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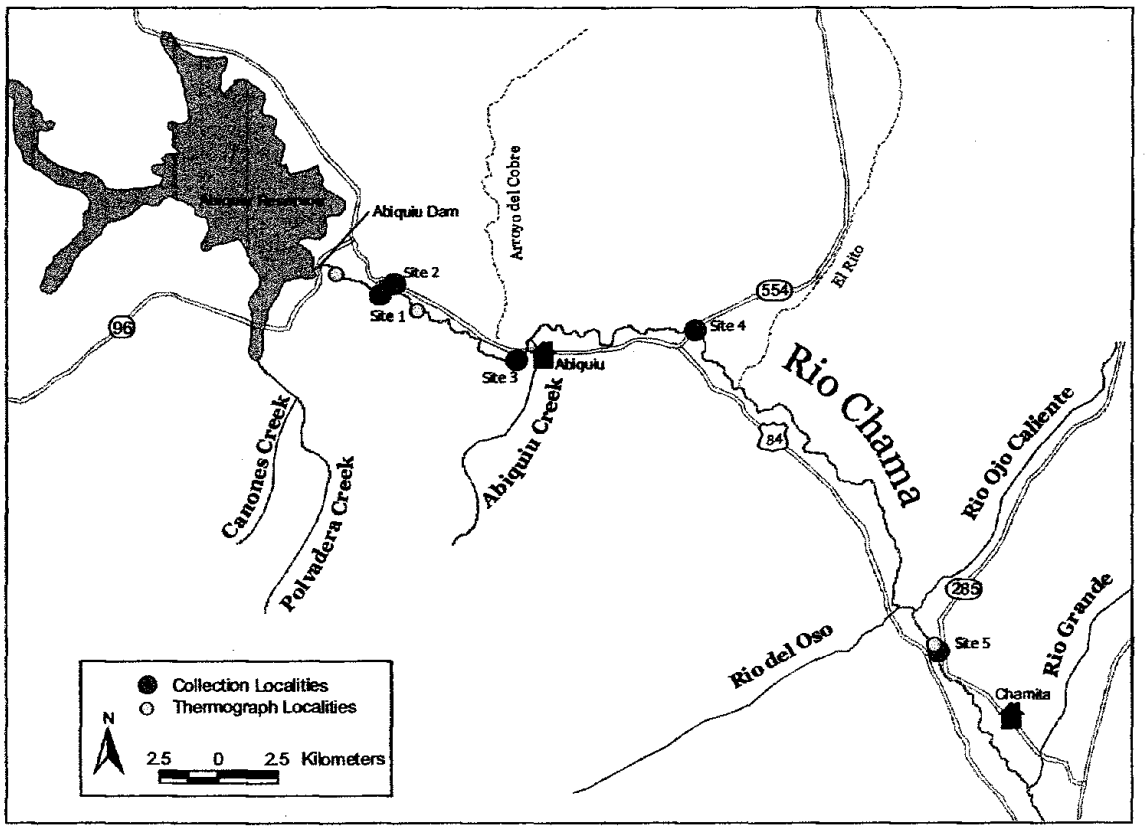
1997-1999 RIO CHAMA ICHTHYOFAUNAL MONITORING:
INSTALLATION OF EMERGENCY GATES AT ABIQUIU DAM

FINAL REPORT



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for:

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EXECUTIVE SUMMARY

Historical collections in the Rio Chama, New Mexico, provided important baseline information about the ichthyofaunal community of this river prior to its impoundment. The fish community of the of Rio Chama was, prior to the 1963 construction of Abiquiu Dam, comprised primarily of native mainstream cyprinids. Several native taxa were extirpated from the Rio Chama following completion and operation of Abiquiu Dam. Concurrent with the loss or decline of native fishes was the introduction and establishment of nonnative fishes, including a self-sustaining nonnative brown trout, *Salmo trutta,* fishery. Native fishes that survived the post-1963 changes in the Rio Chama are considered headwater species adapted to cold or cool waters and relatively high velocity habitats.

Between 1997-1999, the U. S. Army Corps of Engineers undertook the installation of a set of emergency gates in the conduit at Abiquiu Dam that required a marked reduction of flow (ca. 50 cfs). Ichthyofaunal monitoring of the Rio Chama (Abiquiu Dam to Chamita) was performed between April 1997 and October 1999 as part of this project. The primary purpose of this research effort was to provide information on potential impacts of operations and reduced flows on the distribution and abundance of fishes downstream of Abiquiu Dam.

The Rio Chama brown trout fishery has been a concern of natural resource managers ever since it became established in the hypolimnetic releases of Abiquiu Dam. Previous studies strongly recommended that a minimum flow of 70 cfs be released from Abiquiu Dam for brown trout. Low flows were identified as having the potential to isolate and desiccate brown trout redds and greatly reduce spawning and incubation habitats for this gamefish. Between year differences (1997-1999) in catch rates of Age-0 brown trout suggest that their recruitment in the Rio Chama could have been impacted by the extended winter low flow of 1998-1999. Indirect effects of low flow on recruitment could have been a reduced reproductive effort due to lack of suitable spawning habitat and increased mortality of eggs and fry because of suboptimal abiotic conditions. The pronounced decline in brown trout abundance from January 1999 to March 1999 suggested a rapid loss of adult brown trout. The most parsimonious explanation for this decline was highly intensified angling pressure during this period.

Although recommendations have been generated for brown trout, little consideration has been given to native fish species. The decline in the abundance of several native fishes near Abiquiu Dam at the beginning of this study appeared correlated with low flow conditions and concurrent reduction in available habitats. The loss of instream cover and crowding of fishes, as compared with normal flows, may have increased the likelihood of competition or predation. Conversely, low flow conditions may have ultimately benefitted native fishes by reducing the number of predaceous brown trout.

It was difficult to separate and assess the impacts to brown trout and other species caused by shut-downs associated with the installation of emergency gates at Abiquiu Dam. Primary (stranding fish) and secondary (crowding, increased predation and competition, etc.) biotic effects to the ichthyofaunal community certainly resulted from these events. Numerous additional reasons could be posed as an explanation for some of observed changes in the fish community including a combination of physical and biological factors. Sampling of additional sites and during shut-down events, though not contractually obligated, vastly improve the ability to formulate hypothesized effects of these events on the ichthyofaunal community.

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INTRODUCTION

Collections in the Rio Chama, New Mexico, prior to the construction of Abiquiu Dam, were limited but provided important information about the ichthyofaunal community prior to its impoundment in 1963. A total of six museum curated collections were made between 1949 and 1964 in the Rio Chama in New Mexico. Between 1964 and 1983, there were a limited number of samples taken but not enough to accurately track changes in ichthyofaunal community structure and abundance. From the late 1980s to present, there have been numerous Rio Chama collections (made by University of New Mexico personnel) between the outflow of Abiquiu Reservoir and its confluence with the Rio Grande. Platania (1991) and Platania et al. (1996) provided accounts of 1984 and 1994 collections, respectively, from that region. Recent collections (1997-2000) provide insight to the ichthyofauna of the Rio Chama during installation of emergency gates.

The fish community of the of Rio Chama was, prior to the 1963 construction of Abiquiu Dam, comprised primarily of native mainstream cyprinids. Two endemic Rio Grande Basin cyprinids, Rio Grande silvery minnow, *Hybognathus amarus,* and Rio Grande bluntnose shiner, *Notropis simus simus*, reached the northern limit of their ranges in the Rio Chama near Abiquiu (Bestgen and Platania, 1990, 1991). The latter taxon was last collected in 1964 in the Rio Grande near Peña Blanca and is now extinct. Rio Grande silvery minnow now occurs only in the Middle Rio Grande, New Mexico, between Cochiti Dam and Elephant Butte Reservoir (Bestgen and Platania, 1991). Native cyprinids that survived the post-1963 changes in the Rio Chama that resulted from the operation of Abiquiu Dam are generally considered headwater species adapted to cold or cool waters and relatively high velocity habitats.

Concurrent with the loss of mainstream cyprinids was the introduction of nonnative sportfishes. The Rio Chama downstream of Abiquiu Dam supports a self-sustaining brown trout, *Salmo trutta,* fishery. In addition, rainbow trout, *Oncorhynchus mykiss,* are also taken from this cool-water reach of the Rio Chama. Fishes stocked into Abiquiu Reservoir are occasionally transported to and become temporarily established in the lower reaches of the Rio Chama. However, unlike brown trout, these species do not appear to be self-sustaining.

The lower Rio Chama ecosystem has received considerable attention from state and federal resource agencies since the Abiquiu Dam projects of the late 1980s. These projects included a canyon bank-wall stabilization program and installation of a hydroelectric facility by Los Alamos County in 1990. Numerous well-documented water quality infractions accompanied these activities including multiple sediment discharge violations, elevated levels of hazardous materials in soil and water samples, and substandard levels of dissolved oxygen in water discharged at the dam site. The synergistic effects of these multiple perturbations to the aquatic ecosystem was not quantified but was perceived to be detrimental to the ichthyofaunal community. The New Mexico Health and Environment Department, Environmental Improvement Division (EID) stated, in a 1989 letter to the Federal Energy Regulatory Commission (FERC), "the detrimental impacts of these activities on the biota cannot be overestimated." As a result of these infractions, the County of Los Alamos was required to initiate a suite of mitigating actions including a one year (1995) study of the fishes of the Rio Chama downstream of Abiquiu Dam. That work resulted in the most systematic and comprehensive study of the fishes in the lower reaches of the Rio Chama to date (Platania et al. 1996).

Between 1997-1999, the U. S. Army Corps of Engineers (ACE or Corps) undertook the installation of a set of emergency gates in the conduit at Abiquiu Dam. Ichthyofaunal monitoring of the Rio Chama (Abiquiu Dam to Chamita) was performed between April 1997 and October 1999 as part of this project. A marked reduction of flow (reduced to ca. 50 cfs) from Abiquiu Dam was necessary for gate installation. The fish project was to provide information on the potential impact of

these operations and reduced flows on the abundance and distribution of fishes downstream of Abiquiu Dam. The Corps fish sampling protocol specified two sampling trips (at five sites) in 1997 and four collections (at five sites) in 1998 and 1999. As this sampling scheme was not deemed sufficient to provide information necessary to assess the potential impact of low flow conditions on the ichthyofaunal community (by the authors), additional sampling was conducted between November 1998 and March 1999. During this period (November 1998 - March 1999) flows in the Rio Chama downstream of Abiquiu Dam achieved their lowest levels over the tenure of this study.

A portion of the environmental component of the project required the monitoring of fish populations at sites downstream of Abiquiu Dam. Three discrete components of the fish studies were initial population monitoring, fish population monitoring during the installation of the emergency gates, and sampling following completion of the emergency gate project. The goal of the work was to identify changes in the resident fish community prior to, during, and after completion of the project. Additional monitoring of fishes during low flow events was deemed necessary to assess the impact on the ichthyofaunal community during these potentially harsh or lethal conditions.

STUDY AREA

The Rio Chama, the largest tributary of the Rio Grande, originates in the San Juan Mountains of southern Colorado. Snowmelt provides the majority of water in the Rio Chama, but flow is supplemented by transmontane diversions from the San Juan River drainage (Colorado River basin via the San-Juan Chama project). The Rio Chama flows approximately 125 miles (201 km) in a southeasterly direction confluencing with the Rio Grande just upstream of Española, New Mexico. While three mainstem reservoirs (El Vado, Heron, and Abiquiu) make the Rio Chama a highly regulated system, it still contributes a significant volume to the Rio Grande. The largest of these impoundments, Abiquiu Reservoir, was completed in 1963 and is located 32 miles (52 km) upstream of the river's mouth.

From Abiquiu Dam to its confluence with the Rio Grande, the Rio Chama is a fairly wide (30-50 m), low gradient (3.6 m/km), meandering stream with a cobble-gravel substrate and considerable habitat heterogeneity. It flows through an agricultural valley in a series of shallow runs, riffles, and pools. The ichthyofaunal community is composed of coolwater fishes near the hypolimnetic outflow of Abiquiu Reservoir and gradually becomes primarily a warmwater fish community farther downstream and near its confluence with the Rio Grande.

A marked reduction in flow was necessary during the installation of emergency gates to allow the Corps to safely undertake the project. Although flows immediately downstream of Abiquiu Dam occasionally dropped to <10 cfs, the most common discharge volume was about 50 cfs. The low flow period was from November 1998 to March 1999.

Fish Population Monitoring

Fish population monitoring was conducted at five sites on 11 occasions between 4 April 1997 and 14 October 1999. Sampling sites were located in a 28.3 mile (45.5 km) reach of the Rio Chama beginning downstream of Abiquiu Dam (Figure 1). Many of these sites had been sampled during our previous life history and habitat study of the fishes of the Rio Chama (Platania et al., 1996). Sites selected to be sampled for fish contained habitat characteristics representative of that reach of the river.

The uppermost fish population monitoring site sampled (Site 1) was 1.7 miles (2.7 km) downstream of Abiquiu Dam (UTM Coordinates: 4010030N / 374631E; Zone 13). Main channel runs/

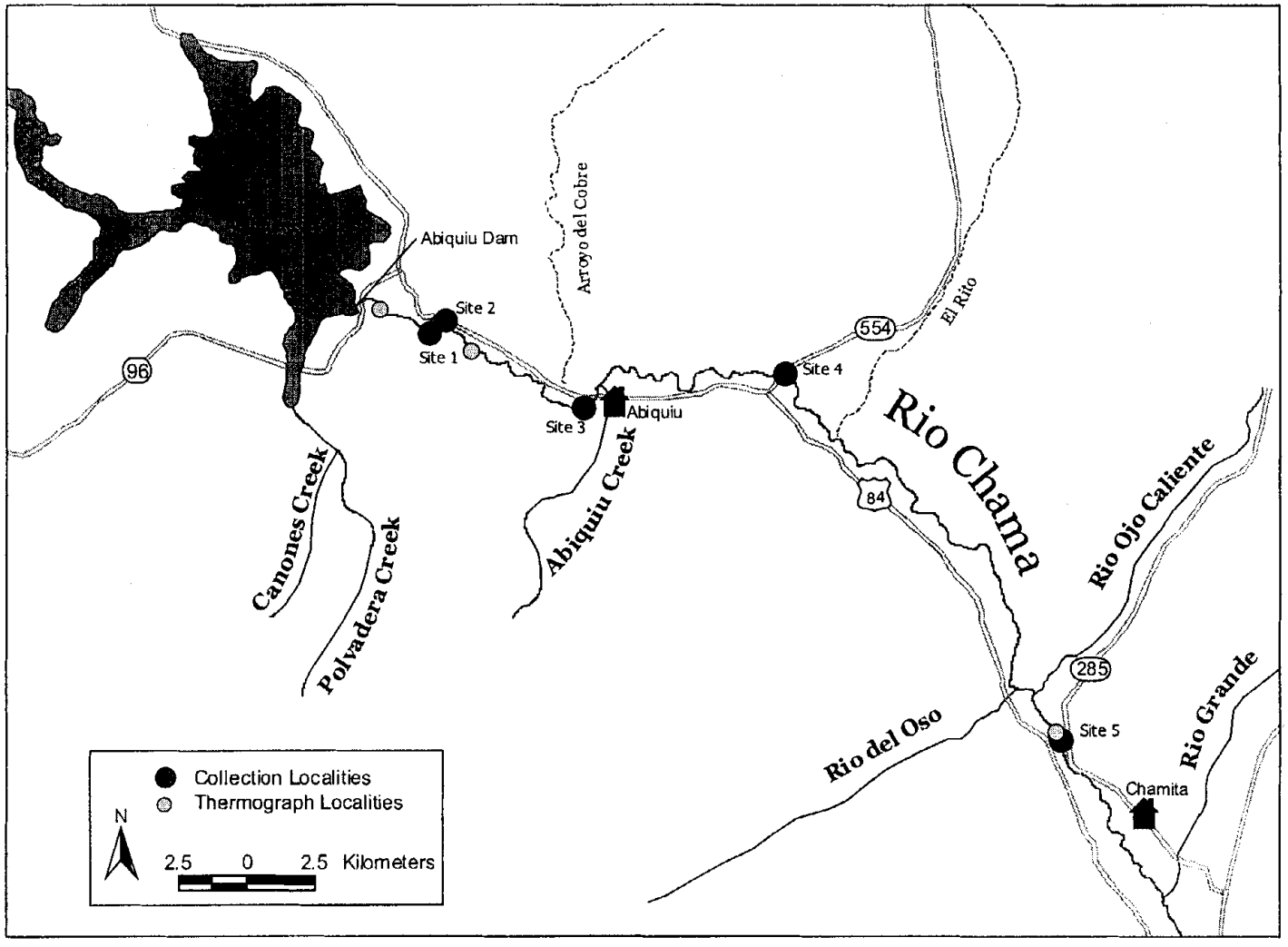

Figure 1. Fish population monitoring sites and thermograph localities in the Rio Chama, New Mexico.

riffles were the most common habitats. The substrata was primarily cobble and gravel with attached algae. Channel width was relatively narrow (ca. 40 m), current was high-to-moderate (typically >0.7 m/s), and depths were generally shallow but varied greatly.

The next site (Site 2) was ca. 2.0 miles (3.2 km) from Abiquiu Dam at a large bend in the river (UTM Coordinates: 4010518N / 375188E; Zone 13). A large island ran the length of the site and divided flow into two channels. There were a relatively large variety of habitats available at this site including main and side channel runs, riffles, and pools. Habitat heterogeneity within this reach was largely due to the sharp meander of the river around the corner and its division into two autonomous channels. Substrate was primarily gravel and cobble overlain with low levels of silt. Numerous small arroyos feed into the Rio Chama upstream of this area and regularly deposit large quantities of silt. Although most of this material is ultimately displaced downstream, it accumulates during periods of low flow.

The third site was ca. 0.5 miles (0.8 km) upstream of US Hwy 84 bridge near Abiquiu, NM (UTM Coordinates: 4007214N / 380343E; Zone 13) and represented the beginning of the transitional area between coolwater with large substrates (i.e., habitats that support brown trout) and warmwater with smaller substrates (i.e., habitats that primarily support native fish). In this reach, the river was straight and narrow with most habitat heterogeneity being provided by the presence of side channels. Substrata at Site 3 was a mixture of gravel, sand, and silt.

Site 4 was at the NM State Hwy 554 bridge crossing of the Rio Chama, ca. 8.8 miles (14.2 km) downstream of Abiquiu, NM (UTM Coordinates: 4008472N / 387873E; Zone 13). Variable instream habitats within this reach were fairly limited except along the shoreline. Most of the site consisted of shallow to moderately deep water over a cobble/silt substrata. Main channel run was the primary habitat.

The final sampling site (Site 5) was at US Hwy 285 bridge crossing of the Rio Chama near Chamita, NM (UTM Coordinates: 3994780N / 398157E; Zone 13). The habitat in this reach was varied and included main and side channel runs and pools. Channel width at this locality was greater than at many of the upstream sites and substrate composition was primarily gravel and sand with occasional silt depositional areas.

METHODS

A Smith-Root Type VII (DC) electrofishing unit with two electrodes was used to collect fish at the five Rio Chama study sites. The electrofishing device produced 0.3-0.7 amps at 400 volts with shocking times ranging from 318-2,444 seconds/site but generally between 1,000-1,500 seconds/site. The individual operating the electrofishing device shocked all available habitats (pools, runs, riffles, backwaters) while two additional people collected stunned specimens using 1/8 inch mesh dip-nets. A fourth person carried buckets containing river water and transported captured fish to live wells for processing. Single collecting passes were made at each sampling site.

An additional collecting technique involved setting a 10 x 6 foot, 3/16 inch mesh seine perpendicular to flow in run or riffle habitats. The individual would then engage the electrofishing unit and agitate the substrate immediately upstream of the seine. Immobilized and dislodged specimens were swept by the current into the seine. This sampling method was particularly effective for collection of benthic species. Larval fish were collected with a 4 x 4 foot, 1/32 inch mesh seine or fine-mesh aquarium nets and preserved in 5% buffered formalin. Catch rate for fish at Rio Chama sites is presented as the number of fish collected per 100 seconds electrofished.

Scientific and common names in this report follow Robins et al. (1991; Table 1). Retained fish were fixed in the field in 10% formalin and returned to the laboratory where they were sorted,

Table 1. Scientific and common names of fish collected from the Rio Chama, New Mexico.

Scientific Name	Common Name
Order Cypriniformes	
Family Cyprinidae	carps and minnows
Cyprinus carpio	common carp
Gila pandora	Rio Grande chub
Pimephales promelas	fathead minnow
Platygobio gracilis	flathead chub
Rhinichthys cataractae	longnose dace
Family Catostomidae	suckers
Carpiodes carpio	river carpsucker
Catostomus commersoni	white sucker
Order Siluriformes	
Family Ictaluridae	bullhead catfishes
Ameiurus melas	black bullhead
Order Salmoniformes	
Family Salmonidae	trouts
Oncorhynchus mykiss	rainbow trout
Salmo trutta	brown trout
Order Cyprinodontiformes	
Family Poeciliidae	livebearers
Gambusia affinis	western mosquitofish
Order Perciformes	
Family Centrarchidae	sunfishes
Micropterus salmoides	largemouth bass

identified to species, counted, and measured (mm standard length, SL). Specimens were ultimately transferred to 70% ethyl alcohol and catalogued into the Division of Fishes, Museum of Southwestern Biology (MSB), University of New Mexico (UNM). Most post Age-0 salmonids captured during this study were counted, identified to species, measured (mm SL), and released unharmed. Population monitoring of fish occurred on 11 occasions: April and October (1997), March, May, September, October, and November (1998), and January, March, July, and October (1999).

Length-frequency histograms were generated from measurements taken on five species (Rio Grande chub, *Gila pandora*, fathead minnow, *Pimephales promelas*, longnose dace, *Rhinicthys cataractae*, white sucker, *Catostomus commersoni*, and brown trout). Specific age-classes were not provided on figures but were discussed in the results section as appropriate. Validation of length ranges of putative age-classes was provided by Platania et al. (1996) and review of published literature.

Specific locations of sample site were derived from U.S. Geological Survey (USGS) 7.5' quadrangles (Abiquiu and Canoñes) and UTM coordinates determined with a Garmin Navigation Geographic Positioning System Instrument. The data presented in this report supersede our interim summary reports on the ichthyofauna in the Rio Chama. Rio Chama discharge for the study period (Figures 2 and 3) was obtained from USGS station-Rio Chama below Abiquiu Dam, NM (# 08287000) and USGS station-Rio Chama near Chamita, NM (#08290000).

RESULTS

Summary of Fish Population Monitoring

A total of 11 sampling trips to five sites were conducted over the course of the project (i.e., 55 collections). The 4,638 individuals collected during the two year project (April 1997-October 1999) documented an ichthyofaunal community (Table 2) comprised of 12 species and one intergeneric hybrid. Specimens of the hybrid (*Gila pandora* x *Rhinichthys cataractae*) were only taken at Site 5 (Table 3). Also noteworthy were the first recent collection of river carpsucker, *Carpiodes carpio*, and the only capture of black bulhead, *Ameiurus melas*, from the Rio Chama. Most species were represented by few individuals and spatial or temporal changes in their abundance were not deemed meaningful.

Only the six most abundant species (longnose dace, *Rhinichthys cataractae*, [n=1,728], brown trout [n=1,131], white sucker, *Catostomus commersoni*, [n=802], Rio Grande chub, *Gila pandora*, [n=326], fathead minnow, *Pimephales promelas*, [n=320], and flathead chub, *Platygobio gracilis* [n=281]) were included in distribution and abundance comparisons. Other species were represented by 1-30 specimens and collectively comprised <1% of the total catch. These taxa were often only found at one site and their combined frequency of occurrence was very low.

Introduced fish species (n=7) outnumbered native fish species (n=5) and they (introduced) cumulatively accounted for 42.6% (n=1,974) of the total catch. White sucker and brown trout were, collectively, the majority (97.9%) of nonnative individuals. Most other introduced fish species were only occasionally collected and their abundance was low at all sites. Three of the seven introduced taxa were gamefish. Brown trout was one of the most abundant fish in the study area. Rainbow trout and smallmouth bass (*Micropterus dolomieu*) were also present but rare and did not appear to maintain naturally reproducing populations.

Most native fishes were moderately abundant (range=281 to 1,728). An exception to this pattern was river carpsucker (n=6) which was only collected on two occasions. Longnose dace was the most abundant native fish collected during this study and its frequency of occurrence (n=54)

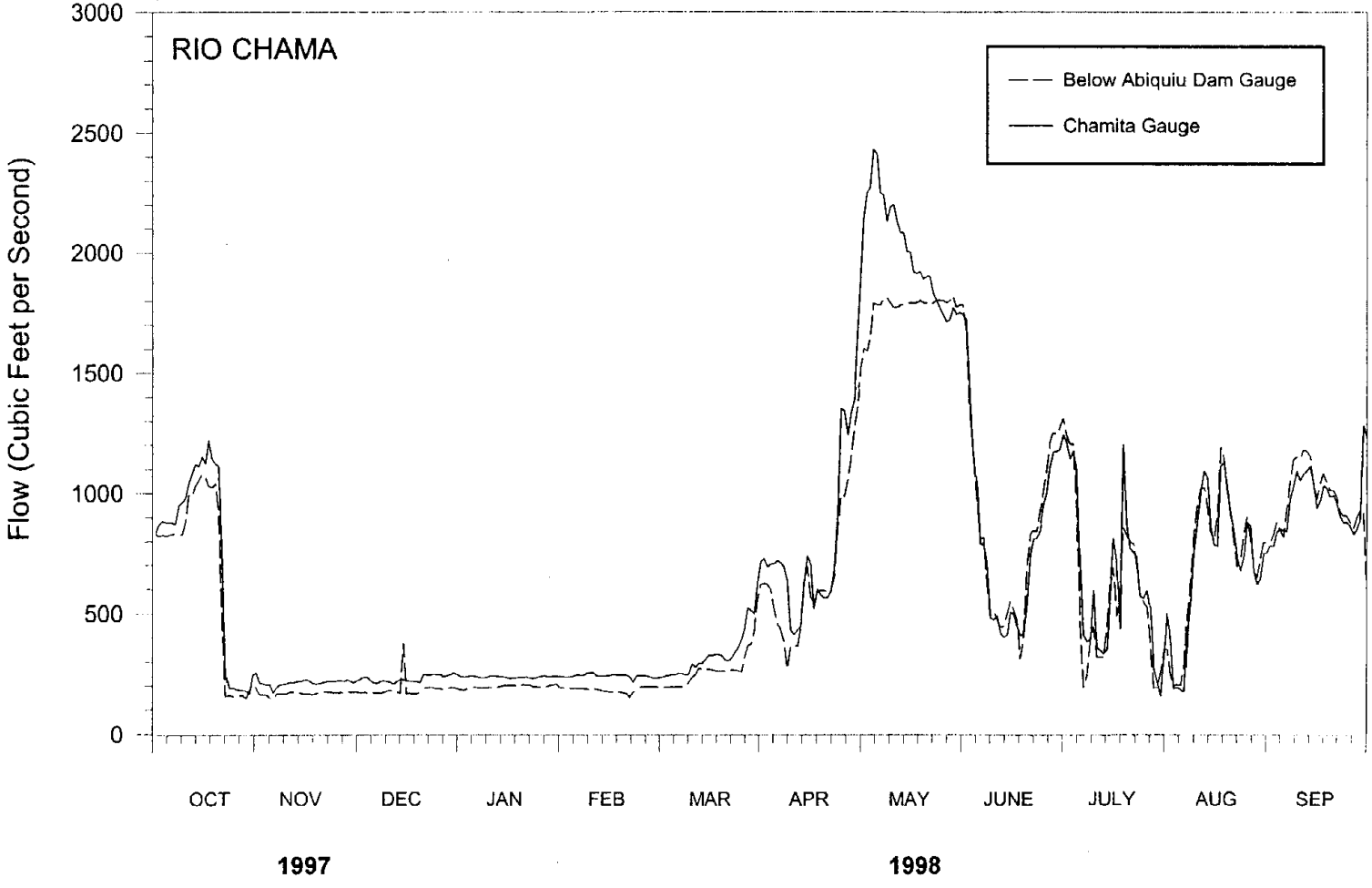

Figure 2. Hydrograph of the Rio Chama below Abiquiu Dam for the 1998 water year.

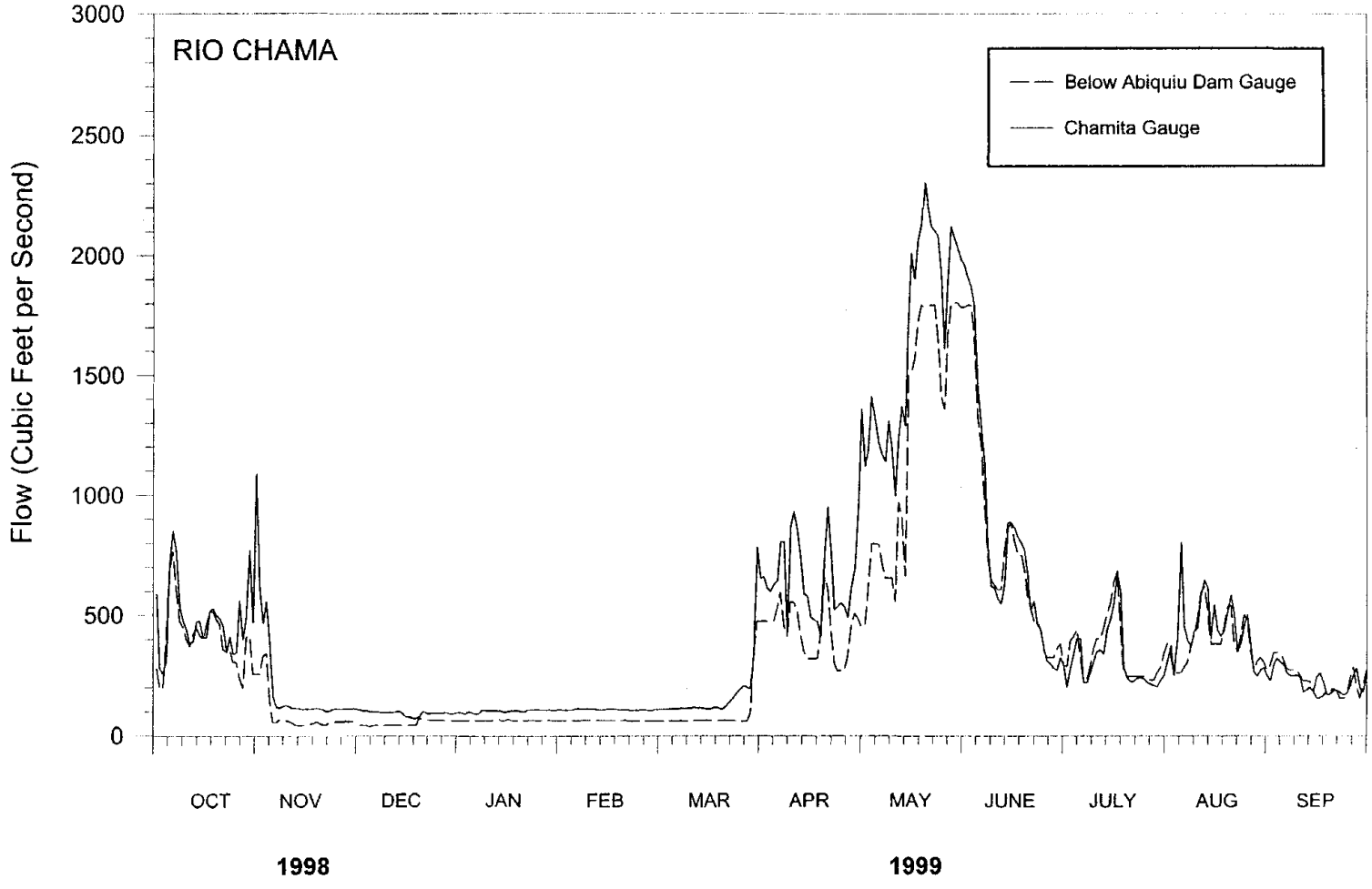

Figure 3. Hydrograph of the Rio Chama below Abiquiu Dam for the 1999 water year.

Table 2. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, April 1997-October 1999.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	4	10	2	0.08
Rio Grande chub	N	326	4	33	6.89
fathead minnow	N	320	5	27	6.76
flathead chub	N	281	6	9	5.93
longnose dace	N	1,728	1	54	37.52
river carpsucker	N	6	8	2	0.13
white sucker	I	802	3	50	16.95
black bullhead	I	1	12	2	0.02
rainbow trout	I	5	9	3	0.11
brown trout	I	1,131	2	53	23.90
western mosquitofish	I	30	7	1	0.63
smallmouth bass	I	1	12	1	0.02
Rhinichthys x *Gila* hybrid	N	3	11	1	0.06
TOTAL		4,638			

[1] N = native; I = introduced

Table 3. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico April 1997-October 1999.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	3	1	4
Rio Grande chub	13	5	56	59	193	326
fathead minnow	46	1	65	116	92	320
flathead chub	-	-	-	-	281	281
longnose dace	378	318	461	146	425	1,728
river carpsucker	-	-	-	-	6	6
white sucker	187	43	379	123	70	802
black bullhead	1	-	-	-	-	1
rainbow trout	4	-	-	1	-	5
brown trout	584	252	138	115	42	1,131
western mosquitofish	-	-	-	-	30	30
smallmouth bass	-	-	1	-	-	1
Rhinichthys x *Gila* hybrid	-	-	-	-	3	3
TOTAL	1,213	619	1,100	563	1,143	4,638
# SPECIES	7	6	6	7	9	12
SHOCKING SEC.	14,576	13,822	12,569	11,426	13,031	58,842
CPUE *	8.32	4.48	8.75	4.93	8.77	7.88

* catch rate per 100 seconds electrofishing

exceeded that of any other species. This benthic native fish was absent from only one collection. Rio Grande chub, fathead minnow, and flathead chub all were moderately abundant (range=281 to 326).

Rio Grande chub, the second-most abundant native taxon, was present at all sampling localities, and taken in over half (n=33 out of 55) of the collections. It was relatively rare at the two upstream sites (Sites 1 and 2) but more abundant at Sites 3 and 4. This species reached its peak abundance at Site 5 (n=193).

A similar pattern of longitudinal distribution and abundance was noted for fathead minnow. This species was moderately abundant at Site 1 and rare at Site 2. Its catch rate increased downstream and the majority of individuals were taken at Sites 4 and 5 (n=116; n=92, respectively). The frequency of occurrence of fathead minnow (n=27) was about the same as that recorded for Rio Grande chub and these taxa were often found in similar instream habitats.

Longnose dace comprised 37.5% of the total catch and 64.9% of the native fish catch and were relatively evenly distributed across sampling localities. Sites 3 and 5 produced the highest numbers of individuals of this species with fewer individuals taken at Sites 1 and 2. The only site where few longnose dace were captured was Site 4.

Nonnative white sucker exhibited a wide range in abundance between sampling localities. This species was moderately abundant at Sites 1 and 4 but most abundant at Site 3. Many fewer white sucker were taken at Site 5 than at sites 1, 3, or 4 and its lowest catch rate was at Site 2. White sucker were found during nearly all sampling efforts (n=50 of 55).

Brown trout numerically dominated the upper reaches of the study area near Site 1. Over 500 individuals were taken at Site 1 and many were also present at Site 2 (n=252). Downstream localities produced progressively fewer brown trout with Site 5 resulting in the capture of only 42 individuals. Brown trout comprised 57.3% of the nonnative fish catch and were collected in all but two sampling efforts.

Several less abundant taxa (common carp, *Cyprinus carpio*, flathead chub, *Platygobio gracilis*, river carpsucker, western mosquitofish, *Gambusia affinis*, and the *Gila pandora* x *Rhinichthys cataractae* hybrid) were found only at the downstream-most sampling localities. Common carp were captured at Sites 4 and 5, while flathead chub, river carpsucker, western mosquitofish, and *Gila pandora* x *Rhinichthys cataractae* were only taken at Site 5. Black bullhead and smallmouth bass were collected from collecting localities upstream of Site 5 but were each only represented by a single individual. Rainbow trout were only taken at Site 1 (n=4) and Site 4 (n=1).

Combined fish catch rate was highest at Sites 1, 3, and 5. Despite their similar overall catch rates, the relative abundance of species occupying these sites varied considerably (i.e., brown trout dominated Site 1, longnose dace and white sucker dominated Site 3, and large numbers of Rio Grande chub and flathead chub accounted for the increased catch rate at Site 5). Catch rates at Sites 2 and 4 were about half those recorded at the other sites. Site 5 produced the highest number of species (n=9) while other sites produced either 6 or 7 species.

Population Monitoring by Sampling Trip

April 1997

The initial population monitoring trip was conducted during a period with mean daily discharge at Abiquiu Dam of about 300-400 cfs. This sampling effort was conducted on 4 April 1997, prior to the substantial release of water (ca. 1,800 cfs) that occurred in late April 1997. All except deep-water habitats could be accessed and water visibility was high. Sampling yielded only a low-moderate number of fish (n=94) and catch rates ranged from 0.95-2.81 fish/100 seconds between sites. Water

temperatures were cool (8-10° C) which, combined with moderately high flow, probably accounted for low catch rates.

A total of four native and three nonnative taxa were recorded during this sampling effort. Longnose dace were the most frequently collected species in April 1997 (Table 4) followed by white sucker. Longnose dace were also the majority (55.3%) of the total catch and were present at all five sites (Table 5). White sucker were captured at all sites except Site 5. The number of brown trout taken was low (n=10) during this sampling trip. Likewise, Rio Grande chub, fathead minnow, flathead chub, and smallmouth bass were only occasionally collected. The number of species present varied between sites because of the occasional presence of rare species. Low catch rates during this sampling trip precluded detection of longitudinal differences in fish abundance.

Rio Grande chub (n=4) were present in shoreline habitats adjacent to areas of low flow at Sites 2, 4, and 5. Individuals ranged in length from 29.3-59.5 mm SL and appeared to be Age-1 or Age-2 (Figure 4). The 59.5 mm SL Rio Grande chub from Site 4 was probably an Age-2 individual.

Fathead minnow collected in April 1997 (n=6) were present in slack water areas along the shoreline and in an inundated backwater. The larger individuals present at Sites 1, 2, and 4 (size range=39.5-47.2 mm SL) were Age-2 fish (Figure 5). Two smaller individuals (ca. 20 mm SL) were likely spawned in autumn of 1996 and therefore were Age-1 fish.

The relatively low number of longnose dace collected hampered accurate determination of age-class structure (Figure 6). The well-defined group of individuals (ca. 25-35 mm SL) collected at Site 2 were Age-1 fish. Some of the largest individuals collected (i.e., >70 mm SL) were probably Age-3 longnose dace and the remainder were Age-2 individuals. Longnose dace were present in areas of rapid flow and were captured by disturbing the substrate to dislodge individuals from interstitial spaces.

White sucker were present at four of five sites. Individuals were occassionally collected in deep pools along the shoreline at several of the sites. There were two white sucker size-classes with only one individual (122.2 mm SL) representing the larger size-class (Figure 7).

Few brown trout were collected and only three of the five sites sampled produced this species. Brown trout ranged from 104.5 mm SL to 133.7 mm SL and all individuals captured appeared to be Age-1 fish (Figure 8). The lack of larger brown trout was likely the result of an inability to access some of the deepest portions of the river.

October 1997

Sampling was conducted prior to the decrease in flow that occurred at the end of October. This sampling effort (20-21 October 1997) occurred during autumn (irrigation) water releases from Abiquiu Dam. During early and mid-October 1997, flow in the Rio Chama downstream of Abiquiu Dam was relatively high with a mean daily discharge of about 1,000 cfs. However, by the end of October 1997 flow was reduced to a mean daily discharge of about 200 cfs. It remained at this level (ca. 200 cfs) throughout the winter of 1997-1998.

The high discharge resulted in overbank flooding and creation of low velocity habitats. The sampling effort yielded a moderate number of fish (n=747), a relatively high number of YOY (young-of-year), and catch rates that ranged from 5.23 to 40.28 fish/100 seconds. Overall catch rate (13.03 fish/100 seconds) for October 1997 was nearly an order magnitude greater than that recorded in April 1997 (1.81 fish/100 seconds). Water temperatures were cool during sampling (13-15° C) and water visibility was low.

A total of four native and three nonnative fish taxa were recorded during this sampling effort (Table 6). The largest number of individuals were taken at the three most downstream sites (Table 7). As expected, the highest catch rates were also observed at downstream sites (Sites 4 and 5). The

Table 4. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, April 1997.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	-	-	-	-.--
Rio Grande chub	N	4	5	3	4.26
fathead minnow	N	6	4	3	6.38
flathead chub	N	1	6	1	1.06
longnose dace	N	52	1	5	55.32
white sucker	I	20	2	4	21.28
brown trout	I	10	3	3	10.64
smallmouth bass	I	1	6	1	1.06
TOTAL	94				

[1] N = native; I = introduced

Table 5. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico, April 1997.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	-	-	-
Rio Grande chub	-	2	-	1	1	4
fathead minnow	1	1	-	4	-	6
flathead chub	-	-	-	-	1	1
longnose dace	12	22	5	7	6	52
white sucker	2	6	8	4	-	20
brown trout	4	3	-	3	-	10
smallmouth bass	-	-	1	-	-	1
TOTAL	19	34	14	19	8	94
# SPECIES	4	5	3	5	3	7
SHOCKING SEC.	1,328	1,391	942	677	845	5,183
CPUE *	1.43	2.44	1.49	2.81	0.95	1.81

* catch rate per 100 seconds electrofishing

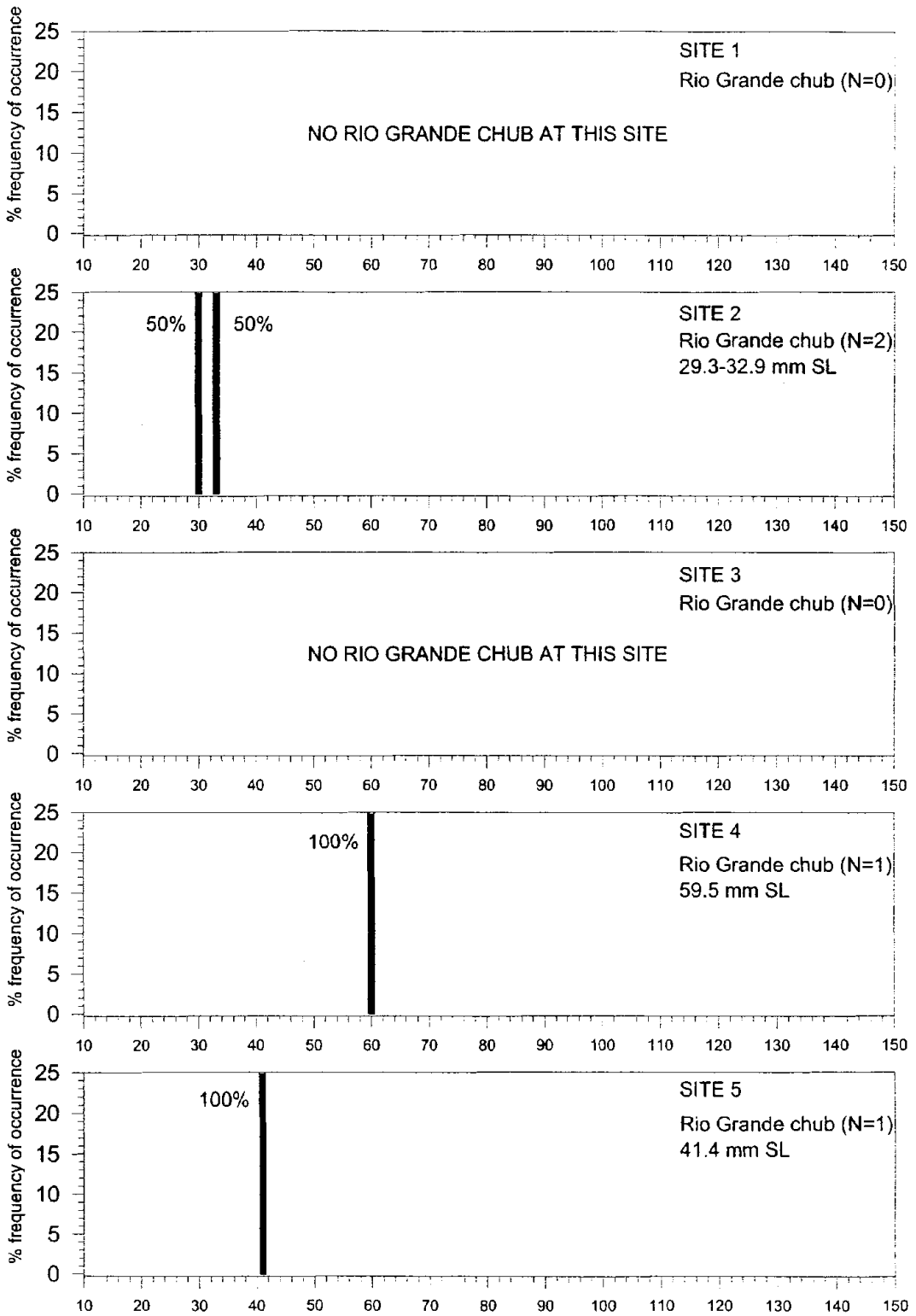

Figure 4. Rio Grande chub length-frequency histograms at five Rio Chama sites, New Mexico, April 1997.

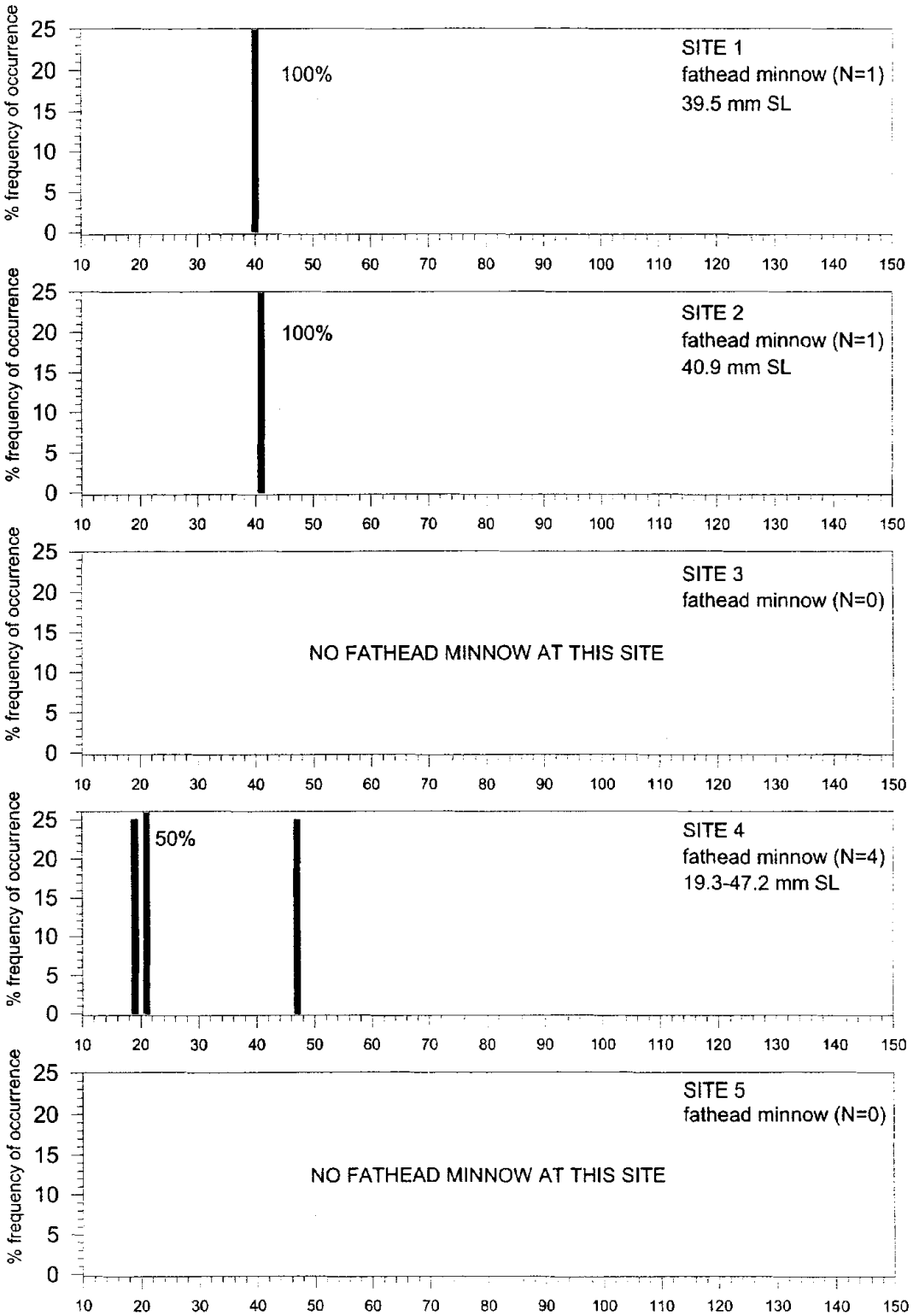

Figure 5. Fathead minnow length-frequency histograms at five Rio Chama sites, New Mexico, April 1997.

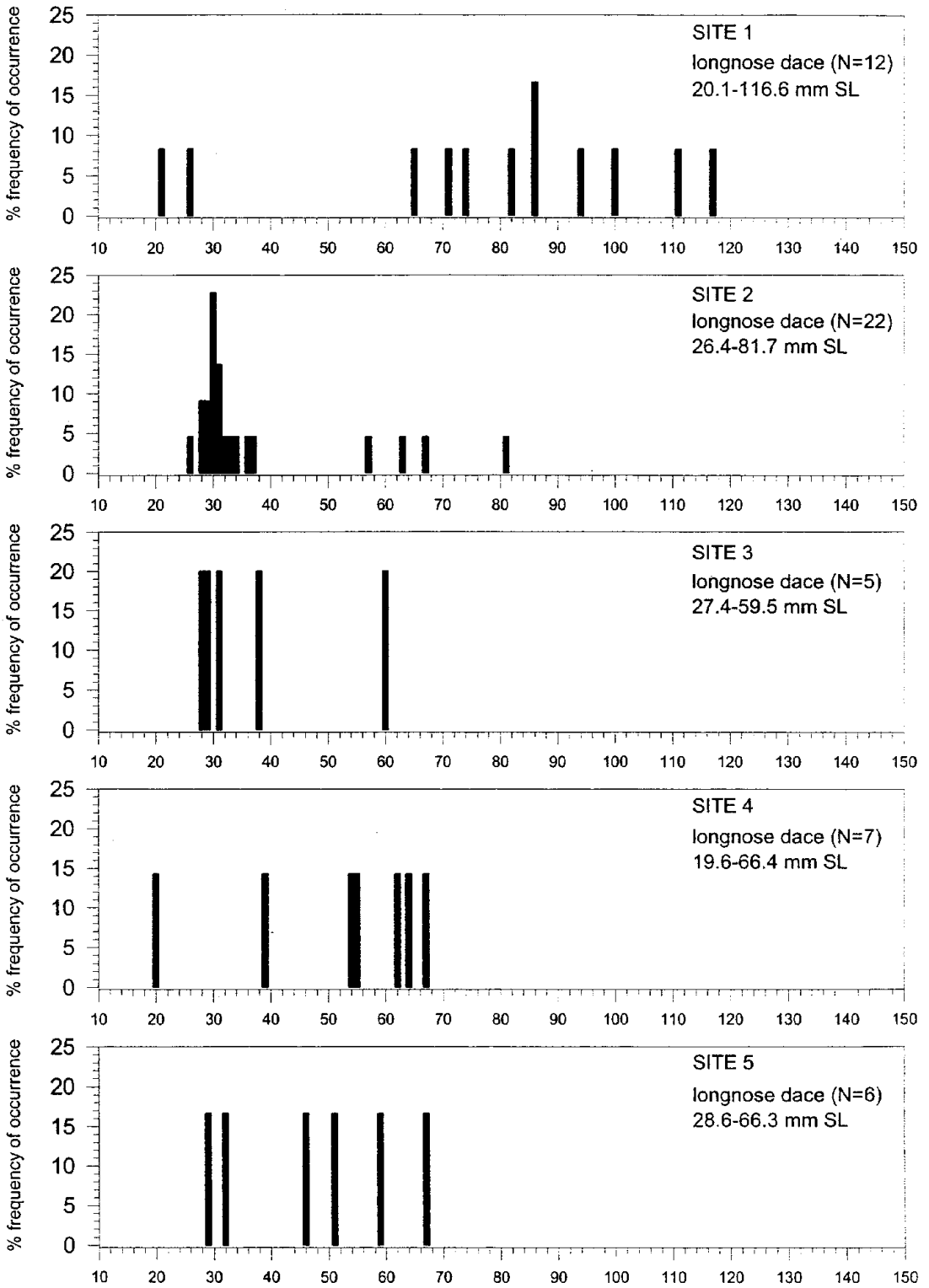

Figure 6. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, April 1997.

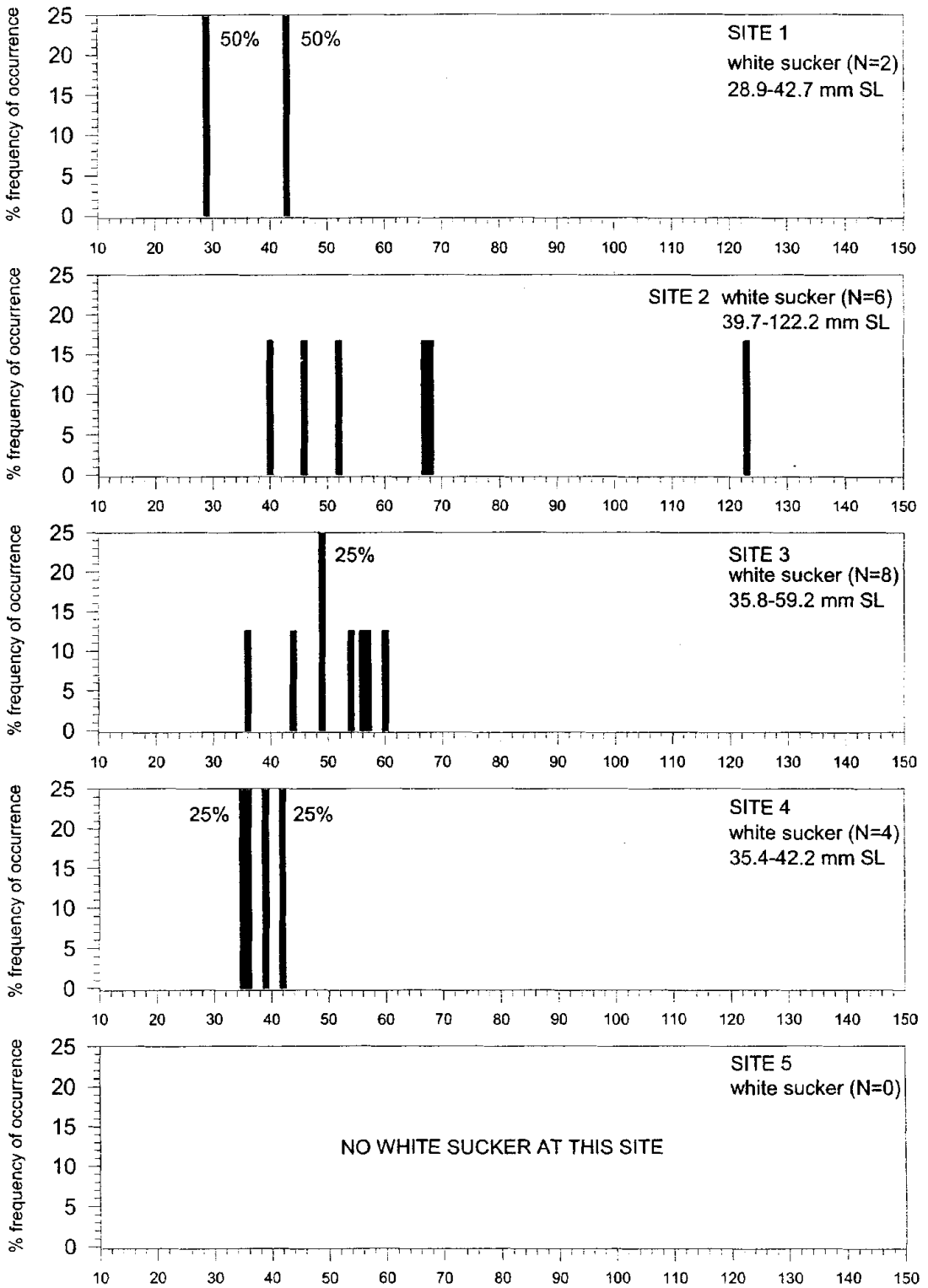

Figure 7. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, April 1997.

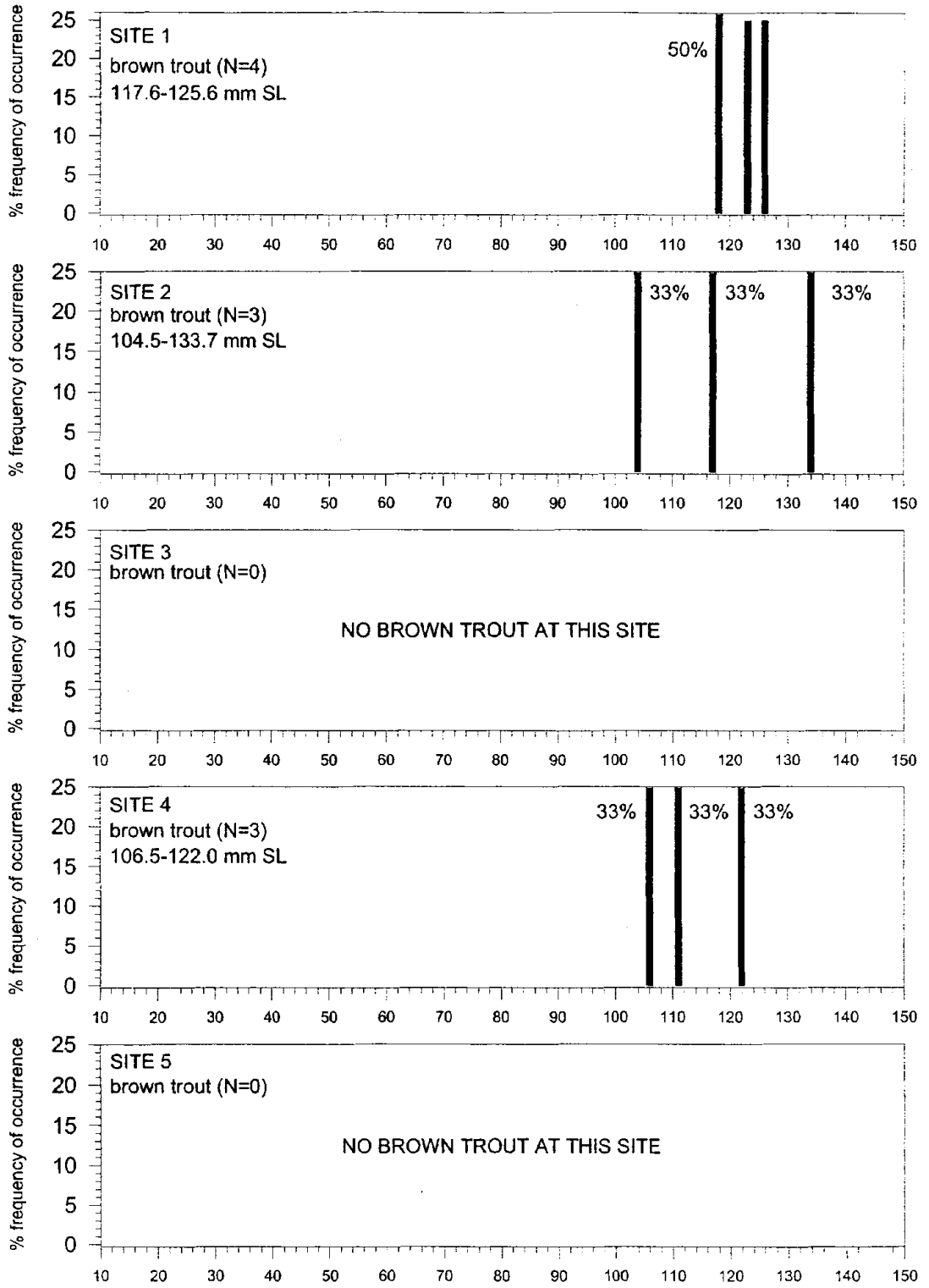

Figure 8. Brown trout length-frequency histograms at five Rio Chama sites, New Mexico, April 1997.

Table 6. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, October 1997.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	3	7	1	0.40
Rio Grande chub	N	49	6	3	6.56
fathead minnow	N	130	3	4	17.40
flathead chub	N	100	4	1	13.39
longnose dace	N	188	2	5	25.17
white sucker	I	199	1	5	26.64
brown trout	I	78	5	5	10.44
smallmouth bass	I	-	-	-	-.—
TOTAL	747				

[1] N = native; I = introduced

Table 7. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico, October 1997.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	3	-	3
Rio Grande chub	-	-	8	28	13	49
fathead minnow	9	-	11	108	2	130
flathead chub	-	-	-	-	100	100
longnose dace	23	28	58	2	77	188
white sucker	47	3	74	69	6	199
brown trout	16	51	6	2	3	78
smallmouth bass	-	-	-	-	-	-
TOTAL	95	82	157	212	201	747
# SPECIES	4	3	5	6	6	7
SHOCKING SEC.	1,463	1,576	1,163	1,039	499	5,740
CPUE *	6.49	5.20	13.50	20.40	40.28	13.01

* catch rate per 100 seconds electrofishing

number of species per site ranged from three (Site 2) to six (Sites 4 and 5) with the number of individuals per species varying widely between sites.

White sucker were the most frequently collected fish in October 1997 followed by longnose dace. Collectively these two species (longnose dace and white sucker) comprised the majority (51.8%) of the total catch during this trip and were both present at all five sites. Fathead minnow were abundant during in October 1997 samples (n=130) occurring at four of the five collecting localities. Brown trout (n=78) were more abundant in October 1997 samples than in April 1997 and were also taken at all five sampling localities. This was one of only two collections during this study to yield common carp (n=3) with all of the October 1997 specimens being collected at Site 4.

Most Rio Grande chub were collected at Site 4 (n=28) with moderate numbers also taken at Site 3 (n=8) and Site 5 (n=13). Shoreline runs with gravel substrate and moderate water velocities produced the majority of Rio Grande chub. Individuals ranged from 19.3-90.5 mm SL and appeared to be Age-0, Age-1, or Age-2+ fish (Figure 9). Specimens about 30 mm SL were Age-0 fish while those between 40-55 mm SL were considered Age-1 chub.

Fathead minnow collected in October 1997 (n=130) were primarily Age-0 and Age-1. Most fathead minnow were taken in low velocity habitats created by over bank flow. The largest individuals (>55 mm SL) were Age-2 and the smaller size-classes (Figure 10; Site 4) were the Age-0 and Age-1 cohorts. The presence of very small fathead minnow (<18 mm SL) was indicative of late summer spawning.

Longnose dace were present at all sites but catch rates of this species varied widely between sampling localities. The well-defined group of individuals (ca. 20-40 mm SL) collected at Sites 3 and 5 were all Age-0 fish (Figure 11). Some of the largest individuals collected (i.e., >90 mm SL) were probably Age-3+ with the remainder being either Age-1 or Age-2 longnose dace. Delineation of older cohorts was not possible because of low sample sizes. Longnose dace were present in most high velocity habitats.

White sucker occurred at all five sites but were relatively rare at Sites 2 and 5. This nonnative sucker, which was collected at several sites, was usually taken in shoreline pools. In October 1997, Age-0 white sucker ranged from about 25-50 mm SL (Figure 12). Given the small number of white sucker >50 mm SL collected, no attempt was made to determine age-classes of white sucker >50 mm SL.

Brown trout were collected from a variety of aquatic habitats including pools, riffles, and runs. This species was found at all sites but its catch rates at downstream localities were low compared to those upstream. Most brown trout appeared to be Age-0 while the 145.5 mm SL individual was probably an Age-1 individual (Figure 13).

March 1998

Mean daily discharge at Abiquiu Dam during this sampling trip (17-18 March 1998) was about 200 cfs allowing easy access to most habitats. This sampling effort yielded only a moderate number of fish (n=224) and catch rates from 0.59-12.47 fish/100 seconds. During the March 1998 sampling period, water visibility was high, temperatures were cold (ca. 7° C), and fish were slow to appear after being shocked. The March 1998 sample occurred prior to the substantial release of water that would occur in April 1998.

A total of four native and two nonnative taxa were recorded during this sampling effort. The highest catch rates were at Sites 3 and 5, while the lowest catch rate was at Site 2. The most frequently collected species in March 1998 were longnose dace (Table 8) with white sucker being the second most abundant fish. Longnose dace were collected at all sites but catch rates were lowest at Sites 2 and 4 (Table 9). White sucker were present at Sites 2, 3, and 4 with the majority of individuals

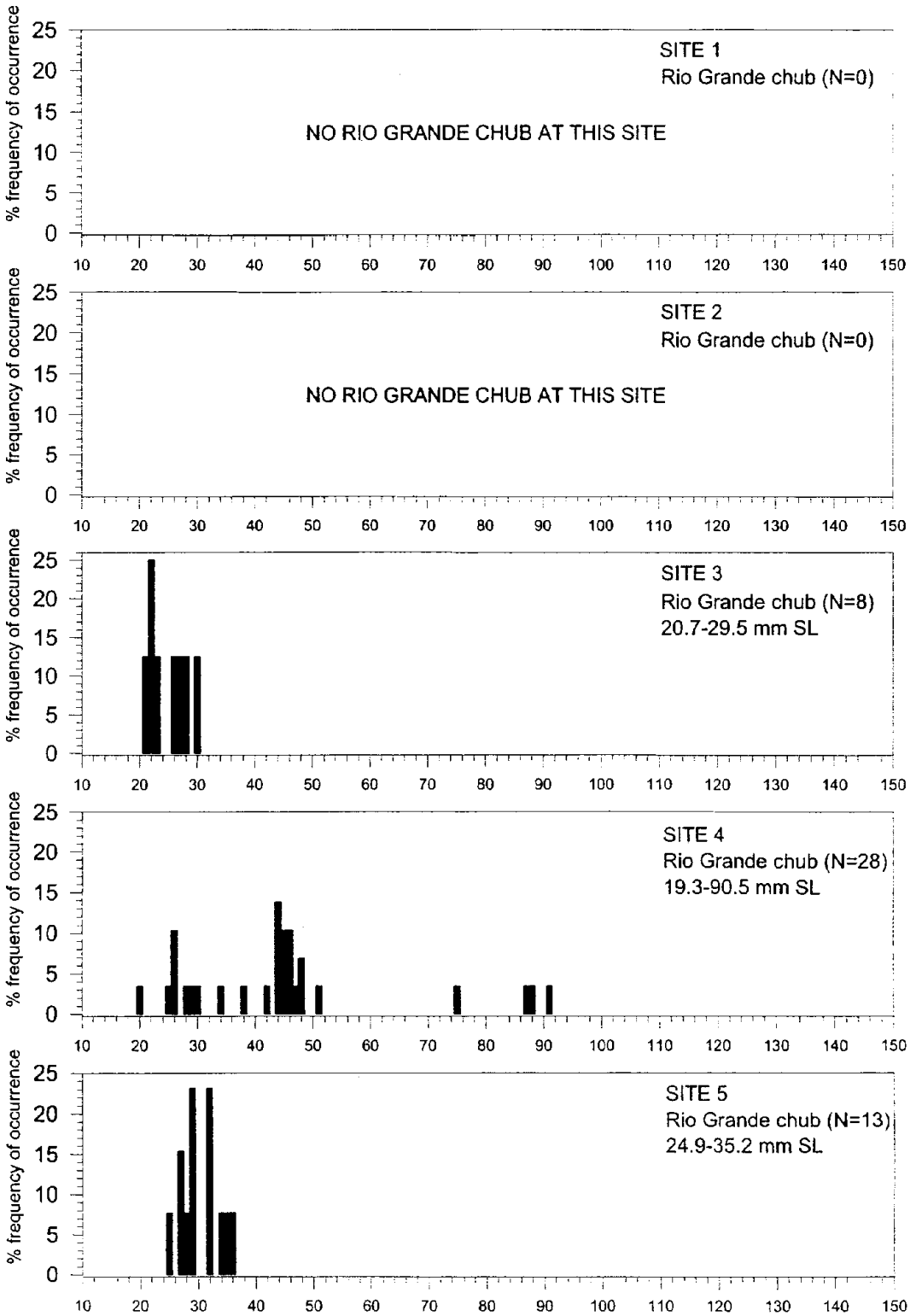

Figure 9. Rio Grande chub length-frequency histograms at five Rio Chama sites, New Mexico, October 1997.

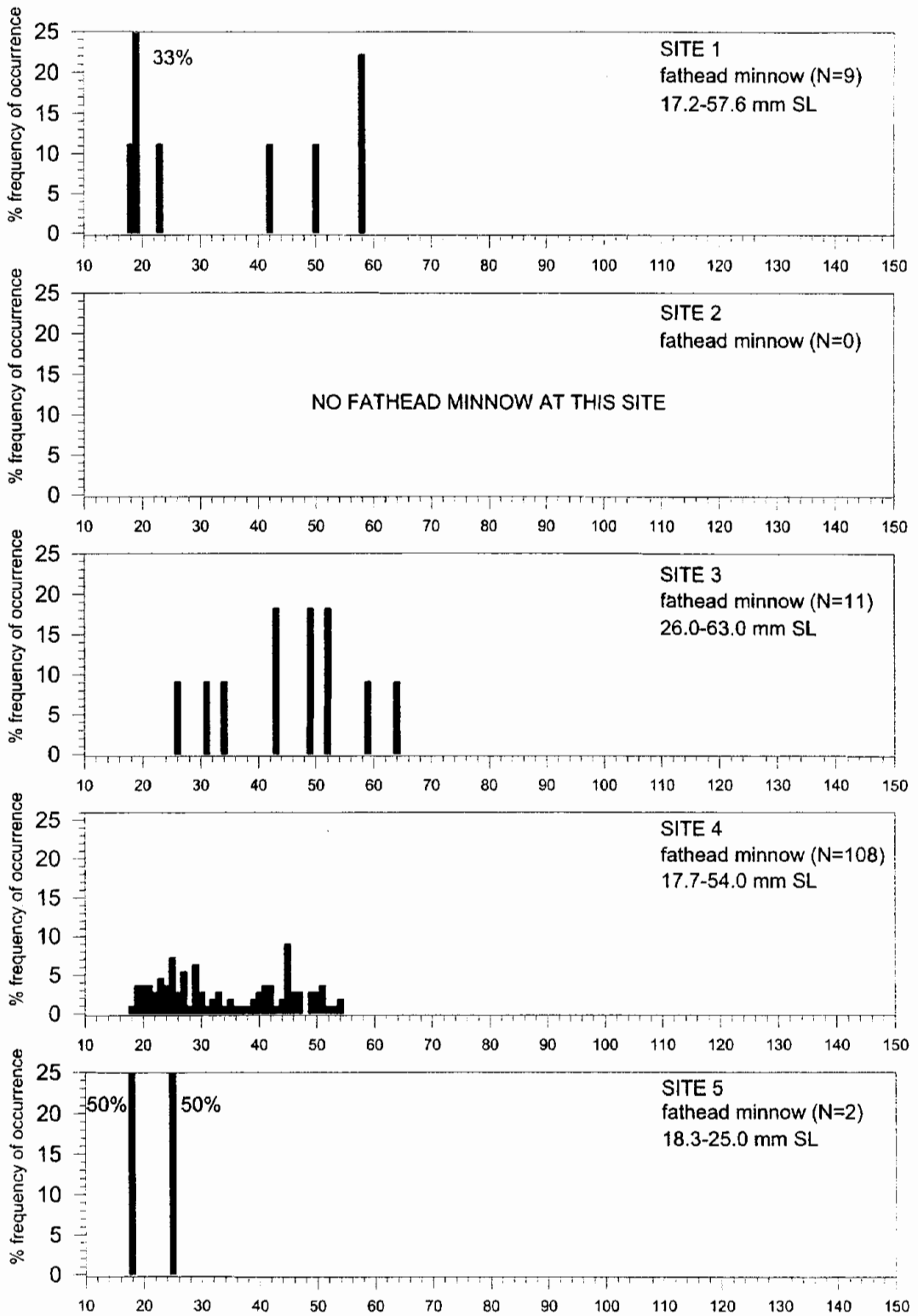

Figure 10. Fathead minnow length-frequency histograms at five Rio Chama sites, New Mexico, October 1997.

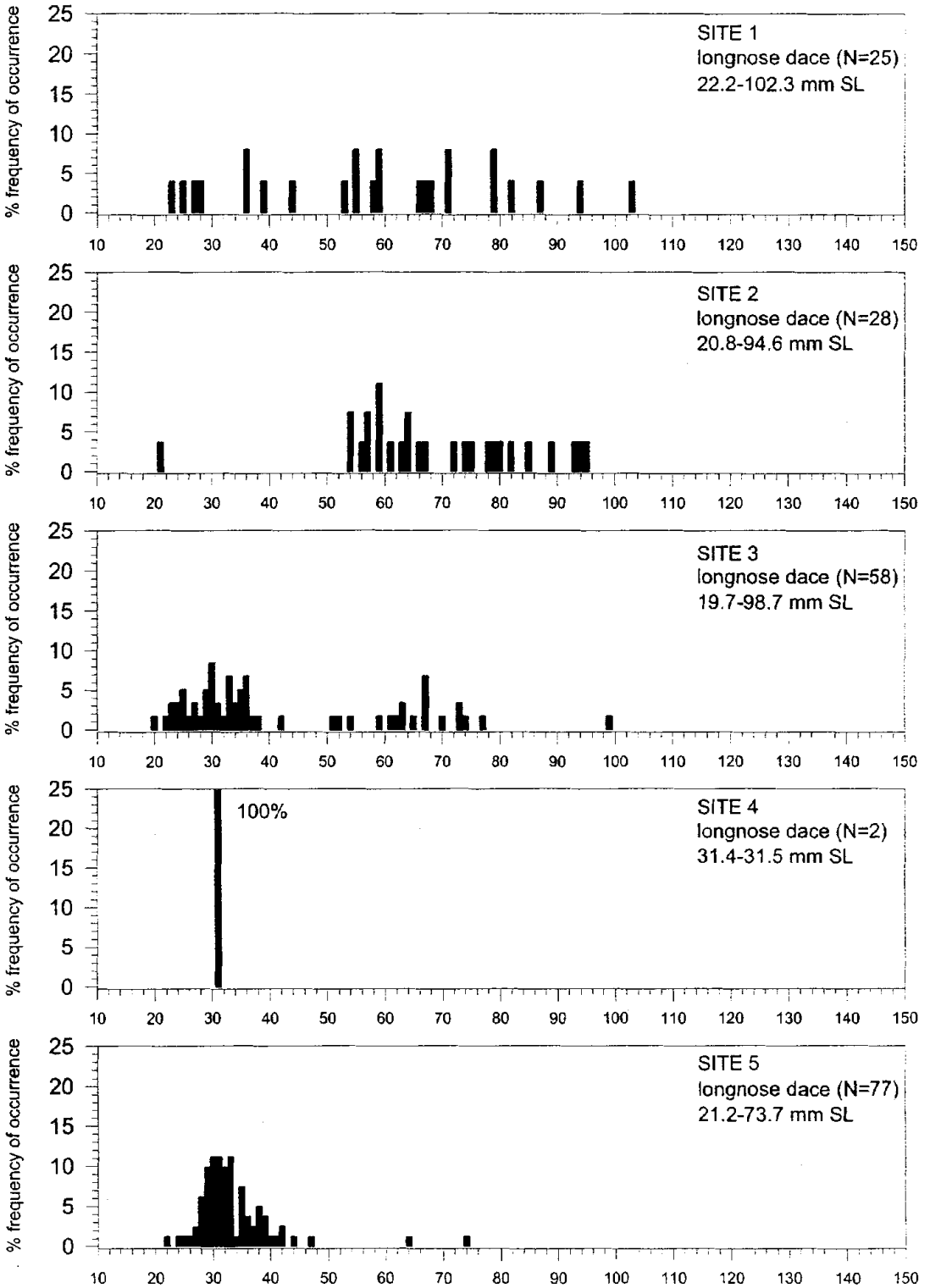

Figure 11. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, October 1997.

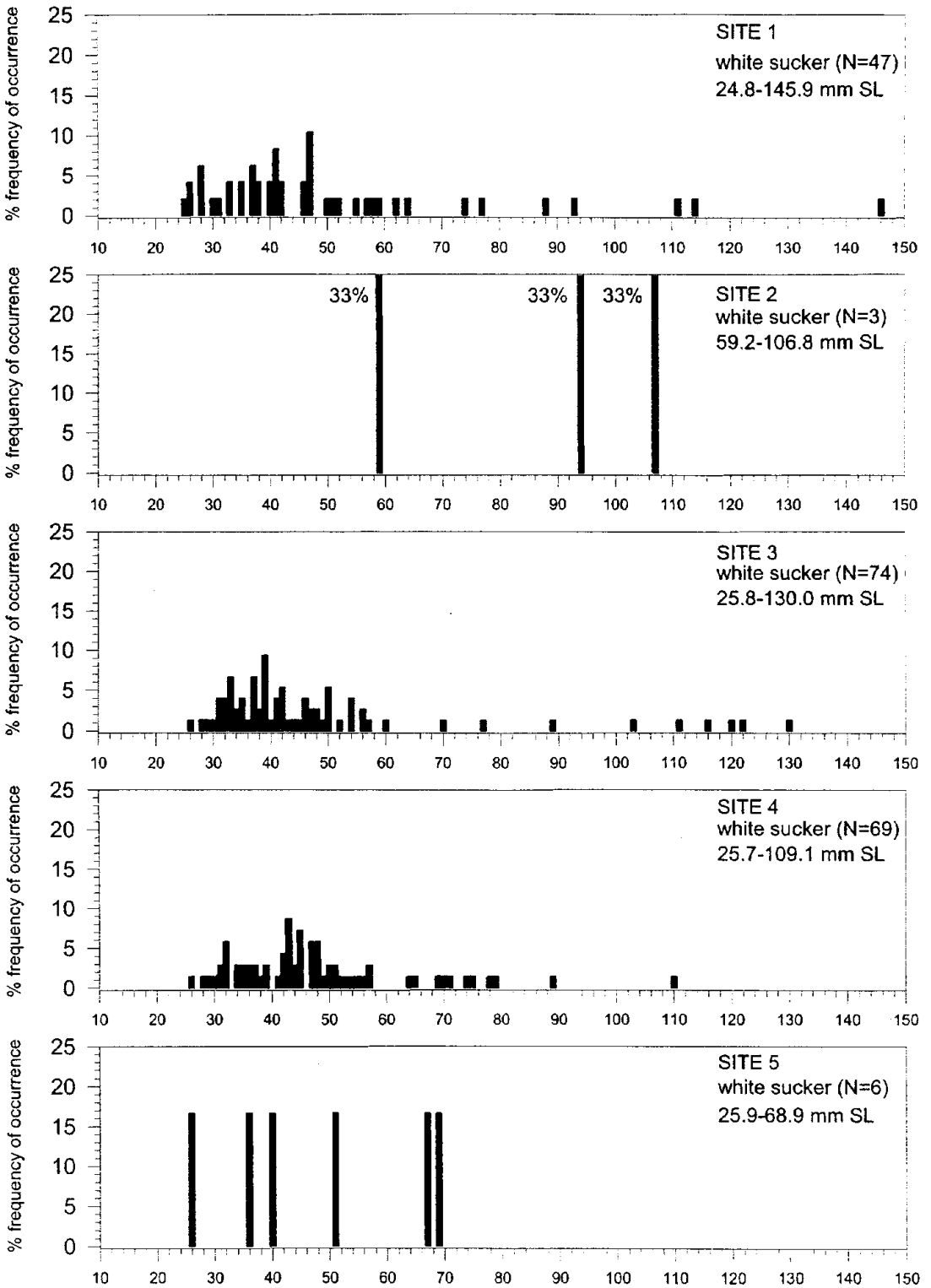

Figure 12. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, October 1997.

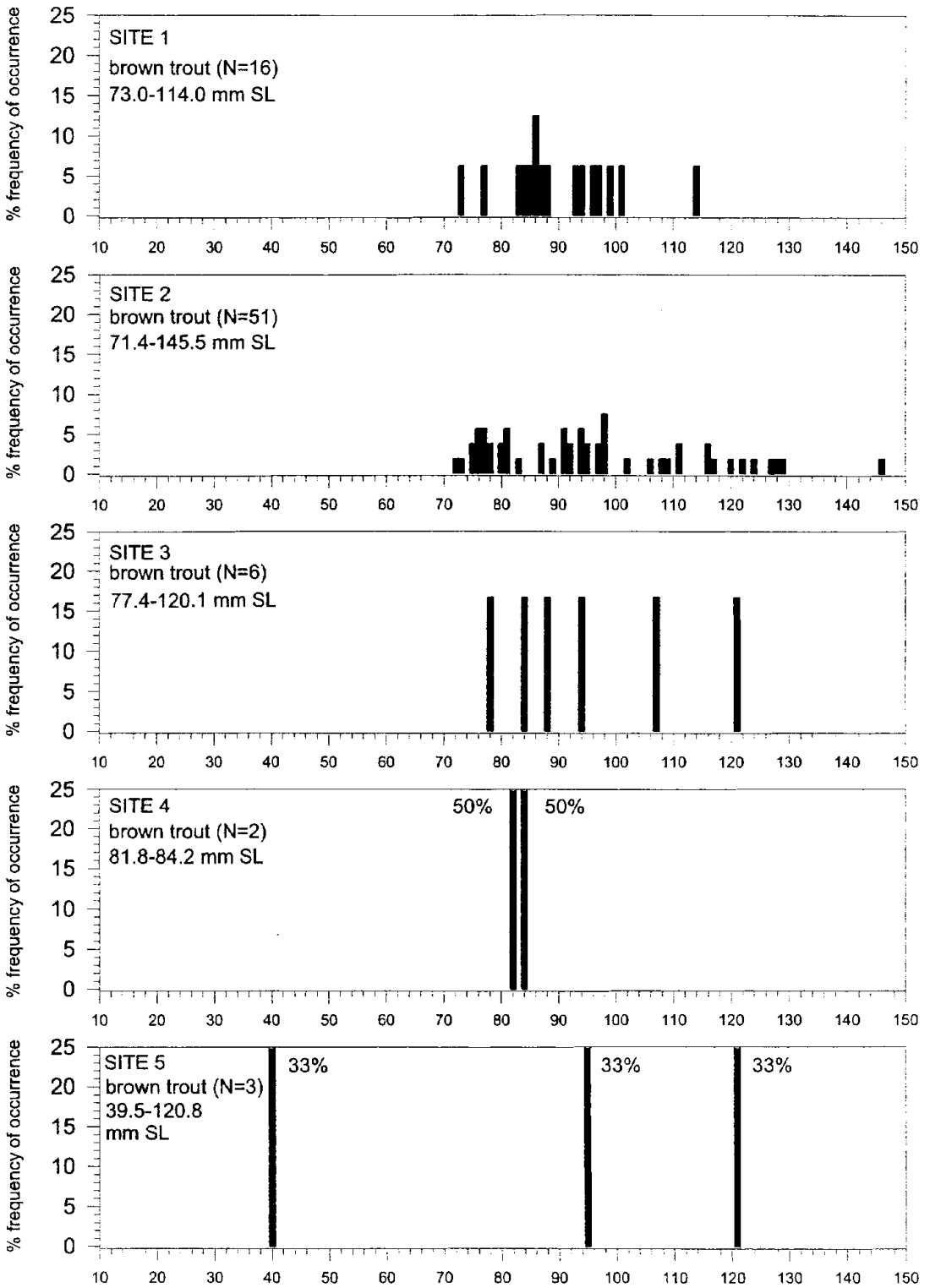

Figure 13. Brown trout length-frequency histograms at five Rio Chama sites, New Mexico, October 1997.

Table 8. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, March 1998.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	-	-	-	-.—
Rio Grande chub	N	39	3	3	17.41
fathead minnow	N	27	4	1	12.05
flathead chub	N	1	6	1	0.45
longnose dace	N	90	1	5	40.18
white sucker	I	54	2	3	24.11
brown trout	I	13	5	5	5.80
smallmouth bass	I	-	-	-	-.—
TOTAL	224				

[1] N = native; I = introduced

Table 9. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico, March 1998.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	-	-	-
Rio Grande chub	-	-	11	15	13	39
fathead minnow	-	-	27	-	-	27
flathead chub	-	-	-	-	1	1
longnose dace	15	2	21	1	51	90
white sucker	-	1	48	5	-	54
brown trout	5	5	1	1	1	13
smallmouth bass	-	-	-	-	-	-
TOTAL	20	8	108	22	66	224
# SPECIES	2	3	5	4	4	6
SHOCKING SEC.	1,384	1,357	866	1,523	822	5,952
CPUE *	1.45	0.59	12.47	1.44	8.03	3.76

* catch rate per 100 seconds electrofishing

(88.9%) taken at Site 3. The brown trout catch (n=13) was low in March 1998 with the majority of the individuals from Site 1 and Site 2 samples. Rio Grande chub and fathead minnow were both collected at middle (Site 3) or downstream (Sites 4 or 5) sampling locations.

Rio Grande chub were collected from a variety of low velocity habitats at Sites 3, 4, and 5 during March 1998. Nearly all individuals collected at Sites 3 and 5 appeared to be Age-1 fish (Figure 14) and ranged from 22.6-37.5 mm SL. The single exception was the 37.5 mm SL individual (Age-2). Rio Grande chub collected at Site 4 were Age-2 individuals that ranged from 38.9 to 52.4 mm SL.

Fathead minnow were only collected at Site 3 in March 1998 (n=27) with at least two and possibly three age-classes present. The largest fathead minnows (size range >60 mm SL) were probably Age-3 fish (Figure 15). Most individuals were taken in a school from a single side channel pool.

Longnose dace were present at all sites but the majority of individuals were collected at Sites 3 and 5. The well-defined size class of longnose dace (ca. 25-40 mm SL) collected at Site 5 were all Age-1 fish (Figure 16). The largest individuals collected (i.e., >70 mm SL) were probably Age-3 while the few remaining fish were Age-2 dace. Longnose dace were present in rapid flows in most riffle habitats but surprisingly few were collected at Site 2.

White sucker were present at three of the five sites sampled in shoreline pools and low velocity runs. The majority of white sucker collected were present in a side channel pool at Site 3. Nearly all white sucker collected were Age-1 (<60 mm SL; Figure 17).

No more than five brown trout were collected at any of the sampling localities during March 1998. All of the 13 brown trout collected during this sampling effort were considered Age-1 fish (Figure 18). Most of the brown trout were taken in shoreline habitats along or adjacent to complex instream cover.

May 1998

Mean daily discharge at Abiquiu Dam during the sampling trip conducted on 28 May 1998 was about 1,800 cfs. Most mid-channel habitats could be not be accessed because of the high discharge. Shoreline areas were easily sampled and produced the majority of collected individuals. High flow created several backwaters and flooded some shoreline grasses. The May 1998 sampling effort yielded 474 fish and catch rates between 2.26 and 14.30 fish/100 seconds. Water temperatures were generally cool during the sampling period (12-14°C) but backwater temperatures increased notably during the day providing warmer areas for YOY fishes.

Three native and two nonnative taxa were recorded during this sampling effort making it one of the most species-poor trips to date. While the number of species per site varied, some of those species that were present were represented by only a few individuals. Longitudinal patterns of fish abundance were, with the exception of the presence of fathead minnow at Site 1, similar to those observed in previous collecting efforts. The highest catch rate was recorded at Site 3 (14.3 fish/100 seconds) with catch rates at the other sites ranging from 2.26 to 5.79 fish/100 seconds.

Longnose dace were the most frequently collected taxa in May 1998 (Table 10) followed by brown trout. Longnose dace were the majority (54.9%) of the total catch and were present at all five sites (Table 11). Brown trout (n=85) were present in all collections and all but five were Age-0 individuals. Moderate numbers of Rio Grande chub and fathead minnow were also collected.

A small number of Rio Grande chub were collected (n=21) during May 1998. Specimens were taken primarily in flooded shoreline areas. The smallest individuals (<25 mm SL) appeared to be Age-0 fish (Figure 19) with the majority of the other Rio Grande chub likely being Age-1 (size range=25-50 mm SL). The few large individuals (n=3) collected at Sites 3 and 5 were Age-2 chub. Rio Grande chub were absent from the upper two sites.

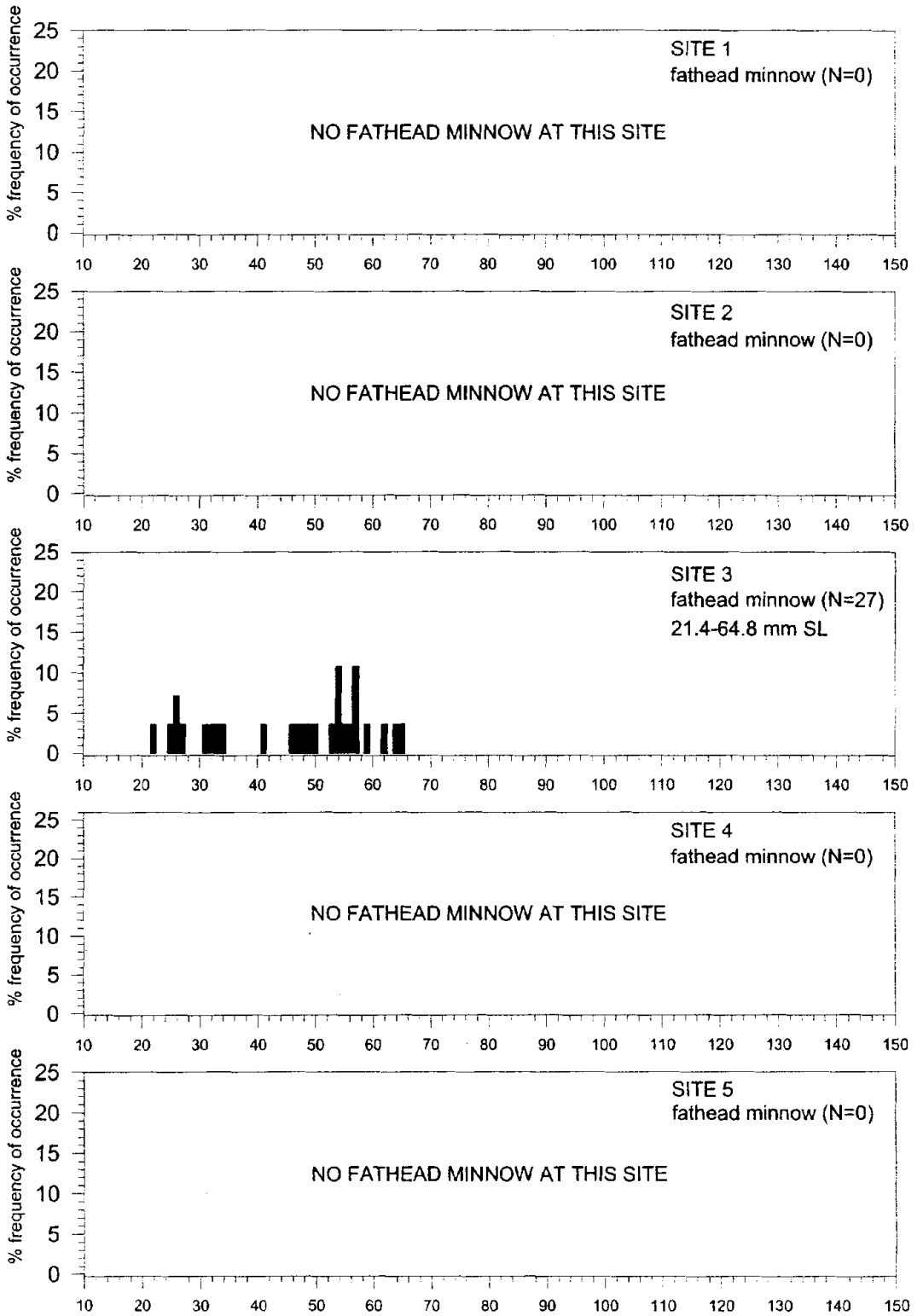

Figure 15. Fathead minnow length-frequency histograms at five Rio Chama sites, New Mexico, March 1998.

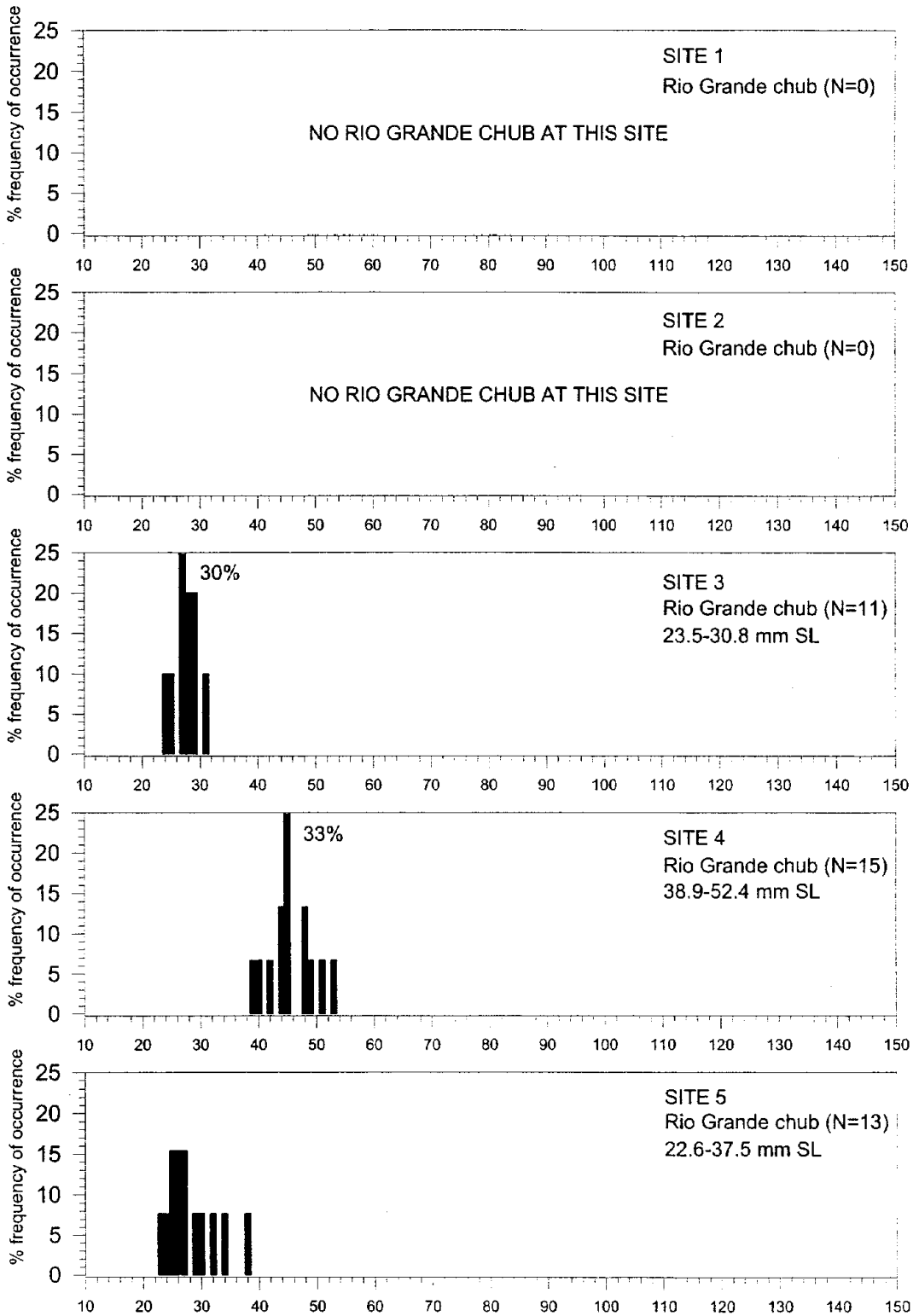

Figure 14. Rio Grande chub length-frequency histograms at five Rio Chama sites, New Mexico, March 1998.

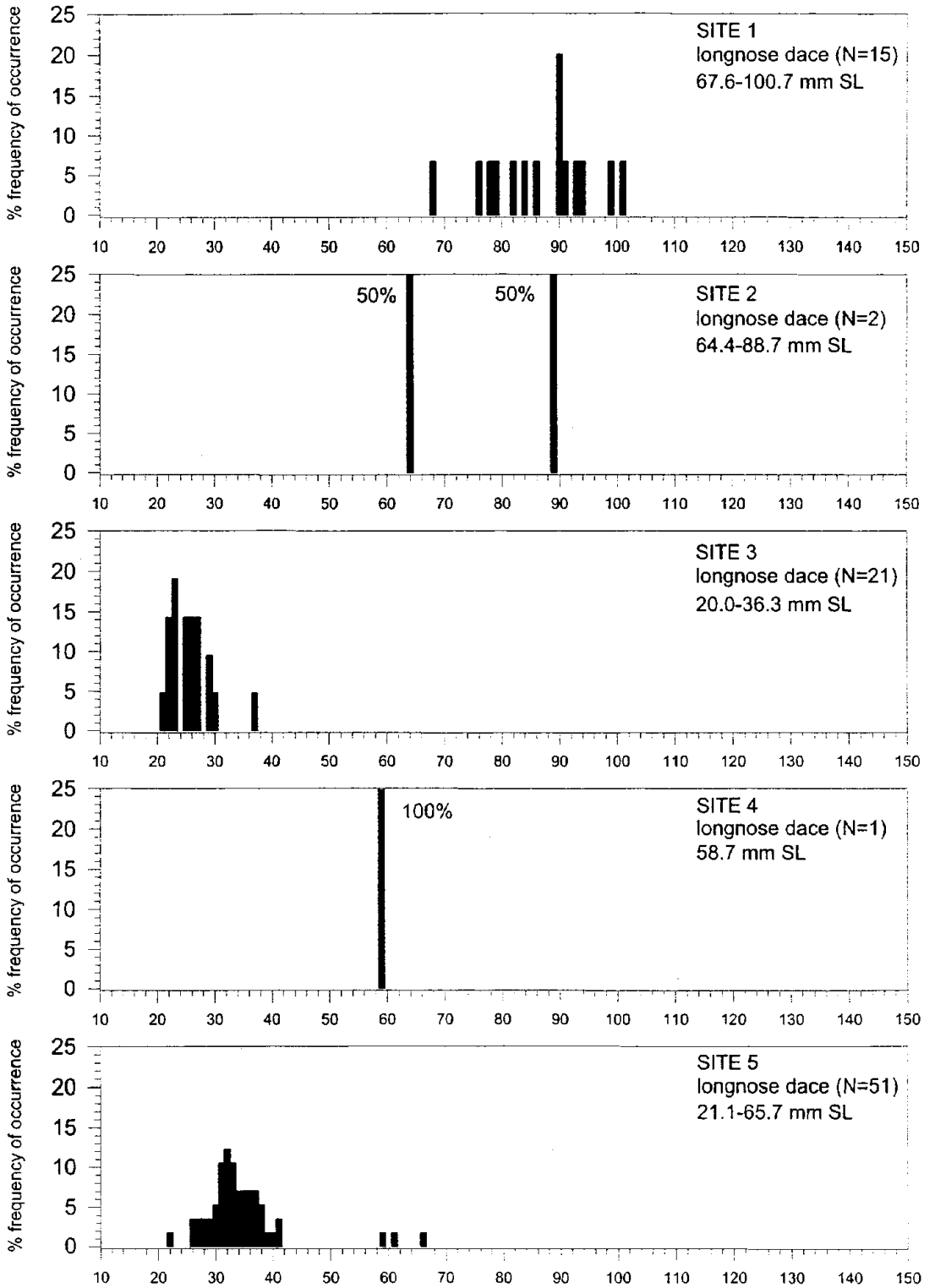

Figure 16. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, March 1998.

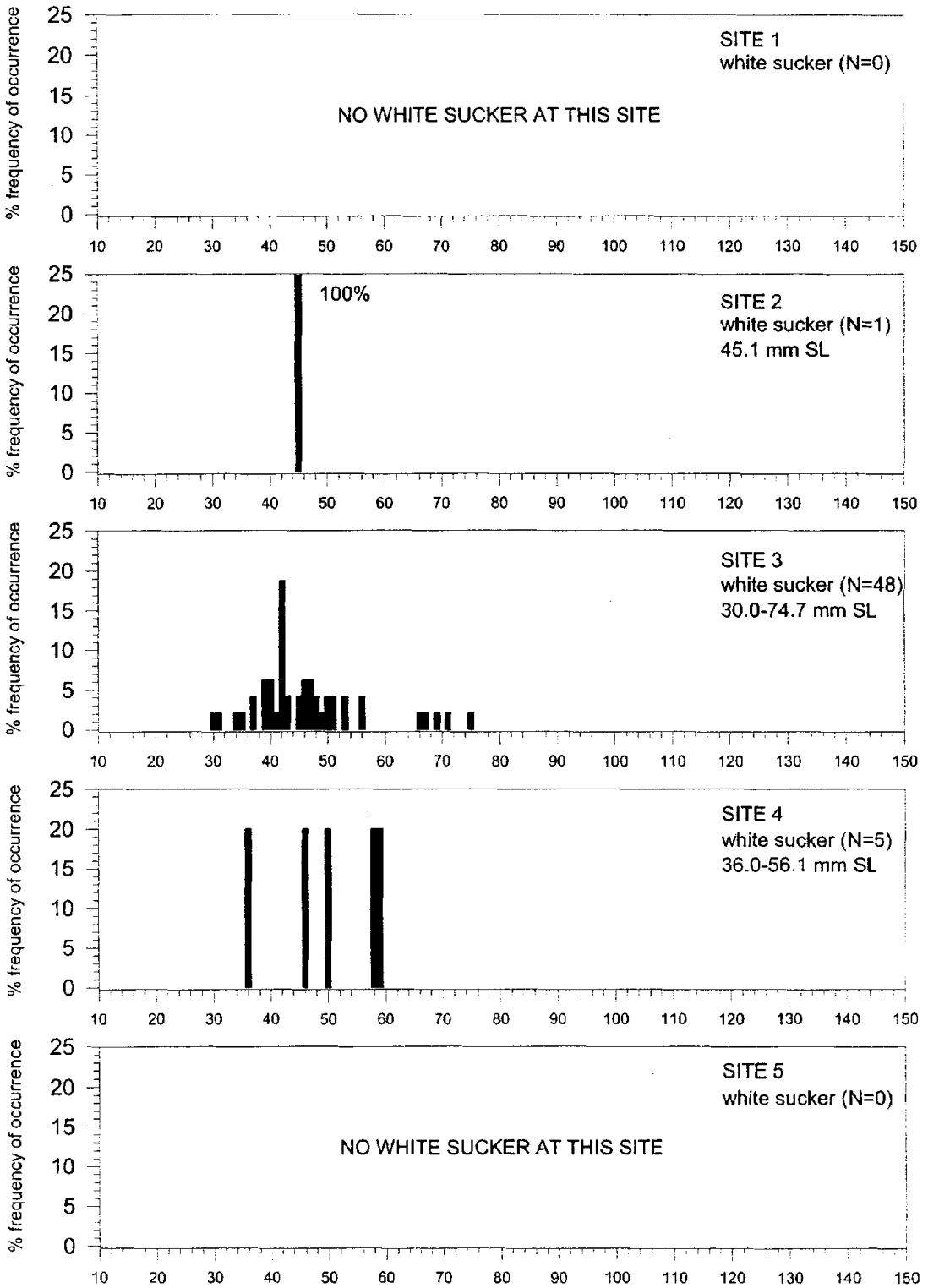

Figure 17. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, March 1998.

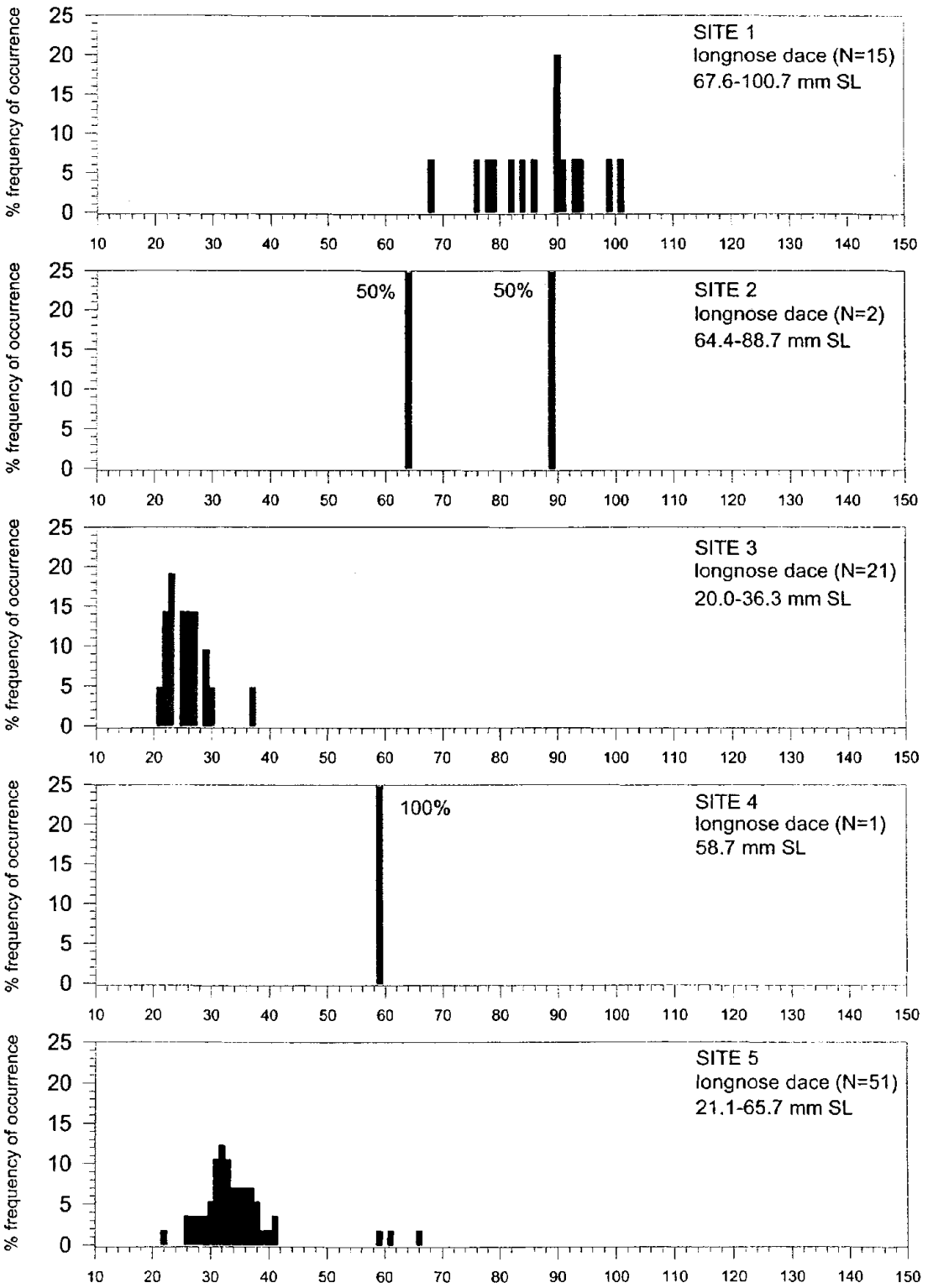

Figure 16. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, March 1998.

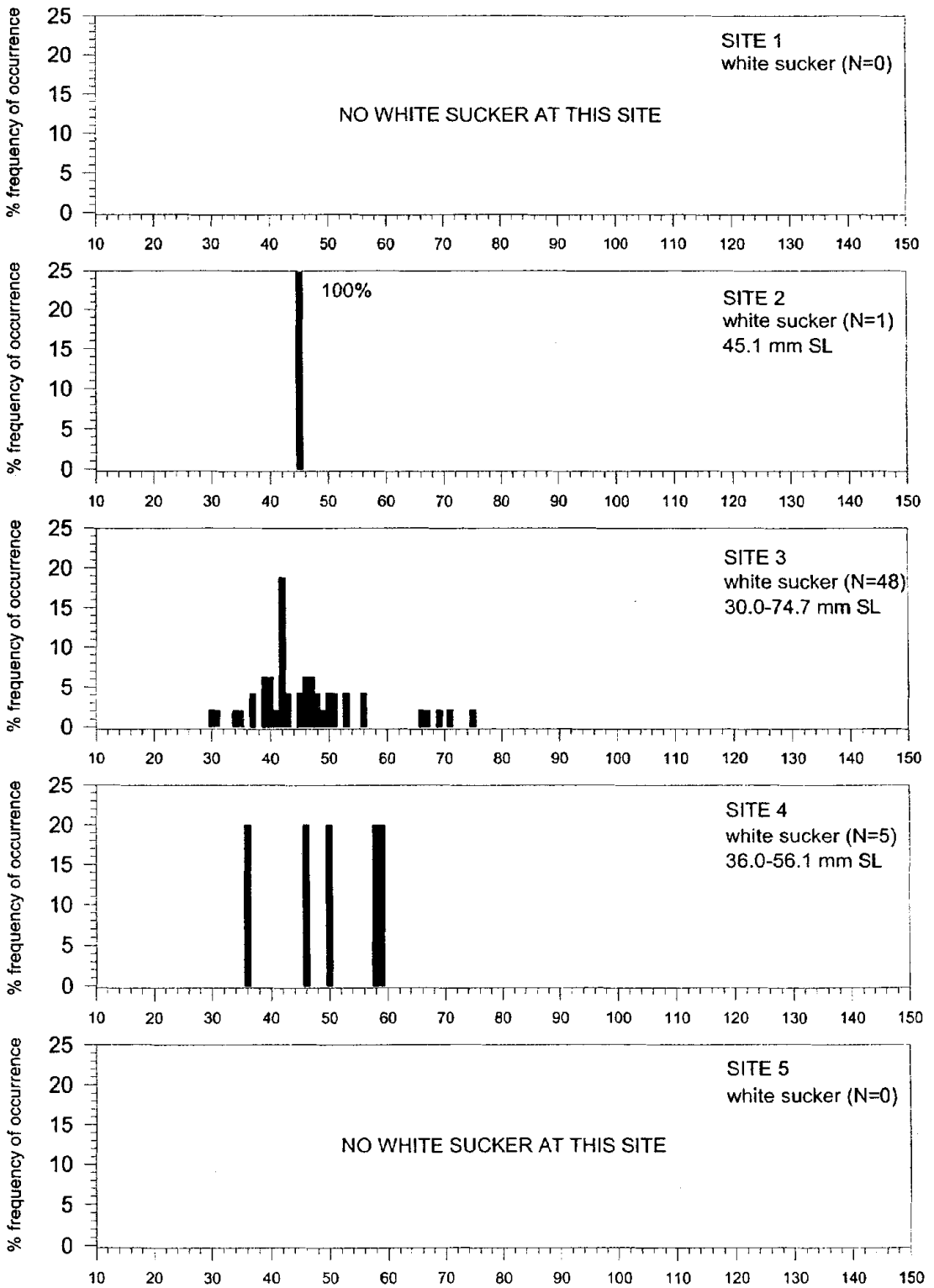

Figure 17. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, March 1998.

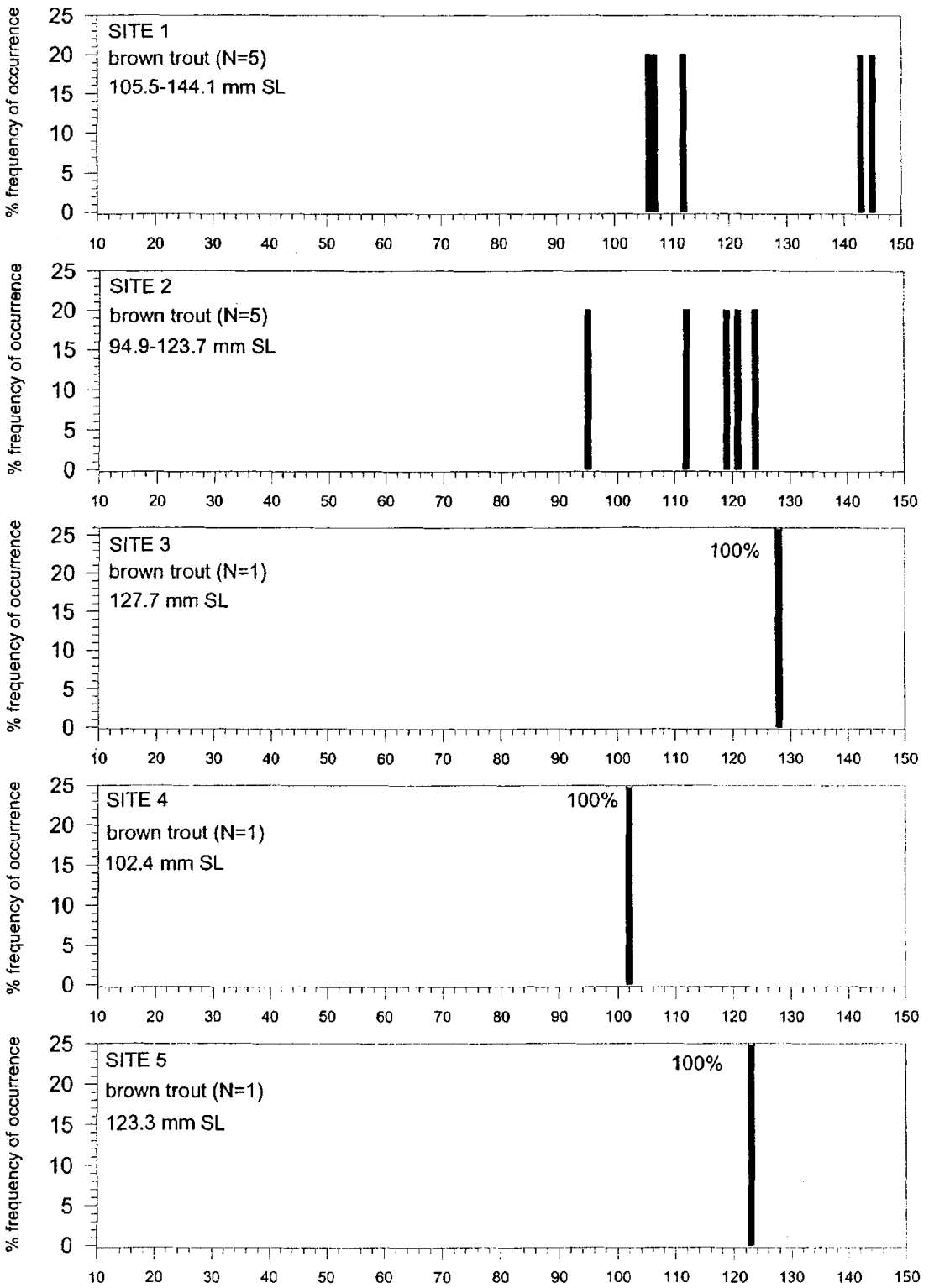

Figure 18. Brown trout length-frequency histograms at five Rio Chama sites, New Mexico, March 1998.

Table 10. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, May 1998.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	-	-	-	-.—
Rio Grande chub	N	21	5	3	4.43
fathead minnow	N	32	4	4	6.75
flathead chub	N	-	-	-	-.—
longnose dace	N	260	1	5	54.85
white sucker	I	76	3	5	16.03
brown trout	I	85	2	5	17.93
smallmouth bass	I	-	-	-	-.—
TOTAL	474				

[1] N = native; I = introduced

Table 11. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico, May 1998.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	-	-	-
Rio Grande chub	-	-	6	2	13	21
fathead minnow	15	-	10	2	5	32
flathead chub	-	-	-	-	-	-
longnose dace	14	13	170	55	8	260
white sucker	14	6	35	20	1	76
brown trout	32	22	12	14	5	85
smallmouth bass	-	-	-	-	-	-
TOTAL	75	41	233	93	32	474
# SPECIES	4	3	5	5	5	5
SHOCKING SEC.	2,444	1,590	1,629	1,606	1,414	8,683
CPUE *	3.07	2.58	14.30	5.79	2.26	5.46

* catch rate per 100 seconds electrofishing

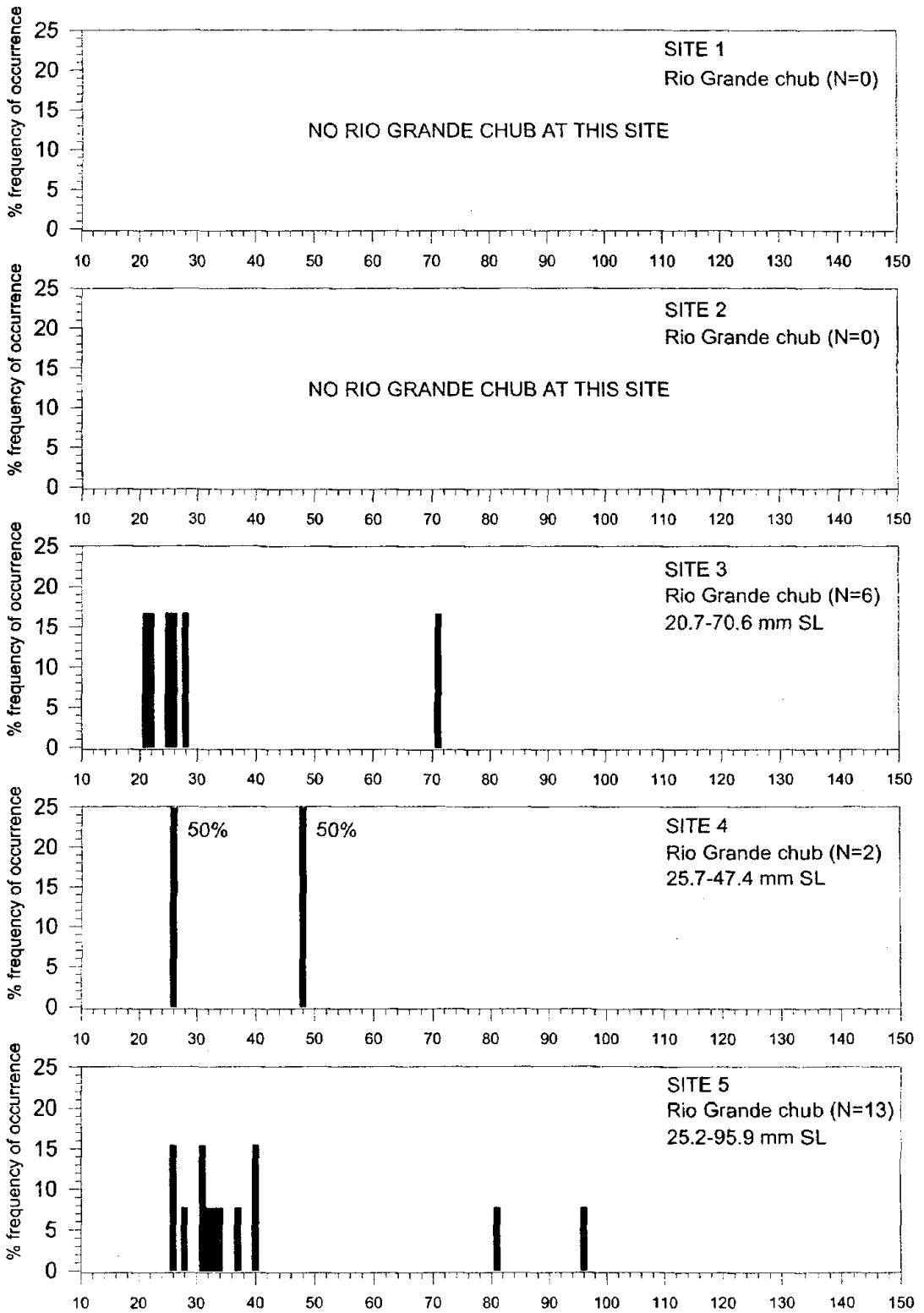

Figure 19. Rio Grande chub length-frequency histograms at five Rio Chama sites, New Mexico, May 1998.

Fathead minnow were present in several backwater and in slack water areas along the shoreline. Adult fathead minnow taken at Site 4 (n=2; 42.8, 45.3 mm SL) were Age-1 fish (Figure 20). All other fathead minnow collected were probably Age-0 specimens with the considerable variation in length likely the result of a multiple protracted spawning events.

The relatively large number of longnose dace collected during May 1998 allowed for high resolution in determination of age-class structure (Figure 21). The well-defined group of individuals (ca. 25-40 mm SL) collected at Site 4 were considered Age-1 individuals. Individuals >70 mm SL were probably Age-3. No representatives of the Age-2 longnose dace cohort were collected. Longnose dace <20 mm SL (Age-0) were likely a result of early spawning in 1998. Low velocity shoreline habitats produced the majority of small fishes, including longnose dace, during this sampling effort.

White sucker were present at all sites sampled but were only moderately abundant at Sites 3 and 4. Most individuals were collected in recently flooded shallow low velocity habitats. The majority of white sucker taken were Age-0 and, as during previous collecting efforts, it was difficult to determine other age-classes because of the low sample size (Figure 22).

The 1998 brown trout cohort (Age-0) was present at all sites (Figure 23) and was taken in the same habitats as other YOY fishes (i.e., low velocity, shallow habitats). Most brown trout captured were Age-0 individuals but a few (n=5) Age-1 brown trout were collected at Site 1. Trout in the older cohort ranged in length from about 120-160 mm SL. The relatively low number of larger brown trout in this sampling effort, as compared with previous samples, was probably the result of inability to effectively sampling deep, fast, habitats at a discharge of 1,800 cfs.

September 1998

This sampling trip (2 September 1998) was conducted during a period when mean daily discharge from Abiquiu Dam ranged from 900 to 1,000 cfs. Recent localized rain storm reduced water clarity and some mid-channel habitats could be not be accessed because of high flow. Shoreline areas were easily sampled and produced most of the individuals collected while accessible mid-channel habitats yielded low numbers of fish. The September 1998 sample contained relatively few fish (n=139) and catch rates were low, ranging from 0.38 to 5.01 fish/100 seconds. Sites 1, 2, and 3 had similar catch rates (range=2.09-2.87 fish/100 seconds). Main channel water temperatures during sampling were 19-21°C.

Three native and two nonnative taxa were recorded in the September 1998 sample. Longitudinal patterns of fish abundance were difficult to discern because of the low number of individuals taken. The highest catch rate was at Site 5 and the lowest catch rate was at Site 4 where only four fish were collected. Longnose dace (Table 12) comprised the majority (52.5%) of the total catch and were present at four of the five sites (Table 13). Brown trout were the second most abundant taxa and all individuals were Age-0 fish (n=35). Rio Grande chub and fathead minnow were the only other species present in September 1998 collections but their relative abundances were low.

Rio Grande chub collected (n=8) at Sites 3 and 5 occurred primarily in shoreline habitats and were associated with boulder cover. The smallest Rio Grande chub (<30 mm SL) were likely Age-0 (Figure 24) with the remainder probably being Age-1 (size range=35-60 mm SL).

Fathead minnow were present in low-velocity habitats at most sites during the September 1998 collecting effort. A single Age-0 individual (25.2 mm SL) was taken at Site 5. All other fathead minnow present at that site (n=5) were Age-1 fish (Figure 25).

Although longnose dace were the most abundant species in this sample, the relatively low number of individuals collected per site made it difficult to accurately determine age-classes based on length-frequency distributions (Figure 26). The well-defined size-class of longnose dace (ca. 15-25

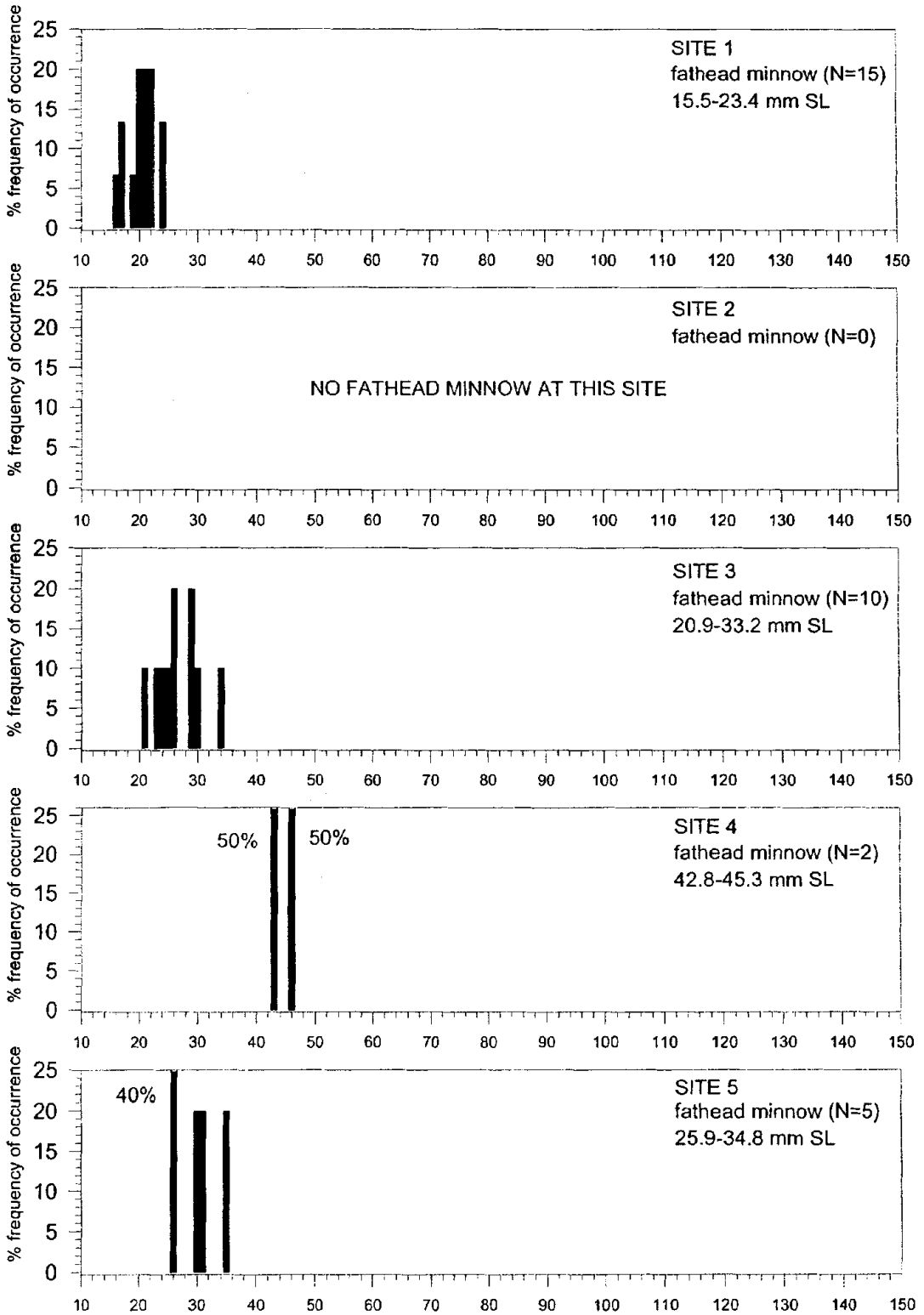

Figure 20. Fathead minnow length-frequency histograms at five Rio Chama sites, New Mexico, May 1998.

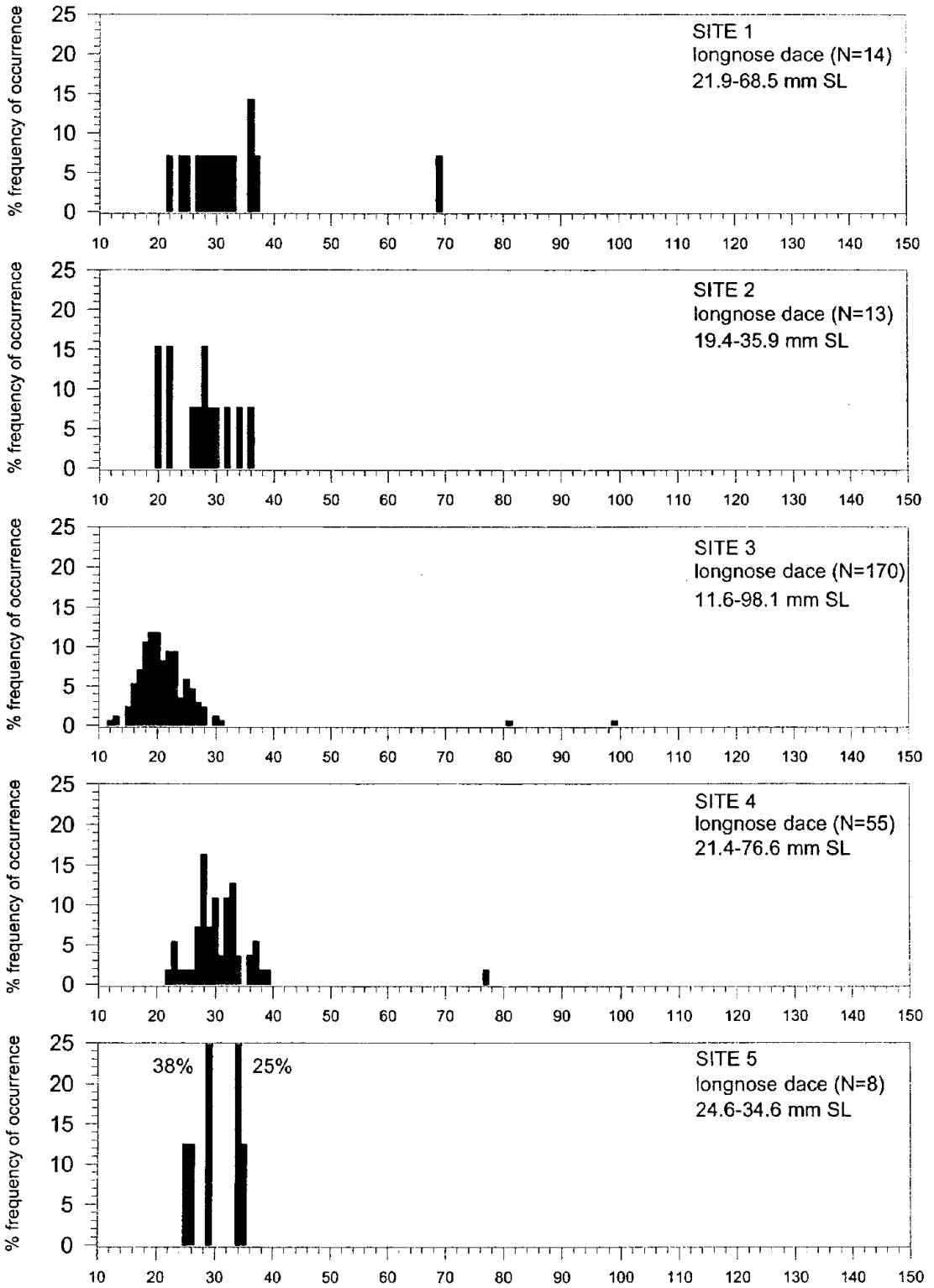

Figure 21. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, May 1998.

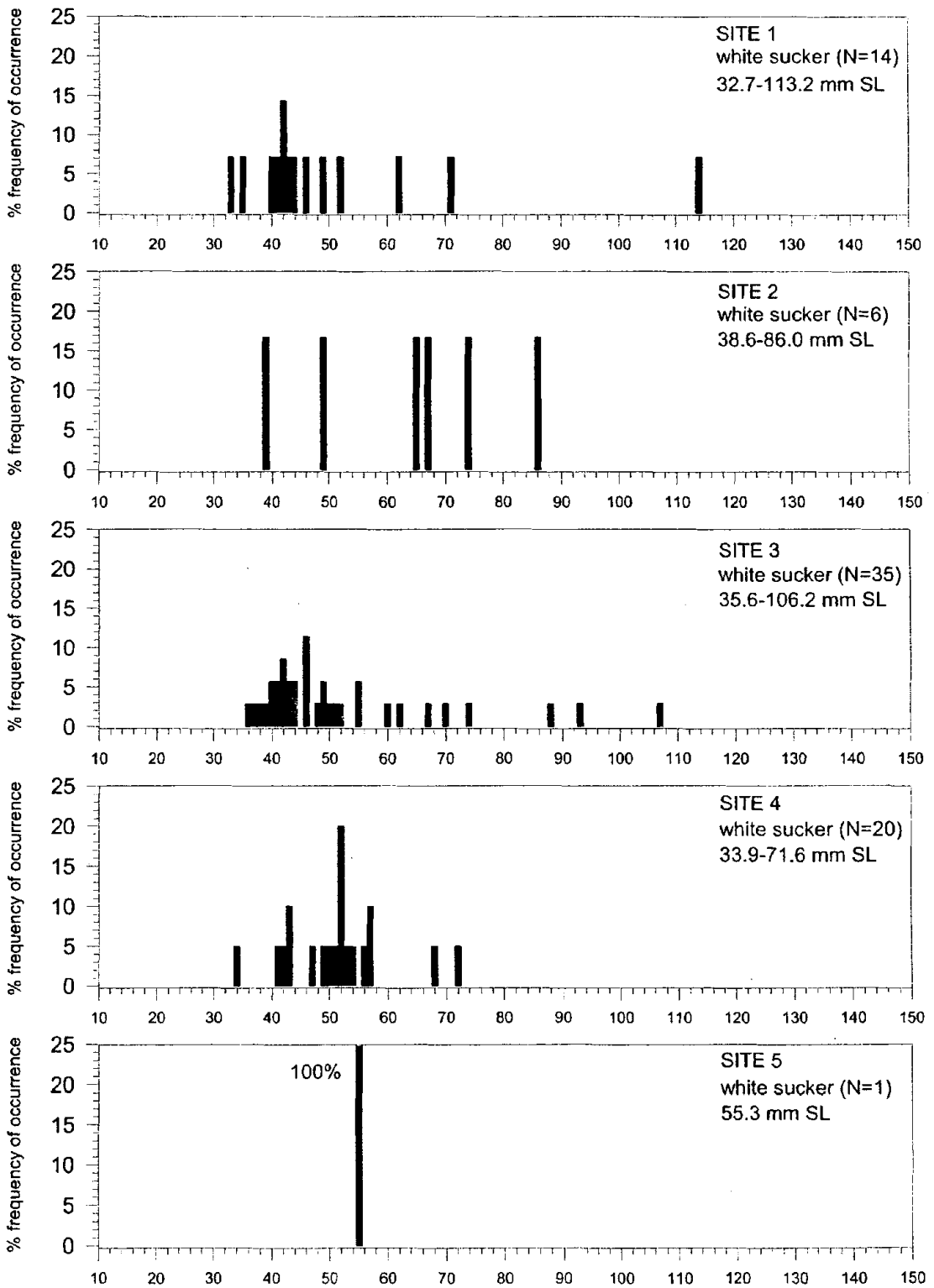

Figure 22. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, May 1998.

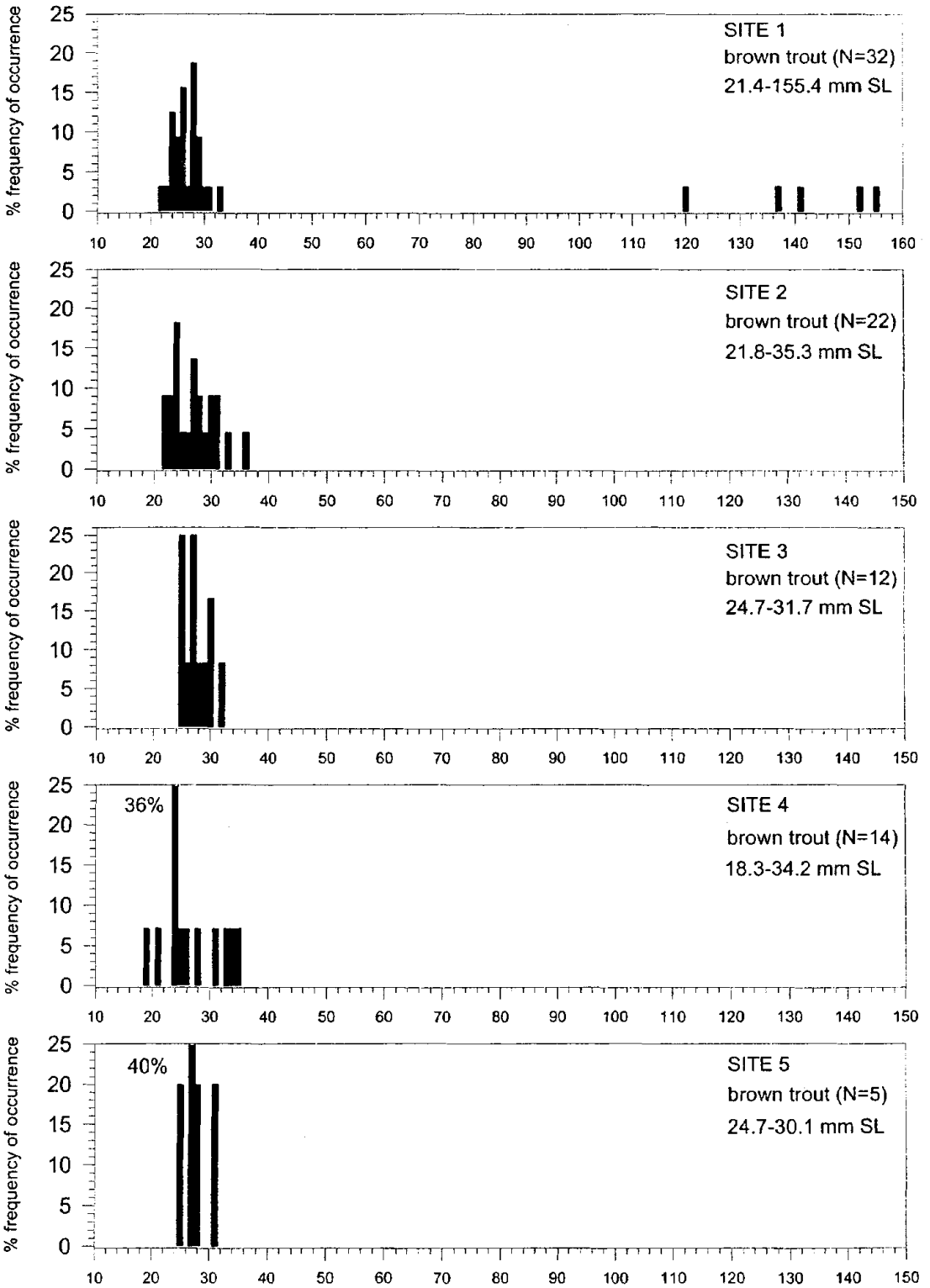

Figure 23. Brown trout length-frequency histograms at five Rio Chama sites, New Mexico, May 1998.

Table 12. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, September 1998.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	-	-	-	-.—
Rio Grande chub	N	8	4	2	5.76
fathead minnow	N	8	4	4	5.76
flathead chub	N	-	-	-	-.—
longnose dace	N	73	1	4	52.52
white sucker	I	15	3	5	10.79
brown trout	I	35	2	5	25.18
smallmouth bass	I	-	-	-	-.—
TOTAL	139				

[1] N = native; I = introduced

Table 13. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico, September 1998.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	-	-	-
Rio Grande chub	-	-	1	-	7	8
fathead minnow	2	-	2	1	3	8
flathead chub	-	-	-	-	-	-
longnose dace	18	19	22	-	14	73
white sucker	7	1	5	1	1	15
brown trout	22	5	4	2	2	35
smallmouth bass	-	-	-	-	-	-
TOTAL	49	25	34	4	27	139
# SPECIES	4	3	5	3	5	5
SHOCKING SEC.	1,779	1,247	1,187	1,333	539	6,085
CPUE *	2.75	2.00	2.86	0.30	5.01	2.28

* catch rate per 100 seconds electrofishing

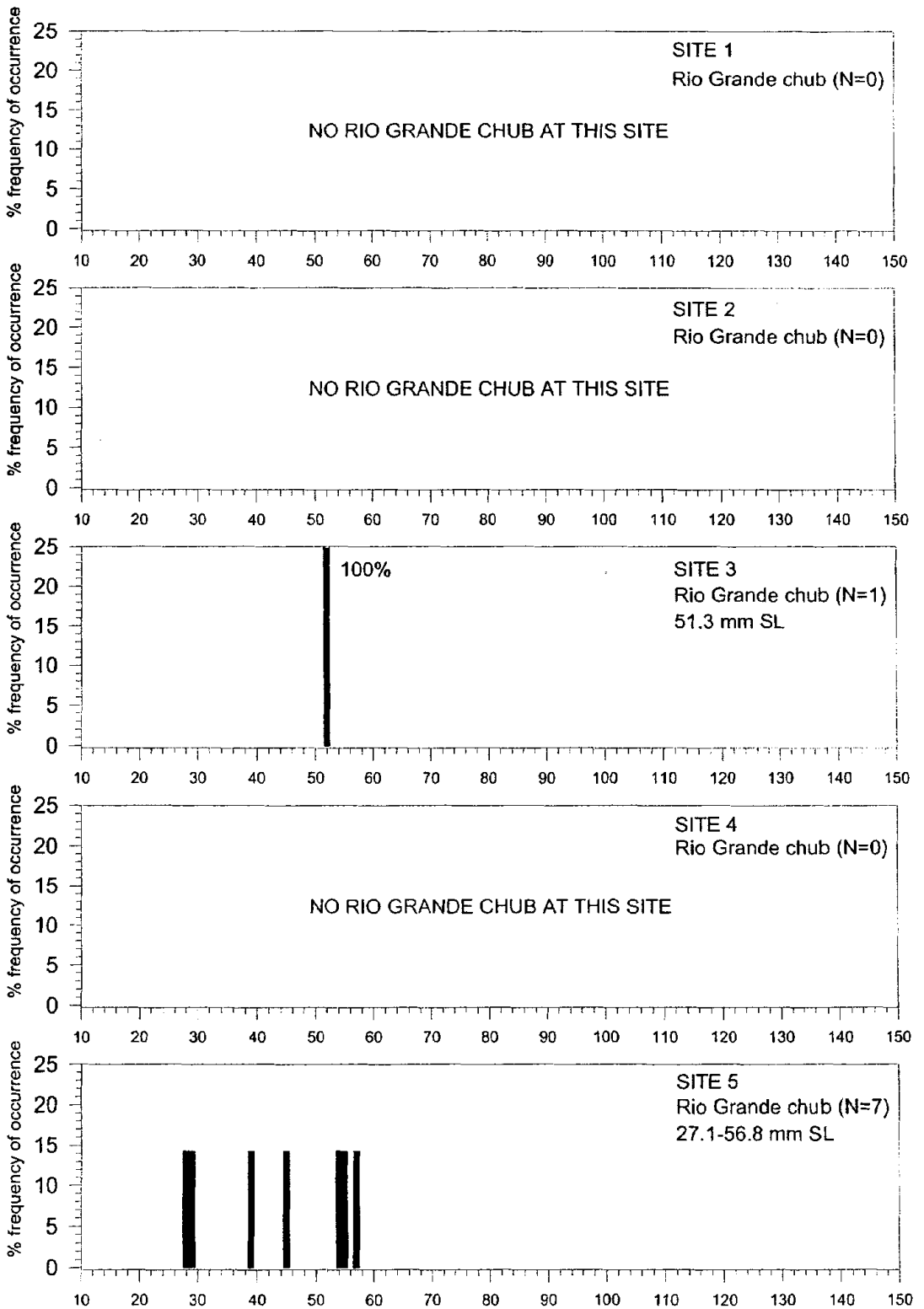

Figure 24. Rio Grande chub length-frequency histograms at five Rio Chama sites, New Mexico, September 1998.

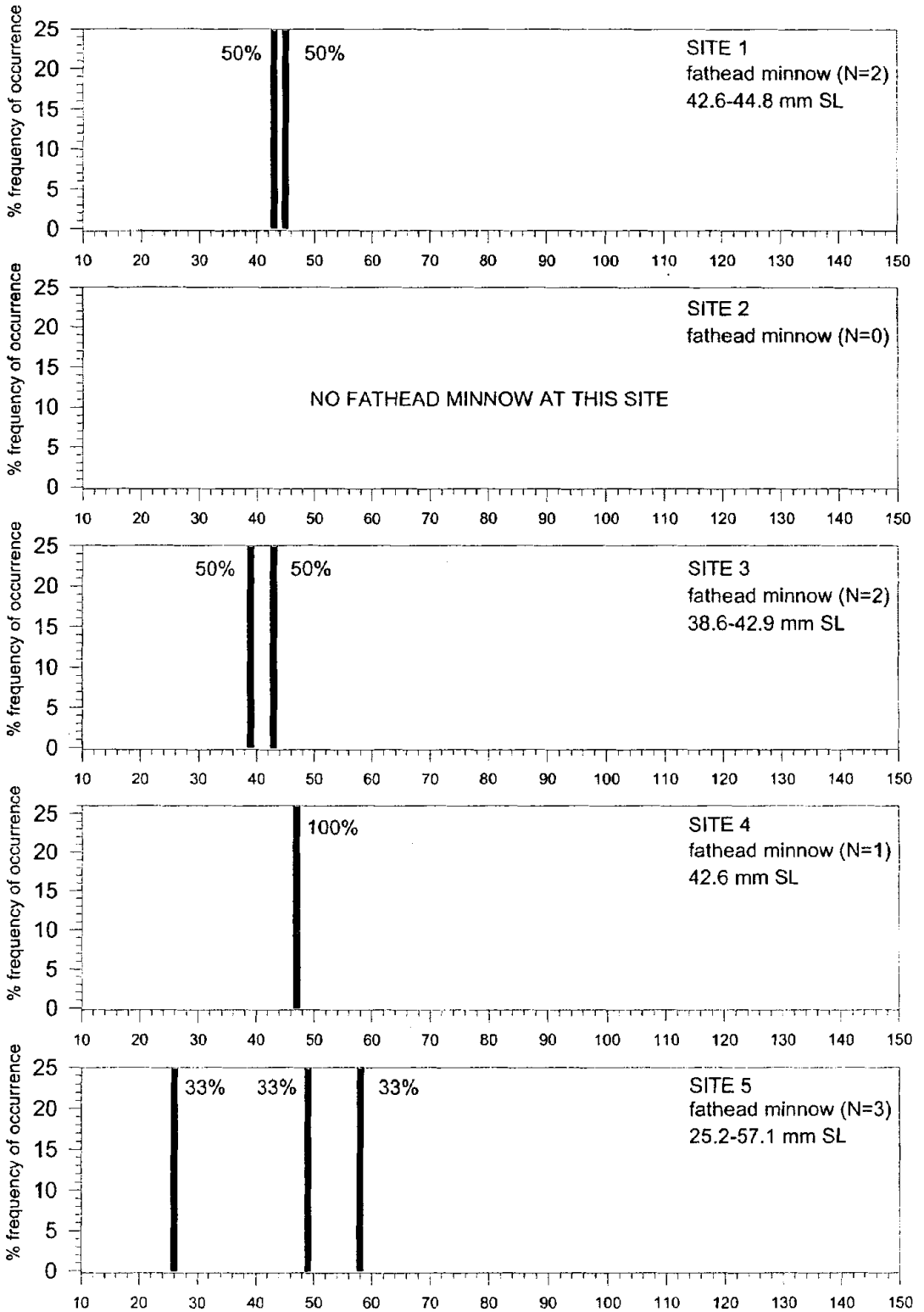

Figure 25. Fathead minnow length-frequency histograms at five Rio Chama sites, New Mexico, September 1998.

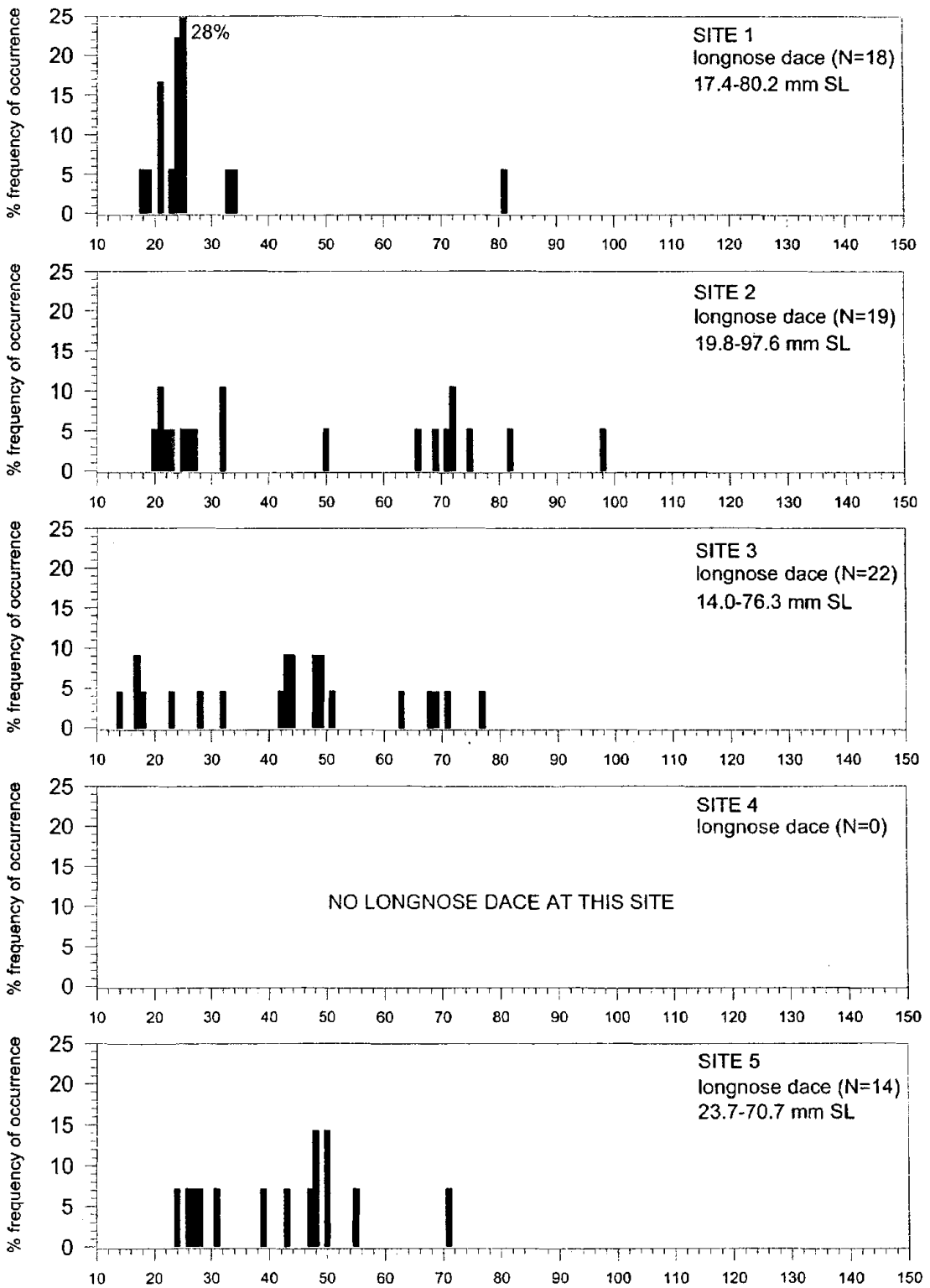

Figure 26. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, September 1998.

mm SL) collected at Site 1 appeared to be Age-0 individuals. The rest of the longnose dace taken in September 1998 were either Age-1 or Age-2 cohorts. Longnose dace were encountered occupying a variety of high-velocity habitats with Age-0 individuals usually taken along the shoreline and larger fish in main channel riffles.

Although white sucker were present at all sites, they were rare in this sampling effort. Individuals were collected from a variety of habitats (pools and runs). The smallest white sucker (ca. 20-30 mm SL) were Age-0 and likely a result of spring spawning. All larger individuals were believed to be Age 1+ (Figure 27).

Age-0 brown trout were present at all sites and were taken in areas with moderate current over cobble/gravel substrata. The 1998 brown trout cohort (Age-0) comprised the majority of the September 1998 collection with one potential Age-1 brown trout collected at Site 2 (Figure 28). Few brown trout were collected at downstream localities.

October 1998

The next sampling trip (20 October 1998) was conducted just prior to a reduction in flow necessitated by the emergency gate installation project. Mean daily discharge at Abiquiu Dam during this collecting effort was about 400 cfs. Most mid-channel habitats were easily accessed. This sampling effort yielded a relatively high number of fish (n=465) from a variety of habitats. Catch rates ranged from 1.76 to 47.17 fish/100 seconds. Water temperatures during the October 1998 sampling trip were cool (ca. 14°C) and fish were somewhat more reclusive than during September 1998.

A total of four native and two nonnative fish taxa were recorded during this sampling effort. The most frequently collected species in October 1998 were longnose dace and brown trout (Table 14). Longnose dace comprised the majority (55.7%) of the total catch and were present at all five sites (Table 15). Rio Grande chub, white sucker, and brown trout were also present at all sites. Rio Grande chub and flathead chub were primarily taken at the downstream-most sites while fathead minnow were distributed throughout the study area. The highest catch rate occurred at Site 5 and the lowest catch rate at Site 4. Catch rates at the other sites (Sites 1, 2, and 3) ranged between 5.53-8.43 fish/100 second. White sucker (n=54) and brown trout (n=43) were relatively common while fathead minnow and flathead chub less common than sucker or trout. Individuals of the *Rhinichthys* x *Gila* intergeneric hybrid were collected at Site 5.

This was the first occasion during this study that Rio Grande chub were collected at all sampling localities. A total of 38 Rio Grande chub were taken at Site 5 with most individuals occupying shoreline habitats. The smallest chubs (<40 mm SL) appeared to be Age-0 fish (Figure 29) while the majority of chub > 40 mm SL were likely Age-1 individuals. The large Rio Grande chubs (> 100 mm SL) collected at Sites 2 and 3 were likely Age-2+.

All fathead minnow taken during the October 1998 sampling effort appeared to be Age-1 (Figure 30). This taxon co-occurred with other species (i.e., Rio Grande chub, white sucker, brown trout) in low water velocity habitats along the shoreline. The presence abundance of fathead minnow at Site 1 was unusual as it was most often encountered at downstream sites.

The relatively high number of longnose dace collected during this sampling trip facilitated the determination of age-class structure (Figure 31). The collection at Site 2 revealed the presence of numerous distinct age-classes (Age-0, <45 mm SL; Age-1, 45-65 mm SL; Age-2, 66-90 mm SL; Age-3+, >90 mm SL) with the largest specimen (108.0 mm SL) being Age-3+. The size-class structure of longnose dace at the other four sites was similar to that at Site 2. The increased catch of this species likely resulted from unimpeded access to instream habitats that accompanied the reduction in flow.

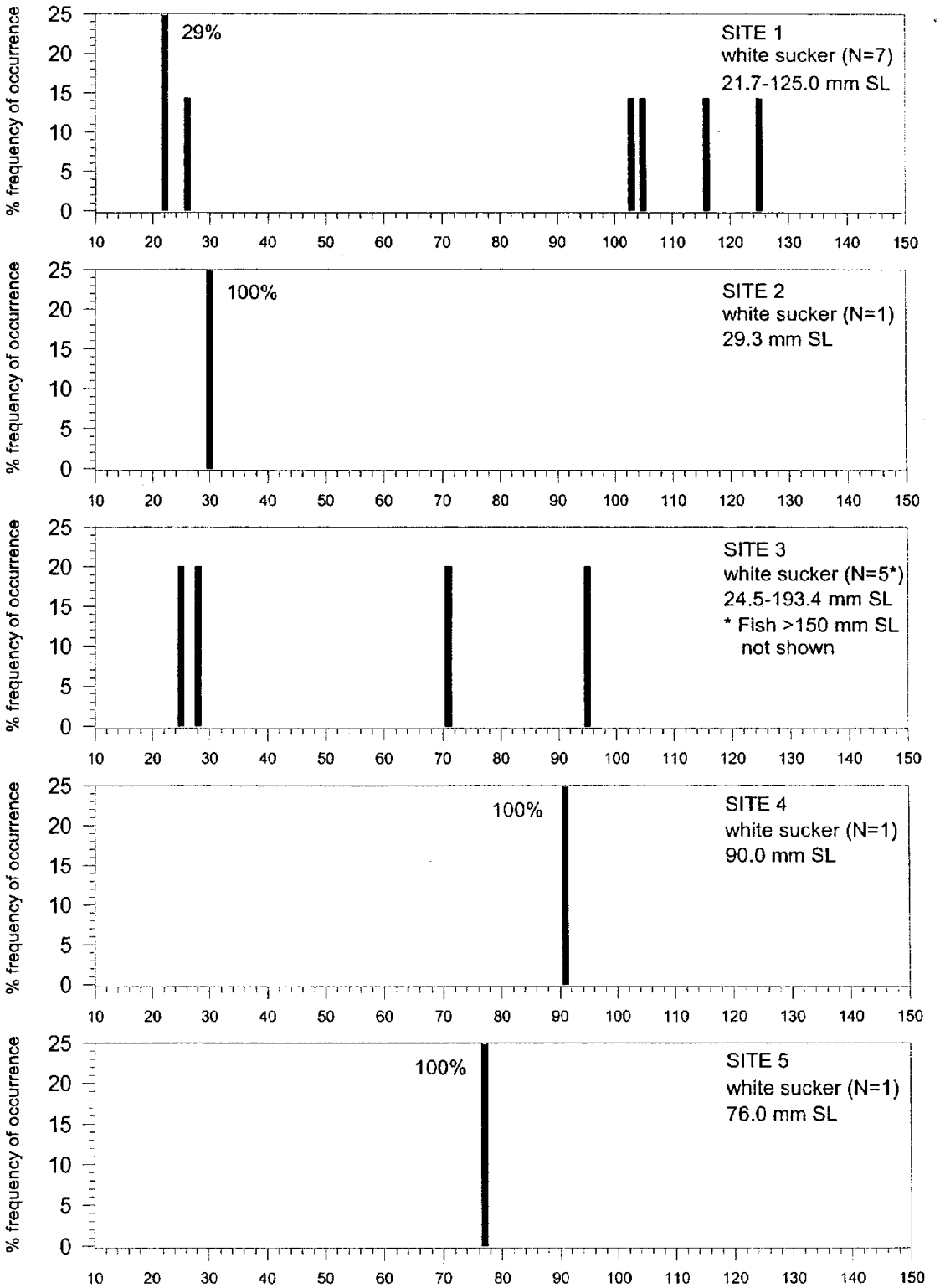

Figure 27. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, September 1998.

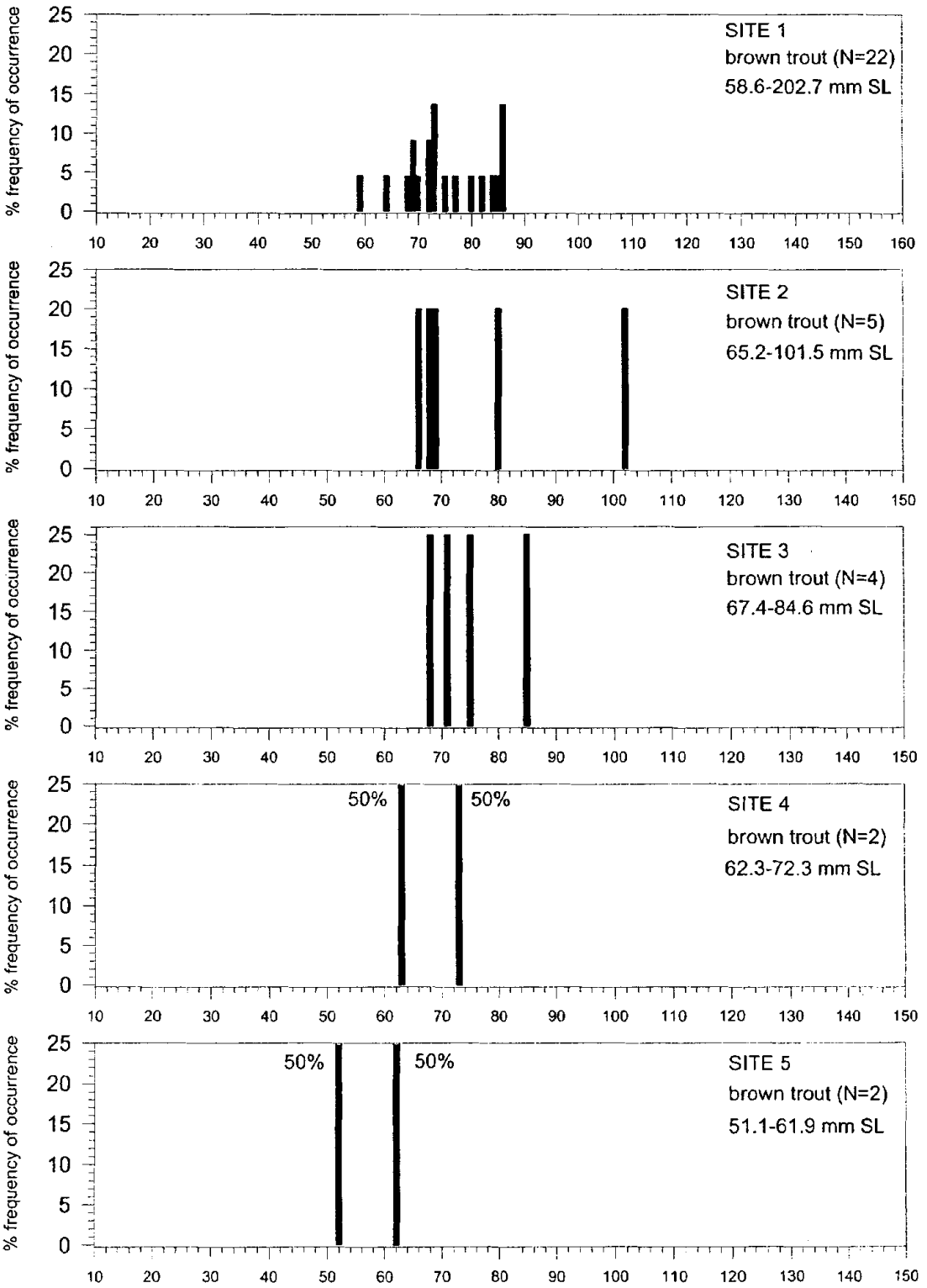

Figure 28. Brown trout length-frequency histograms at five Rio Chama sites, New Mexico, September 1998.

Table 14. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, October 1998.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	-	-	-	-.—
Rio Grande chub	N	38	4	5	8.17
fathead minnow	N	31	6	3	6.67
flathead chub	N	37	5	1	7.96
longnose dace	N	259	1	5	55.70
white sucker	I	54	2	5	11.61
brown trout	I	43	3	5	9.25
Rhinichthys x *Gila* hybrid	N	3	7	1	0.64
TOTAL	465				

[1] N = native; I = introduced

Table 15. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico, October 1998.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	-	-	-
Rio Grande chub	1	1	3	1	32	38
fathead minnow	17	-	11	-	3	31
flathead chub	-	-	-	-	37	37
longnose dace	50	88	45	10	66	259
white sucker	36	6	5	3	4	54
brown trout	14	13	8	2	6	43
Rhinichthys x *Gila* hybrid	-	-	-	-	3	3
TOTAL	118	108	72	16	151	465
# SPECIES	5	4	5	4	7	7
SHOCKING SEC.	1,353	1,091	1,285	908	318	4,955
CPUE *	8.72	9.90	5.60	1.76	47.48	9.38

* catch rate per 100 seconds electrofishing

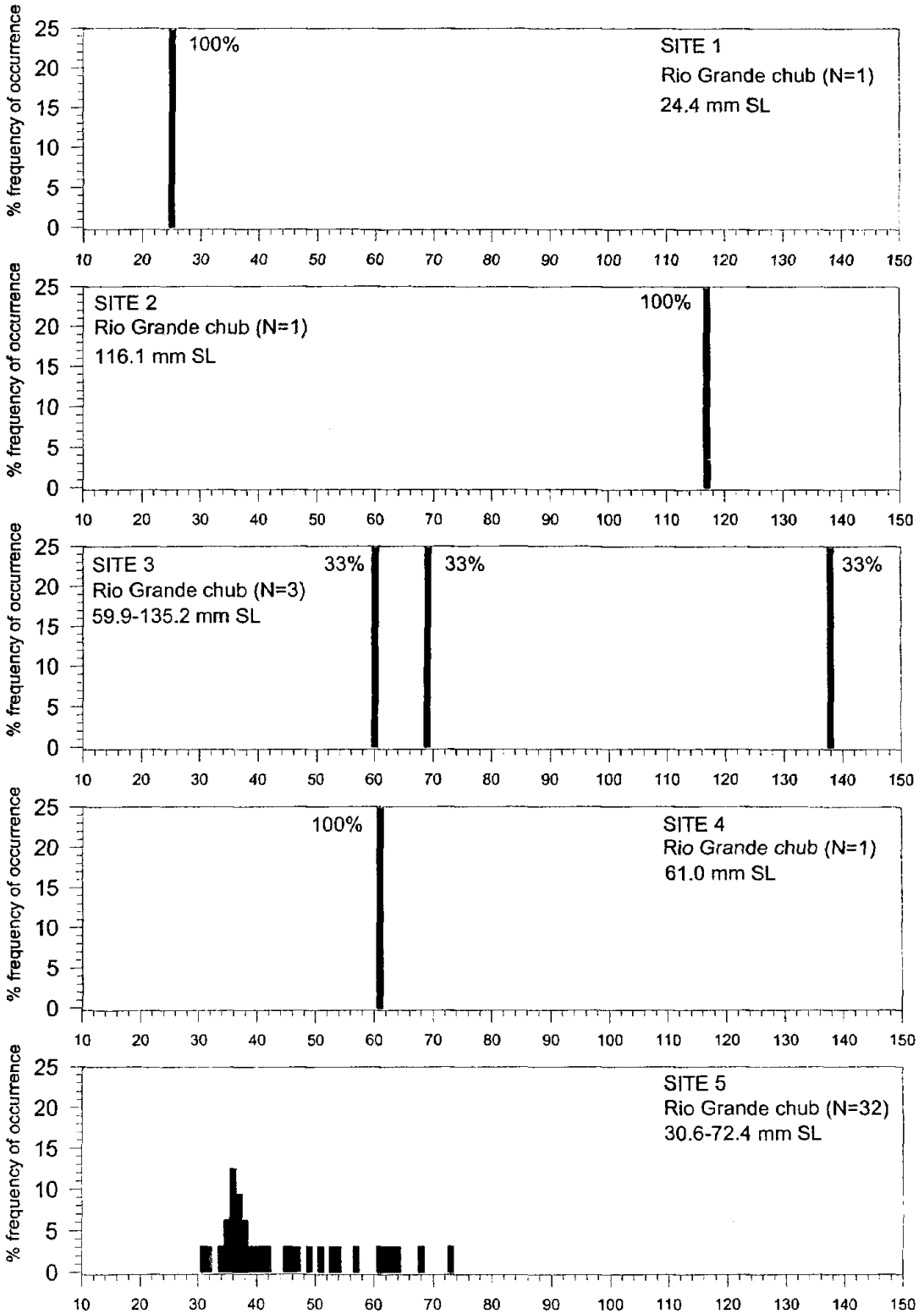

Figure 29. Rio Grande chub length-frequency histograms at five Rio Chama sites, New Mexico, October 1998.

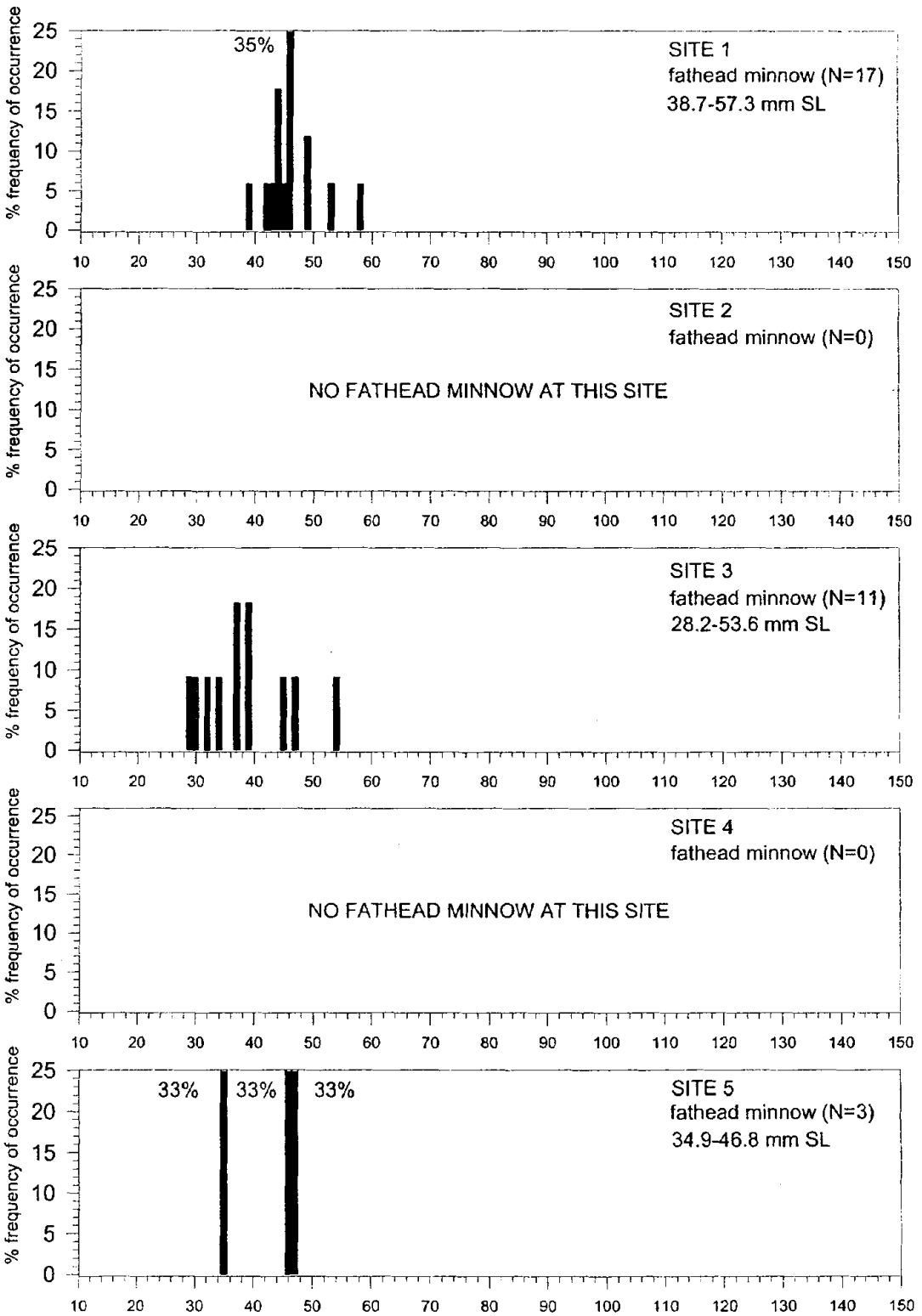

Figure 30. Fathead minnow length-frequency histograms at five Rio Chama sites, New Mexico, October 1998.

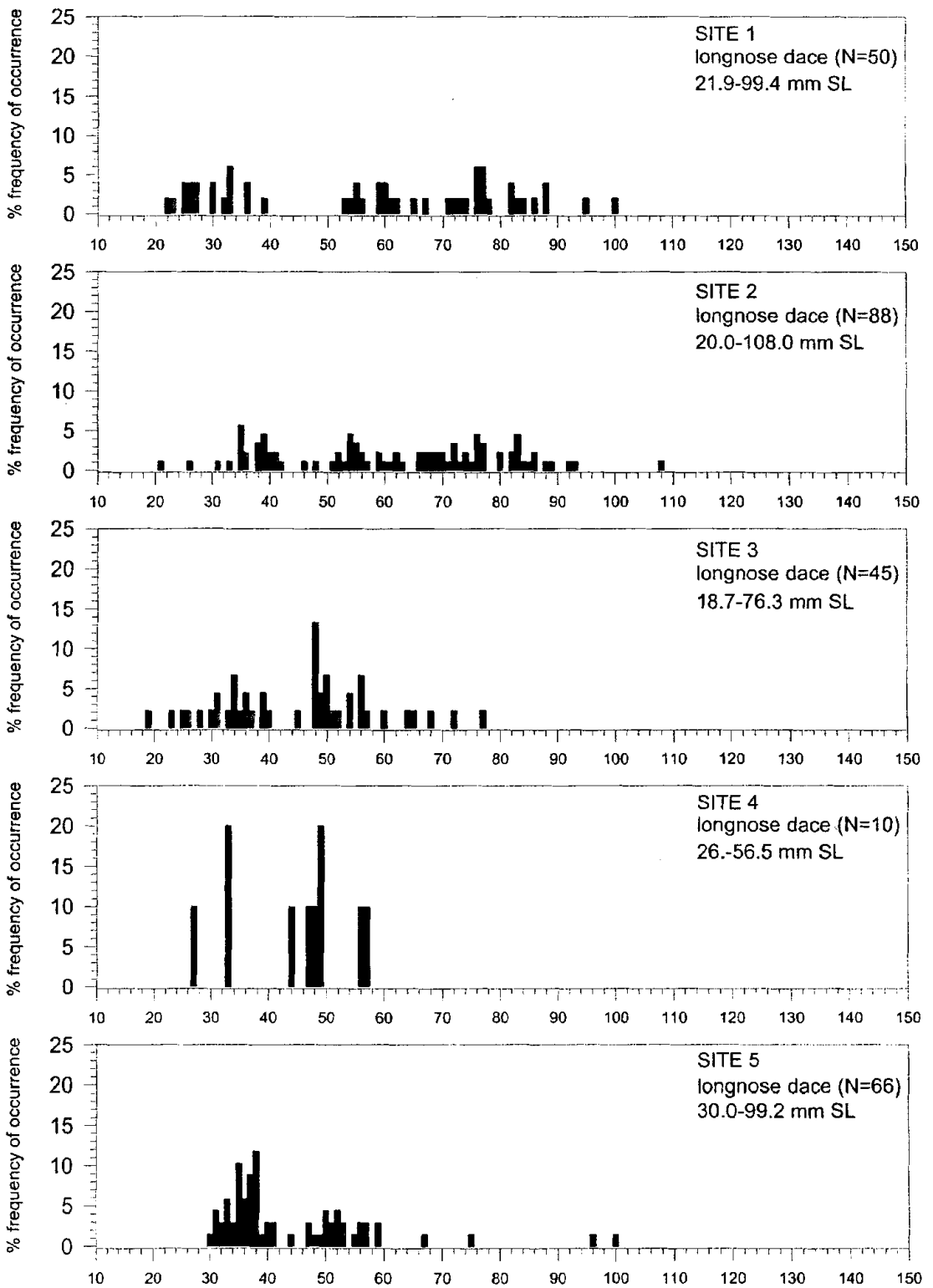

Figure 31. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, October 1998.

White sucker were present at all sites but were only common at Site 1. Only two age-classes of white sucker were taken at most sites. Age-0 individuals were generally between 30-60 mm SL with Age-1 white sucker being ca. 62-150 mm SL (Figure 32).

The 1998 cohort of brown trout was present at all sites (Figure 33). Age-0 trout were taken in the same habitats as other YOY fishes (i.e., low velocity, shallow habitats). All individuals appeared to be Age-0 but the 134.4 mm SL specimen could have been a small Age-1 fish. Brown trout were only moderately abundant during this sampling trip.

November 1998

The final sampling trip of 1998 (18-19 November 1998) occurred while mean daily discharge at Abiquiu Dam was about 50 cfs. A substantial increase in angling pressure was noted during the November collecting effort especially when compared with the previous sampling trip (20 October 1998). In addition, fish were observed congregating around large boulders in deep pools. The high catch rate recorded during the November 1998 sampling effort was likely an artifact of an increase in fish concentration caused by reduced water levels. David Griegos (U.S. Army Corps of Engineers, Abiquiu Reservoir Ranger) reported finding dead fish under algal mats on the river banks soon after the 200 to 50 cfs recession of flow.

Discharge in the Rio Chama below Abiquiu Dam was essentially 0 cfs at 0900 on 18 November 1998. A shut-down of flow had occurred for a period of about one hour because of a malfunctioning pump. Quantification of the magnitude of the detrimental effect of the 0 cfs discharge period on the ichthyofaunal community of the Rio Chama was, unfortunately, beyond the scope of this study.

The low flow meant that all aquatic habitats could be easily accessed, some for the first time since sampling began in April 1997. The extreme low flow markedly improved catch rate efficiency. This sampling effort yielded a high number of fish (n=460) and catch rates of 1.60-18.53 fish/100 seconds. Numerous fishes were either scarred or presented with dermal fungal/bacterial infections. Water temperatures during this sampling effort were cool (11°C) but had not declined notably since October 1998. The river was murky-green in color and water visibility was low.

Five native and two nonnative fish species were recorded in the November 1998 sample making it one of the more species-rich sampling efforts of this project. The majority of the individuals were taken at the downstream-most site although numerous longnose dace, white sucker, and brown trout were taken at Site 1. The highest catch rate was recorded at Site 5 while the other sites had catch rates that ranged from 1.60-5.32 fish/100 second.

Brown trout were the most frequently collected species in November 1998 (Table 16) followed by longnose dace. These two species collectively comprised the majority (57.6%) of the total catch and were present at all five sites (Table 17). Brown trout catch (n=152) was higher than during previous sampling trips primarily because of the increased catch of larger individuals (see Appendix: Table A-1). This was the first sampling effort to yield rainbow trout (n=2). It also produced the first river carpsucker of the study.

Rio Grande chub (n=40) were only collected at Site 5 and occurred primarily in areas with exposed debris. The smallest individual (18.1 mm SL) was Age-0 (Figure 34) with the majority of the remainder being Age-1 (size range=25-55 mm SL). Individuals larger than 55 mm SL could also have been Age-1 but were more likely Age-2 fish.

A moderate number of Age-0 fathead minnow (n=72) were present in shallow pools at Site 5. Individuals <40 mm SL were considered Age-0 while those >40 mm SL were deemed to be Age-1 fish (Figure 35). The absence of fathead minnow from upstream sites was unusual.

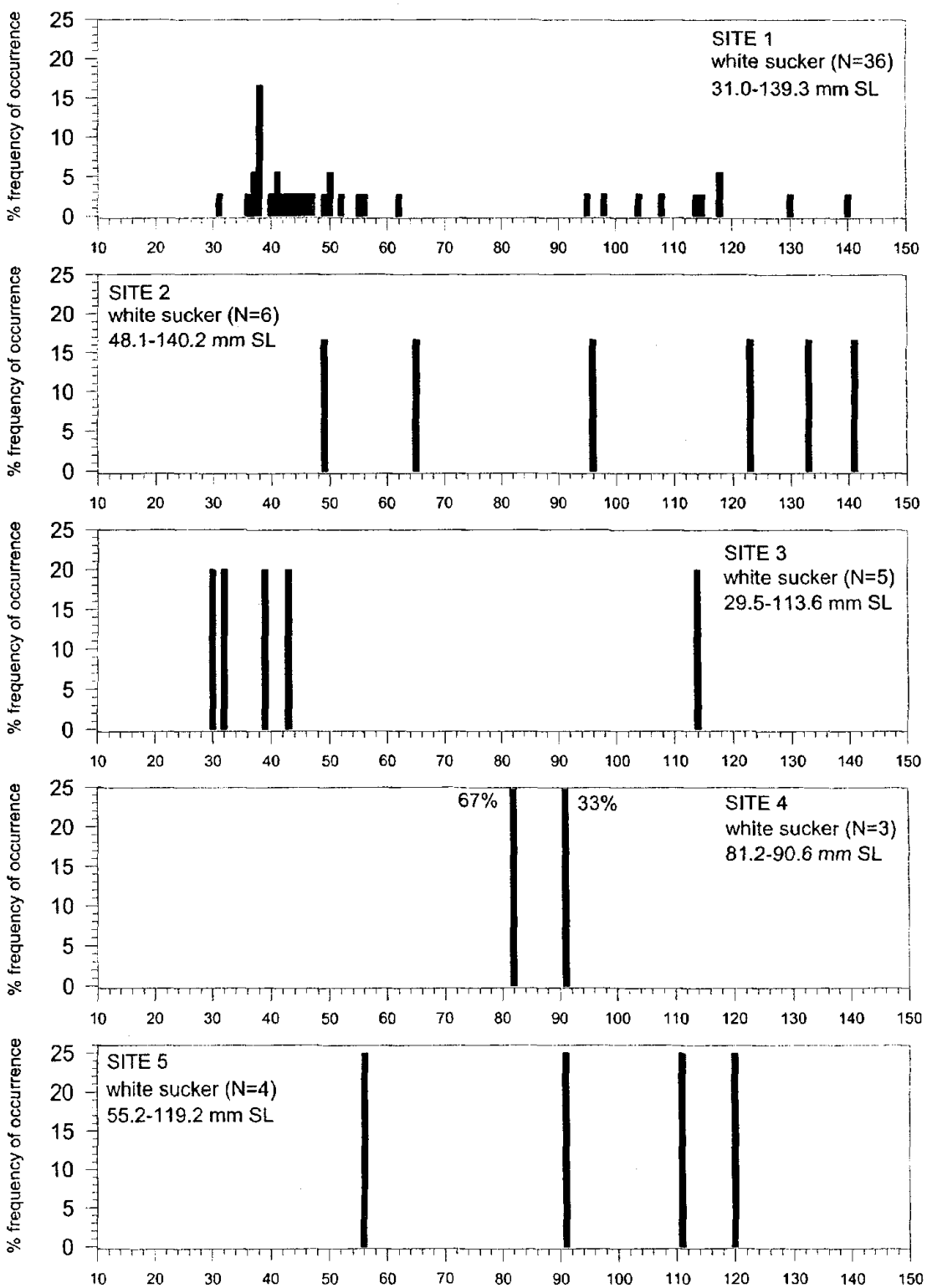

Figure 32. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, October 1998.

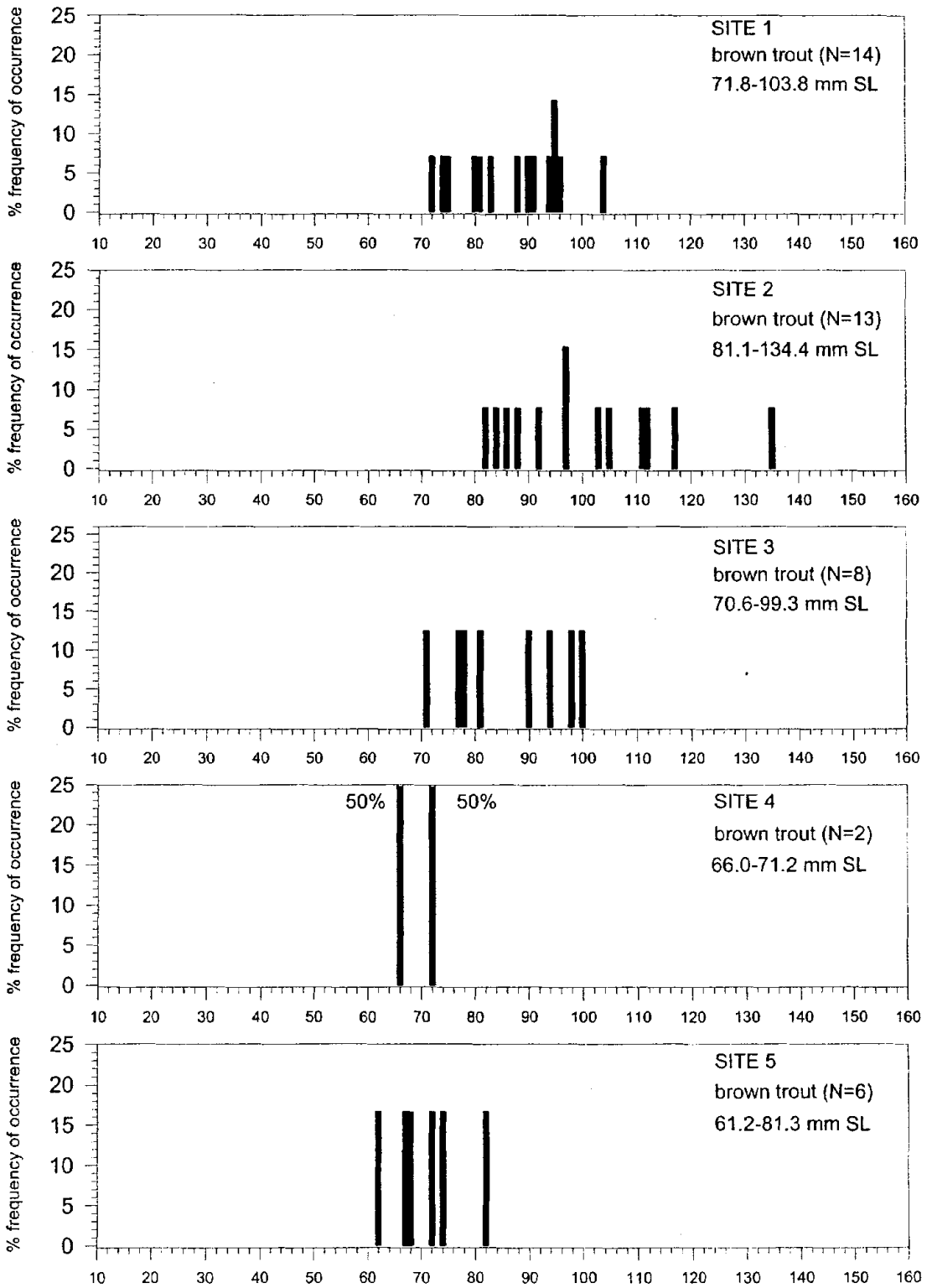

Figure 33. Brown trout length-frequency histograms at five Rio Chama sites, New Mexico, October 1998.

Table 16. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, November 1998.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	-	-	-	-.—
Rio Grande chub	N	40	5	1	8.70
fathead minnow	N	77	3	1	16.74
flathead chub	N	15	6	1	3.26
longnose dace	N	113	2	5	24.57
river carpsucker	N	1	8	1	0.22
white sucker	I	60	4	5	13.04
rainbow trout	I	2	7	2	0.43
brown trout	I	152	1	5	33.04
TOTAL	460				

[1] N = native; I = introduced

Table 17. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico, November 1998.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	-	-	-
Rio Grande chub	-	-	-	-	40	40
fathead minnow	-	-	-	-	77	77
flathead chub	-	-	-	-	15	15
longnose dace	26	9	1	17	60	113
river carpsucker	-	-	-	-	1	1
white sucker	28	1	3	5	23	60
rainbow trout	1	-	-	1	-	2
brown trout	65	31	22	23	11	152
TOTAL	120	41	26	46	227	460
# SPECIES	4	3	3	4	7	8
SHOCKING SEC.	1,608	1,154	1,630	865	1,225	6,482
CPUE *	7.46	3.55	1.60	5.32	18.53	7.10

* catch rate per 100 seconds electrofishing

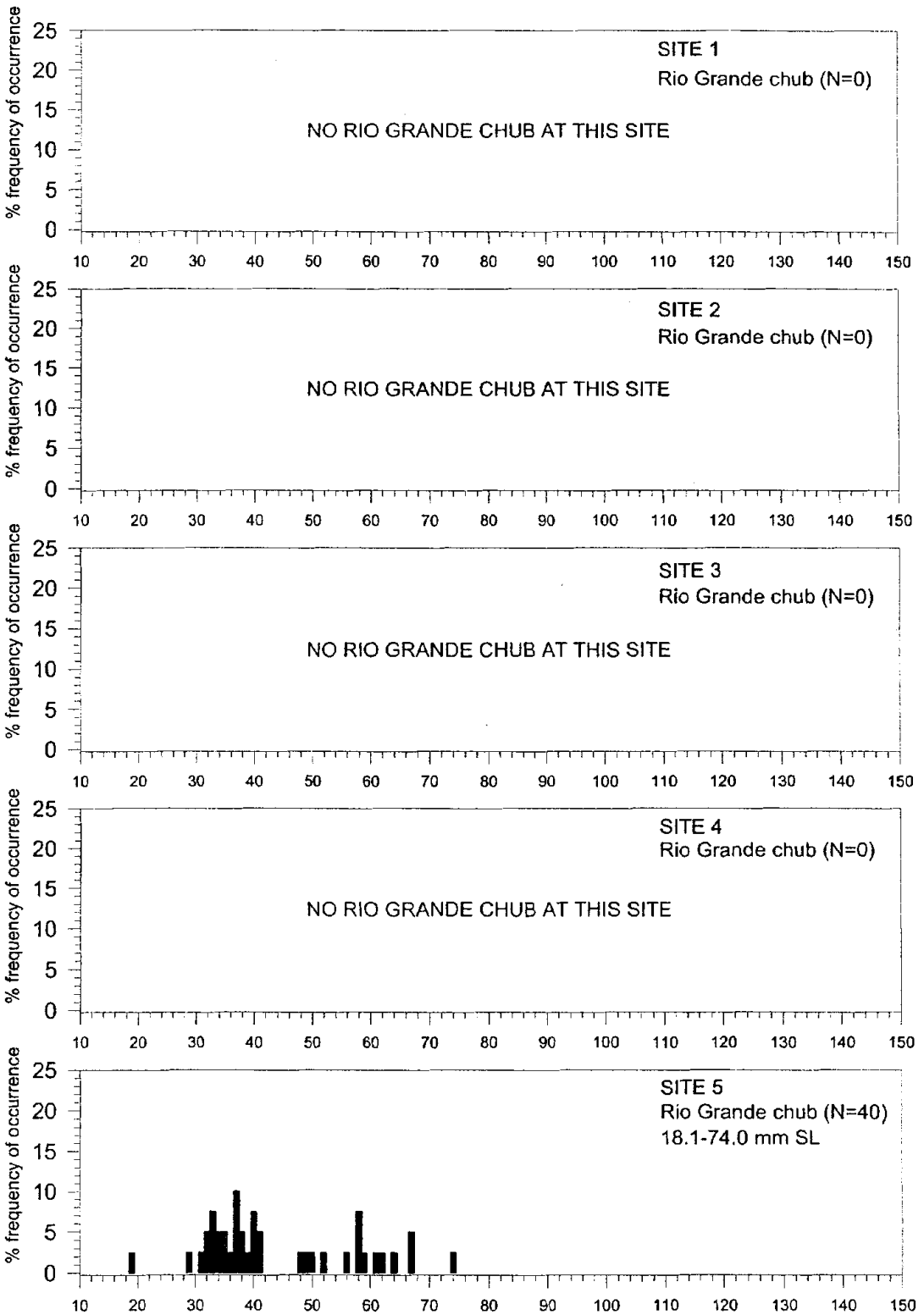

Figure 34. Rio Grande chub length-frequency histograms at five Rio Chama sites, New Mexico, November 1998.

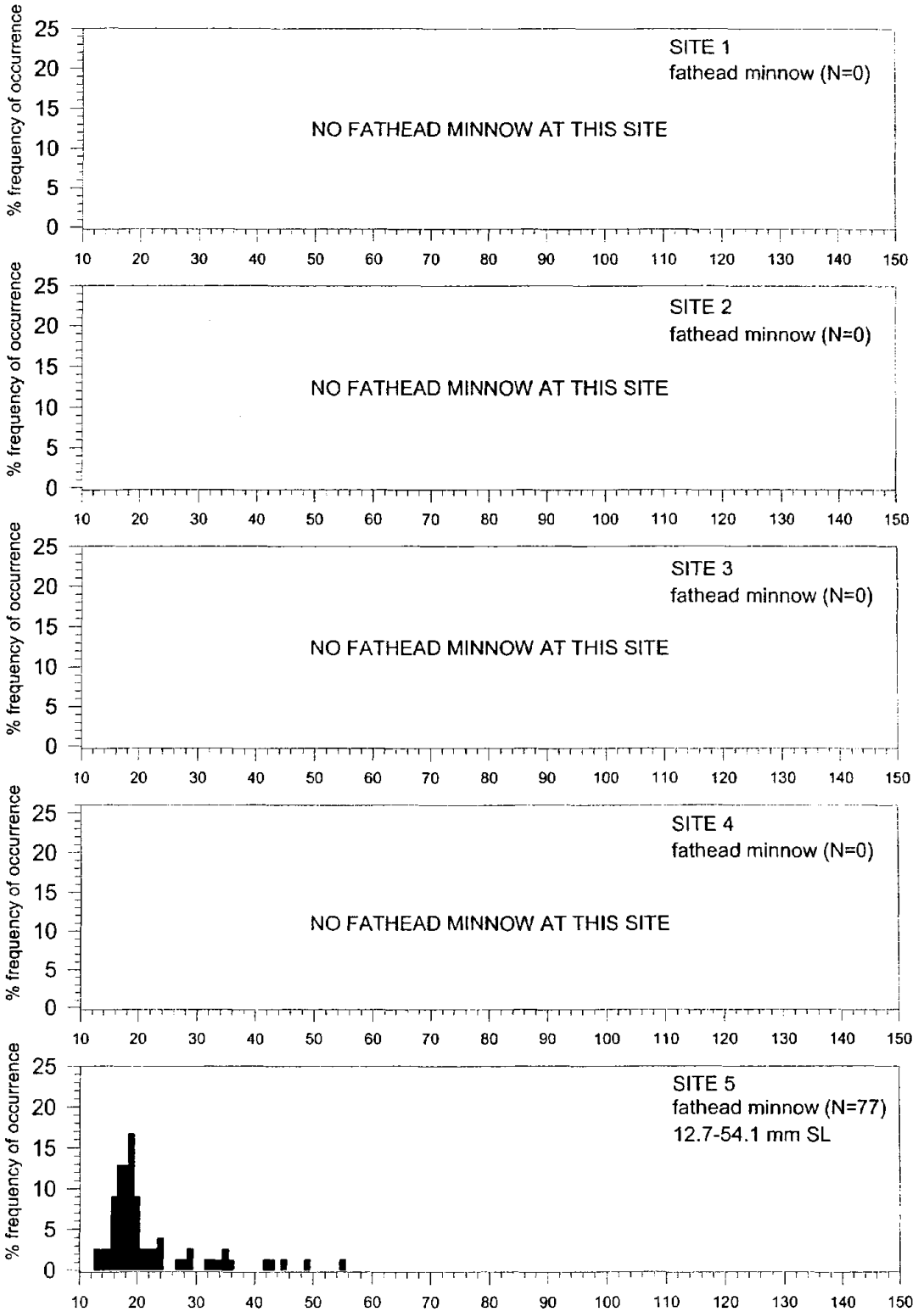

Figure 35. Fathead minnow length-frequency histograms at five Rio Chama sites, New Mexico, November 1998.

Longnose dace were present at all sites but most abundant at Site 5. This longitudinal distribution pattern was quite different than those observed prior to this sampling trip. Longnose dace were relatively abundant and easily collected in shallow riffles. The well-defined 25-40 mm SL size-class from Site 5 appeared to be Age-0 individuals (Figure 36). Eleven longnose dace >90 mm SL were collected and, based on the length frequency histograms, were probably Age-3+.

White sucker were collected at all sampling sites but were rare at Sites 2-4. Individual specimens were taken in a variety of habitats but were most common in areas of low water velocity. The majority of white sucker collected were Age-1 but single Age-0 specimens (size range=36.3-39.2 mm SL) were present at Sites 3 and 5 (Figure 37).

The size range of brown trout collected increased dramatically during this sampling trip (Appendix A; Table A-1). Individuals >200 mm SL were relatively common during the November 1998 collecting effort and a few brown trout exceeding >400 mm SL were captured. The numerically dominant age-class was Age-0 but Age-1+ brown trout were much more abundant in collections than during previous sampling efforts (Figure 38). Several reproductively active brown trout were noted during this sampling effort. Many male brown trout freely released milt upon capture while at least three female brown trout expressed eggs. The majority of large female brown trout appeared to be relatively spent of eggs indicating that the brown trout spawning had likely already peaked.

January 1999

A sampling trip during low winter flows associated with the installation of emergency gates at Abiquiu Dam was conducted on 7 January 1999. This collecting effort was performed during a period when mean daily discharge at Abiquiu Dam was about 50 cfs. Angling pressure was still high and brown trout appeared to have low condition factor. This sampling effort yielded a relatively high number of fish (n=345) and catch rates that ranged from 2.30 to 17.17 fish/100 seconds. Water temperatures were cold (5°C) and water visibility was >1 m. Water visibility had improved noticeably compared to November 1998.

Four native and three nonnative fish taxa were collected in January 1999. Fish catch rates were low to moderate at all sites except Site 1 where the catch rate was extremely high (primarily because of large numbers of brown trout). The highest catch rate at Site 1 was 17.17 fish/100 seconds while the other sites had catch rates between 2.30-6.26 fish/100 seconds. Very few fish were collected at Sites 2 or 4.

The most abundanct species in January 1999 samples was brown trout (Table 18) followed by longnose dace and white sucker, respectively. Brown trout were the majority (69.9%) of the total catch and were present at all five sites (Table 19). As in November 1998, many large brown trout were collected (Table A-1) during this sampling effort. Rio Grande chub, fathead minnow, flathead chub, and rainbow trout were also taken in January 1999 but were less abundant than brown trout, longnose dace, or white sucker.

Rio Grande chub were rare during this trip (n=10) and were present only at Sites 4 and 5. Most Rio Grande chub were Age-1 or Age-2 although a few Age-3+ chub were taken at Site 5 (Figure 39). Areas with debris produced the majority of Rio Grande chub collected.

The only fathead minnow collected was an Age-2 individual (Figure 40) captured at Site 5. This individual was found in an area associated with instream cover. The lack of fathead minnow throughout the study area was unexpected given their abundance in previous sampling trips.

Catch rates of longnose dace were low at Sites 2-4 (n<5) and only moderate (n=20-22) at Sites 1 and 5. The small number of longnose dace did not yield any well defined age-classes in the length frequency histograms (Figure 41). Longnose dace were reclusive and appeared to be occupying areas associated with large cobble substrata.

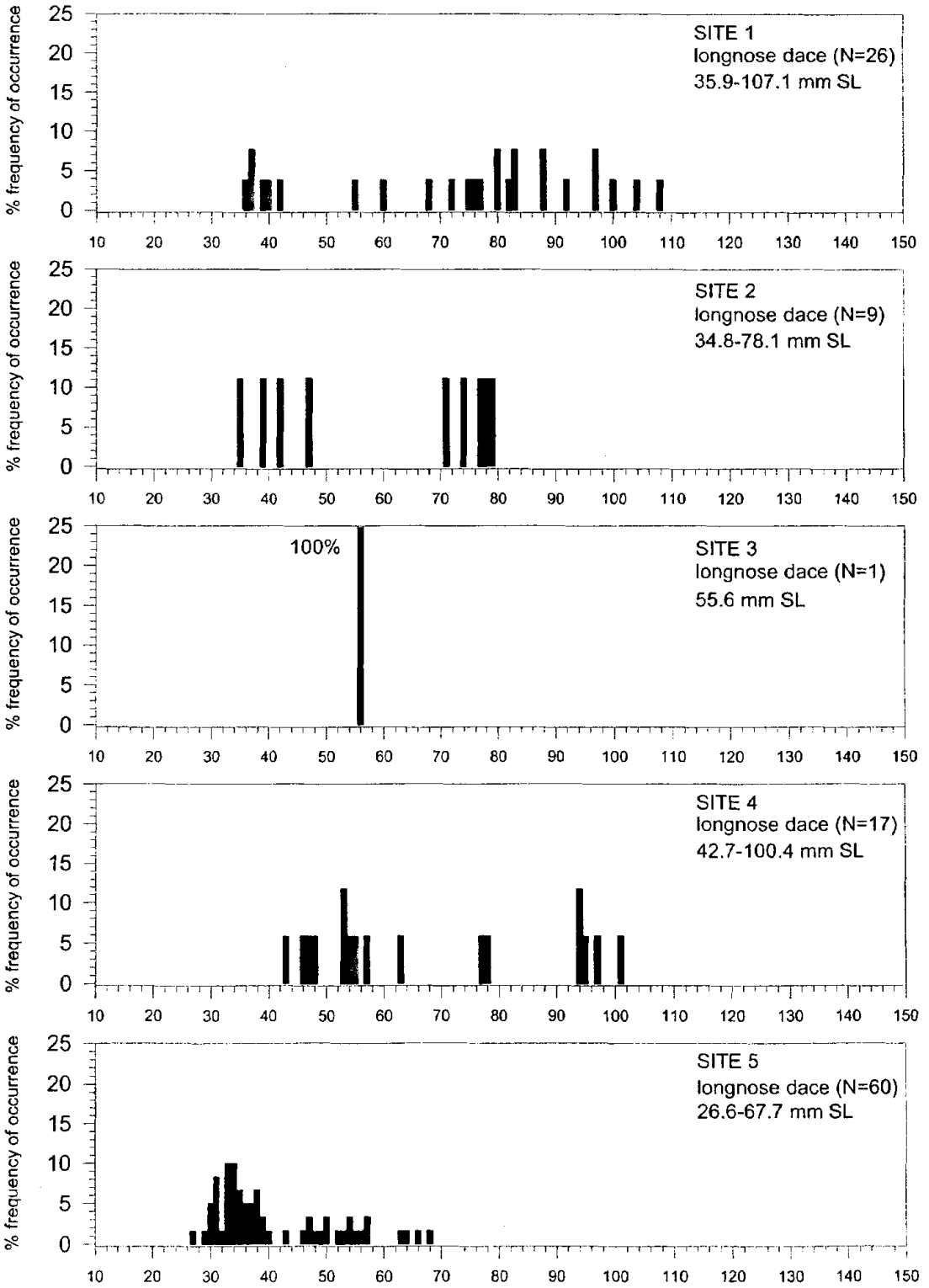

Figure 36. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, November 1998.

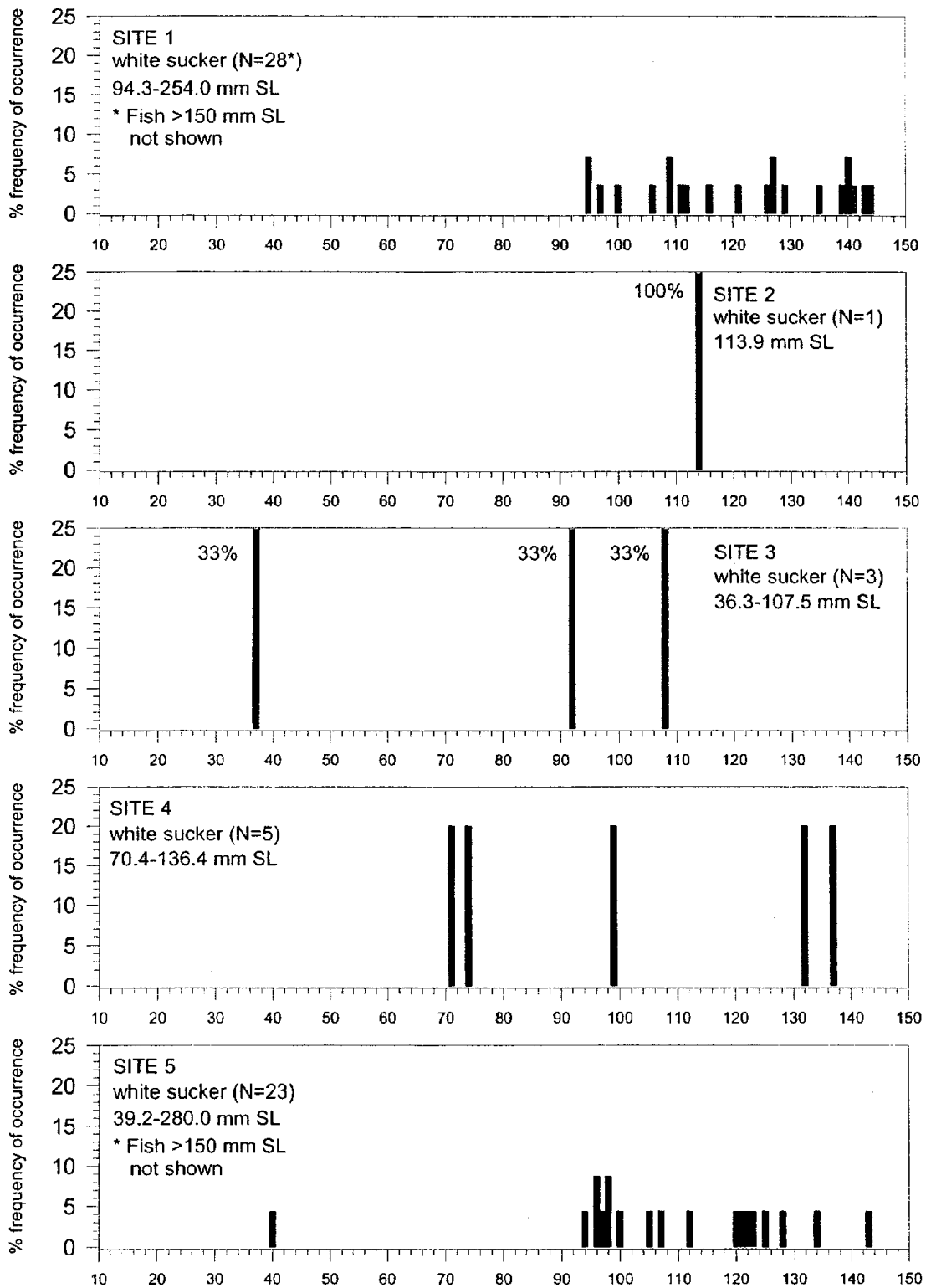

Figure 37. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, November 1998.

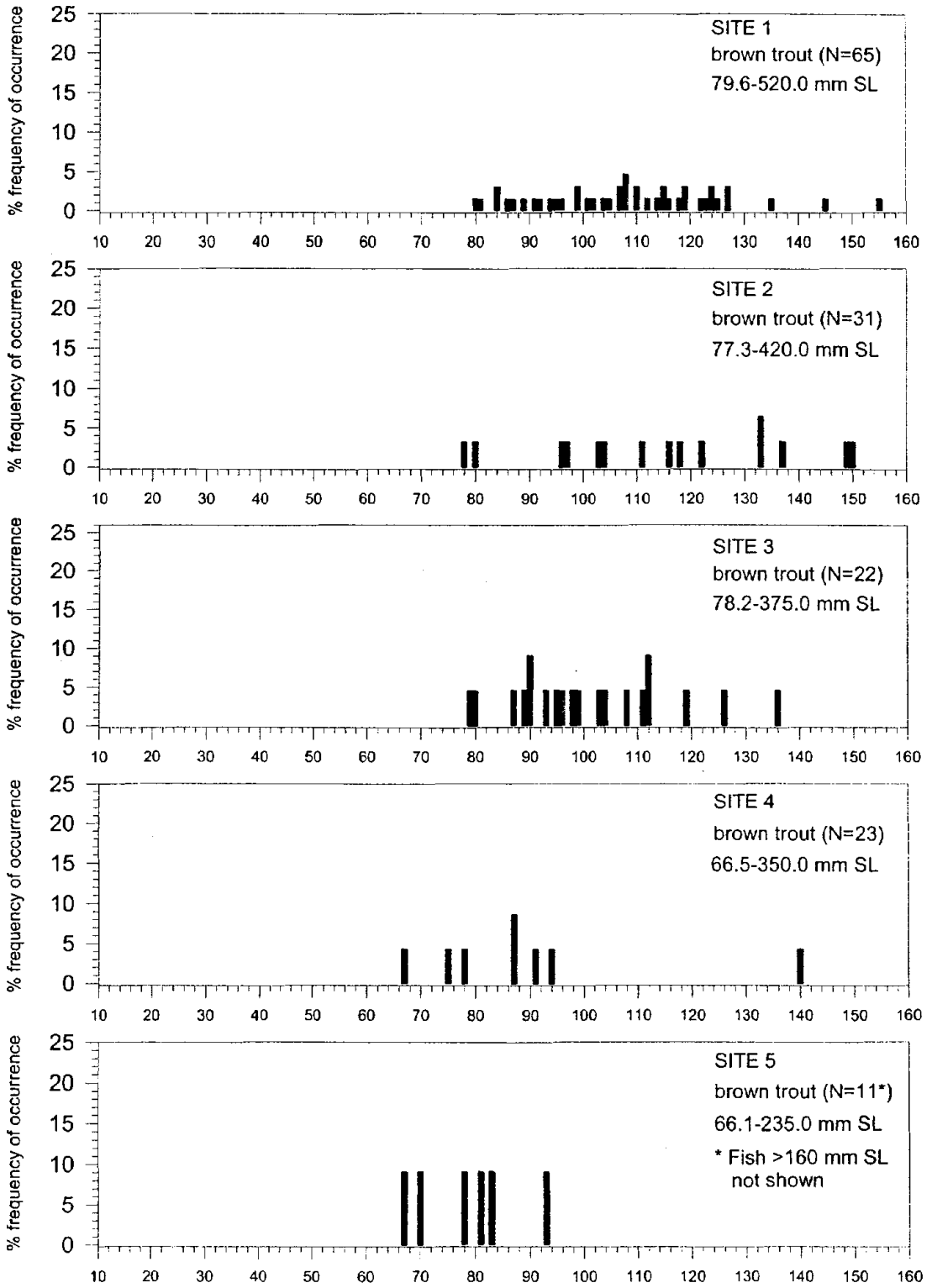

Figure 38. Brown trout length-frequency histograms at five Rio Chama sites, New Mexico, November 1998.

Table 18. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, January 1999.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	-	-	-	-.—
Rio Grande chub	N	10	4	2	2.90
fathead minnow	N	1	7	1	0.29
flathead chub	N	5	5	1	1.45
longnose dace	N	48	2	5	13.91
white sucker	I	37	3	5	10.72
rainbow trout	I	3	6	1	0.87
brown trout	I	241	1	5	69.86
TOTAL	345				

[1] N = native; I = introduced

Table 19. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico, January 1999.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	-	-	-
Rio Grande chub	-	-	-	1	9	10
fathead minnow	-	-	-	-	1	1
flathead chub	-	-	-	-	5	5
longnose dace	20	4	1	1	22	48
white sucker	20	1	3	5	8	37
rainbow trout	3	-	-	-	-	3
brown trout	173	14	34	16	4	241
TOTAL	216	19	38	23	49	345
# SPECIES	4	2	3	4	6	7
SHOCKING SEC.	1,258	825	607	730	500	3,920
CPUE *	17.17	2.30	6.26	3.15	0.98	8.8

* catch rate per 100 seconds electrofishing

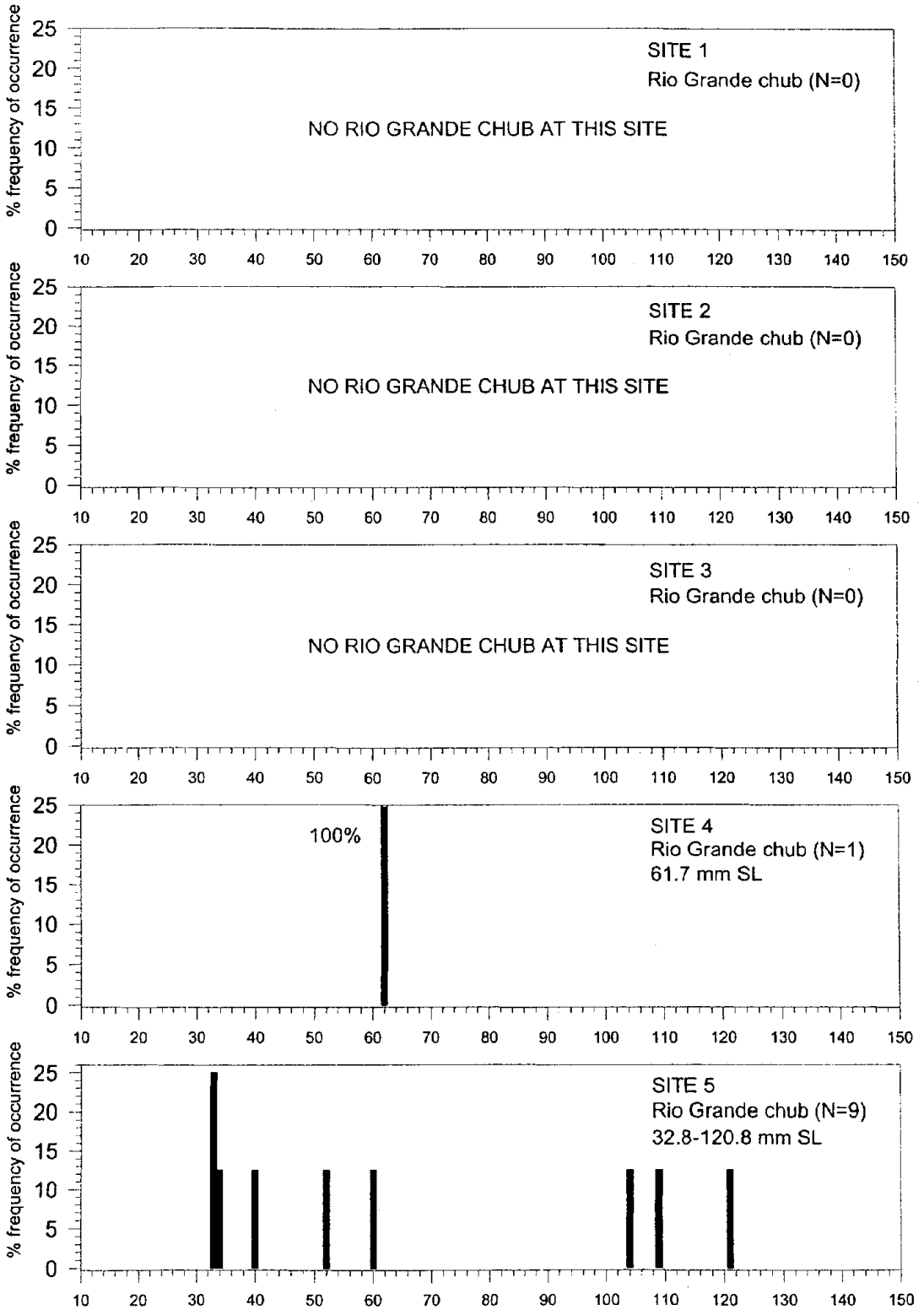

Figure 39. Rio Grande chub length-frequency histograms at five Rio Chama sites, New Mexico, January 1999.

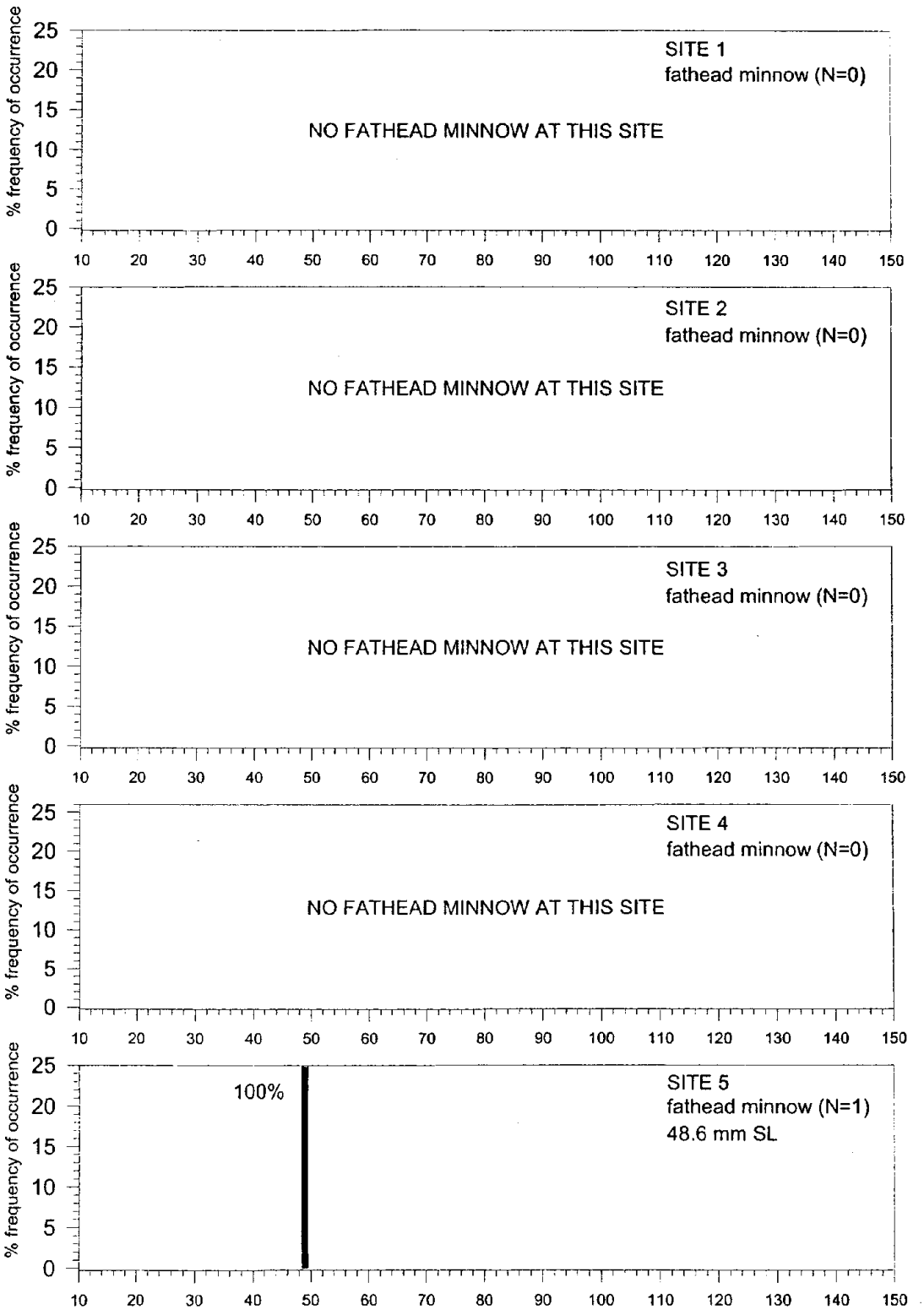

Figure 40. Fathead minnow length-frequency histograms at five Rio Chama sites, New Mexico, January 1999.

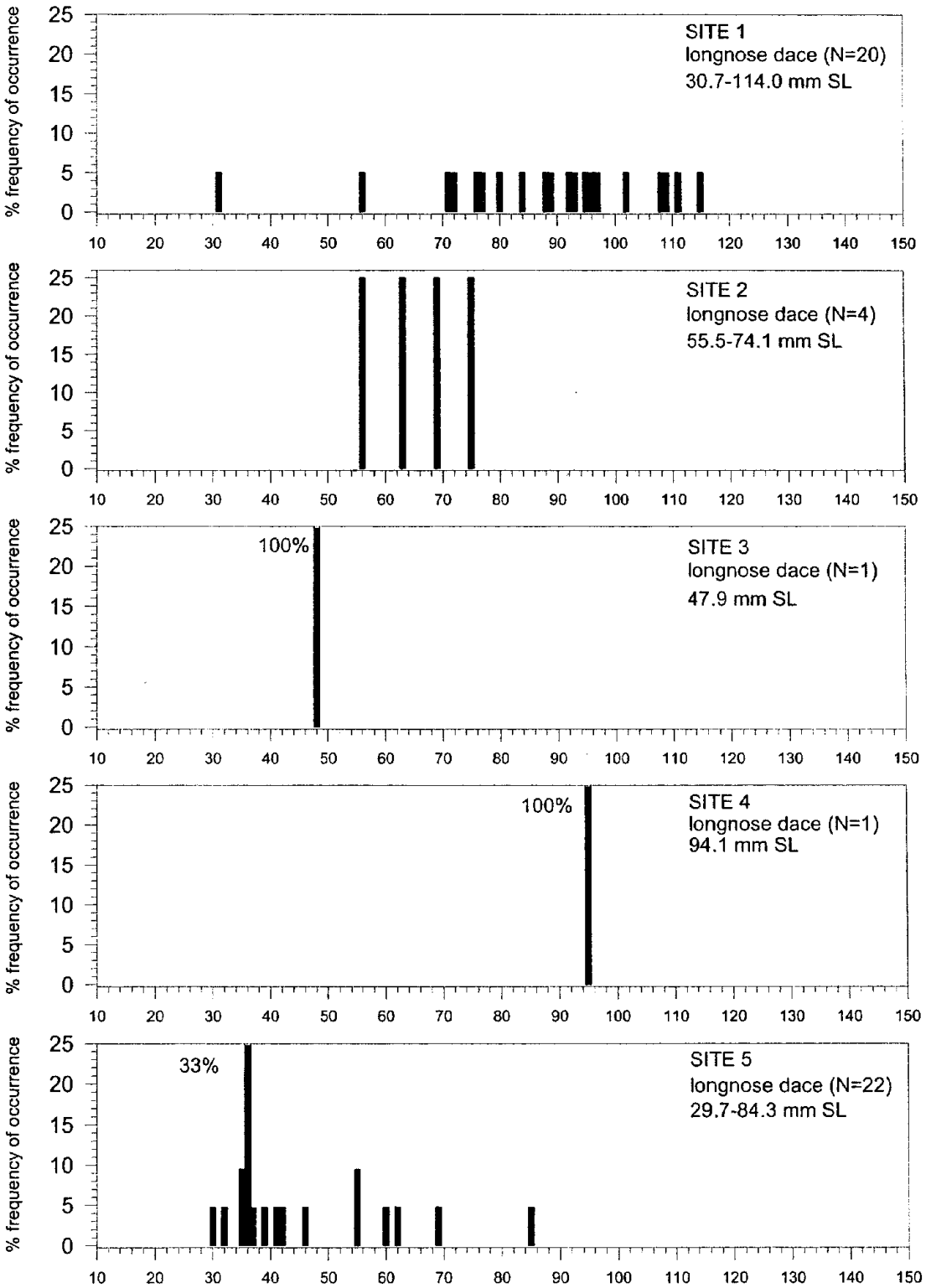

Figure 41. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, January 1999.

White sucker were present at all sites sampled but were rare throughout the study area. Individuals <60 mm SL were Age-1 while those that were 90-150 mm SL were Age-2 (Figure 42). A few white sucker >200 mm SL were also collected.

Many brown trout, including large individuals, were again collected in the January 1999 sampling effort. Site 1 produced 173 brown trout between 82-375 mm SL while 34 trout (81-416 mm SL) were collected at Site 3 (Figure 43). There was a wide variety of age-classes in this sample with Age-1 and Age-2 being most abundant.

March 1999

This sampling trip (10-11 March 1999) was the last conducted during the low flow period associated with construction of emergency gates at Abiquiu Dam. Mean daily discharge at Abiquiu Dam remained at 50 cfs during the duration of March 1999 sampling, all habitats were easily accessed, and sampling efficiency was high. This sampling effort yielded a moderate number of fish (n=273) and catch rates that ranged from 1.76 to 11.00 fish/100 seconds. Water temperatures during this sampling effort were cool (7-11°C) but pools warmed during the day.

Seven fish species, four native and three nonnative, were recorded during this sampling trip. Longitudinal patterns of fish abundance were similar to those observed in previous collecting efforts with the exception of the presence of Rio Grande chub at Site 1 (normally not present). While the number of species varied between sites, numerous taxa were often represented by only a few individuals. The highest catch rate was at Site 1 (11.00 fish/100 seconds) while the other sites had catch rates that ranged from 1.76 to 3.79 fish/100 seconds.

Brown trout was the most commonly collected species in March 1998 (Table 20) with longnose dace being the second most abundant fish. Brown trout and longnose dace were each taken at all five sites (Table 21) and collectively comprised the majority (81.7%) of the total catch. The catch rates of other species were relatively low; most species were collected at only one or two sampling sites. Black bullhead (n=1), captured at Site 1, was the first taken during the study or in any of our previous research activities of the Rio Chama.

Moderate numbers of Rio Grande chub were collected (n=24) during the March 1999 sampling effort. This species was taken at all sites except Site 3 with individuals occurring primarily in areas associated with shoreline debris. The smallest individuals (<50 mm SL) appeared to be Age-1 chub (Figure 44) with those specimens > 50 mm SL being Age-2+ fish. Only two fathead minnow were collected during this sampling effort. The large individual from Site 1 (59.2 mm SL) was an Age-2 fish (Figure 45) while the 30 mm SL fathead minnow captured at Site 3 was an Age-1 fathead minnow.

Three size-classes of longnose dace were detected among the moderately high number of longnose dace (n=97) taken. The Age-1 individuals were about 20-40 mm SL and most were present at Sites 1, 3, and 5 (Figure 46). Site 4 produced the most Age-2 individuals and Site 1 accounted for the majority of Age-3 individuals.

Low numbers (n=19) of white sucker were present, collectively, at Sites 1 and 3 and only two specimens were collected from Site 4. White sucker from Site 3 were 32-51 mm SL (n=11) and were all Age-1 fish (Figure 47). Most Age-1 white sucker collected occupied areas with low-moderate water velocities close to instream cover.

Age-1 brown trout (1998 year class) were taken at all sites and occurred in a variety of moderate to high velocity habitats. The collection of several brown trout <80 mm SL indicated slow growth rates for those individuals during 1998 and early 1999 (Figure 48). Large brown trout (> 200 mm SL) were also collected during the low flows of March 1999, but their abundance was notably

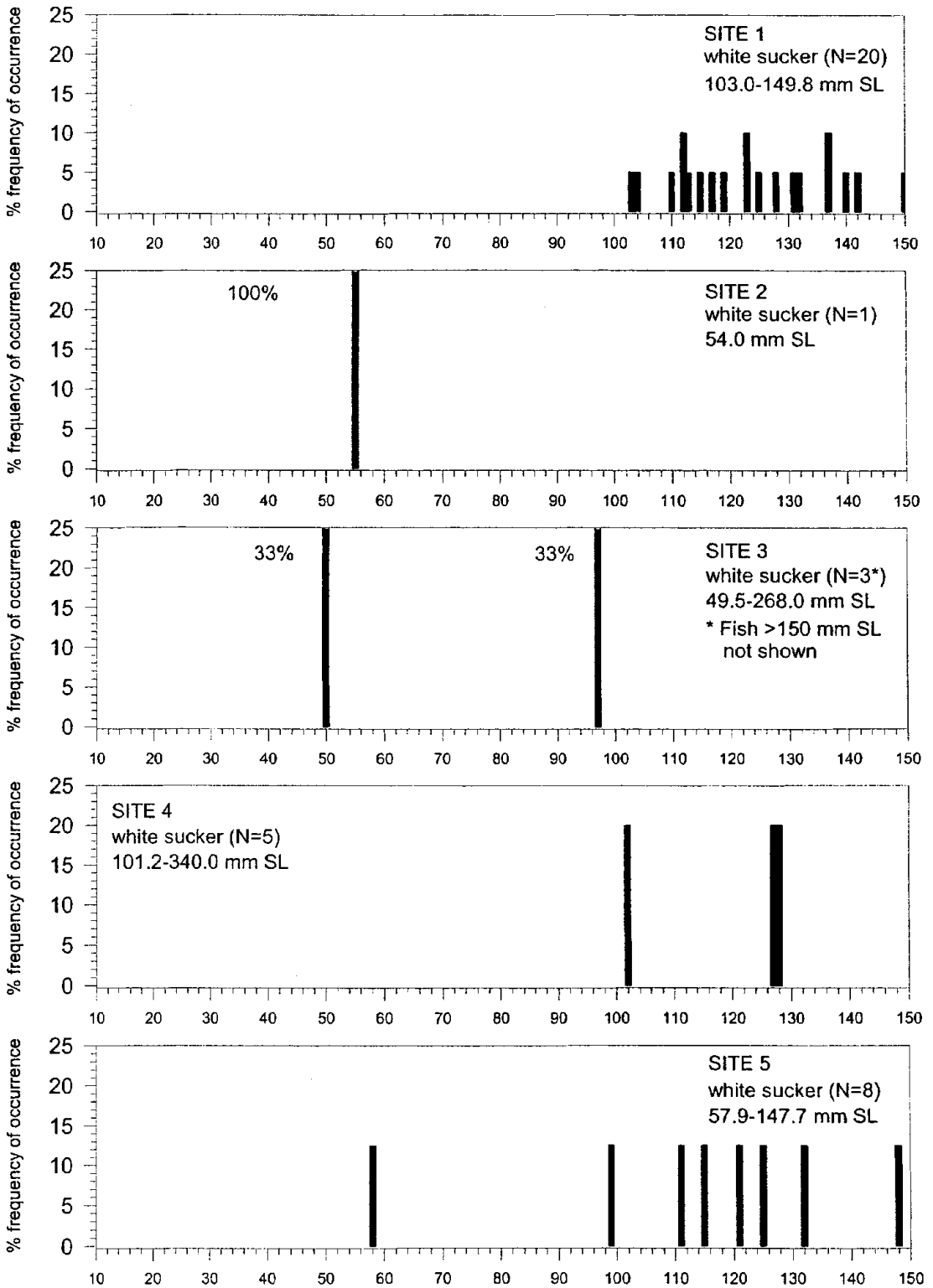

Figure 42. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, January 1999.

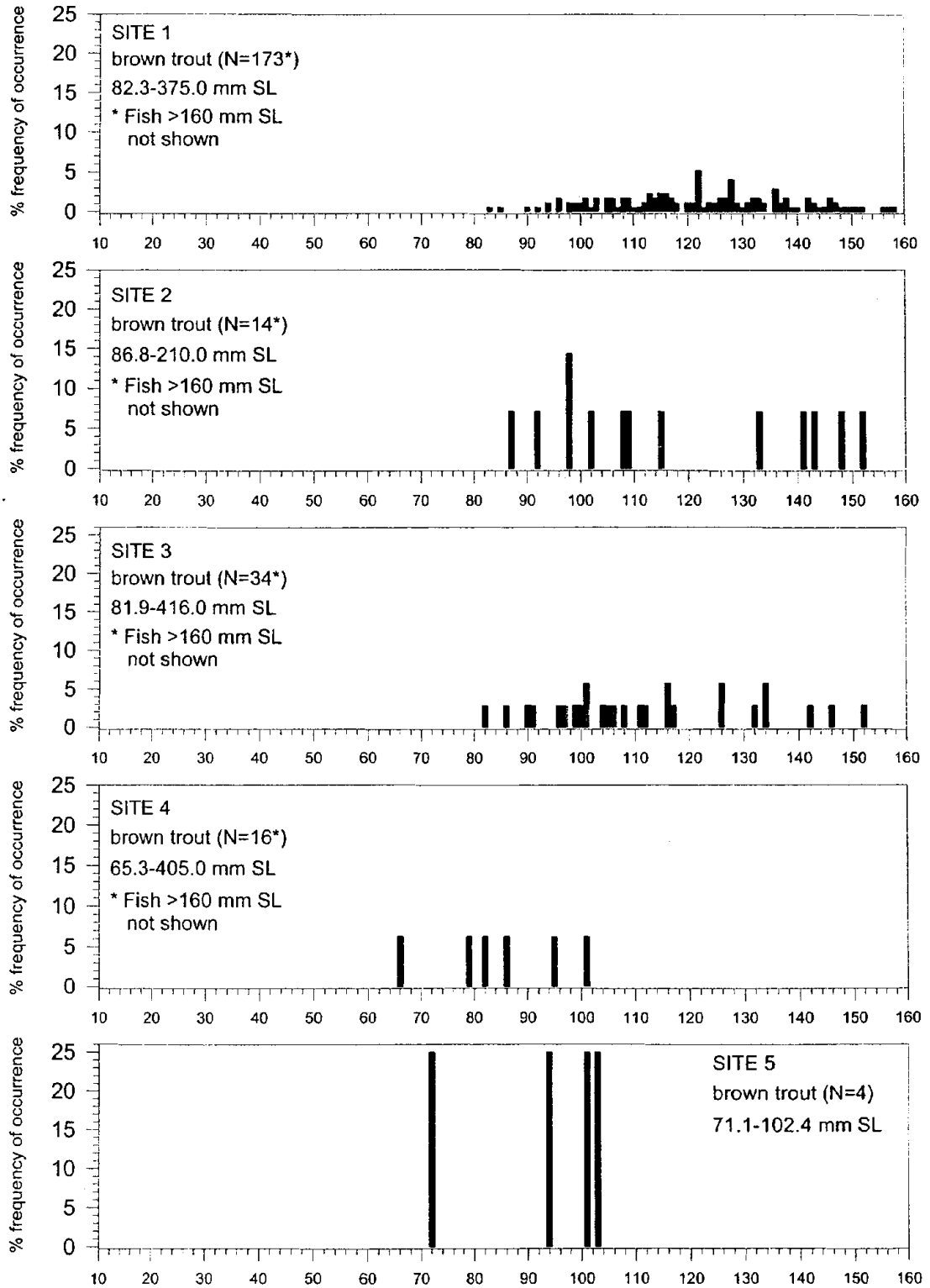

Figure 43. Brown trout length-frequency histograms at five Rio Chama sites, New Mexico, January 1999.

Table 20. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, March 1999.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	-	-	-	-.—
Rio Grande chub	N	24	3	4	8.79
fathead minnow	N	2	5	2	0.73
flathead chub	N	1	6	1	0.37
longnose dace	N	97	2	5	35.53
white sucker	I	22	4	3	8.06
black bullhead	I	1	7	1	0.37
brown trout	I	126	1	5	46.15
TOTAL	273				

[1] N = native; I = introduced

Table 21. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico, March 1999.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	-	-	-
Rio Grande chub	12	1	-	2	9	24
fathead minnow	1	-	1	-	-	2
flathead chub	-	-	-	-	1	1
longnose dace	39	6	11	20	21	97
white sucker	8	-	11	3	-	22
black bullhead	1	-	-	-	-	1
brown trout	77	10	11	23	5	126
TOTAL	138	17	34	48	36	273
# SPECIES	6	3	4	4	4	7
SHOCKING SEC.	1,254	968	1,378	1,267	1,647	6,514
CPUE *	11.00	1.76	2.47	3.79	2.19	4.19

* catch rate per 100 seconds electrofishing

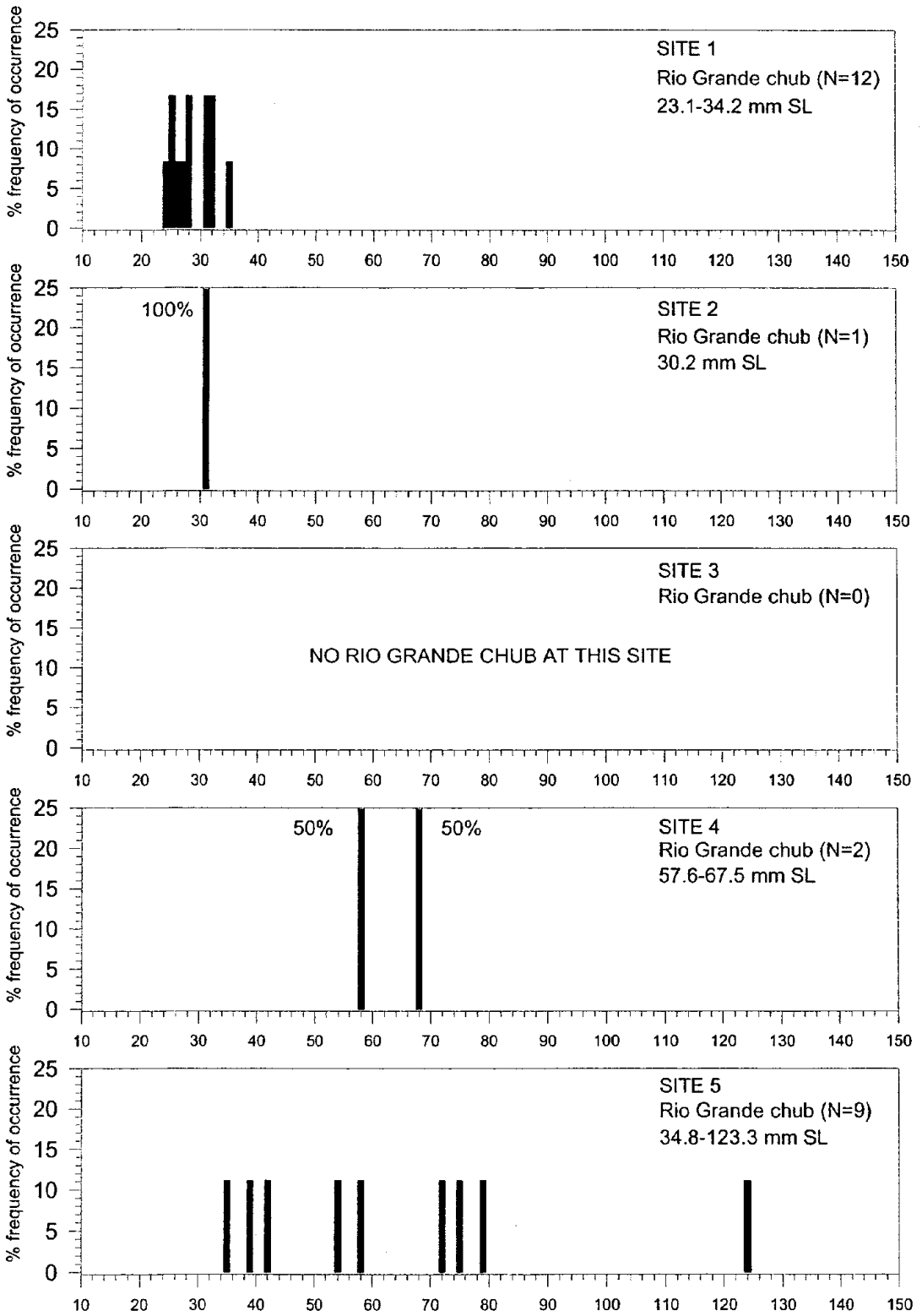

Figure 44. Rio Grande chub length-frequency histograms at five Rio Chama sites, New Mexico, March 1999.

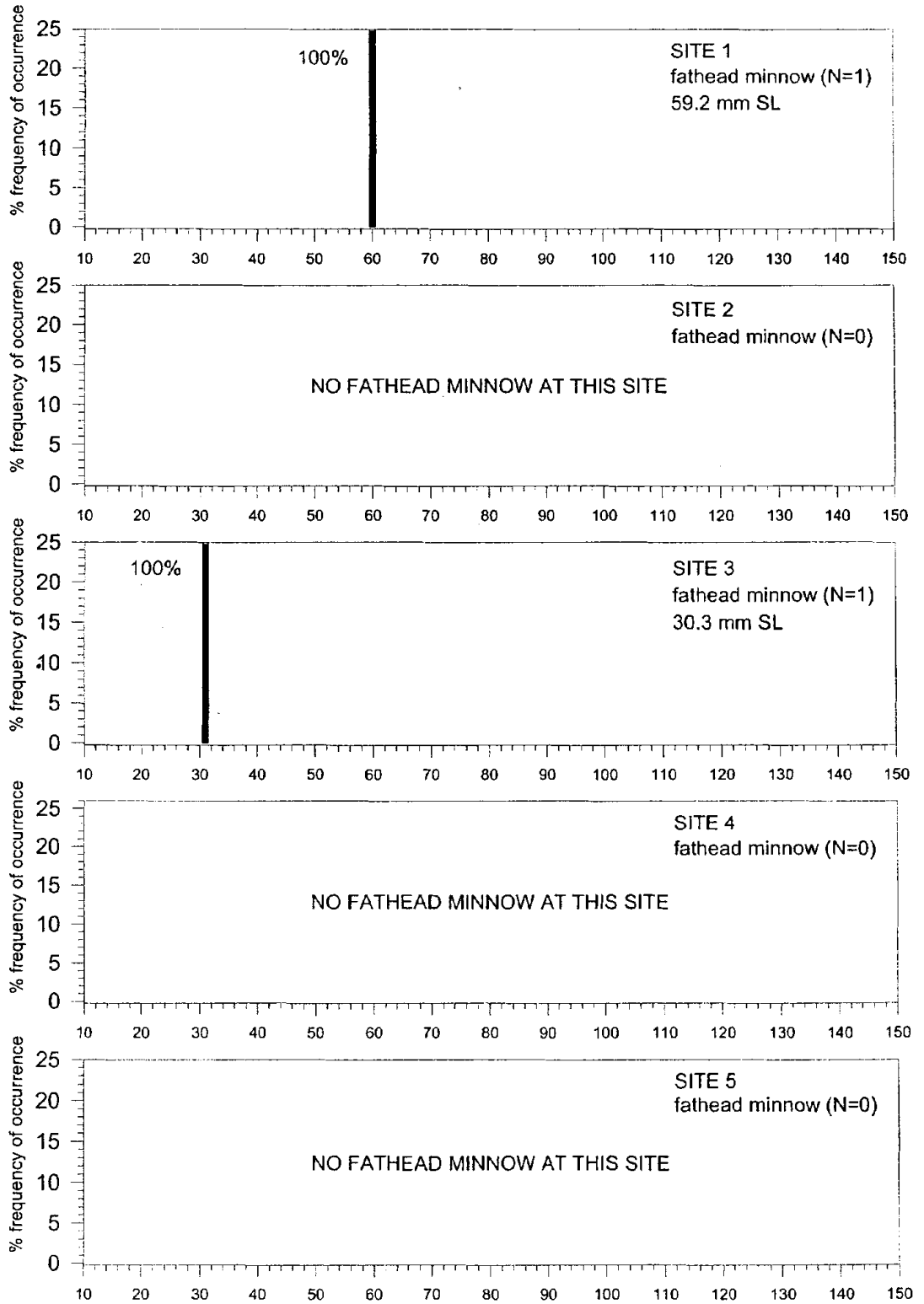

Figure 45. Fathead minnow length-frequency histograms at five Rio Chama sites, New Mexico, March 1999.

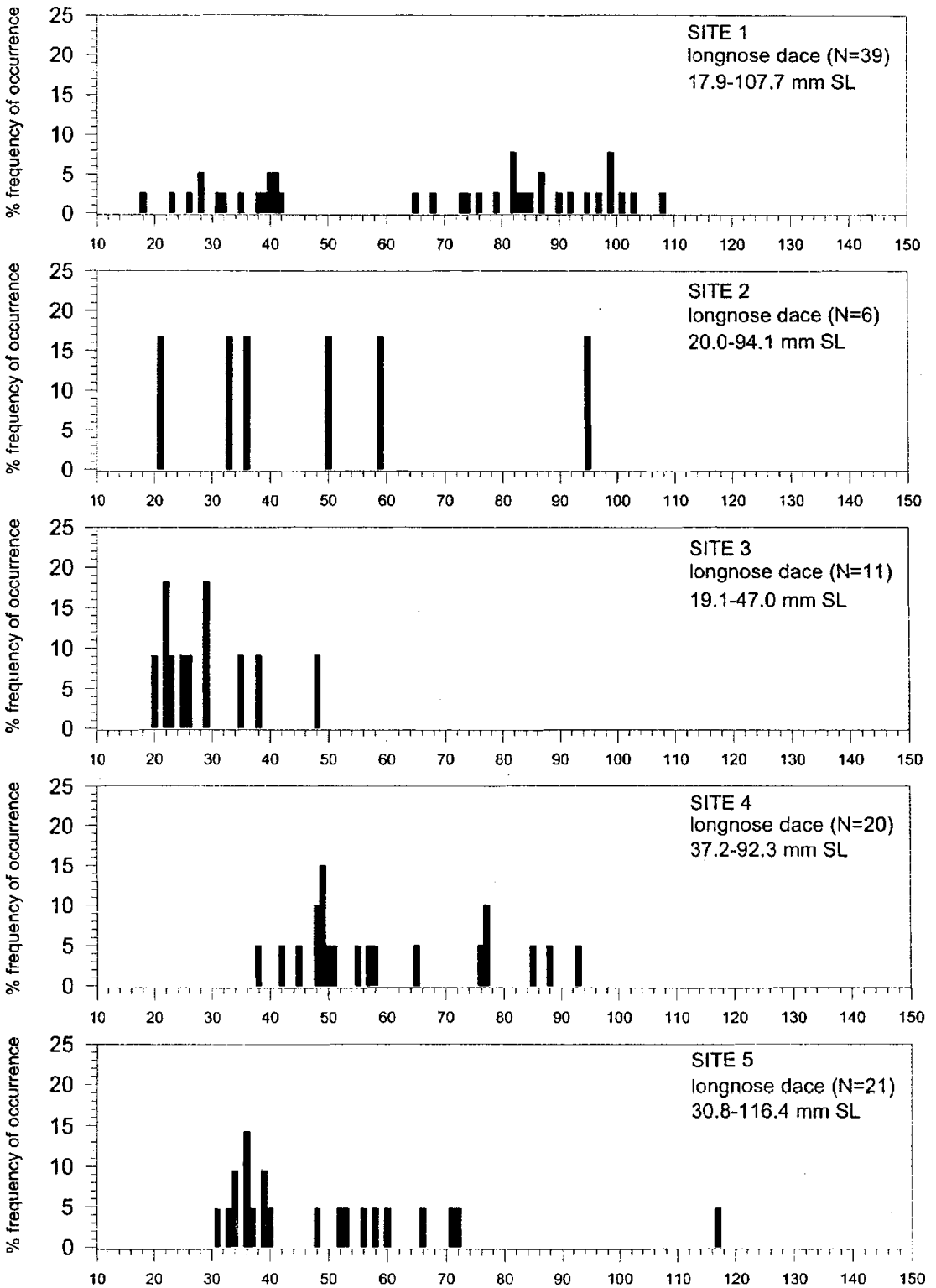

Figure 46. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, March 1999.

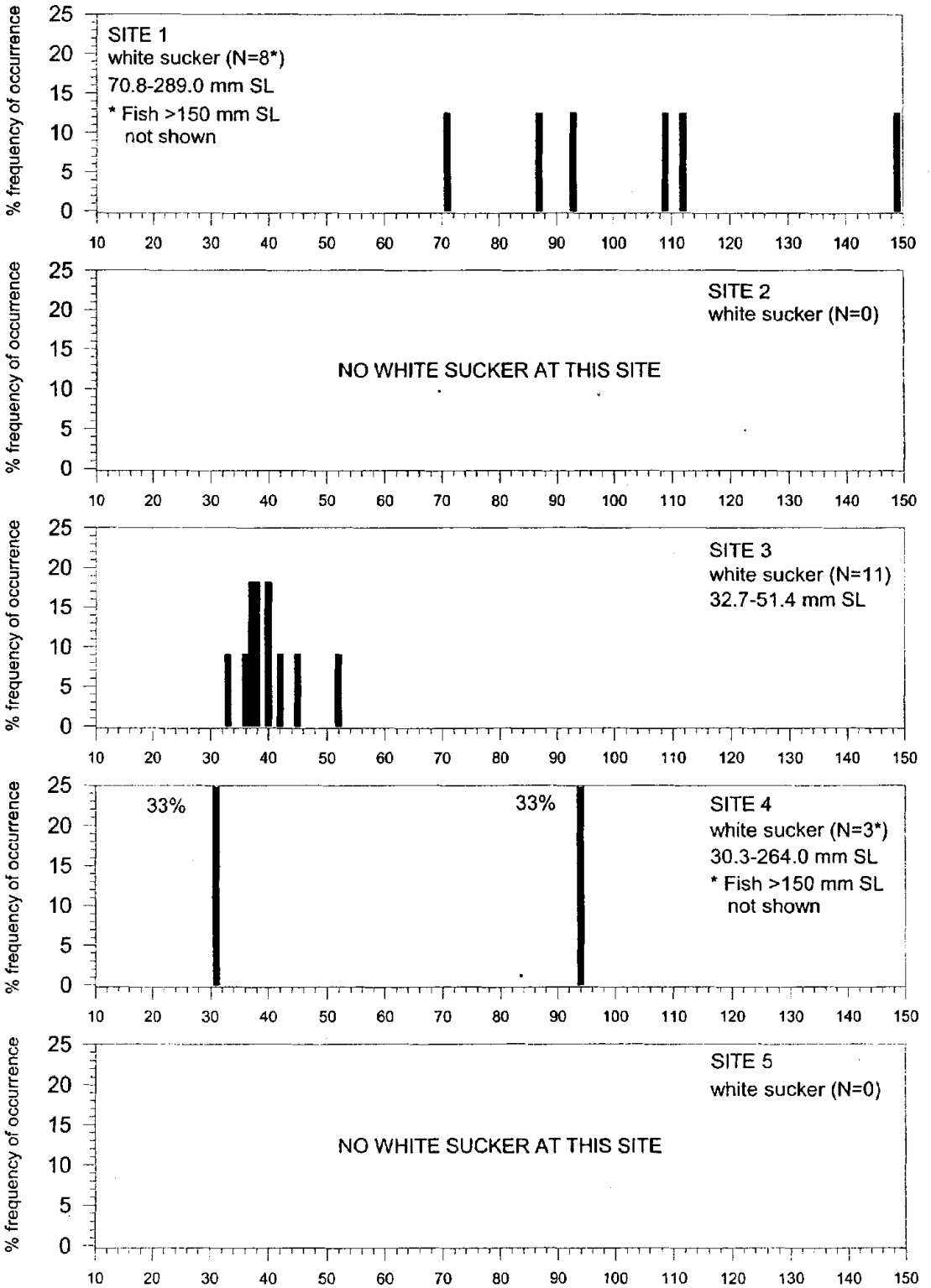

Figure 47. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, March 1999.

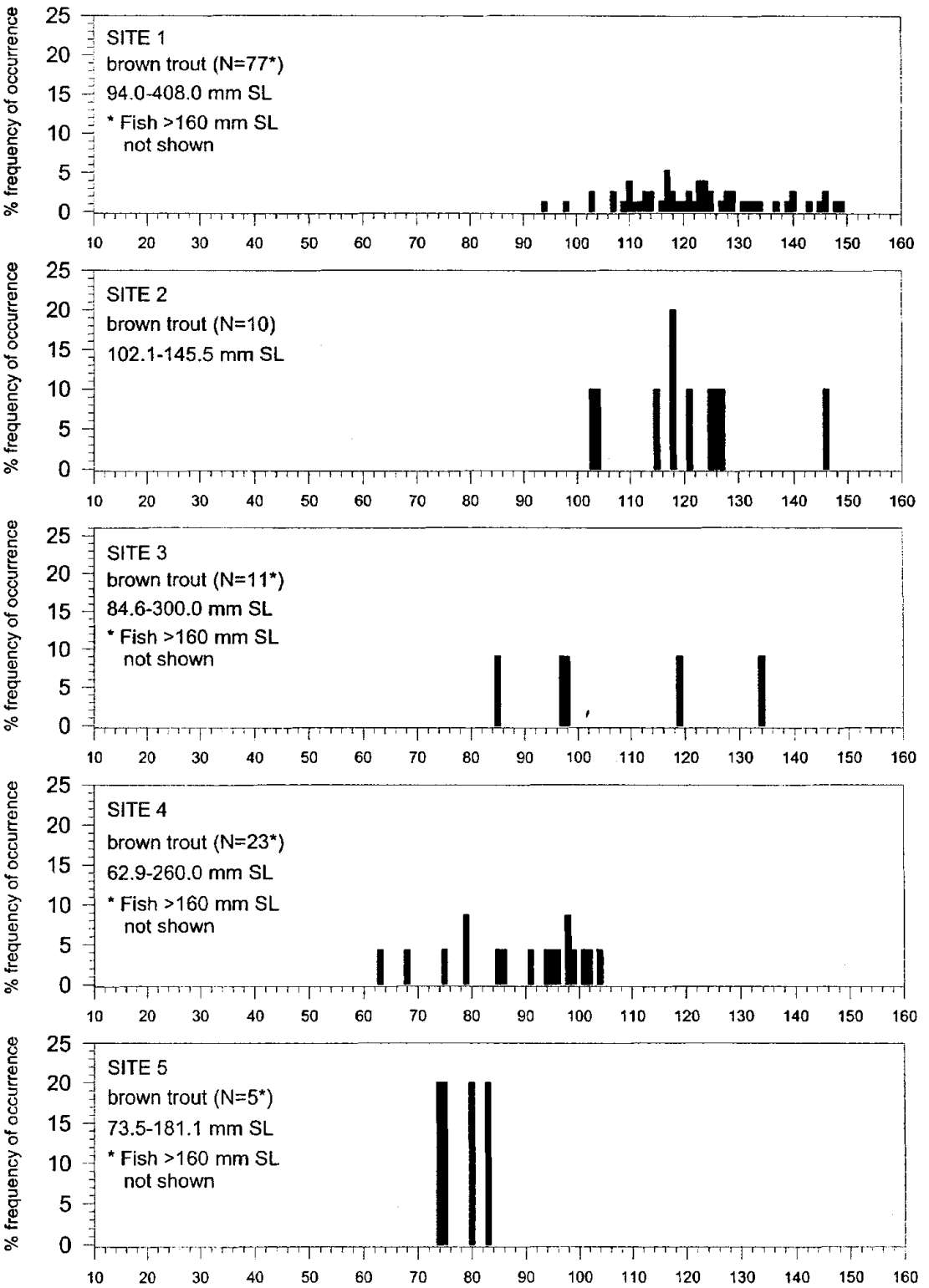

Figure 48. Brown trout length-frequency histograms at five Rio Chama sites, New Mexico, March 1999.

less than during previous sampling efforts (i.e., November 1998, January 1999). The absence of brown trout fry suggested that they had not yet emerged from their redds.

July 1999

The first post-construction sampling trip was conducted on 27 July 1999. This collecting effort was completed during a period when mean daily discharge at Abiquiu Dam was about 250 cfs. Most mid-channel habitats could be accessed although not as easily as during low flow periods (ca. 50 cfs). This sampling effort yielded a very high number of fish (n=822) and catch rates that ranged from 4.34 to 28.16 fish/100 seconds. Water temperatures during this sampling effort were warm (18-22°C) and the temperature of slow velocity habitats increased noticeably during the day. Age-0 fishes comprised the majority of the catch.

Of the nine fish species recorded during this sampling effort, five were native and four were nonnative taxa making it the project's most species-rich sampling effort. Longitudinal patterns of fish abundance were similar to those observed in previous collections. Site 5 produced nine fish species in July 1999, the most species during the tenure of this study. The highest catch rate was at Site 3 (28.16 fish/100 seconds) with catch rates at the other sites ranging from 4.34 to 16.27 fish/100 seconds.

Longnose dace and brown trout were the most commonly collected species in July 1999 (Table 22) comprising (68.3%) of the total catch and occurring at all five sites (Table 23). Brown trout relative abundance was high (n=207) primarily due to the presence of numerous Age-0 individuals. White sucker were also present at all sites but its abundance was only moderate (n=123) compared to the two aforementioned taxa. A single common carp, several river carpsucker (n=5), and western mosquitofish (n=30) also were collected during this sampling effort. Both Rio Grande chub (n=41) and flathead chub (n=59) were also abundant in these collections.

Rio Grande chub were taken at the three most downstream sites but were most common (n=36) at Site 5. Almost all (35 of 36) chub collected at Site 5 were Age-0 fish (Figure 49). Age-1 Rio Grande chub were present at Sites 3, 4, and 5 with a possible Age-2 chub taken at Site 4. Shoreline areas near boulders were the primary habitats occupied by this species.

Only two fathead minnow were collected during July 1999 sampling. Single specimens, likely both Age-1, were taken at Sites 4 and 5 (Figure 50). The lack of fathead minnow from upstream sites and their low abundance is in contrast to several of the previous collecting efforts.

The large number of longnose collected made it possible to more accurately determine age-class structure from length-frequency histograms (Figure 51). Several well-defined cohorts were present in July 1999 collections. The smallest individuals (6-20 mm SL) representing the Age-0 cohort were primarily collected at Site 3. The Age-1 size class was most clearly seen at Sites 1-3 (ca. 30-50 mm SL). It is more likely that the 20-40 mm SL size class from Site 5 represents small Age-1 longnose dace rather than large Age-0 dace. The different representations in relative abundances of age-classes between sites could be caused by differences in habitat availability.

White sucker were present at all sites sampled but were only abundant (n=80) at Site 3. Individuals were collected in shallow low velocity habitats. White sucker < 40 mm SL were considered Age-0 and comprised the majority (82%) of the samples (Figure 52). Low representation of white sucker between 50-150 mm SL precluded determination of Age-1 and older age-classes.

The 1999 brown trout cohort was present at all sites (Figure 53). Age-0 brown trout numerically dominated the July 1999 sample accounting for over 90% of the trout collected. Brown trout of the Age-0 cohort were present in a variety of habitats that included pools, riffles, and runs. A total of eight Age-1 brown trout (1998 cohort), ranging in size from ca. 120 to 160 mm SL, were collected.

Table 22. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, July 1999.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	1	9	1	0.12
Rio Grande chub	N	41	5	3	4.99
fathead minnow	N	2	8	2	0.24
flathead chub	N	59	4	1	7.18
longnose dace	N	354	1	5	43.07
river carpsucker	N	5	7	1	0.61
white sucker	I	123	3	5	14.96
brown trout	I	207	2	5	25.18
western mosquitofish	I	30	6	1	3.65
TOTAL	822				

[1] N = native; I = introduced

Table 23. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico, July 1999.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	-	1	1
Rio Grande chub	-	-	1	4	36	41
fathead minnow	-	-	-	1	1	2
flathead chub	-	-	-	-	59	59
longnose dace	52	96	102	20	84	354
river carpsucker	-	-	-	-	5	5
white sucker	11	10	80	1	21	123
brown trout	96	73	20	15	3	207
western mosquitofish	-	-	-	-	30	30
TOTAL	159	179	203	41	240	822
# SPECIES	3	3	4	5	9	9
SHOCKING SEC.	481	1,615	721	933	1,475	5,225
CPUE *	33.06	11.08	28.16	4.39	16.27	15.73

* catch rate per 100 seconds electrofishing

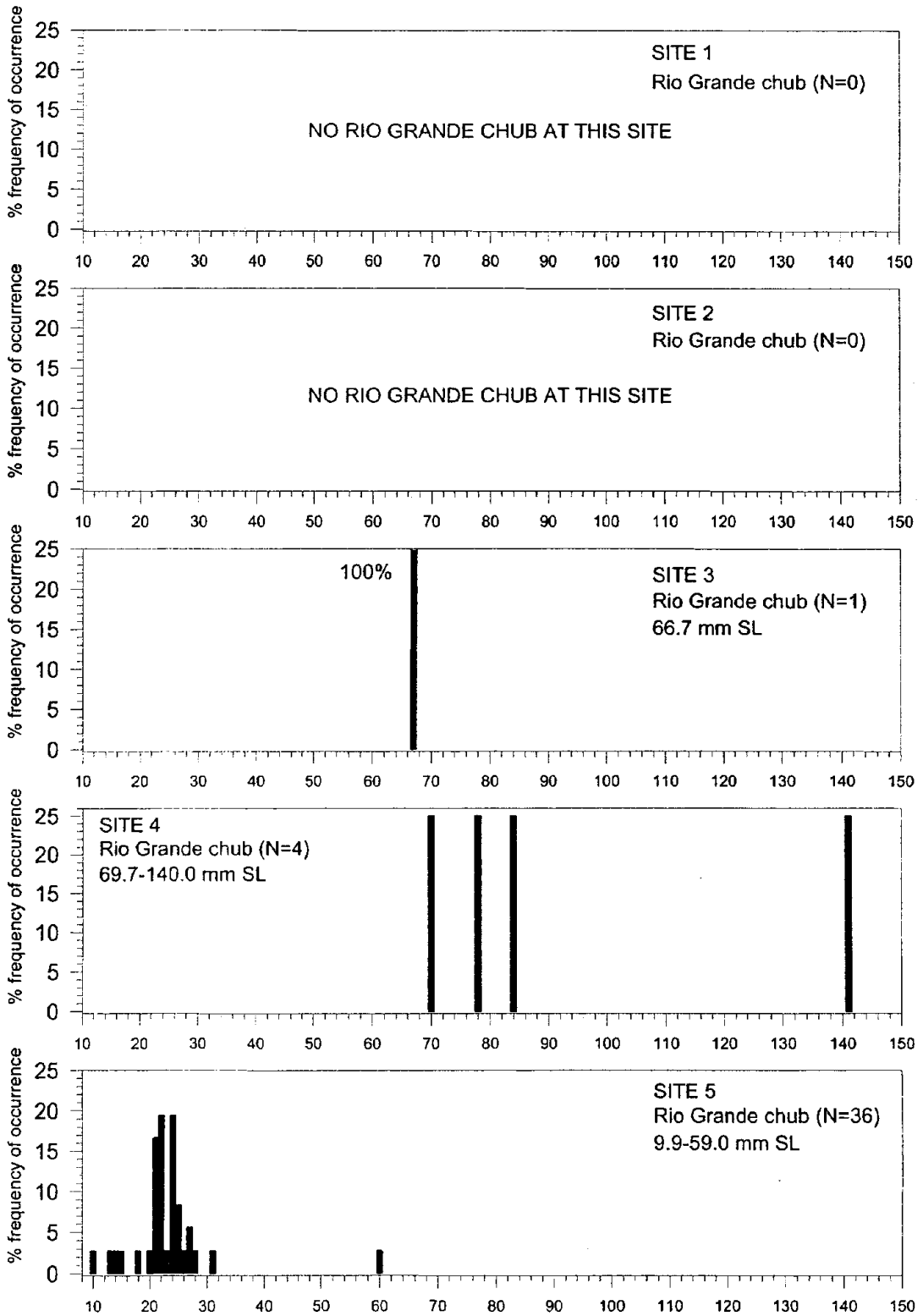

Figure 49. Rio Grande chub length-frequency histograms at five Rio Chama sites, New Mexico, July 1999.

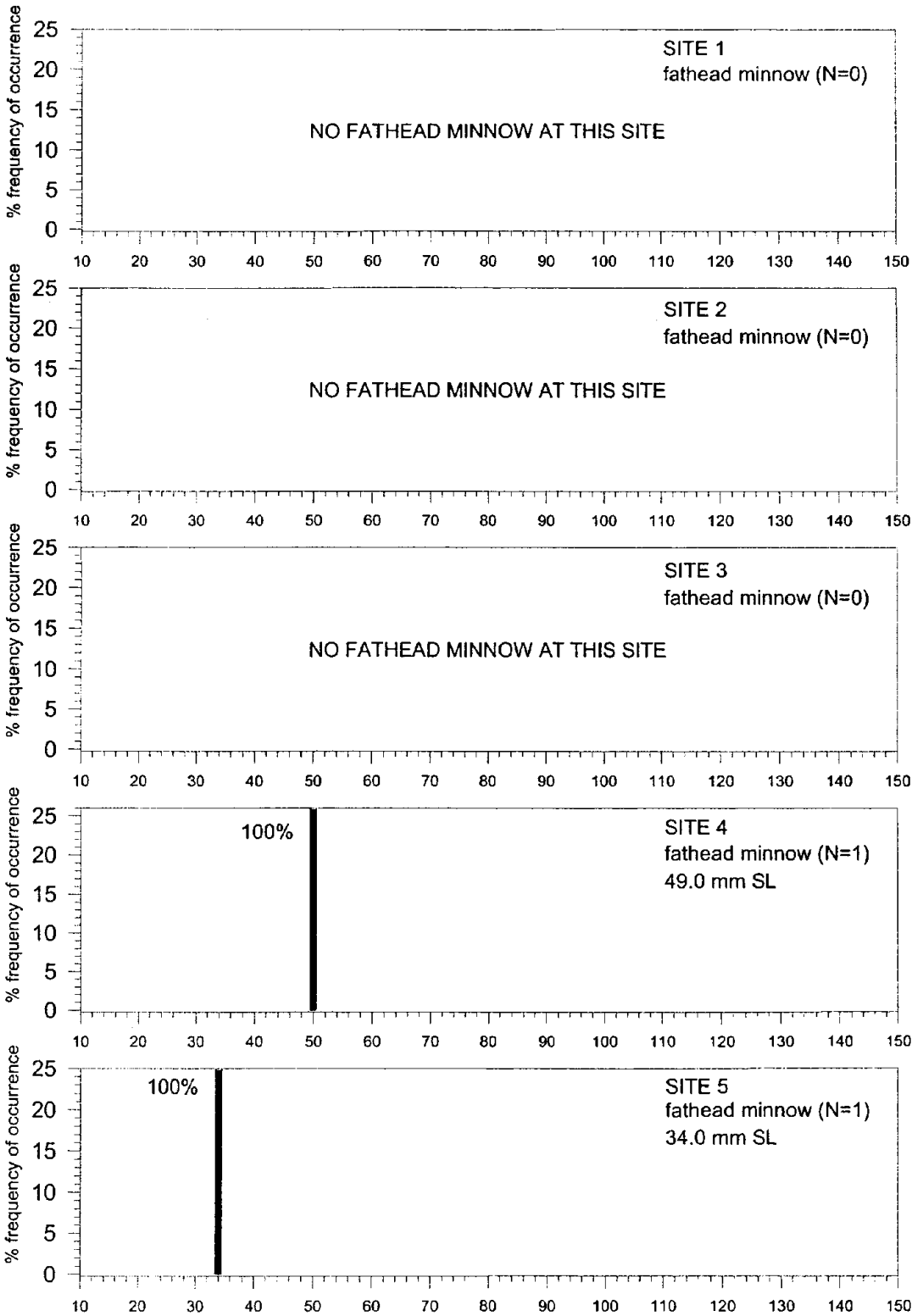

Figure 50. Fathead minnow length-frequency histograms at five Rio Chama sites, New Mexico, July 1999.

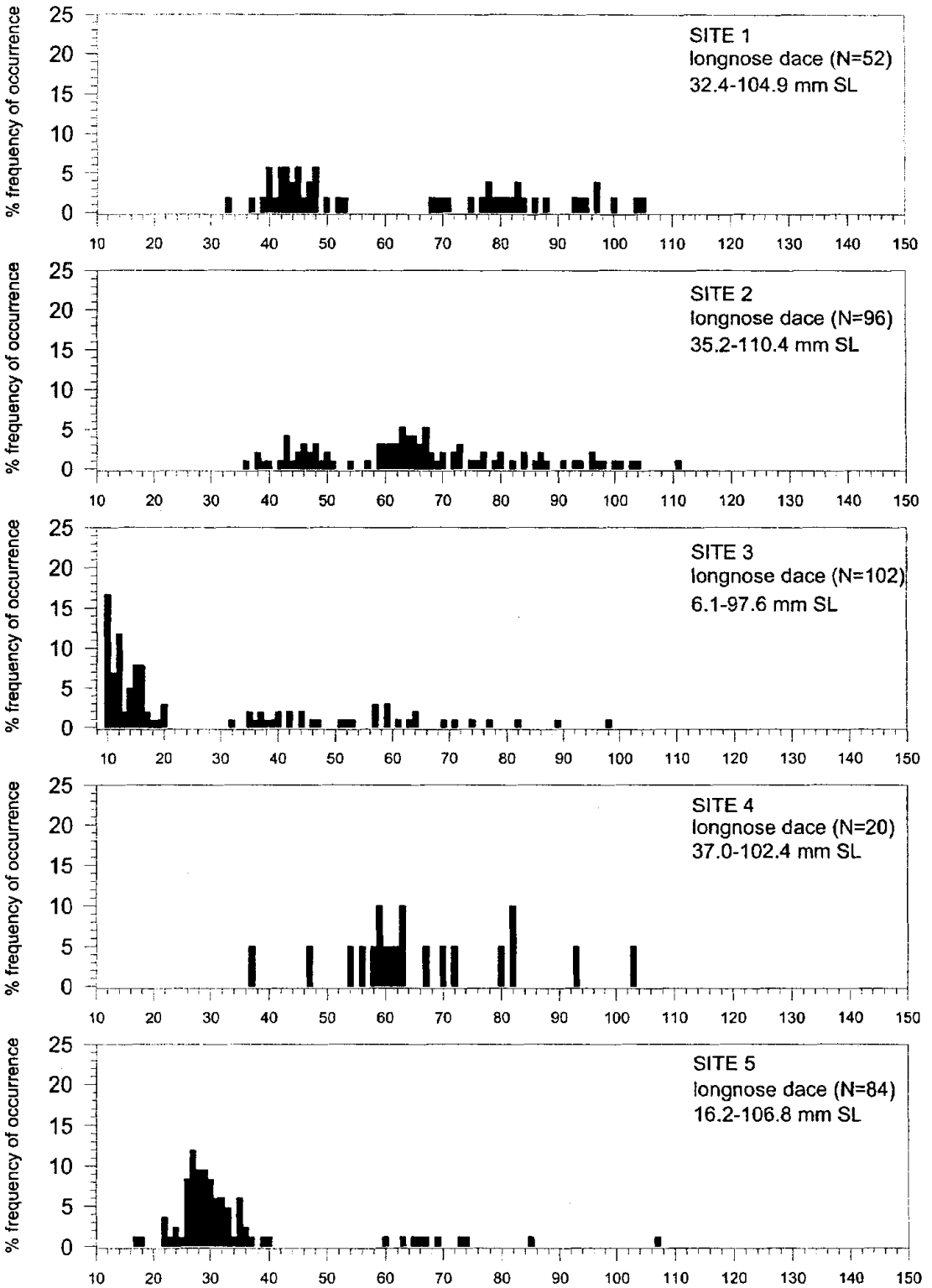

Figure 51. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, July 1999.

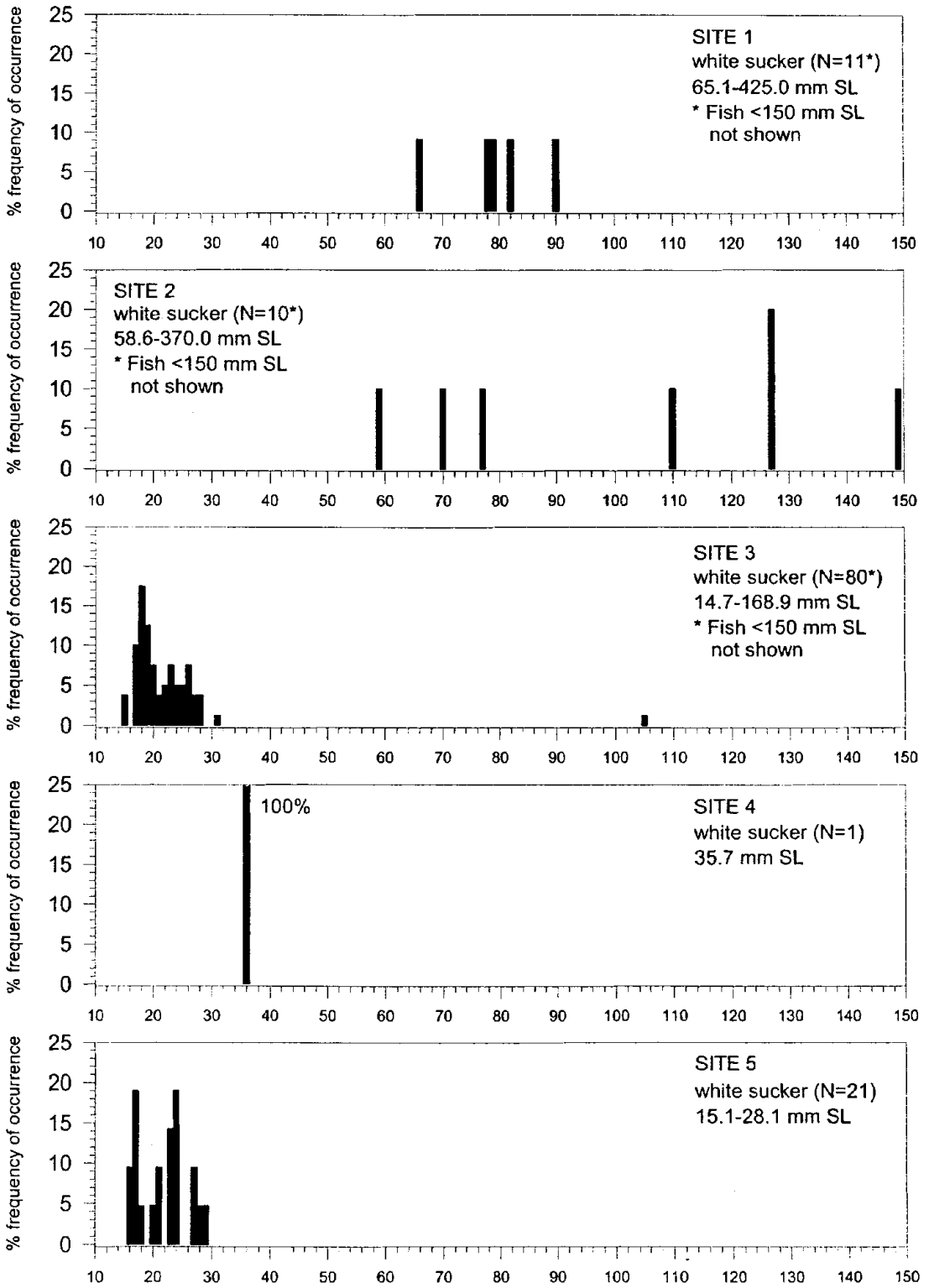

Figure 52. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, July 1999.

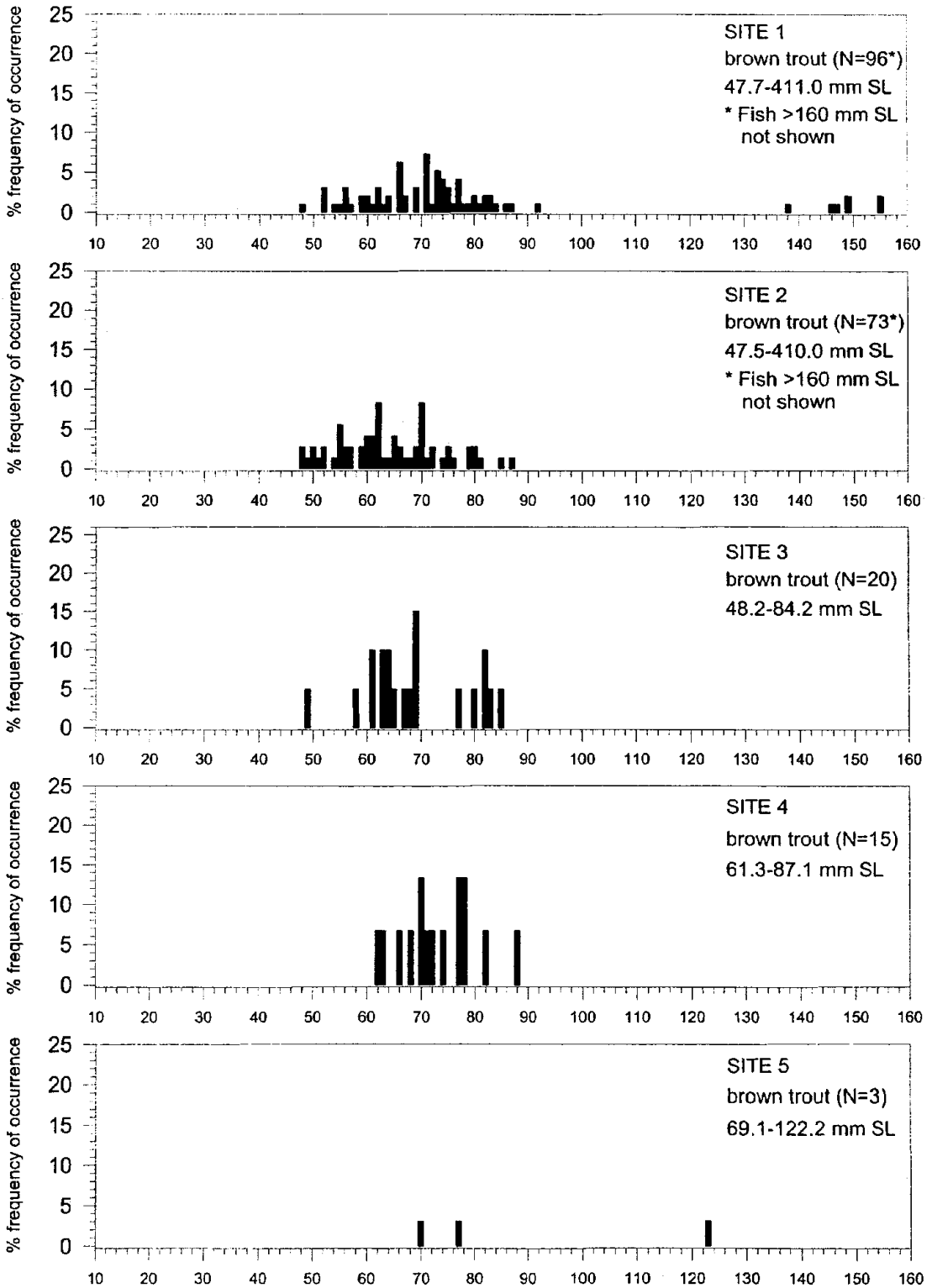

Figure 53. Brown trout length-frequency histograms at five Rio Chama sites, New Mexico, July 1999.

October 1999

The final sampling trip of this study was conducted on 14 October 1999. Flows during this period were relatively low allowing easy access to a wide variety of habitats. A considerable accumulation of silt and sand, perhaps related to low flows punctuated by summer rainstorms, was noted. This sampling effort yielded a high number of fish (n=595) and catch rates from 5.03 to 32.42 fish/100 seconds. Water temperatures were warm during the day (18°C) but cool in the morning (11°C) of this sampling trip.

Four native and two nonnative taxa were recorded during this sampling effort. The highest catch rates were at Sites 1 and 5 (range=31.05-32.42 fish/100 seconds) with catch rates at the other sites ranging from 5.03 to 17.44 fish/100 second. Longnose dace, white sucker, and brown trout numerically dominated the catch (Table 24) and were the only species collected at all five sites (Table 25). Brown trout were relatively common (n=141) and the catch was comprised primarily of Age-0 individuals. Rio Grande chub (n=52) and flathead chub (n=62) were also present in moderate numbers. Only four fathead minnow were collected during this final sampling trip.

The majority (88%) of Rio Grande chub collected during October 1999 were taken, collectively, at Sites 3 and 5. A single Rio Grande chub was collected at Site 2 and five were taken at Sites 4. Chub occurred primarily in side channel shoreline habitats near debris. Individuals <45 mm SL appeared to be Age-0 Rio Grande chub (Figure 54) while the remainder of the catch was distributed throughout several undetermined age-classes. Two small individuals (<15 mm SL) were likely the result of an autumn Rio Grande chub spawn. The 170.1 mm SL Rio Grande chub taken at Site 3 is one of the largest recently reported from the Rio Chama.

Only four fathead minnow were taken during this collecting trip. A single Age-1 fathead minnow was collected at Sites 1 and 3, and two Age-2 fathead minnow were collected at Site 3 (Figure 55). This species was absent from collections from Sites 2, 4, and 5.

Several age-classes of longnose dace could be determined from the specimens collected at Sites 1-5 (Figure 56). The largest collection (n=109), from Site 1, provided the best length-frequency histogram for this sampling trip. Few Age-0 longnose dace were collected at Site 1 but the majority of individuals present at Sites 3 and 5 were members of the 1999 cohort (Age-0). There was only one size class present at Site 5. Longnose dace >90 mm SL were probably Age-3+. Different size-classes of longnose dace were noted occupying different habitats.

White sucker were present at all sites but abundant (n=107) only at Site 3. This sampling locality consistently yielded large numbers of white sucker throughout this study. Age-0 individuals were collected at all sites but Site 3 was comprised of almost all Age-0 individuals (Figure 57).

Age-0 brown trout were represented at all sites. This cohort was present in areas of moderate current and often associated with cobble substrate. Most individuals captured were Age-0 but a few Age-1+ brown trout were at Sites 1 and 2 (Figure 58). The number of brown trout > 200 mm SL was notably lower than during sampling trips in autumn of 1998.

Comparison of Catch per unit effort (CPUE) by Species and Sampling Effort

Cumulative catch rate per species per sampling trip was determined and used to examine temporal changes in the relative abundance of components of the ichthyofaunal community of the Rio Chama (Figure 59). Species only rarely collected (i.e., common carp, river carpsucker, black bullhead, rainbow trout, western mosquitofish, and smallmouth bass) were not included in the comparison. In addition to being only occasionally collected, all of the aforementioned species except common carp were taken from a single sampling site. Flathead chub were moderately abundant but present only at

Table 24. Summary of ichthyofaunal composition and collection data for collections at five Rio Chama sites, New Mexico, October 1999.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
common carp	I	-	-	-	-
Rio Grande chub	N	52	5	4	8.74
fathead minnow	N	4	6	2	0.67
flathead chub	N	62	4	1	10.42
longnose dace	N	194	1	5	32.61
river carpsucker	N	-	-	-	-
white sucker	I	142	2	5	23.87
brown trout	I	141	3	5	23.70
western mosquitofish	I	-	-	-	-
TOTAL	595				

[1] N = native; I = introduced

Table 25. Summary of ichthyofaunal composition at each of the five Rio Chama sites, New Mexico, October 1999.

	COLLECTION LOCALITIES					
	NUMBER OF SPECIMENS PER COLLECTION SITE					
SPECIES	1	2	3	4	5	Total
common carp	-	-	-	-	-	-
Rio Grande chub	-	1	26	5	20	52
fathead minnow	1	-	3	-	-	4
flathead chub	-	-	-	-	62	62
longnose dace	109	31	25	13	16	194
river carpsucker	-	-	-	-	-	-
white sucker	14	8	107	7	6	142
brown trout	80	25	20	14	2	141
western mosquitofish	-	-	-	-	-	-
TOTAL	204	65	181	39	106	595
# SPECIES	4	4	5	4	5	6
SHOCKING SEC.	657	1,226	1,038	775	327	4,023
CPUE *	31.05	5.30	17.44	5.03	32.42	14.79

* catch rate per 100 seconds electrofishing

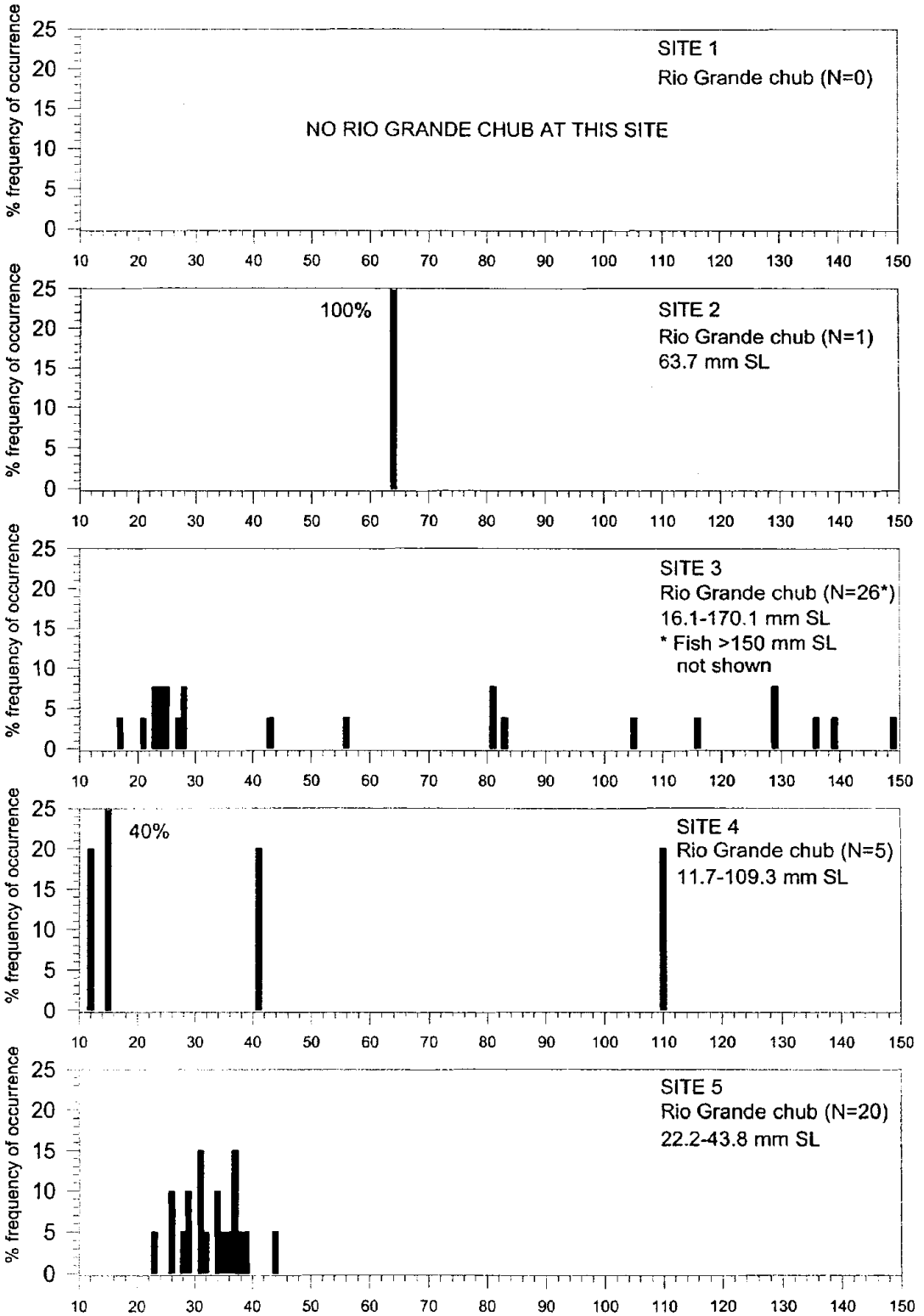

Figure 54. Rio Grande chub length-frequency histograms at five Rio Chama sites, New Mexico, October 1999.

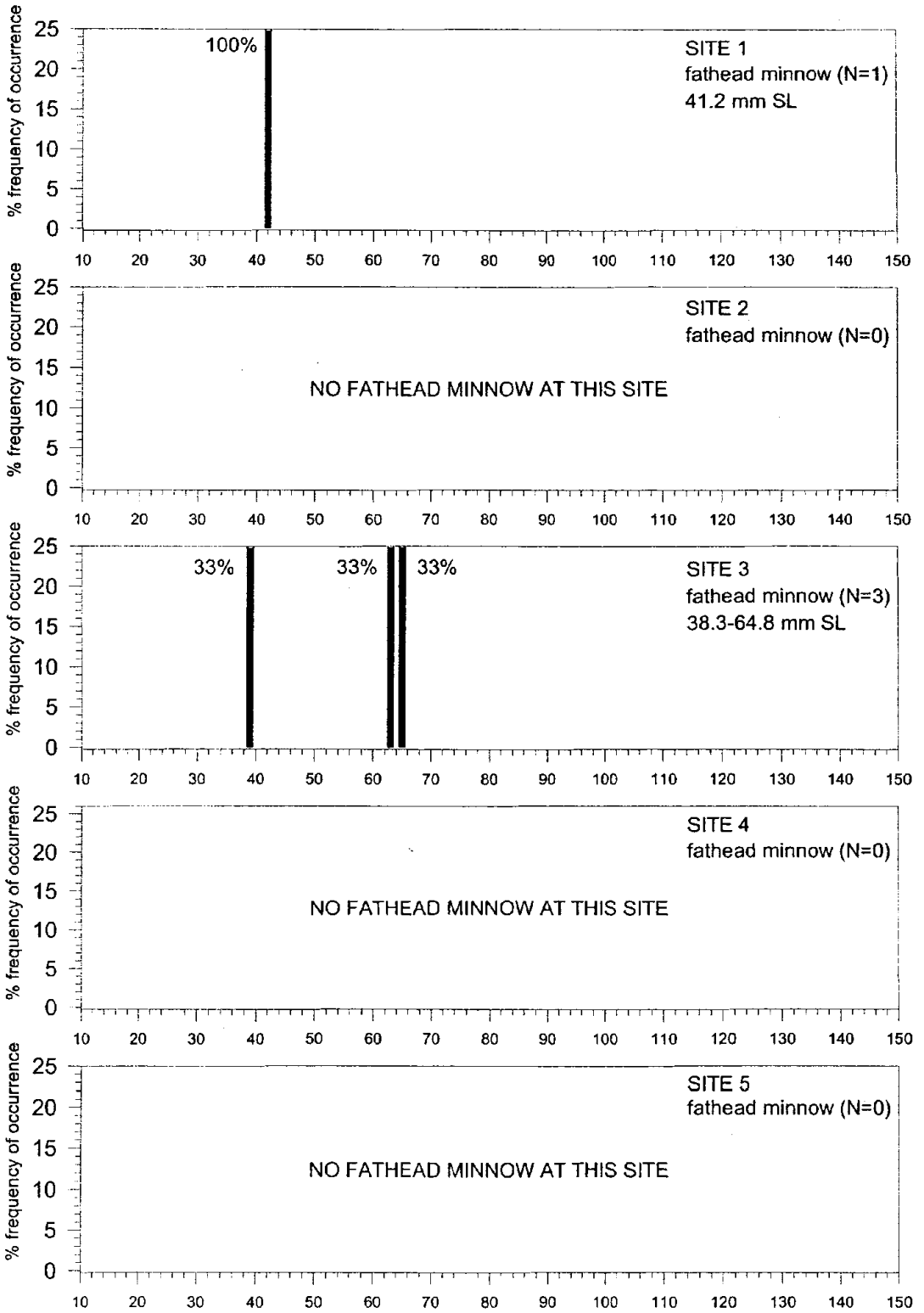

Figure 55. Fathead minnow length-frequency histograms at five Rio Chama sites, New Mexico, October 1999.

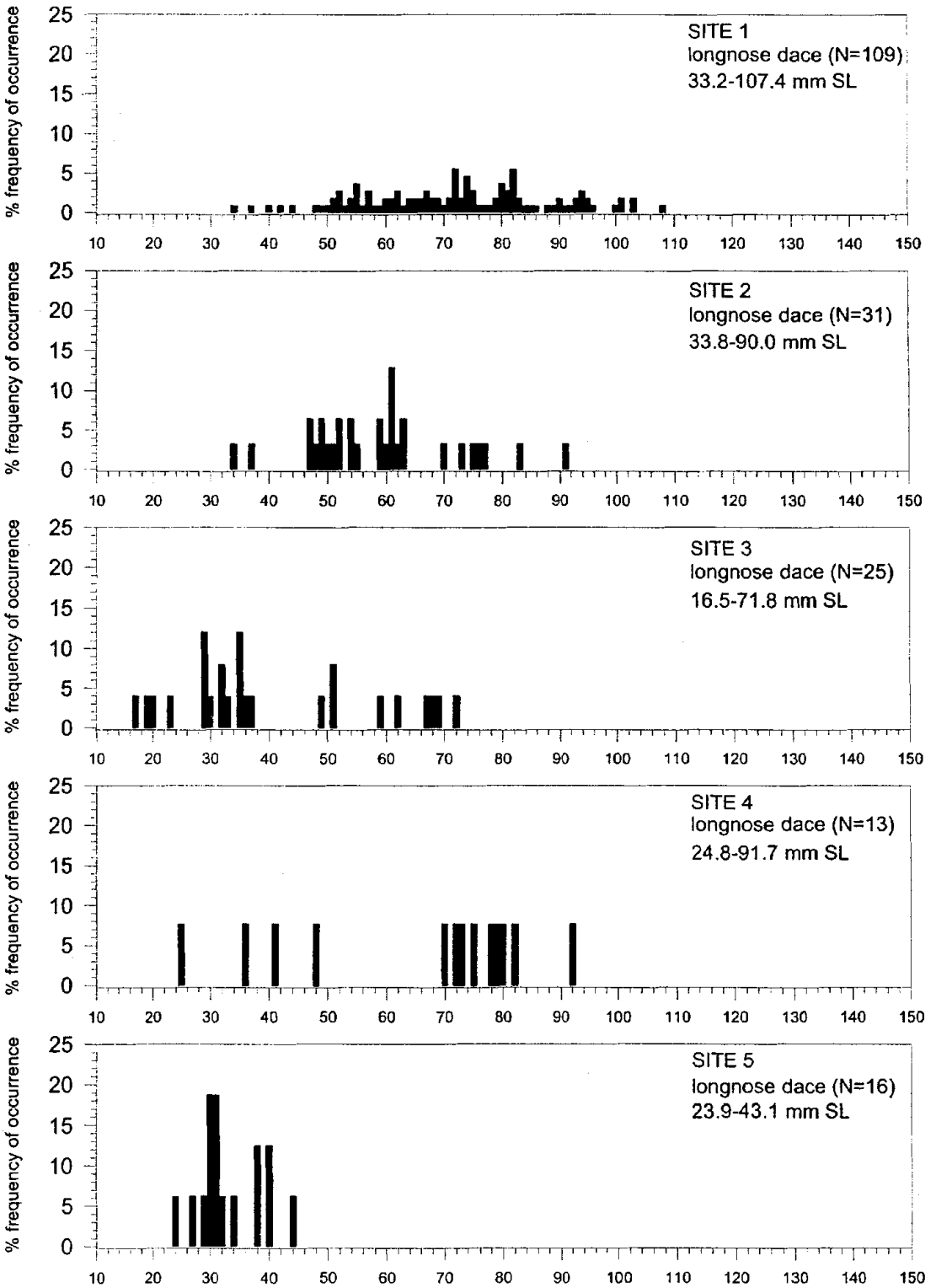

Figure 56. Longnose dace length-frequency histograms at five Rio Chama sites, New Mexico, October 1999.

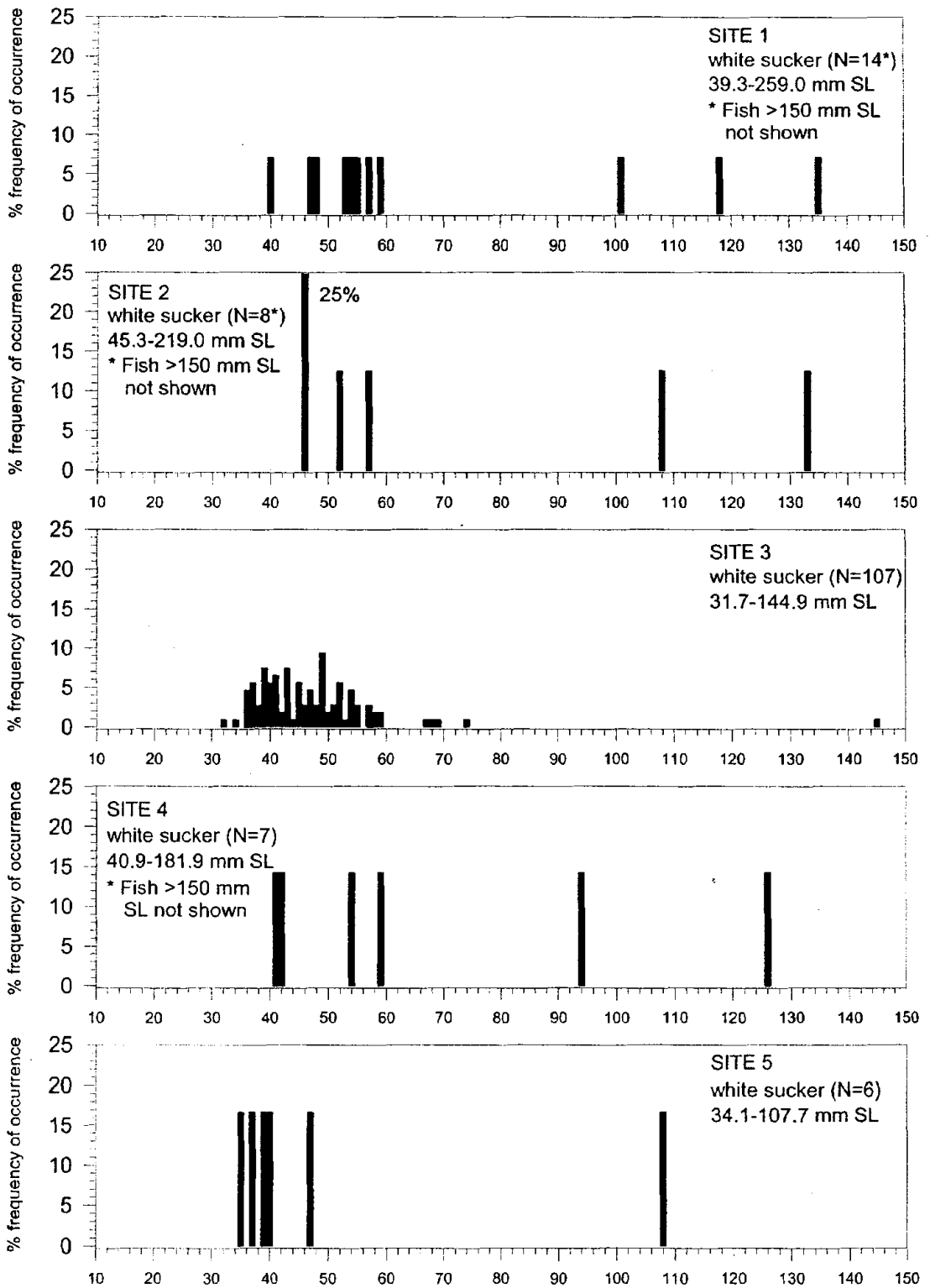

Figure 57. White sucker length-frequency histograms at five Rio Chama sites, New Mexico, October 1999.

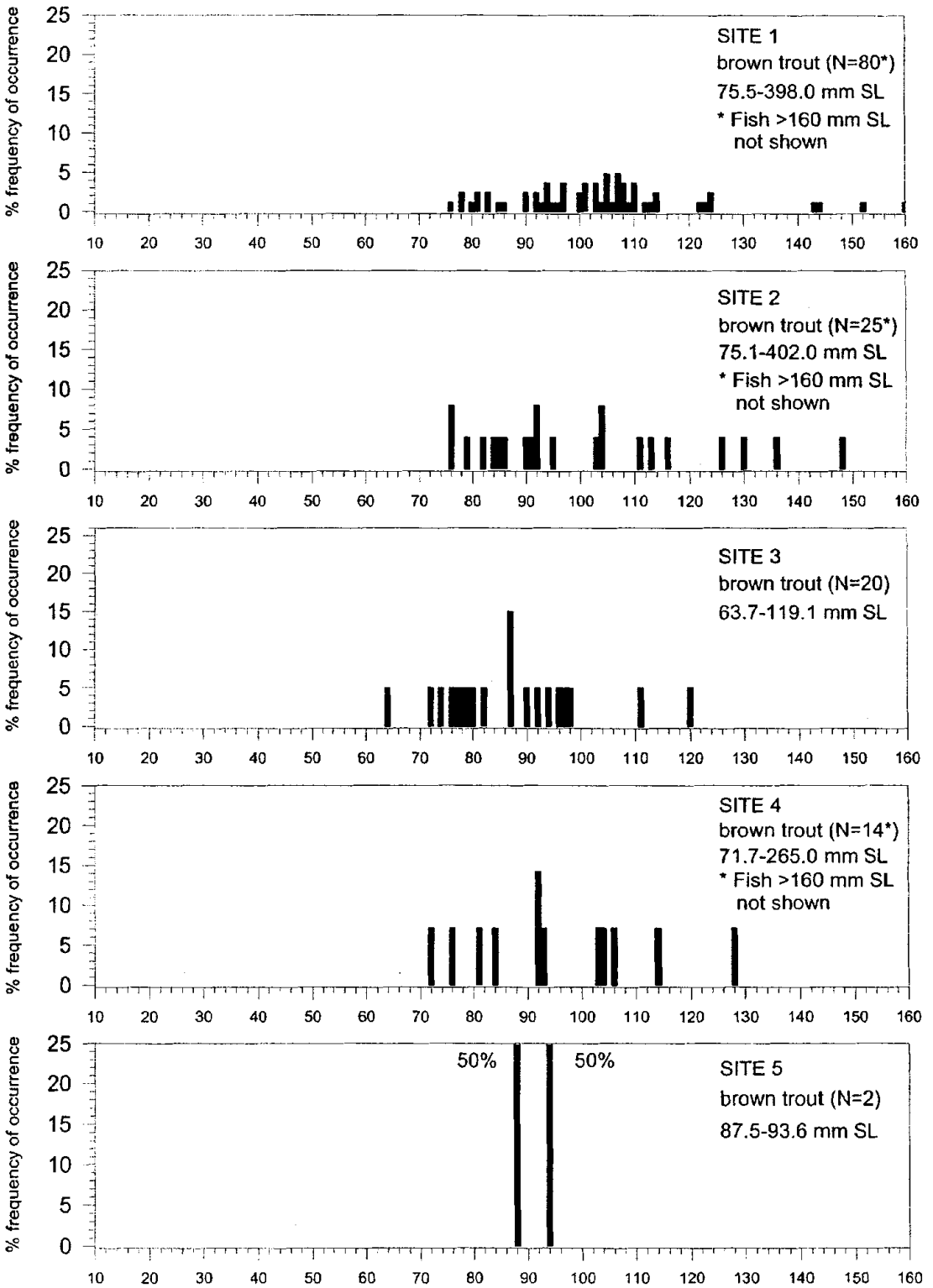

Figure 58. Brown trout length-frequency histograms at five Rio Chama sites, New Mexico, October 1999.

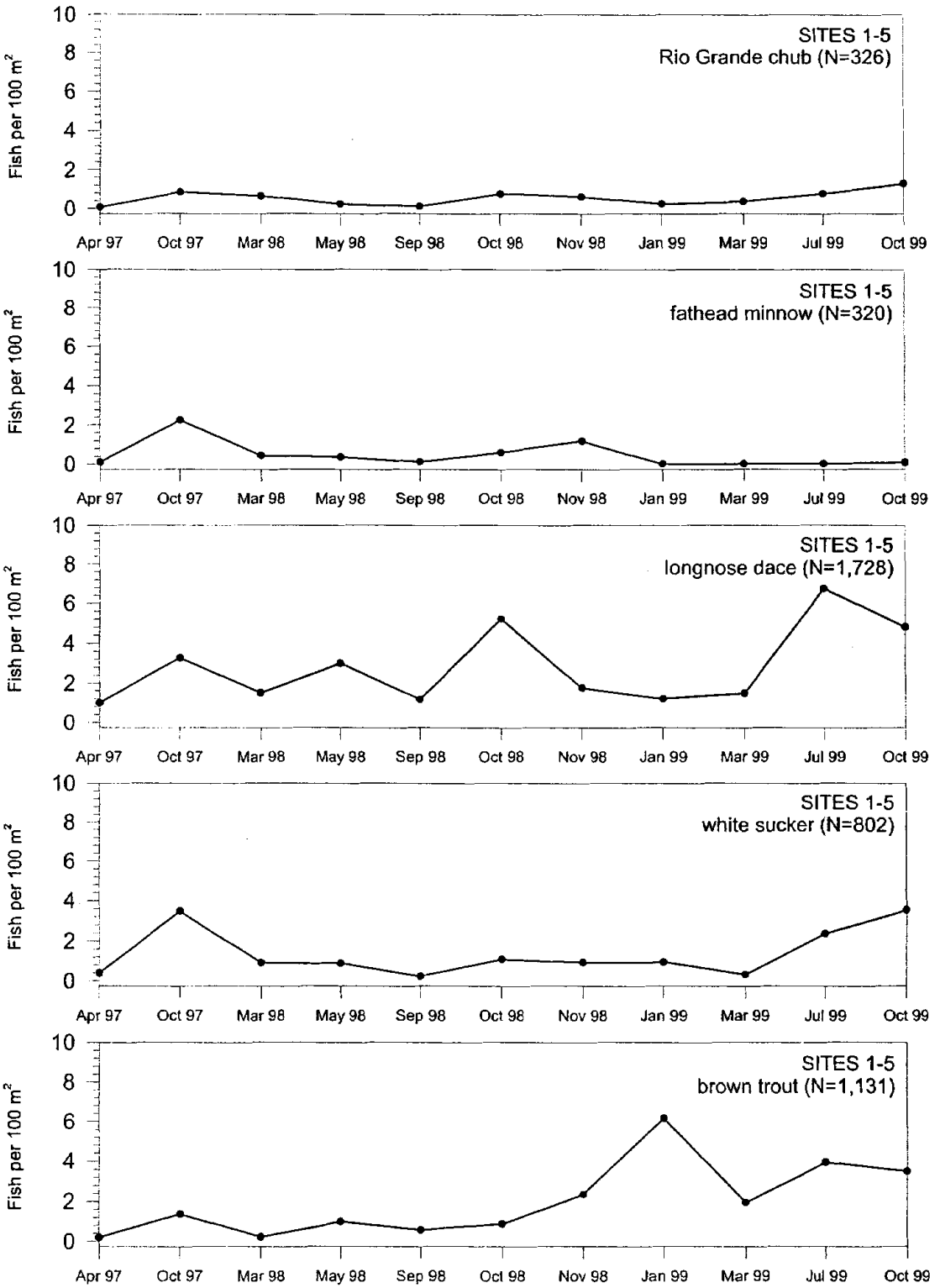

Figure 59. Summary of CPUE by species and sampling effort for Sites 1-5, Rio Chama, New Mexico, April 1997-October 1999.

Site 5. The catch rate of this taxon increased annually following spawning but is not shown in the CPUE analysis because there were no pronounced temporal trends.

The relative abundance of Rio Grande chub collected during the tenure of the study did not vary notably between trips. The CPUE for Rio Grande chub was generally highest in the autumn and decreased during winter sampling. This pattern corresponds to the presumed spring-autumn spawning cycle of this species. Rio Grande chub occurred throughout the study area but the highest catch rates were recorded at downstream sampling localities.

Catch rate for fathead minnow was greatest during autumn of 1997 and 1998. The number of fathead minnow taken during autumn sampling declined from 1997 to 1998 and dropped precipitously from November 1998 to January 1999. Catch rate of this species remained low throughout 1999. The decreases in fathead minnow catch rates were primarily a result of lowered catch in the downstream reaches, although the number of fathead minnow declined at nearly all sites. The occasional collection of large number of Age-0 individuals strongly influence fluctuations in catch rates.

Longnose dace catch rates exhibited a seasonal pattern characterized by increased values during autumn. October (1997, 1998, 1999) catch rates for longnose dace were relatively similar throughout this study. The July 1999 collection contained a large number of longnose dace, primarily Age-0, and produced the greatest catch rate for this species. It is important to note this was also the only mid-summer collection.

White sucker catch rates were slightly lower in March 1999 than in March 1998. Similarly, the October 1997 relative abundance of white sucker was higher than that recorded in October 1998. This species generally achieved its highest relative abundances autumn.

The relative abundance of brown trout was moderately low during 1997 and 1998. The apparent increase of brown trout during winter of 1998-1999 was the result of reduced flows that concentrated existing populations and allowed more efficient sampling of deep and fast flowing water, the principal habitat for brown trout. The low discharge during 1999 contributed to the increased catch of brown trout throughout the year.

Summary of Low Flows

Low flows in the Rio Chama (downstream of Abiquiu Dam) were present for an extended duration during this construction project. Daily flow, as measured at the U.S. Geological Survey (USGS) Rio Chama below Abiquiu Dam Gauge (#08287000), declined from 339 cfs on 3 November 1998 to 51 cfs on 5 November 1998 (Figure 3). Discharge in the Rio Chama remained low (i.e., less than 75 cfs) until 29 March 1999. Mean discharge was 46.3 cfs between 5 November 1998 and 18 December 1998 with extended periods when mean daily flow was <40 cfs (i.e., 12-15 November 1998 and 1-18 December 1998). During the aforementioned low discharge periods, mean daily flow at the USGS Rio Chama near Chamita Gauge (#08290000) was as low as 68 cfs.

Hourly discharge measures from the Rio Chama below Abiquiu Dam Gauge were examined and exceptionally low flow intervals noted. The periods of lowest flow occurred between 16-18 November 1998 and on 4 December 1998. On 16 November 1998 discharge at 1000 hours was only 6.1 cfs. Flow on 17 November 1998 declined to 30 cfs (for 6 hours) and was as low as 7.2 cfs (at 1400 hours). A similar event occurred on 18 November 1998, during a fish sampling effort, and flow was observed declining from 60.1 to 14.2 cfs in only two hours. The last large reduction in discharge occurred on 4 December 1998 when flow was 14.5 cfs at 1000 hours. Discharge from Abiquiu Dam was relatively stable from 19 December 1998 to 28 March 1999.

Daily water temperatures (mean, minimum, and maximum) were taken during the period of low flow from three sites within the study area (Figures 60, 61, and 62). Mean daily water

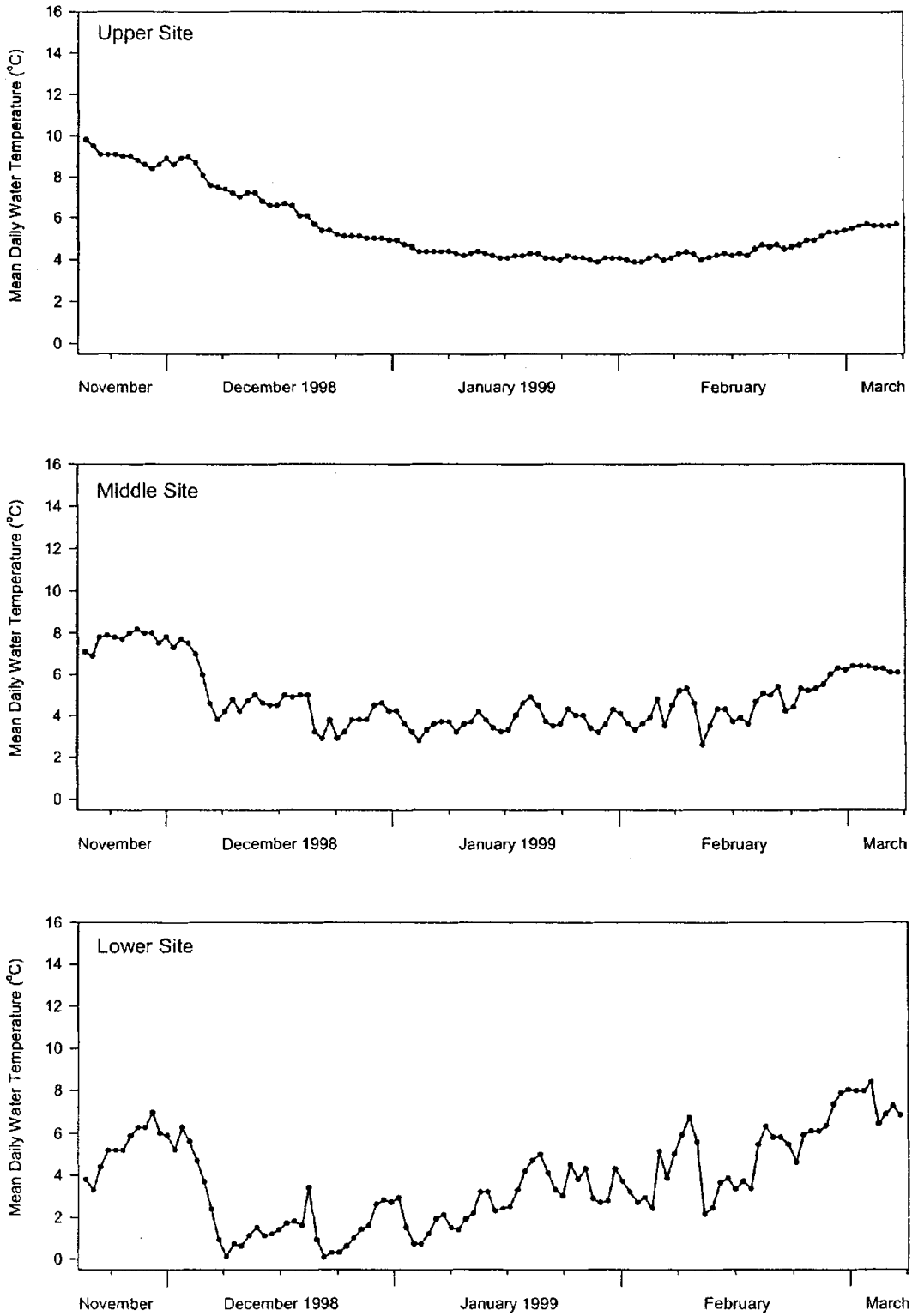

Figure 60. Mean daily water temperature at three sites in the Rio Chama, New Mexico, 20 November 1998 - 9 March 1999.

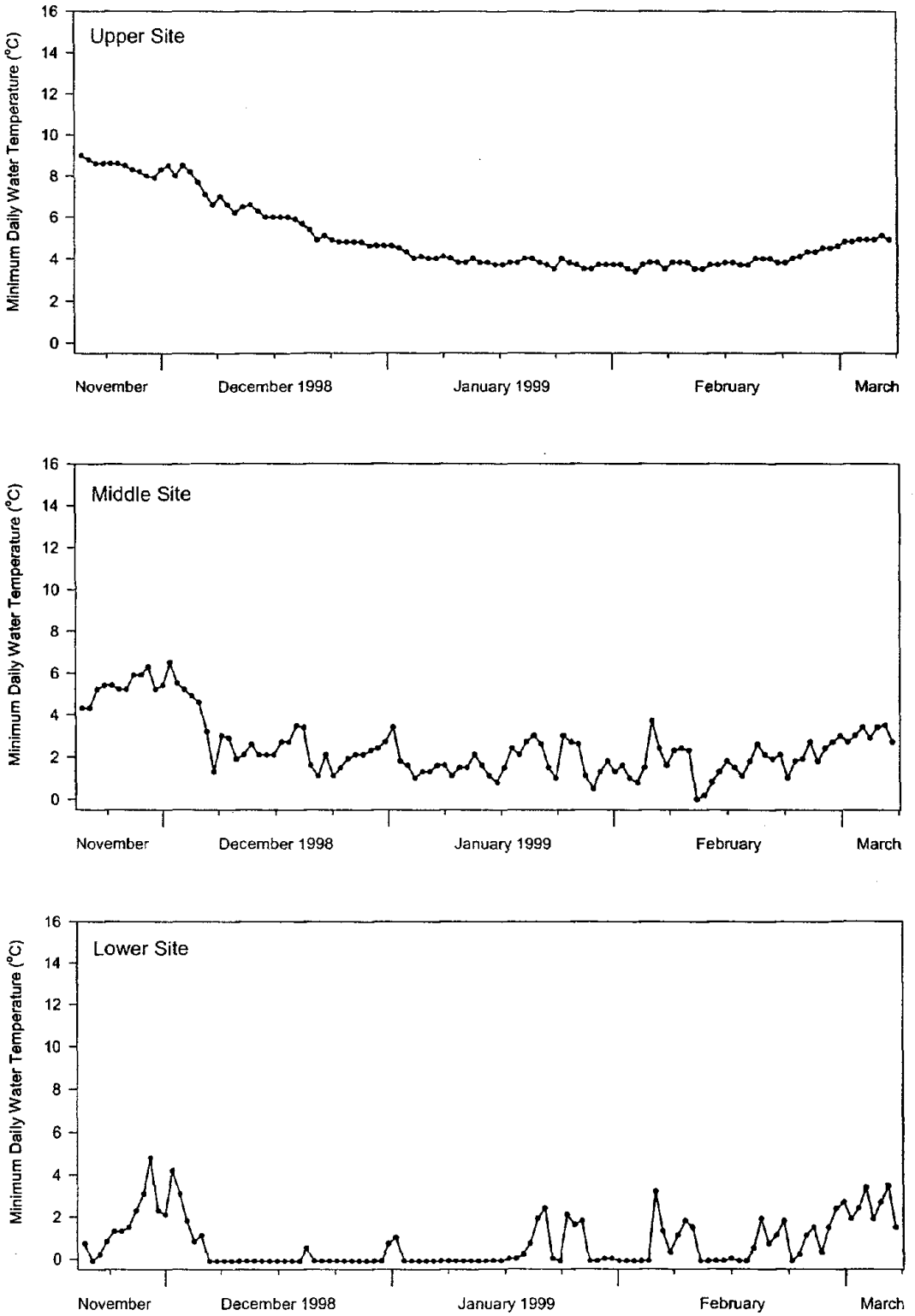

Figure 61. Minimum daily water temperature at three sites in the Rio Chama, New Mexico, 20 November 1998 - 9 March 1999.

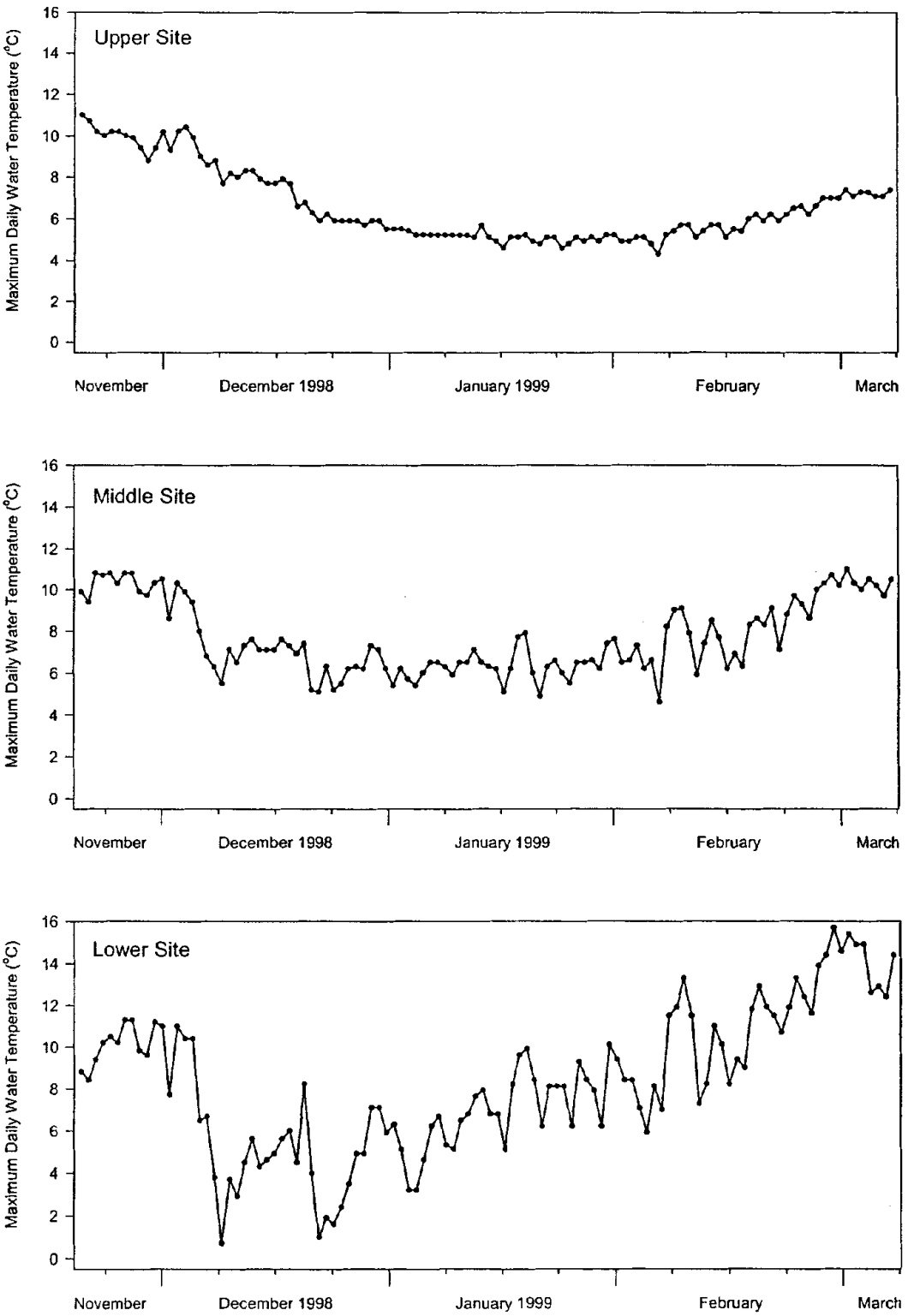

Figure 62. Maximum daily water temperature at three sites in the Rio Chama, New Mexico, 20 November 1998 - 9 March 1999.

temperatures were regularly below 4° C throughout the study area. The coldest water temperatures were recorded during December 1998, January 1999, and February 1999.

The upstream-most thermograph was located about 0.7 miles (1.1 km) downstream of Abiquiu Dam, just upstream of the USGS station-Rio Chama below Abiquiu Dam, NM (# 08287000) and recorded water temperatures that were warmer than those at downstream sites. Mean daily water temperatures at this site ranged between 3.9-9.8°C. Water temperatures dropped from November to late January and then began to warm during mid-February and March. The difference between minimum and maximum water temperatures at this site only averaged 1.6°C (range=0.5 to 2.6°C). Water temperature decreased in a downstream direction as the water was further cooled after being exposed to very cold ambient conditions.

The middle thermograph was about 3 miles (5 km) downstream of Abiquiu Dam. Water temperatures at this site fluctuated more and were colder than at the upstream site. Mean daily water temperature at the middle site ranged between 2.6-8.2°C. The difference between minimum and maximum water temperatures at this site averaged 5.1°C (range=2.0 to 8.3°C).

The downstream-most thermograph was at Site 5 (about 27 miles [43 km] downstream of Abiquiu Dam). The wide range of mean daily water temperatures at this site was between 0.1-8.4°C and the fluctuation in water temperature throughout the day was quite large at this site. The difference between minimum and maximum water temperatures averaged 7.6°C (range=0.8 to 13.6°C) at this locality. During December 1998, when discharge was at its lowest and ambient temperatures were cold, mean daily water temperatures at the downstream-most site were frequently <2° C. Water temperatures at this site steadily increased from January to March 1999.

Brown trout mark-recapture study (Supplemental)

The increased access and sampling efficiency that resulted from the reduced flows provided an opportunity to assess the brown trout population in the Rio Chama immediately downstream of Abiquiu Dam. In addition to the permanent sites selected for the primary study, three supplemental localities were added in an effort to better illuminate population information of Rio Chama brown trout. A mark-recapture study was initiated in November 1998 with a mark that consisted of a single or combination of fin clips. The limited number of fin clip combinations meant that marks could not be site specific but instead were unique to collection dates. Therefore, determining the original location of recaptured fish was not possible, only the date marked.

Brown trout were marked on eight separate occasions between 6 November 1998 and 14 October 1999. The upstream-most sites were the USGS weir (n=22 marked) and the boulder spillway (n=136 marked) both of which were located above Site 1 (n=16). A total of 20 fish were marked at Site 2, 17 at the next supplemental site (between Sites 2 and 3), 14 at Site 3, 29 at Site 4, and four at the lowermost sampling site (Site 5, Chamita).

A total of 258 brown trout between 116 and 570 mm TL were marked and released. The majority of fish (n=120; 75%) were marked within 3.2 km of Abiquiu Dam. Although low recapture rate precluded attempts to estimate the size of the Rio Chama brown trout population, there was other valuable information that was obtained from this effort. Eight brown trout were recaptured during the tenure of this study, all of which occurred within the aforementioned river reach. Six of the recaptured brown trout were taken at the boulder spillway located about 1.7 miles downstream of Abiquiu Dam. Four of the six brown trout recaptured at the boulder spillway (153-274 mm TL) were marked on 7 January 1999 and recaptured 62 days later on 10 March 1999 (the next sampling trip). The other two spillway recaptures (310-355 mm TL) were marked during the 18-19 November 1998 sampling effort and recaptured 330 days later (on 14 October 1999).

Single brown trout recaptures were recorded at Sites 1 and 2. A 294 mm TL brown trout marked 18 November 1998 was recaptured (Site 1) on 10 March 1999 (n=112 days). The brown trout (330 mm TL) recaptured on 27 July 1999 (Site 2) was first collected on 10 March 1999 (n=139 days).

Of the 305 brown trout collected and released during this study, 26.2% (n= 80) were stock size, 37.0% (n= 113) were quality, 12.5% (n= 38) were preferred, 9.2% (n= 28) were memorable, and 4.3% (n= 13) were trophy size. The other 33 brown trout (10.8%) were Age-0 or Age-1 fish that had not recruited to stock size. These numbers probably represented a relatively valid estimation of the size distribution of brown trout that were present during the study period as the low flows allowed access to previously unaccessible river reaches. Pervious reports (Platania et al. 1996) likely under-represent the number of larger sized fish which typically inhabit deep and inaccessible areas.

The relative weight (Wr) of 259 brown trout taken during this study (98.4 + 0.6) was similar to that for brown trout collected in 1990 (99.2 + 0.3) and 1995 (99.3 + 0.4; Platania et al. 1996). No attempt was made to determine Wr by gender in the current study.

An allometric growth curve was generated to describe the relationship between brown trout total length and body mass (Figure 63). Body length-body mass relationships were calculated from 195 collected and released brown trout between 195-570 mm TL. In addition, a regression of standard length versus total length was determined to allow for calculating total length when only standard length is known and, likewise, standard length when only total length is available.

DISCUSSION

The historic flow patterns and sediment input into downstream reaches of the Rio Chama has been drastically altered since the operation of Abiquiu Dam began in 1963. Hydrologic manipulations have resulted in a reduced availability of low velocity habitats and narrowing of the river channel. Small sediments are trapped in Abiquiu Reservoir and result in an armored channel downstream of Abiquiu Dam where relatively sediment-free water is released. Flow downstream of Abiquiu Dam, as in many regulated rivers of North America (Stanford and Ward, 1979), is highly regulated and has resulted in a stabilized substrata, altered discharge and thermal regimes, and negative cascading effects on native biota. Concurrent with these changes to the Rio Chama was a loss of several species of native Cypriniformes (Platania, 1991).

The most notable change that has occurred as a direct result of the operation of Abiquiu Dam are seasonal releases of large volumes of Middle Rio Grande Conservancy District water to supply irrigation needs of downstream users. These releases (>500 ft^3/sec), when following a period of low flow (<100 ft^3/sec), result in rapid declines in dissolved oxygen and low-velocity habitats and increases in suspended sediments (Turner, 1982). The rapidly fluctuating flows and the maintenance of high flows over several weeks likely decrease the primary and secondary productivity in the Rio Chama. In turn, this may result in a rapid decline of suitable habitats for fry and juvenile stages of both native and nonnative species (Turner, 1982). The abundance of YOY Rio Chama fishes in near-shore and floodplain habitats during 1995 suggests the importance of shallow, slow velocity areas with cover (Platania et al., 1996). These areas offer reduced metabolic expenditure, foraging opportunities, and protection from intra- and interspecific competition/predation. Low velocity habitats are rare during high volume water releases from Abiquiu Dam.

Changes in flow patterns, sediment input, and nonnative species composition of the Rio Chama downstream of Abiquiu Dam undoubtedly resulted in the decline and loss of several native species of fish. The Rio Chama downstream of Abiquiu Dam has been transformation from a low velocity tributary of the Rio Grande to a conduit for the occasional massive transport of water. This has resulted in the creation of wealth of high velocity and dearth of low velocities habitats. Widely

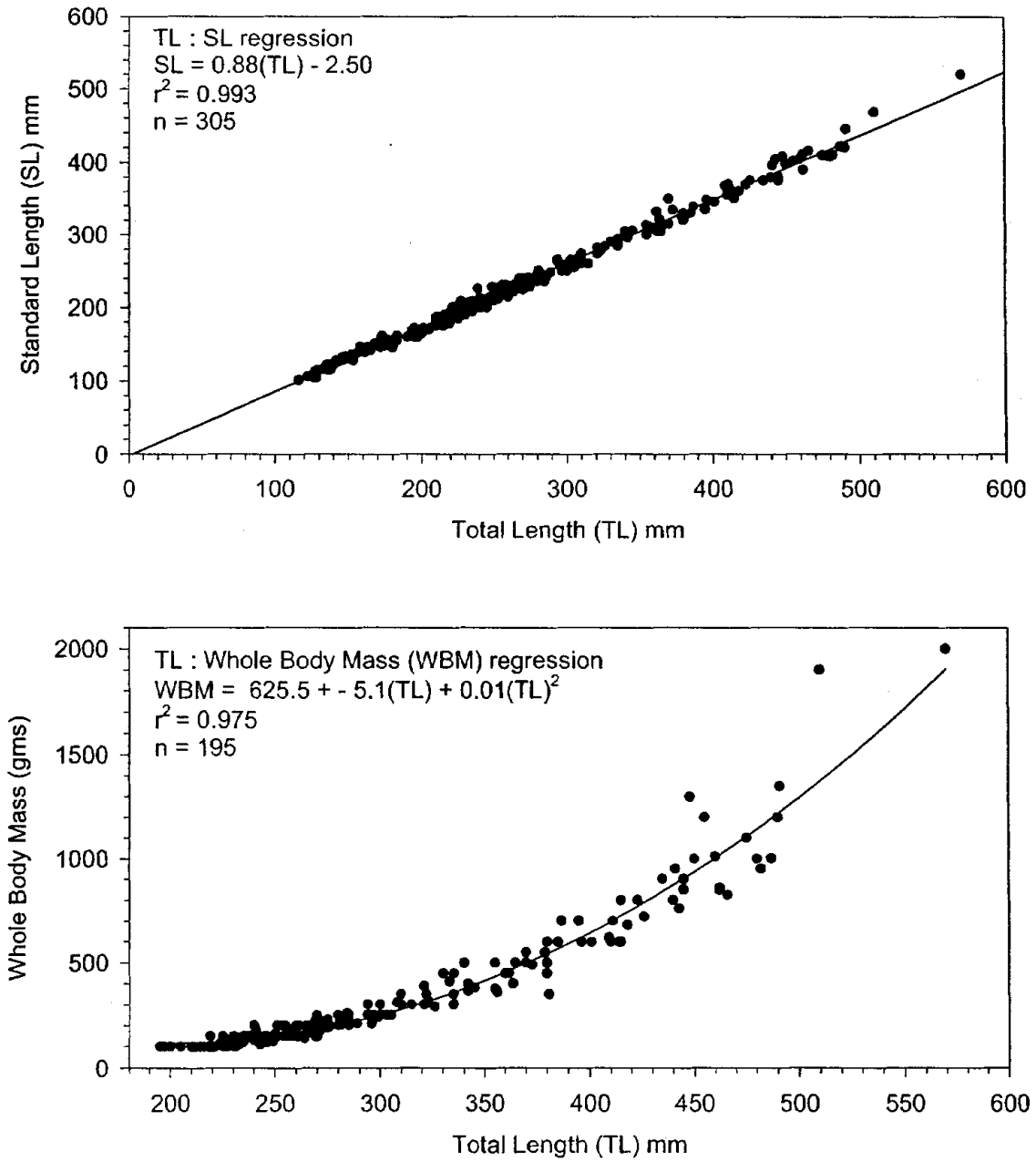

Figure 63. Brown trout standard length (SL) total length (TL) regression and brown trout length (TL) body mass regression.

fluctuating and extended periods of high flow reduce river productivity, eliminate many low velocity habitats necessary for rearing of YOY fishes, and diminish water quality. The synergistic effect of these altered conditions is likely the principal cause for the demise of the native Rio Chama ichthyofauna.

An additional and important change to the Rio Chama downstream of Abiquiu Dam has been the introduction of nonnative gamefishes. Brown trout and rainbow trout prey on fish and were present in our collections. The numerical dominance of brown trout and white sucker in our collections indicates that these two nonnative taxa have become well established in the Rio Chama downstream of Abiquiu Dam. The presence of several other nonnative taxa in low densities is further indication of the susceptibility of the anthropogenetically manipulated Rio Chama to invasion by nonindigenous species. The changes in the fish community downstream of Abiquiu Reservoir from a native to a mixed native and nonnative fauna have occurred over a relatively short duration. This rapidity and thoroughness of the change in the fish community is underscored by the fact that two of the three most abundant species were nonnative. Similarly, four of the five most abundant species in a study instream flow requirements of fish occupying the Rio Chama downstream of Abiquiu Reservoir were nonnative (Turner, 1982).

A study of the brown trout population downstream of Abiquiu Dam was conducted by the U.S. Fish and Wildlife Service, N.M. Ecological Service Office, from 1988-1991 (Hanson, 1992). The primary objectives of that study were to investigate and report on aspects of the reproductive biology and early life-history of brown trout. Hanson (1992) concluded that stable flow needed to be maintained in the Rio Chama downstream of Abiquiu Dam from November through March. This period corresponded with the onset of brown trout spawning and hatching of emergence of brown trout fry, respectively. A minimum flow of 70 cfs from Abiquiu Dam was recommended but Hanson (1992) noted that a flow of 200 cfs would maximize brown trout habitat. Low flows were identified as having the potential to isolate and desiccate brown trout redds and greatly reduce spawning and incubation habitats for this species. Little consideration was given to native fish species.

Reproductively active adult brown trout, collected during the low flow portion (November 1998-March 1999) of this study, indicated that spawning had occurred. Spent female brown trout collected during 18-19 November 1998 suggested that most spawning had already occurred. Areas that appeared necessary for successful spawning and recruitment of brown trout (e.g., higher velocity, moderate depth, gravel-bottomed habitats) were scarce in the study area during the low flow period. Even during times of elevated flows, most habitats with a gravel or cobble substrate had silt or sand in the interstitial spaces. Elevated levels of suspended sediments are lethal to trout eggs which depend on high concentrations of dissolved oxygen and clean gravel-cobble substrata. In low-moderate water velocities, suspended sediments settle and can cover and suffocate fish eggs.

Age-0 brown trout were encountered during this study at catch rates that were relatively similar to 1995. Platania et al. (1996) found Age-0 individuals were 97.7% of the brown trout catch in October 1995 with similar values in November (100%) and December 1995 (97.0%) collections. Examination of the age-structure of brown trout from this study, using flow-years that were most similar to 1995 (1997 and 1999), demonstrated that 98.7% of brown trout in October 1997 were Age-0 and 92.2% of October 1999 individuals were Age-0. Catch rates of Age-0 brown trout were 2.28 fish/100 seconds in October 1995, 1.34 fish/100 seconds in October 1997, and 3.23 fish/100 seconds in October 1999. (Higher overall catch rates in October 1999 were primarily a result of reduced flows compared to previous years.) The affects of the flow reduction and concurrent decrease in adult brown trout abundance documented in November 1998 was not evident in the 1999 Age-0 cohort. This suggests successful spawning by brown trout in November 1998 that probably occurred prior to the reduction of flow.

The pronounced decline in brown trout abundance from January 1999 to March 1999 suggested a rapid loss of individuals. Comparison of cumulative catch rates between January 1999 and March 1999 sampling efforts indicated that the reduced catch rate during the latter effort was primarily the result of a decline in abundance of adult brown trout. The most parsimonious explanation for this decline was intensified angling pressure. Numerous anglers were seen in the study area especially the first two months following the initial decrease in flow. Increased fishing pressure, greater access to all portions of the stream (result of low flow), and confinement of large fish to smaller habitats surely accelerated the loss of brown trout due to angling. The most immediate and visible consequence that will result from marked reduction of the adult (reproductive) brown trout cohort that occurred during low flow periods will be a significant reduction in the number of individuals in the 2000 Age-0 cohort. The cascading negative effects of this event will be evident in brown trout abundance and size-class structure for several years.

Between year differences in catch rates of Age-0 brown trout suggest that their recruitment in the Rio Chama could have been impacted by the extended winter low flow of 1998-1999. Indirect effects of low flow on recruitment could have been a reduced reproductive effort due to lack of suitable spawning habitat and increased mortality of eggs and fry because of suboptimal abiotic conditions. Numerous direct effects of the low flow also could have resulted in poor recruitment of Age-0 brown trout. Angling pressure, changes in water quality (water clarity, temperature etc.), and increased contact with large brown trout in confined habitats could have, individually or in concert, contributed to the decline of the Age-0 cohort.

Examination of temporal abundances at each site for each fish species revealed slight changes. Rio Grande chub abundance was relatively low at all five sites but was generally higher at the downstream-most site (U.S. Hwy 285 bridge crossing, Chamita). The increase in the number of Rio Grande chub taken in deep water habitats was likely an artifact of receding flow which concentrated the fish in formerly unsuitable habitats. The slight decline in the abundance of Rio Grande chub at study sites near Abiquiu Dam appeared correlated with persistent low flow and concurrent reduction in available habitats. The loss of instream cover and crowding of fishes, as compared with normal flows, would have increased the likelihood of encounters with the highly piscivorous brown trout. Alternatively, detrimental changes in physical-chemical conditions of the Rio Chama downstream of Abiquiu Dam following flow reductions may have contributed to the apparent decline in Rio Grande chub. No changes in relative abundance of chub were apparent in the lower reaches of the study area.

Fathead minnow were only occasionally abundant and appeared to be least common at the upstream sites. Few fathead minnow were collected at sites just downstream of Abiquiu Dam immediately after flow was reduced in early November 1998 but this trend was not strong. There were distinguishable temporal patterns in the catch rate of fathead minnow at downstream collecting localities with large numbers of YOY most prevalent in autumn samples.

Flathead chub were taken only at the downstream-most collecting locality. The substrata at Site 5 was primarily sand and gravel compared with cobble at upstream sites. This change in substrata combined with increased water temperature and other physical and biotic parameters was sufficient to support this species. Temporal changes in catch rate of flathead chub appeared random with the exception of increased abundance of YOY following summer reproduction.

Longnose dace and white sucker both were slightly less abundant during periods of low flow in late 1998 and early 1999. Low flow should have resulted in high catch rates because fish were restricted in smaller (surface area and volume) habitats. However, high catch rates were noted only immediately after flows dropped. This suggests that some fish were lost shortly following decreases in flow perhaps for the same reasons Rio Grande chub became less abundant (e.g., competition, predation, decline in physical-chemical water conditions etc.). While longnose dace were relatively

abundant in the upper reaches by October 1999 and seemed to have produced many YOY, white sucker remained relatively scarce throughout the study area.

The abundance of brown trout during low flow periods was again probably and artifact of reduced habitat availability. This trend was observed at all except the Chamita site where this fish was only occasionally taken. There were no noticeable declines in the catch rate of this species following the extended period of low flow, but it did appear that larger individuals (especially those over 200 mm SL) were less abundant. This decline could have been caused by increased angling pressure or the general changes in physical conditions (e.g., water clarity, temperature etc.) during periods of low flow.

Low flow from November 1998 to March 1999 affected both habitat availability and water temperatures within the study area. Changes in habitat availability were visually apparent and resulted in reduced wetted perimeter of the stream channel, decreased water velocities in mesohabitats, and more meandering within the stream channel. A short reach of the Rio Chama downstream of Abiquiu Dam was transformed from a riffle/run system to a run/pool dominated river. Deep and high water velocity habitats were lost during the low flow period. Concurrent with the changes in habitat availability were changes in water temperatures in the Rio Chama. Water temperature at the upstream site near Abiquiu Dam was warmer and did not fluctuate as much as did water temperature at downstream sites. Stratification of water in Abiquiu Reservoir and the location of the pen-stock provided water of a relatively homogeneous temperature to the Rio Chama at the dam and for several kilometers downstream. Ambient conditions at downstream localities in the Rio Chama valley caused mean daily winter water temperatures to be lower and more variable than that at the dam. The daily air temperature regime (cold at night but warming during the day) led to widely fluctuating downstream water temperatures.

Changes in habitat availability in the Rio Chama that resulted from reduced instream flow did not appear detrimental to native fishes, but appeared to negatively impact brown trout. The artificial conditions below Abiquiu Dam that normally maintain a small population of nonnative brown trout were temporarily disrupted by the period of low flow (November 1998 to March 1999) and resulted in a decline in the brown trout fishery. Low flow conditions did not appear to have negatively impacted native populations of fishes in the Rio Chama and may have benefitted them by reducing the number of predaceous brown trout.

It was not possible to accurately measure the effects of periodic shut-down events (that resulted in flows of <25 cfs) on fishes downstream of Abiquiu Dam because we were not made aware of these anomalies until after they had occurred. Comparison of fish catch rates before and after shut-down events, while not ideal, indicated that the short term flow reductions did not strongly impact existing populations of fishes. Stranding of fish during shut-down events (i.e., <25 cfs) occurred but most individuals were able to move to deeper water. The incised channel of the Rio Chama and already low flow (50 cfs) appeared to have concentrated fish into mainly deeper areas (i.e., areas associated with the thalweg). The limited duration of these events likely ameliorated their negative consequences. At downstream sites, the rate of flow recession was much slower than upstream sites and there were few instances of stranded fishes.

Once flow was shut off at the dam, an additional 15-30 minutes was required for all water to be discharged so that flow at Abiquiu Dam was 0 cfs. Immediately downstream of the dam, by-pass drains and culverts provided a base flow of ca. 5-10 cfs throughout the shut-down event. A large proportion of the available aquatic habitat (at 50 cfs) were deep pools which were not in danger of being lost during short term shut-down events. Conversely, shallow (<5 cm) low velocity riffle, run, or pool habitats present at all sites were lost during the shut-downs. Other aquatic habitats became shallower for brief periods. Declines in water level, especially at downstream sites, were not very noticeable. The main apparent impact of shut-down events on aquatic habitat composition was the

rapid drop in water velocities, loss of riffles and runs, and transformation of the river into a series of connected pools.

It was difficult to separate and assess the impacts to brown trout and other species caused by shut-downs associated with the installation of emergency gates at Abiquiu Dam. Primary (stranding fish) and secondary (crowding, increased predation and competition, etc.) biotic effects to the ichthyofaunal community certainly resulted from these events. Numerous additional reasons could be posed as an explanation for some of observed changes in the fish community including a combination of physical and biological factors. Sampling of additional sites and during shut-down events, though not contractually obligated, vastly improve the ability to formulate hypothesized effects of these events on the ichthyofaunal community.

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Table A-1. Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Site 1 Rio Chama, ca. 1.9 miles (3.1 km) downstream of Abiquiu Dam

Date: 2 September 1998 **Field Number:** SPP98-026

Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	340	-

Species: *Salmo trutta* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	210	-

Date: 20 October 1998 **Field Number:** SPP98-031

Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	150	-

Date: 6 November 1998 **Field Number:** SPP98-036

Species: *Salmo trutta* (n=19)

TL (mm)	SL (mm)	Mass (g)
-	300 (n=18)	-
-	600	-

Date: 18 November 1998 **Field Number:** SPP98-041

Species: *Salmo trutta* (n=6)

TL (mm)	SL (mm)	Mass (g)
227	189	100
240	200	150
250	210	150
285	240	250
297	250	250
570	520	2,000

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Site 1 Rio Chama, ca. 1.9 miles (3.1 km) downstream of Abiquiu Dam

Date: 7 January 1999 **Field Number:** SPP99-002
Species: *Salmo trutta* (n=8)

TL (mm)	SL (mm)	Mass (g)
143	126	35
168	149	50
176	148	50
178	156	55
225	203	110
240	213	145
250	210	140
283	237	225

Date: 10 March 1999 **Field Number:** SPP99-029
Species: *Salmo trutta* (n=2)

TL (mm)	SL (mm)	Mass (g)
276	235	195
294	266	250

Date: 27 July 1999 **Field Number:** SPP99-101
Species: *Salmo trutta* (n=2)

TL (mm)	SL (mm)	Mass (g)
216	190	100
259	231	150

Date: 14 October 1999 **Field Number:** SPP99-156
Species: *Salmo trutta* (n=1)

TL (mm)	SL (mm)	Mass (g)
450	398	1,000

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Site 2 Rio Chama, ca. 2.0 miles (3.2 km) downstream of Abiquiu Dam

Date: 4 April 1997 **Field Number:** SPP97-019

Species: *Salmo trutta* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	250	-

Date: 20 October 1997 **Field Number:** SPP97-065

Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	250	-

Species: *Salmo trutta* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	550	-

Date: 2 September 1998 **Field Number:** SPP98-027

Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	360	-

Date: 20 October 1998 **Field Number:** SPP98-032

Species: *Catostomus commersoni* (n=2)

TL (mm)	SL (mm)	Mass (g)
-	200	-
-	250	-

Species: *Salmo trutta* (n=4)

TL (mm)	SL (mm)	Mass (g)
-	200	-
-	200	-
-	250	-
-	300	-

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Site 2 Rio Chama, ca. 2.0 miles (3.2 km) downstream of Abiquiu Dam

Date: 19 November 1998 **Field Number:** SPP98-043
Species: *Salmo trutta* (n=16)

TL (mm)	SL (mm)	Mass (g)
225	190	100
245	200	150
255	225	200
260	215	200
265	225	200
270	230	200
270	230	200
275	230	200
300	250	250
310	260	300
365	305	500
380	330	500
410	355	600
435	375	900
445	380	900
490	420	1,200

Date: 7 January 1999 **Field Number:** SPP99-003
Species: *Salmo trutta* (n=1)

TL (mm)	SL (mm)	Mass (g)
250	210	-

Date: 27 July 1999 **Field Number:** SPP99-099
Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
430	370	950

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Site 2 Rio Chama, ca. 2.0 miles (3.2 km) downstream of Abiquiu Dam

Date: 27 July 1999 **Field Number:** SPP99-099

Species: *Salmo trutta* (n=10)

TL (mm)	SL (mm)	Mass (g)
230	205	100
240	210	200
250	210	150
260	230	150
330	290	450
335	290	450
335	285	350
340	305	500
380	320	600
475	410	1,100

Date: 14 October 1999 **Field Number:** SPP99-154

Species: *Catostomus commersoni* (n=2)

TL (mm)	SL (mm)	Mass (g)
221	193	-
258	219	-

Species: *Salmo trutta* (n=3)

TL (mm)	SL (mm)	Mass (g)
423	369	800
440	379	800
455	402	1,200

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Site 3 Rio Chama, ca. 0.5 miles (0.8 km) upstream of U.S. Hwy 84 bridge

Date: 20 October 1997 **Field Number:** SPP97-066

Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	250	-

Date: 19 November 1998 **Field Number:** SPP98-044

Species: *Salmo trutta* (n=2)

TL (mm)	SL (mm)	Mass (g)
395	335	700
445	375	850

Date: 7 January 1999 **Field Number:** SPP99-004

Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
317	268	390

Species: *Salmo trutta* (n=7)

TL (mm)	SL (mm)	Mass (g)
265	232	170
270	240	150
342	296	400
396	348	600
443	404	760
462	411	860
466	416	825

Date: 11 March 1999 **Field Number:** SPP99-032

Species: *Salmo trutta* (n=5)

TL (mm)	SL (mm)	Mass (g)
380	328	450
401	345	600
418	360	680
462	390	850
487	421	1,000

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Site 4 Rio Chama, at NM State Hwy 554 bridge crossing

Date: 28 May 1998 **Field Number:** SPP98-024
Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	300	-

Date: 2 September 1998 **Field Number:** SPP98-029
Species: *Salmo trutta* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	380	-

Date: 20 October 1998 **Field Number:** SPP98-034
Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	200	-

Date: 19 November 1998 **Field Number:** SPP98-045
Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
280	235	-

Species: *Salmo trutta* (n=15)

TL (mm)	SL (mm)	Mass (g)
190	160	90
190	160	60
205	170	80
210	175	100
215	175	90
235	195	120
235	195	140
235	200	120
235	200	130
240	200	130
250	210	140
260	220	160
305	255	250
365	310	500
415	350	600

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Site 4 Rio Chama, at NM State Hwy 554 bridge crossing

Date: 7 January 1999 **Field Number:** SPP99-005

Species: *Catostomus commersoni* (n=2)

TL (mm)	SL (mm)	Mass (g)
320	286	280
391	340	630

Species: *Salmo trutta* (n=8)

TL (mm)	SL (mm)	Mass (g)
217	186	90
220	194	80
228	197	110
248	215	140
261	225	150
269	236	150
296	257	210
460	405	1,010

Date: 11 March 1999 **Field Number:** SPP99-033

Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
306	264	-

Species: *Salmo trutta* (n=4)

TL (mm)	SL (mm)	Mass (g)
246	209	120
247	209	130
250	213	150
260	220	150

Date: 27 July 1999 **Field Number:** SPP99-097

Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
-	300	-

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Site 4 Rio Chama, at NM State Hwy 554 bridge crossing

Date: 14 October 1999 **Field Number:** SPP99-157

Species: *Salmo trutta* (n=8)

TL (mm)	SL (mm)	Mass (g)
232	200	100
303	265	250

Site 5 Rio Chama, at U.S. Hwy 285 bridge crossing

Date: 19 November 1998 **Field Number:** SPP98-046

Species: *Catostomus commersoni* (n=3)

TL (mm)	SL (mm)	Mass (g)
-	230	-
-	270	-
-	280	-

Species: *Salmo trutta* (n=4)

TL (mm)	SL (mm)	Mass (g)
245	205	150
250	210	160
275	230	190
285	235	200

Date: 7 January 1999 **Field Number:** SPP99-006

Species: *Catostomus commersoni* (n=4)*

Species: *Salmo trutta* (n=5)*

*no length or mass data

Date: 11 March 1999 **Field Number:** SPP99-034

Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
370	320	-

Species: *Salmo trutta* (n=1)

TL (mm)	SL (mm)	Mass (g)
400	360	700

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Supplemental Sampling Sites

Site A Rio Chama, ca. 0.5 miles (0.8 km) downstream of Abiquiu Reservoir at USGS gauge
Date: 18 November 1998 **Field Number:** SPP98-039
Species: *Catostomus commersoni* (n=18)

TL (mm)	SL (mm)	Mass (g)
-	125	-
-	135	-
-	135	-
-	140	-
-	140	-
-	140	-
-	145	-
-	145	-
-	145	-
-	150	-
-	150	-
-	150	-
-	155	-
-	160	-
-	165	-
-	190	-
-	195	-
-	215	-

Species: *Salmo trutta* (n=11)

TL (mm)	SL (mm)	Mass (g)
225	185	100
225	185	100
230	195	150
230	205	150
250	215	150
260	220	150
270	240	250
280	245	200
310	270	300
335	290	450
410	365	600

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Supplemental Sampling Sites

Site A Rio Chama, ca. 0.5 miles (0.8 km) downstream of Abiquiu Reservoir at USGS gauge
Date: 10 March 1999 **Field Number:** SPP99-027
Species: *Catostomus commersoni* (n=2)

TL (mm)	SL (mm)	Mass (g)
215	181	-
229	201	-

Species: *Salmo trutta* (n=11)

TL (mm)	SL (mm)	Mass (g)
221	200	100
230	200	90
231	196	100
234	208	130
281	251	200
294	263	300
342	302	365
411	370	700
448	408	1,300
491	445	1,350
510	468	1,900

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Supplemental Sampling Sites

Site B Rio Chama, ca. 1.7 miles (2.7 km) downstream of Abiquiu Reservoir at USGS gauge
Date: 18 November 1998 **Field Number:** SPP98-040
Species: *Catostomus commersoni* (n=4)

TL (mm)	SL (mm)	Mass (g)
-	135	-
-	140	-
-	150	-
-	235	-

Species: *Oncorhynchus mykiss* (n=1)

TL (mm)	SL (mm)	Mass (g)
221	200	100

Species: *Salmo trutta* (n=18)

TL (mm)	SL (mm)	Mass (g)
180	145	50
183	155	50
195	160	-
200	165	100
214	186	100
220	185	100
225	185	100
235	195	150
235	200	150
250	210	150
250	215	150
260	220	200
362	305	450
370	315	500
370	350	550
379	325	550
385	330	600
482	410	950

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Supplemental Sampling Sites

Site B Rio Chama, ca. 1.7 miles (2.7 km) downstream of Abiquiu Reservoir at USGS gauge
Date: 7 January 1999 **Field Number:** SPP99-001
Species: *Oncorhynchus mykiss* (n=3)

TL (mm)	SL (mm)	Mass (g)
355	321	600
350	310	520
312	283	400

Species: *Salmo trutta* (n=90)

TL (mm)	SL (mm)	Mass (g)
116	101	-
122	106	-
126	105	25
126	106	-
126	109	-
127	105	-
127	113	-
128	105	-
129	115	-
132	116	-
135	120	-
135	122	-
136	115	-
136	118	-
136	118	-
136	122	-
136	122	-
138	116	-
138	122	-
140	122	-
141	125	30
142	127	-
142	127	-
142	128	-
145	128	-
145	128	40
146	128	-
146	132	-
146	132	30
148	130	40
148	133	-
152	133	40

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Supplemental Sampling Sites

Site B Rio Chama, ca. 1.7 miles (2.7 km) downstream of Abiquiu Reservoir at USGS gauge
Date: 7 January 1999 **Field Number:** SPP99-001
Species: *Salmo trutta* (n=90)--continued

TL (mm)	SL (mm)	Mass (g)
152	136	-
152	136	-
152	136	35
153	136	-
154	136	40
156	138	-
156	138	-
156	138	-
158	142	-
158	142	-
158	147	-
161	139	45
162	143	50
163	147	40
164	146	-
165	145	-
165	142	-
166	146	50
166	146	40
168	151	-
171	152	-
172	150	50
172	157	-
173	162	50
175	158	50
183	162	55
193	168	60
210	186	100
212	186	80
218	191	100
222	185	-
226	195	120
226	200	120
227	209	120
229	205	130
232	207	140
233	206	110
235	209	125
241	209	140
241	210	180

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Supplemental Sampling Sites

Site B Rio Chama, ca. 1.7 miles (2.7 km) downstream of Abiquiu Reservoir at USGS gauge

Date: 7 January 1999 **Field Number:** SPP99-001

Species: *Salmo trutta* (n=90)--continued

TL (mm)	SL (mm)	Mass (g)
254	228	150
256	222	170
256	223	-
256	231	150
258	231	180
268	240	180
269	236	200
270	235	170
270	238	160
273	236	220
276	240	200
281	251	220
345	306	380
362	332	450
364	322	400
373	335	490
409	368	620
426	375	720

Date: 10 March 1999 **Field Number:** SPP99-028

Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
324	289	-

Species: *Salmo trutta* (n=24)

TL (mm)	SL (mm)	Mass (g)
134	118	25
153	128	30
172	146	50
174	149	60
195	168	50
195	172	70
201	172	70
229	196	75
239	226	140
249	228	125

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Supplemental Sampling Sites

Site B Rio Chama, ca. 1.7 miles (2.7 km) downstream of Abiquiu Reservoir at USGS gauge

Date: 10 March 1999 **Field Number:** SPP99-028

Species: *Salmo trutta* (n=24)--continued

TL (mm)	SL (mm)	Mass (g)
257	223	150
259	227	160
264	222	140
270	236	150
271	233	170
274	241	195
281	243	225
299	256	240
326	284	290
335	294	300
356	307	360
381	325	350
414	360	600
480	408	1,000

Date: 27 July 1999 **Field Number:** SPP99-100

Species: *Catostomus commersoni* (n=5)

TL (mm)	SL (mm)	Mass (g)
410	361	600
430	359	700
434	368	950
483	413	850
490	425	1,250

Species: *Salmo trutta* (n=17)

TL (mm)	SL (mm)	Mass (g)
212	183	100
219	178	300
221	191	100
224	195	120
230	195	120
230	199	120
233	198	130
242	212	150
243	209	110
269	237	220

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Supplemental Sampling Sites

Site B Rio Chama, ca. 1.7 miles (2.7 km) downstream of Abiquiu Reservoir at USGS gauge
Date: 27 July 1999 **Field Number:** SPP99-100
Species: *Salmo trutta* (n=17)--continued

TL (mm)	SL (mm)	Mass (g)
284	245	260
289	247	210
308	268	310
321	282	390
333	291	410
441	396	950
480	411	1,000

Date: 14 October 1999 **Field Number:** SPP99-155
Species: *Catostomus commersoni* (n=1)

TL (mm)	SL (mm)	Mass (g)
292	259	-

Species: *Salmo trutta* (n=21)

TL (mm)	SL (mm)	Mass (g)
195	164	100
197	160	100
210	179	100
211	187	100
219	184	150
225	187	150
226	192	100
238	201	150
241	204	150
246	210	150
251	216	150
251	215	200
253	212	200
256	219	150
261	227	200
300	259	250
310	274	350
321	274	300
322	279	350
355	313	500
387	339	700

Table A-1. (continued) Length and mass of fishes that were collected and released to the Rio Chama, New Mexico as part of this study.

Supplemental Sampling Sites

Site C Rio Chama, ca. 4.0 miles (6.4 km) downstream of Abiquiu Reservoir at USGS gauge

Date: 19 November 1998 **Field Number:** SPP98-043

Species: *Salmo trutta* (n=11)

TL (mm)	SL (mm)	Mass (g)
205	170	100
230	190	130
235	195	150
245	200	150
250	210	150
270	225	180
280	235	250
300	255	300
315	260	300
360	310	450
415	350	800

Date: 11 March 1999 **Field Number:** SPP99-031

Species: *Salmo trutta* (n=6)

TL (mm)	SL (mm)	Mass (g)
270	229	200
274	234	190
275	228	230
286	241	210
323	278	320
355	300	375

Site D Rio Chama, at U.S. Hwy 84 Bridge

*No fish were released from this site.