[1985]

STREAM FISHERIES INVESTIGATIONS

Federal Aid Study F-51

Job 1. Fish Flow Investigations by R.B. Nehring and R.M. Anderson

Job 3. Special Regulations Evaluations by R.B. Nehring and R.M. Anderson

Job 4. Wild Trout Introductions by R.M. Anderson

Job 6. Colorado River Aquatic Invertebrate Investigations by R.B. Nehring

James B. Ruch, Director

Federal Aid in Fish and Wildlife Restoration

Job Progress Report

F-51

Colorado Division of Wildlife

Fish Research Section

Fort Collins, Colorado

July 1985

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Date October 2, 1985

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THE NATURAL (AND UNNATURAL) HISTORY OF CALIFORNIA TROUT

A SYMPOSIUM

Sponsored by

AMERICAN FISHERIES SOCIETY

California-Nevada Chapter

January 24, 1985

Monterey Holiday Inn at the Beach

Monterey, California

THE NATURAL (AND UNNATURAL) HISTORY

OF CALIFORNIA TROUT

January 24, 1985

Monterey Holiday Inn on the Beach
Monterey, California

Chair: Don Erman, University of California, Berkeley.

8:30 - 8:45	*WELCOME*
	Cay Goude, President-Elect, Cal/Neva Chapter, American Fisheries Society.
8:45 - 9:15	*INTRODUCTORY ADDRESS*
	Robert J. Behnke, Colorado State University.
9:15 - 10:15	*STEELHEAD*
	North Coast - Dennis Lee, California Department of Fish and Game.
	South Coast - Jerry Smith, San Jose State University.
10:15 - 10:30	BREAK
10:30 - 11:00	*RAINBOW TROUT*
	Graham Gall, University of California, Davis.

11:00 - 11:30	*GOLDEN TROUT* Phil Pister, California Department of Fish and Game.
11:30 - 12:00	*REDBAND TROUT* Maria Ellis, The Nature Conservancy.
12:00 - 1:30	LUNCH
1:30 - 3:00	*CUTTHROAT TROUT* *Lahontan* - Don Sada, U. S. Fish and Wildlife Service. *Paiute* - Eric Gerstung, California Department of Fish and Game. *Coastal* - Bill Mitchell, Humboldt State University.
3:00 - 3:15	BREAK
3:15 - 3:45	*BULL TROUT* Mike Rode, California Department of Fish and Game.
3:45 - 4:15	*CONCLUDING REMARKS* Robert J. Behnke, Colorado State University.
4:15 - 5:00	*ROUNDTABLE DISCUSSION*

— WYO — rept —

— candy —

— ~~banquet — etc.~~

Sat.

— ride back!

Artwork by Paul B. Johnson
Courtesy of California Department of Fish and Game

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- understand problem
- use [illegible] - [illegible]
- temp - tolerance (not [illegible])
- sterile fish - multipliers
- [illegible] - grassing [illegible]
- [illegible] - model - distract
- stupefy - obscure - [illegible]

end. sp. - interesting spec. ... ... that could be used.

- N.W. Salmon myth recognized - but still more piecemeal & lip service

Illusion age Technique

empirical ... effect

resolve problems
- committees
- task forces
- need Edison-like system - did not discover electrons basic research
- put to light bulb
- [illegible] system to integrate [illegible] work - power [illegible] transmission lines -

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JOB PROGRESS REPORT

State: Colorado   Name: State Fish Research

Project No. 5506X   Title: Stream Fisheries Investigations

Study No. F-51

Period Covered: July 1, 1984 to June 30, 1985

Study Objective: Quantitatively describe the interrelationships and determine the impacts of flow regimes, special regulations, macroinvertebrate densities and trout species introductions on established trout populations in selected major streams in Colorado.

Job No. 1

Job Title: Fish Flow Investigations

Job Objective: Quantify the interrelationships between flow regimes and trout population dynamics on selected sections of the following streams: Colorado, Arkansas, Taylor, Eagle, South Fork of the Rio Grande, Middle Fork of the South Platte, South Platte, Fryingpan, Rio Grande, Gunnison, Cache la Poudre and St. Vrain rivers.

INTRODUCTION

Background

This project began in 1973 as the "Upper Gunnison River Investigations." In 1975, the title was changed to "Stream Fishery Investigations" (F-51-R). At that time the project included Job 1, "Taylor River Flow Investigations" and Job 2, "Influence of Artificial Stream Flow Alterations on Trout Populations." Job 1 involved studies done from 1973-75 to determine the status of the fishery under the existing Taylor River flow regime and has been reported by Burkhard (1977). In 1976, the flow regime was changed to conform to a pattern specified by Burkhard. Following 3 years of this pattern, the fishery was to be reexamined to determine if any significant changes had taken place.

In 1979, this study was reactivated with Job 1 continued, Job 2 discontinued, and a new Job 3, Special Regulations Evaluations, added. The study continued as two jobs through April 1982. Effective May 1, 1982, the title for Job 1 (Taylor River Flow Investigations) was changed to Fish Flow Investigations. The number of rivers to be examined as a part of Job 1 was increased from 1 (the Taylor River) to 12. During the 1985 field season, we hope to complete all of the remaining cross-sectional analyses on the 12 study streams, including the Arkansas, Rio Grande, Eagle, and Fryingpan rivers.

Job 3, Special Regulations Evaluations, is in the 6th year of evaluation. Job 4, Wild Trout Introduction, is in the 3rd year of study. Job 5, Arkansas River Aquatic Invertebrate Investigations, was terminated at the end of the 1983/84 segment. Job 6, Colorado River Aquatic Invertebrate Investigations, is in the 3rd year of study.

METHODS AND MATERIALS

Fishery biologists for decades have suspected that relationships exist between the amount of water flowing in a stream and the numbers and sizes of fish that occur in a stream (Brett 1951; Bulkley and Benson 1962; Drummond 1966; Gagmark and Bakkala 1960; Johnson 1956; McKernan et al 1950; and Wickett 1958). However, only in the last 7-10 years has it become increasingly possible to document the relationships between stream flows and fish habitat(s).

The base of knowledge in this area has been substantially increased primarily due to the efforts of personnel working for the U.S. Fish and Wildlife Service at the Cooperative Instream Flow Service Group in Fort Collins, Colorado (Stalnaker and Arnett 1976; Bovee et al 1977, Bovee and Cochnauer 1977; Bovee 1978; Bovee and Milhous 1978; and Milhous et al 1981). Without the initiative and efforts of these people, we would probably still be in the "dark ages" as far as the melding and interfacing of fish population data and stream flows through computer modeling and simulations.

The accuracy, precision, and level of sophistication in modeling fish habitat increase almost daily. However, further proliferation of computer models to assess instream flow requirements for fish is of less urgency than long-term biological documentation, i.e., "field proofing" (Annear and Condor 1984). Indeed, long-term biological documentation is the primary goal of Job 1. We have already begun this process of "field-proofing" (Nehring and Anderson 1984), on the South Fork of the Rio Grande. Additional documentation will be presented below.

We use the incremental methodology for collecting field data on stream flow which in turn provides the input data set to the PHABSIM (Physical Habitat Simulation System) and IFG4 computer models to derive weighted usable area (WUA) for the life stages of trout species in each stream under study (Bovee and Milhous 1978; Milhous et al 1981). Weighted usable area (WUA curves) for the various life states of trout for a given stream versus discharge can be determined as soon as the flow data has been reduced and run through the computer simulations. However, procedures specified for this job require analyses of the relationships between age-class and year-class strength with annual discharge patterns. Our experience on the South Fork of the Rio Grande indicates that probably a minimum of 4 years of population estimation data, and perhaps as much as 6-7 years, will be required to make some definitive statements about these relationships. Accordingly, it will probably take until the final project segment (July 1, 1986-June 30, 1987) to complete all analyses on some of these streams.

Plans, procedures, survey methods, and analysis techniques used in this investigation have been previously described by Bovee and Milhous (1978), Nehring (1979), and Hilgert (1982) and will not be discussed in further detail here.

During the next segment we hope to complete collection of the field data and analysis of the cross-section data on all remaining study streams (Arkansas, Rio Grande, Eagle and Fryingpan rivers). Table 1 below reveals the status of the studies on each stream as of June 30, 1985.

Table 1. Fish Flow Invesigations study streams, cross-sectional data collection and analysis.

Stream name	Region	County	Field year	Analysis year	Status
Cache la Poudre	NE	Larimer	83	84	Complete
St. Vrain	NE	Boulder	83	84	Complete
South Platte	NE	Jefferson/ Douglas	82	83	Complete
Arkansas	SE	Chaffee/ Fremont	85	86	
Middle Fork- South Platte	SE	Park	83	85	Complete
Colorado	NW	Grand	83	84	Complete
Eagle	NW	Eagle	85	86	In-process
Fryingpan	NW	Eagle	85	86	In-process
Gunnison	SW	Montrose/ Delta	82	83	Complete
Rio Grande	SW	Mineral/ Rio Grande	85	86	In-process
South Fork- Rio Grande	SW	Mineral/ Rio Grande	82	83	Complete
Taylor	SW	Gunnison	84	84	Complete

RESULTS AND DISCUSSION

Arkansas River

The brown trout population in the Arkansas River responds to spring and summer flows in exactly the same manner, as will be demonstrated in subsequent sections of Job 1 for the Cache la Poudre, Colorado, Gunnison, Rio Grande, St. Vrain, and South Platte rivers. Arkansas River brown trout year-class strength is negatively correlated with late spring and early summer discharge (Table 2).

Table 2. Arkansas River brown trout yearling year class strength (N/ha) versus mean month discharge (ft^3/sec) from April through September 1980-83, at three different electroshocking stations.

Salida	Coaldale	Loma Linda	Year	Mean Monthly Discharge (ft^3/sec) April	May	June	July	Aug.	Sept.
13	124	127	1980	441	1,025	3,930	1,813	760	538
217	251	415	1981	234	427	972	703	540	468
24	81	48	1982	339	676	2,084	1,519	1,192	725
3	14	10	1983	264	407	2,868	3,066	1,433	572
Salida power function r				-.334	-.120	-.847	-.999	-.841	-.418
Coaldale power function r				+.110	+.325	-.518	-.900	-.899	-.378
Loma Linda power function r				-.009	+.207	-.566	-.914	-.970	-.559

A power curve function regression analysis best fits the data, as is usually the case. The Arkansas is somewhat different from the other rivers in that the strongest negative correlations are in July and August for the brown trout rather than in April, May or June. However, the brunt of the run-off in the Arkansas Basin is delayed a month or more (in comparison to most of the other study streams) because of the large number of reservoirs in the headwater areas that capture most of the early run-off. Once the storage reservoirs have reached maximum capacity, then the run-off begins in earnest, often not until mid to late June in most years. Correlations were poor between October spawning flows and brown trout year-class strength, with a coefficient of determination (r^2) of 0.069 for 1980-83. Spawning habitat is clearly not a limiting factor.

Cache la Poudre River

We have been electroshocking the Poudre River as a part of this study from 1980 through 1984. Thus, we have 5 years of electroshocking data on six study sites with which to correlate age 1+ rainbow and brown trout year-class strength with mean monthly discharge for the spring and summer months. At age 1+, neither rainbow or brown trout are of a size to be vulnerable to angler harvest in the Poudre River. Table 3 contains the data analysis on rainbow and brown trout year-class strength versus mean monthly flows from 1979 through 1983. These 5 years ran 5, 2, 18, 10 and 1, respectively, in total annual discharge for the calendar years 1964-83, or 19 years of record. Thus, our data spans from highest to lowest in discharge/annum and undoubtedly represents a true relationship between discharge and year-class strength.

Table 3. Rainbow and brown trout year-class strength (N/ha for age 1+) versus mean monthly discharge, March-September, 1974-83.

Year	Rainbows[a]	Browns[b]	Discharge (ft^3/sec) March	April	May	June	July	Aug.	Sep.
1979	91.2	181.3	24	84	834	2,068	966	563	147
1980	194.4	153.2	149	550	2,581	2,392	674	274	104
1981	185.2	236.8	21	75	367	932	339	200	98
1982	120.4	253.5	19	33	375	1,469	1,307	616	161
1983	39.6	27.3	96	615	1,767	4,768	2,225	709	210
Rainbows power r			+.181	-.323	-.271	-.775	-.860	-.821	-.933
Rainbows linear r			+.141	-.194	-.054	-.718	-.894	-.935	-.956
Browns power r			-.627	-.754	-.622	-.891	-.684	-.480	-.674
Browns linear r			-.622	-.867	-.671	-.976	-.727	-.446	-.631

[a]Average rainbows/ha for 5 stations.
[b]Average browns/ha for 6 stations.

For the brown trout in the Poudre, the strongest negative correlation was for the month of June with the linear regression analysis giving a better fit than the power functions. This phenomenon (best fit for June) is a situation that is found all across Colorado, virtually without exception. When the relationship between brown trout year-class strength and discharge was subjected to regression analysis at each individual study site, June was once again the critical month. When YOY year-class strength (for 1980-84) was regressed against peak flow for the month of June for those years, the correlation coefficient (r) was -.988 for a power function regression analysis.

For the rainbow trout, the strongest negative correlations for the widest range of monthly flows (between years) was in July for both linear and power curve regression analyses, indicating July is probably the most critical month. However, August and September also had high negative correlation coefficients as well, albeit over a much narrower range of flows, especially for the month of September. Thus, we feel the relationship between flow and rainbow year-class strength in September is probably just a fortuitous occurrence rather than a real biological response to small variations in flow. We base this conclusion on the fact that when regression analyses between September flows and rainbow year-class strength were run on the five individual study sites, there was no consistent pattern between stations and the majority of the correlation coefficients (3 of 5) were poor ($r \leq 0.43$). The same was true for the month of August. For the month of July however, correlation coefficients were all strongly negative at each of the individual study sites. Thus we feel July (probably the month of rainbow YOY emergence), and to a lesser extent August, are the critical months when discharge most adversely impacts survival and recruitment of rainbow trout.

Colorado River

We completed an Instream Flow Incremental Methodology (IFIM) analysis and a PHABSIM (Physical Habitat Simulation Methodology) evaluation on the Colorado River at Lone Buck during 1983. The results of this evaluation were initially written up in the 1984 progress report (Anderson, Nehring, and Winters 1984). At that time, we were unable to discern any distinct relationships between year-class strength and flow for any month of the year.

The Colorado River and its rainbow and brown trout populations were an enigma, not responding at all in a manner observed on other streams in this study (see the results and discussion section for the Arkansas, Cache la Poudre, Gunnison, Rio Grande and South Platte rivers elsewhere in the Job 1 write-up). We were probably being limited by two things in last year's write-up: (1) only 3 years of good population data (1981-83); and (2) victims of our own conventional thinking, i.e., looking only for the same type relationships between flow and year-class strength already observed on the above mentioned streams and the South Fork of the Rio Grande (Nehring and Anderson 1983).

However, the Colorado River is somewhat unique in that it is probably one of the most dewatered and heavily controlled streams in Colorado due to the combined impacts of the water collection systems and storage reservoirs in the headwater areas. The Grand Ditch taps virtually every tributary on the west side of the Kawuneeche Valley in Rocky Mountain National Park and diverts it to the East Slope into the Cache la Poudre Basin. The Big Thompson Transmountain Diversion Project collects and stores water from additional headwater tributaries to the Colorado River in Granby and Shadow Mountain reservoirs and Grand Lake and then diverts it into the Big Thompson Basin near Estes Park via the Alva B. Adams Tunnel. An extensive collection system on the branches of Ranch Creek, the Fraser River, Vasquez and St. Louis creeks and the Williams Fork River drainage diverts water to the East Slope via the August P. Gumlick and Moffat tunnels. Beginning in May 1985, the Windy Gap Pump Project will divert up to an additional 50,000 acre-feet ($6.17 \times 10^7 m^3$) of water from the Fraser River Basin into the Big Thompson Project via the Alva B. Adams Tunnel.

In light of these diversions, it is not too difficult to understand that the trout population might respond in a somewhat different or abnormal fashion than the more "normal" responses observed on other streams which have a more "normal" annual discharge hydrograph. That trout have managed to survive, and perhaps even thrive (in some instances) in what still remains of the upper Colorado River, is much more of a tribute to the great adaptability of rainbow, brown, brook, and cutthroat trout than to man's prowess in planning for the concerns of fish and wildlife as he seeks additional sources of water to slake the insatiable thirst of Front Range Colorado.

The key to solving the enigmatic relationship between rainbow and brown trout and the upper Colorado River (between Windy Gap Reservoir and the confluence with Troublesome Creek east of Kremmling, Colorado) lies in the realization that the river channel as it exists now is still the product of much higher spring discharge levels that occurred prior to the construction of the massive reservoirs and collection and diversion systems from the late 19th century up through the 1950's. High spring discharge levels left only rubble, cobble, and boulder aggregates in the mid-channel of the Colorado River. Spawning gravels 6-51 mm (.25-2.0 in.) in diameter were either deposited along the banks in the lower velocity areas or else washed completely out of the system. After 5 successive years of taking rainbow trout spawn in the Colorado River during April from 1981 through 1985, it is clear that rainbow trout spawn in the shallow peripheral areas of the channel where proper water velocities and gravel sizes exist. Most spawning pairs of rainbow trout are collected in water less than .3 meters (1 ft) depth and from .3 to 3 meters (1-10 ft) from the bank over good spawning gravel. Many redds have been observed in these shallow inshore areas.

Regression analysis (Table 4) were run on rainbow (age 2+) year-class strength (N/ha) versus mean monthly discharge (March-August 1979-82) as well as mean discharge from April 16-30, 1979-82. The latter time period has proven to encompass the majority of the rainbow trout spawning activity in the study area since 1981.

Table 4. Regression analyses of rainbow (2+) and brown (1+) year-class strength (N/ha) versus mean monthly flow (ft^3/sec) 1979-83.

Year class	2+ rnbw/ ha	1+ brown/ ha	March	April	May	June	July	Aug.	4/16-4/30
1979	487	--	73	202	683	907	385	142	293
1980	166	19	70	187	718	1,042	361	123	291
1981	20	85	74	124	222	282	180	82	135
1982	62	26	86	143	387	492	467	168	173
1983	—	40	76	136	607	1,975	2,081	401	204
Power functions (r) for 2+ rainbows									
			-.331	+.977	+.933	+.912	+.645	+.583	+.943
Power functions (r) for 1+ browns									
			-.063	-.871	-.807	-.489	+.248	-.248	---

We ran linear, logarithmic, and power function regression analyses on both rainbow and brown trout. Power function regression analyses worked the best (highest correlation coefficients) in all instances. For rainbow trout, we found the highest correlation coefficients in April and April 16-30, the period of peak rainbow spawning activity. Correlation coefficients for rainbow trout (2+) year-class strength versus mean monthly flows were all quite high for May, June, and July as well (in descending order) indicating the elevated water levels are important for good egg incubation and hatching success as well.

One might question why we used year-class strength at age 2+ instead of age 1+ as has been done on most other evaluations in this study in the past. There are several reasons. First, we are correlating rainbow year-class strength from the Parshall study area, a 2 mile (3.2 km) section of river. This area, which we boat shock, gives us our most reliable rainbow population size and age distribution because of the large sample size. Year-in and year-out, the 2+ cohort comprises the greatest portion of the population. We generally sample in excess of 2,000 rainbows each fall at this study site. Second, most of this study section lies on private land and is leased by clubs practicing catch-and-release angling. Thus, angling pressure and harvest are much lower than on the public sections of water upstream, thereby reducing our bias due to angler harvest on the 2+ age group. Third, examination of our life table data (Appendix III, Table III-2) indicates considerable augmentation of individual rainbow year-classes occurs between age 1+ and 2+ at the Parshall study area. Thus, year-class strength is not stabilized or fully recruited until age 2+. Some of this may be due to lower shocking efficiency on age 1+ trout. However, it is more probable that many recruits to a year-class in the Parshall area do not arrive until their third summer of life. We know from our fish marking operation (adipose clip on spawning age rainbows) in the fall of 1981, that many rainbows move upstream many miles in the spring to spawn. Fry and juveniles probably remain in these upstream areas their first 2 years of life where fry and juvenile habitat is better and there is less competition from adult rainbow and brown trout due to higher removal rates from angler harvest in the public water. Finally, water sampling efficiency on larger numbers of larger, older trout (2+ versus 1+) reduces our chances for error with the electroshocking equipment.

We also ran regression analyses of rainbow trout spawning macrohabitat (WUA) versus rainbow year-class strength at age 2+. This regression and all of the above are regressed against the mean monthly flows for the month when that year-class was spawned and hatched, i.e., the 1984 age 2+ rainbow sample (the 1982 year-class is regressed against flows for March-August 1982). As expected, rainbow year-class strength was strongly correlated with mean spawning WUA for April (1979-82), the period of peak rainbow spawning activity. A power function regression analysis gave a correlation coefficient of +.98 for April and +.95 for April 16-30.

Brown trout year-class strength versus spring discharge has strong negative correlations for a power function regression analysis (Table 4) for April and May, 1980-83. This is a pattern that has been repeated in virtually every other stream included in this Job 1 study. Brown trout year-class is inversely correlated with the spring discharge levels. Brown trout fry are very sensitive to high water velocities (Ottaway and Forrest 1983) at the early post-emergence period which invariably occurs on the ascending limb of the spring discharge hydrograph in Colorado. Thus, the response of the brown trout in the Colorado River is similar to that of other streams and brown trout populations around the state.

However, the relationship between brown trout and rainbow trout numerical density in the Colorado River is also quite unique in that rainbow trout often are higher in density and biomass at most study sites in years from 1979-84, even in the public water sections such as the Lone Buck and Paul Gilbert Wildlife areas. Judging from past experience on other public sections of streams across Colorado, angling pressure and harvest on the Colorado River should have reduced the wild rainbow component of the trout population to an insignificant level. Yet even prior to the implementation of special protective regulations in 1981, we found rainbow numbers and biomass to be 4-10 times higher than those for brown trout. Why?

Again, we return to the spawning times and flows for the answer. Examination of the data in Table 5 tells the story. Brown trout in the Colorado River spawn in October. At no time between October 1976 and October 1981 were the daily discharge levels over 100 ft^3/sec during the brown spawning period. In October 1975 and 1982, mean daily discharge levels slightly exceeded 100 ft^3/sec on a few days, but was never over 120 ft^3/sec. In contrast, rainbow spawning flows for April 1976-82 have ranged from a mean monthly flow of 124 to 269 ft^3/sec for those 7 years. Thus, if we compare mean spawning WUA microhabitat values from 1979-82 (Table 5), we find rainbow spawning WUA is from 3.0-7.1 times more abundant than brown spawning WUA for the respective spawning years and year-classes. Similarly, for the ratio for rainbows/ha to browns/ha for each year-class at age 2+, we discover the higher ratios of rainbows to browns is in the years when the ratios of rainbow spawning WUA to brown spawning WUA are also higher. A power curve regression analysis of rainbow WUA/brown WUA (X variable) versus 2+ rainbow/ha-2+ brown/ha (Y variable) for 1979-82 gives a positive correlation coefficient of +0.96.

Table 5. Rainbow and brown trout spawning flows and spawning microhabitat (WUA) for the Colorado River at the Lone Buck Wildlife Area, 1979-82, and corresponding habitat and year-class strength ratios for rainbow:brown trout.

Year class	Brown Trout		Rainbow Trout		Rbw/WUA Brn WUA	Year-class Rbw/ha/ Brn/ha
	$\bar{X}$ Oct Flow	$\bar{X}$ Brn WUA	$\bar{X}$ Apr flow	$\bar{X}$ Rbw WUA		
1979	81	1,497	202	9,900	6.61	2.4
1980	73	1,226	187	8,700	7.10	3.9
1981	78	1,370	124	4,100	2.99	0.34
1982	64	982	143	5,500	5.60	1.0

It is interesting to note that when the advantage of rainbow spawning WUA drops from 3-5 times that of brown trout, brown trout year-class strength equals or exceeds that of the rainbows at age 2+ (see 1981 and 1982 in Table 4). Our creel census and population estimation data from several areas (South Platte, Fryingpan, and Gunnison rivers) shows that where rainbows and brown exist in the wild in sympatry, rainbows are from 3-5 times more vulnerable to angler harvest than brown trout. Thus, it is probably more than just a coincidence that on the Colorado River, rainbows are able to dominate the trout population when rainbow spawning habitat exceeds that of brown trout by a ratio of more than 5:1, i.e., when spawning WUA ratios of rainbows:browns is greater than 5:1, rainbow recruitment is more than enough to offset the rainbow's greater vulnerability to angler harvest.

Thus, brown trout are at a severe competitive disadvantage in the spawning area since they are fall spawners. In the Colorado River, with its massive water storage and diversion facilities, enough water does not remain in the river during the fall and winter months to provide adequate water depth and velocity over the best spawning sites (proper gravel) on the peripheral areas of the channel. Thus, the browns can only attempt spawning over the larger rubble-cobble substrates still watered in mid-channel areas. Undoubtedly, brown trout spawning success suffers accordingly.

Gunnison River

At present, we have 4 years of electroshocking data on the Gunnison River in the Black Canyon (1981-84). The wide range in annual hydrographic patterns in this river from 1980 through 1983 provides an excellent opportunity for "field-proofing" the relationship between salmonid recruitment and spring, early summer discharge patterns. For the calendar years 1980-83, the Gunnison River ran the third highest mean annual discharge in 21 years (1983), the median water for mean annual discharge (1982), a 1 in 7 low water year (1981), and the 1 in 5 high water year (1980) based on mean annual discharge.

Our studies on the South Fork of the Rio Grande (Nehring and Anderson 1984) clearly demonstrate the negative impact of high spring run-off on survival and recruitment of young-of-the-year (YOY) brown trout to the population. Our studies in the Black Canyon of the Gunnison clearly demonstrate a strong negative correlation between rainbow and brown trout year-class strength and mean monthly discharge for June, July, and August 1980-83. Since we cannot effectively electroshock YOY rainbow and brown trout from our Jon boat, because of the small size of the trout, we regressed second summer (1+) rainbow and brown trout (N/ha) against mean monthly discharge for all calendar months in the year each cohort of trout hatched out. Specifically, numbers of 1+ rainbow and brown/ha sampled in August 1981 were regressed against mean monthly flows for January-December 1980, the year the 1981 1+ cohort of trout hatched. We believe this correlation is relatively unbiased by angler harvest as the majority of 1+ browns and rainbows are 23 cm (9 in.) in length or less and have not been subjected to angler harvest for more than a month or two at the time of sampling. Correlation coefficients were poor ($r \leq \pm 0.6$) for most months except for June, July, and August, the months that rainbow and brown trout fry are just emerging or have just emerged from the gravel and are highly vulnerable to high water velocities (Ottaway and Forrest 1983). The data in Table 6 below compares rainbow and brown year-class strength as numbers of 1+ trout/ha and mean monthly discharge from April-August 1980-83. Power curve and linear regression analyses give the best correlation coefficients (r) for both rainbow and brown trout. These correlation coefficients are listed in Table 7 below.

Table 6. Rainbow and brown trout year-class strength (N/ha as 1+ years of age) versus mean monthly flow for year of emergence as fry.

Water year	Sample year	Duncan-Ute rb/ha	Duncan-Ute brn/ha	Smith Fork-N. Fork rb/ha	Smith Fork-N. Fork brn/ha	Mean Monthly Flow (ft^3/sec) April	May	June	July	Aug.
1980	1981	197	641	177	88	1,619	2,124	1,852	1,049	812
1981	1982	212	363	167	122	231	226	234	240	259
1982	1983	111	242	43	140	452	420	759	763	754
1983	1984	4	82	8	65	850	1,148	4,175	4,197	2,000

Table 7. Regression analyses of Gunnison River rainbow and brown trout year-class strength at age 1+ trout versus mean monthly discharge, April-August 1980-83.

Population	Location	Regression type	Correlation coefficient (r) by month April	May	June	July	Aug.
1+ rainbow	Duncan-Ute	Power curve	-.243	-.310	-.739	-.867	-.827
1+ rainbow	Duncan-Ute	Linear	+.049	+.017	-.806	-.896	-.918
1+ brown	Duncan-Ute	Power curve	+.090	+.035	-.484	-.674	-.650
1+ brown	Duncan-Ute	Linear	+.589	-.556	.430	-.621	-.591
1+ rainbow	Smith Fork-North Fork	Power curve	-.138	-.179	-.664	-.820	-.815
1+ rainbow	Smith Fork-North Fork	Linear	+.255	-.243	.578	-.705	-.748
1+ brown	Smith Fork-North Fork	Power curve	-.651	-.727	-.843	-.824	-.745
1+ brown	Smith Fork-North Fork	Linear	-.614	-.675	-.902	-.815	-.781

Middle Fork of the South Platte River

This stream is the only river included in the Job 1 study where no significant relationship can be documented between brown trout year-class strength and stream discharge for the spring-summer months. We have one plausible explanation.

This study stream is far and away the highest elevation study area, near 3,000 m or 10,000 feet elevation. The surrounding area is severly windswept in the winter months and in some years, does not receive more than a minimal snow pack even in above average precipitation years since it lies on the snow shadow (leeward) side of the continental divide. However, mid-winter temperatures can dip to minus 40 C or lower causing the often exposed stream channel to freeze from the bottom (anchor ice) up due to the supercooling effect of wind and low temperatures on the exposed streambank. In these winters, it is quite likely that brown trout redds are frozen solid in the gravel. In such a case, brown trout year-class strength would have no relationship with spring-summer discharge levels.

Rio Grande River

We have not yet initiated cross-sectional analysis of the Rio Grande River to develop WUA habitat curves versus stream discharge. However, we do have 4 years (1981-84) of electroshocking data from two different areas on the Rio Grande River. Thus, it is possible to run a regression analysis of mean monthly discharge versus brown trout year-class strength. We regressed the population density of 1+ brown trout against mean monthly flow from March through September. Numbers of 1+ brown trout were regressed against mean monthly flows for the year of emergence for each cohort. The data used in the regression analysis is presented in Table 8 below.

Table 8. Linear regression analysis of brown trout cohort size (as 1+ juveniles) in the Rio Grande River versus mean monthly discharge.

Water Year	Sample Year	N	Mean monthly discharge (ft^3/sec.) March	April	May	June	July	Aug.	Sept.
			Coller Wildlife Area (2.2 miles)						
1980	1981	1,060	113	276	1,393	2,734	1,557	383	361
1981	1982	1,239	104	377	1,010	1,243	513	400	312
1982	1983	1,206	109	311	988	2,180	992	766	716
1983	1984	994	127	187	1,084	2,421	1,581	738	304
			State Bridge Section (6.8 miles)						
1980	1981	1,310	214	560	2,520	4,967	2,127	500	458
1981	1982	3,276	173	530	1,458	1,734	603	428	390
1982	1983	2,974	231	561	1,810	3,469	1,401	1,052	1,185
1983	1984	1,966	244	379	1,789	4,064	2,005	944	385
			Linear correlation coefficient (r)						
Coller Wildlife Area			-.920	+.938	-.552	-.775	-.941	-.183	+.445
State Bridge Area			-.465	+.207	-.876	-.917	-.918	+.092	+.378

The high correlation coefficients for the Coller Wildlife Area for March and April are purely a function of insignificantly low variations in flow. The rest of the r values for both areas for March, April, August, and September are poor ($r \leq \pm 0.5$). In contrast, the r values for June and July and to a lesser extent May, are consistently high and negative (r ranges from -0.775 to -0.941) again indicating a strong negative correlation between year-class strength and spring-summer discharge. As was the case on the Gunnison River, virtually all 1+ brown trout on the Rio Grande River are less than 20 cm (8 in.) total length at the time of sampling. Thus, cohort density should not be impacted by angler harvest as most anglers release trout less than 20 cm (8 in.) in length.

St. Vrain River

A portion of the St. Vrain River went under catch-and-release management beginning in 1981. Four electroshocking study sites were set up in the fall of 1981 to gather pre-catch and release population data. Once again, we regressed brown trout year-class strength (age 1+) against mean monthly flows for the spring and summer months, March through August 1979-83. The only two stations for which meaningful evaluations could be made for the entire period were the upper two stations, i.e., City Park or Meadow Park, and the Gaging Station. The lower two were subjected to a fish-kill in the summer of 1981 and one station also underwent an extensive stream improvement project in 1981 as well.

Linear regression analysis produced consistently higher correlation coefficients over a power curve regression analysis for both the Meadow Park and Gaging Station study sites, with r values of -0.76 and -0.62 for the two stations, respectively, for the month of May. April also gave strong negative r values of -0.71 and -0.57 for the Meadow Park and Gaging Station study sites, respectively. All other months (March, June, July, and August) resulted in very poor correlation coefficients for both study sites in all months.

With the study sites on the St. Vrain (near Lyons, Colorado) being at a relatively low elevation (5,300 ft or 1,616 m), one would anticipate an earlier hatching time and emergence here as compared to other higher elevation study sites around the state. Indeed this is the case with the strongest relative correlations on the St. Vrain coming in April and May, versus June and July for brown trout populations on the higher elevation study sites and streams across the state, including the Arkansas, Cache la Poudre, Gunnison, Rio Grande, South Fork of the Rio Grande, and Taylor rivers. Only on the Colorado River, a higher elevation stream, were the months of April and May discharges most critical to brown trout emergence, probably due to the impact of thermal hot springs which flow into the Colorado River at Hot Sulphur Springs, about 5 km above our study site. Elevated water temperatures would result in earlier brown trout hatching and emergence time.

South Platte River

We now have 7 years of electroshocking data from the South Platte River. As has been the case on the Arkansas, Cache la Poudre, Gunnison, Rio Grande, South Fork of the Rio Grande, and the St. Vrain rivers, year-class strength for rainbow and brown trout in the South Platte River below Cheesman Dam is strongly (negatively) correlated with spring discharge levels. For brown trout, the discharge levels in April, May, and June are most critical. Rainbow trout year-class strength is very strongly correlated with flows in June and July with the strongest negative correlation coefficient (r) in July.

Both peak daily discharge (per month) and mean monthly discharge correlate very well. With the peak daily discharge, a linear regression provides the best correlation coefficient while a log or power curve function (curvilinear) regression provides the best correlation with mean monthly flow. For a detailed look at the correlations between young-of-the-year (YOY) and age 1+ year-class strength with peak daily flows (by month) and mean monthly flows, see Tables 9-12.

For rainbow trout, there were no strong correlations with April or May monthly flows, nor with lowest May (incubation) flows, indicating that available spawning habitat (in April) nor incubation (May) flows are not a factor limiting or controlling the rainbow trout populations in either the Deckers or Cheesman Canyon study areas.

Table 9. Brown trout year-class strength in the Cheesman Canyon and Deckers area versus various spawning, incubation, and emergence flows in the South Platte River, 1978-84.

Year class	N/ha YOY	N/ha 1+	Peak discharge/month (ft/s) April	May	June	July	Spawn X Oct.	Incubation low winter	spawn minus incubation
1979	993	268	176	39	670	805	25	8	17
1978	657	218	52	121	426	528	75	16	59
1982	604	176	365	509	181	252	96	15	81
1981	939	165	397	303	142	228	71	13	58
1980	48	72	441	1,070	1,300	912	251	16	235
1983	48	46	642	843	1,200	828	127	15	112
1984	34	--	384	931	972	946	149	15	134
r linear YOY[a]			-.616	-.931	-.811	-.647	-.832	-.663	-.826
r log YOY[a]			-.483	-.836	-.726	-.606	-.865	—	-.865
r linear 1+[b]			-.875	-.935	-.662	-.336	-.788	-.626	-.782
r log 1+[b]			-.719	-.924	-.465	-.267	-.881	—	-.872

[a]Deckers Area YOY
[b]Cheesman Canyon 1+

Table 10. Brown trout year-class strength at the above Deckers study section versus mean monthly flows (ft^3/sec) from April-August 1978-83.

Year Class	YOY/ha	N/ha	April	May	June	July	Aug.
1978	657	906	26	48	155	99	67
1979	993	993	63	26	339	512	258
1980	48	460	157	809	953	651	266
1981	939	1,813	232	63	47	144	145
1982	604	1,779	266	316	53	111	591
1983	48	696	239	496	819	478	527
r linear YOY			-.297	-.909	-.843	-.523	-.427
r log YOY			-.324	-.900	-.704	-.474	-.411
r power YOY			-.357	-.853	-.799	-.644	-.420
r linear 1+			+.463	-.542	-.714	-.762	+.122
r log 1+			+.353	-.311	-.950	-.711	+.054
r power 1+			+.223	-.448	-.948	-.737	-.004

Table 11. Rainbow trout year-class strength in Cheesman Canyon versus mean monthly flows (ft^3/sec) from April-September 1978-83.

Year Class	YOY/ha[a]	1+/ha[b]	April	May	June	July	Aug.	Sept.
1978	108	106	26	48	155	99	67	34
1979	26	28	63	26	339	512	258	81
1980	6	16	157	809	953	651	266	126
1981	73	72	232	63	47	144	145	260
1982	185	806	266	316	53	111	591	331
1983	26	78	239	496	819	478	527	236
r power YOY			-.078	-.397	-.862	-.925	-.151	+.094
r power 1+			+.250	-.061	-.686	-.758	+.276	+.388

[a]Deckers area YOY/ha
[b]Cheesman Canyon 1+/ha

Table 12. Linear regression correlations for rainbow trout year-class strength versus peak discharge/month (ft^3/sec) for various spawning, incubation, and emergence flows for the South Platte River, 1978-84.

Year class	YOY/ ha[a]	1+/ ha[b]	April spawn	May Incu- bation	June hatch	July emer- gence	Mean April	Lowest(May) incubation flow
1982	185	806	365	509	181	252	266	256
1978	108	106	52	121	426	528	26	35
1981	73	72	397	303	142	228	232	26
1983	26	78	642	843	1,200	828	189	375
1979	26	28	176	39	670	805	63	21
1980	6	16	441	1,070	1,300	912	157	618
1984	4	--	384	931	972	946	211	356
r linear YOY[a]			-.300	-.434	-.880	-.997	+.208	-.383
r linear 1+[b]			+.026	-.005	-.699	-.891	+.560	+.017

[a]Deckers area YOY/ha
[b]Cheesman Canyon 1+/ha

For brown trout, year-class strength (both YOY and 1+ ages) were negatively correlated with mean monthly flows for October, which on the surface is rather surprising. One would normally anticipate that brown year-class strength would be positively correlated with fall (October) spawning flows. However, the real problem is with the difference between fall spawning flows and low winter flows, i.e., the greater the difference between spawning flows and low winter flows, the poorer the brown trout year-class strength. Higher spawning flows result in higher water velocities with the spawners selecting spawning sites nearer the edges of the channel. Then when mid-winter releases are dropped from 125-250 ft^3/sec in October (the cases for 1980, 1983, and 1984 year-classes) down to 15 ft^3/sec, we find we have our poorest brown trout year-classes. Conversely, in 1978, 1979, 1981, and 1982, the years when October spawning flows ranged from 25-96 ft^3/sec, and the winter incubation flows were dropped to 8-16 ft^3/sec, the magnitude of difference between spawning and incubation flows was much less (Table 9), and we see our strongest year-classes for browns developing. Thus, stability in water releases out of Cheesman Reservoir from October through March would be much preferred even if the flows were lower. However, it would be best if the releases were in the 50-100 ft^3/sec range rather than in the 5-50 ft^3/sec range, as the releases less than 50 ft^3/sec definitely do result in fewer brown recruits and a lower catch-per-man-hour (CPMH) for brown trout 2 years later, as was demonstrated in the relationship between mean winter flows and brown catch-per-man-hour (CPMH) from 1961-70 (Nehring 1980).

Skeptics might ask, "Why do the lower flows during incubation seem to have a negative impact on the browns, but not on the rainbows?" There are two probable reasons. First, the magnitute of the dewatering, often times down to less than 10 ft^3/sec for weeks or even months at a time. Second, the dewatering occurs during the cold winter months when bottom and anchor ice becomes a severe problem in the Deckers area, probably freezing incubating brown eggs in the gravel. Reiser and White (1983) found that the total dewatering of steelhead and chinook salmon redds did not adversely affect egg hatchability as long as the substrate contained at least 4% moisture by weight. However, Reiser and White (1981) also found that alevin survival in dewatered substrates is very low after just a few hours of dewatering. Hobbs (1937), Hardy (1963), and Hawke (1978) all demonstrated excellent survival of dewatered salmonid eggs in New Zealand. However, Becker et al (1982) concur with Reiser and White (1981) that newly hatched and pre-emergent alevin mortality ranges from 50-100% within 1-10 hours after dewatering. Clearly, once salmonid alevin respiration is dependent upon the gill structure, any dewatering of the intra-redd environment has dire consequences for the salmonid population.

It must be kept in mind that many environmental variables will alter the response of salmonid egg hatchability in the wild from the responses in the studies cited above. The slope of the stream channel in larger salmonid streams in the intermountain west is usually much less than 1%. In the study of Reiser and White (1983) the slope of the artificial channel was 2%. They also indicate accumulated fines and sediment in the intra-redd environment will adversely affect survival. Few rivers exist anywhere in the natural environment where some suspended fines or organic debri is not borne in the water column. Thus, to draw the conclusion (from the preceding discussion) that total stream dewatering during salmonid egg incubation periods poses no threat to the survival of a new year-class is an extremely precarious assumption. It is also extremely narrow in scope since no consideration is given to either the survival of the juvenile or adult salmonids, nor to the aquatic invertebrate fauna of the stream.

Taylor River

Cross-sectional analysis was completed on the Taylor River during the 1984 field season. Attempts were made to correlate brown trout year-class (1+) strength with adult WUA based on the IFG4 and PHABSIM computer simulations. Correlations were poor ($r \leq \pm 0.5$). Attempts were also made to correlate brown trout year-class (1+) strength with differences between spawning and incubation flows in the winter months (October-March) of the year a cohort was incubating in the egg stage. Again, correlation coefficients were poor ($r \leq -0.5$). Average density of adult brown trout over four electroshocking stations regressed against differences in the magnitude of fall-winter flows did provide a strong negative correlation ($r=-0.894$) on a linear regression analysis.

This strong negative relationship between adult brown trout density (trout $\geq$15 cm total length/km), versus differences in the magnitude of winter flows indicates severe over-winter mortality in years when the variations between high 7 day flows and low 7 day flows were very large. Indeed in the years when this difference was from 200-500 ft^3/sec, variation between 7 day maximum and minimum winter flows (October-March), the population density was lowest. Conversely, in the years when the differences between maximum and minimum 7 day winter flows were less than 100 ft^3/sec, population densities were the highest. Table 13 contains data indicating the relationship between: gross wetted surface area/1,000 feet of stream channel; adult brown trout WUA/1,000 feet of stream channel; and stream discharge. The data indicate that below 100 ft^3/sec dramatic decreases in gross wetted surface area and adult brown WUA occur. Habitat losses (gross and WUA) become even more dramatic at 75 ft^3/sec. At 25 ft/sec, adult brown trout WUA has dropped to 612 ft^2/1,000 ft stream channel. That represents a 92% reduction from the estimated WUA at 100 ft^3/sec. Examination of U.S.G.S. flow records for the Taylor River below Taylor Park Reservoir indicate water releases from the reservoir were often held at 25-30 ft^3/sec for most of the winter months in the 1960's and early 1970's.

Table 13. Gross wetted surface area, adult brown trout WUA versus discharge on the Taylor River.

Discharge (ft^3/sec)	Gross area ft^2/1,000 ft stream	Adult brown WUA ft^2/1,000 ft stream	Incremental loss of WUA as the flow decreases
25	70,700	612	1,678
50	86,500	2,290	3,280
75	98,800	5,570	2,180
100	104,400	7,750	4,100
125	107,000	11,850	2,160
150	109,900	14,010	1,080
175	111,700	15,090	620
200	113,700	15,710	550
250	117,500	16,260	1,270
300	119,000	17,530	810
350	120,000	18,340	720
400	120,800	19,060	260
450	121,500	19,320	560
500	122,100	19,880	320
600	123,000	20,200	

An optimum flow range in the Taylor River can be predicted by an arithmetic sum of the WUA for all life stages of brown trout at each flow and then determining the range of discharge that provide near maximum WUA. For this study section, a range of flows from 150-300 ft^3/sec provided near maximum WUA for brown trout spawning, fry, and juvenile brown trout, as well as a high level of adult brown trout WUA. All life stage (including adults) maxima for rainbow trout WUA also occur within the 150-300 ft^3/sec discharge range. (Table 13 and Figures V-1 and V-2 in Appendix V). This optimum flow range is not to be construed as an official recommendation by the Colorado Division of

Wildlife for flow releases in the Taylor River. Rather, it is a general guideline from a biological standpoint to be considered in general reservoir operational planning.

The cross-sectional analysis indicates habitat loss becomes increasingly acute as the flow drops below 100 ft^3/sec. Comparison of flow records for the Taylor River below Taylor Park and the Taylor River at Almont indicate that mid-winter flows at Almont are generally 40-50 ft^3/sec higher than the readings in the river below the reservoir. Thus, releases of 50-75 ft^3/sec from the reservoir in mid-winter would result in a 100-125 ft^3/sec discharge at Almont. It seems biologically prudent to recommend that the flow releases out of Taylor Park Reservoir not be dropped below 50 ft^3/sec except for emergency maintenance, and that a minimum release of 75 ft^3/sec would be better for maintaining minimal overwinter habitat for adult brown trout. An optimum range of flows for most brown trout life stages in the Taylor River is 150-300 ft^3/sec. Flow levels above 500 ft^3/sec become increasingly detrimental to the trout population. We hope these flow level guidelines can be considered in the overall operations planning for Taylor Park Reservoir.

RECOMMENDATIONS AND CONCLUSIONS

At this point in the stream flow investigations study we have clearly documented strong inverse relationships between brown and rainbow trout year-class strength versus spring and early summer discharge levels on the Cache la Poudre, Colorado, Gunnison, and South Platte rivers. We have documented the same sort of relationship between brown trout year-class strength and spring-early summer discharge on the Arkansas, Rio Grande, and South Fork of the Rio Grande rivers.

We have also demonstrated the negative impacts of rapid and extreme flow fluctuations on the South Platte, Gunnison, and Taylor rivers at critical times in the trout's life cycle. The most critical times (for the most part) are during the hatching and emergence periods as has been demonstrated in the above discussion. Rapid dewatering (at one end of the spectrum) has dire consequences for the survival of newly hatched but pre-emergence trout alevins, April and May being the critical period for brown alevins in most areas, and June-July the critical period for rainbow alevins. Extreme highs (at the other end of the spectrum) are equally detrimental to post-emergent fry.

Our studies also indicate that the absolute magnitude of spawning flows is of much less critical importance than the magnitude of fluctuations between spawning and incubation flows as has been demonstrated in both this report, and previous progress reports, on the Taylor, South Platte, and Gunnison rivers. Stability of flow between spawning and incubation, and finally hatching is of utmost importance. We have demonstrated the negative impacts of severe, long-term, aggravated dewatering of the upper Colorado River on the brown trout population.

Refining our ability to document the impacts (negative or positive) of streamflow on salmonid populations is of paramount importance. Water development projects will always be a fact of life in the West. Developing a capability to predict the impacts of a water development project on stream trout populations (or any piscine species) before the project becomes a reality will greatly enhance our ability to manage the aquatic resource for the benefit of the fisherman and the fishery.

On the Taylor River, winter flows historically (up to the 1970's) have been manipulated to the detriment of the trout population. Differences between maximimum 7-day releases and minimum 7-day releases were often in excess of 400 ft^3/sec during the winter months in the 1960's and 1970's. Since the mid-1970's, the difference between the maximum and minimum 7-day flow has been less than 100 ft^3/sec, and our population studies (1979-82) indicate a statistically significant increase in the brown trout population compared to 1974-75.

This data, together with the results of th IFG4-PHABSIM analysis, indicates there are five things to be considered in attempting to minimize the impacts of Taylor Park Reservoir releases on the trout population in the lower Taylor River. First, 50-75 ft^3/sec should be the absolute minimum release except for short-term emergency maintenance. Second, attempts should be made to keep the difference between maximum and minimum releases in the fall-winter (October 20-March 1) period to 100 ft^3/sec or less. Third, the winter release pattern for Taylor Park Reservoir should be determined and set in place by October 20 at the latest, so that spawning brown trout will be able to select spawning sites that will have a good chance of being covered with water during the 120 day incubation period (November-March). Fourth, the optimum range of spring-summer flows is in the 150-300 ft^3/sec range. Fifth, maximum flows above 500 ft^3/sec become increasingly detrimental to most life stages of both brown and rainbow trout.

Job No. 3

Job Title: Special Regulations Evaluations

Job Objective: Determine the impacts of special regulations management (including Wild Trout and Gold Medal Trout Waters) on trout population dynamics and the fishing public.

Period Covered: July 1, 1984-June 30, 1985

INTRODUCTION

Background

This job began in 1979 with a study of eight streams. Streams have been added and deleted from this study since that time. A total of 16 streams have been evaluated during the period 1979-1984 and 12 streams are currently under investigation in Job 3. They include the Arkansas, Cache la Poudre, Colorado, Eagle, Fryingpan, Gunnison, Middle Fork of the South Platte, North Platte, Rio Grande, South Platte, St. Vrain and Blue rivers.

In the past 3 years, Colorado has implemented Wild Trout and Gold Medal trout management programs. These programs rely on special restrictive angling regulations to aid in achieving the objective of producing larger numbers of quality-size (14 in. and larger) trout. More than 200 miles of river in Colorado are presently under special regulations management as compared to less than 25 miles in 1981. Evaluation of these areas is a high priority and this project will be responsible for the evaluation of most of the Gold Medal waters.

METHODS AND MATERIALS

Study streams were selected so a wide variety of special regulations could be evaluated. Gold Medal streams were given a high priority. Representative sampling stations were established within the special regulation (experimental) and standard regulation (control) areas. Many of the study sites had been selected at the onset of this project in 1979 (see Nehring 1980). Others were selected because earlier researchers had used them in their studies.

All trout populations were sampled by electrofishing. The electroshocking unit was a Coffelt Model VVP-2C (1,000 to 2,000 watt output) powered by a gasoline generator. On streams shallow enough to wade, the shocking unit and the stationary negative terminal were positioned at mid-station. Three to five positive electrodes were used to shock fish. The field crew usually consisted of seven to ten people.

The crew started at the downstream end of the station and slowly worked upstream collecting the stunned fish in dip nets. The electrofishing stations were from 183 to 366 m in length.

Two methods were used to estimate fish density on these streams. The Seber and LeCren (two pass) method was used on narrow streams where a large proportion (approx. 70% or more) of the population could be taken on the first pass.

First pass trout were held in a large crib until completion of the second pass. The formula for this estimate, described by Seber and LeCren (1967) is:

$$N = \frac{C_1^2}{C_1 - C_2}$$

Where N = the population estimate, C_1 = the first pass catch and C_2 = the second pass catch. The formula to determine the standard error for this estimate is:

$$S.E. = \frac{C_1 C_2 \sqrt{C_1 + C_2}}{(C_1 - C_2)^2}$$

The Peterson method (mark and recapture) was used on streams with lower sampling efficiency. On the first pass, all trout over 15 cm were marked by punching a small hole in their caudal fin. The marked trout were returned to the stream, usually within 15-30 m of the point of capture after the crew advanced far enough upstream. The second pass was completed between 1 and 4 days later. The formula for this method as described by Robson and Regier (1971) is:

$$N = \frac{MC}{R}$$

Where N = density estimate, M = total number of marked fish in the population, C = the number of fish in the sample, and R = the number of marked fish recaptured in the sample. When R was less than 10, one was added to each of the equation terms. The standard error of N is:

$$S.E. = \frac{M^2 C(C-R)}{R^3}$$

On large and deep rivers (Arkansas, Colorado, Gunnison, North Platte and Rio Grande), the electrofishing unit was mounted on a Jon boat. Trout were collected while the boat was in a controlled downstream drift. Stations varied in length from 3.5-11 km (2.2-6.8 miles). One to three marking runs along with one to three recapture runs were made on each station. The Schnabel (multiple mark-recapture) method was used to estimate density. This method is described by Robson and Regier (1971). Because of the size-selectivity of electrofishing gear, separate estimates were computed for 5 cm size-groups and compared to the overall estimate.

All trout captured by electrofishing were measured to the nearest centimeter. Scale samples were also taken from five trout in each centimeter length group at each study site for age-growth analysis.

Length-weight relationships ($W = aL^b$) were developed for rainbow and brown trout for each study stream in the first year it was sampled. In subsequent years, weights were computed from these equations. Biomass estimates were made by multiplying the number of trout in each centimeter group by the estimated weight for that length and then by summing all the centimeter groups to give a total weight estimate per station.

Age determination was made from scales with the aid of a microprojector. The length frequency distribution for the entire population (N/ha) was broken down on the basis of the percentage of each year class in each cm size group. Life tables were then constructed by summing the number of trout/hectare in each age group.

Two methods of obtaining creel information have been used in this study. The count/interview system, as described by Powell (1975) was used in an area where fishermen could easily be seen from the road. This method required that fishermen be counted four times a day at 3-hour intervals. The number of count days per month can vary but were randomly selected by weekdays and weekend days. Between count periods, fishermen were interviewed to obtain pertinent creel data. The count/interview system was utilized in 1984 on the South Platte River.

A voluntary mail-back postcard questionnaire system was found to give estimates very comparable with the count/interview system even though it was much less time consuming (Nehring and Anderson 1981). This system, also used on the South Platte River in 1984, includes having a clerk distribute numbered and dated postcards on the windshields of all vehicles parked at the trail heads used by fishermen. Data on the returned card represented completed trip information. This information was used to generate angler use and harvest statistics for three, 3-mile sections of the South Platte River in a manner similar to the creel censuses completed in 1979, 1980 and 1981.

RESULTS AND DISCUSSION

Arkansas River

In 1985 there was another regulation change on the Arkansas River. The Gold Medal designation downstream of Badger Creek was dropped and the catch-and-release regulation near Loma Linda and Cotapaxi reverted back to the standard regulation. The electrofishing of these two stations was also discontinued. Starting in January 1985, the Gold Medal and the 16 inch minimum size limit with a 2-trout bag limit, covers the same river section, from Stockyard Bridge to Badger Creek (7.5 mi., 12 km). The Salida electrofishing station remains within this area and was sampled on March 5 and 13, 1985.

In 1985 brown trout comprised 98.9% of the trout netted (n = 2,142), compared to 98.6% in 1984. Only one age I (1984) brown trout (12 cm) was caught in March 1985. This indicates recruitment in 1984 was by far the poorest recruitment year between 1980 and 1984, undoubtedly due to the very high 1984 spring discharge level (see Job 1).

The density estimate at Salida of trout over 15 cm of 8,361 ± 1,210 in 1985 was 6% lower, but not significantly different (P 0.05) from the 1984 estimate of 8,915 ± 1,069. However, the density estimates for trout over 15, 30 and 35 cm are 50%, 267% and 258% higher, respectively, in 1985 than was found in 1981, which represented the pre catch-and-release period (Table 14). This suggests that special regulation management has been beneficial to the fishery, albeit at a modest level.

Table 14. Density estimates for brown trout over 15, 30 and 35 cm for the Salida station, Arkansas River, 1981-1985.

	>15 cm		>30 cm	>35 cm
Year	N/ha	kg/ha	N/ha	N/ha
1981[a]	378	84.7	21	2.4
1982	351	98.1	135	11.9
1983	539	94.1	71	5.1
1984	606	135.2	87	10.9
1985	569	129.0	78	8.6

[a]pre catch-and-release population

The higher numbers that occurred in 1982 were an artifact of better growth rates in the 1981 season.

The length frequency histogram (Figure II-1, Appendix II) shows that there has been no substantial increase in the number of trout over 40 cm at the Salida station from 1981 to 1985. Also, the number of trout over 35 cm is still very low when compared to other Gold Medal streams. For example, only 2.4% of the trout over 20 cm were over 35 cm in 1985. These problems appear to be strongly related to the poor quality of the forage of the river and therefore, unrelated to overharvest or special regulation management. Job 5 of the 1984 progress report described in detail the invertebrate forage community of the Arkansas River.

Blue River

Trout population surveys on the Blue River have been conducted for the past 2 years and in 1981. This year, we changed to a fall only sampling schedule. Table 15 summarizes the changes that have occurred in the Blue River brown trout populations. Although brook and rainbow trout were collected, the browns are by far the most abundant, therefore, only the browns are considered in Table 15. The rainbows are stocked and the number of brooks is insignificant.

Table 15. Blue River brown trout population statistics 1981-84.

Station	Sampling period	N	N/ha	Kg/ha	≥ 25 cm 10 in.	≥ 30 cm 12 in.	≥ 35 cm 14 in.
Stream improvement section	Spring 1983	798	1,178	92	349	42	4
	Spring 1984	401	651	83	151	42	12
	Fall 1984	352	574	77	195	53	12
Blue River Campground	Spring 1981	136	163	5	5	1	1
	Spring 1983	245	332	27	32	6	0
	Spring 1984	495	795	100	177	51	8
	Fall 1984	532	782	123	301	75	36
Highway 9 Bridge Station near Slate Creek	Spring 1983	482	583	59	174	40	3
	Spring 1984	468	621	83	208	40	5
	Fall 1984	455	671	103	278	110	29

[a]1981 data at the Blue River campground is for a single pass electroshocking, at about a 50% efficiency, i.e., double all figures to compare between 1981 and 1983-84.

The size structure has shifted dramatically in favor of larger (≥30 cm) older browns at all stations between 1982 and 1984. Brown trout numbers and biomass have increased at the Blue River Campground area and Highway 9 bridge near Slate Creek sampling stations. Only in the stream improvement study area have numbers and biomass decreased.

It is interesting to note that the most dramatic improvement has been in the Blue River Campground study area where fishing pressure is the heaviest and the brown trout population had been the most decimated.

Viewed from virtually any angle or aspect, the response of the Blue River brown trout population to special regulations management has been exceptional. In the spring of 1981, when we first electroshocked in the Blue River Campground area, we collected only two trout larger than 25 cm. One was 27 cm, the other 37 cm. In the spring of 1983 (April 5th) we again collected only two trout larger than 25 cm, one at 28 cm and one at 30 cm. Special regulations went into effect on the Blue River in January 1983; thus, the potential benefits of these regulations (in protecting larger older fish from harvest) would not be manifested before one full angling season had passed; i.e., the spring of 1984. Our shocking studies reveal dramatic increases in numbers of brown trout 25 cm (10 in.) and larger, 30 cm (12 in.) and larger, and 35 cm (14 in.) and larger (Table 15). Our age and growth studies in the spring of 1981 and 1983 revealed we had no brown trout older than 5 years of age and very few more than 4 years old. We now have brown trout up to 7 years old.

In the spring of 1981 we had one, 5-year old brown trout/ha at the Blue River Campground. In the spring of 1984, after 1 year of protective regulations, we had nine, 5-year old brown trout/ha. For the three electroshocking stations, we averaged 14, five-year old brown trout/ha, in the spring of 1984. By the fall of 1984 we averaged 51, four-plus-year-old (fifth summer) brown trout/ha at the three electroshocking stations.

In the spring of 1981 at the Blue River Campground, we had 13, four-year old brown trout/ha. In the spring of 1983 we had dropped to four, 4-year old brown trout/ha. In the spring of 1984 we had 261, four-year old brown trout/ha at the Blue River Campground, a 65 fold increase in one year! We averaged 217, four-year old brown trout/ha at the three electroshocking stations in the spring of 1984. This had increased to an average of 268, three-plus-year-old (fourth summer) brown trout/ha at the three shocking stations by the fall of 1984! (See Life Tables III-2 in Appendix III).

Our age-growth analyses indicate that 33-35 cm (14-15 in.) browns are in their fifth and sixth summer of life and that we cannot expect a major increase in number of brown trout 40 cm (16 in.) in size as the average life span is probably 7 years at the most. But I would anticipate further increases in the number of browns 30-35 cm (12-14 in.) in size over the next 2 years. The cold thermal regime in the Blue River below Dillon Dam, however, may not allow for a better growth rate or maximum size.

It has been argued that if we do not have the biotic potential to grow trout in the Blue River much beyond 35 cm (14 in.), why have a 40 cm (16 in.) minimum size and bag limit? Our rejoiner is, "We do not know for certain if the Blue River has the biotic potential to produce significant numbers of quality or trophy size brown trout or not." Our age and growth data from the late 1970's and early 1980's is probably negatively biased since overharvest was certainly a problem rampant on the Blue River at that time. Thus, the most aggressive, fastest growing brown trout were cropped off by anglers leaving the less aggressive slower growing trout for age and growth analysis. This phenomenon was documented decades ago on the Pigeon River, Michigan (Cooper 1952). The data in Table 16 certainly supports this hypothesis.

Table 16. Average length (based on back-calculated age growth analysis) of 5 year old brown trout at age 4 in the Blue River before 1981 and after 1983-84 implementation of a 14-inch minimum size limit.

Season	Year	N (sample size)	Average length (cm)
Spring	1981	9	26.8
Spring	1983	8	27.7
Spring	1984	23	28.6
Fall	1984	13	30.3

An average increase in length of 3.5 cm (1.4 in.) for age 4 trout since the regulation was implemented certainly supports the contention that the largest, fastest growing fish were being cropped off prior to 1983. This also supports the contention that we should give a 16-inch minimum size limit a chance to work before we "sell short" the unknown biotic potential of the Blue River.

Clearly, as other investigators have known for some time (Engstrom-Heg 1981), and we are discovering as we test various regulations, "size limits ar the most effective means of regulating harvest, and should be used as the primary regulatory tool." Again, quoting Robert Engstrom-Heg (ibid), "creel limits have some regulatory value, but should be used mainly to promote better distribution of the harvest." It is becoming increasingly clear in our studies (as will be demonstrated below in subsequent discussion) that bag limits without size limits are virtually useless as a management tool to maintain or improve angling quality in our Gold Medal waters.

Cache la Poudre River

From 1963 to 1983, special regulation management on the Poudre River consisted of two wild trout waters where bait fishing was prohibited. This restriction apparently had little impact on trout population characteristics such as density, biomass or size structure (Klein 1974, Nehring and Anderson 1983). Starting in January 1983, three of seven electrofishing stations were on areas that had changes in the angling regulation. The Upper Wild Trout (UWTW), Indian Meadows and Lower Wild Trout (LWTW) waters bag limits were reduced from 8 to 2 trout per day. The Indian Meadows area also required all trout less than 16 inch be returned alive to the stream, which in effect is a de facto catch-and-release regulation.

In October 1984 the UWTW electrofishing station was moved 0.4 km downstream. This was done to make an electrofishing station that would be compatible with an IFG4 station. The new station apparently contained more available trout habitat.

By October 1983, both the UWTW and Indian Meadows (new regulation) stations had trout biomass increases of 33% over the 1982 levels. The trout biomass was again found to increase in 1984 for these two stations (Table 17). The Kelly Flat station had a biomass increase of 18% between 1982 and 1983, but by 1984 the biomass had dropped back to the 1982 level. The Lower Control station had no significant difference in biomass between 1982, 1983 and 1984. The large biomass increase in 1984 in the Big Bend station is probably due to the stream improvement work done by the Forest Service at this campground. Numerous boulders and log structures were added to the area in the summers of 1983 and 1984.

Table 17. Density and biomass for five upper Poudre River stations for 1982, 1983, and 1984.

Station	Density N/ha			Biomass Kg/ha		
	1982	1983	1984	1982	1983	1984
Big Bend	493	489	653	59	63	81
Upper Wild Trout	635	738	1,107[a]	72	96	160[a]
Lower Control	818	807	830	100	103	93
Indian Meadows	650	769	751	83	110	114
Kelly Flats	881	939	778	87	103	89

[a]Station relocated in 1984

Life Table data (Table III-2, Appendix III) shows that the older trout (age 3 and up) had better survival in the UWTW and the Indian Meadows stations compared to the Lower Control and Kelly Flat stations since 1983. In 1982 and before there appeared to be no difference in survival rates between these stations. This suggests that the change in regulations has reduced mortality on the older trout in the special regulation areas.

Length frequency histograms (Figure II-6, II-7, Appendix II) show that the two special regulation waters contain more trout over 25 cm for both rainbow and brown trout than the three standard regulation stations. This, plus the higher number of trout over 30 cm in the special waters (Table 18), suggests that the new regulation may be responsible for this since no difference was found in 1982.

Table 18. Number of trout ≥31 cm collected from the five upper Poudre stations.

Station	No./ha 1982	1983	1984
Big Bend	13	18	22
Upper Wild Trout	17	21	47
Lower Control	18	7	7
Indian Meadows	20	22	34
Kelly Flat	4	4	9

The upper Poudre River has a very short growing season and therefore, the trout population has a poor growth rate. However, the invertebrate forage of the upper river appears to be good, and it has been demonstrated that trout can live to an old age in the Poudre, at least 9 years (Klein 1974). These factors may counteract the slow growth rates of the trout population and eventually the upper Poudre may produce a quality trout population with protective regulation management. However, it could take several years for the trout population to respond to a catch-and-release management, if at all.

The threat of overharvest still exists on the Upper Wild Trout Water because it would not take many bag limits of two trout of any size to remove all trout over 30 cm. Therefore, the 16-inch minimum size limit would be a better protective regulation to evaluate the potential of the Poudre to produce quality (≥35 cm) size trout.

There was a significantly lower trout density at the Lower Wild Trout Water in 1984 compared to 1983. This was found inspite of the reduced bag limit at that station. There was no significant difference in trout density between 1983 and 1984 in the lower Poudre standard regulation station. The number of trout over 30 cm was zero in the LWTW and four at the control area. This strongly indicated that overharvest is still occurring on the LWTW even though the bag limit was reduced from 8 to 2 trout per day, and that more protection is needed if the quality of the trout population is to be improved. A size limit, such as that already in effect on the Indian Meadows section, is the only alternative worthy of continued evaluation.

Colorado River

We have sampled the Colorado River since 1979. Due to the interaction of many factors, low flows, high flows, stocking of catchable trout, etc., the data does not give a clear picture of how the new regulation is affecting the trout population. In 1983 a 1 rainbow, 1 brown per day regulation went into effect on the Colorado River from the head of Byers Canyon to Troublesome Creek. This section includes all sampling stations except Pioneer Park, which has a standard 8 fish/day bag limit. Tables 19, 20, and 21 summarize our sampling results.

Table 19. Colorado River trout population density estimates N/ha, 1981-84.

Study section	1979	1981	1982	1983	1984
			Rainbow trout		
Pioneer Park		78	84	275	104
Paul Gilbert		29	16	236	110
Lone Buck	230	98	88	80	180
Parshall	220[a]	889	410	202	210
			Brown trout		
Pioneer Park		56	90	193	63
Paul Gilbert		—	39	137	83
Lone Buck	30	23	27	63	57
Parshall	54[a]	294	175	127	150

[a]Estimates from Con Ritschards Ranch downstream from the Parshall Area.

Table 20. Colorado River trout biomass estimates (kg/ha), 1981-84.

Study section	1979	1981	1982	1983	1984
			Rainbow trout		
Pioneer Park		9	14	34	20
Paul Gilbert		4	4	30	29
Lone Buck	148	31	32	45	54
Parshall	138[a]	231	124	81	78
			Brown trout		
Pioneer Park		10	27	45	19
Paul Gilbert		—	17	29	23
Lone Buck	15	14	17	39	22
Parshall	15[a]	82	48	42	35

[a]Estimates from Con Ritschards Ranch downstream from the Parshall Area.

Table 21. Colorado River, trout/ha ≥35 cm (14 in.), 1981-84.

Study section	1981	1982	1983	1984
		Rainbow trout		
Thompson Ranch	112	75	48	20[a]
Pioneer Park	0	0	15	8
Paul Gilbert	1	2	10	11
Lone Buck	20	33	21	36
Parshall	185	173	86	78
			Brown Trout	
Thompson Ranch	45	48	31	6[a]
Pioneer Park	3	14	25	10
Paul Gilbert	0	15	13	11
Lone Buck	10	17	13	14
Parshall	36	53	25	11

[a]One electrofishing pass only, not a population estimate.

In 1984 populations decreased or remained unchanged in numerical density, biomass and numbers of large fish (≥35 cm) at all the stations except Lone Buck, which has improved. The Parshall station remained relatively stable but is still far above the other stations in quality and quantity. Theoretically, the other stations should be able to approach the population levels of the Parshall section. Physical habitat is similar between all sections; however, the Williams Fork augments the flow at Parshall during the low flow winter months. This may partially account for the Parshall section being consistently better than the other sections. Lower angler harvest by club members on the private waters in the Parshall area undoubtedly has a positive impact as well.

The rainbows at Lone Buck seem to have responded fairly well to the new regulation. All population parameters for rainbows have nearly doubled in the past year. It is particularly encouraging to see the number of large rainbows increasing so dramatically because the rainbows are particularly susceptible to angling. This section now has nearly half as many large rainbows and more large browns than the Parshall section. The brown trout population at Lone Buck has remained relatively unchanged. This is understandable because the browns are not as susceptible to angling, and so the change in regulations would have less impact in altering the population structure. Brown trout density is lower than the rainbows at all stations, probably due to the browns inability to compete with the rainbows, especially in light of the spawning habitat differences for rainbows and browns (see Job 1 discussion for the Colorado River).

While the increases in rainbow and brown numbers/ha, biomass (kg/ha), and numbers ≥35 cm/ha at Lone Buck in 1984 are encouraging, it is discouraging to note that rainbow biomass was 148 kg/ha in 1979 versus 54 kg/ha in 1984. We had 162 trout/ha ≥35 cm in 1979 versus 50/ha that size in 1984. Thus, the 1 rainbow/1 brown bag limit is not having the dramatic impact in improving number of quality size trout that was hoped for in the 2 years since the regulation went into effect.

Pioneer Park received heavy fishing pressure and has a liberal bag limit. As would be expected, all population parameters are low for this station when compared to the other stations. The low number of large rainbows is indicative of the fact that angling pressure is taking a toll on the quality size fish in this section.

Recruitment has been poor at all stations since 1979-80. Good spawning habitat is limited and run-off has been high. The poor recruitment, angling pressure, and low winter flows may be holding the trout population below the full potential of the river. This is especially true in light of the aquatic invertebrate population and productivity of the Colorado River (see Job 6).

Eagle River

We made only one electroshocking pass on the Eagle River at two stations in September 1984. The day we electroshocked, the discharge at Wolcott was 330 ft^3/sec. This flow level greatly hampered our shocking efficiency making it futile to attempt a population estimate. However, we did collect 3 rainbow trout and 32 brown trout. We collected only two brown trout $\geq$35 cm total length, one at 35 cm and one at 38 cm. Only 25% of the brown population were 30 cm or larger. With the limited recruitment (due to the siltation problem from Milk Creek) it is highly unlikely that any restrictive regulation short of total catch-and-release would measurably improve the rainbow and brown trout numbers, biomass, or quality trout density. A high minimum size limit in conjunction with a restrictive bag limit might have a measurable impact in increasing numbers, biomass, and numbers of quality trout.

However, due to the difficulties we encountered in shocking the Eagle River, i.e., high discharge, poor visibility due to siltation from Milk Creek, or both, we plan on dropping the Eagle River from this study at the end of the 1984/85 segment.

Fryingpan River

Trout population surveys conducted on the Fryingpan River from 1978 through 1984 reveal two serious problems. First, hypolimnetic releases from Reudi Dam result in water temperatures much below a tolerable level for rainbow egg incubation for the first 3-4 km below the dam (catch-and-release waters). To enhance the lack of rainbow reproductive success, a supplemental stocking of advanced fingerling rainbows has been implemented. Second, as a result of the 8 trout/day regulation with no terminal tackle restrictions from Basalt to the lower boundary of the catch-and-release section, there was a severe decline of trout 30-35 cm and larger. In 1983 these angling regulations were changed to a one rainbow-one brown trout bag limit with a flies and lures only terminal tackle restriction. The data in Table 22 summarizes what changes have been occurring in the Fryingpan River as a result of the above implementations.

Table 22. Trout density (N/ha) and biomass (kg/ha) statistics on the Fryingpan River, 1978-1984.

Season/Date	Catch-and-release: Ruedi Dam N/ha	Ruedi Dam kg/ha	N/ha ≥35 cm	Catch-and-release: Old Faithful N/ha	Old Faithful kg/ha	N/ha ≥35 cm	Std. regs. 1978-82: Taylor Creek N/ha	Taylor Creek kg/ha	N/ha ≥35 cm
Brown									
Fall 1978	366	87	24	--	--	--	272	43	28
Fall 1979	466	101	44	742	104	10	724	75	22
Spring 1980	251	66	31	483	64	0	469	67	8
Fall 1980	431	87	11	952	131	0	504	78	24
Spring 1981	349	79	17	689	107	27	871	138	30
Fall 1981	461	70	10	873	147	21	591	91	15
Spring 1982	511	83	22	712	114	19	703	131	18
Fall 1982	495	86	23	1,049	169	14	724	157	44
Fall 1983	672	146	54	962	150	7	539	122	47
Fall 1984	582	140	24	1,177	217	17	427	102	37
Rainbow									
Fall 1978	847	208	47	--	--	--	762	95	4
Fall 1979	220	88	49	324	104	48	635	61	25
Spring 1980	297	116	88	263	99	44	422	59	24
Fall 1980	241	73	64	344	83	46	280	30	5
Spring 1981	261	114	105	205	72	43	442	46	11
Fall 1981	138	15	9	93	26	18	349	31	0
Spring 1982	466	126	125	137	45	20	379	34	10
Fall 1982	464	113	53	145	44	20	181	29	23
Fall 1983	574	120	44	746	137	17	101	28	35
Fall 1984	762	280	163	479	163	64	116	28	26

As shown in Table 22, the rainbow trout population in the catch-and-release area declined dramatically after 1978 and up through the fall of 1981 when rainbow numbers were 84% below the 1978 level. Rainbow biomass fell from 208 kg/ha (1978) to 15 kg/ha (1981), a reduction of 93%! This was due to natural mortality in the older age classes and a total lack of rainbow recruitment from natural reproduction. Hypolimnetic releases from Reudi Dam are too cold during the April-May spawning and incubation period. Continuous recording thermograph data for 1980-83 indicates average water temperatures are in the 37-39 F range at this time of year. McAfee (1966) indicated excessive losses of incubating eggs occur at 42 F and below. The only viable solution was to initiate a fingerling stocking program immediately.

The first plant of 30,000 rainbow fingerlings went into the Fryingpan in October 1981. They averaged 11-12 cm in size. Thirty thousand rainbow fingerlings (6-7 cm average size) have also gone into the Fryingpan annually in July or August since 1982. In addition, 2,400 advanced fingerling rainbows were stocked in the upper 4.8 km of river in October of 1982, these fish were adipose-fin clipped. The 30,000 annual fingerling plants have all been spray-marked with fluorescent-orange pigment.

The results of our 1984 electroshocking survey give an indication of the success of the fingerling rainbow planting program as far as augmenting the rainbow component of the Fryingpan River trout population is concerned. The percentage of marked rainbows (spray-marked and fin-clipped) by station is presented in Table 23. Since we know where the 2,400 fin-clipped rainbows were planted (in the Old Faithful study area for the most part), it is quite clear that these fish have not moved very far in the 2 years since stocking. It is also strongly indicative that most (if not all) of the spray-marked fingering rainbows were planted in the upper part of the Fryingpan (catch-and-release area). It seems probable that they were all stocked at the Gaging Station stocking area where the truck can be backed right into the river for easy unloading. Our checks for spray-marked fingerlings in September 1982 indicated 100% (5 of 5) and 88% (15 of 17) of the fingerling rainbows were spray-marked at the Taylor Creek and Big Pullout stations, respectively. In 1983 we had 65% (22 of 34) of the rainbow fingerlings (10-14 cm) spray-marked at the Ruedi Dam station.

Table 23. Percentage of marked rainbows captured in 1984 at the Fryingpan study sections.

Station	Spray-marked		Fin-clipped	
	No.	%	No.	%
Gaging station	17/19	90	22/89	25
Ruedi Dam	14/25	56	49/173	28
Old Faithful	3/6	50	126/167	76
Upper Control	2/6	33	24/31	77
Taylor Creek	1/4	25	0	0

All of the data in the preceding discussion indicates that we have had uneven distribution of the fingerling rainbows planted from 1982 through 1984. We need to make an attempt at more even distribution of the fingerling rainbow plants on the Fryingpan River in 1985.

In September 1983 adipose-clipped rainbows comprised 81% and 89% of the total rainbow population at the Old Faithful and Upper Control stations, respectively. Similarly, in September 1984, 81% and 86% of the rainbows ≥30 cm at the Old Faithful and Upper Control stations, respectively, were adipose-clipped. The average size of the adipose-clipped rainbows in September 1983 was 22.6 cm with a range of 15-30 cm. In September 1984 the average size was 32.3 cm with a range of 21-41 cm, for an average increase in length of 9.7 cm (3.8 in.). The growth and survival of this cohort of rainbow has been excellent up to 2+ years of age.

As the planted fingerling rainbows continue to grow and survive in the catch-and-release area since stocking began in October 1981, we are seeing a dramatic increase in the number of rainbows $\geq$35 cm (14 in.). Numbers of this size rainbow increased four fold at the Ruedi Dam and three fold at the Old Faithful study sites.

Table 22 shows brown trout density (N/ha) and biomass (kg/ha) statistics remain relatively constant in the catch-and-release waters. Numbers of brown trout 35 cm and over rarely exceed and are normally significantly lower than rainbow trout 35 cm in this area. Brown trout densities remain constant because incubating eggs are tolerant of the hypolimnal releases. It is our belief that brown trout do not compete well with high densities of rainbow trout and therefore, numbers remain significantly lower than rainbows.

Density (N/ha) and biomass (kg/ha) statistics (Table 22) of rainbow trout from 1978-82 show a dramatic decline in the Taylor Creek station (standard regulations 1978-82). In 1983 a 1 rainbow-1 brown trout regulation with a fly and lure only terminal tackle restriction replaced the 8 trout/day regulation. Electroshocking surveys in 1983 and 1984 show a continuing slow decline in numbers of biomass of rainbow and brown trout (Table 22 and Figure II-17, Appendix II). However, a creel census was conducted on the Fryingpan River 1979-81 and again in 1983. There was no significant difference in CPMH between 1979 and 1981. In 1983, however, CPMH nearly doubled, even though population estimates remained low and anglers were releasing 92% of all trout caught under the one rainbow-one brown regulation, according to our creel census in 1983. Despite this high return (catch-and-release rate) the rainbow population has not yet really begun to recover after two full angling seasons under the one and one regulation. The question is "why"?

The answer is the rainbow population is so decimated that even a 92% catch-and-release rate allows too much harvest. Our population estimates at Taylor Creek in 1983 and 1984 indicate the rainbow density is only 40/acre. The 1983 creel census showed an average rainbow CPMH (catch-per-man-hour) of 0.554. Angling effort was 216/hour/acre/season in 1983 for a rainbow catch of 120/acre or 3X for each rainbow! With a 92% throw-back that still works out to a harvest of 10 rainbow/acre for 1983. Add in an additional 10 rainbow/acre natural mortality (25%) plus 5% hooking mortality on fly and lure released fish (which works out to six rainbow/acre hooking mortality) and we are losing about 26 rainbow/acre to all sources annually. That is a 65% loss from the population. When total annual mortality (natural plus angling) exceeds 50%, the trout population cannot increase. The most cost effective (and politically acceptable) means of increasing rainbow numbers in the one rainbow-one brown bag limit area will probably be through the stocking of advanced fingerling (5 in.) rainbow. Based on the success and survival rate for the adipose-clipped advanced fingerling stock that went into the catch-and-release area in October 1982, I would think a maximum of 10,000 should be adequate for the entire section from Ruedi to Basalt. They should be adipose-clipped and stocked at each stocking station between August and October 15, 1985.

Gunnison River

The data in Table 24 and Figure II-19 through II-27, Appendix II, summarize the changes that have taken place in the trout fishery in the lower Gunnison River from 1981-1984. The rainbow component of the trout population in the Duncan Trail to Ute Trail area increased steadily from 1981-1983 and then declined by 50% between 1983 and 1984. Due to the high run-off levels since 1982, rainbow reproduction has almost been non-existent since 1981. Our population estimates in 1984 for 1+ rainbows (1983 year class) for the Duncan Ute Trail area (2 miles of river) was 10 rainbows and in the Smith Fork-North Fork section (4 miles of river), there were 26 rainbows for the 1983 year class, i.e., about 5 rainbows/mile for the 1983 year class. The 1984 year class of rainbows will probably be smaller!

In the Smith Fork-North Fork section from 1981-1984, the wild rainbow population has been building up dramatically in total numbers, biomass, and numbers of rainbow trout 40 cm (~16 in.) and larger. The highest rainbow population estimate (7,670 in 1981) was an artifact of the stocking of 50,000 rainbow fingerlings in April 1981 at the Forks Management Area. Catchables were also stocked in May, June and July 1981 in this area. No stocking of any kind has been done in this area since 1981.

Table 24. Trout numbers and biomass data for the Lower Gunnison River, 1981-84.

Year	Population estimate		Biomass (kg/ha)		Numbers ≥40 cm (≥16 in.)	
	RBW	BRN	RBW	BRN	RBW	BRN
			Duncan-Ute Trail			
1981	3,147	8,691	110.7	201.2	471	37
1982	3,721	5,752	110.3	143.8	401	37
1983	4,274	5,861	149.8	134.5	440	21
1984	2,167	5,406	84.5	54.6	408	24
			Smith Fork-North Fork			
1981	7,670	2,170	50.5	25.8	162	52
1982	4,291	3,929	51.3	48.0	121	59
1983	5,598	4,682	80.3	60.1	129	208
1984	5,427	6,992	99.4	41.8	468	121

The brown component of the trout population has been decreasing in the Duncan-Ute Trail area and increasing in the Smith Fork-North Fork area from 1981-1984. The number of 40 cm browns in each study area is far less than the number of rainbows of a similar size. Larger brown trout, because of their more territorial nature, apparently do not compete well with high densities of larger size rainbow trout. We have observed this phenomenon on the South Platte, Colorado, Roaring Fork, Fryingpan and Gunnison rivers.

On September 15, 1984 a tremendous rainstorm struck the Black Canyon area severely eroding the Duncan, Ute and Bobcat trail areas, and washing out sections of the Peach Valley Road near the Falcon Road-Peach Valley Road intersection. We had several reports of significant numbers of dead trout and suckers between Duncan and Ute trails following that storm. One of the authors (Nehring) had just left the area after fishing on the Duncan-Ute Trail section of the river and witnessed first hand the washout of the Peach Valley Road. Several inches of rain fell in less than an hour. A professional river guide (Gabe Magtutu) was also on that section of the river at the time of the storm. One of his client fishermen reported counting more than 100 dead rainbow trout along the east bank of the river in less than a mile. This loss will undoubtedly be reflected in our population survey results for 1985.

We found a strong negative correlation (see Job 1 in this report for details) between rainbow and brown trout year class strength and mean monthly flows in June and July 1980-1983. It is during these months that both rainbow and brown trout are emerging from the gravel and beginning to swim about and are most vulnerable to high water velocities (Ottaway and Forrest 1983). PHABSIM analysis of habitat in the Duncan-Ute Trail section indicates fry and juvenile rainbow and brown trout habitat is maximized at discharges in the 200-600 ft^3/sec range. Maximum discharge in both 1983 and 1984 peaked at over 10,000 ft^3/sec and mean monthly discharge was in excess of 4,000 ft^3/sec for June, July 1983 and 1984. Mean monthly discharge in June 1984 was 7,459 ft^3/sec.

In summary, the special regulation has had a very positive impact in building up the trout population in the most heavily used Smith-Fork to North Fork section since 1981. With the very poor rainbow reproduction since 1981, preservation of the larger older rainbow stocks will be important until we have a successful spawn, hopefully in 1985. A change in regulations for the Black Canyon area is possible for the 1986/87 angling seasons. The Director has directed the Aquatic Resources Section to compile recommendations for simplification of angling regulations for Gold Medal and Wild trout waters by mid-1985. However, it is important that whatever the new regulation is, it should incorporate a size limit of some sort to adequately protect both rainbow and brown trout spawners, as well as control the harvest of quality size trout.

In addition to our electroshocking studies in the Black Canyon of the Gunnison, we also shocked three areas in the upper Gunnison drainage. Single electroshocking runs were made on the Gunnison River from Almont to Gunnison and from the Gunnison Sewage Treatment Plant to Blue Mesa Reservoir in August 1984. A population estimate was also completed on the East River from Roaring Judy Hatchery to Almont, a 6 km (3.7 mi.) section of river, in late September 1984. Examination of the length-frequency histograms (Figures II-23 and II-24, Appendix II) for rainbow and brown trout in the East River, as well as in the Almont-Gunnison, Gunnison-Blue Mesa, and Duncan-Ute Trail sections of the Gunnison River indicate that a significant percentage of the trout in the

Almont-Gunnison and Gunnison-Blue Mesa areas are a quality size, i.e., 30-50 cm (12-20 in.) in size. Our experience in streams where overharvest has been a problem, shows that we would not have this distribution of fish in the larger size classes if over-harvest in the upper Gunnison were a problem. As shown in Table 25, the percentage of rainbow and brown trout at least 30 cm (12 in.) or larger in size in the upper Gunnison River compares very favorably with areas upstream (East River) and downstream (Black Canyon-Duncan to Ute Trail) that are managed for quality angling.

Table 25. Percentage of total trout captured that were ≥30 cm (12 in.)

	Rainbows	Browns
East River - Roaring Judy to Almont	10.2	26.9
Gunnison River - Almont to Gunnison	22.4	28.4
Gunnison River - Gunnison to Blue Mesa	37.2	34.3
Gunnison River - Black Canyon Duncan-Ute Trail	42.9	10.7

On the State Bridge section of the Rio Grande 25.6% of the brown trout population exceeds 30 cm or 12 inches in length. On the Colorado River, 21.4% of the browns and 57.3% of the rainbows are 30 cm in length or larger. On the North Platte, 48.5% of the browns and 26.6% of the rainbows are 30 cm or larger. Clearly, the upper Gunnison (Almont to Blue Mesa) ranks among the best streams in the state from a quality trout fishing standpoint, without any special protective regulations at this time.

The average size and growth for brown trout at a given age in the upper Gunnison River (Almont to Gunnison) is less than that for the browns in the Black Canyon between the Duncan and Ute trail areas (Table 26). However, with the colder water temperatures and shorter growing season in the upper Gunnison, smaller annual growth increments and smaller trout at a similar age are to be expected.

High spring run-off is probably the major environmental factor limiting rainbow trout populations in the upper Gunnison River. Our studies in the Black Canyon clearly indicate high spring run-off in 1982, 1983 and 1984 has severely limited rainbow recruitment and spawning success in the last 3 years. Brown eggs hatch at least 3-6 weeks earlier or more than rainbow eggs resulting in trout recruitment, and survival that is better than it is for rainbows in average and above average run-off years. Based on comparisons of percentages of rainbow and brown trout ≥30 cm (12 in.) in the Gunnison River from Almont to Blue Mesa with those from Gunnison in the Black Canyon, the North Platte, the Rio Grande, and Colorado rivers, we are confident in stating that there is no apparent need for special regulations being applied to the upper Gunnison River at this time.

Table 26. Average size (cm) of brown trout at age in the Gunnison River.

Age	Almont-Gunnison	Black Canyon
1+	15.5	15.9
2+	21.0	26.1
3+	27.7	32.5
4+	33.3	38.8
5+	38.3	46.0
6+	39.6	—

Middle Fork of the South Platte River

The history and effects of special regulation management on the brown trout population from 1979-1983 was summarized and presented in the 1984 F-51-R Annual Progress Report. It was recommended that a more liberal regulation could be adopted, which was done in July 1984 and continues at present. This regulation allows for a daily bag of eight trout of which only two may be over 16 inches in length. Artificial flies and lures only is still required.

The results of the 1984 trout population sample (Table I-8, Appendix I; Figures II-29 and II-30, Appendix II) collected on October 1 and 2, 1984 indicate that the present regulation has not been detrimental to the size structure of the trout population. The 1984 data also did not alter any conclusions or recommendations made last year.

A length-weight relationship was developed for brown trout over 40 cm from weights taken in 1984. This regression was used to recalculate the biomass of the 1983 brown trout population as well. Biomass for brown trout over 40 cm was less in 1984 as compared to 1983 at all four stations (Table 27). This may be attributed to the lower number of trout collected, possibly the result of the spawning mortality in October 1983, or due to the increased fishing pressure and harvest on this stream and Spinney Mountain Reservoir, due to the publicity this stream received in 1983. The increase in the number of trout over 50 cm (Table 27) was due to the appearance of age 5+ trout in the population for the first time since Spinney Mountain Reservoir was completed in 1981.

In contrast to 1983, there were no reports of dead or dying trout in the Middle Fork in the fall of 1984. The autumn of 1984 was much cooler and more typical of normal fall weather than that of 1983. This apparently resulted in water temperatures that were low enough to repress fungal growth. In addition, higher water levels coupled with lower densities and biomass of spawners in the Middle Fork in 1984 (compared to 1983) also would tend to: (1) reduce the concentration of fungal spores in the water; (2) increase available spawning habitat; and (3) reduce overcrowding in the spawning and holding areas.

Table 27. Biomass and number of trout over 40 and 50 cm in the 1983 and 1984 migrating brown trout population.

Station	Biomass kg/ha		N/ha over 40 cm		N/ha over 50 cm	
	1983	1984	1983	1984	1983	1984
Garo Bridge	737	645	655	484	43	164
Gage Station	226	158	210	108	0	65
1 Mile	415	313	359	234	17	94
2 Mile below gage	412	341	379	285	15	76

North Platte River

We have conducted trout population surveys on the North Platte in 4 of the last 5 years (1980, 1982, 1983 and 1984). In 1980 we electroshocked a short section (0.19 mi.) of the river just below the Ginger Quill Ranch. In 1982, 1983 and 1984 we boat-shocked the 3 mile section from the Routt National Forest boundary downstream of the State Line Ranch through the Ginger Quill Ranch. The data in Table 28 summarizes what changes have been occurring with the North Platte trout populations.

Table 28. North Platte trout population statistics 1980-84.

Year	N	Fish/ha	Kg/ha	Trout/ha ≥35 cm (14 in.)
		Brown Trout		
1980	68	61	26.8	22
1982	1,692	96	32.1	22
1983	1,716	97	39.7	21
1984	2,145	121	44.0	24
		Rainbow Trout		
1980	55	49	9.7	3
1982	534	30	8.8	6
1983	590	33	11.4	11
1984	1,756	99	19.2	11

We are beginning to see a dramatic increase in the numbers (fish/ha) and biomass kg/ha of both rainbow and brown trout in the North Platte River. Rainbow numbers and biomass have doubled between 1982 and 1984. The trout population in the study area of the North Platte has met the criteria for Gold Medal designation in both 1983 and 1984, i.e., a sustained biomass in excess of 40 kg/ha and at least 30 trout/ha 35 cm (14 in.) or larger in size.

Age and growth analyses (Table 29) indicate that the average size and growth rate for both rainbows and browns has been very good between 1982 and 1984 indicating the food and habitat conditions are not a limiting factor.

Table 29. Age and growth analyses of North Platte River trout (cm).

Age	Rainbows 1982	Rainbows 1983	Rainbows 1984	Browns 1982	Browns 1983	Browns 1984
1+	22.2	17.2	15.7	20.9	21.0	20.8
2+	27.4	22.1	23.1	24.6	25.7	26.6
3+	33.0	31.2	30.6	35.3	34.5	36.5
4+	38.4	38.4	36.8	37.5	40.6	39.5
5+	—	42.8	37.7	43.0	47.0	40.0

Examination of the Life Table data (Table III-2 in Appendix III) and the length-frequency histograms (Appendix II, Figure II-31 and II-32) reveal significant augmentation of the 1982 and 1983 year classes of brown and rainbow trout in 1984. The enigma is, where did all of these young trout (age 1+ and 2+) come from in 1984? This is especially puzzling for the rainbow component. It is obvious from the length-frequency histogram that we suddenly see the appearance of two incredibly strong year classes in 1984 that were not present in the section in 1983 or 1982. Where did they come from? Our best guess is that both age groups were flushed downstream from upstream nursery areas or tributaries with the unusually heavy run-off in 1984. The only other plausible explanation is that they were stocked as either fingerlings or catchables; however, the circuli patterns on the scale samples do not support that explanation. Furthermore, biologists in Wyoming (Bob McDowell) and Colorado (Doug Krieger) indicate they know of no stocking of fingerling rainbows in tributary streams within 40-50 km (25-30 mi.) or more of the study area.

One plausible explanation is that the rainbows went into the North Platte when a small lake (about 8 ha) on the Ginger Quill Ranch was drained for vegetation control and elimination of sucker and northern creek chub populations. A. D. Hess (Ginger Quill Ranch) has indicated: (1) the lake on the ranch was drained in 1984; and (2) rainbow reproduction takes place in Three Mile Creek, tributary to the lake (and thereby the North Platte). It is quite plausible to assume then that the additional 1,200 (approximate) rainbows in the 1984 estimate (over 1982-83) are recruits that escaped from the Ginger Quill Ranch Lake and Three Mile Creek.

Rio Grande River

The data presented in Tables 30, 31 and 32 summarize the results of our electroshocking studies from 1981-1984 on the Wason Ranch, near Creede, Colorado, the Coller Wildlife Area, near Masonic Park, Colorado (approximately 24 km or 15 mi. downstream from the Wason Ranch) and the State Bridge section (approximately 24 km or 15 miles downstream of the Coller Wildlife Area), respectively.

After our September 1982 electroshocking survey on the Wason Ranch, we recommended that they change the bag limit on their fly water section from two trout and a minimum size of 35 cm (14 in.) to two trout and a maximum size of 35 cm. The 1982 survey revealed that although the fly only section had far greater numbers of brown trout 25-35 cm (10-14 in.) in size than the 8 trout/day section, it had no more browns larger than 35 cm (14 in.) in it than the 8 trout/day section. A creel census on the Wason Ranch in 1983 indicated angling pressure was a mere 35 hours/acre (86 hours/ha) for the entire summer angling season, yet indications were that the quality size (35 cm or 14 in.) stocks of brown trout were being overharvested. Thus, the recommendations to reverse the minimum size limit of 14 inches to a maximum size limit of 14 inches.

After 2 years under the maximum size limit of 14 inches, we now have 3.6 times as many brown trout 14 inches/ha (35 cm) or larger in the fly only - two fish limit section as in the 8 trout/day regulation area. We shocked only three trout (two brown, one rainbow) 40 cm (16 in.) in the standard regulations water and 15 trout (five times as many) 16-23 inches in size out of the fly water! When one considers the habitat for larger browns is much better in the upper section of river (where the limit is 8 trout/day) the change in the lower river is really remarkable. In fact, the fly water has more than four times as many trout 14 inches and larger per acre as the State Bridge section and almost eight times as many as the Coller section of the Rio Grande. As has been the case on sections of the Blue, Gunnison, South Platte, Colorado and Fryingpan rivers where either catch-and-release or severely restricted bag and size limits have been put into effect, the increase in density of quality size trout has been dramatic in just 2 years.

Our 1984 electroshocking survey of the Coller Wildlife Area substantiated the trends already observed from 1981-83. The Coller section of the Rio Grande still has very few brown trout/ha 35 cm or 14 inches when compared to the Wason Ranch and State Bridge sections on the Rio Grande (Tables 30, 31 and 32).

The dramatic disappearance of stocked catchable size rainbows from the Coller Wildlife Area with the cessation of stocking in 1984 was both expected and gratifying to see as far as this study is concerned. The catch-and-release regulation on brown trout under 16 inches in size and two brown bag limit over 16 inches (in effect since 1983) has not yet resulted in an increase in the number of quality size brown trout (14 in. or 35 cm) as compared to the 8 trout/day bag limit in effect through the 1982 angling season. Thus, we see no apparent positive impact from either the regulation change or the stream improvement projects at the present time. However, it is quite possible that the very heavy stocking

Table 30. Wason Ranch trout population statistics.

Year	Fly water section (1.8 mi.) N	Fly water section (1.8 mi.) kg/ha	Fly water section (1.8 mi.) Trout ≥35 cm	8 Trout/day section (1.9 mi.) N	8 Trout/day section (1.9 mi.) kg/ha	8 Trout/day section (1.9 mi.) Trout ≥35 cm
			Brown trout			
1982	3,336	80.4	312 (35)	2,900	52.8	220 (24)
1983	2,581	70.1	312 (35)	2,835	69.3	262 (28)
1984	2,055	89.9	607 (69)	1,136	36.1	170 (18)

Year	Fly water section (1.8 mi.) N	Fly water section (1.8 mi.) kg/ha	8 Trout/day section (1.9 mi.) N	8 Trout/day section (1.9 mi.) kg/ha
		Rainbow trout		
1982	59	1.5	325	5.7
1983	79	1.2	247	5.6
1984	10	0.3	83	2.4

*N/ha is in parenthesis

Table 31. Coller Wildlife Area trout population statistics.

Year	N	kg/ha	N/ha ≥35 cm	N	kg/ha
	Browns			Rainbows	
1981	3,802	42.9	11	2,659	267
1982	4,109	38.9	7	1,000+	--
1983	4,630	38.0	7	1,000+	--
1984	4,979	41.7	9	165	1.9

Table 32. State bridge trout population statistics.

Year	N	kg/ha	N/ha ≥35 cm	N	kg/ha	N/ha ≥35 cm
		Browns			Rainbows	
1981	5,168	39.3	29	295	2.8	4
1982	6,753	38.9	35	143	0.8	1
1983	8,948	45.4	31	285	1.9	2
1984	6,597	32.9	15	325	1.7	2

of catchable size rainbow trout in the Coller Wildlife Area and lack of angler harvest of these catchables has severely depressed the number of quality size trout in the Coller Wildlife Area section of the Rio Grande. Dick Vincent (personal communication) staunchly maintains that excessive stocking and inadequate angler harvest of catchable size rainbows in the Madison River, Montana, severely depressed the number of quality size trout in that river in the 1960's and early 1970's.

This is a possibility on the Coller Wildlife Area of the Rio Grande. Our population estimates on the Rio Grande in August 1981 indicated a population of 3,800 browns and 2,700 rainbows in the 2.2 mile (3.5 km) section of river (Nehring and Anderson 1982). Our shocking surveys in 1982 and 1983 again revealed massive numbers of unharvested rainbow catchables remaining in the river after the end of the angling season. To evaluate the overwinter survival of these fish, we electroshocked the Coller Wildlife Area in May 1984 (stocking ceased in August 1983). We found a ratio of brown to rainbow trout of 4:1. By the time of our fall 1984 estimate, the ratio of browns to rainbows had dropped to 30:1 based on population estimates. If excessive competition from rainbows had a detrimental impact on the survival of quality size brown trout, then removal of this factor should definitely manifest itself in increased numbers of quality size brown trout stocks by the fall of 1986.

As can be seen from the data in Table 32, the State Bridge section of the Rio Grande continues to maintain a borderline Gold Medal quality brown trout population in all years except 1984. This section of river has excellent instream and underbank cover for quality size brown trout (≥35 cm or 14 in.). However, if the dramatic decline in the number of quality size brown/ha continues to be a problem in 1985 (as seen between 1983 and 1984), more restrictive regulations may be required to maintain quality now that the river is gaining notoriety as a producer of trophy size brown trout.

Finally, we began a research project to evaluate the possibility of establishing a wild rainbow component on the Coller Wildlife Area and State Bridge sections of the Rio Grande in 1984. We stocked 6,000

Colorado River rainbow fingerlings on the Coller Wildlife Area and 10,000 in the State Bridge sections of the Rio Grande on October 23, 1984. This program will continue for at least 3 more years and we will continue our shocking studies well into the late 1980's in all probability.

St. Vrain River

The 1984 brown trout population data from the St. Vrain is given in Table I-12, Appendix I and Figures II-45 and II-46 of Appendix II. Table 33 compares total trout density and biomass between electrofishing stations and years. The brown trout population of the Meadow Park station (standard regulations) has been fairly stable from 1980-1984, while the Gaging Station (catch-and-release) trout population has been fluctuating. The Gaging Station has had more trout over 26 cm than the Meadow Park Station since 1982. However, there was a drop from 34 to 21 trout over 26 cm from 1983-1984. It appears that the reason for more trout over 26 cm at the Gaging Station is mostly due to a slightly faster growth rate there. Also, after 4 years of total catch-and-release fishing, there has been no increase in the number of trout over 30 cm at this station (Fig. II-45 and II-46, Appendix II).

Table 33. Density and biomass estimates for the St. Vrain River 1980-1983. Number of trout over 26 cm in parenthesis.

	standard		C & R			
Year	Meadow Park		Gaging Station		Ideal Concrete	
	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha
1980	1,796 (8)	103	1,139 (11)	86	1,406 (14)	116
1981	1,130 (11)	101	444 (16)	53	--[a]	--
1982	1,823 (9)	121	1,243 (38)	102	535 (15)	52
1983	2,132 (9)	156	984 (34)	96	979 (46)	120
1984	2,068 (9)	136	1,610 (21)	123	1,347 (32)	109

[a]Fish kill, no estimate.

There has been a similar pattern of variation in the density of age 2+ trout between the Meadow Park and Gaging stations (Table 34), indicating that harvest is not the primary limiting the number of trout over 20 cm. It was proposed that poor quality pool habitat may be responsible for the lack of larger trout (Anderson, Nehring, and Winter 1984). It is interesting to note that the 1983/84 winter flows were the highest since the catch-and-release regulation was initiated in 1980, and this was the year that also had the greatest number of age 2+ trout in the fall population.

Four brown trout over 35 cm were found in the Ideal Concrete Stations. These trout were taken from the plunge pool below the spillway structure. This indicates that the St. Vrain can produce large trout given adequate pool habitat, and that the lack of pools is probably limiting the production of quality trout.

Table 34. Number of age 2+ brown trout collected 1980-84 and mean monthly flows during the winter months, St. Vrain River.

Year	Meadow Park N/ha	Gage N/ha	Mean Monthly Flow Jan (CFS)	Feb	Mar	Winter minimum (CFS)
1980	206	162	28	29	32	16
1981	259	182	11	12	16	6.5
1982	418	298	12	10	9	2.5
1983	726	473	18	16	41	12
1984	761	716	20	19	25	14

Since there is little biological justification for a catch-and-release regulation on this stream, it seems prudent to identify what will be accomplished by keeping this regulation on the St. Vrain. Perhaps other criteria are important in evaluating the impact of special regulations such as angler satisfaction and socio-economic considerations. It is our understanding that the Longmont Trout Unlimited Chapter has been gathering this kind of data as a club project, and they may be able to offer some reasons to keep this area under catch-and-release management.

South Platte River

Special regulations management began on the South Platte River in January 1976 with the implementation of fly and lure, catch-and-release angling in the 4.8 km (3 mi.) section of the river below Cheesman Dam known as Cheesman Canyon. It continues to be managed that way at the present time. The study section, known as Deckers, was under an 8 trout/day regulation with no size limits or terminal tackle restrictions through December 1982. In January 1983, this section (Lone Rock Campground downstream to the settlement of Scraggy View) went to fly and lure terminal tackle, a 2 brown trout bag limit for browns ≥16 inches with catch-and-release on browns under 16 inches and all rainbows. The section from Scraggy View Picnic Area (USFS) to the confluence with the North Fork of the South Platte, has continuously been under an 8 trout/day bag limit (1976-84).

The reason for changing the regulations in the Deckers section in 1983, while maintaining the status quo in the Cheesman Canyon and Scraggy View study areas, was to eliminate the habitat variable as a controlling factor. We readily admit the best habitat lies in the Cheesman Canyon area, the Deckers area has good habitat, and the Scraggy View area probably has the poorest habitat. However, by changing the regulation only in the Deckers area, while observing population trends in all three areas, we hoped to see significant increases in trout population trends in the Deckers area. This is the essence of what we have observed in 1983 and 1984. For a visual analysis of the trends from 1979 through 1984 in all three areas, see Figures II-42, II-43, and II-44 in Appendix II.

These figures show no significant change in rainbow biomass in 1983 and 1984 for Cheesman Canyon (catch-and-release) and Scraggy View (8 trout/day) study areas. However, rainbow biomass in the Deckers study area increased significantly in 1983 and 1984 over the 1979-82 period. Rainbow numbers $\geq$30 cm in the Deckers study area were 22/ha in the fall of 1982, 92/ha in the fall of 1983, and 194/ha in the fall of 1984, a four fold increase in 1983 (over 1982) and a nine fold increase in 1984 (over 1982)! Rainbows numbers/ha $\geq$35 cm (14 in.) did not change significantly in Cheesman Canyon or the Scraggy View study sections in 1983 or 1984 over the 1979-82 period. Rainbows/ha $\geq$35 cm in the Deckers area increased three fold in 1983 (over 1982) and four fold in 1984 (over 1982)!

Clearly, the environmental variable argument has been eliminated as a controlling factor. We readily recognize that the Deckers study area will probably never even approach the density of rainbows/ha $\geq$30 cm or $\geq$35 cm found in Cheesman Canyon. The habitats and carrying capacities between the areas are undoubtedly grossly different. However, by holding the habitat variable constant within all three areas, while changing the regulation only in the Deckers section and documenting the dramatic increases only in the Deckers section, the regulation change becomes the controlling factor. No one can continue to doubt the dramatic role of angling pressure and harvest on this trout population. Brown numbers and biomass (kg/ha) have not dramatically changed in any of the areas in 1983-84 over the 1979-82 period. However, rainbow biomass and total biomass (rainbow and brown trout) has been at an all time high in the Deckers area for 1983 and 1984 (for our 6 years of record). Conversely, in the Scraggy View (8 trout/day) study section brown biomass, rainbow biomass, and total biomass are at an all time low, again convincing evidence of the detrimental impacts of excessive levels of angling pressure and harvest. We are also at an all time low for numbers of rainbow and brown trout/ha $\geq$30 cm and $\geq$35 cm (zero) in the Scraggy View and Twin Cedars (8 trout/day) study areas in 1984.

Some members of the CDOW continue to ask questions such as: (1) are we discriminating against the bait fishermen with all of these special regulation areas; or (2) are we discriminating against large numbers of women and children with terminal tackle restrictions? At times, it seems we almost have a masochistic obsession that our quality trout management program is totally against the public's desires. In an effort to allay the fears of this possibility (discrimination), we again conducted an intensive creel census on the South Platte in the Cheesman Canyon, Deckers, and Scraggy View study areas from May through September 1984. We not only interviewed to determine angling pressure, catch rates, and harvest by species, but also to determine angling attitudes in the lower two areas towards the new regulation in the Deckers section. The results of the 1984 South Platte creel census are summarized in Appendix IV, Tables IV-1 through IV-9, and Figures IV-1 through IV-7.

We contacted 967 anglers, 474 in the new catch-and-release area at Deckers, and 493 in the Scraggy View 8 trout/day bag area. At Deckers, 84.2% favored the new regulation, 8% had no opinion, and 7.8% were opposed to it. At Scraggy View (8 trout/day area with no terminal tackle restrictions), 67.1% either favored or had no opinion towards the new regulation area at Deckers, and 32.9% were opposed to it. How much more support do we need?

The combined results of all angler attitude surveys we have conducted on the Fryingpan, Arkansas, and South Platte rivers in 1980, 1981 and 1984 indicate overwhelming angler support for our quality trout management programs. Over these 3 years and three rivers, we contacted 2,766 anglers that were fishing in the special regulations area when contacted. As one would expect from anglers fishing in a special regulations area, 2,455 (89%) favored the quality management areas, 149 (5%) had no opinion, and 162 (6%) were opposed to the quality management.

More important was the attitude of anglers fishing in the 8 trout/day bag area (at the time of contact) towards the special regulation management on these three rivers over the 3 years. Of 4,903 anglers contacted, 3,765 (77%) were in favor of the special regulation (even though they were <u>not</u> fishing the area at the time)! Nine percent (453) had no opinion and 685 (14%) were opposed. Overall, 7,669 anglers were contacted, 6,220 (81%) were in favor of quality management, 847 (11%) had no opinion, and 602 (8%) were opposed. How much more support do we need? We say it's time to forget our masochistic obsession with trying to please <u>all</u> anglers <u>all</u> the time and give ourselves (CDOW) a well-deserved pat on the back.

Summaries of creel census statistics for all three study sections on the South Platte for May-September 1984 are presented in Tables IV-4 through IV-9 in Appendix IV. Comparisons in statistics for the Cheesman Canyon and Deckers sections for 1979, 1980, 1981 and 1984 are also presented in Tables IV-1 and IV-2, Appendix IV, as well as Figures IV-1 through IV-5.

In the Cheesman Canyon section (total catch-and-release since 1976), there was no significant difference in brown catch-per-man-hour (CPMH), rainbow CPMH, total CPMH, fisherman hours, total catch, brown catch, rainbow catch, catch $\geq$12 inches, or catch $\geq$15 inches for 1984 compared to 1979, 1980 and 1981. In comparison, in the new regulation area at Deckers, brown CPMH and total CPMH were significantly higher in 1984 versus 1979, 1980 and 1981 (when the bag limit was 8 trout/day). The level of significance was greater than 0.995. Catch of trout $\geq$12 inches, $\geq$15 inches, brown catch, rainbow catch, and total catch were not significantly different in 1984 from 1979, 1980 and 1981 at the 95% level.

Only total hours of angling effort were significantly lower (at 95% level) in the Deckers area in 1984 compared to 1979-81. Superficially, one might conclude that the new special regulation was responsible for the dramatic decline in angling pressure in 1984. However, it is our contention that the tremendously high water year in 1984 was responsible for most of the decline in angling pressure (compared to 1979-81) and <u>not</u> the special regulation. The comparison in angling statistics for 1984 between Deckers (the special regulation section) and Scraggy View (the 8 trout/day section) <u>strongly</u> supports our contention (see Table IV-3 in Appendix IV). Trout catch $\geq$12 inches, $\geq$15 inches, fisherman hours, and total catch were virtually identical for the two areas. If anglers were unhappy with the new special regulation in the Deckers area, one would expect angling hours to be somewhat lower there than in the 8 trout/day stocked sections at Scraggy View where no terminal tackle restrictions were in effect. However, there was less than 400 hours difference (12,624 at Scraggy View versus 12,227 at Deckers) in the angling pressure estimates for the two areas. Furthermore, considering that the number of angling hours in the Cheesman Canyon catch-and-release area (a 3 mile section of river) was 22,377 versus a combined angling hour estimate of 24,851 for the Deckers and Scraggy View sections (6 miles of river), we are all the more correct in concluding anglers like our quality trout management on the South Platte. Anglers "vote" their preference by fishing where they know the fishing is good and they can catch fish.

The final "nail-in-the-coffin" should be a comparison of the costs between quality trout management in the Deckers and Cheesman Canyon areas (on the one hand) versus Scraggy View, the section stocked with catchable size rainbow trout.

According to the 1984 CDOW stocking schedule, the Scraggy View area (from Scraggy View to the North Fork of the South Platte) received 14,000 catchable rainbows at a cost of $9,000 versus zero cost for stocking in the Deckers and Cheesman Canyon area. The very high rainbow CPMH (1.20) in the Scraggy View area is evidence prima facie that the vast majority of the rainbows caught (15,181) probably came off the stocking truck, since our fall electroshocking estimates indicated rainbow population densities were a mere 138 rainbows/ha (56/acre), or a rainbow population estimate of 1,140 for the 3 mile section of river.

Certainly the data indicates the highest CPMH (1.467) was in the Scraggy View 8 trout/day area. It only costs $9,000 to produce that CPMH for 5 months (May-September) versus a CPMH in Cheesman Canyon of 1.207 and a Deckers CPMH of 1.076 at no cost. Total rainbow catch in the Scraggy View area (3 miles or 4.8 km) was estimated at 15,181 from May-September 1984 versus 4,513 rainbows caught (and released) at Deckers, and 16,175 in Cheesman Canyon for the same time period. The brown catch (all wild trout) was 10,800, 8,600 and 3,300 at Cheesman Canyon, Deckers and Scraggy View, respectively.

According to the 1984-85 CDOW Resource Allocation Plan (budget), the total financial outlay for fisheries in Colorado was $5,644,258. The same plan also indicates $4,037,233 went for fish production or 71.5% of the total fisheries budget. Perhaps we need to find out (through another statewide angler attitude survey) if we are spending the vast majority of our fishing license revenues on programs that the angling public wants. Or, are we spending the fishing license revenues on a program that is not cost effective and ultimately, we must begin to cut back, not expand, or else go bankrupt. It has been 12 years since Dick Klein (1973) asked the question, "Are we polluting our streams with trout?" We can honestly say, great strides have been made in stream trout management in Colorado in the interim. However, in an age of shrinking revenues and the need for greater efficiency and cost effective programs in the public sector, we need to reassess where the CDOW is headed in fisheries management. Where are we now and where do we need to be as we enter the 21st century from a fisheries management standpoint?

RECOMMENDATIONS AND CONCLUSIONS

General Conclusions and Recommendations

It is evident from our results on the Cache la Poudre, Colorado and Fryingpan rivers that severely reduced bag limits (without any size restrictions) do little, if any good, in protecting or increasing density, biomass or number of quality size (35 cm or 14 in.) trout. This is especially true for the angler-vulnerable rainbow. To quote Robert Engstrom-Heg (Engstrom-Heg 1981), "Size limits are the most effective means of regulating harvest and should be used as a primary tool. Creel limits have some regulatory value, but should be used mainly to promote better distribution of the harvest." Engstrom-Heg is a research leader with the New York Department of Environmental Conservation. Clearly, our findings in Colorado are not unique to our state; they merely reiterate the findings and conclusions of others in the field.

Arkansas River

The use of special regulations, the 16 inch minimum size limit, probably has contributed to the increase in density of trout under 35 cm witnessed in the Arkansas River; however, the number of trout over 35 cm is still poor. The best chance of improving the quality of the brown trout fishery is through the introduction of a good forage fish species. The mottled sculpin or the paiute sculpin appear to be the best candidates. This should be accomplished as soon as possible. It is also recommended that special regulation management be continued at the present status on this stream for at least 4 or 5 more years. This will provide enough time to see if increasing the length of the regulated area from 1.8 to 7.5 miles was beneficial to the fishery and to see if larger trout can be produced following a forage fish introduction. It will also assist in the efforts to establish a wild rainbow trout population. Lastly, it is recommended that this stream be dropped as a study site on this project and that the area biologist be responsible to monitor future changes in the trout population.

Blue River

After two full seasons under management with a restrictive size and bag limit, the brown trout population of the Blue River has shown a dramatic response to protection. We have seen numbers of brown trout/ha $\geq$25 cm, $\geq$30 cm and $\geq$35 cm, increase from 2 to 10 times over the pre-regulation period. Density of 4 year old brown trout increased 65 fold in just 1 year. The average length of the pre-regulation (1981) 4 year old trout was 26.8 cm. That has increased to 30.3 cm by the fall of 1984 after 2 years of protective regulations. This is strongly indicative of the possibility that the fastest growing, most aggressive trout are most rapidly cropped by anglers. Thus, our assumption that 35 cm (14 in.) is probably the asymptotic growth potential of Blue River brown trout may be erroneous. We recommend that the 2 trout $\geq$16 inch size and bag limit on the Blue River be continued through the next regulation period, probably 1986-88.

Cache la Poudre River

It appears that the trout population of the Indian Meadows area has responded to catch-and-release management after only 2 years with improvements in trout density and biomass and the number of trout over 30 cm. Therefore, it is recommended that the 16 inch minimum size limit remain in effect for at least 3 more years in order to determine the potential of restrictive regulation management on the Poudre River. It is also recommended that the 16 inch minimum size limit be applied to the Upper Wild and the Lower Wild Trout waters. The Upper Wild Trout water area has the potential to produce trophy sized trout in the meadows section. The Lower Wild Trout water currently lacks any quality trout in the population. It may turn out that because of poor insect forage or poor habitat quality, this area can not produce trout over 30 cm. However, overharvest is strongly indicated and a more protective regulation would definitely improve the fishery. It is also recommended that this stream be dropped from the project and that the area biologist take over sampling.

Colorado River

During 1981-82, a 2 trout bag limit was in effect from Parshall to the Sunset Ranch on the Colorado River with a catch-and-release slot of 12-20 inch. An 8 trout/day bag limit was in effect on the Pioneer Park, Paul Gilbert and Lone Buck wildlife areas during 1981-82. In 1983-84 all of the above areas, with the exception of Pioneer Park, went to a 1 rainbow-1 brown trout bag limit. This regulation change has manifested an increase in rainbow and brown trout density (N/ha) and biomass (kg/ha) at the Paul Gilbert and Lone Buck Wildlfe areas in 1983-84, as compared to 1981-82 when the 8 trout/day bag limit was in effect. Conversely, in the Parshall area, all population statistics have been in dramatic decline in 1983-84 under the 1 rainbow-1 brown regulation regime, as compared to 1981-82 when the 2 trout bag, 12-20 inch catch-and-release slot limit was in effect. Undoubtedly, poor recruitment for both rainbow and brown trout in the 1980's has had a negative impact on standing stock and biomass estimates in all study sections. However, it is clear that both rainbow and brown population statistics were as good or better in 1979 under an 8 trout/day regulation as they were in 1983-84 under the 1 rainbow-1 brown trout regulation. Conversely, in 1981-82 the Parshall area had much higher brown and rainbow trout densities and biomass under the 2 trout bag limit with the catch-and-release slot between 12 and 20 inches than it has had either before or since under the 8 trout bag (1979-80) or the 1 rainbow-1 brown bag limit (1983-84).

We recommend the entire study area from Hot Sulphur Springs to the confluence with Troublesome Creek be put under a two trout $\geq$16-inch bag limit with a fly and lure only terminal tackle restriction.

Eagle River

The Eagle River is the most difficult river to electroshock of our 12 study streams, year in year out. We are dropping this river from the study at the end of the 1984-85 segment. However, it is clear from our electroshocking that recruitment is severly limited by the perpetual silt load coming in at Milk Creek and that standing stock and biomass for the Eagle River is probably low as a result. With reduced biomass and density estimates in many years, the Eagle River is peculiarly vulnerable to over-exploitation by anglers. For even minimal densities of quality size rainbow and brown trout to be maintained in the Eagle River, protective regulations with a size regulation are necessary. A two trout ≥16-inch bag limit should adequately protect the river. Without protective regulations, we will probably "yo-yo" between "feast and famine" depending upon angling pressure and levels of run-off which effectively limit the length of the angling season to about 6-8 weeks in heavy run-off years like 1983 and 1984.

Fryingpan River

We have dramatically altered the trout population of the Fryingpan catch-and-release sections with our fingerling rainbow stocking program implemented since October 1981. We have the highest densities of quality size (35 cm or 14 in.) rainbow in this section since studies began in the early 1970's. However, outside the catch-and-release section, rainbow density has basically been stagnant at 100-120/ha since 1981, or 40 rainbow/acre over 15 cm (6 in.) in size. Severe overharvest under the 8 trout bag limit from 1979 through 1982 (without stocking) so decimated rainbow stocks that densities are not even high enough to result in a natural recruitment of 25 rainbow/acre (62/ha) annually.

To remedy this situation, we have only two alternatives. One alternative would be to further restrict harvest with a size restriction. The second alternative is to further augment natural recruitment with an advanced fingerling stocking program. We have opted for the second alternative. With a 75% survival rate on an October 1982 plant of 2,400 adipose-clipped advanced (4-5 in.) rainbow fingerlings in the catch-and-release area through September 1984, we feel this is the best option.

The other alternative, probably a two trout ≥16-inch bag limit would reopen "Pandora's box" on 12 miles of river through private land and could result in this premiere trout water being lost to public access. With stocking agreements in place and virtually all the water open to public angling at present, the augmented stocking alternative seems the most prudent management option.

Gunnison River

The "four trout bag limit, catch-and-release between 12 and 16 inches, with only one trout ≥16 inches in the limit of four in the aggregate" regulation has dramatically altered the trout population structure in the Smith Fork-North Fork section of the Gunnison since 1981. We recommend this regulation stay in place for 1986-88 even though it is presently unique and quite complex. Public acceptance has been good, bait anglers have the easiest access to quality angling at both the upper and lower ends of the restricted water, and the regulation allows the most liberal harvest (four trout) of any quality regulation on streams in the state.

The near record run-off levels of 1983 and 1984 have virtually wiped out rainbow recruitment in 1983 and 1984. Thus, rainbow stocks will soon begin to drop precipituously without a good year class in 1985. At present, the projected run-off for 1985 should allow for at least average rainbow recruitment this year.

Middle Fork of the South Platte River

We recommend this stream continue to be managed as a quality stream in the wild trout program. The current regulation, an 8 trout/day bag limit with only two trout ≥16 inches in the aggregate of eight, is a good regulation from both a biological and a management standpoint. Another alternative would be a 2 trout/day bag limit with no size or terminal tackle restrictions. This stream will be dropped from the study at the end of the 1984-85 segment. Any additional studies will be carried out by the area biologist.

North Platte River

Brown and rainbow trout numbers and biomass were both significantly higher in the North Platte River in 1984. We are convinced that most of this additional recruitment and augmentation of the 1983 and 1983 rainbow year classes resulted from the draining of a small lake on the Ginger Quill Ranch in the fall of 1984. This river meets all of the established criteria for Gold Medal classification. However, recruitment of both rainbow and brown trout year classes is spotty at best and poor in most years. If this river receives additional notoriety and angling pressure as a result of Gold Medal classification, a minimum size and bag limit restriction of two trout ≥16 inches may be necessary to maintain the biomass and quality trout levels to meet the Gold Medal criteria.

Rio Grande River

Reversal of the fly fishing only, two trout ≥14 inch on a section of the Rio Grande at the Wason Ranch to a two trout ≤14 inch has resulted in a 200% increase in density of brown trout ≥14 inches in just 2 years. In the section still managed with an 8 trout/day bag limit, the number of quality size brown trout has remained static since 1982.

On the special regulations section of the Rio Grande at the Coller Wildlife Area, we have not seen any significant change in the numbers of quality-size (≥35 cm) brown trout in 1983-84. However, we have eliminated the stocking of catchable size rainbow trout as a complicating factor. Hopefully, this program might significantly increase the number of quality size brown trout in the study section.

The State Bridge section of the Rio Grande continues to harbor good numbers of quality size brown trout. However, numbers of quality size brown trout may decline if angling pressure increases significantly without any restrictions on size or bag limits.

Finally, the wild rainbow trout introduction program has been extended to the Rio Grande River in 1984 with the stocking of 6,000 fingerlings in the Coller and 10,000 in the State Bridge section. We hope to significantly increase the number of quality size trout in the river through this management program by 1988. Our ultimate objective is to establish a wild rainbow trout population in the Rio Grande River.

South Platte River

The change from an 8 trout/day angling regulation to a two brown trout ≥16 inch with catch-and-release on browns under 16 inches and all rainbows in the Deckers section in 1983 has manifested itself in significant increases in rainbow biomass (kg/ha), numbers/ha ≥30 cm and ≥35 cm in 1983 and 1984 compared to 1979-82. These statistics did not change in either the Cheesman Canyon catch-and-release section (upstream) or the Scraggy View 8 trout/day section (downstream) in 1983-84, compared to 1979-82.

We recommend that the present regulation structure on the South Platte from Cheesman Dam to the North Fork of the South Platte remain in effect for the 1986-88 regulation period. The regulation in the Strontia Springs area should be changed to coincide with the regulation in the Deckers area.

St. Vrain River

Since the trout population has not exhibited a response to the total catch-and-release regulation, the regulation should be changed, strictly from a biological standpoint. This area could be added to the wild trout program and a less restrictive regulation such as the 2 trout/day bag limit might be more appropriate. This stream will be dropped from the Job 3 study at the end of the 1984-85 project segment.

Job No. 4

Job Title: Wild Trout Introductions

Job Objective: To establish, then quantitatively describe, a wild rainbow trout population in the Arkansas River between Salida and Texas Creek.

Period Covered: July 1, 1983 to June 30, 1984

INTRODUCTION

Electrofishing surveys were started on the Arkansas River in the spring of 1981 at the start of Job 3. The trout population of the river is 99+% brown trout with moderate density (300-500/ha) compared to other large rivers such as the Gunnison and Colorado rivers. The Arkansas is characterized by wide sandy-bottom runs, deep open pools and intermittently spaced shallow and deep riffles with high velocities. Scattered boulders provide most of the trout cover. Our electrofishing efforts found that brown trout concentrated around areas of cover and that most deep pools were relatively devoid of trout, thus leaving large amounts of unoccupied habitat. The introduction of a species that could exploit these underutilized habitats would greatly add to the trout standing crop and enhance angling opportunities. Rainbow trout are commonly electroshocked from deep open pools on the Colorado, Gunnison and South Platte and appear to be suited for Arkansas River.

Efforts have been made in the past to introduce rainbow trout to the Arkansas River (Carhart 1950) and catchables were stocked for a number of years, but a self-sustaining population was never established. Domestic strains, though well adapted to hatchery life, have a poor history for long-term survival in the wild (Borgeson 1966). Also, it has been demonstrated that hatchery strains do not successfully compete with resident trout (Miller 1957). Since we feel a two-species trout system would increase density and biomass over present levels and add a trophy fish to the population, we are making another attempt at introducing rainbow trout. But this time a wild strain of rainbow trout, known to be genetically suited to compete with brown trout and successfully reproduce under high spring flows, will be planted.

METHODS AND MATERIALS

Using similar methods as in 1981, 1982 and 1983, wild rainbow trout were spawned in the Colorado River in April 1984. Eggs were taken to the Bellvue Research Hatchery for hatching and rearing. At the time of the plant, March 8, 1985, the fingerlings averaged about 70 to the pound. The total plant was estimated at 9,000 fish and all were stocked inside the Salida electrofishing station, which is under catch-and-release management for trout $\leq$16 inches.

RESULTS AND DISCUSSION

Twenty-two rainbow trout were caught in March 1985 by electrofishing. The largest rainbow trout was 45 cm and the rest ranged in size from 23-34 cm. The number of rainbow caught at the Salida station from 1981-85 are 3, 5, 26, 38 and 22, respectively. The lower number of rainbow trout caught in 1985 compared to 1984 was probably due to the fact that no fry were stocked in 1984 because of total mortality for that plant (Anderson and Nehring 1984).

RECOMMENDATIONS AND CONCLUSIONS

We will continue to have the eggs hatched at Bellvue Research Hatchery and will continue spawning wild rainbow trout in the field until a brood stock is available, hopefully in 1987. Evaluation of the benthic invertebrate community (Anderson, Nehring and Winters 1984) in the Arkansas River indicated that Simuliidae, Chironomidae, and silt tolerant trichopteran species were dominant. It is clear from our studies of tail-race trout populations on the South Platte and Fryingpan rivers that rainbow trout more effectively utilize these food items than brown trout. Thus, if wild rainbows can be established in the Arkansas River, their growth and performance would probably surpass that of the more benthic and cover-oriented brown trout.

Job No.: 6

Job Title: Colorado River Aquatic Invertebrate Investigations

Job Objective: Determine if correlations exist between willow fry (Pteronarcys californica) populations and the temperature and flow regime of the Colorado River, and quantify the importance of the willow fly naiad in the rainbow trout diet.

Period Covered: July 1, 1984-June 30, 1985

INTRODUCTION

For a detailed description of the need for this study, Colorado River Aquatic Invertebrate Investigations, the reader is directed to the two previous progress reports (Nehring and Anderson 1983; Anderson, Nehring and Winters 1984). An extensive literature review was completed and included in last year's progress report (ibid).

The job objective for Job 6 is to "determine if correlations exist between willow fly (Pteronarcys californica) populations and the temperature and flow regimes of the Colorado River, and quantify the importance of the willow fly naiad in the rainbow trout diet." We have demonstrated the importance of the Pteronarcys californica (P.c.) naiad population in the diet of rainbow and brown trout in the Colorado River. We have strong indications that a relationship does exist between P.c. naiad density and flow regime in the Colorado River as will be demonstrated subsequently in this report. We will also demonstrate there is cause for concern about possible stress from low dissolved oxygen and warm water temperatures as the Colorado River approaches 25 C in mid to late summer.

METHODS AND MATERIALS

Methods and materials were adequately described in the 1983 and 1984 Progress Reports and will not be reiterated here.

RESULTS AND DISCUSSION

Probability of Use Curves and WUA

Probability of use curves for Pteronarcys californica (P.c.) naiads for: (1) substrate; (2) average water velocity in ft/sec (as measured at 0.6 depths of the water column); (3) bottom velocity in ft/sec (as measured on the substrate); and (4) depth (in feet) were constructed from measurements made on 23 quantitative square meter benthic samples collected in April 1983. After 3 years of collecting quantitative one square meter Surber samples, I felt that any P.c. naiad density of $100/m^2$ or higher was equivalent to a probability of use of 1.0.

Conversely, a P.c. naiad density of 0/m^2 was equivalent to a probability of use of zero. Ten naiads/m^2 equate to a probability of use of 0.1, 20/m^2 equates to a probability of use of 0.2, etc. Substrate type was classified according to the Brusven substrate index (Brusven 1977; Bovee 1982). This index is outlined in Table 35.

Table 35. Expanded substrate code for use with the Brusven substrate index.

Code	Substrate description	Size range (mm)	Inches
1	Fines (sand and smaller)	3.9	.15
2	Small gravel	4-25	0.16-1.00
3	Medium gravel	25-50	1.00-2.00
4	Large gravel	50-75	2.10-2.95
5	Small cobble	76-150	2.96-5.90
6	Medium cobble	151-225	5.91-8.90
7	Large cobble	226-300	9.00-11.9
8	Small boulder	301-600	12.00-24.0
9	Large boulder	601	24.10-up
10	Bedrock	---	---

Of the four curves (substrate, average velocity, bottom velocity and depth) substrate preference and average velocity are probably the two most important in characterizing the actual habitat requirements for P.c. naiads. As pointed out previously (Anderson, Nehring and Winters 1984), average water velocity is of the utmost importance in maintaining the interstitial spaces in a silt-free condition behind, between and beneath the cobble-rubble substrate. Even though the actual water velocity (in the interstitial spaces) experienced by P.c. naiads in their microhabitat is probably only 0.9-1.8 cm/sec (Knight and Gaufin 1964), it is the average water velocity that must be high enough to keep the "fines" out of the interstitial spaces, thereby maintaining microhabitat integrity.

Substrate size is also a critical microhabitat constituent. Our quantitative sampling during 1982, 1983 and 1984 clearly indicates P.c. naiads very rarely occur in gravel, silt or sand type substrates. Rather, they are found almost exclusively in the small cobble to small boulder substrate types ranging in size from 75-600 mm (2.95-24 in.) with the preferred range probably in the 152-305 mm (6-12 in.) sizes.

Bottom velocity (as measured on the substrate) and depth are probably not very important criteria in truly defining P.c. naiad habitat. Both of these criteria showed much greater random variability than average water velocity and substrate type when used as a predictor of P.c. naiad abundance. In short, when the substrate type was right, P.c. naiad abundance was high irregardless of what the depth and/or bottom velocity was. Therefore, I used only substrate type and average velocity in determining weighted usuable area

(WUA) for P.c. naiads in the Colorado River. Substrate, average velocity, bottom velocity, and depth probability of use curves for P.c. naiads in the Colorado River are shown in Figure V-4 and Appendix V.

The WUA for P.c. naiads in the Colorado River is much higher for 1,000 feet of stream channel than for any life stage of either rainbow or brown trout. The WUA versus discharge curve for P.c. naiads also overlays the peak values of the WUA curves for all life stages of rainbow and brown trout (Figures V-5 , V-6, and V-7 in Appendix V. This indicates that P.c. naiads probably have a better tolerance for higher water velocities, depths and discharge levels than either rainbow or brown trout. At lower discharge levels ($\leq$200 ft^3/sec) WUA curves for P.c. naiads and the various rainbow and brown trout life stages are roughly coincident as far as slope of the curves is concerned. However, the P.c. naiad WUA per 1,000 feet of stream channel is still roughly 3 times as high as the WUA for rainbow and brown trout at any given flow up to 1,000 ft^3/sec.

Pteronarcys californica Naiads as Trout Food

During our rainbow spawning operation in April 1984, 60 rainbow trout were sacrificed for disease analysis. The stomach samples were saved for food habitat analyses. These samples reiterate the already overwhelming evidence (Anderson, Nehring and Winters 1984) that P.c. naiads are the most important food item for rainbow trout in the Colorado River.

Eight of 62 stomach samples (April 27, 1984) were empty, and 25 of 62 contained less than 0.5 ml volume of food items. For all 62 samples combined, P.c. naiads comprised 137.7 ml volume out of a total of 180.5 ml volume. Thus, P.c. naiads comprised 76.3% of the total food volume. Five stomach samples contained between 10 ml and 23 ml volume in P.c. naiads. Numerically, P.c. naiads were also the most numerous food item in the stomachs. We found 287 recognizable food items of which 204 where P.c. naiads or 71% of the food items consumed on a numerical basis.

Pteronarcys californica Population Dynamics

The data in Table 36 indicates the wide variations in the number of P.c. naiads/m^2 occurring in the Colorado River from 1982, 1983 and 1984. Statistical tests (t test for two means) indicate that there is greater variability between years at a given sample site for P.c. naiad density than there is between stations within the same year. There were no statistically significant differences (t-.95) between sample stations (State Ranch versus Parshall) for 1982, 1983 or 1984. However, at the State Ranch site, P.c. naiad density (No./m^2) was significantly higher in 1983 than either 1982 or 1984. State Ranch naiad density in 1982 was significantly higher than 1984 as well. At the Parshall sample site, P.c. naiad density was significantly higher in 1983 (p = .95) as compared to 1982 and 1984 (p = .90). The 1984 Parshall sample was higher than the 1984 State Ranch sample at the 90% level.

Table 36. Pteronarcys californica "willowfly" naiads/m^2 at the State Ranch and Parshall sampling sites.

Year	State Ranch			Parshall		
	N	X	S	N	X	S
1982	10	205	±111	10	135	± 92
1983	5	512	±317	5	392	±346
1984	5	39	± 13	5	97	± 68

Length-frequency histograms (Figures V-8 and V-9 in Appendix V) give a visual representation of P.c. naiad size distribution over the 3 years of the study for both the State Ranch and Parshall sampling sites. The most notable differences are between 1984 and 1982-83 at both stations. Since the density observed in 1984 is a product of the flow conditions in the previous 3 years (for three age groups or cohorts), it appears that high spring run-off levels may have a very dramatic negative impact on the recruitment of P.c. naiad cohorts, similar to the negative relationship between rainbow and brown trout recruitment and spring-summer discharge patterns (see Job 1). The very high spring-summer run-off of 1983; i.e., the record mean monthly discharge for June-July in the Colorado River (for the period 1964 and 1983) certainly seems to have manifested itself in the lowest P.c. naiad density in April 1984 for the 1982-84 period of the study. Not only are total naiad densities the lowest in 1984 (for the period 1982-84), but the survival or recruitment of P.c. naiads of the age I and II cohorts (1983 and 1982, respectively) appears severely depressed. Age I and II cohorts are in the 5-25 mm size range for the most part if one examines the size, age and sex distribution as shown in Figure V-10, Appendix V.

If the level of the spring run-off does have a strong negative impact on the survival and recruitment of age I and II cohorts of P.c. naiads, then the 1985 samples should show the lowest average density/m^2 for the period 1982-85 as the spring-summer (June-July) run-off in 1984 was even higher than in 1983. The WUA versus discharge relationship (Figure V-5 in Appendix V) for P.c. naiads certainly indicates that this should be the case.

Pteronarcys californica Versus Temperature and Dissolved Oxygen

Previously (Anderson, Nehring and Winters 1984), we asked the rhetorical question, "What will be the impact of Windy Gap Dam on the Pteronarcys california population in the Colorado River in a worst case situation?" We hoped the answer would be "no impact." However, the problem still remains a question of trying to predict the total negative impacts of a multiple number of variables acting in concert and, in most cases, in a negatively synergistic fashion. The factors are as follows:

1. Dissolved oxygen saturation decreases with increasing elevation above sea level. The elevation of the Colorado River at Windy Gap Dam is approximately 8,000 feet (2,439 m).

2. The solubility of oxygen in water decreases with increasing temperatures.

3. Oxygen consumption in P.c. naiads increases with increasing temperature along the lines of the Q_{10} effect.

4. Decreasing turbulence in running water tends to decrease the percent saturation.

5. Biological oxygen demand due to organic processes is generally greatest in streams during the late summer months, the period of low flow, highest temperatures, and least turbulence.

From all of the above, it is not too difficult to discern that mid to late summer (July-September) is probably the time when P.c. naiads will be most susceptible to low oxygen stress.

Water temperatures are highest in late summer, water flows are decreasing dramatically in late summer which decreases turbulence, which in turn tends to decrease percent oxygen saturation (Hynes 1972). Again a rhetorical question, "How does all this impact P.c. naiad population in the Colorado River? Again the answer, "Hopefully not much." However, given all the wrong conditions at the most inopportune time, the potential for serious problems exists.

Table 37 contains an estimate of dissolved oxygen levels in the Colorado River at an elevation of 8,000 feet (2,439 m) and various temperatures, assuming 100% saturation. In the Colorado River, submergent aquatic vegetation and organic pollution are minimal; thus, with the extensive riffle areas and moderate gradient, it is probable that the dissolved oxygen levels should remain near 100% saturation. We have had Ryan continuous recording thermographs in the Colorado River at various points between the Windy Gap Dam site and the Con Ritschards Ranch, more than 32 km (20 mi.) downstream since 1980. In both 1980 and 1981, we saw maximum water temperature in the 20-25 C range on many consecutive days in July and August. Temperatures of 25 C are approaching the upper tolerance limits for rainbow and brown trout.

Table 37. Probable dissolved oxygen versus temperature relationship for the Colorado River near Windy Gap Dam, Granby, Colorado (assembled from Reid 1961, and Wetzel 1975).

Temp (C)	Oxygen (mg/l)
0	10.4
5	9.1
10	8.0
15	7.2
20	6.5
25	6.0
30	5.5

The combined impacts of somewhat depressed oxygen levels and temperatures up to 25 C may also be approaching lethal limits for P.c. naiads. At a flow rate of 1.8 cm/sec and a temperature of 10 C, P.c. naiad mortality from oxygen stress occurs at 0.7 mg/l D.O. At a temperature of 15.6 C and a flow rate of 1.8 cm/sec, P.c. naiad mortality commences when D.O. levels drop to 1.8 mg/l D.O. (Knight and Gaufin 1964). Using these two data points as the basis for a linear regression from which to project probable P.c. naiad mortality at 25 C, we estimate a dissolved oxygen level of 4.0 mg/l would result in death due to oxygen stress. If the regression relationship for mortality from oxygen-temperature stress for P.c. naiads is more of a power curve regression than linear, it is quite likely that P.c. naiad mortality may begin at 4.5 mg/l D.O. at a temperature of 25 C . The difference between 4.5 mg/l D.O. (the possible level for lethal effects on P.c. naiads) and 6.0 mg/l D.O. (100% saturation at 25 C and 8,000 feet elevation) is not much margin for error. It would probably be a good idea to attempt some dissolved oxygen-temperature tolerance tests of P.c. naiads in the 20-25 C range.

Finally, examination of the relationship between daily summer discharge and maximum water temperatures for the Colorado River in 1980-81 reveal some very interesting correlations. It turns out that the magnitude of water releases out of Williams Fork Reservoir, near Parshall, Colorado, are of critical importance in maintaining a tolerable thermal regime for trout and P.c. naiads in the Colorado River between Parshall and Kremmling, Colorado. The inflow from Williams Fork Reservoir joins the Colorado at Parshall, Colorado (see Figure V-3 in Appendix V). The critical time period is from about July 1 through September 15. Our thermograph data from both 1980 and 1981 indicates maximum daily water temperatures often approach or exceed 20 C in the Colorado River on the Sheriff Ranch during the July 1-September 1 summer period. As summer flows in the Colorado and Fraser rivers recede, the water temperatures increase dramatically, especially once the flow drops below 200 ft^3/sec. When releases from Williams Fork Reservoir are in the 20-60 ft^3/sec range, water temperatures in the Colorado River (below the confluence with the Williams Fork) almost always range from 20-25 C in July and August for 1980-81. Conversely, when discharges from the

Williams Fork are in the 150-200 ft^3/sec range or higher (in July and August 1981), water temperatures in the Colorado River drop dramatically, up to 7-8 C in a single day! In extremely high water years (1983-84), the problem is not critical; however, in median or below normal water years, the temperature problem could be very critical.

With good cooperation between the Northern Colorado Water Conservancy District, the Colorado Division of Wildlife, and the Denver Water Department, we should be able to avoid any disastrous consequences for the fish and aquatic invertebrate life in the Colorado River. Without good cooperation and foresight, the potential for lethal impacts to aquatic life in the Colorado River definitely exists.

RECOMMENDATIONS AND CONCLUSIONS

It is clear, from our temperature-discharge relationships in the Colorado River in 1980-81, that the potential exists for severe stress (if not lethal) effects from a combination of elevated water temperatures and depressed dissolved oxygen levels to P.c. naiads and/or rainbow and brown trout in the Colorado River below Windy Gap Dam. The potential for stress is worst in the July-September period in median or below normal water years.

Proper operation of the Windy Gap Project after the seasonal pumping period is over is of utmost importance. Windy Gap operations personnel have indicated that it is possible to maintain a minimum pool in Windy Gap Lake and yet allow the Fraser-Colorado River to run straight through the dam on a bottom release basis with virtually no alteration in temperature between inlet and outlet (Gerald Bennett, personal communication).

For the 1985 field season we will attempt to keep five Ryan thermographs operating in the Colorado River at the Con Ritschards, State, Sheriff,and Chimney Rock ranches, as well as monitoring the inlet water temperature to Windy Gap Lake. In addition, logistics and budget permitting, we will attempt to run some dissolved oxygen-water temperature tolerance tests on *Pteronarcys californica* naiads.

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APPENDIX I

Biomass and Standing Crop Estimates 1984-85

Table I-1. Arkansas River standing crop and biomass estimates, March 1985.

Study area description	Study section size Length (m)	Width (m)	Area (ha)	Population statistics Species	N	95% C.I.	N/ha	kg/ha	N/ha
Salida	4.02	36.6	14.7	Brown ≤15	1				
				Brown ≥15	8,361	±1,210	9	129	569
				Rainbow	39	± 28	0.1	0.6	2

Table I-2. Blue River standing crop and biomass estimates, October 15-18, 1984.

Study area description	Study section size Length (m)	Width (m)	Area (ha)	Population statistics Species	N	95% C.I.	N/ha	kg/ha	Trout/ha 35 cm
Blue River stream improvement area (2 trout bag limit - catch-and-release on browns ≤16 in.[a])	305	20.1	0.613	Brown	352	± 70	574	76.8	12
				Rainbow	114	± 57	186	34.6	3
				Total	463	± 86	755	111.4	15
Blue River Campground	366	18.6	0.680	Brown	532	±149	782	123.4	36
				Rainbow	3	--	4	0.5	0
				Brook	1	--	1	Trace	0
				Total	546	±153	803	123.9	36
Blue River Wildlife Area[a]	274	24.7	0.678	Brown	455	±113	671	103.4	29
				Rainbow	16	± 13	24	5.3	0
				Brook	2	--	3	0.5	0
				Kokanee	1	--	--	--	0
				Total	480	±115	708	109.2	29

[a]Same regulation in effect on all areas.

Table I-3. Cache la Poudre standing crop and biomass estimates for trout ≥15 cm, October 1984.

Study section description	Study section size: Length (m)	Width (m)	Area (ha)	Species	Population statistics: N	95% C.I.	Fish/ ha	kg/ha
Big Bend Campground	243.8	18.3	0.446	Brown	201	±43	451	58.2
				Rainbow	90	±45	202	22.6
				Total trout	287	±58	643	80.8
Wild Trout Water 5 mi above Rustic	243.8	18.3	0.446	Brown	197	±31	442	65.8
				Rainbow	297	±40	665	94.3
				Total trout	494	±51	1,108	160.1
Lower Control 3 mi above Rustic	243.8	18.3	0.446	Brown	135	±37	303	37.2
				Rainbow	236	±43	528	55.8
				Total trout	368	±56	825	93.0
Indian Meadow 1 mi below Rustic	243.8	18.3	0.446	Brown	184	±58	412	61.5
				Rainbow	151	±35	339	52.7
				Total trout	335	±65	751	114.2
Kelly Flat Campground[a]	243.8	18.3	0.446	Brown	160	±22	359	44.8
				Rainbow	187	±23	419	44.2
				Total trout	347	±32	778	89.0
Lower Wild Trout control above Greeley Diversion[a]	243.8	19.8	0.483	Brown	290	±93	598	66.0
				Rainbow	55	±45	114	17.8
				Total trout	350	±107	725	83.8
Lower Wild Trout water below Greeley Diversion	243.8	19.8	0.483	Brown	280	±76	580	62.0
				Rainbow	14	±14	29	4.5
				Total trout	303	±79	627	66.5

[a]Population estimates expanded from past data based on efficiency of other similar stations.

Table I-4. Colorado River standing crop and biomass estimates, October 15-18, 1984.

Study section description	Study section size: Length (m)	Width (m)	Area (ha)	Species	Population statistics: N	95% C.I.	Fish /ha	kg/ha	Trout/ha ≥35 cm (14 in.)
Thompson Ranch[a] (private - primarily catch/release	183	19.5	0.357	Rainbow	15[a]	--	42	15.4	20
				Brown	10[a]	--	28	11.4	6
				Total trout	25[a]	--	70	26.8	26
Pioneer Park - public 8 trout/day	183	19.5	0.357	Rainbow	53	±6	104	20.0	8
				Brown	32	±2	63	19.1	10
				Total trout	85	±5	167	39.1	18
State Ranch - public - 1 rainbow; 1 brown Paul Gilbert Wildlife Area	183	28.0	0.512	Rainbow	56	±9	110	28.8	11
				Brown	42	±67	83	23.1	11
				Total trout	88		18	51.9	22
State Ranch - Lone Buck W. A. - public - 1 rainbow; 1 brown	183	28.0	0.512	Rainbow	92	±15	180	53.8	36
				Brown	29	±11	57	21.8	14
				Total trout	124	±19	242	75.6	50
Parshall to Sunset Ranch public/private - 1 rainbow; 1 brown	3,220	36.0	11.6	Rainbow	2,410	±410	208	78.0	78
				Brown	1,735	±408	150	35.3	11
				Brook	12	±20	1	--	0
				Kokanee	20	±35	2	--	0
				Total trout	4,191	±579	361	113.3	89
BLM portion of Parshall section - 1 rainbow; 1 brown	805	36.0	2.9	Rainbow	369	±151	127	54.1	48
				Brown	472	±306	163	42.8	18
				Brook	2	--	1	--	0
				Kokanee	1	--	0.5	--	0
				Total trout	900	±316	310	96.9	66

[a]Electroshocking pass only - not a population estimate. Water was too deep; channel deepened by 1 foot or more by 1984 runoff.

Table I-5. Eagle River standing crop and biomass estimates, September 20, 1984.

Study area description	Study section size Length (m)	Width (m)	Area (ha)	Species	Population statistics $\hat{N}$	95% C.I.	N/ha	kg/ha	Trout/ha ≥ 35 cm (14 in.)
Wolcott near U.S. Hwy. 6 maintenance depot				Rainbow	3[a]	--	4	1.6	0
				Brown	32[a]	--	48	12.0	3
				Total trout	35[a]	--	52	13.6	3

[a]One electroshocking pass only - not a population estimate.

Table I-6. Fryingpan River trout standing crop and biomass estimates, September 17-19, 1984.

Study area description	Study section size Length (m)	Width (m)	Area (ha)	Species	Population statistics $\hat{N}$	95% C.I.	N/ha	kg/ha	Trout/ha ≥35 cm (14 in.)
Gaging station (catch-and-release)	152	15.2	0.231	Rainbow	125	± 37	386	216.5	175
				Brown	173	± 55	534	150.7	31
				Brook	501	±128	1,546	194.0	6
				Cutthroat	4	± 6	12	2	--
				Total trout	819	±140	2,528	563.2	212
Reudi damsite (catch-and-release - below gaging station)	305	15.2	0.464	Rainbow	388	± 80	762	280.1	163
				Brown	296	± 79	582	140.6	24
				Brook	410	± 83	806	109.2	3
				Cutthroat	15	± 24	29	3	--
				Total trout	1,113	±143	2,187	533.0	190
Old Faithful (catch-and-release)	320	18.9	0.605	Rainbow	304	± 44	479	162.7	64
				Brown	746	±126	1,177	216.8	17
				Brook	54	± 32	85	4.7	0
				Cutthroat	2	--	3	trace	0
				Total trout	1,076	±123	1,697	379.5	81
Upper control (1 rainbow/1 brown)	366	18.6	0.681	Rainbow	133	± 51	195	40.5	15
				Brown	338	± 96	496	86.0	14
				Brook	41	± 27	60	2.0	0
				Cutthroat	1	--	2	trace	0
				Total trout	527	±115	774	128.5	29
Taylor Creek (1 rainbow/1 brown)	305	15.2	0.464	Rainbow	54	± 42	116	28.3	26
				Brown	198	± 40	427	102.0	36
				Brook	1	--	2	--	--
				Total trout	248	± 49	534	130.3	62

Table I-7. Gunnison River system standing crop and biomass estimates, August-September 1984.

Study area description	Study section size: Length (m)	Width (m)	Area (ha)	Species	Population statistics: $\hat{N}$	95% C.I.	N/ha	kg/ha	Trout/ha ≥ 35 cm (14 in.)
East River - Roaring Judy to Almont (flies only - catch-and-release over 12 in.)	5,960	15.2	9.06	Brown	5,952	± 758	657	113.0	29
				Rainbow	779	± 376	86	10.9	1
				Brook	27	± 48	3	--	0
				Cutthroat	3	--	--	--	0
				Total trout	6,755	± 833	746	123.9	30
Gunnison River - Almont to Hwy. 135 bridge at Gunnison - 8 trout/day	12,900	33.5	43.9	Brown	6,120[a]	--	142	49.8	26
				Rainbow	1,520[a]	--	35	12.2	8
				Cutthroat	80[a]	--	2	--	0
				Kokanee	40[a]	--	1	--	0
Gunnison River - Gunnison Twin Bridges to Blue Mesa - 8 trout/day	8,050	39.6	31.9	Brown	3,500[b]	--	110	20.3	11
				Rainbow	3,900[b]	--	122	27.3	6
Gunnison River - Duncan Ute Trail (4 trout bag; 1 trout ≥16 in.; catch-and-release 12-16 in.)	3,220	31.0	10	Brown	4,622	± 958	462	46.7	15
				Rainbow	2,167	± 708	217	84.5	110
				Total trout	6,758	±1,188	679	131.2	125
Gunnison River - Smith Fork - North Fork (4 trout bag; 1 trout ≥16 in.; catch-and-release 12-16 in.)	6,440	31.0	20	Brown	6,992	±2,056	350	41.8	22
				Rainbow	5,427	±2,495	271	99.4	138
				Total trout	12,492	±3,058	625	141.2	160

[a]Estimate based on an estimated sampling efficiency of 5%.
[b]Estimate based on 2% sampling efficiency.

Table I-8. Middle Fork of the South Platte River population and standing crop estimates, September 1984.

Study section description	Study section size: Length (m)	Width (m)	Area (ha)	Species	Population statistics: $\hat{N}$	95% C.I.	Fish/ha	kg/ha
Highway 9 bridge (8 trout/day bag area)	183	6.10	0.116	Brown 12-39 cm	105	±16	900	89.7
				Brown ≥40 cm	56	± 3	484	644.5
				Brook[a]	3			
				Rainbow[a]	1			
				Total trout	161	±11	1,388	735.2
Gaging Station bridge (8 trout/day bag area)	183	7.62	0.139	Brown 12-39 cm	120	±16	863	86.7
				Brown ≥40 cm	15	± 1	108	158.0
				Brook[a]	1	--	--	--
				Rainbow[a]	2	--	--	--
				Total trout	136	±13	975	245.7
1 mile below Gage 8 trout/day with two 16 inches	183	6.40	0.117	Brown 12-39 cm	154	±12	1,314	123.7
				Brown ≥40 cm	27	± 2	234	313.1
				Rainbow	1	--	--	--
				Total trout	181	±11	1,550	437.0
2 miles below Gage 8 trout/day with two 16 inches	183	7.20	0.132	Brown 12-39 cm	140	±26	1,061	126.5
				Brown ≥40 cm	38	± 2	285	341.1
				Total trout	172	±18	1,301	467.6

[a]Number caught (no estimates).

Table I-9. North Platte standing crop and biomass estimates, October 3-4, 1984.

Study area description	Study section size: Length (m)	Width (m)	Area (ha)	Species	Population statistics: $\hat{N}$	95% C.I.	N/ha	kg/ha	Trout/ha ≥35 cm (14 in.)
Routt Forest boundary below State Line Ranch bridge through Ginger Quill Ranch	4,830	36.6	17.7	Rainbow	1,756	±526	99	19.2	11
				Brown	2,145	±412	121	44.0	24
				Total trout	3,816	±619	216	63.2	35

Table I-10. Rio Grande River standing crop and biomass estimates, September and October 1984.

Study area description	Study section size: Length (m)	Width (m)	Area (ha)	Species	Population statistics: N	95% C.I.	N/ha	kg/ha	Trout/ha ≥35 cm (14 in.)
Wason Ranch - standard regulations - 8 trout/ day - private	3,060	30.5	9.3	Brown	1,136	± 385	122	36.1	18
				Rainbow	83	± 63	9	2.4	2
				Total trout	1,236	± 391	133	38.5	20
Wason Ranch - fly water - 14 in. maximum size limit - 2 trout/day - private	2,900	30.5	8.8	Brown	2,055	±1,176	233	89.9	69
				Rainbow	171	± 103	10	1.9	0
				Total trout	1,994	±1,091	227	90.2	69
Coller Wildlife Area fly/lure - 2 trout bag ≥16 in. - public	3,540	46.0	16.3	Brown	4,979	± 766	305	41.7	9
				Rainbow	171	± 103	10	1.9	0
				Total trout	5,143	± 773	316	43.6	9
State Bridge - 8 trout/ day - low fishing pressure - private and leased for public mixed	10,950	46.0	50.4	Brown	6,597	±1,005	131	32.9	15
				Rainbow	325	± 305	7	1.7	2
				Total trout	6,602	±1,050	131	34.6	17

Table I-11. South Platte River standing crop and biomass estimates, December 3-6, 1984.

Study section description	Study section size			Species	Population statistics				
	Length (m)	Width (m)	Area (ha)		N	95% C.I.	Fish/ ha	kg/ha	Trout/ha ≥35 cm (14 in.)
Upper Canyon 1.5 mi. above Wigwam Club (catch-and-release)	183	14.0	0.256	Brown	195	± 8	762	193.2	37
				Rainbow	373	±13	1,457	468.6	372
				Total trout	567	±15	2,215	661.8	409
Lower Canyon 0.2 mi. above Wigwam Club (catch-and-release)	183	17.1	0.313	Brown	261	±34	834	221.7	61
				Rainbow	373	±35	1,192	425.4	381
				Total trout	633	±48	2,022	647.1	442
Above Deckers (catch-and-release ≤16 in. starting 1983)	183	17.1	0.313	Brown	393	±34	1,256	191.6	3
				Rainbow	132	± 6	422	101.6	34
				Total trout	511	± 5	1,633	313.2	37
Below Deckers (catch-and-release ≤16 in. starting 1983)	183	17.1	0.313	Brown	407	±22	1,300	199.1	10
				Rainbow	196	±20	626	110.7	11
				Total trout	602	±29	1,923	309.8	21
Scraggy View (8 trout/day)	183	17.1	0.313	Brown	145	± 2	463	54.8	0
				Rainbow	43	± 2	138	20.7	0
				Total trout	187	± 3	597	75.5	0
Twin Cedars (8 trout/day)	244	17.1	0.417	Brown	197	±15	472	49.7	0
				Rainbow	58	± 7	139	18.9	3
				Total trout	254	±16	609	68.6	3

Table I-12. St. Vrain standing crop and biomass estimates, October 11 and 12, 1984.

Study section description	Study section size			Species	Population estimates			
	Length (m)	Width (m)	Area (ha)		N	95% C.I.	fish/ ha	kg/ha
Meadow Park, Lyons	183	10.5	0.192	Brown <13	304	±101	1,583	
				Brown ≥13	397	± 11	2,068	136.2
Gaging Station, Lyons	243.8	14.5	0.354	Brown <13	168	± 13	475	
				Brown ≥13	570	± 57	1,610	122.5
Ideal Concrete, Lyons	137.2	17.4	0.239	Brown <13	165	± 30	690	
				Brown ≥13	322	± 23	1,347	108.8
Martin Marietta, Lyons	183	14.5	0.267	Brown <13	140	± 44	524	
				Brown ≥13	277	±104	1,037	78.0

APPENDIX II

Length-frequency Histograms

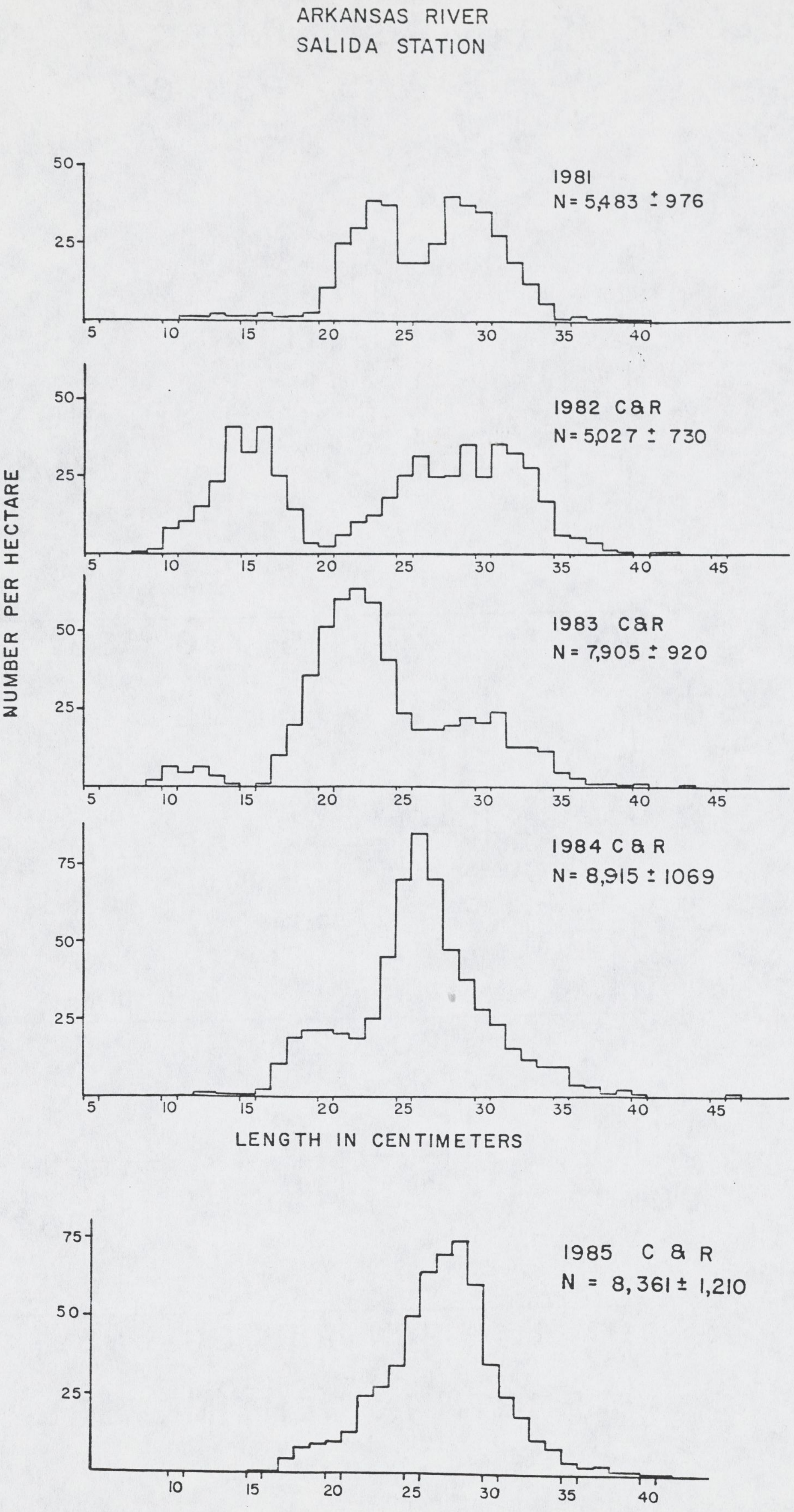


Figure II-1. Arkansas River, Salida Station, brown trout/ha, 1981-85.

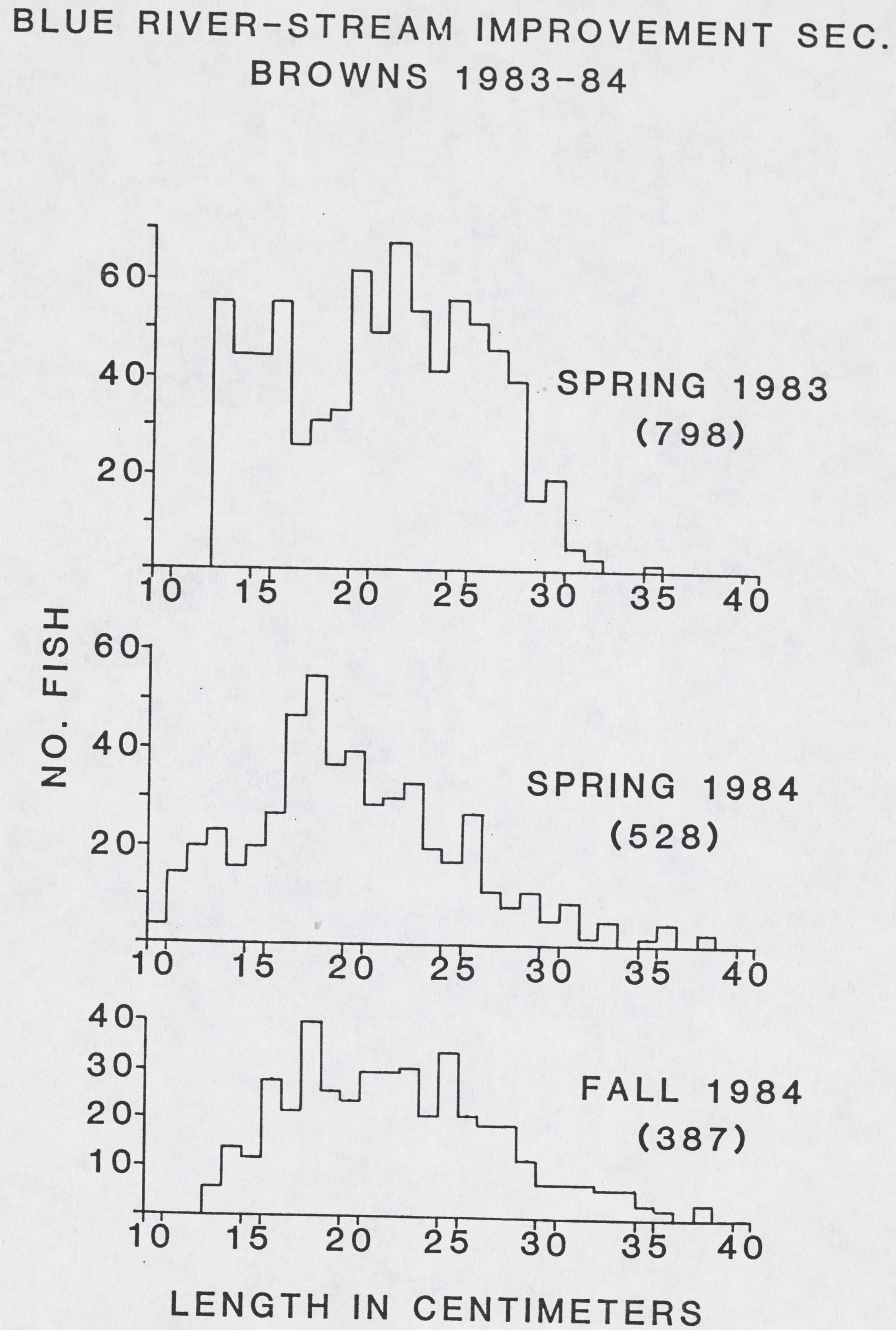


Figure II-2. Blue River, stream improvement section, browns, 1983-84.

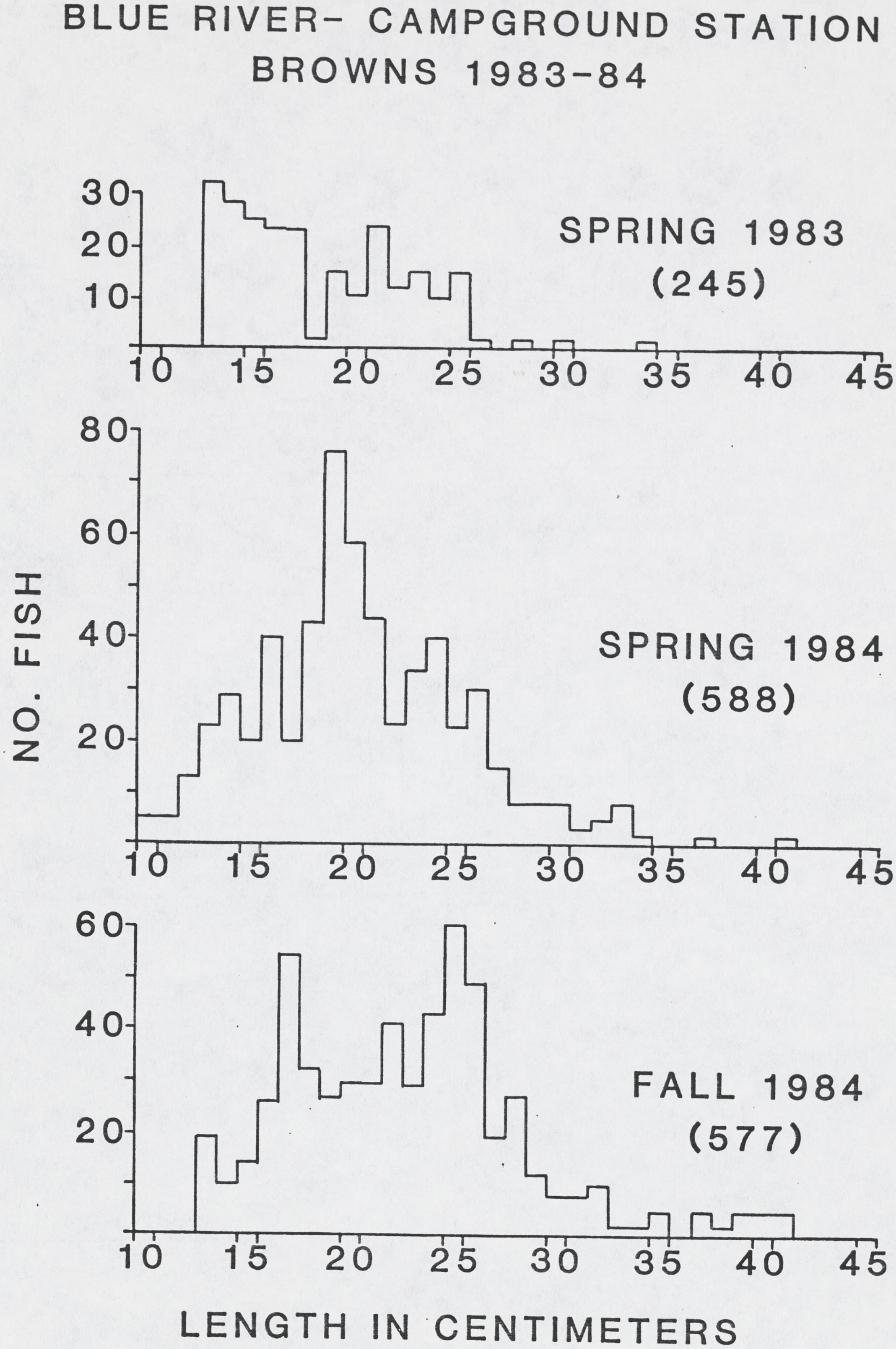


Figure II-3. Blue River, campground station, browns, 1983-84.

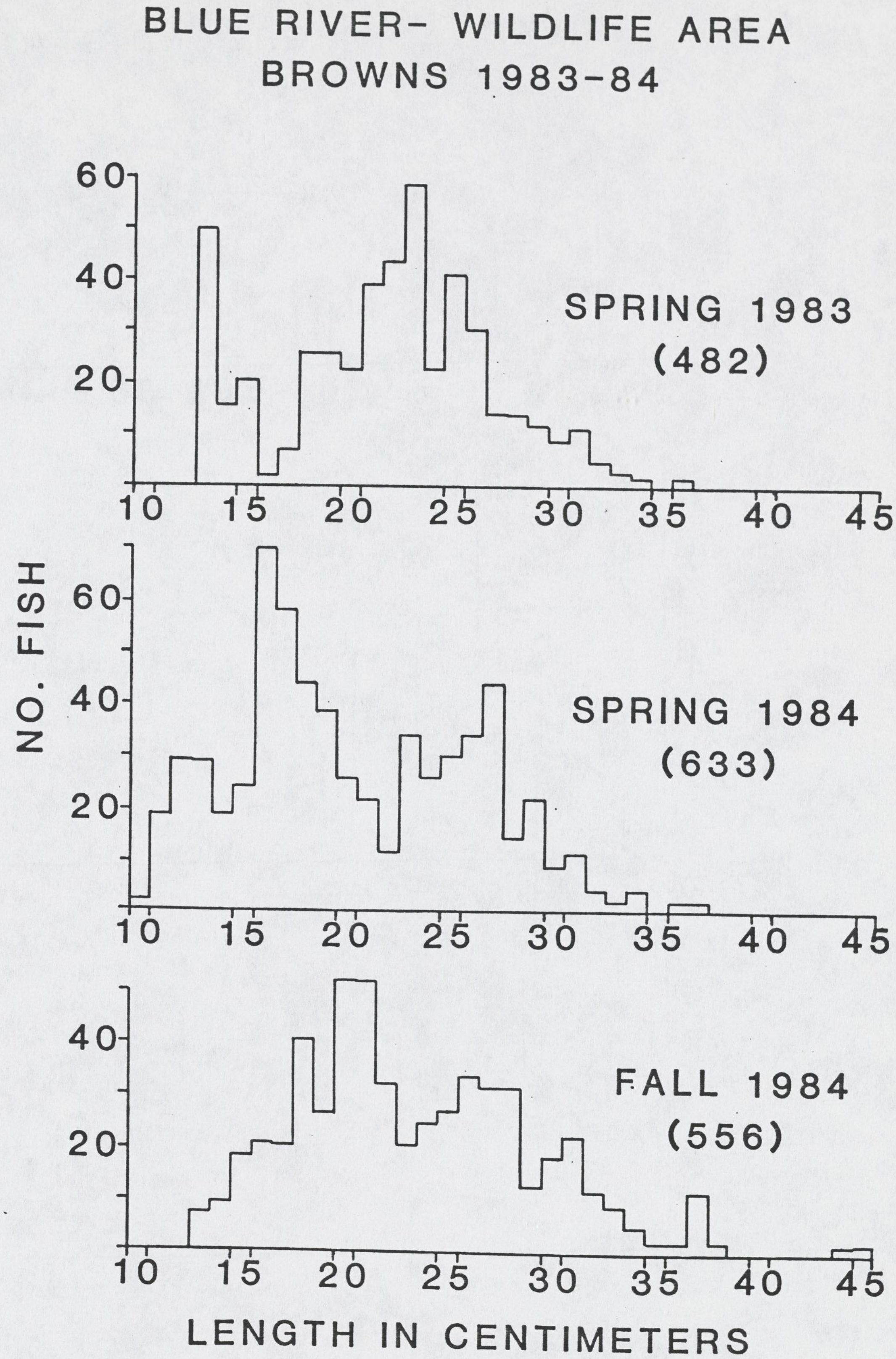


Figure II-4. Blue River Wildlife Area, browns, 1983-84.

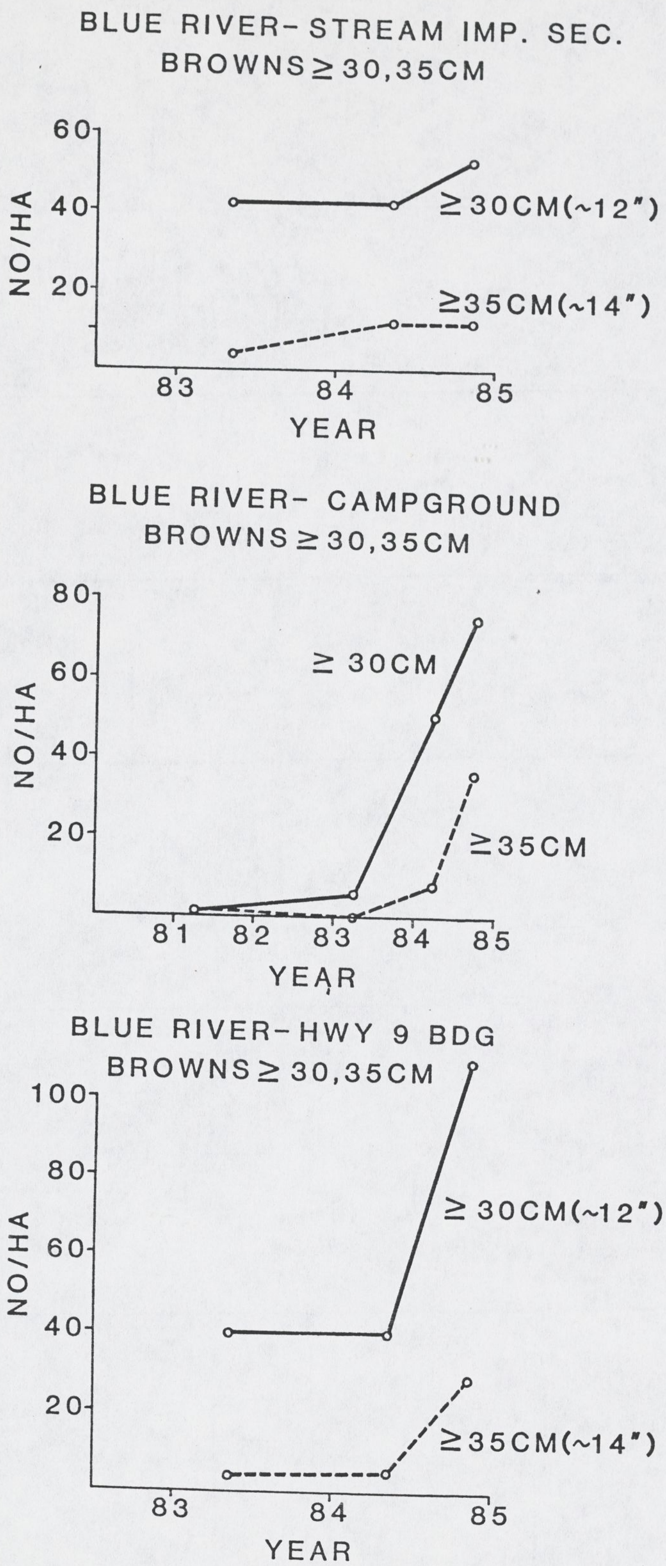


Figure II-5. Blue River, browns/ha $\geq$30 cm, 35 cm, 3 sections.

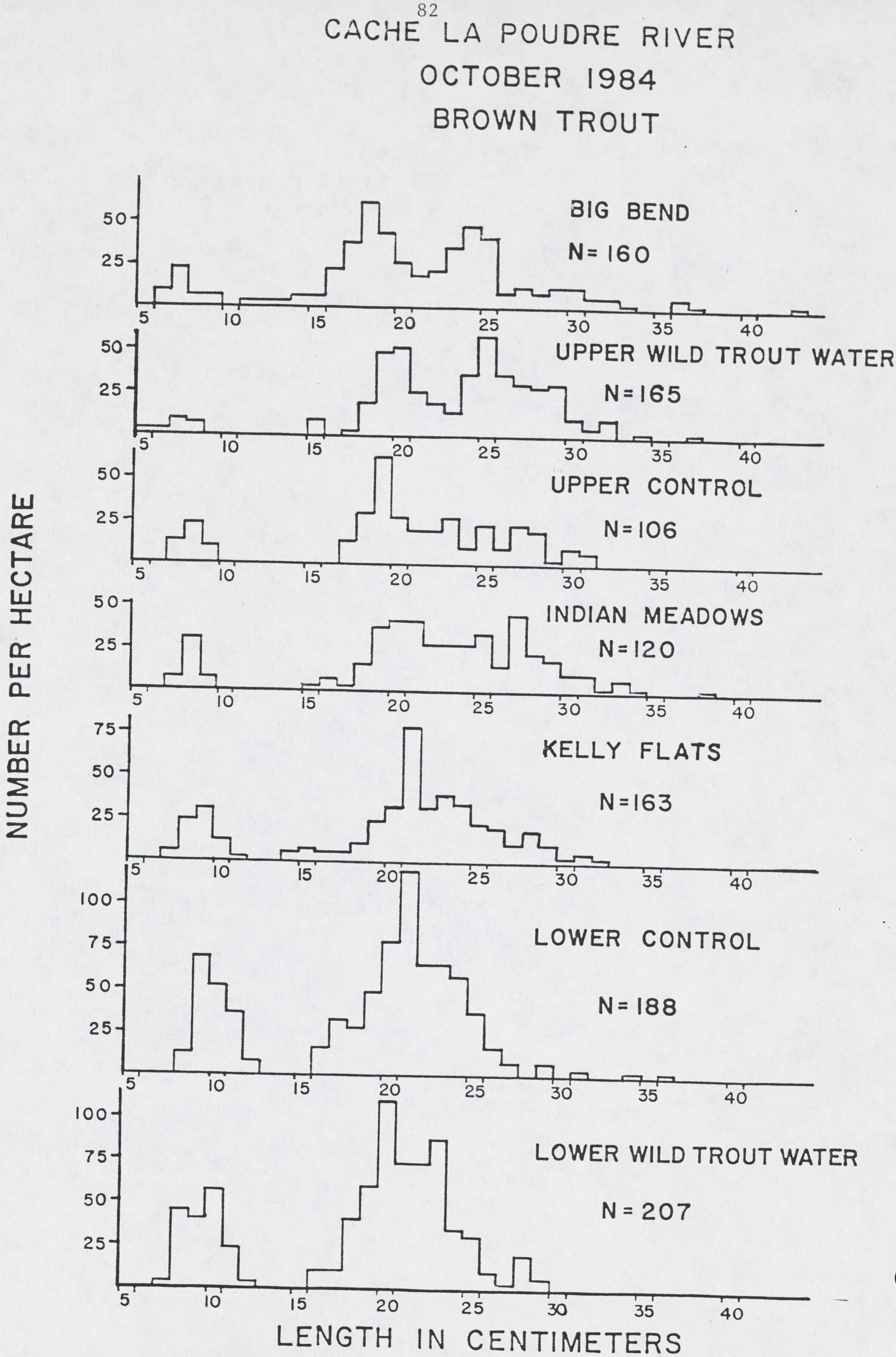


Figure II-6. Cache la Poudre River, browns, October 1984.

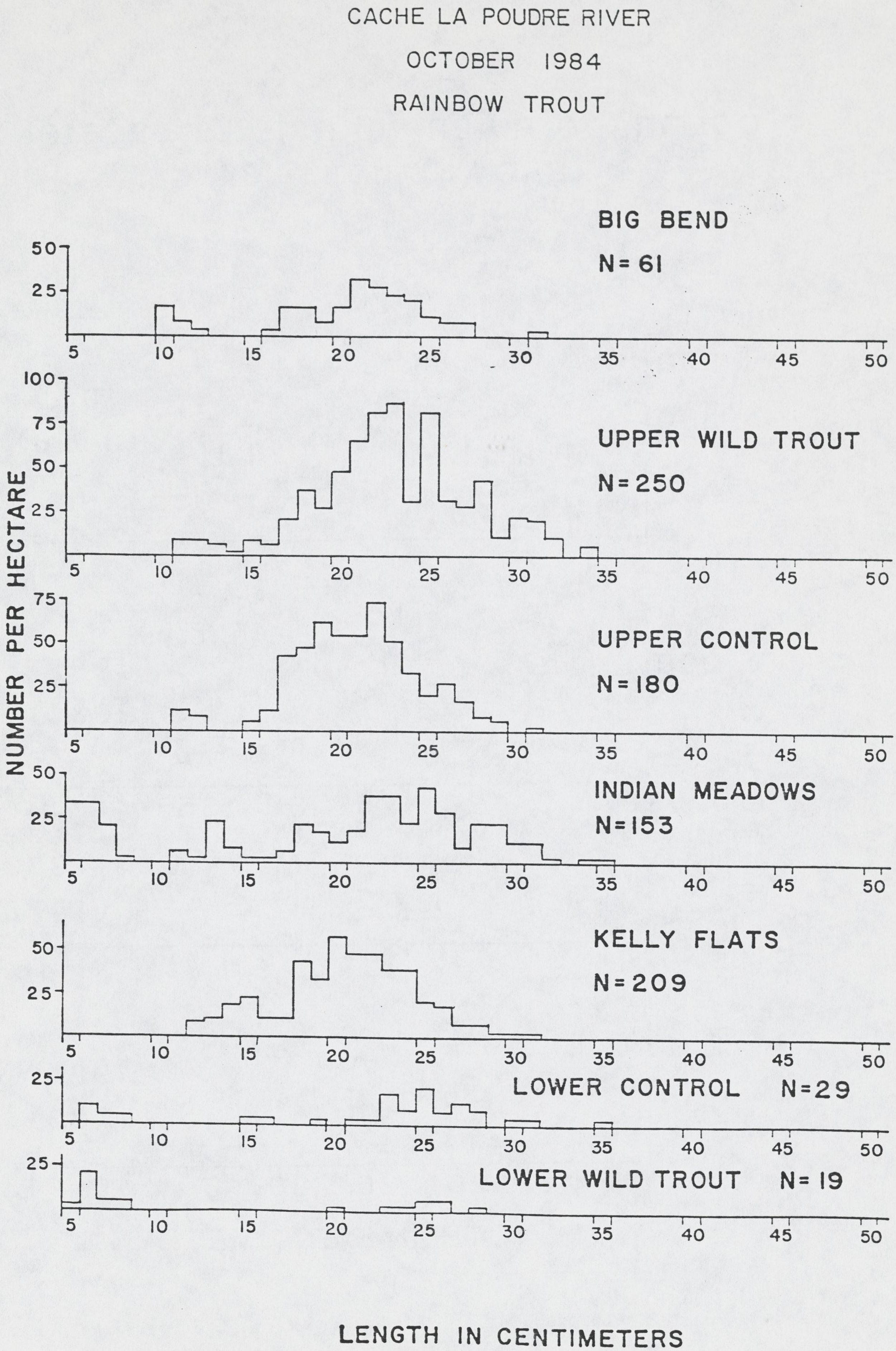


Figure II-7. Cache la Poudre River, rainbows, October 1984.

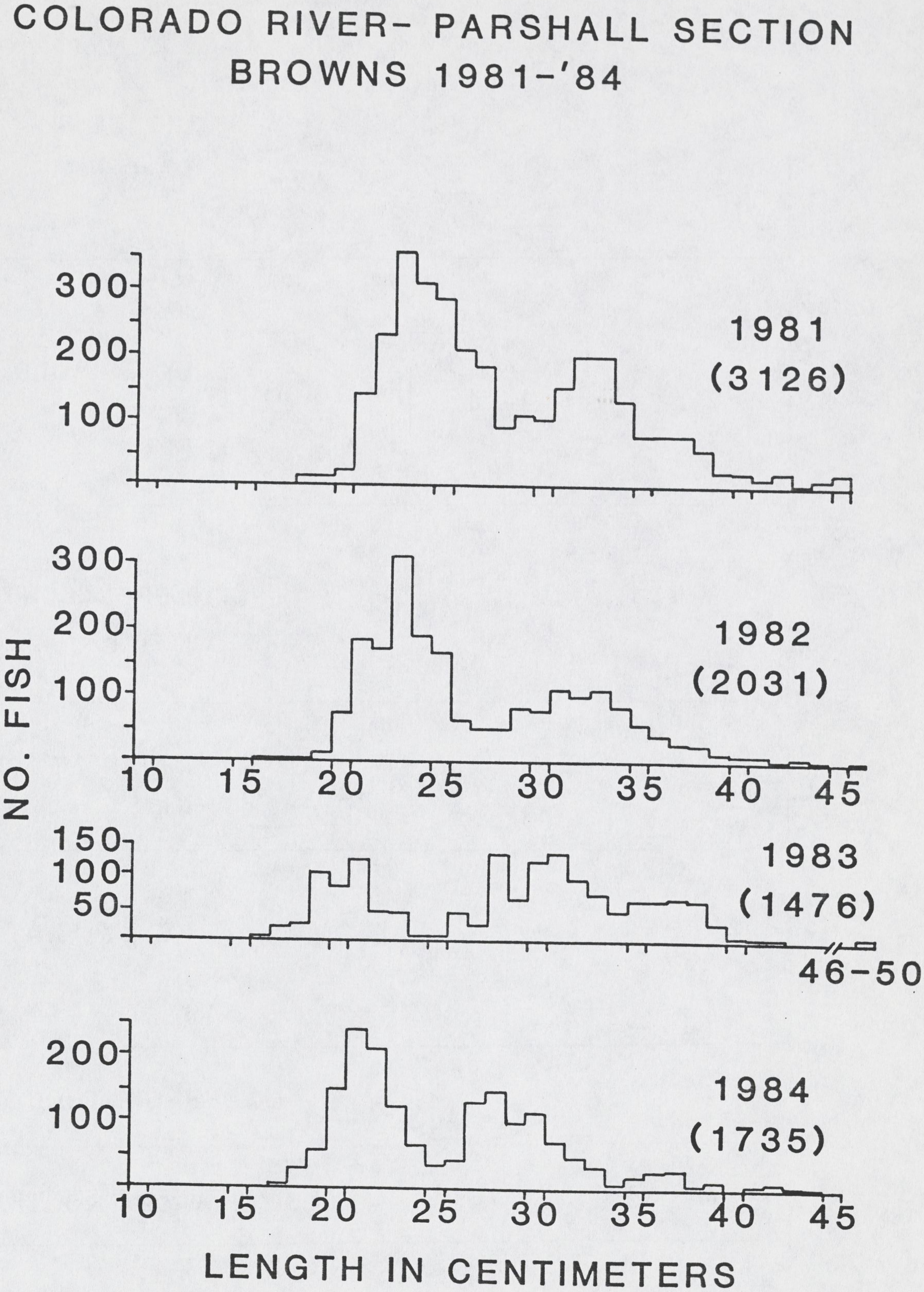


Figure II-8. Colorado River, Parshall section, browns, 1981-84.

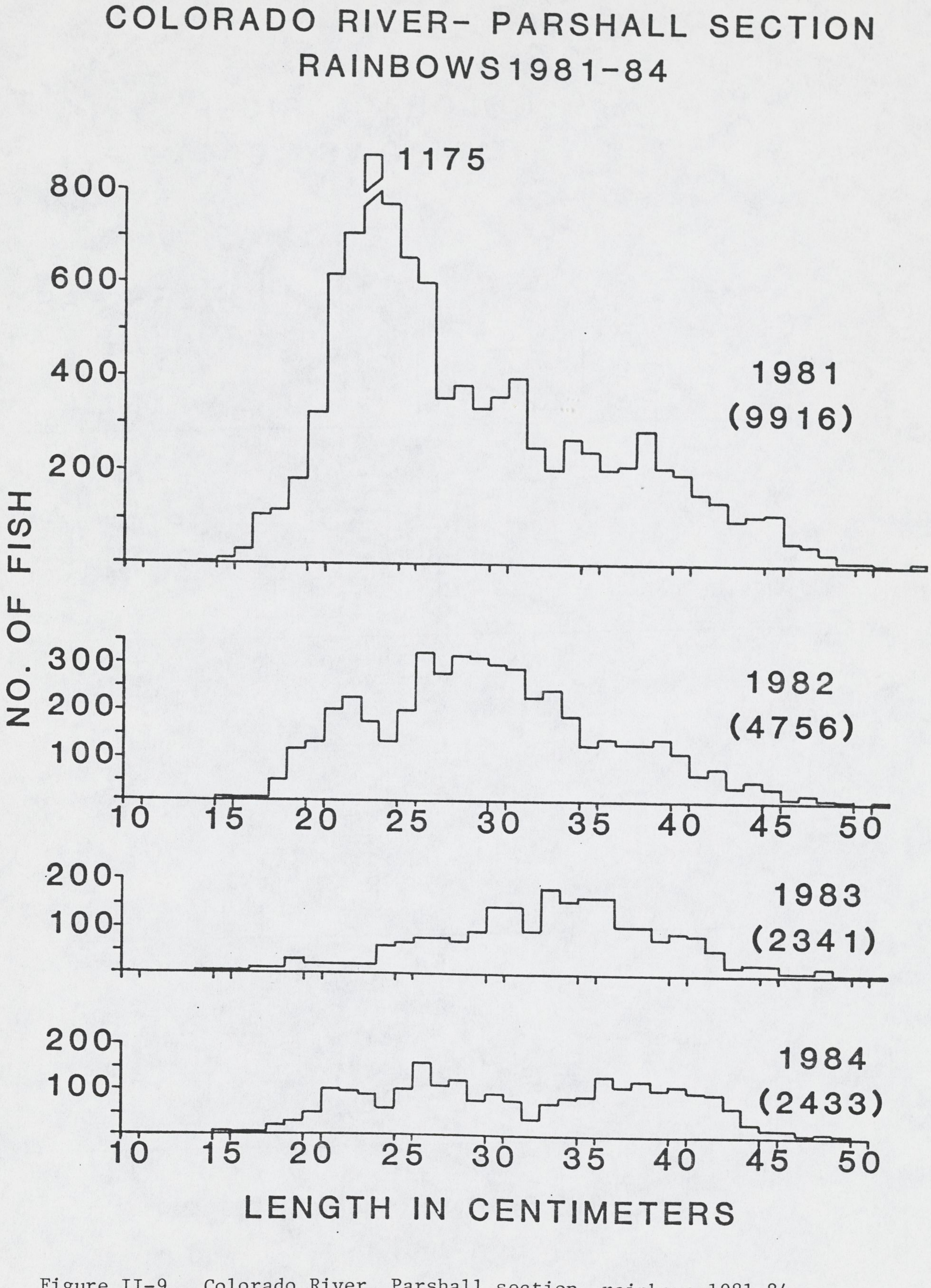


Figure II-9. Colorado River, Parshall section, rainbows, 1981-84.

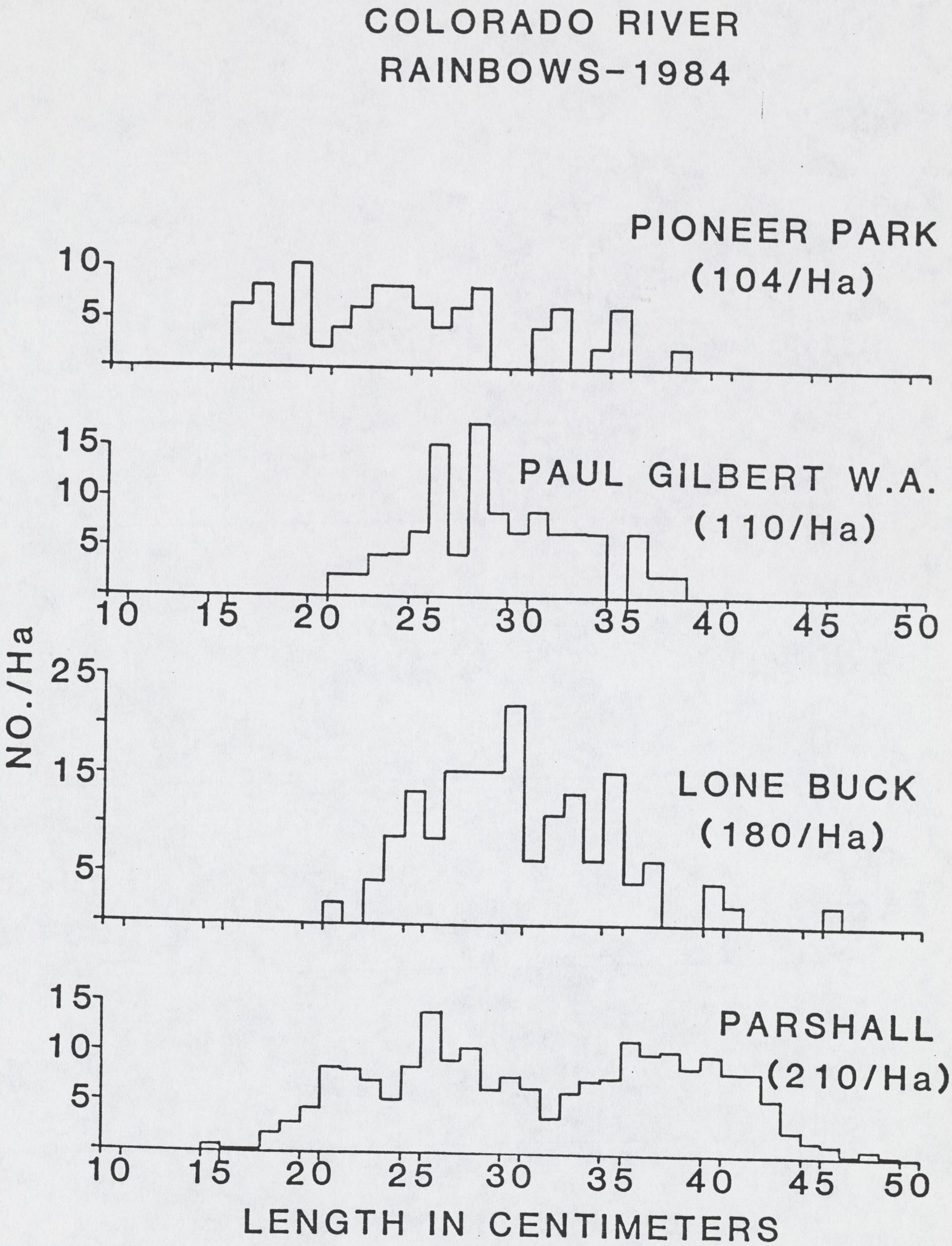


Figure II-10. Colorado River, rainbows/ha 1984, four study areas.

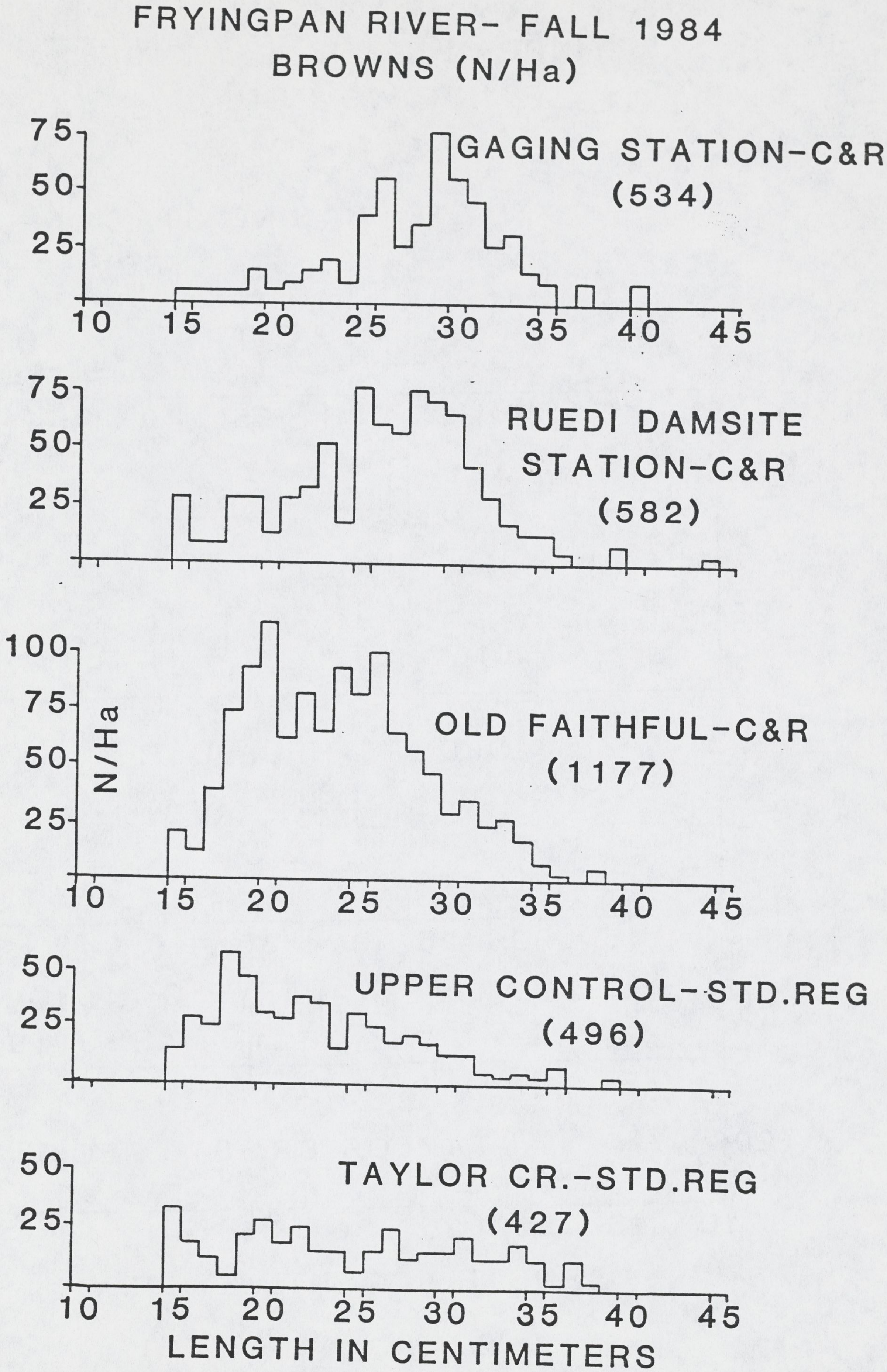


Figure II-11. Fryingpan River, browns/ha 1984, five study areas.

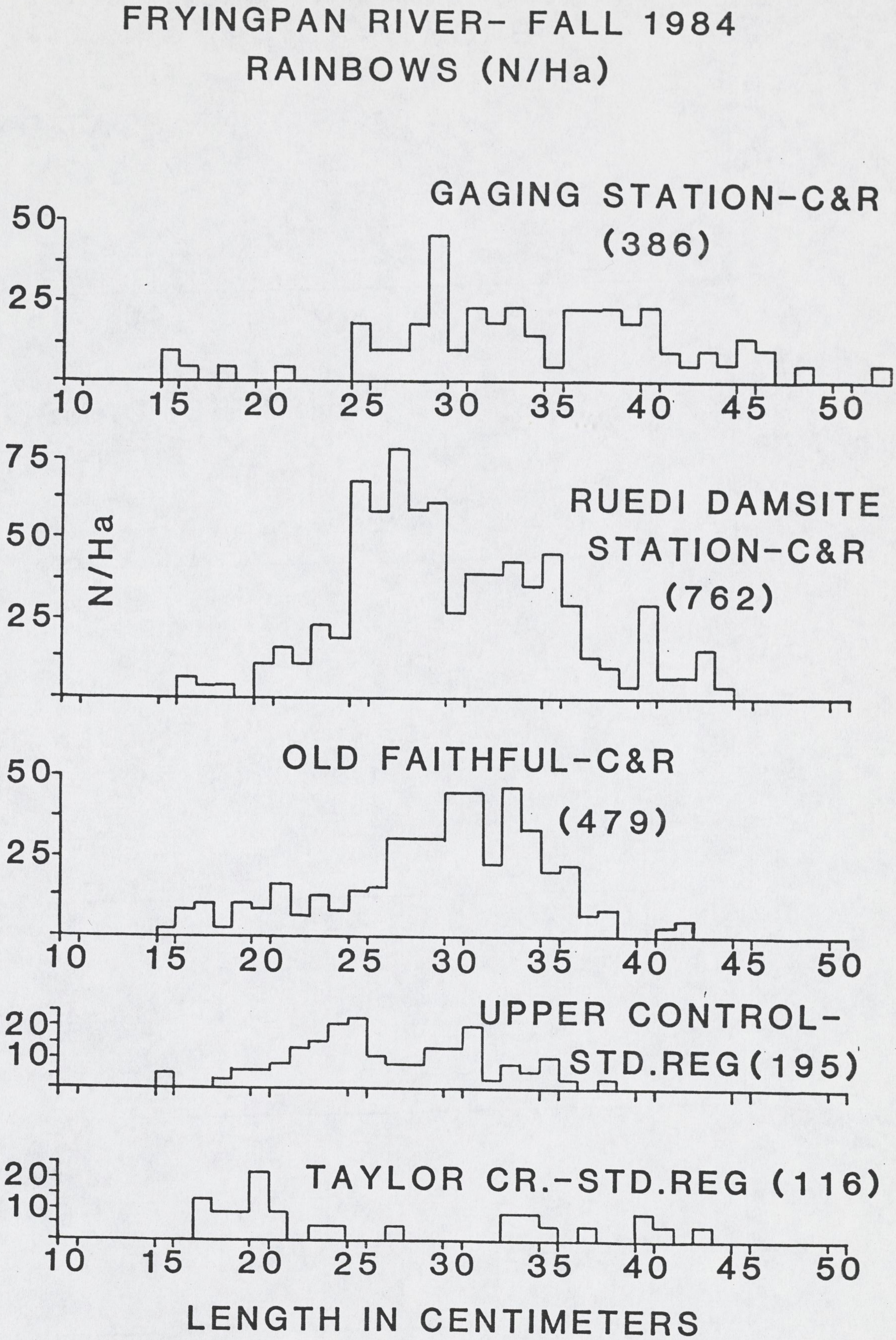


Figure II-12. Fryingpan River, rainbows/ha 1984, five study areas.

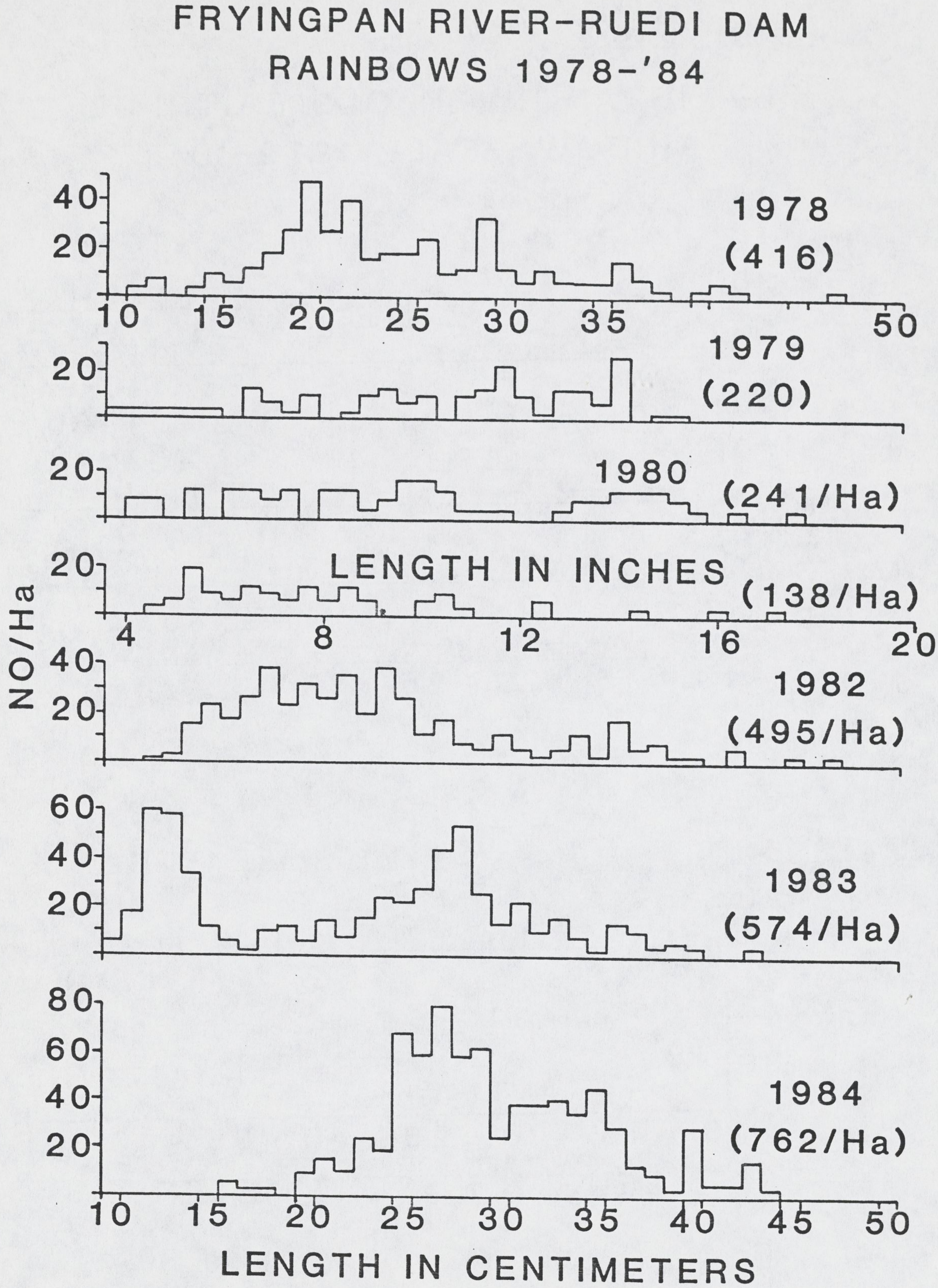


Figure II-13. Fryingpan River, Ruedi Dam, rainbows/ha, 1978-84.

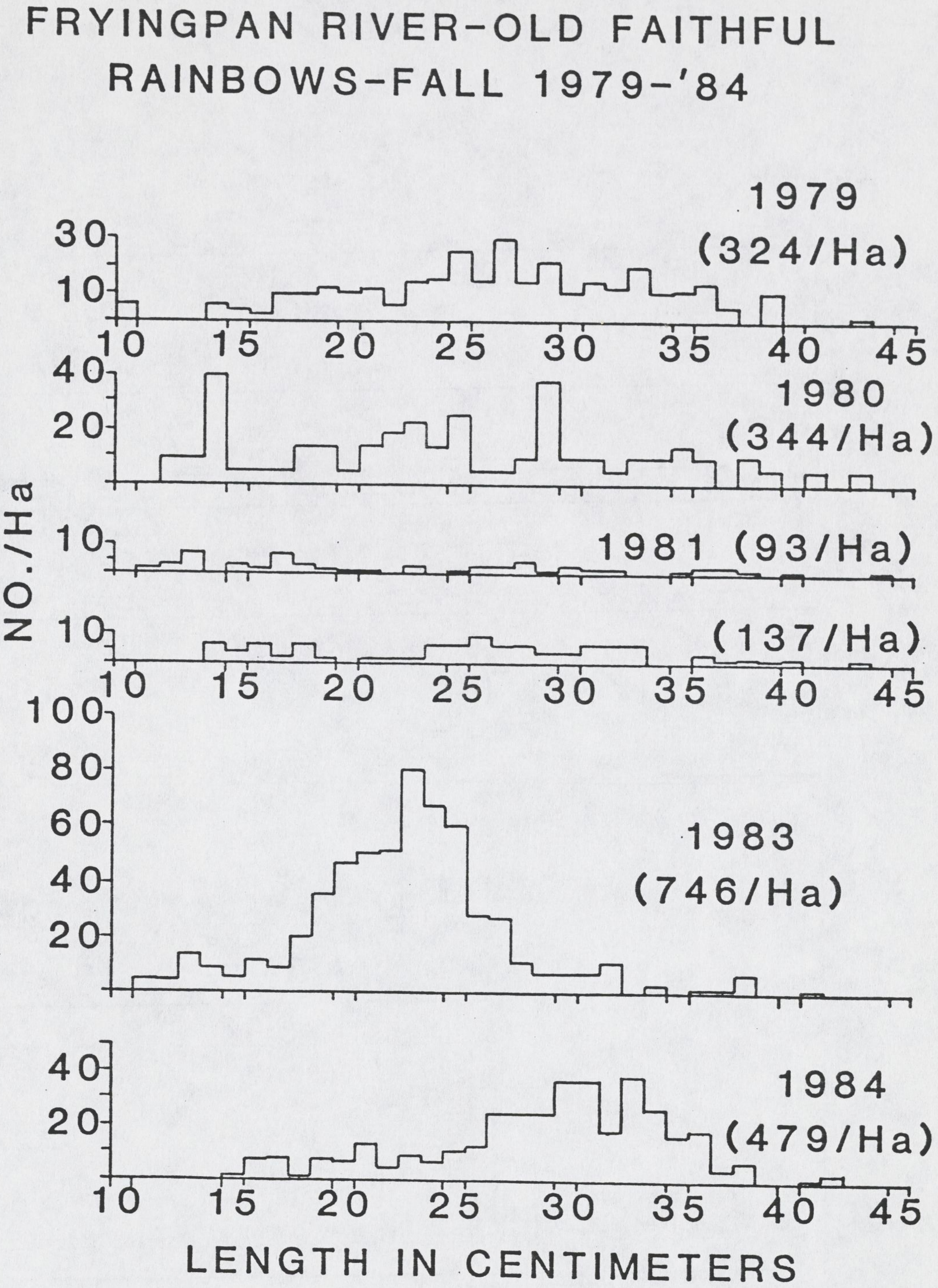


Figure II-14. Fryingpan River, Old Faithful, rainbows/ha, 1979-84.

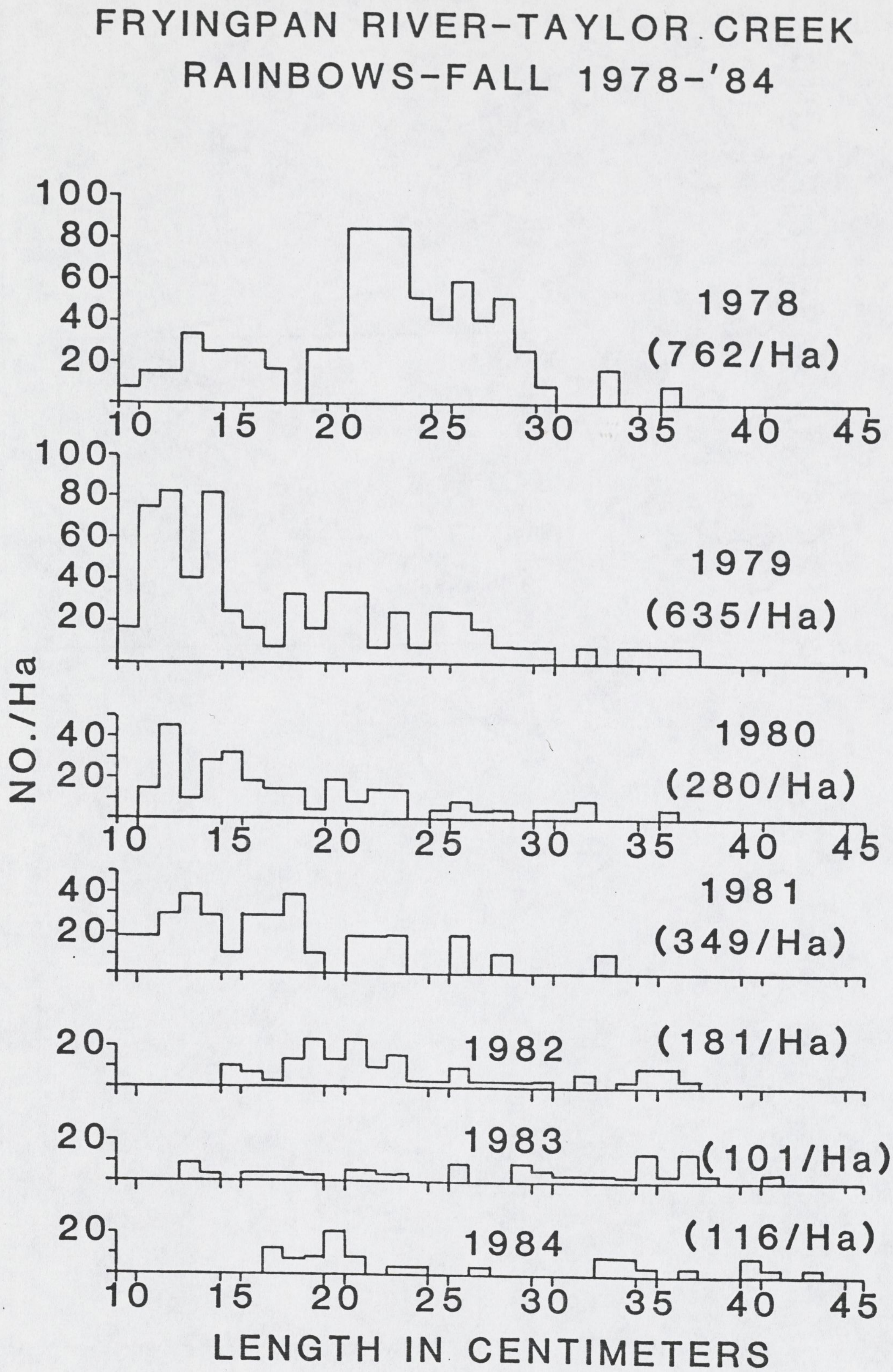


Figure II-15. Fryingpan River, Taylor Creek, rainbows/ha, 1978-84.

FRYINGPAN RIVER- RAINBOWS/ACRE (NUMBERS,POUNDS)
RUEDI DAM

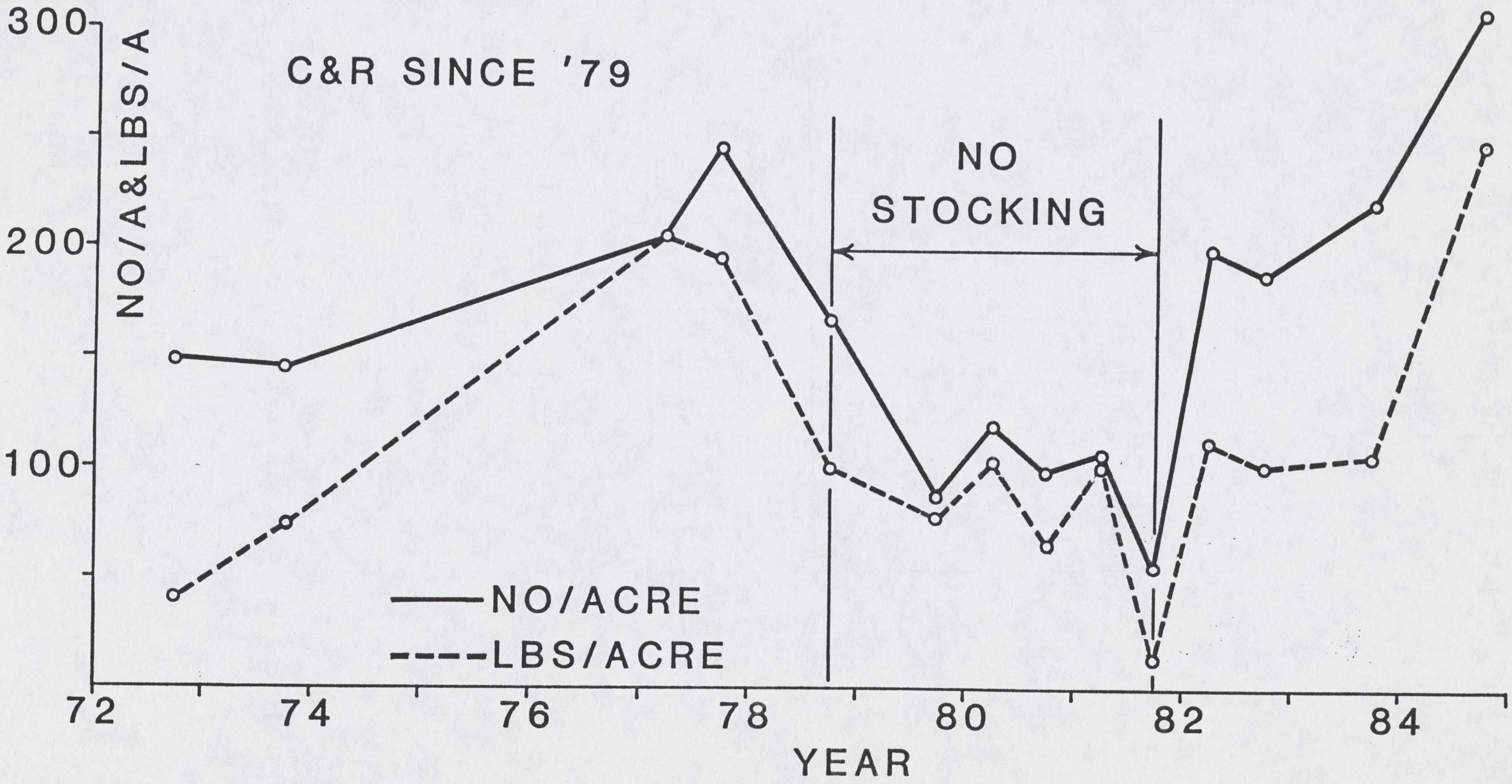


Figure II-16. Fryingpan River, Ruedi Dam, rainbows numbers and pounds/acre. 1972-84.

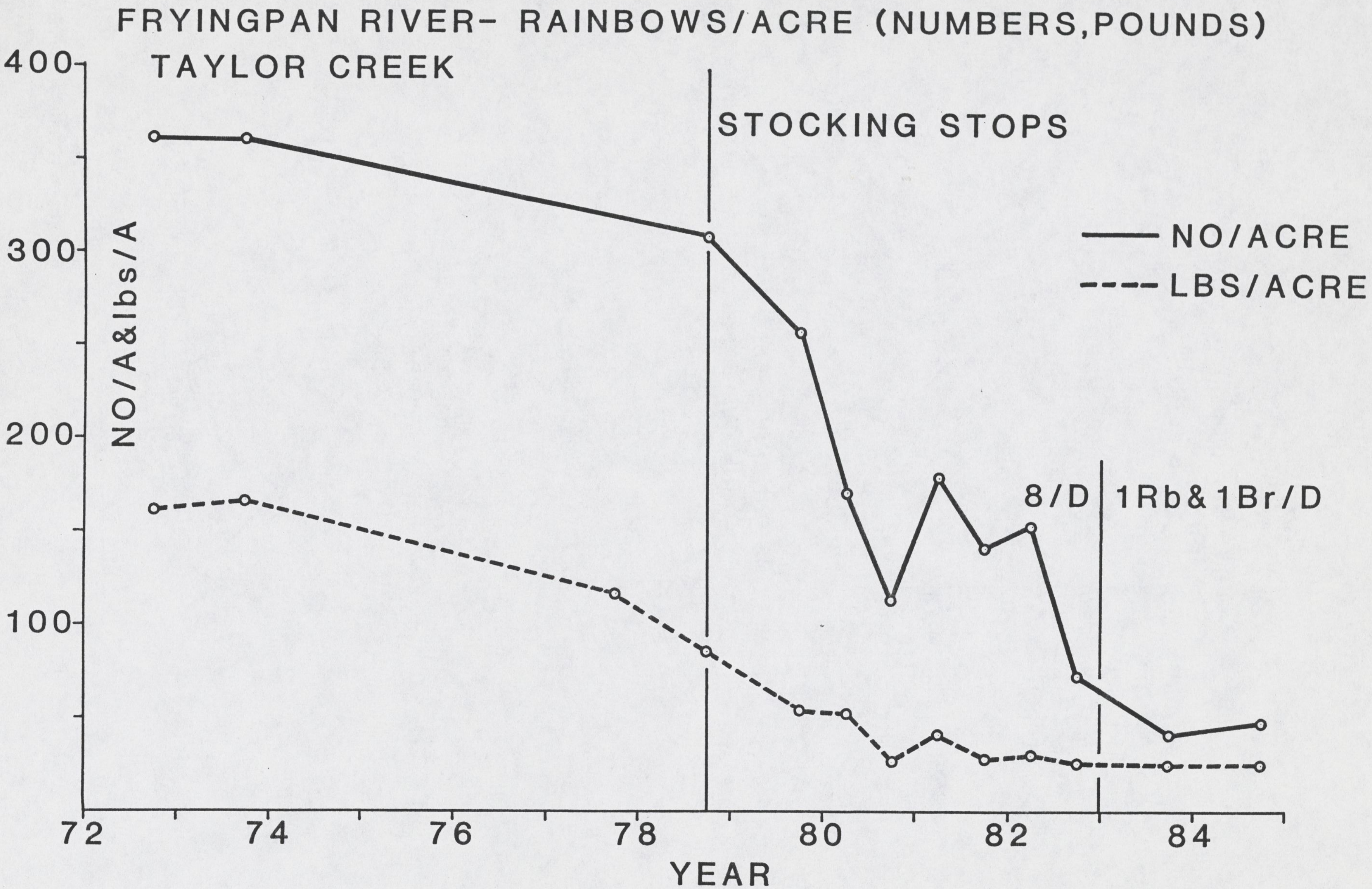


Figure II-17. Fryingpan River, Taylor Creek, rainbows numbers and pounds/acre, 1972-84.

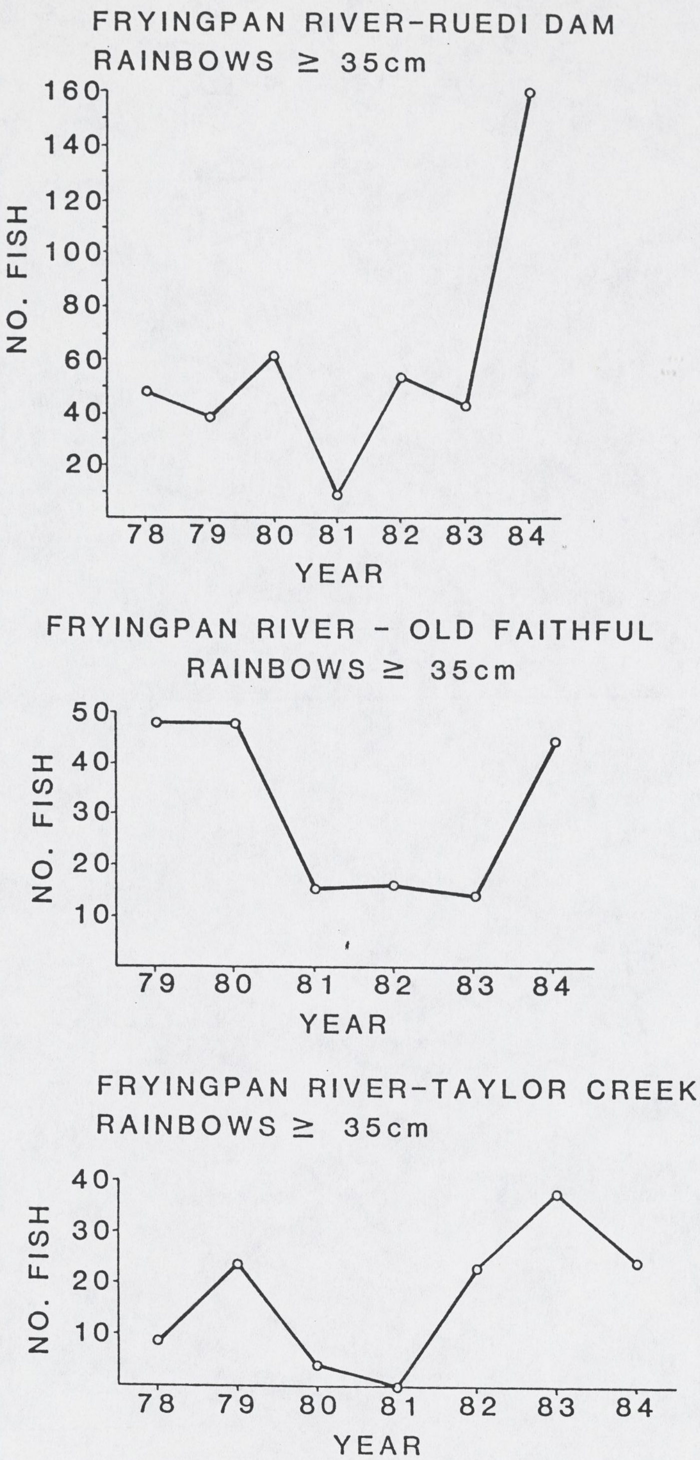


Figure II-18. Fryingpan River, rainbows/ha ≥35 cm, three study areas.

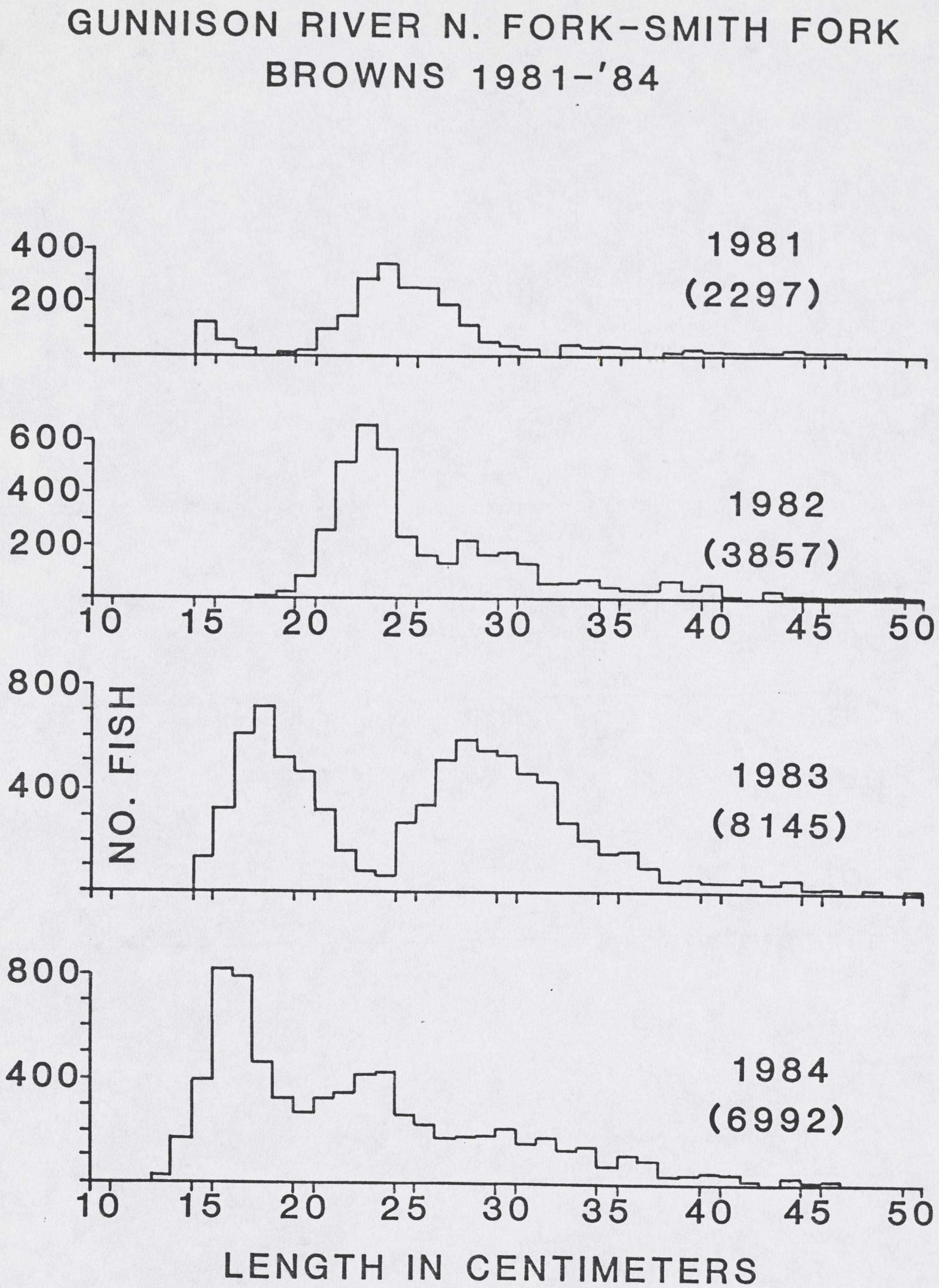


Figure II-19. Gunnison River, North Fork-Smith Fork, browns, 1981-84.

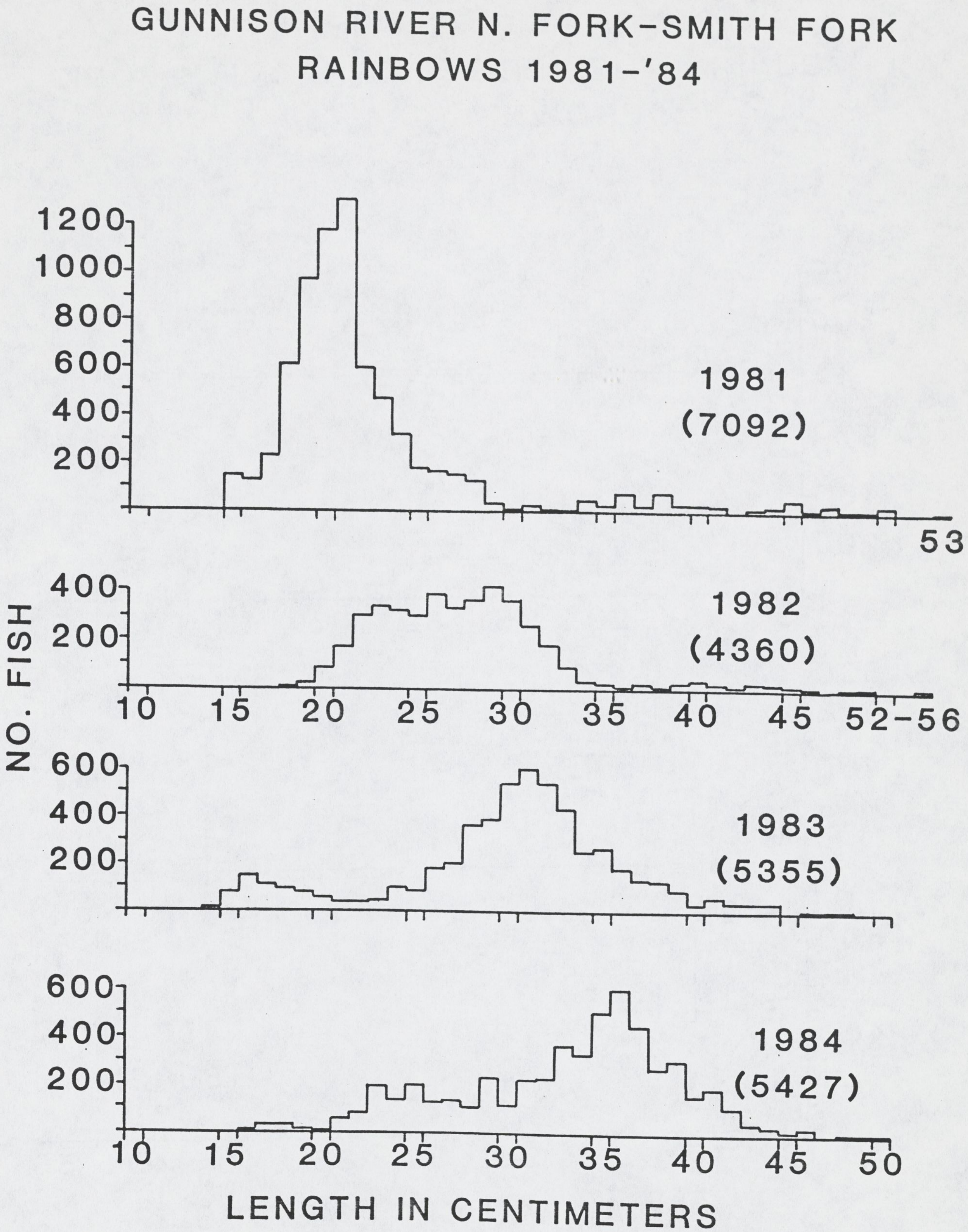


Figure II-20. Gunnison River, North Fork-Smith Fork, rainbows, 1981-84.

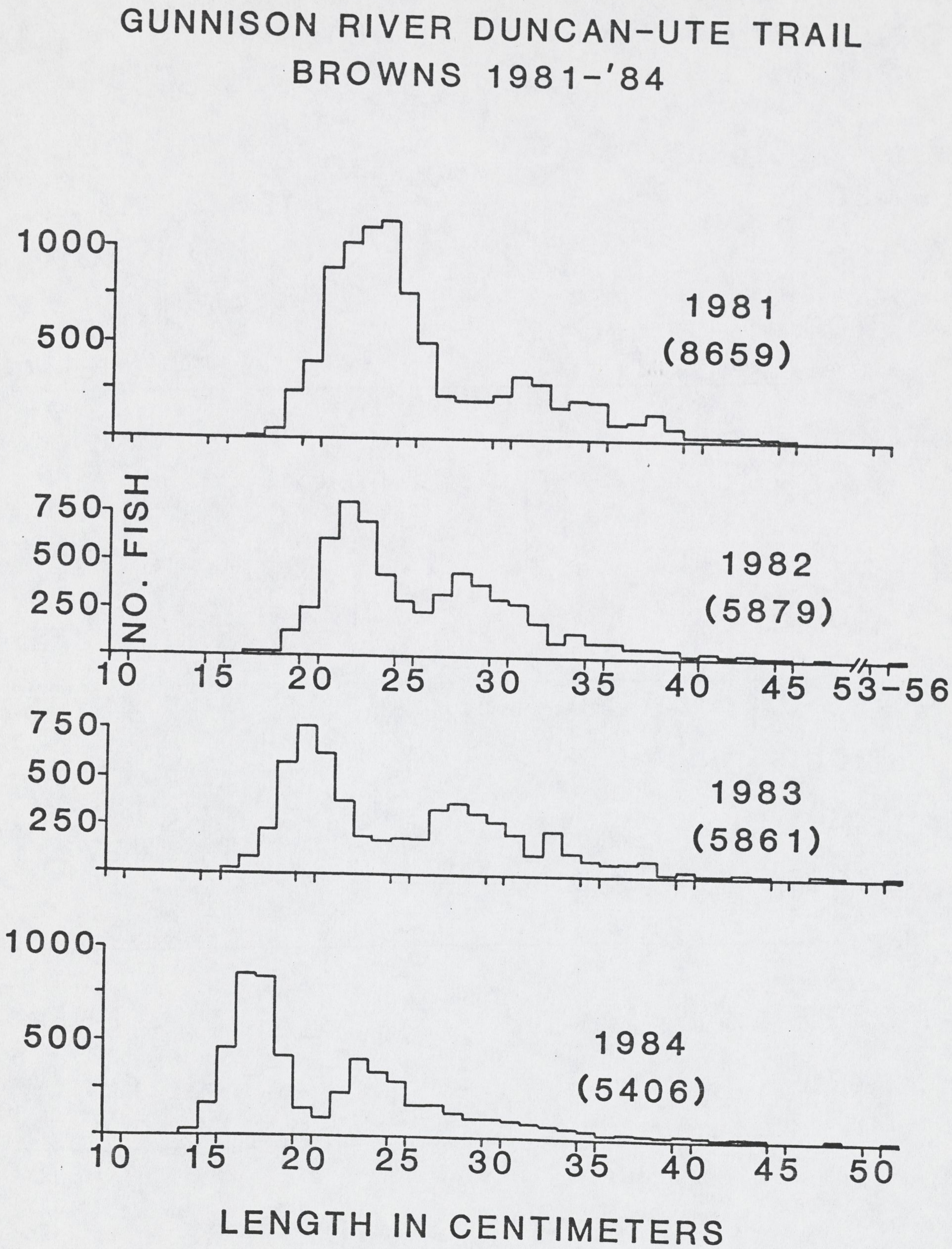


Figure II-21. Gunnison River, Duncan-Ute Trail, browns, 1981-84.

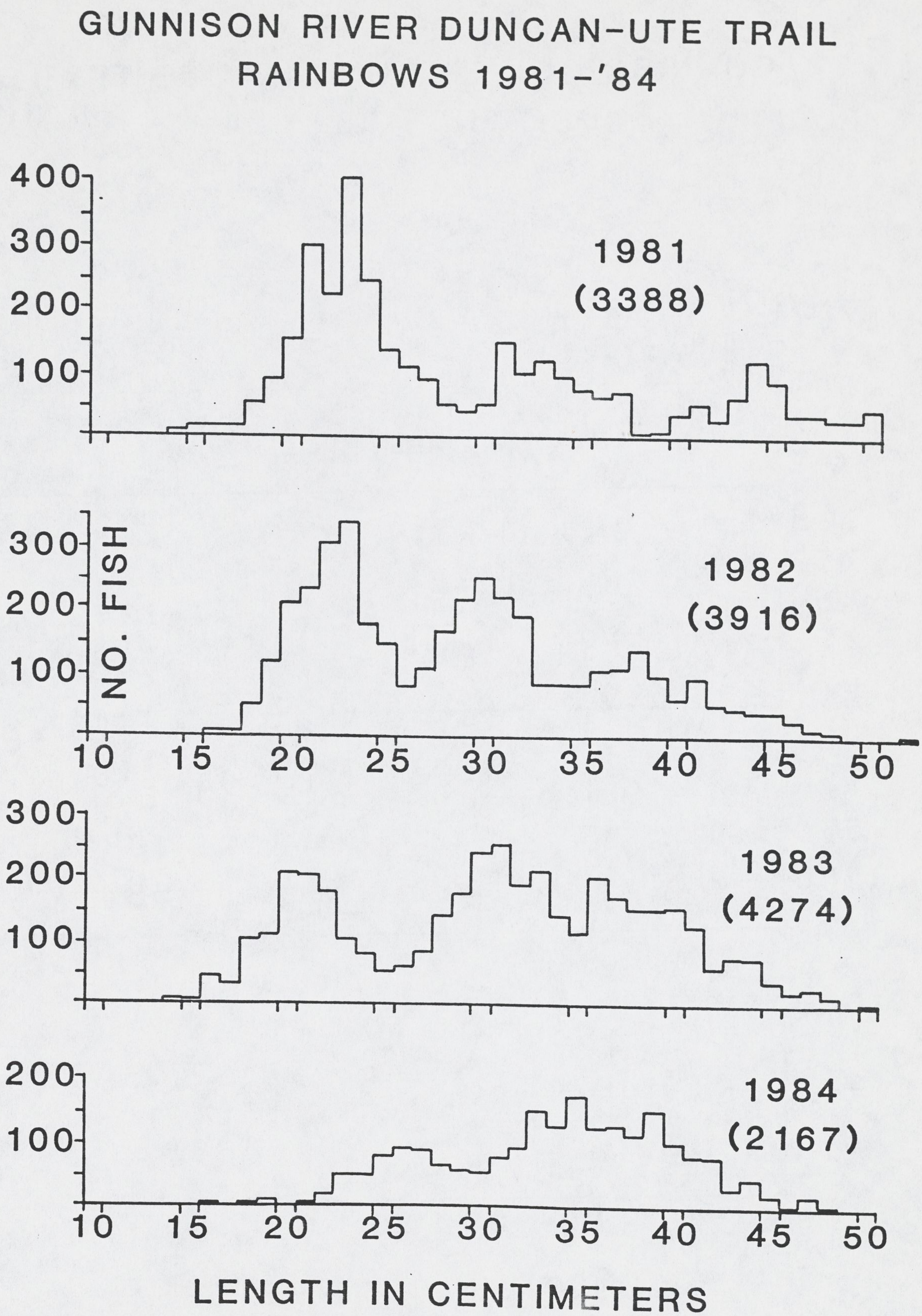


Figure II-22. Gunnison River, Duncan-Ute Trail, rainbows, 1981-84.

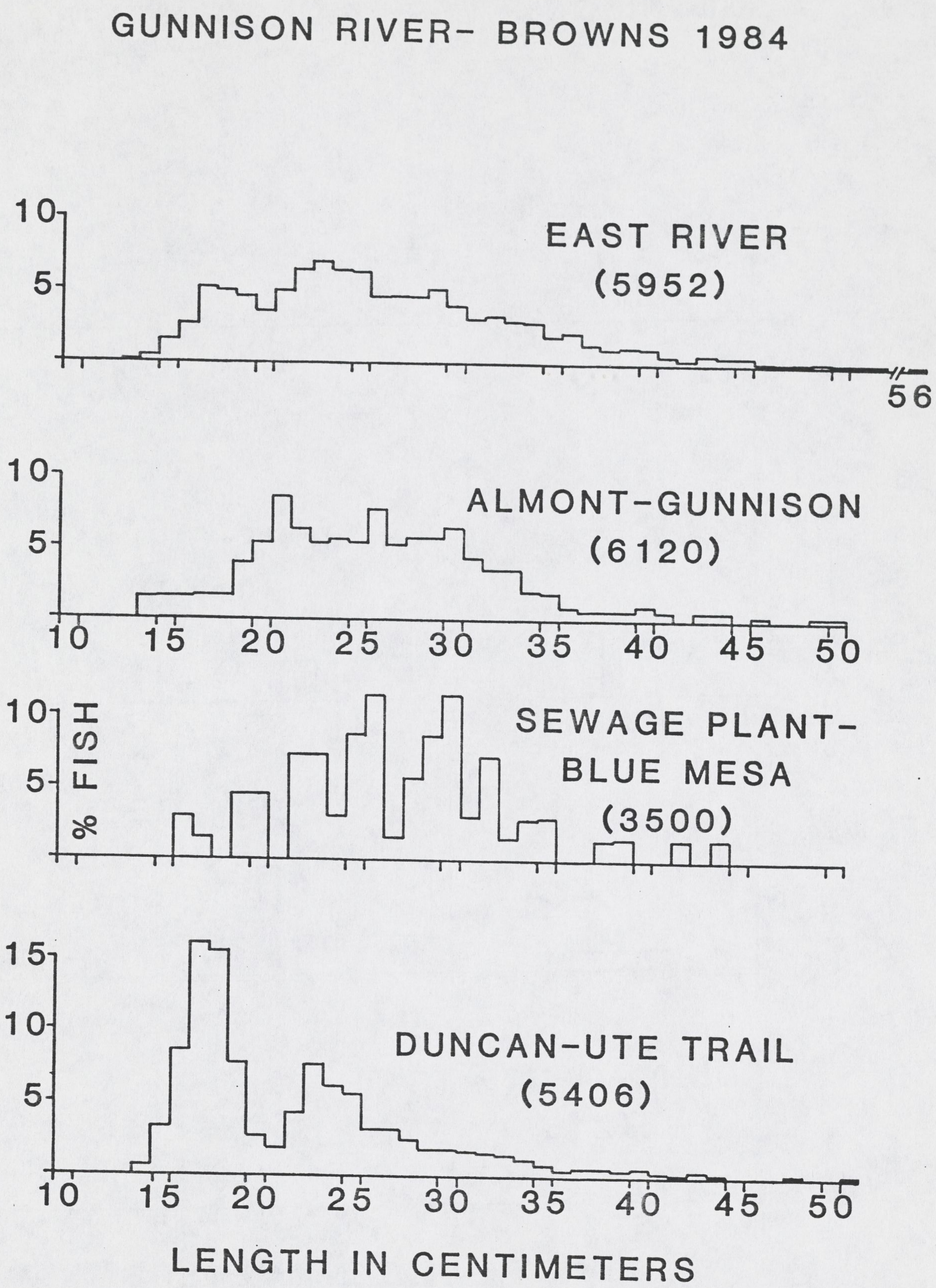


Figure II-23. Gunnison River, browns 1984, four study sections.

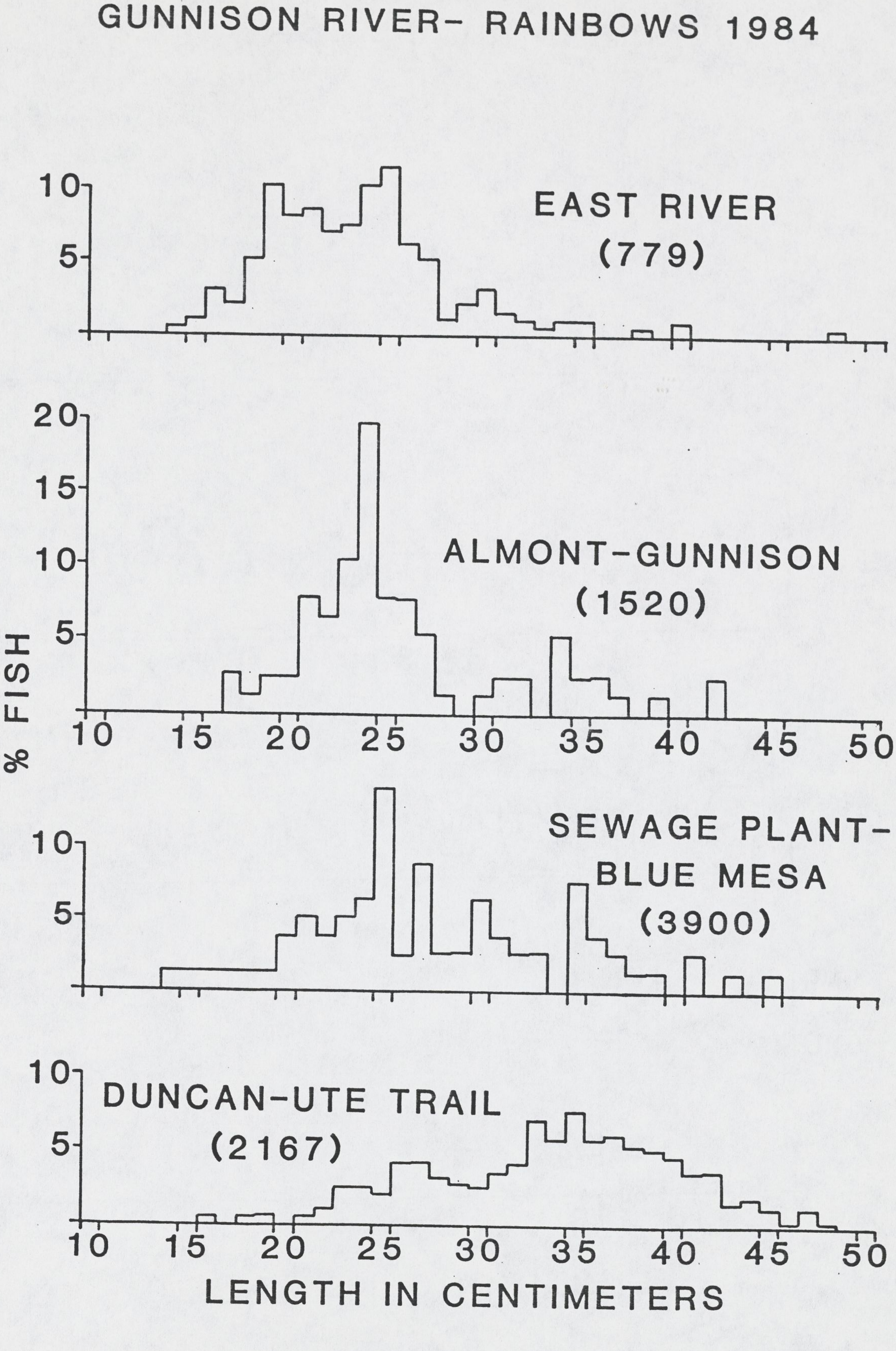


Figure II-24. Gunnison River, rainbows 1984, four study sections.

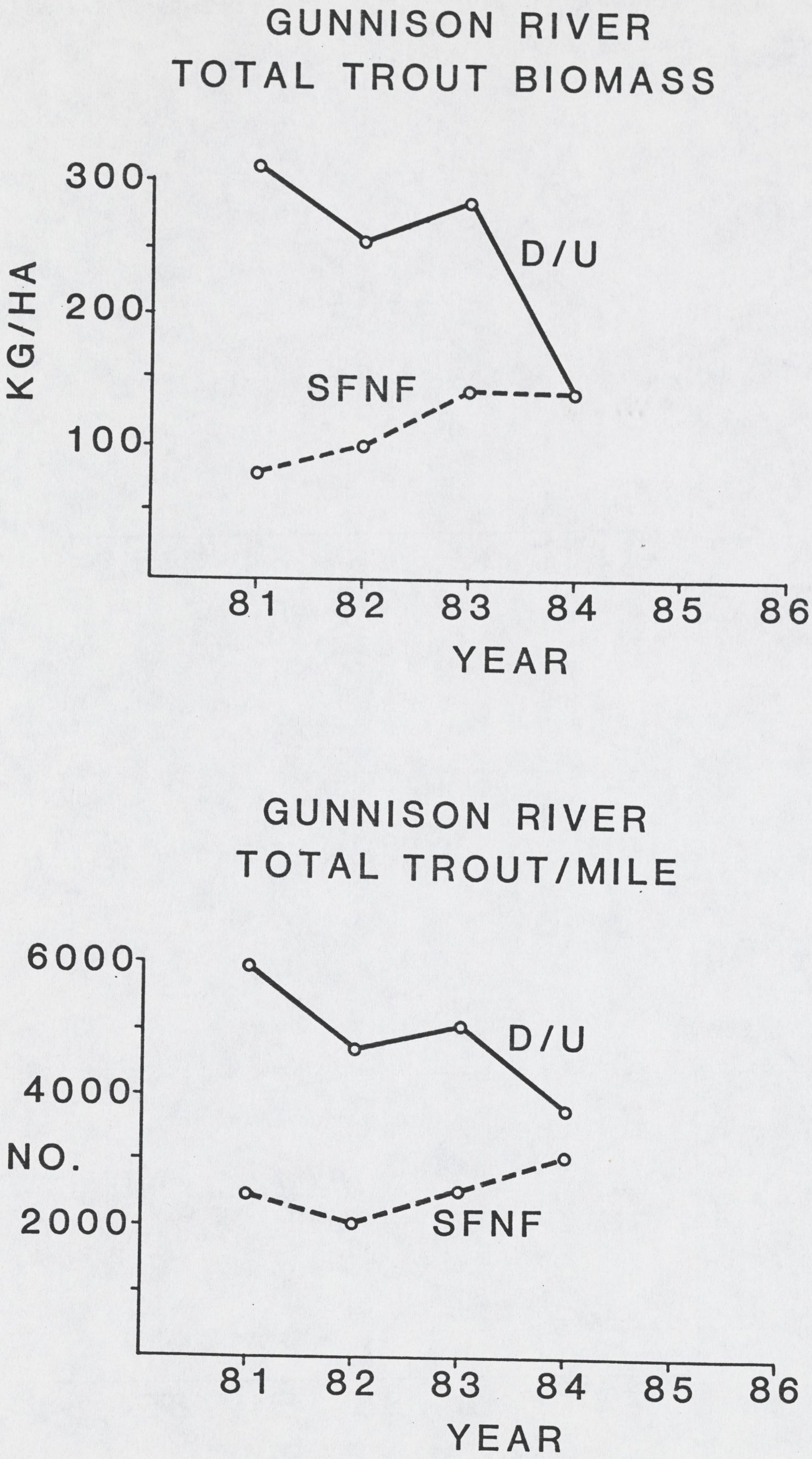
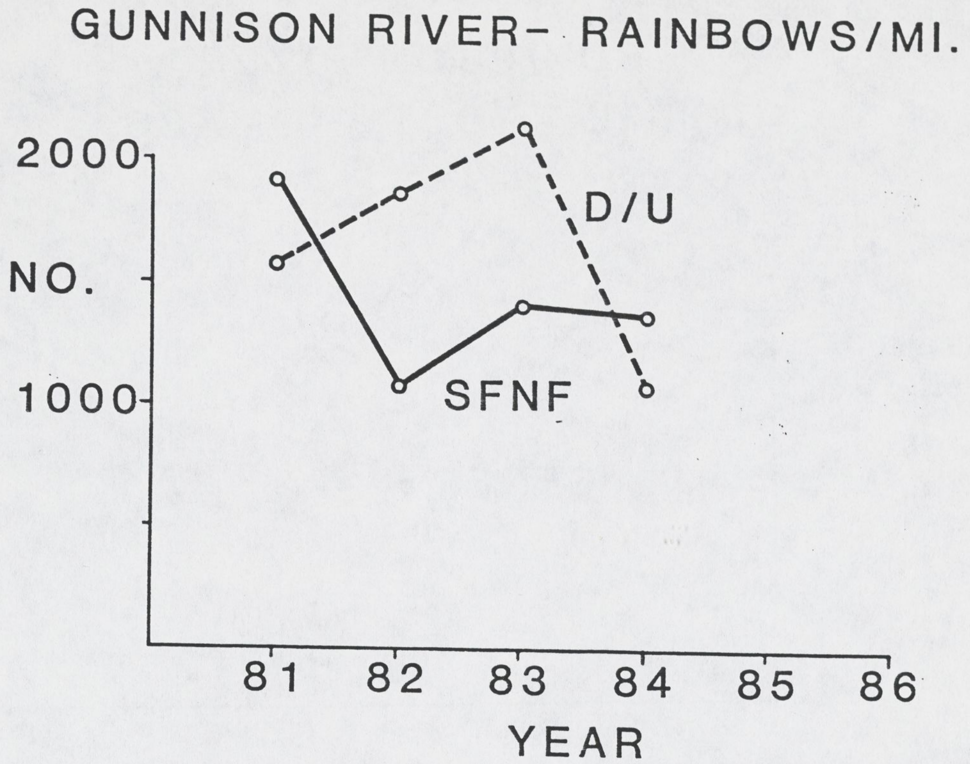


Figure II-25. Gunnison River, total trout biomass and total trout/mile. 1981-84.



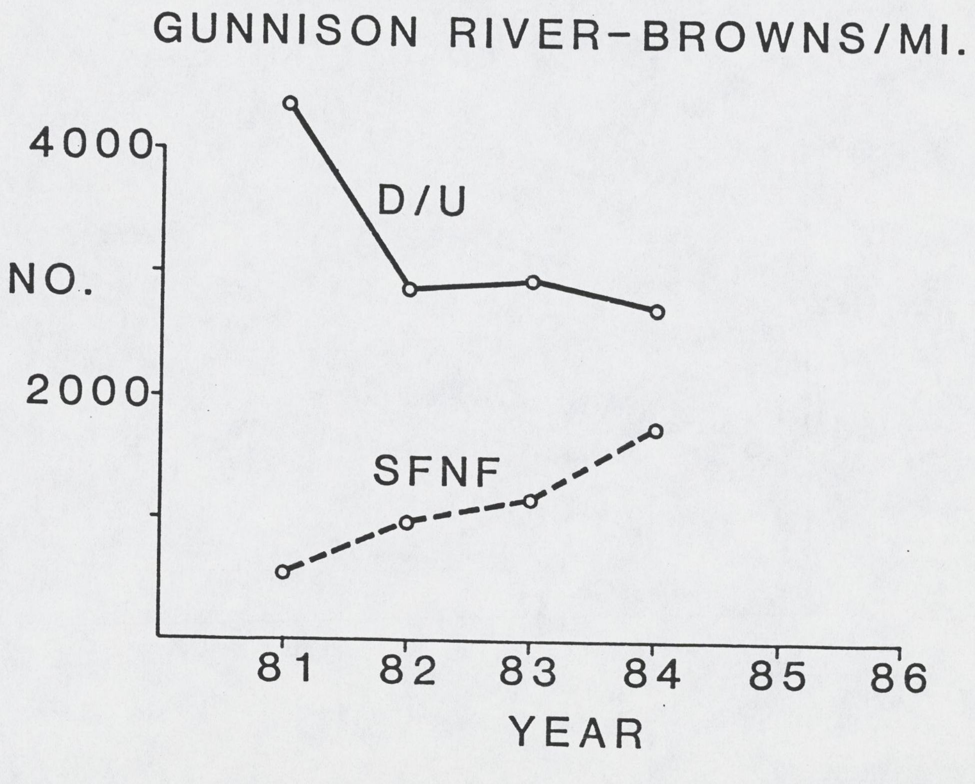


Figure II-26. Gunnison River, rainbows/mile and browns/mile,1981-84.

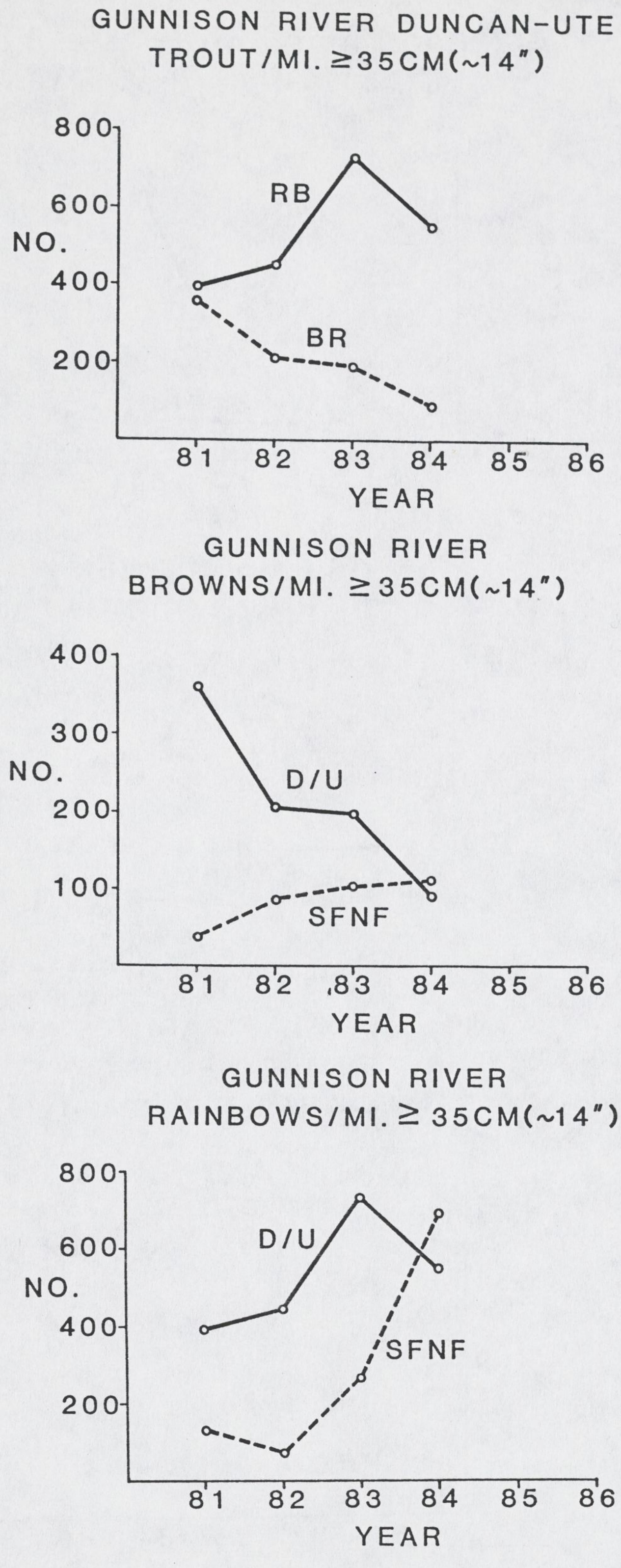


Figure II-27. Gunnison River, trout/mile $\geq$35 cm, browns/mile and rainbows/mile $\geq$35 cm, 1981-84.

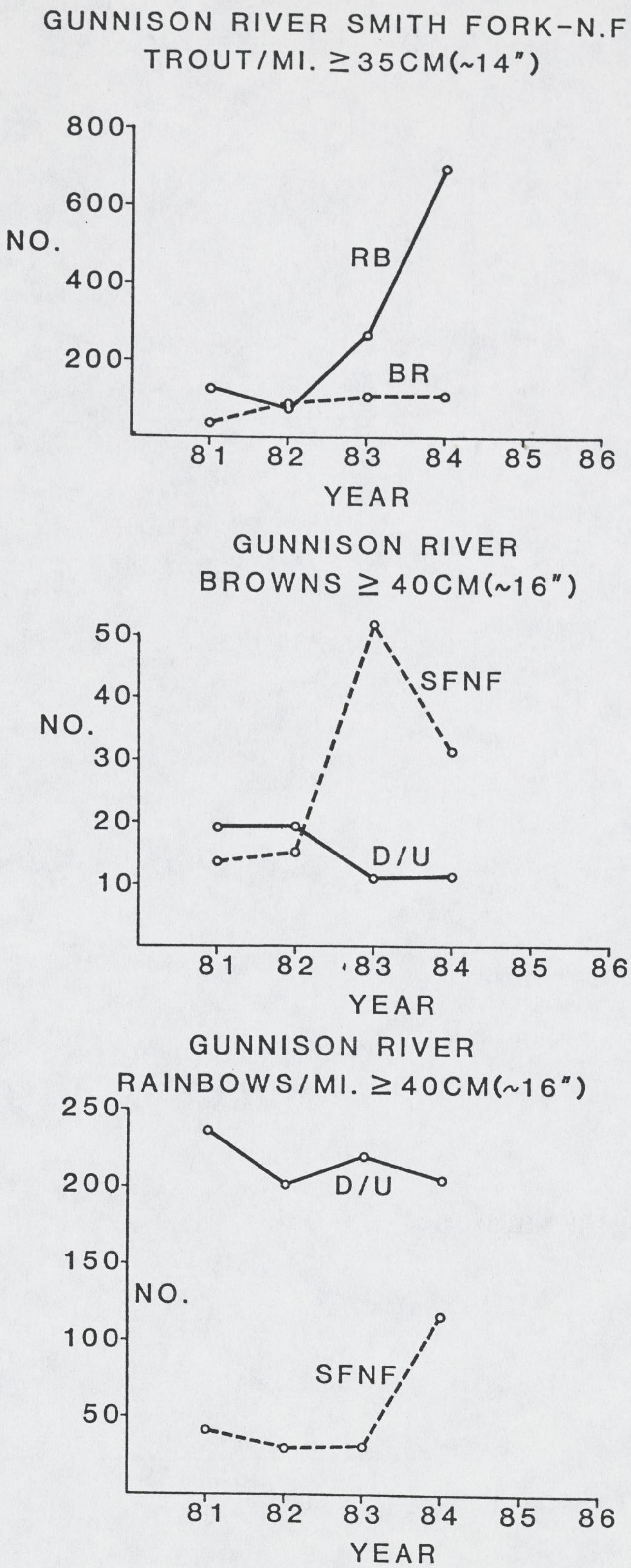


Figure II-28. Gunnison River, Smith Fork-North Fork trout/mile $\geq$35 cm, 1981-84; browns and rainbows/mile $\geq$40 cm.

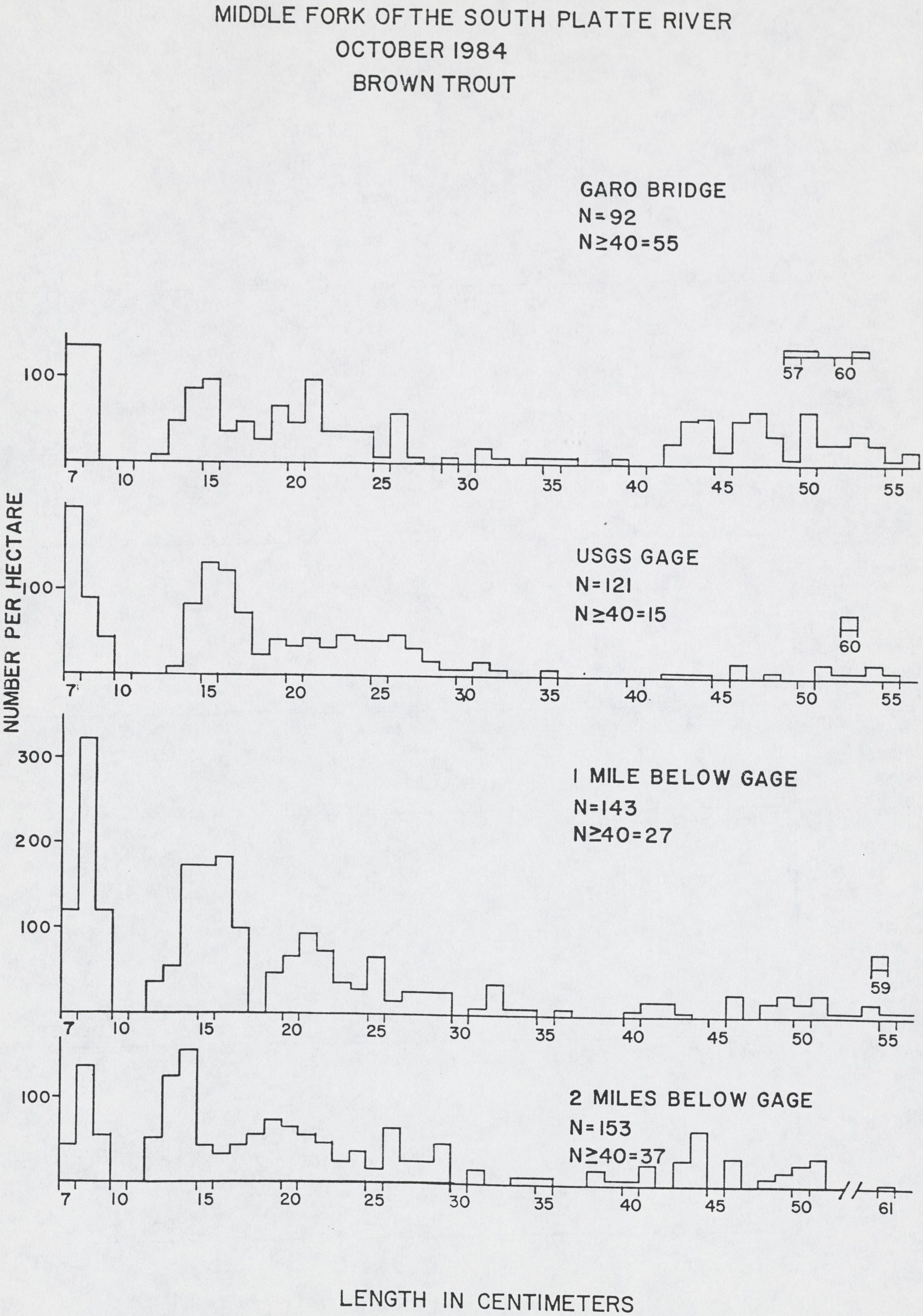


Figure II-29. Middle Fork of the South Platte River, browns, October 1984.

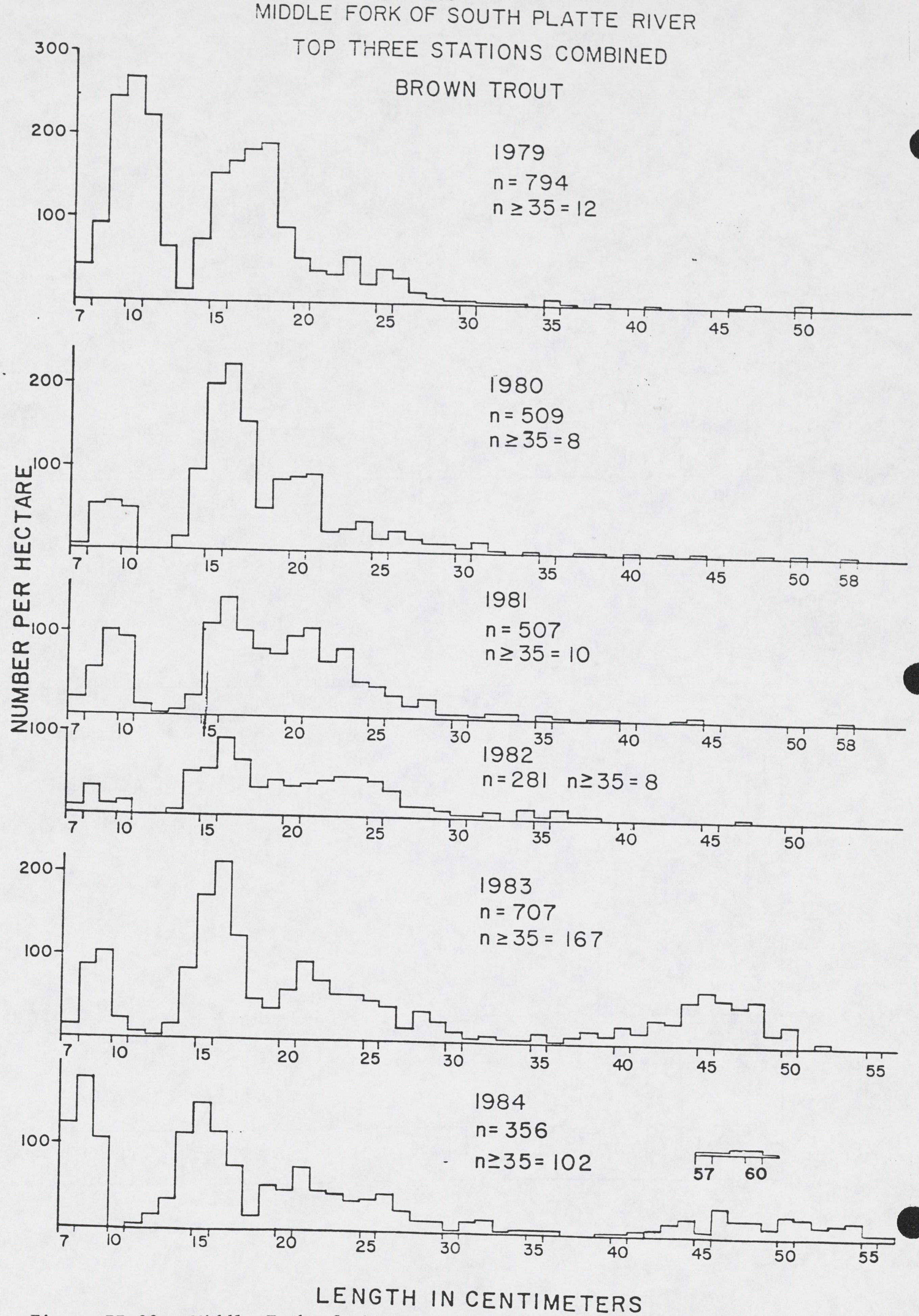


Figure II-30. Middle Fork of the South Platte River, browns, 1979-84.

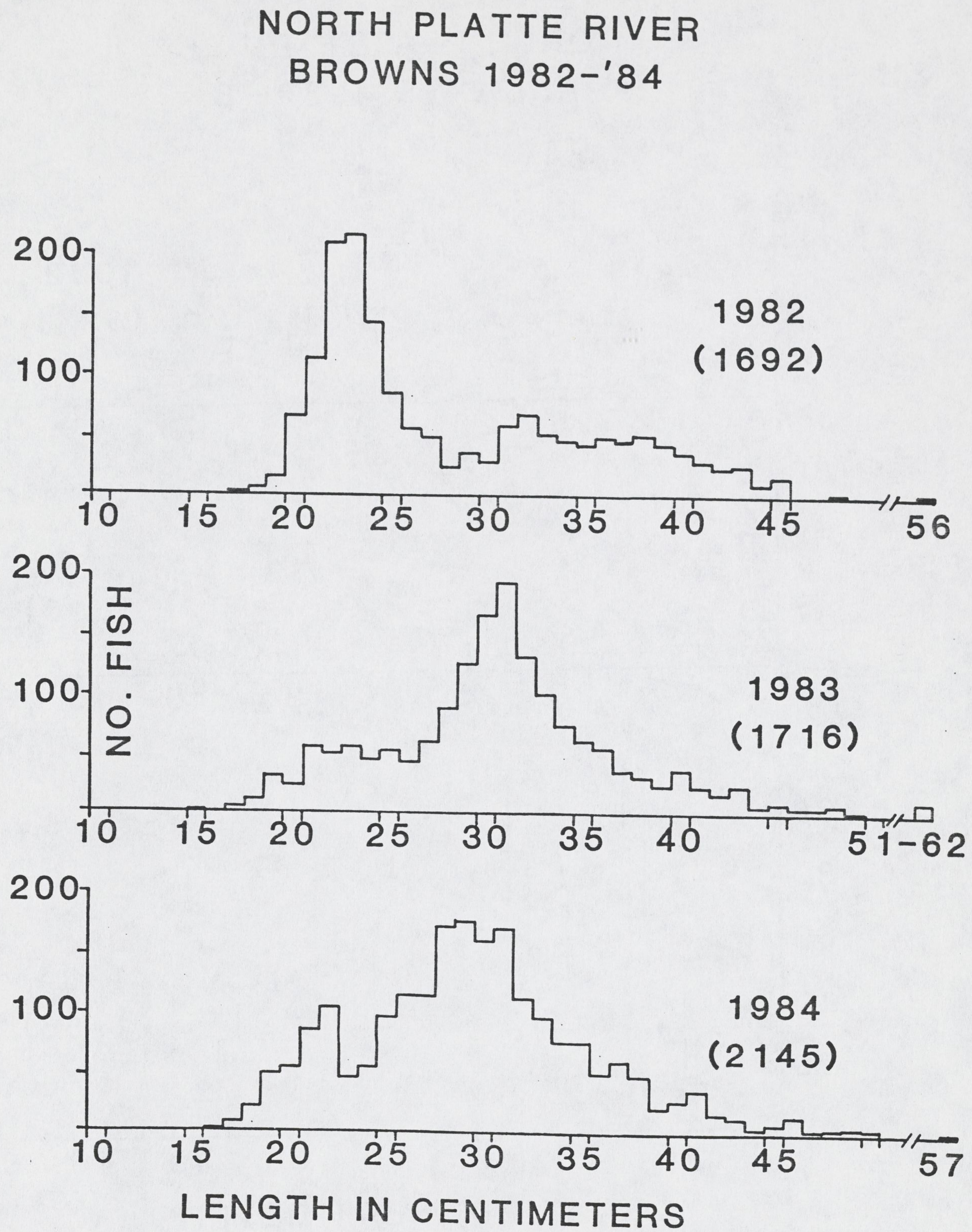


Figure II-31. North Platte River, browns, 1982-84.

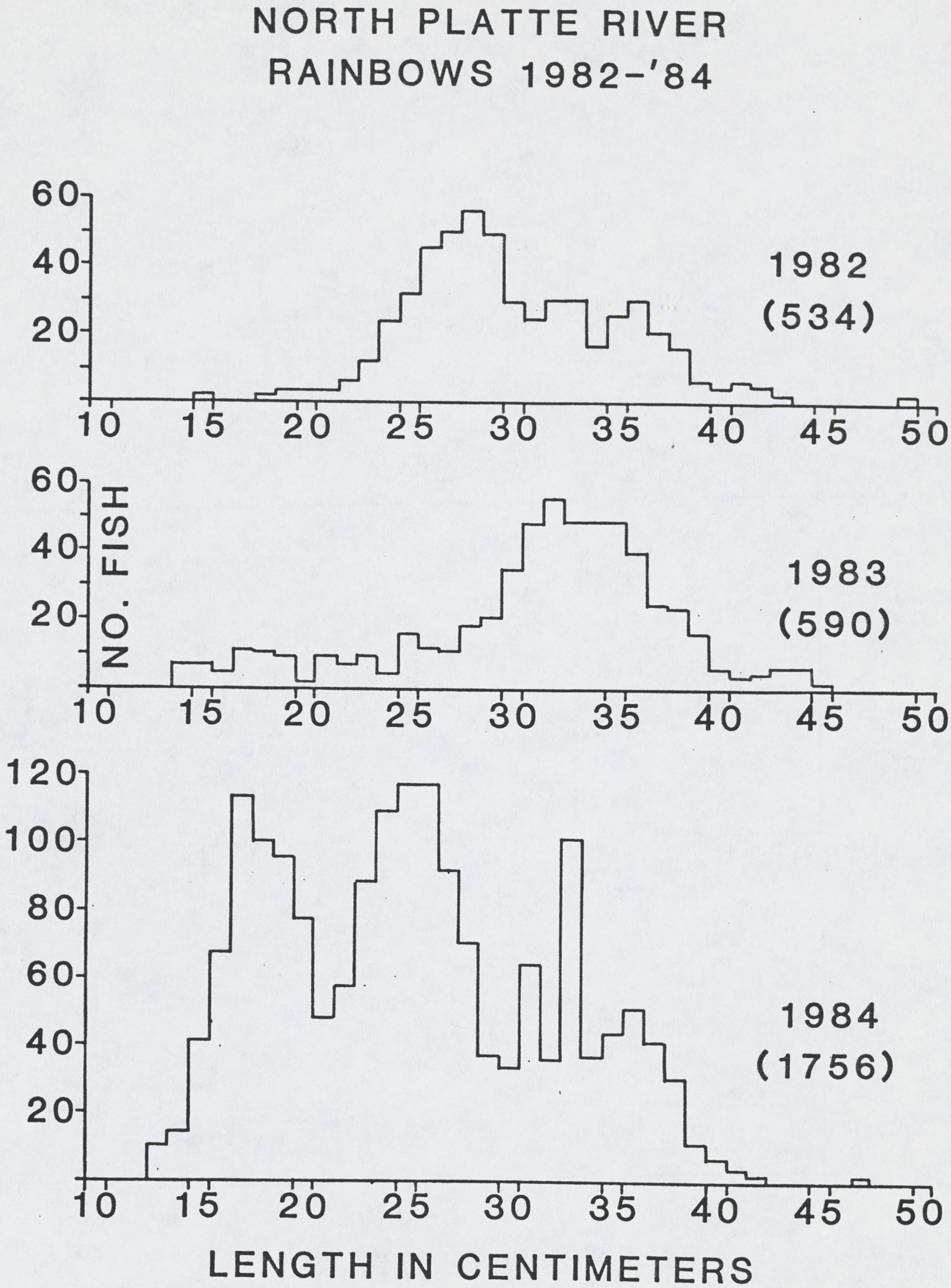


Figure II-32. North Platte River, rainbows, 1982-84.

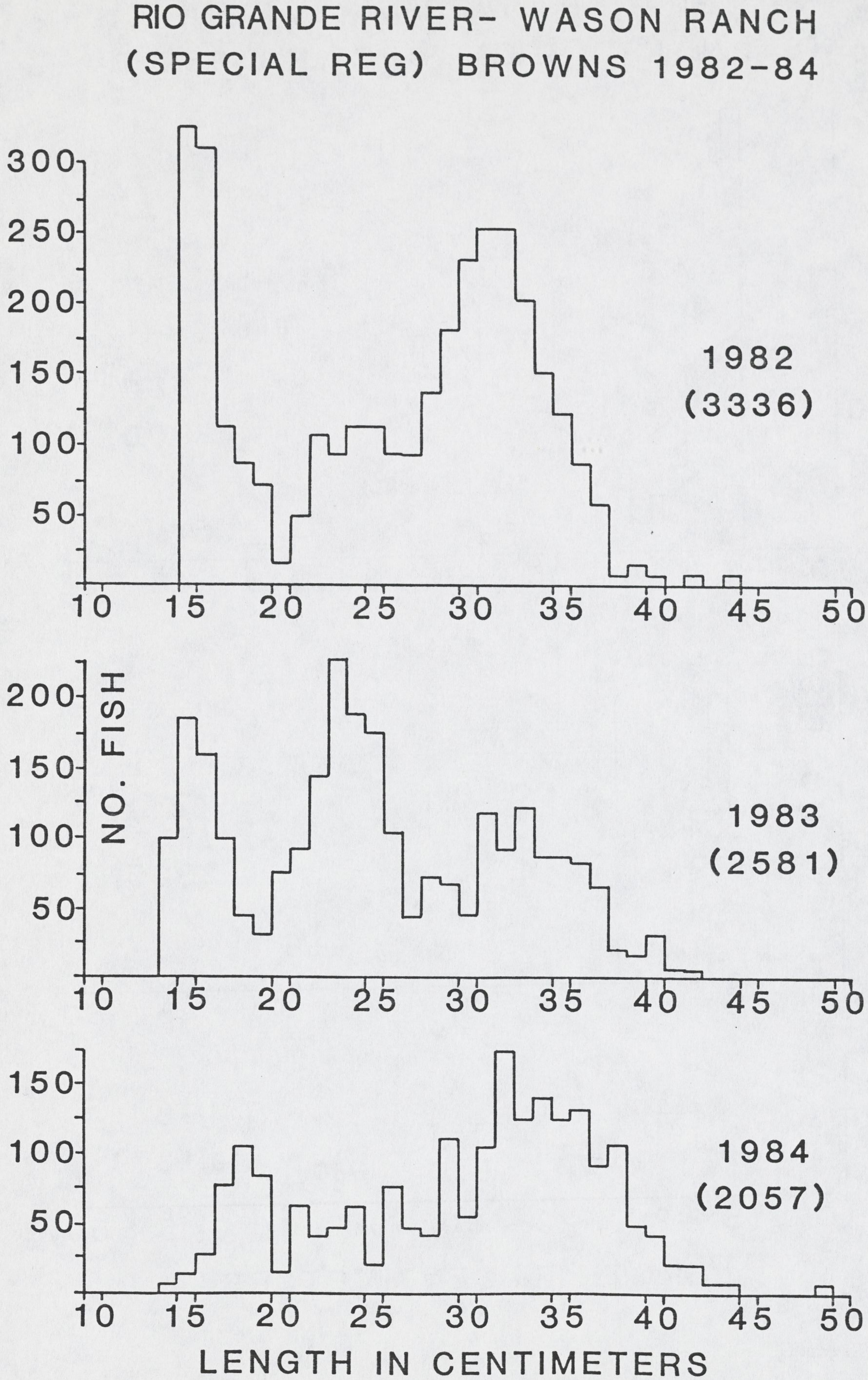


Figure II-33. Rio Grande River, Wason Ranch (special regulations), browns, 1982-84.

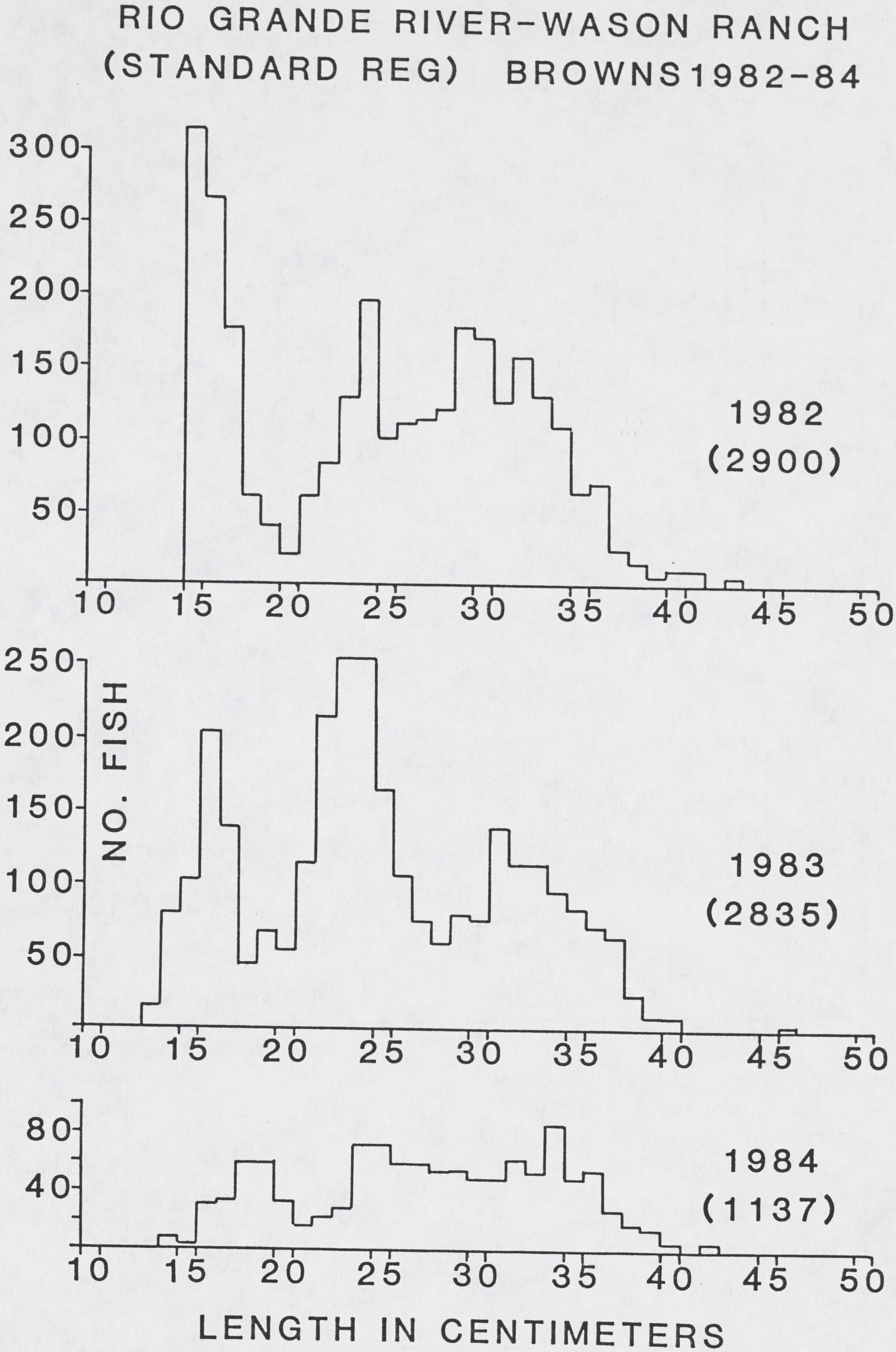


Figure II-34. Rio Grande River, Wason Ranch (standard regulations), browns, 1982-84.

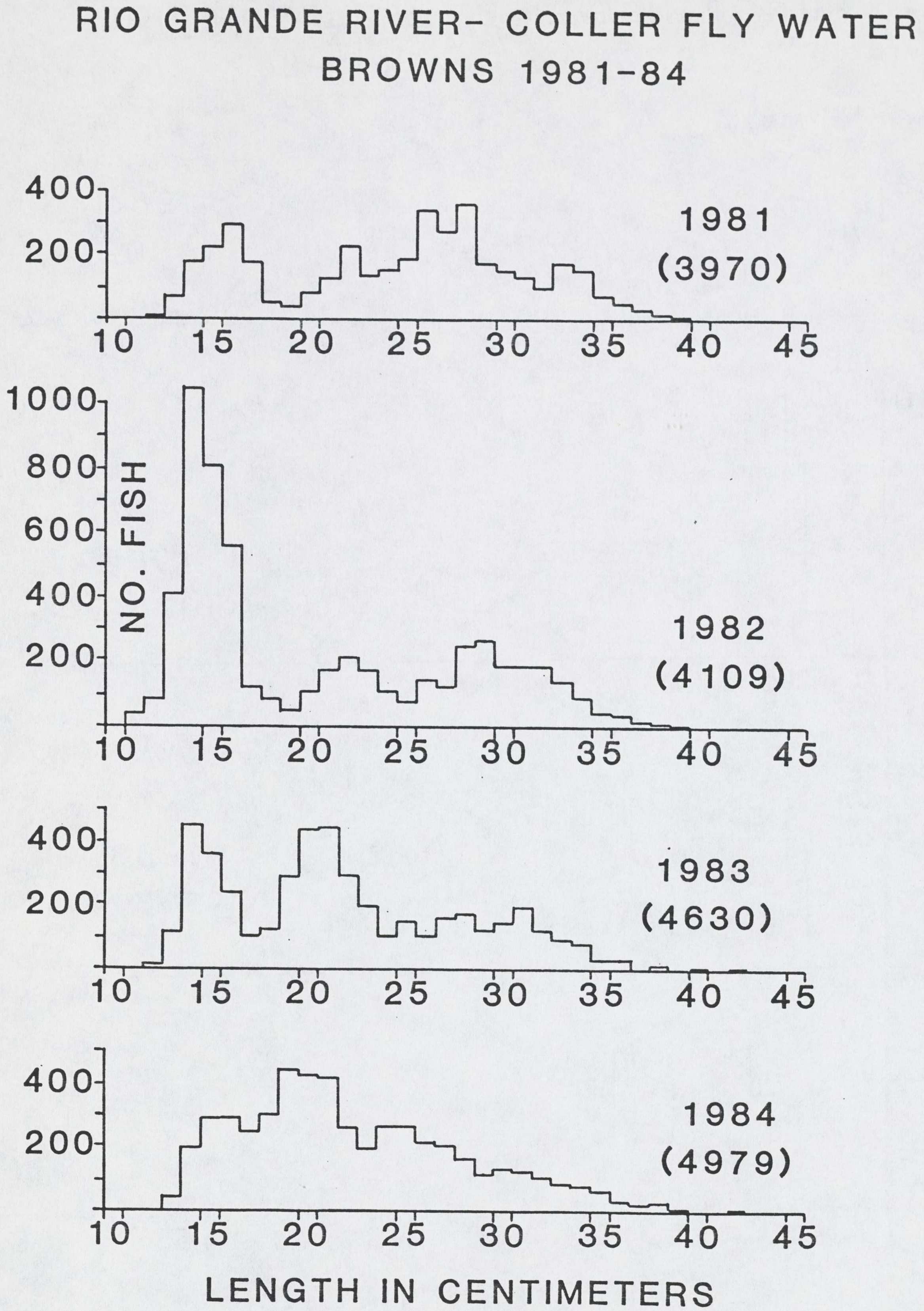


Figure II-35. Rio Grande River, Coller Wildlife Area, browns, 1981-84.

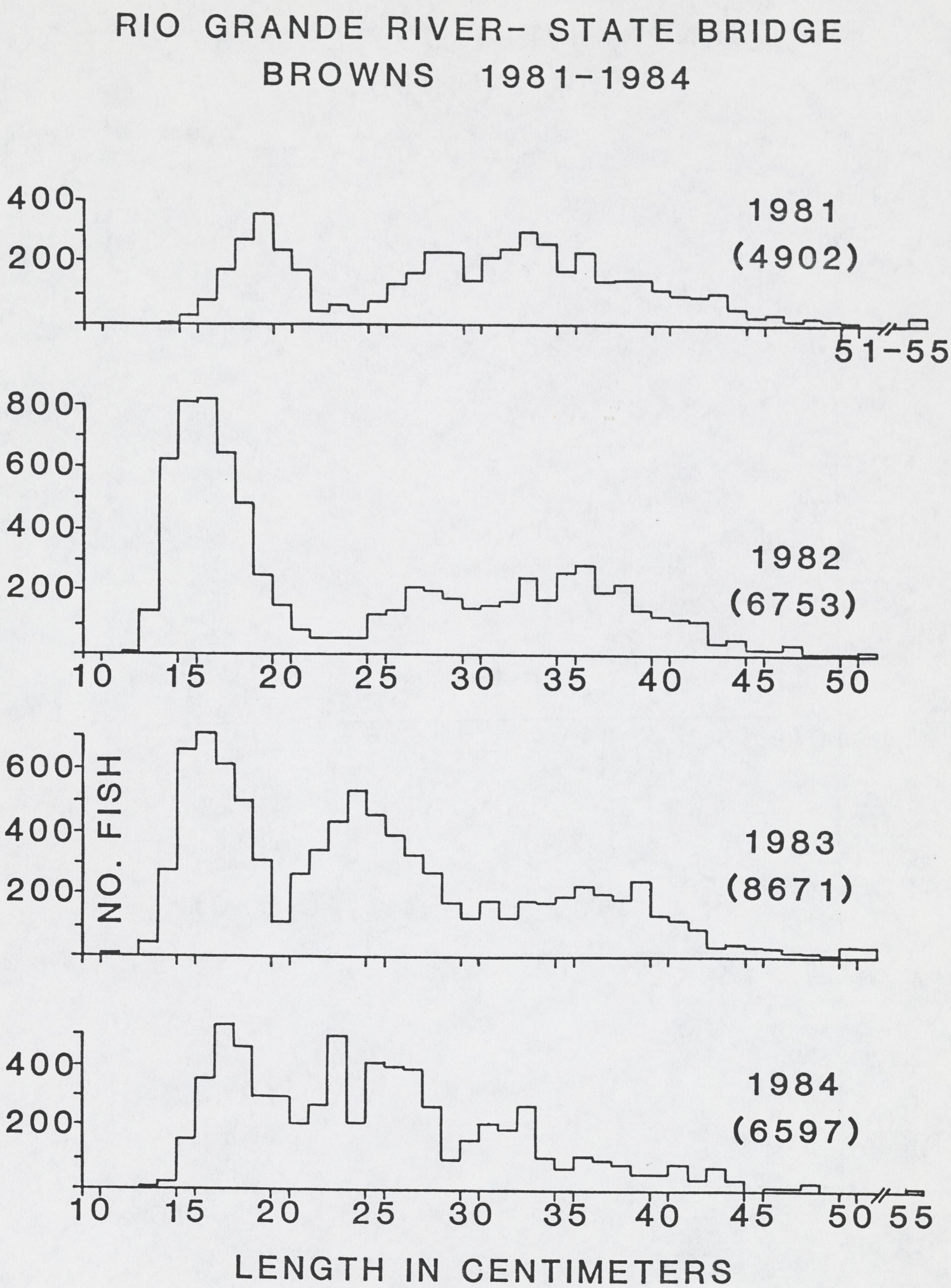


Figure II-36. Rio Grande River, State Bridge, browns, 1981-84.

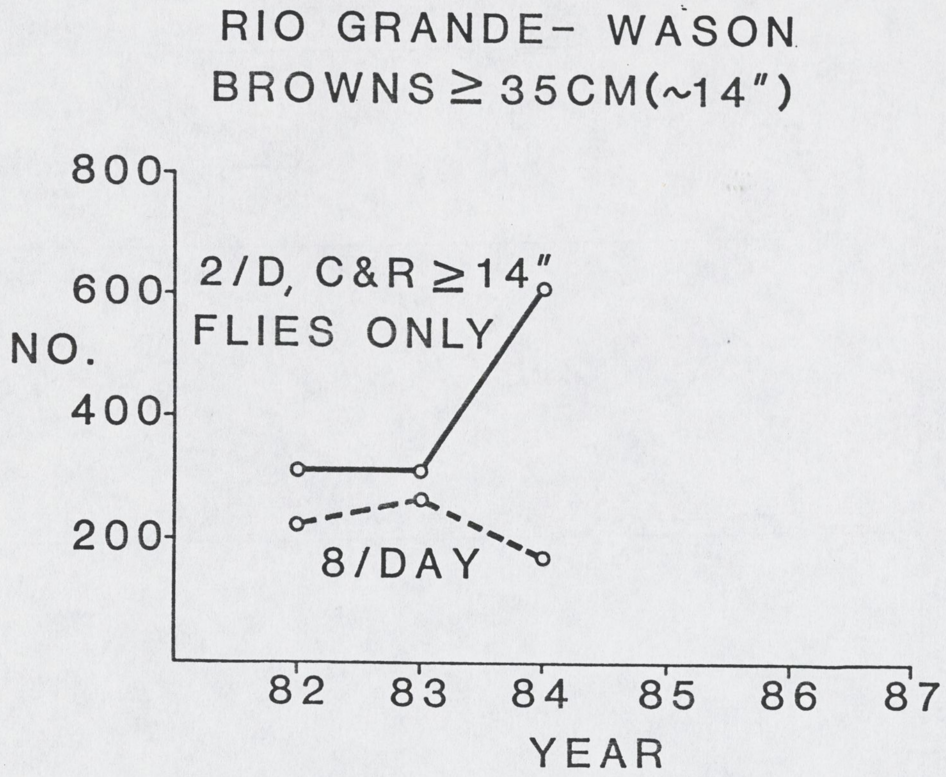


Figure II-37. Rio Grande River, Wason Ranch, browns $\geq$35 cm, 1982-84.

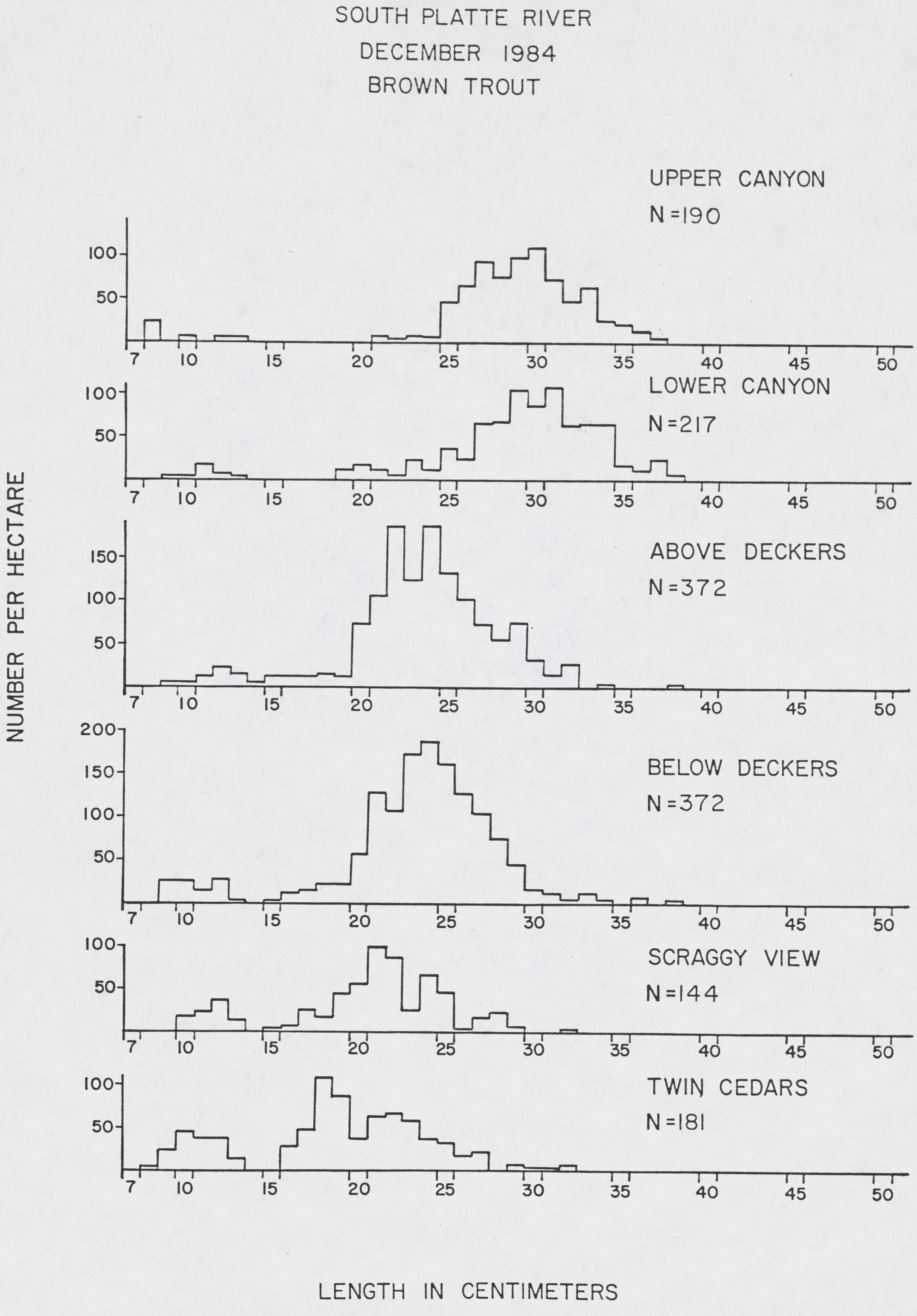


Figure II-38. South Platte River, browns, December 1984.

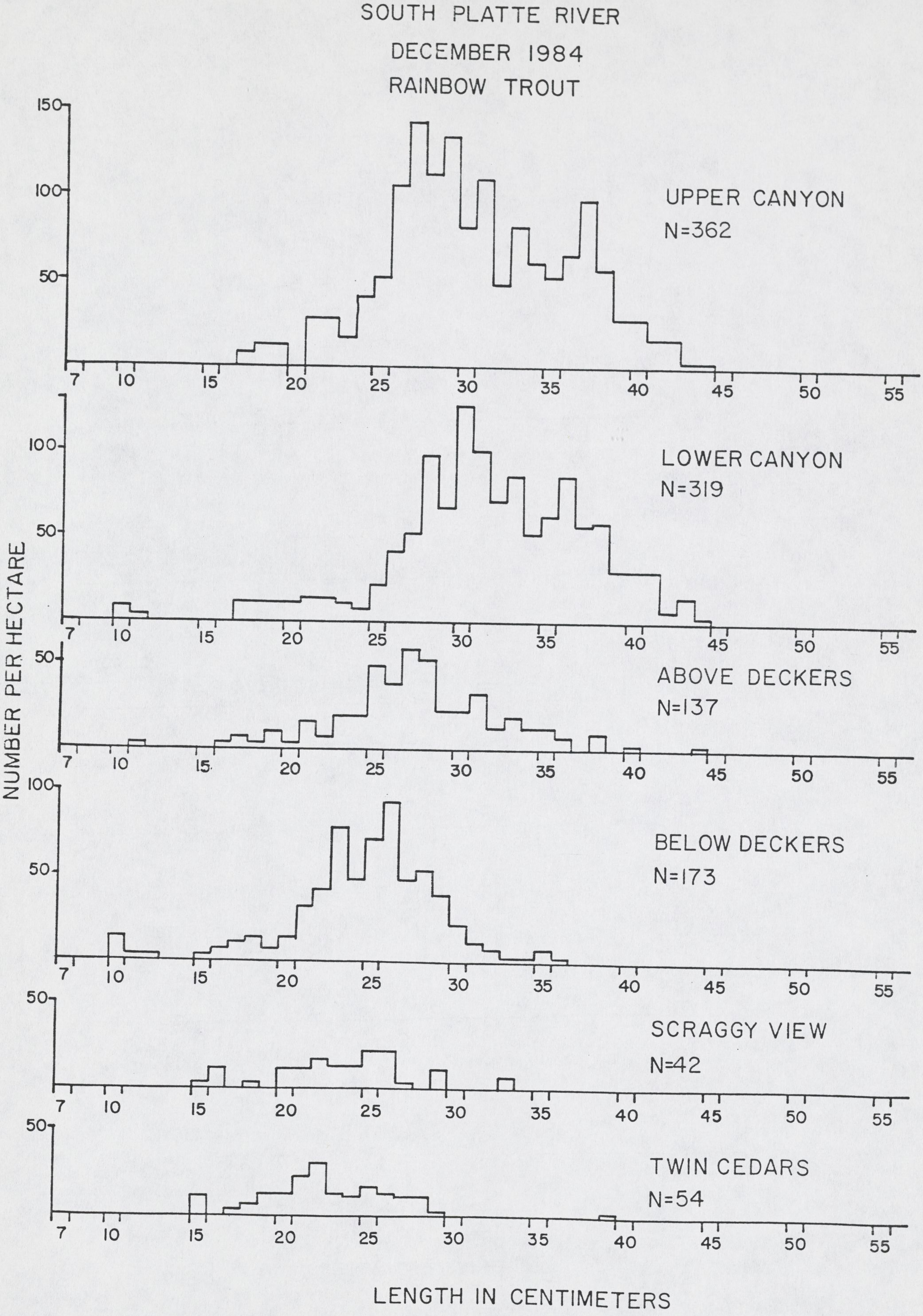


Figure II-39. South Platte River, rainbows, December 1984.

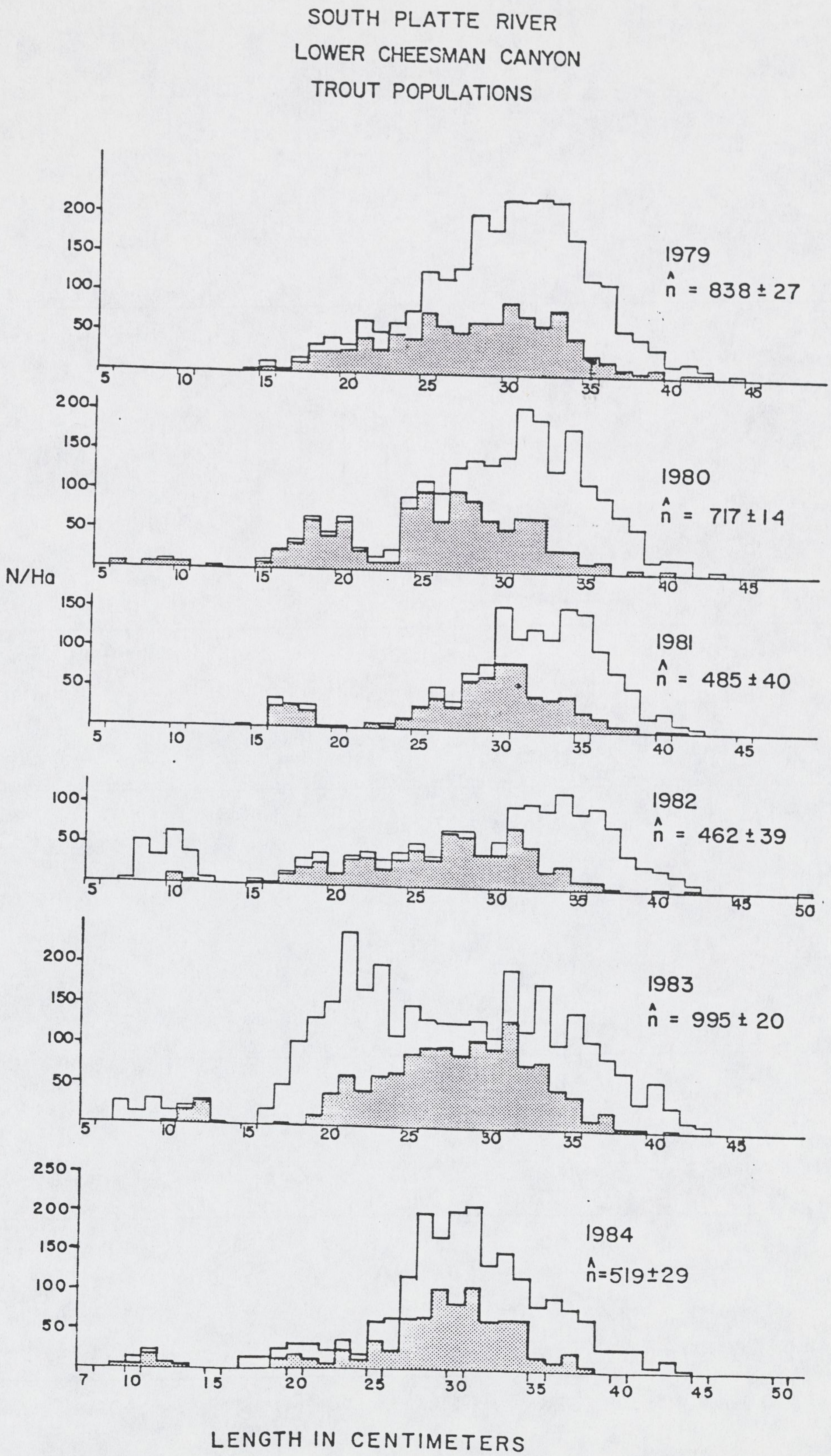


Figure II-40. South Platte River, Lower Cheesman Canyon, trout populations, 1979-84, rainbows (unshaded), browns (shaded).

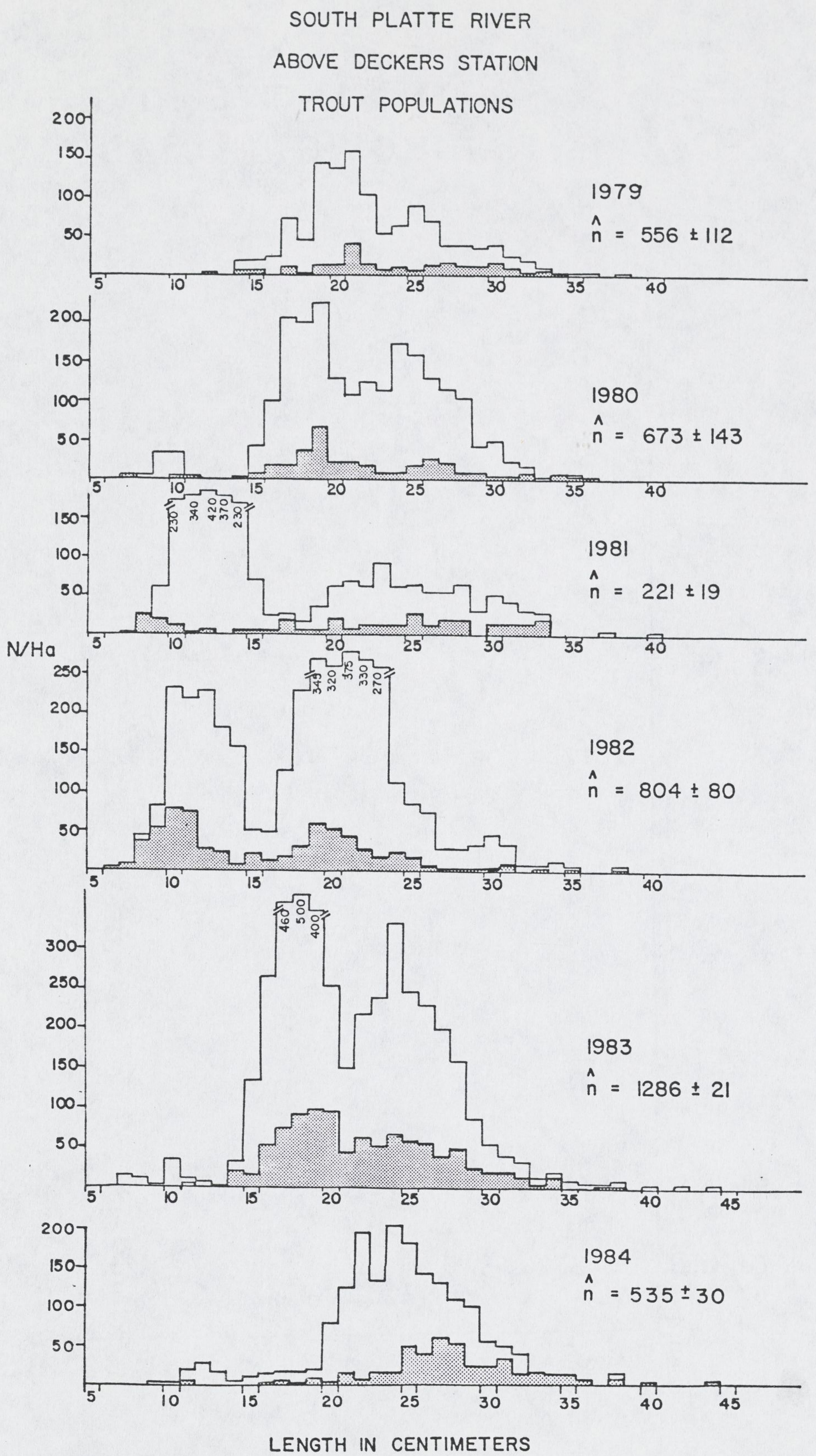


Figure II-41. South Platte River, above Deckers, trout populations, 1979-84, browns (unshaded), rainbows (shaded).

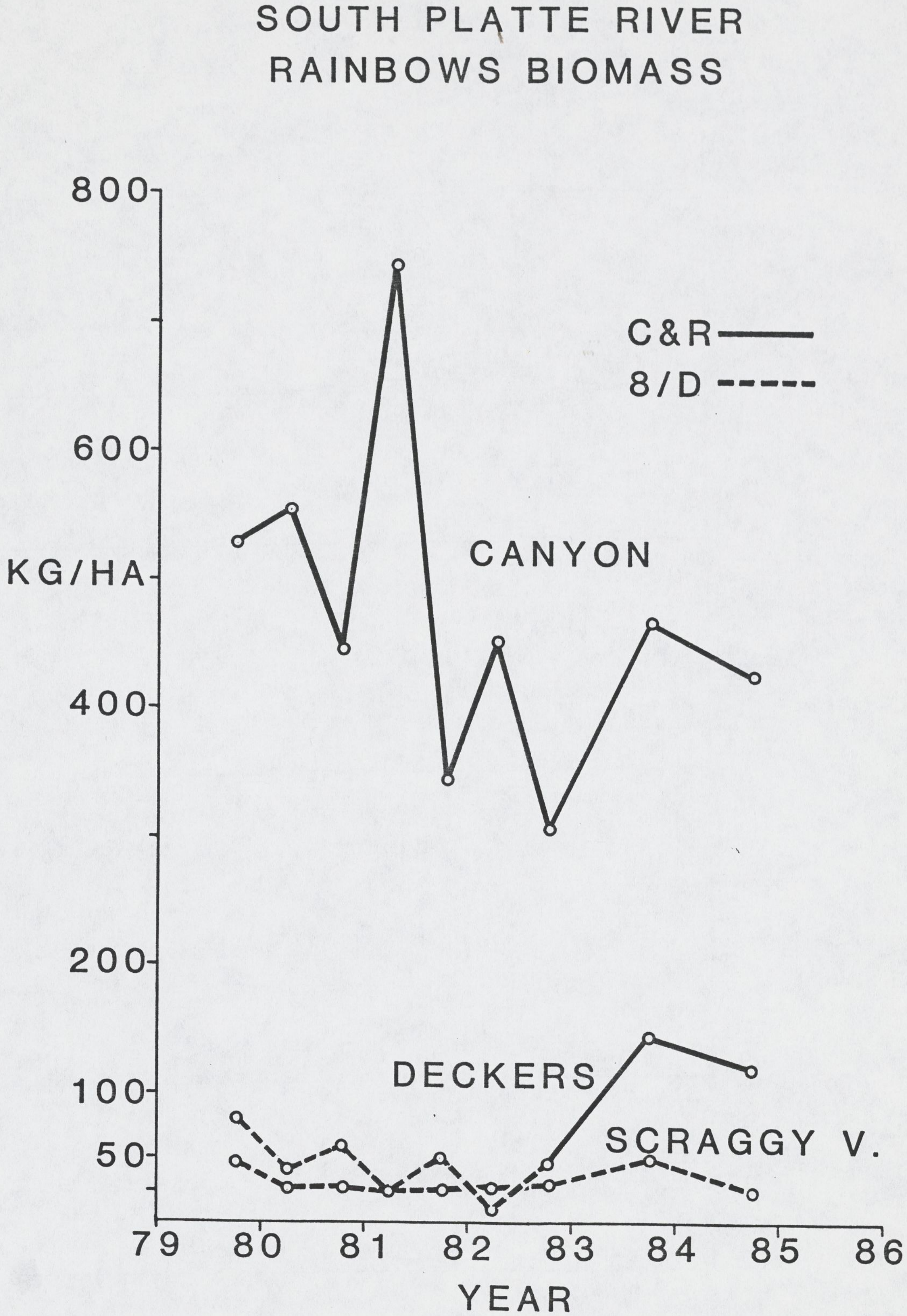


Figure II-42. South Platte River, rainbow biomass, 1979-84, comparison of three study sites.

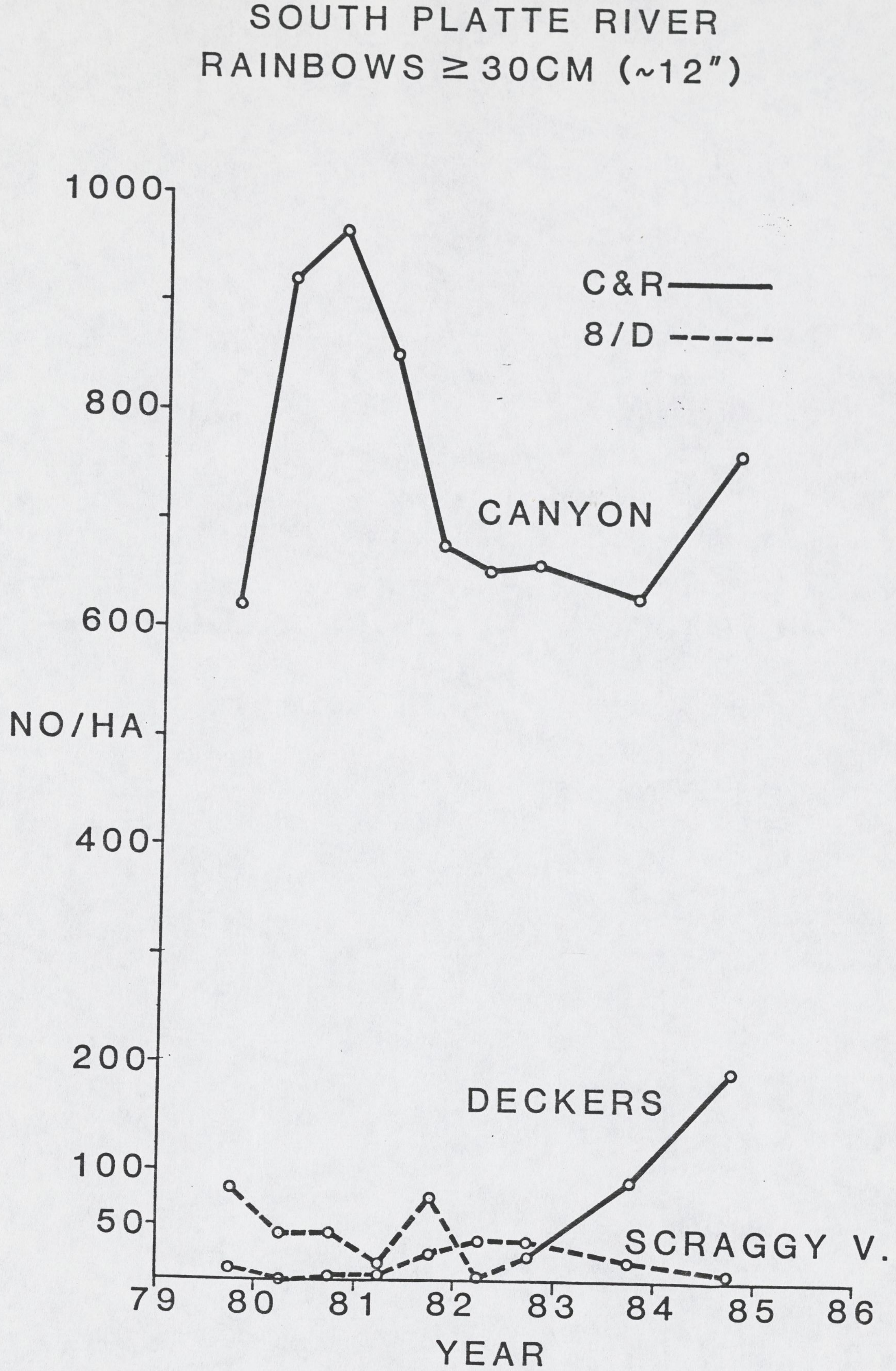


Figure II-43. South Platte River, rainbows ≥30 cm, 1979-84, comparison of three study sites.

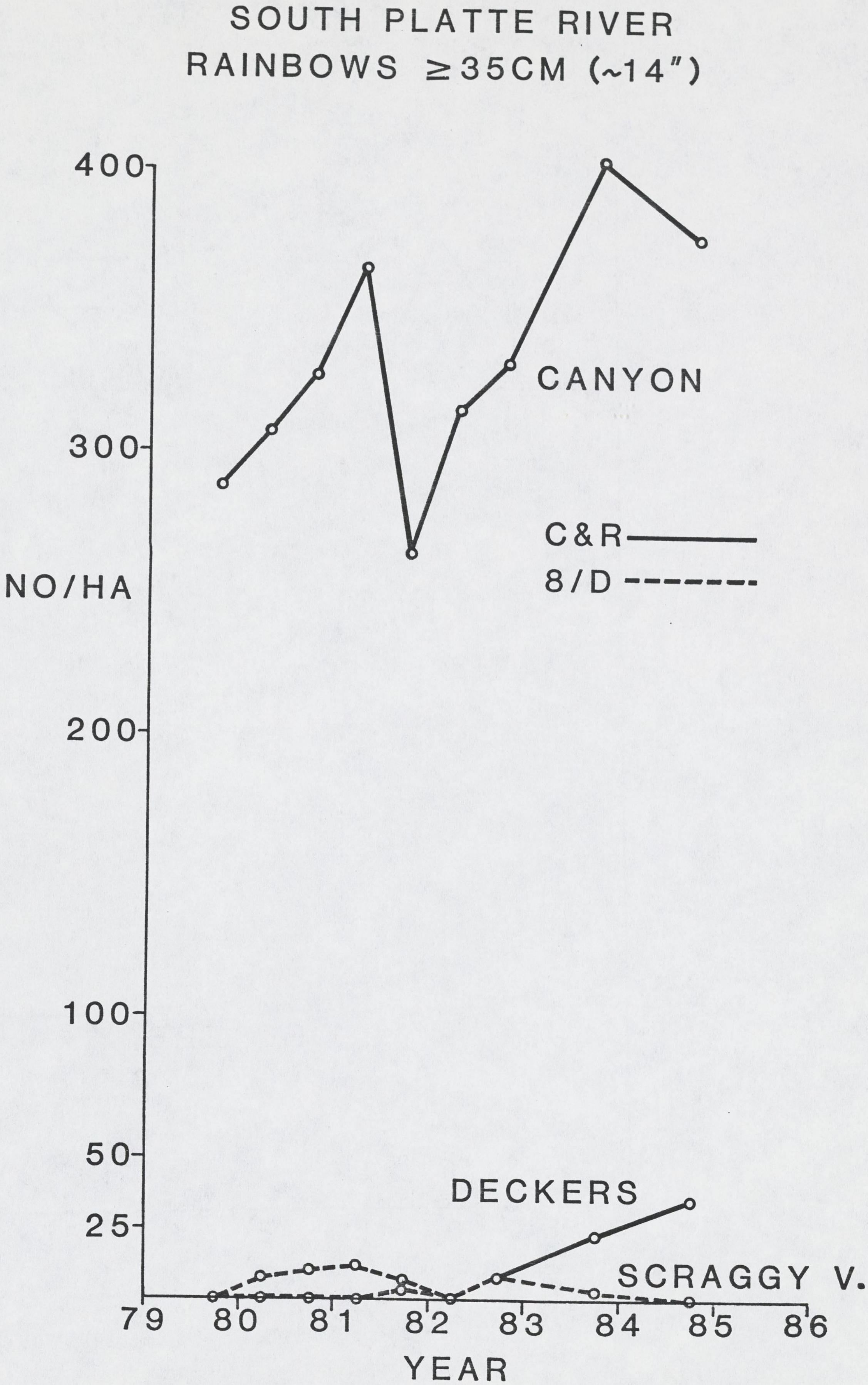


Figure II-44. South Platte River, rainbows $\geq$35 cm, 1979-84, comparison of three study sites.

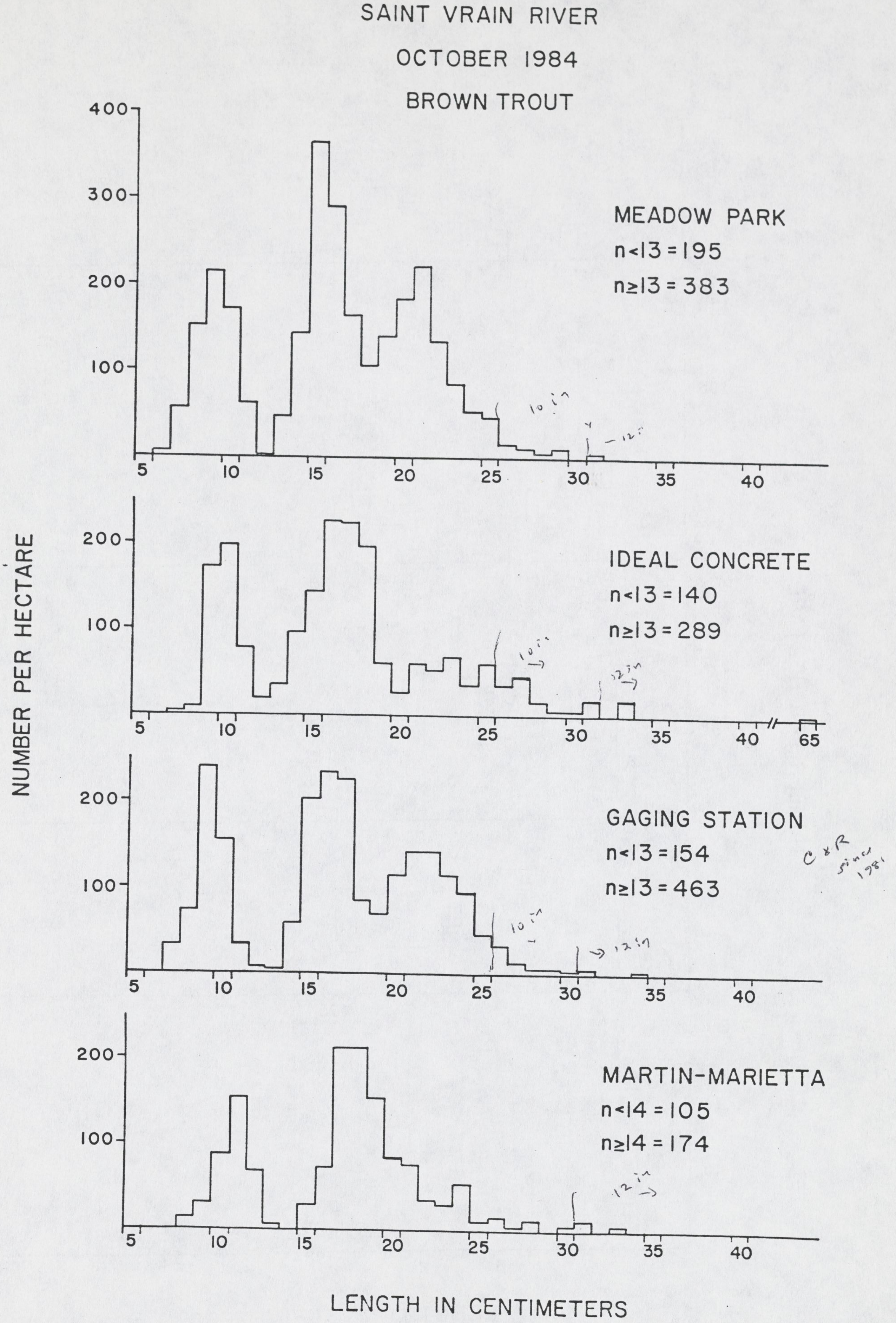


Figure II-45. St. Vrain River, browns, October 1984.

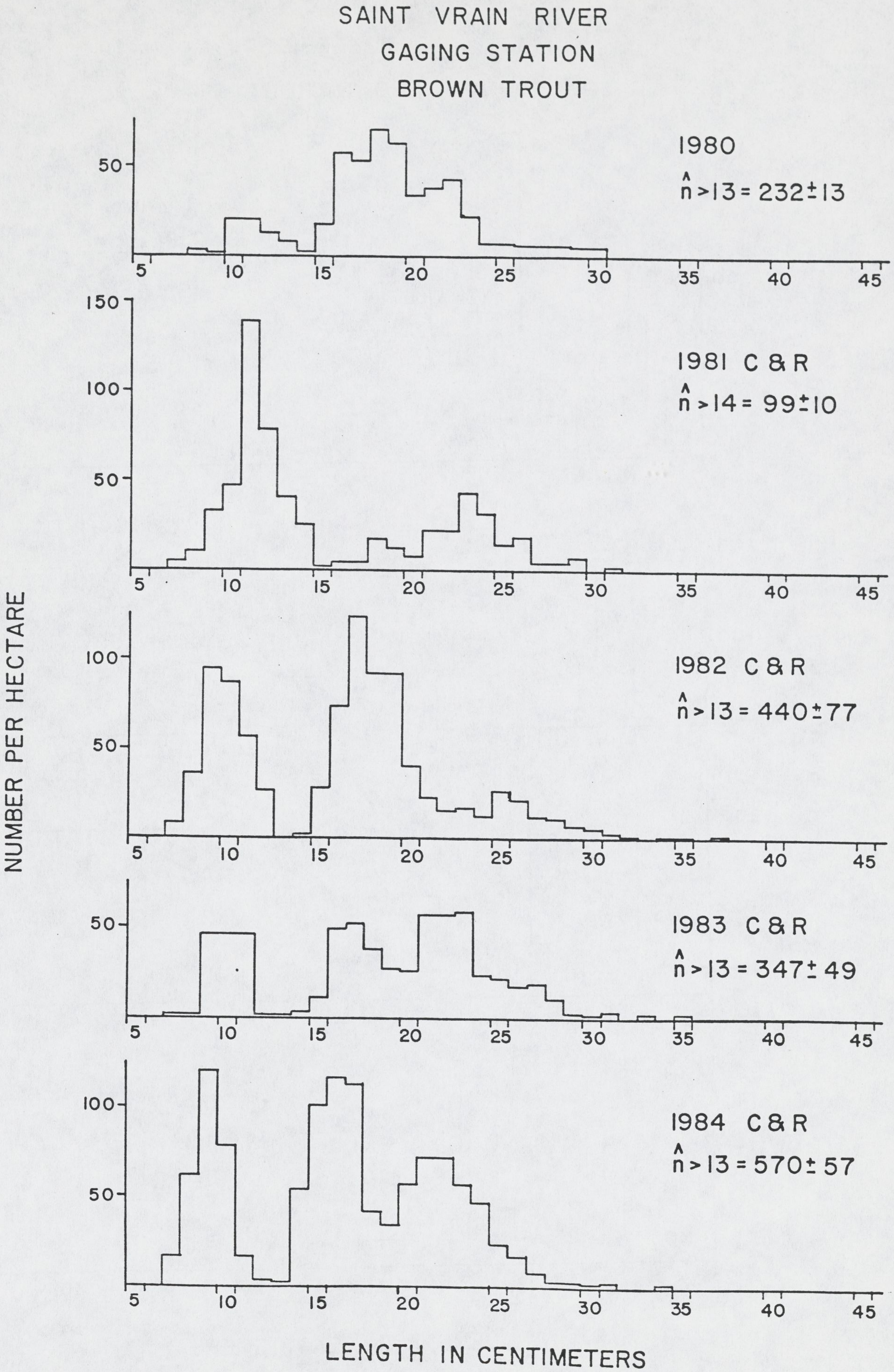


Figure II-46. St. Vrain River, Gaging Station, browns, 1980-84.

APPENDIX III

Age and Growth Tables (III-1)

Life Tables (III-2)

Table III-1. Back-calculated lengths (cm) of trout from F-51-R study streams in 1984.

	Age	N	L_c	S.E.	L_1	S.E.	L_2	S.E.	L_3	S.E.	L_4	S.E.	L_5	S.E.
					Cache la Poudre River (upper station) - brown trout									
1984	0													
1983	1+	10	15.2	0.29	7.8	0.27								
1982	2+	36	19.7	0.40	7.3	0.20	14.3	0.41						
1981	3+	21	26.4	0.36	7.2	0.29	14.5	0.49	21.2	0.34				
1980	4+	12	30.8	0.62	7.3	0.34	14.0	0.73	21.5	0.47	27.2	0.71		
1979	5+	2	35.0		6.2		11.9		21.6		27.1		31.7	
					Cache la Poudre River (upper station) - rainbow trout									
1984	0													
1983	1+	28	13.5	0.35										
1982	2+	29	20.2	0.59	7.1	0.27	14.5	0.48						
1981	3+	23	25.4	0.55	6.1	0.28	13.3	0.64	20.1	0.56				
1980	4+	5	30.0	0.45	5.9	0.674	13.3	1.41	20.4	1.35	26.0	0.64		
1979	5+	5	31.8	0.20	6.0	0.58	12.0	.32	17.1	.33	24.5	.18	28.9	0.31
					Cache la Poudre River (lower station) - brown trout									
1984	0													
1983	1+	13	16.8	0.22	8.9	0.28								
1982	2+	26	21.7	0.49	8.5	0.29	16.2	0.59						
1981	3+	5	25.6	1.83	7.5	1.09	13.9	1.82	20.5	2.00				
					Cache la Poudre River (lower station) - rainbow trout									
1984	0													
1983	1+	2	17.5	1.5										
1982	2+	8	24.1	0.55	8.5	0.54	17.3	0.87						
1981	3+	5	26.8	0.58	7.6	0.56	15.7	0.73	22.0	0.69				

Table III-1. Back-calculated lengths (cm) of trout from F-51-R study streams in 1984 (continued).

Year class	Age	N	L_c	S.D.	L_1	S.D.	L_2	S.D.	L_3	S.D.	L_4	S.D.	L_5	S.D.	L_6	S.D.	L_7	S.D.
							Blue River - browns - Fall 1984											
1983	1+	15	12.1	1.53	5.90	0.94												
1982	2+	40	18.4	2.78	6.34	1.68	13.3	1.68										
1981	3+	33	26.0	3.34	7.48	2.18	15.8	2.93	21.4	3.41								
1980	4+	13	35.1	6.52	7.71	1.39	14.0	2.58	21.4	3.46	30.3	2.50						
1979	5+	9	33.5	1.81	6.14	1.91	11.8	2.29	18.2	3.16	24.5	1.98	30.5	1.62				
1978	6+	1	41.0	--	5.72	--	16.7	--	22.4	--	27.6	--	34.3	--	39.1	--		
							Colorado River - browns - 1984											
1983	1+	20	20.0	1.73	6.92	1.11												
1982	2+	36	31.0	3.57	7.59	1.77	16.7	2.94										
1981	3+	27	31.1	3.06	8.92	1.55	18.4	3.67	25.2	4.79								
1980	4+	17	37.2	3.42	6.97	2.32	14.8	4.51	25.8	3.22	32.8	3.22						
1979	5+	12	38.2	3.60	8.21	1.63	15.6	3.85	24.0	4.92	30.0	5.52	34.8	4.59				
							Colorado River - rainbows - Fall 1984											
1983	1+	19	20.5	2.67	7.55	2.63												
1982	2+	41	23.8	4.08	7.20	1.78	15.1	10.7										
1981	3+	23	31.4	4.67	8.01	1.91	17.3	4.15	24.5	5.79								
1980	4+	30	36.3	3.93	7.16	1.57	17.5	3.89	25.6	4.54	31.4	4.54						
1979	5+	22	41.0	3.41	7.37	1.61	18.1	3.21	25.9	3.56	32.0	3.84	37.7	3.55				
1978	6+	8	43.9	3.31	7.58	1.27	17.4	1.78	23.5	2.61	30.7	2.43	36.4	2.60	40.8	2.60		
							Eagle River - browns - Fall 1984											
1983	1+	4	16.7	0.96	8.26	1.53												
1982	2+	13	23.7	3.65	8.29	3.22	18.4	4.85										
1981	3+	11	30.9	3.50	10.2	2.08	20.2	2.20	26.5	2.62								

L - length(cm) at time of collection
L - back-calculated length (cm) at age 1, 2, 3, 4, etc.
S.D. - standard deviation

Table III-1. Back calculated lengths (cm) of trout from F-51-R study streams in 1984 (continued).

Year class	Age	N	L_c	S.D.	L_1	S.D.	L_2	S.D.	L_3	S.D.	L_4	S.D.	L_5	S.D.	L_6	S.D.	L_7	S.D.	L_8	S.D.
Eagle River - rainbows - Fall 1984																				
1983	1+																			
1982	2+	2	29.0	1.41	7.81	0.52	23.0	4.22												
1981	3+	1	34.0	--	11.3	--	20.6	--	26.0	--										
Fryingpan River - browns - Fall 1984																				
1983	1+	16	14.9	1.24	7.74	1.34														
1982	2+	33	20.6	3.64	7.06	2.05	14.4	2.05												
1981	3+	37	28.6	4.87	7.73	2.27	16.2	4.31	23.5	3.94										
1980	4+	29	31.2	3.77	6.90	1.94	14.6	2.26	21.5	2.93	27.8	1.93								
1979	5+	11	39.2	5.15	7.92	2.83	15.7	3.16	23.5	4.65	29.6	4.74	34.9	4.31						
1978	6+	5	42.0	2.34	7.62	2.00	15.5	3.12	23.3	3.45	29.9	4.67	34.6	4.22	38.6	4.22				
1977	7+																			
1976	8+	1	42.0	--	5.02	--	7.8	--	11.9	--	18.7	--	25.1	--	31	--	35.6	--	38.8	--
Fryingpan River - rainbows - Fall 1984																				
1983	1+	10	15.1	2.18	8.65	1.62														
1982	2+	81	29.2	7.82	10.7	3.75	22.3	7.78												
1981	3+	33	33.0	7.30	8.29	2.00	16.9	3.99	26.5	6.8										
1980	4+	7	33.4	7.48	7.04	2.64	13.0	2.97	21.0	7.02	27.9	7.57								
Gunnison River (Almont to Gunnison) - browns - Summer 1984																				
1983	1+	11	15.5	1.51	8.20	1.06														
1982	2+	36	21.0	3.92	7.12	1.84	15.8	1.84												
1981	3+	37	27.7	3.58	7.79	2.17	17.8	3.25	24.5	3.69										
1980	4+	24	33.3	5.35	6.58	1.98	16.2	5.08	24.2	5.89	30.1	5.89								
1979	5+	13	38.3	5.33	6.05	1.36	14.4	1.93	24.2	4.44	31.8	5.99	35.8	5.33						
1978	6+	5	39.6	3.21	9.83	2.82	18.1	4.43	24.7	5.80	31.8	4.17	34.5	4.18	36.7	4.18				
1977	7+	1	51	--	13.6	--	28.4	--	35.8	--	40.7	--	44.4	--	47.3	--	49.8	--		

Table III-1. Back-calculated lengths (cm) of trout from F-51-R study streams in 1984 (continued).

Year class	Age	N	L_c	S.D.	L_1	S.D.	L_2	S.D.	L_3	S.D.	L_4	S.D.	L_5	S.D.	L_6	S.D.	L_7	S.D.
Gunnison River (Gunnison-Almont) rainbows - Summer 1984																		
1983	1+	43[a]	23.7	3.21	14.6	3.45												
1982	2+	7[b]	21.6	2.44	8.30	2.73	17.2	3.99										
1981	3+	7[b]	28.6	4.86	6.26	1.22	15.7	1.78	24.1	2.60								
1980	4+	6[b]	34.2	5.31	5.70	1.53	14.1	3.70	22.8	5.27	30.2	6.10						
1979	5+	3	36.3	2.51	5.80	1.73	11.3	2.80	18.7	4.13	25.8	3.13	32.0	2.27				
Gunnison River (Gunnison-Blue Mesa) browns - Summer 1984																		
1983	1+	1	25	--	11.6	--												
1982	2+																	
1981	3+	1	38	--	4.6	--	12.8	--	33.9	--								
1980	4+	2	40.0	1.41	9.75	3.32	18.1	7.64	30.2	4.88	37.2							
1979	5+	1	43.0	--	6.50	--	11.8	--	19.0	--	27.8	--	39.2	--				
Gunnison River (Gunnison-Blue Mesa) wild rainbows - Summer 1984																		
1983	1+	5	17.8	3.90	8.24	1.28												
1982	2+	16	26.6	6.83	7.50	2.84	19.3	4.51										
1981	3+	16	30.6	4.21	6.74	1.55	17.8	3.80	24.7	7.20								
1980	4+	6	32.0	2.28	4.75	0.67	16.5	3.78	22.6	4.17	28.3	3.37						
1979	5+	2	37.0	5.66	4.30	0.99	12.6	4.10	21.8	6.72	30.8	6.22	34.4	5.80				
Gunnison River (Gunnison-Blue Mesa) hatchery rainbows - Summer 1984																		
1983	1+	26	24.5	2.64	14.4	2.12												
1982	2+	2	29.5	7.78	11.8	8.77	21.8	10.2										
Gunnison River (Gunnison-Blue Mesa) browns - Summer 1984																		
1983	1+	1	25	--	11.6	--												
1982	2+																	
1981	3+	1	38	--	4.60	--	12.8	--	33.9	--								
1980	4+	2	40.0	1.41	9.75	3.32	18.1	7.64	30.2	4.88	37.2							
1979	5+	1	43.0	--	6.50	--	11.8	--	19.0	--	27.8	--	39.2					

[a]hatchery rainbows
[b]wild rainbows

Table III-1. Back-calculated lengths (cm) of trout from F-51-R study streams in 1984 (continued).

Year class	Age	N	L_c	S.D.	L_1	S.D.	L_2	S.D.	L_3	S.D.	L_4	S.D.	L_5	S.D.	L_6	S.D.	L_7	S.D.
							Gunnison River (Black Canyon) - browns - August 1984											
1983	1+	20	15.9	4.93	9.46	2.05												
1982	2+	77	26.1	7.17	11.2	3.27	20.5	10.8										
1981	3+	51	32.5	7.20	10.7	2.93	21.5	6.54	29.0	6.54								
1980	4+	13	38.8	5.79	10.6	3.34	19.5	4.23	30.3	5.21	35.9	5.21						
1979	5+	2	46.0	2.83	10.6	0.21	18.7	3.39	33.7	0.0	38.7	3.32	43.5	2.62				
							Gunnison River (Black Canyon) - rainbows - August 1984											
1983	1+	12	17.2	1.71	9.42	2.38												
1982	2+	22	23.6	3.30	9.40	2.10	18.6	3.30										
1981	3+	76	31.8	6.45	8.40	2.35	20.3	5.68	27.6	5.77								
1980	4+	52	39.9	5.49	7.84	2.40	20.2	5.26	29.5	5.19	36.5	5.52						
1979	5+	8	45.1	3.09	6.6	0.40	18.3	4.20	28.4	4.99	36.5	2.44	42.7	2.75				
1978	6+	2	43.0	1.41	7.0	0.42	13.0	0.35	18.5	2.12	25.2	1.91	31.2	1.56	37.4	2.05		
							North Platte River - browns - October 1984											
1983	1+	17	20.8	1.74	8.64	2.09												
1982	2+	58	26.6	4.57	7.02	1.70	18.1	3.45										
1981	3+	36	36.5	5.09	8.64	1.99	20.9	4.82	30.8	5.46								
1980	4+	17	39.5	3.28	8.61	1.75	18.7	2.97	27.8	3.61	34.9	3.42						
1979	5+	1	40.0	--	9.36	--	14.0	--	18.7	--	27.6	--	34.9	--				
							North Platte River - rainbows - October 1984											
1983	1+	22	15.7	1.52	6.60	2.44												
1982	2+	47	23.1	3.63	6.58	2.02	16.6	3.05										
1981	3+	33	30.6	3.98	7.92	2.34	17.5	2.83	25.8	3.29								
1980	4+	6	36.8	2.26	7.30	1.43	15.6	2.54	24.4	3.68	31.9	2.53						
1979	5+	3	37.7	0.58	7.32	1.37	15.1	3.47	22.3	4.39	28.7	1.33	33.7	1.85				
1978	6+	2	38.0	1.42	5.78	0.30	13.5	0.57	20.3	2.26	25.7	2.55	30.3	1.63	37.4			

Table III-1. Back-calculated lengths (cm) of trout from F-51-R study streams in 1984 (continued).

Year class	Age	N	L_c	S.D.	L_1	S.D.	L_2	S.D.	L_3	S.D.	L_4	S.D.	L_5	S.D.	L_6	S.D.	L_7	S.D.	L_8	S.D.
Rio Grande River (Coller Flywater) - browns - September 1984																				
1983	1+	18	15.8	1.56	8.74	1.66														
1982	2+	36	20.8	2.84	6.82	1.46	15.3	2.69												
1981	3+	35	28.6	2.86	8.15	1.66	17.1	2.56	27.9	3.30										
1980	4+	22	33.6	4.20	8.75	1.42	17.3	2.85	24.4	3.53	30.1	3.85								
1979	5+	4	35.5	2.50	8.10	1.60	16.5	3.37	24.3	1.53	29.7	2.11	33.0	2.69						
1978	6+	1	37	--	7.87	--	13.8	--	18.1	--	24.8	--	30.7	--	34.2	--				
Rio Grande River (Coller Flywater) - rainbows - Fall 1984																				
1983	1+	2	21.5	9.20	12.2	7.35														
1982	2+	1	24	--	5.69	--	17.9	--		--										
1981	3+	3	27.6	7.23	12.2	3.95	20.5	1.13	27.0	1.45										
Rio Grande River (State Bridge) - browns - September 1984																				
1983	1+	33	17.8	2.05	8.23	1.79														
1982	2+	32	23.2	2.69	7.03	1.52	15.8	2.28												
1981	3+	40	31.3	4.09	8.27	2.02	16.3	3.60	24.6	5.20										
1980	4+	36	36.8	4.65	8.81	2.05	16.3	4.49	24.7	6.36	32.4	4.82								
1979	5+	32	42.1	3.33	6.72	1.76	12.9	3.68	23.8	4.61	32.0	4.68	38.0	4.03						
1978	6+	1	44	--	6.83	--	12.4	--	17.5	--	29.9	--	37.1	--	41.9	--				
1977	7+	1	43	--	5.59	--	13.3	--	21.1	--	28.4	--	34.4	--	38.3	--	39.1	--		
1976	8+	1	55	--	5.42	--	12.0	--	26.7	--	37.6	--	44.5	--	49.2	--	51.1	--	53.1	--
Rio Grande River (State Bridge) - rainbows - Fall 1984																				
1983	1+	17	18.4	5.35	7.73	1.85														
1982	2+	10	27.1	4.58	7.96	3.31	20.9	3.19												
1981	3+	15	34.7	4.38	8.29	1.68	17.7	3.50	29.2	4.71										
1980	4+	2	42.0	1.41	7.86	1.71	18.7	5.87	30.8	2.12	38.5	0.64								
1979	5+	1	44	--	5.81	--	10.4	--	23.7	--	32.8	--	38.2	--						

Table III-1. Back-calculated lengths (cm) of trout from F-51-R study streams in 1984 (concluded).

Year class	Age	N	L_c	S.D.	L_1	S.D.	L_2	S.D.	L_3	S.D.	L_4	S.D.	L_5	S.D.	L_6	S.D.	L_7	S.D.	L_8	S.D.
Rio Grande River (Wason Ranch) - browns - October 1984																				
1983	1+	35	18.3	2.30	9.43	1.75														
1982	2+	23	24.9	2.31	7.64	0.92	16.6	2.43												
1981	3+	26	28.9	4.18	7.88	2.17	15.2	3.38	22.7	5.04										
1980	4+	33	35.3	3.27	8.59	2.12	16.0	4.40	24.5	4.67	31.2	4.66								
1979	5+	9	37.7	4.12	7.23	2.71	14.2	4.58	21.2	4.93	28.4	4.10	34.2	3.89						
1978	6+	4	42.7	12.0	8.00	1.93	14.5	3.67	21.2	5.52	26.8	5.97	32.6	5.95	36.9	5.95				
Rio Grande River (Wason Ranch) - rainbows - October 1984																				
1983	1+	8	24.2	4.59	12.1	3.16														
1982	2+	3	32.2	5.74	13.9	7.38	22.2	7.43												
1981	3+	4	33.5	1.29	9.77	3.66	20.4	5.14	29.1	2.90										
1980	4+	3	37.0	3.61	8.57	0.69	17.8	3.86	27.5	7.12	33.9	4.38								
Taylor River - browns - Fall 1984																				
1983	1+	30	14.7	2.23	5.93	2.20														
1982	2+	27	20.2	2.43	6.05	1.75	14.6	1.75												
1981	3+	33	27.9	3.73	6.97	2.17	15.5	3.21	23.2	3.56										
1980	4+	14	32.7	4.32	6.43	1.60	15.9	2.35	23.2	3.43	29.3	3.43								
1979	5+	13	37.8	3.56	6.72	1.54	15.6	2.45	24.4	3.36	31.2	3.77	35.0	3.66						
1978	6+	4	39.5	4.20	6.32	2.13	15.7	3.90	23.0	5.49	27.3	4.66	31.9	4.26	36.7	4.26				
1977	7+	1	46.0	--	9.37	--	18.3	--	26.8	--	33.6	--	37.0	--	40.9	--	43.9	--		
West Fork San Juan River - rainbows - Fall 1984																				
1983	1+	1	15	--	8.11	--														
1982	2+																			
1981	3+	3	33.3	10.4	6.41	0.74	17.3	4.70	27.6	10.6										
1980	4+	1	32.0	--	6.02	--	14.7	--	26.7	--	32.0	--								
1979	5+	2	40.0	1.41	7.90	--	17.2	1.55	24.4	2.47	32.8	1.77	36.4	0.56						
1978	6+	1	45	--	5.57	--	13.3	--	24.0	--	31.3	--	37.3	--	42.0	--				
West Fork San Juan River - browns - Fall 1984																				
1983	1+																			
1982	2+	1	22	--	8.20	--	14.2	--												
1981	3+	3	34	3.00	7.96	1.35	20.9	3.49	28.5	3.79										
1980	4+	1	37	--	5.86	--	11.7	--	25.3	--	35.5	--								
1979	5+																			
1978	6+	1	44	--	5.36	--	10.0	--	16.8	--	26.5	--	35.8	--	41.1	--				
West Fork San Juan River - brooks - Fall 1984																				
1983	1+																			
1982	2+																			
1981	3+																			
1980	4+	1	28	--	9.88	--	15.6	--	20.6	--	24.7									
1979	5+	1	36	--	9.00	--	15.7	--	21.7	--	27.0	--	31.5							

Table III-1. Back-calculated lengths (cm) of trout from F-51-R study streams in 1984

Year class	Age	N	Lc	S.E.	L_1	S.E.	L_2	S.E.	L_3	S.E.	L_4	S.E.	L_5	S.E.
			Middle Fork of the South Platte River - browns - October 1984											
1983	1+	16	15.1	0.21	8.6	0.92								
1982	2+	38	20.8	0.40	6.5	0.20	14.5	0.36 (non-migrating)						
1982	2+	25	37.6	0.24	8.1	0.30	18.1	0.58 (migrating)						
1981	3+	23	27.5	0.59	7.0	0.28	15.6	0.56	22.2	0.55 (non-migrating)				
1981	3+	43	46.4	0.83	7.1	0.21	16.1	0.48	31.7	1.20 (migrating)				
1980	4+	1	31	--	6.2	--	11.0	--	20.0	--	26.2 (non-migrating)			
1980	4+	15	51.9	0.68	6.9	0.40	15.1	1.00	25.8	1.44	45.9	1.67 (migrating)		
1979	5+	1	60	--	6.6		14.5		18.6		41.3	54.7		
			St. Vrain - browns - October 1984											
1983	1+	30	15.6	0.36	7.2	0.34								
1982	2+	21	23.1	0.57	8.0	0.45	17.2	1.01						

Table III-2. Life Tables - Arkansas River - Salida brown trout/ha.

Year	1984	1983	1982	1981	1980	1979	1978	1977
March 1981					13	199	181	1
March 1982				217	139	209	3	0
March 1983			24	337	157	43	2	0
March 1984		4	347	220	64	4	3	0
March 1985[a]	0.3	33	387	147	2	0		

[a]Based on age structure in 1983.

Table III-2. Life Tables - Blue River - brown trout/ha.

Sample period Season Year	Year class 1983	1982	1981	1980	1979	1978	1977	1976
	Stream improvement section							
Spring 1983		302	477	382	17			
Spring 1984		308	293	192	46	17	2	
Fall 1984	14	289	216	35	20	--	--	
	Blue River Campground							
Spring 1981					87	56	13	1
Spring 1983		160	124	44	4	--	--	--
Spring 1984		246	379	261	41	9	8	--
Fall 1984	24	359	319	57	16	7	--	--
	Blue River below Highway 9 Bridge (near Slate Creek)							
Spring 1983		122	252	185	23	--	--	
Spring 1984		340	214	197	70	16	3	
Fall 1984	15	303	268	60	25	--	--	
	Blue River - Transvideo Wildlife Area							
Spring 1983		65	85	113	27			

Table III-2. Life Tables - Cache la Poudre River (brown trout/ha)(continued).

Sample period Season	Year	Year class 1983	1982	1981	1980	1979	1978	1977	1976
				Big Bend Campground					
Fall	1980					43	100	56	17
Fall	1981				118	104	90	45	27
Fall	1982			349	171	89	37	3	3
Fall	1983		120	210	84	49	4	0	0
Fall	1984	64	250	102	33	15	3	0	0
				Upper Wild Trout Water					
Fall	1980					45	61	28	0
Fall	1981				120	135	123	56	12
Fall	1982			183	110	34	9	0	0
Fall	1983		304	252	111	28	0	0	0
Fall	1984	8	196	179	48	11	0	0	0
				Lower Control					
Fall	1980					46	115	56	4
Fall	1981				104	92	99	42	12
Fall	1982			116	119	46	10	3	0
Fall	1983		156	167	61	12	0	0	0
Fall	1984	0	202	79	22	0	0	0	0
				Indian Meadows					
Fall	1980					27	45	38	0
Fall	1981				56	46	45	16	3
Fall	1982			120	83	43	16	0	0
Fall	1983		162	137	77	39	2	0	0
Fall	1984	15	202	137	42	11	4	0	0
				Kelly Flats Campground					
Fall	1980					132	134	25	0
Fall	1981				128	104	58	20	0
Fall	1982			158	142	35	4	0	0
Fall	1983		347	311	82	8	0	0	0
Fall	1984	21	234	87	22	0	0	0	0
				Lower Cache la Poudre River - wild trout					
Fall	1980					795	457	26	
Fall	1981			185	393	372	14	0	
Fall	1982			495	442	0	0	0	
Fall	1983		432	525	27	0	0	0	
Fall	1984	55	483	42	0	0	0	0	
				Lower Cache la Poudre River - control					
Fall	1981			127	221	311	13	0	
Fall	1982			700	295	4	0	0	
Fall	1983		342	310	14	0	0	0	
Fall	1984	73	483	34	8	0	0	0	

Table III-2. Life Tables - Cache la Poudre River (rainbow trout/ha)(continued).

Sample period Season	Year	Year class 1983	1982	1981	1980	1979	1978	1977	1976
					Big Bend Campground				
Fall	1980					3	27	30	14
Fall	1981				65	29	23	13	
Fall	1982			50	43	15	11		
Fall	1983		12	60	56	19	4		
Fall	1984	29	124	74	4				
					Upper Wild Trout Water				
Fall	1980					69	61	82	36
Fall	1981				181	136	113	49	0
Fall	1982			196	95	69	31	5	0
Fall	1983		160	142	77	23	0	0	0
Fall	1984[a]	29	322	270	54	18	0	0	0
					Lower Control				
Fall	1980					52	63	108	65
Fall	1981				157	196	125	53	0
Fall	1982			258	241	131	31	3	0
Fall	1983		127	324	225	11	0	0	0
Fall	1984	21	358	164	6	0	0	0	0
					Indian Meadows				
Fall	1980					155	150	135	41
Fall	1981				226	203	81	40	0
Fall	1982			122	172	103	40	4	0
Fall	1983		111	245	145	28	0	0	0
Fall	1984	47	139	142	42	14	0	0	0
					Kelly Flats Campground				
Fall	1980					177	107	120	22
Fall	1981				343	177	40	6	0
Fall	1982			300	91	15	0	0	0
Fall	1983		192	209	108	11	0	0	0
Fall	1984	72	246	130	8	0	0	0	0

[a]Station relocated 1984.

Table III-2. Life Tables - Colorado River (brown trout/ha)(continued).

Sample period		Year class							
Season	Year	1983	1982	1981	1980	1979	1978	1977	1976
				Thompson Ranch - catch-and-release					
Fall	1981				12	42	36	24	0
Fall	1982			34	38	65	19	9	0
Fall	1983		37	72	24	5	17	0	
Fall	1984[a]	4	6	6	4	8	0		
				Hot Sulphur Springs (Pioneer Park) - 8 trout/day					
Fall	1981				25	26	6	0	0
Fall	1982			42	21	21	6	0	0
Fall	1983		66	88	22	14	3		
Fall	1984	15	20	13	10	5	0		
				Paul Gilbert Wildlife Area - 1 rainbow-1 brown/day					
Fall	1982			15	4	17	3	0	0
Fall	1983		57	58	13	2	7	0	0
Fall	1984	9	37	35	2	0	0		
				State Ranch (Lone Buck) - 1 rainbow-1 brown/day					
Fall	1981				2	10	6	4	0
Fall	1982			0	2	12	13	0	0
Fall	1983		26	17	9	5	3	3	0
Fall	1984	3	16	26	9	3	0	0	
				Parshall - 1 rainbow-1 brown/day					
Fall	1981				19	206	57	11	2
Fall	1982			85	42	40	8	0	0
Fall	1983		26	59	29	10	2	1	0
Fall	1984	40	63	34	7	6	0	0	

[a]Based on one pass electroshocking only; all other data based on population estimates.

Table III-2. Life Tables - Colorado River (rainbow trout/ha) (continued).

Sample period		Year class									
Season	Year	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
		Thompson Ranch - private access - harvest restricted									
Fall	1980					3	17	62	53	5	3
Fall	1981				31	11	94	84	3	0	0
Fall	1982			6	10	41	88	9	0	0	0
Fall	1983		38	12	79	99	14	0			
Fall	1984[a]	2	11	7	15	7	0				
		Hot Sulphur Springs (Pioneer Park) - 8 trout/day									
Fall	1981				37	38	3	0	0	0	
Fall	1982			26	48	8	2	0	0	0	
Fall	1983		149	50	50	22	4				
Fall	1984	21	57	15	9	2	0				
		Paul Gilbert Wildlife Area - 1 rainbow-1 brown/day									
Fall	1982			5	5	4	0	1	0	0	
Fall	1983		124	42	40	23	6	0	0	0	
Fall	1984	6	51	28	20	5	0				
		State Ranch at Lone Buck - 1 rainbow-1 brown/day									
Fall	1979							76	104	39	11
Fall	1980					1	25	42	22	0	0
Fall	1981				23	17	45	13	0	0	0
Fall	1982			2	20	25	31	10	0	0	0
Fall	1983		18	2	25	30	5	0			
Fall	1984	6	67	51	45	10	1	0			
		Parshall - 1 rainbow-1 brown/day									
Fall	1981				72	487	207	119	10	1	
Fall	1982			61	165	70	82	29	3	0	
Fall	1983		5	20	57	89	29	2	0	0	
Fall	1984	20	62	45	52	23	8	0			

[a]Based on one electroshocking pass only; all other data based on population estimates.

Table III-2. Life Tables - Eagle River (brown trout and rainbow trout/ha)(cont.).

Sample period		Year class								
Season	Year	1983	1982	1981	1980	1979	1978	1977	1976	1975
					Wolcott (brown trout)					
Spring	1980						73	239	41	15
Fall	1980					49	171	33	1	0
Fall	1981			8	13	55	50	8	0	0
Fall	1982			67	15	48	2	0	0	0
Fall	1983		64	136	73	7	0	0	0	
Fall	1984[a]	6	23	20	0					
					Wolcott (rainbow trout)					
Spring	1980						21	45	3	0
Fall	1980				3	27	35	34	0	0
Fall	1981			0	6	1	2	0	0	0
Fall	1983		46	103	30	0				
					Upper End (brown trout) - catch-and-release					
Fall	1981			4	27	48	34	1	4	0
Fall	1983		7	45	24	5	0			
					Upper End (rainbow trout) - catch-and-release					
Fall	1981			7	16	3	13	0	0	0
Fall	1983		19	44	13	0				
					Lower End (brown trout) - catch-and-release					
Fall	1981			5	55	33	35	1	0	0
Fall	1983			5	52	28	4	0		
					Lower End (rainbow trout) - catch-and-release					
Fall	1981			5	76	35	0	0	0	0
Fall	1983		43	105	24	0	0			

[a]Based on one electroshocking pass only; all other data based on population estimates.

Table III-2. Life Tables - Fryingpan River (brown trout/ha)(continued).

Sample season		Year class									
Season	Year	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
		Gaging Station Pool No. 1 - catch-and-release									
Fall	1979						31	109	106	46	17
Fall	1980					24	186	397	168	9	0
Fall	1981				61	50	95	517	0	0	0
Fall	1982			60	50	71	237	8	0		
Fall	1983		26	238	273	156	5	0			
Fall	1984	11	69	221	211	12	10	0			
		Ruedi Damsite Station No. 2 - catch-and-release									
Fall	1978							51	204	108	34
Fall	1979						159	180	69	53	5
Spring	1980						70	91	51	26	13
Fall	1980					51	174	171	31	4	0
Fall	1981				101	113	85	162	0	0	0
Fall	1982			122	97	114	156	6	0	0	0
Fall	1983		66	290	229	76	10	3	0		
Fall	1984	29	125	242	174	9	3	0			
		Old Faithful Station No. 3 - catch-and-release									
Fall	1979						243	352	107	40	0
Spring	1980						194	208	67	14	0
Fall	1980					204	479	248	21	0	0
Fall	1981				121	251	258	243	0	0	0
Fall	1982			270	210	250	311	8	0	0	0
Fall	1983		148	446	300	63	5	0			
Fall	1984	44	497	399	225	12	0				
Upper Standard Regulation Station No. 4 - 1 rainbow-1 brown/day 1983-84, 85											
Fall	1979						252	271	58	27	4
Spring	1980						108	85	22	6	3
Fall	1980					104	226	77	6	0	0
Fall	1981				84	140	117	88	0	0	0
Fall	1982			35	80	107	97	6	0	0	0
Fall	1983		87	178	127	22	0	0			
Fall	1984	49	233	136	75	3	0				
		Taylor River Station No. 5 - 1 rainbow-1 brown/day 1983-84, 85									
Fall	1978							86	198	131	44
Fall	1979						348	265	80	31	0
Spring	1980						237	170	43	13	6
Fall	1980					192	170	110	32	0	0
Fall	1981				151	157	102	180	0	0	0
Fall	1982			103	174	164	273	10	0	0	0
Fall	1983		100	178	188	71	2	0			
Fall	1984	60	131	129	88	19	0				
		Big Pullout Station No. 6 - 1 rainbow-1 brown/day 1983-84, 85									
Fall	1980					30	39	54	16	0	0
Fall	1982			11	8	46	90	5			
Fall	1983		32	49	104	50					

Table III-2. Life Tables - Fryingpan River (rainbow trout/ha)(continued).

Sample period		Year class									
Season	Year	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
Gaging Station Pool No. 1 - catch-and-release											
Fall	1979							51	124	98	20
Fall	1980					31	23	121	112	78	38
Fall	1981				6	29	29	56	44	0	0
Fall	1982			10	323	833	91	70	0	0	0
Fall	1983		30	62	190	139	42	6	0		
Fall	1984	11	227	119	29	0	0	0			
Ruedi Damsite Station No. 2 - catch-and-release											
Fall	1978							46	245	71	41
Fall	1979						30	81	58	40	11
Spring	1980						45	87	84	59	22
Fall	1980					45	71	66	35	16	8
Fall	1981				24	51	44	16	4	0	0
Fall	1982			30	141	203	57	33	0	0	0
Fall	1983		185	108	163	97	18	3	0	0	0
Fall	1984	4	517	198	43	0	0	0			
Old Faithful Station No. 3 - catch-and-release											
Fall	1979						29	134	96	46	19
Spring	1980						26	113	77	35	12
Fall	1980					78	98	84	43	29	12
Fall	1981				18	19	21	26	8	0	0
Fall	1982			4	37	55	30	19			
Fall	1983		64	458	180	35	9	0			
Fall	1984	13	309	118	39	0	0	0			
Upper Standard Regulation Station No. 4 - 1 rainbow-1 brown/day 1983-84, 85											
Fall	1979						125	122	75	19	7
Spring	1980						17	53	20	2	0
Fall	1980					13	19	10	6	0	0
Fall	1981				20	8	28	6	0	0	0
Fall	1982			1	20	22	1	1	0	0	0
Fall	1983		35	231	82	12	2	2			
Fall	1984	6	126	52	11	0	0	0			
Taylor River Station No. 5 - 1 rainbow-1 brown/day 1983-84, 85											
Fall	1978							130	267	84	10
Fall	1979						345	206	53	22	6
Spring	1980						130	212	49	24	7
Fall	1980					140	97	22	11	10	0
Fall	1981				121	123	75	8	5	0	0
Fall	1982			4	59	81	25	12	0	0	0
Fall	1983		13	19	31	24	14	0	0		
Fall	1984	16	66	30	3	0	0	0			
Big Pullout Station No. 6 - 1 rainbow-1 brown/day 1983-84, 85											
Fall	1979						122	168	50	1	0
Fall	1980					146	212	159	50	15	0
Fall	1982			4	43	86	34	13	0	0	0
Fall	1983		20	72	91	49	9	0			

Not sampled in 1984

Table III-2. Life Tables - Gunnison River (numbers/ha)(continued).

Sample period		Year class						
Season	Year	1983	1982	1981	1980	1979	1978	1977
		Smith Fork - North Fork (rainbow trout)						
Fall	1981				314	26	9	6
Fall	1982			167	42	11	7	1
Fall	1983		43	133	86	6	0	0
Fall	1984	8	17	162	80	3	1	0
		Duncan - Ute Trail (rainbow trout)						
Fall	1981				197	91	41	10
Fall	1982			212	85	71	20	3
Fall	1983		111	128	160	18	10	0
Fall	1984	4	15	121	70	5	2	0
		Smith Fork - North Fork (brown trout)						
Fall	1981				88	13	3	2
Fall	1982			122	55	7	1	1
Fall	1983		140	224	36	4	3	0
Fall	1984	65	200	76	9	1	0	0
		Duncan - Ute Trail (brown trout)						
Fall	1981				641	170	31	3
Fall	1982			363	216	14	0	0
Fall	1983		242	300	40	2	2	0
Fall	1984	82	358	90	10	1	0	0
		Almont - Gunnison (brown trout)						
Fall	1984	7	44	55	26	8	2	

Table III-2. Life Tables - Rio Grande River (brown trout/ha)(continued).

Sample period		Year class								
Season	Year	1983	1982	1981	1980	1979	1978	1977	1976	1975
				Coller fly water						
August	1981				65	41	66	64	8	0
August	1982			76	80	93	3	0	0	0
September	1983		74	132	65	12	3	0	0	0
September	1984	61	144	72	24	3	1	0		
				State Bridge section						
August	1981				26	19	36	11	3	2
August	1982			65	21	33	12	2	0	0
September	1983		59	77	21	18	4	0	0	0
September	1984	39	42	28	16	5	1	0		
		Wason Ranch - standard regulations - 8 trout/day 1983-84, 85								
August	1982			63	99	136	13	0	0	0
September	1983		61	130	63	41	9	0	0	0
October	1984	27	27	30	32	5	1	0	0	0
		Wason Ranch - fly water - 2 trout/day; catch-and-release 14 in. 1983-84, 85								
August	1982			71	98	190	19	0	0	0
September	1983		61	123	58	38	13	0	0	0
October	1984	43	30	50	89	14	6	0		
				State Bridge section (rainbow trout)[a]						
August	1982			212	75	94	137	31	0	0
September	1983		62	108	21	39	55	0	0	0
September	1984	140	67	95	5	23	0	0		

[a]Total rainbows/section not per hectare.

Table III-2. Life Tables - South Platte River (brown trout/ha) (continued).

Sample period Season	Year	1983	1982	1981	1980	1979	1978	1977	1976	1975
Upper Canyon section - catch-and-release										
Fall	1979						233	284	218	35
Spring	1980					6	230	385	75	0
Fall	1980					252	568	176	12	0
Spring	1981				12	162	318	43	8	0
Fall	1981				46	203	170	19	0	0
Fall	1982			165	205	203	43	0	0	0
Fall	1983		193	637	412	98	22			
Fall	1984	50	516	191	4					
Lower Canyon section - catch-and-release										
Fall	1979						202	364	421	57
Spring	1980					22	237	595	195	0
Fall	1980					283	563	165	50	0
Spring	1981				36	187	539	242	8	0
Fall	1981				98	286	293	29	0	0
Fall	1982			164	189	235	128	22	0	0
Fall	1983		158	605	197	28	4			
Fall	1984	87	447	269	31					
Above Deckers Bridge section										
Fall	1979						906	366	49	8
Spring	1980					142	816	433	35	0
Fall	1980					993	678	66	31	11
Spring	1981				49	544	397	33	4	0
Fall	1981				460	623	171	12	0	0
Fall	1982			1,813	344	55	4	0	0	0
Fall	1983		1,799	1,205	94	10				
Fall	1984	696	522	14	3					
Below Deckers										
Fall	1982			2,062	449	55				
Fall	1983		1,531	1,335	135	12				
Fall	1984	692	573	32	4					
Scraggy View section - fish/day										
Fall	1979						572	204	32	0
Spring	1980					360	769	264	14	0
Fall	1980					526	195	10	3	0
Spring	1981				161	453	138	18	0	0
Fall	1981				412	301	35	0	0	0
Fall	1982			925	244	23	3	0	0	0
Fall	1983		770	501	13					
Fall	1984	332	131							
Twin Cedars										
Fall	1982			1,000	227	12				
Fall	1983		443	237	12					
Fall	1984	376	93	3						

Table III-2. Life Tables - South Platte River (rainbow trout/ha)(continued).

Sample period Season	Year	Year class 1983	1982	1981	1980	1979	1978	1977	1976	1975
Upper Canyon section - catch-and-release										
Fall	1979						106	682	583	56
Spring	1980						177	786	626	78
Fall	1980					35	344	655	288	139
Spring	1981				4	26	375	505	187	70
Fall	1981				10	155	434	137	49	7
Fall	1982			101	70	132	328	209	32	0
Fall	1983		763	182	335	218	81	8		
Fall	1984	84	497	522	156	168	29	1		
Lower Canyon section - catch-and-release										
Fall	1979						105	758	685	88
Spring	1980						93	732	703	114
Fall	1980					20	621	503	71	0
Spring	1981				8	38	494	873	392	0
Fall	1981				23	86	465	224	45	0
Fall	1982			44	44	68	300	239	44	4
Fall	1983		848	235	398	232	109			
Fall	1984	72	238	522	189	127	44			
Above Deckers Bridge section										
Fall	1979						156	91	57	8
Spring	1980						45	67	51	32
Fall	1980					243	141	30	1	0
Spring	1981				14	54	24	10	7	0
Fall	1981				119	100	54	7	8	0
Fall	1982			275	88	17	10	0	0	0
Fall	1983		561	366	50	19	4	0		
Fall	1984	43	218	132	19	6	3	1		
Below Deckers Bridge section										
Fall	1982			445	139	65	0			
Fall	1983		603	314	40	47	0			
Fall	1984	127	401	90	8					
Scraggy View section										
Fall	1979						89	134	13	0
Spring	1980						53	67	17	1
Fall	1980					162	68	6	0	0
Spring	1981					86	50	6	0	0
Fall	1981				44	62	20	2	0	0
Fall	1982			91	28	31	13	0	0	0
Fall	1983		247	142	17	0	0	0	0	
Fall	1984	51	75	12	0	0				
Twin Cedars										
Fall	1982			237	29	15				
Fall	1983		84	31	4	0				
Fall	1984	74	58	4	2	1				

Table III-2. Life Tables - Middle Fork of the South Platte River (brown trout/ha)(continued).

Sample period		Year class									
Season	Year	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
					Station No. 1 - at Garo Bridge						
Fall	1979						(655)	891	421	171	28
Fall	1980					(353)	1,058	630	68	10	0
Fall	1981				(328)	524	664	71	0	0	0
Fall	1982			(142)	286	237	148	10	0	0	0
Fall	1983		(54)	399	982	383	20	0	0	0	0
Fall	1984	(274)	361	494	430	97	9				
					Station No. 2 - at Gaging Station Bridge						
Fall	1979						(1,007)	606	278	63	46
Fall	1980					(115)	592	267	83	43	8
Fall	1981				(259)	571	550	59	26	0	0
Fall	1982			(54)	289	206	191	19	0	0	0
Fall	1983		(231)	895	573	170	14	0	0	0	0
Fall	1984	(251)	379	359	197	22	14	0			
					Station No. 3 - 1 mile below Gaging Station Bridge						
Fall	1979						(1,624)	983	235	187	23
Fall	1980					(324)	1,047	390	238	12	49
Fall	1981				(538)	766	796	144	17	12	0
Fall	1982			(88)	276	230	217	0	0	0	0
Fall	1983		(496)	839	1,056	428	27	0	0	0	0
Fall	1984	(561)	689	520	281	58	9				
					Station No. 4 - 2 miles below Gaging Station						
Fall	1980					(636)	604	321	265	67	8
Fall	1981				(704)	689	759	129	25	2	0
Fall	1982			(102)	93	107	145	19	0	0	0
Fall	1983		(160)	360	701	336	14	0	0	0	0
Fall	1984	(237)	380	562	377	19	8	0	0	0	0
					Station No. 5 - 3 miles below Gaging Station Bridge						
Fall	1980					(524)	708	321	172	85	19
Fall	1981				(378)	744	645	187	109	48	7
Fall	1982			(97)	234	209	181	15	15	0	0

[a]Number in parenthesis is young-of-the-year/ha.

Table III-2. Life Tables - North Platte River (brown and rainbow/ha)(continued).

Sample period Season	Year	Year class 1983	1982	1981	1980	1979	1978	1977	1976
				Brown trout					
Fall	1982			12	47	13	22	1	1
Fall	1983		10	39	35	12	1	1	0
Fall	1984	13	71	25	9	3	0	0	0
				Rainbow trout					
Fall	1982			4	11	12	2	1	
Fall	1983		2	6	18	6	1	0	
Fall	1984	15	46	22	12	1	2	0	

Table III-2. Life Tables - Taylor River - (brown trout/ha).

Sample period Season	Year	Year class 1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
					Almont Station						
Fall	1979						143	713	289	27	6
Fall	1980					79	438	429	62	37	
Fall	1981				338	385	209	38	44	3	
Fall	1982			1,043	368	285	38	4	0		
Fall	1984	241	397	369	46	4	6	3	0		
					Elsinore Cattle Company						
Fall	1979						228	684	263	39	28
Fall	1980					141	447	385	110	49	
Fall	1981				370	318	146	36	61	14	
Fall	1982			450	275	229	82	8	0		
Fall	1984[a]	410	370	329	77	45	13	0			

[a]Sample taken about 1 mile below original Elsinore Cattle Company site.

Table III-2. Life Tables - St. Vrain River (brown trout/ha)(concluded).

Sample period Season	Year	Year class 1983	1982	1981	1980	1979	1978	1977
				Meadow Park				
Fall	1980				(681)	1,560	206	0
Fall	1981			(1,406)	871	259	0	0
Fall	1982		(354)	1,392	418	15	0	0
Fall	1983	(1,436)	1,388	726	16	0	0	0
Fall	1984	1,290	761	16				
				Gaging Station				
Fall	1980				(353)	796	162	0
Fall	1981			(856)	192	182	0	0
Fall	1982		(698)	892	298	53	1	0
Fall	1983	(274)	473	463	48	0	0	0
Fall	1984	880	716	14				
				Ideal Concrete				
Fall	1980				(473)	1,046	363	15
Fall	1981[a]			(100)	34	34	11	0
Fall	1982		(427)	335	188	11	0	0
Fall	1983	(1,306)	479	406	88	0	4	0
Fall	1984	891	410	28	14	0	4	
				Martin Marietta				
Fall	1980				(303)	174	83	4
Fall	1981[a]			(93)	4	19	7	
Fall	1982		(195)	47	104	15		
Fall	1983	(1,897)	58	99	12			
Fall	1984	686	328	24				

[a]Fish kill, population much reduced.
[b]YOY/ha

APPENDIX IV

Creel Census Data

Table IV-1. Summary of creel census statistics at Deckers (3 mi. of river) on the South Platte River.

	May/Sep. 1979	May/Oct. 1980	May/Sep. 1981	May/Sep. 1984
Trout 12 in. catch	2,108	1,433	3,519	1,578
Trout 15 in. catch	227	108	332	61
FM hours	37,594	32,628	27,120	12,227
Total catch	29,197	22,705	19,369	13,158
Brown catch	13,535	14,183	10,550	8,644
Rainbow catch	15,384	8,522	8,820	4,513
Brown CPMH	0.360	0.434	0.389	0.707
Rainbow CPMH	0.409	0.261	0.325	0.369
Total CPMH	0.777	0.696	0.714	1.076

Table IV-2. Summary of creel census statistics in Cheesman Canyon on the South Platte River.

	May/Sep. 1979	May/Oct. 1980	May/Sep. 1981	May/Sep. 1984
Trout 12 in. catch	15,184	18,796	32,256	16,335
Trout 15 in. catch	3,864	4,385	8,750	4,105
FM hours	25,550	29,954	23,643	22,377
Total catch	25,402	27,861	43,908	26,999
Brown catch	6,514	9,872	10,516	10,824
Rainbow catch	18,798	18,533	33,392	16,175
Brown CPMH	0.255	0.330	0.445	0.484
Rainbow CPMH	0.736	0.619	1.412	0.723
Total CPMH	0.994	0.930	1.857	1.207

Table IV-3. Summary of creel census statistics for the Scraggy View Area (8 trout/day limit) compared to the Deckers Area (catch-and-release area) for May-September 1984.

	Scraggy View		Deckers
Trout ≥12 in.	1,453	(1,981)[a]	1,578
Trout ≥15 in.	72	(98)	61
FM hours	9,258	(12,624)	12,227
Total catch	13,581	(18,519)	13,158
Brown catch	2,248	(3,338)	8,644
Rainbow catch	11,133	(15,181)[b]	4,513
Brown CPMH	0.264		0.707
Rainbow CPMH	1.203		0.369
Total CPMH	1.467		1.076

[a]Data in parenthesis is expanded up to 3 miles of river (from 2.2 mile area censused) to make data comparable to the 3 miles of stream censused near Deckers.

[b]14,000 catchable rainbows were stocked in this section of river at a cost of $9,000 versus zero stocking (and no cost) in the Deckers area.

Table IV-4. Creel census of the South Platte River, Deckers, May-September 1984 (SM1).

Statistics	May		June		July		August		September		Totals	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
FM hours	3,627	245	3,609	669	2,373	346	1,101	237	1,517	242	12,227	862
Total catch	3,093	1,690	4,022	394	3,318	976	1,356	429	1,368	630	13,158	2,131
Creel catch	0		0		0		172	172	0		172	172
Rainbow catch	1,220	896	1,043	281	1,009	533	608	145	533	287	4,513	1,126
Rainbow creeled	0		0		0		172	172	0		172	172
Brown catch	1,873	850	2,878	276	2,310	641	749	367	834	408	8,644	1,229
Brown creeled	0		0		0		0		0		0	
Total CPMH	0.853		1.114		1.398		1.232		0.902		1.076	
Rainbow CPMH	0.336		0.289		0.425		0.552		0.351		0.369	
Brown CPMH	0.516		0.797		0.973		0.680		0.550		0.707	

Table IV-5. Creel census of the South Platte River, Deckers, May-September 1984 (SM2).

Statistics	May		June		July		August		September		Totals	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
FM hours	3,627	245	3,609	669	2,373	346	1,101	237	1,517	242	12,227	862
Total catch	3,115	1,763	3,969	845	2,292	566	993	361	712	252	11,081	2,083
Creel catch	0		0		0		49	86	0		49	86
Rainbow catch	1,197	942	1,321	403	455	251	374	167	408	153	3,756	1,079
Rainbow creeled	0		0		0		49	86	0		49	86
Brown catch	1,918	847	2,648	586	1,836	502	618	219	304	183	7,325	1,180
Brown creeled	0		0		0		0		0		0	
Total CPMH	0.859		1.100		0.966		0.902		0.469		0.906	
Rainbow CPMH	0.330		0.366		0.192		0.340		0.269		0.307	
Brown CPMH	0.529		0.734		0.774		0.561		0.200		0.599	

Table IV-6. Creel census of the South Platte River, Cheesman Canyon, May-September 1984 (SM1).

Statistics	May		June		July		August		September		Totals	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
FM hours	7,306	1,024	4,719	695	4,563	461	2,445	278	3,342	215	22,377	1,367
Total catch	11,949	1,481	5,386	823	4,437	513	1,464	386	3,763	926	26,999	2,035
Creel catch	0		0		250	185	0		0		250	185
Rainbow catch	7,399	877	3,198	469	2,180	444	945	468	2,452	555	16,175	1,315
Rainbow creeled	0		0		27	27	0		0		27	27
Brown catch	4,550	932	2,189	718	2,256	265	519	178	1,310	513	10,824	1,323
Brown creeled	0		0		223	188	0		0		223	188
Total CPMH	1.635		1.141		0.972		0.599		1.126		1.207	
Rainbow CPMH	1.013		0.678		0.478		0.386		0.734		0.723	
Brown CPMH	0.623		0.464		0.494		0.212		0.392		0.484	

Table IV-7. Creel census of the South Platte River, Cheesman Canyon, May-September 1984 (SM2).

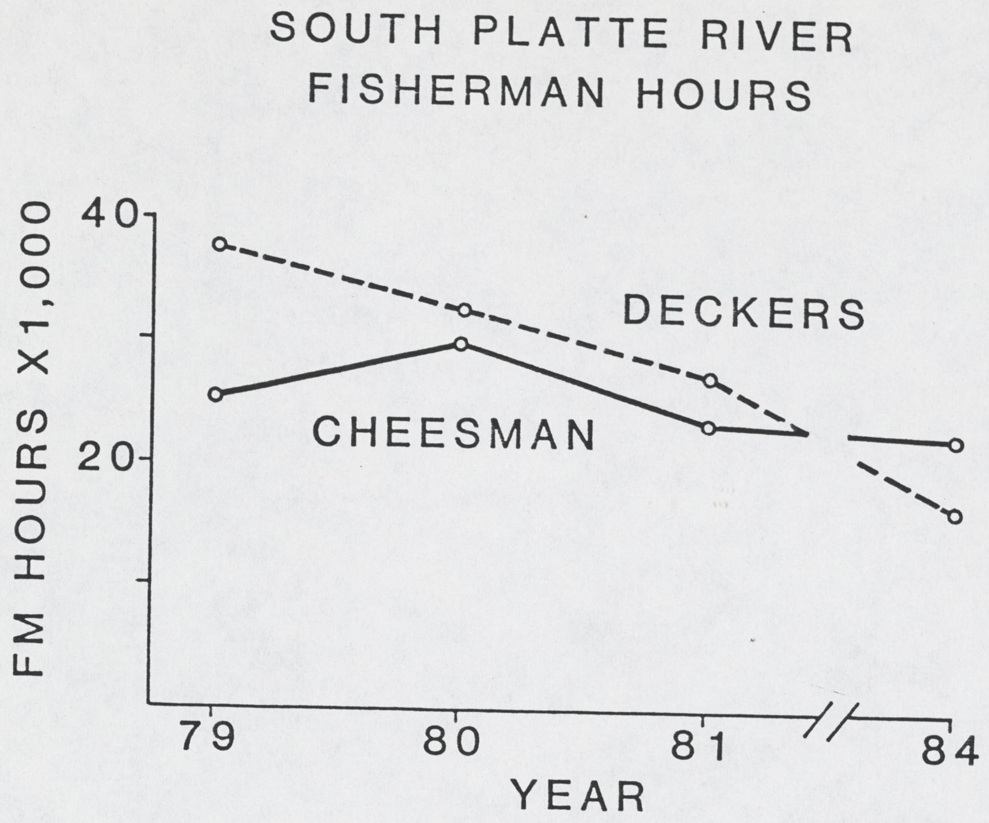
Statistics	May		June		July		August		September		Totals	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
FM hours	7,306	1,024	4,719	695	4,563	461	2,445	278	3,342	215	22,377	1,367
Total catch	10,290	1,919	5,605	1,294	4,466	561	1,412	265	4,038	1,009	25,811	2,600
Creel catch	0		0		253	150	0		0		253	150
Rainbow catch	6,575	1,192	3,152	761	2,242	396	856	412	2,760	704	15,584	1,680
Rainbow creeled	0		0		32	31	0		0		32	31
Brown catch	3,714	829	2,453	899	2,224	377	557	169	1,278	416	10,226	1,357
Brown creeled	0		0		222	158	0		0		222	158
Total CPMH	1.408		1.188		0.979		0.577		1.208		1.153	
Rainbow CPMH	0.900		0.668		0.491		0.350		0.826		0.696	
Brown CPMH	0.508		0.520		0.487		0.228		0.382		0.457	

Table IV-8. Creel census of the South Platte River, Scraggy View, May-September 1984 (SM1).

Statistics	May		June		July		August		September		Totals	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
FM hours	2,130	415	2,667	600	1,852	190	905	223	1,704	336	9,258	748
Total catch	4,288	3,397	2,328	662	2,393	810	2,019	1,153	2,552	997	13,581	3,868
Creel catch	2,058	1,522	1,501	482	983	366	1,046	858	1,224	680	6,814	1,970
Rainbow catch	3,412	2,658	1,892	407	1,754	734	1,803	1,091	2,271	963	11,133	3,144
Rainbow creeled	1,604	1,186	1,344	382	763	384	830	830	1,076	651	5,618	1,677
Brown catch	876	769	436	289	639	145	216	216	281	134	2,448	871
Brown creeled	454	357	157	121	220	109	216	216	150	71	1,196	454
Total CPMH	2.013		0.873		1.292		2.231		1.498		1.467	
Rainbow CPMH	1.602		0.709		0.947		1.992		1.333		1.203	
Brown CPMH	0.411		0.163		0.345		0.239		0.165		0.264	

Table IV-9. Creel census of the South Platte River, Scraggy View, May-September 1984 (SM2).

Statistics	May		June		July		August		September		Totals	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
FM hours	2,130	415	2,667	600	1,852	190	905	223	1,704	336	9,258	748
Total catch	3,422	2,705	2,376	692	2,335	822	1,639	756	2,967	786	12,739	3,109
Creel catch	1,720	1,239	1,524	476	970	218	1,009	467	1,412	530	6,635	1,519
Rainbow catch	2,670	2,102	1,921	531	1,734	699	1,483	754	2,513	749	10,321	2,522
Rainbow creeled	1,306	951	1,360	410	753	283	854	475	1,192	503	5,465	1,278
Brown catch	752	624	456	239	601	215	155	153	454	152	2,418	735
Brown creeled	414	306	164	101	217	127	155	153	219	65	1,170	385
Total CPMH	1.606		0.891		1.261		1.811		1.741		1.376	
Rainbow CPMH	1.253		0.720		0.936		1.639		1.475		1.115	
Brown CPMH	0.353		0.171		0.324		0.171		0.266		0.261	



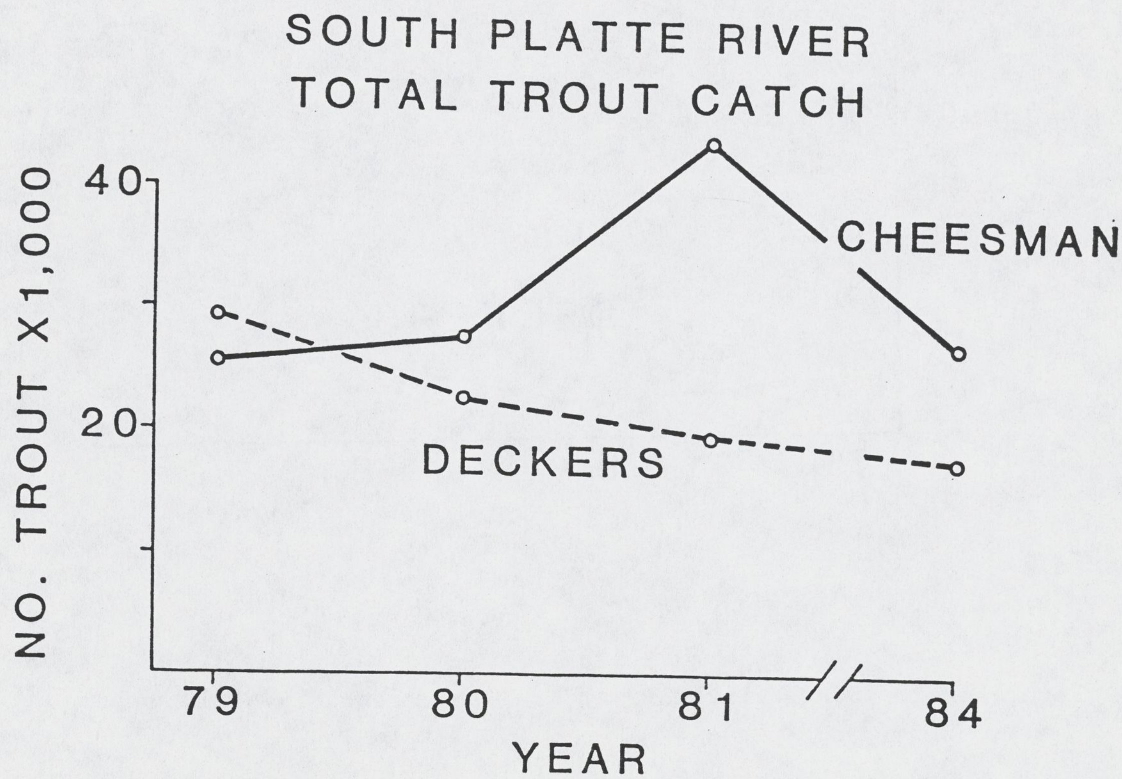


Figure IV-1. South Platte River, fisherman hours and total catch, 1979-81, 84.

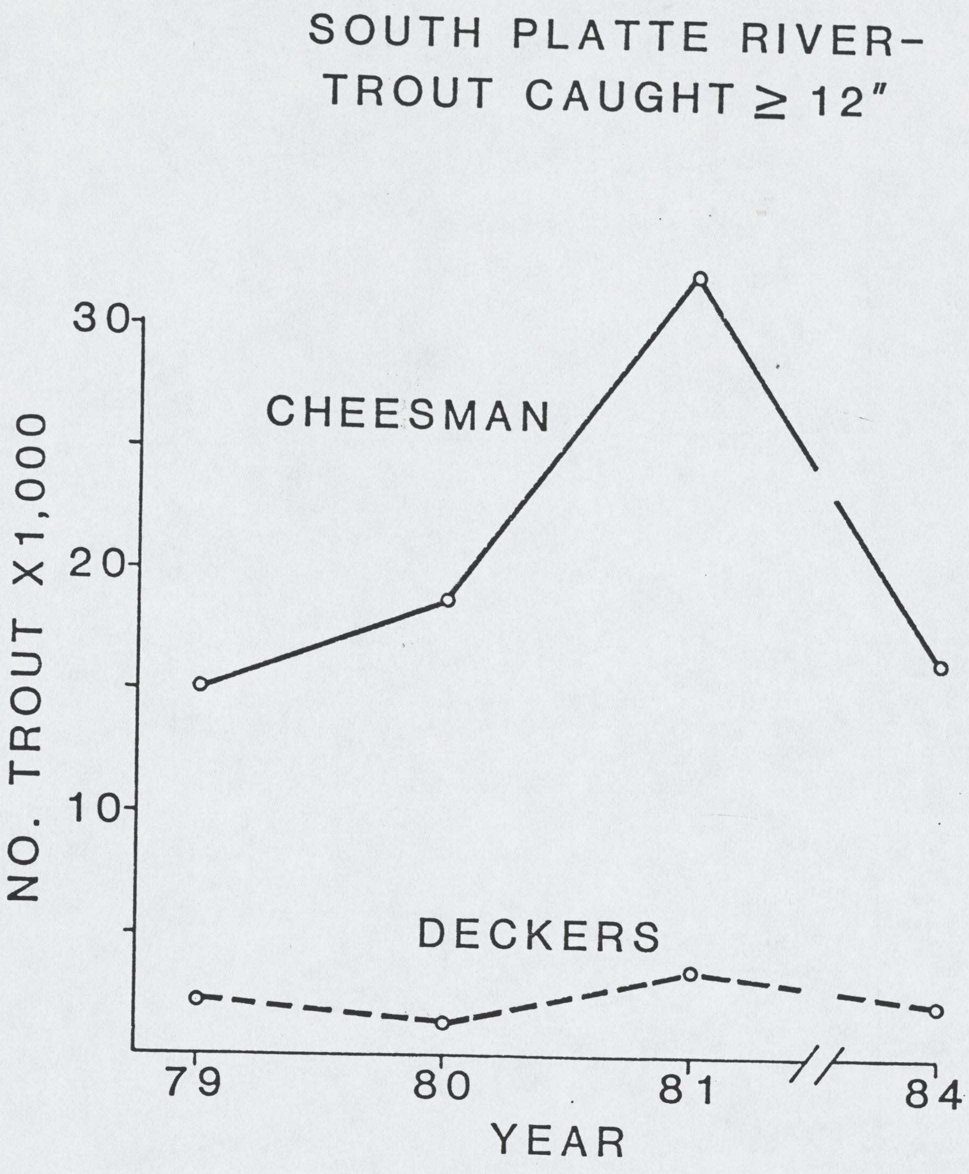


Figure IV-2. South Platte River, rainbow catch, 1979-81, 84.

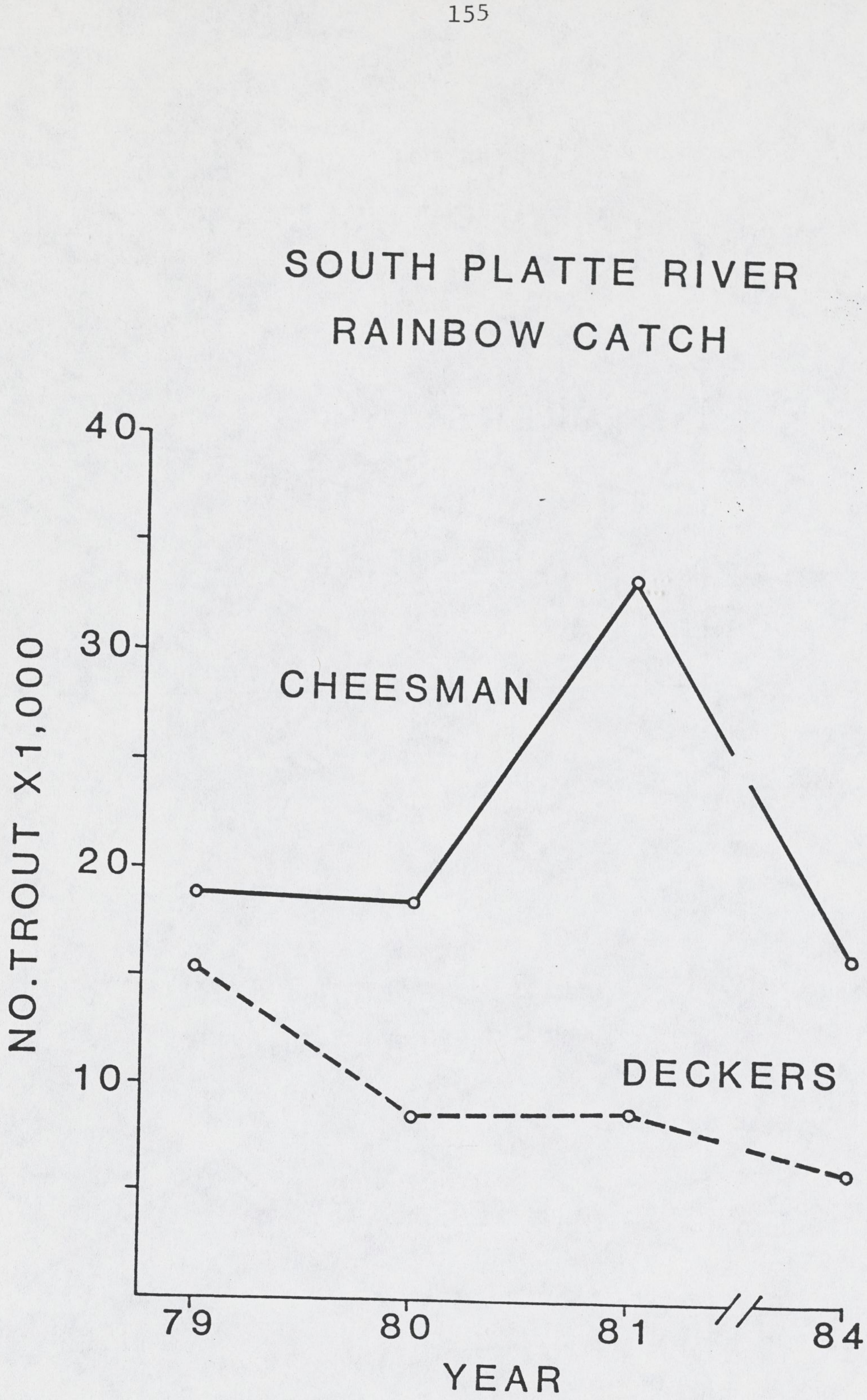
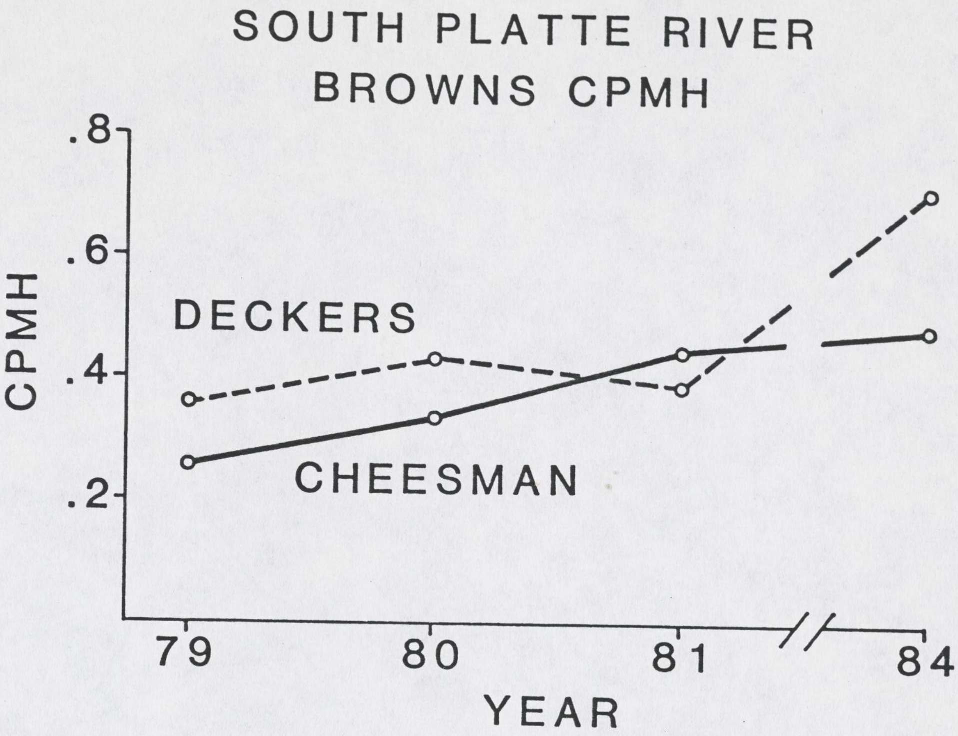


Figure IV-3. South Platte River, trout caught ≥ 12 inches, 1979-81, 84.



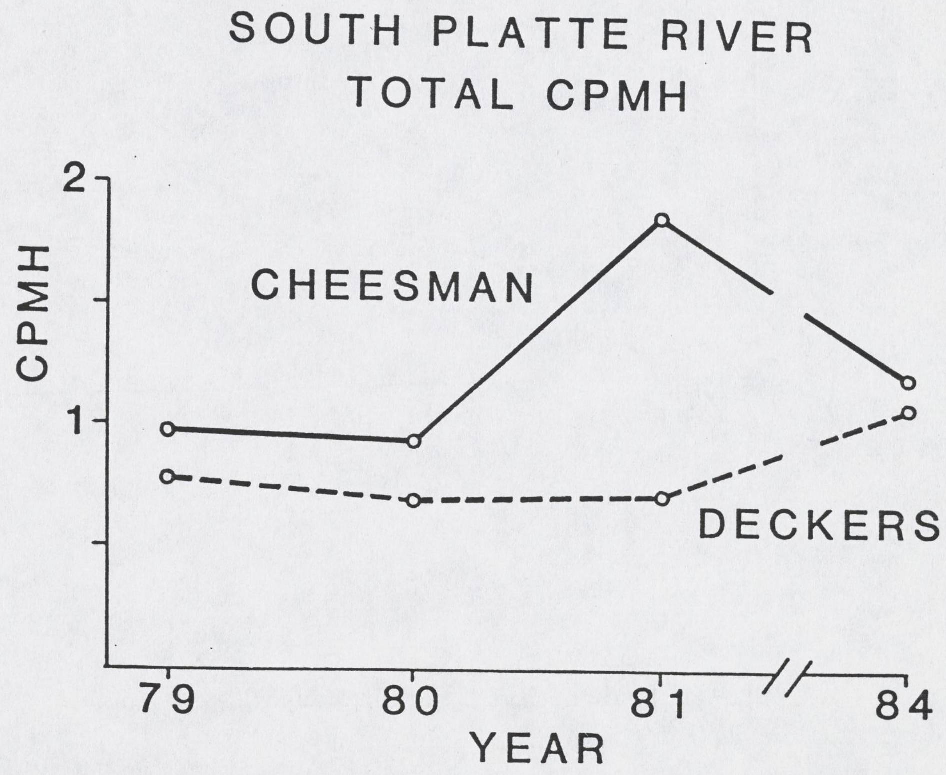


Figure IV-4. South Platte River, brown CPMH, total CPMH, 1979-81, 84.

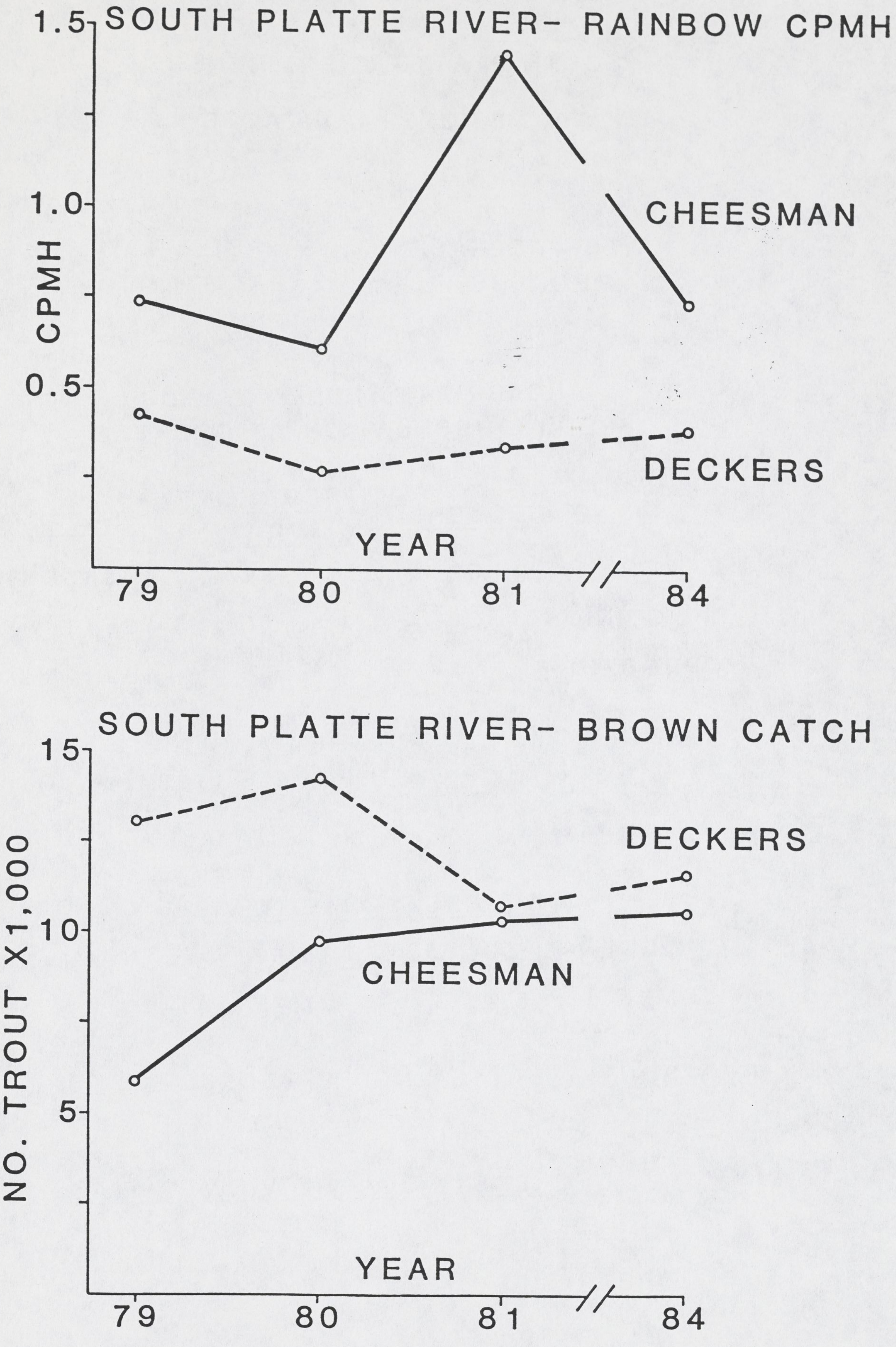


Figure IV-5. South Platte River, rainbow CPMH, brown catch, 1979-81, 84.

SOUTH PLATTE CREEL CENSUS

967 ANGLER CONTACTS

CATCH/RELEASE DECKERS	8 TROUT/DAY SCRAGGY VIEW
474	493

ANGLER ATTITUDE TOWARDS SPECIAL REGULATION AT DECKERS

	DECKERS	SCRAGGY VIEW	TOTAL
FAVOR	399	234	633 (66%)
NO OPINION	38	97	135 (14%)
OPPOSED	37	162	199 (20%)

WOMEN & CHILDREN ANGLERS ON THE SOUTH PLATTE (1984)

	DECKERS	SCRAGGY VIEW	TOTAL
CHILDREN	5.3%	8.5%	6.9%
WOMEN	5.7%	7.7%	6.7%

SOUTH PLATTE ANGLER TACKLE TYPES

	DECKERS	SCRAGGY VIEW	TOTAL
FLY	248	79	327 (34%)
LURE	211	125	336 (35%)
BAIT	15	289	304 (31%)

Figure IV-6. South Platte River, angler contacts, attitudes, woman and children, and tackle types by regulation area.

ATTITUDE OF ANGLERS CONTACTED IN
8 TROUT/DAY ANGLING AREA TOWARDS
SPECIAL REGULATIONS MANAGEMENT-

YEAR	IN FAVOR	NO OPINION	OPPOSED
1980	2,212	149	185
1981	1,319	207	337
1984	234	97	163
TOTALS	3,765	453	685
	77%	9%	14%

ATTITUDE OF ANGLERS CONTACTED IN
A SPECIAL REGULATION AREA TOWARD
SPECIAL REGULATION MANAGEMENT-

YEAR	IN FAVOR	NO OPINION	OPPOSED
1980	1,606	81	65
1981	450	30	60
1984	399	38	37
TOTALS	2,455	149	162
	89%	5%	6%

OVERALL ANGLER ATTITUDES TOWARDS
SPECIAL REGULATIONS MANAGEMENT
ON SOUTH PLATTE, FRYINGPAN, AND
ARKANSAS RIVERS 1980-1984.

ANGLERS SURVEYED	7,669	
ANGLERS IN FAVOR	6,220	81%
ANGLERS OPPOSED	847	11%
NO OPINION	602	8%

Figure IV-7. Angler attitudes towards special regulations management on the Arkansas, Fryingpan, and South Platte rivers, 1980, 81, and 84.

APPENDIX V

Aquatic Invertebrate Tables

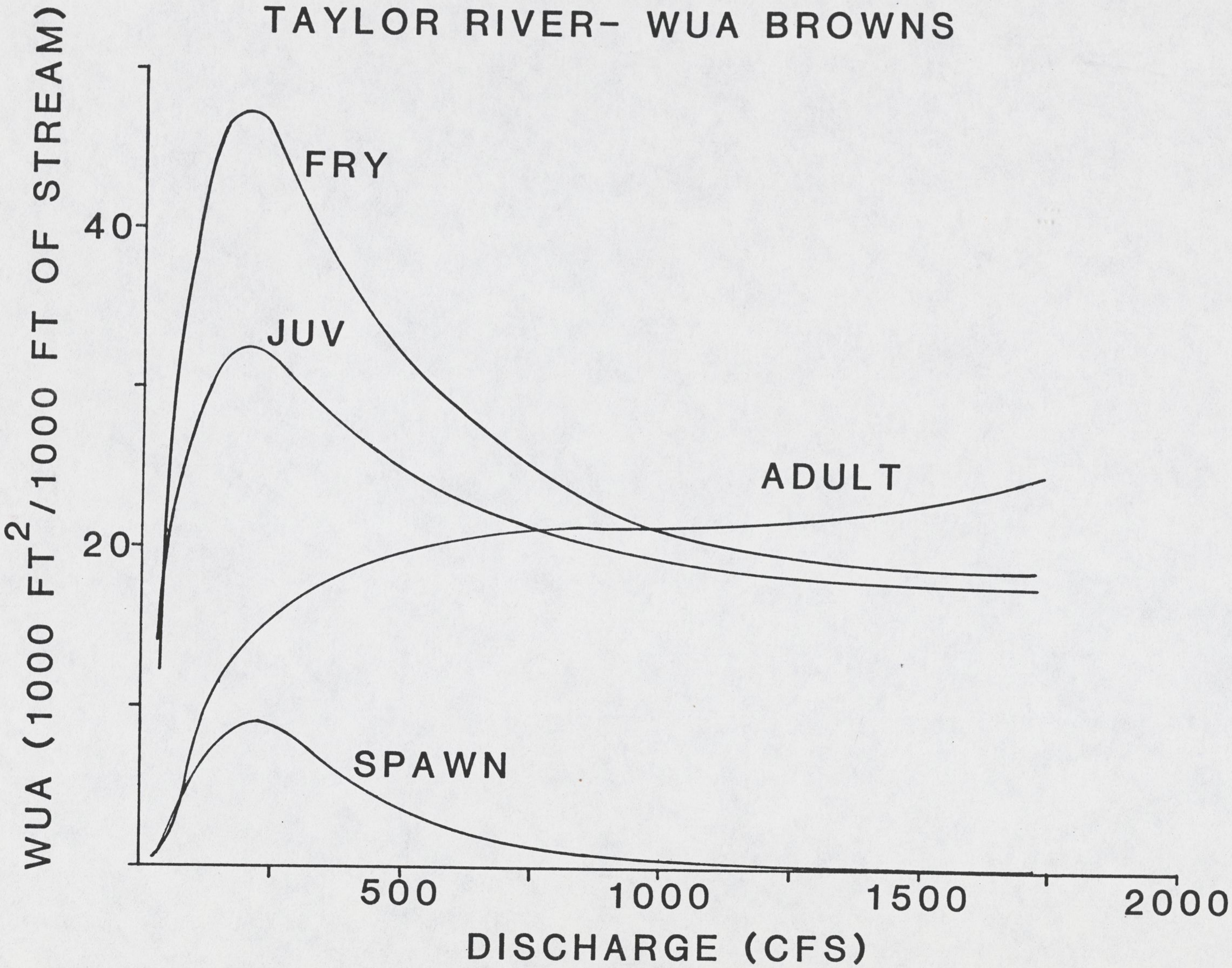


Figure V-1. Taylor River, WUA for browns versus discharge.

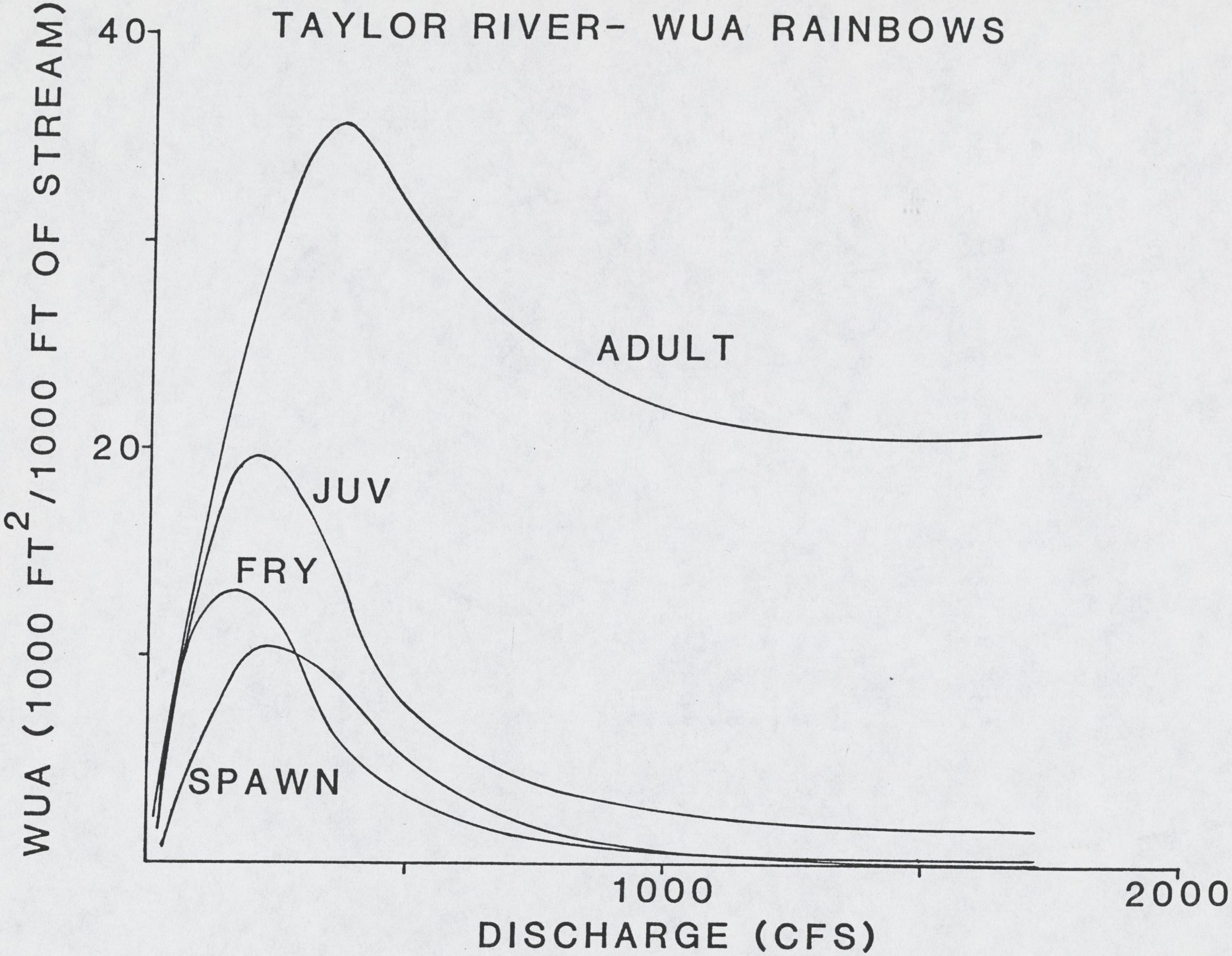


Figure V-2. Taylor River, WUA for rainbows versus discharge.

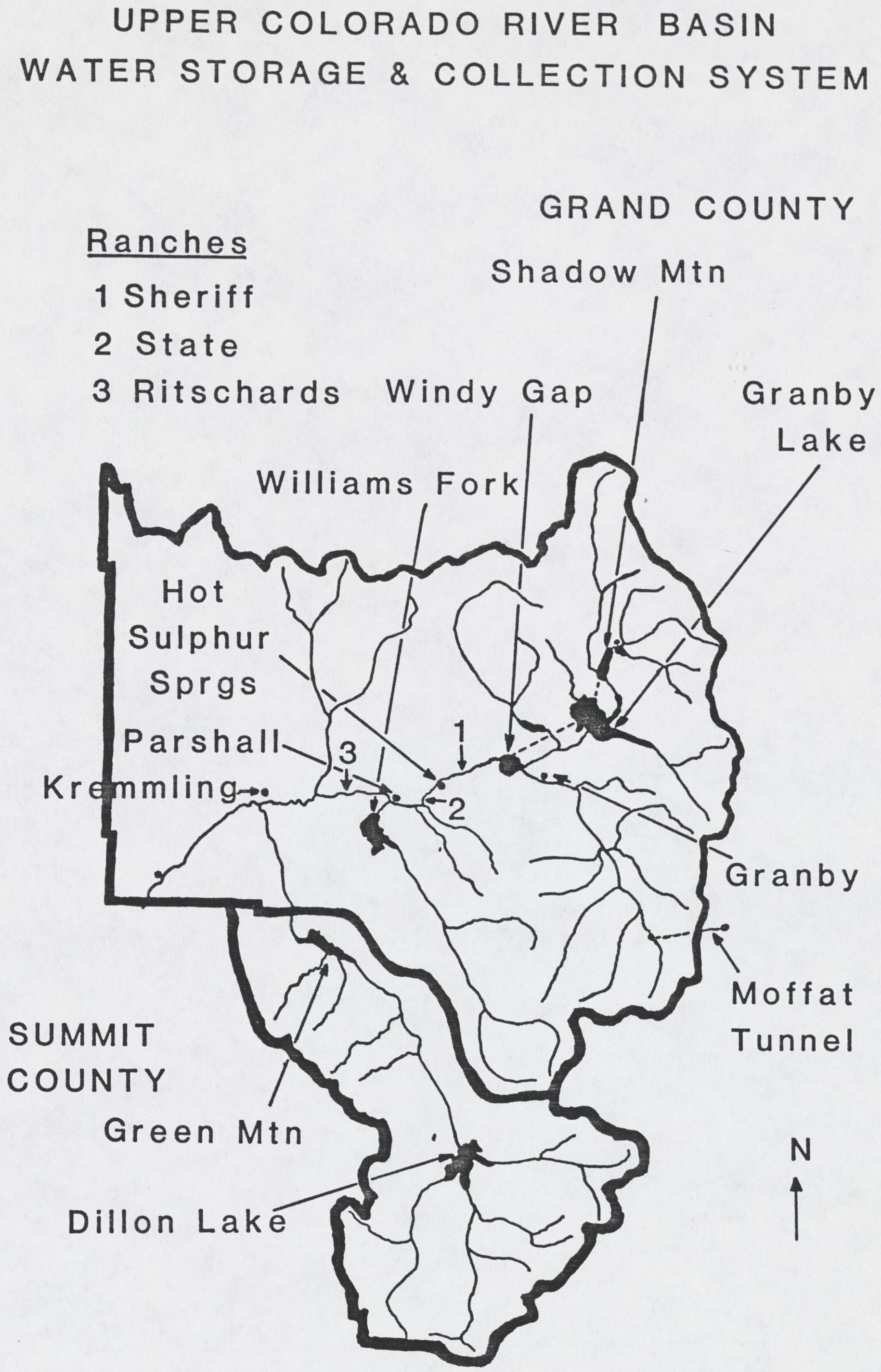


Figure V-3. Upper Colorado River basin water storage and collection system, Grand and Summit counties.

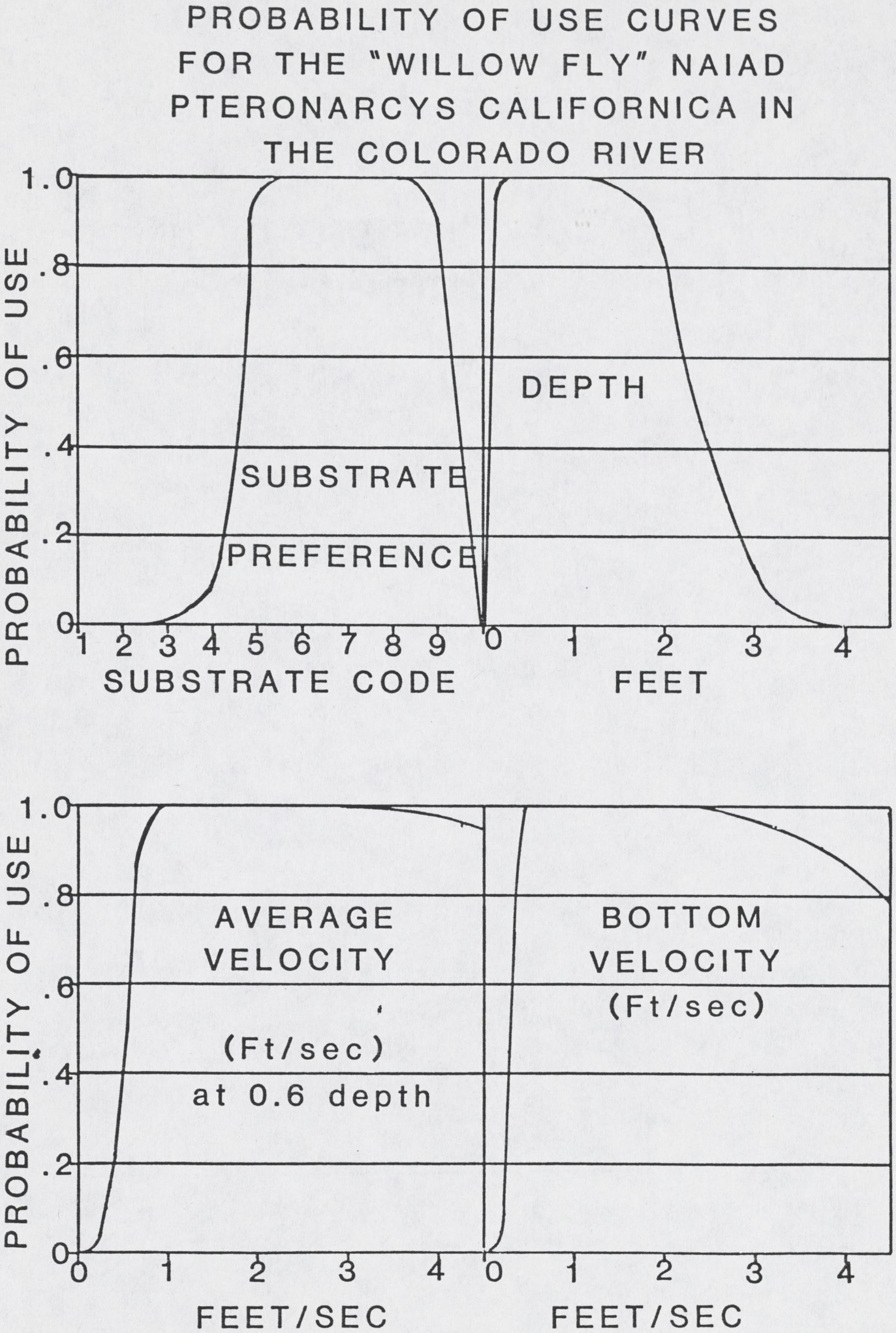


Figure V-4. Probability of use curves for the "willow fly" naiad. Pteronarcys californica in the Colorado River.

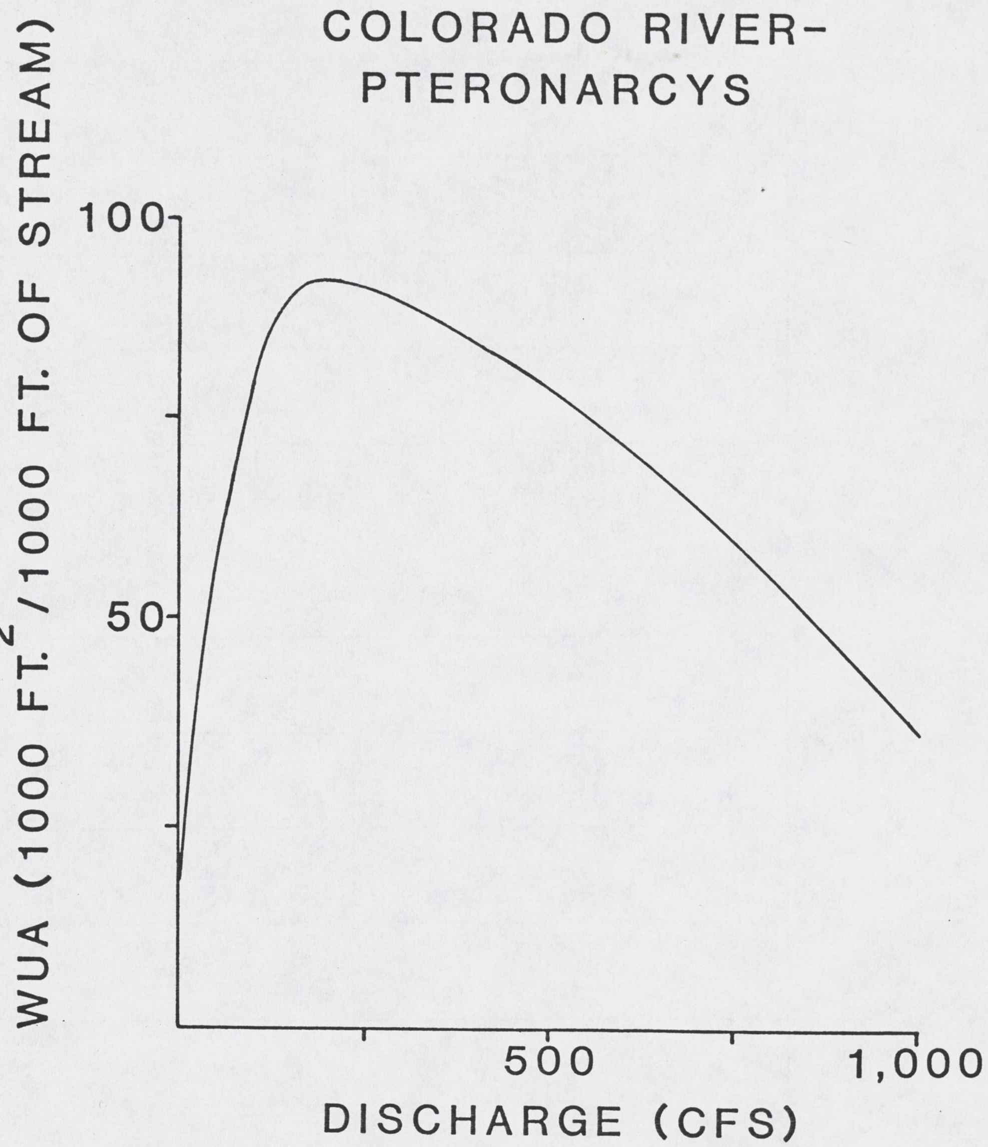


Figure V-5. Colorado River, Pteronarcys WUA (substrate and average velocity) versus discharge.

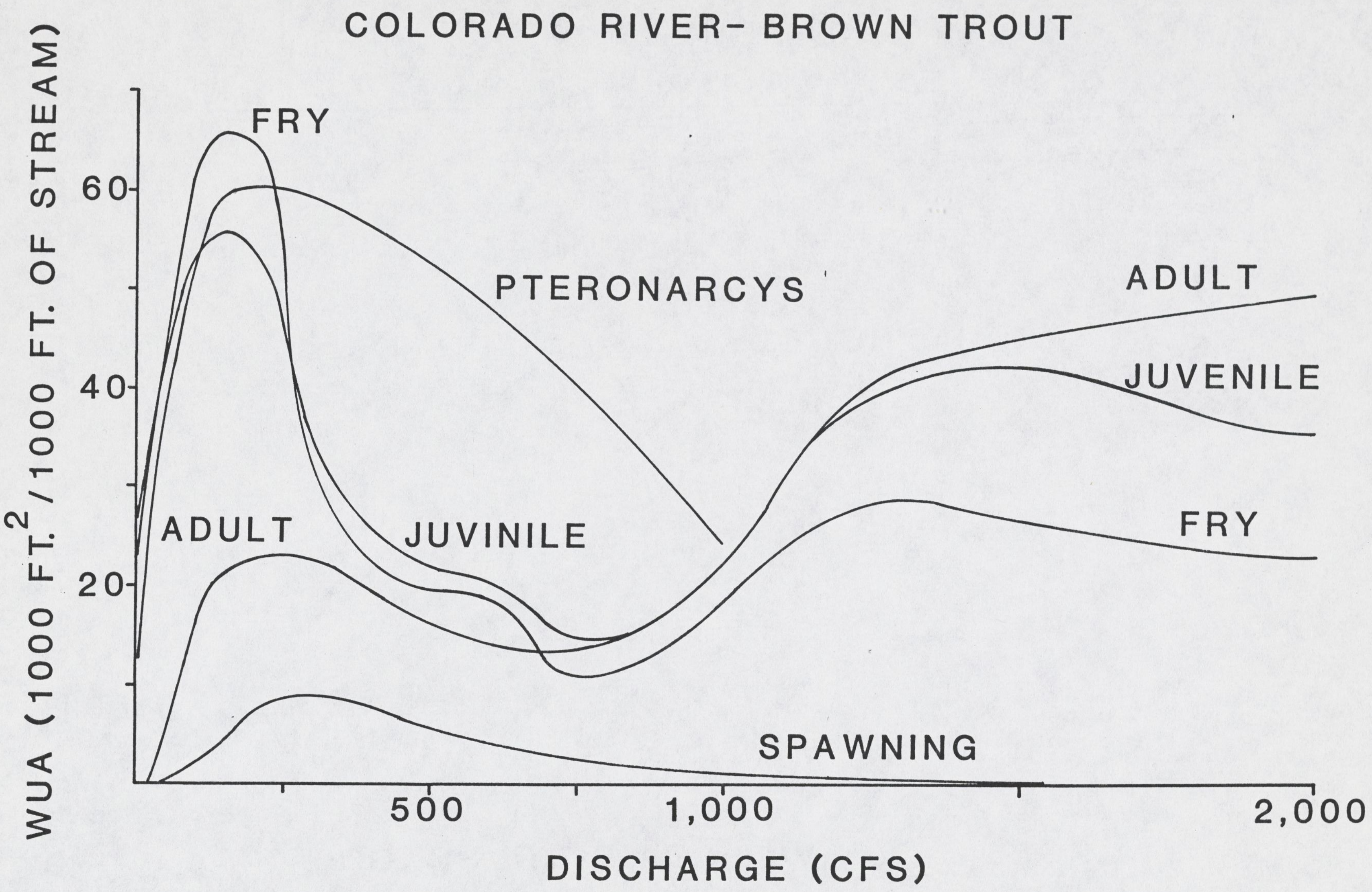


Figure V-6. Colorado River, brown trout WUA vs *Pteronarcys* WUA.

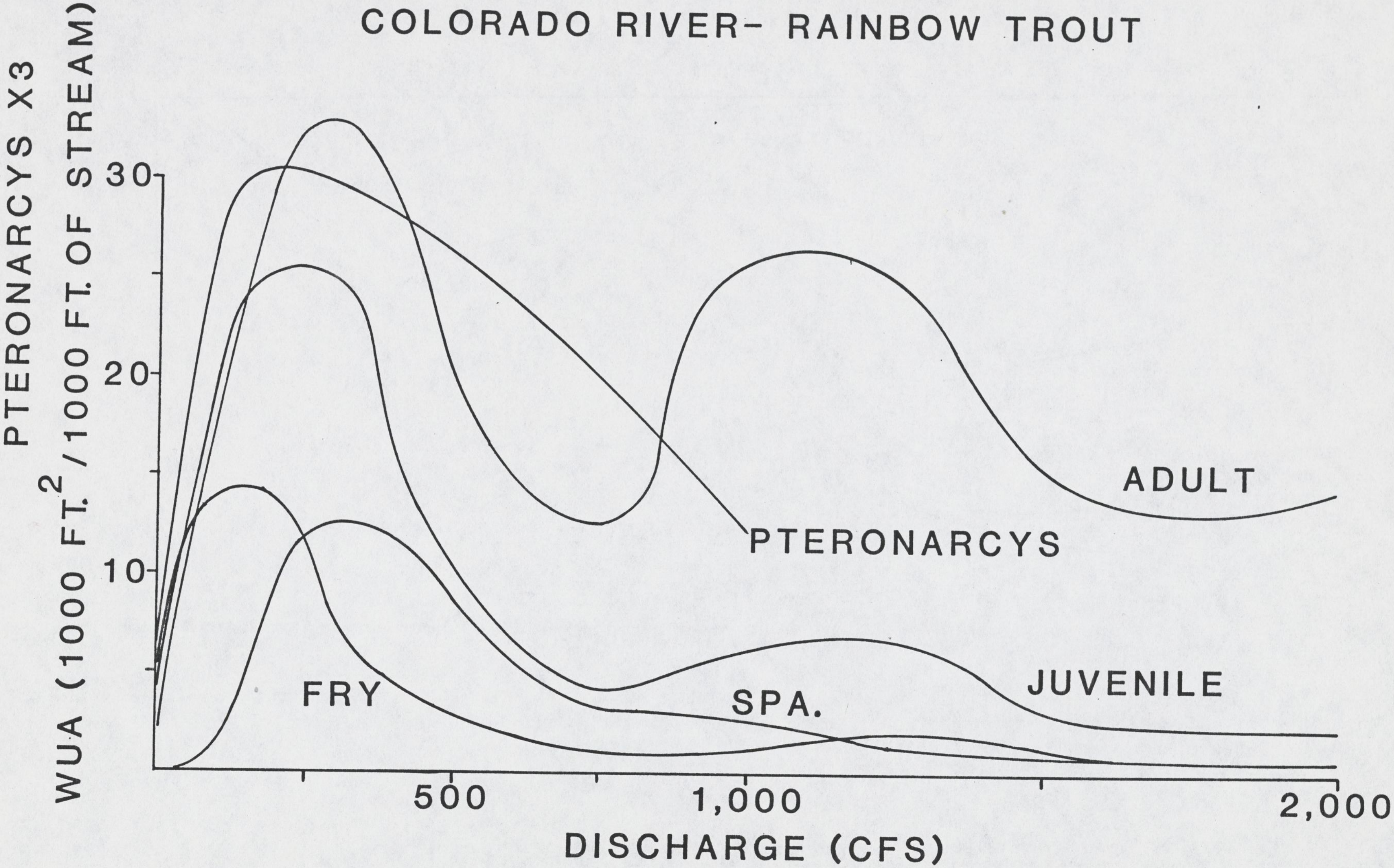


Figure V-7. Colorado River, rainbow trout WUA versus *Pteronarcys* WUA.

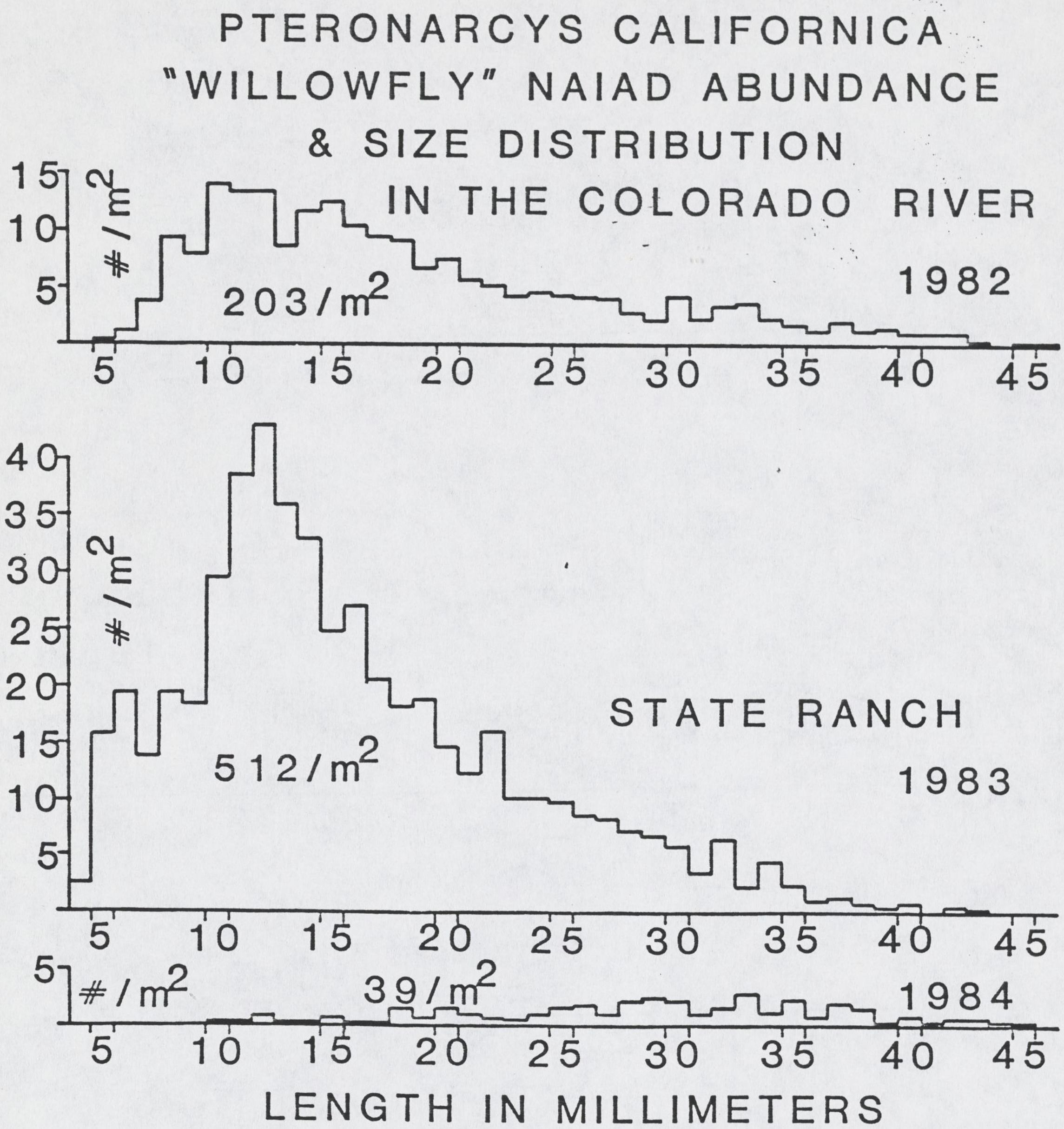


Figure V-8. Pteronarcys californica naiad abundance and size distribution/m^2 in the Colorado River on the State Ranch Wildlife Area, 1982-84.

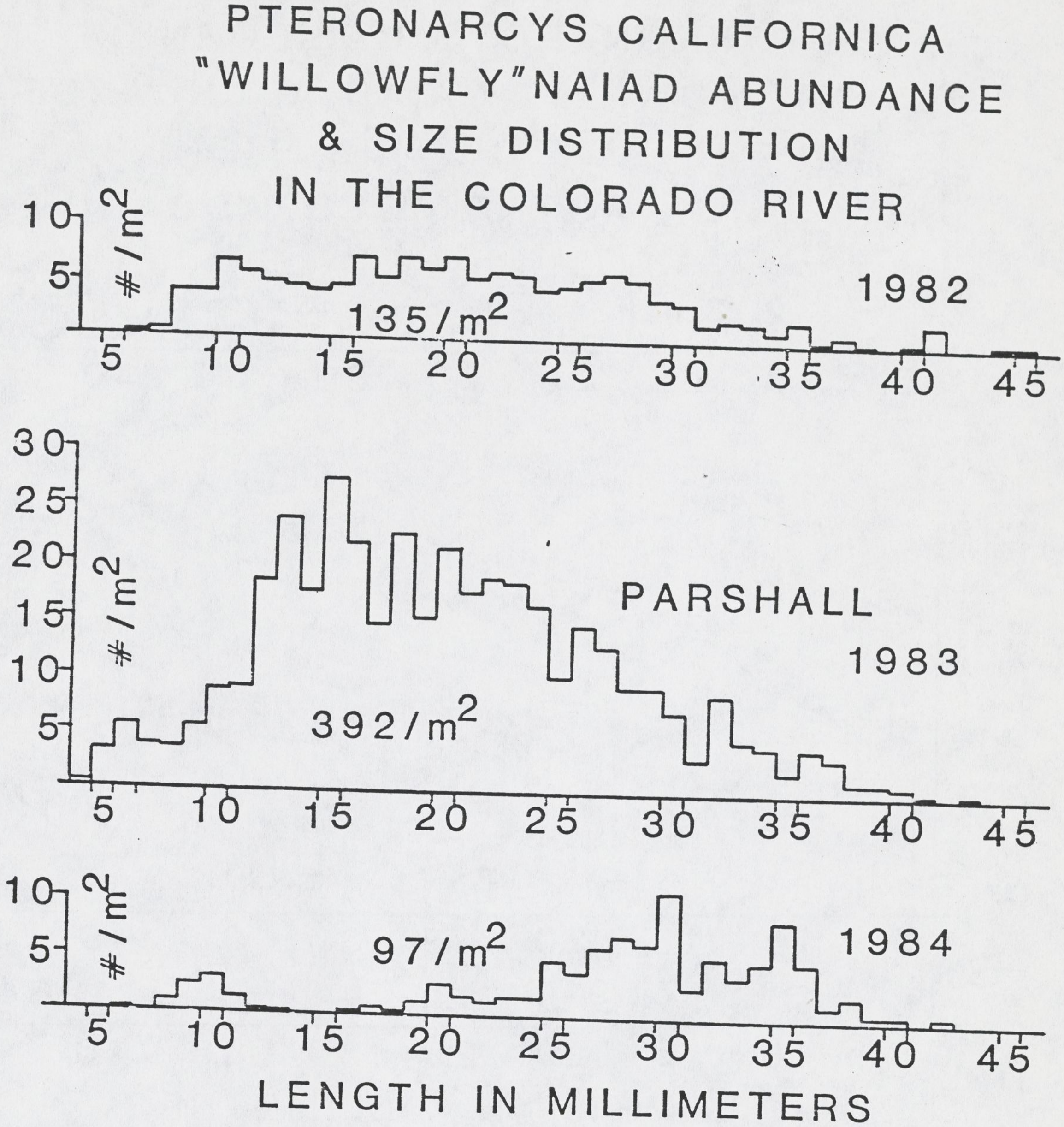


Figure V-9. Pteronarcys californica naiad abundance and size distribution/m^2 in the Colorado River near Parshall, 1982-84.

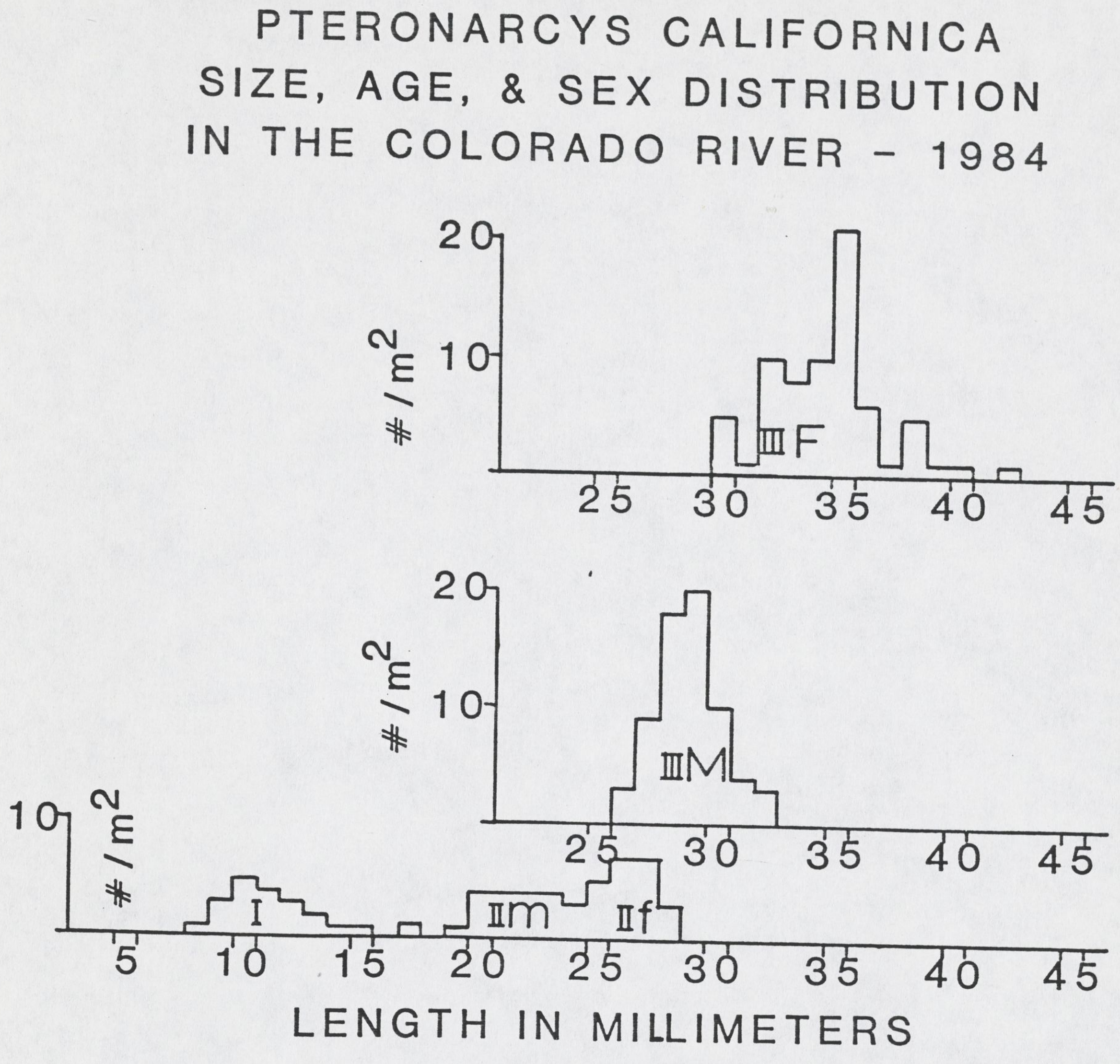


Figure V-10. Pteronarcys californica size, age, and sex distribution/m^2 in the Colorado River, 1984.

[1988]

STREAM FISHERIES INVESTIGATIONS

Federal Aid Project F-51-R

Job 1. Fish Flow Investigations

Job 2. Wild Trout Introductions

by

R. Barry Nehring
Wildlife Researcher

James B. Ruch, Director

Federal Aid in Fish and Wildlife Restoration

Job Progress Report

F-51

Colorado Division of Wildlife

Aquatic Research Section

Fort Collins, Colorado

July 1988

STATE OF COLORADO

Roy Romer, Governor

COLORADO DEPARTMENT OF NATURAL RESOURCES

Clyde O. Martz, Executive Director

COLORADO DIVISION OF WILDLIFE

James B. Ruch, Director
Ed Prenzlow, Deputy Director

Ed Kochman, State Wildlife Manager, Aquatic

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State: Colorado

Project No.: 02-01-131 Name: State Fish Research

Study No.: F-51 Title: Stream Fisheries Investigations

Period Covered: July 1, 1987 to June 30, 1988

Study Objective: To quantify the interrelationships, then determine and document, through professional publications, the impacts of special regulations, macroinvertebrate densities, flow regimes, and trout species introductions on established trout populations in selected major streams in Colorado.

Job No. 1

Job Title: Fish Flow Investigations

Job Objective: To quantify and document, through professional publication, the interrelationships between streamflow regimes and trout population dynamics on selected sections of the following streams: the Arkansas, Cache la Poudre, Colorado, Fryingpan, Gunnison, Middle Fork of the South Platte, Rio Grande, South Fork of the Rio Grande, South Platte, St. Vrain, and Taylor rivers.

INTRODUCTION

This job (during the current segment) is in a state of transition. Current documentation called for preparation of several reports and manuscripts as well as assisting regional biologists with set-up and analysis of IFIM/PHABSIM studies and making monthly minimum and optimum flow recommendations on 11 study streams.

A professional paper on the interrelationships between stream discharge, fry weighted usable area (WUA), and rainbow and brown trout year-class strength was given at the Western Division of the American Fisheries Society (WDAFS) meeting in Salt Lake City, Utah, in July 1987. The paper (Nehring and Miller 1987) is to be published in the WDAFS proceedings from that meeting.

A final report on the results of the IFIM/PHABSIM analyses completed on the 11 study streams has been completed and submitted under separate cover (Nehring 1988). That final report will serve as a rough manuscript for a paper on "field-proofing" the IFIM/PHABSIM methodology to be submitted to a major peer-reviewed journal during the 1988-1989 segment. The paper will be presented at the national AFS meeting in Toronto, Canada, in September 1988.

The primary purpose of this job progress report is to make monthly minimum and optimum flow recommendations on all study streams where we have completed IFIM/PHABSIM studies.

METHODS

Several important insights into the interrelationships between streamflow, trout habitat (by life stage), and trout population dynamics came out of the IFIM/PHABSIM studies. In most instances, the limiting life stage for both rainbow and brown trout was the fry. In a few instances, the spawning/incubation habitat was limiting. There were no instances where the data analysis indicated the weighted usable area (WUA) habitat values for the juvenile and adult life stages were limiting.

In light of the above general findings, minimum and optimum flow recommendations on a critical and seasonal period basis will be made for each of the study streams by life stage and species as follows:

1. Spawning/incubation/hatching
2. Two- to four-week-old fry
3. Juvenile
4. Adult

The flow recommendations for spawning, incubation, and hatching will be made as one minimum recommendation. Flows should not be allowed to fall (if at all possible) below the spawning level at any time during those three life stages. Reiser and White (1981, 1983); Becker, Neitzel, and Fickeisen (1982); Becker, Neitzel, and Abernethy (1983); and Neitzel and Becker (1985) made several salient points in evaluating the impacts of redd dewatering on salmonid reproductive success. Among other things, they found that redd dewatering for up to 8 hours or more for several days to weeks did not have a detrimental impact on egg and embryo survival as long as: 1) intra-gravel humidity levels were maintained at 100% saturation; and 2) maximum and minimum intra-gravel temperature extremes did not reach the lethal limit. These findings, however, applied only to the pre-hatching developmental period. Once hatching occurred, removal of intra-gravel water flows for even 1-3 hours resulted in heavy mortality for sac fry and intra-gravel dwelling alevins. Thus, to minimize the negative impacts of flow reductions due to either thermal shock and/or loss of intra-gravel flows during the post-hatching intra-gravel life stage, one minimum flow recommendation will be made. Fry, juvenile, and adult life stage flow recommendations will be made for both minimum and optimum conditions.

Trout population data and USGS gaging record information were used together with the IFIM/PHABSIM data to formulate the minimum and optimum flow recommendations. Post-emergent fry collections have been made on all of the study streams to define the critical fry emergence period (Table 1). Spawning, incubation, and hatching periods were defined from field observations and general biological information and life history characteristics.

The flow recommendations made in this report are meant to be realistic guidelines for protecting minimum and optimum flow and habitat requirements for the rainbow and/or brown trout populations within the stream study sections as defined in Table 2. The recommendations are not meant to be rigid limits that must be steadfastly adhered to. Rather, they are guidelines that should adequately protect the wild trout populations found in the study streams to a reasonable degree. The minimum flow recommendation for spawning, incubation, and hatching are the most critical of the recommendations. The critical time periods for spawning, incubation, and hatching occur to a large degree during the low flow periods when additional diversions and other man-induced flow reductions will often have dramatic negative impacts on the subsequent survival of the next trout year-class.

Table 1. Fry average size (mm), range, and time of collection by study stream.

Stream	Species	Date	Sample size (n)	Mean size (mm)	Standard deviation	Range (mm)
Arkansas River	Browns	05/25/88	19	33.3	5.30	23-46
Blue River	Browns	05/23/88	11	20.7	1.68	18-23
Cache la Poudre	Browns[a]	04/27/88	35	13.6	2.10	11-17
Cache la Poudre	Browns[a]	05/24/88	14	21.2	1.93	17-23
Cache la Poudre	Browns[b]	05/24/88	10	24.1	2.13	22-28
Cache la Poudre	Browns[a]	06/24/88	14	27.1	3.10	24-36
Cache la Poudre	Whitefish[a]	06/24/88	11	25.7	0.90	24-27
Cache la Poudre	Browns[b]	06/24/88	18	38.7	7.68	24-48
Cache la Poudre	Rainbows[b]	06/24/88	1	26.0	--	--
Colorado River	Browns[c]	05/23/88	9	24.4	1.42	23-27
Colorado River	Browns[g]	06/24/88	8	37.5	4.87	31-44
Colorado River	Rainbows[g]	06/24/88	9	28.3	4.72	23-36
Fryingpan River	Browns	05/23/88	20	23.8	1.25	22-27
Fryingpan River	Browns	06/28/88	2	32.5	13.40	23-42
Fryingpan River	Rainbows	06/28/88	15	24.3	1.16	22-27
Gunnison River	Browns	05/25/86	10	31.5	3.03	28-37
Gunnison River	Browns	06/06/86	15	34.7	5.30	25-44
Gunnison River	Browns	06/26/86	15	45.5	7.10	34-55
Gunnison River	Rainbows	06/26/86	23	27.7	4.73	24-37
Gunnison River	Browns	07/14/86	7	61.7	4.27	55-66
Gunnison River	Rainbows	07/14/86	32	35.1	6.81	24-46
Gunnison River	Browns	04/11/87	1	23.0	--	--
Gunnison River	Browns	04/11/87	2	26.0	1.41	25-27
Gunnison River	Browns	04/25/87	11	24.6	1.36	23-27
Gunnison River	Browns	05/09/87	9	26.8	2.47	24-32
Gunnison River	Browns	05/23/87	32	28.7	3.48	24-38
Gunnison River	Browns	06/03/87	19	32.9	4.48	28-42
Gunnison River	Browns	06/12/87	32	33.0	4.01	29-47
Gunnison River	Browns	06/19/87	21	33.7	5.66	24-47
Gunnison River	Browns	06/24/87	13	39.7	4.21	33-46
Gunnison River	Rainbows	06/12/87	2	25.5	2.12	24-27
Gunnison River	Rainbows	06/24/87	17	28.1	2.56	23-33
Gunnison River	Rainbows	06/27/87	12	26.2	2.55	24-31
Gunnison River	Browns	05/07/88	10	27.2	3.01	21-32
Gunnison River	Browns	05/28/88	20	31.0	3.80	24-39
Gunnison River	Browns	06/16/88	8	42.8	3.96	38-49
Gunnison River	Rainbows	06/16/88	15	25.3	2.09	23-30
Rio Grande River	Browns[d]	05/26/88	13	23.6	1.45	20-25
Rio Grande River	Browns[e]	05/26/88	5	25.0	1.73	24-28

Table 1. Fry average size (mm), range, and time of collection by study stream (concluded).

Stream	Species	Date	Sample size (n)	Mean size (mm)	Standard deviation	Range (mm)
Rio Grande River	Browns[d]	06/29/88	15	36.1	6.19	23-43
Rio Grande River	Browns[e]	06/29/88	38	31.3	3.66	23-39
Rio Grande River	Browns[f]	06/29/88	3	27.0	6.08	23-34
S. Fk. Rio Grande	Browns	06/29/88	33	26.2	3.25	20-32
St. Vrain	Browns	05/25/88	12	29.2	3.24	25-34
South Platte	Browns	05/12/88	9	24.4	1.33	22-26
South Platte	Browns	05/25/88	12	26.2	1.19	24-28
South Platte	Browns	06/20/88	14	37.7	3.12	34-46
South Platte	Rainbows	06/20/88	27	26.1	2.71	22-32
Taylor River	Browns	05/26/88	12	24.7	2.57	22-32

[a]Upper wild trout area (April sample--pre-swim-up sac fry).
[b]Lower wild trout area.
[c]Below Williams Fork confluence.
[d]State Bridge section.
[e]Coller Wildlife Area.
[f]Rio Grande Fisherman Area.
[g]Above Williams Fork confluence.

Table 2. Flow investigations stream study sections for minimum and optimum flow recommendations.

Stream	Counties	Upper terminus	Lower terminus
Arkansas River	Chaffee/Fremont	S. Fork-Arkansas River	Badger Creek
Blue River	Summit	Straight Creek	Slate Creek
Cache la Poudre River	Larimer	Little S. Fork-Cache la Poudre River	N. Fork Cache la Poudre River
Colorado River	Grand	Fraser River	Williams Fork River
Fryingpan River	Pitkin/Eagle	Rocky Fork Creek	Roaring Fork River
Gunnison River	Montrose/Delta	Crystal Dam	N. Fork Gunnison River
Middle Fork-South Platte	Park	Trout Creek	S. Fork S. Platte River
Rio Grande River	Mineral/Rio Grande	Willow Creek	S. Fork-Rio Grande River
St. Vrain River	Boulder	S. Fork-St. Vrain Creek	Left-hand Creek
S. Fork-Rio Grande	Mineral/Rio Grande	Park Creek	Beaver Creek
S. Platte River	Jefferson/Douglas	Cheesman Dam	Horse Creek
Taylor River	Gunnison	Spring Creek	East River

RESULTS AND DISCUSSION

Table 3 contains the minimum and optimum flow recommendations for each study stream by species and life stage with the critical time periods. Table 1 contains data on the average size (mm), standard deviation, and range of fry sizes by species and date of collection for each study stream. This information was critical to the definition of the hatching and emergence times on each study stream.

Table 3. Minimum and optimum flow recommendations for IFIM/PHABSIM study streams by time period, species, and life stage.

Species	Life stage	Critical Time period	Minimum Flow	Optimum Flow
		Arkansas River		
Brown	Spawning	10/15-11/15	200	400
Brown	Incubation	11/01-04/01	200	400
Brown	Hatching	03/01-05/15	200	400
Brown	Fry	04/01-06/01	200	400
Brown	Juvenile	06/01-10/15	200	400
Brown	Adult	12 months	200	400
		Blue River		
Brown	Spawning	10/15-11/15	50	--
Brown	Incubation	11/01-05/30	50	--
Brown	Hatching	04/01-06/01	50	--
Brown	Fry	05/20-07/01	50	100
Brown	Juvenile	07/01-10/15	50	100
Brown	Adult	12 months	50	100
Rainbow	Spawning	04/15-06/01	50	--
Rainbow	Incubation	04/15-07/01	50	--
Rainbow	Hatching	06/01-07/01	50	--
Rainbow	Fry	06/15-07/15	50	100
Rainbow	Juvenile	07/15-10/15	50	100
Rainbow	Adult	12 months	50	100
		Cache la Poudre River		
Brown	Spawning	10/15-11/15	50	--
Brown	Incubation	11/01-05/30	50	--
Brown	Hatching	04/01-06/01	50	--
Brown	Fry	05/20-07/01	50	50
Brown	Juvenile	07/01-10/15	50	100
Brown	Adult	12 months	50	100
Rainbow	Spawning	04/15-05/30	100	--
Rainbow	Incubation	04/15-07/15	100	--
Rainbow	Hatching	06/15-07/15	100	--
Rainbow	Fry	07/01-08/01	50	50
Rainbow	Juvenile	08/01-11/01	50	50
Rainbow	Adult	12 months	100	150

Table 3. Minimum and optimum flow recommendations for IFIM/PHABSIM study streams by time period, species, and life stage (continued).

Species	Life stage	Critical Time period	Minimum Flow	Optimum Flow
		Colorado River		
Brown	Spawning	10/15-11/15	125	250
Brown	Incubation	11/01-04/01	125	250
Brown	Hatching	04/01-06/01	125	250
Brown	Fry	05/15-06/15	125	125
Brown	Juvenile	06/15-10/15	125	200
Brown	Adult	12 months	125	200
Rainbow	Spawning	04/20-05/10	175	300
Rainbow	Incubation	04/20-06/15	175	300
Rainbow	Hatching	05/01-07/01	175	300
Rainbow	Fry	06/15-07/15	125	125
Rainbow	Juvenile	07/15-10/15	125	175
Rainbow	Adult	12 months	125	200
		Fryingpan River		
Brown	Spawning	10/15-11/15	65	100
Brown	Incubation	11/01-04/30	65	100
Brown	Hatching	04/01-05/30	65	100
Brown	Fry	05/15-06/15	50	100
Brown	Juvenile	06/15-10/15	50	100
Brown	Adult	12 months	50	100
Rainbow	Spawning	04/01-05/15	65	100
Rainbow	Incubation	04/15-06/15	65	100
Rainbow	Hatching	06/01-07/01	65	100
Rainbow	Fry	06/15-07/15	50	100
Rainbow	Juvenile	07/15-10/15	50	150
Rainbow	Adult	12 months	50	250
		Gunnison River (Black Canyon)		
Brown	Spawning	10/15-11/15	300	1,200
Brown	Incubation	11/01-04/01	300	1,200
Brown	Hatching	03/15-05/15	300	1,200
Brown	Fry	05/01-06/15	300	300
Brown	Juvenile	06/15-10/15	300	300
Brown	Adult	12 months	300	500
Rainbow	Spawning	04/01-05/15	300	1,000
Rainbow	Incubation	04/15-06/15	300	1,000
Rainbow	Hatching	06/01-07/01	300	1,000
Rainbow	Fry	06/15-07/15	300	300
Rainbow	Juvenile	07/15-10/15	300	300
Rainbow	Adult	12 months	300	500

Table 3. Minimum and optimum flow recommendations for IFIM/PHABSIM study streams by time period, species, and life stage (continued).

Species	Life stage	Critical Time period	Minimum Flow	Optimum Flow
		Middle Fork of the South Platte		
Brown	Spawning	10/01-11/15	20	60
Brown	Incubation	10/15-05/01	20	60
Brown	Hatching	04/01-06/01	20	60
Brown	Fry	06/01-07/15	20	20
Brown	Juvenile	07/15-10/15	20	40
Brown	Adult	12 months	20	60
		Rio Grande River		
Brown	Spawning	10/01-11/15	100	150
Brown	Incubation	10/15-05/01	100	150
Brown	Hatching	04/01-07/01	100	150
Brown	Fry	06/01-07/15	100	150
Brown	Juvenile	07/15-10/15	100	200
Brown	Adult	12 months	100	200
Rainbow	Spawning	04/20-05/15	200	500
Rainbow	Incubation	05/01-07/01	200	500
Rainbow	Hatching	06/15-07/15	200	500
Rainbow	Fry	07/01-08/01	100	300
Rainbow	Juvenile	08/01-10/15	100	300
Rainbow	Adult	12 months	200	300
		South Fork of the Rio Grande River		
Brown	Spawning	10/01-11/15	30	45
Brown	Incubation	10/15-05/30	30	45
Brown	Hatching	05/01-07/01	30	45
Brown	Fry	06/01-07/15	45	70
Brown	Juvenile	07/15-10/15	45	125
Brown	Adult	12 months	45	125
		St. Vrain River		
Brown	Spawning	10/15-11/15	20	40
Brown	Incubation	11/01-04/01	20	40
Brown	Hatching	03/15-04/15	20	40
Brown	Fry	04/01-05/15	20	60
Brown	Juvenile	05/15-10/15	20	80
Brown	Adult	12 months	20	60
		South Platte		
Brown	Spawning	10/15-11/15	50	100
Brown	Incubation	11/01-04/30	50	100
Brown	Hatching	04/01-06/01	50	100
Brown	Fry	05/01-06/15	50	50
Brown	Juvenile	06/15-10/15	50	150
Brown	Adult	12 months	50	150

Table 3. Minimum and optimum flow recommendations for IFIM/PHABSIM study streams by time period, species, and life stage (concluded).

Species	Life stage	Critical Time period	Minimum Flow	Optimum Flow
Rainbow	Spawning	04/01-05/15	100	150
Rainbow	Incubation	04/01-06/01	100	150
Rainbow	Hatching	06/01-07/01	100	150
Rainbow	Fry	06/15-07/15	50	50
Rainbow	Juvenile	07/15-10/15	50	150
Rainbow	Adult	12 months	100	225
		Taylor River		
Brown	Spawning	10/15-11/15	50	100
Brown	Incubation	11/01-05/01	50	100
Brown	Hatching	04/01-06/01	50	100
Brown	Fry	05/15-07/01	50	50
Brown	Juvenile	07/01-10/15	50	200
Brown	Adult	12 months	50	250

Arkansas River

Minimum flows for all brown trout life stages in the Arkansas River (Table 3) within the study section is 200 cfs and the optimum is 400 cfs. The only time (in the past 20 years) that the minimum flow (at the Wellsville gage (within the study area) was less than 200 cfs was in 1977, the near record low water year. The 400 cfs optimum flow is met or exceeded the majority of the time. Therefore, both the minimum and optimum flow recommendation for the Arkansas River (Table 3) should be targets the water management agencies should be able to maintain almost all of the time. The data in Table 1 indicates the brown trout in the Arkansas River (on May 25th) are the largest fry (on average) of any group from any study stream in any year. They also had the widest range in size of any stream (in late-May) which indicates their hatching and emergence in the Arkansas River is spread over perhaps a 2-month period, i.e., April-May.

Blue River

Minimum and optimum flow recommendations for both rainbow and brown trout in the Blue River are 50 cfs and 100 cfs, respectively, for all life stages (Table 3). According to flow records for the Blue River below Dillon Dam, the minimum flow recommendation of 50 cfs has been violated in 12 years since 1965 and 10 times in the past 10 years. Flow reductions below 20 cfs for a week or more during the critical winter-early spring brown egg incubation and hatching period have been commonplace occurrences since 1977. Since the Denver Water Department (DWD) operates Dillon Dam, these dramatic flow reductions clearly indicate the cavalier attitude of the DWD towards the needs of aquatic wildlife and other recreation uses and users of water in streams. Flows in the Blue River below Dillon Dam have been dropped to the 9-18 cfs range every year from 1976 through 1985! These reductions have almost invariably occurred from October through April during the critical winter period when all life stages of the brown trout are largely (if not totally) immobile in the gravel and very susceptible to freezing during dewatering operations.

Cache la Poudre River

Minimum flow recommendations for brown trout in the Cache la Poudre River are 50 cfs for all life stages, while optimum flows for juvenile and adult brown trout is 100 cfs. Spawning, incubation, and hatching minimum flow recommendations for rainbow trout are 100 cfs, while fry and juvenile rainbow minimum flows are 50 cfs. The adult rainbow minimum flow needed is 100 cfs, with an optimum of 150 cfs. While the minimum flow recommendations for rainbows are double those of browns for many life stages (see Table 3), they are flows that are almost always in the river for the spring-summer spawning, incubation, and hatching life stages under any sort of hydrological regime. The year-round adult rainbow minimum flow recommendation of 100 cfs is a flow level that is not currently met during the winter months in any year.

Colorado River

Minimum flow recommendations for brown trout in the Colorado River for all life stages are 125 cfs, while optimum flows vary from 125 to 250 cfs, depending upon life stage. Minimum flows for rainbow spawning, incubation, and hatching are 175 cfs, while minimum flows for fry, juvenile, and adult rainbows are 125 cfs. Optimum flows for rainbow trout (depending upon life stage) range from 125 to 300 cfs (Table 3).

Examination of the flow records for the Colorado River at Hot Sulphur Springs reveal that most of the minimum flows and, in many instances, the optimum flows for rainbow trout are met most of the time in the majority of calendar years. The adult rainbow trout optimum flow of 200 cfs is the only life stage that is significantly violated in the late summer to early spring (September-March) period in most years.

In contrast to the rainbows, minimum flows for brown trout spawning, incubation, and hatching are almost never met. Using the 125 cfs minimum flow recommendation and applying it as the standard, the records show that there were only 12 months out of 154 possible for the September-March period from October 1964 through September 1986 when the mean monthly flow for brown trout was reached only 7.8% of the time for the September-March period. Eight of those 12 months have come in the 1983-85 period, the direct result of the incredibly high water years in 1983 and 1984.

Table 4 shows the comparison between the mean monthly discharge from 1905 through 1945 (essentially pre-Granby Reservoir-Big Thompson Project) and 1964-1985 (the current operational scenario for the Colorado River at Hot Sulphur Springs. It should be noted, however, that the additional drain put on the Colorado River (at Hot Sulphur Springs) by the Windy Gap Dam and Diversion Project, as of 1985, is not reflected in the data. Given these statistics, it is obvious that the Colorado River should not be dewatered further.

Table 4. Mean monthly discharge (cfs) of the Colorado River at Hot Sulphur Springs, pre (1905-1945) and post (1964-1985) Big Thompson Project.

Mean monthly discharge	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1964-85	72	73	100	254	697	919	513	164	89	89	85	75
1905-45	103	102	143	499	1845	3110	1200	434	246	225	152	115
1964-85[a]	30.1	28.4	30.1	49.1	62.2	70.5	57.3	62.2	63.8	55.3	44.1	34.8

[a]Percent reduction from 1905-45 average

Rainbow trout have a three- to sevenfold advantage over brown trout in the spawning, incubation, and hatching arena (Nehring 1986). Thus, it is not too difficult to understand why the trout fishery in the upper Colorado River is the only one in the state where wild rainbows have dominated brown trout in numbers and density without the aid of a special protective angling regulations. It is also a classic example of the detrimental impacts of excessive dewatering of streams by impoundments and transmountain diversions. Ward (1984) indicates the annual flow of the upper Colorado River near Granby, Colorado, was reduced 91% with the construction and operation of Granby Reservoir.

Fryingpan River

Minimum flows for rainbow and brown trout for spawning, incubation, and hatching in the Fryingpan River are 65 cfs, while optimum flows for the same life stages are 100 cfs. Minimum flows for the fry, juvenile, and adult life stages are 50 cfs for both rainbow and brown trout. Optimum flows for fry, juvenile, and adult brown trout are 100 cfs. Optimum flows for fry, juvenile, and adult rainbow trout are 100, 150, and 250 cfs, respectively.

Ruedi Reservoir has controlled the flows in the Fryingpan River since May 1968. The impacts of impoundment and flow regulation of the Fryingpan River, as a result of Ruedi Reservoir, stand in stark contrast to the impacts of Granby Reservoir and other transmountain diversions on the Colorado River. Since October 1970 there have been only 21 months of 192 (82% of the time) when a minimum flow of 100 cfs was not met. There have been only 6 months out of 192 (a mere 3% of the time) when a minimum flow of 50 cfs has not been the mean monthly discharge in the Fryingpan River. The U.S. Bureau of Reclamation personnel that operate Ruedi Reservoir as a part of the Fryingpan/Arkansas Project, have done a phenomenal job of maintaining flows in the Fryingpan River to optimize the stream trout fishery that has developed there over the past two decades. In my estimation, their record of cooperation and concern for the best interests of the Fryingpan River aquatic resource is unparalled in Colorado in the 20th Century.

Gunnison River

The minimum flow recommendation for all life stages of rainbow and brown trout are 300 cfs. This flow provides good to excellent habitat conditions for virtually every life stage of both trout species. Discharge levels below 300 cfs begin to cause dramatic reductions in spawning habitat for both rainbow and brown trout as well as significant decreases in total wetted surface area.

Optimum flows for brown and rainbow trout spawning, incubation, and hatching are 1,200 and 1,000 cfs, respectively. These flows provide access to extensive higher elevation spawning beds composed of optimum-sized gravels that are not available at lower flows. The 300 cfs minimum and optimum flow is also recommended for rainbow and brown trout fry and juvenile life stages.

The optimum flow recommendation for adult rainbow and brown trout is 500 cfs.

Water and power management agencies (U.S. Bureau of Reclamation [USBR] Uncompahgre Valley Water User's Association [UVWUA] Western Area Power Administration [WAPA]) have become acutely aware of the public interest that has developed concerning the world-class trout fishery in the Black Canyon of the Gunnison in the 1980's. This awareness has resulted in much more attention and care being taken by these management agencies to minimize the timing, duration, and magnitude of flow fluctuations on the Gunnison River. As a result of this attention to detail, we have three consecutive very strong year-classes (1986-1988) of both rainbow and brown trout in the Gunnison Gorge.

Middle Fork of the South Platte River

Brown trout are the only viable resident wild trout species in this river above Spinney Mountain Reservoir at the present time. Minimum flow recommendations for all life stages of brown trout are 20 cfs, while optimum flow recommendations vary from 20 to 60 cfs, depending upon the life stage (Table 3). The lack of a USGS gage and discharge records for this section of river precludes any evaluation of how often the minimum and optimum flow recommendations can realistically be met.

Rio Grande River

Minimum flow recommendations for all life stages of brown trout are 100 cfs, while optimum flow recommendations range from 150-200 cfs, depending upon life stage (Table 3). Minimum flow recommendations for rainbow spawning, incubation, hatching, and adult life stages are 200 cfs versus 100 cfs for rainbow fry and juvenile life stages.

Optimum flow recommendations for brown trout range from 150-200 cfs, compared to 300-500 cfs for rainbow trout, depending upon the life stage. Examination of the flow records for the Wagon Wheel Gap USGS gage indicate that the minimum flow recommendations can be met in most months of most years. The minimum flow of 100 cfs has been met or exceeded in every month since October 1979. Thus, water management agencies should have little problem in maintaining this minimum flow most of the time under present operational patterns.

South Fork of the Rio Grande River

Brown trout are the only resident wild trout species that currently exists in the South Fork of the Rio Grande below the confluence with Park Creek. Minimum flow recommendations for brown trout spawning, incubation, and hatching are 30 cfs, while 45 cfs is the minimum for fry, juvenile, and adult life stages. Optimum flow recommendations range from 45-125 cfs, depending upon life stage (Table 3).

Examination of the flow records for the USGS gage on the South Fork of the Rio Grande (SFRG) at South Fork, Colorado, for 1964-85 indicate that the minimum flow of 30 cfs for spawning, incubation, and hatching has been maintained in most years and in every year since 1979. Similarly, the optimum flow regimes of 45-125 cfs are maintained in most months of most years, except during the fall-early spring periods (October-March). It is not surprising that the brown trout density and biomass in the South Fork of the Rio Grande River has remained as consistently high as it has. Year-class strength is determined primarily by the amount of fry habitat during June, the month of brown trout fry emergence on the SFRG (Nehring and Anderson, 1984). Barring any unforeseen water development projects in the basin that drastically alters the flow regime, the brown trout fishery in the SFRG should remain a valuable asset and "drawing card" for the tourist industry in the South Fork area.

St. Vrain River

Similar to the SFRG, brown trout are the only resident wild salmonid species in the St. Vrain River within the study area. The minimum flow recommendation for all life stages of brown trout is 20 cfs. Optimum flow recommendations range from 40-80 cfs, depending upon life stage (Table 3).

Examination of the USGS gage records for the St. Vrain River at Lyons, Colorado, indicate that the minimum flows drop below 20 cfs with regularity during the winter-early spring period. Minimum flows have occasionally dropped to catostrophically low levels, such as during the drought year of 1976-77 when mean monthly discharge never exceeded 10 cfs from December 1976 through March 1977. We have observed very high levels of mortality on adult brown trout between age 3 and 4 on the St. Vrain River from 1978 through 1981 (Nehring and Anderson 1985). Temperature records indicate that water temperature at the study site should not be limiting to brown trout. Thus, it is quite possible that flow-induced reductions in adult trout winter habitat may be limiting the adult brown trout component of the trout populations. Adult brown trout are the most cover-oriented trout species (Butler and Hawthorne 1968) and are susceptible to dewatering of under-cut banks and areas of over-hanging vegetation along the channel perimeter. This trout population did not respond to a catch-and-release regulation imposed on the fishery for approximately 5 years. Nehring and Anderson (1985) hypothesized that a lack of adult brown trout habitat associated with adequate cover (such as pools or overhead cover) was probably limiting this trout population.

South Platte River

Minimum flow recommendations for all life stages of brown trout are 50 cfs, while optimum flow recommendations for brown trout range from 50-150 cfs, depending upon the life stage. Minimum spawning, incubation, hatching, and adult flows for rainbow trout are 100 cfs, while 50 cfs is the minimum flow recommendation for rainbow fry and juvenile life stages. Optimum flow recommendations for rainbow trout range from 50-225 cfs for the various life stages. See Table 3 for details.

Maintenance of reasonable minimum flows during the most vulnerable life stages (spawning, incubation, hatching, and fry) are of paramount importance in maintaining thriving rainbow and brown trout populations in the South Platte River below Cheesman Reservoir, which is owned and operated by the Denver Water Department (DWD) as part of its water storage and supply system. However, maintenance of stable minimum flows for trout (or any other sort of recreation) has not been the hallmark of the DWD's flow management regime in the South Platte River.

The DWD would like the environmental community, angling groups, and the Colorado Division of Wildlife to believe that their water management plan and Cheesman Dam, in particular, are the primary reasons for the gold medal trout fishery that exists in Cheesman Canyon. However, nothing could be further from the truth. Rather, the catch-and-release regulation implemented on the Cheesman Canyon section of the South Platte in 1976 is the primary reason for the development of the world-class trout fishery. Tanner (1954) found that the average size of rainbow and brown trout caught in Cheesman Canyon was 11.9 inches and 10.4 inches, respectively. Anglers harvested an estimated 390 pounds of trout per mile in a 90-day period, which is a harvest estimate of about 50 pounds/acre in a 90-day period. Under the present catch-and- release regulation, the average size of rainbow trout in the population has been in the 13-14-inch range, while the browns average about 12 inches in the population. Total estimated catch in 1954 from June 15 through September 15 was 2,352 for 8,751 hours of angling effort. Thus, total catch-per-man-hour (CPMH) was 0.27. A creel census in Cheesman Canyon for June-September 1986 (Nehring 1987) revealed anglers caught an estimated 39,900 trout while angling for 34,600 hours of effort for an average CPMH of 1.15. The operation of Cheesman Reservoir by the DWD has not changed measurably between the 1950's and 1980's, but the management of the Cheesman Canyon fishery has with the implementation of catch-and-release angling regulations in 1976. Anglers caught an estimated 46,600 trout 12 inches and larger and 12,700 trout 15 inches and larger in the Cheesman Canyon section of the South Platte River from May through September 1986 (Nehring 1987).

In the eventuality that Two Forks or some alternative Two Forks is built, whatever portion of the South Platte below Cheesman Reservoir remains a free-flowing stream should be protected with true minimum flow requirements that are adhered to by the DWD. Examination of the USGS discharge records reveal the way in which the DWD operates Cheesman Reservoir. Flows are operated totally towards maximization of the water yield and benefit of the DWD's water supply system. Winter flows regularly drop into the 20 cfs range, periodically to less than 10 cfs. April spawning flows for rainbows often are as high as 300-400 cfs and then flows are reduced to 30-60 cfs during the incubation and hatching period. That was the modus operandi in 1981, 1982, and again in 1988. The trout fishery that exists in the South Platte below Cheesman Dam is as good as it is because of restrictive angling regulations. These regulations effectively reduce the harvest by about 95% or more, thus preserving older, larger fish for several years that are then available for spawning and successful reproduction when conditions are optimum, usually by accidental coincidence.

However, with meaningful minimum flow levels that are maintained during the spawning, incubation, hatching, and emergence periods fishing in the South Platte River would be even more consistent and better than it is now. At present, successful reproduction takes place largely by accident by the incidental convergence of natural hydrologic patterns and the DWD's operational pattern of Cheesman Reservoir. Typically, we have observed one strong rainbow year-class about once every 5 years, i.e., 1976, 1977, 1982, and a moderately good one in 1986. Clearly, it could be much better with some attention to detail during the critical April-June period.

Taylor River

Brown trout are the only viable wild trout population in the Taylor River. The minimum flow for all life stages of brown trout is 50 cfs, while optimum flows range from 50-250 cfs depending upon time and critical life stage(s). The recommendations by life stage are contained in Table 3.

Since 1977, the USBR and UVWUA have done an excellent job of flow management out of Taylor River Reservoir that has dramatically improved the brown trout density and biomass in the Taylor River (Nehring, Anderson, and Winters 1983). The agreements to stabilize releases out of Taylor Reservoir prior to the onset of brown spawning in late October each year since 1976 has resulted in statistically significant increases in brown trout density. Brown trout density increased by 90% during the flow-stabilization period of evaluation (1979-82) over the pre-stabilization period of 1974-75 (Nehring 1988).

CONCLUSIONS

A few pertinent points need to be made in summary. First of all, the minimum flow recommendations made in this report (Table 3) are just that. It should not be construed that these minimum flow recommendations are safe levels for constant low-flows on a long-term basis, i.e., a year or more. Rather, they should be interpreted as short-term flow recommendations that will adequately protect the trout population through the various critical life stages. Second, even the optimum flows for trout are just recommendations. Optimum trout flows cannot be construed as being optimum flows for the total aquatic stream ecosystem. Without periodic flushing flows, for example, riffle areas will eventually become choked with organic and inorganic debris and the food producing capability of the stream will be jeopardized. I feel we can assume that the optimum flows have a high probability of protecting the total aquatic stream ecosystem for a long period of time (years) quite well. The optimum flows could more realistically be considered targets or guidelines for water resource management agencies to shoot for on a planning and operations basis.

Finally, these minimum flow recommendations are meant to be used as guidelines in deriving minimum flow recommendations for the Colorado Water Conservation Board. However, they apply only as guidelines and only for the stream segments as outlined in Table 1. Fine-tuning, in many cases upwards, might be biologically justified by area and regional biologists with a more intimate and thorough working knowledge of the riverine resources referred to in this report that lie within their respective area(s) of responsibility.

Study Title: Stream Fisheries Investigations Job No. 2

Job Title: Wild Trout Introductions

Job Objective: To establish, then quantitatively describe, wild rainbow trout populations in the upper Gunnison (Almont to Gunnison), Rio Grande (above Creede to Del Norte), Animas (at and downstream from Durango), and Blue rivers (between Dillon and Green Mountain reservoirs).

Period Covered: July 1, 1987 through June 30, 1988

INTRODUCTION

New documentation was written for Federal Aid Project F-51 (Stream Fisheries Investigations) to cover a 5-year study plan from July 1, 1987 through June 30, 1992. Under the old documentation (1982-87) the study entitled, "Wild Trout Introductions," was designed as Job 4. Under the new documentation (1987-92), this job is designated as Job 2. The number of study streams has been expanded from one, the Rio Grande River, to four. The three streams added to the study are the Blue, upper Gunnison, and Animas rivers, as shown in the job objective.

Electroshocking surveys on some of the larger trout streams, such as the Rio Grande and Arkansas rivers, have shown brown trout to be the dominant species of salmonid almost to the exclusion of other salmonids such as the rainbow. Yet, our studies on many other streams where special regulations (Nehring 1987) have been used to protect the vulnerable rainbow stocks from over-harvest by anglers, reveal that rainbow populations will actually thrive, and in many cases, outcompete and outproduce brown trout. We have observed dramatic changes from brown trout dominance in streams managed under an eight trout/day angling limit to rainbow dominance 3-5 years after imposition of restrictive angling regulations. Rainbow trout become numerically superior to the browns in biomass, density, and numbers of quality size (35 cm or 14 in.) trout. Rainbows also provide a catch rate from 3-5 times greater than the brown trout on a per fish basis.

The objectives of Colorado's Gold Medal Trout Management program are threefold:

1. Maintain trout biomass at 45 kg/ha (40 lb/ac).

2. Maintain quality trout density ($\geq$35 cm or 14 in.) at 30/ha (12/ac) on a sustained basis.

3. Maintain total catch-per-man-hour (CPMH) at 0.7 trout/hour or higher.

With these objectives in mind, it is almost a necessity that our gold medal waters be managed with a rainbow coexisting in sympatry with the brown trout. The second and third objectives are difficult to meet on a sustained basis with allopatric brown trout populations.

METHODS AND MATERIALS

Wild rainbow trout have been spawned in the Colorado River every spring since 1981. Annual egg-takes from this operation have ranged between 40,000 and 80,000. Eggs have been incubated, hatched, and reared to fingerling size at four different hatcheries over the past 6 years; however, for the past 4 years, the eggs have been taken to the Bellvue Research Hatchery and Roaring Judy rearing units. Progeny from the Research Hatchery are being used to establish a brood stock of the Colorado River rainbows (CRR).

With the expansion of the study rivers from one (the Rio Grande) to four, including the Animas, Blue, and upper Gunnison rivers, the decision was made to use a strain of rainbow referred to as the Tasmanian rainbow (TAS) in conjunction with the Colorado River rainbow (CRR) as an additional study species. While the overall objective of the study is to establish "wild" rainbow populations in the four study rivers, a sub-objective of the study is to determine if a domesticated hatchery rainbow strain, such as the TAS, will perform equally well over the long-term in natural stream environments, or does a truly wild CRR strain outperform all other rainbow strains. Since we know that TAS rainbows worked very well in the Fryingpan River (Nehring 1987), the decision was made to use the TAS strain as the "domestic" fingerling rainbow stock in this experiment.

Population estimates are made once each year to evaluate the growth and survival of the CRR and TAS rainbow plants, as well as the density and biomass of the resident brown trout populations. Boat electroshocking techniques are employed on the large rivers in the study (Animas, upper Gunnison, and Rio Grande rivers) while walk shocking techniques are used on the smaller Blue River. Since none of the four study streams have an endemic rainbow populations, all rainbow stocks are of hatchery origin. The annual plants of rainbow fingerlings are separated on the basis of different fin clips and age/growth analysis using scale reading and back-calculated length analyses.

Table 5 contains the Animas River stocking history information by study section, species, numbers, sizes, marks, and stocking date.

The Blue River received two plants of rainbow fingerlings in late August, early September 1987. The plants consisted of 9,000 CRR rainbows from the Fish Research Hatchery that averaged 5 cm (1.97 in.) in size, were unmarked, and planted August 31st. The Blue River was also stocked with 25,000 TAS strain rainbow fingerlings that were marked with an adipose fin-clip. These fingerlings averaged 8.38 cm (3.3 in.) in size and were also planted on August 31st. All fingerlings were point stocked out of the hatchery trucks.

Table 5. Animas River "Wild Trout Introductions Study" fingerling stocking records, 1981-87.

Date of plant	Strain	Numbers	Average size cm	Average size inches	Marks	Number/ha
		Animas River #1 (Purple Cliffs section)				
05/81	Browns	21,750	5.18	2.04	None	1,843
06/82	Browns	15,000	5.61	2.21	None	1,271
07/82	Browns	17,028	4.93	1.94	None	1,443
07/83	Browns	10,048	6.00	2.36	None	852
07/84	Browns	12,700	5.92	2.33	None	1,076
08/85	Browns	14,337	7.47	2.94	None	1,215
08/86	Browns	8,100	11.40	4.50	Adipose	686
08/87	Browns	9,990	9.65	3.80	Adipose	847
08/87	TAS	10,000	8.71	3.43	None	847
		Animas River #2 (32nd Street Bridge to Highway 160 Bridge				
05/81	Browns	21,750	5.18	2.04	None	1,647
06/82	Browns	15,000	5.61	2.21	None	1,136
07/82	Browns	17,028	4.93	1.94	None	1,290
07/83	Browns	10,048	6.00	2.36	None	761
07/84	Browns	12,700	5.92	2.33	None	962
08/85	Browns	14,337	7.47	2.94	None	1,086
08/86	Browns	8,100	11.40	4.50	Adipose	614
08/87	Browns	9,990[a]	9.65	3.80	Adipose	757
08/87	TAS	10,000[a]	8.71	3.43	None	758

[a]These fingerling were hand-stocked and distributed out of a Jon boat floating through the section. All others were point stocks or dumps from stocking truck.

The upper Gunnison River from Almont to Rocky River Resort has been stocked with fingerling rainbows of various strains, numbers, and sizes since 1985, as shown in Table 6. The strains stocked include Hot Creek (California) rainbows (HCC), Bellaire (BELL) strain rainbows, and CRR and TAS strains of rainbows.

The rainbow fingerling stocking history for the three study areas of the Rio Grande River are shown in Table 7.

Table 6. Upper Gunnison River "Wild Trout Introductions Study" fingerling stocking records, 1985-87.

Date of plant	Strain	Numbers	Average size cm	Average size inches	Marks	Number/ha
09/04/85	HCC	10,000	16.50	6.5	Adipose	364
09/23/86	BELL	10,000[a]	12.40	4.9	Adipose	364
09/23/86	CRR	12,500[a]	5.08	2.0	None	455
08/28/87	TAS	25,000[a]	8.38	3.3	Adipose	909
08/28/87	CRR	25,000[a]	5.00	1.97	None	909

[a]All boat stocked except the 1985 plant of HCC rainbows.

Table 7. Rainbow trout stocking history for the Coller, State Bridge, and Rio Grande fishery area (above Creede) of the Rio Grande, 1984-87.

Date of plant	Planting method	Strain	Numbers	Average size cm	Average size inches	Marks	Number/ha
		State Bridge section (50 ha)					
10/22/84	Boat	CRR	10,000	5.3	2.1	None	198
09/11/85	Boat	HCC	10,000	15.5	6.1	Adipose	198
09/25/85	Boat	CRR	16,000	5.1	2.0	None	317
08/06/86	Boat	CRR	2,316	21.1	8.3	LP	46
09/24/86	Boat	BELL	10,000	12.5	4.9	Adipose	198
08/27/87	Boat[a]	CRR	23,250	11.2	4.4	Adipose	465
08/27/87	Boat[a]	TAS	23,250	8.13	3.2	None	465
		Coller Wildlife area (16.3 ha)					
10/22/84	Truck	CRR	6,000	5.3	2.1	None	368
09/11/85	Truck	HCC	6,000	15.5	6.1	Adipose	368
09/25/85	Truck	CRR	8,400	5.1	2.0	None	515
09/25/86	Truck	CRR	6,000	5.8	2.3	None	368
09/24/86	Truck	BELL	6,000	12.5	5.0	Adipose	368
08/27/87	Boat	CRR	9,300	11.2	4.4	Adipose	570
08/27/87	Boat	TAS	9,300	8.13	3.2	None	570
		Rio Grande fisherman area (15.3 ha)					
09/25/86	Boat	CRR	13,300	5.8	2.3	None	869
08/27/87	Truck	CRR	13,950	11.2	4.4	Adipose	911
08/27/87	Truck	TAS	13,950	8.13	3.2	None	911

[a]Approximately one-third of the trout were boat shocked in the upper one-third of the section while two-thirds were point stocked at two points approximately one-half and three-fourths of the distance through the section.

RESULTS AND DISCUSSION

Animas River

The Animas River running through Durango has had no documented natural reproduction of trout of any species for many years. Any number of factors (or combinations of factors) including siltation, sewage pollution, or heavy metal toxicity could be the reason(s) for the lack of reproduction. The Colorado Division of Wildlife (CDOW) has managed this river for most of the past decade with a mix of catchable rainbows augmented by large annual plants of Snake River cutthroat trout (SRN) and brown trout fingerling plants.

After several years under this management plan, it was determined that survival of the brown trout fingerling plants was much better than the SRN plants. In particular, the survival of larger brown fingerlings (10 cm or 4 in. average size) appeared to be much better and more cost effective than 2-inch (5 cm) fingerling plants (Nehring 1986). As a result of these preliminary investigations, it was decided to include the Animas River as an additional stream in this study beginning in 1987. CRR and TAS rainbow fingerling plants were to be included in the evaluation together with the continued plants of brown trout fingerlings, as shown in Table 5.

The data in Table 8 contains the population estimates for all unmarked brown trout for both stations (Animas 1 and 2) combined since 1981. The highest densities recorded (for brown trout at age 1+) prior to the time when the sizes of the fingerlings stocked were increased were in 1982 and 1984, when the age 1+ brown estimates were 711 and 757, respectively. Nehring (1986) reported that 75-90% of the 711 age 1+ browns captured in 1983 were from a plant of 2,088 brown fingerlings that ranged in size from 7.6-15.2 cm (3-6 in.), while those from the 1984 plant averaged 5.9 cm (2.33 in.) at stocking. The age 1+ survivor's estimate from the 1985 plants were 1,071 from a plant that averaged 7.47 cm (2.94 in.) in length and were the largest brown fingerlings planted up through 1985 (Tables 5 and 8).

Table 8. Animas River brown trout life table 1977-87 from 32nd Street Bridge to Purple Cliffs for unmarked browns.

Year/ date	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977
12/81[a]						116	444	236	45	3
11/82					711	354	369	123	30	0
12/83[a]				271	484	204	64	2	0	
12/85			25	78	242	116	46	8		
12/86		1,071	757	236	274	184	78	11		
12/87	31	86	237	138	35	30	2	0		

[a]1981 and 1983 estimates went only from Durango Hatchery to Purple Cliffs; thus, estimates are probably low when compared to 1982 and 1985.

Beginning in 1986 and continuing through 1987, the average size of the brown fingerling plants were increased to approximately 10 cm (4 in.) in an effort to further increase the survival rate. In addition, both the 1986 and 1987 plants were given an adipose clip to discover once and for all what portion of the brown trout population was coming from natural reproduction, either in the Animas River proper or side tributaries such as Hermosa Creek. As shown in Table 8, estimated density of unmarked browns from the 1986 year-class captured during the December 1987 electroshocking operation was 31 for the entire section. In contrast, the estimate of adipose-clipped brown trout from the 1986 plant was 958. Thus, out of a total estimate of 989 brown trout from the 1986 year-class, 97% (958) were from the adipose-clipped hatchery plant and 3% (31) were from unknown sources.

The population estimates for the 1987 plant of adipose-clipped brown trout for Animas 1 and 2 were 62 and 1,351, respectively. The 1987 plant of adipose-clipped brown trout averaged 14.7 cm and ranged in size from 11 cm to 20 cm. They averaged 9.65 cm when stocked in late August 1987. The average increase in length was 5.09 cm in slightly more than 90 days after stocking. One hundred percent of all browns under 20 cm in length sampled in December 1987 were adipose-clipped.

Tasmanian (TAS) rainbow fingerlings were also stocked in the Animas River (sections 1 and 2) in late August 1987. These fingerlings were not marked and averaged 8.71 cm in length at stocking. They ranged in size from 11-21 cm total length and averaged 16.3 cm. Population estimates for the TAS rainbows for the Animas River, sections 1 and 2, were 116 and 1,324, respectively. Reiterating, the population estimates for the 1987 adipose-clipped plants of brown trout fingerlings were 62 and 1,351 for Animas River sections 1 and 2, respectively. If the sections were stocked with equal numbers of both species as shown in Table 5, what could be the explanation for the poor survival of the fingerlings planted in section 1 of the Animas River? The most likely explanation is that those stocked in section 2 were hand-stocked in small numbers evenly throughout the entire reach out of a Jon boat. In contrast, those fingerlings stocked in section 1 were planted out of hatchery trucks at fewer distribution points and much higher densities at each point. This technique probably leads to high losses to predation by larger brown trout and/or avian predators such as king fishers and mergansers. Heavy predation losses to brown trout were noted in the fingerling plants made on the Coller Wildlife area of the Rio Grande in both 1985 (Nehring 1986) and in 1987.

It is gratifying to see that both rainbow and brown trout fingerlings stocked in the Animas River in 1986 and 1987 are surviving at least as well as expected, if not better.

Blue River

The Blue River (between Dillon and Green Mountain reservoirs) was first stocked with fingerling rainbows (both CRR and TAS strains) in late-August 1987. Due to their small size at stocking, the slow growth rates in the Blue River (high elevation and cold water temperatures), and only 45 days between stocking and our population estimates, no population estimates were possible. However, we did collect some fingerlings of both (CRR and TAS) strains at the three electroshocking sites in October 1988. A few were also collected in late-April 1988 while electroshocking under the I-70 overpass in Silverthorne. We should get some indication of survival in October 1988 when the average size should be in the 12-15-cm range.

Gunnison River

An 8-km (5 miles) section of the upper Gunnison River has received heavy plants of three hatchery strains of rainbow, and one wild (CRR) strain rainbow since the late summer of 1985. The fingerlings stocking history was given in Table 6. The HCC strain rainbows stocked in 1985 had totally disappeared by September 1986, with an estimated survival of 0.11% one year after stocking. This was the identical survival of the HCC strain in the State Bridge (SB) section of the Rio Grande, while survival of the HCC strain in the Coller Wildlife Area (CWA) section of the Rio Grande was only 0.017% (Nehring 1987).

In September 1986, this 8-km section of the upper Gunnison was stocked with 10,000 adipose-clipped Bellaire (BELL) strain rainbows which averaged 12.4 cm (4.9 in.) at stocking. In addition, 12,500 CRR strain rainbows averaging 5 cm (2 in.) were also stocked the same day. Results of the 1987 electroshocking of the upper Gunnison River stations as well as comparative data from 1985 through 1987 are given in Table 9.

Table 9. Upper Gunnison River trout standing crop (15 cm and larger) estimates, September 1985-87.

	1985	1986	1987
Almont to Lost Canyon Resort Bridge (12.4 ha)			
Brown	2,990	3,123	3,715
Wild rainbow[c]	287	863	1,079
Catchable rainbow	1,152	769	1,524
Adipose-clipped rainbow	6,138[a]	0[a]	180[b]
Total rainbows	4,883	1,386	2,785
Total trout	7,277	4,674	6,457
Lost Canyon Bridge to Rocky River Resort Bridge (15.1 ha)			
Brown	3,759	4,676	3,618
Wild rainbow[c]	258	275	928
Adipose-clipped rainbow	1,307[a]	11[a]	71[b]
Catchable rainbows	132	223	95
Total rainbow	1,394	601	950
Total trout	5,160	5,322	4,568

[a]HCC strain rainbows
[b]BELL strain rainbows
[c]Includes CRR rainbow starting in 1987

Brown trout population estimates have consistently increased between 1985 and 1987 at the Almont to Lost Canyon Resort Bridge while they have fluctuated up and down at the Lost Canyon to Rocky River Resort section. Wild rainbow estimates have increased dramatically in 1987 over the 1985-86 estimates for both sections. Catchable rainbow stocking on the Almont to Lost Canyon Resort Bridge section has been an on-going management practice through 1987 as this section is either on public land or open to public angling by virtue of a stocking agreement between the CDOW and private landowners.

The HCC strain rainbows stocked in August-September 1985 were found in abundance in September 1985 during the population estimation period. However, they were almost totally gone from both sections by September 1986. Only 11 remained of the 10,000 stocked, for an estimated survival of 0.011%. Similarly, of the 10,000 BELL strain rainbows stocked in late-summer 1986, an estimated 251 remained in September 1987, for an estimated survival of 2.5%. Both plants were adipose-clipped. The HCC strain averaged 16.5 cm in length and the BELL strain averaged 12.4 cm in length at stocking. Thus, both strains were certainly large enough at stocking to survive the rigors of stream life, assuming the genetic material and "wildness" was present in those strains.

It will be 1988 or 1989 before we begin to see any potential survival for the 1986 and 1987 plants of CRR rainbows showing up in the population estimates as these cohorts were both under 5 cm average size at stocking. However, we did collect some of both the CRR and TAS strain rainbows during our September 1987 population estimation procedures.

Rio Grande River

The stocking records for numbers, sizes, strains, and dates for the three study areas on the Rio Grande River are presented in Table 11. During the current segment of the study, a third study area was added to this investigation. The new area, the Rio Grande Fisherman Area (RGFA), is approximately 19 hectares in area and 6 km (3.7 miles) long, located just upstream of the U.S.F.S. Marshall Park Campground near Creede, Colorado. The other two study areas are the State Bridge (SB) section near Del Norte and the Coller Wildlife Area (CWA) near South Fork.

Rainbow and brown trout population and biomass estimates for the SB section of the Rio Grande River from 1981 through 1987 are given in Table 10. Stocking of CRR fingerlings began in October 1984 and has continued since then. The increase in rainbow density and biomass estimates since 1985 has been dramatic. Examination of the rainbow life table data (Table 11) clearly indicates the dramatic increases in rainbow year-class strength since 1984. Survival of the 1984 and 1985 plants 2 years after stocking has been very good. It appears, heavy mortality occurs between the fry (age 0+) and juvenile (age 1+) life stages. Minimum survival at age 1+ for the 1984 and 1985 cohorts is 4.7% and 12.4%, respectively. We stocked 12,500 CRR fingerlings in September 1986 that averaged 5.1 cm in length. The 1986 rainbow cohort estimate was 544, for a minimum survival estimate of 4.35%. The term minimum survival is used, since there are no restrictions on emigration out of the section either upstream or downstream. Survival of the 1984 and 1985 cohorts at age 2+ was estimated at 4.07% and 5.7%, respectively. The fry survival rates at age 1+, 2+, and 3+ for the SB section are very similar to those reported by Hume and Parkinson (1988) for steelhead fry ranging in size from 0.2-6 g. Hume and Parkinson (1987) reported that stocking densities of steelhead fry between 0.3 and 0.7 fry/m^2 maximized the production of steelhead parr and smolts. They also reported that downstream dispersal of point-stocked fry was very poor, similar to the findings in other studies (Mortensen 1977; Egglishaw and Shackley 1980). We have found this to be the case in our studies as well.

Table 10. State Bridge trout population estimates, Rio Grande River, 1981-87.

Year	Browns			Rainbows		
	N	kg/ha	N/ha 35 cm	N	kg/ha	N/ha 35 cm
1981	5,168	39.3	29	295	2.8	4
1982	6,753	38.9	35	143	0.8	1
1983	8,948	45.4	31	285	1.9	2
1984	6,597	32.9	15	325	1.7	2
1985	6,372	30.9	28	896	3.5	3
1986	6,373	32.0	24	2,077	5.2	2
1987	7,483	35.8	35	1,791	4.1	3

Table 11. State Bridge total rainbow trout per section, Rio Grande River.

Sample period		Year class											
Month	Year	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Aug.	1982						212	75	94	137	31	0	0
Sept.	1983					62	108	21	39	55	0	0	0
Sept.	1984				140	67	95	5	23	0	0		
Sept.	1985			466	233	87	79	29	0				
Sept.	1986		1,652	407	163	64	7						
Sept.	1987	544	740	153	80	34	1						

All three study sections on the Rio Grande received the largest stocking of CRR and TAS strain rainbows in 1987 since the study began (Table 7). It was also the first planting of CRR strain rainbows that exceeded 10 cm (4 in.) in size. I am hopeful that we will see a large increase in rainbow density at all three study areas with the increase in both numbers and average size of fingerlings stocked.

Survival of stocked rainbow fingerlings in the CWA section of the Rio Grande continues to be lower than that in the SB section. Attributing all of the "wild" rainbows and adipose-clipped rainbows collected in 1987 to the 1986 plants results in an estimate of 2.6% survival over one year, compared to an estimated survival of 4.35% for the 1986 cohort of CRR strain rainbow in the SB section.

However, the estimated survival rate for the CRR strain rainbow was 3.0%, while the survival of BELL strain rainbow was estimated at 0.33%, an order of magnitude lower than the CRR strain. This is much lower than the estimated survival of the BELL strain plant of 3.78% for the 1986 cohort in the SB section. Considering that the average size of the BELL strain rainbows was 12.5 cm (4.9 in.) at stocking versus an average size of 5.1 cm (2 in.) for the 1986 CRR strain cohort, the cost-effectiveness of the CRR strain rainbows is obvious. The cost per 1,000 two-inch fingerlings at Roaring Judy Hatchery (the source of most of the 1986 plants in the Rio Grande) is $35.07 versus $100.14 per 1,000 for the 5-inch fingerlings. Thus, the CRR strain rainbow are approximately three times more cost-effective and they survive at a higher rate. The cost of the 1986 BELL plant should be adjusted for the 15% poorer survival rate (compared to the 1986 CRR plant). Thus, the true cost is $115.24, which is 3.24 times greater than the cost of the CRR strain.

The economic comparisons of the two strains (Bell and CRR) are more dramatic on the CWA section. Reiterating, the estimated survival of the 1986 CRR cohort was 3.0% versus 0.33% for the BELL strain. Thus, survival of the CRR strain was 9.09 times higher, making the real cost of the BELL cohort $910.27 per 1,000 fingerlings or approximately 26 times more costly, i.e., $910.27 versus $35.07 per 1,000 fingerlings.

The 1986 year-class of "wild" rainbows for the RGFA was estimated at 794. If all of these fish were considered to be survivors of the 1986 plant of 13,300 CRR rainbows, the estimated survival would be 5.97%, somewhat better than both the SB and CWA sections. No BELL strain rainbow were stocked in the RGFA section in 1986.

RECOMMENDATIONS AND CONCLUSIONS

Expansion of the "Wild Trout Introductions" study to four streams, including the Animas, Blue, upper Gunnison, and Rio Grande rivers, should provide an excellent test of "wild" (CRR) and domestic hatchery strain (TAS) rainbows in natural stream conditions. The Blue River is the only true tailrace fishery situation of the four study streams.

Thus far, we have evaluated three domestic strain rainbows, HCC, and BELL strain rainbows (Tables 6 and 7) on the upper Gunnison and Rio Grande rivers, as well as the Eagle Lake rainbow (ELR) on the Arkansas River (Nehring 1987). Compared to the CRR strain "wild" rainbow, all three domestic strains have been dismal failures when survival in the wild for longer than one year is the primary evaluation criterion. However, based on the survival of the TAS strain rainbows in the Fryingpan River for more than 4 years (Nehring 1987) and excellent survival in the Animas River 4 months after stocking, I am hopeful this "domestic" TAS strain rainbow may be more successful at surviving in the wild.

The first stocking of the CRR strain rainbow in excess of 10 cm (4 in.) average size took place in 1987. Thus, beginning in 1988 we will have the first evaluation of any potential benefits of increased average size at stocking using this bonafide wild rainbow stock in the Rio Grande River. It is readily apparent already that the CRR strain of "wild" rainbow is far superior to most "domestic" strain rainbows when it comes to long-term survival (1-3 years) in natural stream environments in Colorado. While the performance of the TAS strain rainbow has been outstanding on the Fryingpan River (Nehring 1986, 1987), its performance in a more natural (non-tailrace) stream environment remains untested. Evaluation of the first stocking (1987) of TAS rainbows in the study streams will come during the 1988-89 segment.

Tentative conclusions about expected survival rates of fingerling plants in the natural stream environment are as follows. First, a survival rate of 5-10% one calendar year after stocking seems to be a reasonable expectation for rainbow fingerlings under 10 cm (4 in.) total length. Secondly, point stocking is much less effective than scatter-stocking, preferably by boat. Thus, survival of boat-stocked fingerling, both rainbow and brown trout, has been far superior to point-stocking (walking) techniques on the upper Gunnison, Rio Grande, and Animas rivers. These conclusions are supported by the findings of others (Hume and Parkinson 1987, 1988).

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Table I-1. Animas River standing crop and biomass estimates, December 1987.

Study area	Study Section Size: Length (m)	Width (m)	Area (ha)	Species	Population statistics: N	95% C.I.	N/ha	trout/ha ≥35 cm
Animas 1-Four Corners Marine[2] to Purple Cliffs above reservation	3,860	30.5	11.8	Brown-unmarked[a]	269	±125	23	14
				Brown-adipose clip[b]	199	±183	17	0
				Rainbow (TAS)[c]	83	±112	7	0
				Catchable trout	163	±89	14	1
				All rainbows	238	±134	20	1
				Total trout	693	±241	59	16
Animas 2-32nd Street Bridge to Highway 160 Bridge near Holiday Inn	4,346	30.5	13.2	Brown-unmarked[a]	323	±141	24	11
				Brown-adipose clip[b]	1,808	±1,084	137	0
				Rainbow (TAS)[c]	1,324	--	100	0
				Catchable rainbow	1,316	±683	100	2
				All rainbows	4,218	±1,256	320	4
				Total trout	3,800	±1,058	288	13

[a]Browns from 1985 and older year-classes.
[b]Browns from adipose-clipped plants in 1986 and 1987.
[c]Tasmanian strain rainbow plants from 1987.
[d]Former designation was Pueblo Paving.

Table I-2. Summary of Animas River trout population density and biomass statistics from 1981 through 1987.

Statistic	12/81	11/82	12/83	2/85	12/86	12/87
Animas #1 Pueblo Paving to Purple Cliffs (2.4 miles)						
Browns 15 cm & up-unmarked	727	656	518	278	1,824	269
Browns 30 cm & up-unmarked	589	415	399	254	255	262
Browns 35 cm & up-unmarked	359	272	266	208	179	182
Browns 40 cm & up-unmarked	192	166	76	136	87	91
Browns-adipose clipped (86-87 plants)					48	199
Rainbows 15 cm & up	110	20	71	135	286	238
Snake River cutthroats 15 cm & up	288	28	4	0	0	2
Catchable rainbows	--	--	--	--	82	163
Brown biomass (kg/ha)	40.0	32.9	24.9	14.7	41.9	22.3
Rainbows biomass (kg/ha)	4.2	0.6	2.7	4.5	4.8	12.6
Snake River cutthroat biomass (kg/ha)	5.2	0.9	--	0	0	0
Animas #2 32nd Street Bridge - Holiday Inn Bridge (2.7 miles)						
Browns 15 cm & up-unmarked	167[a]	931	507[a]	252	751	323
Browns 30 cm & up-unmarked	112	609	449	192	361	249
Browns 35 cm & up-unmarked	61	406	130	142	294	140
Browns 40 cm & up-unmarked	41	203	27	56	147	83
Browns-adipose clipped (87-87 plants)					527	1,808
Rainbows 15 cm & up	94	98	232	32	539	4,218
Snake River cutthroat 15 cm & up	275	90	30	0	0	3
Brown biomass (kg/ha)	15.4	41.1	30.9	9.4	22.0	37.0
Rainbow biomass (kg/ha)	2.8	1.4	8.6	0.7	0.3	34.2
Snake River cutthroat biomass (kg/ha)	5.2	2.9	--	0	0	0
Rainbow broodfish biomass (kg/ha)				3.6		
Browns adipose clip biomass (kg/ha)					3.12	23.7

[a]Estimates in 1981 and 1983 ran from the Durango Hatchery to the Holiday Inn (1.2 miles).

Table I-3. Blue River standing crop and biomass estimates, October 19, 1987.

Study area description	Study section size: Length (m)	Width (m)	Area (ha)	Species	Population statistics: N	95% C.I.	N/ha	kg/ha	trout/ha ≥ 35 cm (14 in.)
Stream improvement section above Blue River campground	305	20.1	0.613	Brown	737	±112	1,203	193	51
				Wild rainbow	13	±5	21	7.2	10
				Rainbow[a]	40	±13	65	22.1	36
				Brook	3	±3	5	0.4	0
				Total trout	777	±111	1,268	222.7	94
Blue River U.S.F.S. Campground	366	18.6	0.680	Brown	549	±165	807	132.3	59
				Wild rainbow	4	±2	6	2.2	2
				Rainbow[a]	2	±1	3	0.1	0
				Brook	1	±2	1	0	0
				Total trout	541	±155	795	134.7	60
Blue River Wildlife Area-near Ute Pass turn-off	274	24.7	0.678	Brown	490	±168	723	120.8	25
				All rainbow	15	± 18	22	4.3	11
				Brook	1	--	--	--	0
				Total trout	522	±179	770	125.1	37

[a]Adipose-clipped rainbows.

Table I-4. Gunnison River standing crop and biomass estimates, September-November, 1987.

Study area description	Study section size: Length (m)	Width (m)	Area (ha)	Population statistics: Species	N	95% C.I.	N/ha	kg/ha	trout/ha ≥35 cm
Almont to Lost Canyon	3,700	33.5	12.4	Brown	3,715	±907	300	92.6	36
Resort Bridge				Rainbow-wild	1,079	±833	87	19.7	3
8 trout/day, public				Catch. rainbow	1,524	±827	123	21.7	0
access				Adipose rainbow[a]	180	±120	15	1.7	0
				Other trout[b]	4	--	--	--	0
				All rainbow	2,785	±1,056	225	43.1	3
				All trout	6,457	±1,276	521	135.7	36
Lost Canyon Resort	4,500	33.5	15.1	Brown	3,618	±785	240	75.8	27
to Rocky River Resort				Rainbow-wild	928	±670	61	18.6	15
Bridge - 8 trout/day				Rainbow-adipose[a]	71	±47	5	0.7	0
restricted private				Catch. rainbow	95	±95	6	1.3	0
access				Total rainbow	950	±440	63	20.6	15
				Total trout	4,568	±868	303	96.4	40
Duncan-Ute Trail	3,220	31.0	10.0	Brown	12,360	±3,970	1,236	170.2	51
4 trout/day; 1 over				Rainbow	11,105	±3,326	1,110	236.9	156
16 inches; catch-and-				Total trout	23,383	±5,123	2,338	407.1	223
release 12-16 inches									
Smith Fork-North Fork	6,440	31.0	20	Brown	6,382	±2,257	319	65.0	48
4 trout/day; 1 over				Rainbow	12,154	±3,608	608	185.7	114
16 inches; catch-and-				Total trout	18,403	±3,996	920	250.7	160
release 12-16 inches									
North Fork-Austin	12,900	45.7	59	Brown	4,699	±3,030	68	17.8	14
8 trout/day; limited				Rainbow	7,865	±8,966	114	33.6	22
access; heavy siltation				Total trout	11,727	±5,432	170	51.4	34

[a]Adipose-clipped Bellaire (BELL) strain rainbow, planted on September 23, 1986.
[b]Includes brook, cutthroat, and Snake River cutthroat.

Table I-5. Summary of Gunnison River trout population statistics, 1981-87

Species	Size (cm)	1981	1982	1983	1984	1985	1986	1987
Duncan - Ute Trail area (2 miles - 3.2 km - 10 ha)								
Brown	15 & up	869	603	586	541	330	469	1,236
Brown	30 & up	194	141	139	58	58	112	228
Brown	35 & up	71	43	39	18	13	31	72
Brown	40 & up[a]	119	97	81	59	32	37	211
Rainbow	15 & up	339	392	427	217	346	275	1,110
Rainbow	30 & up	140	181	253	162	333	193	273
Rainbow	35 & up	84	97	146	110	261	190	194
Rainbow	40 & up[a]	600	423	651	401	892	1,447	1,573
Brown biomass	(kg/ha)	201.2	143.8	134.5	54.6	53.6	69.8	170.2
Rainbow biomass	(kg/ha)	110.7	110.3	149.8	84.5	164.5	132.8	236.9
Smith Fork - North Fork section (4 miles - 6.4 km - 20 ha)								
Brown	15 & up	115	186	407	351	249	128	319
Brown	30 & up	14	40	128	61	55	76	105
Brown	35 & up	8	16	34	22	26	38	53
Brown	40 & up[a]	69	120	216	128	126	165	447
Rainbow	15 & up	355	228	268	275	205	180	608
Rainbow	30 & up	16	66	169	206	193	162	246
Rainbow	35 & up	10	16	51	140	140	155	190
Rainbow	40 & up	234	192	222	626	770	1,895	2,504
Brown biomass	(kg/ha)	25.8	48.0	104.5	41.8	45.4	33.3	65.0
Rainbow biomass	(kg/ha)	50.5	51.3	81.3	99.4	91.3	98.8	185.7

[a]All estimates are per hectare (2.47 acres) except for number 40 & up which are for the entire section of river.

Table I-6. Rio Grande River standing crop and biomass estimates, September 1987.

Study area	Study section size: Length (m)	Width (m)	Area (ha)	Species	Population statistics: N	95% C.I.	N/ha	kg/ha	trout/ha ≥35 cm
State Bridge section	10,950	46.0	50.4	Brown	7,483	±1,422	148	35.8	35
				Rainbow-wild[a]	1,791	±1,054	31	6.4	3
				Rainbow-adipose[b]	376	±260	7	0.9	0
				Rainbow-L. pelv.[c]	3	±3	0	0	0
				Total rainbow	1,791	±1,100	36	7.1	3
				Total trout	9,212	±1,625	183	43.1	25
Coller Wildlife Area	3,540	46.0	16.3	Brown	4,164	±714	255	50.0	16
				Rainbow-wild[a]	280	±157	17	3.0	1
				Rainbow-adipose[b]	31	±40	2	0.1	0
				Rainbow-cat.	375	±282	23	3.6	0
				Total rainbow	764	±373	47	6.7	1
				Total trout	4,909	±795	301	56.7	17
Rio Grande Fisherman Area	5,990	31.7	19.0	Brown	2,862	±638	151	31.3	18
				Rainbow-wild[a]	1,112	±426	59	10.5	5
				Rainbow-adipose[d]	615	±873	33	1.2	0
				Rainbow-cat.	1,000	±369	53	8.6	0
				Total Rbw	2,456	±657	130	20.8	5
				Total trout	5,339	±915	283	51.6	23

[a]Rainbows from wild Colorado River stock spawned on the Colorado River (1984, 1985, 1986).
[b]Rainbows from Bellaire hatchery strain stocked in September 1986.
[c]Catchable plant survivors from a pelvic-clipped plant of 2,316 Colorado River stock rainbows - 4.2/lb; planted on August 6, 1986.
[d]Largest of adipose-clipped CRR rainbows stocked in August 1987.

Table I-7. South Platte River standing crop and biomass estimates, October 22-24, 1987.

Study area description	Study section size: Length (m)	Width (m)	Area (ha)	Population statistics: Species	N	95% C.I.	N/ha	kg/ha	trout/ha ≥35 cm
Upper Canyon catch and release	183	18.0	0.329	Brown	234	±4	915	202.7	19
				Rainbow	195	±5	763	314.8	165
				Total trout	429	±8	1,677	517.6	184
Lower Canyon catch and release	183	22.6	0.413	Brown	258	±24	822	190.7	19
				Rainbow	230	±34	735	317.3	177
				Total trout	486	±39	1,552	508.0	189
Above Deckers Bridge 2 trout over 16 inches	183	22.6	0.413	Brown	641	±13	2,049	319.1	6
				Rainbow	224	±25	716	185.1	52
				Total trout	863	±33	2,756	504.2	54
Below Deckers Bridge 2 trout over 16 inches	183	23.2	0.424	Brown	621	±30	1,984	248.3	11
				Rainbow	278	±20	889	146.1	33
				Total trout	899	±34	2,873	394.4	44
Scraggy View Picnic area (U.S.F.S.) 2 trout/day-no size restructions	183	23.2	0.424	Brown	545	±10	1,741	205.1	7
				Rainbow	151	±5	481	81.0	20
				Total trout	696	±11	2,222	286.1	26
Twin Cedars area 2 trout/day-no size restrictions	183	23.2	0.424	Brown	411	±16	985	114.4	0
				Wild rainbow	148	±25	356	46.4	3
				Total trout	552	±23	1,325	160.8	3

Table I-8. Rainbow and brown trout numbers/ha and biomass (kg/ha) for the South Platte River 1979-87.

	Fall 1979		Spring 1980		Fall 1980		Spring 1981		Fall 1981		Spring 1982		Fall 1982		Fall 1983		Fall 1984		Fall 1985		Fall 1986		Fall 1987	
	kg/ha	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha	N/ha	kg/ha	N/ha
Upper Canyon - stream width = 18 meters																								
Brown	133.8	592	115.2	542	149.4	784	76.0	423	77.8	341	84.7	419	88.5	480	157.9	772	150.3	593	135.5	529	139.0	547	202.7	915
Rainbow	348.6	1110	393.7	1297	373.5	1137	329.7	908	242.0	617	245.0	635	248.8	678	313.6	1235	364.6	1134	443.9	1069	289.0	872	314.8	763
Total	482.4	1702	508.9	1831	522.9	1896	405.7	1331	319.8	924	325.7	1054	337.3	1155	471.5	2006	514.9	1723	579.4	1599	428.0	1422	517.6	1677
Lower Canyon - stream width = 22.6 meters																								
Brown	192.2	791	175.5	795	165.0	805	169.9	766	134.7	534	163.7	738	121.1	559	244.1	1032	167.8	631	119.7	449	143.3	608	190.7	822
Rainbow	401.1	1238	422.3	1243	336.0	929	566.4	1467	258.8	638	344.0	832	233.5	561	359.3	1378	321.9	802	262.2	597	315.2	634	317.3	735
Total	593.3	2024	597.8	2009	501.0	1734	736.3	2261	392.8	1168	507.7	1569	354.6	1117	603.4	2406	489.7	1530	381.9	1039	458.5	1242	508.0	1552
Above Deckers - stream width = 22.6 meters																								
Brown	140.7	1097	137.0	1079	163.5	1318	103.2	733	184.7	957	76.7	496	189.5	1683	269.5	2352	145.0	951	158.4	979	202.4	1179	319.1	2049
Rainbow	61.3	369	28.0	152	43.8	314	14.6	89	40.1	213	5.7	41	32.0	285	106.4	757	76.9	319	173.1	590	165.4	483	185.1	716
Total	202.0	1466	165.0	1231	207.3	1627	117.8	812	224.8	1163	82.4	534	221.5	1944	375.9	3107	221.9	1236	331.5	1557	367.9	1657	504.2	2756
Below Deckers - stream width = 23.2 meters																								
Brown	--	--	--	--	--	--	--	--	--	--	112.3	669	217.7	1908	280.0	2219	146.8	958	134.7	798	189.4	958	248.3	1984
Rainbow	--	--	--	--	--	--	--	--	--	--	30.0	150	53.4	445	88.1	710	81.6	461	90.1	377	116.2	410	146.1	889
Total	--	--	--	--	--	--	--	--	--	--	142.3	814	271.1	2343	368.1	2923	228.4	1417	224.8	1175	305.6	1368	394.4	2873
Scraggy View - stream width = 23.2 meters																								
Brown	104.7	717	108.4	1037	60.8	568	60.9	492	84.8	551	70.2	513	101.6	881	98.2	946	40.4	341	76.3	537	101.1	667	205.1	1741
Rainbow	32.4	210	16.2	102	18.6	174	16.0	125	18.4	94	16.4	71	20.0	120	37.2	299	15.3	102	31.8	146	44.3	241	81.0	482
Total	137.1	921	124.6	1103	78.6	737	76.9	607	103.2	643	86.6	582	121.6	996	135.4	1246	55.7	440	108.1	678	145.4	906	286.0	2222
Twin Cedars - stream width = 23.2 meters																								
Brown	--	--	--	--	--	--	--	--	--	--	108.3	826	101.1	918	51.5	509	36.6	348	41.6	308	58.8	405	114.4	985
Rainbow	--	--	--	--	--	--	--	--	--	--	30.5	184	19.1	200	8.8	88	13.9	103	14.3	71	24.4	116	46.4	356
Total	--	--	--	--	--	--	--	--	--	--	138.8	1010	120.2	1114	60.3	596	50.5	449	55.9	379	83.2	520	160.8	1325

Table II-1. Back calculated lengths (cm) of trout from F-51 study streams 1987.

Year class	N	Age (year)	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.
Animas River Unmarked - Browns - December 1987																						
1986	8	1+	26.6	1.19	13.7	.82																
1985	20	2+	29.5	.85	11.6	.67	23.3	.94														
1984	39	3+	35.1	.68	10.2	.28	18.1	.88	29.8	.74												
1983	27	4+	40.2	.82	10.1	.52	20.3	1.52	30.7	1.10	37.3	.87										
1982	11	5+	46.5	.94	10.5	.10	20.8	1.50	32.0	1.10	39.0	.95	43.6	.81								
1981	10	6+	48.8	1.05	9.9	.95	19.1	.63	29.9	1.22	38.1	1.22	43.2	1.13	46.6	1.13						
1980	1	7+	54.0	----	9.4	----	17.9	----	21.8	----	33.9	----	42.1	----	47.7	----	51.4	----				
Animas River Adipose - Clipped Browns - December 1987																						
1987	48	0+	18.4	.65	12.4	.23																
1986	43	1+	29.2	.45	12.2	.37	19.6	.59														
Animas River - Rainbows - December 1987																						
1986	102	1	22.2	.68	16.3	.50																
1985	16	2	31.6	1.47	14.8	.65	25.2	1.30														
1984	1	3	40.0	----	8.7	----	30.2	----	38.8	----												
1983	1	4	50.0	----	12.1	----	22.9	----	41.1	----	47.7	----										
Blue River - Browns - October 1987																						
1986	28	1+	13.6	.34	7.7	.18																
1985	41	2+	20.4	.38	7.5	.26	15.1	.39														
1984	10	3+	26.7	.60	8.6	.47	14.8	.52	22.2	.53												
1983	32	4+	28.9	1.00	7.6	.32	14.1	.63	20.2	.76	25.7	.86										
1982	11	5+	34.1	.92	8.9	.30	15.7	.49	20.7	.54	27.3	.91	31.2	.95								
1981	8	6+	37.4	.86	7.5	.56	13.1	.92	18.9	1.2	24.8	1.1	30.2	.92	34.7	1.1						
1980	1	7+	36.0	----	6.6	----	10.1	----	14.0	----	17.9	----	25.4	----	31.4	----	34.2	----				
Colorado River Rainbows -- October 1987																						
1986	12	1+	18.4	17.4	10.4	.69																
1985	12	2+	26.8	.42	11.0	.24	19.7	.51														
Gunnison River-Black Canyon - Rainbows - September 1987																						
1986	72	1+	20.8	.52	11.4	.24																
1985	51	2+	32.5	.41	10.9	.15	24.9	.44														
1984	6	3+	39.5	1.84	12.6	.74	27.6	1.13	35.5	1.47												
1983	17	4+	41.0	.61	13.0	.56	24.8	1.28	31.6	1.11	37.1	.68										
1982	30	5+	45.3	.48	11.4	.28	20.8	.78	27.9	.87	35.1	.71	40.9	.55								
1981	30	6+	44.5	1.49	11.6	.34	19.7	.89	25.7	1.04	31.1	1.16	36.9	1.26	41.7	1.38						
1980	7	7+	47.9	.91	11.3	.38	19.1	1.53	27.5	1.18	32.3	1.12	36.1	.55	39.8	.72	44.9	.83				

Table II-1. Back calculated lengths (cm) of trout from F-51 study streams 1987 (continued).

Year class	N	Age (year)	L_c	S.E.	L_1	S.E.	L_2	S.E.	L_3	S.E.	L_4	S.E.	L_5	S.E.	L_6	S.E.	L_7	S.E.	L_8	S.E.	L_9	S.E.	L_{10}	S.E.	L_{11}	S.E.
Gunnison River-North Fork to Austin - Rainbows - September 1987																										
1986	52	1+	26.5	.71	14.8	.37																				
1985	52	2+	34.4	.69	15.2	.53	29.0	.62																		
1984	13	3+	38.2	.90	14.3	.54	28.2	1.21	34.8	.98																
1983	10	4+	39.7	.84	14.7	.79	24.0	1.45	32.5	1.45	36.7	.90														
1982	5	5+	42.4	1.32	13.9	1.10	26.2	2.08	31.6	1.79	35.9	1.91	39.7	1.26												
1981	3	6+	42.0	.58	12.8	.68	18.3	.58	25.4	2.57	30.5	2.10	34.7	2.01	38.0	1.18										
1980	6	7+	45.0	.77	13.8	.80	20.9	1.69	26.6	2.02	30.3	2.02	34.4	1.63	37.5	1.37	41.8	.80								
1979	1	8+	51.0	----	11.7	----	17.9	----	24.7	----	34.2	----	38.4	----	42.6	----	45.3	----	48.1	----						
1978	1	9+	49.0	----	15.8	----	22.1	----	28.7	----	31.3	----	35.5	----	39.1	----	42.5	----	43.8	----	46.9	----				
Gunnison River-North Fork to Austin - Browns - September 1987																										
1986	36	1+	26.4	.80	15.6	.50																				
1985	23	2+	32.9	.70	14.9	.59	26.3	.92																		
1984	21	3+	37.6	.64	15.5	.73	26.8	1.13	34.6	.62																
1983	20	4+	40.2	.92	14.5	.50	23.9	.77	31.5	.70	36.7	.81														
1982	6	5+	41.8	.83	14.0	1.17	20.6	1.05	28.1	.91	33.5	.84	39.2	.79												
1981	3	6+	42.7	.88	14.2	.86	19.8	.40	24.9	1.62	29.9	2.0	34.1	2.16	38.4	1.92										
1980	1	7+	42.0	.80	10.6	----	13.4	----	19.4	----	24.4	----	30.4	----	34.6	----	38.5	----								
Gunnison River-Black Canyon - Browns - September 1987																										
1986	83	1+	19.3	.60	12.5	.30																				
1985	34	2+	30.7	.38	12.9	.32	25.9	.35																		
1984	9	3+	37.6	1.24	12.2	.44	23.8	1.65	32.5	1.35																
1983	30	4+	39.6	.64	11.3	.60	20.1	1.20	29.8	.98	36.0	.81														
1982	16	5+	40.1	.70	10.5	.56	16.9	.97	24.3	1.00	31.5	1.02	37.0	.81												
1981	7	6+	45.7	2.63	12.1	1.21	18.2	1.54	27.9	2.28	33.4	2.55	38.3	2.27	43.0	2.48										
1980	2	7+	48.0	----	10.5	3.08	17.1	3.90	25.4	2.27	30.2	2.37	34.2	.84	40.2	.10	43.6	.10								
Gunnison River-At Almont Browns -- October 1987																										
1986	38	1+	16.6	.38	8.2	.20																				
1985	39	2+	22.7	.51	8.8	.27	17.0	.37																		
1984	19	3+	27.9	.63	9.2	.34	17.7	.75	23.2	.70																
1983	33	4+	35.3	.76	9.4	.34	18.0	.64	25.7	.87	31.4	.73														
1982	37	5+	40.6	.79	10.0	.33	18.9	.64	26.9	.85	33.1	.70	37.3	.73												
1981	14	6+	49.6	1.70	9.7	.52	19.7	1.00	29.3	1.56	37.5	1.48	41.7	1.51	45.9	1.66										
1980	3	7+	54.0	3.06	11.2	1.73	19.1	2.71	27.1	2.17	36.4	1.44	40.3	1.68	44.7	3.13	49.9	3.39								
Gunnison River-At Almont Bellaire - Rainbows - October 1987																										
1986	16	1+	23.1	.53	15.7	.38																				
Gunnison River-At Almont "Wild" - Rainbows - October 1987																										
1986	23	1+	18.8	.71	10.9	.46																				
1985	34	2+	25.1	.58	10.3	.46	18.7	.56																		
1984	39	3+	29.6	.58	10.4	.28	17.6	.47	24.3	.55																
1983	11	4+	36.0	1.04	11.6	1.07	19.6	1.15	27.5	1.09	32.6	1.20														
1982	16	5+	38.1	.60	.96	.33	17.1	.62	24.4	.78	30.7	.67	35.2	.64												
1981	7	6+	41.0	.58	.95	.66	19.4	.81	27.2	.95	31.9	.97	36.1	.84	38.6	.73										

Table II-1. Back calculated lengths (cm) of trout from F-51 study streams 1987 (continued).

Year class	N	Age (year)	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.	L	S.E.
Gunnison River-At Almont Rifle Falls Colorado River - Rainbows - 1987 (Pre-plant)																										
1986	21	1	11.4	.73	8.4	.45																				
Rio Grande Coller - Browns - September 1987																										
1986	33	1+	13.7	.32	8.8	.21																				
1985	30	2+	20.0	.35	9.1	.24	16.1	.35																		
1984	29	3+	26.4	.50	9.6	.15	17.0	.39	23.1	.48																
1983	22	4+	31.1	.72	9.4	.28	17.1	.61	23.3	.66	28.1	.62														
1982	18	5+	35.3	.40	9.6	.28	17.2	.62	23.7	.51	28.5	.48	32.0	.53												
Rio Grande Coller - Wild Rainbows - September 1987																										
1986	2	1+	16.5	.50	11.0	.62																				
1985	20	2+	23.5	.78	12.0	.47	19.1	.76																		
1984	11	3+	28.6	1.30	12.0	.27	17.9	.64	23.1	.88																
1983	2	4+	31.5	2.50	14.4	2.83	19.5	2.85	24.0	3.20	28.3	1.59														
Rio Grande Coller - Bel-Aire Rainbows - September 1987																										
1986	9	1	19.0	.62	12.6	.61																				
Rio Grande Coller-Colorado River Rainbows - September 1987																										
1986	6	1+	14.8	.75	9.4	.39																				
1985	9	2+	21.2	.72	7.7	.55	16.3	.70																		
1984	2	3+	29.0	3.00	10.6	2.14	18.2	.47	25.6	2.56																
Rio Grande Coller - Hatchery Rainbows - September 1987																										
1986	10	1+	25.7	.76	20.9	.86																				
Rio Grande Marshal Park - Browns - September 1987																										
1986	37	1+	15.1	.33	8.4	.23																				
1985	40	2+	21.5	.62	7.9	.26	15.2	.48																		
1984	38	3+	29.0	.58	8.7	.25	16.5	.43	23.4	.59																
1983	27	4+	34.3	.58	9.1	.47	18.0	.70	25.4	.75	30.6	.72														
1982	28	5+	38.7	.81	9.1	.38	17.6	.64	24.9	.76	30.6	1.14	35.8	.82												
1981	14	6+	40.9	.78	9.7	.49	16.9	1.04	24.9	1.19	31.6	1.04	36.3	.89	39.0	.75										
1980	2	7+	41.5	1.50	10.1	1.32	16.2	1.88	23.9	.16	30.7	.45	34.6	1.10	38.5	.95	40.3	1.43								
1976	1	11	77.0	----	9.5	----	18.6	----	24.9	----	31.8	----	37.1	----	42.1	----	49.1	----	55.5	----	63.1	----	68.4	----	74.1	---
Rio Grande Marshal Park - Colorado River Rainbows - September 1987																										
1986	35	1	15.1	.30	8.6	.32																				
1985	56	2	19.7	.29	6.9	.20	13.9	.24																		

Table II-1. Back calculated lengths (cm) of trout from F-51 study streams 1987 (continued).

Year class	N	Age (year)	L_c	S.E.	L_1	S.E.	L_2	S.E.	L_3	S.E.	L_4	S.E.	L_5	S.E..	L_6	S.E.	L_7	S.E.	L_8	S.E.	L_9	S.E.
Rio Grande State Bridge - Browns - September 1987																						
1986	42	1+	16.1	.43	10.1	.20																
1985	48	2+	24.5	.56	10.8	.19	19.2	.43														
1984	33	3+	31.7	.47	11.1	.27	21.1	.39	28.0	.46												
1983	28	4+	38.3	.62	11.4	.42	21.2	.66	29.3	.76	35.7	.70										
1982	27	5+	39.6	1.06	11.3	.42	18.8	.88	26.6	1.06	32.6	1.08	37.0	1.05								
1981	12	6+	45.0	.48	11.8	.50	19.6	1.25	28.7	1.20	35.2	1.11	40.2	.52	43.2	.51						
1980	2	7+	50.0	3.00	10.7	.35	17.6	2.06	25.8	.21	35.0	.40	40.1	2.14	45.3	2.15	47.9	2.43				
1979	1	8+	47.0	----	9.2	----	14.7	----	27.6	----	31.6	----	38.0	----	41.8	----	43.1	----	44.7	----		
1978	1	9+	45.0	----	12.9	----	25.9	----	32.9	----	37.3	----	39.1	----	40.1	----	41.2	----	42.3	----	43.4	----
Rio Grande State Bridge - Wild Rainbows - September 1987																						
1986	1	1+	25.0	----	16.1	----																
1985	21	2+	27.6	.50	11.4	.61	20.5	.61														
1984	6	3+	36.2	.95	12.8	1.11	24.1	1.57	31.3	1.12												
1983	4	4+	40.5	1.26	11.9	1.14	20.2	2.17	29.9	3.37	37.8	1.77										
1982	2	5+	39.5	2.50	14.2	.17	19.7	1.32	28.9	2.88	34.3	2.44	37.8	2.35								
1981	1	6+	46.0	----	12.3	----	22.7	----	29.0	----	35.3	----	40.4	----	44.0	----						
Rio Grande State Bridge - Colorado River Rainbows - September 1987																						
1986	43	1	16.7	.47	10.3	.32																
1985	23	2	25.4	.61	7.8	.39	17.7	.53														
1984	7	3	31.3	.92	7.8	.48	17.1	1.20	26.4	1.07												
1983	3	4	32.3	2.03	7.9	.26	14.7	.96	21.3	2.26	28.5	2.45										
Rio Grande State Bridge - Bel-Aire Rainbows - September 1987																						
1986	22	1+	22.5	.36	17.8	.28																
South Platte River - Browns - October 1987																						
1987	2	0+	11.0	1.0	8.4*	1.25																
1986	52	1+	19.2	.42	11.7	.29	16.5*	.40														
1985	21	2+	25.8	.38	11.4	.43	20.3	.54	23.7*	.39												
1984	7	3+	31.9	1.84	13.7	.63	24.3	1.59	28.9	1.77	30.6*	1.84										
1983	6	4+	35.7	.56	10.8	.56	20.9	1.04	26.6	1.62	31.8	1.17	34.0*	.54								
1982	5	5+	36.0	.63	9.6	.65	15.0	1.06	21.8	1.10	28.5	.61	32.6	.28	34.5*	.62						
1981	1	6+	37.0	----	11.7	----	16.4	----	23.4	----	27.5	----	30.7	----	32.0	----	35.1*	----				
South Platte River - Rainbows - October 1987																						
1987	1	0+	10.0	----	9.7*	----																
1986	52	1+	20.8	.40	14.8	.24	18.6*	.34														
1985	15	2+	26.5	.44	14.1	.28	21.1	.59	24.4*	.51												
1984	21	3+	31.2	.64	14.9	.30	21.0	.61	26.0	.71	29.2*	.68										
1983	40	4+	36.6	.58	15.7	.28	21.8	.45	27.9	.43	31.5	.41	34.4*	.53								
1982	17	5+	38.2	.71	14.5	.35	20.7	.64	26.4	.66	30.5	.56	33.7	.62	36.3	.57						
Taylor River - Browns - November 1987																						
1986	31	1+	13.2	.31	6.7	.21																
1985	39	2+	18.9	.38	7.0	.23	13.5	.33														
1984	24	3+	24.3	.54	7.1	.24	13.8	.32	19.5	.42												
1983	31	4+	30.6	.81	7.4	.31	14.7	.42	21.5	.63	27.0	.77										
1982	25	5+	34.4	1.70	6.9	.29	14.3	.65	20.2	.92	26.0	1.26	30.8	1.47								
1981	11	6+	43.1	2.05	8.0	.64	15.8	.90	23.1	1.43	29.6	1.55	35.1	1.53	40.0	1.97						
1980	3	7+	38.3	1.86	8.3	2.22	13.9	2.42	20.7	2.38	27.2	2.57	30.2	2.40	33.4	2.48	35.9	2.05				
1979	1	8+	37.0	----	6.5	----	12.8	----	19.6	----	22.9	----	26.9	----	28.7	----	32.1	----	35.1	----		

*Thermal check

Table II-2. Life Tables - Blue River (brown trout/ha).

Sample period Season	Year	Year class 1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976
					Stream improvement section							
Spring	1983					302	477	382	17			
Spring	1984					308	293	192	46	17	2	
Fall	1984				14	289	216	35	20	--	--	
Fall	1985			266	196	445	170	35	1			
Fall	1986		624	131	357	167	67	8				
Fall	1987	322	634	109	256	64	33	3				
					Blue River Campground							
Spring	1981								87	56	13	1
Spring	1983					160	124	44	4	--	--	--
Spring	1984					246	379	261	41	9	8	--
Fall	1984				24	359	319	57	16	7	--	--
Fall	1985			210	164	292	96	23	4	0		
Fall	1986		256	106	211	114	33	9	1			
Fall	1987	274	439	53	157	49	22	2	0			
					Blue River below Highway 9 Bridge (near Slate Creek)							
Spring	1983					122	252	185	23	--	--	
Spring	1984					340	214	197	70	16	3	
Fall	1984				15	303	268	60	25	--	--	
Fall	1985			98	179	331	97	23	3			
Fall	1986		278	51	204	102	29	8	2			
Fall	1987	215	310	50	207	39	16	1	0			

Table II-2. Life Tables - Gunnison River (numbers/ha) (continued).

Sample period		Year class									
Season	Year	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977
					Almont - Lost Canyon (brown trout)						
Fall	1986		72	53	77	40	16	1			
Fall	1987	149	145	58	42	23	3	0			
					Lost Canyon (rainbow trout)						
Fall	1986		20	17	15	18	5				
Fall	1987	23	65	33	1	3	1				
					Duncan - Ute Trail (brown trout)						
Fall	1981							641	170	31	3
Fall	1982						363	216	14	0	0
Fall	1983					242	300	40	2	2	0
Fall	1984				82	358	90	10	1	0	0
Fall	1985			36	56	208	30	0	0		
Fall	1986		345	24	84	14	1	0			
Fall	1987	982	188	6	20	6	1	0			
					Duncan - Ute Trail (rainbow trout)						
Fall	1981							197	91	41	10
Fall	1982						212	85	71	20	3
Fall	1983					111	128	160	18	10	0
Fall	1984				4	15	121	70	5	2	0
Fall	1985			7	4	170	151	11	3	0	
Fall	1986		61	11	32	84	63	8	0		
Fall	1987	902	77	4	21	36	39	2	0		
					Rocky River - Lost Canyon (brown trout)						
Fall	1986		56	67	110	64	18	1			
Fall	1987	83	95	40	41	19	2	1			
					Rocky River - Lost Canyon (rainbow trout)						
Fall	1986		5	2	2	7	4				
Fall	1987	87	30	16	4	4	5				
					Smith Fork - North Fork (brown trout)						
Fall	1981							88	13	3	2
Fall	1982						122	55	7	1	1
Fall	1983					140	224	36	4	3	0
Fall	1984				65	200	76	9	1	0	0
Fall	1985			10	58	152	27	0	0		
Fall	1986		49	10	50	17	2	0			
Fall	1987	211	62	8	18	10	1	0			
					Smith Fork - North Fork (rainbow trout)						
Fall	1981							177	26	9	6
Fall	1982						167	42	11	7	1
Fall	1983					43	133	86	6	0	0
Fall	1984				8	17	162	80	3	1	0
Fall	1985			1	6	108	84	4	1	0	
Fall	1986		13	16	37	65	39	5	0		
Fall	1987	483	171	11	24	21	21	4	0		

Table II-2. Life Tables - Rio Grande River (brown trout/ha) (continued).

Sample period		Year class											
Month	Year	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
						Coller fly water							
Aug.	1981							65	41	66	64	8	0
Aug.	1982						76	80	93	3	0	0	0
Sept.	1983					74	132	65	12	3	0	0	0
Sept.	1984				61	144	72	24	3	1	0		
Sept.	1985			56	63	117	34	3	0	0			
Sept.	1986		68	66	40	68	11	0					
Sept.	1987	51	73	74	46	21	0						
						State Bridge section							
Aug.	1981							26	19	36	11	3	2
Aug.	1982						65	21	33	12	2	0	0
Sept.	1983					59	77	21	18	4	0	0	0
Sept.	1984				39	42	28	16	5	1	0		
Sept.	1985			43	29	33	16	5	1	0	0		
Sept.	1986		45	29	27	19	7	1					
Sept.	1987	102	55	21	11	7	1	1					
		Wason Ranch - standard regulations - 8 trout/day 1983-84, 85											
Aug.	1982						63	99	136	13	0	0	0
Sept.	1983					61	130	63	41	9	0	0	0
Oct.	1984				27	27	30	32	5	1	0	0	0
Oct.	1985			18	94	45	25	5	1	0			
Oct.	1986		29	48	67	11	10	5					
Wason Ranch - fly water - 2 trout/day; catch-and-release 14 in. 1983-84, 85													
Aug.	1982						71	98	190	19	0	0	0
Sept.	1983					61	123	58	38	13	0	0	0
Oct.	1984				43	30	50	89	14	6	0		
Oct.	1985			9	67	96	16	5	1	0			
Oct.	1986		33	45	63	13	13	11					
						State Bridge section (rainbow trout)[a]							
Aug.	1982						212	75	94	137	31	0	0
Sept.	1983					62	108	21	39	55	0	0	0
Sept.	1984				140	67	95	5	23	0	0		
Sept.	1985			466	233	87	79	29	0				
Sept.	1986		1,652	407	163	64	7						
Sept.	1987	544	740	153	80	34	1						

[a]Total rainbows/section not per hectare.

Table II-2. Life Tables - South Platte River (brown trout/ha) (continued).

Sample period		Year class											
Season	Year	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
Upper Canyon section - catch-and-release													
Fall	1979									233	284	218	35
Spring	1980								6	230	385	75	0
Fall	1980								252	568	176	12	0
Spring	1981							12	162	318	43	8	0
Fall	1981							46	203	170	19	0	0
Fall	1982						165	205	203	43	0	0	0
Fall	1983					193	637	412	98	22			
Fall	1984				50	516	191	4					
Fall	1985			119	241	284	36	0					
Fall	1986		123	363	210	11	0						
Fall	1987	219	314	295	66	21	0						
Lower Canyon section - catch-and-release													
Fall	1979									202	364	421	57
Spring	1980								22	237	595	195	0
Fall	1980								283	563	165	50	0
Spring	1981							36	187	539	242	8	0
Fall	1981							98	286	293	29	0	0
Fall	1982						164	189	235	128	22	0	0
Fall	1983					158	605	197	28	4			
Fall	1984				87	447	269	31					
Fall	1985			117	208	240	56						
Fall	1986		314	274	225	19	0						
Fall	1987	165	276	292	56	25	0						
Above Deckers Bridge section													
Fall	1979									906	366	49	8
Spring	1980								142	816	433	35	0
Fall	1980								993	678	66	31	11
Spring	1981							49	544	397	33	4	0
Fall	1981							460	623	171	12	0	0
Fall	1982						1,813	344	55	4	0	0	0
Fall	1983					1,799	1,205	94	10				
Fall	1984				696	522	14	3					
Fall	1985			555	639	113	7	0					
Fall	1986		950	644	164	2	0						
Fall	1987	1096	612	308	33	7							
Below Deckers													
Fall	1982						2,062	449	55				
Fall	1983					1,531	1,335	135	12				
Fall	1984				692	573	32	4					
Fall	1985			457	572	59	12						
Fall	1986		860	573	232	1	0						
Fall	1987	982	511	307	39	14							

Table II-2. Life Tables - South Platte River (brown trout/ha) (continued).

Sample period		Year class											
Season	Year	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
						Scraggy View section - fish/day							
Fall	1979									572	204	32	0
Spring	1980								360	769	264	14	0
Fall	1980								526	195	10	3	0
Spring	1981							161	453	138	18	0	0
Fall	1981							412	301	35	0	0	0
Fall	1982						925	244	23	3	0	0	0
Fall	1983					770	501	13					
Fall	1984				332	131	0						
Fall	1985			509	311	27	3						
Fall	1986		1090	341	49	0	0						
Fall	1987	1358	284	102	4	3	0						
						Twin Cedars							
Fall	1982						1,000	227	12				
Fall	1983					443	237	12					
Fall	1984				376	93	3						
Fall	1985			266	197	11	0						
Fall	1986		1026	198	23	0							
Fall	1987	735	195	38	3	0							

Table II-2. Life Tables - South Platte River (rainbow trout/ha) (continued).

Sample period		Year class											
Season	Year	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
						Upper Canyon section - catch-and-release							
Fall	1979									106	682	583	56
Spring	1980									177	786	626	78
Fall	1980								35	344	655	288	139
Spring	1981							4	26	375	505	187	70
Fall	1981							10	155	434	137	49	7
Fall	1982						101	70	132	328	209	32	0
Fall	1983					763	182	335	218	81	8		
Fall	1984				84	497	522	156	168	29	1		
Fall	1985			10	70	780	412	63	37	5	0		
Fall	1986		14	15	168	666	218	43	4				
Fall	1987	61	41	136	388	137	0						
						Lower Canyon section - catch-and-release							
Fall	1979									105	758	685	88
Spring	1980									93	732	703	114
Fall	1980								20	621	503	71	0
Spring	1981							8	38	494	873	392	0
Fall	1981							23	86	465	224	45	0
Fall	1982						44	44	68	300	239	44	4
Fall	1983					848	235	398	232	109			
Fall	1984				72	238	522	189	127	44			
Fall	1985			15	39	433	248	32	23	1			
Fall	1986		39	3	78	418	211	64	8				
Fall	1987	119	32	72	345	165							
						Above Deckers Bridge section							
Fall	1979									156	91	57	8
Spring	1980									45	67	51	32
Fall	1980								243	141	30	1	0
Spring	1981							14	54	24	10	7	0
Fall	1981							119	100	54	7	8	0
Fall	1982						275	88	17	10	0	0	0
Fall	1983					561	366	50	19	4	0		
Fall	1984				43	218	132	19	6	3	1		
Fall	1985			22	112	502	128	3	4				
Fall	1986		71	25	126	288	94	10		3			
Fall	1987	333	79	106	162	52	0						
						Below Deckers Bridge section							
Fall	1982						445	139	65	0			
Fall	1983					603	314	40	47	0			
Fall	1984				127	401	90	8	0				
Fall	1985			3	32	115	326	38	1				
Fall	1986		99	25	130	223	61	4					
Fall	1987	454	104	159	141	31							

Table II-2. Life Tables - South Platte River (rainbow trout/ha) (concluded).

Sample period		Year class											
Season	Year	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975
						Scraggy View section							
Fall	1979									89	134	13	0
Spring	1980									53	67	17	1
Fall	1980								162	68	6	0	0
Spring	1981								86	50	6	0	0
Fall	1981							44	62	20	2	0	0
Fall	1982						91	28	31	13	0	0	0
Fall	1983					247	142	17	0	0	0	0	
Fall	1984				51	75	12	0	0				
Fall	1985			24	48	114	12	0	0				
Fall	1986		174	33	36	63	15	0					
Fall	1987	299	79	57	41	6	0						
						Twin Cedars							
Fall	1982						237	29	15				
Fall	1983					84	31	4	0				
Fall	1984				74	58	4	2	1				
Fall	1985			21	57	2	0	0	0				
Fall	1986		55	23	23	20	2						
Fall	1987	278	44	19	10	2	0						

Table III-1. Creel census, voluntary postcard (complete trip), Rio Grande River Marshall Park Fisherman Area, June-August 1987, #42539.

Statistics	June mean	July mean	August mean	Totals mean	Totals S.E.
FM hours	1,123	3,493	2,900	7,516	658
Total catch	1,410	3,069	3,629	8,108	1,402
Creel catch	966	1,829	2,373	5,168	1,121
Rainbow catch	493	2,012	3,052	5,557	826
Rainbow creeled	270	1,261	2,070	3,601	632
Brown catch	917	763	577	2,257	702
Brown creeled	697	324	303	1,324	678
Rainbow CPMH	.439	.576	1.052	.739	.085
Brown CPMH	.817	.218	.199	.300	.085
Total CPMH	1.256	.879	1.251	1.079	.150

Table III-2. Creel census, count-interview (incomplete trip), Rio Grande River Marshall Park Fisherman Area, June-August 1987, #42539.

Statistics	June mean	July mean	August mean	Totals mean	Totals S.E.
FM hours	1,116	3,478	2,900	7,494	663
Total catch	347	1,971	1,976	4,294	672
Creel catch	228	1,020	1,666	2,914	526
Rainbow catch	62	1,311	1,652	3,025	499
Rainbow creeled	62	877	1,449	2,388	429
Brown catch	285	660	324	1,269	373
Brown creeled	166	144	216	525	176.5
Rainbow CPMH	.056	.377	.570	.404	.059
Brown CPMH	.255	.190	.112	.169	.048
Total CPMH	.311	.567	.681	.573	.079

Table III-3. Water temperature data for the Blue River, 1987.

	May	Jun	Jul	Aug	Sep	Oct
Upper						
Mean monthly T(C)	7.7	11.5	12.4	8.1		
Mean monthly high	10.8	13.3	14.1	11.1		
Range	13.8-7.7	15.8-10.8	17.2-11.0	13.4-8.8		
Mean monthly low	5.1	9.2	9.1	5.6		
Range	7.0-3.1	12.0-6.4	11.8-6.4	6.8-4.3		
Lower[a]						
Mean monthly T(C)	8.2	11.5	13.6	11.2	7.9	6.8
Mean monthly high	10.6	13.7	16.0	15.4	10.9	8.8
Range	12.9-8.2	15.9-11.4	18.9-13.0	20.2-10.5	12.9-8.8	10.5-7.0
Mean monthly low	6.0	8.5	11.3	8.4	5.4	4.9
Range	7.2-4.8	10.8-6.1	12.9-9.7	10.2-6.5	7.3-3.5	6.7-3.1

[a]June, September, and October were partial months.