AGE, GROWTH, AND MIGRATION OF COHO SALMON AND STEELHEAD TROUT IN JACOBY CREEK, CALIFORNIA

by

Wayne G. Harper

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Wayne G. Harper

Approved by the Master's Thesis Committee

Robert R. Van Kirk

Robert R. VanKirk, Chairman

George H. Allen

George H. Allen

Thomas J. Hassler

Thomas J. Hassler

William R. Sise

Natural Resources Graduate Program

Approved by the Dean of Graduate Studies

Alba M. Gillespie

Alba M. Gillespie

ABSTRACT

Aspects of the life histories of the coho salmon (<u>Oncorhynchus kisutch</u>) and steelhead trout (<u>Salmo gairdneri</u>) were studied in Jacoby Creek, a small coastal stream located in northern California, from October 1976 through February 1979. Juvenile coho biomass ranged from 0.0 to 3.8 g/m^2 but rarely exceeded 0.5 g/m^2. The majority of coho smolts emigrated in April and May at age 1/0. An estimated 5,000 coho smolts passed downstream during the 1977 migration period. Adult coho entered Jacoby Creek from October through January with peak movement in December. Coho spawners return either as males in the spawning season following smolt emigration (age 1/1) or as males and females in the second spawning season following emigration (age 1/2). An estimated 123 salmon entered Jacoby Creek in the 1977-78 spawning season.

Four age classes of juvenile steelhead were present in Jacoby Creek. The relationship between body length and scale radius for juvenile steelhead can be described by the equation $Y = 33.55 + 3.86X$ ($r = 0.91$). The majority of the steelhead smolt emigration took place from March through May at age 2/0. Adult steelhead entered Jacoby Creek from December through April, peaking in January and March. Eleven age categories were found among steelhead spawners. The most frequent categories were 2/2 and 2/1 for initial spawners and 2/1S.1 for repeat spawners. An estimated 217 steelhead entered Jacoby Creek to spawn in 1977-78. The arrival of both steelhead and coho spawners was closely associated with large increases in streamflow.

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INTRODUCTION

Jacoby Creek supports native runs of coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*), two of the most important fishes found in the coastal streams of northern California. The number of coho and steelhead spawners entering Jacoby Creek has been on the decline; local residents reported that prior to 1965, spawning runs were many times larger than those of recent years. This decline in the runs coincides with stream habitat degradation. A stream survey conducted in June 1964 indicated that Jacoby Creek had suitable salmonid habitat and good spawning gravel with virtually no silt throughout its length (California Department Fish and Game 1964). Since 1964, improper logging and road construction practices have been responsible for immense watershed damage and heavy silt deposition in the stream (California Department Fish and Game 1972; Johnson 1972; Pillsbury 1972). Residential growth in the lower drainage may be threatening watershed values further.

Recently, local interest has been generated to rehabilitate the quality of the watershed and to enhance and manage remaining salmonid stocks in Jacoby Creek. Effective management of a fishery resource requires an understanding of the species life history characteristics. The general objective of this study was to provide life history information on the native coho salmon and steelhead populations inhabiting Jacoby Creek. Specific objectives were to determine:

1) The size, age composition, and timing of adult coho and steelhead migrations entering Jacoby Creek.

2) The age, growth, and population characteristics of juvenile coho and steelhead residing in Jacoby Creek.

3) The size, age composition, and timing of coho and steelhead smolt migrations leaving Jacoby Creek.

The study began in October 1976, and was completed in February 1979. The intent of this investigation was to provide baseline data for a long-term, comprehensive life history study of salmonid populations in Jacoby Creek.

STUDY AREA

Jacoby Creek, located in northern California, enters Humboldt Bay three kilometers south of the city of Arcata (Figure 1). The stream is 17 kilometers long and drains a watershed of approximately 42 square kilometers. The mean elevation is 346 meters, ranging from sea level at the mouth to 728 meters at Boynton Prairie. The stream gradient is moderately steep, dropping an average of 3.7 percent (37 meters/kilometer).

The creek has a dendritic drainage pattern with a large alluvial flood plain near its mouth (Figure 2). The mouth remains open throughout the year; continuous flow is maintained through the dry season by the slow release of ground and bank storage. The creek is subject to highly variable flows; flood discharge peaks and ebbs very rapidly in the drainage. Discharge from the upper 6.07 square miles (15.7 km^2) of the watershed from 1954-1964, ranged from a minimum of 0.6 ft^3/sec (cfs) in September 1957 to a maximum of 1670 cfs in December of 1954 (U.S. Geological Survey 1964).

The climate is characterized by mild, dry summers and cool, wet winters. The middle and lower regions of the drainage are cooled by coastal fog throughout the spring and summer. The watershed has a mean annual precipitation of 60.65 inches; over 90 percent of which occurs from October through April (Elford and McDonough 1974).

The primary geological formation found in the watershed is the Franciscan Formation. This formation is characterized by shear zones which collect water and result in numerous slumps and landslides. It is considered a poor formation for road-building (Johnson 1972).

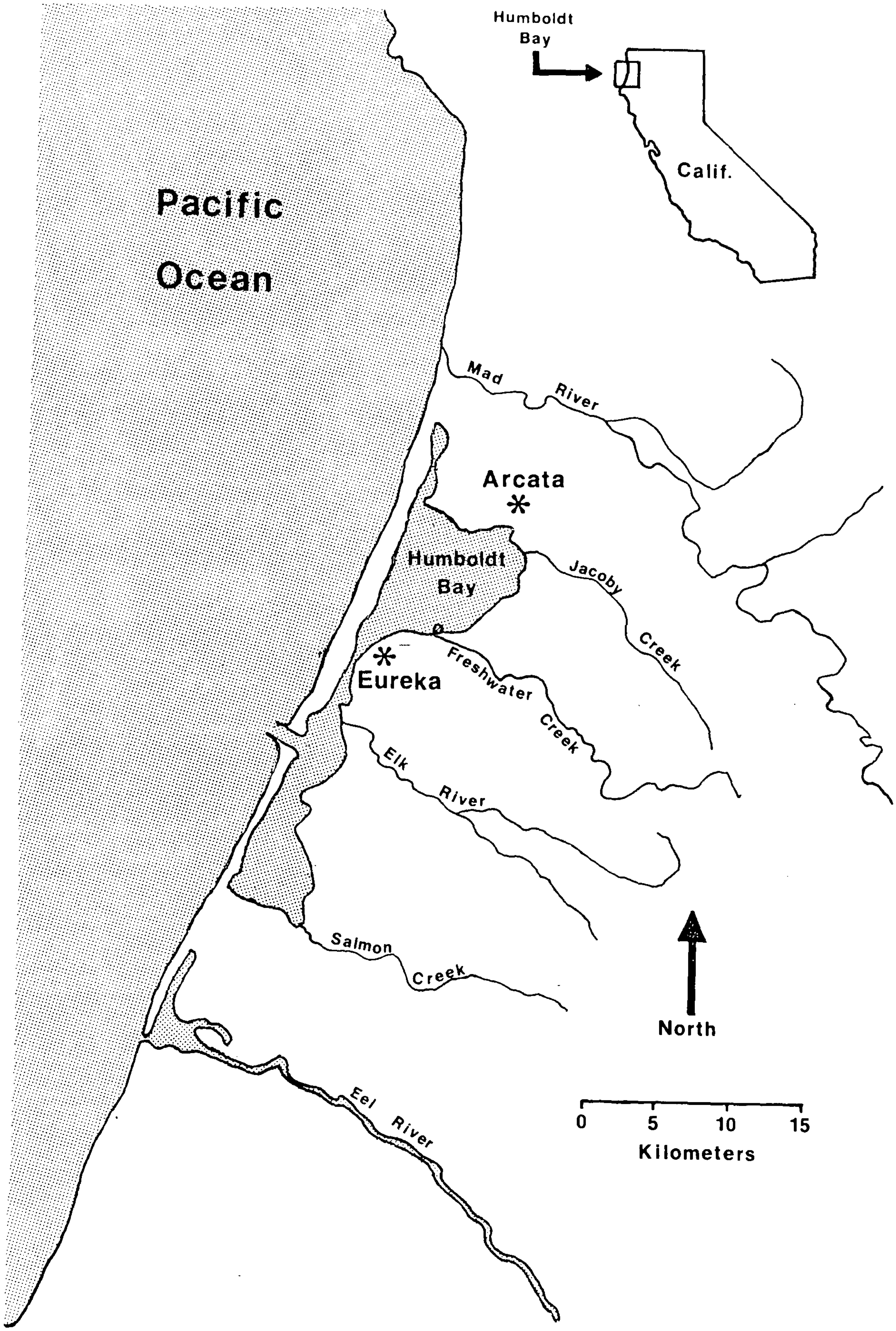

Figure 1. Location map for Jacoby Creek, California.

Figure 2. Upstream aerial view of Jacoby Creek watershed.

Second growth forests cover the middle and upper sectors of the watershed. Dominant tree species are redwood (*Sequoia sempervirens*), Douglas fir (*Pseudotsuga menziesii*), sitka spruce (*Picea sitchensis*), grand fir (*Abies grandis*), and western hemlock (*Tsuga heterophylla*). Common shrubs are evergreen huckleberry (*Vaccinium ovatum*), salal (*Gaultheria shallon*), and salmon berry (*Rubus spectabilis*). The lower portion of the drainage consists of mixed grassland and pastures with a dense canopy of red alder (*Alnus rubra*) and willow (*Salix spp.*) lining the stream.

The study area was restricted to the anadromous zone of the stream which extends from the mouth to a large clay slide, 8.3 kilometers upstream (Figure 3). Historically, anadromous salmonid movement extended 9.7 kilometers upstream to a six-meter waterfall barrier. The lower four kilometers of the creek is characterized by a high percentage of shallow, silt-filled pools. Most of the spawning habitat is found above this region where sedimentation is lighter and spawning gravel is available. Spawning habitat is limited by streambed compaction. The average streambed width in the study area is 6.7 meters.

The fish fauna of Jacoby Creek consists of steelhead trout, coho salmon, cutthroat trout (*Salmo clarki*), threespine stickleback (*Gasterosteus aculeatus*), Pacific lamprey (*Entosphenus tridentatus*), and the Pacific brook lamprey (*Lampetra pacifica*). Some resident rainbow trout are present in the anadromous zone of the creek and are common above the migratory barrier. Fish captured straying into lower Jacoby Creek included eulachon (*Thaleichthys pacificus*), surf smelt (*Hypomesus pretiosus*), and juvenile chinook salmon (*Oncorhynchus tshawytscha*).

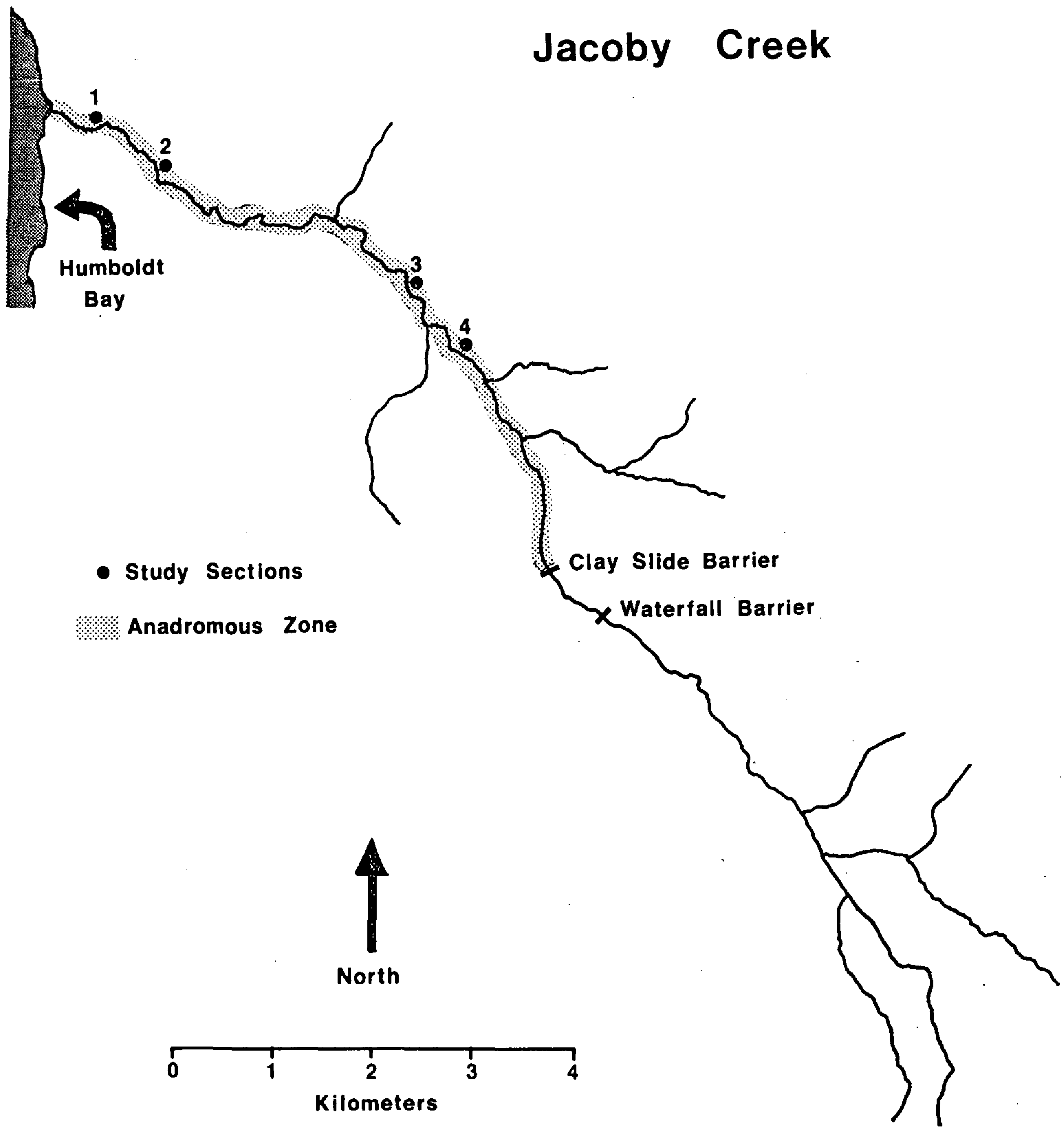

Figure 3. Jacoby Creek, Humboldt County, California.

METHODS AND MATERIALS

Field Procedures

Juveniles

Electrofishing. Most juvenile salmonids were captured by electrofishing using a battery-powered backpack electroshocker (Figure 4). Except for high flow periods, juvenile populations were sampled monthly (last week of each month) by electrofishing surveys. Captured fish were anesthetized with MS-222 (tricaine methyl sulfonate), measured in fork length to the nearest mm, and released back into the stream. Scales for age and growth analysis were collected from juvenile fish during the March 1977 sample period. Scales were removed from an area between the lateral line and dorsal fin and stored dry in coin envelopes. For population studies, study sections were blocked at the upper and lower ends with small mesh block seines. Captured juveniles were placed in buckets or live boxes until sampling was completed. Fish were anesthetized, measured, and weighed to the nearest 0.1 gram. For mark-and-recapture studies, juveniles were collected from blocked sections, marked with a partial dorsal lobe clip and returned to the study section. Juvenile fish were then allowed to mix for several days before being resampled.

Downstream Trapping. Two inclined-plane downstream traps were installed in April 1977 to monitor outmigration (Figure 5). Traps, located 400 meters above the mouth, were checked each day between 4 April and 12 June 1977 when low streamflow negated juvenile

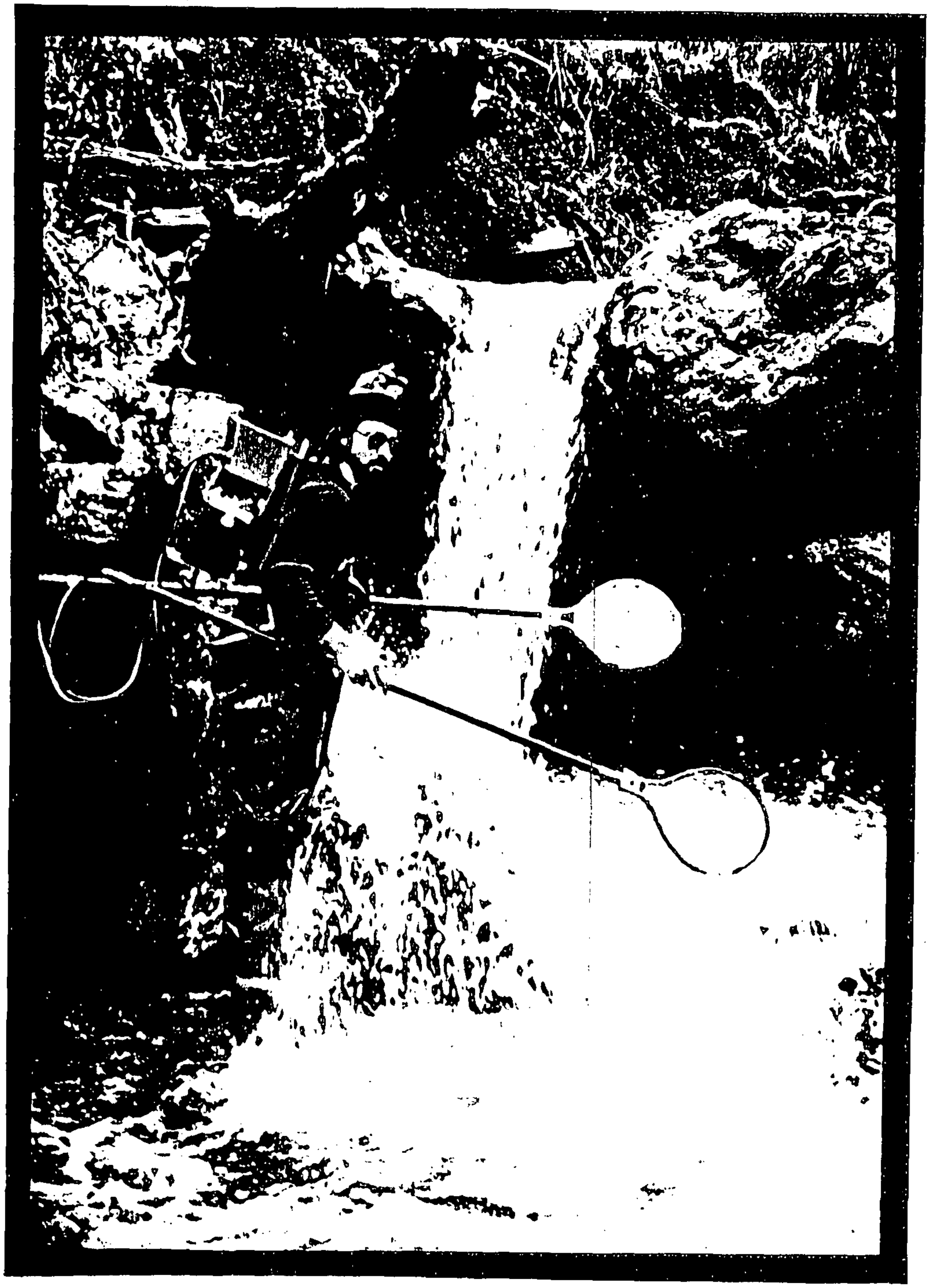

Figure 4. Electrofishing in Jacoby Creek. Note migration barrier in background.

Figure 5. Downstream view of smolt traps, April, 1977.

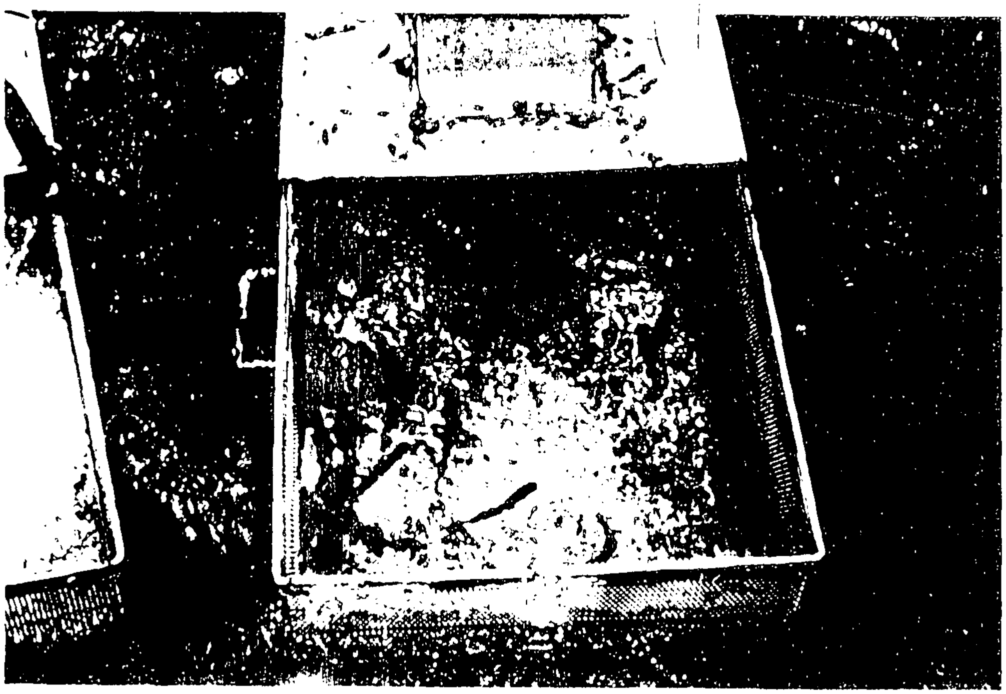

Figure 6. Coho migrants captured in downstream trap.

migration (Figure 6). Trapped salmonids were anesthetized, counted, measured, and weighed (Figures 7, 8). Scales were taken periodically on size-selected smolts. Each trap consisted of a perforated metal apron (157.5 x 96.5 cm) attached to a metal collecting box (77.5 x 45.7 x 23.5 cm). Migrants were directed into a 17.8 x 15.2 cm aperature at the head of each apron; strips of plastic were placed in the aprons to channel flow through the openings. Logs were aligned in a "V" manner alongside the traps to direct streamflow into the aprons.

Study Sections. Population studies of juvenile coho salmon and steelhead were conducted in four study sections of Jacoby Creek (Figure 3). The major criteria used in the selection of these study areas were: 1) representation of the various habitats found in the anadromous zone of the creek, and 2) ease of stream accessibility. Each stream section, with the exception of Section 1, was sampled during 1976 and 1977 in late summer or early fall when juvenile populations became relatively stable. Study Section 1 was sampled only in 1976. Study sections were 92 meters long with the exception of Section 1 which was 82 meters long. Stream surface area was calculated for Sections 2 and 3. Surface area was determined by multiplying the length of the stream section by its mean width.

Adults

Electrofishing. Most adult spawners were captured by periodic electrofishing throughout the spawning season. Fork and total length, weight, sex, species, date, and location were recorded and a scale sample taken from each fish captured. Adults were measured to the nearest 0.5 cm and weighed to the nearest .06 lb (Figures 9, 10).

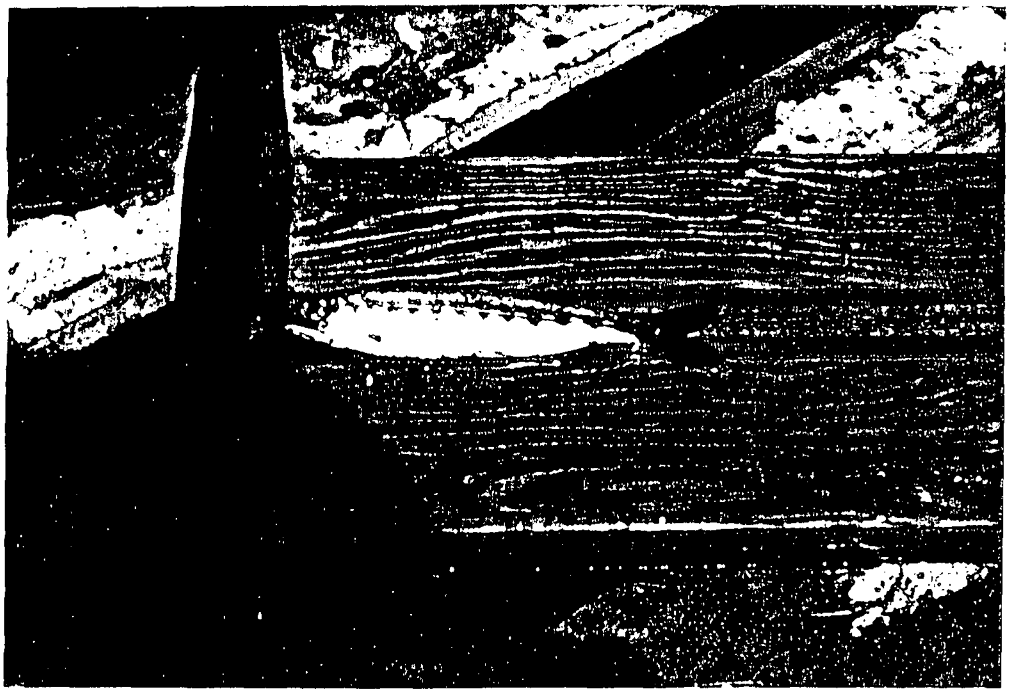

Figure 7. Coho salmon smolt.

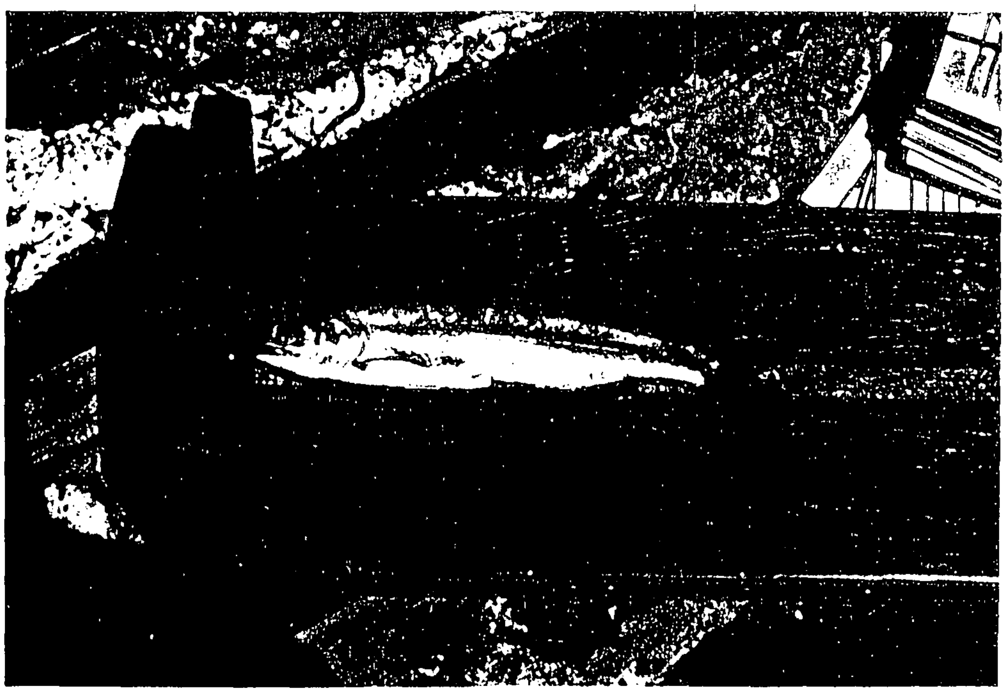

Figure 8. Steelhead smolt.

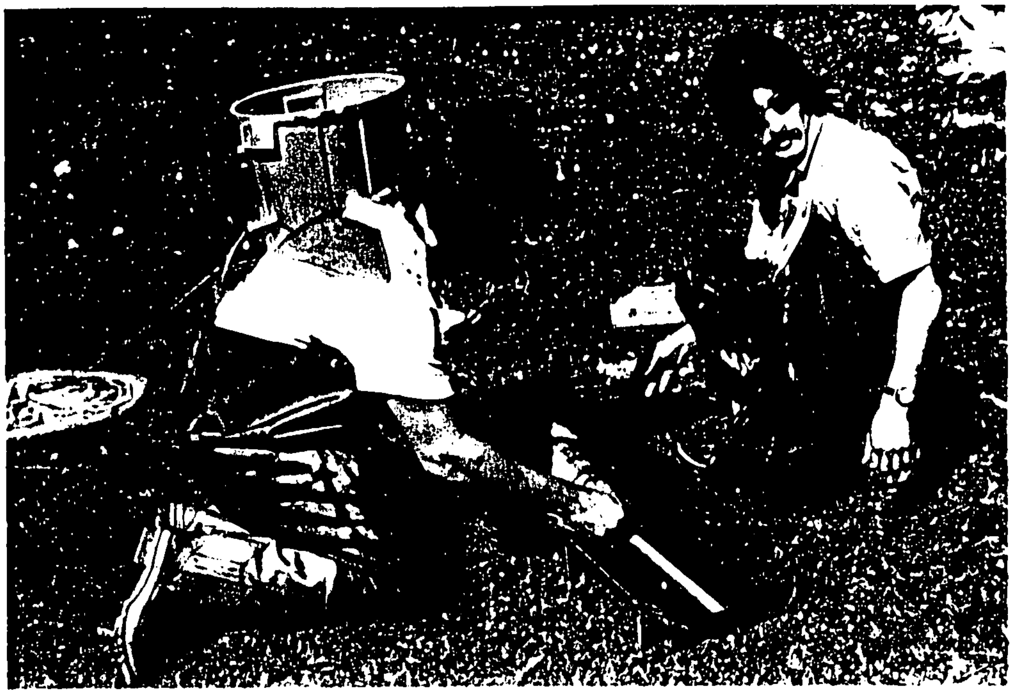

Figure 9. Adult steelhead being measured.

Figure 10. Adult steelhead being weighed.

The latter measurement was then converted to the nearest 0.1 kg. Scales were taken between the anterior portion of the dorsal fin and the lateral line. Coho salmon were marked with an adipose clip and tagged with a numbered metal strap tag. Steelhead were marked with a similar clip and tagged with a numbered vinyl "Floy" anchor tag (Figure 11).

Upstream Trapping. A 12.2 m weir was completed in October 1977 to ascertain the timing and run size of adult salmonids entering Jacoby Creek. The weir was operational for the 1977-78 spawning season; it was checked daily from 15 October to 15 May 1978. During periods of high water the weir became submerged and spawners passed upstream undetected (Figure 12). Additional fish escaped when holes occasionally developed under or around the edges of the weir. Captured adults were removed from the trap with a large net and held in 30 gal plastic cans and then processed in the same manner as discussed in the previous section (Figures 13, 14). Processed fish were released just upstream from the weir after recovering from the anesthetic.

The weir, located 400 m upstream from the mouth, stood 1.1 m high with a base width of 2.8 m. Wooden slats (152.4 x 4.5 x 4.5 cm) lined the face of the weir. Maximum space between each slat was 3.2 cm. Fish were directed through a 14 cm V-type opening into a trap covered with 24 mm^2 wire-mesh screen. Upstream trap dimensions were 1.8 x 1.3 x 1.2 m. Gabions filled with rocks were placed in the streambed underneath the weir to prevent undercutting during high flows.

To analyze factors influencing adult migration, four environmental variables were monitored during upstream trapping: water temperature, streamflow, rainfall, and barometric pressure. Water temperature and streamflow was measured each time the trap was checked. Water

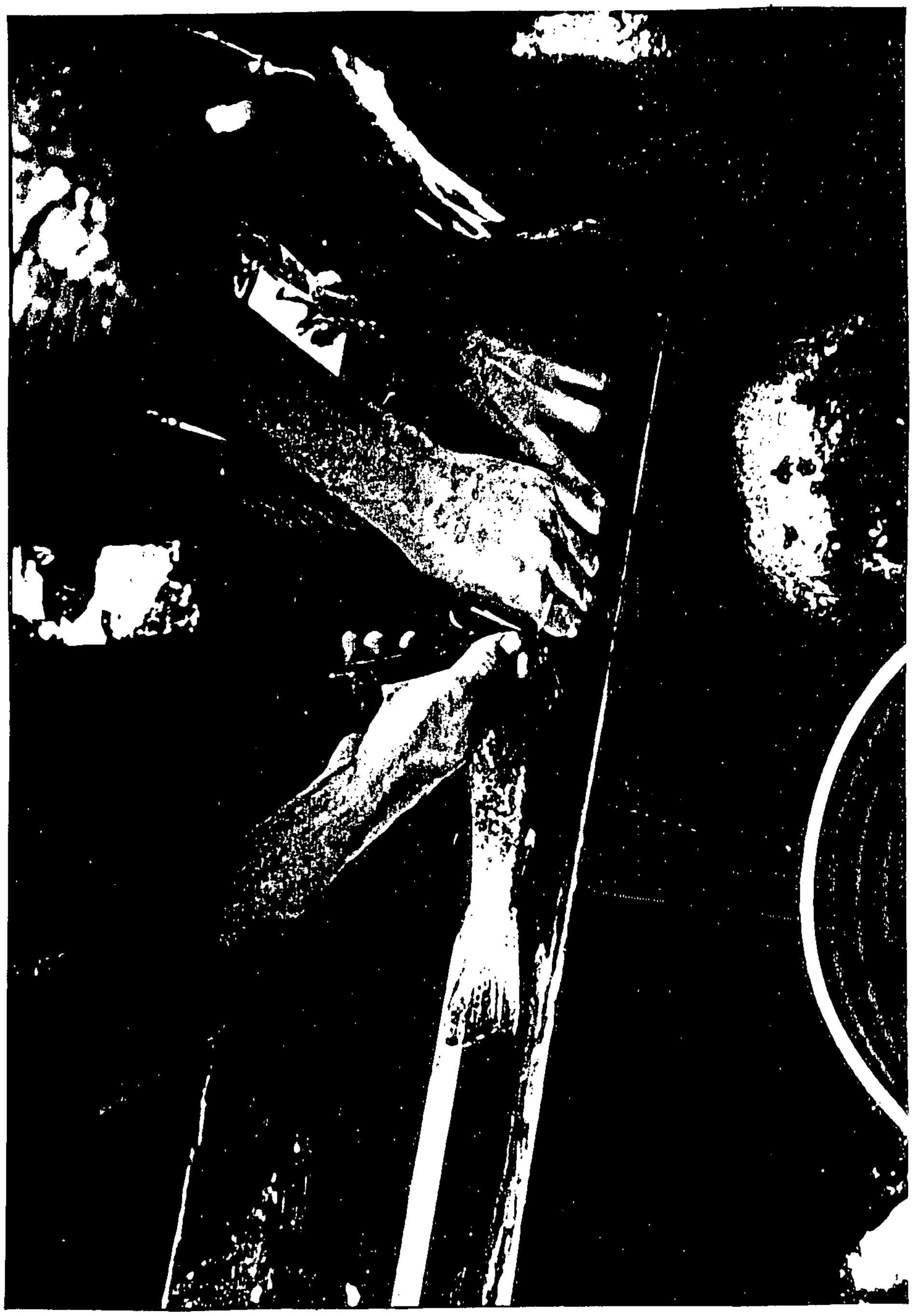

Figure 11. Anchor tagging of adult steelhead.

Figure 12. Submerged weir during high flow period.

Figure 13. Removing adult migrant from upstream trap.

Figure 14. Adult coho salmon ready for processing.

temperature was taken with a hand thermometer accurate to 1^{o} F; streamflow was measured with an Ott current meter. Daily rainfall records were obtained from a private weather station located at Jacoby Creek, California (Lester pers. comm. 1979). Barometric pressure data was gathered from the U.S. weather station located in Eureka, California.

Laboratory Procedures

Juveniles

Conversion Factors. Although some field measurements were recorded in total length, conversion factors were used to express all results in fork length. This permitted the comparison of data from this study with results from similar investigations. The least squares method was used to develop the equation to convert total length (TL) into fork length (FL). Based on a sample of 189 fish, the equation of best fit for juvenile steelhead was FL = -.6734 + .9344(TL). For coho salmon, the equation of best fit, FL = .92 + .8948(TL), was based on a sample of 26 juveniles.

Scale Analysis. Juvenile scales were cleansed and sorted under a dissecting microscope. Six to nine non-regenerated scales were wet mounted between glass microscope slides. Scales were viewed at 48x magnification on a Quantor 307 microfiche projector. Scales were read at least twice; a third reading was conducted if a difference in age between previous readings was observed. Scales which could not be aged with confidence after the third reading were excluded from the age analysis.

The method for indicating age in this study is the method used by Shapovalov and Taft (1954). For juvenile fish, years spent in the creek prior to migration is presented on the left side of a diagonal.

For example, a juvenile captured after two years in stream residence would be designated 2/0. Because the majority of stream fish formed an annulus prior to March, juveniles were considered to be one year older on 1 March.

Scale measurements, used to back-calculate growth of juvenile steelhead, were made along the anterolateral radius of the most legible scale. The back-calculation of fork length at each annulus was based on the Lee-Fraser equation:

$$Ln - c = \frac{Sn}{S} (L - c)$$

where Ln = length of fish when annulus "n" was formed

c = correction factor

Sn = radius of annulus "n"

S = total scale radius

L = length of fish at time of capture

Back-calculations were run on the CDC 3150 computer using the growth program outlined by Mawson and Reed (1970).

Condition Factor. Condition factor, or the coefficient of condition (K), is a mathematical estimate of the relative robustness or plumpness of a fish. Derived from the length and weight measurements of fish collected in the field, condition factors were calculated from the following equation:

$$K = \frac{W \times 10^5}{L^3}$$

where W = weight in grams

L = fork length in millimeters

Population Analysis. Population estimates were made over two-month intervals, October - November in 1976 and July - August in 1977. Both removal and mark-and-recapture methods were employed since neither was satisfactory for all sample dates. Estimates were made with year classes combined (steelhead) since the probability of any one fish being captured was generally greater than 75 percent.

The two-catch method was used for the removal estimates and 95 percent confidence intervals calculated using the equations presented by Seber and LeCren (1967). This method was employed during sampling periods when stream conditions permitted a large majority of juveniles to be captured. The condition that the second catch did not exceed one-half the first was met with the exception of the October 1976 sampling period. On this occasion, two additional passes were conducted to represent an effort equal to the combined first two passes.

For the mark-and-recapture estimates, Chapman's (1951) modification of the standard Petersen method was employed. The equation is:

$$\hat{N} = \frac{(M + 1)\ (C + 1)}{(R + 1)}$$

where $\hat{N}$ = population size estimate at time of marking

M = number of marked fish

C = number of fish examined for marks

R = number of marked fish recaptured

Ninety-five percent confidence intervals were calculated from Chapman's equation as given in Ricker (1975). The condition that $MC > 4N$, necessary to produce an unbiased estimate (Robson and Regier 1964), was met on each occasion.

Biomass measurements of juvenile populations were calculated for Study Sections 2 and 3 in both years. Total biomass for a species was derived for a study section by multiplying the mean weight of the sampled population by the population estimate.

Emigration Analysis. Estimates of coho smolt emigration were made for five-day periods during the 1977 downstream migration season. When streamflows permitted, total counts of migrants were made by downstream trapping. During periods when traps were only partially operational, daily estimates were made by multiplying the mean number of captured fish on successful trapping days by the number of successful trapping days. Electrofishing estimates, conducted near the mouth of the stream, were used during five-day periods when traps were completely unoperational.

Adults

Scale Analysis. Scale samples were used to determine life history data. Adult scales were cleaned, mounted on glass slides, and read at a magnification of 42x on a Quantor Model 307 projector. Scales were read at least three times. Adults with regenerated scales were eliminated from the age study.

The method for denoting the age of salmon and steelhead is described by Shapovalov and Taft (1954). Years of freshwater residence are recorded on the left side of a diagonal and years of saltwater residence on the right side. When applicable, the letter "S" indicates previous spawning activity. For example, a steelhead captured after spending two years in the stream and two years in the ocean before returning to spawn would be designated 2/2. If the same fish had previously spawned in the year prior to recovery, it would be represented by 2/1S.1.

Condition Factor. Condition factors were calculated for adult salmonids in the same manner as presented in the previous section for juveniles.

Statistical Analysis. Chi-square analysis was used in the determination of statistical differences between the observed and expected adult sex ratios (Sokal and Rohlf 1969).

RESULTS

Juvenile Coho Salmon

Length-Weight Relationship

A length-weight relationship was determined for juvenile coho salmon in Jacoby Creek based on a sample of 200 fish captured during 1976 and 1977. These fish ranged in fork length from 55 to 118 mm and in weight from 2.0 to 18.3 grams. The least squares method was used to calculate the regression of weight on length for the unsexed sample. The equation of best fit was $W = aL^b$ or $\log W = \log a + b (\log L)$, where $\log a = -4.453$ and $b = 2.714$ with a correlation coefficient (r) of 0.95.

Condition Factor

Condition factors were calculated for juvenile coho salmon (1976 year-class) in October, November, and March. The mean condition factor of 43 coho collected in October was 1.27; sixteen fish taken in November averaged 1.15. For 51 salmon captured in March the average condition factor was 1.24. Eleven coho salmon of the 1977 year-class, collected in August, had a mean condition factor of 1.27.

Age and Growth

Scale analysis from 134 juvenile coho salmon collected in late March indicated that only one age class was present in Jacoby Creek. Since almost all coho collected had formed an annulus prior to this time, the age group was designated 1/0. This analysis was in agreement with aged adult fish which had only one year of freshwater residence. No attempt was made to back-calculate growth to annulus formation.

Three phases of seasonal growth were shown by juvenile coho salmon in Jacoby Creek represented by the 1977 year-class (Figure 15). Following fry emergence in April and May, a period of rapid growth was evident until September when a near cessation of growth occurred. A slight increase in coho growth was apparent in October. Winter growth was minimal, averaging only 1.5 mm per month from November through January. Rapid growth resumed in February but small sample sizes in January, February, and March make determination of growth rates during this time period unreliable. Limited growth data available on the 1976 year-class indicated rapid March growth (Table 1).

Population and Distribution

Coho year-class strength in Jacoby Creek showed great variability from year to year. The 1976 year-class was relatively strong; juveniles were present from the mouth of the stream to the upper cascade region. In contrast, the 1977 year-class was relatively weak with only small populations of fish pocketed in the middle sector of the creek. Changes in coho abundance from 1976 to 1977 were most evident in two study sections. In Study Section 3, the coho population was more than six times greater in 1976 than in 1977 (Table 2). A significant population ($N = 38$) of coho was present in the upper cascade section in 1976; however, the next year no salmon were found there.

Coho biomass ranged from 0.0 to 3.8 g/m^2 but rarely exceeded 0.5 g/m^2. The highest coho biomass estimate was recorded at Study Section 3 where the stream habitat is characterized by a high percentage of shallow pools.

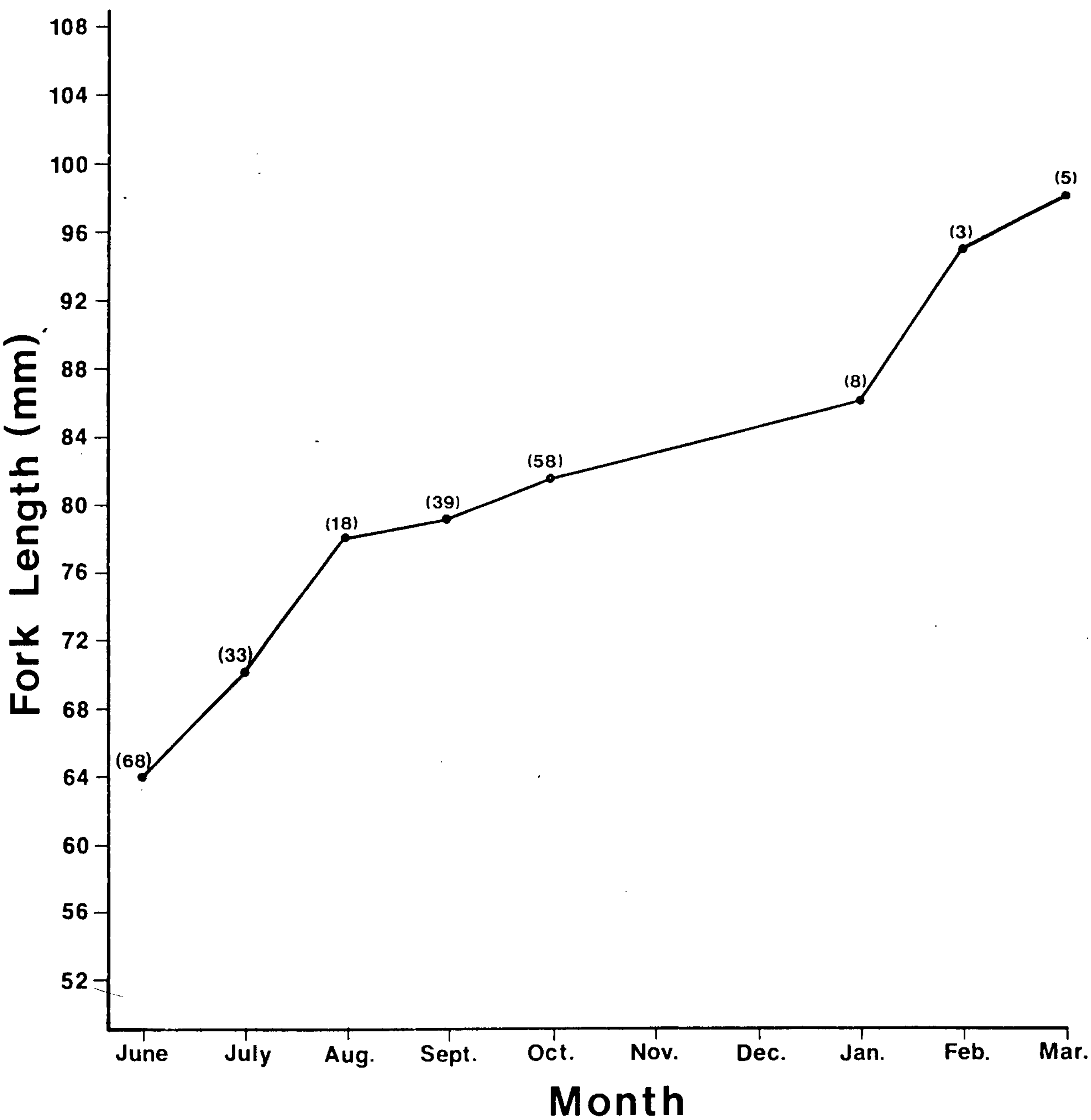

Figure 15. Monthly growth of juvenile coho salmon in Jacoby Creek, June 1977 - March 1978. Sample size in parenthesis.

Table 1. Monthly mean length and growth increments for juvenile coho salmon in Jacoby Creek.

Year Class	Date	Fork Length (mm)	Growth/Month (mm)
1976	Feb. 77	79.9 (109)*	--
	Mar. 77	90.0 (134)	10.1
1977	June 77	64.1 (68)	--
	July 77	70.3 (33)	6.2
	Aug. 77	78.2 (18)	7.9
	Sept. 77	79.3 (39)	1.1
	Oct. 77	81.6 (58)	2.3
	Jan. 78	86.2 (8)	1.5
	Feb. 78	94.9 (3)	8.7
	Mar. 78	98.1 (5)	3.2

* Sample size in parenthesis

Table 2. Population data for juvenile coho salmon in four Jacoby Creek study sections, 1976 and 1977.

Study Section	Date	Number Captured	Estimate Method	Population Estimate	Conf. Interval	Biomass (g/m^2)
1	Nov. 76	4	--	--	--	0.1*
2	Oct. 76	4	Removal	4	--	0.1
	July 77	2	--	--	--	0.0
3	Oct. 76	113	Petersen	215	177-253	3.8
	Aug. 77	11	Removal	31	11-131	0.5
4	Nov. 76	31	Petersen	38	31-54	0.5*
	July 77	0	--	--	--	0.0

* Estimated

Seaward Migration

Seaward migration of coho salmon was in progress when downstream trapping commenced in April 1977. A total of 2,149 coho smolts were trapped during a 14-week period from 4 April - 12 June, 1977 (Figure 16). Additional smolts passed uncounted during this period when high flows disrupted trapping. Peak migration occurred during early May. Overall, an estimated 5,000 coho smolts passed downstream during the 1977 migration period. Although no trapping was carried out in the following season, electrofishing survey results indicate that the 1978 migration was less than 2,000 smolts.

Scale analysis and length frequency distribution indicated that all seaward-migrating coho were age 1/0 (Figure 17). Coho smolts ranged in length from 72 to 132 mm with a mean length of 100.5 mm. Mean length and weight of migrants increased as the run progressed (Table 3). Condition factors varied only slightly throughout the run.

Table 3. Mean length, weight, and condition factor of coho salmon smolts in Jacoby Creek by 23-day period.

Date	Fork Length (mm)	Weight (g)	Condition Factor
April 1 - April 24	98.5(989)*	9.85(850)	1.03(850)
April 25 - May 18	100.9(867)	11.06(279)	1.06(279)
May 19 - June 11	105.5(293)	12.21(215)	1.05(215)
Total	100.5(2149)	10.48(1344)	1.04(1344)

* Sample size in parenthesis

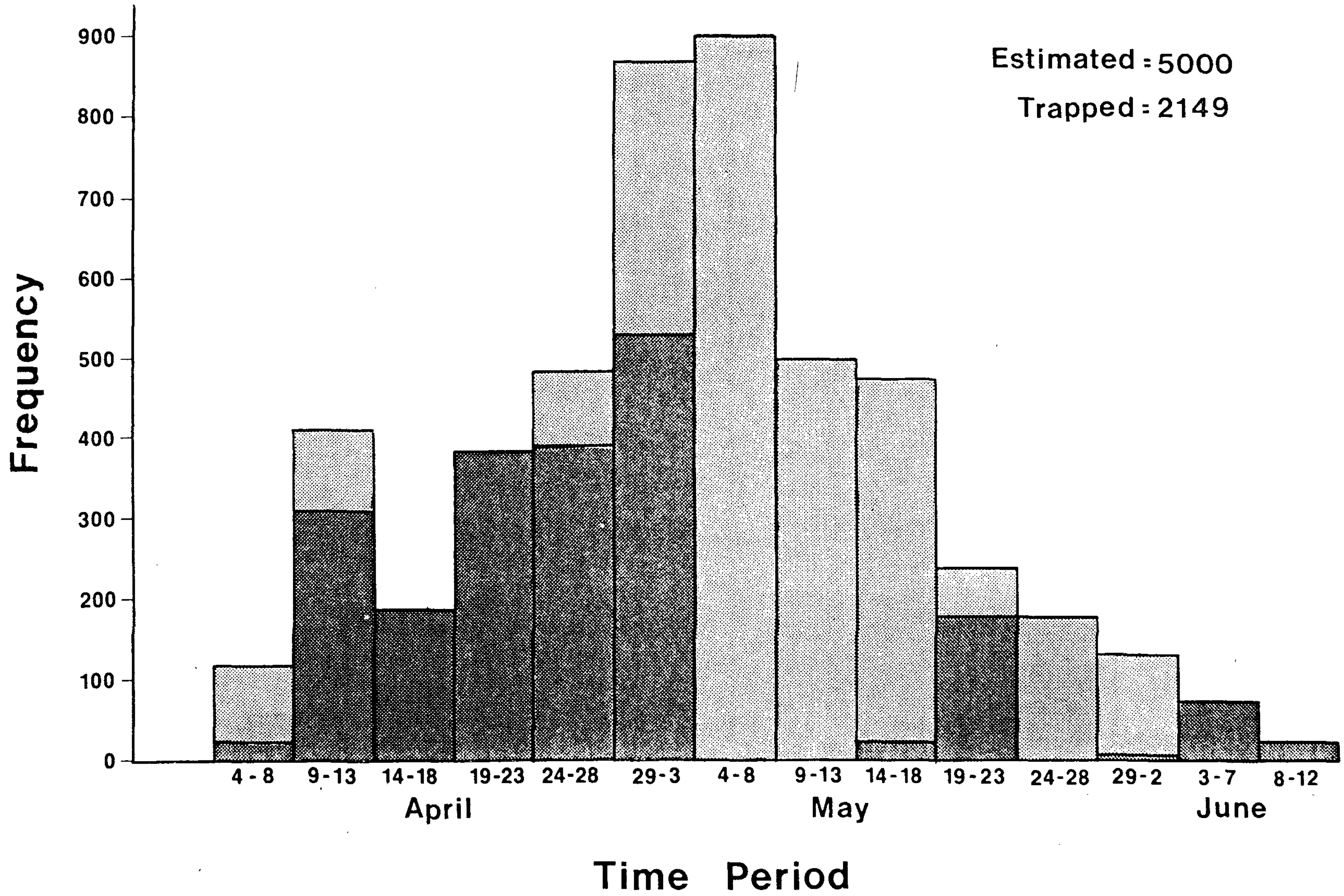

Figure 16. Number of coho smolts emigrating from Jacoby Creek by five-day period from 4 April through 12 June, 1977. (Dark area indicates number trapped, light area indicates number estimated.)

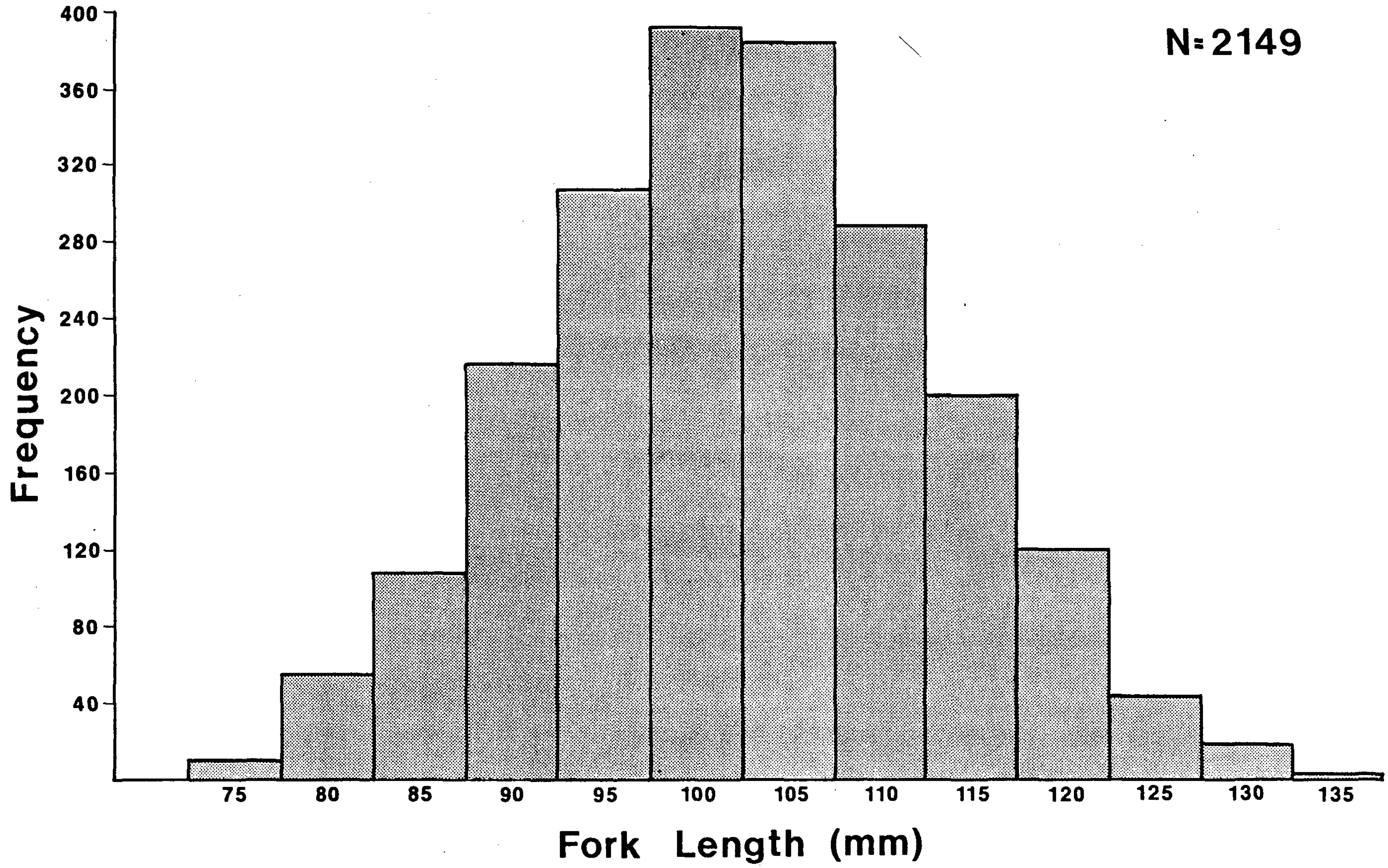

Figure 17. Length-frequency distribution of coho salmon smolts captured in Jacoby Creek from April through June, 1977.

Extensive coho emigration was initiated by increases in streamflow associated with rainstorm activity (Figure 18). As the migration period progressed, coho smolts were more willing to migrate during periods of low flow. Coho primarily migrated downstream during the hours of darkness, moving in small schools of 10 to 30 individuals. During June, a few recently-emerged coho fry appeared in the downstream traps.

Adult Coho Salmon

Time of Migration

Coho salmon entered Jacoby Creek from October through January and remained as late as February. The earliest fish were taken in the upstream trap on 25 October 1977; the latest on 9 January 1978. Ninety-five percent of all adult salmon captured over three seasons were taken in the two-month period from 25 November - 25 January (Appendix A,B,C). Peak upstream migration occurred in December.

The arrival of adult coho into the creek was closely associated with large increases in streamflow (Figure 19). Salmon entered the creek on both rising and falling stream levels but ceased movement into the trap when flows fell below 21 cfs (Appendix F). Adults escaped over the weir during high flows in excess of 400 cfs. There was no apparent trend toward early or late arrivals being comprised primarily of one sex or age group. No diurnal preference was noted for coho stream entry.

Size of Migration

A total of 121 adult coho salmon were captured in Jacoby Creek over the three spawning seasons; 30 in 1976-77, 50 in 1977-78, and

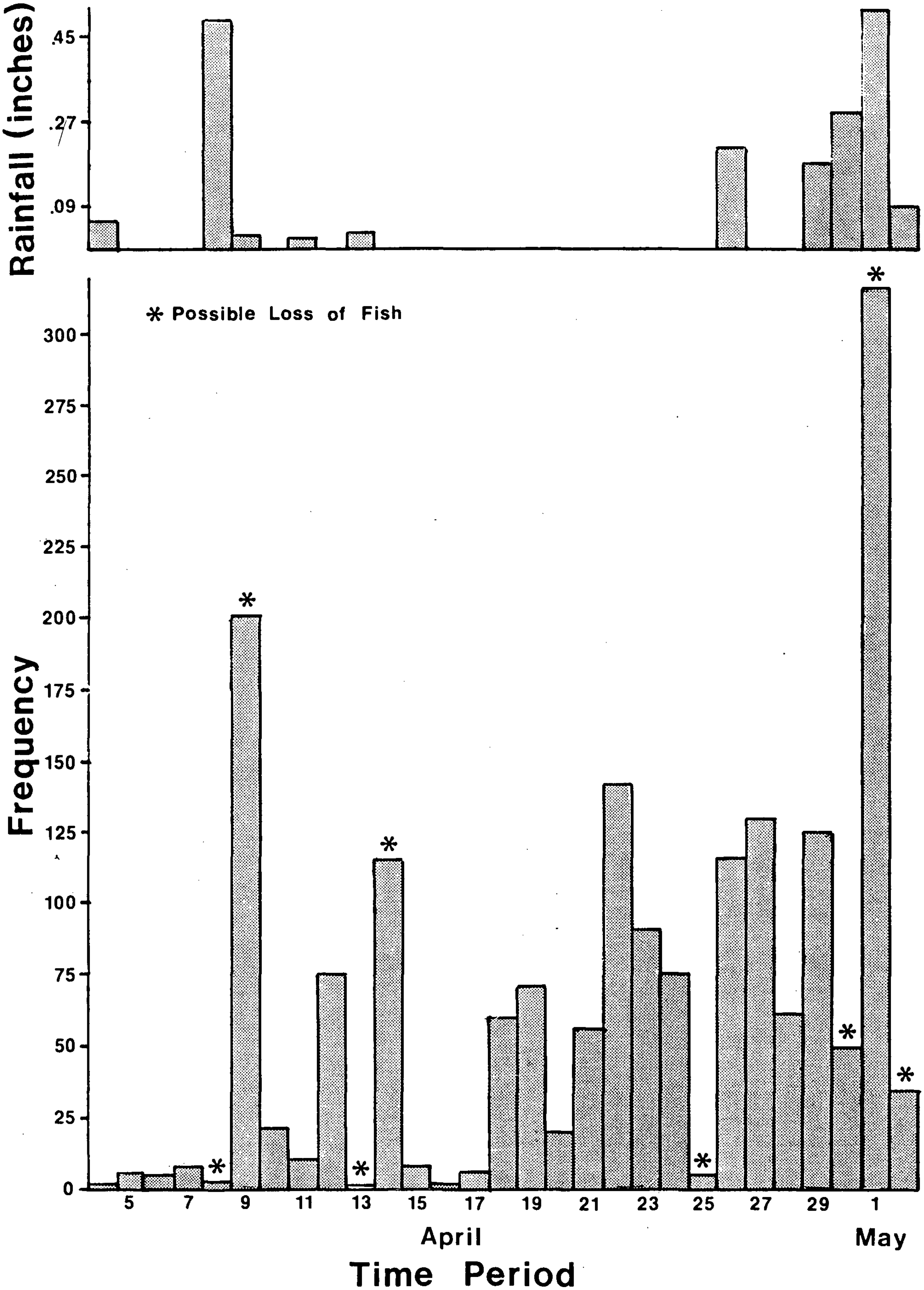

Figure 18. Number of coho smolts emigrating from Jacoby Creek and rainfall for the period 4 April - 2 May, 1977.

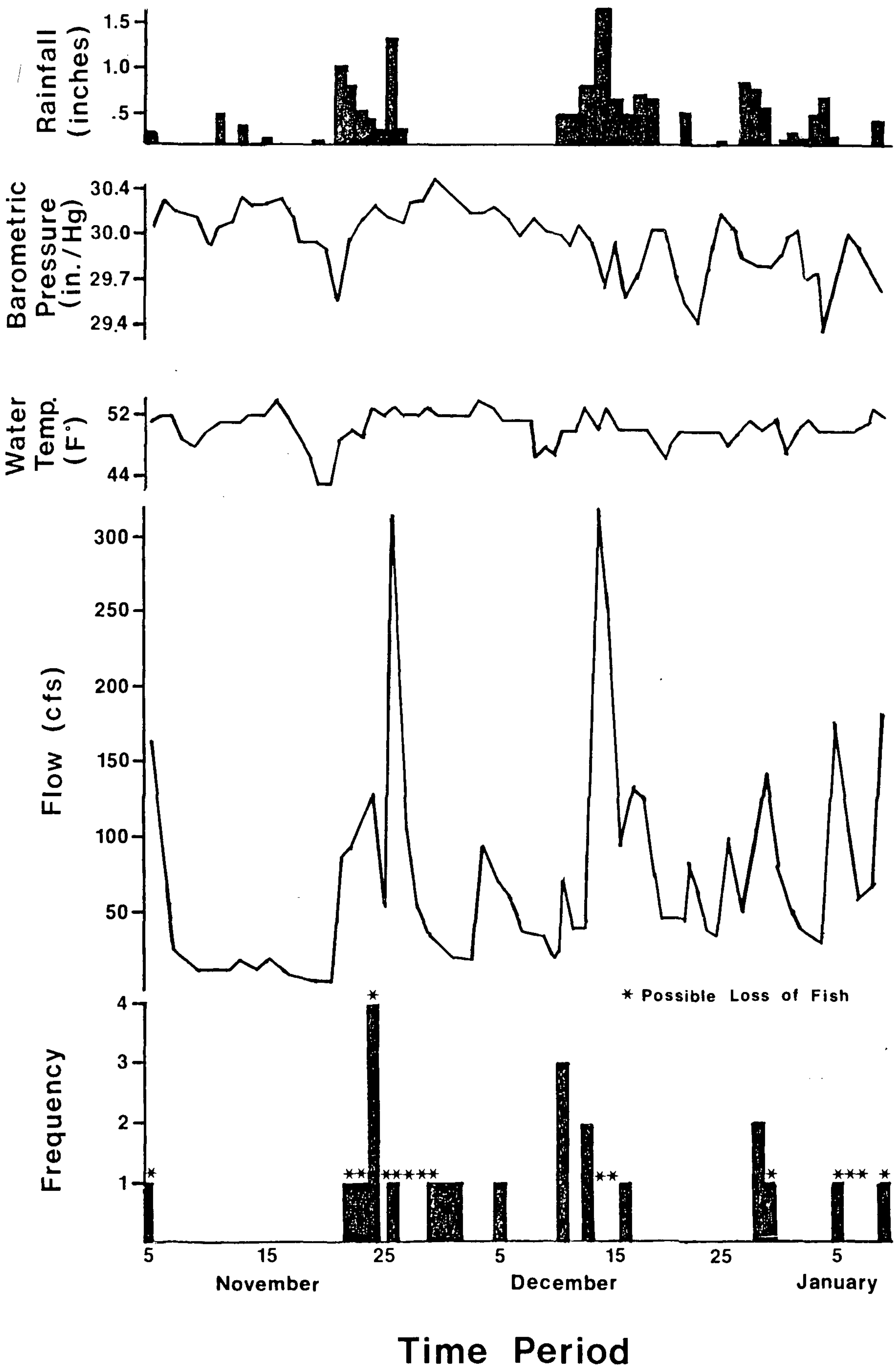

Figure 19. Time of adult coho salmon entry into Jacoby Creek in relation to four environmental factors from November 1977 through January 1978.

41 in 1978-79. During the 1977-78 season, when the upstream trap was in operation, the estimated total coho escapement was 123 fish using Chapman's (1951) modification of the standard Petersen method. Twenty-two adults were tagged at the weir upon entering the creek. Subsequent electrofishing surveys recovered 31 salmon including five of the fish previously tagged. The small sample sizes resulted in a wide confidence interval ranging from 82 to 164 fish at the 95 percent probability level. No attempt was made to estimate coho run size in 1976-77 and 1978-79. However, based on adult electrofishing and the resulting number of emergent coho fry in spring, coho escapement appeared to be some what less in 1976-77 and considerably more in 1978-79 than the 123 salmon estimated in 1977-78.

Age Characteristics

Two coho age categories were present in Jacoby Creek. Scale analysis indicated that all adults return either as males in the spawning season following smolt emigration (age 1/1) or as males and females in the second spawning season following emigration (age 1/2). Age 1/1 fish comprised 51.3 percent of the spawning run, ranging from 36.6 to 62.8 percent over a three-year period (Table 4). Age 1/2 males averaged 22.1 percent of the run ranging from 11.6 to 36.6 percent while 1/2 females formed 26.6 percent with a range from 25.6 to 27.6 percent.

Sex Ratio

The overall male to female ratio for adult coho salmon captured on the spawning grounds was 2.77:1. The male to female ratio varied slightly between seasons: 2.63:1 in 1976-77; 2.91:1 in 1977-78; and

Table 4. Composition of the vital statistics for Jacoby Creek coho salmon during the 1976-77, 1977-78, and 1978-79 seasons.

Age Category	Sex	Number in Each Age Category	Percent in Each Age Category	Mean Fork Length (cm)	Range of Fork Lengths (cm)	Mean Weight (kg)	Range of Weights (kg)
				1976-77			
1/1	M	16	55.2	43.0	32.5-52.0	0.9	0.4-1.8
1/2	M	5	17.2	68.0	57.0-80.5	3.8	2.0-6.5
1/2	F	8	27.6	71.0	66.0-76.0	4.6	3.4-5.4
				1977-78			
1/1	M	27	62.8	39.0	26.5-47.5	0.8	0.2-1.3
1/2	M	5	11.6	69.5	61.5-78.5	3.8	2.4-5.4
1/2	F	11	25.6	70.5	60.0-78.0	4.6	2.7-6.7
				1978-79			
1/1	M	15	36.6	44.5	39.5-53.0	1.1	0.6-1.8
1/2	M	15	36.6	56.5	38.5-77.5	2.6	0.7-5.2
1/2	F	11	26.8	62.0	49.5-72.0	3.2	1.5-5.5
				Total			
1/1	M	58	51.3	41.5	26.5-53.0	0.9	0.2-1.8
1/2	M	25	22.1	61.5	38.5-80.5	3.1	0.7-6.5
1/2	F	30	26.6	67.5	49.5-78.0	4.0	1.5-6.7

2.73:1 in 1978-79. The sex ratio for salmon captured just after entering the creek in 1977-78 when the weir was operational was 2.33:1. The high male to female ratio of salmon in Jacoby Creek was a result of the large proportion of early-returning male jacks (Table 4). Exclusive of jacks, females outnumbered males in the 1976-77 and 1977-78 spawning seasons while males comprised the majority in the 1978-79 season. Among age 1/2 adults, the overall male to female sex ratio was 0.83:1.

Length and Weight

The mean length and weight of age 1/1 males, age 1/2 males and age 1/2 females for each season is given in Table 4. Among 1/2 salmon, females as a group attained a larger size each season than did males. Age 1/2 coho from the 1978-79 season were noticeably smaller than age 1/2 fish collected in the previous two seasons. Age 1/1 coho of the same brood year, captured the previous season, were also significantly smaller than jacks taken in other years.

The length frequencies of coho salmon form a bimodal distribution with little overlap occurring between the two age groups (Figure 20). Coho captured in the 1976-77 and 1977-78 spawning seasons show no size overlap between age groups; however, considerable overlap is seen in 1978-79. This probably results from the size reduction noted in three-year-old fish.

Shapovalov and Taft (1954) found a demarcation line of 49 cm separated 99.1 percent of the 1/1 and 1/2 age groups correctly. Applied to the Jacoby Creek coho salmon, this line correctly separates 95.6 percent of the spawners: three age 1/2 fish falling below it and two age 1/1 jacks above it.

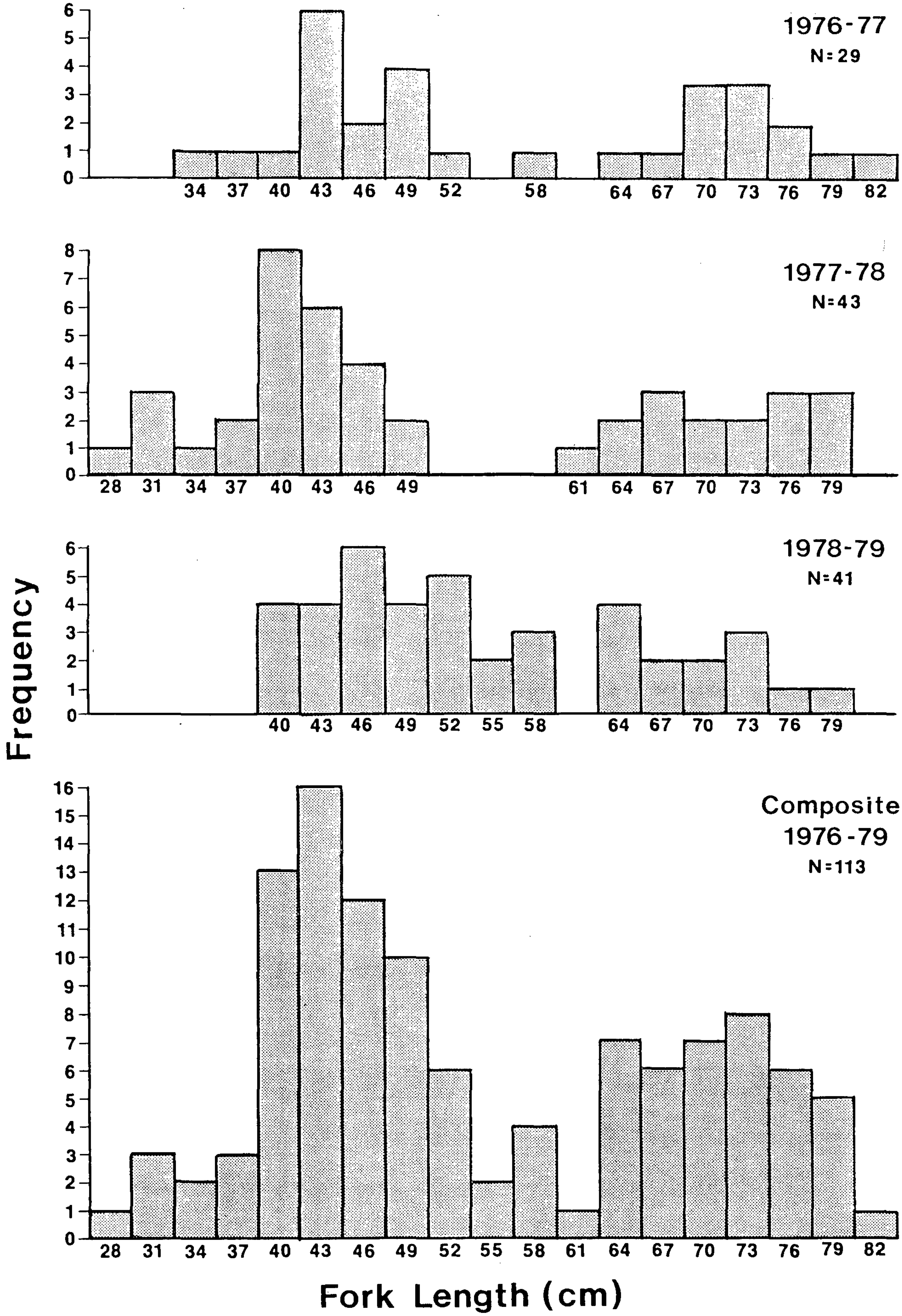

Figure 20. Length-frequencies of adult coho salmon captured in Jacoby Creek during the 1976-77, 1977-78, and 1978-79 seasons.

A length-weight relationship curve was constructed for Jacoby Creek coho based on a sample of 298 fish captured over a four-year period from 1976-79 (Figure 21). Length and weight measurements from 98 adults and 200 unsexed juveniles were used in the computations. These fish ranged in length from 5.5 to 80.5 cm and in weight from 2 to 6660 grams. The least squares method was used to calculate the regression for each sex. The equation of best fit for males was $\log W = -4.131 + 2.984 (\log L)$ and for females $\log W = -5.137 + 3.345 (\text{Log } L)$. The composite length-weight equation was $\log W = -5.468 + 3.151 (\text{Log } L)$ with $r = 0.98$.

Condition

Twenty adult coho salmon captured in the upstream trap just after entering the creek were examined to determine sexual maturity. Eleven of the 14 males (78.6 percent) were found to be sexually mature or ripe while five of the six females (83.3 percent) were classified as sexually immature or green.

Condition factors calculated for the 20 salmon averaged 1.23 and ranged from 0.94 to 1.40. The mean condition factor was 1.21 for the 14 adult males and 1.29 for the six adult females.

Spawning

Spawning primarily occurred during the months of December and January. Coho salmon as a group spawned lower in Jacoby Creek than did steelhead. Coho preferred the middle portion of the creek where stream gradient was shallow and spawning gravel was most available. Most of the observed redds were located near the lower end of pools just above the riffle breakwater. Tributary spawning was uncommon; salmon were

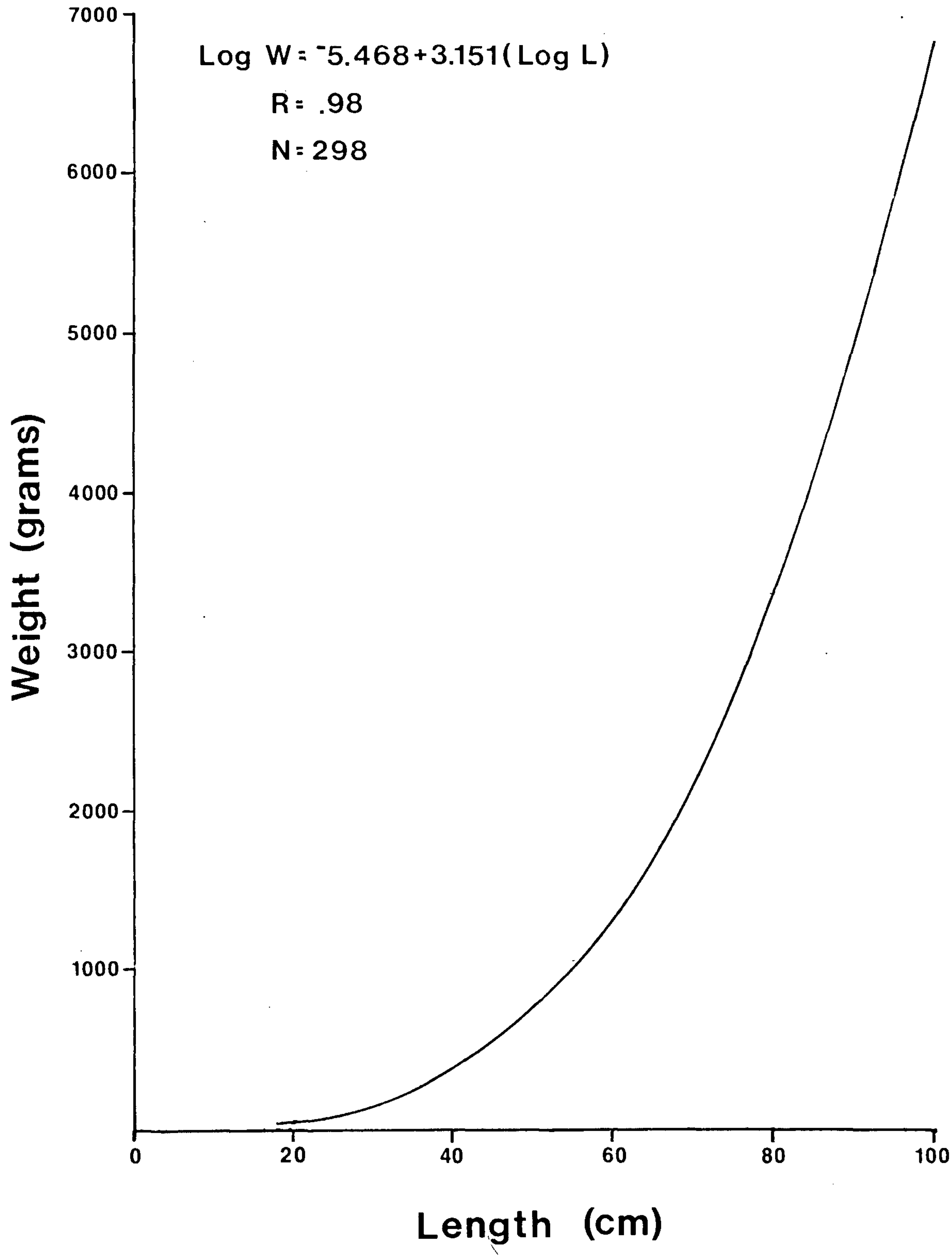

Figure 21. Length-weight relationship for coho salmon from Jacoby Creek. Sexes are combined.

known to enter only one tributary in the drainage.

Coho spawning in Jacoby Creek spent varying lengths of time in stream residence. Three previously tagged spent salmon were recovered by electrofishing. Two male jacks had a stream residency of 35 and 58 days; one female survived 32 days. One age 1/2 male carcass was recovered after only 16 days in the creek.

Juvenile Steelhead

Length-Weight Relationship

The relationship between fork length and weight of 324 juvenile steelhead was calculated from fish collected in 1976 and 1977. These fish ranged in length from 42 to 223 mm and in weight from 0.7 to 145.4 grams. The length-weight relationship displayed an exponential increase in weight on length, fitting the equation $W = aL^b$ or $\log W = \log a + b (\log L)$. The calculated length-weight relationship of unsexed juvenile steelhead was $\log W = -4.123 + 2.996 (\log L)$ with $r = 0.99$.

Condition Factor

Condition factors were determined for 224 juvenile steelhead captured in March. Age 1/0 steelhead, with an average of 1.37, had the highest mean condition factor among the four age groups. Age 2/0 steelhead had a mean condition factor of 1.20; age 3/0 fish averaged 1.19. The two age 4/0 juveniles had a condition factor of 1.28 which also represented the weighted mean figure of all ages combined. The mean condition factor of 43 steelhead taken in July-August from all age groups, was 1.13. For 45 steelhead collected in October-November, the average condition factor was 1.17.

Age and Growth

Length-Frequency Distribution. Length distribution of juvenile steelhead by age group, collected in March 1977, is given in Table 5. Age 1/0 and 2/0 steelhead formed distinct modes with only slightly overlapping ranges. Age 3/0 steelhead showed considerable length overlapping with the larger age 2/0 fish.

Length-frequency histograms of steelhead were recorded for eight months during a ten-month period from June 1977 through March 1978 (Figures 22, 23). The modes of the 0+/0 and 1+/0 age groups were readily discernable and seasonal growth could be observed. The modal progression indicated a pattern of rapid growth from June through August and slow growth in September and October. Little or no growth was apparent during the winter. Rapid growth resumed in March. During periods of rapid growth, age 0+/0 steelhead gained an average of 10 mm per month, while the age 1+/0 fish averaged 5 mm per month. The length frequency modes during February, the period of annulus formation, agreed reasonably well with the mean calculated fork lengths for the respective age groups (Table 6).

Age Composition. The age composition of juvenile steelhead, collected in March 1977, consisted of four age groups (Table 5). Age group 1/0 was the largest, represented by 71.4 percent of the 416 fish aged. Age 2/0 accounted for 25.0 percent, and age 3/0 with 3.1 percent of the total. Age 4/0 steelhead formed a negligible proportion (0.5 percent) of the population.

Young-of-the-year (age 0+/0) steelhead dominated the four study sections in October-November 1976. From length-frequency distributions,

Table 5. Length distribution by age group and age composition for Jacoby Creek juvenile steelhead, March 18-30, 1977. N = 416.

Fork Length (mm)	Age Group			
	1/0	2/0	3/0	4/0
51-60	1			
61-70	4			
71-80	35			
81-90	91			
91-100	85			
101-110	57			
111-120	17	1		
121-130	7	15		
131-140		27		
141-150		16		
151-160		18		
161-170		17	1	
171-180		6	4	
181-190		1	3	
191-200		3	4	
201-210			1	
211-220				1
221-230				1
Total	297	104	13	2
Percentage	71.4	25.0	3.1	0.5

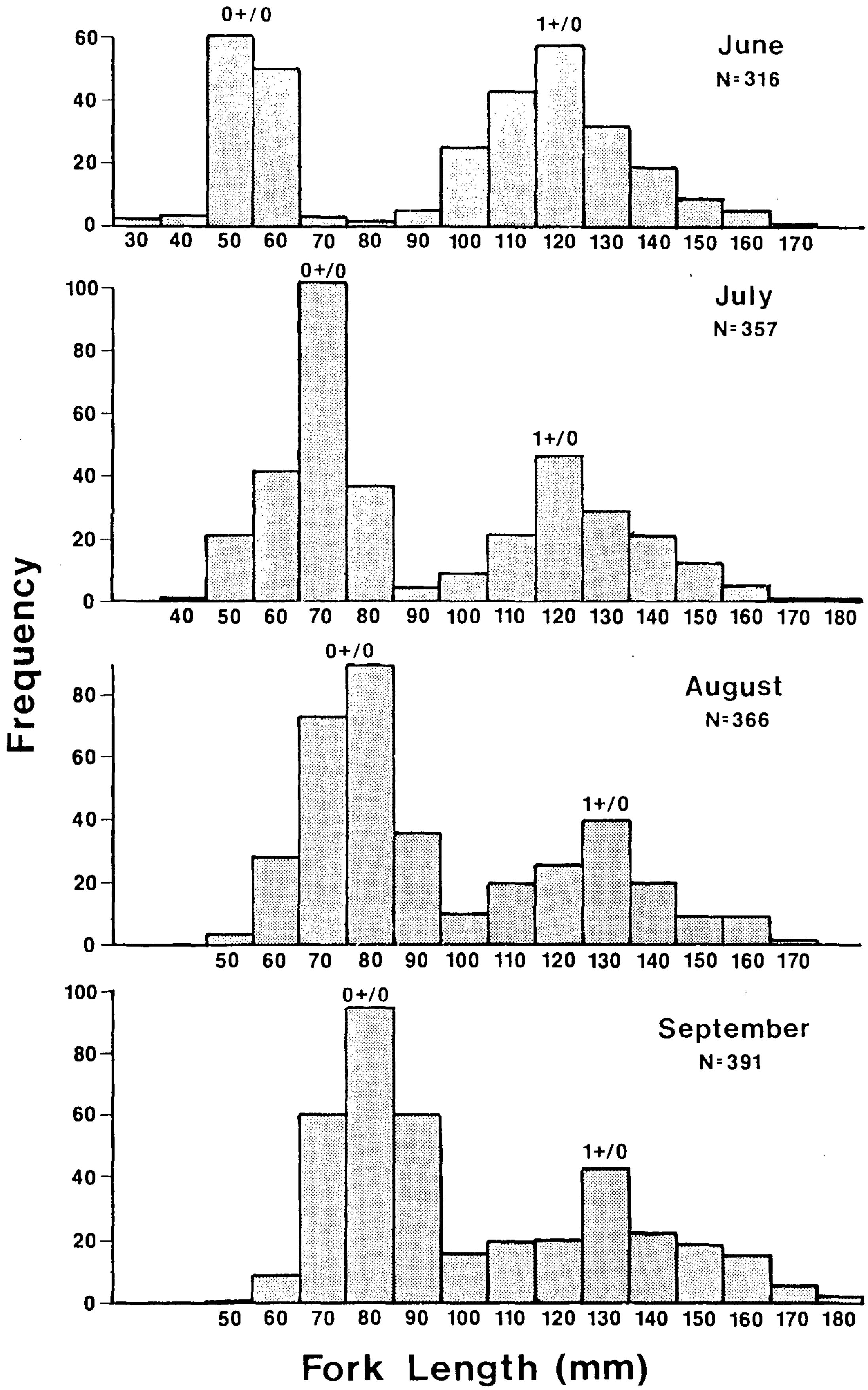

Figure 22. Length-frequencies of juvenile steelhead from Jacoby Creek, June - September, 1977.

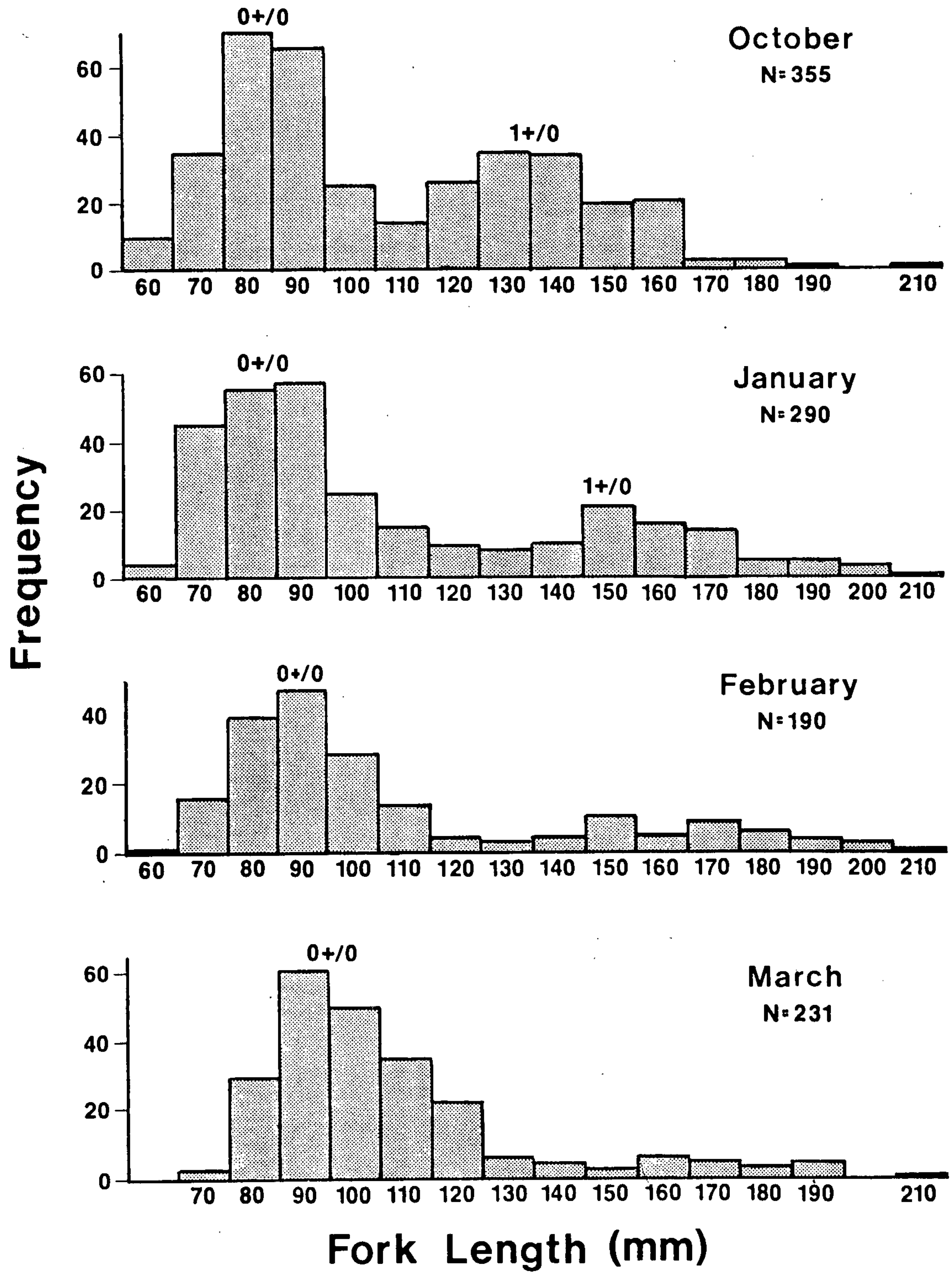

Figure 23. Length-frequencies of juvenile steelhead from Jacoby Creek, October 1977, January - March, 1978.

Table 6. Mean calculated fork length (FL) in millimeters of juvenile steelhead captured in Jacoby Creek. N = 224.

Age Category	Year Class	Mean FL at Capture	Annulus 1	Annulus 2	Annulus 3	Annulus 4
1/0	1976	96.0	87.1			
2/0	1975	148.4	87.6	136.3		
3/0	1974	187.6	86.0	132.6	172.8	
4/0	1973	218.0	88.9	123.0	158.7	203.6
Grand mean FL			87.3	135.7	170.9	203.6
Annual growth increment			87.3	48.4	35.2	32.7
Number of fish			105	104	13	2

age 0+/0 fish were estimated to represent 83 percent of the total steelhead population collected. Young-of-the-year estimates ranged from a high of 92 percent in the upper cascade region to a low of 75 percent near the mouth of the stream.

It should be noted that age composition data was estimated from samples collected by electrofishing. Cooper and Lagler (1956) reported a difference in efficiency of electrofishing for small and large fish. It is possible, therefore, that the above age group estimates may be negatively biased for younger fish.

Body-Scale Relationship. The relationship between anterior scale radius and fork length of juvenile steelhead was judged to be linear and was calculated by the least squares method (Tesch 1971). The regression equation obtained was $Y = 33.55 + 3.86 X$ with a correlation coefficient of 0.91 (Figure 24). The intercept value of 33.5 mm was used as a correction factor in back-calculations of steelhead length.

Calculated Growth. Scales from 224 juvenile steelhead were used in the back-calculation of mean lengths at annuli formation for each group. Overall, the calculated mean lengths (FL) were 87.4 mm for formation of the first annulus, 135.7 mm for the second annulus, 170.9 mm for the third, and 203.6 mm for the fourth (Table 6). The greatest stream growth increment occurred in the first year of life, followed by a general decrease in increments in successive years of stream residence (Figure 25). Back-calculated lengths among different year classes were similar and agreed well with actual lengths of fish of corresponding ages (Figures 22, 23).

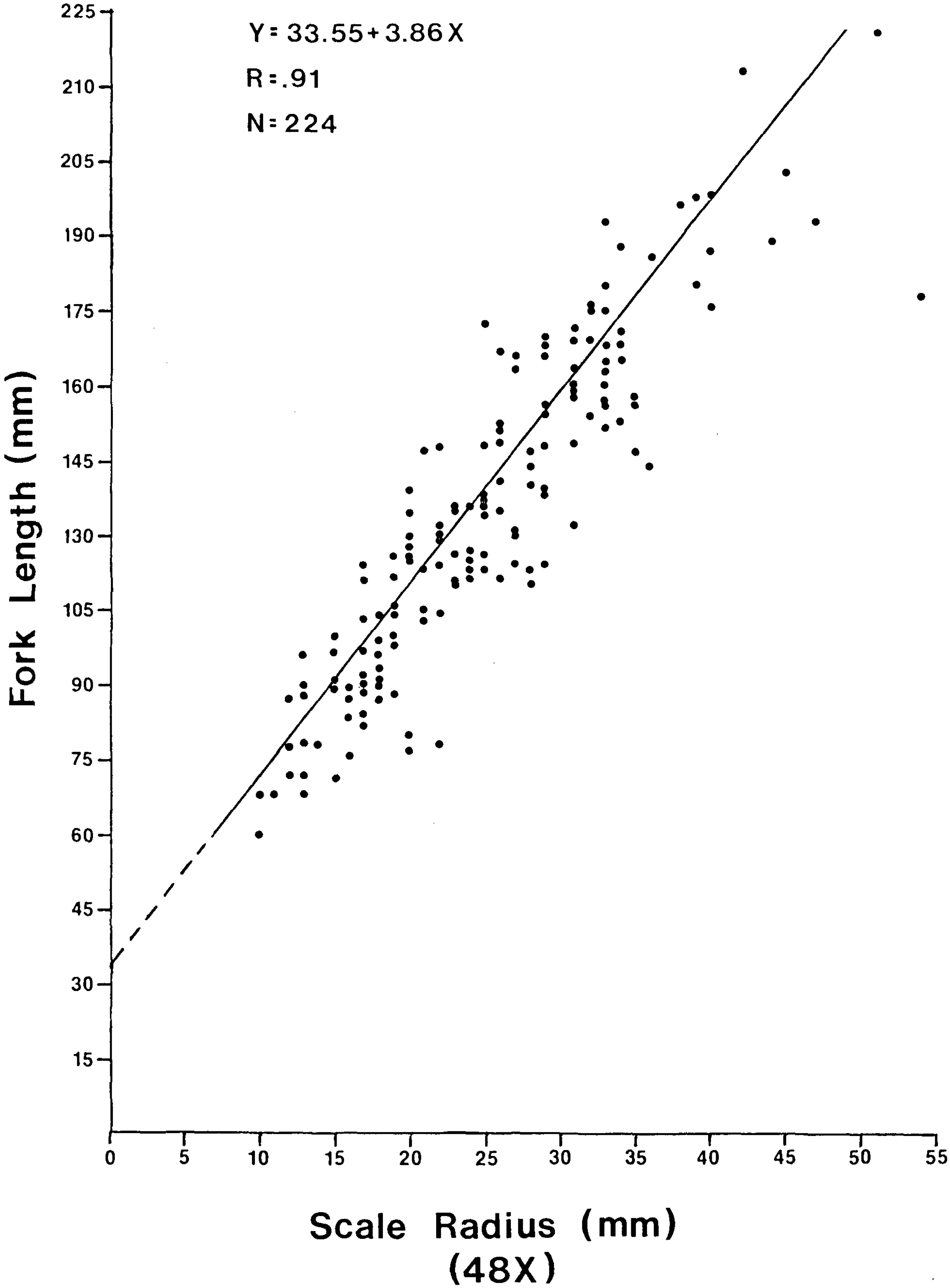

Figure 24. Body-scale relationship for juvenile steelhead captured in Jacoby Creek, California.

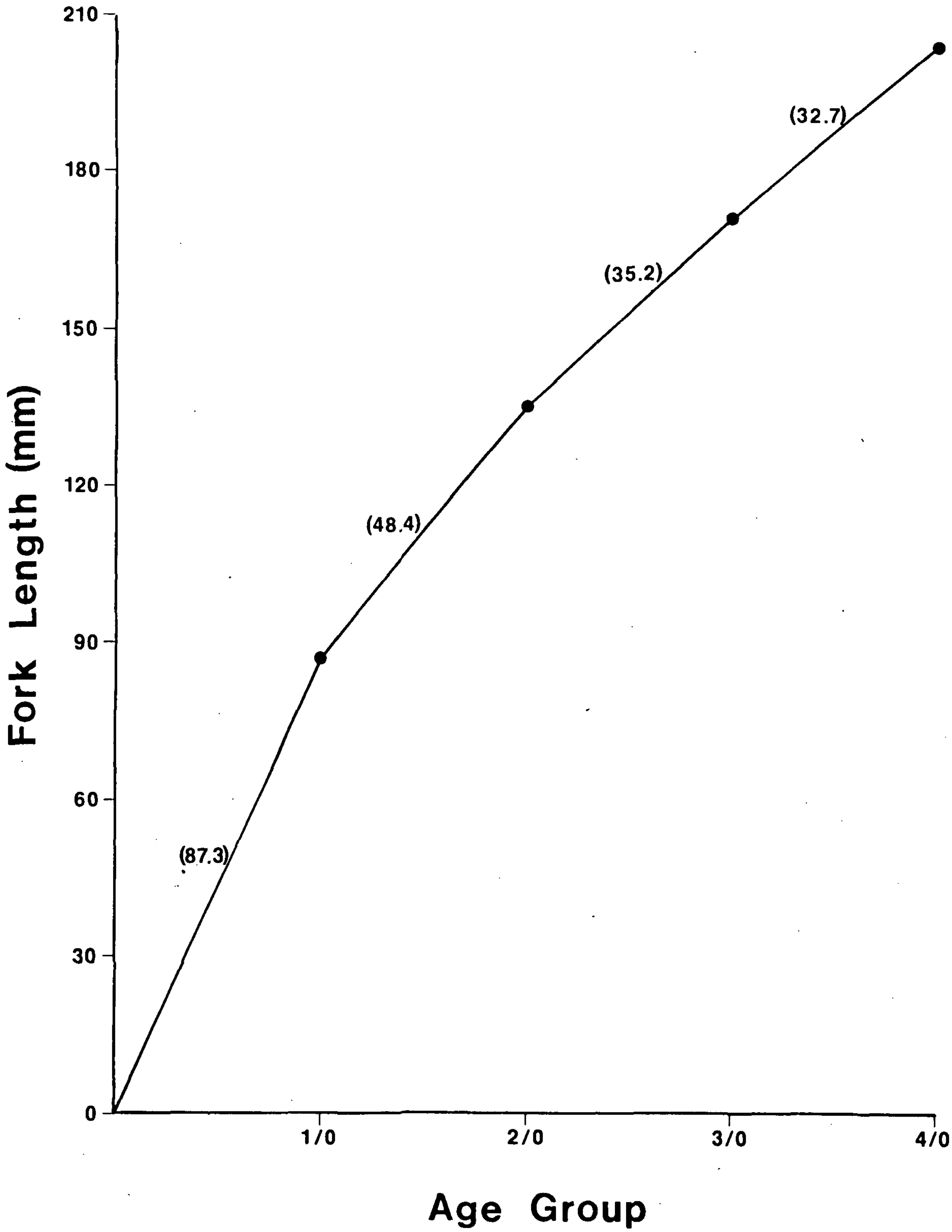

Figure 25. Calculated stream growth in length of juvenile steelhead from Jacoby Creek. Annual growth increment in parenthesis.

Population and Distribution

In contrast to the coho populations, steelhead were more abundantly distributed throughout the creek (Table 7). Although measurements were limited, the similarity of biomasses for 1976 and 1977 suggests that the stream may have been near carrying capacity for steelhead. Steelhead numbers generally declined with downstream distance. Steelhead were most abundant in the upper, cascade portion of the stream and least abundant near the mouth of the creek.

Downstream Migration

Electrofishing surveys conducted in Jacoby Creek indicated that steelhead smolts were present in the stream throughout the year but that the majority of smolt emigration took place from March through May. A total of 388 downstream-migrating steelhead were trapped during the 14-week period from 4 April - 12 June 1977. Peak migration during this period occurred in early May. Numerous steelhead passed the traps uncounted during high flow periods. Unlike the coho salmon migration, in which all fish migrated to sea, a large number of smaller steelhead migrants were not smolts and presumably remained in the lower portion of the creek.

Scale analysis and length frequency distribution indicated that four age classes of steelhead were found to be present in the migration (Figure 26). Sixty-two percent of the steelhead were age 1/0, ranging in length from 72 to 122 mm. Age 2/0 migrants, 134 to 191 mm in length, comprised 30 percent of the run while age 3/0 steelhead ranging in size form 180 to 210 mm, represented eight percent of the migration. Only one age 4/0 fish was captured, measuring 214 mm in length.

Table 7. Population data for juvenile steelhead in four Jacoby Creek study sections, 1976 and 1977.

Study Section	Date	Number Captured	Estimate Method	Population Estimate	Conf. Interval	Biomass (g/m^2)
1	Nov. 76	72	Petersen	108	79-137	--
2	Oct. 76	121	Removal	149	118-180	4.5
	July 77	82	Petersen	126	89-163	5.5
3	Oct. 76	115	Petersen	164	132-195	5.5
	Aug. 77	162	Removal	205	164-245	5.5
4	Nov. 76	240	Petersen	317	280-353	--
	July 77	259	Removal	323	276-370	--

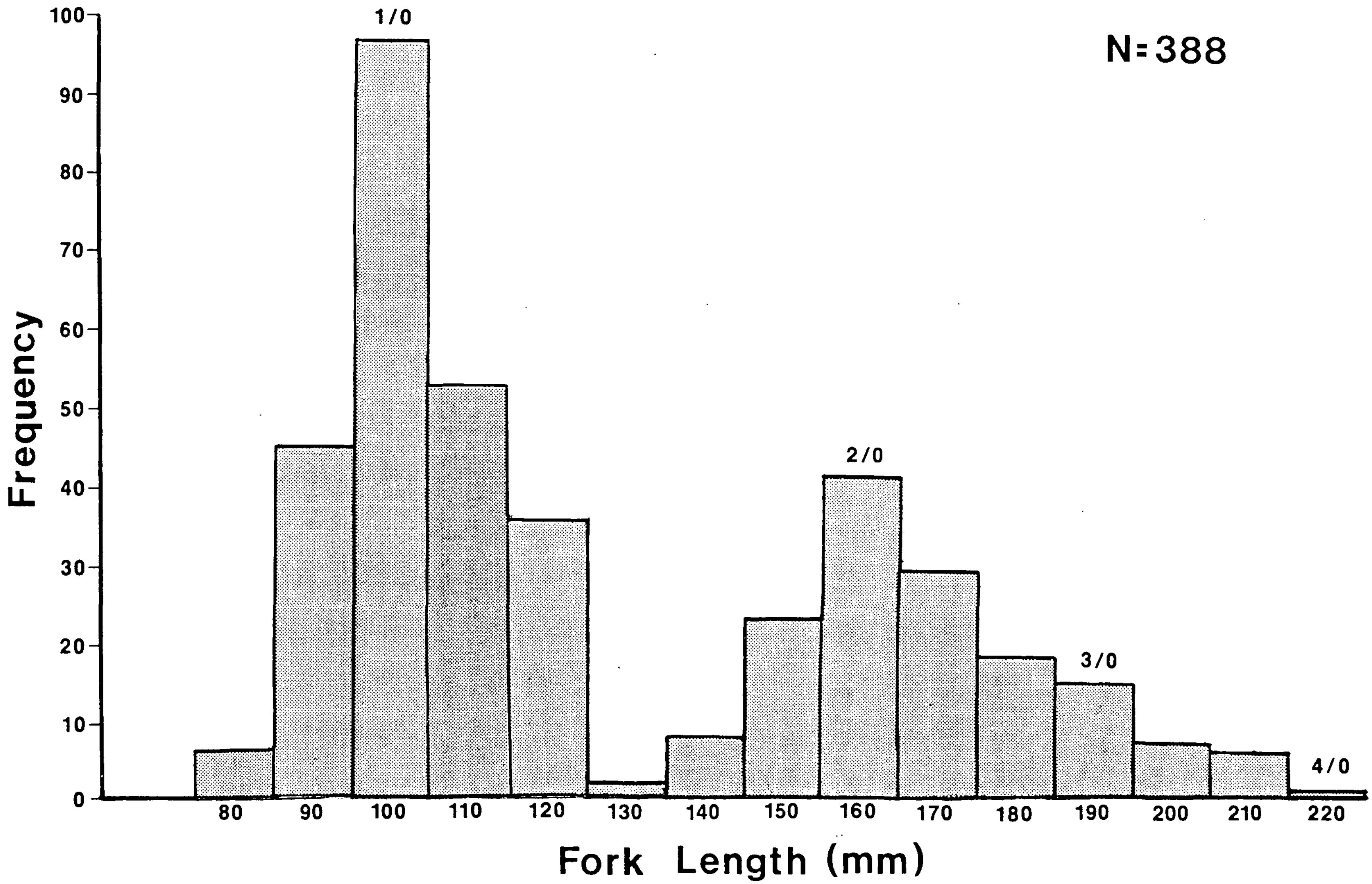

Figure 26. Length-frequency distribution of downstream-migrating juvenile steelhead captured in Jacoby Creek from April through June, 1977.

Although age 1/0 juveniles comprised the majority of the steelhead migrants, it was apparent that most of these fish were not migrating out to sea as smolts. Most of the age 1/0 steelhead lacked the "silvery" coloration characteristic of a smolting fish and as a group had a mean condition factor (1.06) much higher than that expected of a typical "slimmed" steelhead smolt. With this in mind, and the fact that virtually all age 2/0 and older migrants were smolts, only steelhead greater than 130 mm were used in smolt analysis. Therefore, it was inevitable that some age 1/0 steelhead smolts were excluded from this analysis.

As the season progressed, there was a gradual decrease in the mean size of steelhead smolts (>130 mm) (Table 8). Further support for this trend was evident from an electrofishing survey that was conducted near the mouth of the creek in March which found steelhead smolts averaging greater than 170 mm. Condition factors of steelhead smolts varied only slightly throughout the run and had values (<1.0) reflecting the slimmer state of the smolting fish.

Table 8. Mean fork length and condition factor for steelhead smolts (>130 mm) in Jacoby Creek by nine-day period, April 3 - May 2, 1977.

Date	Fork Length (mm)	Condition Factor
April 3 - April 12	167.7 (39)*	0.92 (39)
April 13 - April 22	163.8 (26)	0.89 (26)
April 23 - May 2	162.8 (83)	0.89 (35)
Total	164.3 (148)	0.90 (100)

* Sample size in parenthesis

Steelhead smolts migrated downstream during periods of rainstorm activity when streamflow increased (Figure 27). Steelhead, unlike the coho salmon, appeared much more reluctant to migrate during periods of low streamflow. Large numbers of steelhead were observed holed-up in pools above the trapping area prior to the inundation of the downstream traps. Steelhead primarily migrated during the hours of darkness.

A slight migration of emergent steelhead fry appeared at the trap site during early June 1977. Approximately 100 fry, ranging in length from 40 to 59 mm, were trapped during a two-week period.

Adult Steelhead

Time of Migration

Steelhead trout entered Jacoby Creek from December through April and generally remained as late as June. One adult was observed in July. The earliest trout was captured on 7 December; the latest on 20 June. Despite this extended upstream migration period, 92 percent of the adult steelhead were taken during a 13-week period from 5 January - 5 April (Appendix D, E). Peak migration occurred in January and March. The out-migration of spent steelhead started in February, peaked in March, and was completed by June. The earliest date for the capture of a spent female was 2 February; the latest date for an unspawned female was 8 April.

Larger steelhead comprised the majority of early-run trout during the 1976-77 spawning season. Seventy-nine percent of the steelhead collected on or before 19 March belonged to age categories which has spent at least two years at sea. In contrast, 70 percent of the adult spawners captured after 19 March belonged to the smaller-sized 2/1 and 3/1 age

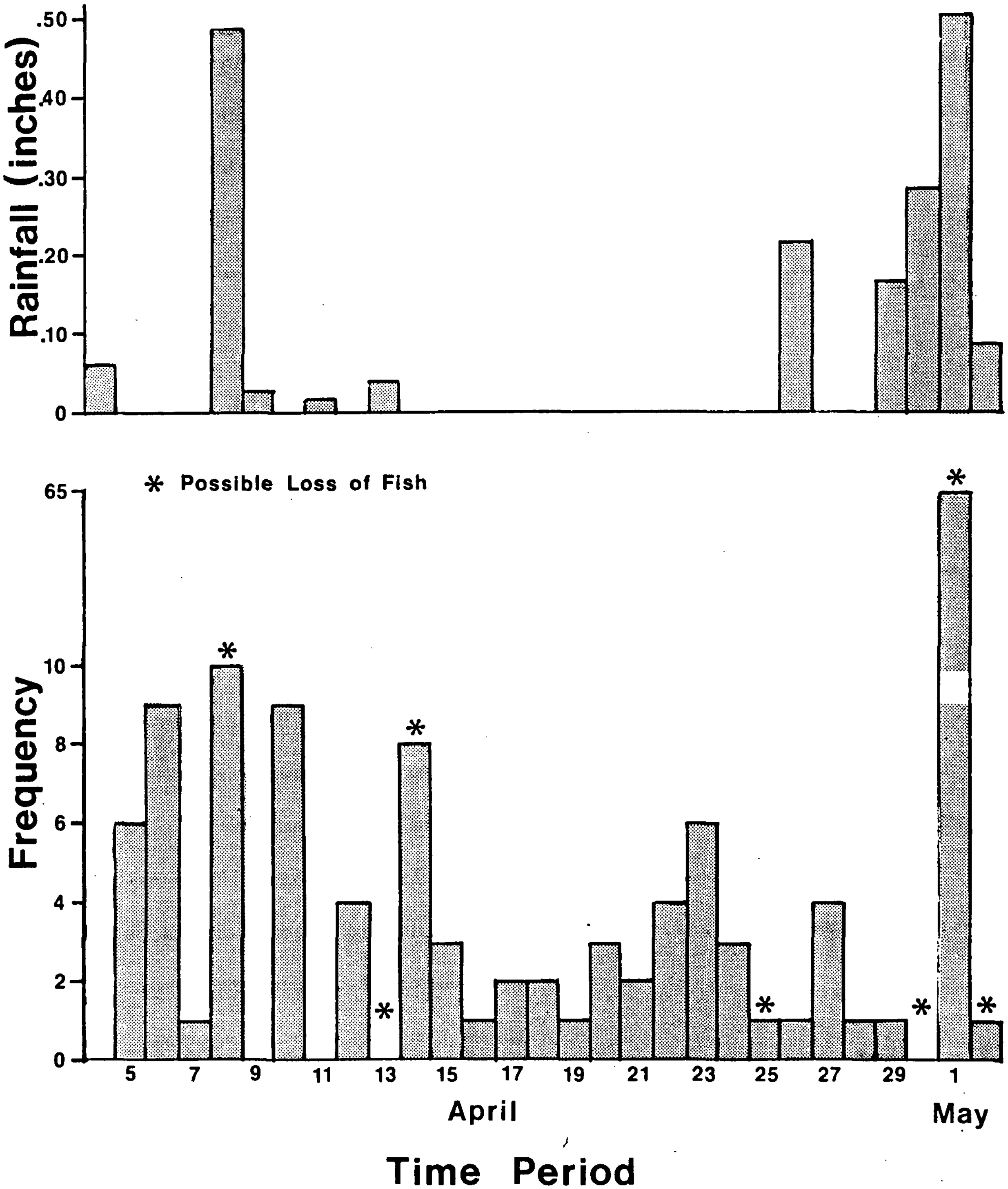

Figure 27. Number of steelhead smolts emigrating from Jacoby Creek and rainfall for the period 4 April - 2 May, 1977.

categories. The trend was not evident in the 1977-78 run when only five age 2/1 and 3/1 steelhead were collected. Neither early nor late-arriving fish were primarily composed of one sex.

As in the case of coho salmon, the arrival of steelhead spawners was closely associated with large increases in streamflow (Figure 28). Steelhead entered the stream on both rising and falling stream levels but never entered the trap when flows fell below 21 cfs. There was no apparent preference in the diurnal movement of steelhead spawners.

Size of Migration

A total of 111 adult steelhead were captured in Jacoby Creek during the 1976-77 and 1977-78 spawning seasons. Of this total, 47 adults were collected in 1976-77 and the remaining 64 spawners were taken in 1977-78.

An estimate of steelhead escapement in 1977-78 was made using Chapman's (1951) modification of the standard Peterson method. Fifty steelhead were tagged prior to spawning; subsequent trapping of spent adults and carcass surveys recovered three tagged steelhead in a sample of 16 fish. An estimated 217 steelhead entered Jacoby Creek to spawn in 1977-78. A confidence interval, ranging from 121 to 312 fish, was calculated at 95 percent probability level. No attempt was made to estimate steelhead escapement in 1976-77.

Age Characteristics

Eleven age categories were found among the adult steelhead population in Jacoby Creek (Table 9). The most frequent age categories were 2/2 and 2/1 for initial spawners and 2/1S.1 for repeat spawners. During the 1976-77 season, the 2/1 (28.3 percent) and 2/2 (26.1 percent) age groups comprised 54.4 percent of the total run. The 2/2 age group

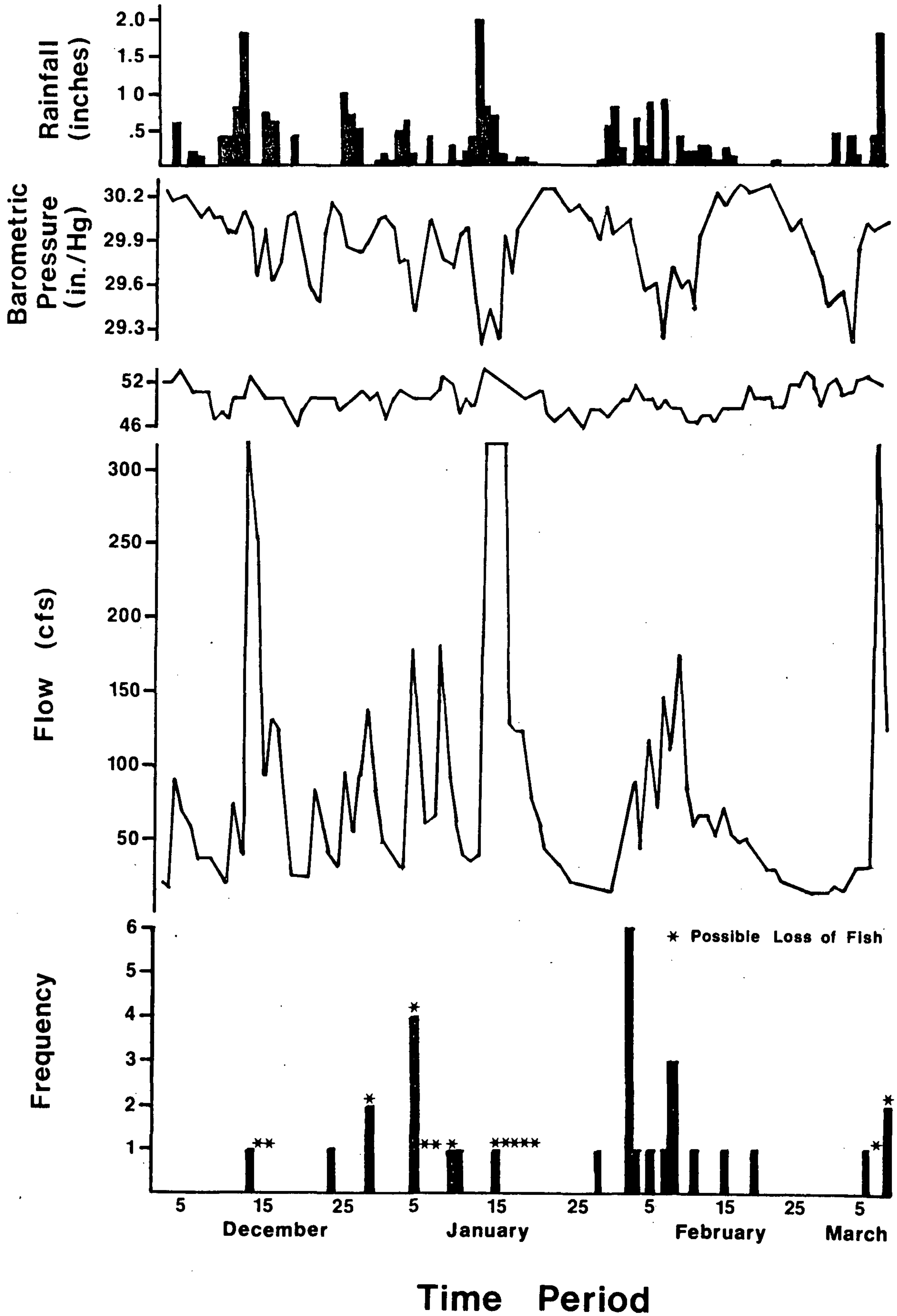

Figure 28. Time of adult steelhead entry into Jacoby Creek in relation to four environmental factors from December 1977 through March 1978.

Table 9. Composition of the vital statistics for Jacoby Creek steelhead during the 1976-77 and 1977-78 seasons.

Age Category	Sex	Number in Each Age Category	Percent in Each Age Category	Mean Fork Length (cm)	Range of Fork Lengths (cm)	Mean Weight (kg)	Range of Weights (kg)
2/1	M	12	11.0	50.6	43.0-55.0	1.2	0.8-2.0
	F	5	4.6	53.3	47.5-58.5	1.7	1.1-2.4
	Total	17	15.6	51.4	43.0-58.5	1.5	0.8-2.4
3/1	M	3	2.8	55.0	53.0-57.5	1.9	1.5-2.5
	F	6	5.5	56.2	52.5-59.5	2.1	1.6-2.4
	Total	9	8.3	55.8	52.5-59.5	2.1	1.5-2.5
1/2	M	2	1.8	74.0	65.5-82.5	4.6	3.0-6.2
	F	9	8.3	70.1	66.0-77.0	3.6	2.7-5.0
	Total	11	10.1	70.8	65.5-82.5	3.8	2.7-6.2
2/2	M	25	23.0	73.2	62.5-86.0	4.4	2.7-6.5
	F	24	22.0	69.6	65.5-74.0	3.7	2.4-4.6
	Total	49	45.0	71.4	62.5-86.0	4.0	2.4-6.5
3/2	M	0	0.0	-	-	-	-
	F	2	1.8	69.0	68.0-70.0	3.3	3.1-3.5
	Total	2	1.8	69.0	68.0-70.0	3.3	3.1-3.5
2/3	M	2	1.8	74.3	73.5-75.0	5.1	4.8-5.3
	F	0	0.0	-	-	-	-
	Total	2	1.8	74.3	73.5-75.0	5.1	4.8-5.3
2/1S.1	M	5	4.6	63.5	58.0-75.0	3.2	2.2-5.2
	F	6	5.5	67.4	65.0-71.0	3.4	3.1-4.0
	Total	11	10.1	65.6	58.0-75.0	3.3	2.2-5.2
3/1S.1	M	1	0.9	66.0	66.0	3.3	3.3
	F	0	0.0	-	-	-	-
	Total	1	0.9	66.0	66.0	3.3	3.3
1/1.1S.1	M	0	0.0	-	-	-	-
	F	1	0.9	77.5	77.5	4.8	4.8
	Total	1	0.9	77.5	77.5	4.8	4.8
2/1.1S.1	M	1	0.9	67.5	67.5	3.6	3.6
	F	3	2.8	75.3	74.5-77.0	4.4	4.1-4.6
	Total	4	3.7	73.4	67.5-77.0	4.2	3.6-4.6
2/2S.1	M	0	0.0	-	-	-	-
	F	2	1.8	72.8	72.0-73.5	4.6	4.3-4.8
	Total	2	1.8	72.8	72.0-73.5	4.6	4.3-4.8
Total	M	51	46.8	65.7	43.0-86.0	3.4	0.8-6.5
	F	58	53.2	67.2	47.5-77.5	3.4	1.1-5.0
	Total	109	100.0	66.5	43.0-86.0	3.4	0.8-6.5

predominated the 1977-78 spawning run, representing 58.7 percent of the steelhead captured. Overall, the majority of spawners were represented by five age categories: 2/2 (45.0 percent), 2/1 (15.6 percent), 2/1S.1 (10.1 percent), 1/2 (10.1 percent), and 3/1 (8.3 percent). Together, these five categories formed 89.1 percent of the run.

The total ages of the adult steelhead ranged from three to five years (Table 10). The majority of spawners were four years of age (64.2 percent) with three and five-year fish comprising 25.7 and 10.1 percent of the run, respectively. A majority of adults (62.2 percent) spent two years at sea prior to their initial spawning migration. Eighty-nine percent of all steelhead spawners remained two or more years in the stream before migrating seaward as smolts.

Spawning History

The majority of steelhead were first spawners (Table 10). First spawners represented 80.9 and 84.4 percent of the 1976-77 and 1977-78 spawning runs, respectively. Virtually all repeat spawners were second spawners (89.5 percent). Only one fish each season was spawning for the third time. Repeat spawners were captured throughout the season with no trend towards early or late entry. One female spawner was recaptured in 1978 after being tagged during the previous season.

Sex Ratio

The male to female ratio for the combined two seasons was 1:1.13. Among first spawners, the ratio was 1:1.04. Neither sex ratio was significantly different ($p > .05$) from the expected ratio of 1:1. Although both sexes were near equally represented among first spawners (49:51 percent), females predominated among repeat spawners (63 percent). A total

Table 10. Number of Jacoby Creek steelhead of two seasons by spawning class and total age. N = 109.

Spawning Class	Total Age 3	4	5	Total	Total in Percent
First Spawners	28	58	4	90	82.6
Second Spawners	--	12	5	17	15.6
Third Spawners	--	--	2	2	1.8
Total	28	70	11	109	100
Total in Percent	25.7	64.2	10.1		

of 19 repeat spawners had a male to female ratio of 1:1.71. During the 1976-77 season, males outnumbered females with a sex ratio of 1:0.88, while females comprised the majority (1:1.37) of steelhead captured in the 1977-78 season.

Length and Weight

The means and ranges of fork lengths and weights for Jacoby Creek adult steelhead collected in 1976-77 and 1977-78 are presented in Table 9. Among steelhead that returned to spawn after one year at sea, females on the average attained a larger size than males. This is seen in the 2/1, 3/1, and 2/1S.1 age categories. In contrast, males were generally larger in age groups of spawners which spent two years at sea prior to upstream migration. This is evident in age categories 1/2 and 2/2. Repeat spawners were noticeably smaller than initial spawners of the same year class which had spent the same number of seasons in fresh water and in the ocean.

The length frequencies of adult steelhead form a bimodal distribution with the two peaks representing the number of seasons spent in saltwater (Figure 29). Noticeable in the 1977-78 season is the few number of steelhead spawners with only one season of ocean residency (<65 cm).

A length-weight relationship curve was determined for Jacoby Creek steelhead based on a sample of 400 fish captured over a three-year period from 1976-78 (Figure 30). A total of 86 adults and 314 unsexed juveniles were used in the computations. Trout ranged in length from 4.2 to 86.0 cm and in weight from 0.7 to 6500 grams. The growth curve displayed an exponential increase in weight with length, fitting the formula $\log W = \log a + b (\log L)$. The equation of best fit for males was $\log W = -4.198 +$

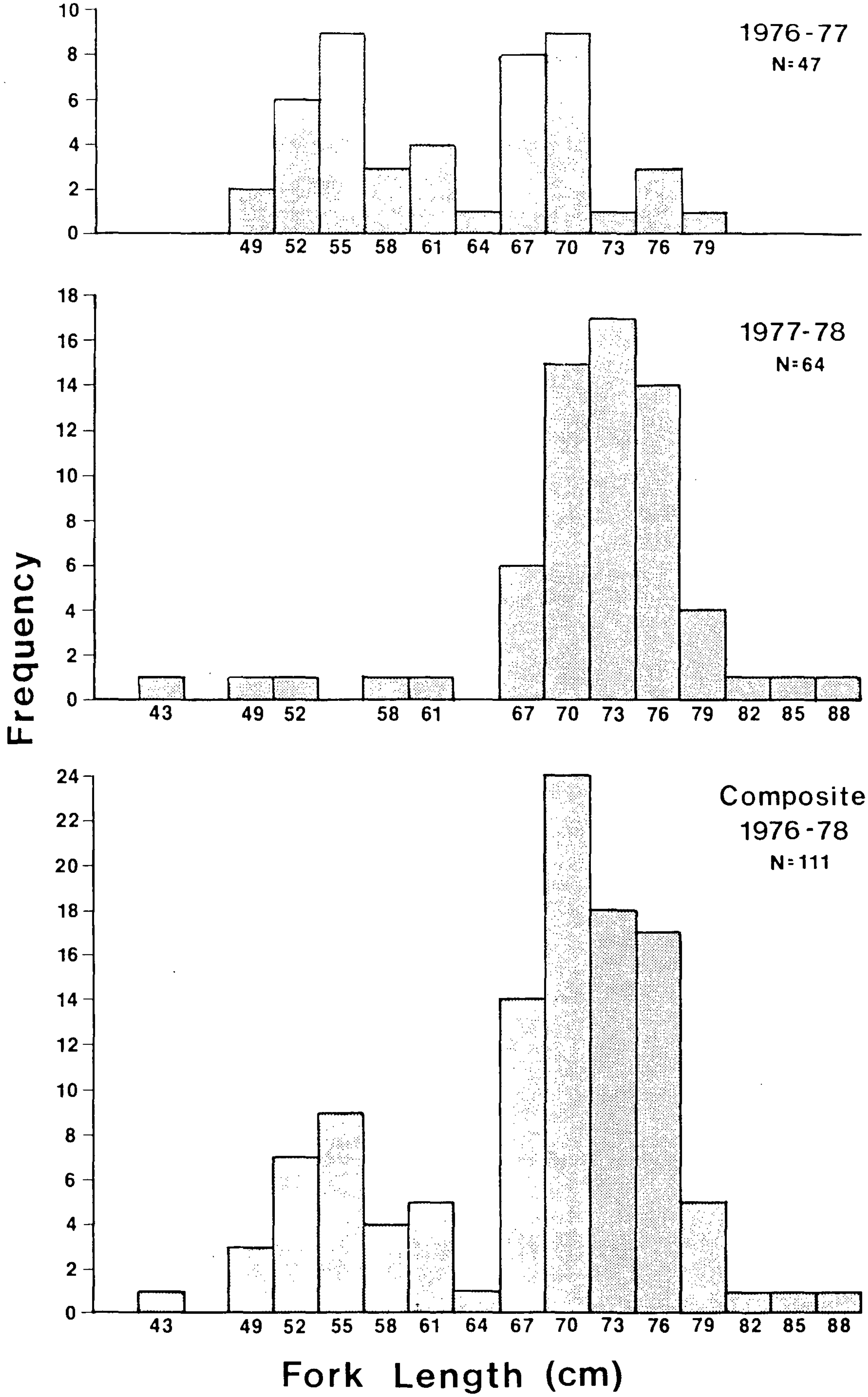

Figure 29. Length-frequencies of adult steelhead captured in Jacoby Creek during the 1976-77 and 1977-78 seasons.

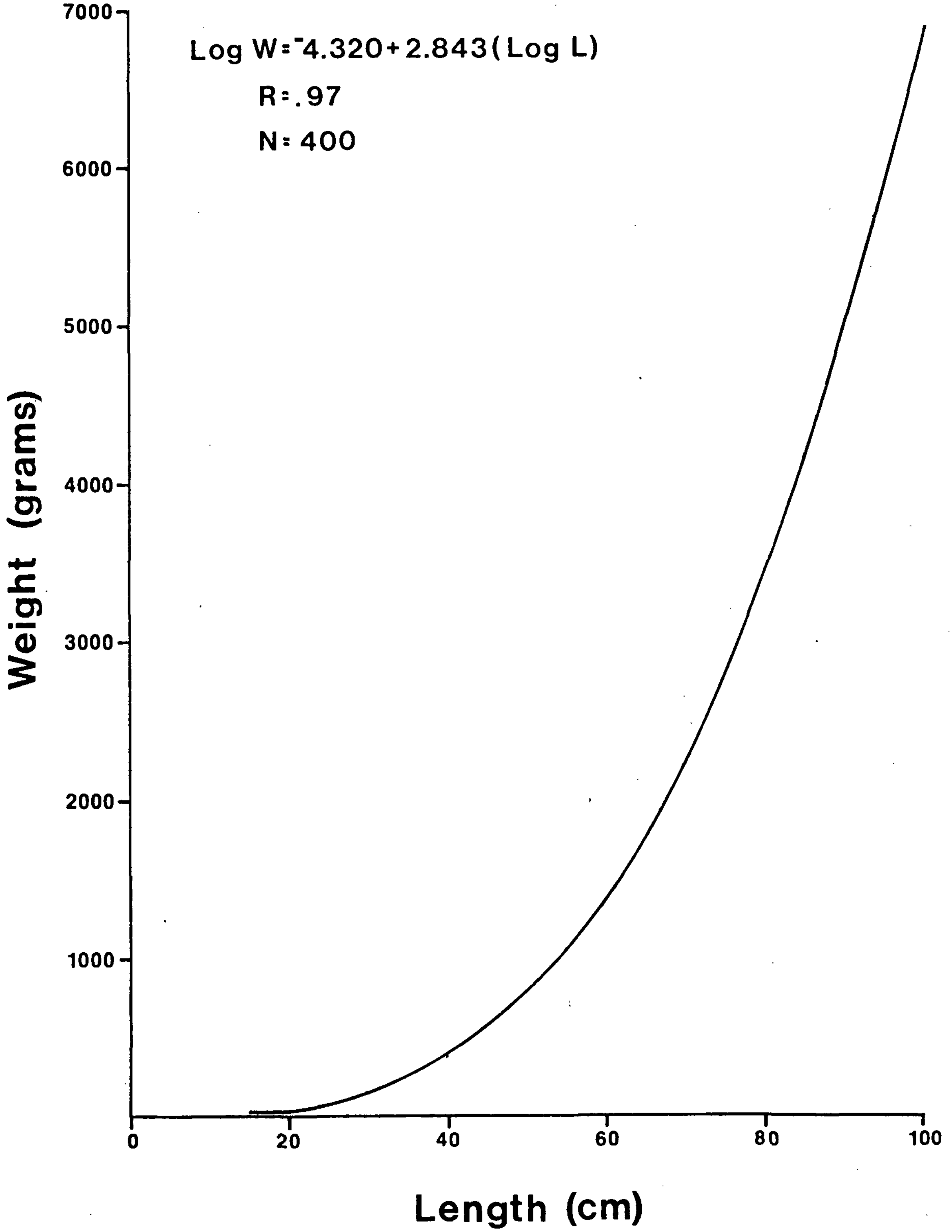

Figure 30. Length-weight relationship for steelhead from Jacoby Creek. Sexes are combined.

2.915 (log L) and for females was log W = -4.859 + 2.692 (log L). The composite length-weight equation was log W = -4.320 + 2.843 (log L) with r = 0.97.

Condition

Thirty adult steelhead captured in the upstream trap just after entering the stream were examined for sexual maturity. Unlike coho salmon, the vast majority of steelhead entering the creek were sexually immature or green (86.7 percent). No females were found to be sexually mature while only 28.6 percent of the males had some degree of ripeness (milt extracted).

Condition factors calculated for the 30 spawners averaged 1.15 and ranged from 1.03 to 1.29. The mean condition factor for the 16 female adults was 1.14 while the average condition factor for the 14 males was 1.16.

Spawning

Spawning occurred primarily from February through April. Steelhead typically migrated greater distances up Jacoby Creek to spawn than did the coho salmon. Steelhead preferred the upper cascade region of the creek; spawners were captured up to the migration barrier, 8.3 kilometers upstream. Steelhead redds were most commonly located in the lower end of pools just above riffle breakwater. No tributary spawning by steelhead was observed.

Electrofishing surveys indicated that male steelhead tended to remain in Jacoby Creek longer than females following spawning activity. Prior to 3 April, 13 of 15 spent steelhead recovered at the weir on their descent seaward were females. One female, previously tagged upon entering the creek, had a stream residence of only 28 days.

STRAYING

Several adult coho salmon captured in Jacoby Creek during the 1976-77 and 1977-78 spawning seasons were non-native, fin-clipped fish. These strays were from the Arcata Wastewater Salmon Project, where juvenile salmon are raised in brackish water rearing ponds fertilized with domestic wastewater (Miyamoto 1979). In the spring of 1976, 12,000 coho smolts (9,000 of which were fin-clipped) were released in the estuary of Jolly Giant Creek, located approximately 1.6 km northwest of the mouth of Jacoby Creek.

One fin-clipped salmon (jack) was captured in Jacoby Creek during the 1976-77 season. Based on the 3:1 marked-to-unmarked ratio for pond-reared salmon, it would be expected that all unmarked salmon captured that season would be native fish. Miyamoto (1979), using scale analysis to separate pond-reared salmon from native Jacoby Creek salmon, concluded that nine (7 clipped/2 unclipped) of the 50 coho (18 percent) captured in Jacoby Creek during 1977-78 were pond-reared salmon. Based upon this percentage, an estimated 22 pond-reared salmon entered Jacoby Creek during the 1977-78 spawning season.

In this study fin-clipped salmon were excluded from all data analysis with the exception of the run-size estimate in 1977-78. The run-size estimate includes both marked and unmarked pond-reared salmon as well as native unmarked salmon.

DISCUSSION

Coho Salmon

Juveniles

The single age class of juvenile coho salmon present in Jacoby Creek is typical for the species in the southern portion of its range (Shapovalov and Taft 1954; Salo and Bayliff 1958; Willis 1962; Edie 1975). In contrast, multiple age classes are found more often in streams of more northern latitude (Crone 1968; Armstrong 1970; Drucker 1972).

The juvenile coho population in Jacoby Creek was much larger in 1976-77 than in 1977-78. Variations in average annual streamflow have been shown to significantly affect the number of juvenile coho in Washington streams (Smoker 1953). However, as suggested by Crone and Bond (1976) for Sashin Creek, Alaska, other factors such as parental escapement, original number of coho fry, and competition probably have more influence in determining the number of juvenile coho residing in Jacoby Creek. Coho fry were exceptionally scarce in 1977, suggesting that the spawning run had not seeded the stream to carrying capacity.

Biomass measurements for juvenile coho in Jacoby Creek were generally lower than those reported in other similar streams of the Pacific coast (Chapman 1965; Narver 1972; Narver and Anderson 1974; Moring and Lantz 1974; Moring and Lantz 1975; Edie 1975). The estimated mean biomass for the four study sections over the two-year period was 0.71 g/m^2. Five coastal streams of northern California surveyed by Burns (1971) had coho biomasses ranging from 0.2 to 2.1 g/m^2. The low population densities in 1977-78 apparently reduced competition as salmon attained greater mean lengths than in 1976-77, when densities were greater (Table 1). However, between-year differences in mean lengths of salmon may be due in part to differences each year in the emergent time (Au 1972).

The general growth pattern of juvenile coho in Jacoby Creek is similar to that reported for juvenile salmonids in streams of Oregon and California (Au 1972, Cross 1975, Reeves 1979). Juvenile coho captured in the lower portion of the creek were larger on the average than salmon caught higher in the stream. Shapovalov and Taft (1954) noted a similar trend in Waddell Creek, indicating that more favorable growing conditions exist in the lower sector of a stream allowing for faster growth. Presently, in Jacoby Creek, it is not known if larger-size coho migrate lower in the stream or whether salmon which reside in the lower portion of the creek grow faster.

Coho smolt emigration from Jacoby Creek took place primarily during April and May; peak migration occurred during the first week in May. Similar findings have been reported in coastal streams of California, Oregon, and Washington (Shapovalov and Taft 1954; Salo and Bayliff 1958; Willis 1962; Healey 1973; Moring and Lantz 1975). Coho smolts in streams of more northern latitude migrate later in the season; over a month separates the midpoint of migration in the coastal streams of California versus those in central Alaska (Drucker 1972). The primary factors which govern the timing and extent of migration include flow, water temperature, size of smolts, and latitude (Moring and Lantz 1975). Low flow and high stream temperatures advance the time of coho emigration (Shapovalov and Taft 1954). Willis (1962) observed an increase in the number of coho migrants with an increase in streamflow at Spring Creek, Oregon. Similar behavior was observed in Jacoby Creek, although as the season progressed, coho smolts were more willing to migrate during periods of lower flow (Figure 18).

Juvenile coho along the Pacific coast spend one to three years in fresh water before migrating as smolts out to sea (Gilbert 1922; Israel 1933; Armstrong 1970; Drucker 1972). In streams south of Alaska, however, most juvenile coho migrate to sea after spending only one year in stream residence (Shapovalov and Taft 1954; Salo and Bayliff 1958; Willis 1962; Moring and Lantz 1975). Data from Jacoby Creek agrees with these findings.

Information on the size of migrating coho salmon smolts from spawning streams along the Pacific coast is presented in Table 11. Coho smolts from Jacoby Creek were generally larger than those reported in other stream studies. As the migration progressed there was a gradual increase in coho smolt size (Table 3). Kabel and German (1967) noted a similar trend in the size of coho migrants leaving Caspar Creek, California. The larger size of the late-migrating smolts is probably a reflection of rapid spring growth. Other workers, with data collected over a series of seasons have noted an opposite trend; a decrease in size with time of migration (Shapovalov and Taft 1954, Salo and Bayliff 1958). According to Shapovalov and Taft (1954), this trend was attributed to smolts having to reach a "migration size" before leaving the stream. Crone (1968) and others have suggested that smolting is a function of size rather than age.

There was a decrease in the condition factor of juvenile coho accompanying the parr-smolt transformation in Jacoby Creek. Drucker

Table 11. Mean fork lengths of coho salmon smolts from streams along the Pacific coast, arranged geographically from north to south.

Stream	Mean Length	Range of Mean Length	Number of Seasons	Reference
Hood Bay Creek, AK	87.4	84.7-90.0	2	Armstrong (1970)
Minter Creek, WA	98.0	96.3-99.7	2	Salo and Bayliff (1958)
Gnat Creek, OR	114.9	101-121	6	Willis (1962)
Deer Creek, OR	88.7	88.7	1	Chapman (1961)
Flynn Creek, OR	88.1	88.1	1	Chapman (1961)
Jacoby Creek, CA	100.5	100.5	1	Present Study
Caspar Creek, CA	90.2	90.2	1	Kabel and German (1967)
Waddell Creek, CA	112.1	103.1-116.6	9	Shapovalov and Taft (1954)

(1972), in his study at Karluk Lake, Alaska, also found low condition factors among coho smolts leaving fresh water. The "slimmed state" of the smolt appears to be common among salmonids and is most likely attributed to the physiological stress of smoltification.

Adults

The migration pattern of adult coho salmon entering Jacoby Creek was similar to that reported in other streams of southern Oregon and northern California. Coho spawners entered Needle Branch, Deer Creek and Flynn Creek, Oregon from mid-November to early February (Moring and Lantz 1975). During a nine-year study, Shapovalov and Taft (1954) reported that 96 percent of the coho salmon entered Waddell Creek, California from 10 December to 10 February. In contrast, most adult coho migrations in northern Oregon and Washington were completed by the end of November (Salo and Bayliff 1958, Willis 1962).

The arrival sequence of adult coho into Jacoby Creek indicates that the spawning run is closely associated with large increases in streamflow. Au (1972) suggested that part of the effect of stream discharge may be purely mechanical; a minimum flow level is necessary for adults to successfully navigate the stream. Banks (1969) noted that the relationship between upstream migration and streamflow is most evident in small streams having rapid runoff and a species of salmon with a short spawning season. Other studies conducted on small coastal streams have also found coho entry directly related to streamflow (Shapovalov and Taft 1954, Kabel and German 1967, Moring and Lantz 1975, Miyamoto 1979).

Although streamflow appears to be the primary environmental stimulus affecting migration movement, other environmental factors such as light, water temperature, and barometric pressure have also been shown to influence the time of migration (Neave 1943, Briggs 1953, Allen 1959). These environmental factors may become increasingly important in the larger streams where flow is not a physically limiting factor. Chapman (1941) concluded that environmental factors affecting upstream movement of salmonids are "probably multiple with complex inter-relationships". It is interesting to note that all salmon (three) captured in the upstream trap when streamflow was less than 40 cfs were ripe-and-running males. This may indicate that some coho migratory movement was influenced more by a physiological factor (gonad maturation) than by environmental factors.

Previous studies conducted on coastal streams in California have shown that adult coho return to spawn after spending one or two growing seasons in the ocean (Murphy 1952, Shapovalov and Taft 1954, Kabel and German 1967). Drucker (1972) reported that in California, the southern limit of the range of coho salmon, the major class is age 1/2, but that jack salmon (age 1/1) contribute significantly to the runs. Similar results were found in Jacoby Creek.

Coho spawners in Jacoby Creek were of average length compared to coho taken in other streams of the Pacific coast (Marr 1943, Shapovalov and Taft 1954, Salo 1955, Allen 1958, Willis 1962, Crone 1968, Moring and Lantz 1975). Drucker (1972), in his summary of the life history characteristics of the species, concluded that the size of coho salmon from the various spawning streams along the Pacific coast was quite variable and did not seem to follow any set geographic pattern. Shapovalov and Taft (1954) noted that the size of coho was not correlated with size of stream.

In Jacoby Creek, female coho on the average were larger than males each season, although the largest fish were often males. Similar results were reported in the Drift Creek study streams (Au 1972). However, some workers found male coho on the average to be slightly larger than females (Marr 1943, Shapovalov and Taft 1954). Salo and Bayliff (1958) observed that coho salmon in the early and late portions of the Minter Creek run tended to be smaller fish. No size trend of coho spawners entering Jacoby Creek over the course of a season was evident.

The mean lengths of jack salmon (age 1/1) in the 1977-78 season and the age 1/2 salmon in the 1978-79 season appear to represent unusually small coho spawners for the respective age groups. This would indicate a possible correlation of size among fish of the same brood year. However, Shapovalov and Taft (1954), in nine years of study at Waddell Creek, found no correlation between the mean length attained by the jacks (age 1/1) of a given brood year and the two-year-ocean (age 1/2) fish of the same brood season. They postulated that the size of returning coho adults is primarily determined during the last growing season in the ocean. Further support of this premise is given by Gunsolus (1978), who indicated that a strong correlation existed between coastal ocean upwelling and the ultimate size of maturing coho spawners (i.e. poor upwelling with small size; good upwelling with large size). Zirges (pers. comm. 1979) stated that the ocean upwelling index off the Oregon coast in the spring of 1978 was one of the poorest recorded in the last 20 years. The size relationship between age 1/2 coho in 1978-79 and jack salmon in 1977-78 may represent a chance occurrence; however, reasons for the small size of jack salmon in 1977-78 remain unclear.

The mean condition factor for coho salmon entering Jacoby Creek (1.23) was higher than those reported by Moring and Lantz (1975) for the Drift Creek study streams. The mean condition factor for coho spawners entering Needle Branch and Deer Creek was 1.12; for Flynn Creek the average was 1.11. Caution should be used when assessing the value of comparing condition factors of fish from different stream localities. Rounsefell and Everhart (1953) indicated that condition factors were valid only in comparing fish of the same age, sex, length and time of sample.

In Jacoby Creek, the overall male to female ratio on the spawning grounds (2.77:1) was higher than for coho captured in the weir (2.33:1). Gribanov (1948) attributes higher male to female ratios on the spawning grounds to longer male survival after spawning. Other weir studies have generally found lower sex ratios for coho salmon than those reported in Jacoby Creek. Including jacks, Moring and Lantz (1975) found a 2.6:1, 2.1:1, and 1.6:1 ratio, males to females, for coho returning to Deer Creek, Flynn Creek, and Needle Branch, Oregon, respectively. Including jacks, the coho ratio in Waddell Creek, California was 1.28:1, males to females. Without jacks, the ratio dropped to 0.92:1 (Shapovalov and Taft 1954). Similar results were reported by Murphy (1952) on the South Fork Eel River, California where the male to female sex ratio was 1.34:1 with jacks and 0.83:1 without the younger males. Willis (1962) found a 1:1 sex ratio in Gnat Creek, Oregon among coho exclusive of jacks.

The mean percentage sex composition of age 1/1 jacks, age 1/2 males and age 1/2 females in the coho run at Jacoby Creek are compared in Table 12 with similar data from other study streams in California, Oregon, and Washington. The average percentage of age 1/2 females in

Table 12. Percent sex composition by age of coho salmon from streams along the Pacific coast, arranged by average run size.

Stream	Ave. Run Size	Age 1/1 Males	Age 1/2 Males	Age 1/2 Females
S. Fk - Eel River, CA	13,515	22%	35%	43%
Minter Creek, WA	2,280	12	43	45
Waddell Creek, CA	313	18	40	42
Gnat Creek, OR	149	56	22	22
Deer Creek, OR	146	17	65	18
Jacoby Creek, CA	123	51	22	27
Flynn Creek, OR	92	24	56	20
Spring Creek, OR	90	29	46	25
Needle Branch, OR	45	40	40	20

Jacoby Creek was generally similar to other streams with small runs of coho, i.e., Gnat Creek, Deer Creek, Flynn Creek, Spring Creek and Needle Branch; but only half that of larger-run streams, i.e., South Fork Eel River, Minter Creek, and Waddell Creek. Moring and Lantz (1975) reported a direct correlation between coho run size and the percentages of various age groups; proportion of age 1/2 salmon increased and the proportion of jacks decreased with increasing run size. With the exception of Gnat Creek, Jacoby Creek has a much higher percentage of jacks (51 percent) than was reported in other streams. Percentage of jacks was lowest at Minter Creek, the northernmost study stream. Drucker (1972) suggested that differences in coho age composition from various streams may represent a geographical cline with older age groups comprising the larger percentages in more northern latitudes.

The coho jack percentage in Jacoby Creek was generally twice that found in the other streams. However, reasons for this high proportion of jacks are unclear. Moring and Lantz (1975) found no discernable change in coho age groups resulting from logging. Noble (1958) indicated that accelerated growth was a factor in the early maturation of coho salmon at Minter Creek. Lorz (1971) found early sexual maturity in coho positively related to smolt size. However, Willis (1962) concluded that no significant correlation existed between the average size of smolts and the percentage of returning jacks in Gnat Creek. Noble (1958) postulated that genetic factors are the primary cause of jacks with growth and environmental conditions causing variability in the observed results.

Observations in Jacoby Creek indicate that both genetic and growth factors may be contributing towards the high percentage of coho jacks. Electrofishing surveys revealed that jacks were, on many occasions, the only males in attendance with females while on the spawning grounds. Stream growth may be a factor, as coho smolts captured in the spring of 1977 were larger than average size when compared to other stream studies.

The number of coho spawners entering Jacoby Creek appears to be quite variable from year to year; however, it is apparent that recent escapements are considerably lower than pre-1965 levels. Although optimal escapement levels for coho are unknown, it is probable that the number of spawning females entering Jacoby Creek is too low to seed the stream to its maximum juvenile rearing capacity. Salo and Bayliff (1958), Chapman (1962), and Moring and Lantz (1975) have reported that spawning runs in fully-seeded streams can be quite variable and still produce the same number of smolts. In Jacoby Creek, there was an estimated two-fold difference in the number of salmon smolts produced in 1977 and 1978.

Steelhead

Juveniles

Juvenile steelhead generally spend one to four years in fresh water before migrating seaward (Sumner 1948; Shapovalov and Taft 1954; Chapman 1958; Bali 1959; Kabel and German 1967); however, reports of steelhead spending five years in stream residence before commencing a migration have been noted (Narver 1969; Jones 1977). In Jacoby Creek, steelhead generally spend two or three years in fresh water before migrating into Humboldt Bay.

The seasonal growth pattern for juvenile steelhead in Jacoby Creek parallels that reported earlier for juvenile coho. Cross (1975) noted a similar pattern of growth for steelhead in Singley Creek, California. A cessation of growth occurred in September in association with high stream temperatures and minimum flows. As pointed out by Mundie (1969), reduced flow results in a reduction of available territory, increase in water temperature and metabolism, and a reduction of food in the form of terrestrial drift. In October, growth commenced for a short period in response to more favorable stream conditions created by early seasonal rains. Rapid growth resumed in March. Shapovalov and Taft (1954) suggested that resumption of heavy feeding in spring is influenced by both rising temperatures and an abundance of aquatic food organisms.

Back-calculated fork lengths for juvenile steelhead in Jacoby Creek compare closely with those reported by Cross (1975) for Singley Creek steelhead. Juvenile steelhead in Singley Creek had an average fork length of 88 mm at the first annulus, and 130 mm at the second annulus. Calculated values for Jacoby Creek steelhead were 87.3 and 135.7 mm for the first and second annuli, respectively. Lee's phenomenon, a decrease in the lengths of younger fish calculated for successively older age groups, was evident after the first year of life. This probably reflects the tendency of slow-growing fish having a longer stream residence before migrating seaward.

The timing of steelhead smolt emigration from Jacoby Creek is typical of that reported in other California streams. Shapovalov and Taft (1954) found peak migration in Waddell Creek occurring in spring with a smaller, secondary peak in fall. Healey (1973) reported steelhead smolts migrating in the Trinity River from March through May with peak movement occurring in early May. Peak emigration in Caspar Creek occurred in early May (Kabel and German 1967). Sheppard (1972) noted that the principle migration times in Oregon and Washington streams were from April through June with a peak occurring in mid-April.

Environmental factors and body size influence downstream migration of steelhead smolts (Shapovalov and Taft 1954). Water temperature and streamflow appear to be the primary environmental factors affecting downstream movement (Andrews 1958; Hallock et al. 1961). Low flow and high temperatures advance the time of migration (Shapovalov and Taft 1954). Although data is limited, it is apparent in Jacoby Creek that the greatest number of smolts migrated during periods of increased streamflow.

The size and age at which juvenile steelhead migrate from Pacific coastal streams has been studied by various workers (Pautzke and Meigs 1940; Gudjonsson 1946; Sumner 1952; Maher and Larkin 1954; Shapovalov and Taft 1954; Andrews 1958; Bali 1959; Hallock et al. 1961; Willis 1962). In Oregon, Andrews (1958) reported an overall mean length of 163 mm for wild downstream-migrating steelhead in the Alsea River, while Willis (1962) showed a mode value of 157.5 mm for steelhead migrants leaving Gnat Creek. These values are similar to the mean length of 164.3 mm for steelhead smolts in Jacoby Creek.

Size, rather than age, appears to be the primary factor governing the downstream movement of steelhead smolts. Gudjonsson (1946) postulated that steelhead must attain a certain minimum length in order to reach a physiological state enabling a seaward migration. Royal (1972), in his review of the Washington anadromous trout program, suggested a critical minimum of six inches (152 mm) total length. In Jacoby Creek juvenile steelhead generally spend two years in stream residence in order to attain migration size (Figures 22, 23). Other investigators of coastal streams in California, Oregon, and Washington have also noted that the vast majority of steelhead smolts migrate seaward after spending two years in fresh water (Meigs and Pautzke 1941; Gudjonsson 1946; Sumner 1948; Shapovalov and Taft 1954; Larson and Ward 1954; Chapman 1957; Andrews 1958; Hallock et al. 1961). As observed in Jacoby Creek, Jones (1973) and Shapovalov and Taft (1954) reported that larger steelhead smolts tended to migrate earlier in the spring migration than did smaller smolts. Chapman (1958) noted that steelhead which entered the ocean as small smolts tended to remain there longer than did fish that went to the sea as large smolts.

The downstream migration of steelhead fry has been noted in other Pacific coastal streams (Sumner 1952; Shapovalov and Taft 1954; Larson and Ward 1954; Chapman 1958). McFadden (1969) postulated that the emigration of salmonid fry occurs as a result of density-dependant competition for territory. Chapman (1961) indicated that fry may be displaced into the ocean before reaching a stage of maturity necessary for ocean survival. The absence of a 0+ freshwater growth pattern from adult scales suggests a low or nonexistent survival of seaward-migrating steelhead fry in Jacoby Creek.

Adults

The migration pattern of adult steelhead entering Jacoby Creek is similar to that reported in other streams along the Pacific coast (Maher and Larkin 1954, Shapovalov and Taft 1954, Bali 1959, Kabel and German 1967, Cross 1975, Kralik and Sowerwine 1977). The increasing earliness of the spawning run with progression to the north, which was noted for coho salmon, is not apparent in steelhead. Shapovalov and

Taft (1954), observing two peaks in the migration timing of Waddell Creek steelhead, concluded that fish of different age categories enter streams at different times of the season. This phenomenon was apparent in Jacoby Creek during the 1976-77 spawning season.

As in the case for coho salmon, steelhead entry into Jacoby Creek is directly related to streamflow. Previously discussed, the environmental factors affecting migration movement in salmon can be generally applied to steelhead (see: Discussion, page 70). Shapovalov and Taft (1954) noted that steelhead appear to be less exacting than coho with regard to the conditions under which they will ascend a fish-way (weir).

The maximum age for steelhead spawners is generally considered to be seven years (Moring and Lantz 1975); however, two reports of nine-year-old fish have been documented (Sumner 1948, Washington 1970). In Jacoby Creek the oldest steelhead were only five years of age (Table 10). This may reflect the apparent low survival of spawners during the drought seasons of 1975-76 and 1976-77. Poor survival of early-run steelhead (December - January) was evident during the 1976-77 season when lack of rainfall resulted in the stranding of adults during low water. Electro-fishing surveys conducted in February 1977 failed to recover a single live spawner, although several steelhead carcasses were noted along the stream bank.

The age composition of spawning steelhead with a given drainage varies from year to year (Maher and Larkin 1954, Shapovalov and Taft 1954). In Jacoby Creek, five-year-old steelhead contributed 37.0 percent of the 1976-77 run, but comprised only 17.5 percent in 1977-78. The contribution of four-year-old fish increased from 54.3 percent in 1976-77 to 71.4 percent in 1977-78, while trout three years of age varied only slightly from 8.7 to 11.1 percent between the respective seasons. From these percentages, it appears that the 1973 year-class was relatively weak when compared to year-classes produced in 1972 and 1974. Differences in year-class strengths probably account for yearly variation in the age composition of Jacoby Creek steelhead.

The number of years spent in the ocean by steelhead prior to first spawning is not constant in streams along the California coast (Table 13). The majority of adult steelhead entering Jacoby Creek spent two years at sea before commencing their initial upstream migration.

Table 13. Percent ocean age at first spawning for winter steelhead entering California coastal streams, arranged geographically from north to south.

Stream	Ocean age at first spawning			Reference
	1	2	3	
Klamath River	78.0	21.5	0.5	Kesner (1969)
Hatchery Creek	16.7	61.9	21.4	Kralik and Sowerwine (1977)
Mad River *	28.6	68.6	2.8	Forsgren (1979)
Jacoby Creek	36.0	62.2	1.8	Present Study
Singley Creek	62.7	35.6	1.7	Cross (1975)
Waddell Creek	56.2	43.5	0.3	Shapovalov and Taft (1954)

* Native fish only

Comparison of repeat spawning percentages of steelhead populations from various California streams in given in Table 14. It is interesting to note that the percentage of repeat spawners in California steelhead populations is remarkably consistent from stream to stream. Chapman (1957) reported a percentage of 11.1 for repeat steelhead spawners in the Alsea River, Oregon. The proportion of repeat spawners in anglers' catches from the Chilliwack River, British Columbia was 5.3 percent (Maher and Larkin 1954). Withler (1966) noted a general trend of progressively fewer repeat spawners in Pacific coastal streams from south to north.

Table 14. Percent repeat spawners and percent of repeat spawners spawning for second through fifth time of steelhead in California streams by trapping.

	Percentage					
Stream	Repeat Spawners	2x	3x	4x	5x	Reference
Mad River *	22.9	75.0	25.0	--	--	Forsgren (1979)
Jacoby Creek	17.1	89.5	10.5	--	--	Present Study
Singley Creek	21.0	85.0	15.0	--	--	Cross (1975)
Sacramento River	17.0	82.3	11.8	--	5.9	Hallock et al. (1961)
Waddell Creek	17.2	87.1	12.2	0.6	0.1	Shapovalov and Taft (1954)

* Native fish only.

Survival following spawning was higher among females than among males (Shapovalov and Taft 1954; Bali 1959; Pautzke and Meigs 1940; Withler 1966). Jones (1977), investigating steelhead in Petersburg Creek, Alaska, indicated that male steelhead spent an average of 13 days longer on the spawning grounds than did females. As pointed out by Meigs and Pautzke (1941), males generally spawn with more than one female and hence are exposed to more prolonged physical exertion and dangers of stream residence. The greater proportion of females in the steelhead run to Jacoby Creek is primarily a result of the higher survival among female repeat spawners over males and the relatively high percentage of repeat spawners in the run.

The male to female ratio of 1:1.13 for adult steelhead in Jacoby Creek is typical of ratios reported in other streams along the Pacific coast. Shapovalov and Taft (1954) reported an identical ratio of 1:1.13, males to females, for nine seasons of trap returns in Waddell Creek, California. Kralik and Sowerwine (1977) found a sex ratio of 1:1.33 favoring females for steelhead returning to Hatchery Creek, California. In British Columbia, Maher and Larkin (1954) reported a female dominant ratio of 1:1.39 in the Chilliwack River. Sex ratios near 1:1 were reported for several streams in Washington (Pautzke and Meigs 1940). Jones (1977) reported male to female ratios of 1:1.12 and 1:1.88 for initial and repeat spawners, respectively, in Petersburg Creek, Alaska. These are very similar to the respective values of 1:1.04 and 1:1.71 for initial and repeat spawners in Jacoby Creek.

Adult steelhead entering Jacoby Creek were of average length when compared to other steelhead populations along the Pacific coast. In California, Kralik and Sowerwine (1977) found a mean length of

70.2 cm for steelhead entering Hatchery Creek, while Shapovalov and Taft (1954) reported a value of 58.2 cm for Waddell Creek steelhead. Spawners from Jacoby Creek had a mean length of 66.5 cm. Bali (1959), summarizing data from numerous coastal streams in Oregon, calculated a mean length of 66.3 cm for steelhead in the southern region, 66.8 cm in the central region, and 67.3 cm for spawners in the northern region. In Alaska, Jones (1977) found a mean size of 77.8 cm for adult steelhead entering Petersburg Creek. Sheppard (1972) noted that mean size of adult steelhead along the Pacific coast increases from southern to northern streams. Geographical size differences are partly influenced by the tendency of steelhead of more northern latitudes to spend more time in the ocean (Withler 1966). Maher and Larkin (1954) and others found ocean age more important in determining steelhead size than total age.

In Jacoby Creek, female steelhead were larger than males for fish that returned after one year in the ocean, while males were larger among fish which spent two years at sea. Shapovalov and Taft (1954) and Forsgren (1979) noted the same trend among respective steelhead populations in Waddell Creek and the Mad River; Bali (1959) reported an opposite trend for Oregon steelhead.

CONCLUSION

Native stocks of coho salmon and steelhead trout in Jacoby Creek are at a lower level of abundance than they were historically. Coho escapement into the stream is highly variable from year to year, although present numbers of spawners appear too low for full seeding of existing coho rearing habitat. Jacks (age 1/1 males) contribute significantly to the coho spawning run each year, particularly in seasons of low return of age 1/2 salmon. Steelhead escapement into the creek is more stable and much higher than coho escapement. Studies suggest that the available habitat in the stream may be at or near carrying capacity for juvenile steelhead.

Improper land use practices have severely degraded salmonid habitat in Jacoby Creek. Unless steps are taken to protect the stream environment, continued declines in the runs can be expected. Continued logging in the upper drainage and increasing residential growth in the lower watershed necessitates formulation of a land use policy that will provide protection for the salmonid resource. Larger runs of wild salmon and steelhead in Jacoby Creek could probably be achieved with proper protection of adult spawners and better land use management.

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PERSONAL COMMUNICATIONS

Communicant	Address	Date
Lester, Dr. W.L.	Department of Biology Humboldt State University Arcata, California 95521	6 May 1978
Zirges, M.H.	Oregon Department Fish and Wildlife Oregon St. Univ. Marine Station Newport, Oregon 97365	2 July 1979

APPENDICES

Appendix A. Adult coho salmon captured in Jacoby Creek by electrofishing during the 1976-77 season.

Date captured	Number	Sex	Age category	Fork length (cm)	Weight (kg)	Condition	Mark
1/8/77	1	M	1/1	42.0	0.7	Ripe	RV
	2	M	1/1	45.5	-	Ripe	-
	3	M	1/2	68.0	3.7	Ripe	-
	4	M	1/1	38.0	-	Ripe	-
	5	M	1/1	40.5	0.8	Ripe	-
	6	M	1/2	80.5	6.5	Ripe	-
	7	M	1/1	49.0	-	Ripe	-
	8	M	1/1	44.0	0.9	Ripe	-
1/9/77	9	F	1/2	76.0	5.4	Green	-
	10	M	1/1	42.5	0.8	Ripe	-
	11	M	1/1	41.5	0.9	Ripe	-
	12	M	1/1	46.5	1.1	Ripe	-
	13	M	1/1	37.0	0.5	Ripe	-
	14	F	1/2	68.5	4.1	Green	-
	15	M	1/1	46.5	1.1	Ripe	-
	16	F	1/2	71.5	5.3	Green	-
1/10/77	17	F	1/2	68.0	3.5	Spent	-
	18	M	1/2	64.0	3.2	Ripe	-
	19	M	1/1	41.0	0.6	Ripe	-
	20	M	1/2	70.5	3.9	Ripe	-
1/15/77	21	F	1/2	73.5	4.3	Spent	-
	22	M	1/2	57.0	2.0	Ripe	-
1/17/77	23	F	1/2	74.0	4.2	Spent	-
	24	F	1/2	66.0	3.4	Ripe	-
1/18/77	25	M	1/1	43.0	0.9	Ripe	-
	26	M	1/1	52.0	1.8	Ripe	-
1/21/77	27	F	1/2	70.5	3.8	Spent	-
1/22/77	28	M	1/1	47.0	1.3	Ripe	-
	29	M	1/1	41.5	0.8	Ripe	-
	30	M	1/1	32.5	0.4	Ripe	-

Appendix B. Adult coho salmon captured in Jacoby Creek by trapping and electrofishing during the 1977-78 season.

Date captured	Number	Sex	Age category	Fork length (cm)	Weight (kg)	Condition	Mark
10/25/77	1*	F	1/2	69.5	4.2	Green	-
11/5/77	2*	F	1/2	71.0	4.5	Green	RV
11/22/77	3*	F	1/2	67.0	3.7	Green	-
11/23/77	4*	M	1/2	75.0	5.0	Green	RV
11/24/77	5*	F	1/2	78.0	6.7	Green	-
	6*	M	1/1	41.0	0.9	Ripe	-
	7*	F	1/2	67.5	3.6	Ripe	RP-RV
	8*	M	1/1	43.0	1.0	Green	-
11/26/77	9*	M	1/1	39.5	0.9	Green	-
11/29/77	10*	M	1/2	61.5	2.5	Ripe	-
11/30/77	11*	M	1/2	69.5	3.4	Ripe	-
	12	M	1/2	76.0	5.4	Ripe	-
12/1/77	13*	M	1/2	61.0	2.4	Ripe	RV
12/5/77	14*	M	1/1	40.0	0.9	Green	-
12/10/77	15	M	1/2	68.0	-	Spent	RV
12/11/77	16*	M	1/1	40.5	0.8	Ripe	-
	17*	M	1/1	46.0	1.3	Ripe	-
	18*	M	1/1	39.0	0.7	Ripe	-
12/13/77	19*	M	1/1	41.5	0.9	Ripe	-
	20	M	1/2	70.5	-	Spent	RV
	21	M	1/2	64.5	-	Spent	RV
	22*	F	1/2	75.0	5.6	Ripe	-
12/15/77	23	M	1/1	40.0	-	Ripe	-
12/16/77	24*	M	1/2	63.0	2.4	Ripe	-
12/20/77	25	F	1/2	72.0	5.1	Green	-
	26	M	1/1	30.0	0.4	Ripe	-
	27	M	1/1	28.5	0.4	Ripe	-
	28	M	1/1	46.5	1.3	Ripe	-
	29	F	1/2	60.0	2.7	Ripe	-
	30	F	1/2	71.5	5.1	Green	-
	31	M	1/1	36.5	0.6	Ripe	-
	32	M	1/1	45.0	1.2	Ripe	-
	33	M	1/1	38.5	0.8	Ripe	-
	34	M	1/1	30.5	0.4	Ripe	-
12/26/77	35	M	1/1	26.5	0.2	Spent	-
	36	M	1/1	31.5	0.3	Ripe	-
	37	M	1/1	39.5	0.7	Ripe	-
	38	M	1/1	37.0	0.6	Ripe	-
12/29/77	39*	M	1/1	47.5	1.3	Ripe	-
	40*	F	1/2	76.0	5.8	Green	-
12/30/77	41*	M	1/1	41.5	1.0	Ripe	-
1/3/78	42	M	1/1	42.0	0.8	Ripe	-
	43	F	1/2	66.0	3.3	Spent	-
1/5/78	44*	M	1/1	38.5	0.6	Ripe	-
1/6/78	45	M	1/1	38.0	0.6	Ripe	-
1/9/78	46*	F	1/2	66.0	3.4	Green	-
1/12/78	47	M	1/2	78.5	5.1	Ripe	-
	48	F	1/2	77.0	5.8	Spent	-
1/13/78	49	M	1/1	44.0	-	Spent	-
2/1/78	50	M	1/1	45.0	0.9	Ripe	-

* Captured in the upstream trap.

Appendix C. Adult coho salmon captured in Jacoby Creek by electrofishing during the 1978-79 season.

Date captured	Number	Sex	Age category	Fork length (cm)	Weight (kg)	Condition	Mark
12/2/78	1	M	1/1	42.0	1.1	Green	-
	2	F	1/2	72.0	5.5	Green	-
	3	M	1/1	45.0	1.3	Green	-
	4	M	1/2	38.5	0.7	Ripe	-
	5	F	1/2	49.5	1.5	Green	-
	6	M	1/1	41.0	0.9	Green	-
	7	M	1/2	64.0	3.8	Green	-
	8	M	1/2	58.0	2.5	Ripe	-
	9	M	1/1	42.0	1.0	Green	-
12/7/78	10	M	1/1	43.5	1.1	Ripe	-
	11	F	1/2	51.5	1.8	Green	-
	12	M	1/1	46.5	1.3	Ripe	-
	13	F	1/2	68.0	4.8	Green	-
	14	M	1/2	64.5	3.2	Ripe	-
	15	M	1/2	50.5	1.7	Ripe	-
	16	M	1/2	39.5	0.9	Ripe	-
	17	F	1/2	55.5	2.0	Green	-
	18	M	1/2	54.0	1.9	Ripe	-
1/18/79	19	F	1/2	71.0	4.2	Spent	-
	20	M	1/2	74.0	5.2	Ripe	-
	21	M	1/2	46.0	1.1	Ripe	-
	22	F	1/2	57.0	2.0	Ripe	-
	23	F	1/2	69.0	4.0	Spent	-
	24	M	1/1	46.5	0.6	Ripe	-
	25	M	1/1	44.0	1.0	Ripe	-
	26	F	1/2	51.5	1.5	Ripe	-
	27	M	1/1	53.0	1.8	Ripe	-
	28	M	1/2	63.5	3.0	Ripe	-
	29	M	1/1	47.0	1.3	Ripe	-
	30	M	1/2	50.0	1.3	Ripe	-
	31	M	1/2	62.5	2.9	Ripe	-
	32	M	1/1	40.0	0.8	Ripe	-
	33	F	1/2	63.5	3.6	Green	-
	34	M	1/1	39.5	0.7	Ripe	-
1/25/79	35	M	1/1	45.0	0.9	Ripe	-
	36	M	1/2	77.5	5.0	Spent	-
	37	F	1/2	71.0	4.4	Ripe	-
	38	M	1/1	45.5	1.0	Ripe	-
	39	M	1/2	66.5	4.4	Ripe	-
	40	M	1/2	42.0	0.8	Ripe	-
	41	M	1/1	47.5	1.0	Ripe	-

Appendix D. Adult steelhead captured in Jacoby Creek by electrofishing during the 1976-77 season.

Date captured	Number	Sex	Age category	Fork length (cm)	Weight (kg)	Condition
1/15/77	1	M	2/2	67.5	3.4	Ripe
1/23/77	2	M	2/2	69.5	3.6	Ripe
3/4/77	3	M	2/1S.1	65.0	3.3	Ripe
	4	M	2/1S.1	60.5	2.7	Ripe
	5	M	2/1	55.0	2.0	Ripe
3/5/77	6	M	1/2	65.5	3.0	Ripe
	7	M	3/1	57.5	2.5	Ripe
	8	F	1/2	72.5	3.4	Ripe
	9	F	1/2	68.0	4.0	Ripe
	10	M	3/1S.1	66.0	3.3	Ripe
	11	M	2/2	67.0	3.3	Ripe
3/14/77	12	M	3/1	53.0	1.8	Ripe
	13	F	2/2	68.0	3.6	Ripe
	14	M	2/1S.1	58.0	2.2	Ripe
	15	F	2/1S.1	67.0	3.1	Ripe
3/16/77	16	F	1/2	66.0	3.5	Ripe
	17	M	2/1S.1	59.0	2.4	Ripe
	18	F	2/1.1S.1	74.5	4.5	Ripe
3/19/77	19	F	3/1	54.0	2.4	Ripe
	20	F	2/2	68.0	3.4	Ripe
	21	F	-/2	66.5	3.8	Ripe
	22	M	2/2	68.0	3.3	Ripe
	23	F	3/1	57.0	2.3	Ripe
	24	F	2/2	69.0	3.8	Ripe
3/20/77	25	M	2/1	53.5	1.8	Ripe
3/21/77	26	M	2/1	50.5	1.3	Ripe
3/22/77	27	M	2/1	54.5	1.7	Ripe
	28	F	2/1.1S.1	77.0	4.1	Spent
	29	F	2/1	51.5	1.6	Ripe
	30	M	2/1	50.5	1.4	Ripe
	31	F	2/2	66.5	2.7	Spent
	32	F	2/2S.1	73.5	4.8	Green
	33	F	2/2	69.0	4.1	Green
	34	M	2/1	51.5	1.5	Ripe
	35	M	2/1	49.0	1.3	Ripe
4/1/77	36	F	2/2	69.5	3.6	Green
	37	F	3/1	52.5	1.6	Green
	38	M	2/1	49.5	1.4	Ripe
	39	F	2/1	54.5	1.9	Green
	40	M	2/2	73.5	3.9	Ripe
	41	F	2/1	54.5	1.7	Green
4/3/77	42	M	2/2	62.5	2.7	Ripe
4/8/77	43	F	3/1	59.5	2.3	Green
4/10/77	44	F	3/1	58.5	2.0	Spent
	45	M	2/1	51.0	1.2	Spent
6/3/77	46	M	2/1	48.0	1.1	Spent
6/20/77	47	M	3/1	54.5	1.5	Spent

Appendix E. Adult steelhead captured in Jacoby Creek by trapping and electrofishing during the 1977-78 season.

Date captured	Number	Sex	Age category	Fork length (cm)	Weight (kg)	Condition
12/13/77	1*	F	2/1	47.5	1.1	Green
12/24/77	2*	M	2/2	73.5	4.1	Green
12/30/77	3*	M	2/2	73.0	4.3	Green
	4*	F	2/2	74.0	4.3	Green
1/5/78	5*	M	2/2	79.0	5.7	Green
	6*	M	2/2	82.0	6.5	Green
	7*	M	2/2	74.0	5.0	Green
	8*	F	2/1S.1	69.5	3.7	Green
1/9/78	9*	F	2/2	68.0	3.9	Green
1/10/78	10*	F	1/2	77.0	5.0	Green
1/12/78	11	F	1/2	69.0	4.2	Green
	12	M	2/2	78.5	5.8	Green
1/15/78	13*	F	2/1.1S.1	74.5	4.6	Green
1/22/78	14	F	2/2	69.0	3.9	Green
	15	M	-/2	74.0	4.3	Ripe
1/26/78	16	F	2/2	67.0	3.6	Green
	17	F	2/2	68.5	4.1	Green
	18	M	2/2	72.5	4.7	Ripe
1/29/78	19*	M	2/1S.1	75.0	5.2	Green
2/2/78	20*	F	2/1S.1	65.5	3.3	Green
	21	F	2/2	68.0	2.9	Spent
	22*	F	1/1.1S.1	77.5	4.8	Green
	23*	M	2/2	74.0	4.7	Green
	24*	F	2/2	73.0	4.5	Green
	25*	F	2/1S.1	65.0	3.1	Green
	26*	F	2/2	69.0	3.9	Green
2/3/78	27*	F	2/2S.1	72.0	4.3	Green
2/5/78	28*	M	2/3	73.5	4.8	Green
2/7/78	29*	M	1/2	82.5	6.2	Ripe
2/8/78	30*	M	2/1	51.5	1.5	Green
	31*	F	2/2	72.0	4.5	Green
	32*	M	2/2	74.5	4.5	Ripe
2/11/78	33*	F	2/2	71.0	4.6	Green
2/15/78	34*	M	2/3	75.0	5.3	Ripe
2/19/78	35*	M	2/1.1S.1	67.5	3.6	Green
2/23/78	36	M	2/2	74.0	4.5	Ripe
	37	F	2/2	71.5	4.3	Spent
	38	M	2/2	72.5	3.7	Ripe
2/27/78	39	F	2/2	74.0	3.6	Spent
3/3/78	40	M	2/2	73.0	4.6	Ripe
	41	M	2/2	68.5	3.4	Ripe
	42	M	2/1	43.0	0.8	Ripe
3/6/78	43*	M	2/2	75.5	4.9	Ripe
3/9/78	44*	F	2/1S.1	71.0	4.0	Green
	45*	F	2/1	58.5	2.4	Green
3/15/78	46	M	2/2	86.0	6.4	Ripe
	47	M	2/2	70.5	4.1	Ripe

Appendix E. (Continued)

Date captured	Number	Sex	Age category	Fork length (cm)	Weight (kg)	Condition
	48	M	2/2	72.0	3.6	Ripe
	49	F	3/1	55.5	2.1	Green
3/16/78	50	F	2/1S.1	66.5	3.1	Ripe
	51	F	1/2	69.5	4.0	Ripe
	52	F	2/2	65.5	3.1	Ripe
3/19/78	53	F	3/2	68.0	3.5	Spent
3/26/78	54	F	2/2	66.5	3.0	Spent
	55	M	2/2	76.0	4.8	Spent
4/2/78	56	F	2/2	68.0	2.4	Spent
	57	F	2/2	72.0	3.5	Spent
	58	F	2/2	72.0	3.3	Spent
	59	F	1/2	68.5	2.7	Spent
	60	F	1/2	71.0	3.1	Spent
	61	F	3/2	70.0	3.1	Spent
	62	F	1/2	69.5	2.8	Spent
	63	F	2/2	71.0	3.2	Spent
	64	M	2/2	72.0	3.2	Spent

* Captured in the upstream trap.

Appendix F. Upstream trapping of coho salmon by age and sex in Jacoby Creek and associated environmental variables, 1977-78 season.

Date captured	Age 1/1 male	Age 1/2 male	Age 1/2 female	Temp. ^oF	Flow CFS	Rain inches	Baro. Press. in. Hg
			NOVEMBER - 1977				
1	0	0	0	56	6	-	30.100
2	0	0	0	53	14	0.31	30.045
3	0	0	0	52	7	-	29.920
4	0	0	0	50	7	1.70	29.720
5	0	0	1	51	165	0.14	30.050
6	0	0	0	52	69	-	30.230
7	0	0	0	52	28	-	30.165
8	0	0	0	49	19	-	30.135
9	0	0	0	48	12	-	30.120
10	0	0	0	50	10	-	29.930
11	0	0	0	51	10	0.42	30.065
12	0	0	0	51	12	-	30.095
13	0	0	0	52	19	0.30	30.250
14	0	0	0	52	15	-	30.235
15	0	0	0	54	12	0.08	30.230
16	0	0	0	52	10	-	30.265
17	0	0	0	49	8	-	30.135
18	0	0	0	47	8	-	29.975
19	0	0	0	43	6	0.04	29.970
20	0	0	0	43	7	-	29.910
21	0	0	0	49	87	1.15	29.570
22	0	0	1	50	97	0.82	29.980
23	0	1	0	49	97	0.56	30.115
24	2	0	2	53	130	0.28	30.190
25	0	0	0	52	56	0.14	30.160
26	1	0	0	53	313	1.41	30.130
27	0	0	0	52	104	0.18	30.100
28	0	0	0	52	52	-	30.240
29	0	1	0	53	35	-	30.380
30	0	1	0	52	25	-	30.295
			DECEMBER - 1977				
1	0	1	0	52	21	-	30.225
2	0	0	0	52	18	-	30.150
3	0	0	0	54	92	0.62	30.155
4	0	0	0	53	70	-	30.180
5	1	0	0	51	60	0.20	30.105
6	0	0	0	51	38	0.16	30.020
7	0	0	0	51	38	0.08	30.105
8	0	0	0	47	35	-	30.020
9	0	0	0	48	27	-	30.005
10	0	0	0	47	20	-	29.930
11	3	0	0	50	77	0.40	29.910
12	0	0	0	50	39	0.41	30.085
13	1	0	1	53	40	0.81	29.960
14	0	0	0	-	Flood	1.86	29.630
15	0	0	0	50	252	0.58	29.975
16	0	1	0	50	93	0.42	29.595

Appendix F. (Continued).

Date captured	Age 1/1 male	Age 1/2 male	Age 1/ female	Temp. F^o	Flow CFS	Rain inches	Baro. Press. in. Hg
17	0	0	0	50	132	0.73	29.730
18	0	0	0	49	125	0.64	30.040
19	0	0	0	46	72	-	30.065
20	0	0	0	49	47	-	29.720
21	0	0	0	50	47	0.41	29.540
22	0	0	0	50	46	-	29.460
23	0	0	0	50	84	0.04	29.910
24	0	0	0	50	62	-	30.145
25	0	0	0	48	41	-	30.055
26	0	0	0	49	32	0.05	29.835
27	0	0	0	50	99	-	29.805
28	0	0	0	51	49	0.85	29.800
29	1	0	1	50	94	0.73	29.875
30	1	0	0	51	140	0.56	30.015
31	0	0	0	47	83	-	30.050
JANUARY - 1978							
1	0	0	0	50	48	0.06	29.940
2	0	0	0	51	40	0.15	29.715
3	0	0	0	-	-	0.06	29.765
4	0	0	0	50	31	0.48	29.380
5	1	0	0	50	178	0.67	29.685
6	0	0	0	50	102	0.15	30.020
7	0	0	0	51	60	0.03	29.925
8	0	0	0	53	65	0.38	29.750
9	0	0	1	52	181	-	29.635

Appendix G. Upstream trapping of steelhead trout by sex in Jacoby Creek and associated environmental variables, 1977-78 season.

Date captured	Male	Female	Temp. F^{o}	Flow CFS	Rain inches	Baro. Press. in. Hg
			DECEMBER - 1977			
1	0	0	52	21	-	30.225
2	0	0	52	18	-	30.150
3	0	0	54	92	0.62	30.155
4	0	0	53	70	-	30.180
5	0	0	51	60	0.20	30.105
6	0	0	51	38	0.16	30.020
7	0	0	51	38	0.08	30.105
8	0	0	47	35	-	30.020
9	0	0	48	27	-	30.005
10	0	0	47	20	-	29.930
11	0	0	50	77	0.40	29.910
12	0	0	50	39	0.41	30.085
13	0	1	53	40	0.81	29.960
14	0	0	-	Flood	1.86	29.630
15	0	0	50	252	0.58	29.975
16	0	0	50	93	0.42	29.595
17	0	0	50	132	0.73	29.730
18	0	0	49	125	0.64	30.040
19	0	0	46	72	-	30.065
20	0	0	49	47	-	29.720
21	0	0	50	47	0.41	29.540
22	0	0	50	46	-	29.460
23	0	0	50	84	0.04	29.910
24	1	0	50	62	-	30.145
25	0	0	48	41	-	30.055
26	0	0	49	32	0.05	29.835
27	0	0	50	99	-	29.805
28	0	0	51	49	0.85	29.800
29	0	0	50	94	0.73	29.875
30	1	1	51	140	0.56	30.015
31	0	0	47	83	-	30.050
			JANUARY - 1978			
1	0	0	50	48	0.06	29.940
2	0	0	51	40	0.15	29.715
3	0	0	-	-	0.06	29.765
4	0	0	50	31	0.48	29.380
5	3	1	50	178	0.67	29.685
6	0	0	50	102	0.15	30.020
7	0	0	51	60	0.03	29.925
8	0	0	53	65	0.38	29.750
9	0	1	52	181	-	29.635
10	0	1	48	95	-	29.710
11	0	0	50	63	0.15	29.910
12	0	0	49	41	0.03	29.975
13	0	0	54	37	0.24	29.660
14	0	0	53	41	0.41	29.175
15	0	1	-	Flood	2.05	29.415
16	0	0	-	Flood	0.81	29.210

Appendix G. (Continued)

Date captured	Male	Female	Temp. F^{o}	Flow CFS	Rain inches	Baro. Press. in. Hg
17	0	0	-	Flood	0.73	29.930
18	0	0	51	134	0.17	29.645
19	0	0	50	125	0.02	29.880
20	0	0	50	125	0.12	30.065
21	0	0	51	80	0.12	30.155
22	0	0	48	66	0.05	30.230
23	0	0	47	48	-	30.255
24	0	0	48	39	-	30.245
25	0	0	49	34	-	30.165
26	0	0	48	27	-	30.095
27	0	0	46	23	-	30.125
28	0	0	49	21	-	30.090
29	1	1	49	21	-	30.025
30	0	0	48	19	-	29.885
31	0	0	49	18	0.04	30.005
			FEBRUARY - 1978			
1	0	0	50	38	0.58	29.925
2	1	5	50	60	0.80	29.985
3	0	1	52	91	0.25	30.020
4	0	0	50	49	-	29.755
5	1	0	50	121	0.64	29.580
6	0	0	49	73	0.27	29.565
7	1	0	50	144	0.84	29.590
8	2	1	49	113	0.09	29.235
9	0	0	49	176	0.92	29.710
10	0	0	47	85	-	29.575
11	0	1	47	60	0.42	29.645
12	0	0	48	67	0.20	29.420
13	0	0	48	67	0.15	29.915
14	0	0	47	54	0.24	30.065
15	1	0	49	77	0.27	30.220
16	0	0	49	56	0.06	30.090
17	0	0	49	49	0.23	30.195
18	0	0	52	52	0.15	30.280
19	1	0	50	44	-	30.200
20	0	0	50	36	-	30.225
21	0	0	50	30	-	30.265
22	0	0	49	29	-	30.150
23	0	0	49	24	-	30.030
24	0	0	52	22	0.06	29.960
25	0	0	52	19	-	30.035
26	0	0	54	18	-	29.920
27	0	0	53	16	-	29.820
28	0	0	53	15	-	29.640

Appendix G. (Continued)

Date captured	Male	Female	Temp. F^{o}	Flow CFS	Rain inches	Baro. Press. in. Hg
			MARCH - 1978			
1	0	0	49	14	-	29.455
2	0	0	52	20	0.46	29.485
3	0	0	53	18	-	29.540
4	0	0	51	25	0.40	29.190
5	0	0	51	32	0.17	29.810
6	1	0	53	30	-	30.005
7	0	0	53	33	0.41	29.955
8	0	0	-	Flood	1.80	29.985
9	0	2	52	127	-	30.000