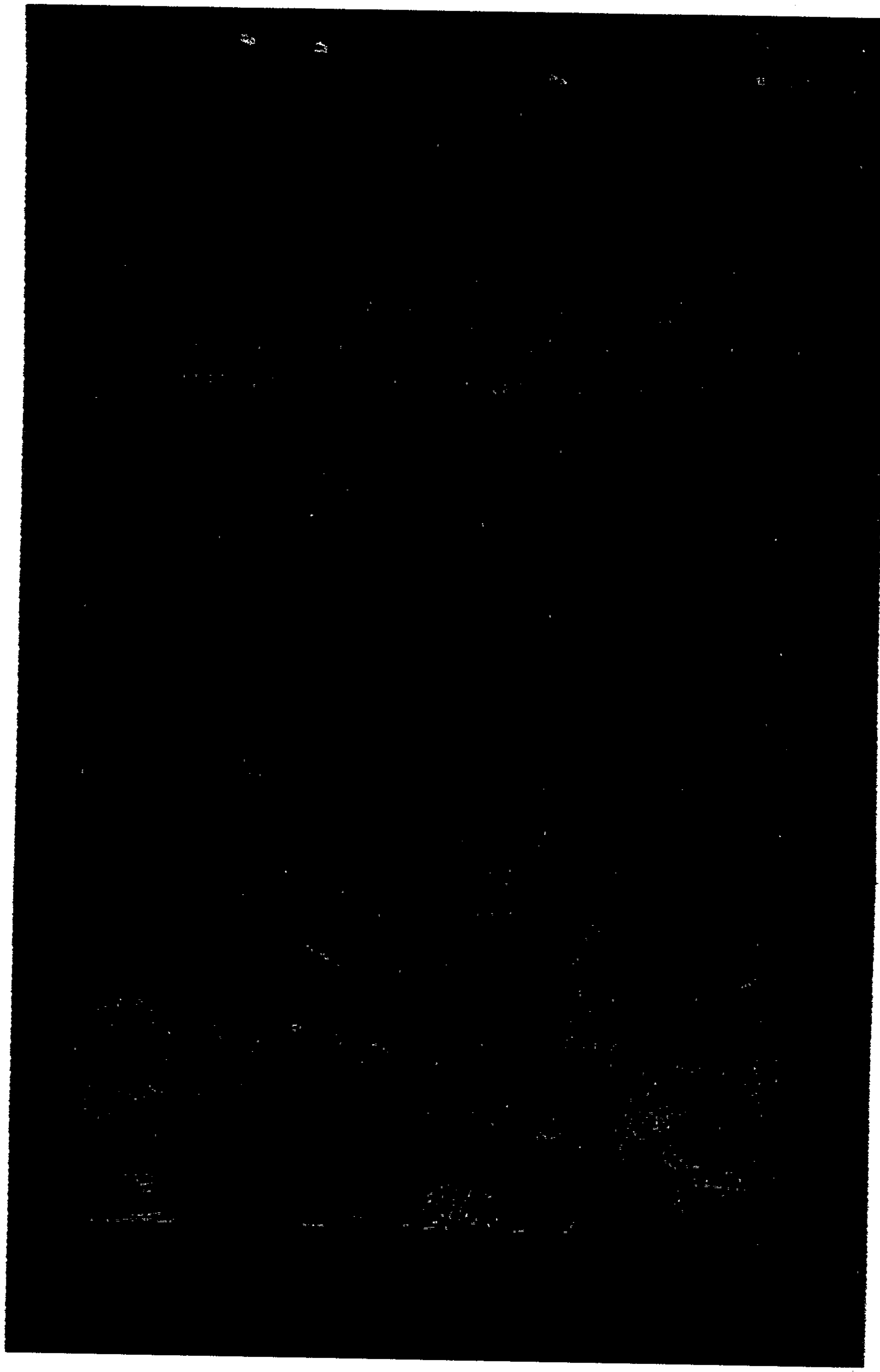

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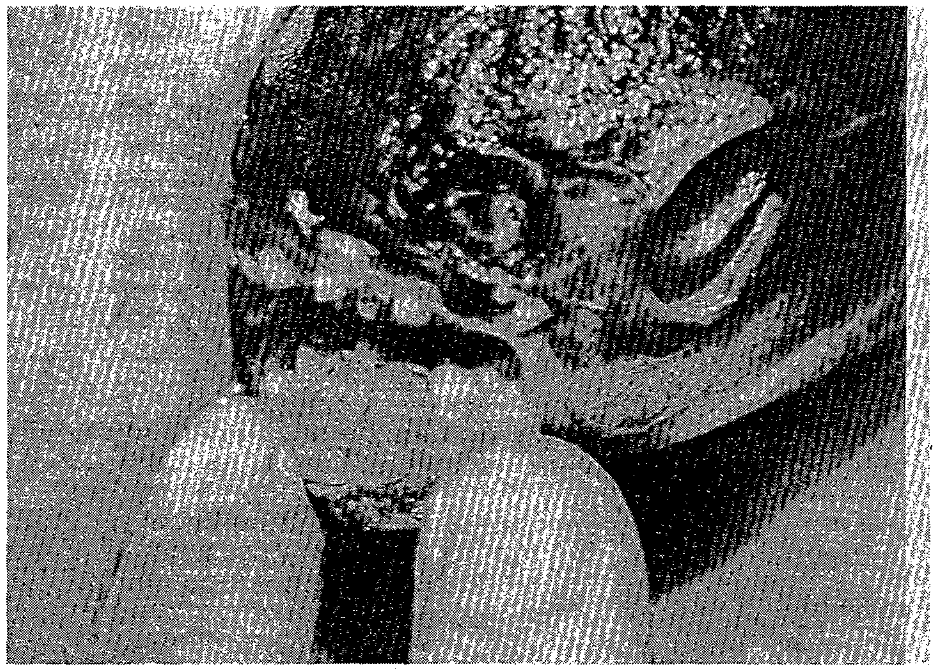

Figure 3. Lower dentition of pacu. *Photograph by Martin R. Brittan.*

The original descriptions of the six nominal species, mostly dating from the early and middle 19th century, are sketchy and based on one or only a few specimens. There have been no recent revisions of the genus and scientific specimens are few, although *Colossoma* are common food fishes in tropical fresh waters of South America. The specimen closely compares to some in the California Academy of Sciences identified by Stanley W. Weitzman and William I. Follett as *Colossoma nigripinnus* Cope. Specimens identified as *Colossoma bidens* had much smaller scales. The senior author tentatively identified the Sacramento specimen as *C. nigripinnus.*

The specimen showed no evidence of disease or parasites. How long it had been in the river is not known, but since pacus and piranhas are generally sympatric and have comparable ecological requirements, some deductions can be made. Temperatures in the Sacramento River were unusually high during summer 1977, a drought year, and between mid-May and mid-October were above 18 C which is approximately the minimum temperature at which most tropical lowland fishes can maintain themselves. Temperatures at which such fishes could comfortably exist occurred between mid-June and mid-September: June 28, 25.1 C; July 28, 24.8 C; August 8, 25.0 C; September 13, 23.3 C. The higher temperatures are within breeding range. During most years midsummer temperatures average about 20–21 C, and in some years run as low as 17–18 C. Mid-winter temperatures range from 6.5 to 9.0 C and would be lethal. Evidence that the fish did not over-winter comes from the scales, which exhibited no growth rings or stress checks.

Gery (1973) and Sterba (1962) give maximum lengths of 60–80 cm and a weight of 10 kg for *Colossoma.* Lovshin, et al. (1974) report seeing the larger pacus, called tambaqui, reaching a maximum length of 89 cm and a weight of over 13 kg in the Manaus, Brazil, market; they also report that fishermen say tambaqui exceed 20 kg. *Colossoma* grow rapidly in sufficiently roomy aquaria, as much as an inch a month. They are frequently a problem when they outgrow an aquarium. Our specimen was probably released into the river sometime after early June, probably a few days before being caught, in view of the empty digestive tract, since there is considerable algae and vegetable debris in the river. It is unlikely that this species or others with the same temperature requirements could overwinter in Northern California waters. However, any new hot water discharge into natural waters should be considered to be capable of creating survival and/or reproductive conditions.

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EFFECT OF FIRST PECTORAL FIN RAY REMOVAL ON SURVIVAL AND ESTIMATED HARVEST RATE OF WHITE STURGEON IN THE SACRAMENTO-SAN JOAQUIN ESTUARY

INTRODUCTION

Sturgeon ages commonly are estimated from annual growth patterns in cross sections of the first, or anterior, ray of the pectoral fin. However, removal of fin rays during a tagging study may affect survival of the fish and bias estimates of population parameters estimated from tag recoveries. Several authors have released sturgeon after removal of the anterior pectoral fin ray without discussing the effect on subsequent survival (Cuerrier and Roussow 1951; Pycha 1956; Priegel 1973). Bajkov (1949) stated that white sturgeon *(Acipenser transmontanus)* appear to withstand removal of a fin ray without any damage, but offered no evidence for his conclusions.

To determine the effect of pectoral fin ray removal on survival and estimated harvest rate of white sturgeon, I evaluated tag returns from the Sacramento-San Joaquin Estuary, California.

METHODS

In fall 1974 sturgeon were captured with trammel nets in San Pablo Bay and tagged with disc dangler tags placed beneath the anterior part of the dorsal fin. Capture and tagging methods have previously been described (Chadwick 1963; Miller 1972). Five dollar reward tags were used exclusively to assure a high rate of angler response.

To determine the age composition of tagged fish, the first ray of the left pectoral fin was removed from every second sturgeon tagged. Prior to tagging, the fish was placed on its right side on the boat deck and the fin ray was severed as close to its articulation as possible. Large cutting pliers or a small hand saw were used to cut the ray. This procedure required less than 1 minute per fish. To facilitate analysis, fin rays were removed only from fish with odd numbered tags. For convenience, I will refer to fish with the fin ray removed as odd numbered and those with intact pectoral fins as even numbered.

Harvest rates were calculated from first year returns of each tag type. Confidence limits for harvest rates were estimated assuming tag returns followed a Poisson distribution.

I analyzed 3 years of tag returns to determine the effect of pectoral fin ray removal. Returns of odd and even numbered tags were compared using a standard chi-square test of independence (Sokal and Rohlf 1969). Mortality due only to fin ray removal was estimated as: 1—ratio of odd:even tag return percentages. I estimated survival separately for odd and even numbered tags using a linear regression of logarithm of returns against time (Ricker 1975). The antilogarithm of the slope of the regression line is an estimate of annual survival.

RESULTS AND DISCUSSION

A total of 712 legal sized ($\geq$ 101.6 cm total length) white sturgeon was tagged in 1974. Of those, 358 had the first ray of the left pectoral fin removed and 354 did not.

The tag returns indicate fin ray removal caused mortality (Table 1). During the first year, 13 odd numbered and 20 even numbered tags were returned, yielding harvest rate estimates of 0.036 and 0.056, respectively. The respective 95% confidence intervals were 0.019–0.060 and 0.036–0.085. While the difference in these return rates was not statistically significant, the difference was significant at the end of 2 ($X^2 = 5.24$, $P < 0.025$) and 3 ($X^2 = 8.20$, $P < 0.005$) years due to continued higher returns of even numbered tags.

The decrease in the ratio of odd:even tag return percentages was relatively small after the first year, indicating that most mortality due to fin ray removal occurred in the first year. However, the fact that this ratio did decrease suggests some mortality occurred during the second year also (Table 1).

After the first year, estimated annual survival of odd numbered sturgeon was 0.88 and estimated survival of even numbered fish was 0.95 (Figure 1). These estimates are imprecise since return sample sizes are small and the points do not fall in a straight line.

I conclude that removing the first ray of the pectoral fin of white sturgeon causes substantial mortality during the first year and less mortality thereafter. Also, consistently greater returns of even number tags in all 3 years indicates that mortality from pectoral fin ray removal results in an underestimate of exploitation and that the best estimate of exploitation rate is based on even numbered tags alone. If fin ray removal is used in conjunction with a sturgeon tagging program, estimates of population parameters derived from tag recoveries may exhibit serious bias.

TABLE 1. Tags Received During the First 3 Return Years from White Sturgeon Tagged in San Pablo Bay in Fall 1974. Odd numbered tags are from fish with the primary ray of the left pectoral fin removed for age determination. Even numbered tags are from fish without fin ray removal.

Return year	*Odd tags returned*		*Even tags returned*		*Total returns*	*Ratio odd:even percentages*	*Mortality due to fin ray removal (1—ratio odd:even percentages)*	*Estimated annual mortality increment due to fin ray removal*
	Number	*Percent*	*Number*	*Percent*				
1974–75	13	3.6	20	5.6	33	0.64	0.36	0.36
1975–76	10	2.8	20	5.6	30	0.50	0.50	0.14
1976–77	10	2.8	18	5.1	28	0.55	0.45	–0.05
Total	33	9.2	58	16.4	91	0.56		

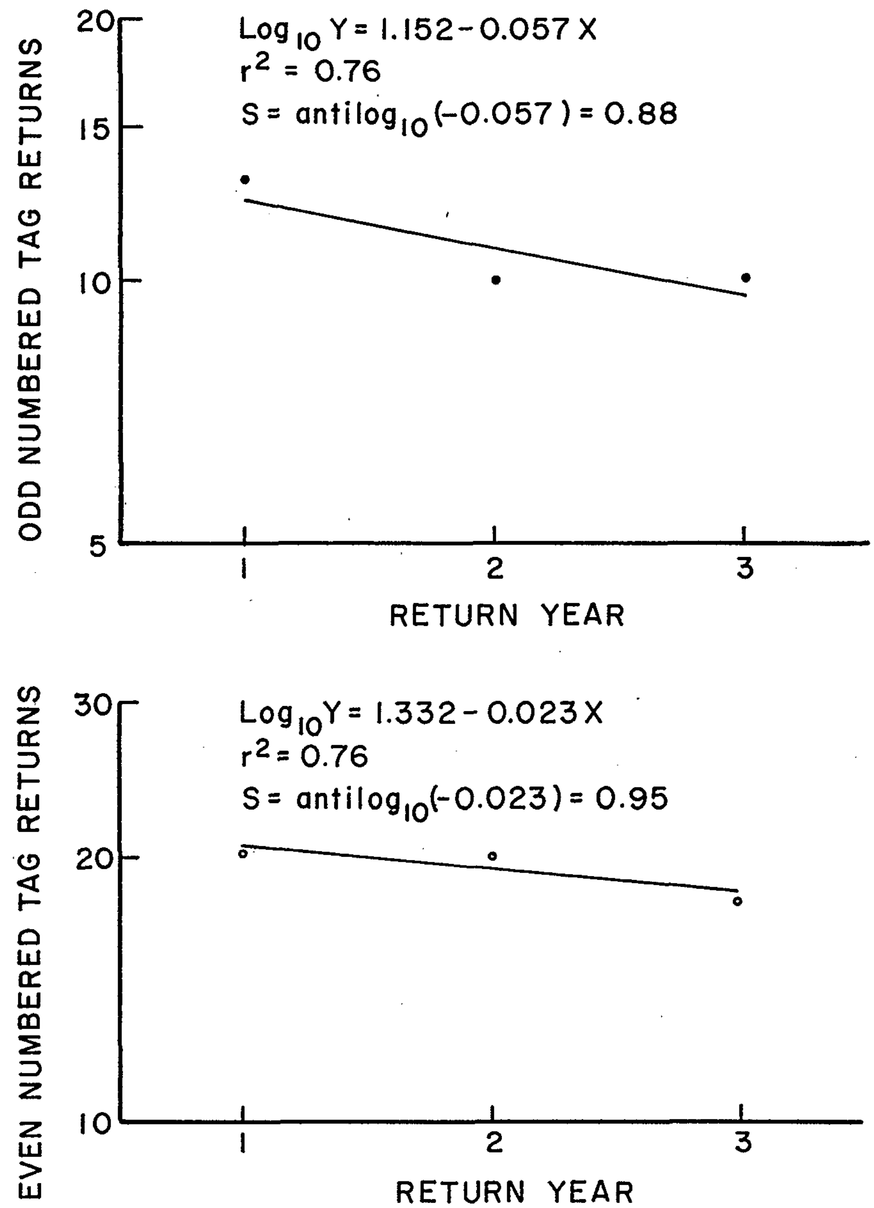

FIGURE 1. Tag returns from white sturgeon tagged in San Pablo Bay in fall 1974. The antilogarithm of slope is an estimate of annual survival rate (S). Slope and survival are calculated separately for odd numbered fish with the first ray of the left pectoral fin removed (a) and even numbered fish with no fin ray removed (b).

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EVIDENCE OF SUCCESSFUL REPRODUCTION OF STEELHEAD RAINBOW TROUT, *SALMO GAIRDNERI GAIRDNERI,* IN THE VENTURA RIVER, CALIFORNIA

In recent years there have been scattered reports of adult steelhead trout being caught in the Ventura River, Ventura County, fish which could be remnants of a run that once numbered 4–5,000 adults (Clanton and Jarvis 1946). The question has remained, however, whether these fish were strays from other river systems or whether they could be progeny of successful steelhead reproduction in the Ventura River (Mark Capelli, Friends of the Ventura River, pers. commun.). This note briefly describes a useful technique for identifying juvenile steelhead and provides data supporting their presence in the Ventura River.

Rybock, Horton, and Fessler (1975) showed that steelhead trout juveniles can be distinguished from resident rainbow trout on the basis of otolith nuclei (ON) dimensions. Since spawning steelhead trout females are substantially larger than spawning resident rainbow trout females and have larger eggs and emergent larvae, the earliest formed otolith morphological mark (the ON, or metamorphic check) has a larger width and length in steelhead trout than in resident rainbow trout. Statistically significant differences between the ON size distributions of different samples indicate the existence of distinct fish populations.

Nine dorsal fin clipped juvenile steelhead trout and 11 wild rainbow trout were captured on February 16, 1977 by electroshocking a stretch of the middle Ventura River 10.5–12.9 km above the mouth. The marked steelhead trout were survivors of a July 1976 plant of 11,000 fingerlings. An additional seven unmarked rainbow trout were captured in the upper Ventura River (22.6 km above the mouth) on February 17, 1977. This location is above Robles Diversion Dam, completed in 1959, which prevents upstream migration of fish under most flow conditions.

Otoliths were removed, stored in 100% glycerin, and measured using an ocular microscope (see McKern, Horton, and Koski 1974 and Rybock et al. 1975 for details of the procedure).

Despite clearing in glycerin, 20% (11/54) of the otoliths were unreadable. All but two fish, however, had at least one readable otolith. ON measurements recorded for the Ventura River trout were within resident and steelhead trout ON width and length ranges reported from other Pacific coastal streams (McKern et al. 1974, Rybock et al. 1975). Only ON widths were consistently distinct enough to accurately measure in all readable otoliths.

The comparison of ON widths showed distinct distributions for unmarked trout taken from above Robles Diversion Dam and marked steelhead trout taken from the middle Ventura River (Figures 1*a* and 1*c*). The ON width distribution for unmarked trout taken from the middle Ventura River, however, spanned nearly the entire range of both marked and unmarked trout (Figure 1*b*). Differences in the mean ON widths of the three groups were analyzed by the "t" test for small samples (Alder and Roessler 1968). The differences between the

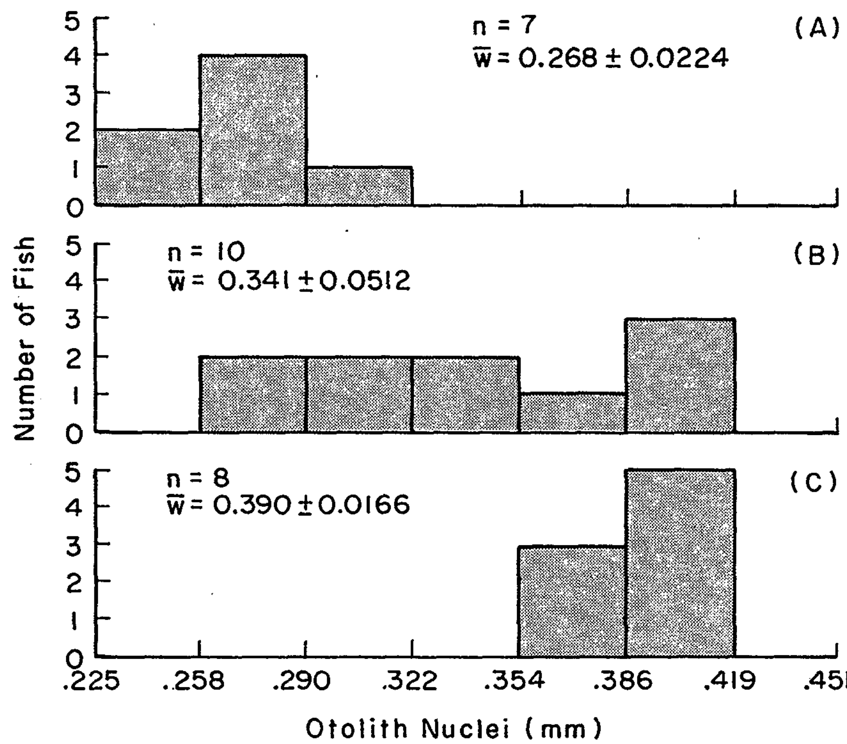

Figure 1. Frequency distributions and means (±1 S.D.) of ON widths (millimeters) representing: (A) unmarked rainbow trout above Robles Diversion Dam, Ventura River, (B) unmarked rainbow trout from below Robles Diversion Dam, and (C) marked steelhead rainbow trout from below Robles Diversion Dam.

means were all significant ($p < 0.05$), particularly between the trout collected above Robles Diversion Dam and the marked steelhead ($p < 0.001$).

Unmarked trout captured in the middle Ventura River included fish having ON widths within the resident rainbow trout and steelhead trout ranges. The former group is either wild resident rainbow trout or planted rainbow trout that have moved downstream from the Department of Fish and Game catchable trout release sites 25 to 32 km above the mouth. The latter group is either wild steelhead trout or hatchery steelhead trout with regenerated dorsal fins. Since the marked steelhead were dorsal fin clipped only 8 months prior to the study, it is unlikely that they would be misidentified.

The existence of wild steelhead trout juveniles, as judged by the otolith results, implies that some natural spawning and subsequent adult return occurs in the river. However, many questions concerning these fish remain: (i) what percentage of the adult steelhead entering the Ventura River originate elsewhere, (ii) what is the proportion of steelhead trout in the rainbow trout population below the diversion dam, (iii) do any steelhead trout pass the diversion dam and spawn in the upper river, and (iv) what can be done to more effectively protect and enhance the natural steelhead trout run?

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NOTES ON A HYBRIDIZATION EXPERIMENT BETWEEN RAINBOW AND GOLDEN TROUT

In an earlier note (Gold, Pipkin, and Gall 1976), we presented the results of a fortuitous hybridization experiment between a rainbow trout, *Salmo gairdneri,* female and a golden trout *Salmo aguabonita* male. The hatch and developmental data from that cross were limited, but supported field observations that hybridization between the two species could occur with ease (Dill 1950; Schreck and Behnke 1971; Gold and Gall 1975). This note is a follow-up on that cross.

By 7 May 1975, only one of the six RT x GT hybrid fingerlings remained alive, the rest having succumbed to *Chondrococcus columnaris* infection or gill disease. On 31 December 1976, the survivor, a 2-year-old female, was stripped of

641 normal-sized eggs. These were divided into four lots of roughly 160 eggs each and fertilized with the sperm of four 2-year-old males from the domesticated rainbow trout strain RTD (Gall 1975). The males were 3 months past their spawning peak, but when examined had numerous motile sperm. No golden trout males were available for the complementary backcross. The four lots of fertilized eggs were water hardened and incubated in separate chambers of a Heath-Tecna incubator. Water temperatures during incubation ranged from 9–13 C (median = 11 C). At this temperature, RTD eggs normally eye-up within 13 days and hatch within 29 days (Gall and Pipkin, unpublished data).

None of the backcross embryos developed normally. After 17 days, roughly 80% of the eggs showed no indication of embryonic development. The remainder displayed a single, large, dark spot (not a true "eye") accompanied by several hemorrhagic streaks. Some of these "spots" grew larger, but by 6 February none of the embryos had hatched. On 15 February all embryos had ceased development and were discarded. A systems failure at the Davis hatchery on 16 June 1976 resulted in the death of the hybrid female.

Meristic and morphometric data from the hybrid are compared with mean values for rainbow and golden trout from our unpublished data (Table 1). Hybrid indices computed after Hubbs and Juronuma (1942) were intermediate (.16–.83) for 8 of 27 characteristics.

Life colors of the hybrid were more or less typical of *S. aguabonita* (Evermann 1905), although much less pronounced. Parr-type marks, typical of adult *S. aguabonita* but not adult *S. gairdneri,* were not present. The dorsal, caudal, and adipose fins were moderately spotted, but the body was almost immaculate (Figure 1). Approximately 20–25 small spots, crescent-shaped and diffuse as in *S. gairdneri,* were present on the dorsal region of the caudal peduncle, posterior to the adipose fin. The parents of the hybrid, *S. gairdneri* (♀) and *S. aguabonita* (♂), were heavily and moderately spotted, respectively. The paucity of spots on the body of the hybrid was suggestive of the pattern typical of the Paiute cutthroat trout (Ryan and Nicola 1976).

Data indicative of interspecific hybridization among western trouts are abundant, and have stemmed by-in-large from field studies where one species was introduced (by man) into waters occupied by a second species (e.g. Schreck and Behnke 1971; Behnke 1972; Gold and Gall 1975). As a result, it has been generally assumed that reproductive isolating mechanisms among most western trouts are less than complete, and that forced sympatry will usually result in introgressive hybridization. The sympatric coastal cutthroat, *S. clarki clarki,* and anadromous rainbow trout, *S gairdneri,* are among the few cited exceptions (Behnke 1972). Miller (1972), however, has pointed out that there is little if any experimental data on western trouts regarding mating discrimination or fertility of hybrids.

The failure to obtain backcross progeny from the RT x GT hybrid female may reflect a barrier to hybridization between the two species. The experimental conditions under which the backcross was made were far superior to those of the original parental cross, and there was partial embryogenesis in about 20% of the fertilized eggs. It is conceivable that "hybrid breakdown" (Dobzhansky 1970) was the cause of embryonic mortality, and that reproductive isolating

TABLE 1. Morphological Data † of RT x GT Hybrid, *Salmo gairdneri*, and *Salmo aguabonita*

Character	*Hybrid* (*n* = *1*)	*Salmo gairdneri* (*n* = *20*)	*Salmo aguabonita* (*n* = *32*)
Standard length, cm	26.9	21.4	10.4
Pyloric caecae	43*	59.6	33.3
Dorsal fin rays	11	12.3	12.1
Anal fin rays	11*	11.3	10.7
Pectoral fin rays	16	14.6	15.7
Pelvic fin rays	9	10.1	9.0
Branchiostegal rays (total)	22	22.0	23.9
Gill rakers (left)	18	18.8	19.9
Vertebrae	62*	62.5	60.0
Scales, lateral line	123	121.5	117.3
Scales, lateral series	154*	135.8	183.0
Scales above lateral line	30	–	–
Scales below lateral line	31	–	–
Interneural bones	13	–	–
Interhaemal bones	13	–	–
Thousands of standard length			
Body depth	264*	268	248
Head length	233	235	289
Head width	145	126	134
Least interorbit	70	75	74
Occiput to snout length	167	177	209
Maxilla length	93*	87	125
Caudal peduncle length	146	164	148
Caudal peduncle depth	113	104	101
Predorsal length	470	509	536
Preanal length	751	782	773
Prepectoral length	265	219	252
Prepelvic length	544	558	560
Dorsal, base length	141	139	140
Anal, base length	116	91	101
Pectoral length	163*	127	181
Pelvic length	138*	103	145
Eye diameter	43	45	71

* Values intermediate between means of parental species (cf. text)
† Data for *S. gairdneri* and *S. aguabonita* represent sample means ($\bar{X}$).

mechanisms among western trouts are more complete than presently believed. Busack (1977), for example, has recently presented evidence of two closely related inland cutthroat trout forms which coexist sympatrically without apparent gene exchange. The introgression frequently observed among western trouts in nature may indicate the well-known relationship between hybridization and habitat disruption (Anderson 1949).