Garrett	1997	1998

STUDENT PAPER AWARDS

CARL L. HUBBS AWARD (Best paper given by a student at annual symposium)

1986 Diana Papoulias, Arizona State University

1987 Francisco Abarca-Gonzalez, Arizona State University

1988 Joe Quattro, Rutgers University

1989 Brett Riddle, University of New Mexico

1990 Isabel Montes-Pérez, Universidad Autónoma de Baja California (Ensenada)

FRANCES HUBBS MILLER AWARD (Best paper given by a Mexican student at annual symposium)

1987 Carlos Chávez-Toledo, Escuela Superior de Ecología, Hermosillo

1988 No entrant

1989 Francisco Abarca-Gonzalez, Arizona State University

1990 Manuel M. Villalobos-Ramirez, Universidad Autónoma de Baja California (Ensenada)

List #1

Lastname	Firstname	City	State
Abarca	Francisco and Gabriela	Scottsdale	AZ
Aitkin	Kevin	Phoenix	AZ
Allendorf	Fred W.	Washington	DC
Altenbach	Chris	Albuquerque	NM
Anderson	Susan	Tucson	AZ
Angradi	Ted	Pocatello	ID
Archer	Donald L.	Salt Lake City	UT
Armantrout	Neil B.	Eugene	OR
Bagley	Brian	Phoenix	AZ
Bauman	Chris Clay	Cedar Crest	NM
Behnke	Robert	Ft. Collins	CO
Bennett	Jim	Denver	CO
Berg	Bill	Davis	CA
Beyers	Dan	Ft Collins	CO
Bianchi	Ed	Tiburon	CA
Bilhorn	Thomas W.	San Diego	CA
Bisson	Henri	Phoenix	AZ
Bolster	Betsy	Rancho Cordova	CA
Bowler	Peter	Irvine	CA
Brady	Mark	Ft. Collins	CO
Brittan	Martin R.	Folsom	CA
Burke	Tom	Boulder City	NV
Burr	Brooks M.	Carbondale	IL
Burton	Jerry	Albuquerque	NM
Buth	Don	Los Angeles	CA
Campoy Favela	Jose R.	Hermosillo	Sonora, Mexico
Chambers	Steven M.	Albuquerque	NM
Chart	Tom	Price	Utah
Chavez-Toedo	Carlos	Hermosillo	Sonora, Mexico
Childs	Mike R.	Phoenix	AZ
Clark	Norm	Tempe	AZ
Cobble	Kevin	Douglas	AZ
Conner	Patrick	Ft Worth	TX
Cooper	~~USFS~~ Jim	Albuquerque	NM
Cordery	Ted	Phoenix	AZ
Cordery	Ted	Phoenix	AZ
Counihan	Timothy D.	Las Cruces	NM
Crist	Larry	Logan	UT
Crouse	Mike	Portland	OR
DeMarais	Alyce and Bruce	Tempe	AZ
Deacon	James E.	Las Vegas	NV
Divine	George	Albuquerque	NM
Douglas	Michael	Tempe	AZ
Dowling	Tom	Tempe	AZ
Edwards	Bob	Edinburg	TX
Elder	Howard	Las Cruces	NM
Ellis	Susan	Rancho Cordova	CA
Evans	R. Paul	Provo	UT
Ferjanin	Ken	Port Orchard	WA
Fore	Paul L.	Albuquerque	NM
Foster & Mary Leb	Bob	Ronceverte	WV
Fowler-Propst	Jennifer	Albuquerque	NM
Glowienka	Dennis	Canon City	CO
Guerrero	Eddie	Caliente	NV
Gustafson	Eric S.	Las Vegas	NV
Haglund	Thomas R.	Los Angeles	CA
Hales	Don	Dexter	NM
Hanlon	John	Laguna Niguel	CA

Lastname	Firstname	City	State
Harris	Reed	Salt Lake City	UT
Hatch	Michael	Santa Fe	NM
Hawkins	John	Ft. Collins	CO
Hendrickson	Dean	Phoenix	AZ
Hiebert	Steve	Denver	CO
Holden	Paul	Logan	UT
Hubbs	Clark	Austin	TX
Jacks	Stewart	San Carlos	AZ
Jakle	Marty	Scottsdale	AZ
Jensen	Buddy	Dexter	NM
Johnson	Jim	Fayetteville	AR
Juarez-Romero	Lourdes	Hermosillo	Sonora, Mexico
Kelsch	Steven W.	Portales	NM
Kepner	William G.	Phoenix	AZ
Knapp	Mary	Taos	NM
Knight	Denise	Salt Lake City	UT
Kobetich	Gail C.	Citrus Heights	CA
Koch	Ted	Pocatello	ID
Kodni-Brown	Astrid	Albuquerque	NM
Lane	Dave	Nanaimo	BC Canada
Langenstein	Steve	Shoshone	ID
Leibfried	Bill	Flagstaff	AZ
Leonard	Mike	Prescott	AZ
Liess	Bill	Albuquerque	NM
Loiselle	Paul V.	Brooklyn	NY
Lorentzen	Ed	Sacramento	CA
Love	Bob	Yorba Linda	CA
Lucas	Lauren	Laramie	WY
M. Isabel Montes P.		Ensenada	BC, Mexico
Marsh	Paul C.	Tempe	AZ
Martin	Larry	Pahrump	NV
Masslich	Bill	Logan	UT
McAda	Chuck	Clifton	CO
McKay	Tom	Price	UT
McNatt	Randy	Reno	NV
Meffe	Gary K.	Aiken	SC
Miller	Robert Rush	Ann Arbor	MI
Minckley	W.L.	Tempe	AZ
Montgomery	Linn	Flagstaff	AZ
Muth	Robert	Ft. Collins	CO
Navarre	Dick	Reno	NV
Norton	Nancy	Dallas	TX
Oakley	David D.	Tempe	AZ
Osmundson	Doug	Grand Junction	CO
Parmenter	Steve	Bishop	CA
Pease	Chris S.	Santa Fe	NM
Peden	Alex	Victoria	BC, Canada
Pister	Phil	Bishop	CA
Prats	Erika	Phoenix	AZ
President		Tempe	AZ
Propst	David L.	Santa Fe	NM
Reddle	Brett	Albuquerque	NM
Riggs	Alan	Lakewood	CO
Rodriguez	Carlos	New York	NY
Rodriguez	Julio C.	Hermosillo	Sonora, Mexico
Roy	Richard	Albuquerque	NM
Ruiz-Campos	Gorgonio	Ensenada	BC, Mexico
Russi	Terry L.	Bishop	CA
Sada	Don	Bishop	CA

Lastname	Firstname	City	State
Schmidt	Konrad	St. Paul	MN
Shiozawa	Dennis K.	Provo	UT
Shull	Alisa	Ft Worth	TX
Sjoberg	Jon C.	Las Vegas	NV
Smith	Diann	Phoenix	AZ
Smith	Michael	New York	NY
Snelson	F.F.	Orlando	FL
Springer	Craig	University Park	NM
Starnes	Wayne	Washington	DC
Stefferud	Jerry	Phoenix	AZ
Stefferud	Sally	Phoenix	AZ
Storch	Donna	Taos	NM
Strekal	Tom	Carson City	NM
Stroh	Terence L.	Zuni	NM
Stuart	James N.	Albuquerque	NM
Stuart	Leon	Pinetop	AZ
Stumpff	Bill	Albuquerque	NM
Tharalson	Teresa	Chandler	AZ
Thomas	Andy	Albuquerque	NM
Threloff	Douglas L.	Pahrump	NV
Timmons	Ross	Tempe	AZ
Turner	Paul	Las Cruces	NM
Valdes	Arcadio	San Nicolas de los Garza	N.L., Mexico
Valles Rios	Martha E.	Ensenada	BC, Mexico
Vives	Stephen	Tempe	AZ
Vrijenhoek	Bob	New Brunswick	NJ
Ward	John H.	Tempe	AZ
Warren	Peter	Tucson	AZ
Whitney	Jeff	Prescott Valley	AZ
Wick	Edmund	Ft. Collins	CO
Williams	Bob	Salt Lake City	UT
Williams	Caryl	Tempe	AZ
Williams	Jack E.	Washington	DC
Williams	James D.	Gainesville	FL
Williams	Mark	Salida	CO
Williams	Rick	Boise	ID
Wilson	Bob	Santa Fe	NM
Yess	Scott	Parker	AZ
Young	Doug	Salt Lake City	UT
Yruretagoyena	Carlos	Chula Vista	CA
Zuckerman	Larry	Pratt	KS