8/8

Pat + Heidi –

See Pages 37 + 38.
Hwy 45 bridge site
is About 500 yds below
GCID gravel DAM.

Julie Brown
DFG

Tributary Rearing by Sacramento River Salmon and Steelhead

Interim Report October 30. 1994

Paul E. Maslin, and William R. McKinney
Dept. of Biol. Dept. CSU, Chico
Chico, CA 95929
(916)898-5757 or 342-1579

Introduction

Over the past ten years, ichthyology classes from CSU, Chico have collected with seines at a number of smaller tributaries in the Sacramento Valley, measuring and releasing captured fish. Very commonly juvenile chinook salmon were found in these streams in the spring. They were often the most abundant fish observed, particularly in downstream intermittent portions of streams such as Mud and Rock Creeks (roughly from Highway 99 E to the Sacramento River). Although density was not determined, they were fairly abundant; it was not unusual to capture 100 in a short haul with a 30 ft seine. Yearling steelhead were also collected, but in lesser abundance. In 1993 we began a more intensive investigation of this phenomenon.

Procedure

Sample sites were established on a number of smaller tributaries (Big Chico Creek, Mud Creek, Rock Creek including Kusal Slough, Pine Creek, Toomes Creek, Dye Creek, Elder Creek, Thomes Creek, and Stony Creek) in the Sacramento Valley within Butte, Glenn and Tehama counties. We used a 30 foot X 6 foot seine to capture fish in suitable habitat areas (usually pools or runs) of the tributaries. Captured juvenile salmon and small minnows were transferred by dipnet to 5-gal buckets of clean water for immediate processing. Fish larger than about 150 mm, which might injure the smaller juveniles, were placed into separate buckets and processed separately. Small numbers of juveniles, usually 10-12 at a time, were transferred into a smaller bucket containing dilute tricane methanesulfonate (MS 222, brand name Finquel from Argent Chemical Company). After they lost equilibrium, they were measured to the nearest mm on a fish board, then transferred to fresh water for recovery. Fish larger than 150 mm, since they had potential for immediate catch and consumption by anglers, were not anaesthetized. Instead, the fish board was placed in the bucket with the fish, then the fish was gently guided to nose up to the zero board and measurement was made without complete removal from the water. The fish was then lifted quickly on the board and released into another bucket. As soon as they recovered from the anesthetic, all fish were released into the habitat from which they were captured. All individuals of all fish species captured were measured, unless an exceptionally large number was captured, in which case a subsample was processed. Although mortality was very low, an occasional fish was crushed by a rock or a bigger fish in the seine. All mortalities were noted and preserved for stomach analysis in the lab. Water temperature at all sites was measured with a mercury thermometer.

Results

A summary of our observations in different tributaries is given in Tables 1 through 3. Estimates of tributary growth rates are given in table 4. Stomach contents are given in Table 5. Size distributions of juvenile chinooks and steelhead collected at various sites and times are presented in Figures 1 through 23.

Discussion

While the ease of capturing juvenile chinooks suggests that they are quite abundant in these tributaries, our sampling technique is not quantitative. It should not even be considered relative from site to site or even time to time at the same site because factors such as snags, water depth, and luck all play a part. Certainly, when and where we caught many fish, there were lots of fish present. Failure to catch many (or any) at a site could mean there were few or no fish present or it could mean sampling conditions were not good. We selected sample sites where we thought we would be able to catch fish, but in many cases the area provided only marginal fishing conditions at the time of our visit. However our rather extensive experience seining fish (over 30 years for the senior author) counts for something. If we failed to catch juvenile salmon at a site, there were probably not many there, especially at sites where we were able to capture many fish of other species or where we had formerly captured many chinooks at similar flow volume.

In some cases, juveniles found in a tributary may have represented the offspring of adults that either strayed into the tributary in high water or were returning to their natal stream. However, several facts suggest that most salmonids observed in the tributaries came from the river as juveniles, rather than from eggs spawned in the tributaries: Low rainfall throughout the study period except for 1993 provided only limited opportunity for spawners to ascend the tributaries. A variety of size classes were found at many sites, while the limited tributary spawning possible could have provided only one or two size classes. Juveniles were present in size classes that could not be explained by local spawning (Figures 2, 3, 4, 6, 7, 9abc, 10abc, 11ab, 17b). For example, the chinooks captured in early January in Mud Creek ranged from 48 to 133 mm and those captured in Pine Creek ranged from 78 to 109 mm (Figures 10a and 12a). Adult salmon could not ascend these creeks until December, 1993, so there was not time for locally-spawned fish to even hatch, let alone grow to the sizes observed. When different sites from the same tributary were collected on the same day, the smallest fish tended to be found in downstream sites (Figures 3, 9bc, 10bc, 12b, 13, 15ab, 16, 17b), suggesting that the juveniles came up the creeks from the river, rather than down the tributaries from an upstream spawning site (In almost all cases, suitable spawning habitat does not exist in the lower end of the tributaries). In some cases the tendency was quite marked, as though a new cohort of fish had entered the mouth, but not yet moved upstream where an older cohort could be found (Fig 9b). In both 1993 and 1994, we found marked juvenile chinooks and steelhead in several tributaries (Tables 1 and 2). These could only have come from the Coleman Hatchery by way of the Sacramento River. (A few which were retained for tag analysis verified this.) Although the juvenile salmon in lower Rock Creek (Kusal Slough) and the extreme lower end of Mud Creek could have arrived passively with Sacramento overflow in 1993, those further upstream that year in Mud Creek could only have reached capture sites by actively swimming. If those observed in 1988, 1990, 1991, and 1994 came from the river, they would have had to deliberately move into and up the tributaries, since the Sacramento did not overflow in those years. It seems likely that river-spawned (or hatchery-released) Sacramento juvenile chinooks and steelhead regularly make their way into tributary streams. Use of off-channel and tributary sites for rearing by chinooks has already been documented for the Taku River in Alaska (Murphy *et al.* 1989), the Fraser River in British Columbia (Murray and Rosenau 1989; Scrivener *et al.* 1994, and the Salmon River in Idaho, (Richards *et al.* 1992).

Data being collected by the California Department of Fish and Game in down-migrant traps in the Sacramento River, Butte and Chico Creeks suggest that many small juveniles choose to move downstream, rather than to stay in their natal stream until smolting (See Figure 25). At least some of these small juveniles rear in the lower reaches of non-natal tributaries.

When flow was available, the juvenile chinooks generally left the tributaries after reaching a size of 70 to 90 mm. In Spring, 1993, they appeared to remain in the tributaries, even through several high water events, until smolting. The mean size of adipose-clipped fish increased through the 1993 season, but the percent which were clipped, declined as the season progressed (Table 3). The size distribution moved to the right as the fish grew, but truncated on the right side (Figures 6-8). As fish grew to the 80 to 90 mm range, they disappeared from the tributaries, presumably by migrating downstream. This size corresponds well with the values of 80 to 105 mm given by Reimers and Loeffel, 1967. During the drought years, there was no open channel for them to migrate out and larger fish were captured in 1988, 1990, and 1991, and 1994, but in 1993 they were free to go as they chose and few fish over 90 mm were observed. By 5/12/93 juvenile chinooks were essentially gone from the study sites from which out-migration was possible even though temperature remained well within tolerated range (Figures 6-8). Presumably the fish reached a physiological age or size for emigration (Folmar and Dickhoff, 1980) and left. 1994 represents a typical low-water year. By late March, 1994, the lower ends Mud, Rock (Kusal) and Pine Creeks were reduced to intermittent pools and both chinooks and steelhead were trapped. Most individuals of earlier maturing cohorts, including winter-run and spring-run chinooks achieved sufficient size and left while the East-side tributaries were still flowing to the river. Few adipose-clipped fish big enough to be winter-run were seen after early March. Many fall-run chinooks were trapped by the early dry-down in Mud, Rock, and Pine Creeks this year. On the West side, Elder and Thomes Creek retained a connection with the river, although Elder was reduced to a trickle near the mouth. Later samples (3/31 and 4/4) from Thomes suggest that many of the larger size classes still present (trapped) in the East-side tributaries were no longer represented in Thomes, presumably having emigrated (Figure 16; compare Figures 10e and 12b). Both Thomes and Elder Creeks were still flowing on 5/14/94, but temperatures of 24°C at 11 am in Elder and 21.6°C at 11:30 am in Thomes suggest that late afternoon temperatures would exceed the thermal tolerance of chinook salmon in both streams. No salmon were captured, although 13 squawfish and 24 hardheads were captured in Thomes Creek. Sampling was not even attempted in Elder, where only a few very small minnows could be observed. Probably the creek had been completely dewatered prior to the rain of 4/9/94.

Even though temporarily trapped by low water, tributary juvenile salmonids may escape on the brief flow of a spring rain. On April 8, 1994, 369 chinook salmon, ranging in size from 70 to 105 mm, were captured in a *ca.* 50 m seine haul in an isolated pool at West Sacramento Avenue in Mud Creek (Figure 10de). That night and the next day a sufficient amount of rain fell to induce flow about 15 cm deep between pools. By April 13, 1994, Mud Creek pools were isolated again. A similar seine haul in the identical pool on April 13, 1994, yielded 10 chinook salmon. However, data from another Mud Creek pool suggests that larger juveniles, which perhaps have passed the period of migratory urge, may not take advantage of a similar opportunity for egress. On 4/24/94 a combination of rainfall and irrigation runoff caused a continuous flow from the confluence of Kusal Slough with Mud Creek to the river. The depth of water limited sampling in a pool below the Kusal confluence, but 15 chinooks, ranging in size from 70 to 115 mm, were captured. By 5/1/94, the pool was isolated again and 115 chinooks, ranging in size from 85 to 120 mm, were captured(Figure 10e). These fish were mostly larger than the ones that emigrated from the West Sacramento Avenue pool during a brief period of stream flow. Further investigation is needed regarding the relationship of size and other factors to out-migration from these small tributaries.

By mid-May, 1994, the creek reaches under observation were either reduced to isolated pools (Mud, Rock, Pine, Dye, Stony) or too warm for salmonids (Elder, Thomes). In Big Chico Creek the temperature was marginal (22°C on May 11) and while a few salmon remained, numbers were reduced to a few percent of April values.

Temporal changes in the size distribution of juvenile salmon at a site reflect three factors: growth of the fish, arrival of new (usually small) fish from downstream (or upstream if there was any spawning in the tributary), and emigration of juveniles as they reach smolt size. Average size at a site may stay the same or become smaller even though individual fish are growing. However, distinct modes can sometimes be followed and, in drier years, the streams become intermittent, preventing movement to or from a site and permitting clear growth estimates to be made (Table 4) although estimates from trapped fish may be low due to the sub-optimal living conditions associated with isolated pools. Fish, such as those in Stony Creek, captured from isolated, shrunken pools were usually observed to be in poorer condition and more easily stressed than those from open systems.

At many sites, Mud Creek, Kusal (Rock), Stony, the lower sites in Elder and Thomes, by far the majority of fish captured were chinooks (Tables 1 & 2). At other sites, perhaps where water was more permanent, large populations of minnows were found. Predatory fish were relatively uncommon at any of the sample sites. Some adult squawfish migrated into these streams for spawning but did not stay in the downstream reaches where the salmon were congregated. When returning to the river the squawfish mostly left with one high water event.

The most abundant predatory fish observed were steelhead, mostly one-year old fish (Table 2; Figures 18-21). Most were characterized by the clubbed fins typical of hatchery-reared fish. (41% of the steelhead observed were adipose-clipped fish raised by Coleman Hatchery and released at Ball's Ferry). A few (the three smaller ones observed on 1/10/94 in Mud Creek, the two observed in Elder Creek, and the one observed at the Piva Huller in Rock Creek) showed no sign of hatchery life. The 430 mm steelhead observed on 1/10/94 in Mud Creek appeared to be a returning spawner temporarily trapped by low water. It's dorsal fin rays were bent as though it had been reared in a hatchery. The three steelhead observed in Mud Creek in 1993 all appeared to be hatchery fish. One surely was, since it's adipose fin had been clipped. Big Chico Creek has a spawning population of steelhead. Of the steelhead observed in Big Chico Creek and Lindo Channel, only the two captured on 3/25/94 between the Mud Creek confluence and the Lindo Channel confluence showed the characteristic fin clubbing of hatchery fish (both had clipped adipose fins, confirming their hatchery origin). The four steelhead captured in Lindo Channel looked like wild fish. Numerous young-of-the-year steelhead were observed holding feeding stations in riffles in Upper Bidwell Park on 5/1/94, although only a few were captured. Surprisingly, young-of-the-year steelhead were also captured just above the confluence of Chico Creek with Mud Creek. Did these baby steelhead move into the creek from a spawning site in the river, or did some adult steelhead spawn in the lower end of the creek rather than migrate further upstream under this year's low flow conditions?

The wide range of sizes and scattering of modes of juvenile chinooks collected in 1994 (Figures 10-17) suggest that several races were represented in the tributaries. We observed adipose-clipped chinooks in two very different size categories. Large clipped fish, found in Mud, Rock, and Thomes Creeks, would fall into the winter-run size category and were carefully handled and released to avoid stress. Marked fish of a much smaller size category found found at later dates in Chico, Elder, and Thomes Creeks were collected and taken to Colleen Harvey, DFG, for tag analysis. She determined that they were fall-run fish from Coleman Hatchery which had been released on March 10, below the Red Bluff Diversion Dam. For the unmarked fish, one can attempt to deduce race on the basis of size. We compared our data with Frank Fisher's projected size ranges (Fisher, 1994) for the various races and classified all juveniles collected to race. Figure 24 shows the percentages of fish classified by size to each race in the different creeks. Some error may arise in this extension of Fisher's data if fish are growing at different rates in the tributaries than in the mainstem. For example, if tributary growth is faster, some fall run fish may have been classified as spring run and some spring-run fish may have been classified as winter-run. However, even with allowance for error, the percentage of spring-run and winter-run fish observed in some tributaries is surprising. Chico Creek would be expected to have spring-run salmon, since they spawn in upstream reaches, but Mud, Rock, Pine, Toomes, and Thomes Creeks also had a substantial percent of spring-run fish. Overall, 28%, of fish captured in the small tributaries would be classified by size as spring-run; higher by an order of magnitude than one would expect from the relative size of the runs in the Sacramento system. The same is true for the endangered winter-run. Several factors may contribute to this discrepancy.

First, temporary tributaries are rich in food for juvenile chinooks, containing abundant mayflies, midges and caddis flies. Because the streams are ephemeral, the insect populations are timed to the stream and to the little salmon. When the salmon arrive, the streams have only been running a short time, small, short-lived, opportunistic diptera are abundant, and longer-lived insects have recently hatched. Consequently, food in the right size range is available; as the salmon grow, so do the longer-lived insects like mayflies and stoneflies, remaining bite-sized. About mid March, the sucker and squawfish fry hatch, providing an additional rich food source. Stomach contents of salmon which died as a result of our sampling process were subsequently examined under a dissecting microscope. Of 92 examined, only one had an empty stomach. Even those collected from isolated pools where the water temperature was well above optimum had reasonable quantities of food in their stomachs. Aquatic stages of diptera, ephemeroptera, plecoptera, hemiptera and coleoptera and their adults and a miscellany of terrestrial insects were commonly eaten (Table 5). The juveniles seemed to specialize on a particular food type, often having eaten many individuals (Table 6).

Other habitat variables which might favor one race over another include temperature, which would be warmer during the day in small tributaries than in the reservoir-cooled river. From December through mid-April, the warmer temperatures in the tributaries would favor more rapid growth of juvenile chinooks. Later in the year tributaries become warm enough to be stressful. Predation is very much less in temporary tributaries, which have no resident fish fauna, but increases as the streams become lower and thus more accessible to wading birds. The chance of death from stranding as small tributaries dry also increases dramatically later in the season. Because of this seasonable variability, tributary rearing is a better strategy for winter and spring-run races which complete juvenile rearing between December and mid-April (See Table 7.) These races may have evolved a varied repertoire of rearing strategies. In the 1993-1994 season, DFG personnel operated a screw trap at Adam's dam in Butte Creek (well downstream of spring-run spawning). Figure 25 shows the number of juvenile chinooks they captured each month. By far the majority (80%) of spring-run down-migrants were captured early in the season at sizes less than 50 mm even though the 1993-1994 season had no significant flushing flows to move the fry. In years with winter storms, most spring-run juveniles may wash out as fry. Deliberate fry out-migration may be an evolutionary strategy to cope with the problems of fry wash-out and sub optimal winter rearing temperatures in natal streams. Temporary tributaries provide an attractive alternative rearing site for those fry.

The life strategy of steelhead does not seem to fit temporary tributaries. Early in the season, there is little food in the size range appropriate for a steelhead, except for the baby salmon. Later in the season, the insects and cyprinoid fry are big enough to be utilized. However, steelhead which try to remain in the tributary for an additional year of rearing will be subject to stranding, predation, and lethal temperatures unless they migrate far upstream. Most steelhead observed were clearly hatchery fish. Quite possibly, their presence in temporary tributaries is a phenomenon of hatchery release of yearling fish which are not ready to smolt and subsequently try to find some other habitat in which to complete the juvenile phase of their life cycle.

Projected Work

We would like to continue the study, under perhaps different weather conditions. We want to include additional tributaries, and refine the range and time of tributary use. We intend to begin looking at the ephemeral tributaries as soon as they begin flowing, and follow their populations until all salmonids have emigrated or the streams dry down. If we capture marked chinooks from , we would like to return some of them to Coleman Hatchery for positive identification.

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Table 1. Juvenile salmon and steelhead captured in Sacramento River tributaries in 1993.

Stream	km from river	Chinooks observed total	Chinooks observed adipose clipped	Steelhead observed total	Steelhead observed adipose clipped	total other species
Mud Creek	3.9-6.7	278	**9**	3	**1**	26
Kusal Slough	3.7	124	**5**	0	0	21
Toomes Creek	1.0 -1.6	85	**1**	0	0	many
Pine Creek	4.8	16	0	0	0	many

Table 2. Juvenile salmon and steelhead captured in Sacramento River tributaries in 1994. — Dates?

	km from river	Chinooks observed total	Chinooks observed adipose clipped	Steelhead observed total	Steelhead observed adipose clipped	total individuals other species
Big Chico Creek						
Mud Confluence	1.2	1300	**3**	6	**2**	202
Between Mud & Lindo	2.0	80	0	0	0	6
Lindo Confluence	3.8	48	0	0	0	102
Grape Way	5.5	3	0	0	0	0
Oak lawn		0	0	0	0	64
Mangrove-Manzanita (Lindo)		80	0	4	0	NR
Upper End Bidwell Park		3	0	5	0	NR
Mud Creek						
Chico Conf. to Kusal Conf.	2.3-3.2	410	**2**	16	**5**	104
West Sacramento Ave.	3.9	1390	**12**	38	**17**	84
Meridian	6.7	63	0	2	**1**	230
Bell	8.5	85	0	0	0	7
Nord	10.8	104	0	0	0	0
Esplanade	11.9	63	0	11	**6**	4
Upper Sample	13.1	7	0	0	0	1
Rock Creek (Kusal)						
W. Sac	3.8	111	**4**	77	**35**	3
Red Barn	5.9	61	0	8	1	30
Highway 32	7.0	76	**1**	0	0	0
Nord Gianella	10.7	1	0	0	0	1
Piva Huller	12.8	53	**1**	1	0	11
Highway 99	17.4	13	0	0	0	12

Table 2. (Continued)

	km from river	Chinooks observed total	Chinooks observed adipose clipped	Steelhead observed total	Steelhead observed adipose clipped	total individuals other species
Pine Creek						
Nord Gianella	6.0	138	0	2	2	34
Wilson Landing	7.8	129	0	4	2	4
Pool 1/2 Mi above Wilson	8.6	57	0	2	2	11
Bennett	10.4	40	0	0	0	18
Cana	13.4	12	0	0	0	0
Singer Creek	22.1	1	0	0	0	0
Deer Creek						
Highway 99	4.6	195	0	0	0	22
Toomes Creek						
Highway 99	1.6	211	0	0	0	63
Vina Tehama Road	2.5	13	0	0	0	1
Dye Creek						
end of 7th Ave	2.0	101	0	0	0	many
Elder Creek						
Lower samples	0.5	239	4	0	0	40
end of levy road	1.8	144	0	0	0	5
Gerber downstream	3.7	108	0	0	0	200
TC Canal	4.8	129	0	0	0	116
Highway 99 W	5.8	0	0	2	0	41
Upper end of levy	7.0	0	0	0	0	many
Thomes Creek						
Hall Road	2.7	161	4	0	0	251
Fox's Sand	3.4	7	1	0	0	6
Hwy. 99 W	7.0	30	0	0	0	99
Rawson Road	11.5	4	0	0	0	104
Stony Creek						
Near Mouth	0.3	166	0	0	0	34
Big Bend Dump	1.3	182	0	6	1	25
Nature Conservancy	1.6	288	0	1	1	3
Highway 45	4.8	56	0	0	0	3

Table 3. Temporal changes in observation of marked chinook juveniles in Spring, 1993.

date	Site	percent marked
3/31/93	Mud Creek	4.9
4/8/93	Kusal Slough	4.0
4/22/93	Mud Creek	2.4
4/28/93	Toomes Creek	1.2

Table 4. Growth estimates for juvenile chinook salmon at selected tributary sites.

Site	Figure	Period	Rate (mm/day)
Kusal at W. Sac.	11b	Mid March 94	0.6
Mud at W. Sac.	10c	Mid March 94	0.6
Mud at W. Sac.	10d	Mar 23 - April 8, 94	0.63
Chico near Mud	9c	Mar 25 - April 8, 94	0.86
Mud at W. Sac.	4	Late March 90	0.8
Mud at W. Sac.	4	Early April 90	1.4
Mud at W. Sac.	4	Mid April 90	0.7
Stony at TNC	17b	Mar 2 - April 10, 94	0.41

↑ What is growth rate for river juveniles? (in these time periods)

Table 5. Percent of tributary juvenile chinooks which ate particular foods (N=92).

Macro Aquatic		Micro Aquatic		Terrestrial	
Midge Larvae	55	Cladoceran	11	Midge Adult	27
Midge Pupae	47	Ostracod	10	Blackfly Adult	17
Mayfly	29	Copepod	9	Aphid	14
Stonefly	16			Springtail	11
Blackfly	11			Mayfly Adult	7
Boatman	11			Ant	4
Beetle Larva	10			Spider	3
Small Fish	8			Beetle Adult	2
Dancefly	2			Beetle Grub	2
Caddis	1			Stonefly Adult	1
Damselfly	1			Moth	1
Crayfish	1			Grasshopper	1
				Leafhopper	1
				Oligochaete	1
TOTAL	**86**	**TOTAL**	**14**	**TOTAL**	**52**
EMPTY	1				

Table 6. The number of food items eaten per juvenile chinook by fish which selected any of a particular food category (N=55).

	fish	Number eaten / fish
Macro Aquatic	42	21.9
Micro Aquatic	13	306.8
terrestrial	21	5.19

Table 7. Relative conditions of alternative rearing habitats for different races of chinook salmon.

Winter-Run

	Temperature	Food	Predation	Stranding	Score
Main river	+	+	- -	0	0
Valley Tribs	++	++	-	-	2
Delta	++	++	- -	0	2

Spring-Run

	Temperature	Food	Predation	Stranding	Score
Natal stream	+	+	-	0	1
Main river	+	+	- -	0	0
Valley Tribs	++	++	-	-	2
Delta	++	++	- -	0	2

Fall-Run

	Temperature	Food	Predation	Stranding	Score
Main river	++	+	- -	0	1
Valley Tribs	+	++	-	-	1
Delta	++	++	- -	0	2

Late-fall-Run

	Temperature	Food	Predation	Stranding	Score
Main river	++	+	- -	0	1
Valley Tribs	-	++	- -	- -	-3
Delta	++	++	- -	0	2

← What does this score mean? symbols? -- vs. - ++ vs. +

Figure 1. Juvenile chinook salmon observed in Mud Creek in Spring, 1984.

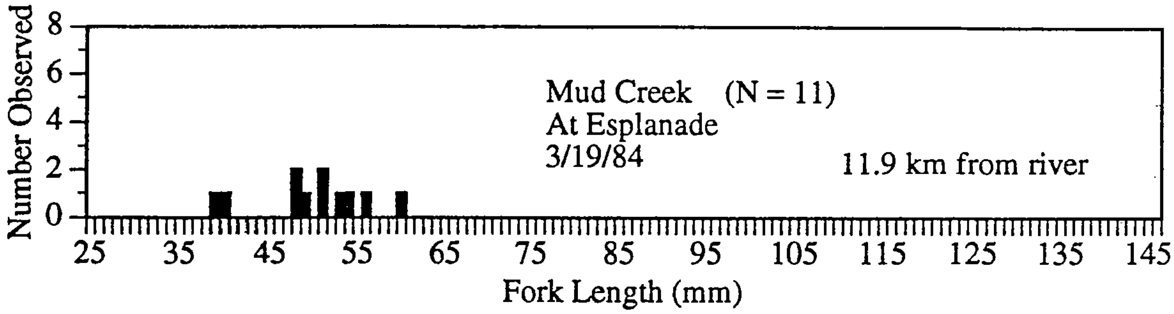


Figure 2. Juvenile chinook salmon observed in Mud and Rock Creeks in Spring, 1988.

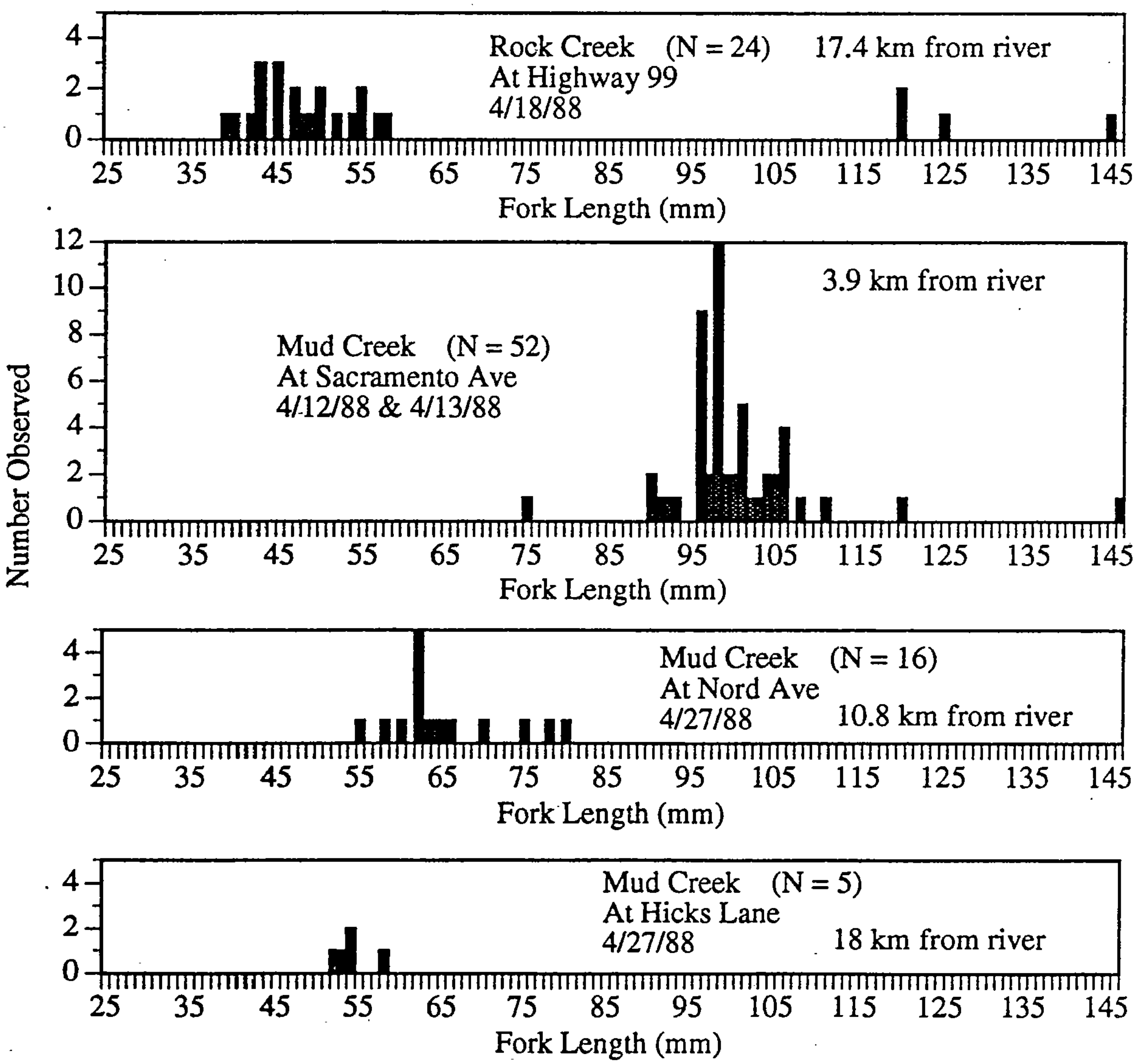


Figure 3. Juvenile chinook salmon observed at the mouth of Big Chico Creek and in Kusal Slough and Mud Creek on March 19, 1990.

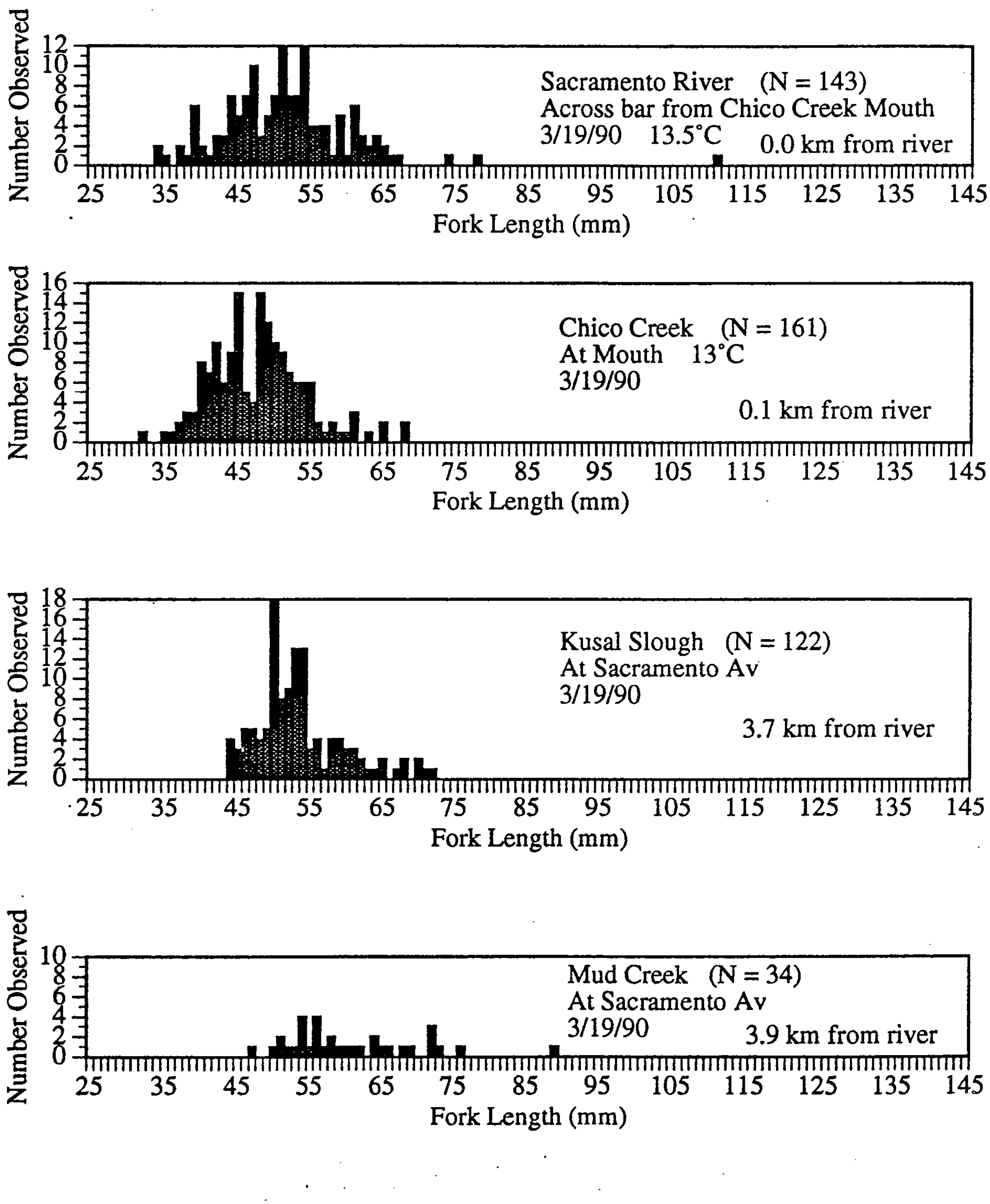


Figure 4. Juvenile chinook salmon observed in Mud Creek in Spring, 1990.

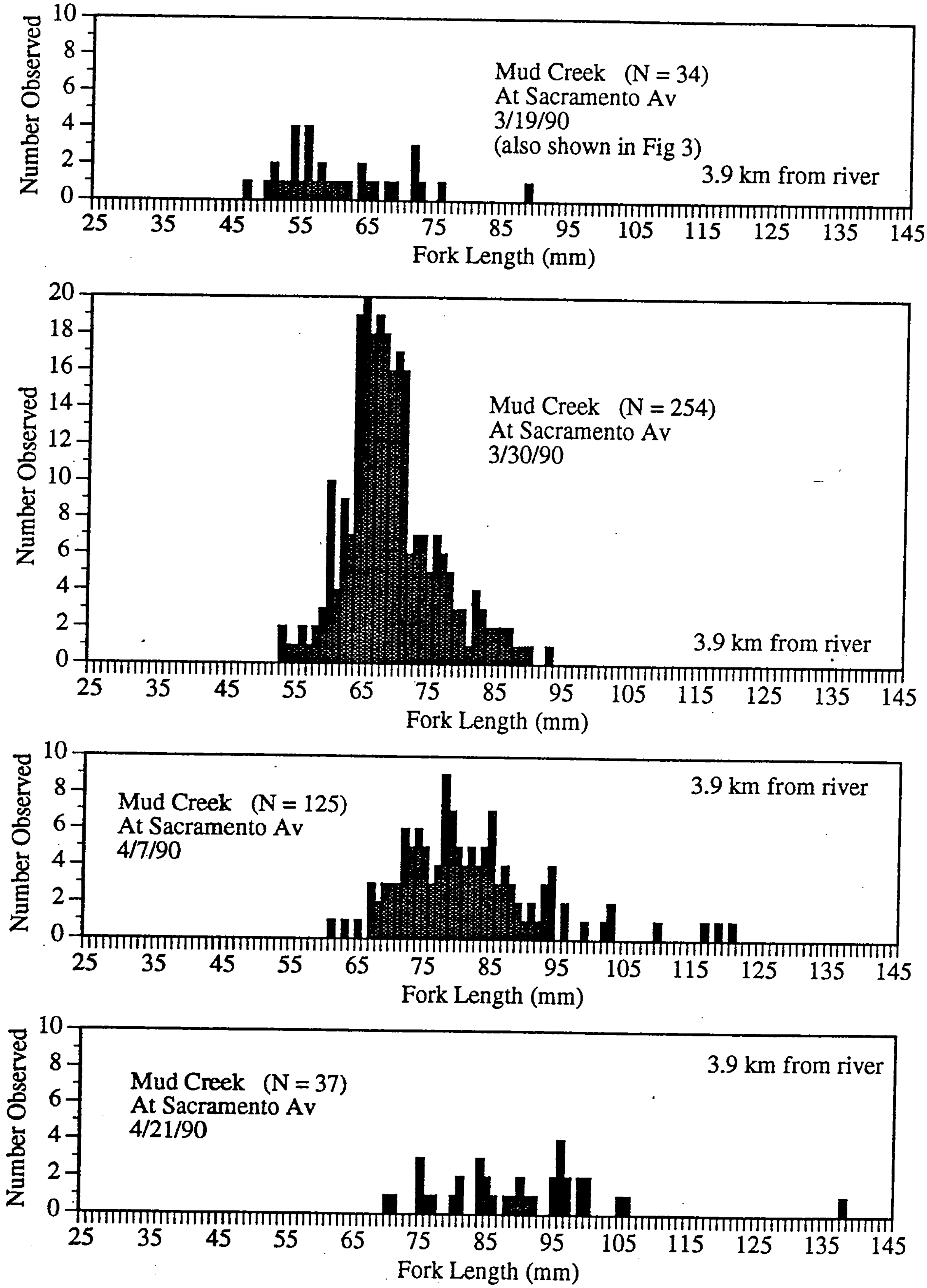
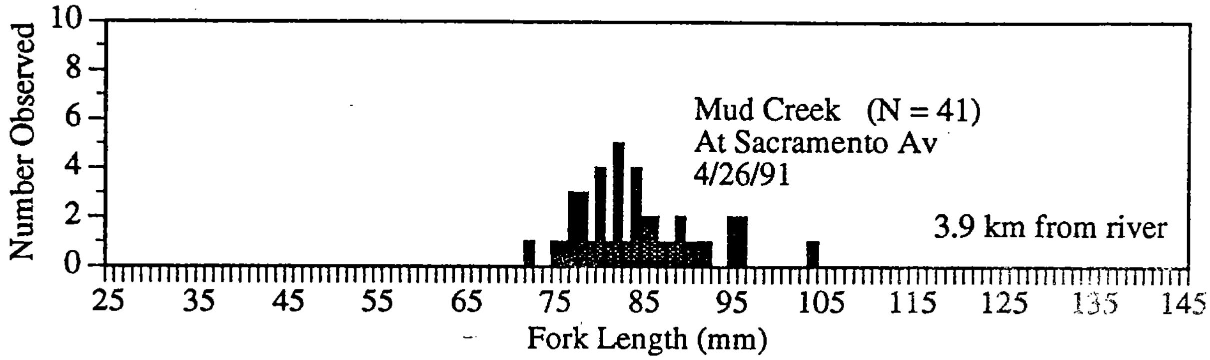


Figure 5. Juvenile chinook salmon observed in Mud Creek in Spring, 1991.



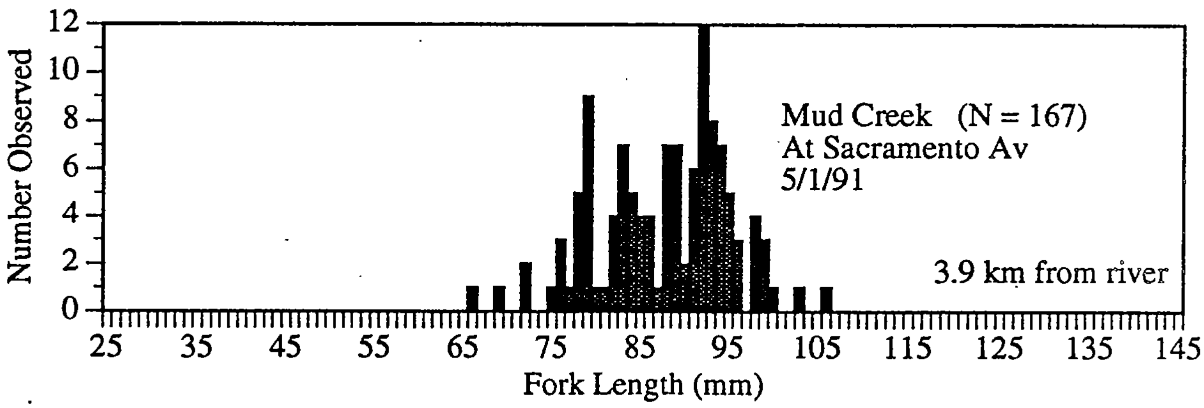


Figure 6. Juvenile chinook salmon observed in Mud Creek in Spring, 1993.

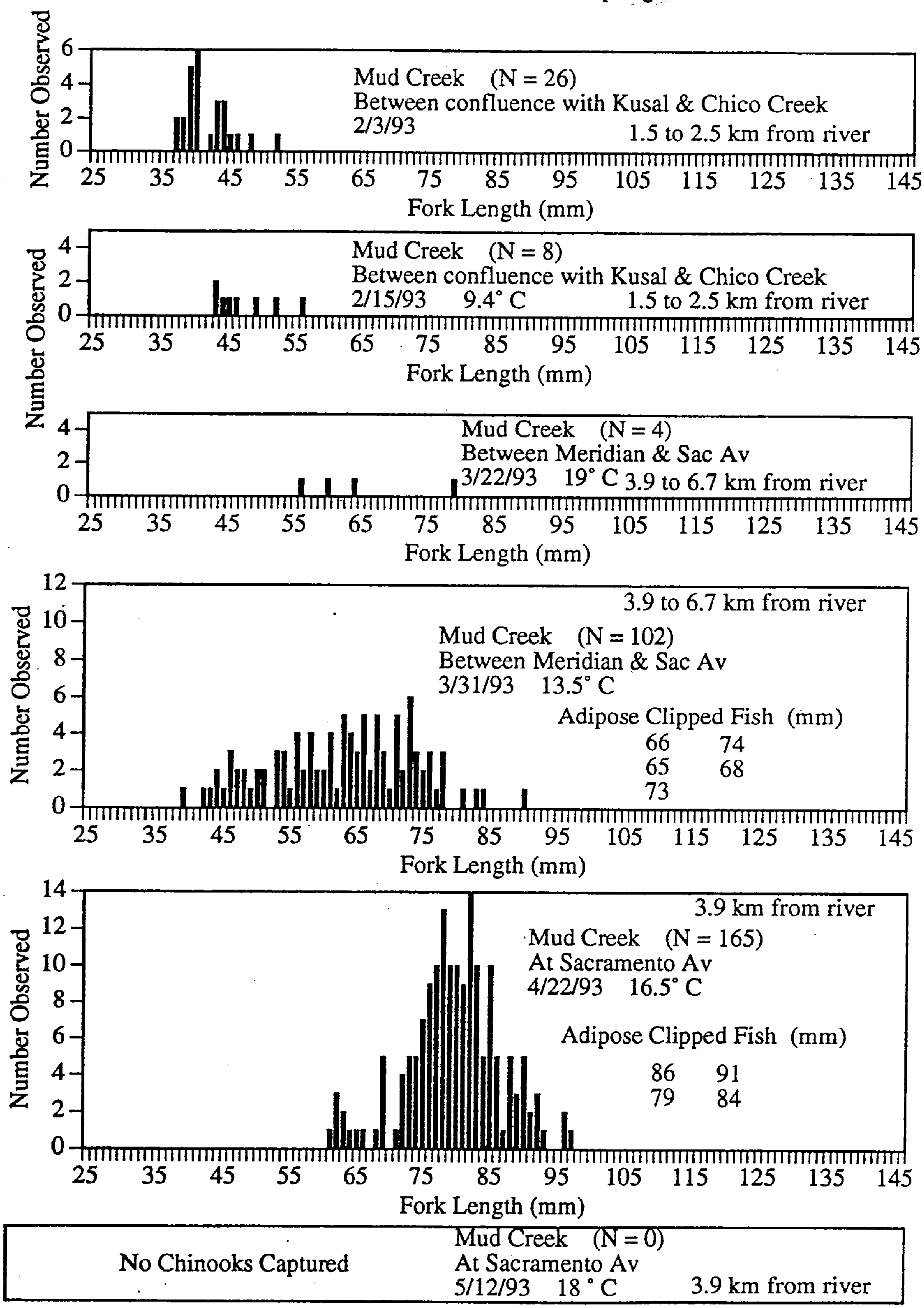
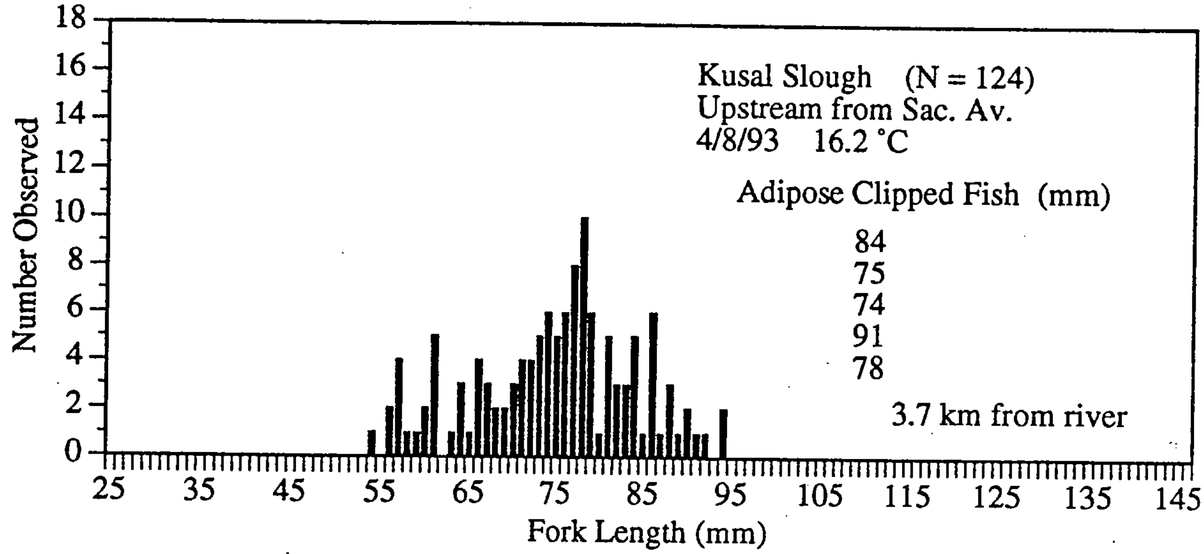


Figure 7. Juvenile chinook salmon observed in Kusal Slough (Rock Creek) in Spring, 1993.



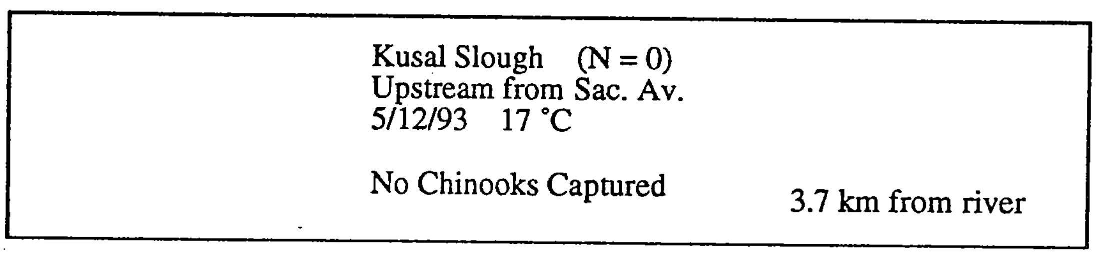
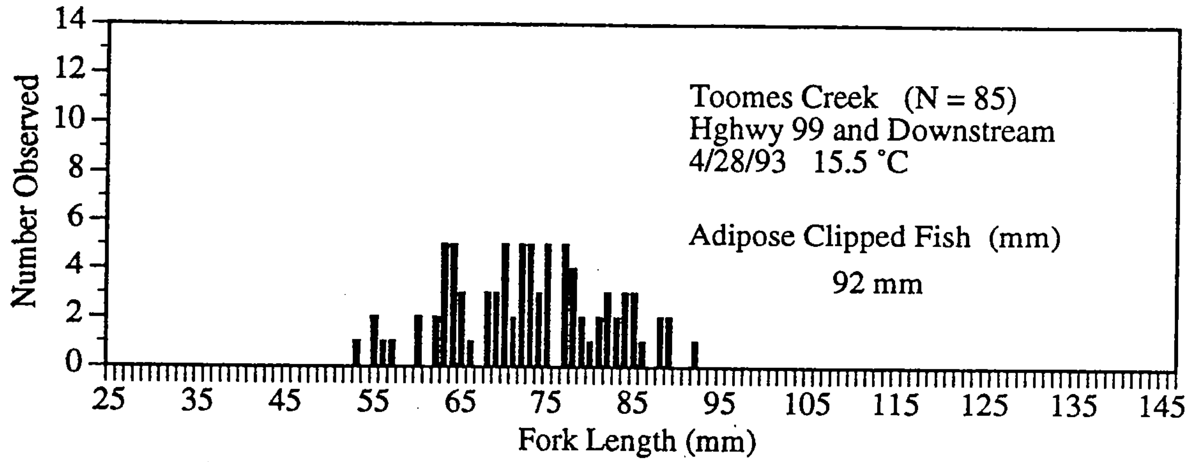
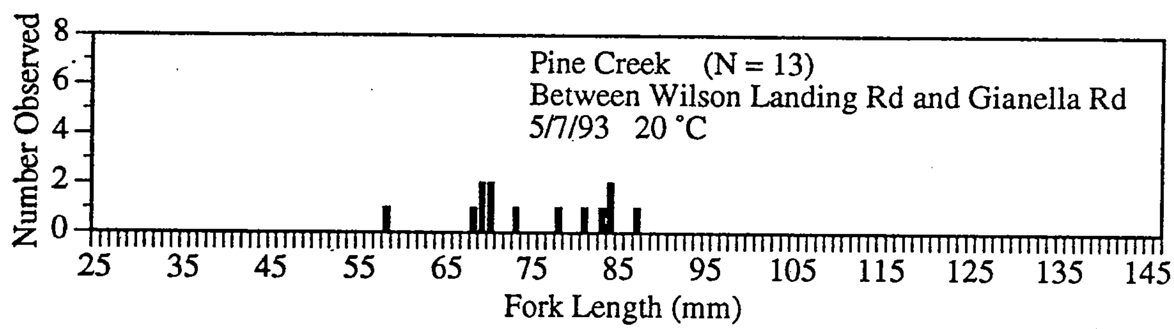


Figure 8. Juvenile chinook salmon observed in Toomes and Pine Creeks in Spring, 1993





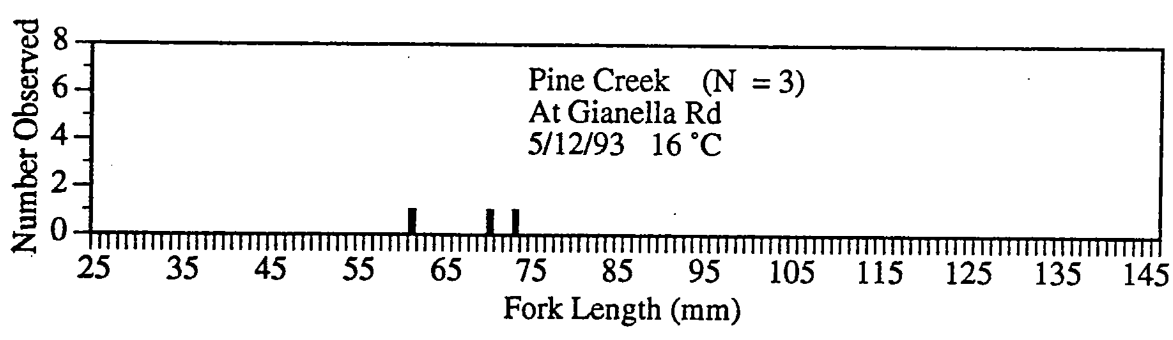
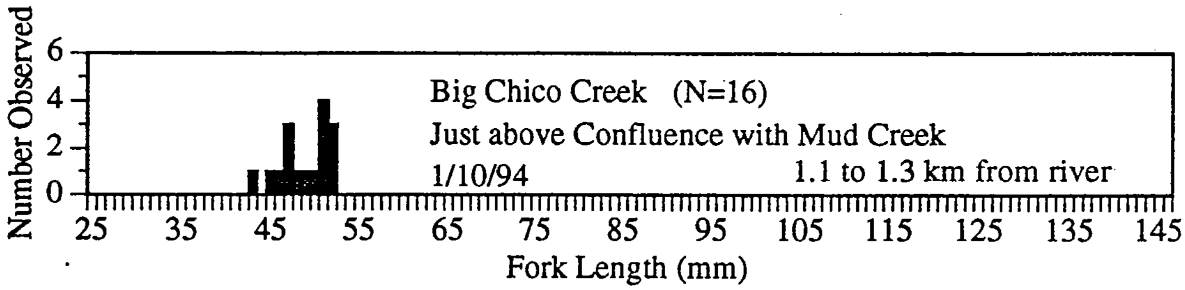
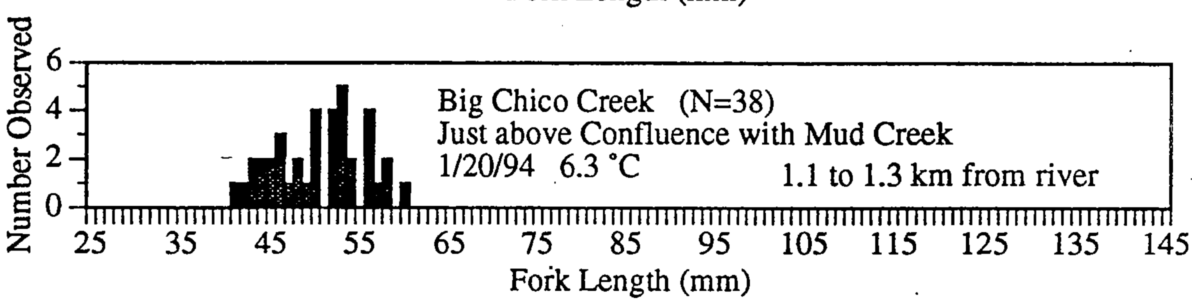
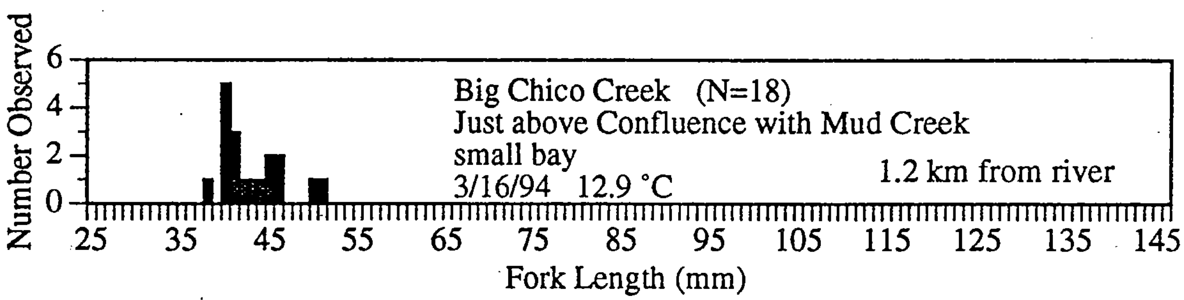


Figure 9. Juvenile chinook salmon observed in Big Chico Creek in Spring, 1994.







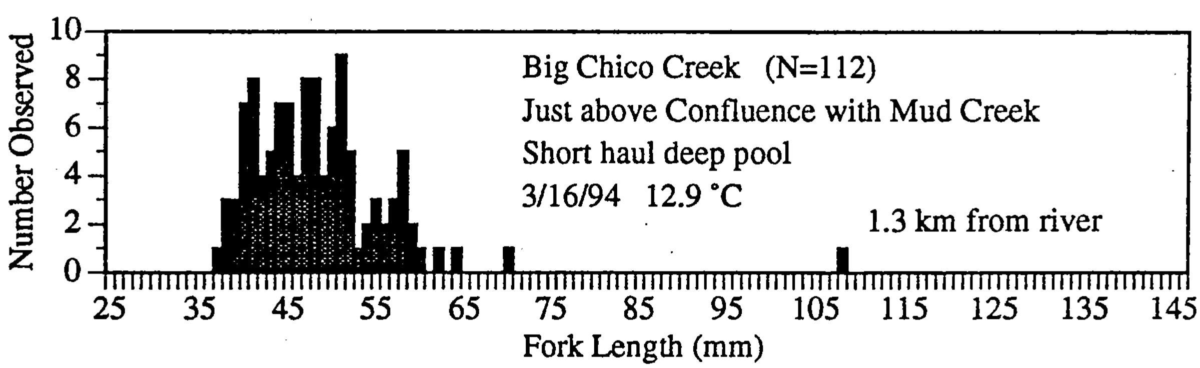
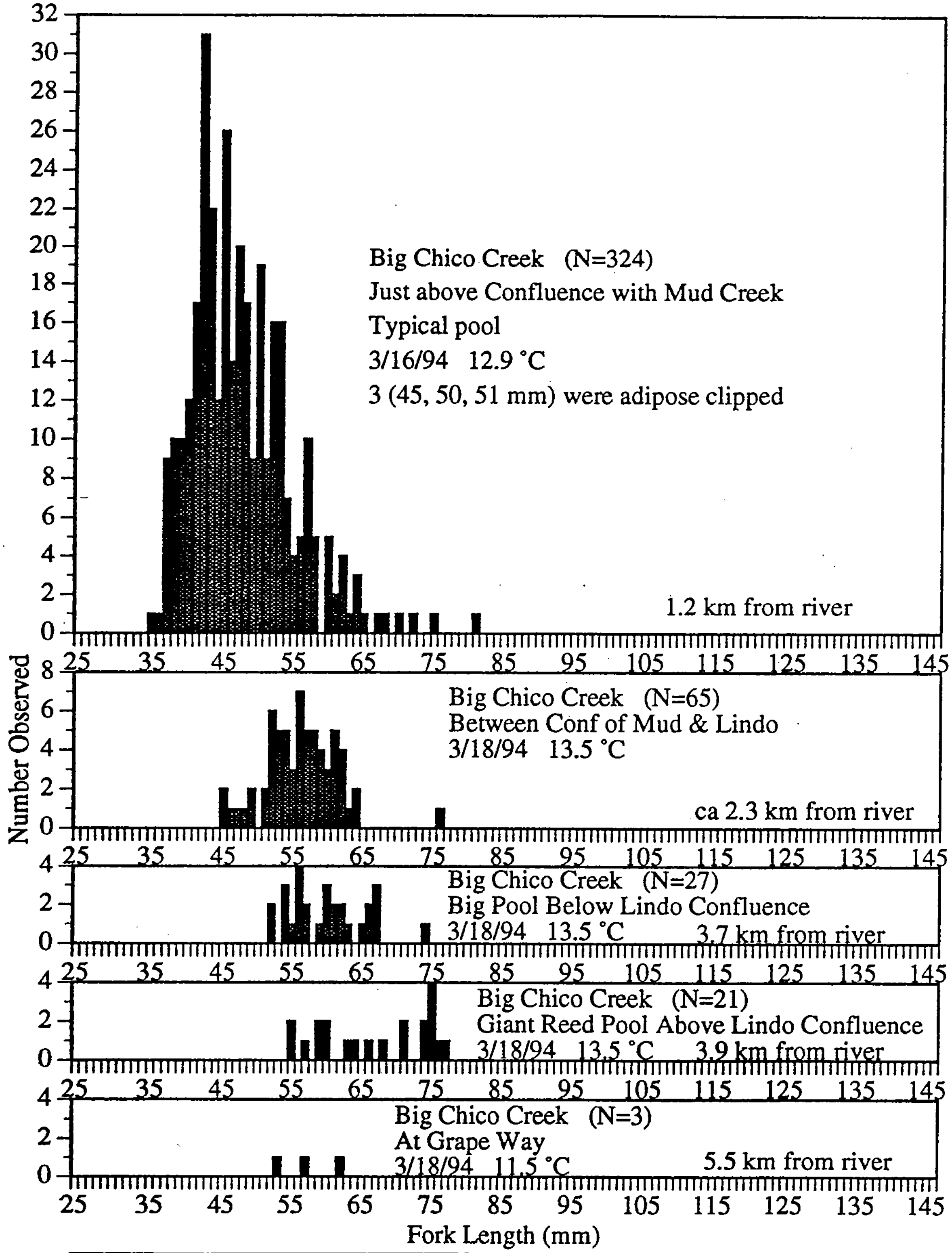


Figure 9b. Juvenile chinook salmon observed in Big Chico Creek in Spring, 1994 (cont.).



Big Chico Creek (N=0)
At Oaklawn Ave.
3/18/94 11.5 °C

47 Hardheads and 17 Squawfish
No Salmon
ca 7 km from river

Figure 9c. Juvenile chinook salmon observed in Big Chico Creek in Spring, 1994 (cont.).

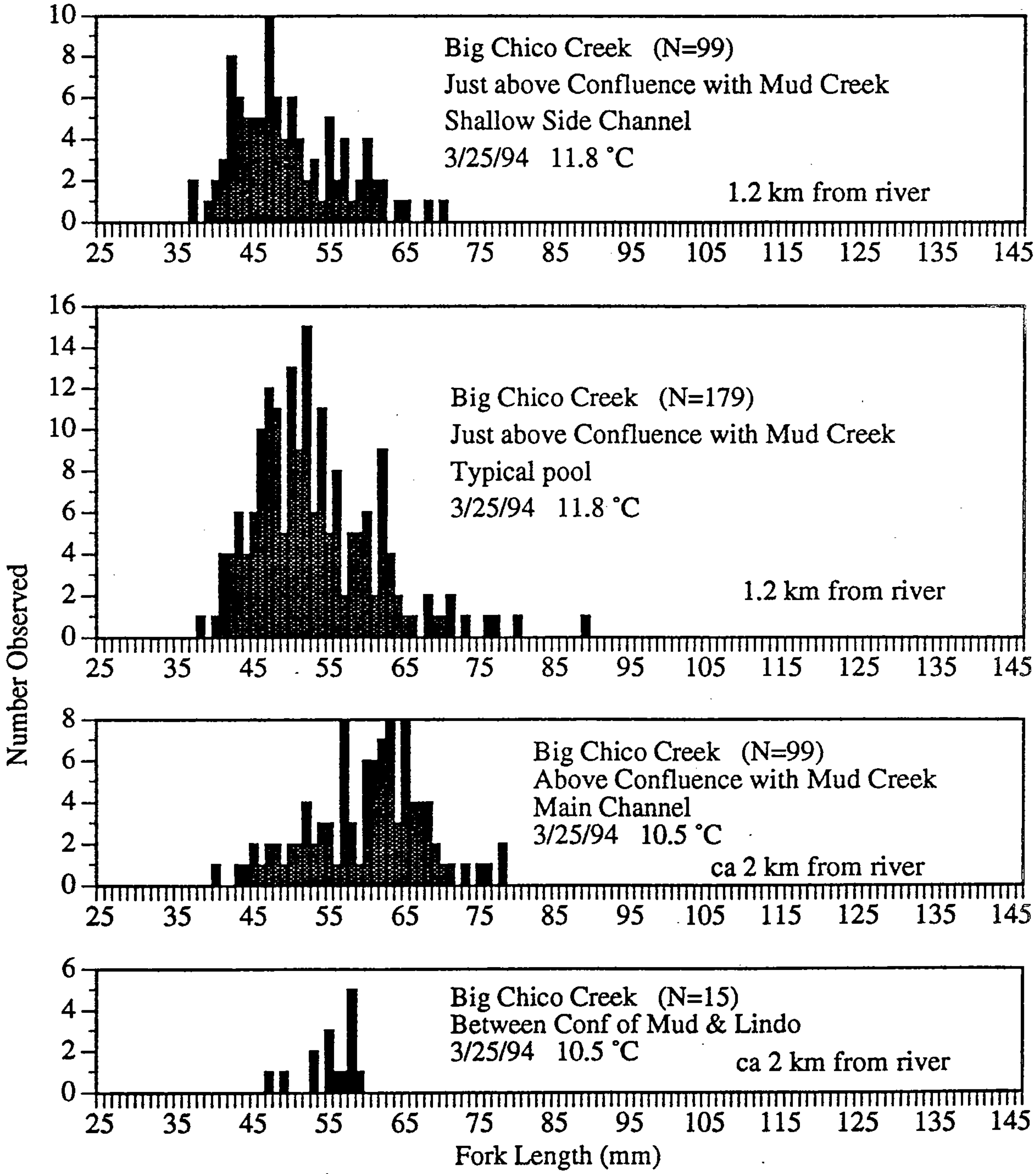


Figure 9d. Juvenile chinook salmon observed in Big Chico Creek in Spring, 1994 (cont.).

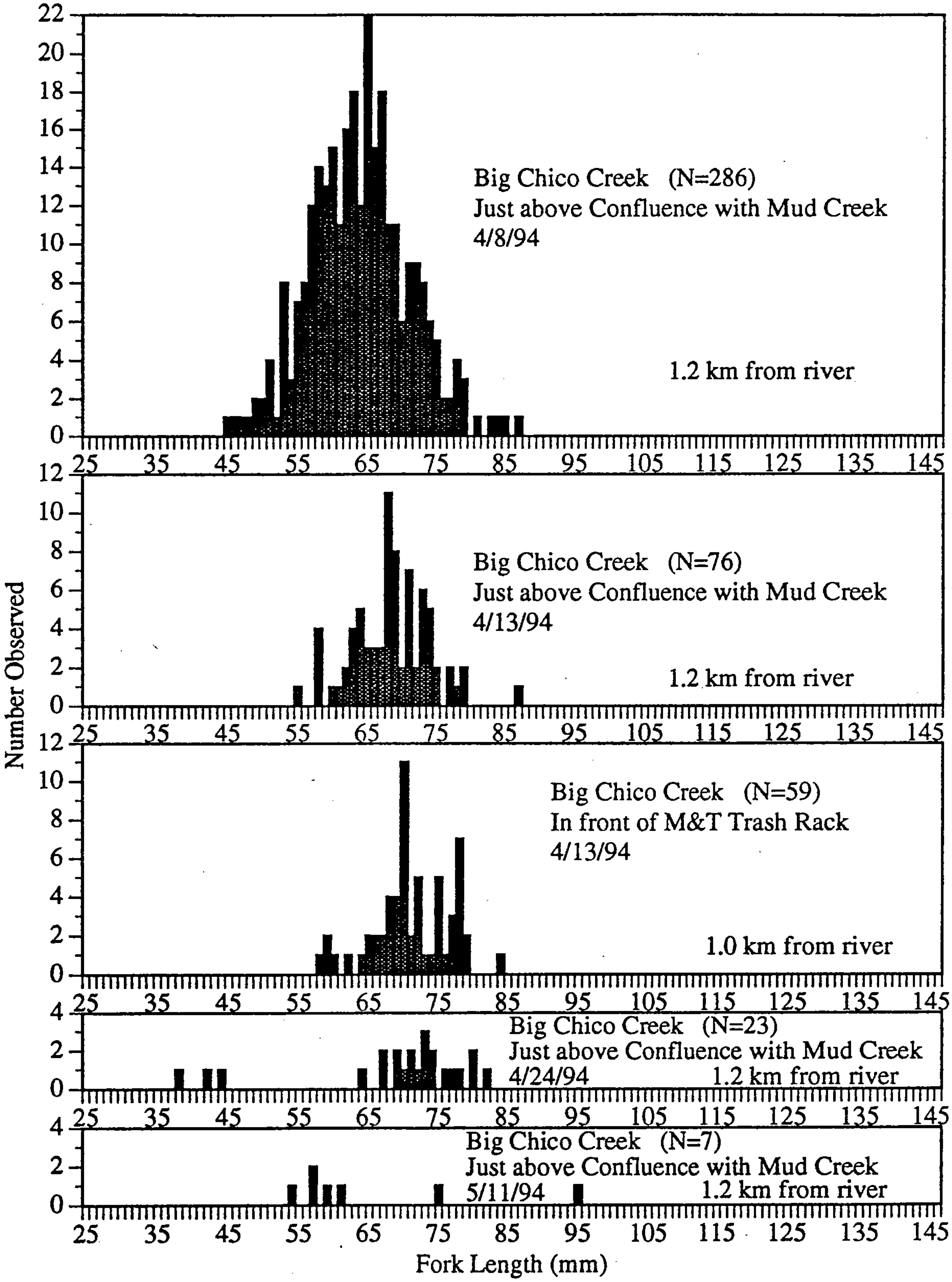


Figure 10. Juvenile chinook salmon observed in Mud Creek in Spring, 1994.

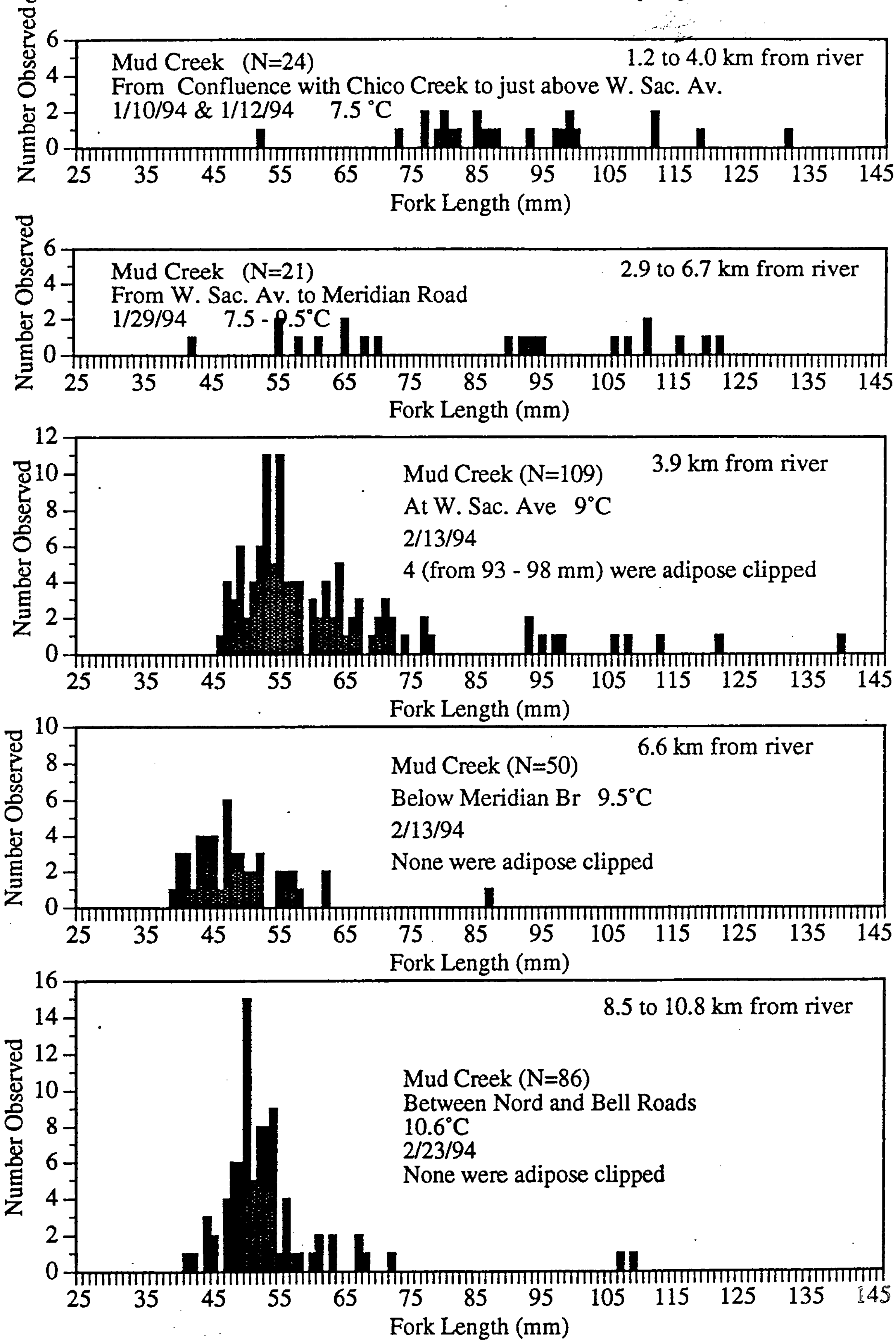


Figure 10b. Juvenile chinook salmon observed in Mud Creek in Spring, 1994 (cont.).

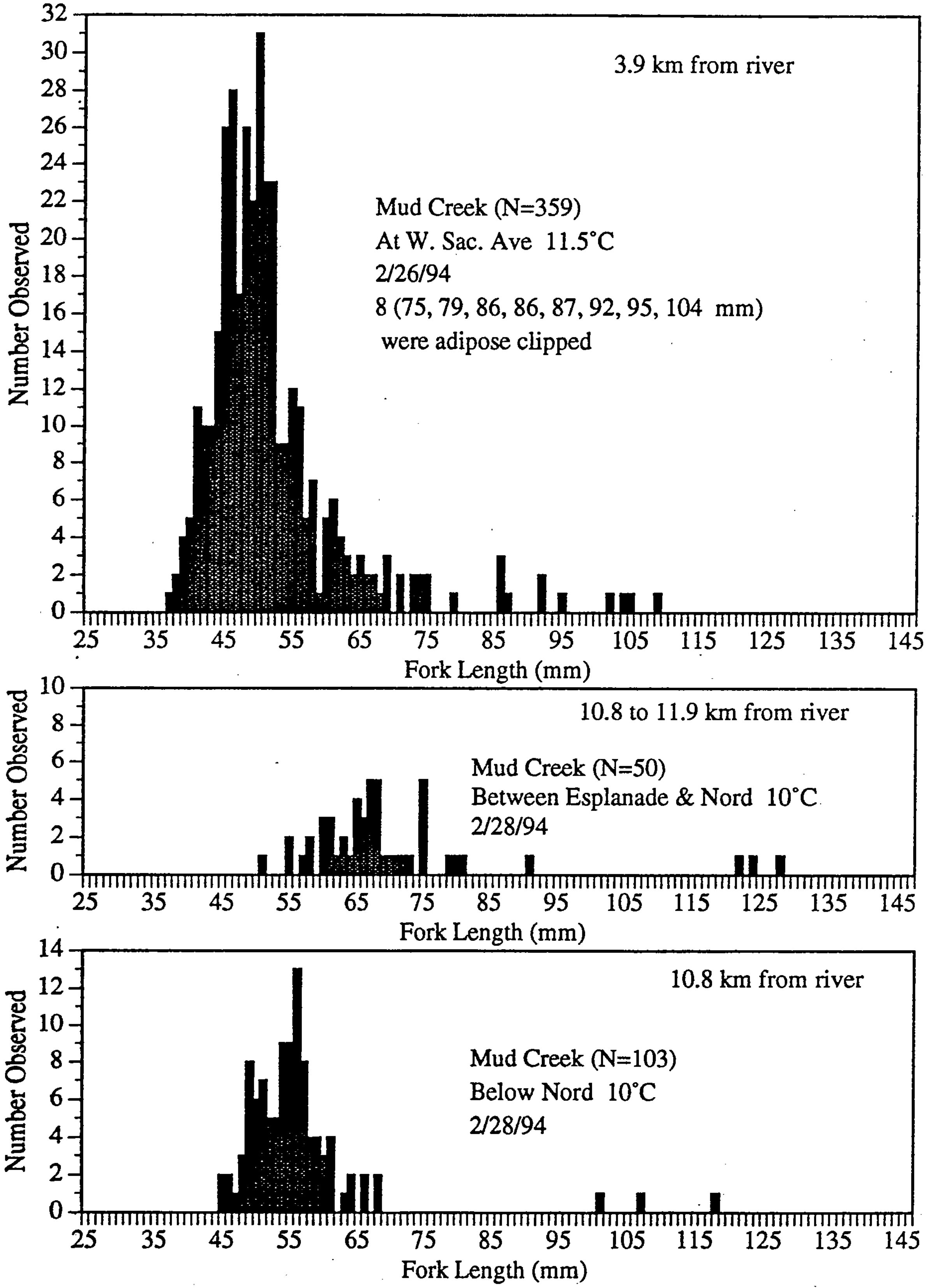


Figure 10c. Juvenile chinook salmon observed in Mud Creek in Spring, 1994 (cont.).

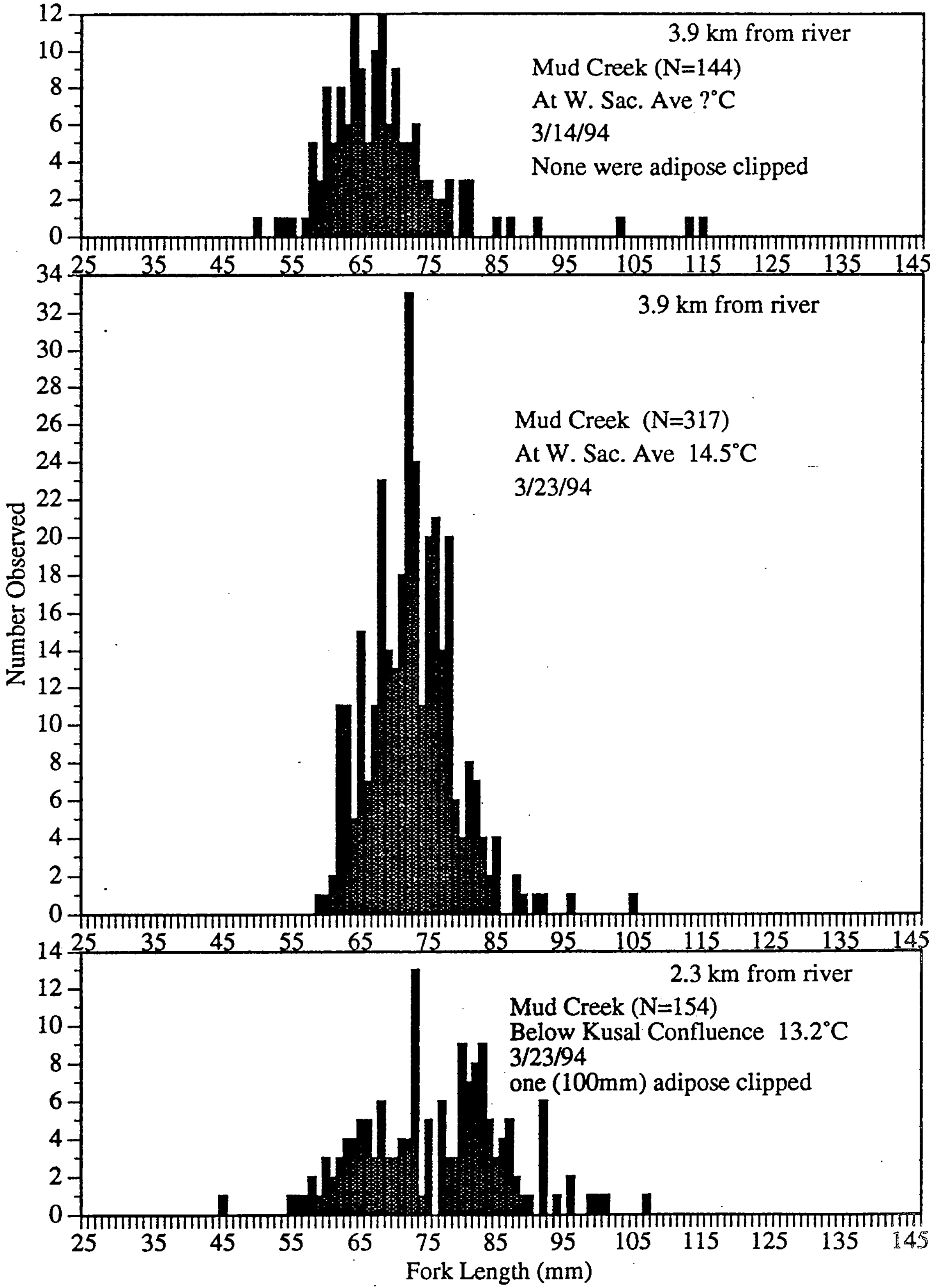


Figure 10d. Juvenile chinook salmon observed in Mud Creek in Spring, 1994 (cont.):

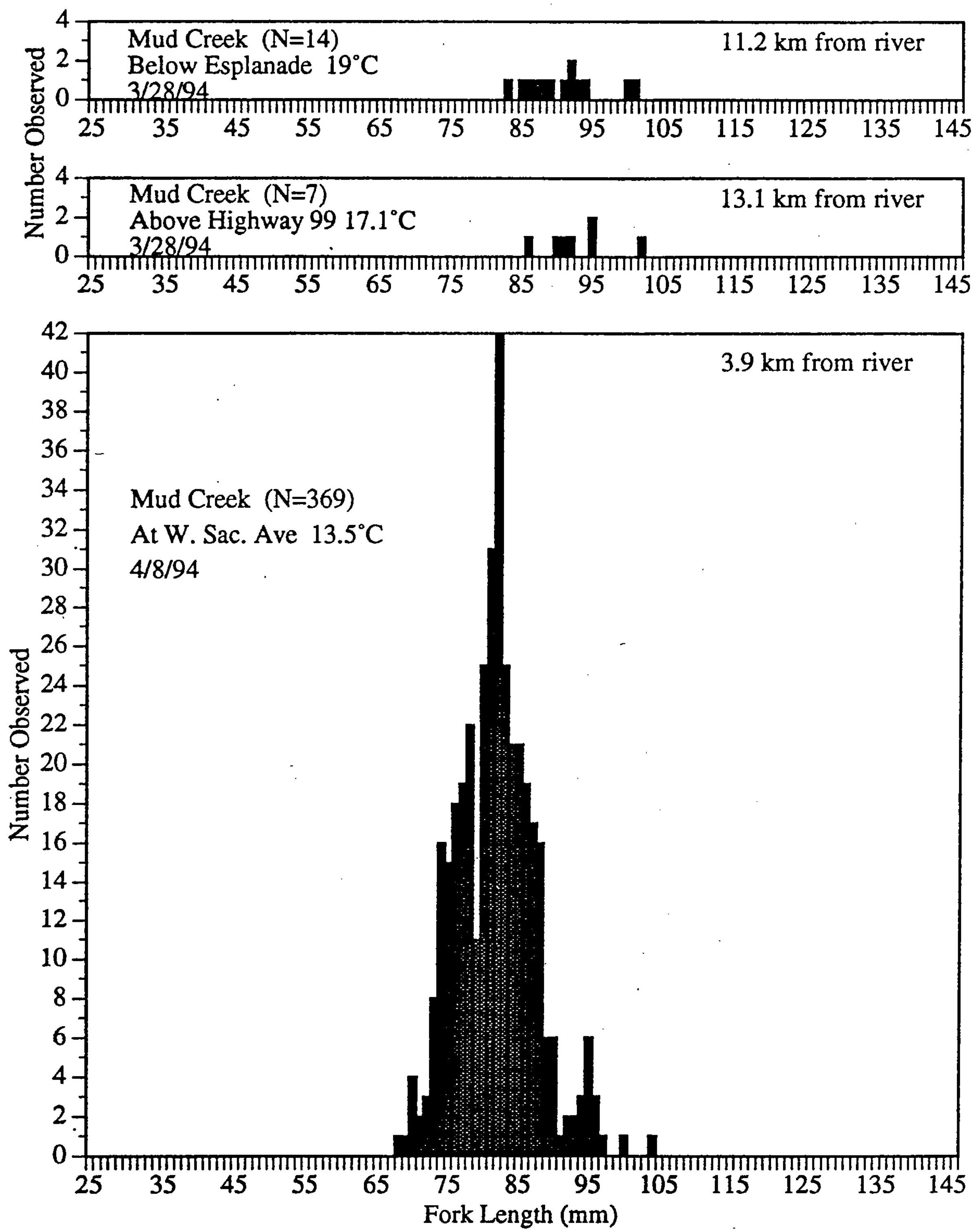


Figure 10e. Juvenile chinook salmon observed in Mud Creek in Spring, 1994 (cont.).

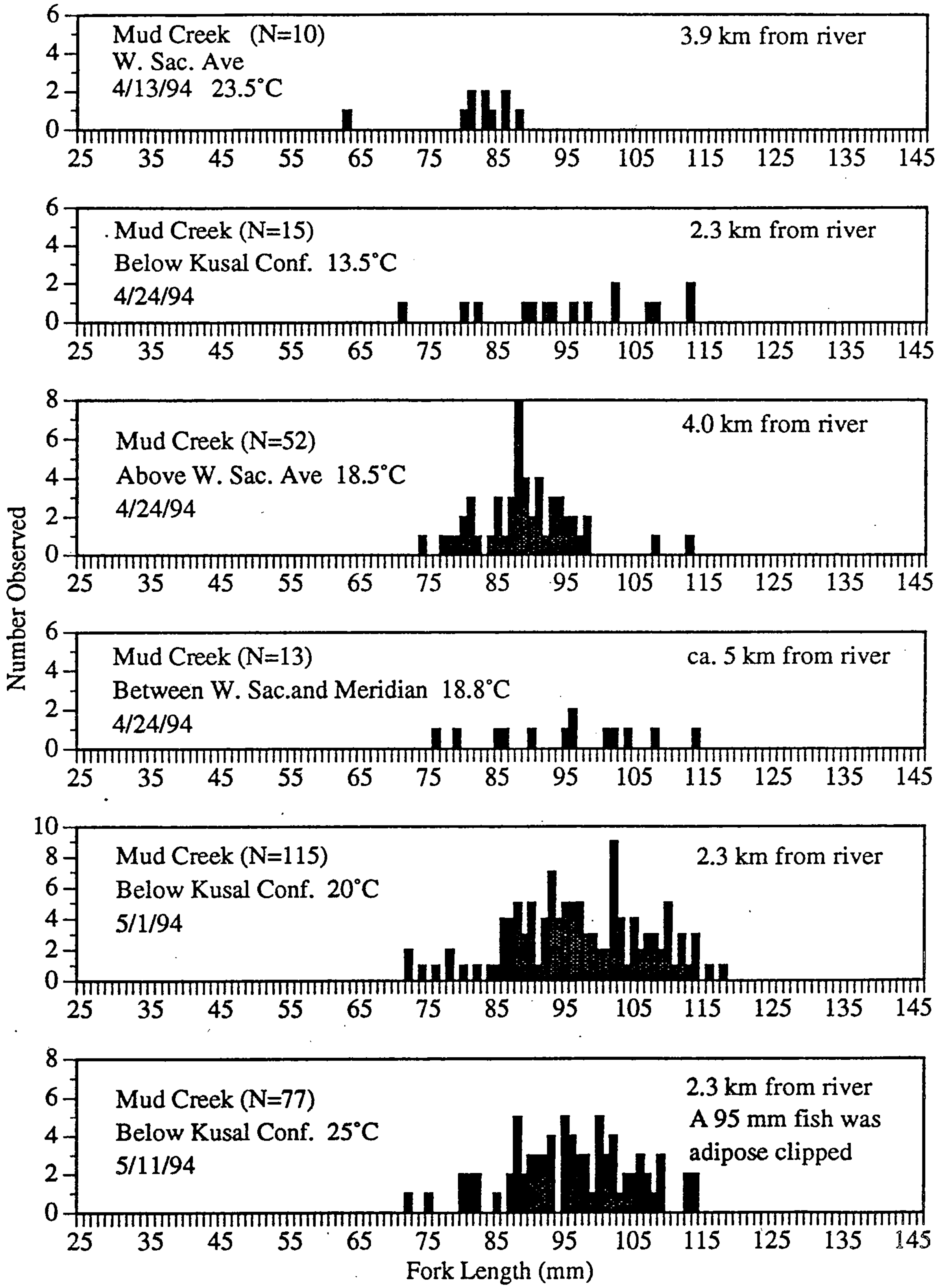


Figure 11. Juvenile chinook salmon observed in Kusal Slough (Rock Creek) in Spring, 1994.

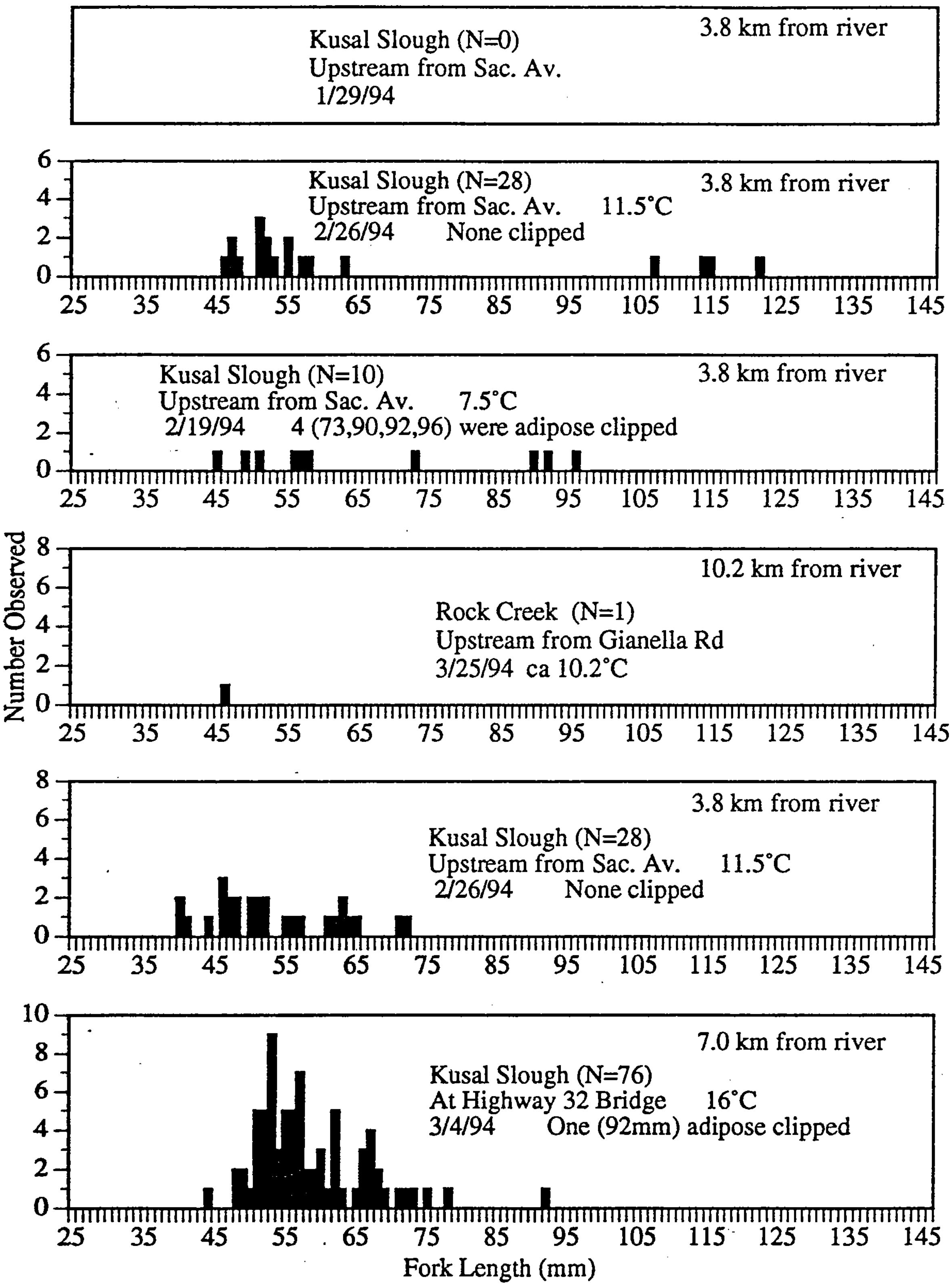


Figure 11b. Juvenile chinook salmon observed in Kusal Slough (Rock Creek) in Spring, 1994 (cont.).

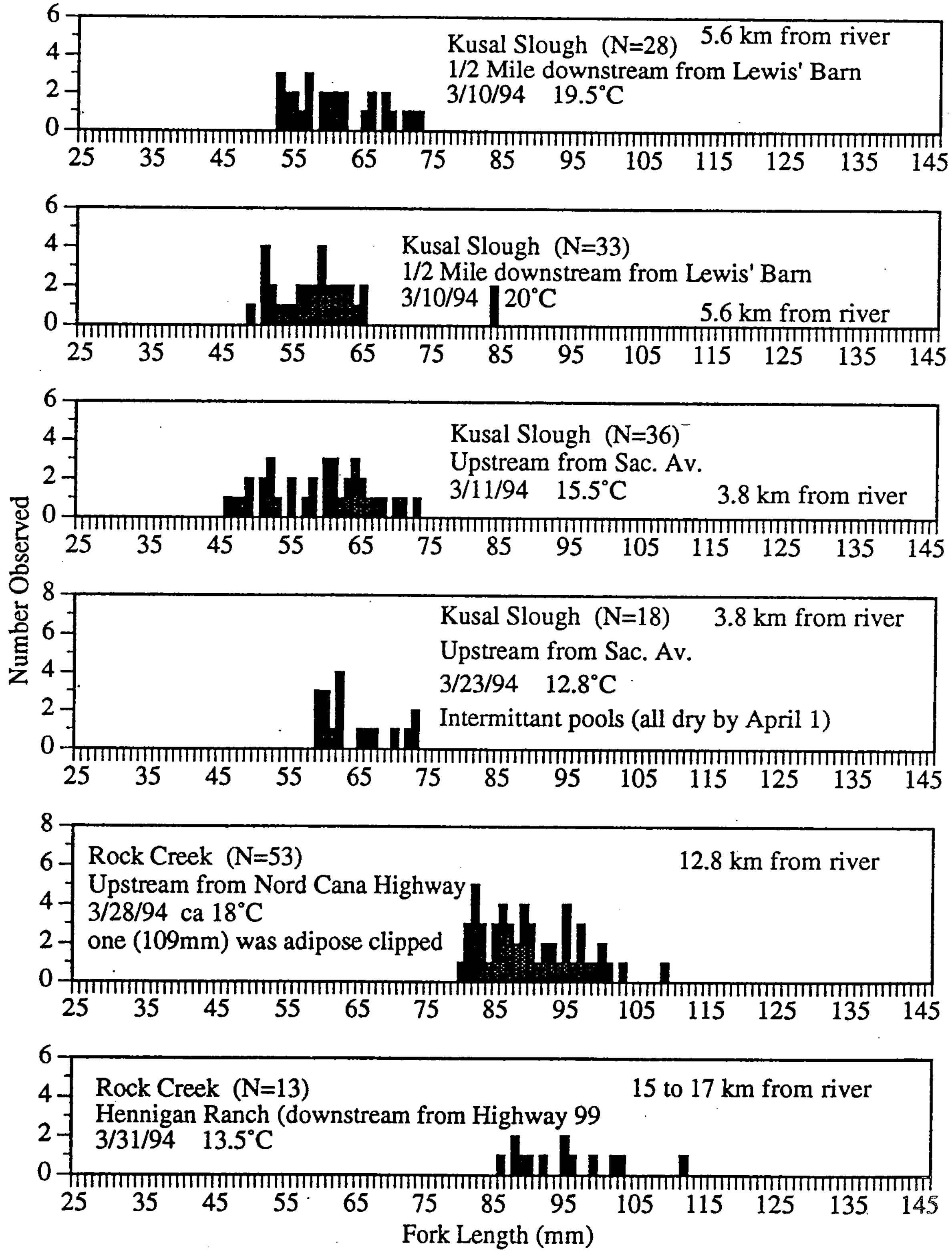


Figure 12. Juvenile chinook salmon observed in Pine Creek in Spring, 1994.

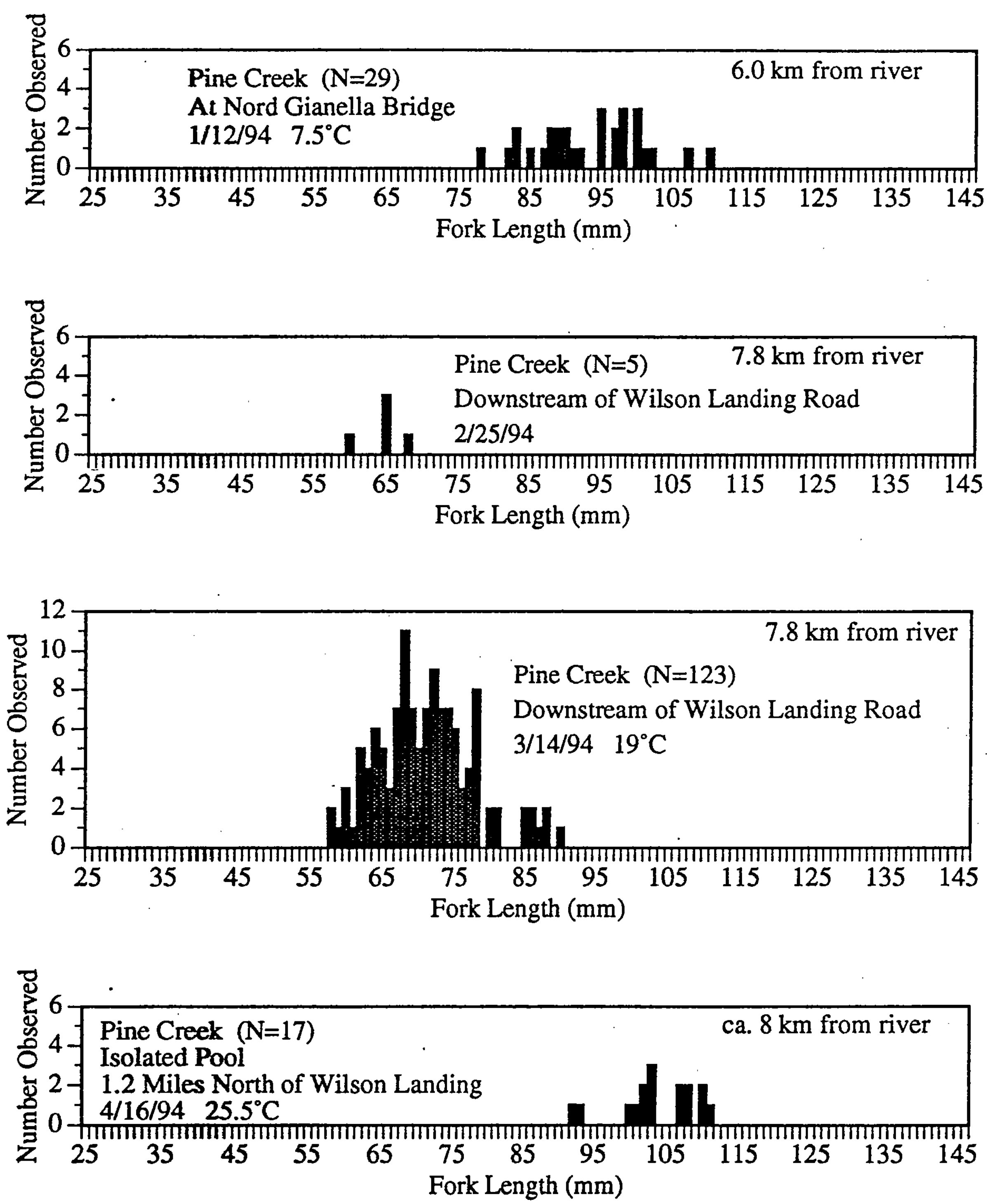


Figure 12b. Juvenile chinook salmon observed in Pine Creek in Spring, 1994 (cont.).

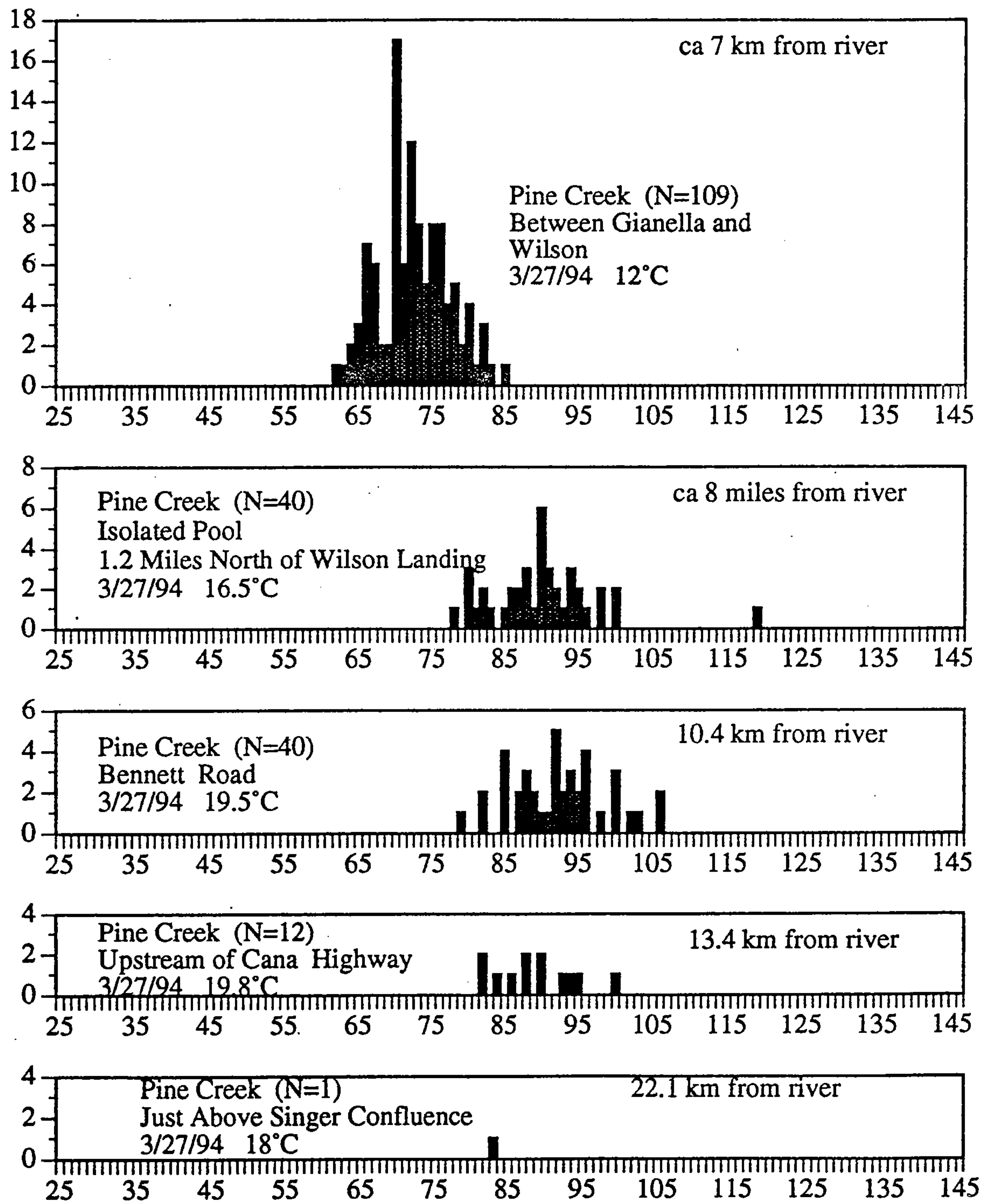


Figure 13. Juvenile chinook salmon observed in ToomesCreek in Spring, 1994.

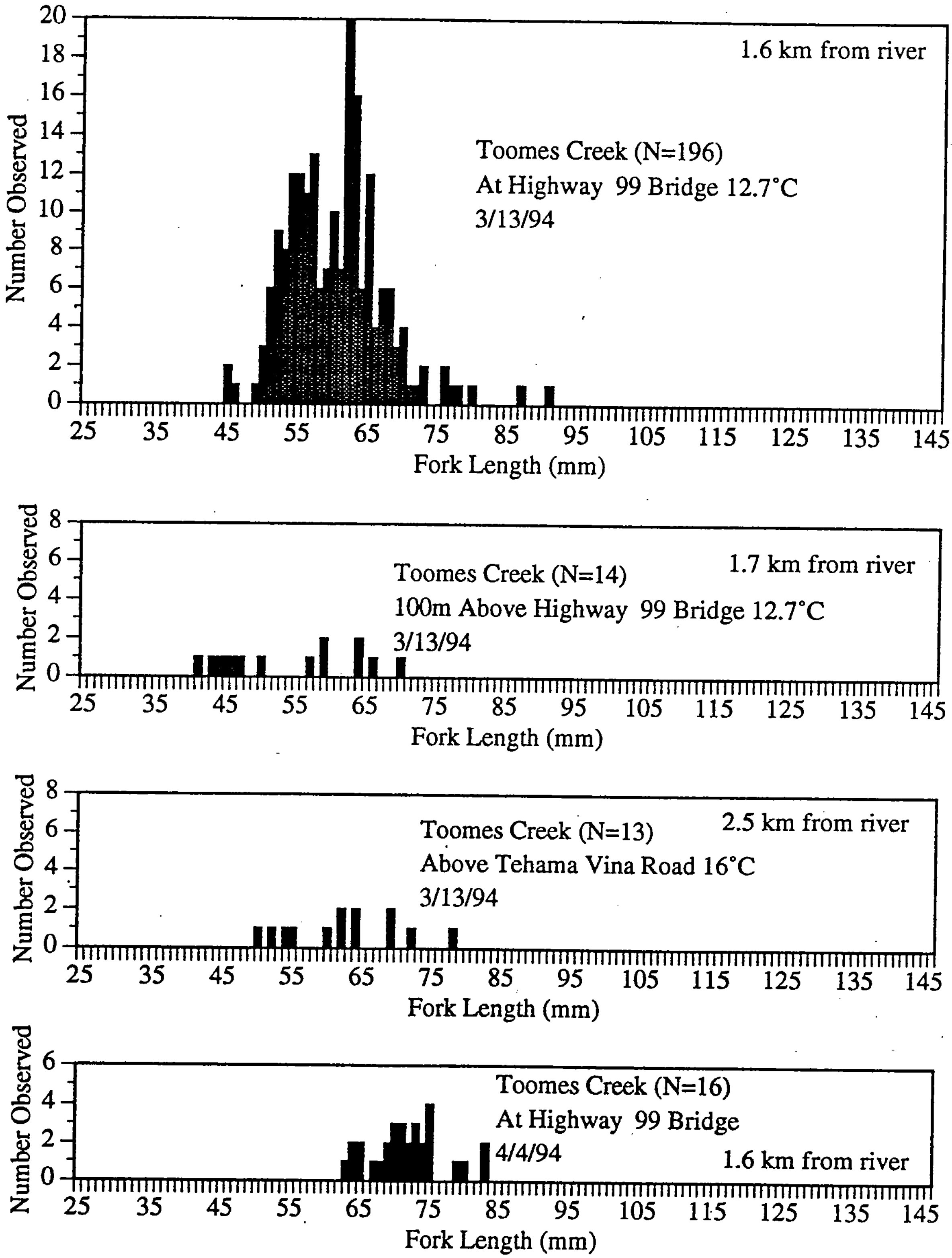
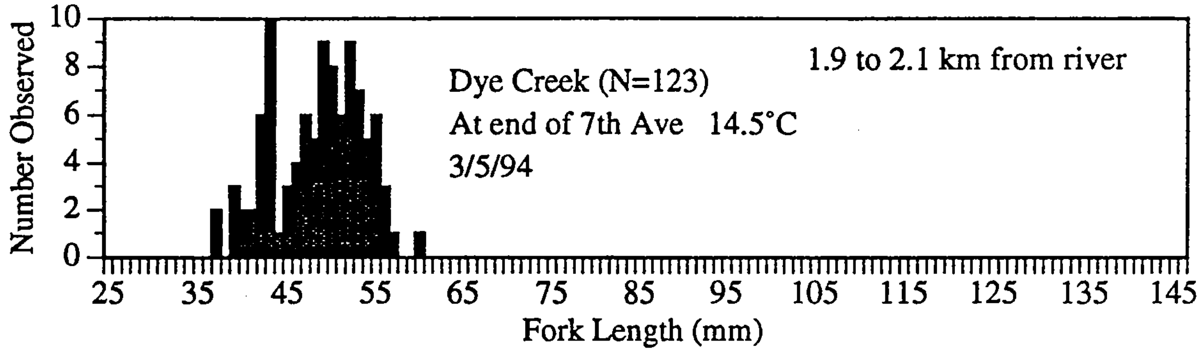


Figure 14. Juvenile chinook salmon observed in DyeCreek in Spring, 1994.



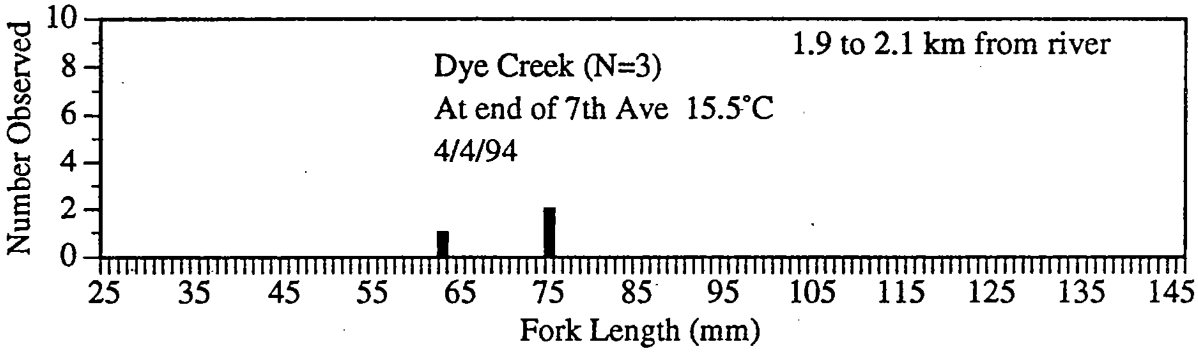


Figure 15. Juvenile chinook salmon observed in Elder Creek in Spring, 1994.

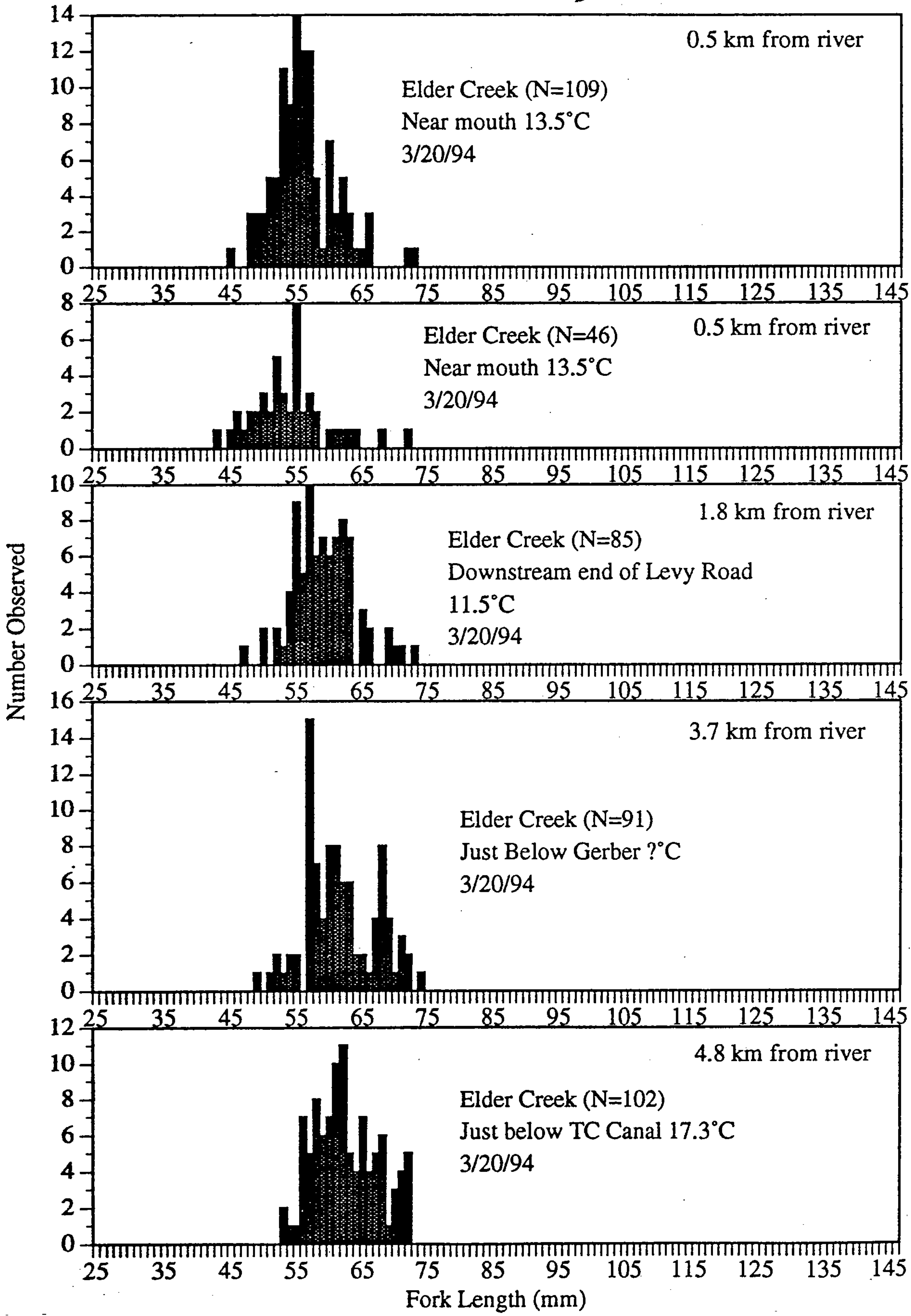


Figure 15b. Juvenile chinook salmon observed in Elder Creek in Spring, 1994 (cont.).

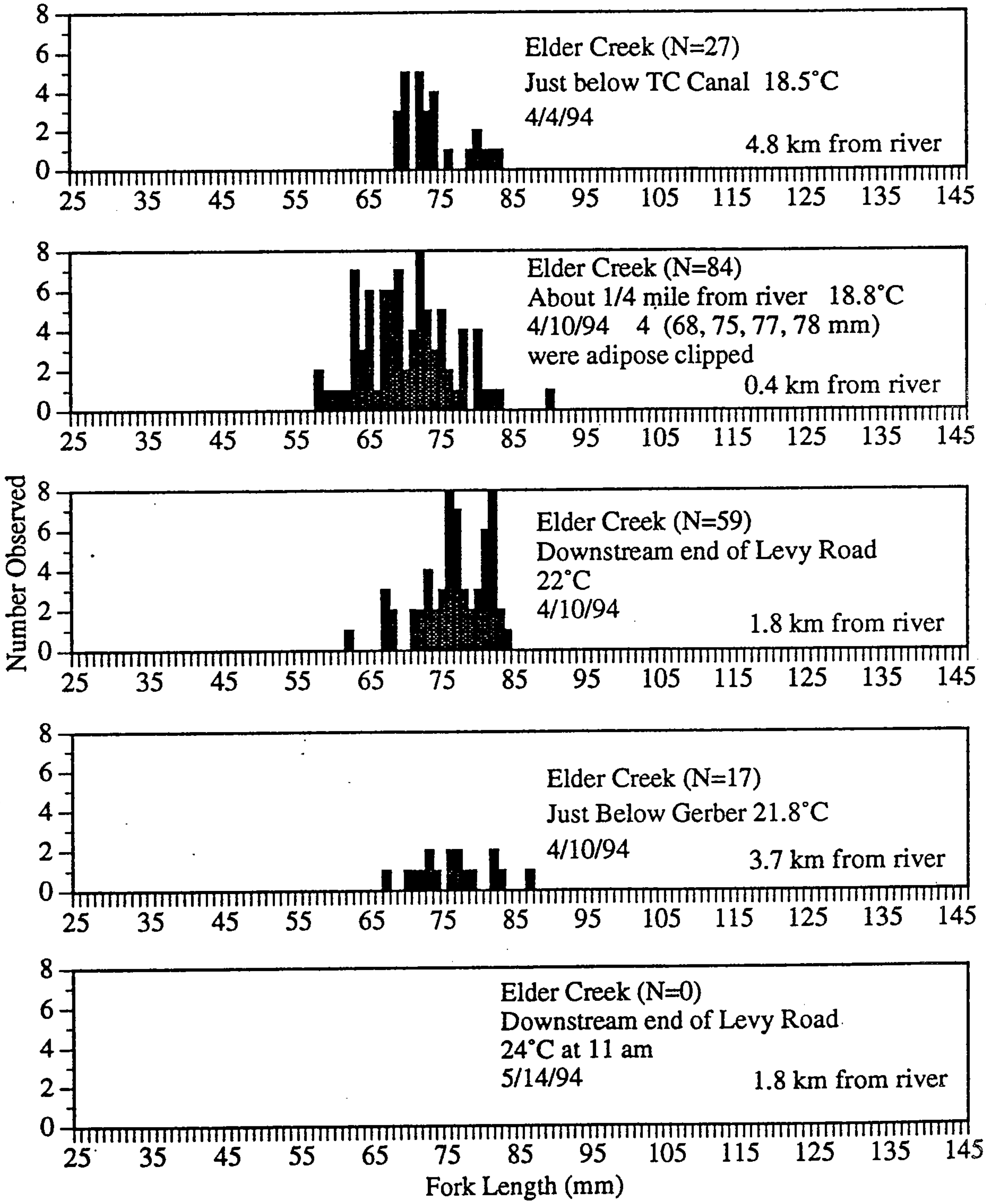


Figure 16. Juvenile chinook salmon observed in Thomes Creek in Spring, 1994.

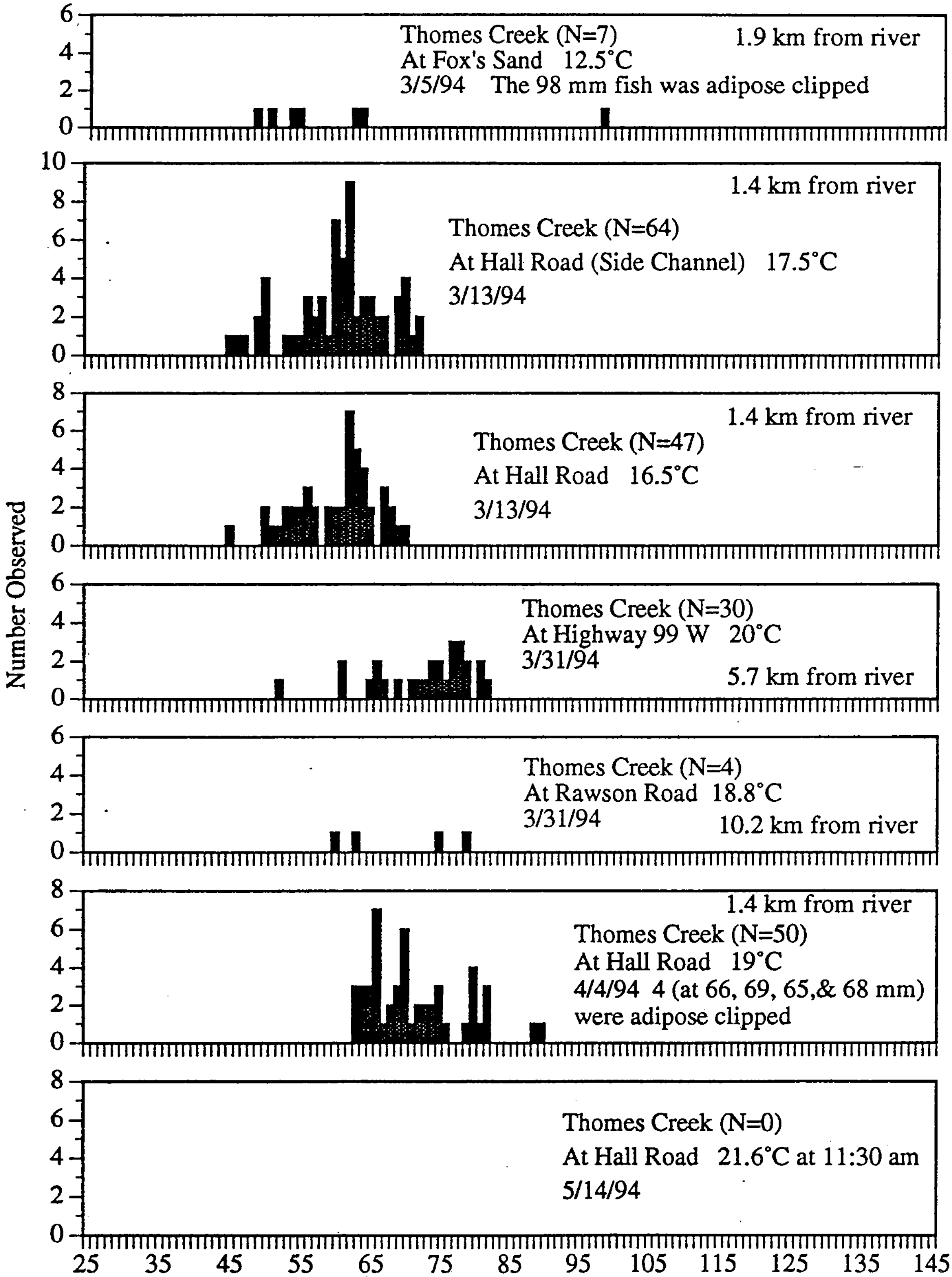
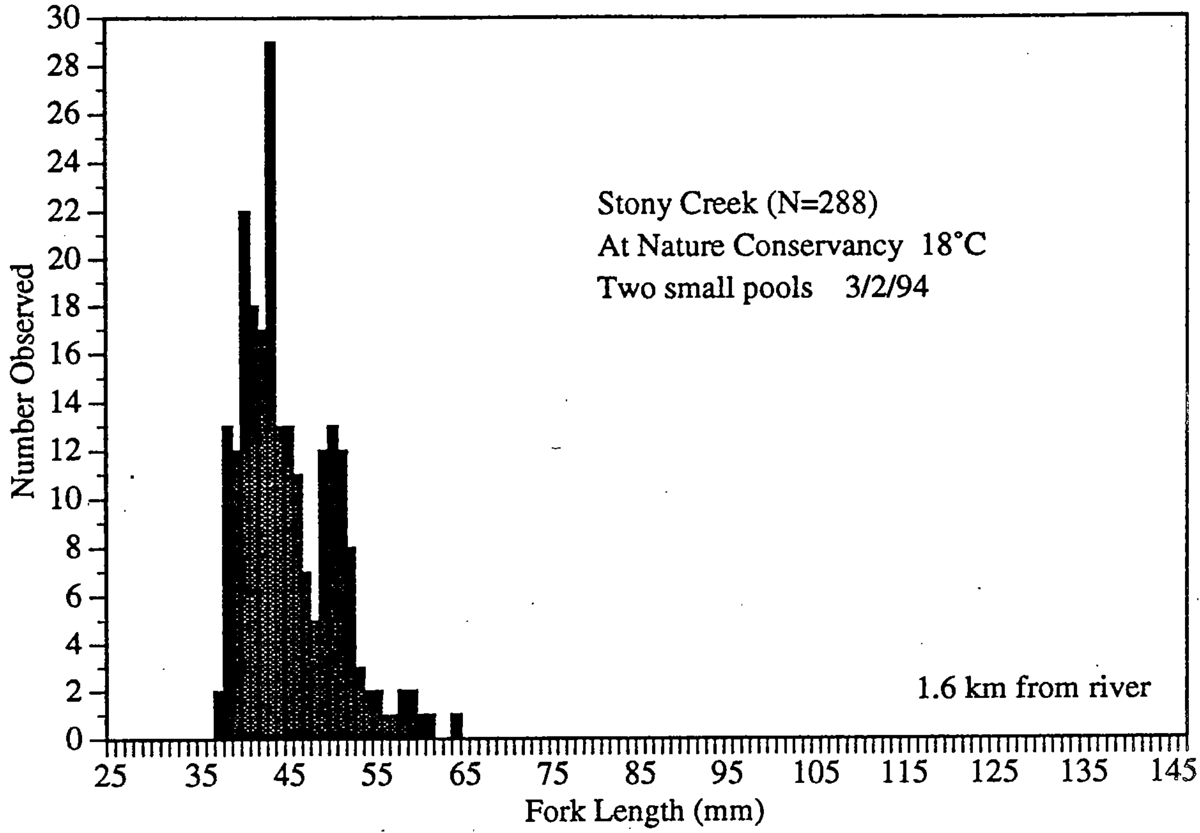


Figure 17. Juvenile chinook salmon observed in Stony Creek in Spring, 1994.



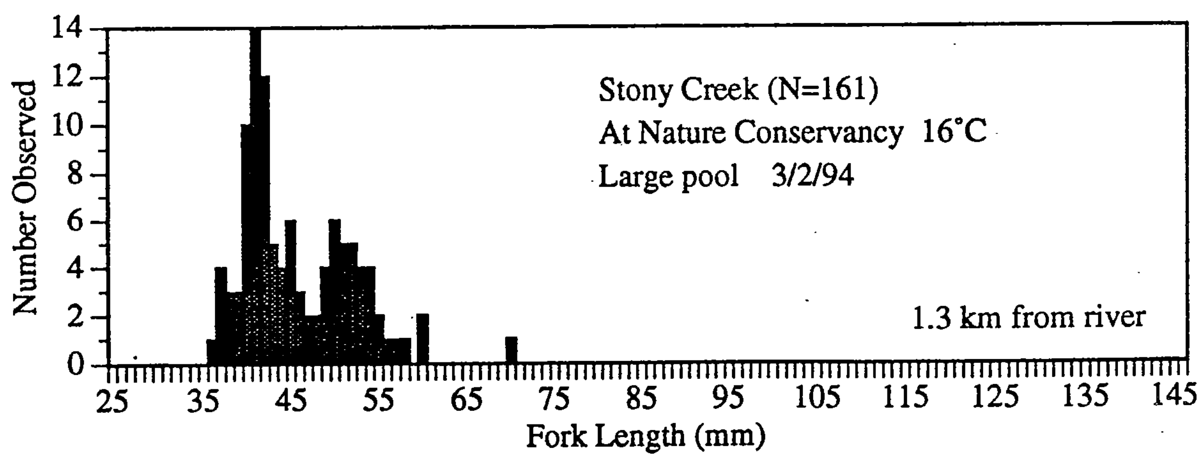
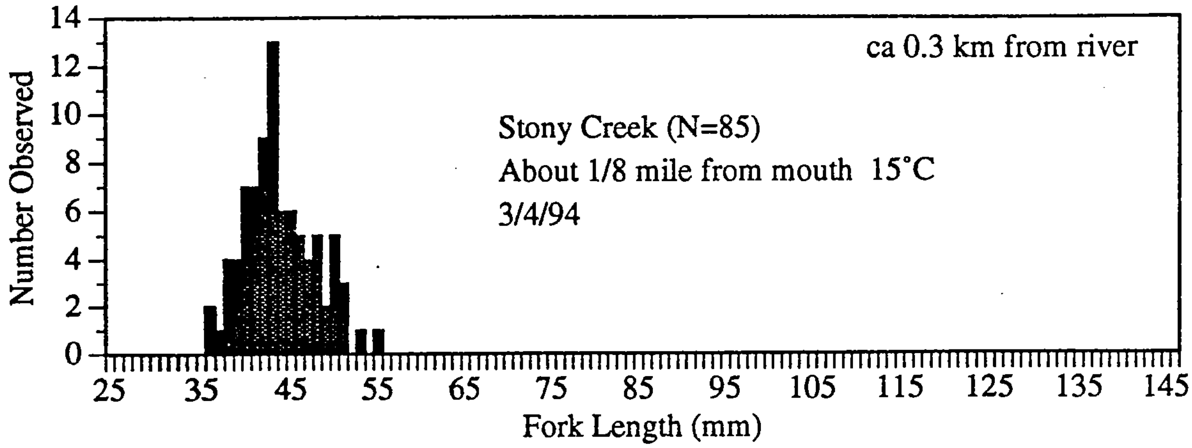
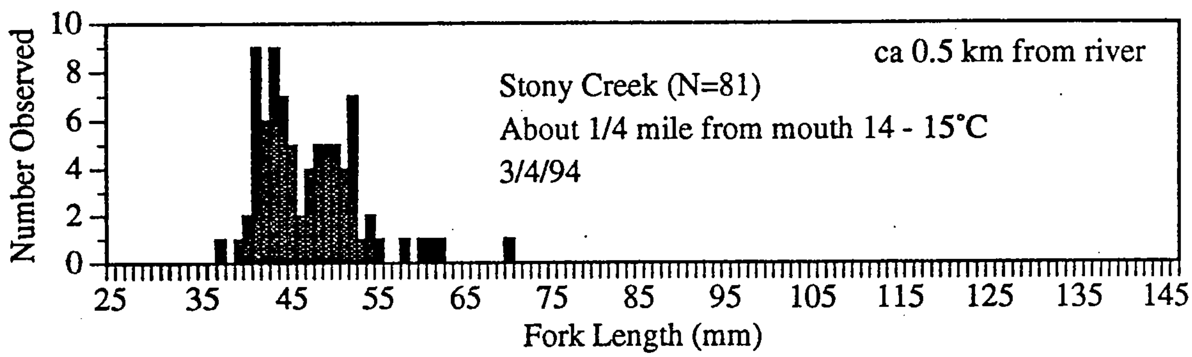
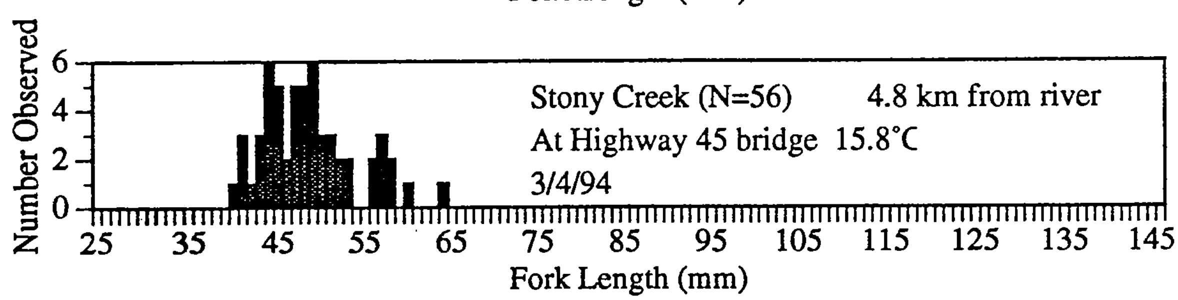


Figure 17b. Juvenile chinook salmon observed in Stony Creek in Spring, 1994 (cont).







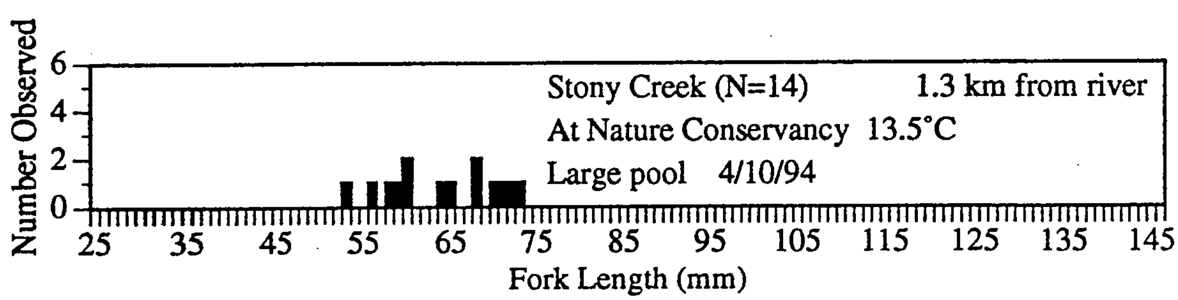


Figure 18. Steelhead observed in Big Chico Creek and Lindo Channel in Spring, 1994.

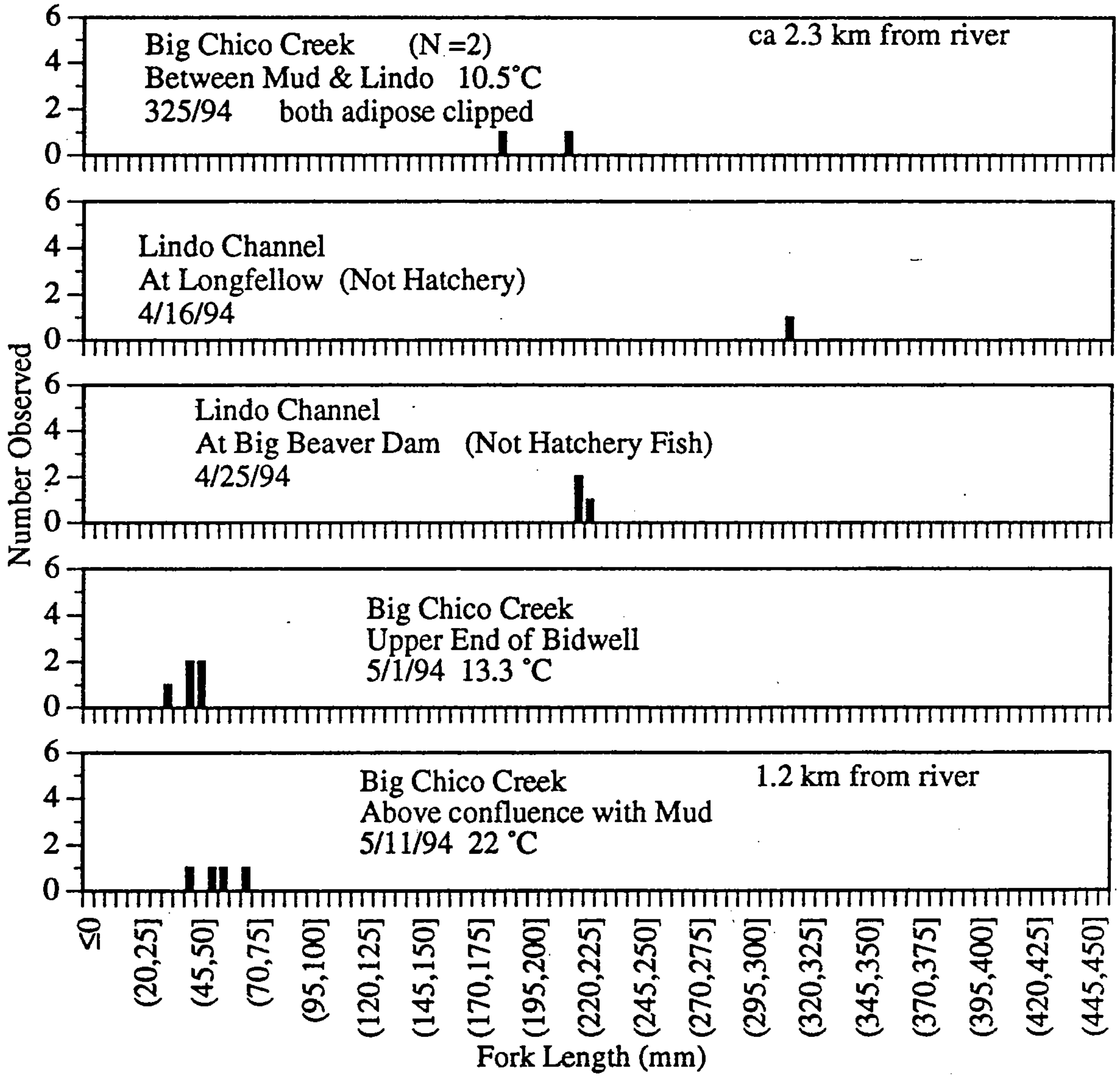


Figure 19. Steelhead observed in Mud Creek in Spring, 1994.

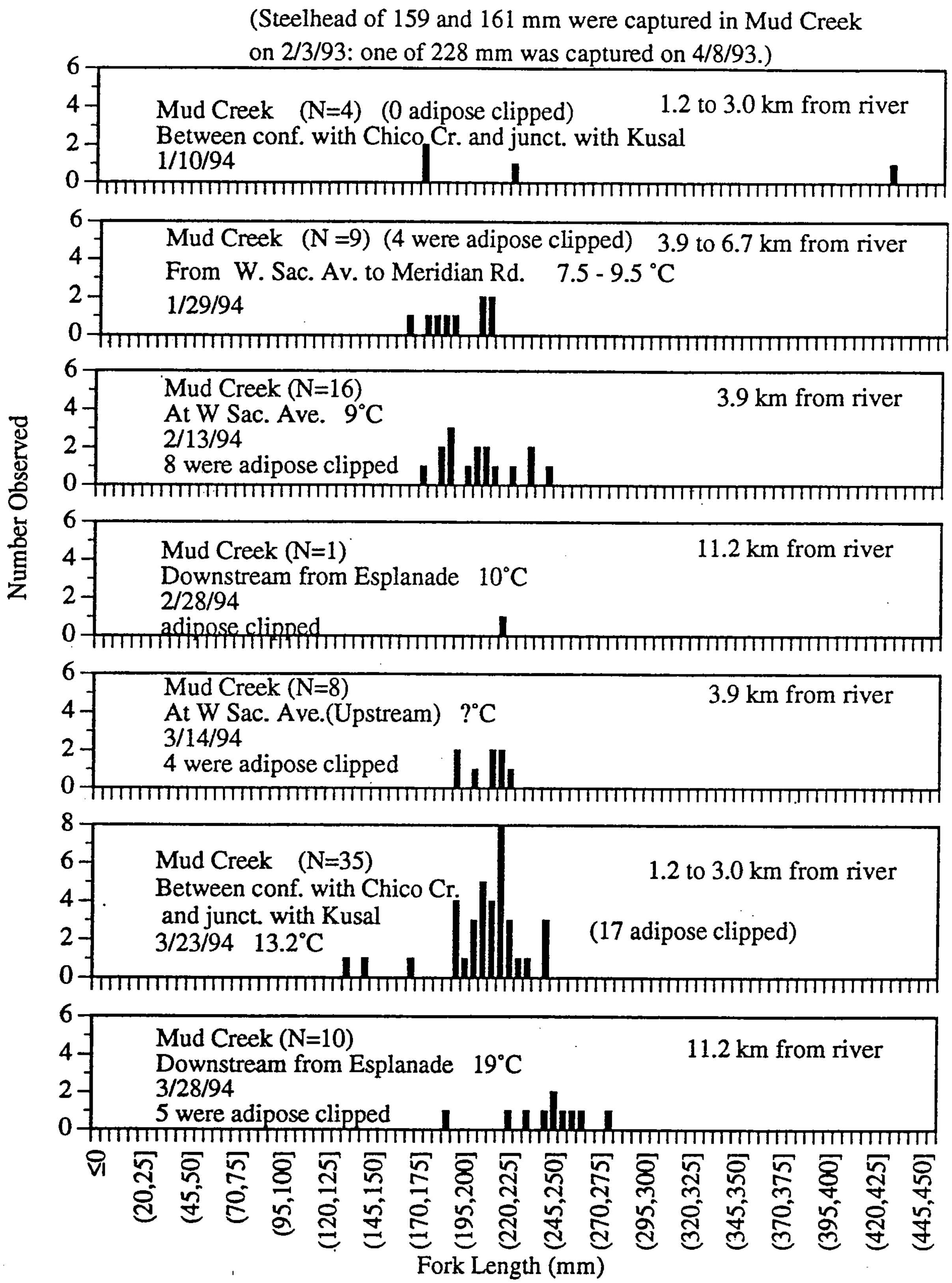


Figure 19b. Steelhead observed in Mud Creek in Spring, 1994 (cont.).

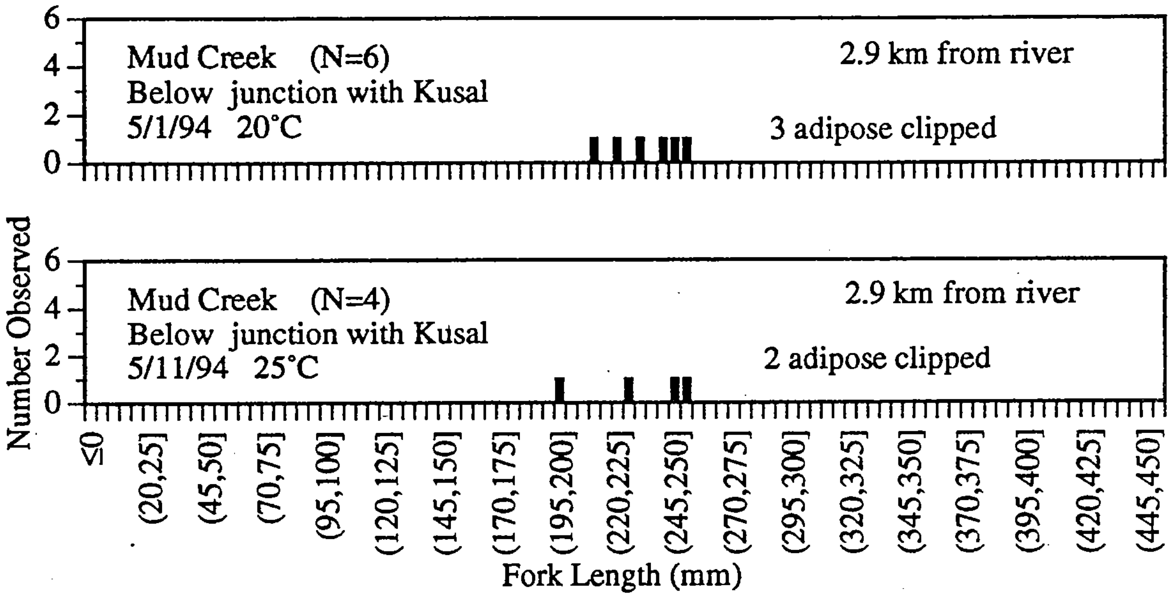


Figure 20. Steelhead observed in Kusal Slough (Rock Creek) in Spring, 1994.

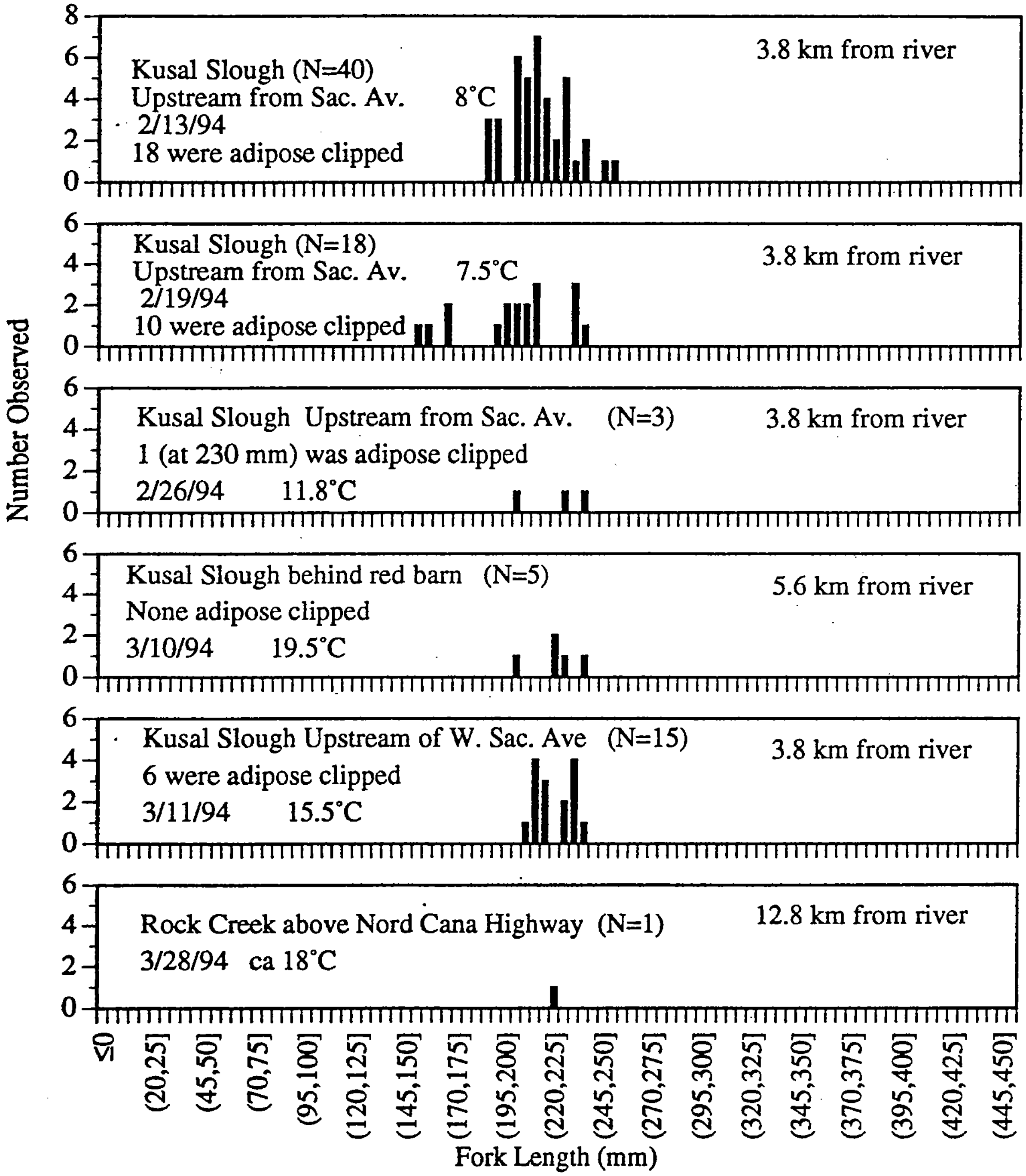


Figure 21. Steelhead observed in Pine Creek in Spring, 1994.

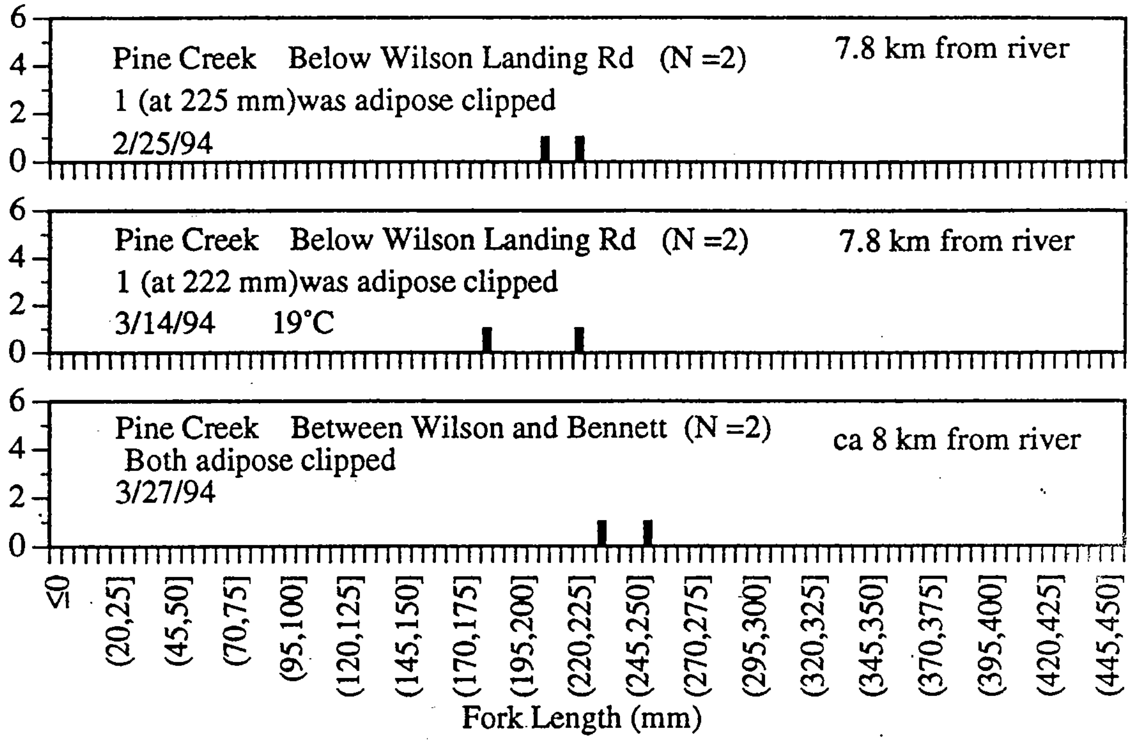


Figure 22. Steelhead observed in Elder Creek in Spring, 1994.

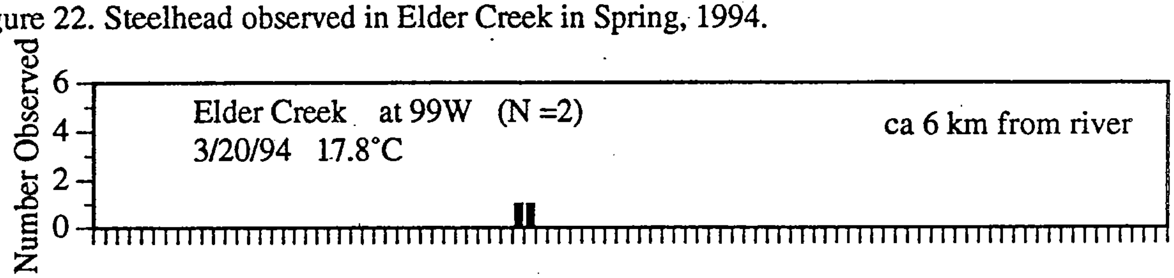


Figure 23. Steelhead observed in Stony Creek in Spring, 1994.

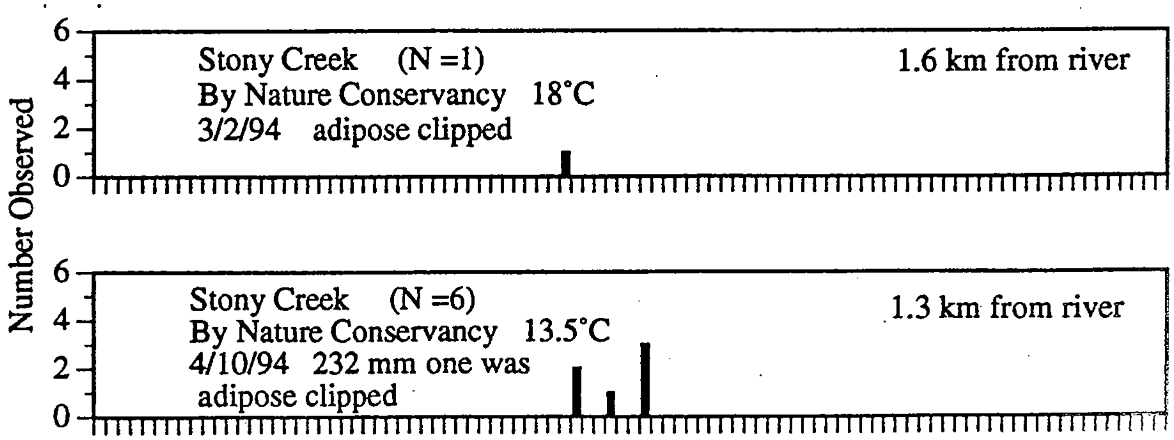


Figure 24. Distribution of chinook races in the seine catch from different tributaries (Number caught shown in parentheses).

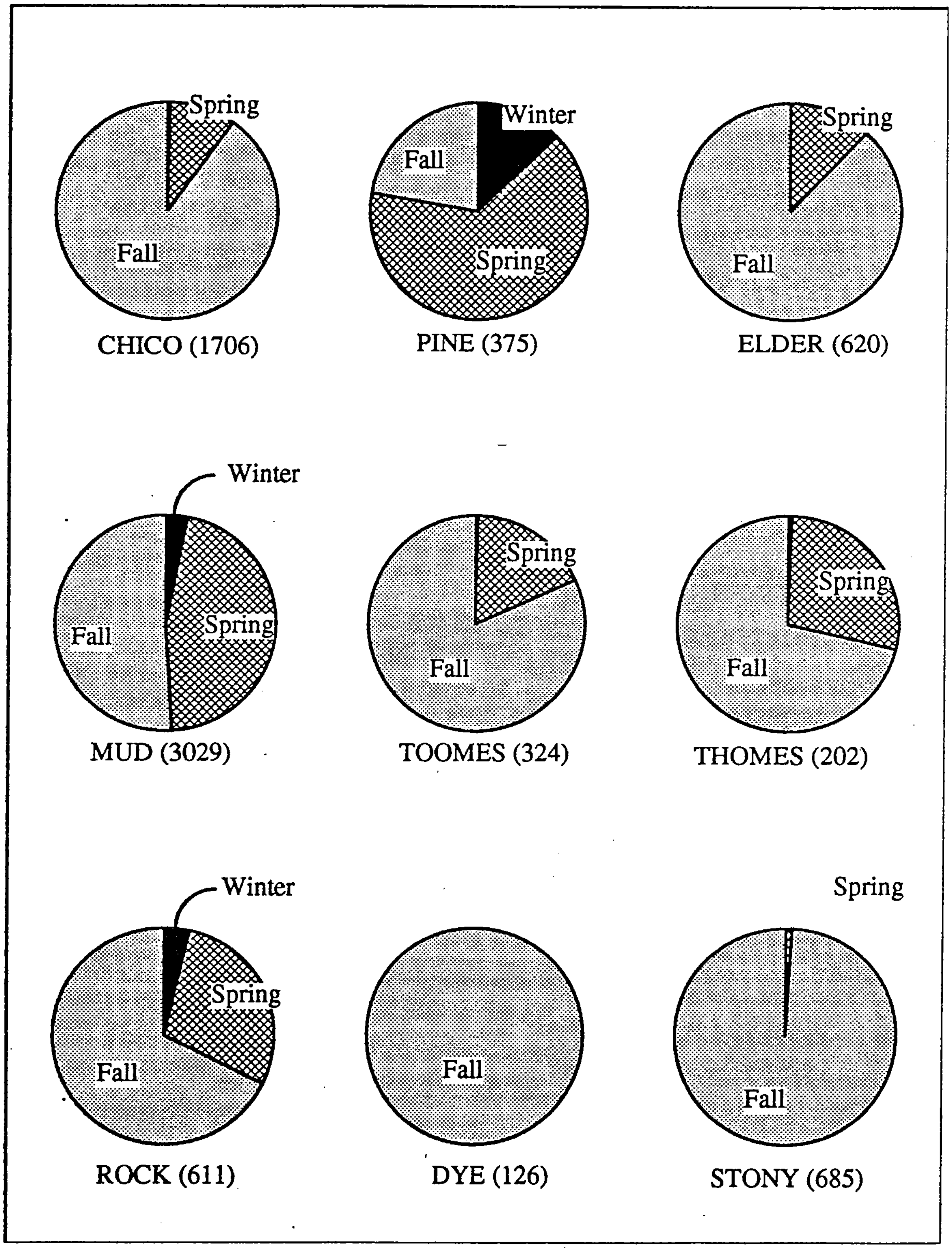


Figure 25. Monthly screw-trap captures at Adam's Dam in Butte Creek; Spring, 1994.