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Title FOOD HABITS, GROWTH, AND PRODUCTION OF JUVENILE SPRING CHINOOK SALMON, ONCORHYNCHUS TSHAWYTSCHA (WALBAUM), IN A EUTROPHIC RESERVOIR

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Abstract approved ____________________
(Major professor)

Juvenile spring chinook salmon, Oncorhynchus tshawytscha (Walbaum), were reared in a Central Oregon reservoir. Production and carrying capacity estimates were made from information collected on reservoir limnology and the food habits, growth and survival of the salmon.

Happy Valley Reservoir, a heavily-sedimented impoundment of about 18.5 acres, is very fertile and apparently supports high densities of benthos and plankton. Summer conditions include surface temperatures above 80° Fahrenheit and thermal and dissolved oxygen stratification. Ice cover and temperatures below 40° F. occur in the winter.

Salmon fry planted in 1961 (75,300) and in 1962 (150,000) suffered first-summer mortalities in excess of 80 percent,

primarily due to predation by salmon of previous plants. Additional losses in 1961 were caused by a flood which carried many of the fry over the reservoir spillway, and by algal toxins and high temperatures occurring in the summer.

During the summer the salmon occupied the upper ten feet of water in apparent avoidance of low oxygen concentrations below. Despite summer temperatures near their lethal limit of 77.2° F., the salmon were observed to feed at the surface in the mornings and evenings.

June through September was the growing season, although increase in length continued through the winter; condition factors above 1.25 were attained during the first summer of residence, but steady decreases in condition occurred during the winter when average weights remained nearly constant. After nine to ten months of growth, the 1961 plant averaged 62 grams and 16 centimeters, while the 1962 plant averaged 22 grams and 12 centimeters. After their second summer (22 months), the 1961 plant averaged 87 grams and 20 centimeters. These growth rates, especially for 1961, are much higher than those of stream-inhabiting chinook salmon.

Availability of food was adjudged the limiting factor in growth; competition was more intense in 1962 than in 1961 due to the presence of more fish, and individual growth was slower.

Production, defined as the total elaboration of tissue for a specific time period, was estimated at 69 kg./acre for first-year salmon in both 1961 and 1962. An estimated 14 kg./acre was elaborated by the second-year salmon in 1962. Three-fourths of the production occurred from June to September. The high production values corroborate chemical evidence of the high basic fertility of the reservoir.

Entomostraca and chaoborid larvae were the primary food sources for first-year salmon; older salmon fed more on littoral fauna (Chironomidae, Coenagrionidae, Gastropoda, etc.) in apparent response to competition from the younger fish. Oxygen stratification in limiting vertical movement by the fish likely emphasized the use of zooplankton as food by juvenile fish.

Carrying capacity of the reservoir is estimated at 40 kg./acre or 5.2 kg./acre-foot for first-year salmon. The presence of a similar biomass of older salmon is believed to have had little effect on the carrying capacity due to a difference in food habits.

Despite its high productive capacity, the reservoir is considered marginal in its potential use as a rearing site for chinook salmon due to the severe summer conditions and possibility of summer mortalities.

FOOD HABITS, GROWTH, AND PRODUCTION OF JUVENILE SPRING CHINOOK SALMON *ONCORHYNCHUS TSHAWYTSCHA* (WALBAUM), IN A EUTROPHIC RESERVOIR

by

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FOOD HABITS, GROWTH, AND PRODUCTION OF JUVENILE SPRING CHINOOK SALMON, *ONCORHYNCHUS TSHAWYTSCHA* (WALBAUM), IN A EUTROPHIC RESERVOIR

INTRODUCTION

General

This research concerned the natural impoundment-rearing of juvenile spring chinook salmon, *Oncorhynchus tshawytscha* (Walbaum), in a Central Oregon reservoir. Conducted by the Department of Fish and Game Management at Oregon State University, the investigation was supported by contracts 14-17-0001-374 (1961) and 14-17-0001-544 (1962-63) from the United States Department of Interior. Investigation of food habits, survival, growth, and migration habits of the salmon were designed, with complementary studies of chemical and biological conditions in the reservoir. In addition, carrying capacity estimates were planned with relation to volume and surface acreage measurements.

Previous studies at Happy Valley Reservoir had been conducted on a mixed plant of 30,000 coho salmon, *Oncorhynchus kisutch* (Walbaum), and 23,000 spring chinook salmon made in January of 1959. Indications were that growth was quite rapid, with coho salmon averaging 41 grams and the chinook salmon 32 grams after 16 months of residence. Survival of the mixed population was estimated at

90 percent to June 1960 (16). Chemical treatment to remove survivors of the 1959 plant as well as resident rainbow trout (*Salmo gairdneri* Richardson) was incomplete; consequently, some information was collected on these fish in later work. Where pertinent, this information will be presented.

Methods and Procedures

The investigation was conducted according to a general outline suggested for such studies by the Bureau of Commercial Fisheries. Standard limnological techniques were employed.

A stadia survey and depth-sounding provided data from which a hydrographic map was made. Area and volume were computed from this map. Temperature patterns of the upper strata of water were recorded with a maximum-minimum thermometer and constant-recording thermographs. A transistorized thermometer was used to take vertical temperature series.

A Kemmerer water bottle was employed to take water samples in vertical series for pH and dissolved oxygen determinations. The Winkler method was used for the oxygen determinations, and either a color-comparator or portable conductivity meter was used to measure the pH.

Determinations included total dissolved solids, volatile dissolved solids, and total water phosphorus. The same water sample sufficed for the first two; after the suspended solids were removed by centrifugation, the sample was evaporated at 60° Centigrade and ignited at 600° C. for these measurements. The phosphorus analyses were conducted by the analytical laboratory of the Department of Soils at Oregon State University.

Planktonic and benthic organisms were not sampled quantitatively, although the dominant types were noted, as were the periods and types of algal blooms.

From 14 to 60 chinook salmon were collected at approximately one-month intervals for food and growth studies. These collections, in addition to the more extensive ones for survival estimates, were made with gill nets and beach seines.

Each fish in a monthly sample was measured for fork length to the nearest millimeter and weighed on a double-pan balance to the nearest 0.1 gram. Those to be used in the food analyses were preserved in 10 percent formalin after their body cavities had been slit open. The exception to this procedure involved the recently planted fish which were preserved in 70 percent ethyl alcohol or 5 percent formalin prior to measurement.

The condition factor for each fish was computed from the following formula, as modified from Rounsefell and Everhart (15, p. 322):

$$K = \frac{100\ W}{L^3}$$

where K = a condition factor near unity,

W = weight in grams,

L = fork length in centimeters.

In preparation for stomach analyses, the preserved fish were transferred to 5 percent formalin and eventually to 20 percent isopropyl alcohol. The analyses were handled on a random composite basis for each sample, with fish from a particular sample being chosen at random until a composite of the contents from 10 fish with recognizable stomach contents could be attained. Only contents from the anterior half of the stomach were analyzed in order to reduce error due to partially digested foods. This composite was then mixed and a random sub-sample extracted from it for dry-weight analysis. The composite analysis was made feasible by the limited nature of the stomach contents.

In total, stomachs from 17 samples of salmon from the 1961 plant were thus analyzed for the period April 22, 1961 to November 18, 1962.

Population estimates were determined through the mark-and-recapture method. Fish were captured with seines, anesthetized in an 8 to 12 parts per million (p. p. m.) solution of quinaldine, marked with a fin-clip, and then distributed over the reservoir in accord with the apparent distribution of the population. Fins clipped were both pelvics and anterior third of the anal on the 1961 plant, and adipose and posterior third of the anal on the 1962 plant.

Description of Reservoir

Located on the Warm Springs Indian Reservation at about 2,500 feet elevation, Happy Valley Reservoir is an irrigation reservoir of about 18.5 acres. The dam, constructed in the late 1930's, is an earth-fill type with a broken rock cover. Maximum depth is about 42 feet and the average depth about 15 feet at full pool (Figure 1). The impoundment is heavily sedimented with an organic muck, as exhibited by its extensive central plain region. Oxygen depletion occurs in the thermocline and hypolimnion during the summer thermal stratification period. Quartz Creek flows intermittently but usually replaces summer-used irrigation water with run-off in the early spring.

Rooted aquatic vegetation is limited by the lack of an extensive littoral zone, except in the inlet area. *Potamogeton pectinatus* L. (sago pond weed) is the most abundant species, covering much of

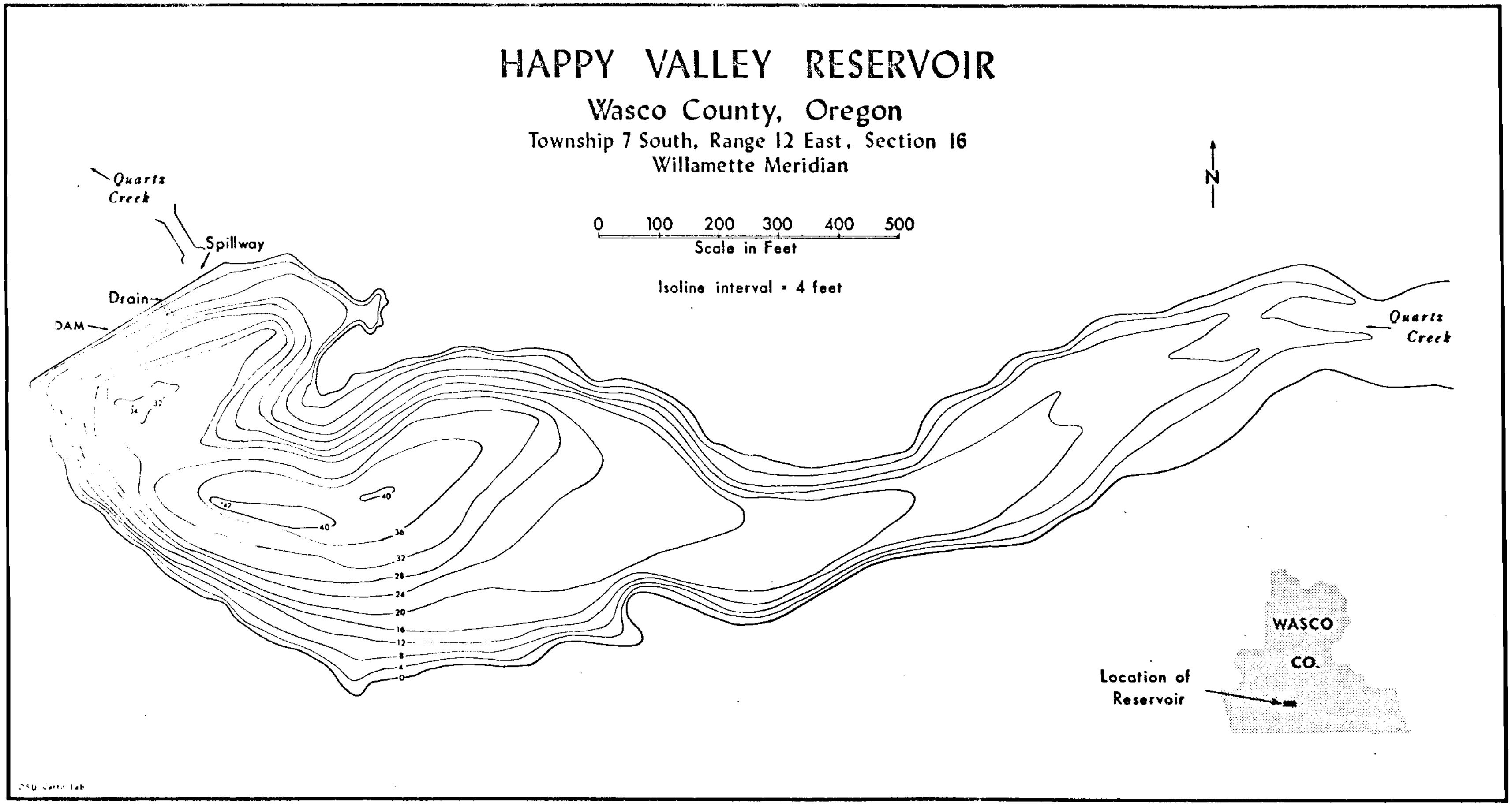

HAPPY VALLEY RESERVOIR
Wasco County, Oregon
Township 7 South, Range 12 East, Section 16
Willamette Meridian
0 100 200 300 400 500
Scale in Feet
Isoline interval = 4 feet
Quartz Creek
Spillway
Drain
DAM
Quartz Creek
WASCO CO.
Location of Reservoir

Figure 1

the upper inlet area until the sudden water drawdowns from summer irrigation occur.

Benthic fauna is of limited composition below the littoral zone, with oligochaetes, and chironomid and chaoborid larvae predominating. Littoral fauna includes larvae of Ephemeroptera, Odonata (mostly Coenagrionidae), Trichoptera and Chironomidae. Amphipods are abundant, while some crayfish (Pacifasticus) and gastropods (Physa) also occur.

The native rainbow trout, although able to reproduce naturally in Quartz Creek, have been kept at low numbers by the chemical treatment of the reservoir and subsequent gill netting. The most prominent planktonic form in the reservoir is the blue-green alga Aphanizomenon which occurs in heavy concentrations during much of the summer. Another blue-green alga, Microcystis (=Polycystis), is occasionally abundant during late summer. Pandorina, a green flagellate, was once noted as a winter bloom. Cladocera and lesser numbers of other Entomostraca compose the bulk of the zooplankton, and were noted to be abundant at various times during the year including the winter under ice cover.

Data collected from water chemistry analyses indicate a high basic fertility for the reservoir. Total dissolved solids generally exceeded 80 p. p. m. and occasionally 220 p. p. m. Total water phosphorus concentrations over 0. 3 p. p. m. at the bottom and 0. 1 p. p. m. at the surface were found. Surface pH values of 9. 0 to 10. 0 during the summer reflected high photosynthetic activity. Appendices 1 to 4 graphically summarize the data on these analyses, in addition to those on methyl orange alkalinity and volatile dissolved solids.

The wide temperature ranges of the region induce reservoir conditions varying from winter ice cover to surface temperatures above 80° Fahrenheit in the summer. Midwinter temperatures below 40° F. are common, while June to August temperatures frequently exceed 75° F. (Figure 2).

Organic decomposition during summer stratification removes dissolved oxygen below the maximum mixing depth of 16 feet. Maximal depth of 3 milligrams per liter (mg. /l.) dissolved oxygen from mid-July to the end of August 1961 was generally between 7 and 10 feet. Temperature and dissolved oxygen profiles are presented in Figure 3 for August 1, 1961 as an example of the midsummer period. In this example, which likely does not represent the extreme for that day, it is apparent that fish seeking temperatures below 68° F. would have to accept dissolved oxygen concentrations below 5 mg. /l.

An ice cover up to seven inches thick was indicative of the

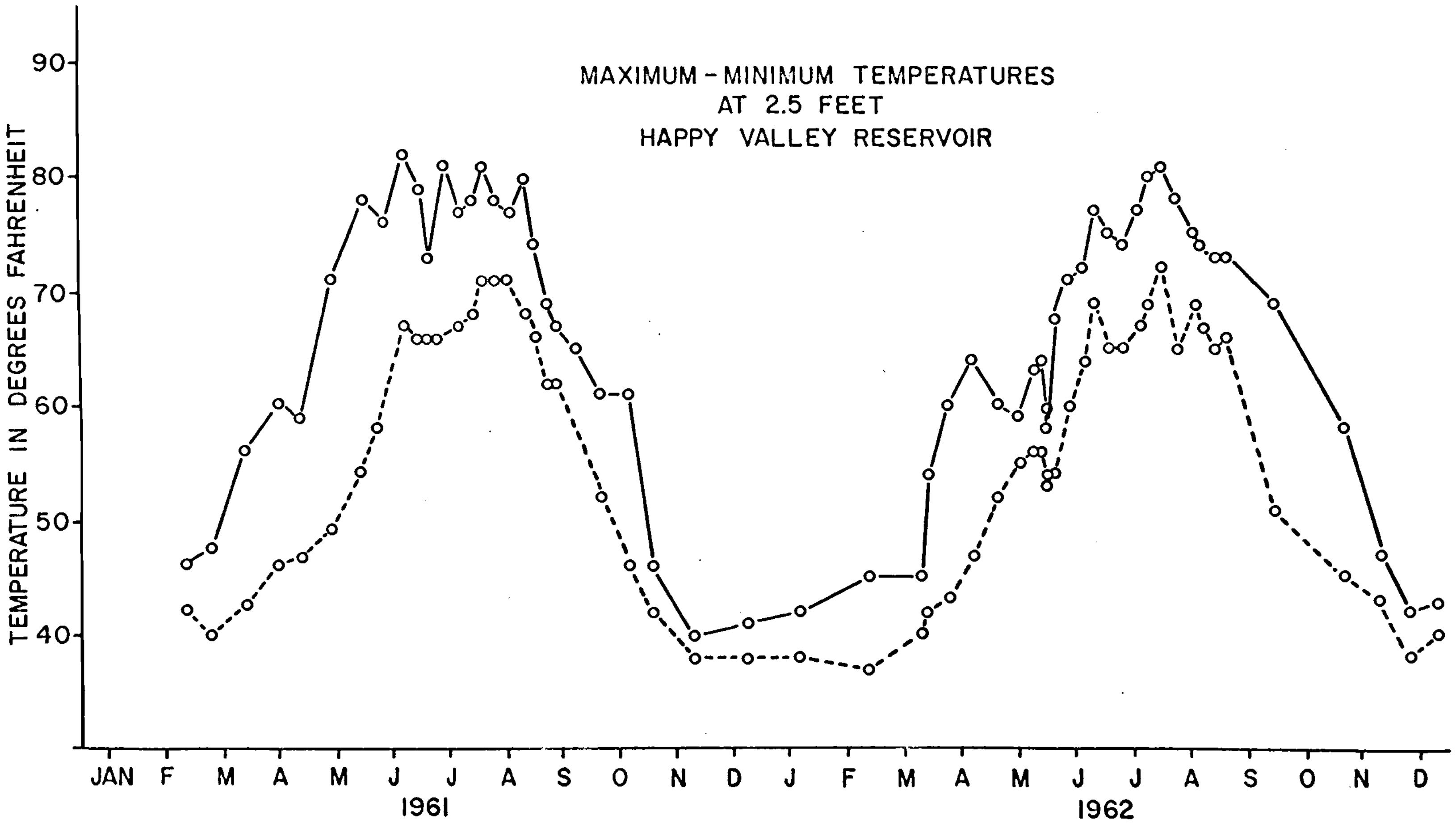

MAXIMUM - MINIMUM TEMPERATURES
AT 2.5 FEET
HAPPY VALLEY RESERVOIR
TEMPERATURE IN DEGREES FAHRENHEIT
90
80
70
60
50
40
JAN
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
A
S
O
N
D
1961
1962

Figure 2

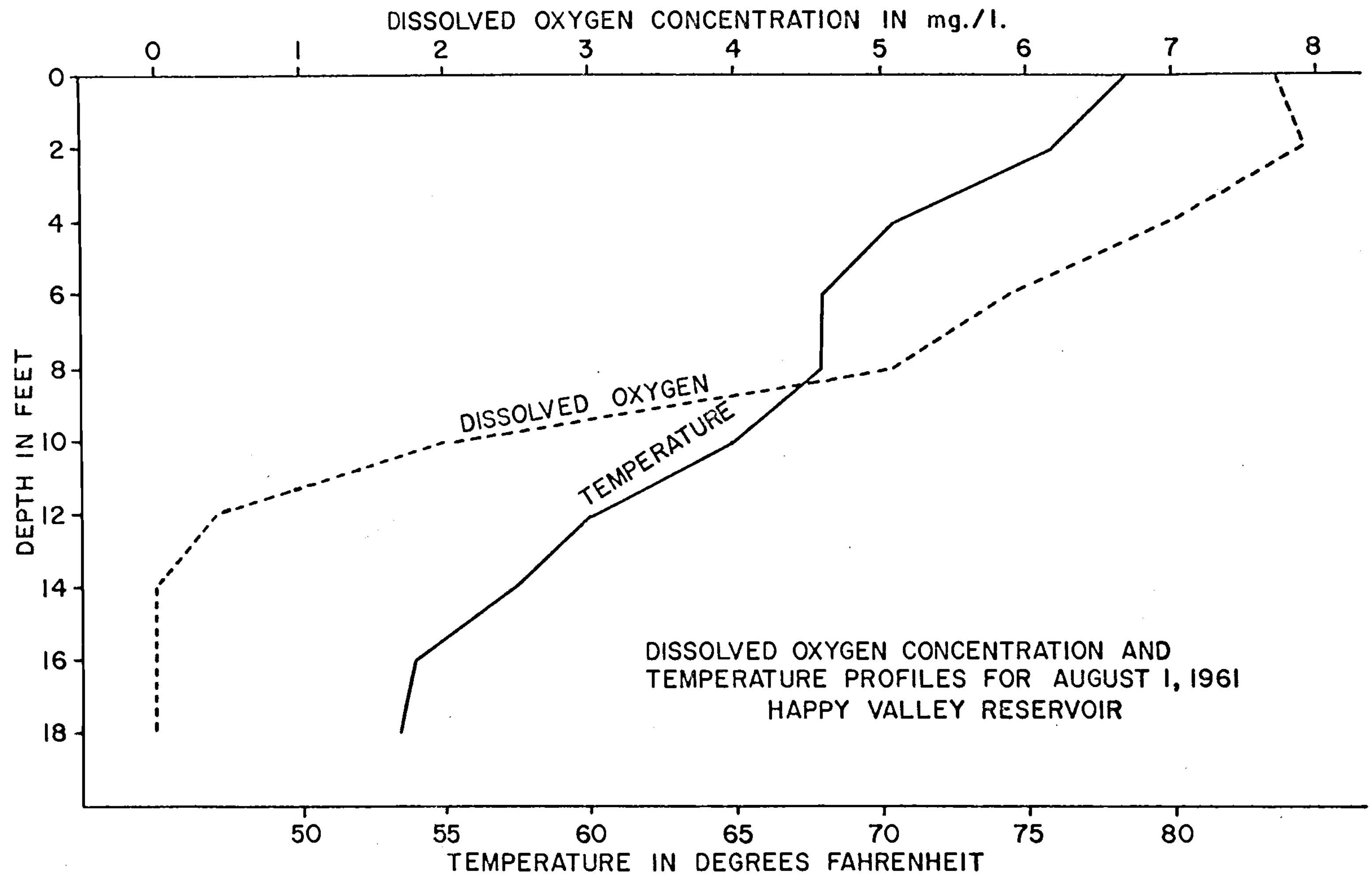

DISSOLVED OXYGEN CONCENTRATION IN mg./l.
0 1 2 3 4 5 6 7 8
DEPTH IN FEET
0 2 4 6 8 10 12 14 16 18
DISSOLVED OXYGEN
TEMPERATURE
DISSOLVED OXYGEN CONCENTRATION AND
TEMPERATURE PROFILES FOR AUGUST 1, 1961
HAPPY VALLEY RESERVOIR
50 55 60 65 70 75 80
TEMPERATURE IN DEGREES FAHRENHEIT

Figure 3

cold conditions existing during the 1961-62 winter; water temperatures averaged near 40° F. from late November 1961 until April 1962. Dissolved oxygen concentrations below the ice, however, were adequate to sustain fish life.

General Observations of Chinook Salmon

Happy Valley Reservoir, a eutrophic impoundment with very warm summer conditions, is markedly different as a rearing site from the streams naturally inhabited by the juvenile chinook salmon. Spring chinook salmon normally make the parr-to-smolt transformation during the spring after one year of fresh-water residence. In the reservoir, a year's residence includes environmental changes due to stratification conditions, water drawdown, freshets, and heavy algal blooms. This section will deal with the observed habits of the salmon in response to these conditions.

Dealing first with the summer influences, the basic statement may be made that the salmon existed during the summer under extremely marginal conditions. Oxygen deficiencies below about 10 feet limited the fish to the upper layer of water. In this upper stratum they were subjected to the possible harmful effects of high temperatures, diel fluctuations of dissolved oxygen, high pH ranges, and toxins released by the decomposition of the blue-green algae.

The upper lethal limit for chinook salmon fry has been estimated by Brett (3, p. 274 and 305) at 77.2° F., using the criterion of a 50 percent mortality after indefinite exposure. Davison et al. (6, p. 955 and 964) concluded that juvenile coho salmon kept at temperatures of 68° F. or below could tolerate dissolved oxygen concentrations of 2 mg./l., but ". . . . were sluggish, consumed little of the food offered, and lost weight . . . ." These experiments indicated that the 50 percent lethal limit was 1.5 mg./l. at 68° F., with rapidly increasing oxygen requirements above this temperature.

By noting the depth at which fish were gill-netted and by observing their "echoes" on the dial of a portable depth-sounder, it was concluded that the salmon tended to congregate at a depth of five to six feet while compromising the two midsummer stresses of low oxygen and high temperature. This depth was typically just above the zone of abrupt decline in dissolved oxygen concentration, and afforded concentrations of above 4 mg./l. with temperatures in the 67° to 69° F. region.

Either as a means of temporary escape from the stresses of this upper stratum or during feeding excursions to the productive benthic areas, the chinook salmon might be expected to have ventured below the epilimnion. Evidence to the contrary is found in the results of some 400 hours of gill net sets made during the stratification period; in no case were either the planted salmon or native rainbow trout found utilizing water below 12 feet in depth. Most were found in the zone from 3 to 8 feet. Since only a few sets were made in waters less than 15 feet in depth, however, it cannot be strongly asserted that the salmon did not move into deoxygenated water while feeding on benthic fauna 10 to 15 feet deep.

The apparent habit of avoidance is in accord with the results of experiments made by Whitmore, Warren and Doudoroff (18) who stated that chinook salmon juveniles, particularly at summer temperatures, showed directed avoidance reactions to dissolved oxygen concentrations of 4.5 mg./l. and less.

Temperature alone was never observed to exceed the estimated lethal limit (77.2° F.) below the four-foot level. During only one period (July 31 to August 3, 1961) was a mortality of salmon directly observed; this occurred when daily temperature maxima were reaching 73° F. at five feet and the decomposition of an algal bloom was in process. Mortalities of various fish types have been reported (17, p. 261; 2, p. 55-56) in apparent response to toxins released by decomposing blue-green algae. These conditions seem to be a likely contributing factor in the low survival (see following section) that was observed in the 1961 and 1962 plants of chinook salmon.

Nocturnal dissolved oxygen reduction from algal respiration was checked only once, the night of July 31, 1961 following the first observations of the mortality mentioned above. The fact that daytime pH values on August 1 were relatively low (9.0 or less) and oxygen levels nearly constant (5 to 8 mg./l. through the 24 hour check in the upper 6 feet of water) gives credence to the hypothesis that toxic substances were in good part responsible for this mortality. Most likely, the cumulative effect of the stresses previously mentioned resulted in some of the losses indicated by survival estimates.

Possible schooling tendencies of the chinook salmon were indicated by summer aggregations found at sites which had no apparent temperature or oxygen advantage. The deeper areas bordering the dam face and the southwest corner were particularly noted in this regard. In contrast, an obvious temperature reaction caused the salmon to congregate in the inlet area after a midsummer freshet brought a cooler water mass into the reservoir. On August 14, 1962 surface temperatures were measured at 76° F. in the lower reservoir and 66° F. in the inlet. The temperature soon equalized, but some salmon remained concentrated in the inlet until late September when the fall turnover began.

Observations of feeding fish supplemented by gill net operations indicated a lack of summer daytime activity by the chinook salmon. The fish typically were seen rising along the shallower shoreline areas during the early morning and about an hour before dusk. During the summer of 1962, tremendous swarms of chironomid adults and other Diptera provided an attraction to the fish which were noted to rise and actively feed despite surface temperatures of 70° to 74° F.

Winter observations indicated that the chinook salmon were more uniformly distributed about the reservoir. No vertical limitation was evident. Cold water resulted in no evident mortality, but apparently reduced the activity of the fish and resulted in reduced gill net catches.

The lower lethal limit (50 percent mortality) was estimated by Brett (4) at 33.4° F. for chinook salmon fry acclimated to 50° F. Cold tolerance, Brett indicates, is gained slowly among fish. Winter temperatures at Happy Valley, however, were obtained only after about a two-month period of decreasing temperatures (Figure 2). This period seems sufficient for the salmon to acclimate to cold, but deaths from cold still appear possible considering the winter temperatures below 40° F.

SURVIVAL OF PLANTED CHINOOK SALMON

The two plants made during the study period included 75,300 unfed fry at 1,500 per pound (February 8, 1961) and 150,000 advanced fry at 1,000 per pound (March 22, 1962). The second plant had been hatchery-reared for three weeks.

Two population estimates were made of each plant during their reservoir residence. In constructing survival curves, a procedure necessary for the production estimates that follow, it is necessary to assign the indicated mortalities to the most logical periods for the intervals between point estimates. These assignments are made in light of available knowledge of mortalities. The population estimates themselves are based upon several mark-and-recapture operations; Appendix 5 presents the method of analysis and statistical derivations for the data collected.

Predation at planting by residual salmon and native rainbow trout produced major losses of both plants of chinook salmon. The presence of predators was unexpected when the 1961 plant was made since chemical treatment was thought to have removed the fish. In 1962, predation from yearling salmon was anticipated and a large, fine-mesh seine was used to impound and protect the newly-planted fry. Additionally, numerous gill nets were installed to deter predator movement in the area. Initial predation was largely reduced by these measures.

In addition to predation and possible post-planting mortalities, the 1961 plant suffered losses due to a flash flood on February 11, 1961 which carried many of the fry over the spillway. Such a loss did not occur in 1962. Estimates made on March 22, 1961 and May 1, 1962 placed initial survivals at 28,600 (38 percent) and 123,000 (82 percent) for the two plants respectively.

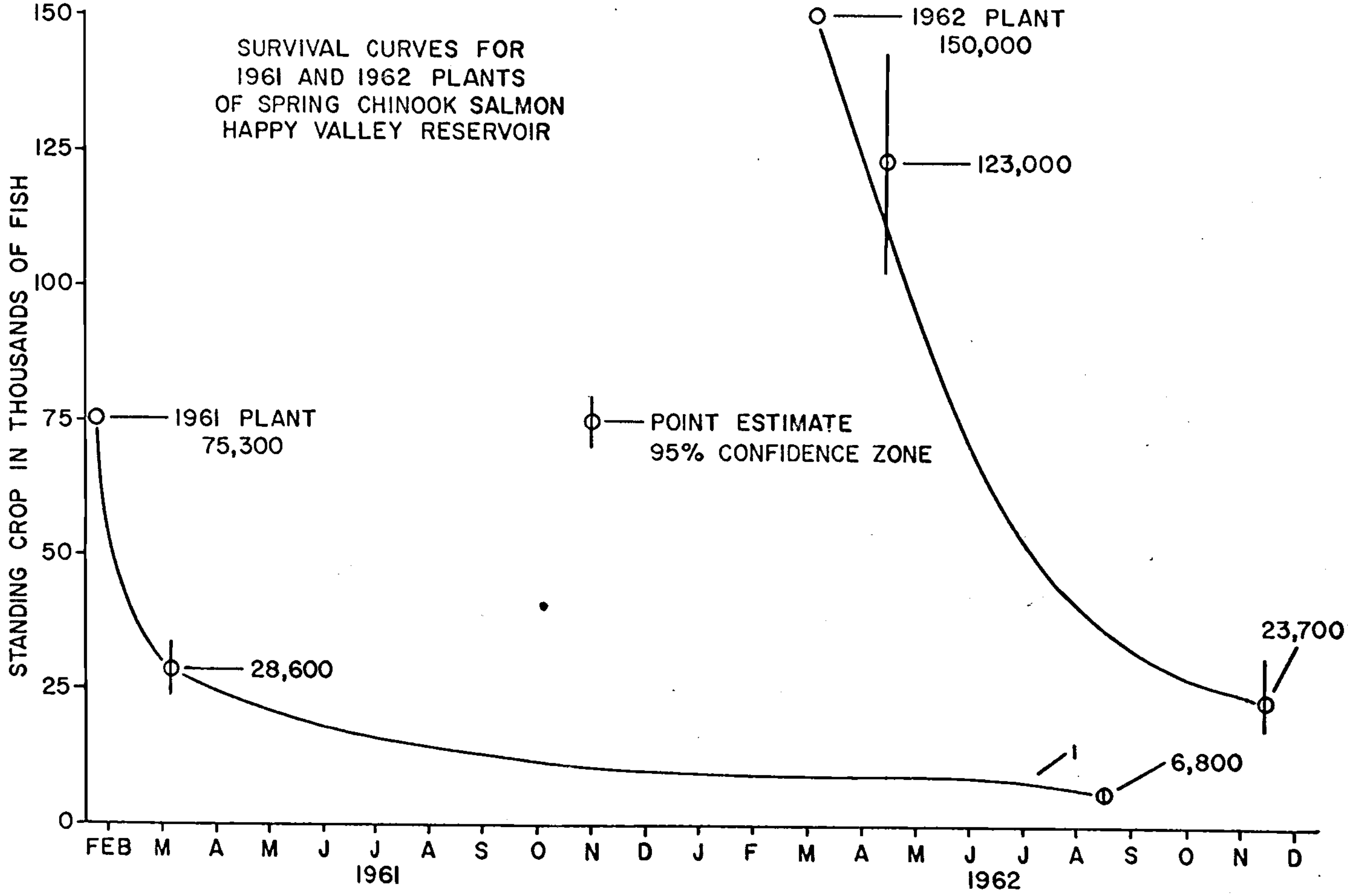
Working from these initial survival estimates, further losses may be attributed to (1.) continued predation, (2.) removal for biological sampling and transplantation, (3.) severe summer conditions, (4.) severe winter conditions, and (5.) maturation. Losses of the 1962 plant are better understood than those of the 1961 plant and will be discussed first.

The second population estimate of the 1962 plant, made in late November 1962, indicated that only 23,000 or 19 percent of the fish surviving initial losses still remained. Examination of the stomachs of 310 yearling salmon revealed that the predatory activities of these fish could account for one-half or more of the indicated loss. Predation from other forms (avian and terrestrial) was rarely seen.

Sampling and transplantation procedures removed only 2,000 of the 1962 fish, and mortalities from winter conditions before the second estimate was made do not seem likely. Chinook salmon which had matured precocially and were therefore subject to an early death were rarely observed in first-year fish, indicating little or no loss from this cause.

Severe summer conditions in conjunction with predation seem to be the most logical causes for the mortality. The latter cause appears the more important in light of Shelton's (16) estimation of 90 percent survival for the 1959 mixed plant of spring chinook and coho salmon after a 16 month residence with no older salmon present. With this in mind, a survival curve was fitted to the data in Figure 4; an exponential mortality rate was approximated by eye as best expressing the types and periods of mortality.

In late August of 1962, the second population estimate of the 1961 plant was made; it indicated that 6,800 of these salmon still survived. Of those lost during the time since the first estimate, 2,500 had been removed in July and August of 1962 for transplantation purposes. This known loss is accounted for in the survival curve (Figure 4). The curve again assumes predation and first-summer mortalities as the main cause of the losses.



1. Known loss of 2,500 one-year chinooks in July and August for transplantation.

Figure 4

GROWTH

Despite the extremes and variations of temperature and other conditions of the reservoir, the chinook salmon showed rapid growth rates during both summers of the study. The growing season extends from early June through September, with much of the growth occurring during the severe midsummer period. Increases in weight were very small, and decreases may have occurred during the cold midwinter period. At this time, length increase continued but the average condition of the fish steadily decreased. Figures 5, 6, and 7 illustrate changes in average weight, fork length, and condition factor for both the 1961 and 1962 plants of chinook salmon. In Appendices 6 through 11 may be found the data and statistical derivations from which these graphs are constructed.

Members of the 1962 plant grew at a slower rate than those of the 1961 plant. Average size at the end of the first summer of growth was 20 to 25 grams for the 1962 plant and 60 to 65 grams for the 1961 plant. Partial cause for this difference may be found in a later planting date in 1962 (March 22) and the restriction of the 1962 plant for a month following planting to a small area behind the protection barrier. Escapees from this enclosure, if not eaten, grew at a very high rate, approaching that of members of the

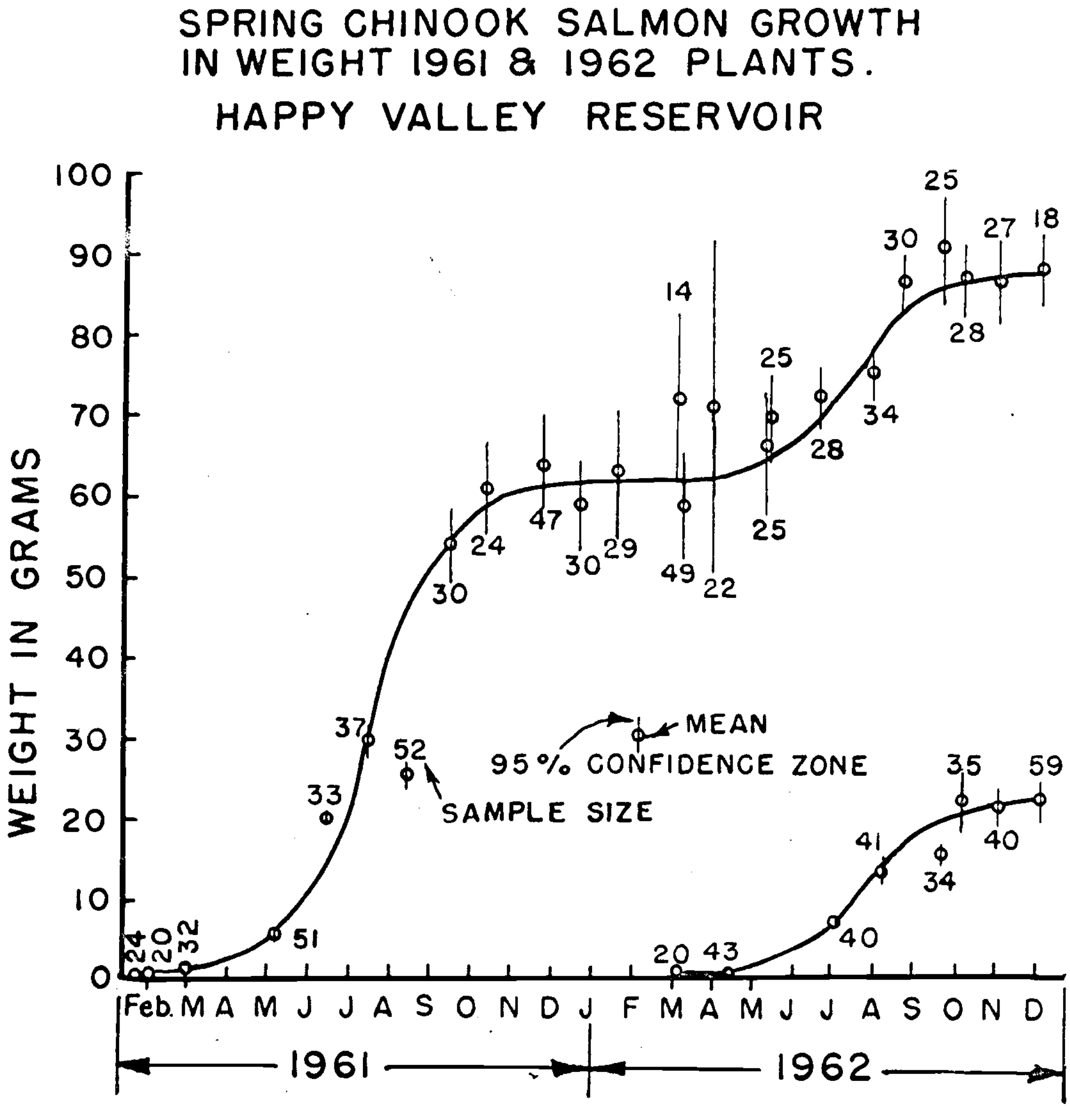

SPRING CHINOOK SALMON GROWTH
IN WEIGHT 1961 & 1962 PLANTS.
HAPPY VALLEY RESERVOIR
WEIGHT IN GRAMS
MEAN
95% CONFIDENCE ZONE
SAMPLE SIZE
Feb. M A M J J A S O N D J F M A M J J A S O N D
1961
1962

Figure 5

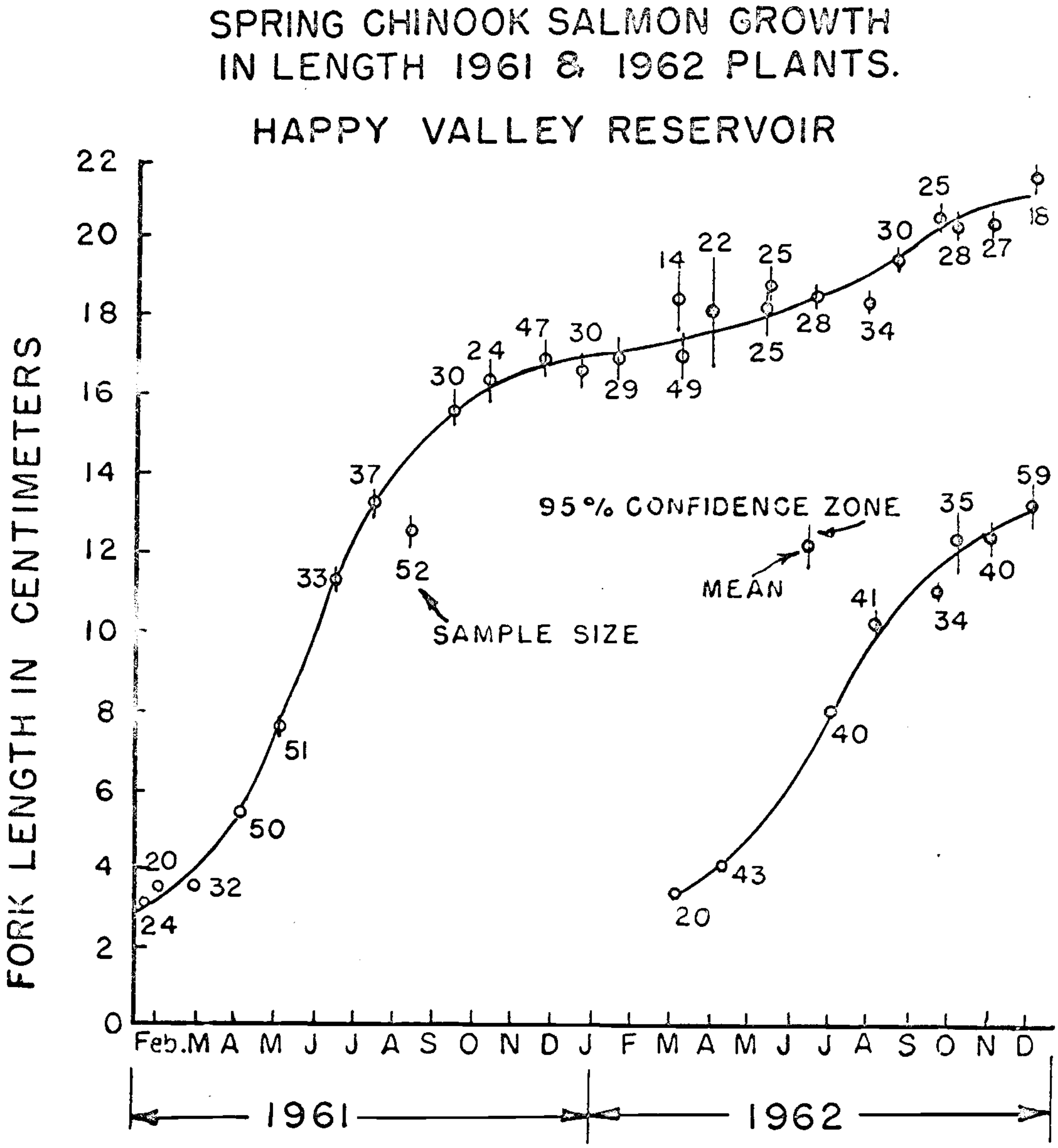

SPRING CHINOOK SALMON GROWTH
IN LENGTH 1961 & 1962 PLANTS.
HAPPY VALLEY RESERVOIR
FORK LENGTH IN CENTIMETERS
95% CONFIDENCE ZONE
MEAN
SAMPLE SIZE
Feb. M A M J J A S O N D J F M A M J J A S O N D
1961
1962

Figure 6

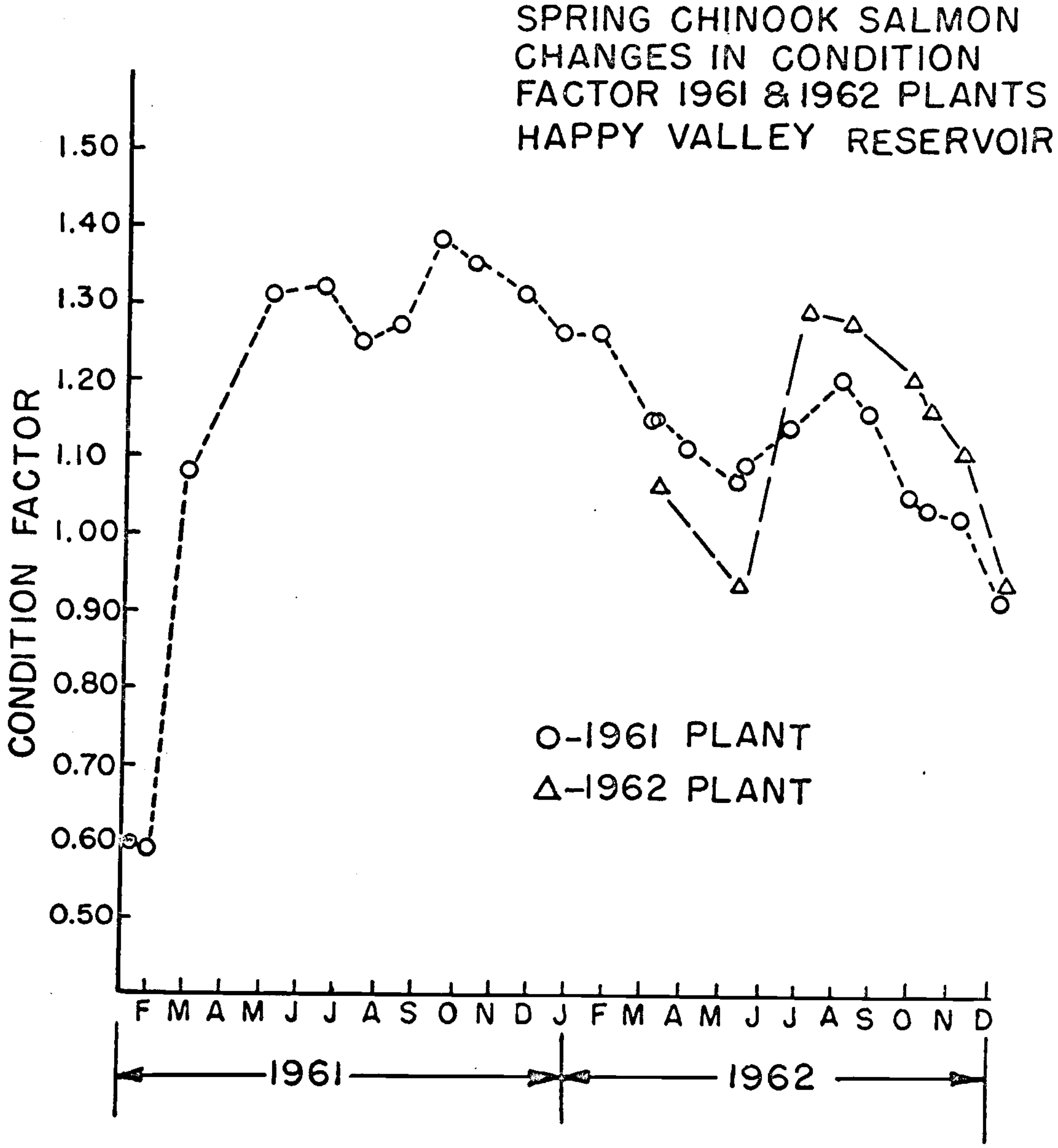

SPRING CHINOOK SALMON
CHANGES IN CONDITION
FACTOR 1961 & 1962 PLANTS
HAPPY VALLEY RESERVOIR
CONDITION FACTOR
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
O-1961 PLANT
Δ-1962 PLANT
F M A M J J A S O N D J F M A M J J A S O N D
1961
1962

Figure 7

previous plant a year earlier. In contrast, the enclosed fish were very near their planting size when finally released. It is because of this induced variability in size that the growth curves for the 1962 plant are based primarily upon samples with wide confidence intervals.

The continuation of a reduced growth rate by the younger fish seems attributable to the increased competition for food and/or space caused by the presence of greater numbers of fish in 1962. Ricker and Foerster (14, p. 192) working in this regard on Cultus Lake juvenile sockeye salmon (Oncorhynchus nerka [Walbaum]) postulate ". . . a very nice regulatory mechanism. . . , that is, ". . . the more fry present, the less each eats, hence the slower it grows, and hence the longer it remains at a size especially vulnerable to predator attack." This observation seems appropriate here considering the heavy losses estimated for the 1962 salmon.

The high first-summer ranges of the average condition factor of salmon from both plants (1.20 to 1.38) as well as their rapid growth rates suggest a high supportive capacity by the reservoir. No summer decrease in growth is apparent from the growth curves (Figures 5 and 6), despite conditions which resulted in observed mortalities. The condition of the fish (Figure 7) increased during the summer and decreased during the winter in close correlation with seasonal temperature changes (Figure 2).

A comparison of these first-summer growth patterns to that of stream-inhabiting chinook salmon is useful. Ten down-stream migrating chinook salmon taken for this comparison from the Deschutes River in February 1962 averaged 16 grams. Breuser (5, p. 62) measured chinook salmon of the Willamette River through their first summer of growth; averaging 2.35 grams in May, the fish increased to 20.17 grams by November. These figures are similar to those on the 1962 plant at Happy Valley. Growth in cooler and smaller streams would be substantially less than in the Willamette or Deschutes, however. For example, a small sample of spring chinook salmon captured on August 16, 1961 in the Warm Springs River, a cool-water stream near Happy Valley Reservoir, averaged about 3 grams. On the same date reservoir fish averaged near 35 grams, and a year later members of the 1962 plant averaged 12 grams.

From the preceding information concerning the growth of the salmon in streams, it seems likely that members of the 1961 plant, decreasing in numbers from 30,000 during their first summer, were growing in nearly an unlimited habitat due to warm temperatures, abundant food and limited competition. Their growth during this period is similar to that of the 1959 plant after the June 1960 chemical treatment of the reservoir had drastically reduced this mixed population of chinook and coho salmon. Average weights at the time of treatment were about 32 grams and 41 grams for the chinook and coho salmon respectively (16). The fact that the coho salmon had shown the better growth indicates that they were the better competitors in the pond habitat.

Subsequent checks on the remnant population made in the early summer of 1961 indicated that the salmon had increased in weight by 500 to 600 percent, and were averaging about 200 grams (chinook salmon) and 275 grams (coho salmon). In contrast, the 1961 chinook salmon increased in average weight from 62 to only 87 grams during their second (1962) summer; competition from the 1962 plant for the available food is the probable cause of this reduced growth.

Describing the growth achieved by chinook salmon in New Hampshire lakes, Hoover (11) states that the fish generally matured at four years, by which time they averaged about five pounds. Under conditions of abundant foods in the form of smelt (Osmerus mordax), however, average sizes of 10 to 12 pounds were reached and one fish of 16 pounds was found. Hoover thus also implies a food regulation of growth, with these "land-locked" salmon being capable of growth approaching that of sea-run fish when abundant foods were present. Similarly, Johnson and Hasler (13, p. 129) depicted food and the space over which it was concentrated as a primary limiting factor for trout growth in the lakes they studied.

At Happy Valley, under circumstances of low competition, growth by first-year and second-year chinook salmon was rapid; increased size as obtained in the New Hampshire lakes, however, would likely have found restriction in the lack of a forage fish or other larger foods.

PRODUCTION

The production of a given group of organisms, as defined by Ivlev (12, p. 98-120), is the total elaboration of tissue by that group over a given time period, regardless of the fate of the tissue. Ricker and Foerster (14, p. 173-211) used this viewpoint with mathematical formulation to calculate the production of juvenile sockeye salmon in Cultus Lake. Allen (1, p. 160-217) described a graphical method of computation which is used here.

Allen's method involves the use of survival and growth curves by plotting estimated population sizes against average weights at successive intervals. The area under the curve between plottings (month intervals are used here) represents the net production for that period. The reliability of such production estimates, as pointed out by Allen, finds the lesser support in the survival estimates. Particular regard should be given here to the rather subjective distribution of the mortalities; for example, annual production of the 1962 plant could be increased in estimation by one-half if mortalities were assumed to have occurred later in the summer. As mentioned, however, the survival curves seem reliable in light of the observed character of the mortality (primarily predation). For both year classes of fish, extrapolation of the survival and growth curves was necessary in order to complete production estimates through December 1962.

Figures 8 and 9 present the production curves as described above for the 1961 and 1962 plants of chinook salmon. Total production for the 1961 plant in its first year (from planting to December 31, 1961) was 1,031 kilograms (kg.). A similar biomass--1,039 kg. --was elaborated by the 1962 salmon in their first year, with less individual growth being attained by larger numbers of fish. The yearling (1961) salmon produced only 203 kg. in 1962 due to the smaller size of the population and the limitation of growth imposed either by competition from the 1962 plant or, less likely, by the lack of suitable foods for fish of their size. The total of production by both age classes in 1962 was estimated at 1,242 kg. In both years, 75 to 80 percent of the production occurred in the June through September period (Figure 10). Similarly, two-thirds to three-quarters of the sockeye production in Cultus Lake occurred between June 15 and September 15 (14, p. 191). Gerking (9, p. 45) states that ". . . production is an event of the summer . . ." in the bluegill sunfish (Lepomis macrochirus Rafinesque) of the Indiana lake he studied. These observations simply assert the importance of the limited growing season in temperate waters.

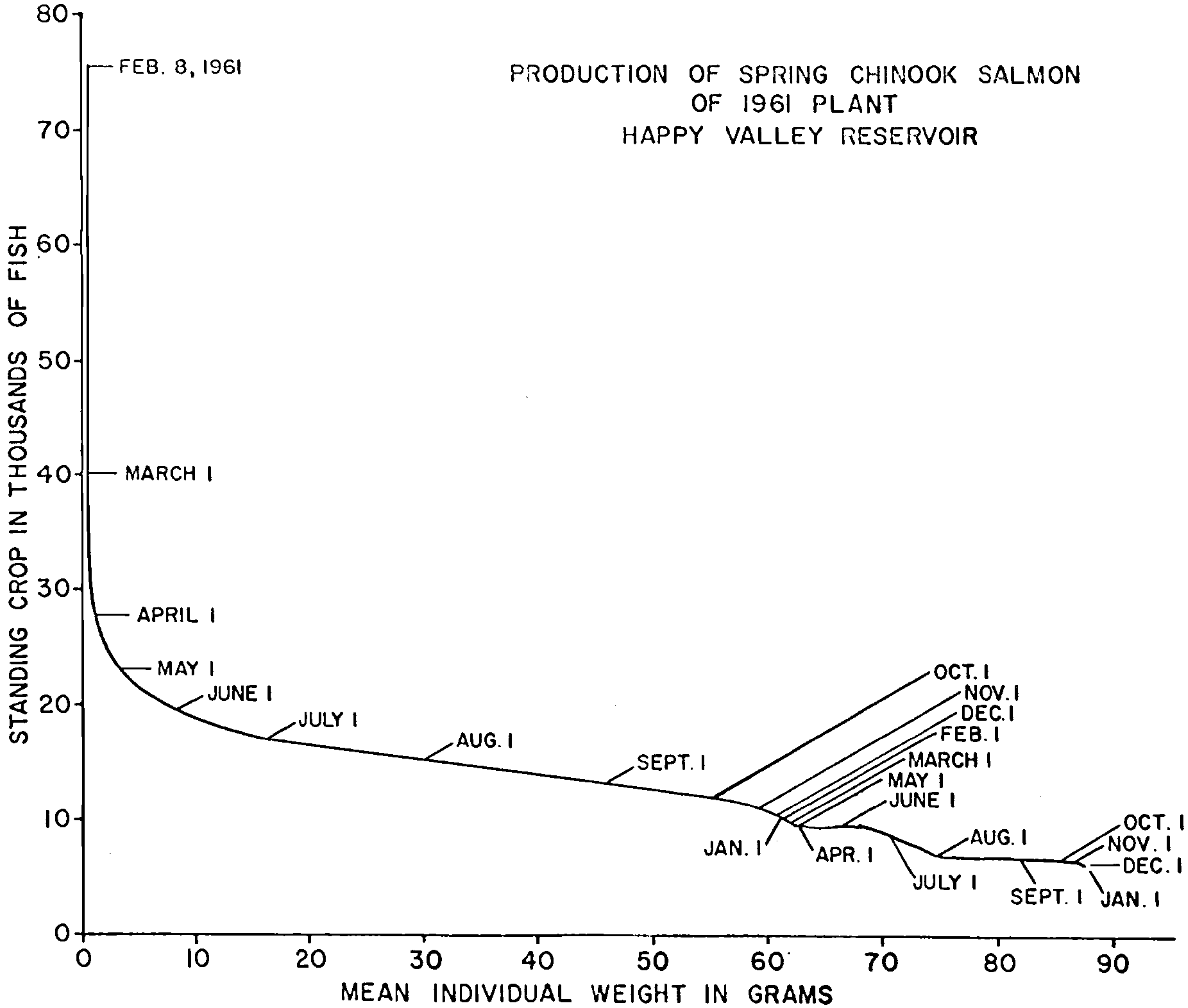

PRODUCTION OF SPRING CHINOOK SALMON
OF 1961 PLANT
HAPPY VALLEY RESERVOIR
STANDING CROP IN THOUSANDS OF FISH
MEAN INDIVIDUAL WEIGHT IN GRAMS
FEB. 8, 1961
MARCH 1
APRIL 1
MAY 1
JUNE 1
JULY 1
AUG. 1
SEPT. 1
OCT. 1
NOV. 1
DEC. 1
JAN. 1
FEB. 1
MARCH 1
APR. 1
MAY 1
JUNE 1
JULY 1
AUG. 1
SEPT. 1
OCT. 1
NOV. 1
DEC. 1
JAN. 1
0
10
20
30
40
50
60
70
80
90

Figure 8

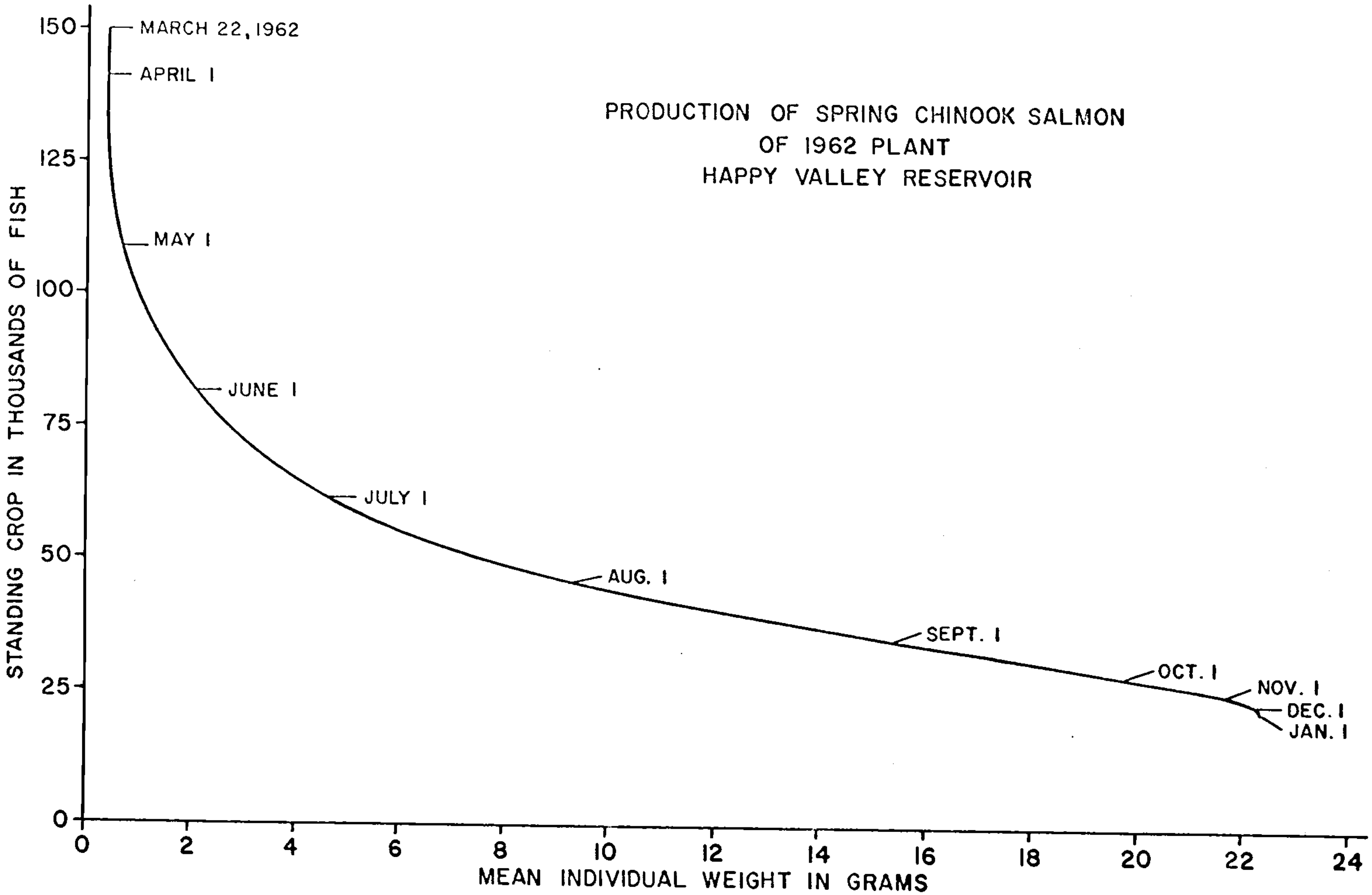

PRODUCTION OF SPRING CHINOOK SALMON
OF 1962 PLANT
HAPPY VALLEY RESERVOIR
STANDING CROP IN THOUSANDS OF FISH
MEAN INDIVIDUAL WEIGHT IN GRAMS
150
125
100
75
50
25
0
2
4
6
8
10
12
14
16
18
20
22
24
MARCH 22, 1962
APRIL 1
MAY 1
JUNE 1
JULY 1
AUG. 1
SEPT. 1
OCT. 1
NOV. 1
DEC. 1
JAN. 1

Figure 9

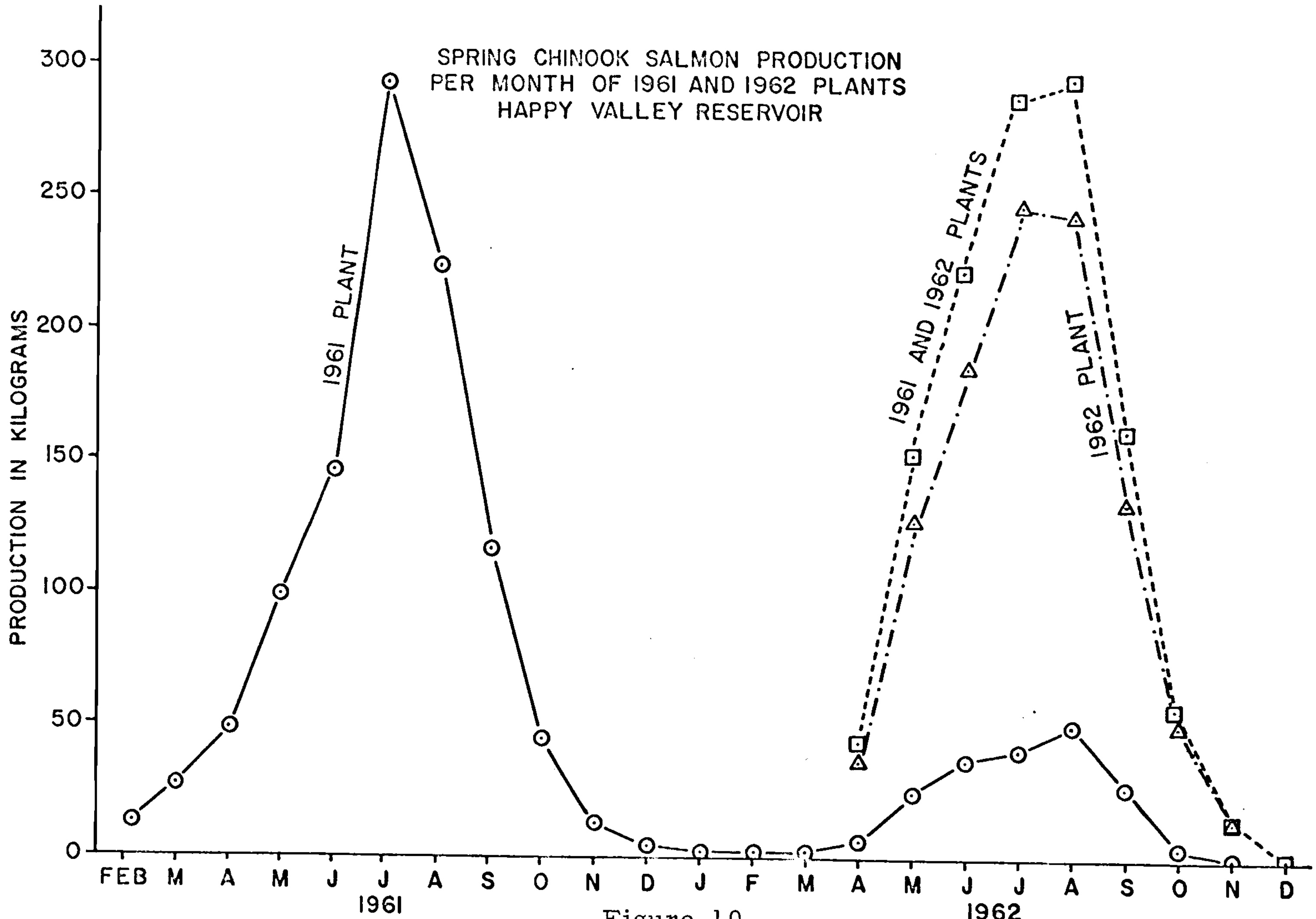

SPRING CHINOOK SALMON PRODUCTION
PER MONTH OF 1961 AND 1962 PLANTS
HAPPY VALLEY RESERVOIR
PRODUCTION IN KILOGRAMS
300
250
200
150
100
50
0
1961 PLANT
1961 AND 1962 PLANTS
1962 PLANT
FEB M A M J J A S O N D J F M A M J J A S O N D
1961
1962

Figure 10

In making comparisons of the annual production rates for Happy Valley, consideration should be given the resident rainbow trout and residual salmon of the 1959 plant. It is reasonable to assume that the trout population remained small and constant in its effect on salmon production for 1961 and 1962. Survivors of the 1959 plant, on the other hand, were disappearing from the reservoir during the summer of 1961, presumably due to the compounded effect of maturation and summer conditions. Their presence, therefore, would have exerted the greatest effect in 1961, with the result that total production of salmon was probably somewhat larger than that computed (1,031 kg.).

Further insight into the productive capacity of the reservoir may be obtained from Shelton's (16) survival and growth data on the 1959 plant. The biomass present June 1960 is estimated at 1,810 kg., assuming that the chinook and coho salmon each survived at the rate (90 percent) estimated for the mixed population. The 1,810 kg. very likely represent almost the total production, since the mortality was low and probably occurred soon after the plants were made (January 8 and 30). Allowing for growth in the early spring of 1960, total production for 1959 may be approximated at 1,500 kg.

The high productive capacity of Happy Valley is apparent when it is compared on a unit area basis with other bodies of water.

An average summer surface area of 15 acres is used in this computation due to the summer concentration of production; the resultant values are 100, 69, and 83 kg./acre/year for 1959, 1961, and 1962 respectively. These figures ignore the influence of the trout and residual salmon of the 1959 plant.

Hansen (10) measured the production of young largemouth bass, Micropterus salmoides (Lacepede), in half-acre experimental ponds near Corvallis, Oregon. These fertilized ponds showed annual production rates of up to 61 kg./acre. Gerking (9, p. 32-78) estimated bluegill production at 37 kg./acre/ year for a small Indiana lake; several age-classes of bluegills were present as were other warm water fishes.

For the large and oligotrophic Cultus Lake, Ricker and Foerster (14, p. 173-211) indicated maximum annual production of young sockeyes as 24 kg./acre, with values generally running considerably less. The midwestern dystrophic lakes of three to six acres studied by Johnson and Hasler (13, p. 113-134) supported similar production of young rainbow trout with estimated annual rates of 7.7 to 34 kg./acre. These lakes are similar to Cultus Lake in their low supportive capacity and the dependence of the resident salmonids on Entomostraca for food. Other species inhabiting Cultus Lake, however, were not included in the production estimates, whereas the dystrophic lakes contained only rainbow trout.

In comparison, fish inhabiting Happy Valley also rely heavily on Entomostraca for food (see following section), but the reservoir is highly eutrophic, and annual production rates are double or more those of Cultus and the dystrophic lakes in terms of young salmonids. In Gerking's (9) study, the character of the fish population makes the production estimate less comparable, since the value would likely have been higher among a pure population of juvenile fish. Only the production of juvenile centrarchids in the fertilized ponds studied by Hansen (10) appears to approach that of the organically rich reservoir of this study.

FOOD HABITS

The information on the food habits of the planted chinook salmon was obtained from gravimetric (dry weight) stomach analyses made on 17 samples of the 1961 salmon taken between April 1961 and November 1962. Appendix 12 contains the results of the analyses, which are summarized in Table 1 according to the average percentage composition of the stomach contents for each food type. The shells of the snails were found to comprise two-thirds of the dry weight of the animals and were accounted for accordingly.

The two most important food items were Entomostraca (primarily Cladocera) at 44.1 percent and chaoborid larvae at 15.3 percent. These organisms were taken primarily in 1961 (Appendix 12), while other organisms became more important in 1962 when competition from the 1962 plant presumably widened the range of acceptable foods. The fact that the 1961 plant fed heavily on the Entomostraca and chaoborids until the release of the 1962 plant is argument for competition rather than increased size as cause for their shift in food habits.

Emphasizing this change in food habits is a comparison of the amount of Entomostraca taken during the roughly similar periods of April 22 to October 1, 1961 and May 19 to October 6, 1962. The

Table 1. Stomach contents (dry weight) summarized for 17 samples of chinook salmon of 1961 plant, April 1961 to November 1962.

Food Type	Average Percentage Composition
Entomostraca	44.1
Aquatic Gastropoda	10.6
Zygoptera	8.5
Chaoboridae (larvae)	15.3
Chaoboridae (pupae)	0.8
Chironomidae (larvae)	0.5
Chironomidae (pupae)	6.6
Crayfish	3.1
Aquatic Hemiptera	0.9
Aquatic Annelida	0.2
Chinook salmon of 1962 plant	3.0
Amphipoda	2.4
Terrestrial	
Hymenoptera, Coleoptera, Lepidoptera	4.0

Entomostraca formed 59 percent of the food taken in the first growing season and less than 8 percent in the 1962 summer. In similar manner, chaoborid larvae fell from 35 percent in 1961 to a complete absence the following year. Benthic forms were taken more frequently in 1962, with snails, damsel fly naiads (Coenagrionidae), and pupating chironomids forming the bulk of the food.

During both summers, foraging of the salmon appears to have been restricted to the upper 10 to 12 feet of water because of oxygen stratification. Thus, the planktonic Entomostraca and vertically-migrating chaoborid larvae were taken initially, and in 1962 littoral fauna and emerging chironomid pupae were heavily preyed upon.

Studies such as those by Johnson and Hasler (13, p. 122) and Ricker and Foerster (14, p. 196) have shown the Entomostraca to be the primary food type taken by certain lake resident juvenile salmonids. The coho salmon fry of the small lake in the Kamchatka peninsula studied by Dvinin, however, fed on insects (midges and mosquitos), although older fish took some zooplankton. In a food-habit study of stream-inhabiting coho and chinook salmon juveniles, Brueser (5, p. 11-14) found mainly Diptera and Ephemeroptera nymphs. Availability probably plays a major role in these differences of food habits -- i.e. planktonic forms in a stratified lake and "drift" organisms in a stream would be available forms, with the salmon capable of eating a variety of foods.

At Happy Valley, the 1961 plant evidently found the zooplankton available in large quantities during 1961, but competition reduced this availability in 1962 and resulted in reduced growth as the year-old salmon sought supplementary foods. Cursory examinations of stomachs from salmon of the 1962 plant revealed that these fish preyed heavily on the Entomostraca during the summer of 1962; pupating chironomids also were taken in the spring. Thus, the first-year fish, due to their smaller size and greater numbers, appear to have been effective enough in their utilization of the Entomostraca that this food was little used by the second-year salmon.

DISCUSSION

High survival to the smolt stage is of primary importance in the impoundment-rearing of salmon. Undoubtedly, survival of the juvenile salmon in these studies would have been much higher had predation and the 1961 flood not occurred. Summer temperatures near their upper lethal limit (77.2° F.) and the occurrence of a summer mortality in 1961, however, imply that living conditions for the salmon were marginal. On this account, impoundments with summer conditions similar to those of Happy Valley should be considered marginal in their potential use as rearing sites, despite possible high production rates by surviving salmon.

For comparisons with other impoundments, the production rates (apparently over 70 kg./acre/year) may be used in conjunction with the water chemistry analyses; both measurements infer a high productive potential for the reservoir. The carrying capacity of the reservoir for juvenile salmon may be inferred from standing crop in biomass estimates derived from Figures 4 and 5.

On a 15 acre basis, November populations of the first-year salmon were 42 kg./acre in 1961 and 35 kg./acre in 1962. An additional 37 kg./acre of second-year salmon present in 1962 was likely approximated in 1961 by third-year salmon of the 1959 plant. The supposition that the older salmon in either year had little effect upon the carrying capacity for first-year salmon is based on three observations made for 1962: (1.) the food habits of the two year classes of fish were different, (2.) annual production of the 1961 salmon was only 14 kg. /acre as compared to 69 kg. /acre for the 1962 salmon, (3.) much of this "production" by the older fish was in reality juvenile production obtained through cannibalism.

The older fish appear to have been of primary importance as predators and not as competitors, and the yield of juvenile fish to the smolt stage may be approximated by their standing crops in November of 1961 and 1962 -- about 40 kg. /acre. The limiting factor, as in Cultus Lake (8, p. 274), appears to have been the availability during the growing season of entomostracan foods.

Assuming that 15 grams would be a desirable size for smolt-age fish, the 40 kg. /acre represents 2,700 fish as the potential yield per acre in numbers of fish. On a volume basis, comparative figures would be 5.2 kg. /acre foot or 3,500 fish/acre-foot of water. Due to summer oxygen stratification, the effective living space is estimated at 115 acre-feet for the latter computations, as opposed to the 200 acre-feet estimated for total summer volume.

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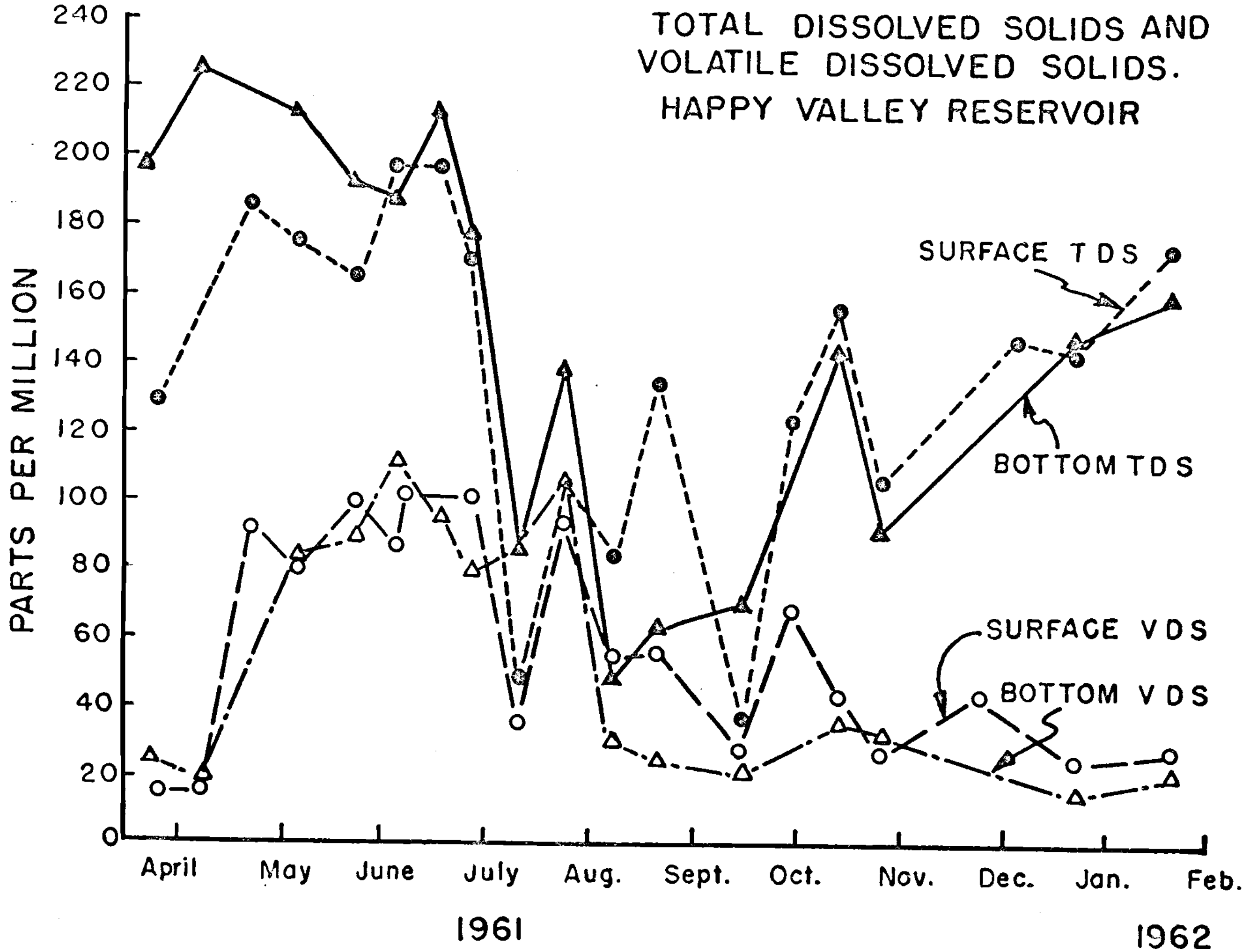
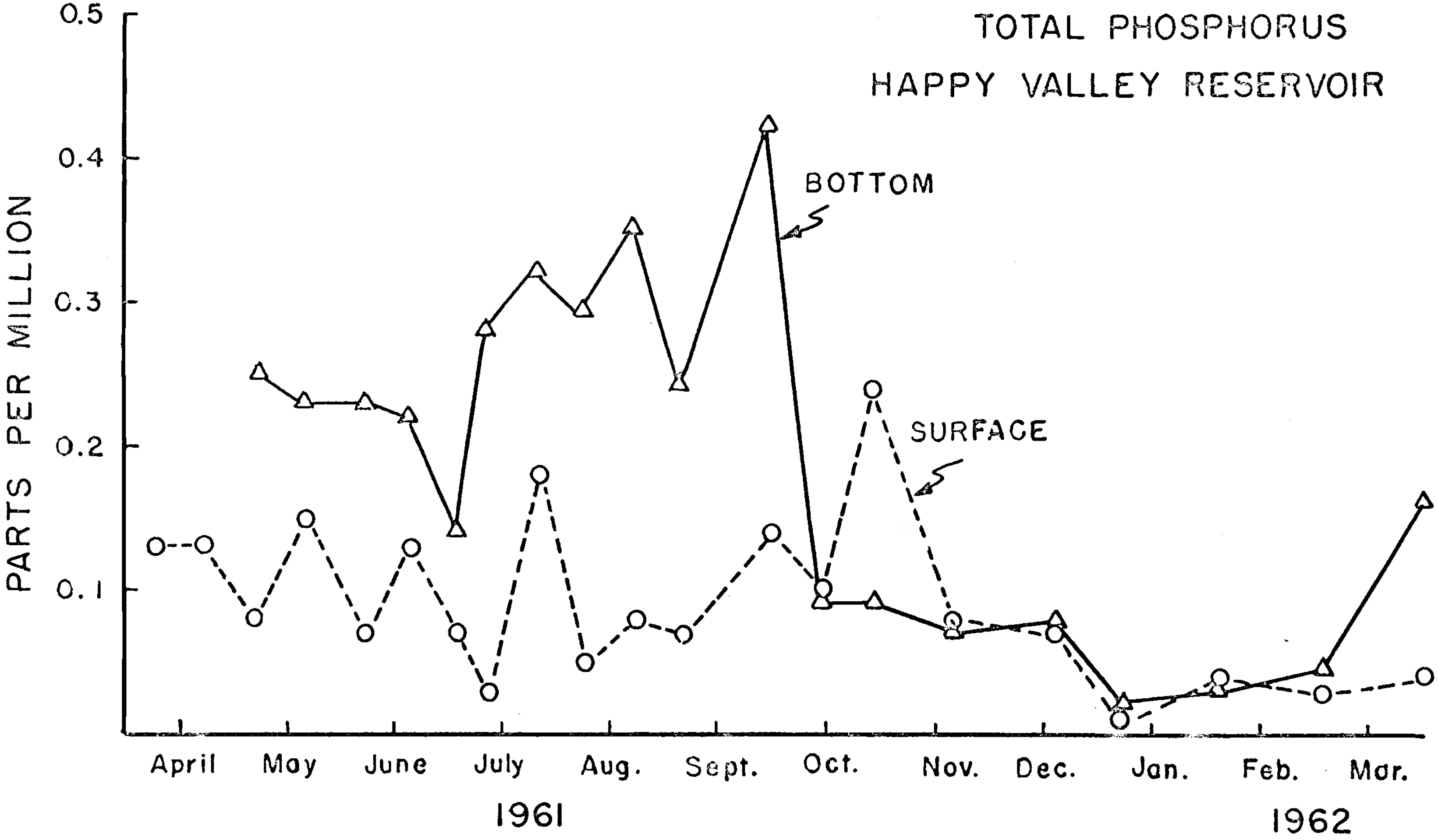
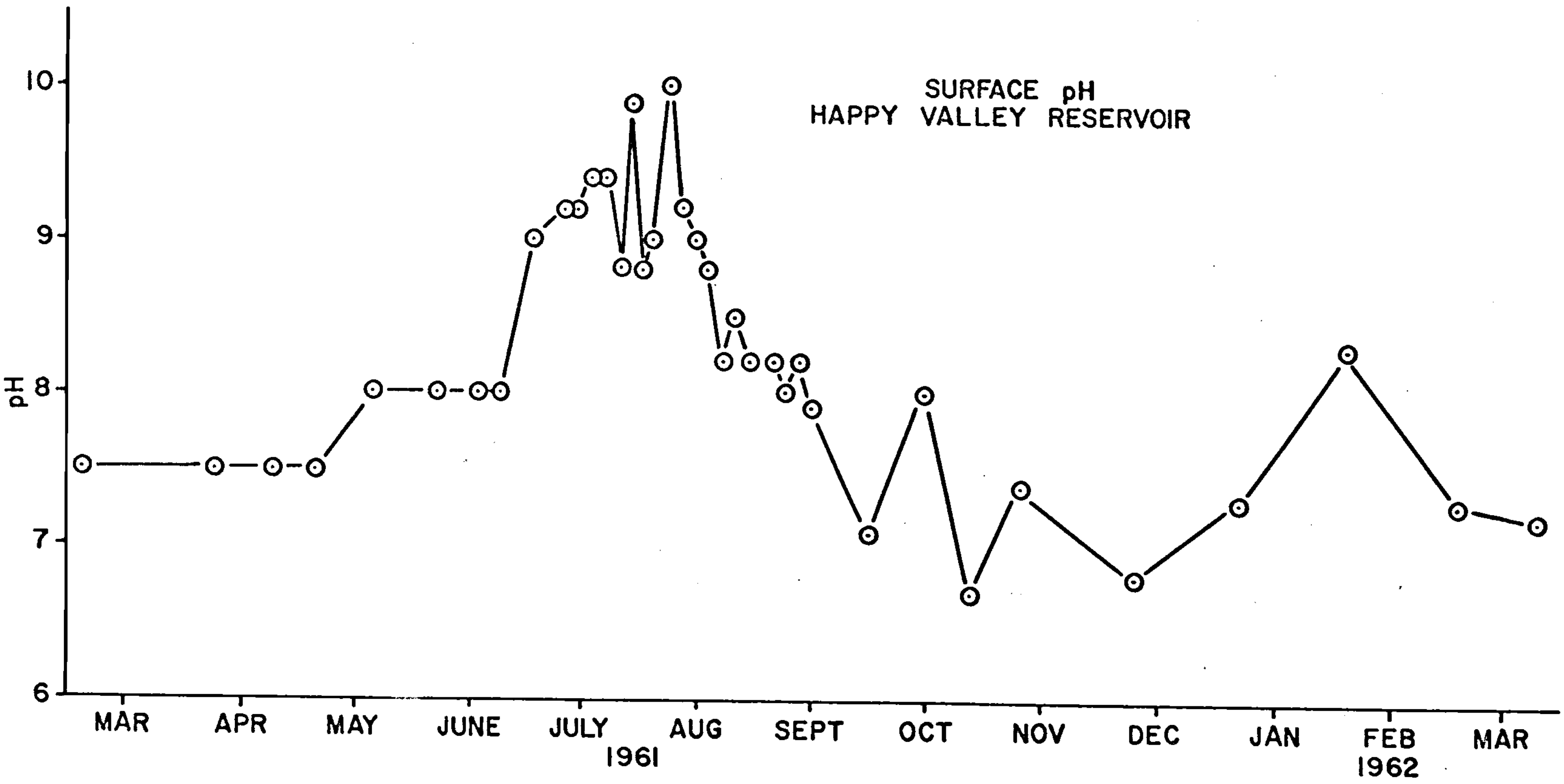
APPENDIX


TOTAL DISSOLVED SOLIDS AND
VOLATILE DISSOLVED SOLIDS.
HAPPY VALLEY RESERVOIR
PARTS PER MILLION
240
220
200
180
160
140
120
100
80
60
40
20
0
SURFACE T D S
BOTTOM T D S
SURFACE V D S
BOTTOM V D S
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
1961
1962

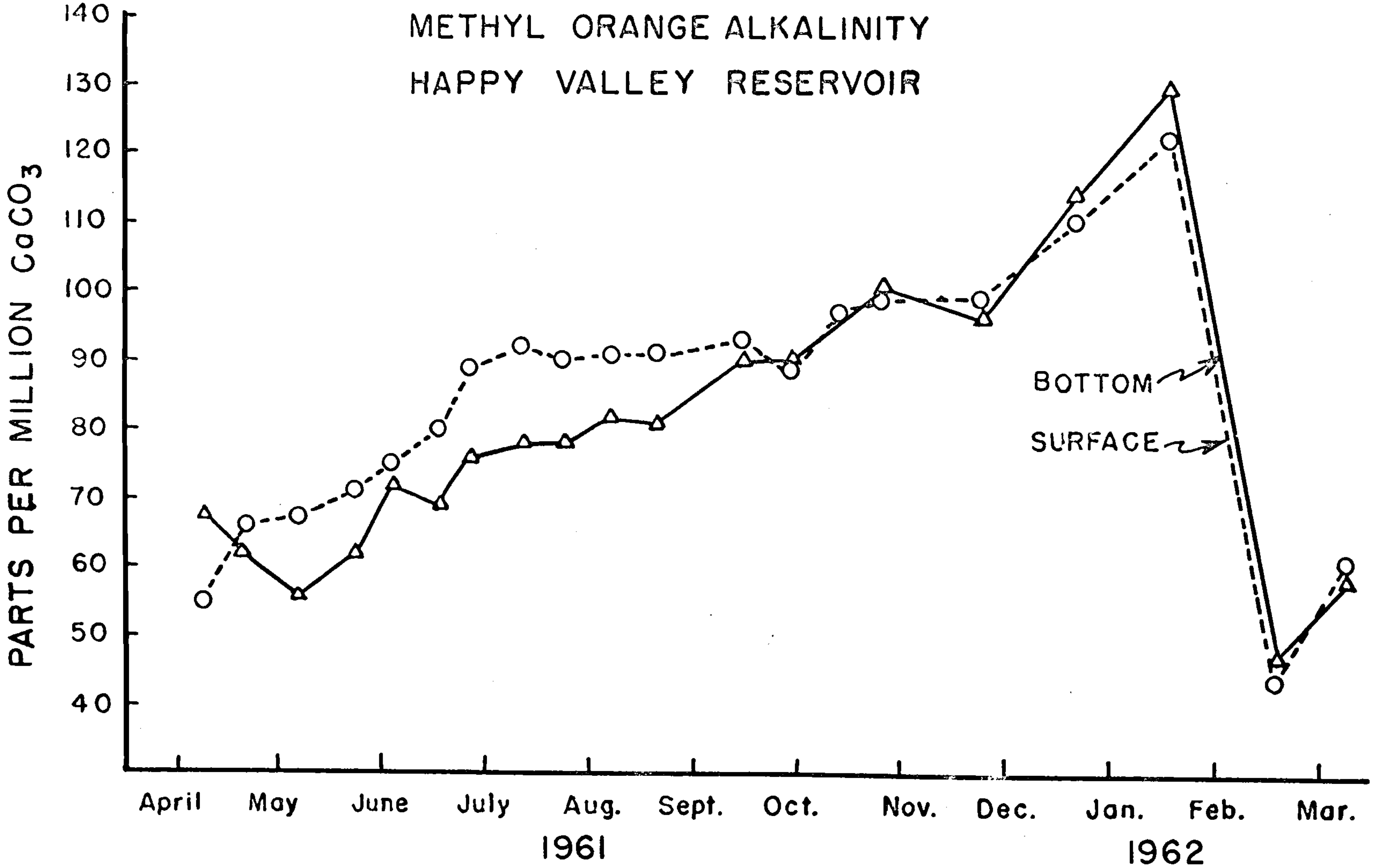
Appendix 1


TOTAL PHOSPHORUS
HAPPY VALLEY RESERVOIR
BOTTOM
SURFACE
PARTS PER MILLION
0.5
0.4
0.3
0.2
0.1
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
1961
1962

Appendix 2


SURFACE pH
HAPPY VALLEY RESERVOIR
pH
10
9
8
7
6
MAR
APR
MAY
JUNE
JULY
1961
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
1962
MAR

Appendix 3


METHYL ORANGE ALKALINITY
HAPPY VALLEY RESERVOIR
PARTS PER MILLION CaCO3
140
130
120
110
100
90
80
70
60
50
40
BOTTOM
SURFACE
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
1961
1962

Appendix 4

Appendix 5. Statistics for the estimation of standing crop in numbers of 1961 and 1962 plants of chinook salmon.

Date	Fin mark	Number marked	Marks recovered	Total catch	Estimate of population at marking time	Standard error of population estimate	95% confidence limits L	95% confidence limits U
1961 PLANT								
3-22-61	Both pelvics	984	133	3,871	28,640[1]	2,440	23,760	33,520
8-1-62	Anterior 1/3 of Anal	1,203	131	739	6,786[1]	538	5,710	7,862
1962 PLANT								
5-1-62	Adipose	5,080	143	3,461	122,950[1]	10,070	102,810	143,090
11-30-62	Posterior 1/3 of Anal	1,793	59	1,261	23,722[2]	--[3]	18,900	31,845

[1] Direct-proportion, formula taken from Rounsefell and Everhart (14, p. 90).

[2] Schnabel estimate, formula taken from Rounsefell and Everhart (14, p. 91-92).

[3] Limits set with Poisson distribution (14, p. 92).

Appendix 6. Confidence limits for mean weights of chinook salmon of 1961 plant.

Date	Mean weight grams	Sample size	Variance	Half of 95 % confidence zone	Limits L	Limits U
2-8-61	0.2[1]	24	--[4]	--	--	--
2-18-61	0.2[1]	20	--[4]	--	--	--
3-15-61	0.5[2]	32	--[4]	--	--	--
4-22-61	--[3]	--	--	--	--	--
5-20-61	6.1	51	2.86	0.5	5.6	6.6
6-30-61	20.3	33	9.01	1.1	19.2	21.4
7-31-61	29.9	37	49.23	2.2	27.7	32.1
8-28-61	25.4	52	55.90	2.1	23.3	27.5
9-30-61	54.8	30	172.67	4.7	50.1	59.5
10-28-61	61.2	24	242.28	6.6	54.6	67.8
12-9-61	64.3	47	534.24	6.8	57.5	71.1
1-6-62	59.0	30	241.53	5.8	53.2	64.8
2-4-62	63.2	29	503.01	8.5	54.7	71.7
3-20-62	72.5	14	355.42	10.9	61.6	83.4
3-23-62	59.0	49	581.84	6.9	52.1	65.9
4-15-62	71.2	22	2,190.86	20.8	50.4	92.0
5-28-62	66.5	25	516.62	9.4	57.1	75.9
5-29-62	70.7	25	173.27	5.4	65.3	76.1
7-5-62	72.2	28	78.80	3.4	68.8	75.6
8-14-62	75.4	34	88.79	3.3	72.1	78.7
9-6-62	86.6	30	127.57	4.2	82.4	90.8
10-7-62	90.9	25	239.08	6.4	84.5	97.3
10-21-62	87.0	28	145.64	4.7	82.3	91.7
11-17-62	86.3	27	205.51	5.7	80.6	92.0
12-18-62	88.1	18	74.33	4.3	83.8	92.4

[1] Weights from fish preserved in 70 percent ethyl alcohol.

[2] Weights from fish preserved in 5 percent formalin.

[3] Weights incorrectly taken.

[4] Values too small for use.

Appendix 7. Confidence limits for mean weights of chinook salmon of 1962 plant.

Date	Mean weight grams	Sample size	Variance	Half of 95 % confidence zone	Limits L	Limits U
3-22-62	0.4[1]	20	--[3]	--	--	--
4-28-62	0.6[2]	43	--[3]	--	--	--
7-18-62	7.2	40	--[3]	--	--	--
8-21-62	13.7	41	21.22	1.5	12.2	15.2
10-7-62	15.8	34	3.88	0.7	15.1	16.5
10-21-62	22.3	35	145.92	4.2	18.1	26.5
11-17-62	21.5	40	64.80	2.6	18.9	24.1
12-18-62	22.4	59	87.87	2.4	20.0	24.8

[1] Weights from fish preserved in 5 percent formalin.

[2] Average of samples taken inside and outside of barrier.

[3] Not calculated because fish weighed in groups.

Appendix 8. Confidence limits for mean lengths of chinook salmon of 1961 plant.

Date	Mean fork length cm	Sample size	Variance	Half of 95% confidence zone	Limits L	Limits U
2-8-61	3.1[1]	24	--[3]	--	--	--
2-18-61	3.5[1]	20	--[3]	--	--	--
3-15-61	3.5[2]	32	--[3]	--	--	--
4-22-61	5.5	50	--[3]	--	--	--
5-20-61	7.7	51	0.39	0.2	7.5	7.9
6-30-61	11.4	33	0.85	0.3	11.1	11.7
7-31-61	13.3	37	0.88	0.3	13.0	13.6
8-28-61	12.5	52	1.62	0.4	12.1	12.9
9-30-61	15.7	30	1.59	0.5	15.2	16.2
10-28-61	16.4	24	1.70	0.6	15.8	17.0
12-9-61	16.9	47	3.07	0.5	16.4	17.4
1-6-62	16.6	30	1.95	0.5	16.1	17.1
2-4-62	17.0	29	2.56	0.6	16.4	17.6
3-20-62	18.4	14	1.71	0.8	17.6	19.2
3-23-62	17.0	49	4.66	0.6	16.4	17.6
4-15-62	18.1	22	10.38	1.4	16.7	19.5
5-28-62	18.2	25	2.68	0.7	17.5	18.9
5-29-62	18.6	25	1.12	0.4	18.2	19.0
7-5-62	18.5	28	0.63	0.3	18.2	18.8
8-14-62	18.4	34	0.53	0.3	18.1	18.7
9-6-62	19.5	30	0.85	0.3	19.2	19.8
10-7-62	20.5	25	1.15	0.4	20.1	20.9
10-21-62	20.3	28	1.01	0.4	19.9	20.7
11-17-62	20.3	27	1.27	0.4	19.9	20.7
12-18-62	21.4	18	0.70	0.4	21.0	21.8

[1] Lengths from fish preserved in 70 percent ethyl alcohol.

[2] Lengths from fish preserved in 5 percent formalin.

[3] Values too small for use.

Appendix 9. Confidence limits for mean lengths of chinook salmon of 1962 plant.

Date	Mean fork length cm	Sample size	Variance	Half of 95% confidence zone	Limits L	Limits U
3-22-62	3.3[1]	20	--[3]	--	--	--
4-28-62	4.1[2]	43	--[3]	--	--	--
7-18-62	8.0	40	--[3]	--	--	--
8-21-62	10.2	41	0.89	0.3	9.9	10.5
10-7-62	11.0	34	0.35	0.2	10.8	11.2
10-21-62	12.2	35	4.19	0.7	11.5	12.9
11-17-62	12.4	40	2.42	0.5	11.9	12.9
12-18-62	13.1	59	3.36	0.5	12.6	13.6

[1] Lengths from fish preserved in 5 percent formalin.

[2] Average of samples taken inside and outside of barrier.

[3] Values too small for use.

Appendix 10. **Confidence limits for mean condition factors of chinook salmon of 1961 plant.**

Date	Mean condition factor	Sample size	Variance	Half of 95% confidence zone	Limits L	Limits U
2-8-61	0.60[1]	24	--[4]	--	--	--
2-18-61	0.59[1]	20	--[4]	--	--	--
3-15-61	1.08[2]	32	0.008	0.03	1.05	1.11
4-22-61	--[3]	--	--	--	--	--
5-20-61	1.31	51	0.022	0.04	1.27	1.35
6-30-61	1.32	33	0.009	0.03	1.29	1.35
7-31-61	1.25	37	0.010	0.03	1.22	1.28
8-28-61	1.27	52	0.009	0.03	1.24	1.30
9-30-61	1.38	30	0.009	0.04	1.34	1.42
10-28-61	1.35	24	0.004	0.03	1.32	1.38
12-9-61	1.31	47	0.007	0.03	1.28	1.34
1-6-62	1.26	30	0.005	0.03	1.23	1.29
2-4-62	1.26	29	0.004	0.03	1.23	1.29
3-20-62	1.15	14	0.042	0.12	1.03	1.27
3-23-62	1.15	49	0.004	0.02	1.13	1.17
4-15-62	1.11	22	0.013	0.05	1.06	1.16
5-28-62	1.07	25	0.004	0.03	1.04	1.10
5-29-62	1.09	25	0.010	0.04	1.05	1.13
7-5-62	1.14	28	0.014	0.05	1.09	1.19
8-14-62	1.20	34	0.007	0.03	1.17	1.23
9-6-62	1.16	30	0.003	0.02	1.14	1.18
10-7-62	1.05	25	0.004	0.03	1.02	1.08
10-21-62	1.03	28	0.007	0.03	1.00	1.06
11-17-62	1.02	27	0.003	0.02	1.00	1.04
12-18-62	0.91	18	0.006	0.04	0.87	0.95

[1] Measurements from fish preserved in 70 percent ethyl alcohol.

[2] Measurements from fish preserved in 5 percent formalin.

[3] Values not calculated due to lack of correct weight measurements.

[4] Values too small for use.

Appendix 11. **Confidence limits for mean condition factors of chinook salmon of 1962 plant.**

Date	Mean condition factor	Sample size	Variance	Half of 95% confidence zone	Limits L	Limits U
3-22-62	1.06[1]	20	--[4]	--	--	--
4-28-62	0.93[2]	43	--[4]	--	--	--
7-18-62	1.29[3]	40	--[4]	--	--	--
8-21-62	1.27	41	0.009	0.03	1.24	1.30
10-7-62	1.20	34	0.008	0.03	1.17	1.23
10-21-62	1.16	35	0.095	0.11	1.05	1.27
11-17-62	1.10	40	0.005	0.07	1.03	1.17
12-18-62	0.93	59	0.008	0.07	0.86	1.00

[1] Fish preserved in 5 percent formalin before measurements; weighed in one group.

[2] Average of samples taken inside and outside of barrier; weighed in three groups.

[3] Fish weighed in groups of five.

4 Not calculated because fish weighed in groups.

Appendix 12. Percentage composition by dry weight of 17 samples of stomach contents from chinook salmon of 1961 plant, April 1961 to November 1962.

	1961							1962										Aver. per- cent
	4-22	7-1	8-10	8-28	10-1	10-29	12-10	1-1	2-4	3-23	5-29	7-5	8-14	9-6	10-6	10-29	11-18	
Entomostraca	18.72	55.88	30.77	91.72	98.26	99.28	90.61	96.07	100.00	29.24				39.04				44.1
Aquatic Gastropoda															100.00		80.01	10.6
Zygoptera	0.52	0.73		0.45	1.59	0.72						3.15	68.97	60.96			8.11	8.5
Chaoboridae																		
larvae	74.91	24.18	69.23	7.83			9.39	3.93		70.76								15.3
pupae												6.49	6.92					0.8
Chironomidae																		
larvae	5.33	3.07																0.5
pupae		1.22									79.02	6.98	24.11					6.6
Crayfish												52.59						3.1
Aquatic Hemiptera		14.92																0.9
Aquatic Annelida																	3.50	0.2
Chinook salmon of 1962 plant											20.98	30.35						3.0
Amphipoda	0.52											0.44				31.31	8.38	2.4
Terrestrial																		
Hymenoptera																64.54		3.8
Coleoptera																4.15		0.2
Lepidoptera					0.15													0.0