

State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

LOWER YUBA RIVER CHINOOK SALMON, *ONCORHYNCHUS*
TSHAWYTSHA, AND STEELHEAD, *ONCORHYNCHUS MYKISS*, JUVENILE
OUTMIGRATION 1999 – 2000.

by

Ian Drury
Sacramento Valley and Central Sierra Region

June 2001

INTRODUCTION

The lower Yuba River, a tributary of the Feather River, drains a watershed of 1,339 square miles, originating in the higher elevations of the west slope of the Sierra Nevada. The Yuba River is drained by the North Yuba River, Middle Yuba River, and the South Yuba River. The three tributaries converge near, and are impounded by, the U.S. Army Corps of Engineers' (ACOE) Englebright Dam (approximately 24 river miles east of the city of Marysville), which represents the upper limits of anadromous fish migrations.

The lower Yuba River provides spawning and rearing habitat for adult and juvenile spring- and fall-run chinook salmon, as well as Central Valley steelhead trout (DFG, 1991). Limited information indicates that late-fall chinook salmon are present also. The river supports American shad and striped bass below Daguerre Point Dam (approximately 12 river miles below Englebright Dam). Lower Yuba River anadromous salmonid populations have been adversely affected by water and land use practices such as mining, dam construction, and water diversion for agriculture (DFG, 1991). These practices affect both adult (upstream) and juvenile (downstream) migrations, as well as create losses in habitat through the fluctuation of in-stream flows and temperatures during essential migrations and spawning periods. Additionally, unscreened or inadequately screened water diversions and increased poaching at unattended fish ladders located at Daguerre Pt. Dam adversely affect lower Yuba River anadromous populations (DFG, 1991). Currently, spring-run chinook salmon are listed as Threatened under both the Federal and State Endangered Species acts, while Central Valley steelhead trout are listed as Threatened under the Federal Endangered Species Act.

Limited life history information on juvenile salmonids (spring-, fall-, and late fall-run chinook salmon and steelhead trout) in the lower Yuba River exists.

This study was conducted to begin development of baseline information for the Central Valley Project Improvement Act, Comprehensive Assessment and Monitoring Program (CAMP) for juvenile chinook salmon and steelhead trout life history strategies on the lower Yuba River. The data collected represent trends and do not represent a relative abundance or any other account of total population. Data were collected to determine and document the timing and duration of emergence and downstream movement, size of downstream migrants (by date), as well as an attempt to determine if the different races of juvenile chinook salmon can be differentiated by size and time of capture.

METHODS AND MATERIALS

Trapping

Fish were captured using an uncalibrated, standard rotary screw trap with an eight-foot diameter cone, manufactured by E.G. Solutions (Corvallis, Oregon). Fish were trapped at one location for the duration of the season, approximately 6 river miles east of the city of Marysville, directly across the river from the end of Hallwood Boulevard. Essentially, the sampling site is downstream of all potential salmon spawning habitat. Except during extraordinarily high water flows or during periods of excessive debris, the trap was fished 24 hours per day, seven days a week from November 25, 1999 through June 30, 2000.

Processing Capture Fish

All fish were netted from the live-box and immediately placed into a shallow tub of fresh river water. Juvenile chinook salmon and steelhead trout were separated from other species and transferred with small aquarium nets into buckets equipped with portable aerators and held for processing.

A sub-sample of 30 juvenile chinook salmon was anesthetized in a bucket containing a weak solution ($2/3$ gram per liter of water) of tricaine

methanesulfonate (MS-222). Upon immobilization, each fish was measured to the nearest millimeter (mm) in fork length (FL), and weighed to the nearest 0.01 gram (g). An additional sub-sample containing a minimum of 100 juvenile salmon, or 10% of the total captured (whichever was greatest), was then measured and weighed using the same protocol. All remaining salmon were then individually counted. If the number of salmon remaining to be counted was too great to efficiently count individuals (> 20,000 fish), then volumetric estimation was used in lieu of an exact enumeration. This was accomplished by filling a standardized container to the half full mark and adding a documented number of fish until a complete volume was reached without the loss of any water. This process was repeated three times to produce an average number of fish for the known volume. Finally, all juvenile salmon were released approximately 100 meters downstream of the rotary screw trap.

All juvenile steelhead trout were individually measured and weighed using the above protocol. In addition, a juvenile steelhead trout life-stage rating protocol (smolt index), based on ontogenetic characteristics, was utilized to provide information about smolt development over time and space (Snider and Titus, 1995). In this rating system, each individual steelhead trout was given a numeric code that represented its particular smolting stage. As with salmon, all steelhead trout were released approximately 100 meters downstream of the rotary screw trap.

All non-salmonids were identified to species, and released approximately 100 yards downstream of the rotary screw trap.

Site Variables

Site variables were collected for each day of sampling. Revolutions per minute (RPM) were collected using a rotary counter fixed to the trap. Turbidity measurements were collected first through the use of a secchi disk and later by

using an electronic turbidity meter (HACH Portable 2100P). River flows were obtained from the California Data Exchange Center (CDEC) using as reference the lower Yuba River gage near Marysville, California.

RESULTS AND DISCUSSION

A total of 498,165 chinook salmon and 544 steelhead trout were captured (Appendixes A and B). The first chinook salmon and steelhead trout were captured on November 25, 1999 and December 2, 1999, respectively. During the 219 day sampling period, 205 days were sampled (> 93%).

Chinook Salmon

Timing of Emergence and Duration of Downstream Movement

Salmon emergence and downstream movement (outmigration) had already begun at the time of trap deployment, as fish were captured on the first day of sampling (November 25, 1999). By early-December, relatively large numbers of fish were being caught (Table 1). Coinciding with the first large river flow events of the sampling season, captures quickly rose to a peak in mid-to late-January (Figures 1 and 2). Numbers of fish captured then started to decline dramatically through the second half of February before leveling off throughout March. Another small rise in numbers occurred that lasted from early April through late May. Small numbers of salmon were captured in June up to the last day of sampling (June 29, 2000).

During the period of December 16, 1999 through February 15, 2000, 93% of all juvenile salmon sampled were captured. Within this period, the last two weeks of January produced the largest number of fish captured, 244,569 (49% of total). It should be noted that during this two-week period there were times when it was not feasible to completely enumerate catches. A volumetric estimate (85,230 fish) was made on January 17, 2000. A visual estimate of greater than 100,000 fish was made on January 19, 2000, because the fish were under

significant stress and needed to be released without enumeration in order to prevent excessive mortality. The high numbers of fish captured during this period correlated with extremely high and fluctuating river flows (Figure 1). The high flows prevented the trap from being fished for 7 (January 24 through January 29 and January 31) of the 16 possible sample days. The large numbers of fish captured between early January and early February suggests a significantly larger number of fish may have migrated during this time of extremely high flows when the trap was not fished.

Emergence and downstream migration had begun prior to the deployment of the rotary screw trap. Eleven chinook salmon ranging from 35mm to 40 mm were captured on the first day of sampling. This supports past documentation that spring-run chinook salmon begin emerging in November and may begin migration within the next few weeks (CDFG, 1991). By late-June, only 24 salmon were captured indicating the end of the emigration period (Table 1).

Table 1. Semi-monthly captures of chinook salmon on the lower Yuba River, December 1999 through June 2000

Period	N	Fork Length (mm)			Percent
		Min	Mean	Max	
December 1 - 15	12,368	29	36	92	2.5
December 16-31	53,623	30	37	124	10.8
January 1 - 15	82,656	30	38	63	16.5
January 16 - 30	244,569	31	39	118	49.1
February 1 - 15	86,390	32	39	71	17.2
February 16 - 29	5,327	32	40	126	1.1
March 1 - 15	1,455	31	41	84	0.3
March 16 - 31	1,180	28	41	116	0.2
April 1 - 15	2,505	30	52	105	0.5
April 16 - 30	1,972	33	68	152	0.4
May 1 - 15	2,533	34	70	134	0.5
May 16 - 31	3,452	36	76	162	0.7
June 1 - 15	111	53	77	98	0.1
June 16 - 30	24	61	73	94	0.1
Totals	498,165				100

*The number of fish was estimated volumetrically on January 17, 2000, and visually on January 19, 2000.

Figure 1. Semi-monthly flows on the lower Yuba River, December 1999 through June 2000

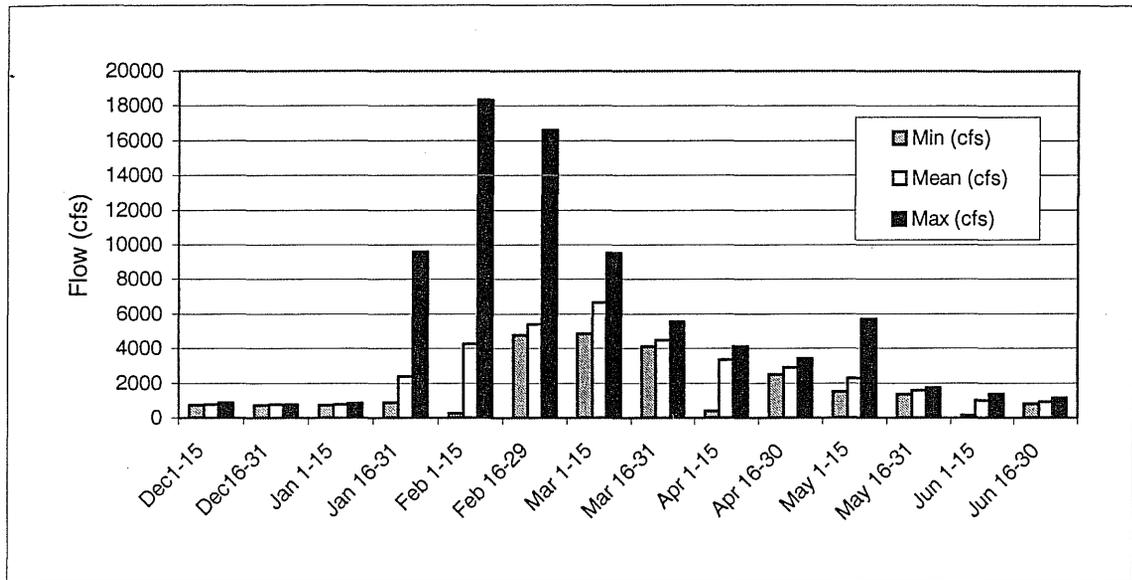
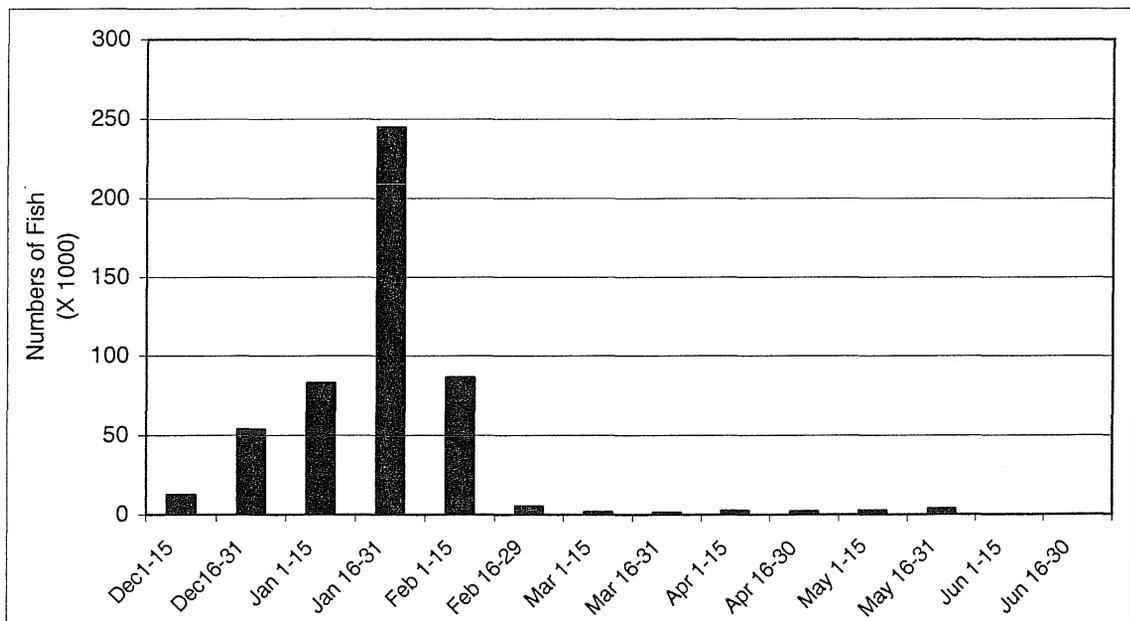


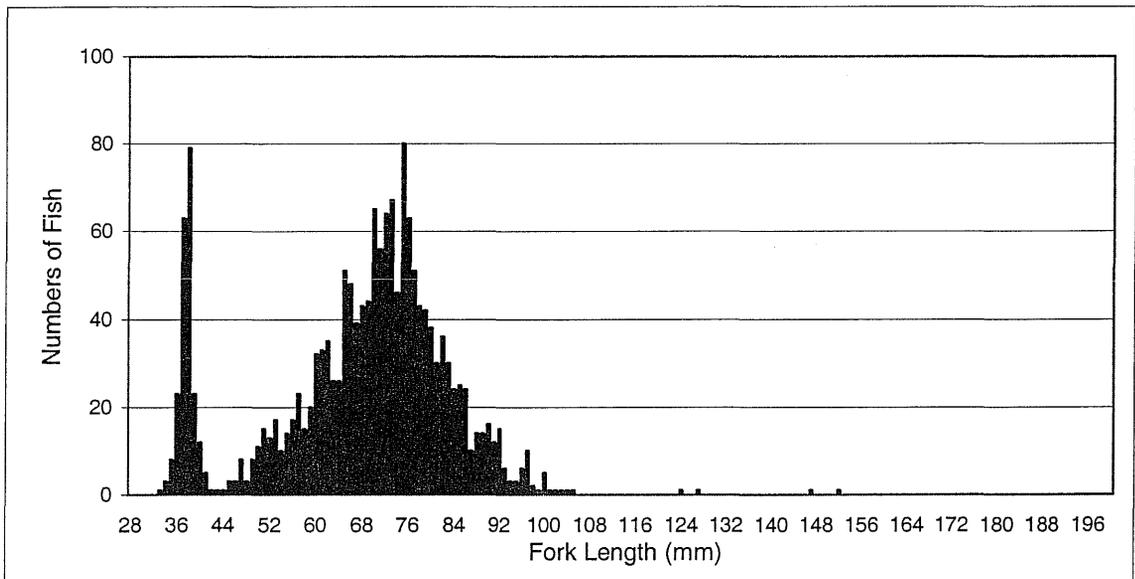
Figure 2. Semi-monthly captures of chinook salmon on the lower Yuba River, December 1999 through June 2000



Size of Downstream Migrants

The length-frequency data indicate that more than one race of chinook salmon may be present (Figure 3). Throughout the sampling season, and within specific semi-monthly periods, the salmon ranged in size from 28mm 162mm FL (Table 1). Although the mean fork length for any given period appears to compare well with fall-run chinook salmon from other Central Valley watersheds (Fisher, 1992), the length-frequency data show two other groups of fish, which appear to occupy different size classes. One of these is larger than fall-run chinook salmon, and one is smaller. The data fit well with length frequency tables for spring- and late-fall-run chinook salmon in other Central Valley watersheds (Fisher, 1992) and the knowledge that these runs exist in the system.

Figure 3. Semi-monthly length-frequency of chinook salmon on the lower Yuba River, March 16-31, 2000



*Graph is an example

Steelhead Trout

Timing of Emergence and Duration of Downstream Movement

Steelhead trout were caught throughout the entire sampling period, from December 2, 1999 through June 30, 2000 (Table 2). Initially, numbers were low, with only 3 fish captured in the first period (December 1, 1999 through December 15, 1999). Generally, the rate of capture stayed relatively constant through the end of March 2000, but peaked slightly with the high flow events in the last half of January. During this time, 30 steelhead trout were captured; it is likely that the numbers could have been higher because the trap was not fished for 7 of the 16 possible sampling days due to river conditions.

Beginning in early April 2000, numbers of steelhead trout captured increased steadily, from a low of 37 in the first half of April, to a high of 190 fish in the last half of June. The total of 190 steelhead trout captured in the final period of the survey was 2.5 times greater than in any other period.

Table 2. Semi-monthly captures of steelhead trout on the Lower Yuba River, December 1999 through June 2000

Period	N	Fork Length (mm)			Percent
		Min	Mean	Max	
December 1-15	3	88	96	106	0.6
December 16-31	4	75	90	103	0.7
January 1-15	6	91	107	120	1.1
January 16-31	30	71	104	186	5.5
February 1-15	13	43	96	184	2.4
February 16-29	14	37	158	300	2.6
March 1-15	8	67	125	300	1.5
March 16-31	12	72	96	140	2.2
April 1-15	37	65	98	198	6.8
April 16-30	41	35	124	192	7.5
May 1-15	49	46	88	300	9.1
May 16-31	72	31	75	200	13.2
June 1-15	65	34	69	300	11.9
June 16-30	190	42	60	200	34.9
Totals	544				100

Size of Downstream Migrants

There was less variation in the size of steelhead trout captured prior to the high flow events of late-January than during the rest of the sampling season. Before these high flow events, steelhead trout ranged in size from 88mm to 120mm FL (Table 2). However, from mid-January through late-April, steelhead trout captured exhibited a much greater variety of sizes. During this time steelhead trout show a mean fork length of 114mm and range from 35mm to 300mm. From early May through the duration of the project in late June variation in steelhead trout fork lengths remained high but the mean fork length for this period decreased to 73mm.

Smolting Index

The smolting index, or life-stage rating protocol, was used to classify 499 of the possible 544 steelhead trout captured (Table 3). Of those sampled, one individual was rated as a Yolk-Sac Fry (0.2%), 75 were rated as Fry (15.1%), 373 were rated as Parr (74.7%), 37 were rated as Silvery Parr (7.4%), and 13 were rated as Smolt (2.6%). For all months but one during the sampling season, Parr were the dominant life stage; in May, Fry outnumbered Parr by eight individuals. All other life stages were seen in relatively small numbers throughout the sampling season.

Table 3. Smolting Index for steelhead trout captured on the Lower Yuba River, December 1999 through June 2000

Smolting Index	February	March	April	May	June	Total	Percent
Yolk-Sac fry	0	0	0	1	0	1	0.2
Fry	0	0	2	68	5	75	15.1
Parr	19	17	56	60	221	373	74.7
Silvery Parr	3	2	18	5	9	37	7.4
Smolt	5	0	1	4	3	13	2.6
Totals	27	19	77	138	238	499	100.0

Non-target Species

In addition to chinook salmon and steelhead trout, sixteen other fish species common to the Sacramento River system were encountered during the sampling season (Appendix C)

Site Variables

Flow Rate

Daily flows varied widely throughout the sampling season, as well as within half month sampling periods. Daily flows ranged from approximately 18,000 cubic feet per second (cfs) to approximately 175cfs (Appendix D). High flows were associated mainly with storm events during the rainy season (January 1, 2000 through March 31, 2000); relatively low flow (175cfs) periods may have been associated with the hydro-electrical facilities located at Englebright Dam going "off line" for short periods (12-24 hours).

Turbidity

Turbidity was measured differently throughout the sampling season (Appendix E). Prior to February 1, 2000, turbidity readings were not taken. Between February 1 and May 3, 2000, turbidity readings were taken using a secchi disk. Beginning May 4, a turbidity meter was used. Secchi disk readings ranged from 0.5 feet in the first half of February, to 4 feet in the first half of March. There was great variation in secchi disk readings from February 1 through April 1, at which time turbidity leveled off at 2.5 feet through May 3. Beginning on May 4, turbidity ranged from a high of 2.0 natural turbidity units (ntu) in the weeks of May 4 through May 15, to a low of 0.7 ntu in the last two weeks of the season, using a turbidity meter.

Rotary Screw Trap

Revolutions Per Minute (RPM)

Revolutions per minute of the rotary screw trap's cone (the actual fishing device) varied from 7.75 to less than 2.0 RPMs throughout the sampling season (Appendix F). Variation within the two-week sampling periods was greater during the first half of the season (December 1, 1999 through March 15, 2000) than during the second half (March 15, 2000 through June 29, 2000). RPMs are an indication of how well a rotary screw trap is fishing. RPMs are a function of two main variables, the river's flow rate and the placement of the trap to fish the greatest amount of flow possible. The trapping site used in this sampling regime was chosen to maximize these two variables.

ACKNOWLEDGMENTS

Funding for the project was provided through the Comprehensive Assessment and Monitoring Program of the Central Valley Project Improvement Act, U.S. Fish and Wildlife Service Agreement # 14-48-11300-97-J211. The California Department of Fish and Game appreciates the help and support of Mr. Larry Puckett, and Mr. Andy Hamilton, U.S. Fish and Wildlife Service.

Special thanks to: Kelli Felker, Jennifer Lane, David Lunsford, Scott Morgan, John Nelson, Andy Popper, and Paul Ward.

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APPENDIX A

Lower Yuba River chinook salmon outmigration December 1999 – June 2000

Figure

1. Semi-monthly chinook salmon trapping totals
2. Semi-monthly chinook salmon fork lengths
- 3-16. Semi-monthly chinook salmon length frequencies

Figure 1. Chinook salmon trapping totals
December 1999 through June 2000

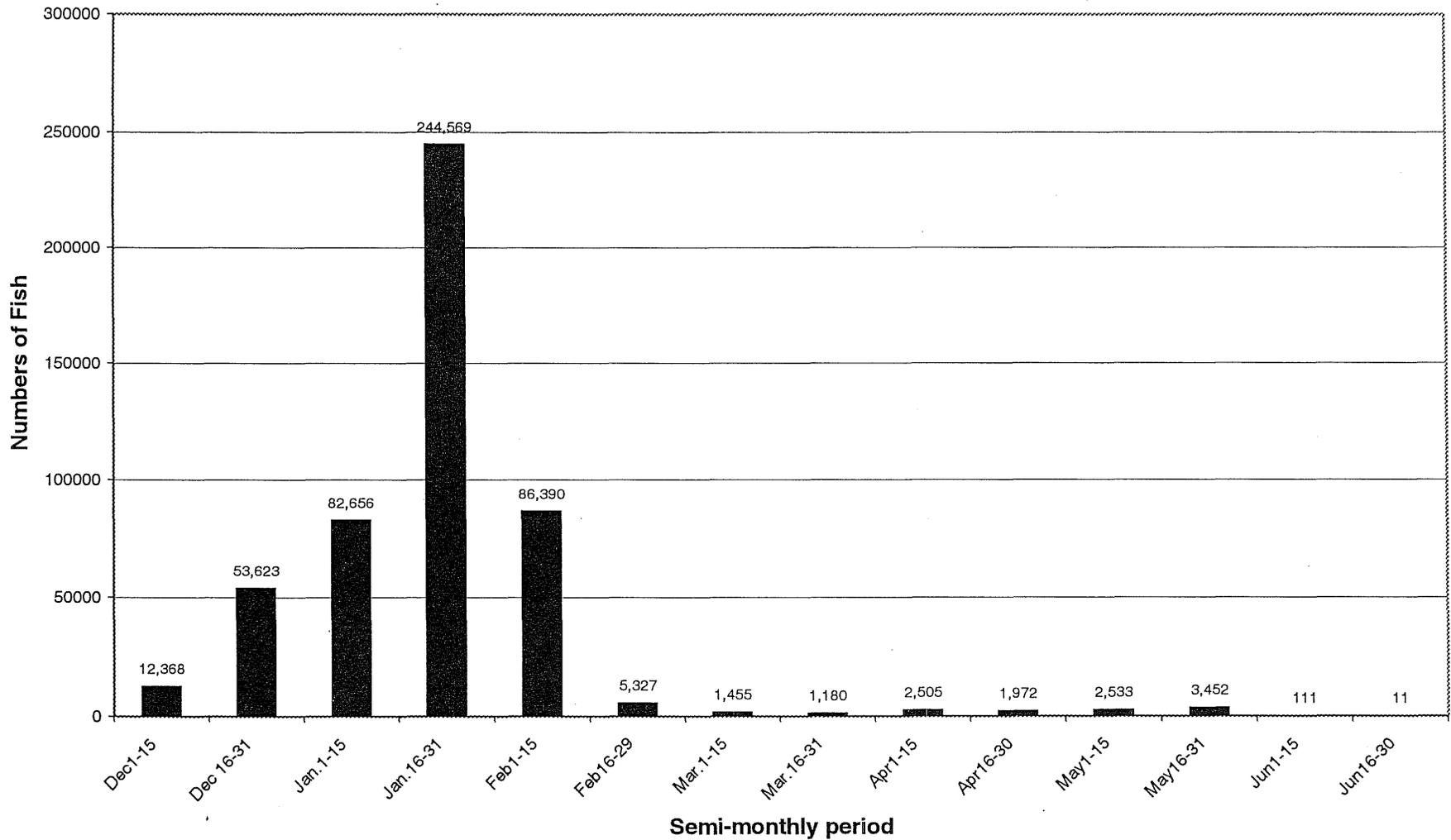
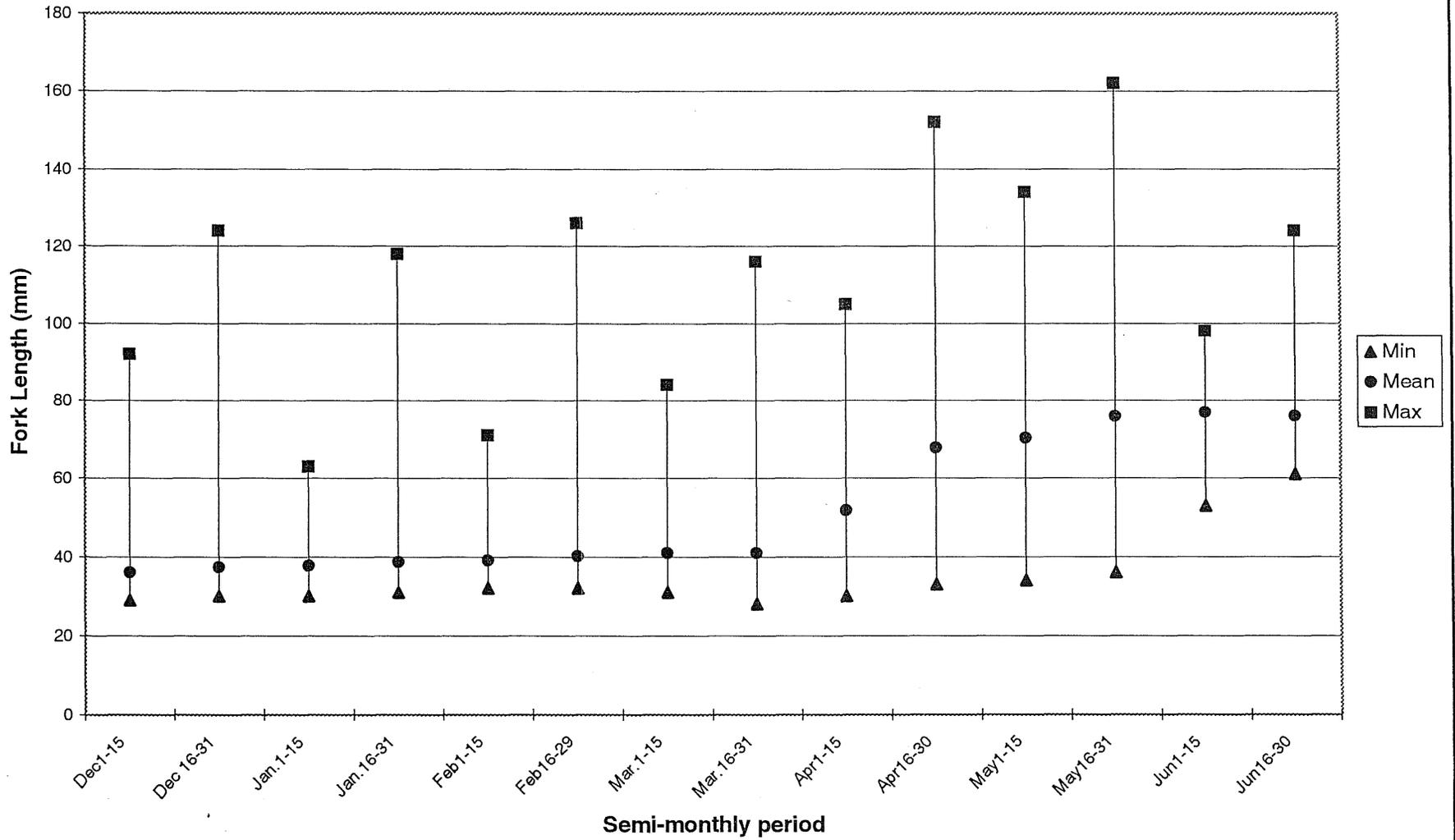
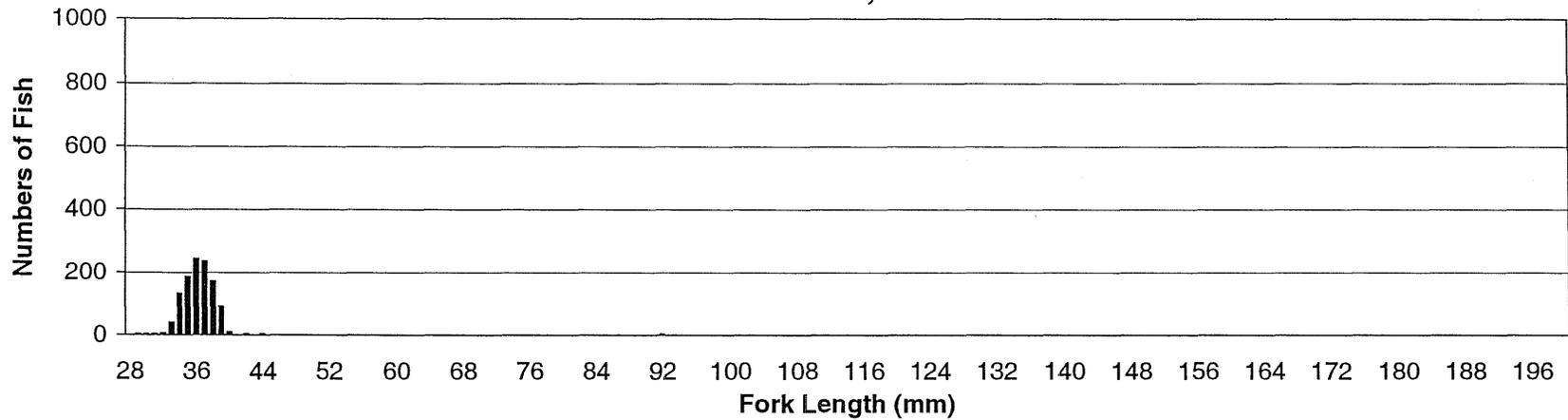


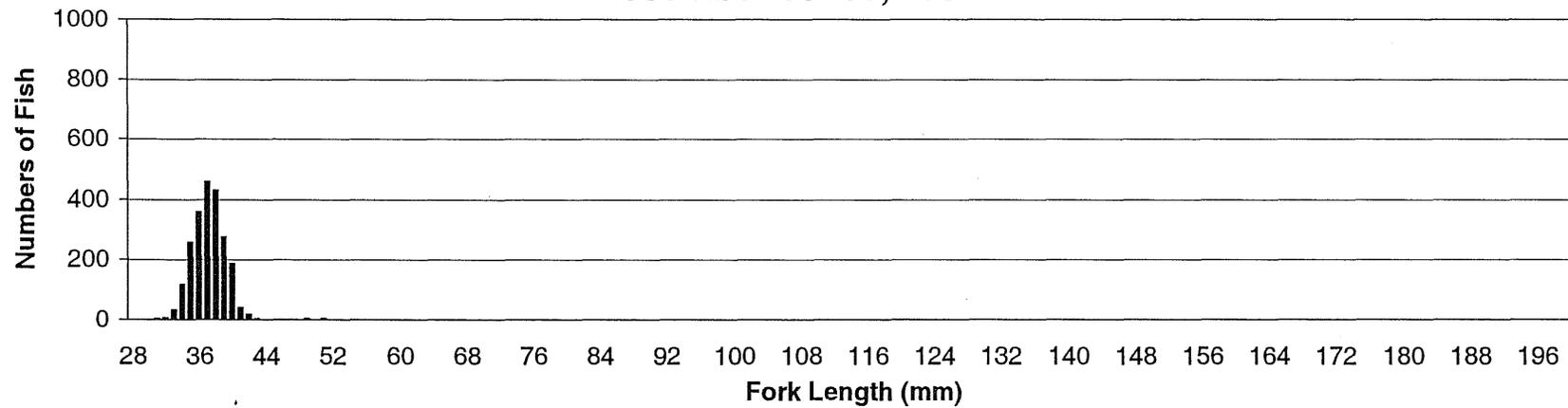
Figure 2. Chinook salmon fork lengths
December 1999 through June 2000



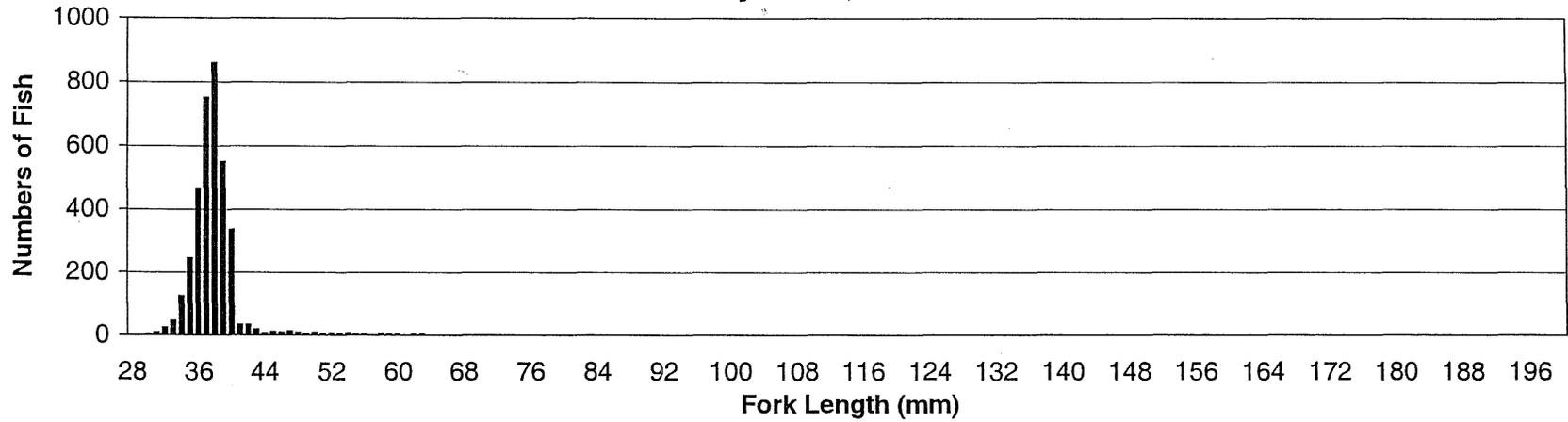
**Figure 3. Chinook salmon length frequency
December 1 -15, 1999**



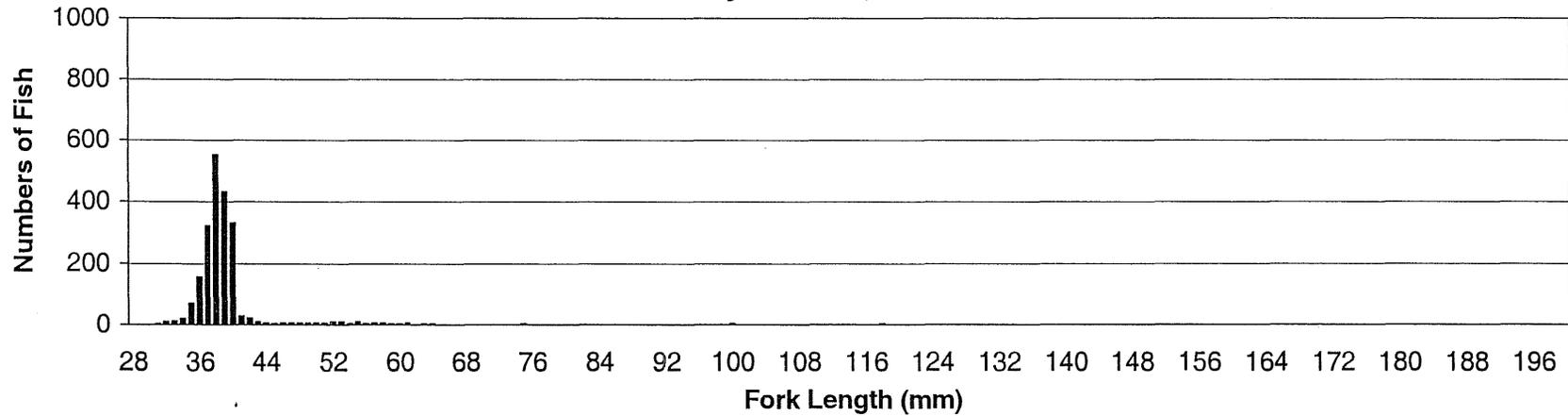
**Figure 4. Chinook salmon length frequency
December 16 -31, 1999**



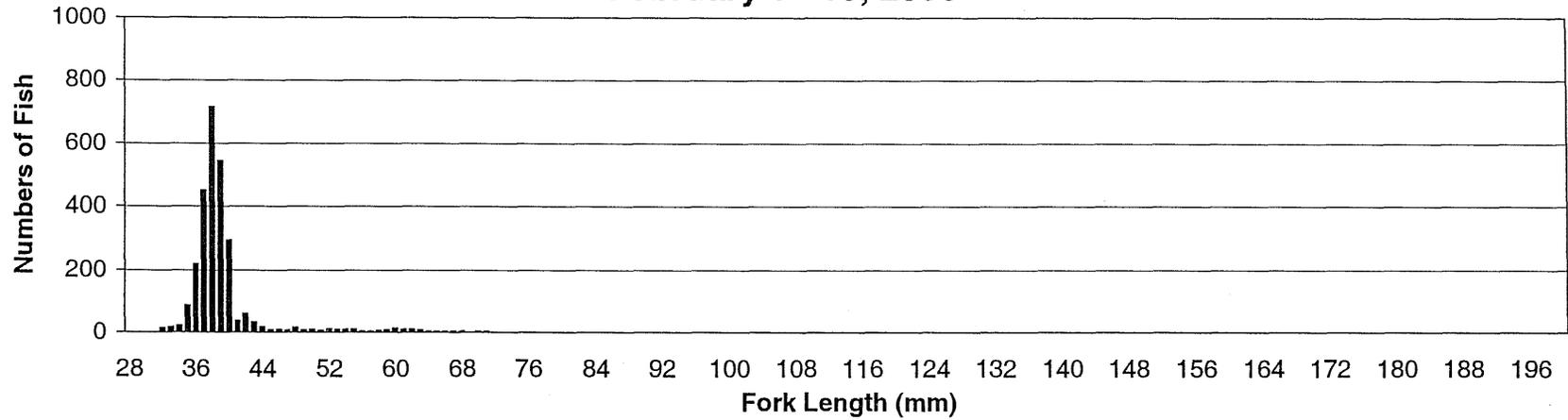
**Figure 5. Chinook salmon length frequency
January 1- 15, 2000**



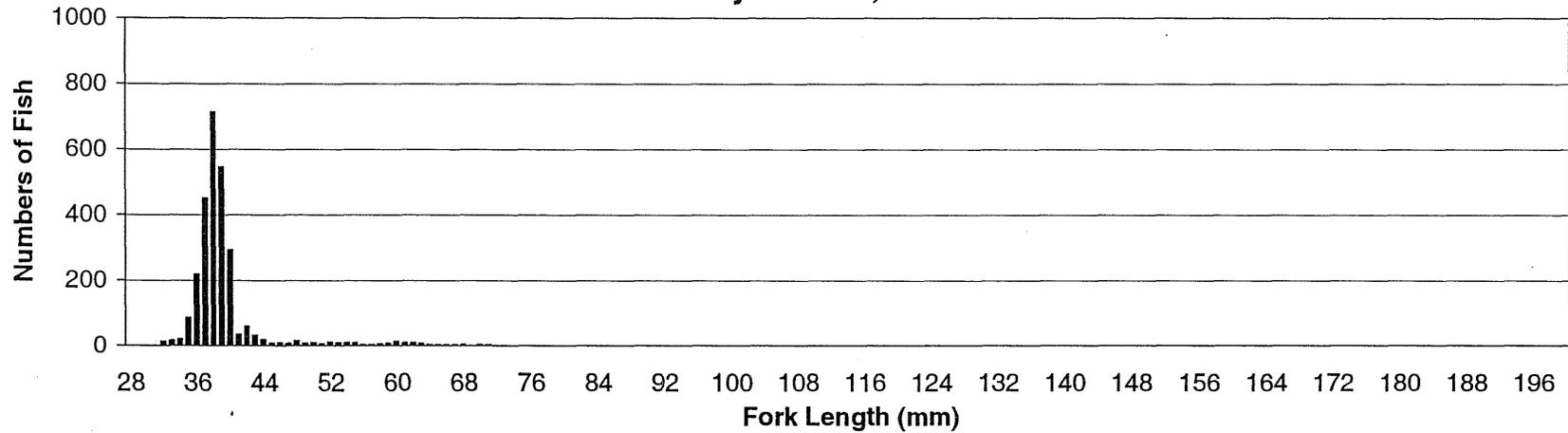
**Figure 6. Chinook salmon length frequency
January 16 - 31, 2000**



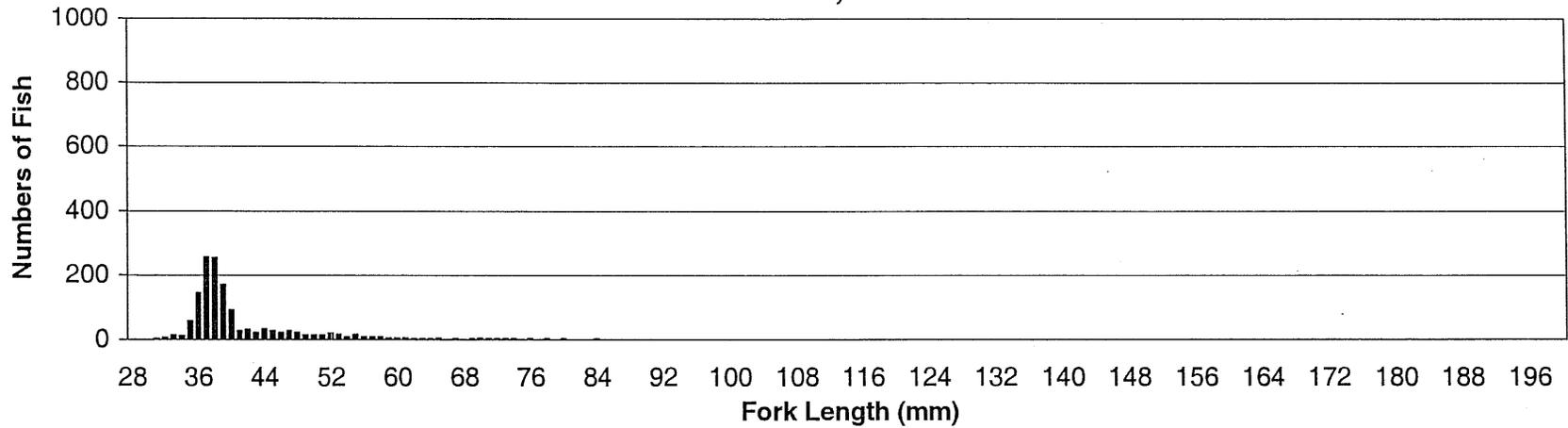
**Figure 7. Chinook salmon length frequency
February 1 - 15, 2000**



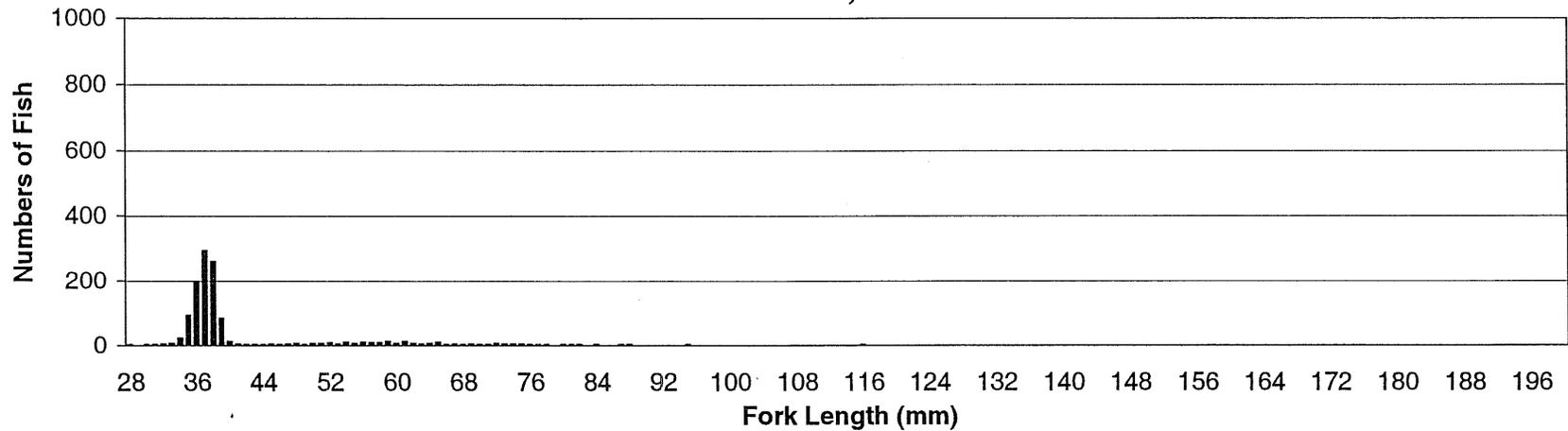
**Figure 8. Chinook salmon length frequency
February 16 - 29, 2000**



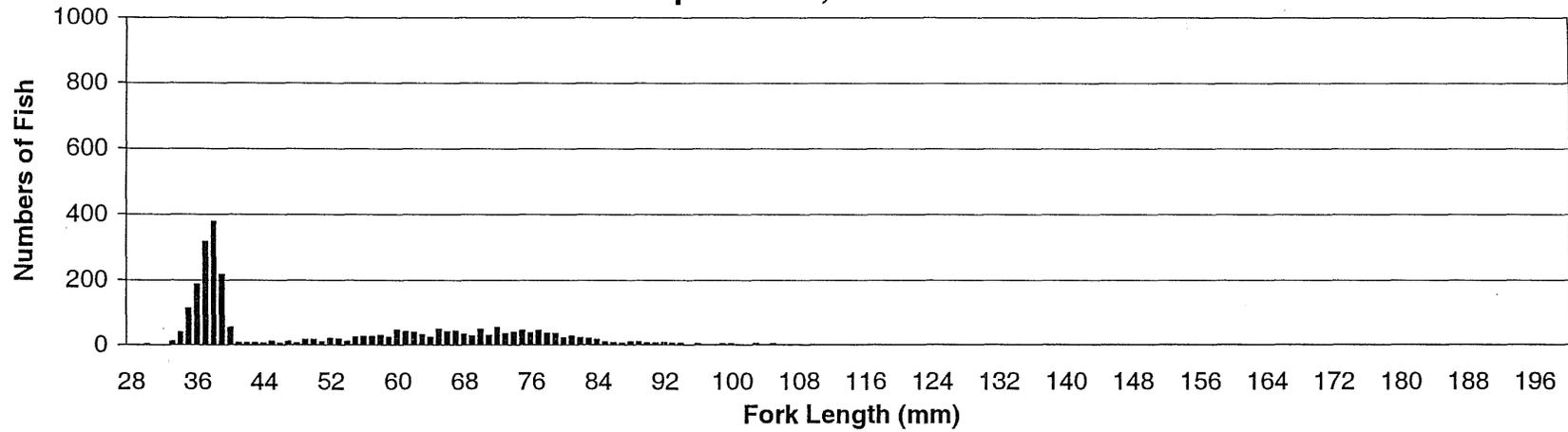
**Figure 9. Chinook salmon length frequency
March 1 - 15, 2000**



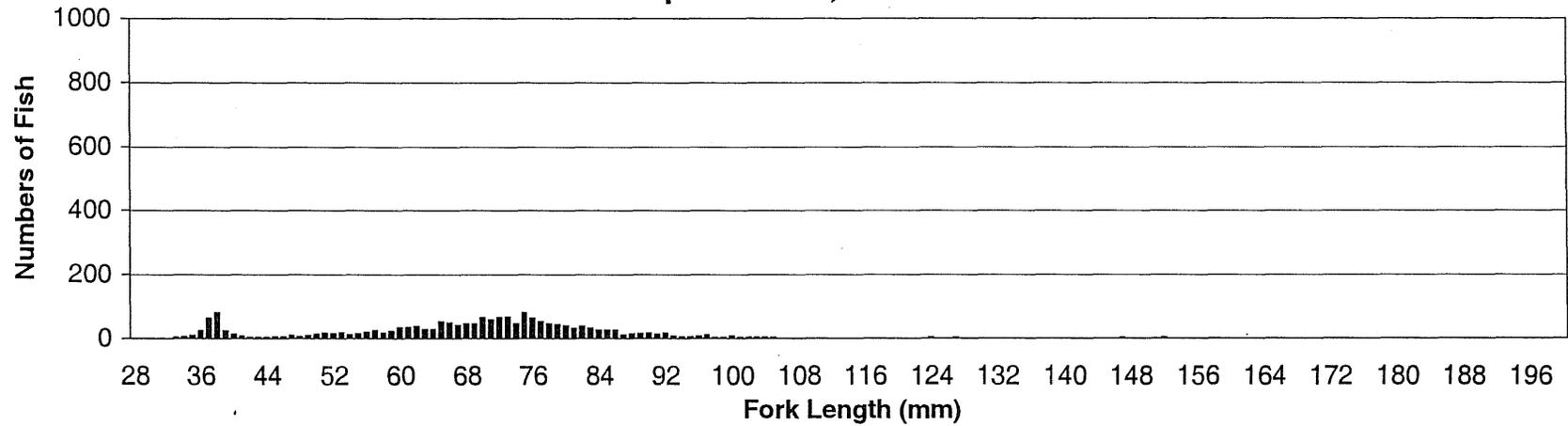
**Figure 10. Chinook salmon length frequency
March 16 - 31, 2000**



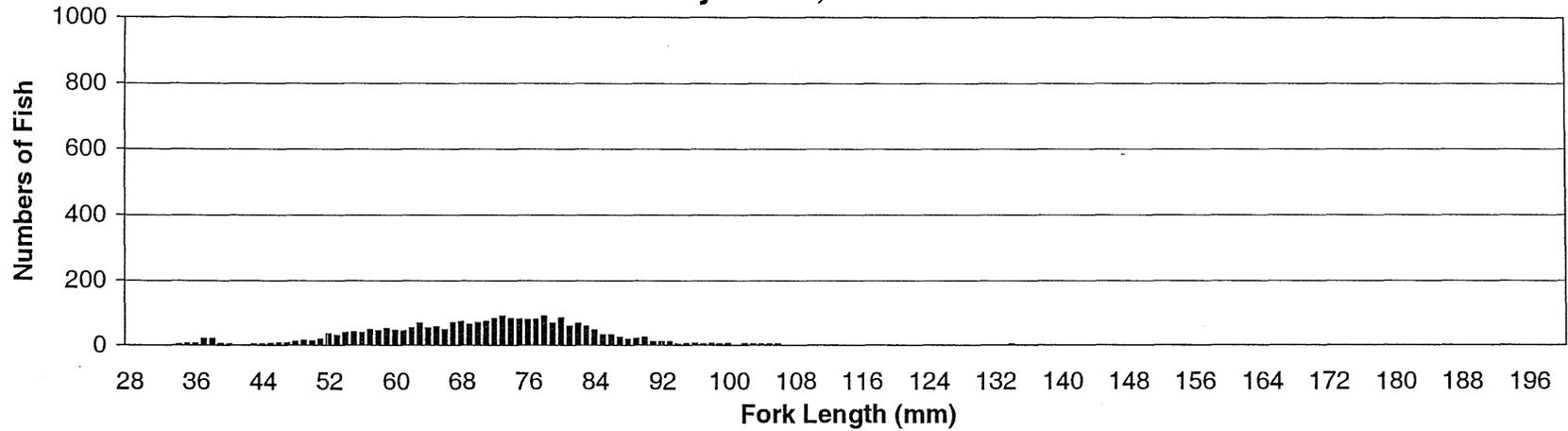
**Figure 11. Chinook salmon length frequency
April 1 -15, 2000**



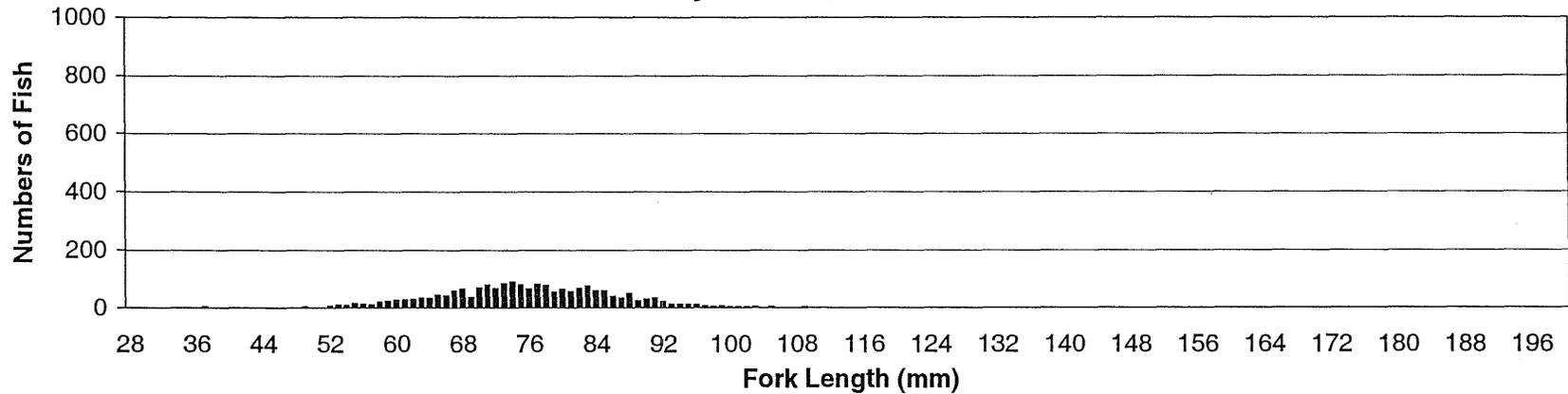
**Figure 12. Chinook salmon length frequency
April 16 -30, 2000**



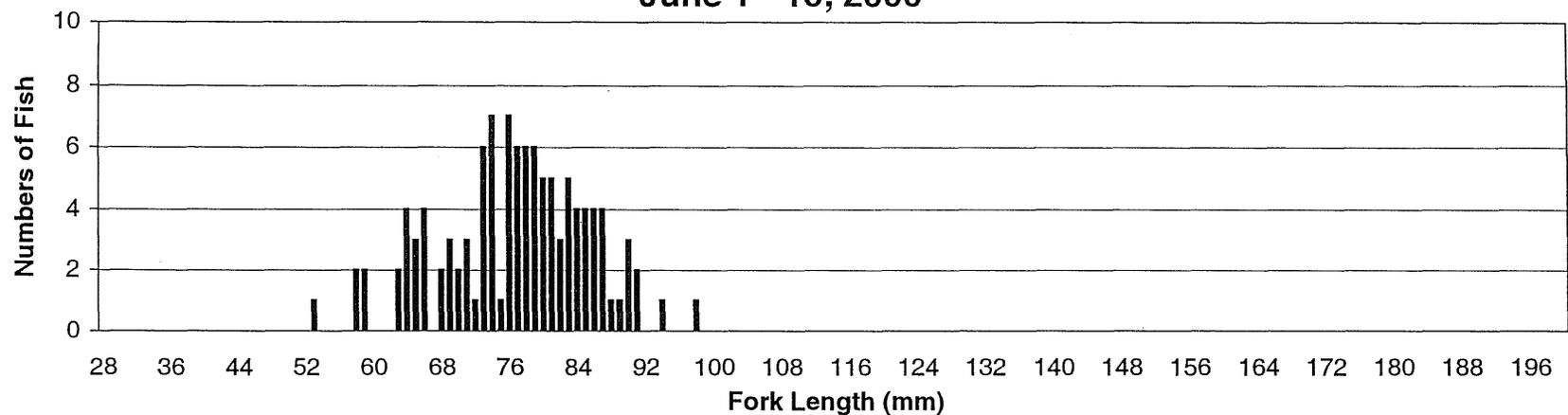
**Figure 13. Chinook salmon length frequency
May 1 - 15, 2000**



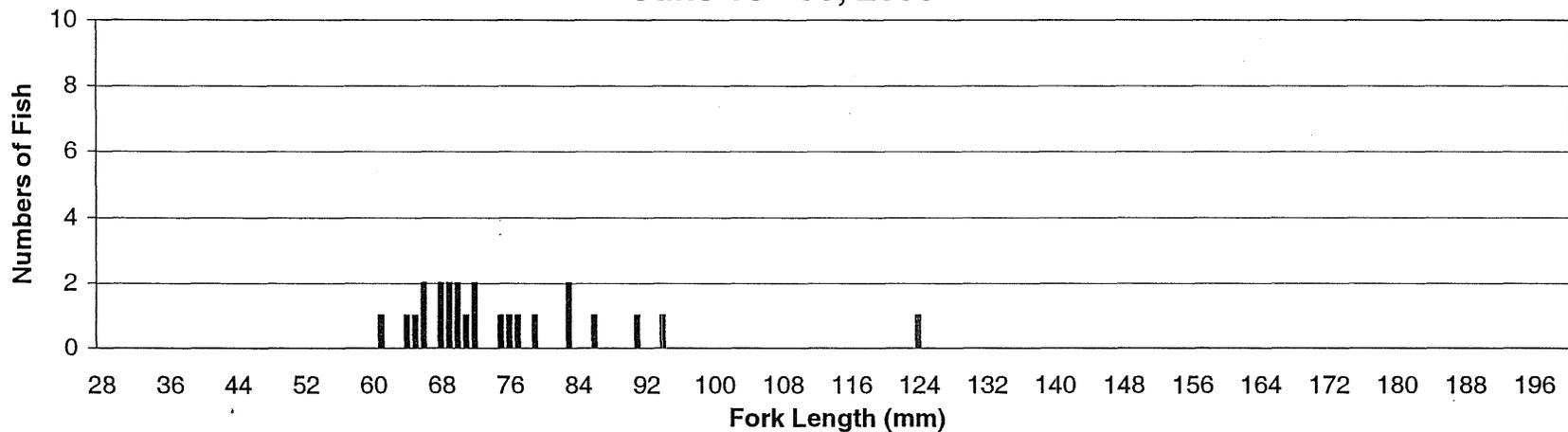
**Figure 14. Chinook salmon length frequency
May 16 - 31, 2000**



**Figure 15. Chinook salmon length frequency
June 1 - 15, 2000**



**Figure 16. Chinook salmon length frequency
June 16 - 30, 2000**



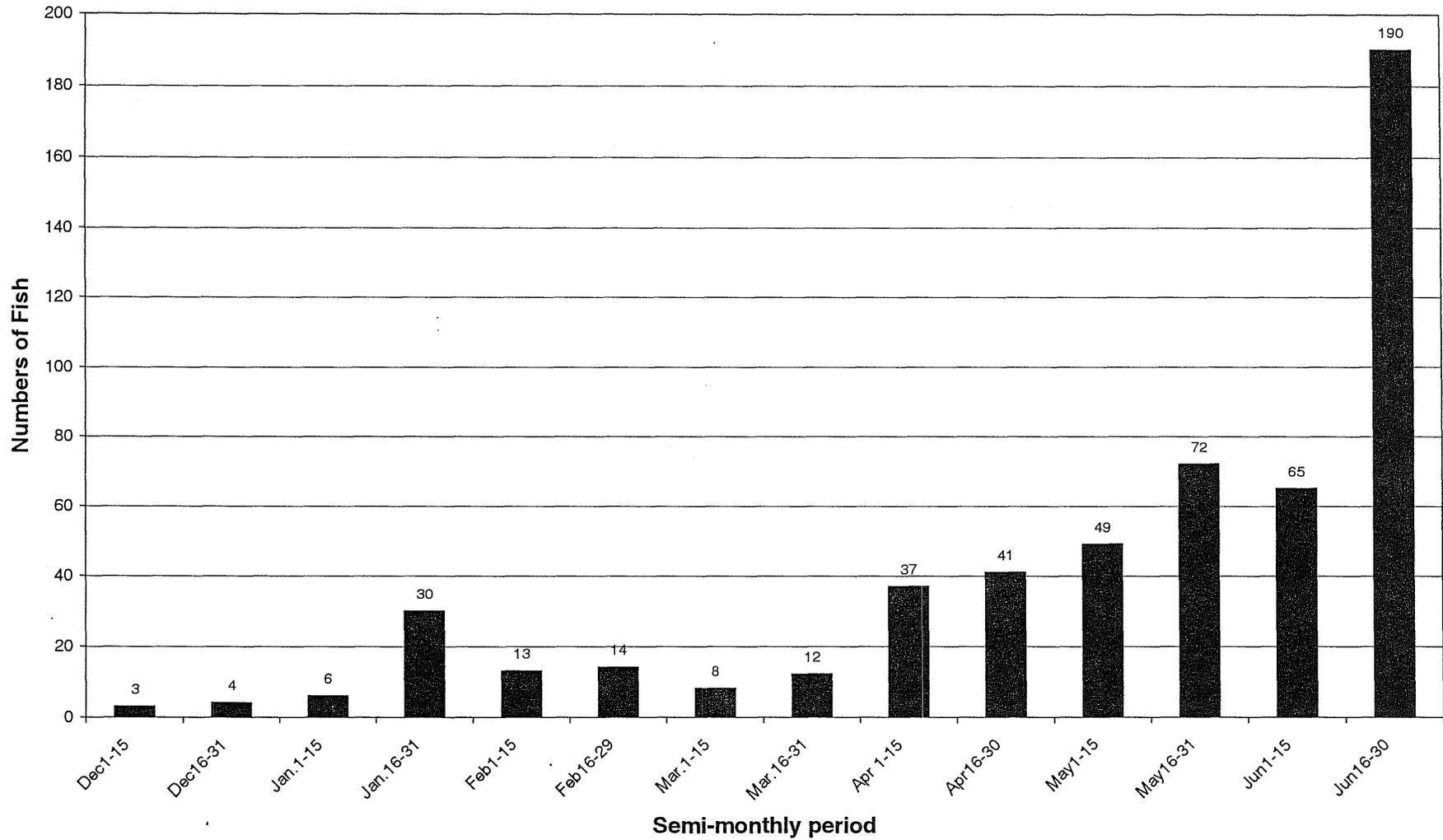
APPENDIX B

Lower Yuba River steelhead trout outmigration December 1999 – June 2000

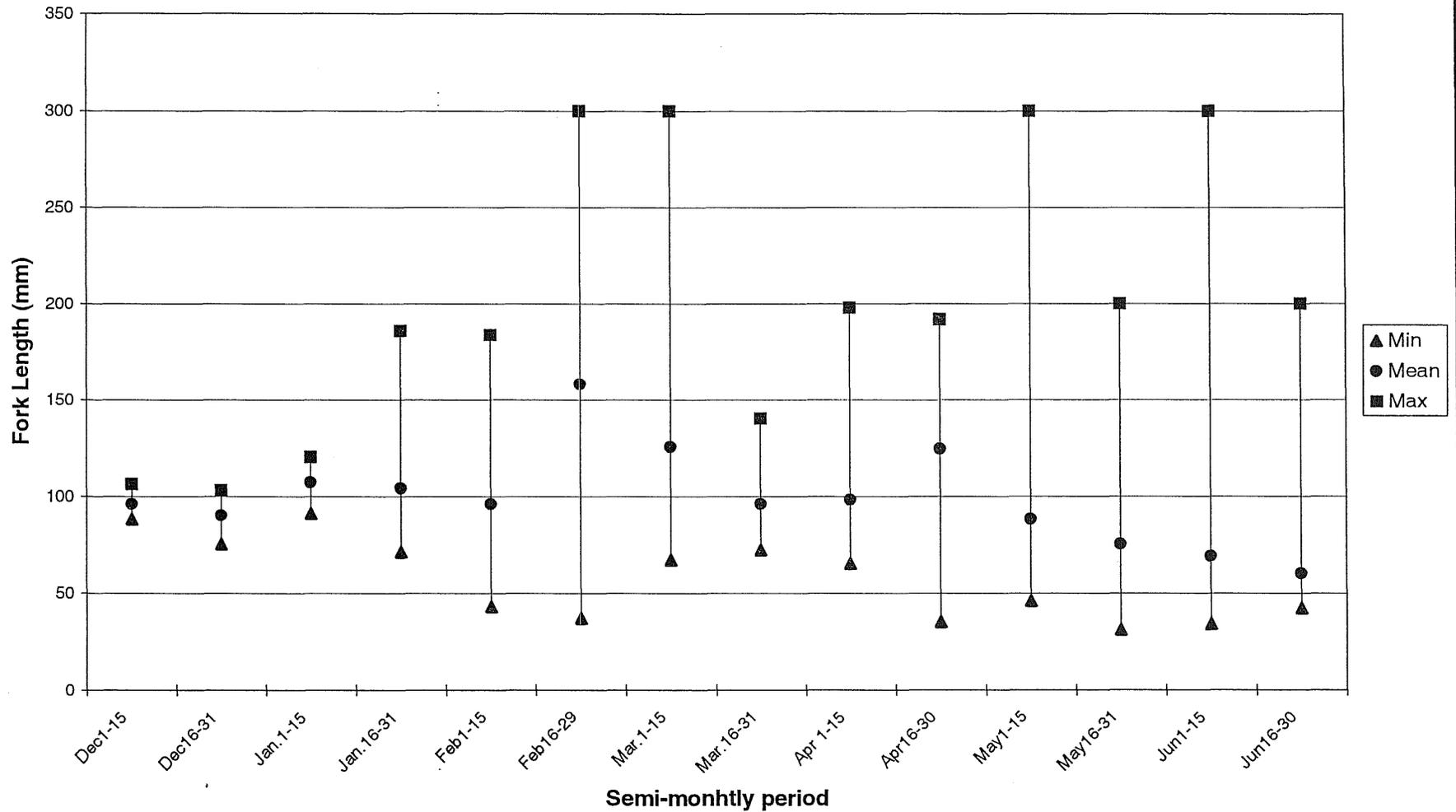
Figure

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2. Semi-monthly steelhead trout fork lengths
- 3-16. Semi-monthly steelhead trout length frequencies

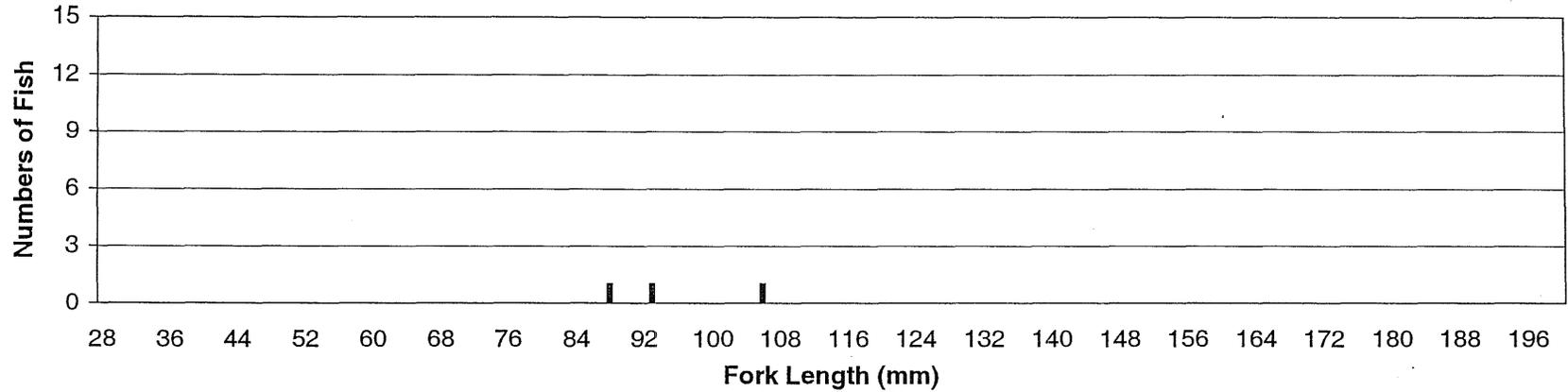
**Figure 1. Steelhead trout trapping totals
December 1999 through June 2000**



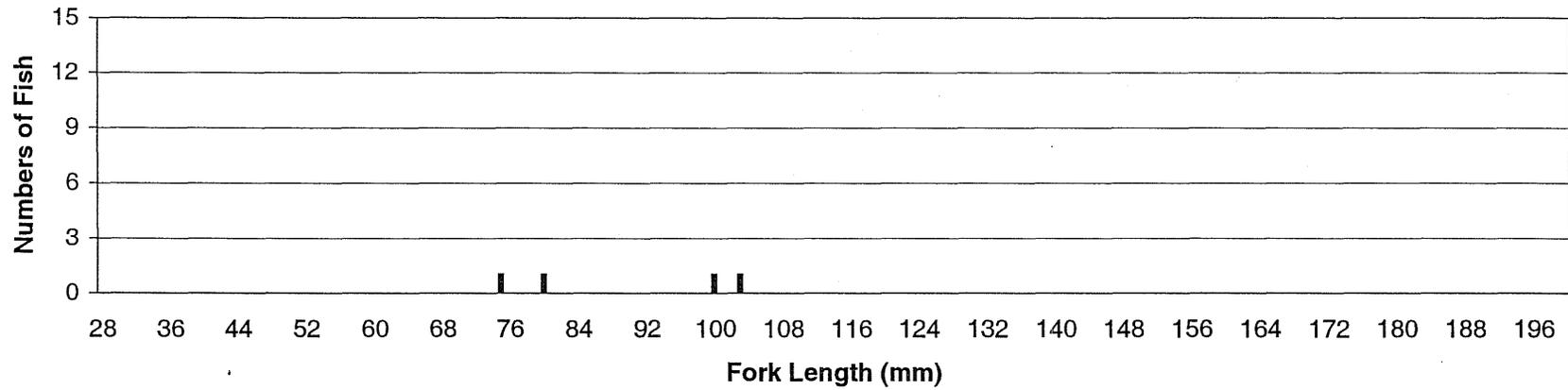
**Figure 2. Steelhead trout fork lengths
December 1999 through June 2000**



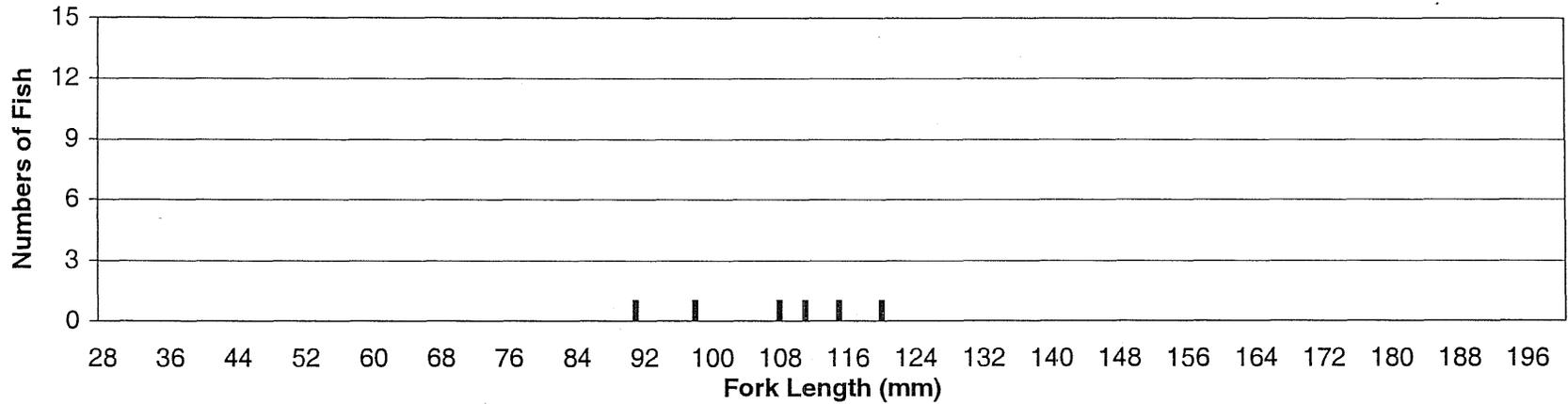
**Figure 3. Steelhead trout length frequency
December 1 - 15, 1999**



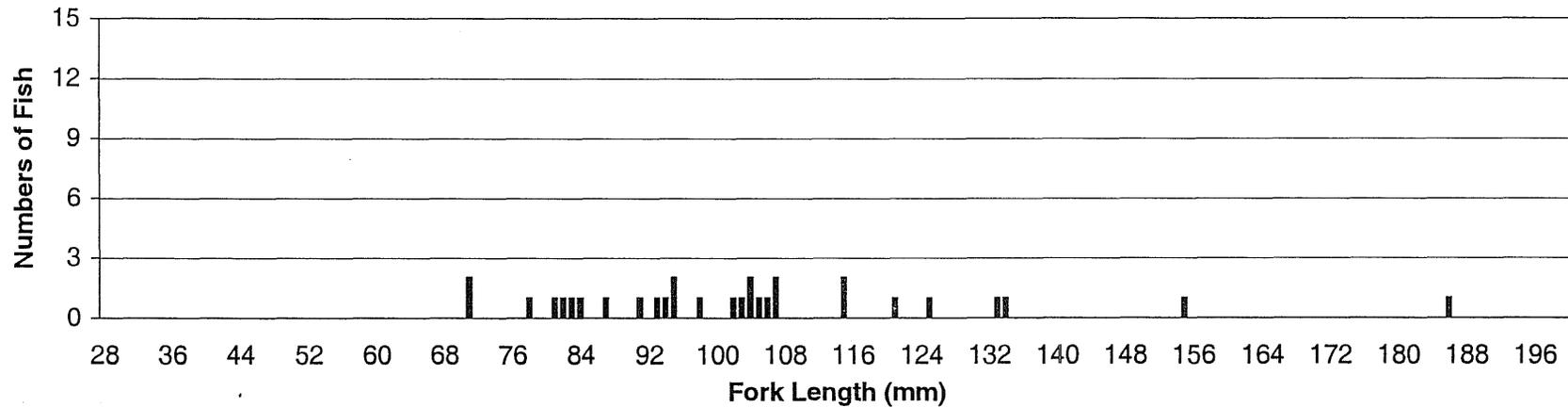
**Figure 4. Steelhead trout length frequency
December 16 - 31, 1999**



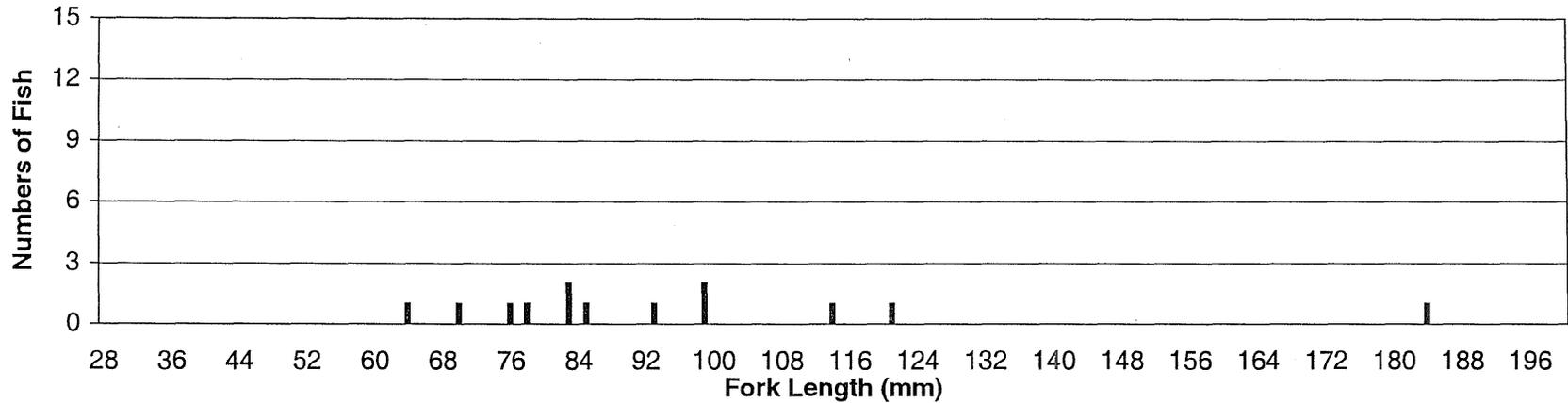
**Figure 5. Steelhead trout length frequency
January 1 - 15, 2000**



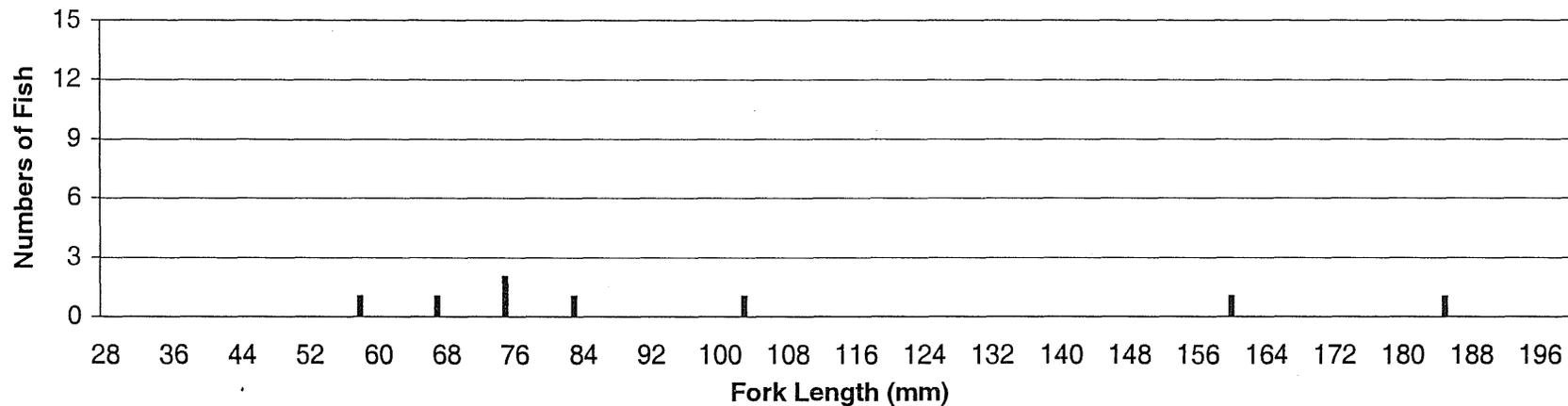
**Figure 6. Steelhead trout length frequency
January 16 - 31, 2000**



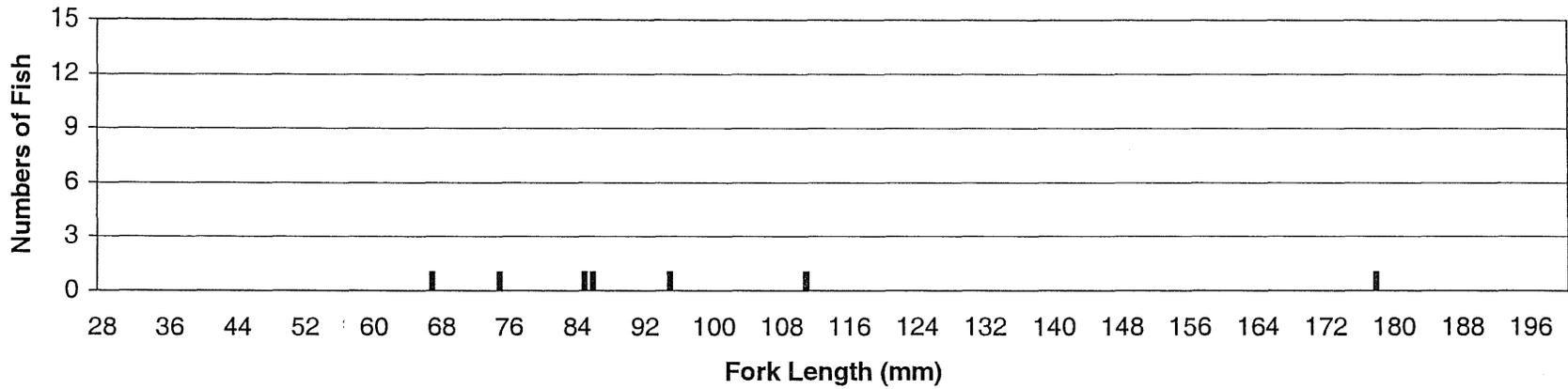
**Figure 7. Steelhead trout length frequency
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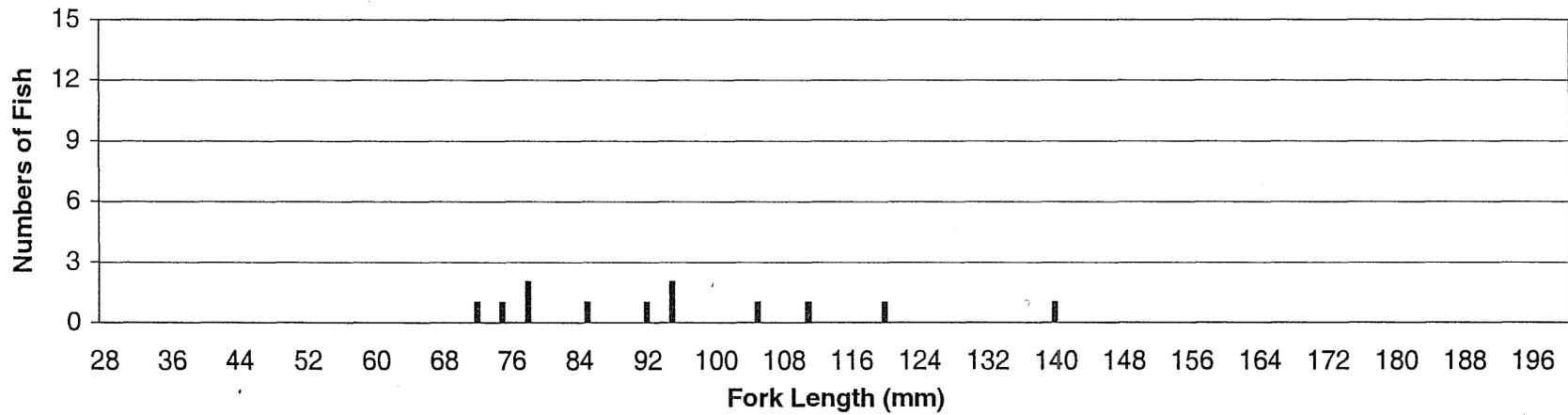
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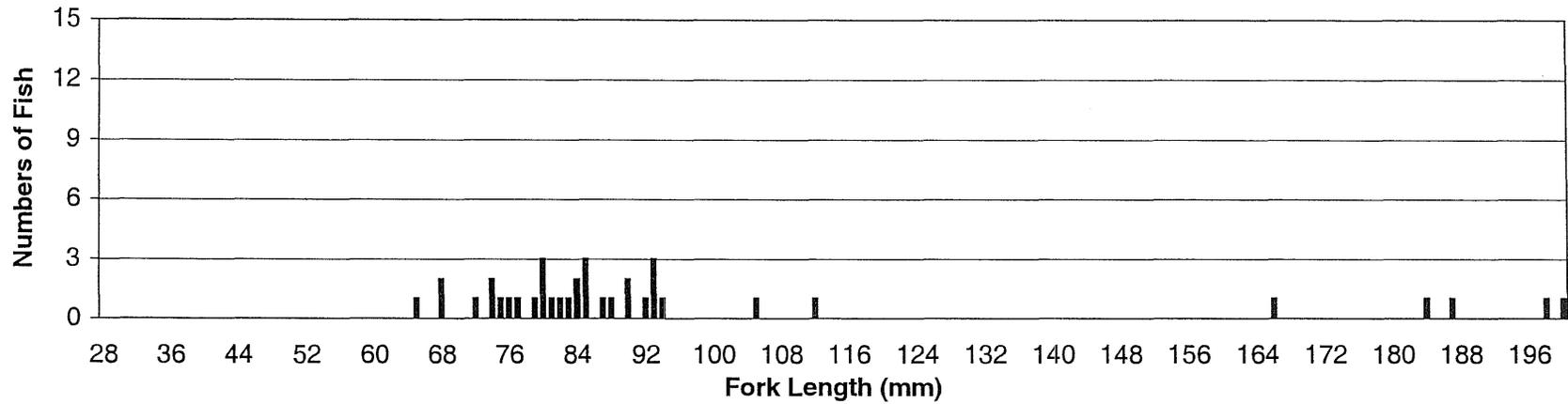
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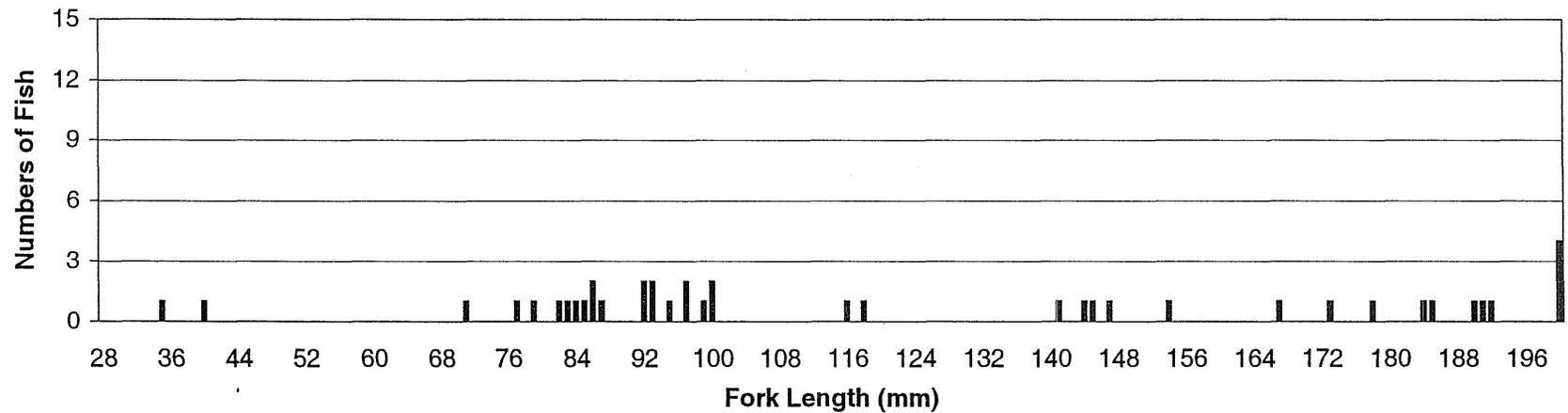
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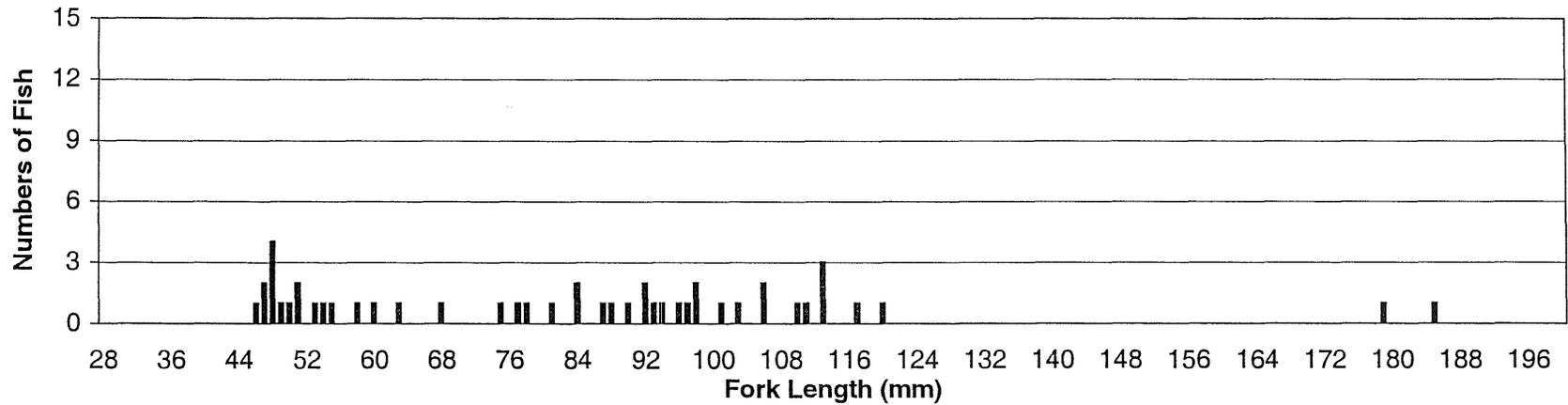
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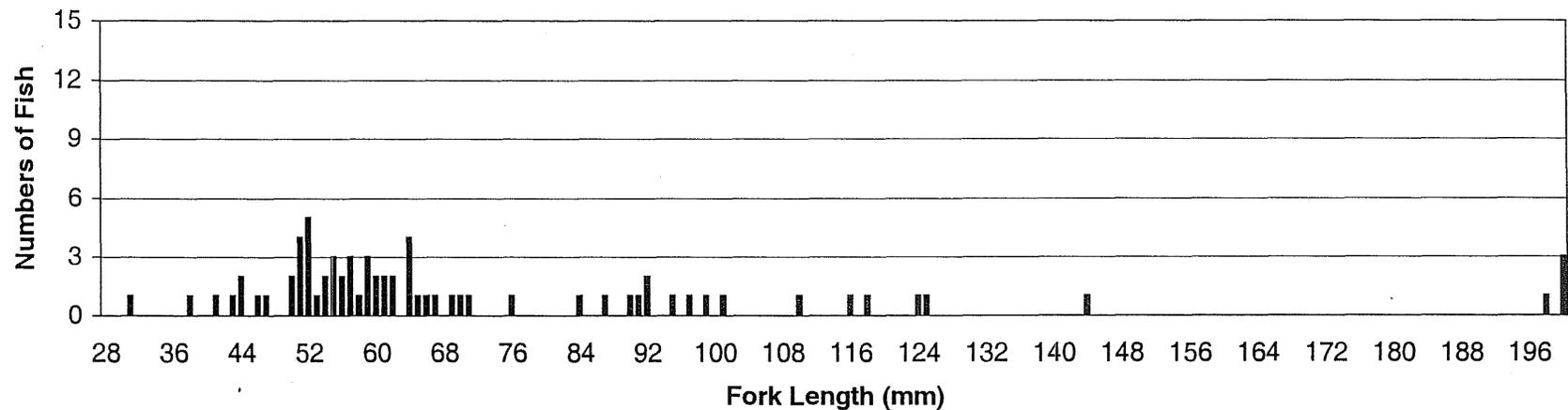
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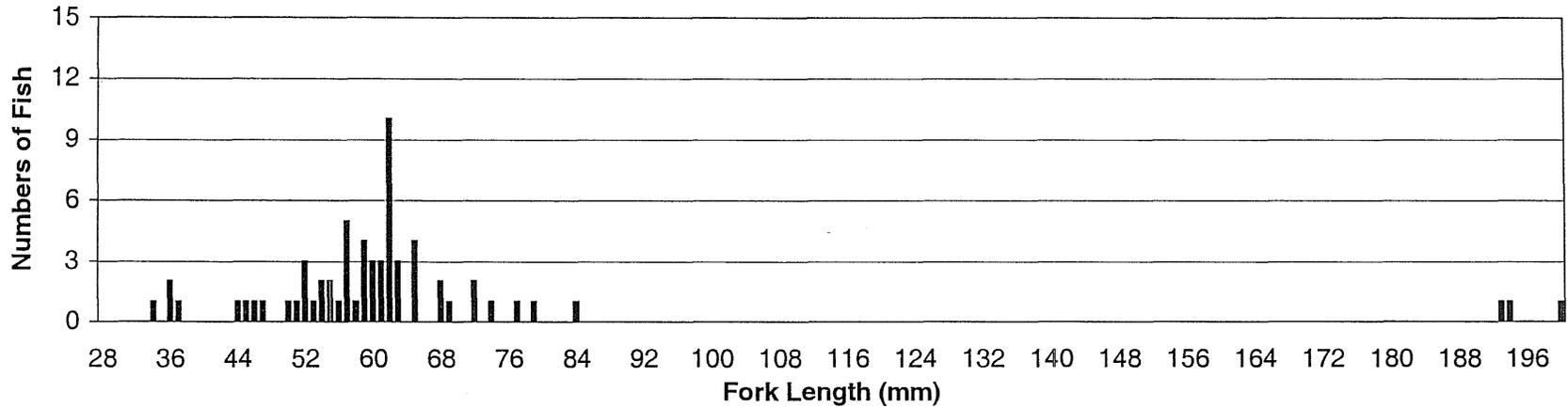
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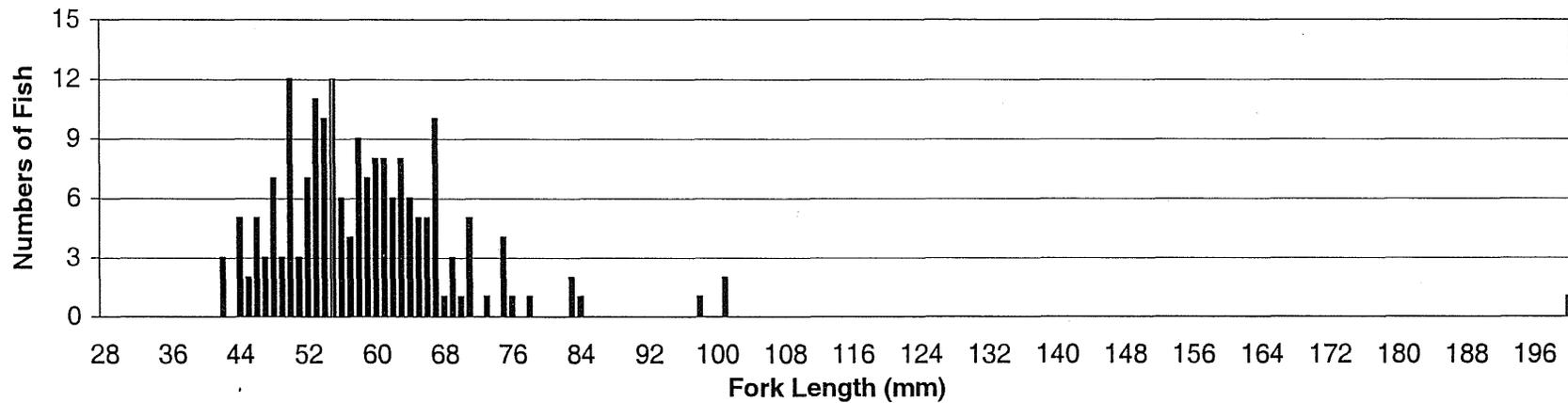
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APPENDIX C

Lower Yuba River non-target fish species captured
December 1999 – June 2000

Figure

1. Common and scientific names of non-target species

**Figure 1. Common and Scientific Names of Fishes
Captured on the Lower Yuba River,
December 1999 – June 2000**

Petromyzontidae	
Pacific lamprey	<i>Lampetra tridentatus</i>
Clupeidae	
American shad	<i>Alosa sapidissima</i>
Salmonidea	
Chinook salmon	<i>Oncorhynchus tshawytscha</i>
Steelhead trout (resident and anadromous)	<i>Oncorhynchus mykiss</i>
Cyprinidae	
Carp	<i>Cyprinus carpio</i>
California roach	<i>Hesperoleucus symmetricus</i>
Hardhead	<i>Mylopharodon conocephalus</i>
Golden shiner	<i>Notemigonus crysoleucas</i>
Sacramento squawfish	<i>Ptychocheilus grandis</i>
Speckled dace	<i>Rhinichthys osculus</i>
Catostomidae	
Sacramento sucker	<i>Catostromus occidentalis</i>
Ictaluridae	
White catfish	<i>Ictalurus catus</i>
Poeciliidae	
Mosquito fish	<i>Gambusia affinis</i>
Centrarchidae	
Green sunfish	<i>Lepomis cyanellus</i>
Bluegill	<i>Lepomis macrochirus</i>
Smallmouth bass	<i>Micropterus dolomieu</i>
Largemouth bass	<i>Micropterus salmoides</i>
Cottidae	
Riffle sculpin	<i>Cottus gulosus</i>

APPENDIX D

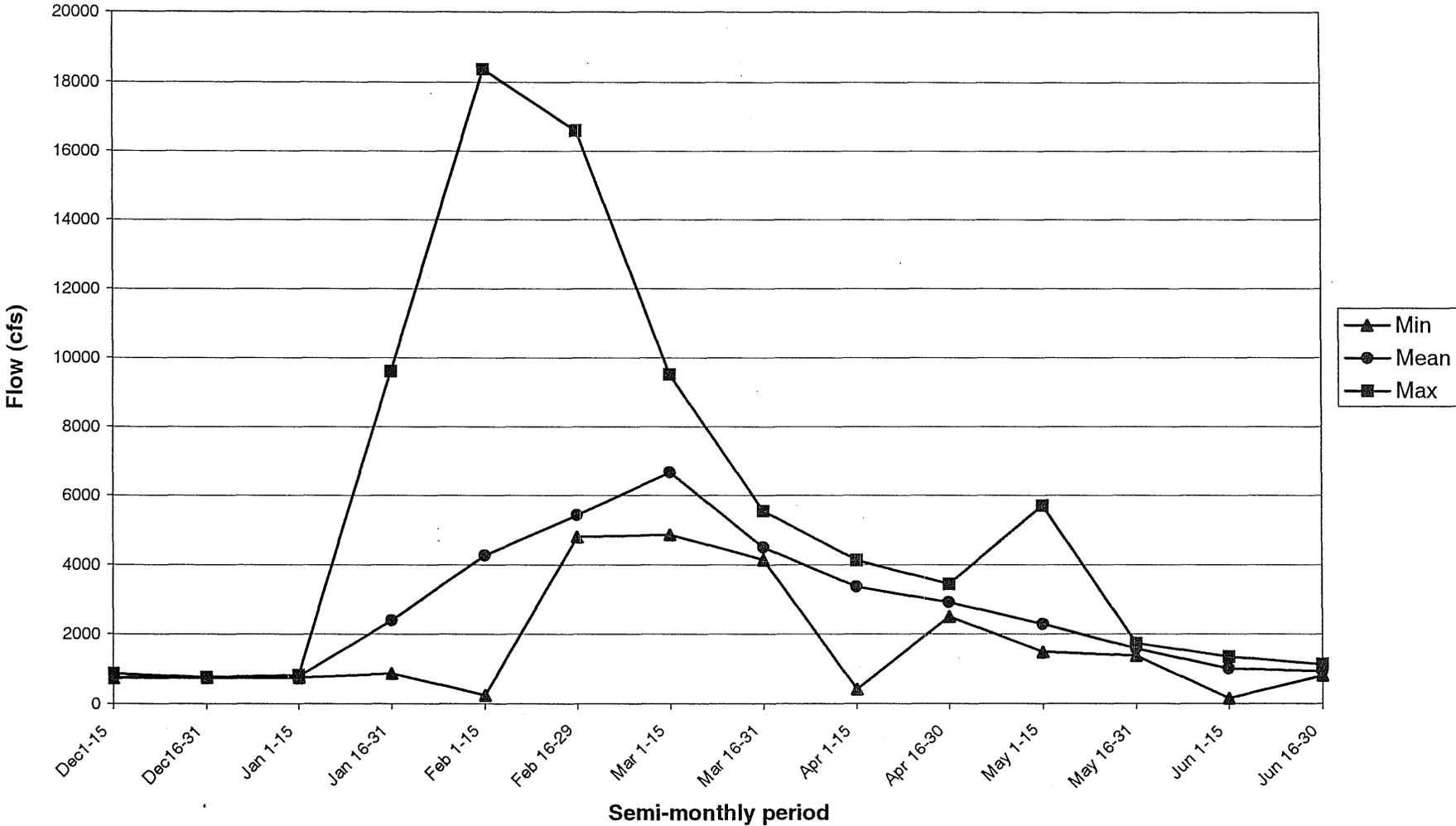
Lower Yuba River flow rates at the Marysville gage December 1999 – June 2000

Figure

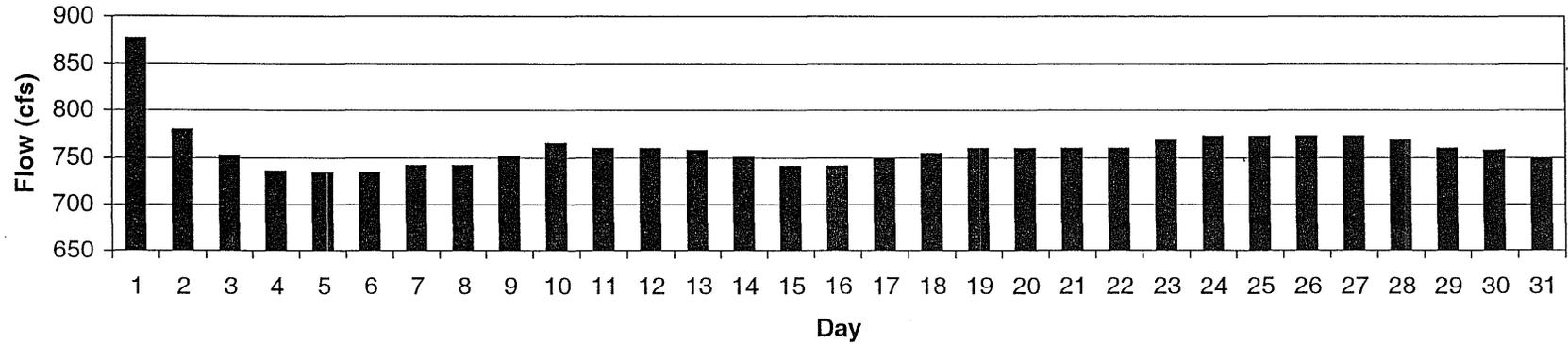
1. Semi-monthly flow rate at the Marysville gage
- 2-8. Average daily flow rates at the Marysville gage

Figure 1. Flow rate on the Lower Yuba River (Marysville gage)

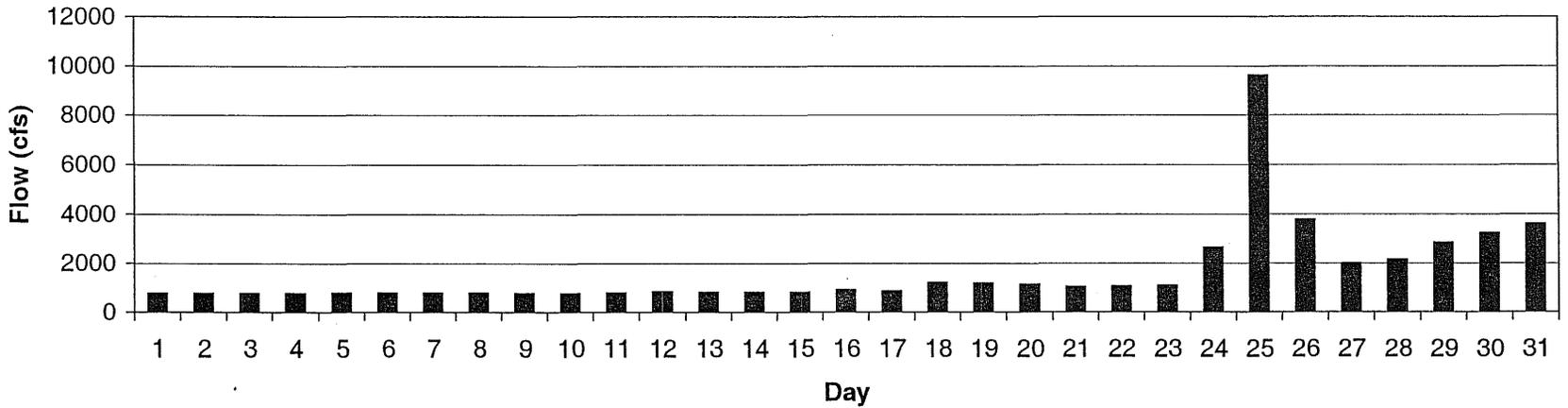
December 1999 through June 2000



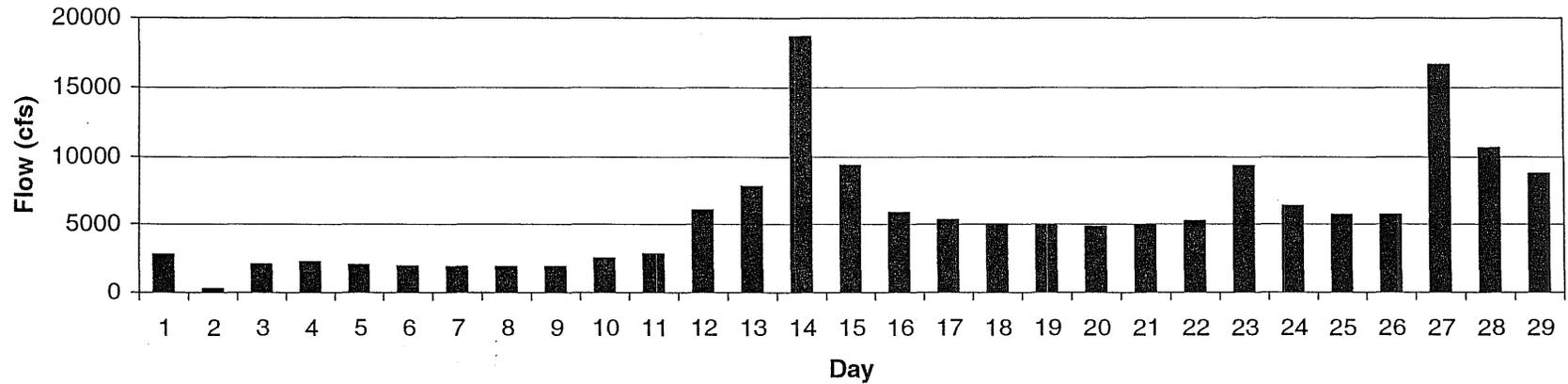
**Figure 2. Average Daily Flow Rate on the Lower Yuba River
(Marysville gage) December 1999**



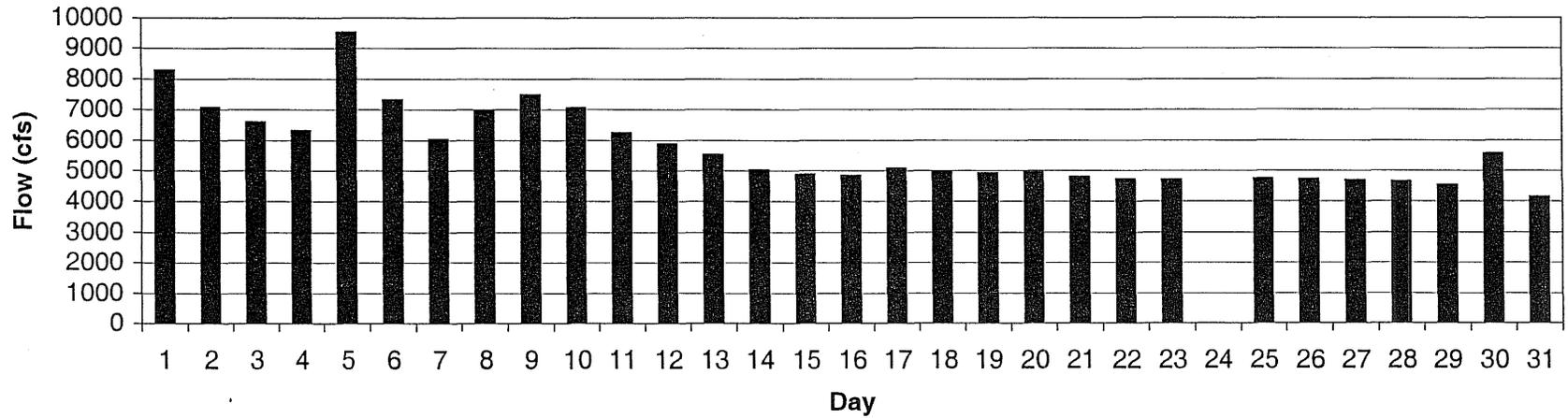
**Figure 3. Average Daily Flow Rate on the Lower Yuba River
(Marysville gage) January 2000**



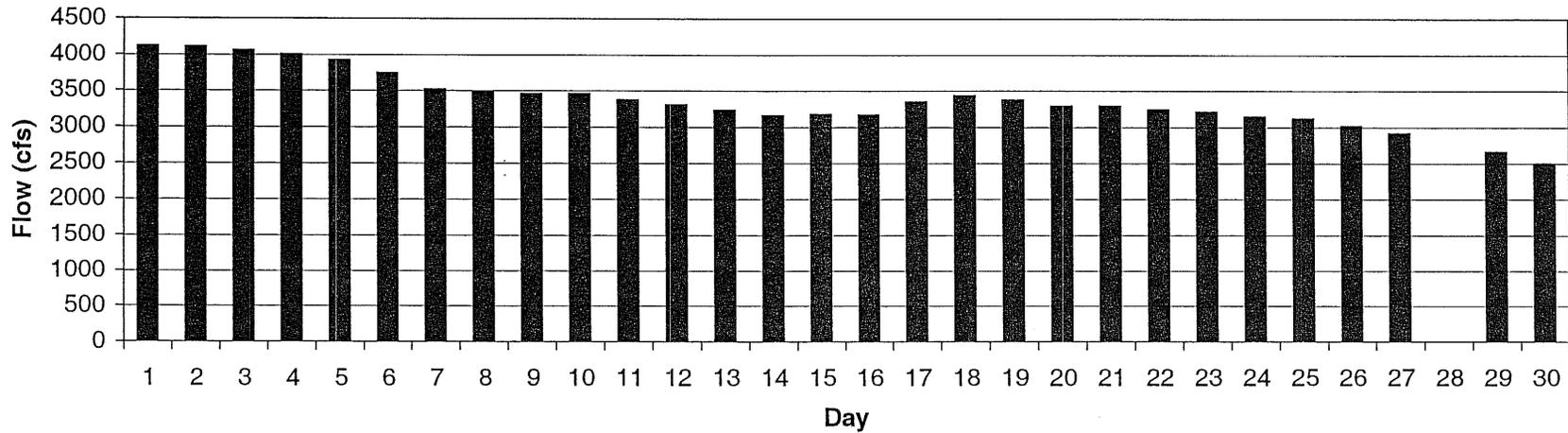
**Figure 4. Average Daily Flow Rate on the Lower Yuba River
(Marysville gage) February 2000**



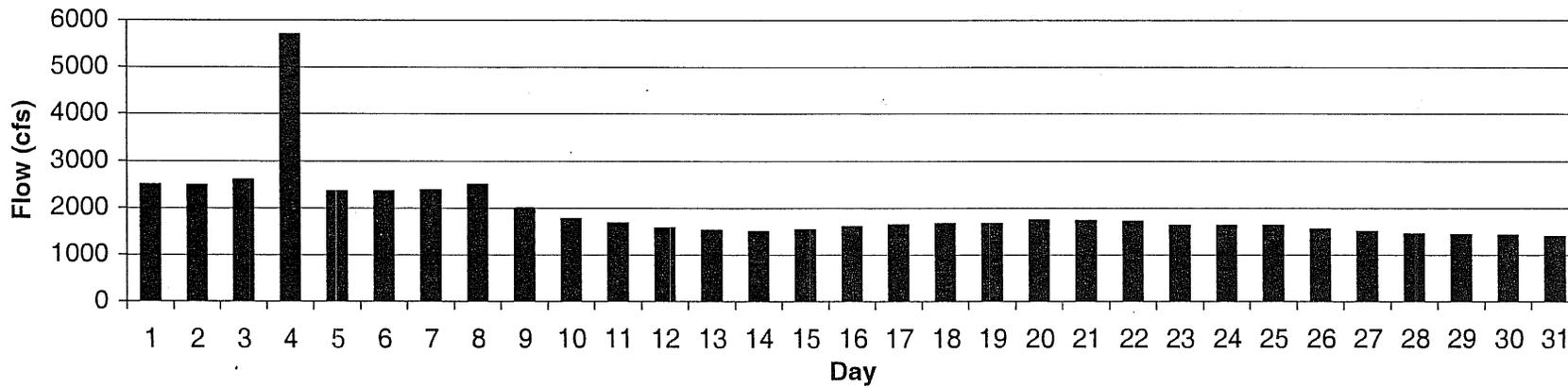
**Figure 5. Average Daily Flow Rate on the Lower Yuba River
(Marysville gage) March 2000**



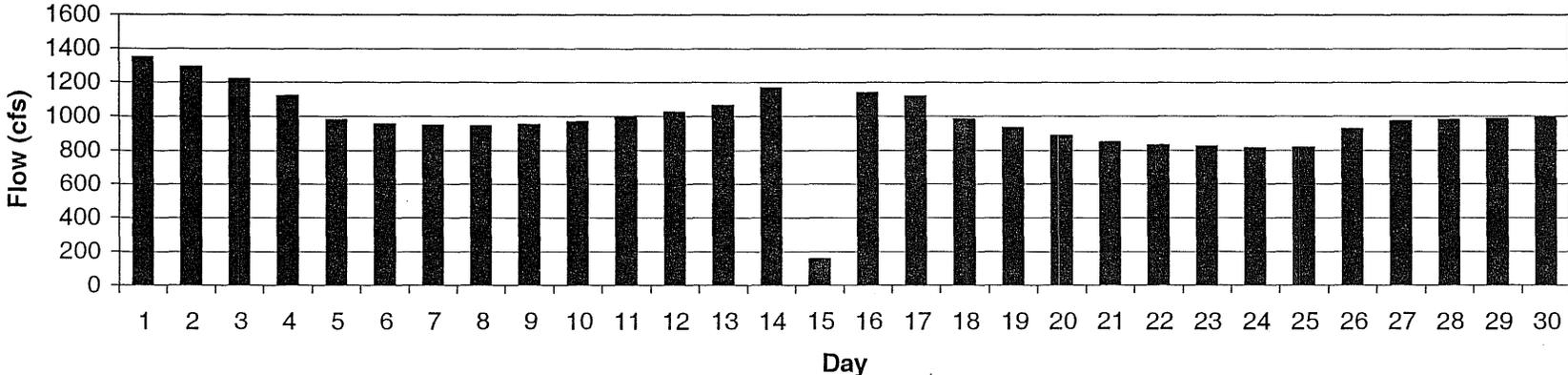
**Figure 6. Average Daily Flow Rate on the Lower Yuba River
(Marysville gage) April 2000**



**Figure 7. Average Daily Flow Rate on the Lower Yuba River
(Marysville gage) May 2000**



**Figure 8. Average Daily Flow Rate on the Lower Yuba River
(Marysville gage) June 2000**



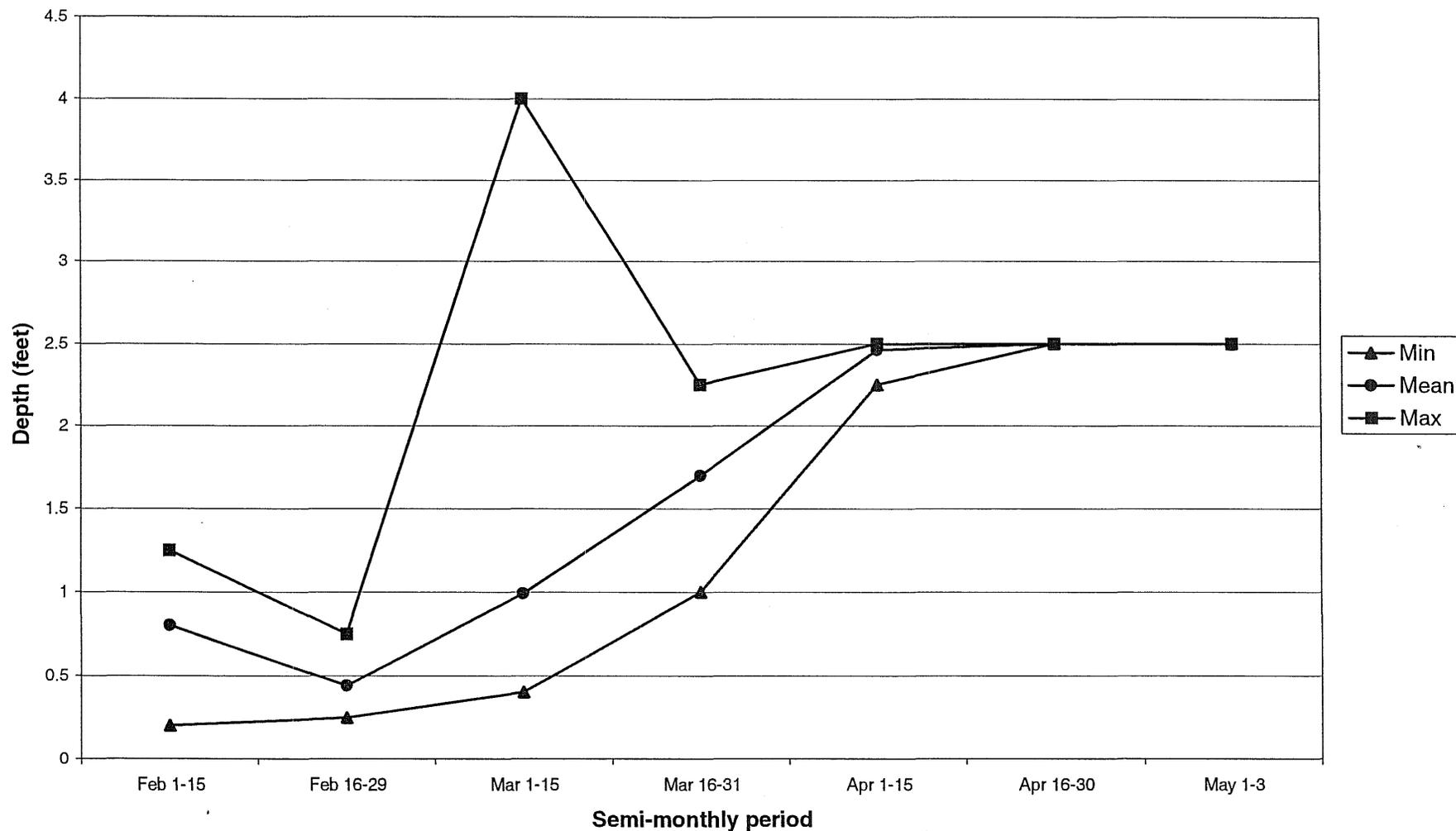
APPENDIX E

Lower Yuba River turbidity December 1999 – June 2000

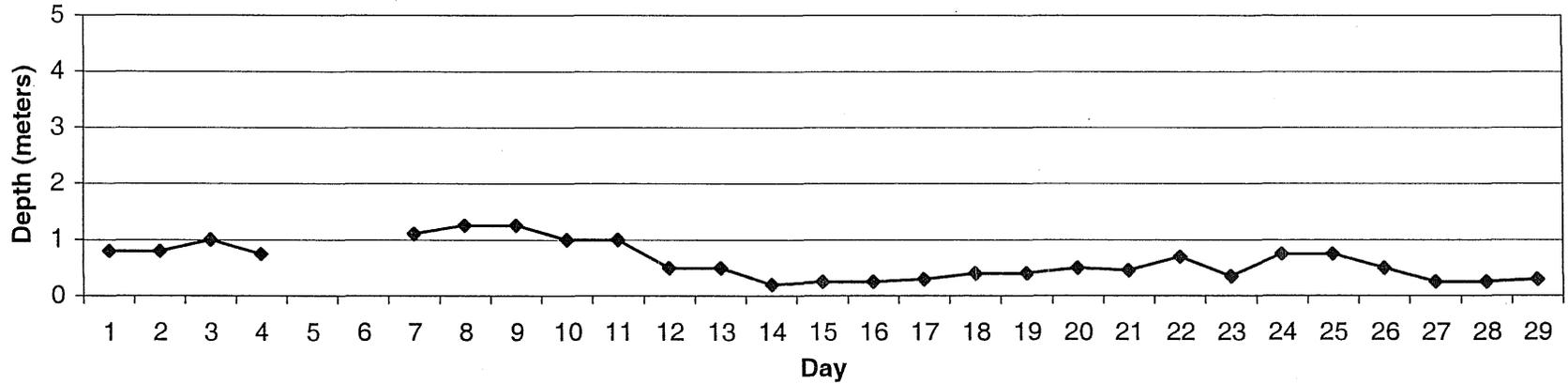
Figure

1. Semi-monthly turbidity readings with Secchi disk (February 1, 2000 – May 3, 2000)
- 2-4. Daily turbidity readings with Secchi disk (February 1, 2000 – May 3, 2000)
5. Semi-monthly turbidity readings with turbidity meter (May 4, 2000 – June 30, 2000)
- 6-7. Daily turbidity readings with turbidity meter (May 4, 2000 – June 30, 2000)

Figure 1. Turbidity on the Lower Yuba River (Secchi disk)
February 1, 2000 through May 3, 2000



**Figure 2. Daily turbidity on the Lower Yuba River (Secchi disk)
February 2000**



**Figure 3. Daily turbidity on the Lower Yuba River (Secchi disk)
March 2000**

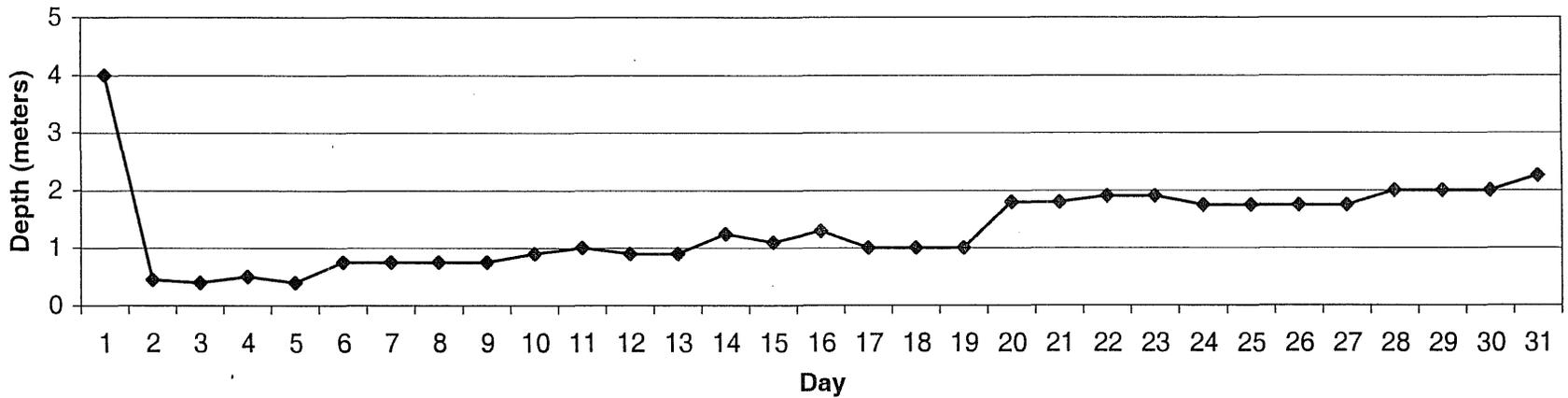


Figure 4. Daily turbidity on the Lower Yuba River (Secchi disk)
April 2000

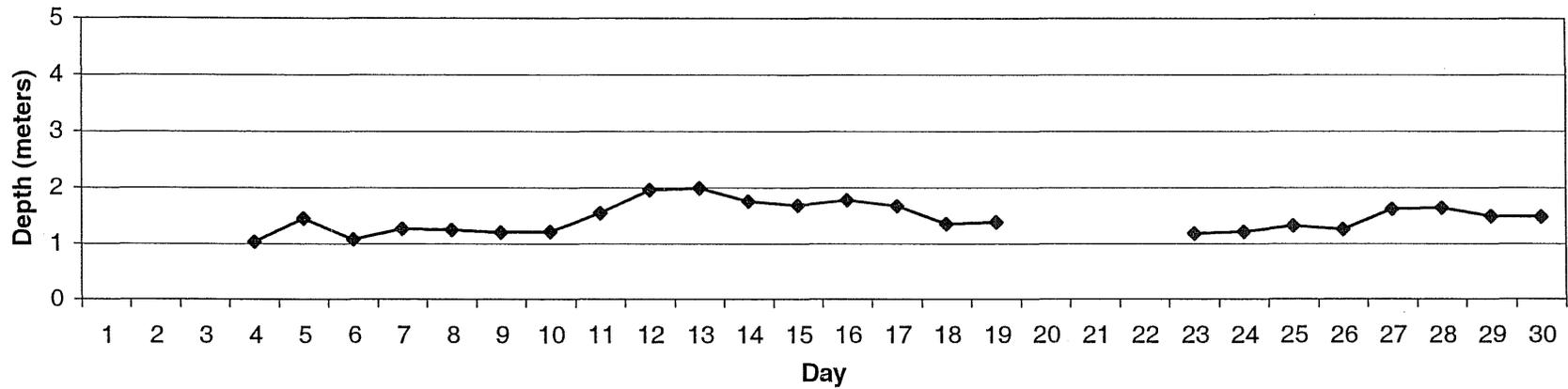
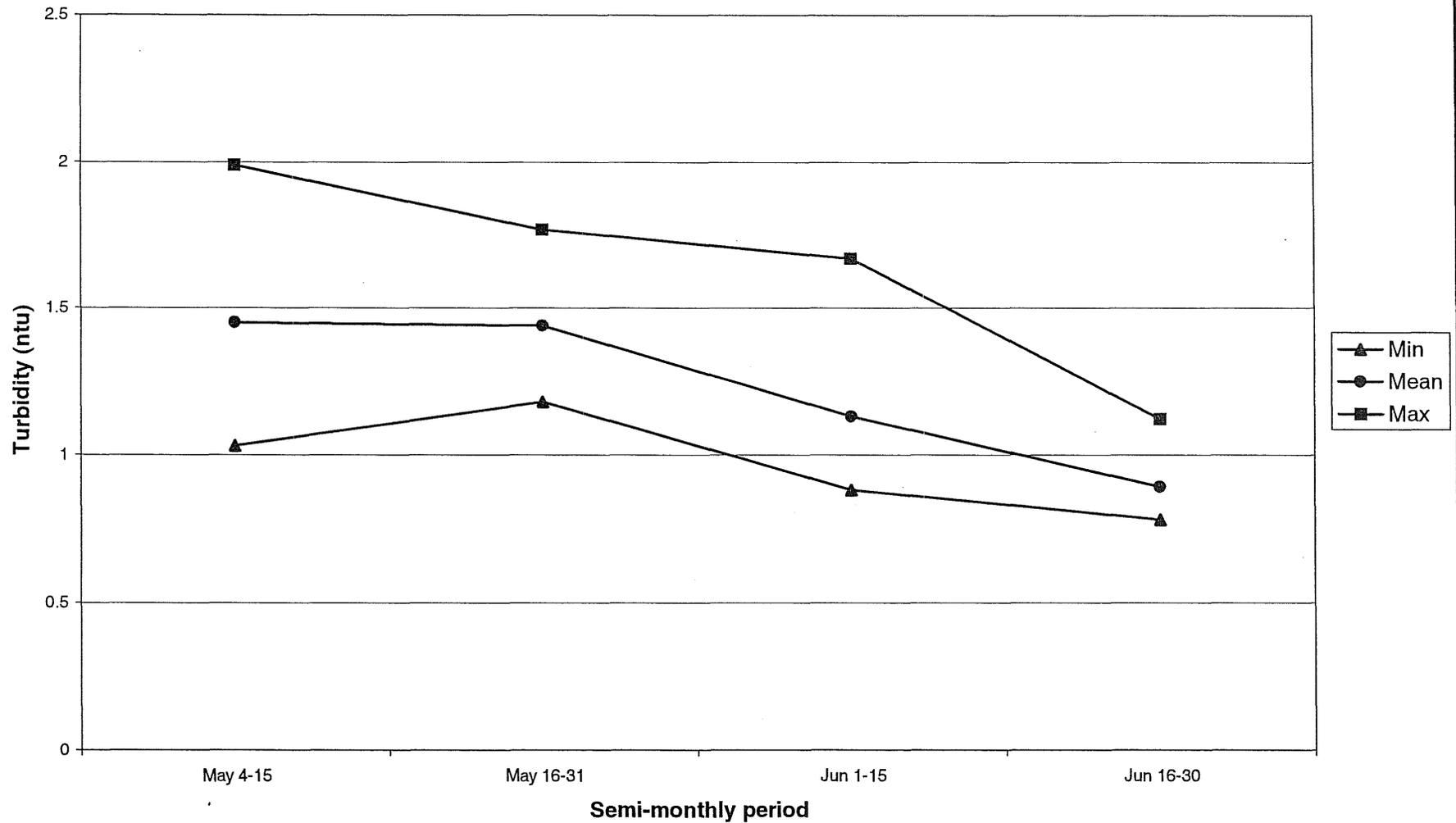
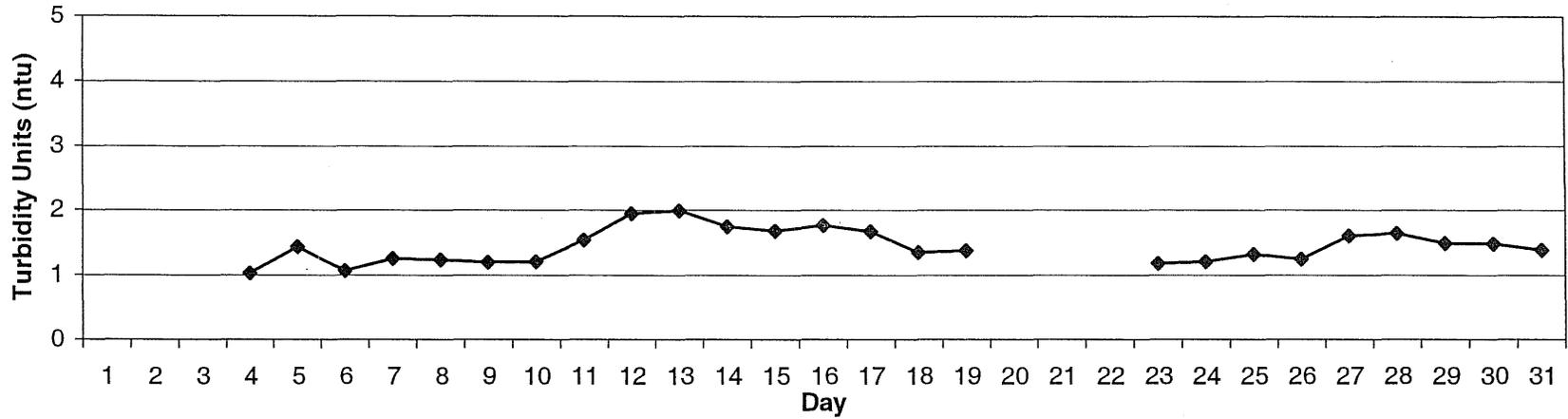


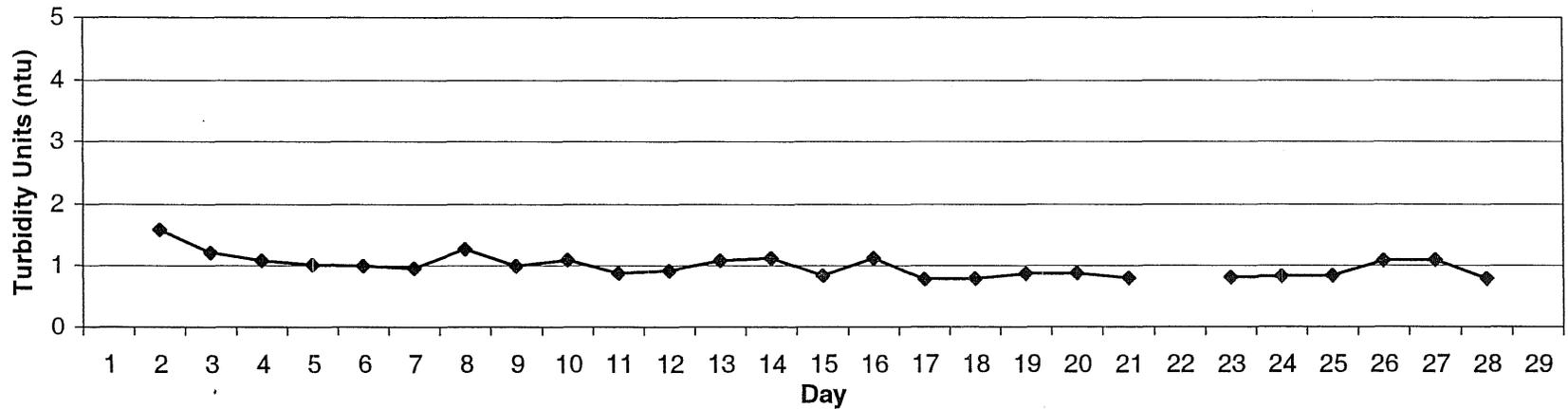
Figure 5. Turbidity on the Lower Yuba River (turbidity meter)
May 4, 2000 through June 30, 2000



**Figure 6. Daily turbidity on the Lower Yuba River (turbidity meter)
May 2000**



**Figure 7. Daily turbidity on the Lower Yuba River (turbidity meter)
June 2000**



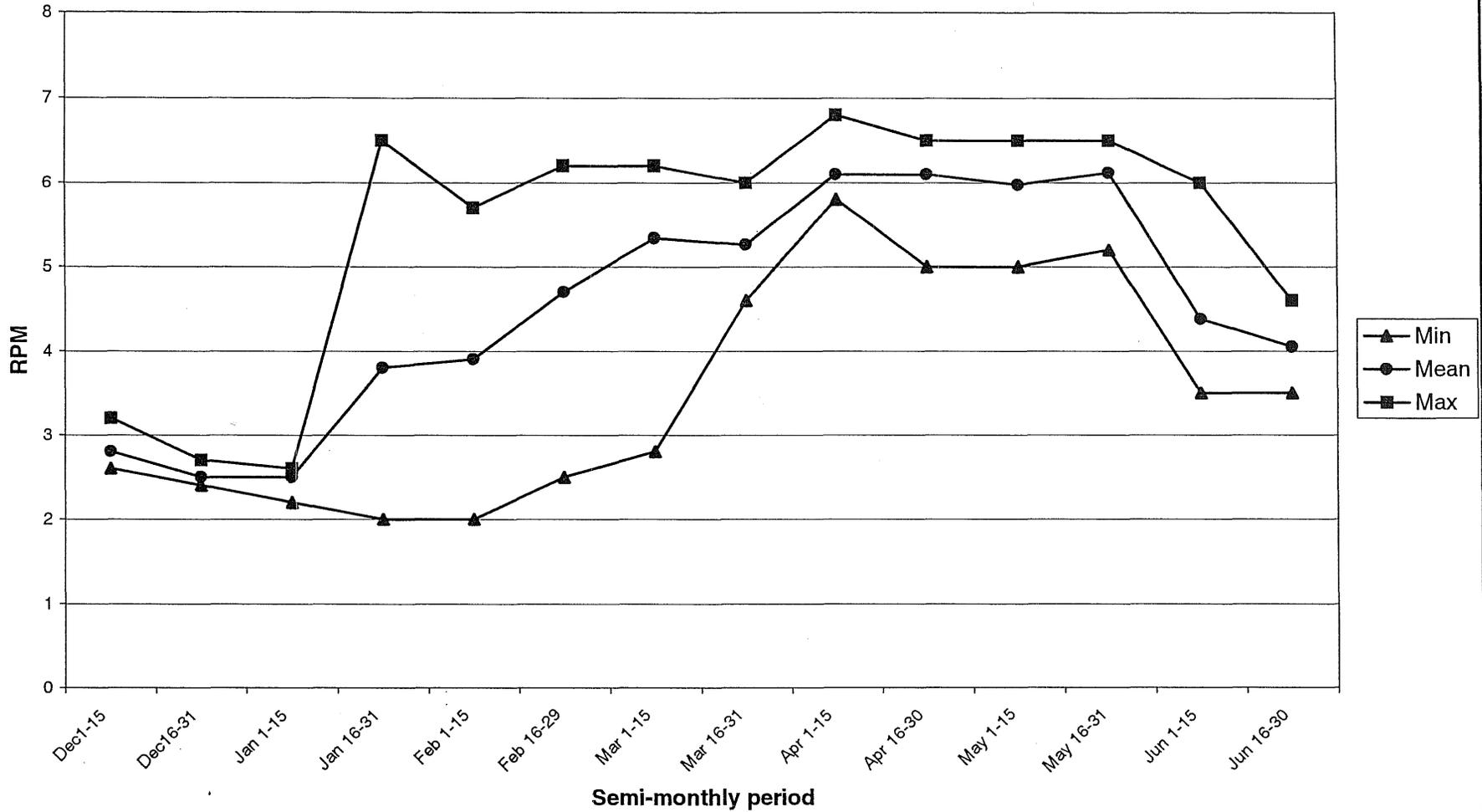
APPENDIX F

Lower Yuba River rotary screw trap revolutions per minute
December 1999 – June 2000

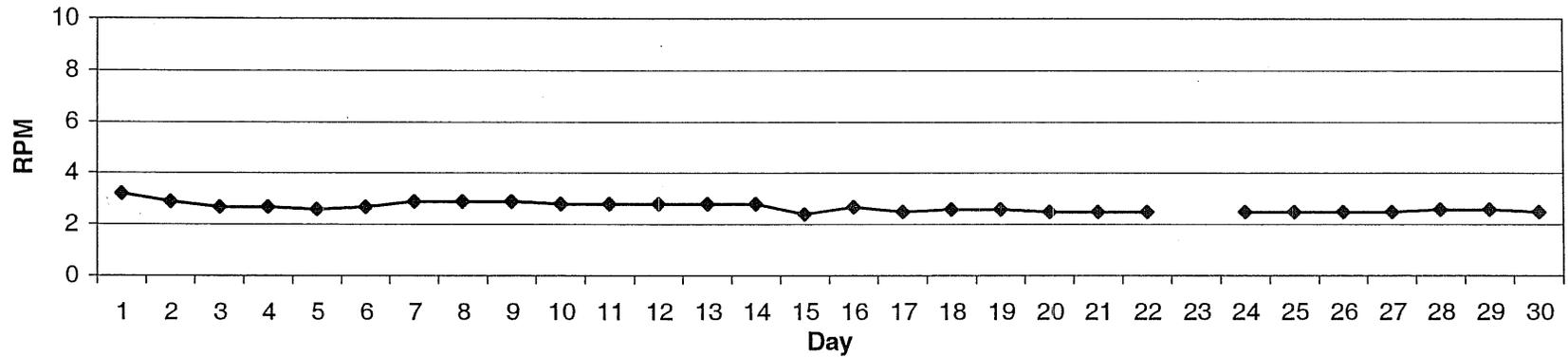
Figure

1. Semi-monthly rotary screw trap revolutions per minute
- 2-8. Daily rotary screw trap revolutions per minute

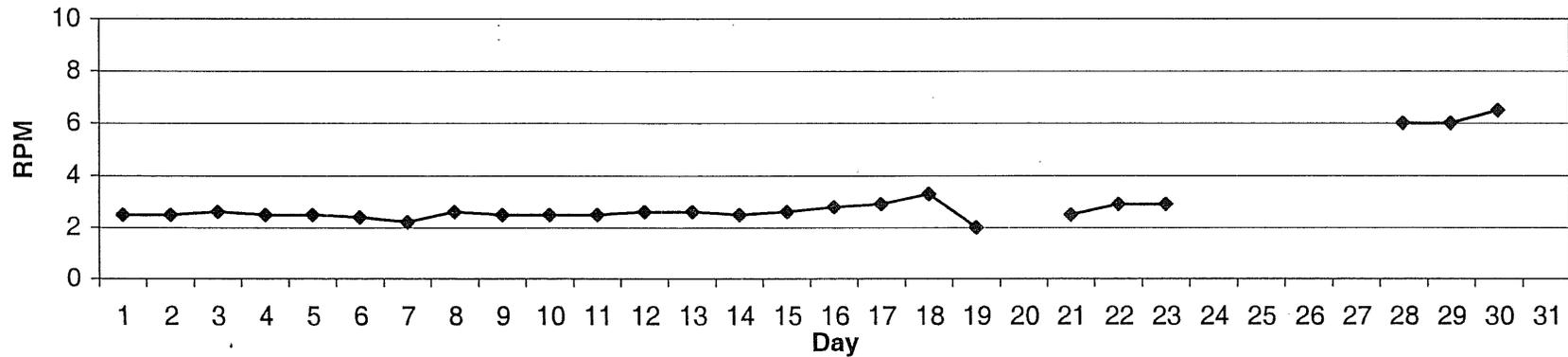
Figure 1. Rotary Screw Trap Revolutions Per Minute on the Lower Yuba River
December 1999 through June 2000



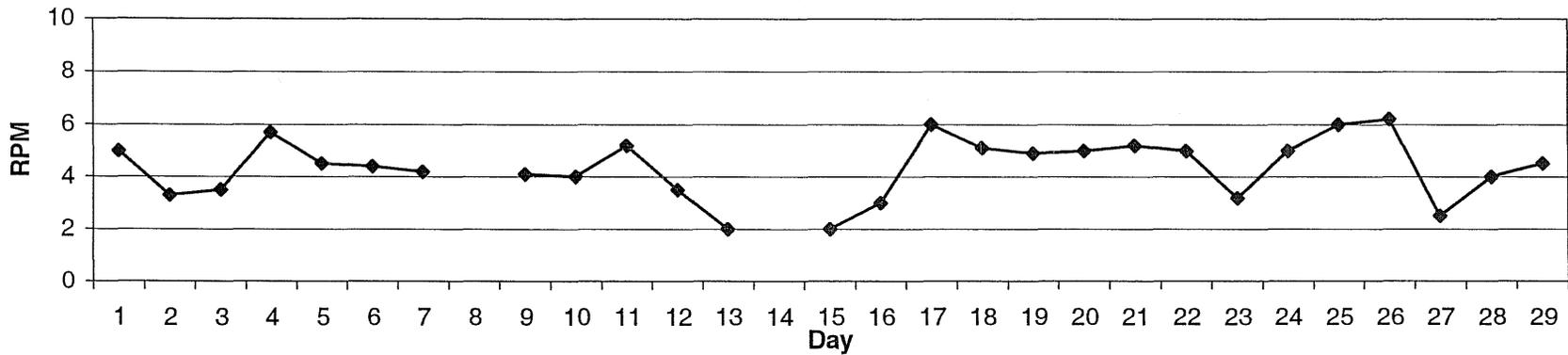
**Figure 2. Daily rotary screw trap revolutions per minute on the Lower Yuba River
December 1999**



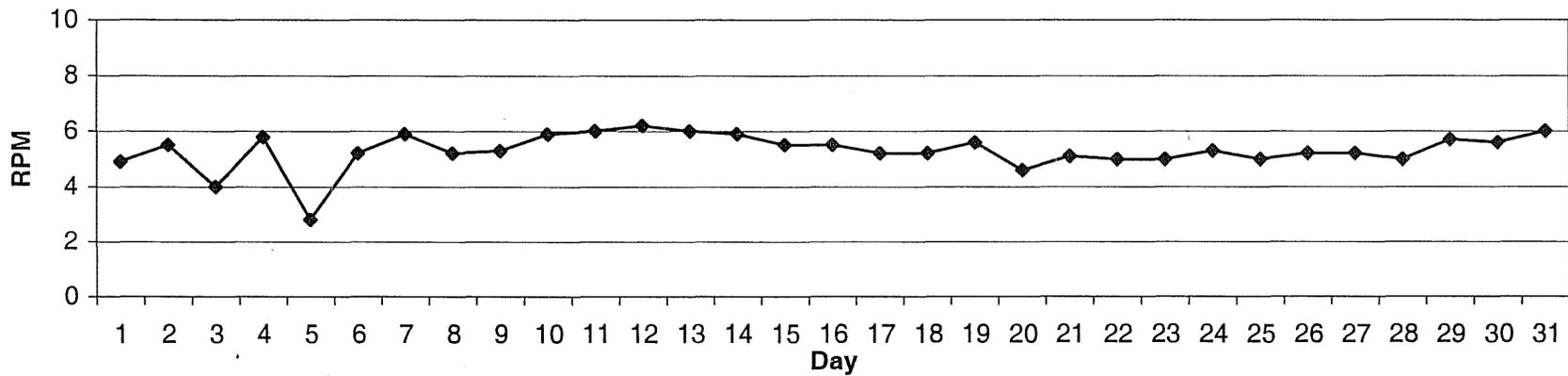
**Figure 3. Daily rotary screw trap revolutions per minute on the Lower Yuba River
January 2000**



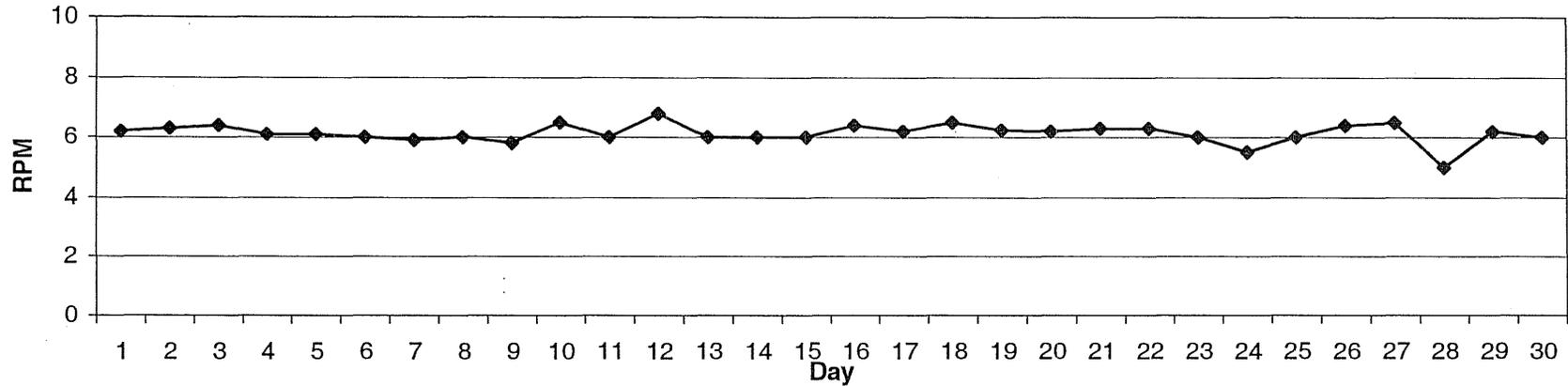
**Figure 4. Daily rotary screw trap revolutions per minute on the Lower Yuba River
February 2000**



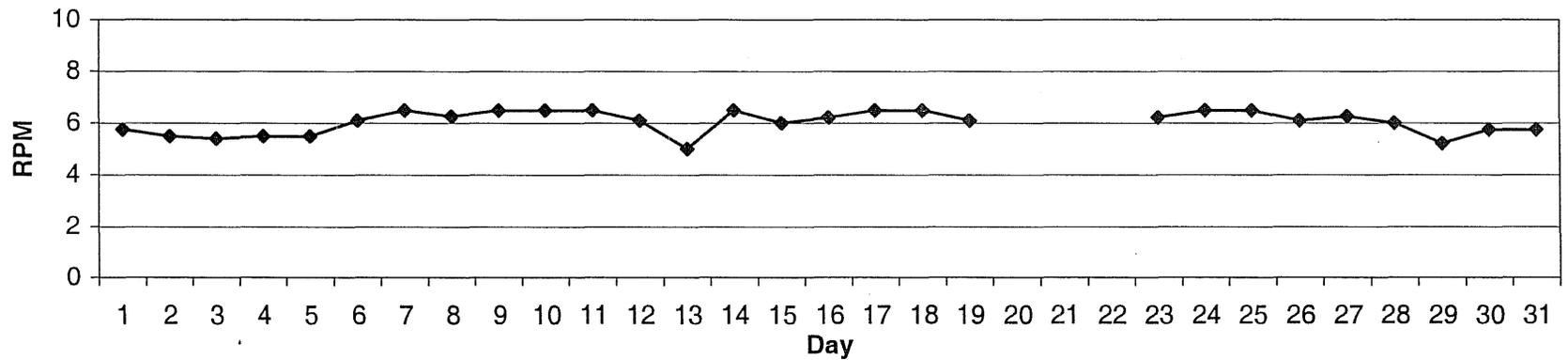
**Figure 5. Daily rotary screw trap revolutions per minute on the Lower Yuba River
March 2000**



**Figure 6. Daily rotary screw trap revolutions per minute on the Lower Yuba River
River
April 2000**



**Figure 7. Daily rotary screw trap revolutions per minute on the Lower Yuba River
River
May 2000**



**Figure 8. Daily rotary screw trap revolutions per minute on the Lower Yuba River
June 2000**

