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Title: A POPULATION STUDY OF THE RAINBOW TROUT (SALMO GAIRDNERI) IN A CENTRAL OREGON STREAM

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James D. Hall

The rainbow trout population in Elder Creek, Oregon was studied between June 1965 and November 1966. The physical characteristics of the stream during the summer season were described. Rainbow trout were captured in each of three sections on the stream by electrofishing and were tagged and measured. Population size, mortality, recruitment, growth rate, and production was estimated for fish in each section where data were sufficient. Estimates were made of the yield of trout to the sport fishery.

The water in Elder Creek is relatively low in concentration of dissolved solids. The stream lies in a canyon of mostly bedrock and large cobbles with very little spawning gravel. Water temperature was found to be near the maximum for trout suitability in the lower reaches of the stream.

Reliable estimates of population size and their variation were

obtained within the summer of 1966. Population size estimates for the summer of 1965 were not reliable because of the small numbers of trout that could be obtained during this period. Therefore estimates of annual rates of mortality, growth, and production were not possible. Growth rates were estimated for marked and for unmarked fish during the summer of 1966. Marked fish were found to have a markedly lower growth than unmarked fish.

Of 755 observations of trout movement during the study less than four percent were found to have moved more than 300 feet. Immigration of adult fish into the population was either insignificant or not detectable.

Although Elder Creek has a good population of legal-sized native trout, fishing pressure on the stream is relatively light. The lower reaches are fished more heavily than the headwaters, which probably receive no angling pressure during some fishing seasons.

A Population Study of the Rainbow Trout (*Salmo gairdneri*) in a Central Oregon Stream

by

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INTRODUCTION

The increasing demand for recreation and other uses of our public and private timberlands has intensified the need to reduce conflict among the many uses of such land. Since logging activities on a watershed appear to influence a stream and its fish population (Chapman, 1962; Sheridan and McNeil, 1960), knowledge of these effects and their magnitude is needed. With such information it would be possible to modify logging practices so as to ameliorate any adverse effects they might have on populations of trout.

The effects of clear-cut logging practices on a stream and its fauna are being studied in certain coastal areas (Chapman *et al.*, 1961). However there is little knowledge of the effects of the selective logging practices employed in the pine forests. In 1965 the Weyerhaeuser Company and Oregon State University initiated a five-year investigation on Elder Creek, situated in an old-growth forest of ponderosa pine, *Pinus ponderosa*, in Lake County, Oregon. The first two years were to be devoted to a pre-logging inventory, the third year to the logging operation, and the remaining two years to a post-logging inventory. Three one-half-mile sections of the stream were selected for the study; the uppermost section was to serve as a control section, and the lower two as treatment sections. The sections will be referred to in this paper as the upper, middle, and lower sections, respectively.

This paper presents the results of the pre-logging inventory phase of the investigation concerned with the effects of selective logging on rainbow trout, Salmo gairdneri, Richardson. The study was conducted between June 1965 and November 1966.

Because this was a preliminary study and manpower was limited, major emphasis was given to studies of the trout population and its physical environment. The primary objectives of this research were: (1) to describe the physical characteristics of Elder Creek; (2) to determine the population size, growth rate, movements, and exploitation of rainbow trout in Elder Creek.

DESCRIPTION OF THE AREA

Elder Creek comprises part of the watershed of the Chewaucan River, the major source of water for Lake Abert, a catchment basin for a closed system drainage. The study area lies about 35 miles northwest of Lakeview, Oregon (Figure 1).

Most of the lower portion of the stream lies within the Chewaucan Management Unit of the Weyerhaeuser Company, although some is in other private and U. S. Forest Service ownership. The headwaters of the stream, which include the upper section, are in the Fremont National Forest, administered by the U. S. Forest Service.

From an elevation of about 6300 feet at its source, Elder Creek descends 1700 feet in 12 miles and drains an area of approximately 35 square miles. The only significant barrier to fish passage on the stream is a falls 15 feet high located 800 feet upstream from the upper section. During the summer in the study sections Elder Creek averaged 9 inches in depth and 18 feet in width. The surface area of the entire stream was estimated to be approximately 27 acres. The minimum discharge that I measured in the three sections was two cubic feet per second in September 1966. There was evidence that water levels in the upper section during winter floods in 1964-65 reached four to five feet above normal summer levels.

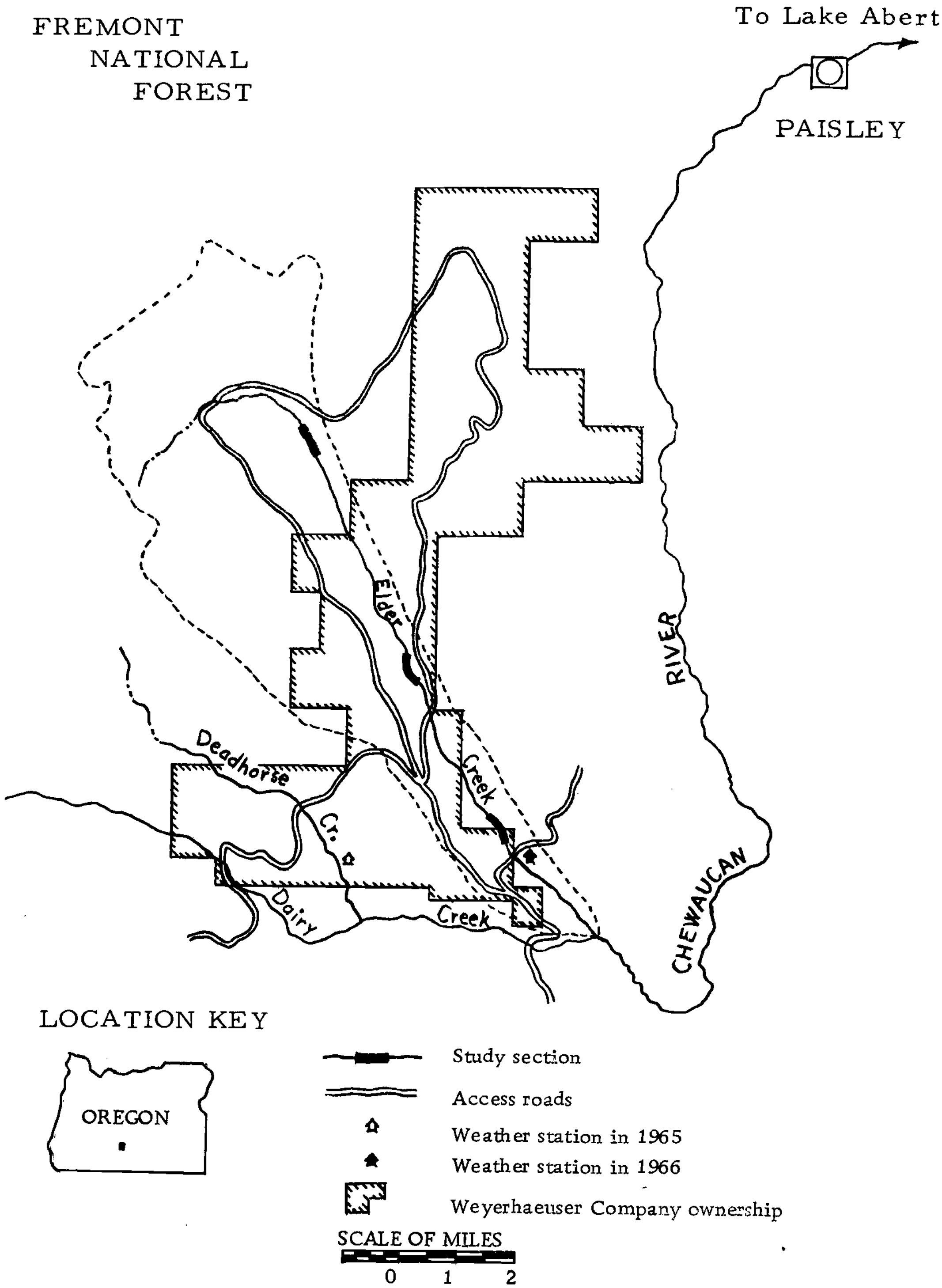


Figure 1. Location map of study area.

The stream channel meanders through extensive grassy meadows above the upper section and in and below the lower section. The stream flows in a V-shaped canyon between the two meadow areas.

The over-story is predominately ponderosa pine with some lodgepole pine, Pinus contorta, and white fir, Abies concolor, at the lower elevations. Lodgepole pine is the dominant species at higher elevations. There are a few scattered stands of quaking aspen, Populus tremuloides, in the meadows and considerable white alder, Alnus purshiana, and willow, Salix sp., along the stream. The understory is primarily green manzanita, Arctostaphylos patula, and snowbrush, Ceanothus velutinus, under the pine canopy. Sagebrush, Artemisia sp., is on a few open hillsides scattered throughout the area.

The middle section has a denser canopy than either of the other two sections. Alder is very thick at the stream edge and the pine overstory is continuous. A large portion of the lower section is in open grassy meadows where the overstory is sparse or absent. A small portion of the lower section has dense alder shading the stream. Although the pine overstory is at the stream edge in some areas of the upper section, there is no alder along the stream and there are several open hillsides bordering the stream.

Basalt, andesite, and rhyolite, with associated tuff, agglomerate and minor fluvial and lacustrine deposits comprise most of the mountain masses in the region (U. S. Gelogical Survey, 1950). These materials are well exposed in the scarps of Hart Mountain, Abert Rim, Winter Ridge, and the Warner Mountains. The predominant soils in the Elder Creek drainage have been derived from volcanic materials.

From 1929 through 1955 the Oregon State Game Commission liberated 200,000 fingerling and 4,500 legal-sized rainbow trout in Elder Creek. In 1932 and 1937 a total of 26,000 fingerling brook trout, *Salvelinus fontinalis*, was liberated. No trout have been liberated since 1955 (Koski, 1967). At present about ten percent of the trout in the lower two sections are brook trout, while less than one percent in the upper section are brook trout.

METHODS

All data were gathered during the summer and early fall of each year due to the relative inaccessability of the area during the winter and spring. Knowledge of the events occurring in the remainder of the year will necessarily be limited.

The Environment

Study Sections

Each section was marked off in intervals 100 feet long with numbered wooden stakes placed near the stream edge. When the stake was located adjacent to a permanent landmark such as a large boulder, the landmark was also numbered. At the beginning of the second summer I replaced all stakes that were missing or destroyed.

During the summer the stream width was measured at points 25 feet from each end of each 100-foot interval. Three depth measurements, spaced equidistant across the stream, were taken with each width measurement. The pool-to-riffle ratio and the percentage composition of bottom types were visually estimated for each 100-foot interval.

Weather

A simple weather station consisting of a maximum-minimum thermometer and a small rain gauge was maintained during both summers. During 1965 the station was located on Deadhorse Creek about four miles west of the middle section of Elder Creek; during 1966 it was located at the base of the lower section (Figure 1). Recordings were made daily, usually between 4:00 PM and 8:00 PM.

Stream Temperature

Thermographs were maintained in the lower and middle sections in the summer of 1965 and in all three sections in the summer of 1966. The charts were changed weekly and the thermograph temperature recording was checked with a pocket thermometer.

Sediment

A bed-material sampler similar to that employed by McNeil and Ahnell (1964) was used to secure 25 samples each in the middle and upper sections. Each area of two-inch and smaller gravel was considered a possible spawning site and assigned a number. One sample, consisting of a four-inch column of gravel six inches in diameter, was taken from each of 25 randomly selected possible spawning sites in each section. The sampler was worked manually into the gravel to a depth of four inches; then the contents that could be removed by hand were placed into a one-gallon plastic jar. The remaining water and its suspended sediment were trapped by sealing off the bottom of the sampler with a metal disc having a leather gasket around its perimeter. The sampler was then lifted out of the bed, and the contents were poured into the jar containing the gravel.

Each sample was graded through a series of seven standard Tyler seives having mesh openings of 50.8, 25.4, 12.7, 6.35, 3.327, 1.65, and 0.833 millimeters. Percentages of each size class were determined volumetrically by the technique used by McNeil and Ahnell (1964). The water containing suspended material smaller than 0.833 millimeters was placed in a graduated cylinder and allowed to settle 45 minutes. The volume of sediment was then read directly.

Stream Flow

Stream discharge was determined three times in each summer and once in November 1965 with the two-point method in 1965 and the six-tenths depth method in 1966 (Wisler and Brater, 1959). Velocity was measured with a Gurley pygmy current meter.

Chemical Quality

A water sample was secured about every three months from June 1965 through November 1966. The samples were analyzed by the U. S. Geological Survey laboratory in Portland, Oregon.

The Trout Population

Field Data Collection

A mark-and-recapture program was employed to provide data for estimating the vital statistics of the trout population. During the summer of 1965 a battery-powered backpack electroshocker was used to collect fish. This shocker proved inadequate for the water conditions that prevailed; as a result, very few fish were taken. A variable-voltage D. C. pulsator, powered by a gasoline-driven 110 Volt A. C. generator, was operated as a backpack unit in 1966. This unit proved quite satisfactory and resulted in a substantial increase in the number of fish captured. The operator probed the stream with one electrode and netted stunned fish with a dip net. An assistant handled the other electrode as a ground screen and helped net the stunned fish with another dip net.

Each section was sampled three times during each summer and in November 1966; only the middle section was sampled in November 1965. The dates of sampling are summarized in Appendix A. Each section of the stream was traversed once during each sampling time. Captured fish were placed into a plastic bucket containing fresh water. Fifty to 200 feet of stream were sampled before the fish were processed, depending upon the number of fish captured. Species of fish other than trout were counted but not removed from the stream.

All trout were anesthetized with tricaine methanesulfonate (MS-222) for marking and measurement. A pelvic fin was clipped from young-of-the-year fish. Older fish were tagged with a 3/16 x 3/32 x 1/32-inch numbered green plastic tag (developed by the Oregon Fish Commission for its reservoir investigations) attached by a vinyl thread loop. The vinyl was threaded through the fish's back with a sewing needle just anterior to the posterior insertion of the dorsal fin. The adipose fin was clipped from each fish when tagged. Fish bearing tags were recorded as recaptures by tag number.

The fork-length of all trout was measured to the nearest millimeter. Individual weights, recorded to the nearest gram, were obtained for samples of 40 to 80 fish tagged in each section in August 1966. A scale sample was taken from each fish tagged from the area between the lateral line and the posterior insertion of the dorsal fin. The location of capture or recapture was recorded, then the fish was revived in fresh water and released in its respective location.

Population Estimates

Three to four "point" estimates (Ricker, 1958) of population size were made each summer. Separate estimates were made for the Age 0, I, and II+ fish. The Age II and older age-groups were combined to provide a group large enough for meaningful estimates. Most samples of young-of-the-year fish were too small to provide data for meaningful estimates.

Each sample was separated into age-groups by length-frequency analysis (Appendix B). Age analysis of scales from those fish in the overlapping areas of the length-frequency groups was used to verify the boundaries of age-groups.

A modification of the Petersen formula was used to estimate the population size (Ricker, 1958):

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

Where

$\hat{N}$ = estimate of population size

M = number of marked fish released into the population

C = sample size in recovery sample

R = number of marked fish in recovery sample

Ninety-five percent confidence limits for the estimates of population size were computed from the confidence limits given for the expectation of a Poisson variable (Chapman and Overton, 1966). The sampling program was designed for analysis by the method of Jolly (1965). However, the small number of fish taken in 1965 precluded effective use of that method.

The chief conditions necessary for the use of the Petersen method are: that marked fish suffer the same natural mortality as the unmarked; that the marked fish do not lose their mark; that all marks are recognized and reported; that there is only a negligible amount of immigration into the catchable population; that the marked fish are as vulnerable to the fishing being carried on as are the unmarked ones; and that the marked fish become randomly mixed with the unmarked (Ricker, 1958).

Most of the assumptions required by the Petersen method were probably satisfied. Each fish handled was not released until it could swim away upright. The tags were readily identifiable but if they were lost the clipped adipose fin was easily recognizable. Of 623 recaptures only 1.3 percent were observed to have lost tags. I have concluded from inspection of the data that little or no immigration of fish older than young-of-the-year occurred.

An electric shocker is selective for the larger fish, but calculation of separate estimates for individual age-groups probably minimized the error associated with this selectivity (Cooper and Lagler, 1956; and Ricker, 1958).

The assumption that marked fish mixed randomly with unmarked fish probably was not fully satisfied. Although effort was made to shock all water equally, the relative ease of shocking in certain areas probably dictated the distribution of the effort to some degree.

If the shocking effort is not proportional to the numbers of fish present in each area, then marked fish will have a greater probability of recapture than unmarked fish; this will bias estimates of population size downward (Allen, 1951). Because of the relative accessibility of this small stream, however, this effect was probably not too important.

Immigration and Mortality

Examination of successive ratios of recaptures to the total sample from a given marking day will provide data for estimates of immigration (Ricker, 1958). If immigration occurs, the ratio R_t/C_t will decrease with time. I calculated these ratios and constructed 95 percent confidence limits for the ratios based on each sample (Chapman and Overton, 1966).

Estimates of the number of fish from a given age-group present at the beginning of a period and still alive at the end of the period have been employed to estimate mortality rates of that group (McFadden 1961). I estimated the total annual mortality rate by use of the formula (Ricker, 1958):

$$\hat{a} = \frac{\hat{N}_t - \hat{N}_{t+1}}{\hat{N}_t}$$

Where

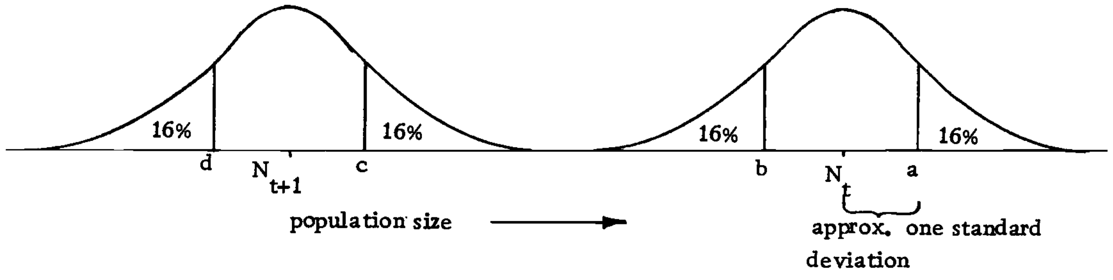
$\hat{a}$ = estimated annual mortality rate

$\hat{N}_t$ = estimated number present at the beginning of the year

$\hat{N}_{t+1}$ = estimated number present at the end of the year

Because mortality and immigration rates appeared to be minimal during the summer, the Schnabel method (Chapman and Overton, 1966) was used to estimate the average summer population size of the 1964+ year-class in each of the upper and middle sections during 1965 and 1966. Insufficient data from the lower section and from the younger fish in all areas prevented meaningful estimates to be made of population size for the summer of 1965. Thus annual mortality rates could not be estimated for these fish.

The approximate upper 95 percent confidence limit for the mortality rate was constructed by considering the upper critical region for the distribution of estimates of population size at the beginning of the period ($\hat{N}_t$) and the lower critical region for the distribution at the end of the period ($\hat{N}_{t+1}$). The probability of an estimate of N_t lying in the upper region and an estimate of N_{t+1} in the lower region is the product of the probabilities of those regions (Figure 2). Therefore 16 percent critical regions in each tail were used for the distribution of estimates of population size both at the beginning and end of the period ($0.16 \times 0.16 = 0.025$). The resulting critical regions are approximately one standard deviation away from the mean or one-half the distance between the mean and the 95 percent critical region (two standard deviations). The approximate lower 95 percent confidence limit for the mortality rate was constructed in a similar manner. If either of the confidence limits for the morality rate were calculated to be greater than one or less than zero, then one or zero, respectively, was used for that limit.



Approximated upper 95 percent limit for the mortality rate = $\frac{a-d}{a}$

Approximated lower 95 percent limit for the mortality rate = $\frac{b-c}{b}$

Figure 2. Method of construction of confidence limits for mortality rates.

Growth, Production, and Condition

An estimate of production, defined by Ricker (1958) as the total elaboration of tissue regardless of its fate, requires knowledge of population size, both at the beginning and at the end of the period, the average individual weight, and the growth rate for the period. Meaningful estimates of population size were available only for the

1965 year-class during the summer of 1966. Therefore the growth rates used were only for that period. Length units were converted to weight units by the length-weight regression equation (Ricker, 1958):

$$W = aL^b$$

Where

W = weight

L = length

a = Y intercept in regression

b = slope coefficient in regression

The slope coefficient from the length-weight regression transformed to logarithms was calculated for each section by a computer program utilizing all fish in each section for which both length and weight data were available (Appendix C). The instantaneous rate of growth in weight was calculated for individually marked fish,which were measured both at the beginning and at the end of the period,by use of the formula (Ricker, 1958; Overton, 1967):

$$g = \frac{b}{nt} \sum \ln\left(\frac{l_t}{l_o}\right)$$

Where

g = daily instantaneous rate of growth in weight

l_o = length of individual at the beginning of period

l_t = length of individual at the end of period

t = length of period in days

b = slope in length-weight regression

n = number of fish

ln = natural logarithm

$\sum \ln (\frac{l_t}{l_o})$ = summation over individual fish

To test the reliability of a method with data for average lengths, the daily instantaneous rate of growth in weight was then calculated for those same fish using the formula:

$$g = \frac{b}{t} \ln (\frac{\bar{l}_t}{\bar{l}_o})$$

Where

$\bar{l}_o$ = average length of fish at beginning of period

$\bar{l}_t$ = average length of fish at end of period

The results for the two calculations were sufficiently similar to justify use of average lengths (Table 6). The latter formula was then used to calculate instantaneous growth in weight for unmarked fish, which provided a larger sample size. A comparison of growth rates between marked and unmarked fish was then made to determine the effects of tagging on growth rate.

Since there was shocker selectivity for larger fish, a reverse

"Lee's phenomenon" (Ricker, 1958) was probably in effect. I assumed, however, that it was negligible within one age-group. There was no evidence of a correlation between fish size and mortality rate.

Production was calculated for the 1965 year-class in the upper section from July 7, 1966 to September 16, 1966 and in the middle section from June 29, 1966 to September 10, 1966 by use of the formula (Hunt, 1966):

$$\text{Production} = gt \left[\frac{(\hat{N}_o \times \bar{W}_o) + (\hat{N}_t \times \bar{W}_t)}{2} \right]$$

Where

g = daily instantaneous growth rate of unmarked fish

t = length of production period in days

$\hat{N}_o$ = estimated population size at beginning of period

$\hat{N}_t$ = estimated population size at end of period

$\bar{W}_o$ = mean individual weight at beginning of period

$\bar{W}_t$ = mean individual weight at end of period

The condition factor during August 1966 was computed for fish in each section by use of the formula (Lagler, 1956):

$$K = \frac{W}{L^3}$$

Where

K = coefficient of condition for the metric system

W = weight in grams

L = length in millimeters

The calculations were made with the computer program noted previously.

Movement

The distance and direction that each tagged fish had moved since its last capture were determined (Appendix D). In the summer of 1966 such large numbers of fish were handled that it became impractical to record the location of a given fish with greater accuracy than within 100 feet. Previously fish location had been recorded to the nearest ten feet.

Exploitation

An effort was made to contact as many anglers as possible in the area. This effort included full-time creel census on most of the weekends throughout each summer and contact of those anglers encountered while I was in the field engaged in other activities. In August 1965 I recorded the percentage of the total legal angling hours that I spent in the field in each section.

Data from each angler contact included number of man-hours fished, the number, and when practical, the lengths and weights of fish taken. Collections were also made of the gonads and stomachs of as many fish as possible.

During the summer of 1966 five signs were constructed which briefly explained the project and solicited cooperation from the anglers. Blank creel census forms were provided with each sign. The signs were placed at the most commonly used parking and camping areas of the anglers. The placement of these signs was too late to be of significant value in my study, but their acceptance seemed to indicate they would be successful during future angling seasons.

RESULTS

The Environment

Study Sections

The physical configuration of the middle and upper sections is similar; the lower section differs mainly in the factors of pool-to-riffle ratio and gradient (Table 1). A detailed estimate of the percentage of gravel in the lower section was not made, however there is a considerably larger percentage of possible spawning gravel in this section than in the other two. Cobbles and bedrock constitute a large percentage of the stream bed, resulting in relatively small amounts of suitable spawning gravel in the upper two sections.

Table 1. Physical characteristics of study sections of Elder Creek during summer of 1965. Depth and width measurements made September 4 to September 21, 1965.

Characteristic	Section: Upper	Middle	Lower
Length (ft)	2500	2700	2700
Mean Width (ft)	14.2	17.8	22.9
Mean Depth (in)	8.6	9.4	10.1
Surface Area (yd^2)	3944	5340	6870
Gravel Area (yd^2)	68	89	no data
Percent Gravel	1.6	1.7	--
Pool/Riffle Ratio	19/81	19/81	35/65
Approximate Gradient (ft/100 ft)	3.8	3.8	1.2

Weather

The summer of 1965 generally was cooler than that of 1966 (Figure 3). The mean temperature for July and August of 1965 was about ten degrees lower than the mean for July and August recorded at Paisley, Oregon from 1931 through 1960 (U. S. Weather Bureau, 1965; U. S. Weather Bureau, n.d.).

The rainfall that occurred in July and August in the summer of 1965 and 1966 was 2.19 and 0.95 inches, respectively as compared to the mean rainfall at Paisley of 0.59 inches measured in the summers of 1931 through 1960 (U. S. Weather Bureau, 1965; U. S. Weather Bureau, n.d.). Rainfall was near the two-inch level for four of those thirty summers.

Stream Temperature

The mean water temperature in 1965 was considerably cooler and the weekly range was generally less than in 1966 (Figure 4). This difference was likely the result of the heavier, more widely dispersed total rainfall and of general cloudiness in the summer of 1965. It was probably within the range of normal yearly variation. The third thermograph was in Deadhorse Creek in 1965, so data are not available for the upper section in 1965.

In 1966 the weekly ranges of water temperature in the middle

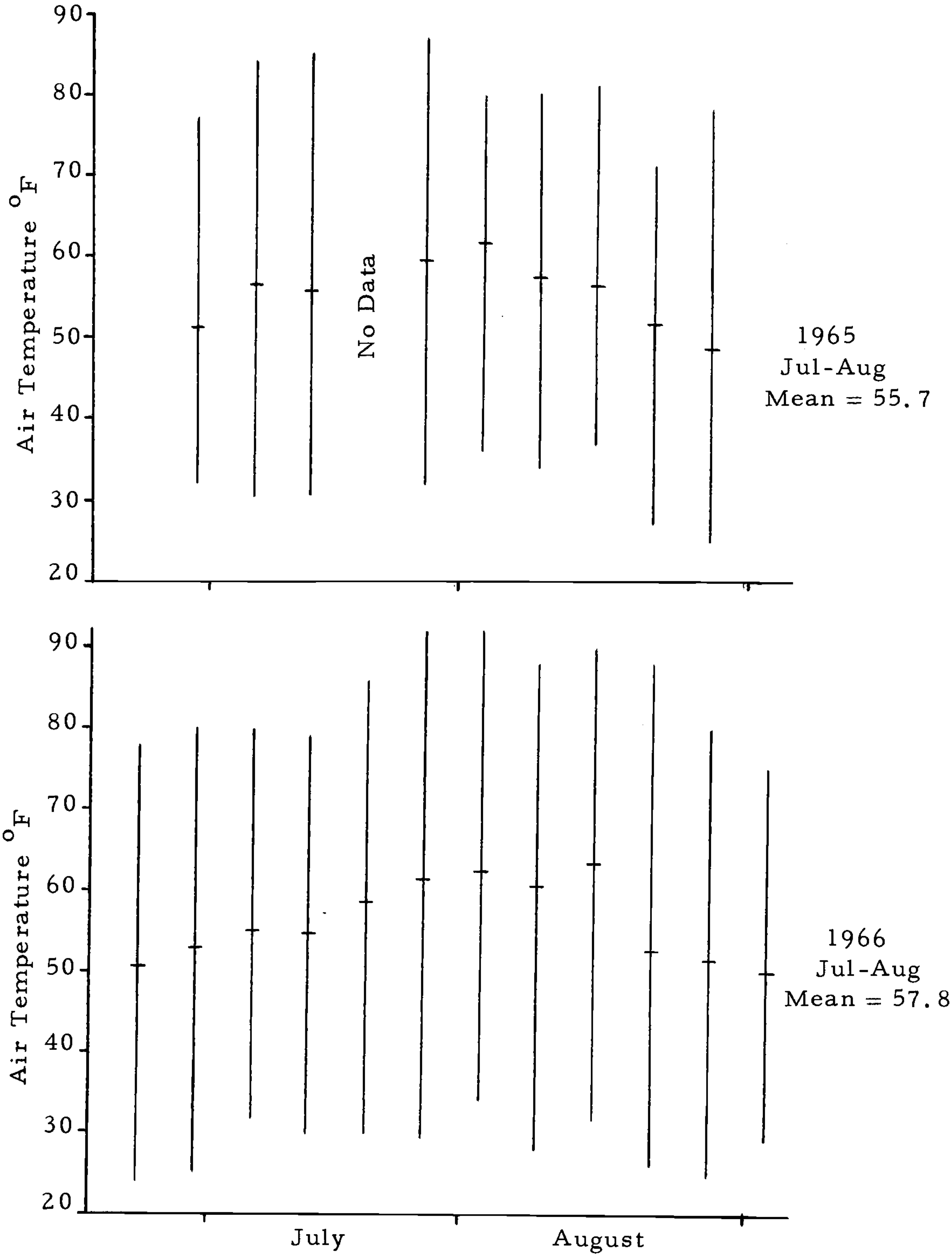


Figure 3. Weekly range and weekly mean air temperatures recorded on Deadhorse Creek in 1965 and near the mouth of Elder Creek in 1966.

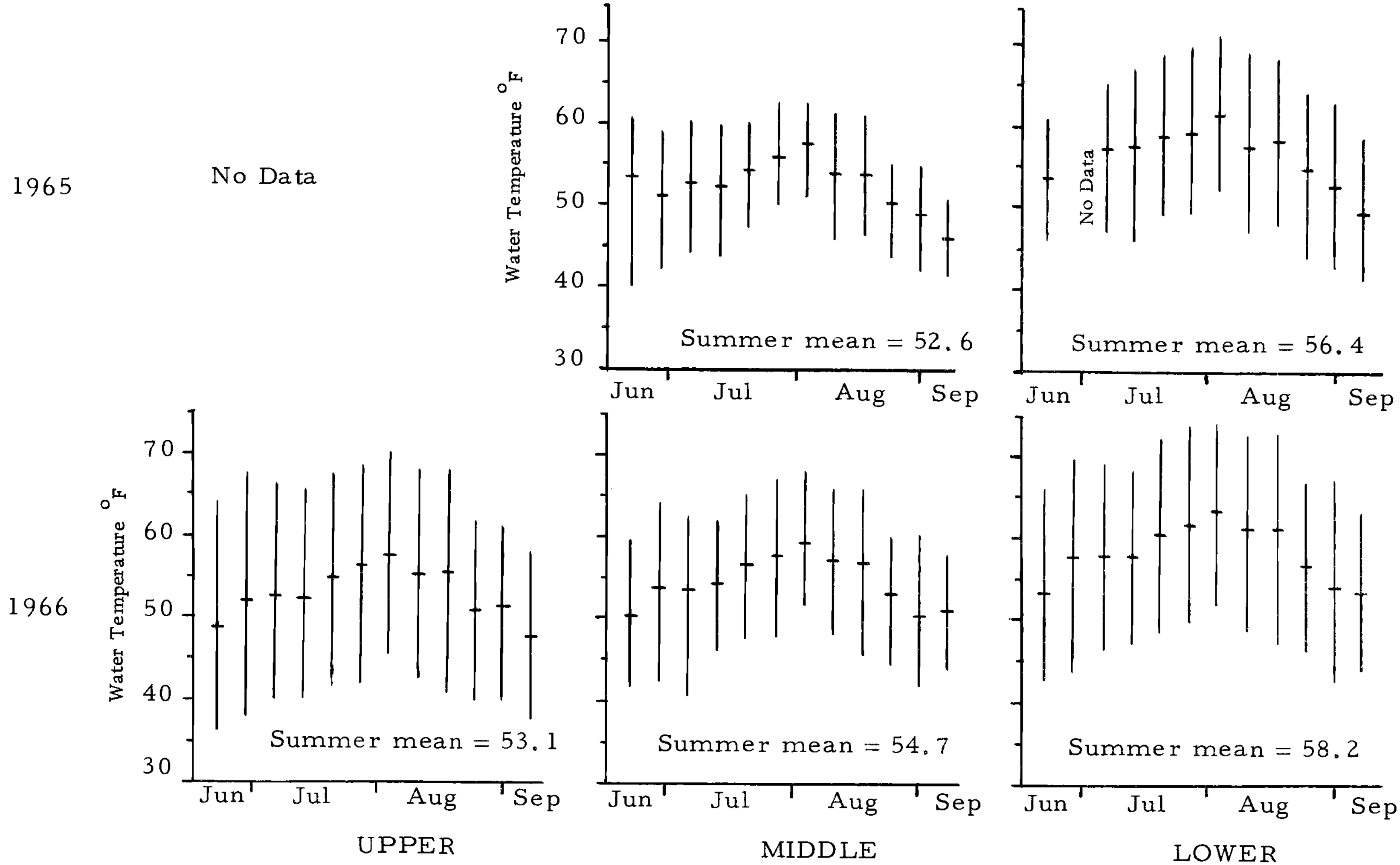


Figure 4. Weekly range and weekly mean water temperature of the middle and lower sections during 1965 and the upper, middle, and lower sections during 1966. Weekly means (indicated by the cross-bars) are averages of daily means.

section were less than those in the upper and lower sections. The summer mean was only slightly higher in the middle section than in the upper section, however both warmer and cooler temperatures occurred in the upper section. The open meadows in the lower and above the upper sections allow more solar radiation to reach the stream in those sections. The increased radiation was the likely cause of the larger temperature fluctuations there. The summer means of the lower section were three to five degrees warmer than the other two sections. The dense overstory in the middle section filters much of the solar radiation.

The water temperature reached 74°F in the lower section, not greatly below the maximum temperature (78°F) that many biologists agree that rainbow trout can withstand for short periods of time without adverse effects (Leitritz, 1959).

Sediment

The mean percentage of gravel passing through the 3.327 millimeter and 0.833 millimeter sieves in each section was similar (Table 2). The percentage of fine sediments of both sizes was slightly lower in the upper two sections of Elder Creek than in any of the three streams studied by Koski (1966). However the percentage passing through the 0.833 millimeter sieve is generally greater than McNeil and Ahnell (1964) found in their study streams.

Table 2. Size composition of spawning gravels in the upper and middle sections of Elder Creek. Data are mean percentages by volume of 25 samples from each section.

Section	Sieve size (millimeters)								
	Retained in							Passed through	
	50.8	25.4	12.7	6.35	3.327	1.65	0.833	<0.833	<3.327
Upper	7.0	10.5	16.4	17.5	11.9	8.3	7.3	21.0	36.7
Middle	9.8	14.1	16.7	13.9	10.4	9.2	8.4	17.5	34.7

Stream Flow

Three single measurements of discharge in a summer do not reveal the variation present in summer flow patterns, however they do suggest the general level and trend of discharge during this period (Figure 5). Stream discharge in the summer of 1966 was about one half of that in 1965. The higher runoff in 1965 than in 1966 was obviously a result of the greater rainfall during this period. The last two measurements taken in 1966 are probably indicative of the lowest summer flow levels to be expected under average conditions.

Discharge in the lower section was generally less than it was in the middle. This apparently was caused by diversion of water into an irrigation ditch that originates above the flow measurement station in the lower section. Measurements were not taken in the ditch.

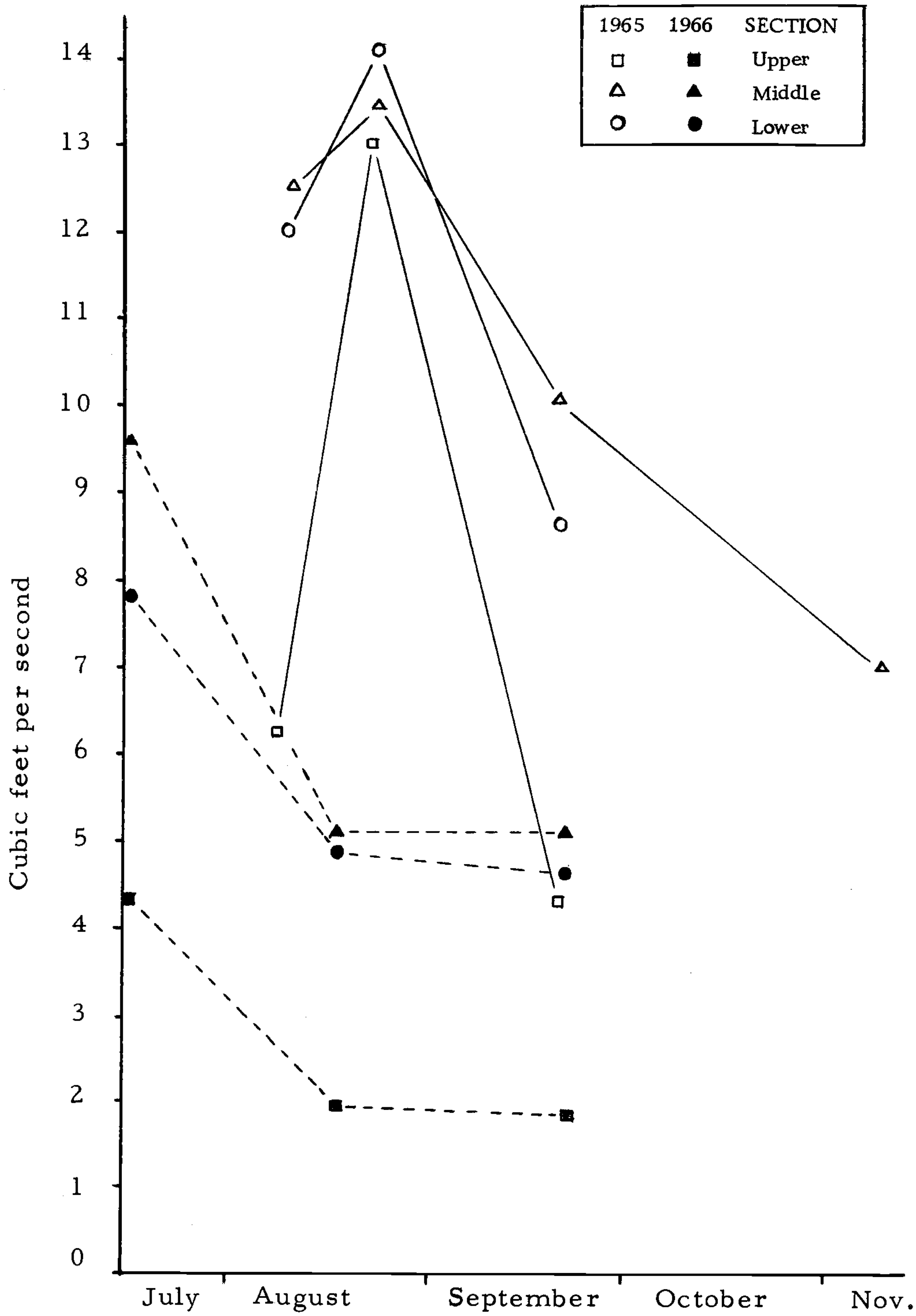


Figure 5. Measured stream flows of three sections of Elder Creek in 1965 and 1966.

Chemical Quality

The water in Elder Creek is relatively low in concentration of dissolved solids (Table 3). Concentrations of dissolved solids tended to increase slightly from spring to fall with a corresponding increase in hardness and specific conductance. The hardness of Elder Creek, based on six samples, ranged from 11 to 19 parts per million. This was substantially less than that of some well known productive trout streams, the Horokiwi Stream in New Zealand (30 ppm; Allen, 1951) and Lawrence Creek, Wisconsin (162 ppm; Hunt, 1966). The low conductivity of the water in Elder Creek contributed to the difficulties of collecting fish with electrofishing gear.

Other Animals

The speckled dace, *Rhinichthys osculus carringtoni*, was the only species of fish other than trout encountered in Elder Creek. From 270 to 310 were counted during each shocking of the lower section in 1966. Only 130 were counted during the entire summer of 1965, likely the result of inadequate electrofishing gear used in that summer. Dace were not encountered in the upper or middle sections of Elder Creek.

A brood of six American mergansers, *Mergus merganser americanus*, was reared on the lower section during the summer of

Table 3. Results of chemical analysis of water from Elder Creek.

	June 29, 1965	Sept. 23, 1965	Dec. 17, 1965	May 26, 1966	Aug. 26, 1966	Nov. 7, 1966
Silica (SiO_2)	23 ppm	30 ppm	32 ppm	26 ppm	28 ppm	29 ppm
Iron (Fe)	.06	.05	.06	.10	.05	.08
Calcium (Ca)	2.8	4.0	4.0	3.0	4.1	4.5
Magnesium (Mg)	1.0	1.8	1.9	1.2	1.9	1.9
Sodium (Na)	3.2	3.5	4.0	3.1	3.8	4.2
Potassium (K)	1.2	1.7	1.7	1.1	1.8	1.6
Bicarbonate (HCO_3)	23	32	34	23	34	38
Carbonate (CO_3)	0	0	0	0	0	0
Sulfate (SO_4)	.0	.0	.2	.4	.2	.0
Chloride (Cl)	.0	.2	.5	.0	.2	.0
Fluoride (F)	.0	.0	.1	.1	.0	.1
Nitrate (NO_3)	.0	.0	.1	.1	.3	.3
Orthophosphate (as PO_4)	--	.12	.12	.05	.13	.12
Dissolved solids	37	55	64	50	60	64
Hardness						
as $CaCO_3$	11	17	18	12	18	19
Noncarbonate	0	0	0	0	0	0
Specific Conductance (micromhos at 25 C)	38	51	58	40	55	54
pH	7.3	7.6	7.3	7.1	7.0	7.3

1966. Several observations were made of mergansers flying along the stream during the two summers.

The Trout Population

Population Size

The population size of each year-class varied in an apparently unrelated fashion among the three sections (Figure 6). The 1964+ year-class showed a moderate decrease in the upper section, little or no decrease in the lower section, but showed a marked decrease in the middle section. The population level was relatively low for this group in the lower section. The 1965 year-class showed no apparent decrease in any of the three sections in the summer of 1966. However in the upper section there were fewer fish of the 1965 year-class than of the 1964+ year-class. This suggests either a higher survival rate for the 1964+ year-class, some immigration of the 1964+ year-class into the section, or a combination of both. Examination of the mortality rates and immigration for the 1964+ year-class (Tables 4 and 5) suggests that the lower mortality rate for these fish in the upper section was probably the most important factor contributing to their greater abundance in that section. The estimated population size of the 1966 year-class varied considerably among the three sections. The estimates of population size and their

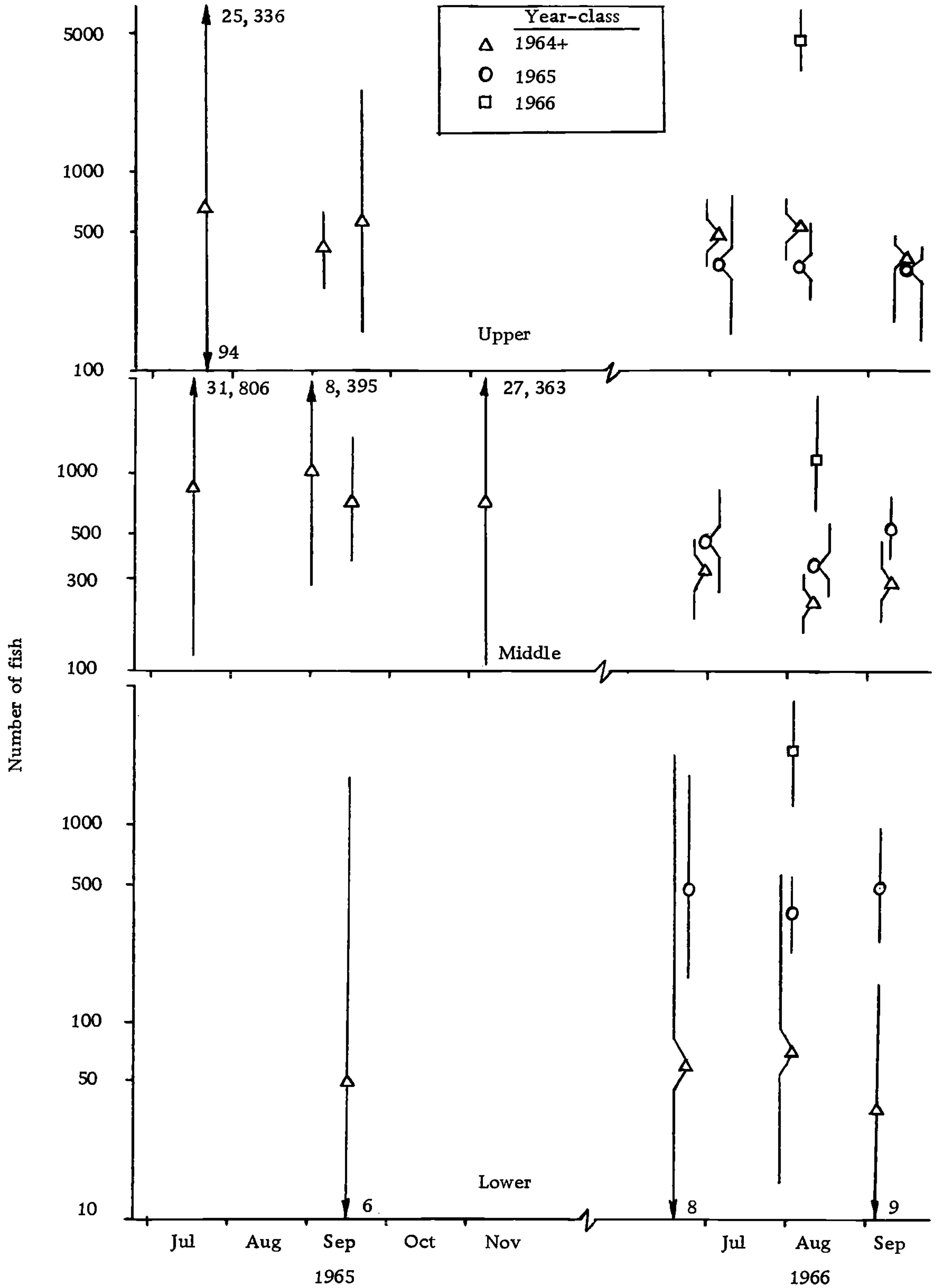


Figure 6. Estimated population size and 95 percent confidence limits of year-classes in each section of Elder Creek.

Table 4. Schedule of recapture ratios (R_t/C_t) and their 95 percent confidence limits from a given marking date for the upper and middle sections of Elder Creek.

Date of marking		Date of Recovery: 9-7-65	9-17-65	7-5-66	8-9-66	9-16-66	11-8-66
UPPER SECTION							
7-22-65	1964+ Year-class	0.008 (0.106-0.000)	---	0.010 (0.133-0.001)	0.007 (0.094-0.000)	0.007 (0.094-0.000)	---
9-7-65	1964+ Year-class		0.313 (0.514-0.205)	0.202 (0.332-0.132)	0.150 (0.242-0.099)	0.186 (0.283-0.129)	0.169 (0.362-0.091)
7-5-66	1964+ Year-class				0.163 (0.259-0.011)	0.200 (0.303-0.014)	0.102 (0.282-0.044)
8-9-66	1964+ Year-class					0.217 (0.321-0.152)	0.271 (0.490-0.168)
7-5-66	1965 Year-class				0.100 (0.234-0.048)	0.085 (0.191-0.043)	0.029 (0.398-0.001)
8-9-66	1965 Year-class					0.217 (0.348-0.145)	0.171 (0.477-0.074)

Cont. on next page

Table 4. Cont.

Date of marking		Date of Recovery 8-30-65	9-15-65	11-6-65	6-29-66	8-10-66	9-10-66	11-10-66
					MIDDLE SECTION			
7-16-65		0.021 (0.291-0.001)	0.032 (0.209-0.006)	0.027 (0.120-0.007)	0.051 (0.186-0.017)	0.030 (0.134-0.008)	0.026 (0.172-0.005)	0.014 (0.201-0.001)
8-30-65	1964+ Year-class		0.032 (0.211-0.006)	0.080 (0.179-0.041)	0.038 (0.174-0.010)	0.040 (0.144-0.013)	0.039 (0.179-0.011)	0.029 (0.189-0.005)
9-15-65	1964+ Year-class			0.053 (0.148-0.022)	0.051 (0.186-0.017)	0.059 (0.165-0.026)	0.065 (0.204-0.026)	0.057 (0.210-0.020)
6-29-66	1964+ Year-class					0.238 (0.377-0.160)	0.158 (0.313-0.090)	0.217 (0.398-0.131)
8-10-66	1964+ Year-class						0.289 (0.471-0.191)	0.217 (0.398-0.131)
6-29-66	1965 Year-class					0.139 (0.269-0.081)	0.147 (0.263-0.090)	0.091 (0.187-0.050)
8-10-66	1965 Year-class						0.202 (0.328-0.133)	0.182 (0.294-0.120)

95 percent confidence limits are listed in Appendix E.

Immigration and Mortality

Examination of successive ratios of recapture to total sample size from tags applied at a given time and their 95 percent confidence limits suggests that if immigration did occur it was either insignificant or data were insufficient to detect it (Table 4).

The estimated annual mortality rate of the 1964+ year-class in the middle section is markedly greater than that in the upper section (Table 5). Data from the lower section and from other age-groups were insufficient for estimates. The corresponding instantaneous annual mortality rates are 0.28 and 1.12 for the upper and middle sections respectively. Heavier angling pressure in the middle section may have contributed to the significantly greater mortality rate in the middle section compared to the upper section (Appendix F).

Table 5. Schnabel population estimates for fish of 1964+ year-class in the upper and middle sections of Elder Creek in 1965 and 1966 with the resulting estimated mortality rates and their corresponding 95 percent confidence limits.

Section	$\hat{N}$ (68% limits) 1965	$\hat{N}$ (68% limits) 1966	$\hat{a}$ (95% limits)
Upper	583 (512-710)	444 (356-636)	0.245 (0.000-0.498)
Middle	949 (820-1165)	309 (240-748)	0.674 (0.417-0.785)

Table 6. Daily instantaneous growth rates for fish of age I in each section in 1966 for marked and for unmarked individuals.

Dates	Using marked individual lengths separately $g = \frac{b}{nt} \sum \ln \left(\frac{l_t}{l_o} \right)$	Using the average length of marked individuals $g = \frac{b}{t} \ln \left(\frac{\bar{l}_t}{l_o} \right)$	Using the average length of unmarked individuals $g = \frac{b}{t} \ln \left(\frac{\bar{l}_t}{\bar{l}_o} \right)$
		Upper	
7-7-66 to 8-9-66	0.0057 $n = 9$	0.0056 $n = 9$	0.0100 $n_o = 41$ $n_t = 78$
8-9-66 to 9-16-66	0.0036 $n = 25$	0.0036 $n = 25$	0.0072 $n_o = 78$ $n_t = 44$
7-7-66 to 9-16-66	0.0051 $n = 9$	0.0050 $n = 9$	0.0086 $n_o = 41$ $n_t = 44$
		Middle	
6-29-66 to 8-10-66	0.0079 $n = 13$	0.0077 $n = 13$	0.0110 $n_o = 71$ $n_t = 81$
8-10-66 to 9-10-66	0.0025 $n = 26$	0.0025 $n = 26$	0.0034 $n_o = 81$ $n_t = 71$
6-29-66 to 9-10-66	0.0057 $n = 16$	0.0057 $n = 16$	0.0078 $n_o = 71$ $n_t = 71$
		Lower	
6-26-66 to 8-4-66	0.0073 $n = 7$	0.0071 $n = 7$	0.0069 $n_o = 46$ $n_t = 107$
8-4-66 to 9-6-66	0.0032 $n = 24$	0.0038 $n = 24$	0.0038 $n_o = 107$ $n_t = 67$
6-26-66 to 9-6-66	0.0031 $n = 4$	0.0030 $n = 4$	0.0066 $n_o = 46$ $n_t = 67$

Growth, Production, and Condition

The growth of each year-class appears to have been similar among the three sections (Figures 7, 8, and 9). Examination of the growth rates for marked and unmarked fish (Table 6) shows that the process of capture and tagging evidently caused a substantial decrease in growth rate for the marked fish.

The daily instantaneous growth in weight for unmarked fish for the summer of 1966 is listed with the other data needed for production estimates in Table 7. The resulting estimates of net production are expressed in terms of grams and in pounds per acre elaborated for the period.

Table 7. Data used in estimates of production for fish of the 1965 year-class in the upper and middle sections of Elder Creek from July 7, to September 16, 1966.

Section	g	t	$\hat{N}_o$	$\bar{W}_o$	$\hat{N}_t$	$\bar{W}_t$	Production grams	Production lb/acre
Upper	.0086	73	336	7.78	238	14.57	1909	5.16
Middle	.0078	72	443	6.78	511	11.92	2554	5.10

The condition factor in August 1966 was 1.20, 1.12, and 1.14 for the fish in the upper, middle, and lower sections, respectively (Appendix C).

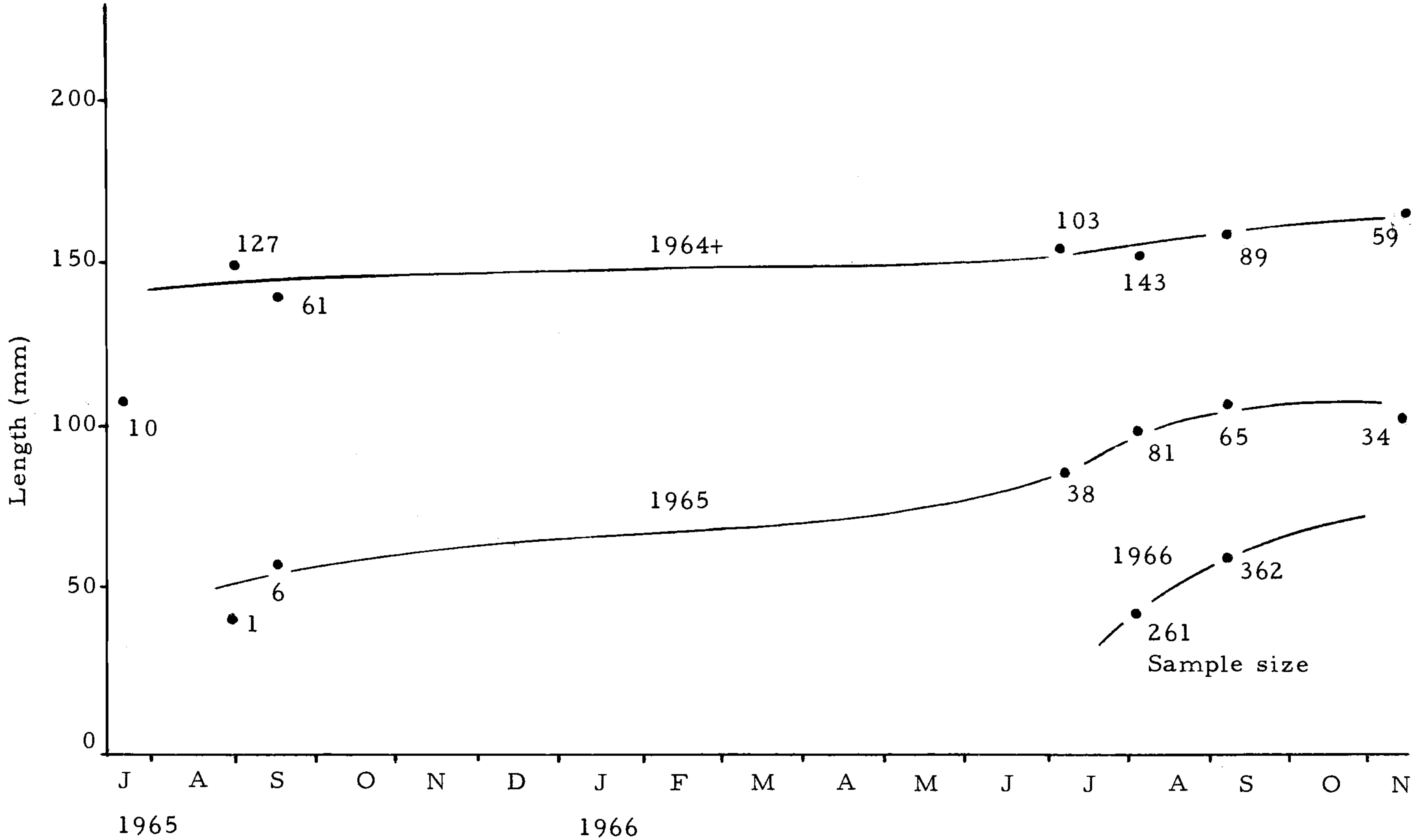


Figure 7. Growth in length of trout in the upper section by year-classes.

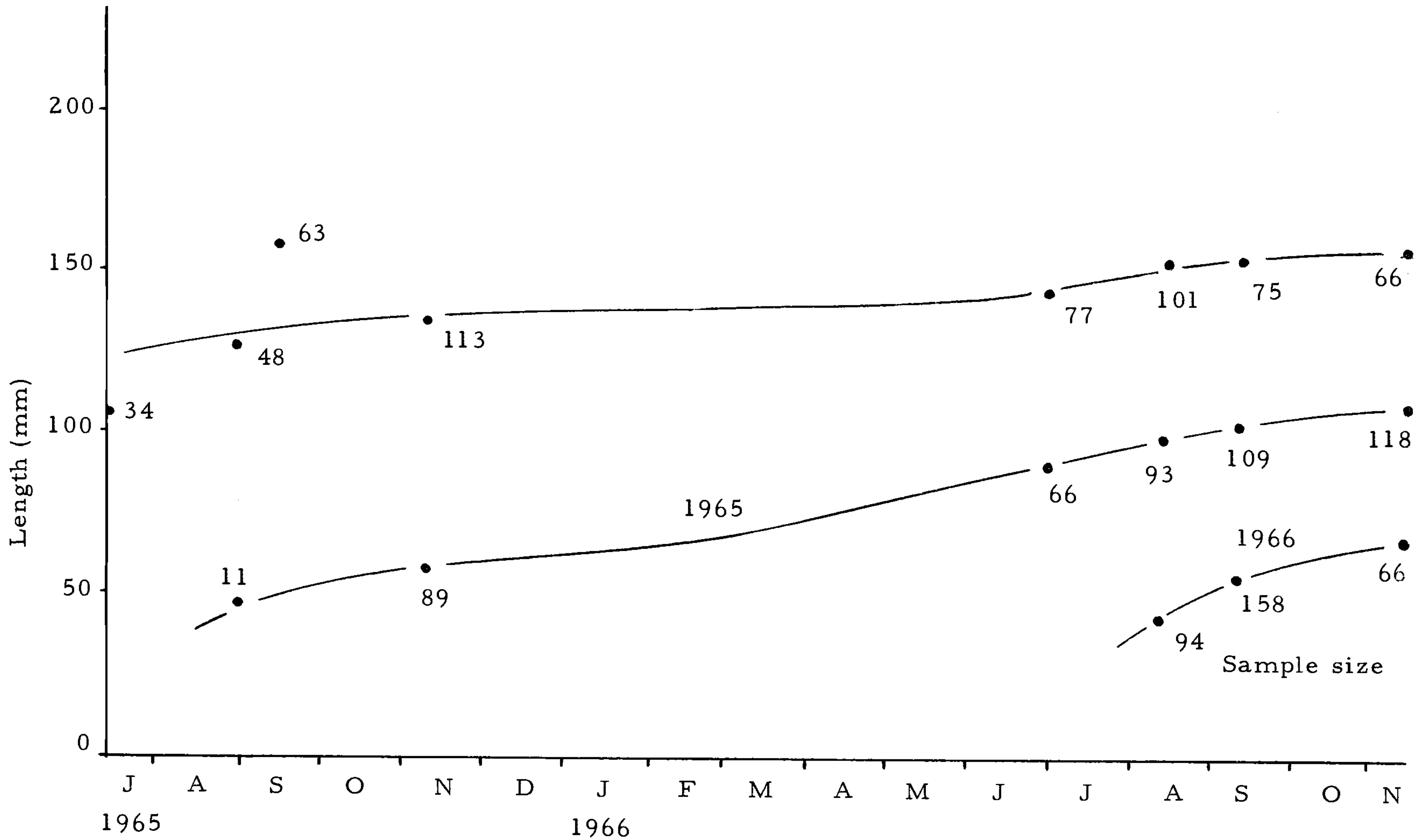


Figure 8. Growth in length of trout in the middle section by year-classes.

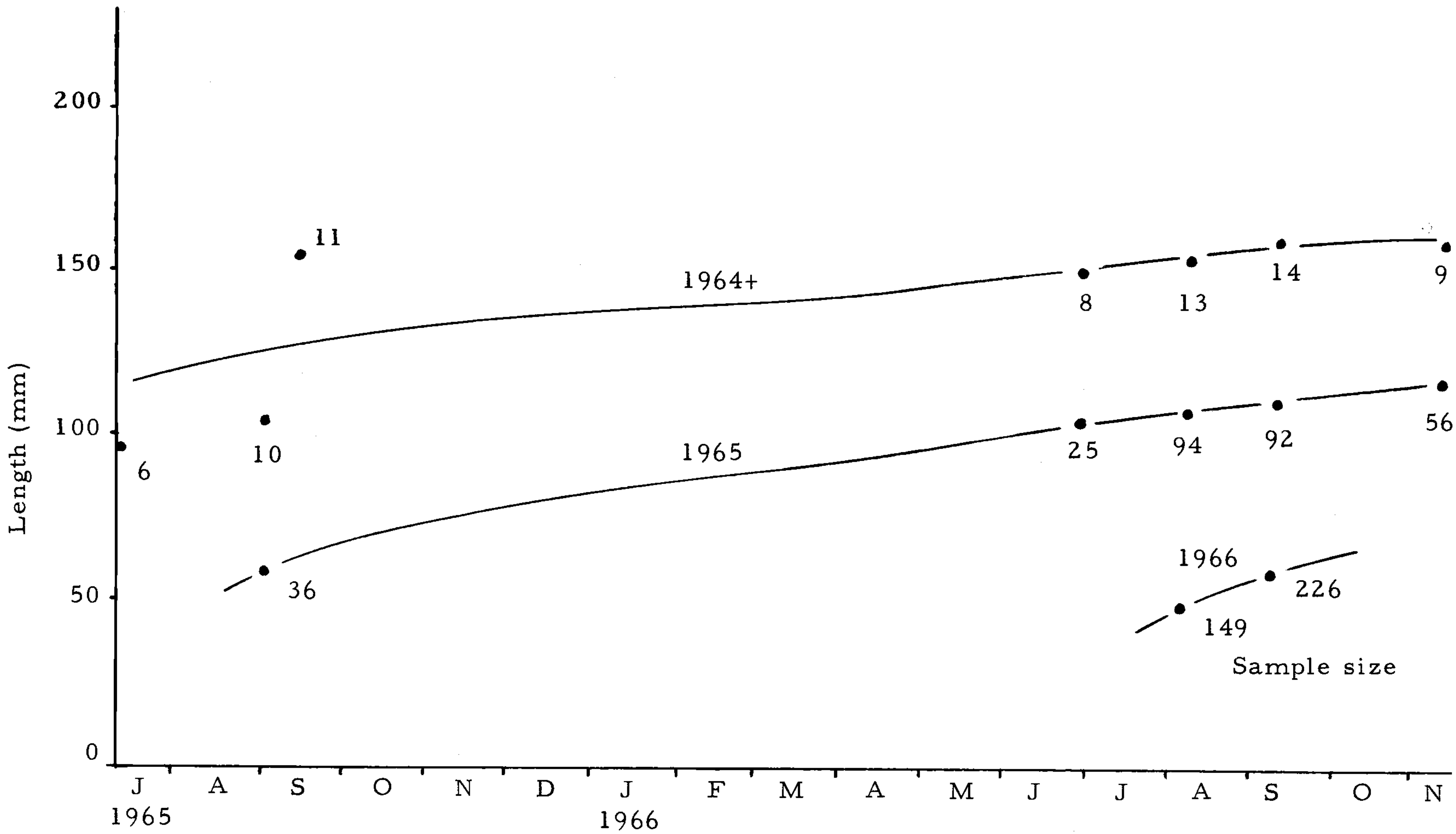


Figure 9. Growth in length of trout in the lower section by year-classes.

Movement

Very few of the recaptured trout were found to have moved more than 300 feet (Table 8). However, it cannot be said that movement did not occur out of and back into the area between observations. This evidence coupled with that from recapture ratios (Table 4) strengthens belief that there was little immigration into any of the three sections.

Exploitation

Based on the estimates of the percentage of effort in August 1965, I spent an average of 12 percent of the total legal angling hours in each section during the weekends and 6.7 percent during the weekdays of each summer. However I feel that the data collected during this time represent considerably more than 12 and 6.7 percent of the total. Much of the creel census effort was designed to take as near a complete census as possible. Therefore days when higher angling pressure was expected were chosen for censusing. I estimated that the values listed in Appendix F probably represent about 80 percent of the total catch and effort.

The data listed were collected from anglers who fished not only within the study sections, but rather on Elder Creek in the general area of each section. I would estimate that from 25 to 50

Table 8. Observations of movement of tagged fish within Elder Creek, 1965-1966.

	Upper		Middle		Lower	
	Between Summers	Within Summers	Between Summers	Within Summers	Between Summers	Within Summers
Number of fish observed to move less than 300 ft.	91	256	48	271	3	61
Number of fish observed to move more than 300 ft.	3	9	1	7	1	4
Total number of observations	94	265	49	278	4	65
Percent of fish moving less than 300 ft.	96.8	96.6	98.0	97.5	75.0	93.8
Percent of fish moving more than 300 ft.	3.2	3.4	2.0	2.5	25.0	6.2

	Between and Within Summers		
	Upper	Middle	Lower
Percent of fish moving less than 300 ft.	96.7	97.6	92.8
Percent of fish moving more than 300 ft.	3.3	2.4	7.2

percent of the anglers' fishing time was within the study sections.

Fishing in Elder Creek appears to be rather rewarding, as 371 rainbow trout were caught in 104 angler-trips (Table 9). This was probably a result of the low fishing pressure on the stream. The fishing pressure in the headwaters is very light, but it increases in the middle and lower sections. The lower portion is probably the most heavily fished, as it is accessible from one of the most commonly used roads in the area. The middle section is accessible from an excellent but less used road and the upper section is not directly accessible by road.

Table 9. Catch statistics for Elder Creek during August 1965 and the summer of 1966.

	Aug. 6 to Sept. 6, 1965					June 18 to Sept. 11, 1966				
	angler-trips	trout caught	hours per angler	fish per angler	fish per hour	angler-trips	trout caught	hours per angler	fish per angler	fish per hour
					Upper					
Week-ends	0	0	0.0	0.0	0.0	6	6	1.2	1.0	0.9
Weekdays	3	0	0.3	0.0	0.0	7	22	2.3	3.1	1.4
Total	3	0	0.3	0.0	0.0	13	28	1.8	2.2	1.2
					Middle					
Week-ends	4	30	2.8	7.5	2.7	19	65	1.4	3.4	2.5
Weekdays	3	26	2.7	8.7	3.3	18	93	2.3	5.2	2.2
Total	7	56	2.7	8.0	3.0	37	158	1.8	4.3	2.3
					Lower					
Week-ends	11	38	1.6	3.5	2.1	24	77	2.1	3.2	1.5
Weekdays	0	0	0.0	0.0	0.0	9	14	2.1	1.6	0.7
Total	11	38	1.6	3.5	2.1	33	91	2.1	2.8	1.3
					All					
Week-ends	15	68	1.9	4.5	2.3	49	148	1.7	3.0	1.8
Weekdays	6	26	1.5	4.3	2.9	34	129	2.3	3.8	1.7
Grand Total	21	94	1.8	4.5	2.5	83	277	1.9	3.3	1.7

DISCUSSION

In the original planning of the project a one-half mile section on Deadhorse Creek was to be an additional control. However the water temperature, species composition and population size, and general stream configuration were so different from Elder Creek that its use as a control was discarded. The major source of water for Deadhorse Creek was a large spring about 100 yards upstream from the upper boundary of the study section. As a result the water temperature in the section fluctuated very little (plus or minus five degrees) from $40^{\circ}F$ regardless of the weather or the time of year. Also the stream discharge tended to remain rather constant. There are many logs and other organic debris in Deadhorse Creek, probably as a result of the lack of scouring during high runoff periods and of the several beaver dams on the stream. Brook trout make up about 30 percent of the total population in Deadhorse Creek, a much greater proportion than that in Elder Creek.

The relationship between the water temperature in the upper section of Elder Creek and either of the two lower sections appears to remain constant as long as weekly means in the upper section remain above $50^{\circ}F$ (Figure 10). These results suggest that the upper section would serve as a good control section on water temperature for the two treatment sections through the warmer part of the summer.

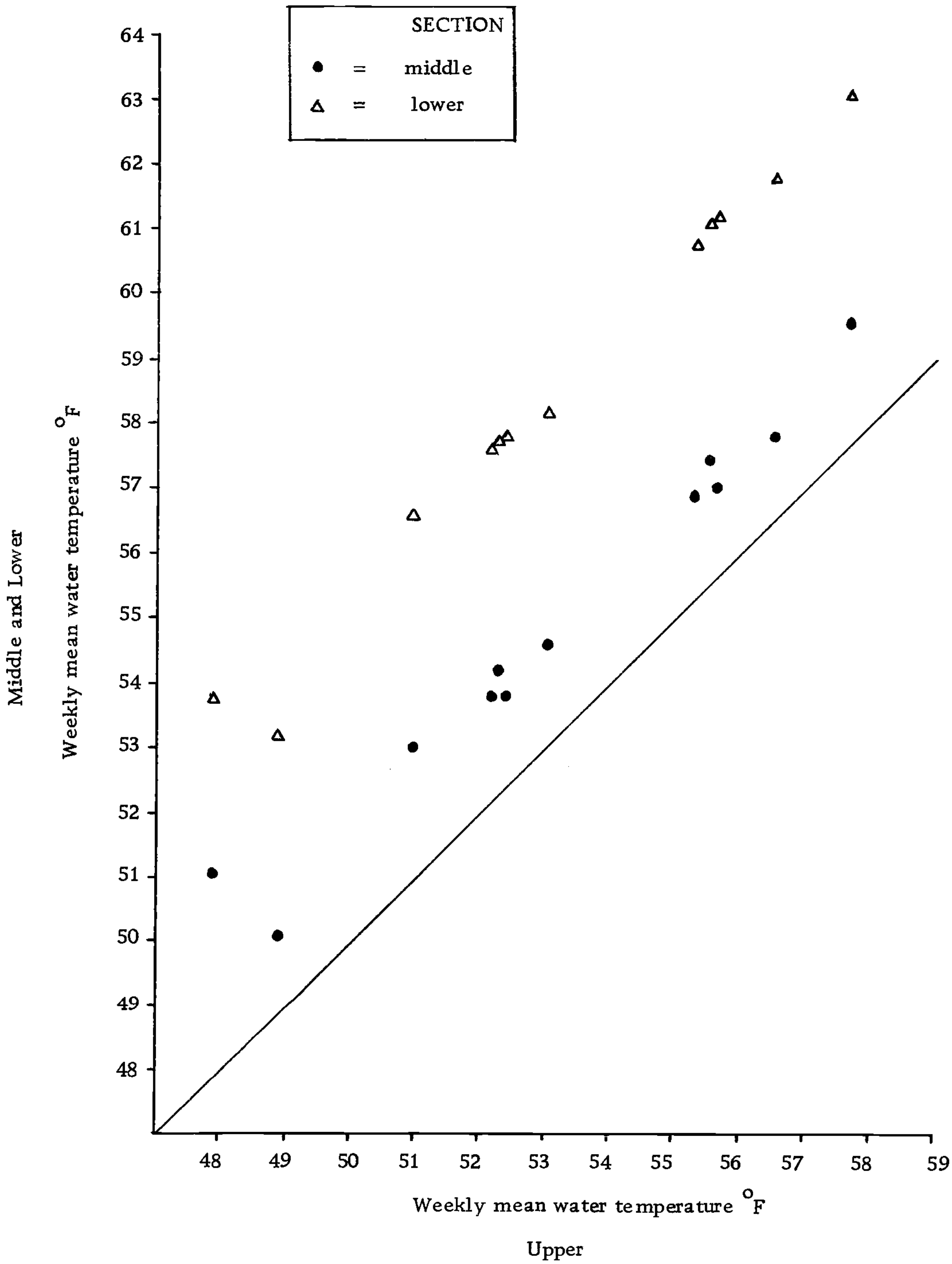


Figure 10. The relationship between the weekly mean water temperatures in the upper section and those in the lower and middle sections during the summer of 1966.

If the stream canopy is removed from the middle section the mean and range of water temperature will increase in that section. Since the range of temperature downstream from the middle section may already be near the maximum tolerance level for trout, such an increase in temperature in the middle section may cause much less favorable conditions for trout in the lower portion of the stream than presently exist.

The design of this study was based on the supposition that any major detrimental effects of selective logging would result from an increase in fine sediments in spawning gravel and subsequent reduction of embryo survival. Since estimates of survival to emergence could not be attempted in the study, it was felt that analysis of the youngest age-group for which sufficient data could be collected would best reveal any changes that might occur. Therefore emphasis has generally been placed on fish of age-group I and on measurement of the amount of fine gravel material in the spawning areas.

There are other areas of concern that should be considered to improve the study design. Observations of movement must be made during the spawning season to determine the general spawning grounds for the fish in each section. If the fish from the treatment sections spawn upstream from the area to be logged then any effects the logging might have on spawning activities and embryo survival would not be detected.

If fish from the Chewaucan River spawn in the area to be logged then logging could affect the trout populations in the lower reaches of the system. Evidence of downstream migration of young trout collected from June 28, to September 22, 1966 with a downstream-migrant trap suggested that Elder Creek may not contribute significantly to the trout population in the lower reaches; only 47 young-of-the-year were trapped during that time. However, further study would be required to substantiate this result.

The decrease in rate of growth of marked fish suggests that bias may be built into the design. Since in excess of 50 percent of the population is now marked, and the reduction in growth rate appears to be on the order of 50 percent, the effects of this tagging process on the trout and trout production could well confound analysis of any effects logging might have. The increments to the length of six-inch fish having growth rates corresponding to the marked and unmarked fish in the middle section would be 0.8 and 1.5 inches, respectively, after 72 days of growth during the summer.

Production was calculated only for the 1965 year-class in the upper and middle sections because that is the youngest age-group for which I have meaningful estimates of population size. Data are insufficient to calculate total production of the stream, therefore examination of production in a particular age-group of fish will provide the most meaningful comparisons for the effects of logging on production. However, it should be noted that the final calculations will be only as reliable, at best, as the least reliable component. If there is more than one component with low reliability then in the final calculations the degree of uncertainty is compounded.

Estimates of population size play a major role in this study to determine the effects of selective logging on trout. Detection of possible changes in the population size is one of the primary objectives of the study. Detection of possible changes in mortality rates and in production is also a basic objective. The estimates of mortality rate and production used in this paper both require population size estimates for calculation.

As a result of the inadequacy of the battery-powered shocker, data taken in 1965 were insufficient for meaningful estimates of population parameters. However,enough data were collected in the middle section to suggest the among-year and within-year variation in estimates of population size that might be expected. With these variances known, the size of the study (the number of estimates per year and years of replication) needed to detect a given change in population size with a given percentage of confidence can be determined. If the size of the study is fixed,then the amount of change that could be detected with a given probability, or the probability of detection of a given percentage change in the population can be determined. The equation used for these determinations is

(Overton, 1967):

$$\frac{d}{\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)\sigma^2_{\bar{x}}}} = z_a - z_o$$

Where

d = $\mu_o - \mu_a$ = desired detectable difference

$\sigma^2_{\bar{x}}$ = variance of population estimates

n_1 = number of years before treatment

n_2 = number of years after treatment

z_o is chosen such that the probability of rejecting the null hypothesis (H_o) if $\mu = \mu_o$ is α

z_a is such that the probability of rejecting the null hypothesis (H_o) if $\mu = \mu_a$ is β (power of the test)

In the example (Figure 11), $\alpha = .05$ and is the conventional controlled one-tailed rejection region, and β is shown to be a non-controlled rejection region. If the power of the test is to be at least .95 then z_a must be at least 1.64.

I selected to determine the power to detect 25 and 50 percent changes in population size with two or three years of data before and after treatment (Table 10). If a control section is available upstream, then only within-year variation need be considered, but if no control is available, then among-year variation must also be included. Although the selection of the percentage change to be

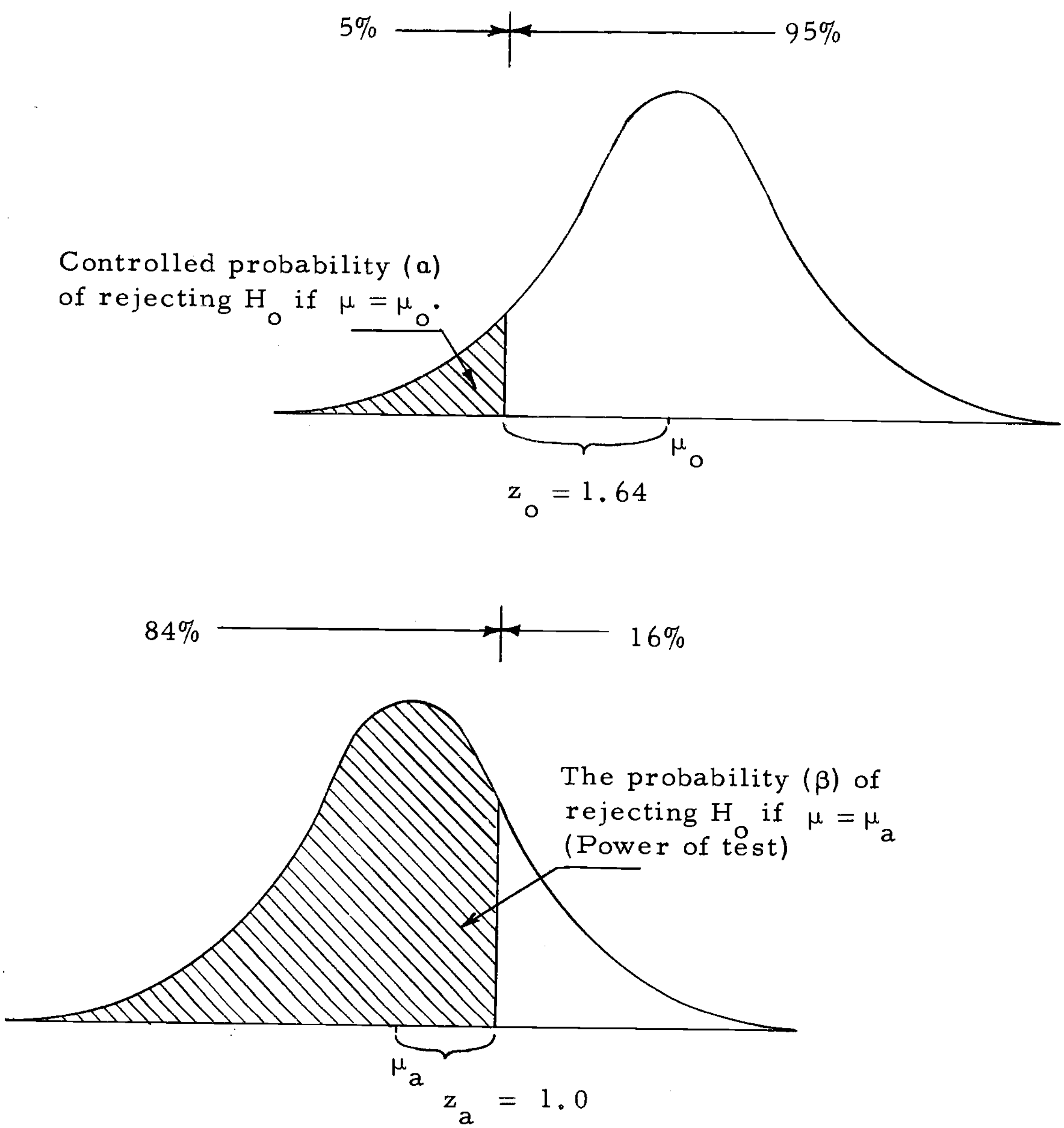


Figure 11. Probability of rejecting a true null hypothesis (H_o: $\mu = \mu_o$) or rejecting H_o if $\mu = \mu_a$.

Table 10. Probabilities of detecting 50 percent and 25 percent reductions in population size based on estimates of age-groups I and II+ when a control is and is not available.

	Control Available				Control Not Available		
	Age-group I		Age-group II+		Age-group II+		
	Replication		Replication		Replication		
	2 years before 2 years after	3 years before 3 years after	2 years before 2 years after	3 years before 3 years after	2 years before 2 years after	2 years before 3 years after	3 years before 3 years after
Probability of detecting a 50 percent change			Upper				
	.99	.99+	.79	.93			
			Middle				
	.99+	.99+	.99	.99+	.72	.80	.87
			Lower				
	.98	.99+	.72	.87			
Probability of detecting a 25 percent change			Upper				
	.58	.75	<.50	<.50			
			Middle				
	.77	.89	.56	.77		.28	
			Lower				
	.50	.70	<.50	<.50			

detected is arbitrary, as is the selection of the power desired, I feel that detection of a 25 percent change in population size with a power of .95 is necessary for adequate evaluation of the effects of logging. Examination of the results shows that this is not possible with the present size of the study. The data used to estimate the between-year variation were rather few, and an additional year of information would make the conclusions more reliable. In any event, however, it appears necessary to re-evaluate the objectives and design of the study in the light of this information.

BIBLIOGRAPHY

Allen, K. Radway. 1951. The Horokiwi Stream. Wellington. 231p. (New Zealand. Marine Department. Bulletin no. 10)

Chapman, D. G. and W. S. Overton. 1966. Estimating and testing differences between population levels by the Schnabel estimation method. Journal of Wildlife Management 30(1):173-180.

Chapman, Donald W. 1962. Effects of logging upon fish resources of the west coast. Journal of Forestry 60(8): 533-537.

Chapman, Donald W. et al. 1961. Summary report. Alsea watershed study. Corvallis. 52p. (Oregon. State University. Agricultural Experiment Station. Miscellaneous paper no. 110)

Cooper, G. P. and K. F. Lagler. 1956. The measurement of fish population size. Transactions of the North American Wildlife Conference 21:281-297.

Hunt, Robert L. 1966. Production and angler harvest of wild brook trout in Lawrence Creek, Wisconsin. Madison. 52p. (Wisconsin. Conservation Department. Technical bulletin no. 35)

Jolly, G. M. 1965. Explicit estimates from capture-recapture data with both death and immigration - stochastic model. Biometrika 52:225-247.

Koski, K Victor. 1966. The survival of coho salmon (Oncorhynchus kisutch) from egg deposition to emergence in three Oregon coastal streams. Master's thesis. Corvallis, Oregon State University. 84 numb. leaves.

Koski, R. O. 1967. Chief of Liberations, Oregon State Game Commission. Personal communication. Portland, Oregon.

Lagler, Karl F. 1956. Freshwater fishery biology. Dubuque, Iowa, William C. Brown. 360p.

Leitritz, Earl. 1959. Trout and salmon culture. Sacramento. 169p. (California. Department of Fish and Game. Fish bulletin no. 107)

McFadden, James T. 1961. A population study of the brook trout, Salvelinus fontinalis. [Ithaca, N.Y.], Wildlife Society. 73p. (Wildlife Monographs no. 7)

McNeil, William J. and W. H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. Washington. 15p. (U.S. Fish and Wildlife Service. Special Scientific Report--Fisheries no. 469)

Oregon. State Water Resources Board. 1961. Goose and Summer Lakes drainage basin. Salem. 1 sheet.

Overton, W. S. 1967. Professor, Oregon State University, Department of Statistics. Personal communication. Corvallis, Oregon.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Ottawa. 300p. (Canada. Fisheries Research Board. Bulletin no. 119)

Sheridan, William L. and William J. McNeil. 1960. Effects of logging on the productivity of pink salmon streams in Alaska. Contribution of the University of Washington Fisheries Research Institute no. 77:16-17.

U. S. Geological Survey. 1950. Geological map of the southern part of Lake County, Oregon. Washington, D. C. 1 sheet.

U. S. Weather Bureau. n.d. Climatography of the United States no. 11-31. Supplement for 1931 through 1952. Oregon. Washington. 70p.

U. S. Weather Bureau. 1965. Climatography of the United States no. 86-31. Supplement for 1951 through 1960. Oregon. Washington. 95p.

Wisler, C. O. and E. F. Brater. 1959. Hydrology. New York, John Wiley and Sons, Inc. 408p.

APPENDICES

APPENDIX A

SUMMARY OF MARK AND RECAPTURE DATA FOR THE UPPER SECTION OF ELDER CREEK

			Recaptures																
			The number last captured in time							The number tagged in time								Total	
Date	Sample Time	Sample Size	1	2	3	4	5	6	7	1	2	3	4	5	6	7	Total recaptures	new fish	Number released
									1964+ Year-class										
7-22-65	1	10															0	10	10
9-7-65	2	130	1							1							1	129	130
9-17-65	3	67	0	21						0	21						21	0	21
7-5-66	4	104	0	17	3					1	19	0					20	93	103
8-9-66	5	147	1	14	2	30				1	22	0	24				47	100	147
9-16-66	6	145	1	10	2	35	40			1	27	0	29	31			88	57	145
11-8-66	7	59	0	3	0	1	10	32		0	10	0	6	16	14		46	0	46
									1965 Year-class										
7-5-66	4	38															0	37	37
8-9-66	5	81				8							8				8	72	80
9-16-66	6	106				9	23						9	23			32	74	106
11-8-66	7	35				0	2	15					1	6	10		17	0	17
									1966 Year-class										
7-5-66	4	3															0	3	3
8-9-66	5	261															0	261	261
9-16-66	6	575															32	543	575
11-8-66	7																		

SUMMARY OF MARK AND RECAPTURE DATA FOR THE MIDDLE SECTION OF ELDER CREEK

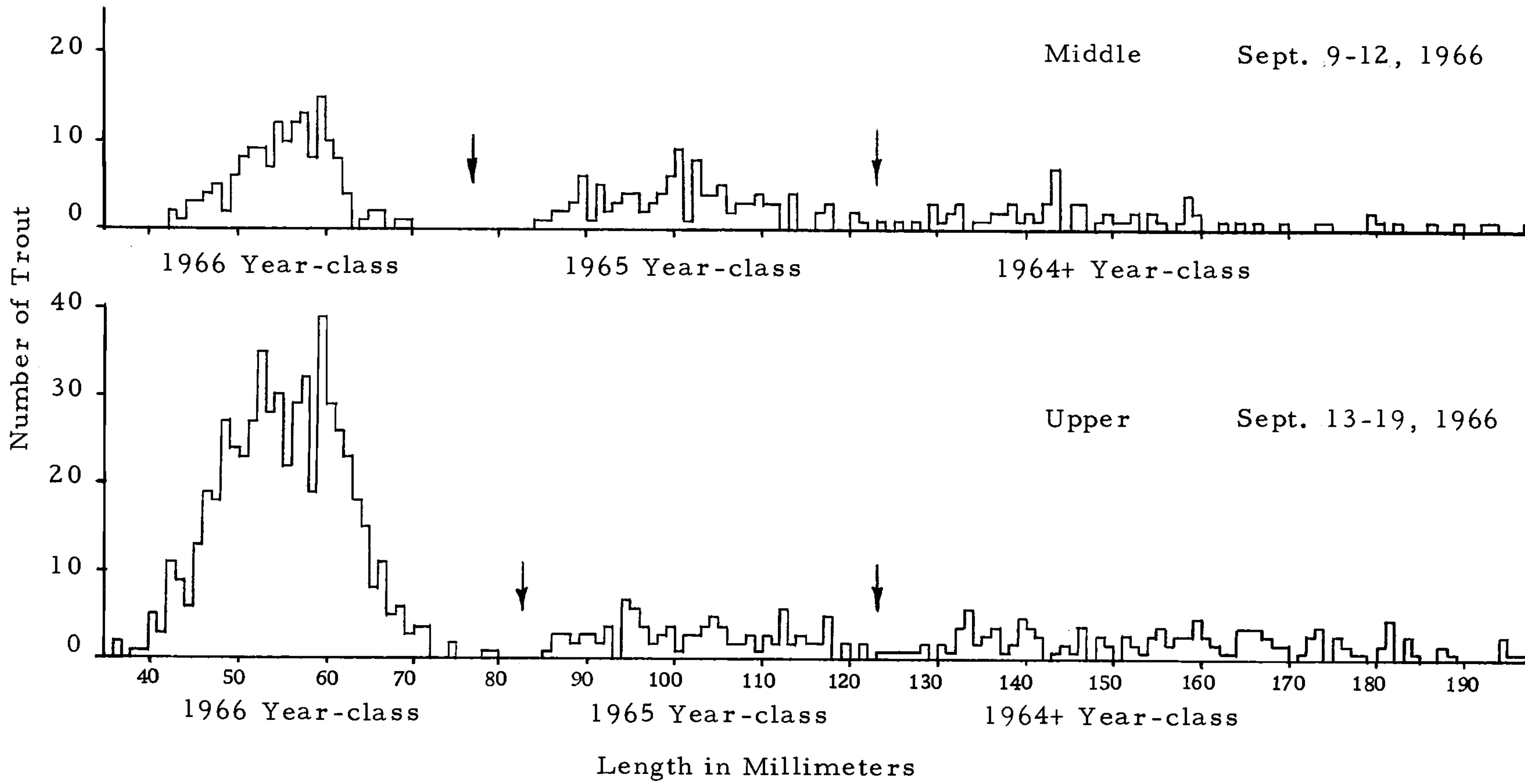
Date	Sample Time	Sample Size	Recaptures: The number last captured in time 1	2	3	4	5	6	7	Recaptures: The number tagged in time 1	2	3	4	5	6	7	Total recaptures	Total new fish	Number released
										1964+ Year-class									
7-16-65	1	34															0	34	34
8-30-65	2	48	1							1							1	47	48
9-15-65	3	62	2	2						2	2						4	58	62
11-6-65	4	113	2	7	9					3	9	6					18	0	18
6-29-66	5	78	4	3	3	1				4	3	4	0				11	66	77
8-10-66	6	101	2	4	4	2	25			3	4	6	0	24			37	64	101
9-10-66	7	76	1	2	2	0	5	35		2	3	5	0	12	23		45	31	76
11-10-66	8	69	1	0	0	1	7	15	18	1	2	4	0	15	15	5	42	0	42
										1965 Year-class									
6-29-66	5	67															0	66	66
8-10-66	6	93					13							13			13	80	93
9-10-66	7	109					13	26		1				16	22		39	70	109
11-10-66	8	121					5	21	25					11	22	18	51	0	51
										1966 Year-class									
6-29-66	5	5															0	5	5
8-10-66	6	94															0	94	94
9-10-66	7	158															11	147	158
11-10-66	8																		

SUMMARY OF MARK AND RECAPTURE DATA FOR THE LOWER SECTION OF ELDER CREEK

Date	Sample Time	Sample Size	Recaptures: The number last captured in time							Recaptures: The number tagged in time							Total recapture	Total new fish	Number released
			1	2	3	4	5	6	7	1	2	3	4	5	6	7			
1964+ Year-class																			
7-10-65	1	6															0	6	6
9-2-65	2	10	0							0							0	10	10
9-14-65	3	11	0	0						0	0						0	11	11
6-26-66	4	8	0	0	1					0	0	1					1	7	8
8-4-66	5	14	0	0	0	1				0	0	0	1				1	13	14
9-6-66	6	14	0	0	0	0	2			0	0	0	0	2			2	12	14
11-9-66	7	9	0	0	0	1	1	3		0	0	1	0	1	3		5	0	5
1965 Year-class																			
6-26-66	4	25															0	25	25
8-4-66	5	94				4							4				4	90	94
9-6-66	6	94				4	25						4	25			29	64	92
11-9-66	7	57				1	7	10					1	8	9		18	0	18
1966 Year-class																			
6-26-66	4	3															0	3	3
8-4-66	5	149															0	149	149
9-6-66	6	233															14	219	233
11-9-66	7																		

APPENDIX B

LENGTH-FREQUENCIES FOR A SAMPLE EACH IN THE UPPER AND MIDDLE SECTIONS OF ELDER CREEK



APPENDIX C

SCHEDULE OF LENGTH-WEIGHT REGRESSION DATA FROM COMPUTER PROGRAM

Section	Sample Size	Intercept (a)	Slope (b)	KFL Mean	KFL Std. Err.
Upper	47	-4. 58294	2. 83504	1. 20017	0. 02021
Middle	51	-4. 73987	2. 89689	1. 12445	0. 01334
Lower	81	-4. 49274	2. 78215	1. 13943	0. 01200

APPENDIX D

SCHEDULE OF OBSERVATIONS OF MOVEMENTS IN THE UPPER SECTION OF ELDER CREEK

		Date of Recovery											
		9-7-65		9-17-65		7-5-66		8-9-66		9-16-66		11-8-66	
Date of marking	Movement	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations
7-22-65	<300	47	1	57	0	348	1	383	1	421	1	475	0
	>300		0		0		0		0		0		0
9-7-65	<300			10	20	301	19	336	21	374	27	428	10
	>300				0		1		1		1		0
9-17-65	<300					291	3	326	2	364	5	418	1
	>300						0		0		0		0
7-5-66	<300							35	37	73	41	127	9
	>300								2		2		1
8-9-66	<300									38	78	92	26
	>300										0		1
9-16-66	<300											54	44
	>300												3

SCHEDULE OF OBSERVATIONS OF MOVEMENTS IN THE MIDDLE SECTION OF ELDER CREEK

		Date of Recovery													
		8-30-65		9-15-65		11-6-65		6-29-66		8-10-66		9-10-66		11-10-66	
Date of marking	Movement	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations
7-16-65	<300 ft.	45	1	61	2	113	3	348	4	390	3	421	3	462	2
	>300 ft.		0		0		0		0		0		0		0
8-30-65	<300 ft.			16	2	68	9	303	3	345	4	376	3	417	3
	>300 ft.				0		0		0		0		0		0
9-15-65	<300 ft.					52	7	287	4	329	6	360	4	401	4
	>300 ft.						1		0		0		1		0
11-6-65	<300 ft.							235	1	277	2	308	1	349	1
	>300 ft.								0		0		0		0
6-29-66	<300 ft.									42	39	73	29	114	30
	>300 ft.										0		1		1
8-10-66	<300 ft.											31	60	72	48
	>300 ft.												0		3
9-10-66	<300 ft.													41	41
	>300 ft.														1

SCHEDULE OF OBSERVATIONS OF MOVEMENTS IN THE LOWER SECTION OF ELDER CREEK

		Date of Recovery											
		9-2-65		9-14-65		6-26-66		8-4-66		9-6-66		11-9-66	
Date of marking	Movement	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations	Days between observations	Number of observations
7-10-65	<300 ft.	54	0	66	1	351	0	390	0	422	0	486	0
	>300 ft.		0		0		0		0		0		0
9-2-65	<300 ft.			12	0	297	1	336	1	368	0	432	0
	>300 ft.				0		0		0		0		0
9-14-65	<300 ft.					285	0	324	0	356	0	420	1
	>300 ft.						1		0		0		0
6-26-66	<300 ft.							39	8	71	4	135	1
	>300 ft.								1		0		0
8-4-66	<300 ft.									32	25	96	6
	>300 ft.										2		1
9-6-66	<300 ft.											64	16
	>300 ft.												0

APPENDIX E

SCHEDULE OF DATA USED IN MAKING PETERSEN POINT ESTIMATES

Date of marking	1966 Year-class				1965 Year-class				1964+ Year-class			
	M	R	C	N (LCL - UCL)	M	R	C	N (LCL - UCL)	M	R	C	N (LCL - UCL)
Upper												
7-22-65									10	1	130	655 (94-25336)
9-7-65									130	21	67	402 (253-635)
9-17-65									21	3	104	551 (161-2686)
7-5-66					37	8	81	336 (158-767)	103	30	147	492 (336-719)
8-9-66	261	32	575	4554 (3133-6527)	80	23	106	329 (230-554)	147	40	145	523 (377-724)
9-16-66					106	15	35	238 (135-412)	145	32	59	264 (181-376)
Middle												
7-16-65									34	1	48	833 (118-31806)
8-30-65									48	2	62	1008 (288-8395)
9-15-65									62	9	113	707 (347-1520)
11-6-65									18	1	78	711 (101-27363)
6-29-66					66	13	93	443 (246-816)	77	25	101	302 (198-460)
8-10-66	94	11	158	1245 (623-2320)	93	26	109	379 (251-571)	101	35	76	216 (151-304)
9-10-66					109	25	121	511 (377-779)	76	18	69	280 (170-461)
Lower												
7-10-65												
9-2-65												
9-14-65									11	1	8	50 (6-1715)
6-26-66					25	4	94	475 (162-1734)	8	1	14	60 (8-2183)
8-4-66	149	14	233	2324 (1299-4116)	94	25	94	343 (225-522)	14	2	14	70 (15-553)
9-6-66					92	10	57	485 (245-986)	14	3	9	35 (9-155)

APPENDIX F

SCHEDULE OF CREEL CENSUS DATA FOR A SAMPLE IN THE SUMMER OF 1965 AND FOR THE WHOLE SUMMER OF 1966

	Aug. 6, 1965 to Sept. 6, 1965		June 18, 1966 to Sept. 11, 1966	
	Week-ends	Weekdays	Week-ends	Weekdays
Upper				
Total angling hours available	130	273		
Hours of creel census effort	12 1/2	10		
Number of angler contacts	0	1	2	2
Number of anglers	0	3	6	7
Number of angler-hours	0	1	7	16
Number of rainbow trout caught	0	0	6	22
Middle				
Total angling hours available	130	273		
Hours of creel census effort	9 1/4	22 1/2		
Number of angler contacts	2	2	9	6
Number of anglers	4	3	19	18
Number of angler-hours	11	8	26	41 1/2
Number of rainbow trout caught	30	26	65	93
Lower				
Total angling hours available	130	273		
Hours of creel census effort	25	20		
Number of angler contacts	5	0	12	3
Number of anglers	11	0	24	9
Number of angler-hours	18	0	50	19
Number of rainbow trout caught	38	0	77	14