Northwest Fish Cultural Conference

University of Washington

December 4th - 5th, 1956

H. J. Campbell

Growth Response of Trout to Lake Fertilizers

Jack Donaldson
Washington Department of Game
Seattle, Washington

As a fish cultural technique the use of fertilizers in lakes is probably the oldest and certainly the most accepted in many areas of the world. The Chinese more than 2,000 years ago first practiced aquatic fertilization. Since then it has become less of an art and more of a science, although there is still much to be learned before it can be used as a separate tool in the management of trout waters. However, the addition of elements into waters which are deficient seems as logical as the addition of fertilizers to the soil to make up for the needs in growing farm crops.

From an economic point of view a fertilization program is more than justified when compared with the high costs of maintaining a fishery by planting legal size fish. In our poorer fish producing lakes the fry (500 per pound) stocking rate is around 500 fish per acre, and at a cost of $2.25 per acre. Assuming a survival of 20%, which is probably better than average, the lake would open the fishing season the following year with 100 legal size fish per acre. This, however, is just one half of what a good producing lake of similar size would produce. Therefore, if the fish population in the poor lake is to be kept at the same level as that in the good lake a plant of 100 legal fish to the acre must be made. This would cost an additional $10.00 per acre as legal fish cost about ten cents a piece. The purpose of a fertilization program would be to enrich the waters in order to increase production to where it is possible to plant 1,000 or more fry per acre and get a better survival of bigger fish. Present efforts indicate that this increase may be brought about at a cost as low as $5.00 per acre.

With this in mind the Department of Game has initiated a program of exploratory work to determine the deficiences of various bodies of water; to determine the various types of materials needed and methods of application; and to build up a storehouse of knowledge on the physical, chemical and biological makeup of Washington waters.

A small eutrophic lake, 21.4 surface acres, 22 feet maximum depth, and 236 acre feet, was selected for exploratory work with fertilizers. This lake with its boggy margins and brown colored water due to the excessive humic acids, had a pH of 5.6; the sun penetrated to only three to four feet and there was a sharp thermocline at 7.5 feet. The fish production was fair the first year following the rehabilitation in 1952. However, in 1954 and 1955 the fish on opening day were 6.5 inches and less in length.

Since the fall of 1955, 3,200 pounds of oyster shell, $CaCO_3$; 5,300 pounds of slaked lime, $Ca(OH)_2$; and 6,900 pounds of crab meal have been added to the lake in small doses. The alkali materials were used in an effort to reduce the acidity and cause the clearing of the water by precipitating the humic acids. This was accomplished with the slaked lime. The light penetration was increased to ten feet while the pH rose to 8.3 and then steadied between 7.0 and 7.5. The clearing of the water more than doubled the inhabitable area in the lake.

On the opening day of fishing in 1956 the fish averaged 8.7 inches which is over two inches larger than the previous years. A calculation from marked - unmarked ratios and length-weight relationships showed an increase of 460 pounds of fish for the entire lake or 22 pounds to the acre. Figuring the total cost of materials and manpower expended on the fertilization at $198.00 for the first year, it can be determined that the increased fish production cost 43 cents per pound. With more efficient materials and methods it will be possible to trim this figure considerably.

The ultimate of this program is to be able to apply fertilizers to lakes known to be poor trout producers, with the expected result of a greater sustained yield of catchable fish.

Spring Chinook Salmon Holding and Spawning Operations

U. S. Fish Cultural Station
Bruce Cannady
U. S. Fish & Wildlife Service
Carson, Washington

The annual transportation of adult spring chinook salmon from Bonneville Dam to the holding pond at the Carson station for the purpose of spawning is a continuing operation begun in 1954, and continued in 1955 and 1956. The operations in 1954 were minor in nature, since the trapping facilities at Bonneville Dam were not completed until mid-summer of that year. However, 497 adults in 1955 and 500 adults in 1956, were trapped at Bonneville Dam in either April or May, and were transported to the holding pond at Carson, held until spawning time in August-September, at which time the eggs were taken from these fish.

These operations are divided into four phases: (1) The trapping and counting operations at Bonneville Dam, (2) The hauling operations from Bonneville Dam to the Carson holding pond, (3) The holding operations from the time the fish are received until the end of the spawning, (4) The spawning operations.

All phases of these operations for the past two years have been quite successful, when compared to previous activities of this nature. Two tables are appended to this report to present data for analytical purposes.

(1) The trapping and counting operations at Bonneville Dam: To establish the proper time for the capture and transportation of the adult spring chinook salmon it was determined to begin trapping operations at Bonneville Dam when the numbers of this species of fish passing this point would show an upward trend in late April or early May. In 1955 this occurred during late April, while the upswing in the counts were about two weeks later in 1956. Therefore, the counting and hauling were conducted April 19-April 27,1955; May 4-May 8,1956.

Unusual success was encountered in 1955, when sex tabulations (see Table I) revealed that 70% of the population trapped were females. No such luck occurred in 1956, as only 54% of the numbers trapped were found to be females. Although the trapping dates were later in 1956, these fish were captured at a lower point of the upward trend than occurred in 1955. This may have resulted in smaller fish being trapped, as reports from the counting station at Bonneville Dam signified that the fish passing that point were larger after trapping operations were terminated. This is supported by the evidence of the weights of females at the time of spawning operation. (See Table II). Also, a large number of jack salmon were taken this year, 44, while only 1 was captured during the 1955 operations.

(2) The hauling operations from Bonneville Dam to the Carson holding pond: This phase of operations has been highly successful during the past two years. No mortalities were experienced during the periods of transportation. About 50-65 fish were hauled in each load, depending upon the length of time required to count and trap a load of fish. The fish were hauled in our transport tanker which carries a 1,000 gallon tank with a closed venturi circulation system.

The first mortaility in 1955 occurred on May 12 or 15 days after the hauling operations were completed, and only 7 fish died during the 105 days from the termination of hauling operations to the beginning of spawning operations. In 1956, the first fish did not die until 51 days after the completion of hauling operations, and only 6 mortalities occurred during the 93 days between the end of the transportation of fish to the start of spawning operations.

Some steelhead were acquired during these initial phases in both years, and in 1956 four suckers were captured. These scrap fish were killed in the holding pond a short while after their receipt. These acquisitions are unavoidable, since all fish that are trapped are hauled and dumped into the holding pond. No attempt to segregate these fish, since it is our policy to handle the adult chinook salmon as little as possible.

(3) The holding operations from the time the fish are received until the end of spawning: An examination of Table I, reveals that the number of fish handled during this phase of operations were nearly the same: 497 in 1955, and 500 in 1956. The holding mortalities for all fish were slightly higher this year: 20% to 18%. More important, however, are the data showing the mortalities of females for 1956 to be slightly lower, 17% to 18%, than last year. The holding mortalities of males increased considerable this year; from 17% in 1955 to 24% in 1956. Why this should be higher than the female losses is unknown. Since the males are not as important as the females, this is only a minor problem.

An examination of the breakdown of female mortalities in the holding stage reveals that the number of females that spawned out in the holding pond decreased from 42% in 1955, to 34% in 1956. This seems to indicate that our pond trapping operations, water flows, and water temperatures were more favorable this year. Also, all the living fish entered the trap at the end of the season this year, while seining operations were conducted last year to capture the last dozen or so fish.

(4) The spawning operations: Spawning operations were begun on virtually the same dates in both years, August 9, 1956, and August 10, 1955, and were completed September 20, 1956 and September 23, 1955. After these two years experience it may be expected that the spawning period should extend approximately 40 days from August 10-September 20th.

As was done in 1955, the weight, length, flesh color, and scale samples were taken from all fish used in spawning operations. Evaluations of the color data have not been completed, nor have the results of the scale samples been tabulated.

An evaluation of the weights of the females show that 213 females averaged 13.0 pounds each before spawning in 1955, while 216 females averaged 12.4 pounds each in 1956. Since these constituted a large percentage of the total number, they can be used as a fair average for all females spawned. Previous observations of the fish when they were hauled in May 1956, indicated that this year's stock were generally smaller than those captured in 1955. These data bear out this prediction. However, it should be realized that these weights were taken at spawning time when the females were weighing the least because of physiological deterioration. They probably weighed twice this when they were captured.

During spawning all eggs were collected from females wherever possible. Many females were partially spent, and many were in a moribund condition. This policy necessarily lowered the average number of eggs retained after shocking. Our goal, however, was to obtain as many eggs as possible from these fish.

An examination of Table II, reveals that 1,256,000 eggs were collected in 1955, while only 907,000 were collected in 1956. The survival to the eyed stage was higher, however, in 1956, 93% this year to 90% for the last year. These results are very satisfactory when consideration is given to the fact that all eggs were taken and counted regardless of source. The number of green females killed by mistake was lowered from 3 to 1, so improvement has been made in this feature.

After the numbers of eggs collected were estimated and computed, it was found that less eggs were taken per female in 1956 than in 1955, the number averaging 4,470 in 1955 as opposed to 4,049 in 1956. It was also found that the eggs taken in 1956 were slightly larger than those taken last year, 1778 per pound to 1823 per pound. Although the females were smaller this year than last, the numbers of eggs taken per pound of female were computed to nearly the same figure, 344 to 327. When the weights of females were correlated to the average number of eggs per pound of female, these figures are found to be comparable.

To summarize it is believed that the Bonneville trapping operations were not quite as successful this year as last, since more jack salmon were captured, the average weight of females was less, and the ratio of females to males was less. These factors tended to reduce the potential number of eggs that could be collected. Most of these items are beyond our control, unless the decision was made to risk waiting until later in the run to trap the segment of fish required for our operation. However, the holding and spawning operations showed definite improvement, since our female holding mortalities were lower and our eyed egg percentage was higher.

On the basis of this report it appears that approximately 628 fish would be required from the trapping facilities to insure obtaining 1,000,000 eyed eggs. This figure is obtained by using the following formula:

(1) $\dfrac{\text{Number of eyed eggs required}}{\text{Percentage expected eyed eggs survival}} \times 100$ equals No. Green Eggs Required

(2) $\dfrac{\text{No. Green Eggs Required}}{\text{No. Green Eggs per female}}$ equals Numbers Females to Spawn Required

(3) $\dfrac{\text{No. Females to Spawn}}{\text{Female Survival Percentage}} \times 100$ equals No. Females Required

(4) $\dfrac{\text{No. Females Required}}{\text{Expected percentage females}} \times 100$ equals Total No. Fish Required

By Substitution in the above equation:

(1) $\dfrac{1,000,000}{90} \times 100$ equals 1,111,111

(2) $\dfrac{1,111,111}{4,000}$ equals 278

(3) $\frac{278}{82}$ X 100 equals 339

(4) $\frac{339}{54}$ X 100 equals 628

TABLE I

	NUMBERS		PERCENT	
	1955	1956	1955	1956
Number of Salmon Counted at Dam	517	546	---	---
Less Non Recoveries	20	46	---	---
Number Handled at Carson	497	500	---	---
Total Number of Females	346	271	70%	54%
Total Number Males (Including Jacks)	151	229	30%	46%
Total Handled	497	500	100%	100%
Total Holding Mortalities (Both Sexes)	87	101	18%	20%
Total Spawning Mortalities (Both Sexes)	410	399	82%	80%
Total Handled	497	500	100%	100%
Total Mortalities-Females				
Holding	62	46	18%	17%
Spawning	284	225	82%	83%
Total Females Handled	346	271	100%	100%
Total Mortalities-Males				
Holding	25	55	17%	24%
Spawning	126	174	83%	76%
Total Males Handled	151	229	100%	100%
Holding Mortalities-Female				
Spawned Out	26	16	42%	34%
With Eggs	36	30	58%	66%
Total Holding Mortalities-Females	62	46	100%	100%
Spawning Mortalities-Females				
Spawned	281	224	99%	99.6%
Immature	3	1	1%	0.4%
Total Spawning Mortalities-Females	284	225	100%	100.0%

TABLE II

	1955	1956
Number Eggs Collected	1,256,000	907,000
Number Eggs Eyed	1,130,401	841,479
Percent Eggs Eyed	90%	93%
Number Females Spawned	281	225
Average Number Eggs Per Pound	1,823	1,778
Average Number Eggs Per Female	4,470	4,049
Average Weight Per Female - Pounds	13.0	12.4
Average Number Eggs Per Pound of Female	344	327
Average Weight of Eggs Per Pound of Female	2.45	2.28

Diet Trials of Commercial Dry Meal Mix

Bruce Cannady
U. S. Fish & Wildlife Service
Carson, Washington

An experiment was conducted at the Carson Fish-cultural Station for ten weeks in January - March, 1956, to test a 100% commercial mixed meal diet with two liver-fish product diets. Spring chinook salmon unfed fry were used. The water temperature throughout the term of the experiment was 44 degrees. Approximately 4,865 fish were carried in each of six troughs. The liver-fish products diets were fed at levels determined by a chinook feeding chart, and the dry meal diet was fed at 50% of this level.

Results of this experiment are listed below:

Diet Composition

	III	V	Clarks Fry Feed
Beef Liver	33 1/3%	33 1/3%	
Pork Liver	33 1/3%	33 1/3%	
Salmon Eggs	33 1/3%		
Turbot		33 1/3%	
Dry Meal			100%

Results - 10 Weeks

	III		V		Clarks Fry Feed	
	3A	3B	5A	5B	Ca	Cb
Conversion	3.8	3.4	4.7	4.5	10.9	10.9
% Gain	156	165	125	126	25	24
%Mortality	0.8	1.1	3.6	1.2	3.2	2.6

Egg and Fry Cabinet

C. F. Brittain
Washington Department of Fisheries
Seattle, Washington

We first heard of an incubation cabinet about fifteen years ago, which was developed by Fish and Wildlife Service personnel at Yellowstone Park, so the idea of incubation cabinet containers with introduction of water at the top and down through the various trays or containers is an old one in fish cultural work.

These initial cabinets were used, as far as we know, for egg incubation only, as the eyed eggs were removed and placed in troughs and baskets for hatching.

Our first experience hatching fry in screened bottom trays in our standard deep troughs was carried out at Minter Creek and Green River in the fall of 1942. We were highly skeptical of the merit of such procedure, as we had been taught by early supervisors that the resulting shells from the eggs during the hatching interval would plug the successive screened bottom trays and smothered fry would result.

Our approach on the first experiments at Green River in 1942 were as follows:

Our standard deep trough consisting of 9 sections was used; each section containing five 18" X 14" X 2" trays and an 18" X 14" X 1" cover tray.

Capacity loading for each tray for salmon was at 5,000 fry per tray, or 25,000 fry per section; total capacity of 225,000 fry per deep trough.

Trough No. 1, using fly screen in all trays, contained three sections of fall chinook eggs. Trough No. 2 contained six sections of fall chinook eggs. Trough No. 3 contained nine sections of fall chinook eggs, or a full loading.

When the first appearance of premature hatching was observed through the cover tray, a special watch was maintained 24 hours per day, as we had anticipated trouble with the excess egg shells. Much to our surprise we found the shells had a tendency to disintegrate to an extent that would permit water flows through the stacks. We occasionally brushed the tops of the cover trays to free excess shells deposited there.

When the fry were weighed from the experimental troughs and placed into rearing ponds we found mortalities comparable or lower than hatching in baskets and shallow troughs. Also, we had the fry in the proper place without handling, as the previous method had been to hatch in shallow troughs and move the newly hatched fry into the deep troughs for the period required for absorption of the egg sack.

We were sure now that hatching in a screened bottom container was efficient, safe and also saved considerable effort, especially at stations where a days hatch exceeded 2,000,000 fry. This cleared away any doubts that may have delayed construction of an egg and fry cabinet.

During 1952, while attending the fish cultural school conducted by Burroughs at Leavenworth, we overheard someone ask Burroughs questions in regard to a cabinet with water flow introduced at the top for incubation and hatching blueback salmon.

It wasn't until 1953, after a discussion with our Engineering Section regarding deep troughs and hatchery capacity in relation to the square feet required, that we again had thoughts in regard to our conception of an egg and fry cabinet. The idea was further accelerated by the proposal that deep troughs could be stacked one upon another as the "only way to get more hatching space in a given number of square feet" was to go "<u>up</u>"!

At this time we immediately began designing our conception of an egg and fry cabinet that would answer our requirements at the average salmon station.

Initial reasoning and funds available dictated the following:

(1) Cabinets should have a capacity of approximately 100,000 fry with floor space held to approximately 4 square feet per cabinet.

(2) The proto type would have to be constructed of wood using water-proof marine plywood and utilizing the conventional deep trough tray.

(3) Overall height should not exceed seven feet, operator using a moveable step or platform for reaching the higher portions of the cabinet.

(4) Each tray should have an upwelling action so that possible dead pockets in each tray would be held at a minimum.

(5) Inflow and outflow from each tray should both be located at one end so that any tray could be removed and the remainder of the cabinet would continue to operate.

(6) Each tray should have a screened cover to prevent loss of fry over spillways.

(7) Each tray should contain a plug or stopper so that each tray could be dewatered.

(8) Each tray should contain a device with which to remove silt that would accumulate under each fry compartment as we have, at most of our stations during high water periods, severe mud and debris problems.

(9) Cabinets must be constructed in sections of 4 units for mobility and the various water heads available.

This wood proto type was a result of the above thinking.

OXYGEN TESTS
EGG & FRY CABINET VS. DEEP TROUGHS

Water 50° F. approximately
Test Animals Used Were Silvers at 52 per pound

	Pounds of Fish	Container	Flow	Do Hi Reading	Do Low Reading
	100	Egg & Fry Cabinet	15 GPM	10.0 ppm	8.7
	100	Deep Trough	15 GPM	9.8	5.2
	100	Egg & Fry Cabinet	10 GPM	9.9	8.3
Loading cut ----	60	Deep Trough	5 GPM	9.6	2.9
due to oxy-	100	Egg & Fry Cabinet	$2\frac{1}{2}$ GPM	9.9	3.5
gen starva- tion.	---	Deep Trough - Not run - Fish liberated due to oxygen starvation.			

After operating the proto type for one season, we found it very successful and it caught the imagination of hatchery operating personnel. We have found that there is generally a very good reason operating personnel will not go along with some of the new ideas. If the change saves time, hatchery people will welcome it, if not, interest soon lags (and that is putting it mildly).

We now had a workable cabinet and could conceive that such a cabinet would be useful as:

(1) A space saver
(2) A water saver
(3) A mobile light unit for field eyeing and hatching of salmon.
(4) A possible egg sack fry hauling unit using a water container and pumping water to units from the water chamber.
(5) An auxiliary hatching unit at any hatchery having a fry capacity shortage.
(6) Having versatility due to possible use in 1, 2, 3 or 4 stacks high where height of water head was a critical factor, at point of possible use.

The ideas for fabrication of a proposed all aluminum cabinet, using perforated aluminum sheet (3-S) with .003 diameter holes at 42 per square inch, was drawn by our drafting section and placed out on bid. Prices on each unit stack of 5 complete with stand ran from $1,200.00 to $700.00. The first designed all aluminum cabinet, after much changing to cut costs, was bid in at $516.00 for a 4 unit stack of 20 trays with capacity of 100,000 fry.

About this time Mr. Roberson, of L. N. Roberson Company became interested in the cabinet on the basis of plastic outer tray and aluminum fry compartment. The above cabinets were constructed in minimum numbers and tested in the field. Results of the above tests indicated problems with the aluminum due to oxidation or electrolysis or both. We presently are working with Mr. Roberson in hope that an all plastic cabinet tray can be developed to sell for a price that will make them available to interested parties who may have use for such cabinets.

Costs:

Fully equipped deep troughs vs. eggs and fry cabinet

1 cabinet egg and fry -----	$500.00
1 deep trough --------------	$376.00

Concrete deep troughs with trays, cover trays, knurled studs, etc., in place, in hatchery.

We do not propose eliminating present hatching methods, due to the cost, but would suggest the egg and fry cabinet will take its place along with other methods for incubation of trout and salmon eggs through to the feeding period.

Plans and specifications for the newly developed, all plastic trays and metal cabinets can be obtained from L. N. Roberson Company, 1539 East 103rd Street, Seattle 55, Washington.

Note:

Capacity for the above cabinet for fall chinook or silver salmon should be a maximum of 5,000 eggs or fry per tray, 25,000 eggs or fry per stack of 5 and 100,000 eggs or fry for the 4 unit cabinet. Flow of water, considered to be adequate for salmon eggs or fry, is 3 to 5 G.P.M. at normal temperatures.

Protein Requirements of Salmon

—Clun Hood R.
Keystone 8-222

John E. Halver
Salmon Nutrition Laboratory
Cook, Washington

Diet experiments with chinook salmon (Oncorhynchus tshawytscha) at two different water temperatures (46°F. and 58°F.) using isocaloric diets at different protein levels have indicated a difference in growth response at comparable protein levels for the two temperatures. The protein component fed was a casein-gelatin mixture supplemented with crystalline amino acids to approximate the amino acid composition of whole egg protein. Variations in protein levels were arranged by adjusting the protein and carbohydrate components while leaving all other ingredients constant.

Plots of percentage weight gains versus protein content of the diet for each two-week feeding period resulted in a series of straight curves with positive slopes at the lower levels and inflection points at one protein level. The inflection point where the slopes of the curves inverted was at a different dietary protein content for the two water temperatures with the warmer environment indicating a greater protein demand.

Comparative Histological Studies of Wild and Hatchery Salmonid

W. T. Yasutake
Salmon Nutrition Laboratory
Cook, Washington

It has been suspected for quite some time that there are differences between wild and hatchery reared fish. The present study was designed, therefore, to investigate if histological differences are common characteristics of wild and hatchery salmonids.

Histological examinations were made from the fish samples collected from streams and hatcheries located in Washington and Oregon. The tissues were evaluated for (1) liver fat, (2) pancreatic and visceral fat, (3) indications of disease, (4) degree of parasitism, and (5) presence of ceroid.

With few exceptions the liver, pancreas and viscera of the hatchery fish were rated as more fatty than wild fish. These differences were present in very young hatchery fish and became more extreme as the period of hatchery rearing increased. Wild fish had more ceroid deposition indicating that the fatty acids of this group were more highly unsaturated. There were little differences in disease incidence, but parasitism was more pronounced in wild fish.

A Chemical Comparison of Wild and Hatchery Salmonids

A. N. Woodall
Salmon Nutrition Laboratory
Cook, Washington

Proximate (protein, fat and ash) analyses were conducted on 129 samples of wild and hatchery reared salmonids collected throughout Washington and Oregon. Nine species were represented in the samples. Each sample consisted of approximately 500 grams of fish. Mean values of the analyses of the hatchery samples were compared statistically with the wild samples for each species and for each group within a single species. The hatchery samples generally showed significantly higher fat and lower protein and ash content than did their wild counterpart.

A Simple Method of Amino Acid Determinations of Fish Food

Warren E. Shanks
Salmon Nutrition Laboratory
Cook, Washington

ABSTRACT

The qualitative requirements of chinook salmon are known and in the near future the quantitative requirements will also be determined.

To fully utilize this information, extensive analysis of diets and adequate quality control measures will be required to ensure maintenance of the proper levels of these nutrients in fish food.

A review of existing methods of amino acid analysis is in order. Of the analytical procedures available, paper chromatography appears to be the most rapid and economical. It should be possible to analyze a protein for the ten essential amino acids in approximately the same time required for a single microbiological analysis.

Chromatographically separated amino acids can be measured quantitatively by photometry. The concentrations of specific amino acids in the sample can be determined by interpolation on standard curves from known concentrations run simultaneously with the unknown.

Demonstration chromatograms and standard curves of four amino acids were presented.

A Rectangular-Recirculating Rearing Pond

Roger E. Burrows
U. S. Fish & Wildlife Service
Entiat, Washington

A rectangular-recirculating rearing pond has been developed and the preliminary testing of the prototype completed. This pond is 50 feet long and 16½ feet wide with a 6-inch center wall, 2 inflows, and a center outlet. It employs turning vanes to direct the water flow.

The pond was developed to meet the requirements established as critical in previous investigations. The hydraulic characteristics were determined from model studies and the biological evaluations made in the prototype. Results of the biological evaluations are given in the following table:

Comparison of Rectangular-Recirculating and Foster-Lucas ponds:

	Rectangular	Foster-Lucas
Stocked 6/20/56	175.5 lbs.	175.5 lbs.
Weight 10/7/56	1,320 lbs.	1,331 lbs.
Water Capacity	2,100 cu. ft.	4,450 cu. ft.
Pound/Cu. Ft.	0.63 lbs.	0.30 lbs.
Inflow	160 gpm.	200 gpm.
Pound/GPM	8.25 lbs.	6.65 lbs.
Mortality	324 fish	325 fish
Percent Mortality	1%	1%
Disease Treatments	None	10-day PMA

One of the most significant results of this evaluation was the disease inhibiting quality of the rectangular pond. Over the three month period no disease treatments were necessary. The Foster-Lucas control pond, on the other hand, developed bacterial gill disease three weeks after stocking and required continued treatments at 10-day intervals with PMA to hold the disease in check.

The flow pattern and current velocity of the rectangular pond was such as to deliver 90 percent of the debris and excrement to the outlet screens with only the heaviest particles settling along the center wall. As a result the pond could be effectively cleaned in 10 minutes with a small brush.

Current velocities within the pond varied from 1 foot per second at the ends to 0.2 foot per second along the center wall. Floating feeds distributed evenly throughout the pond.

This preliminary evaluation has not determined the optimum carrying capacity of the rectangular pond. It is obvious, however, that it is far in excess of that of the Foster-Lucas. The indications are that the rectangular pond will have a potential in excess of 2,000 pounds per pond or 13 pounds of fish per gallon of water inflow. Evaluations on this basis will be made in 1957.

The Effect of Controlled Light On Sexual Maturation of Adult Blueback Salmon

Roger E. Burrows
U. S. Fish & Wildlife Service
Entiat, Washington

An experiment in which adult blueback salmon were subjected to a shortened period of artificial light as compared to natural daylight resulted in an acceleration of sexual maturation. Spawning was advanced 19 days in the lot of fish subjected to 9½ hours of artificial light when compared to the lot exposed to natural daylight. A comparison of the mortalities and overall production of the two lots is shown in the following table:

	Control Pond	Reduced Light Pond
No. of females	39	34
Mortality	12	5
Percent Mortality	30.8%	14.7%
No. of eggs taken	79,725	82,277
Percent green egg mortality	3.8%	12.5%
No. of eyed eggs produced	76,689	72,006
Potential egg supply	112.827	98,362
Percent total survival	68.0%	73.2%

Although the green egg mortality appears to be higher in the experimental group than in the control lot the difference is not statistically significant. The increased female survival in the experimental group more than compensates for the increased egg mortality.

Light, not temperature appears to be the prime factor effecting acceleration of sexual maturation. In this experiment the reduced light group began spawning 19 days earlier and at a two degree warmer water temperature than the control group. The time of spawning in the control group in this experiment and a similar one in 1955 was essentially the same although the temperature was 2.5° lower in 1955.

An Evaluation of Bound Diets

Bobby D. Combs
U. S. Fish & Wildlife Service
Entiat, Washington

The diet binding experiments conducted at the Entiat Salmon Cultural Laboratory in 1956 were designed to compare the growth rate of fish fed a test diet of different consistencies: one unbound, one bound with salt alone and several bound with commercial binding agents in combination with salt. The test diet consisted of 12.5 percent each of hog liver and beef lung, 25 percent arrow-toothed halibut, 40 percent salmon viscera, and 5 percent each of seal meal and distiller's solubles.

A colorimetric method of determining degree of bind was developed to determine the optimum amounts of the commercial binders to add to the test diet. The addition of salt increased the effectiveness of every binding agent tested. The various binding agents and percentages of each used may be found in table 1.

The results of the experiment may be summarized as follows:

1. A colorimetric method for determining the degree of bind of hatchery diets has been developed.

2. Bound diets proved much more efficient than an unbound diet. Over 100 percent greater gain was produced by most of the bound diets as compared to the unbound diet.

3. The diet containing Jaguar, although well bound, produced significantly less growth than the other bound diets.

4. The test diet bound with salt alone produced as much growth as the same diet bound with commercial binders. The added cost of commercial binders cannot, therefore, be justified since good, nutritious diets which are easily bound with salt alone can be designed.

5. Diets containing CMC or Carbopol in sufficient quantities to produce a good bind were very stiff and difficult to feed.

TABLE 1. -- Evaluation of Binding Experiment

Diet No.	1	2	3	4	5	6	7	8	9
Binder Used	None	Salt 2%	CB-35 2% Salt 1%	K-707 2% Salt 1%	CMC 2% Salt 2%	Jaguar 2% Salt 2%	Kelcosol 2% Salt 2%	Kraystay 2% Salt 2%	Carbopol 2% Salt 1%
Cost of Binder Per Pound of Diet	0.00	0.0004	0.0068	0.0043	0.0154	0.0112	0.0264	0.0304	0.0502
Percent Gain	81.0	171.9	168.6	158.9	164.6	114.8	169.2	178.8	167.1
Conversion	4.55	2.50	2.60	2.75	2.66	3.38	2.62	2.48	2.58
Cost per Pound of Diet	0.0700	0.0704	0.0768	0.0743	0.0854	0.0812	0.0964	0.1004	0.1202
Cost per Pound of Fish Produced	0.3185	0.1760	0.1997	0.2043	0.2372	0.2744	0.2525	0.2490	0.3101

Relationship Between Water Temperature and Time of Hatch of Chinook Salmon Eggs

Bobby D. Combs
U. S. Fish & Wildlife Service
Entiat, Washington

The time of hatch of 32 lots of chinook salmon eggs incubated at constant temperatures ranging from 37° F. to 60.0° F. were available for analysis. These data demonstrated a close correlation between water temperature and time of hatch. The theory of thermal summation proved valid within this temperature range providing that a threshold temperature of 31.5° F. was used to calculate the thermal units. The number of thermal units per day multiplied by the number of days required to hatch produced a constant with insignificant variation between temperatures. The 99 percent level of hatching proved to be the most reliable statistic indicating that precocious hatching affected both the 1 percent level and the midpoint in time of hatch. Precocity was most apparent at the extremes of the temperature range tested.

A Progress Report on Tuberculosis and Kidney Disease Research

James W. Wood
Oregon Fish Commission
Portland, Oregon

Tuberculosis

A total of 6.1 percent of the 2,547 adult spring chinook salmon returning to the hatchery egg collecting station on the Middle Willamette River in 1956 were found to be infected with tuberculosis. The tubercular fish were not found to be as capable of surviving the holding period preceeding maturation as were non-tubercular fish. It is possible that this differential mortality rate commenced prior to the time the fish arrived at the Dexter holding ponds.

Five groups of 1951 brood year spring chinook salmon were marked and released in the Middle Willamette in a time of release study. Most of these fish returned as four-year-olds in 1955 and five-year-olds in 1956. As shown in Figure 1, all of the fish examined from the three groups reared 8 to 12 months at the hatchery were found to be tubercular while only 5 of the 19 fish examined that were reared 3 to 5 months at the hatchery had tuberculosis. This suggests that the length of the rearing periods affects the incidence of tuberculosis in hatchery reared fish. It is interesting to note that there were no mature females among the returnees from the three groups of marked fish with the longest hatchery rearing periods. The only females observed in these longer reared fish were 4 D-LV and 1 LP marked females with grossly undeveloped egg skeins.

Table 1. Tuberculosis in the 1951 Brood Year Marked Spring Chinook Upon Their Return to the Middle Willamette River.

Mark	Number of Fish Released	Length of Rearing Periods (months)	Number of Fish Returning			Number of Tubercular Returnees		Number of Mature Females	
			1954	1955	1956	1955	1956	1955	1956
D	32,000	3	0	3	4	2	1	0	2
LV	32,000	5	1 (1)	5	7	1	1	1	4
LP	32,000	8	0	1	0	1	0	0	0
An	31,000	10	0	1	1	1	1	0	0
D-LV	221,000	12	1 (1)	12 (2)	2	11	2	0	0

(1) Jacks, not examined for tuberculosis
(2) Only 11 examined for tuberculosis

It is probable that tuberculosis is a hatchery caused disease as tuberculosis was found in all of 235 marked silver salmon returning to two hatcheries while none of 184 "wild" silver salmon examined from Tenmile Lake were tubercular.

Chinook salmon caught by the gill net fishery in the Columbia River during February and May were examined for tuberculosis. Approximately 12 percent of those examined in February and 10 percent of those examined in May were found to be tubercular. The use of the viscera of these fish for hatchery food greatly enhances the probability of hatchery reared fish contracting the disease.

Kidney Disease

Kidney disease was found in 21.1 percent of the 2,547 adult spring chinook salmon returning to the egg collecting station on the Middle Willamette River in 1956.

As in 1955, controlled experiments in 1956 demonstrated that kidney disease could be transmitted by feeding to young chinook salmon.

Five antibiotics (potassium penicillin, procaine penicillin, aureomycin, terramycin, and bacitracin) and one sulfonamide (Gantrisin) were fed to paired lots in a controlled experiment at a level of 2 gm./100 pounds of fish in a diet containing 50 percent salmon flesh and viscera from infected adult salmon. This was done in an experiment to discover drugs other than sulfamethazine that would block the transmission of kidney disease by feeding. Sulfamethazine has previously proven successful in preventing the transmission of the disease by feeding, however, some question has arisen as to the advisability of feeding sulfamethazine over an extended period.

Disease Control Studies

Robert R. Rucker
Fish and Wildlife Service
Seattle, Washington

The prevention of disease is the most desirable method of control. A number of cases of sunburn on fish, which should be germane to this subject, have been brought to my attention in the last few years. One in particular was at Spearfish, South Dakota. Tremendous numbers of the rainbow, brook and brown trout were dying at the station. The mortality on the eight-inch rainbows alone, for instance, in a group of a little over 150,000 fish on September 3rd., was 700; on September 4th, 7,000; September 5th, 17,000; and the mortality peaked on September 6th, with 28,000 fish dying--this was twenty percent of the population. The appearance of the lesion on the fish was first a sloughing of the mucus on the back between the head and the dorsal fin. Later, the epithelium peeled and then the chorium was exposed. Often the chorium broke, exposing the muscle, which on occasion became necrotic, forming a definite lesion in the muscle tissue. Types of therapy for possible bacterial infections had been employed in unfruitful attempts to control this lesion. Roccal, malachite green, copper sulfate, formalin, and some of the sulfonamides were used. None of them proved efficacious. This type of lesion is known to follow excess use of phenothiazine. At the Spearfish stations phenothiazine had been used at 14 grams per 10 pounds food in half of the food fed to the fish on August 29, 30, 31, and September 1, and it was about five days after this that the mortality started increasing so drastically. A similar type lesion might be attributed to a nutritional deficiency as lack of one of the vitamins or to a myxobacterial infection as <u>Cytophaga psychrophila</u>. The temperature at the station was always maintained at 52° the water supply being from springs. An examination of the fish did not show the presence of parasites that could cause this type of lesion. Pathogenic bacteria were not found on direct examination nor culturing. An experiment was set up using healthy fish and injecting them with suspensions from the lesions and suspensions of kidney material. The results of these experiments were all negative. No organism was found associated with the disease. Fish in the ponds, however, did show the presence of a secondary fungus. This was controlled somewhat by the use of malachite green at a concentration of 1:200,000 for one hour.

An experiment to test the effect of shade and a black dye in the water was carried out this year. Three raceways were stocked with brown trout, each received 150 pounds of fish or a total of 8,835 fish. A strip of canvas was suspended over one, so partial shade was available. Another raceway was given a solution of nigrosin daily from 8:30 a.m. to 4:30 p.m.; the third section was left unshaded. The experiment was started on May 24, 1956. By early July there were definite sunburn lesions in the unshaded section. By August 10th, sunburn lesions were observed in the nigrosin treated section, and on September 13th, the experiment was terminated with no sunburn lesions in the raceway with the strip of canvas. At this time there were some lesions in the nigrosin section and many lesions in the unshaded section. The mortality in these fish was not excessive. The total number of fish in the three groups at the end of the experiment was: for the canvas 8,476, nigrosin 8,310, and for the unshaded section 8,402. The weights of each of the groups were relatively similar, being 513, 512 and 530 pounds respectively. The experiment indicates that the exposure to sunshine is probably the cause of these lesions. The lesions develop but apparently do not in themselves kill the fish. The fungus infections or other secondary pathogens often cause the mortality. Even with the low water temperatures at this station, the cold-water myxobacteria apparently were of no consequence.

A call was made recently to the Creston, Montana Station because the cutthroat trout fingerlings were dying in excessive amounts. The lesion on these fish was similar to the one at Spearfish, South Dakota, appearing as a necrotic area between the head and the dorsal fin. No pathogens or cause of mortality could be found other than attributing this lesion to ultraviolet radiation or sunburn. Previously, shade had been used on these ponds, but in recent years it had been removed. The shade was returned to the ponds and the condition cleared up.

The Coleman, California Station at one time lowered the water level during the day in the ponds to give a greater flow of water over the fish. By reducing the depth of the water in the daytime, fish developed a lesion on the backs similar to the sunburn lesion. In California it is called back peel. To alleviate this condition, the ponds were maintained at the full level throughout the day. The lesions disappeared and did not reappear, indicating that they were caused by the sunshine on the fish in the shallow waters.

Therefore, the control of sunburn or back peel caused by excess ultraviolet radiation can be controlled by the provision of shade, not necessarily over the whole pond, but shade available to the fish. A spray over the surface of the water or breaking the surface of the water might also be considered as a control for sunburn.

Progress Report on Fish Disease Studies

B. J. Earp
Washington Department of Fisheries
Seattle, Washington

Treatment Losses

Undue losses among fall chinook fingerlings occurred at two hatcheries of the State of Washington Department of Fisheries following treatment with Lignasan, and for which the cause was not definitely established. In both instances the affected fish had been reared approximately seventy days in fresh water and were infected with bacterial gill disease.

At the Nemah hatchery, 108,000 fingerling fall chinook were treated with Lignasan at 1:500,000 in a Foster-Lucas type pond (80' X 20') with the water at an average depth of six inches. Total weight of the fish in the pond was between 450 and 600 pounds and the temperature of the water was between 50°F and 56°F. Following the one hour treatment 17,846 fish were lost or 16% of the population.

At the Issaquah hatchery 430,000 fingerling fall chinook in four ponds of the same type were treated in exactly the same manner. Weight of the fish in each pond was approximately 480 pounds and the temperature of the water was between 52°F and 62°F. The fish became markedly distressed after one-half hour of treatment and the water supply was turned on. Total loss in the four ponds following treatment was 332,121 fish or 77% of the original population.

The following day the same type of fish were treated in troughs for one hour periods in Lignasan at 1:500,000 and at 1:250,000. No losses occurred in either dilution. Approximately 1,000 fingerlings were then treated in a standard pond at 1:500,000 in six inches of water. No loss occurred after one hour of treatment.

It would appear that a lack of oxygen may have been the prime cause of loss although losses from this cause were unexpected in view of the relatively light pond populations and moderate water temperatures.

A similar kill was experienced at the Green River hatchery the previous year following treatment of fall chinook salmon (reared 80 days) with formalin at 1:5,000 dilution in a standard pond having an average depth of six inches. Total weight of fish in the pond was 570 pounds and the water temperature on the day of treatment was between 48°F and 56°F. Losses following treatment were approximately 2,000 fish out of 113,000 or a loss of 1.8%. The following day a similar pond was treated with formalin at 1:5,000 but with the depth of water at one foot instead of six inches. No undue mortalities occurred. Additional fish, treated in troughs with formalin at 1:4,000 did not suffer any mortality.

Further tests will be conducted to determine if Lignasan exhibits any adverse effects on fingerling fall chinook salmon of this age group, or if this species is particularly sensitive to treatment in general at this age period.

Kidney Disease Studies

The feeding of a prophylactic dosage level of Sulfamethazine (Sulmet, Lederle) to silver and spring chinook salmon at the Klickitat hatchery for the control of kidney disease was continued during 1956 for the third consecutive year. This hatchery has a history of severe infection with kidney disease dating back to 1951 when the hatchery was first put into operation.

Silver salmon stocks of the brood years 1950, 1951 and 1952 sustained rearing losses of 42%, 39% and 47% respectively from kidney disease. Experiments conducted at the hatchery in 1953 indicated that a low level dosage of 2 grams of Sulfamethazine per 100 pounds of fish fed daily throughout the rearing period would control kidney disease so that losses from the disease were very low.

The 1953 brood of silver salmon and subsequently the broods of 1954 and 1955 were maintained for the entire rearing period on the prophylactic dose of 2 grams Sulfamethazine per 100 pounds of fish per day. Losses in the 1953 brood for the rearing period was 7%. The 1954 brood of silver salmon were divided equally and one half put on the prophylactic dosage at the start of the rearing period while the other half was untreated as a control. By September, losses in the untreated groups were significantly higher than in those receiving prophylaxis and symptoms of kidney disease became very apparent in the untreated lots. Prophylaxis was then started in the untreated lots and continued in both groups until the end of the rearing period. The average loss in all groups for the entire rearing period was 5.4%. Uninterupted phophylaxis was administered to the 1955 brood silver salmon. Loss for the rearing period April 1, 1956 to December 1, 1956 was 0.21%.

In 1956, adult migrant silver salmon of the 1953 brood which had received prophylaxis throughout their entire rearing returned to the Klickitat river. Of the original plant of approximately 1,000,000 fingerlings, 46,000 were marked at release by the removal of the adipose fin. Of the 4,600 adult silver salmon returning to the hatchery rack 166 were marked adipose. Observers at a counting station at the mouth of the Klickitat river some 40 miles from the hatchery counted some 4,800 adult silvers and it was estimated that this represented 80% of the fish actually ascending the river with an estimated total run of some 6,000 fish.

A representative sample of the spawning adults, including some of the marked returnees were examined for evidence of kidney disease. None was found in any of the fish examined.

Returns from Hatchery-reared fall Chinook Releases into Deschutes River

Robert W. Saalfeld
Washington Department of Fisheries

The development of the Deschutes River as a brood stream for fall chinook salmon (<u>O. tschawytscha</u>) was initiated by the Washington Department of Fisheries in 1946, when 414,000 60-day reared fall chinook fingerlings of the Soos Creek (Green River hatchery) stock were released into the Deschutes estuary. Hatchery reared chinook fingerlings of the Soos Creek stock have been released into the estuary or Capitol lake in every succeeding year except 1949 and 1954. Chinook have reproduced naturally in the river every year since 1949, when the majority of the 4-year old returnees from the initial release were allowed to spawn in the upper watershed.

The Deschutes River is a lowland stream which originates in the Cascade Mountain foothills some 40 miles southeast of Olympia. It is a relatively slow moving, meandering stream until it reaches the community of Tumwater, immediately south of Olympia. Here it cataracts over three falls, each a barrier to upstream migrating salmon and steelhead. At the base thereof, it enters the partially man-made Capitol Lake, from which it reaches Budd Inlet in Puget Sound by means of a tide-gate under the Olympia-Aberdeen highway. Capitol Lake is a body of fresh water created by the construction, in 1949-1950, of an earth fill dam across the lower end of the Deschutes estuary. Previously, the estuarial basin between Tumwater falls (lower-most) and Budd Inlet proper consisted of an extensive intertidal zone of sand and mud flats.

Changing conditions during the construction of Capitol Lake dam and the three Deschutes fishways necessitated the use of several temporary devices for capture and transportation of returning adult fish. In the fall of 1948, the 3-year old fish from the 1945 brood release returned and were observed at the base of Tumwater falls, a number of these fish were gill-netted and the eggs from the females were transferred to the Minter Creek hatchery for hatching. The progeny from this stock were never returned to the Deschutes, but were planted elsewhere. In 1949, a round haul (beach seine) was utilized in capturing the returning adults from the 1945 and 1946 broods. During the period of 1950-1952 the weir-type fishway in Capitol Lake was in operation and a trap was installed within the upper portion, where the fish were captured and transported above the falls for natural spawning. In 1952, the trap was necessarily modified to a floating type and it proved to be unsatisfactory and most of the fish escaped un-recorded into Capitol Lake. By the 1953 season, the vertical-baffle fishway (NO.1) around Tumwater falls was complete and the 1953 and 1954 escapements were trapped at the head of this fishway. In November 1954, the three Hells Gate type fishways were complete thus by-passing Tumwater falls, an intermediate cascade area, and the Puget Sound Power and Light dam and upper falls, and giving fish free access to the headwaters of the Deschutes River.

The return of an estimated 7,000 spawners from the 1945 brood release was the initial indication that the Deschutes watershed would be a significant new contributor to Puget Sound salmon runs. This return represented an estimated 1.64 percent return of adults back to the stream from the original release (414,000). During the period of 1946-1956 the percent of fish returning to the stream from each brood year release of hatchery reared stock has consistently been near one percent. This percentage of individual brood years has varied from a low of 0.68 percent to a high of 1.74 percent.

During this ten year period it is estimated that over 20,000 fish have returned to the river. Based upon recoveries of marked hatchery fish liberated into the river, it is estimated that the Deschutes project (hatchery plus natural production) has added at least 57,000 salmon to the take of sports and commercial fishermen. This production already has amortized the $300,000 cost of the entire Deschutes fishway system.

Abstract of Discussion Concerning Survivals of Salmon as Affected by Variables in Rearing and Planting Techniques

C. H. Ellis
Department of Fisheries

Discussion was carried on pointing out that techniques other than the normally obvious ones, such as nutrition control, disease control, size control, etc., could have considerable influence on survivals of salmon. Review was made of an experiment conducted by the Washington Department of Fisheries in 1955, whereby young chinook salmon of the 1954 brood were liberated at various locations over a 200 mile stretch of the Columbia River. During the season of 1956, two year old fish, the first returns from this experiment began to put in appearance at various hatchery racks on the Columbia River watershed. From these early and preliminary returns of two year old fish, it was interesting to note that out of a total of 46 marked chinook recovered, 41 were from releases of fish in the lower portion of theColumbia River, i.e., in areas nearest the sea. From these early returns, there is some indication that place of liberation, alone, may have considerable effect upon survivals of salmon.

Results of another experiment conducted by the Department of Fisheries to test effects of the use of salt water in its relationship to the survival of salmon was briefly discussed. In general, the experiment consisted of rearing four lots of 30,000 each of fall chinook salmon at the Samish hatchery for the usual three months of fresh water rearing. However, only one of these lots was released at the usual time, i.e., after three months of fresh water rearing, with release being made at the mouth of the Samish River, in the brackish water area. The second lot was taken to the salt water station at Deception Pass and in a short period of five days converted to salt water and then returned to the mouth of the Samish River for release. The third lot was taken to Deception Pass station and reared 25 days in salt water and then released in the mouth of the Samish River. The fourth lot was reared 60 days in salt water, at Deception Pass station, and also released at the mouth of the Samish River in the estuarial area. Returns of chinook to the racks as three year olds in 1955 and as four year olds in 1956 gave some rather significant differences in relation to the period of rearing that the young fish had had in salt water. It was found that the greatest return was released from those fish which had been reared 90 days in fresh water and then merely converted to salt water in the short five day period and released. This procedure gave a return of 213 fish or .75 per cent of the number of marked liberated. Those fish that had no salt water rearing gave a return of 132 fish or 0.47 per cent of the number of fish liberated. In comparison, those fish that had been reared 25 days in salt water only gave a return of 76 individual fish or only 0.25 per cent of the number of fish liberated, while those fish which had been reared 60 days in salt water only gave a return of 51 individual fish or 0.19 per cent of the number of fish liberated. It remains to be seen, however, whether or not this procedure will hold up in duplicated experiments.

There is now at sea, a duplication of the Samish experiment by release of several lots of fall chinook of the 1955 brood from the Hoodsport station on Hood Canal. If returns from the Hoodsport experiment will closely follow those that were experienced on the Samish River, considerable significance can be attached to this new routine. The results from procedure of this nature can only be considered preliminary at this time; however, results indicate strong trends to the effect that survivals of salmon can be affected by the medium of rearing, i.e., use of salt water.

Returns of fall chinook salmon to the Deschutes this past season demonstrated that another factor can very clearly affect survival of salmon. In this case, it was the stock that was used which made the great difference in returns. In 1953, two lots of marked chinook salmon, approximately equal in number, and handled in the same manner, were marked and liberated in the Deschutes River; fish were of the 1952 brood stock. The only difference between the two lots was that one was from a local (Puget Sound) stock and the other was from an imported stock from an outside area, namely, the Columbia River. The fish were differentially marked so that the adult returnees could properly be segregated. Returns from these two lots appeared in 1955 as three year olds and in 1956 as four year olds. Returns from the two different groups indicated the great effect that the use of different stocks could have upon returns. From the local stock group there was a total return of 1, 175 fish to the Deschutes River. From the Columbia River stock there was a return of only 51 fish. Restated, the survivals of the local stock was one percent of the number of fish liberated, while survivals of the import stock was only four hundredths of one percent or 25 to 1 in favor of the local stock over the import stock. Here again is another demonstration of the importance of another factor that can very definitely affect survival of salmon.

Summarized, three things have been demonstrated experimentally to have considerable affect upon survivals of salmon: (1), placement of the plants; (2), use of different media for rearing (salt water) and (3), utilization of different stocks.

Progress Report on Diet Experiments with Salmon

J. A. Coates
Washington Department of Fisheries
Seattle, Washington

Brine Shrimp

The use of brine shrimp nauplii as a food for young pink salmon was quite successful in reducing the numbers of mortalities due to "pinheads", under small experimental conditions. (1955 Fish Cultural Conference Report)

The same diet was used this year on a larger scale. Two groups of 100,000 pink salmon fry were fed pink salmon production diet and brine shrimp nauplii, respectively. The two diets were fed for a total of 105 days. One half of each pond was marked and released after 75 days rearing. The remainder of each pond was reared for an additional 30 days, differentially marked and released. The rearing period was divided into fourteen days fresh water, sixteen days conversion to salt water and the remainder of the time in sea water.

These four differentially marked groups should return in the fall of 1957 and should give us some insite as to the overall effects of the brine shrimp diet fed for seventy-five and one hundred five days, respectively, as compared to the pink salmon production diet fed for these same rearing times.

In summary:

PRODUCTION DIET		BRINE SHRIMP NAUPLII	
Starting population	100,000	Starting population	100,000
Planted	48,479	Planted	90,720
Loss	51,521	Loss	9,280
or 51.52 percent mortality		or 9.3 percent mortality	

Preliminary Report on the Tests of Commericial Fish Foods

Several commercially prepared dry fish foods were tested against the Washington State Department of Fisheries production diet this year. These diets were Ralston Purina "Fish Chow", Alber's "F-2" and Alber's "Friskies", and Small's "Nutra-dine". The Washington State Department of Fisheries production diet was 15 percent beef liver, 25 percent spawned-out salmon carcass, 58 percent salmon viscera and 2 percent salt. The dried diets were fed at one-third the rate of the production diet.

None of the commercially prepared diets produced growth or experienced as low a mortality rate as the production diet when fed to silver salmon, although the Alber's "F-2" did produce better growth than the other dried commerical diets.

The products of the Ralston Purina Company and the Alber's Company have been fed successfully to trout in Missouri and California. These two companies have expressed interest in this field and have indicated that they will try to improve their product so that it can be utilized efficiently by salmon.

Feeding Experiments with Cutthroat Trout

Harry W. Baker
U. S. Fish & Wildlife Service
Ennis, Montana

The difficulty in the rearing of cutthroat trout has long been recognized by those fish culturists engaged in the rearing of this species. It is unfortunate, indeed, that research work has, for the most part, been entirely lacking or of little significance, in determining the nutritional requirements of the cutthroat.

During the season of 1954 Lew Garlick proposed that the Ennis, Creston and Bozeman, Montana hatcheries, (the Creston hatchery has been engaged quite extensively in the propagation of cutthroat for a considerable number of years) run trial lots for purpose of studying the comparative growth rates and determine the feasibility, of using one of the stations as a fostering unit for the Creston station in order to provide a large yearling cutthroat trout for planting. After the program had been put into operation in 1954 and the cutthroat at Ennis, had reach 2 inches to 2½ inches in length, typical pantothentic acid deficiencies developed - clubbed gills and a distinct greyish fringe around the posterior of the gill cover. Mortalities also began to increase. The diet consisted as follows: first three weeks, beef liver straight; second three weeks, beef liver with 2% A & D fish oil added after which time the A & D fish oil was discontinued and meals gradually added, starting at 10% and increased gradually to 25%.. This dough feed, as we call it, was fed through a ricer for about three weeks. Then a blower feed consisting of 50% meal and 50% meat was fed. Symptoms of pantothentic acid deficiencies began to appear soon after the transfer to blower feed, and mortalities began to increase. Food conversion went to 8.9 as compared to a previous average of 3.6. Percent gain dropped to 20.5% as compared to 81.1 the previous month. The critical period occurred during the month of September. The only means of increasing the pantothentic acid, at the time, was to increase the amount of liver. This was accomplished by eliminating the spleen and using a diet of 50% beef liver and 50% dry meals. Within one week the mortality was arrested and improvement was such that during the month of October our conversion was back to 3.6 and the percent gain up to 52.8. No further difficulty was encountered during the remainder of the period we had the fish - they were shipped back to Creston the later part of November 1954.

1955 Experiment

The experiment conducted in 1955 with the use of calcium pantothenate was began after the critical period of the fish was over, that is they were past the 2 - 3 inch size. It is the writers opinion that there is a possibility that at least two additional vitamin deficiences exist, vitamin A and B_{12}, or riboflavin or B_6 - pycidovine. Also some work should be done on biotin.

The fish for this experiment were hatched from a pure strain of cutthroat trout eggs received from Creston, Montana June 12, 1955. The experiment was started November 1, 1955 and continued through February 15, 1956. They were set up in concrete hatching tanks 3 ft. by 13 ft. 2 inches with a depth of 32 inches. Water level was carried at 24 inches and a flow of 64 gallons per minute maintained in each tank.

Three diets were used and two tanks set up for each.

Tanks No. 20 and 25 contained 9,383 fish at 10.07 gms. each totaling 208 lbs. They were fed an all meat diet consisting of 49% beef liver, 49% spleen and 2% salt.

Tanks No. 21 and 24 contained 9,660 fish at 9.87 gms. each totaling 210 lbs. They were fed Cortland #6 diet consisting of 25% beef liver, 25% spleen, 12% salmon meal, 12% cottonseed meal, 12% middlings, 12% distillers solubles and 2% salt.

Tanks No. 22 and 23 contained 9,974 fish at 9.56 gms. each totaling 210 lbs. They were fed Cortland #6 diet with a .25 gms Pantothenic acid added per 200 lbs. of fish.

Bi-monthly each pair of tanks were weighed and cut back to 200 lbs.

The following charts and graphs show the results of this experiment for 7 bi-monthly periods, 107 days or 15 plus weeks.

The fish receiving the all meat diet began to show signs of diet deficiency after five weeks feeding. It was discontinued January 16, 1956 because of high losses and symptoms of high deficiencies believed to be due to high level of proteins and shortage of carbohydrates. Lack of growth, slimness of body, sluggishness and some signs of edema began to be very apparent in this period. After discontinuing this part of the experiment the fish involved were fed a Cortland diet consisting of 50% liver, 12% salmon meal, 12% cottonseed meal, 12% middlings, 12% distillers solubles and 2% salt. A very good recovery was made in four weeks of this feed.

<u>CONCLUSIONS:</u>

An all meat diet appears to be unsatisfactory as a cutthroat diet even using a high liver level.

Cortland #6 is a satisfactory feed for cutthroat trout but shows some vitamin deficiency.

Cortland #6 diet with .25 gms. Pantothenic acid added per 200 lbs. of body weight produces stronger, faster growing fish without any signs of vitamin or other deficiencies.

Cutthroat trout of this size will not tolerate high levels of protein as indicated by all-meat diet part of experiment.

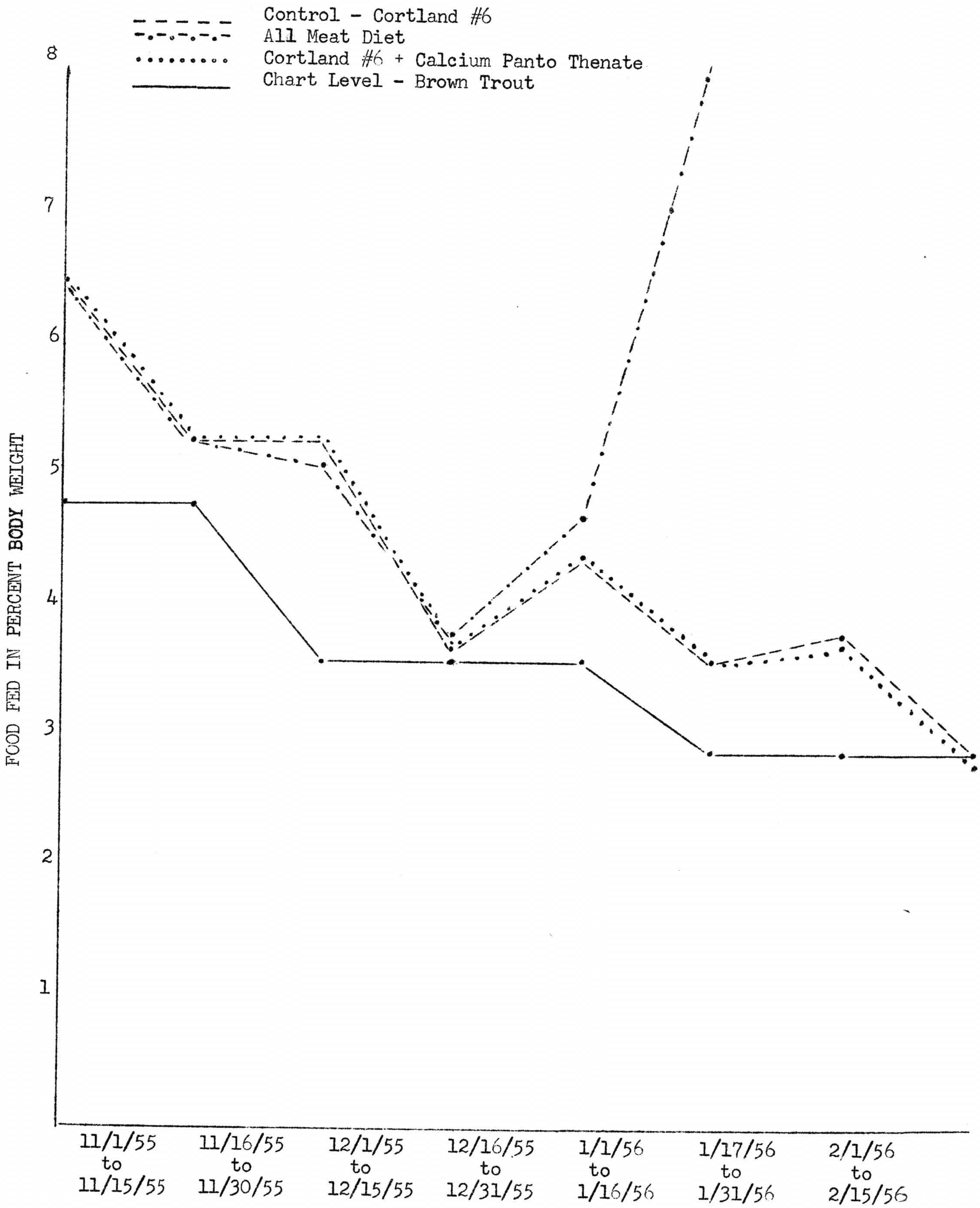
We desire to carry on future experiments as above but using smaller fish and conducting them for a six or seven month period.

1956

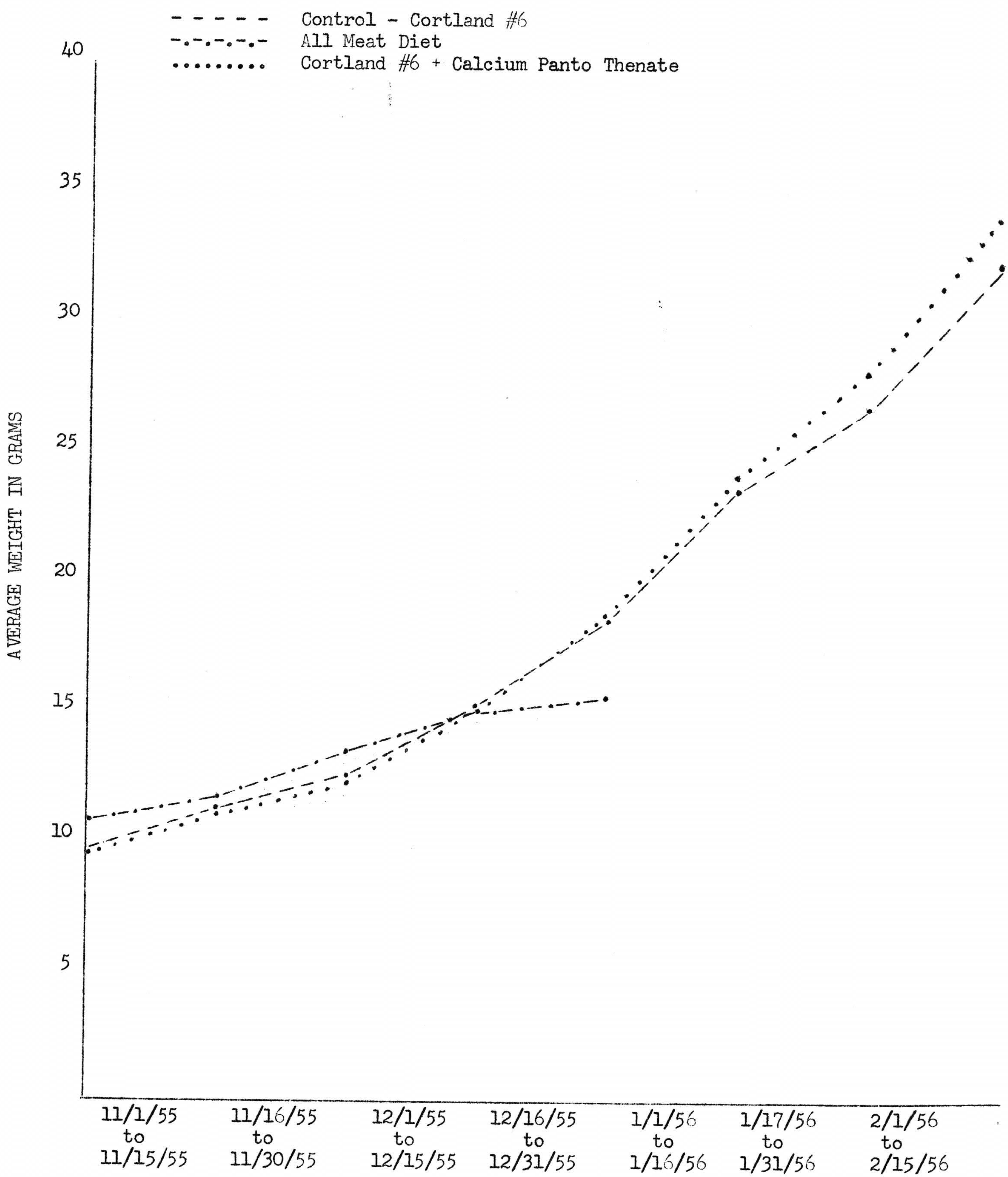
We haven't carried our experiment for 1956 very far as yet. We do, however, expect considerable information, particularly with the use of all diet pellets. Unfortunately, in previous years we did not have facilities for blood determinations which we now have and blood counts will be included as part of the experiment on the individual diets.

LOT 5-CT FEEDING EXPERIMENT
FOOD FED IN PERCENT BODY WEIGHT

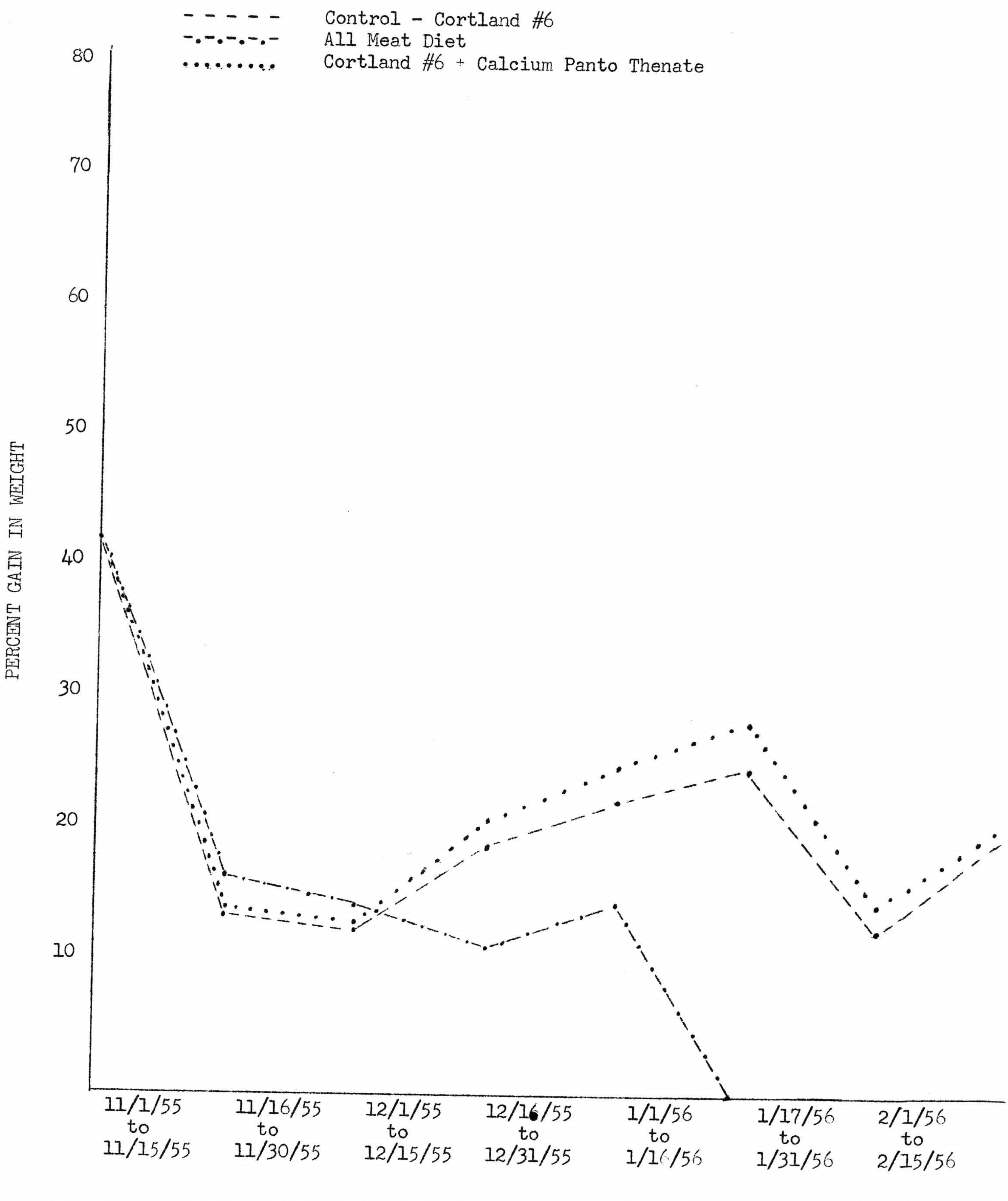
1955-1956



LOT 5-CT FEEDING EXPERIMENT
AVERAGE WEIGHT IN GRAMS 1955-1956

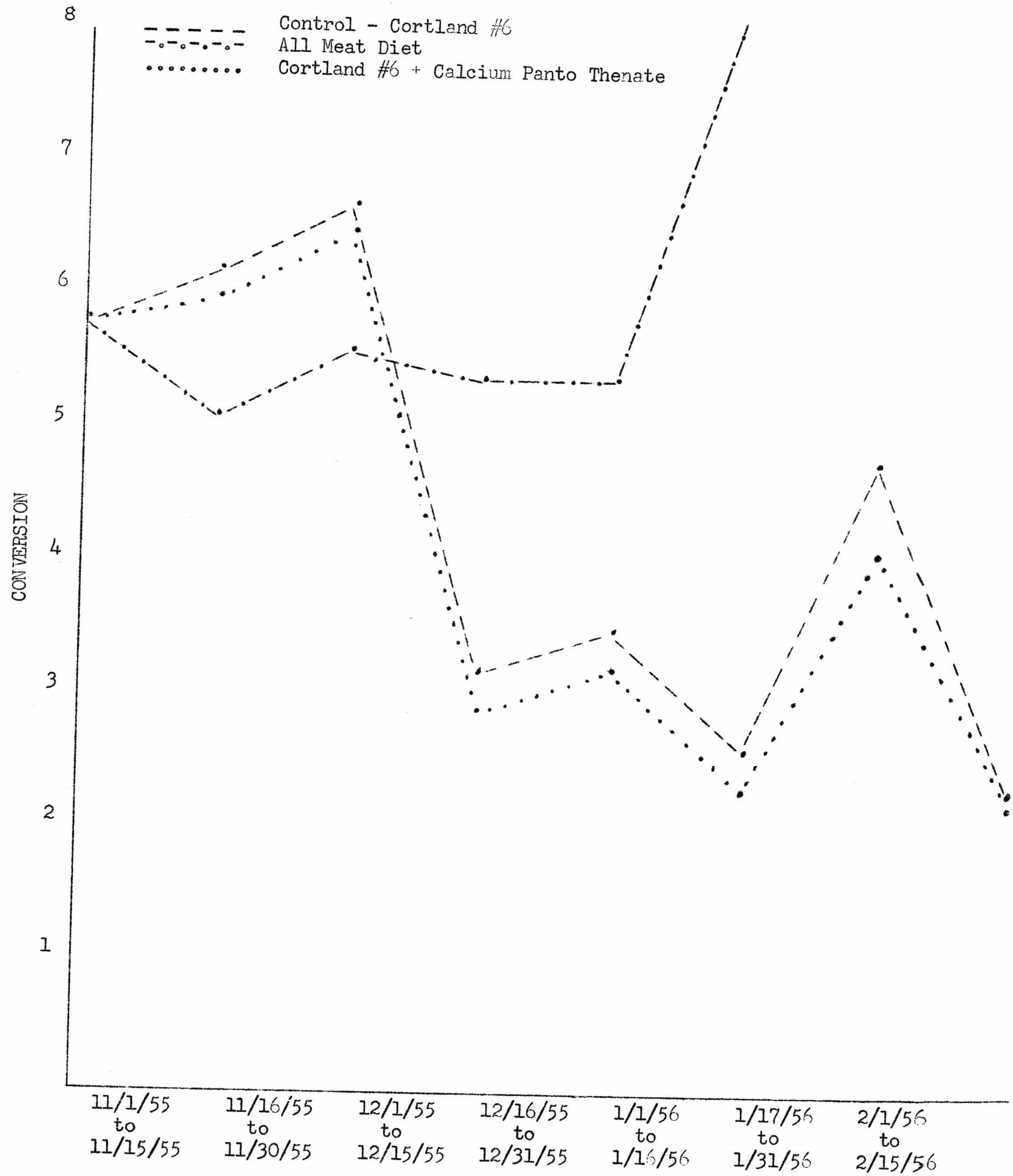


LOT 5-CT FEEDING EXPERIMENT
PERCENT GAIN IN WEIGHT 1955-1956

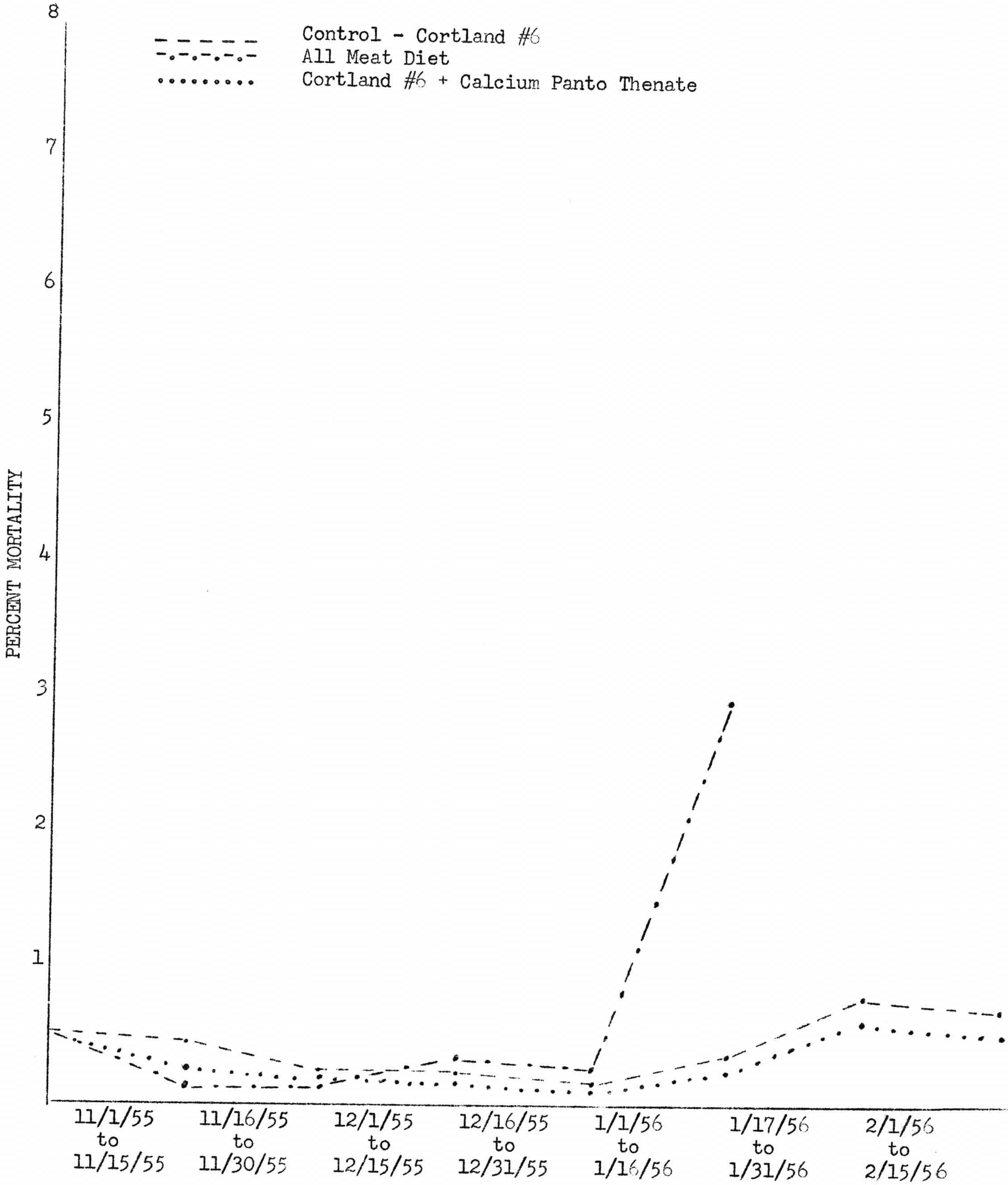


LOT 5-CT FEEDING EXPERIMENT
CONVERSION

1955-1956



LOT 5-CT FEEDING EXPERIMENT
PERCENT MORTALITY 1955-1956



A Progress Report on Nutritional Research in Oregon

Wallace F. Hublou
Oregon Fish Commission
Portland, Oregon

INTRODUCTION

The Oregon Fish Commission first entered the field of fish nutrition in 1948 in a cooperative project with the Astoria Seafoods Laboratory, an extension of the Food Technicians Department, Oregon State College. The program is much the same now as it was then - the Fish Commission supplies the facilities and personnel necessary to carry on the studies and the Seafoods Laboratory compounds the diets and does all of the chemical analyses. At present these studies are being conducted at two laboratories; one at the Oakridge hatchery on the Middle Fork of the Willamette River, and the other at the Sandy River hatchery located on Cedar Creek.

The nutritional experiments have been divided into three series, all of which are interrelated. The first two series are centered about the test diet. This diet is a purified, sometimes called 'synthetic', diet, which contains no fish or meat products. This purified diet is used as a minimum control. All that is expected of this diet is that it keep the fish alive with a fair amount of growth. We now call this diet the Oregon Purified diet, or for short, OPD. It is a modification of the original Wisconsin Purified diet reported by Barbara McLaren in 1947. Individual components are tested as additives to, or substitutes in, the OPD diet. Any added growth stimulus or improved general health in fish on these diets is attributed directly to the added or substituted component. Once a tested component has proven to be nutritionally beneficial, and is also cheap and available, it is combined with other suitable components and worked into our third series. This is our 'production' series. The first two series are not concerned with cost but the third series is. A diet in the third series must be essentially a production diet, and one that can with little alteration, be used by our hatcheries. The form of a diet in our production series is a soft pellet, which we produce ourselves.

1955-1956 Production Diet

1955 was the first year any attempt was made to produce a production diet, all of the previous experiments were mainly for testing and preparing for this phase of the program. At last years meeting a progress report on this experiment was given covering the period from May 23, 1955 to November 3 1955. The complete results of that experiment are given on Table 1.

1956 Studies

This year we are again running production type diets; using a pond at both the Sandy and Oakridge hatcheries. These experiments will not be terminated until the spring of 1957 and will be reported on next years meeting.

The mechanics of preparing and storing the soft pellet poses many interesting problems. Part of our work for 1956 was designed to experiment with methods of handling this pelletized diet. The pellet is normally prepared and fed fresh. The pellets were prepared at the beginning of the experiment, frozen, and stored until fed in one phase of the experiment. The pellets were also prepared, oven dried, and stored and then at the time of feeding they were reconstituted with a predetermined moisture content. These two alterations plus the use of an anti-oxidant in the diet to retard rancidity comprise the three methods of handling the pellets which were investigated this year. Graphs 1-5 show lot weight gain, percent mortaility, and hemoglobin levels for the diets as follows:

Graph #1 - Lot 6 - 1956 pellet diet (Meal mix 55%, Turbot 20%, Tuna Viscera 25%)
Lot 13 - 1955 pellet diet (Meal mix 45%, Turbot 40%, Tuna Liver 15%)

The 1955 pellet diet has attained better growth, lower mortality , and a higher hemoglobin level than the 1956 pellet diet. The 1956 pellet was altered from the 1955 diet to make the pellet slightly drier, cheaper, and also lower the fat level.

Graph #2 - Lot 6 - 1956 pellet diet (fed fresh)
Lot 14 - 1956 pellet diet + anti-oxidant (fed fresh)

The growth attained by both lots has been essentially the same, the percent mortality also very similar. The hemoglobin level was higher in Lot 14 during the first part of the experiment but has since dropped to that of Lot 6.

Graph #3 - Lot 6 - 1956 pellet diet (fed fresh)
Lot 8 - 1956 pellet diet; frozen
Lot 9 - 1956 pellet diet; frozen + anti-oxidant

The growth attained by all three lots has been essentially the same. The mortality has been higher in Lot 8 and lowest in Lot 9. The hemoglobin levels are at present better in the frozen lots (8 and 9).

Graph #4 - Lot 6 - 1956 pellet diet (fed fresh)
Lot 10 - 1956 pellet diet; dried, reconstituted and fed
Lot 11 - Same as Lot 10 with the addition of an anti-oxidant

The growth attained by the dried pellets has not been as good as Lot 6. The mortality was lower in Lot 11. The hemoglobin levels are the same at the present time.

(Oakridge Spring Chinook)
Graph #5 - Lot 1 - 1956 pellet diet (fed fresh)
Lot 3 - 1956 pellet diet; dried + anti-oxidant & reconstituted when fed
Lot 4 - 1956 pellet diet; frozen + anti-oxidant

The growth attained by the pellet diet fed fresh, Lot 1, was greater than that for either the frozen or dried pellet lots. The mortality was higher for both Lot 3 and Lot 4. The hemoglobin level was higher for Lot 1 than for Lot 3. The level for Lot 4 dropped rapidly during October and the fish became very anemic. This was attributed mostly to a freezer failure which allowed the stored frozen pellets to become rancid. The addition of the anti-oxidant may have retarded the rancidity somewhat but not for long.

During 1956 one component was also evaluated by substituting it for part of the test diet. Graph #6 shows the results in the same manner as the other graphs.

Graph #6 - Lot 1 - Maximum control (equal parts beef liver, hog liver, salmon viscera + 2% salt)
Lot 2-0 - Minimum control (Oregon Purified Diet)
Lot 3 - Menhaden Meal modified OPD

The diet being evaluated, Lot 3, attained somewhat better lot growth than the minimum control. The mortality was somewhat lower for Lot 3 than either control lots. The hemoglobin level for Lot 3 was very little better at the last check than was the minimum control.

TABLE I

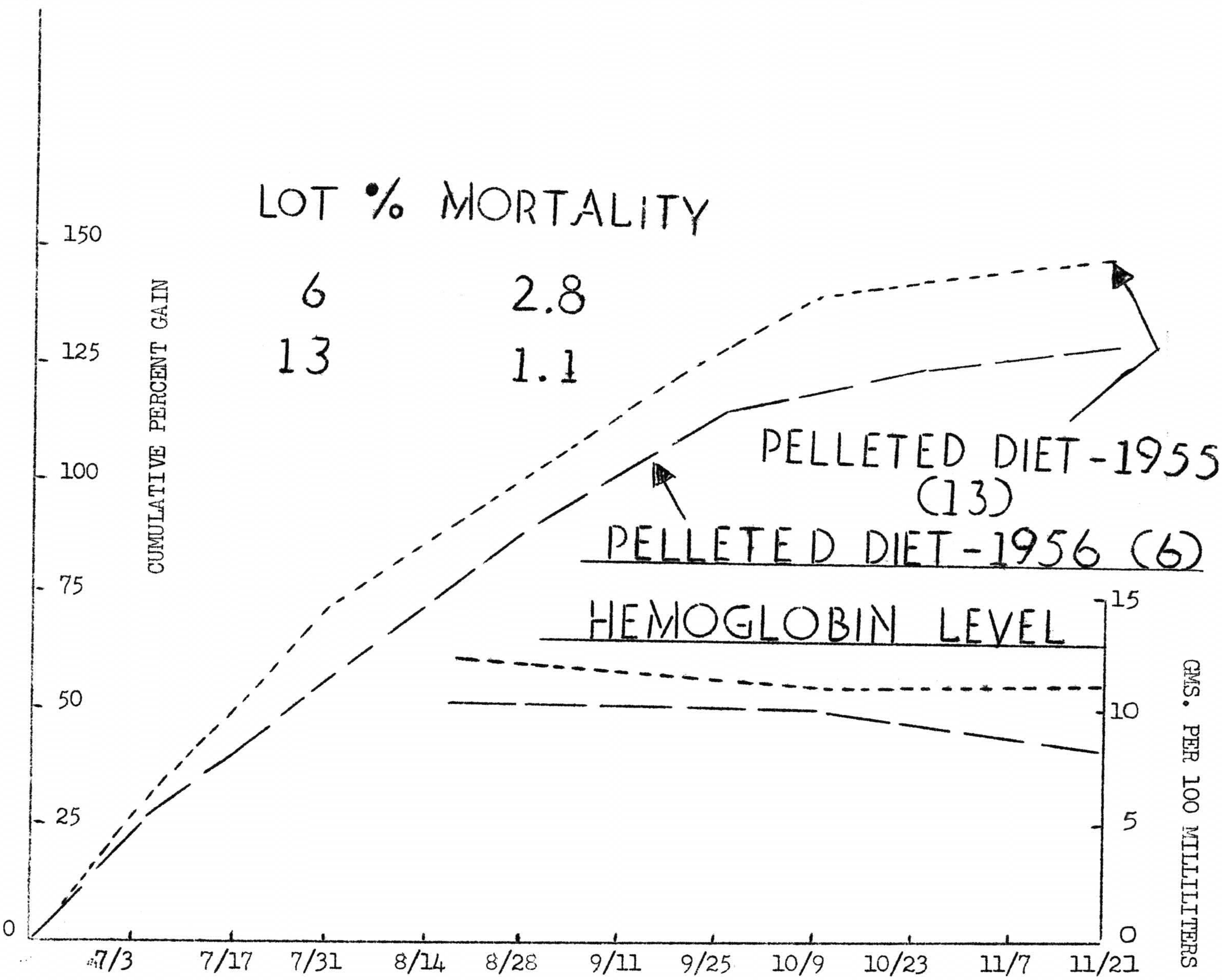
PRODUCTION DIETS - SANDY HATCHERY, 1955-56

Experiment Started: 5/23/55
Experiment Terminated: 2/14/56

	LOT A (Experimental Diet)	LOT B (Hatchery Diet)
DIET COMPONENTS	45% Meal mixture. 40% Turbot, in the round, fresh frozen 15% Tuna liver, albacore or yellowfin, fresh frozen	60% Salmon Viscera. 20% Commercial meal fed as pellets. 5% Each, liver and horse meat, fresh frozen. 4% Each, lungs and spleen, fresh frozen. 2% Sheep cheeks and tripe, fresh frozen.
MOISTURE OF DIET	41.2%	64.4% (Average)
FOOD FED, WET DRY	1,841 pounds 1,083 pounds	5,029 pounds 1,792 pounds
LOT WEIGHT GAIN	801 pounds	754 pounds
CONVERSION, WET DRY	2.30 (Conversion figures = Pounds of food 1.35 required to produce 1 pound of fish).	6.67 2.38
COST OF FOOD, WET DRY	10 cents per pound 17 cents per pound	8 cents per pound 23 cents per pound
TOTAL COST OF FOOD	$185.94	$407.35
FOOD COST TO PRODUCE 1 POUND OF FISH	23 cents per pound	54 cents per pound
TOTAL MORTALITY	13.2%	3.9%
SIZE OF FISH	18 per pound	20 per pound

GRAPH I

EXPERIMENTAL DIET STUDIES ON SANDY RIVER SILVERS
IN 1956

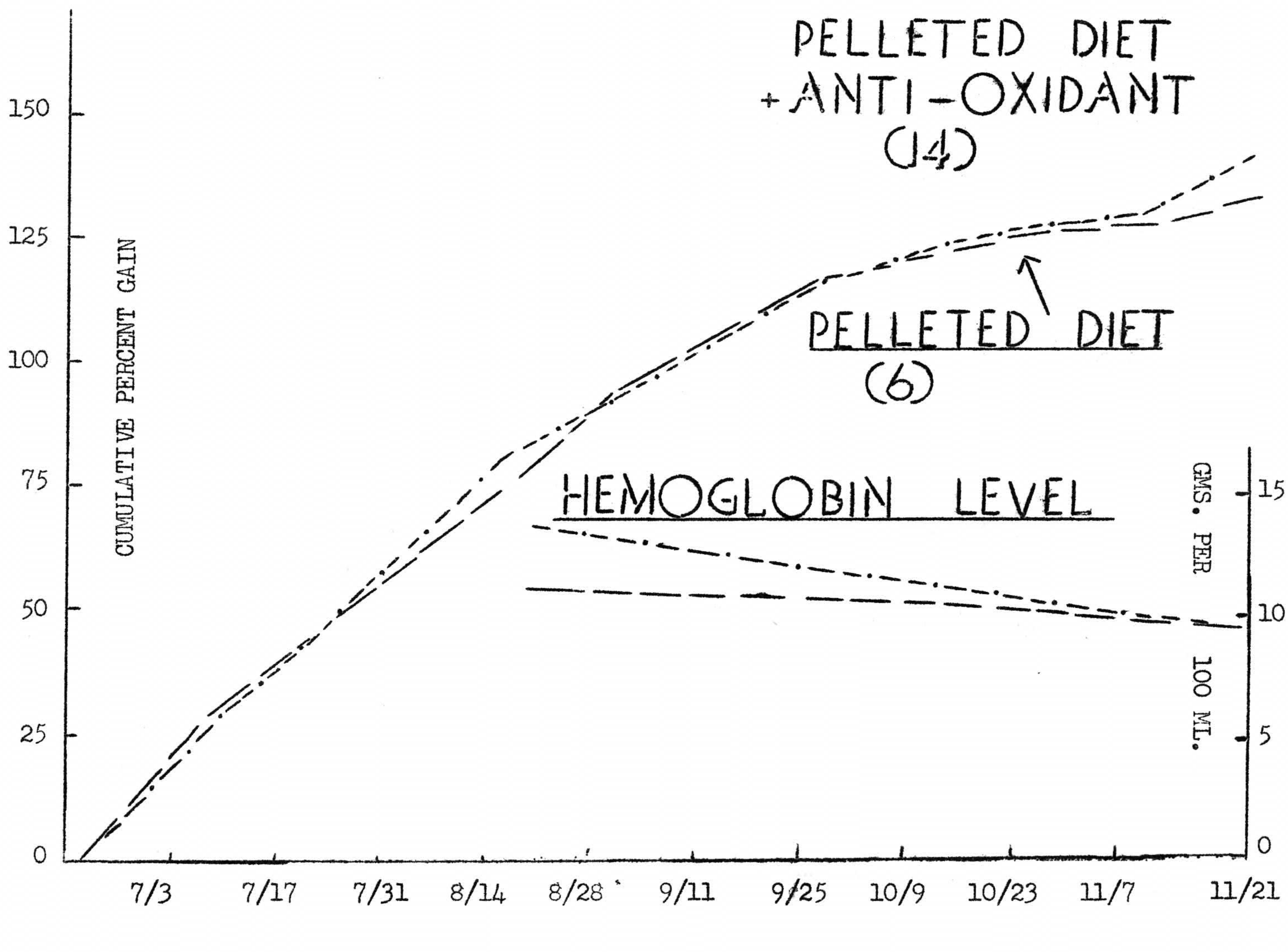


WEIGH DATES

EXPERIMENTAL DIET STUDIES ON SANDY RIVER SILVERS
IN 1956

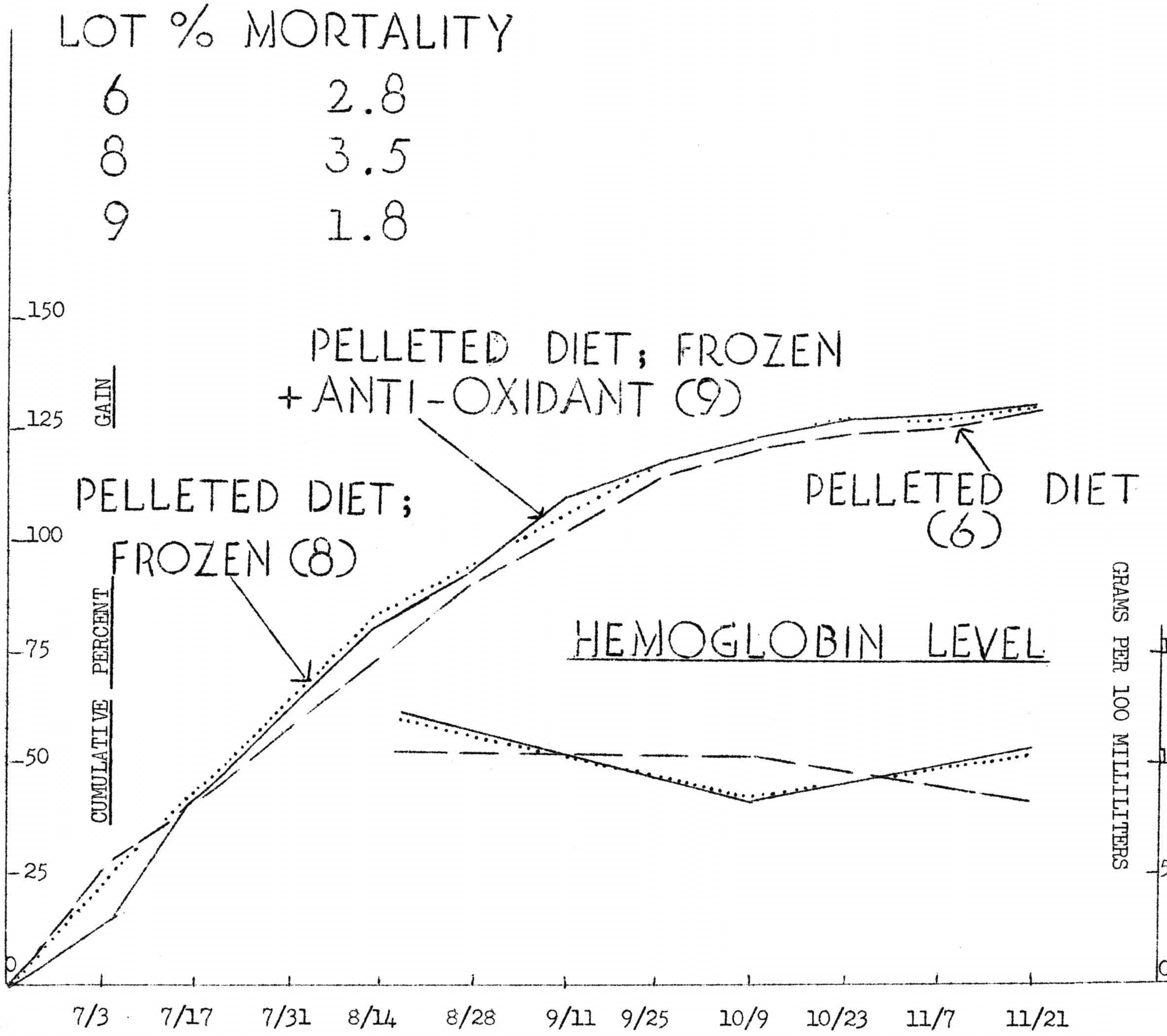
GRAPH II

LOT	% MORTALITY
6	2.8
14	2.1



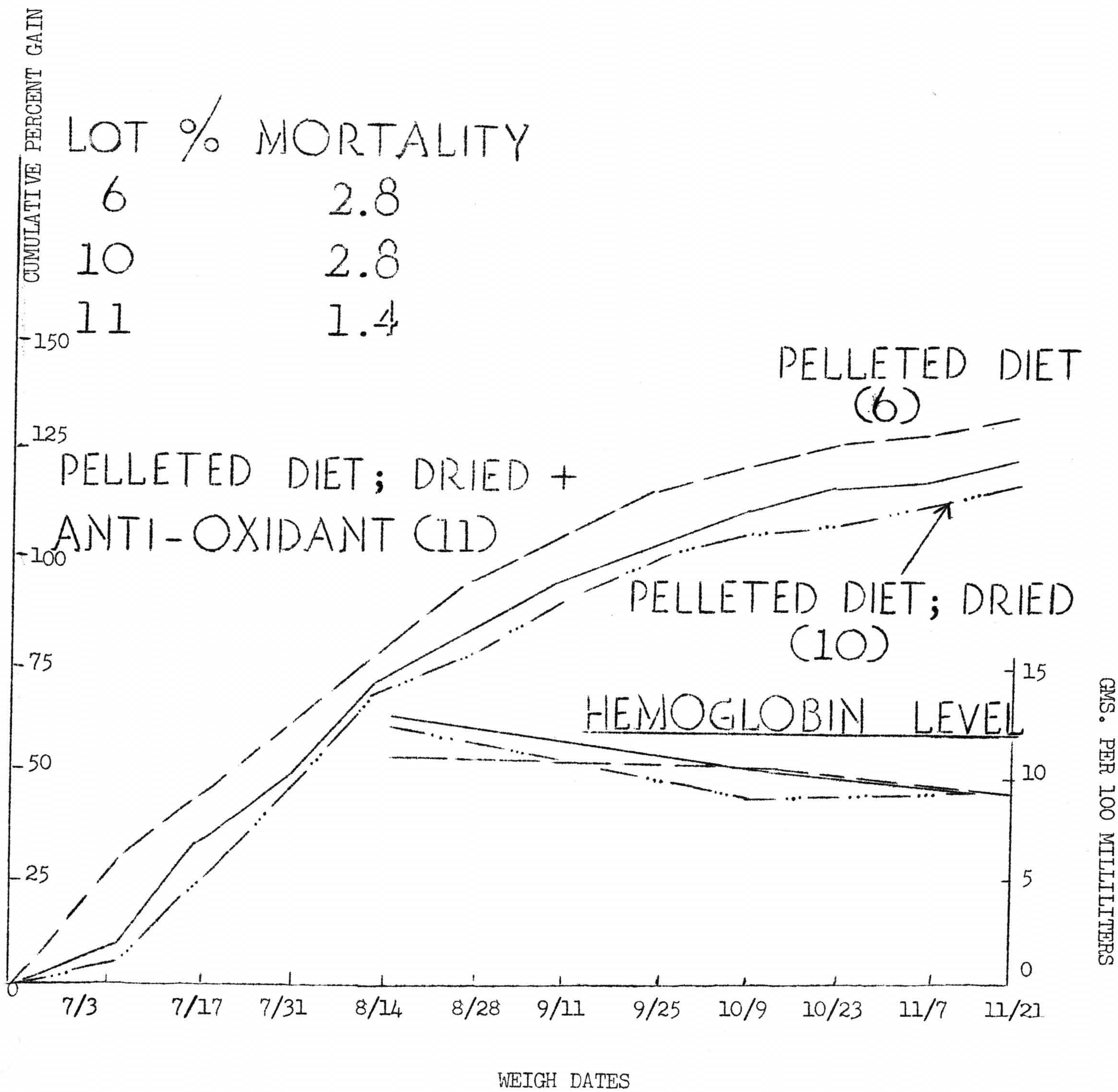
WEIGH DATES

EXPERIMENTAL DIET STUDIES ON SANDY RIVER SILVERS
IN 1956

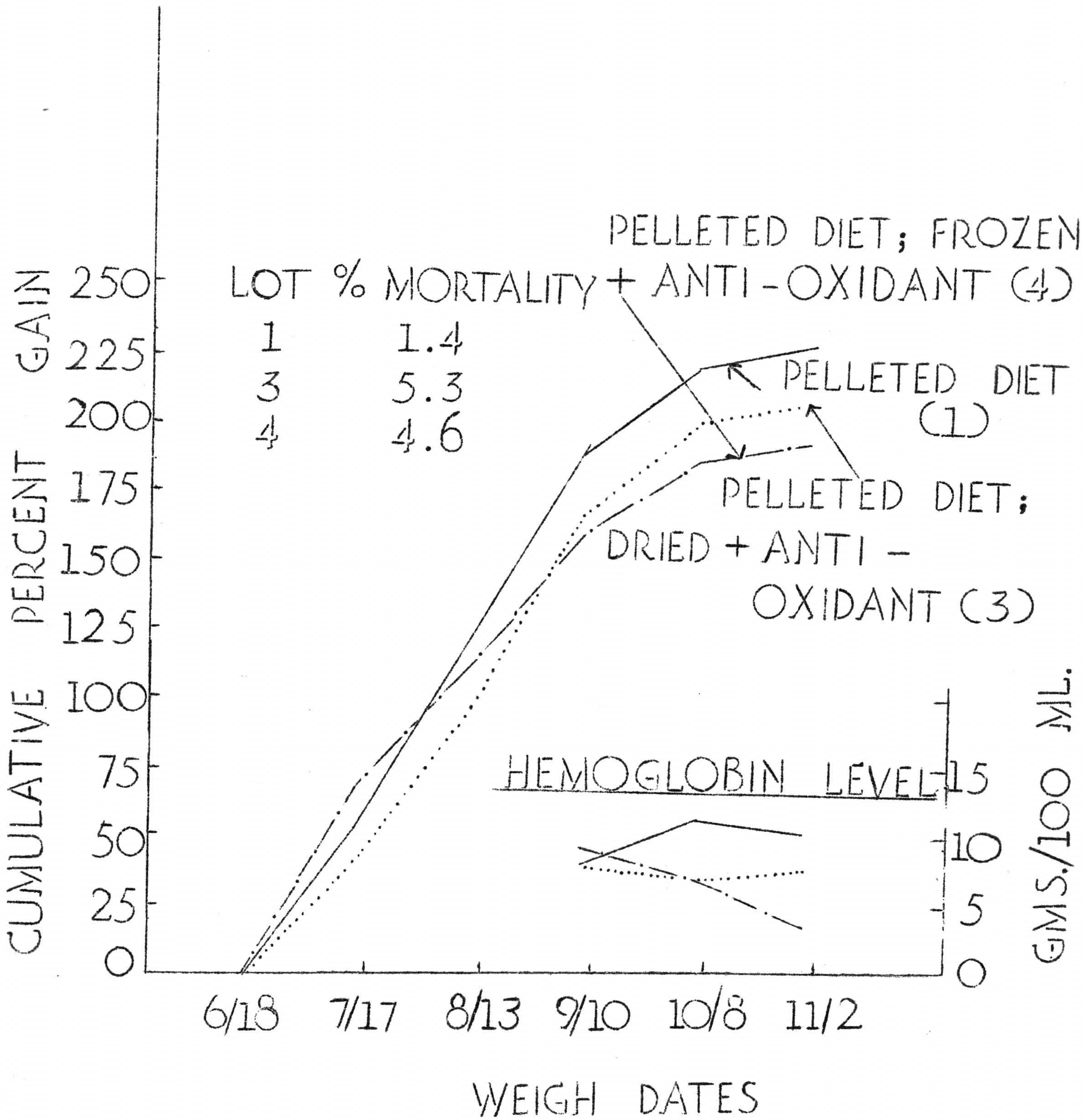


EXPERIMENTAL DIET STUDIES ON SANDY RIVER SILVERS
IN 1956

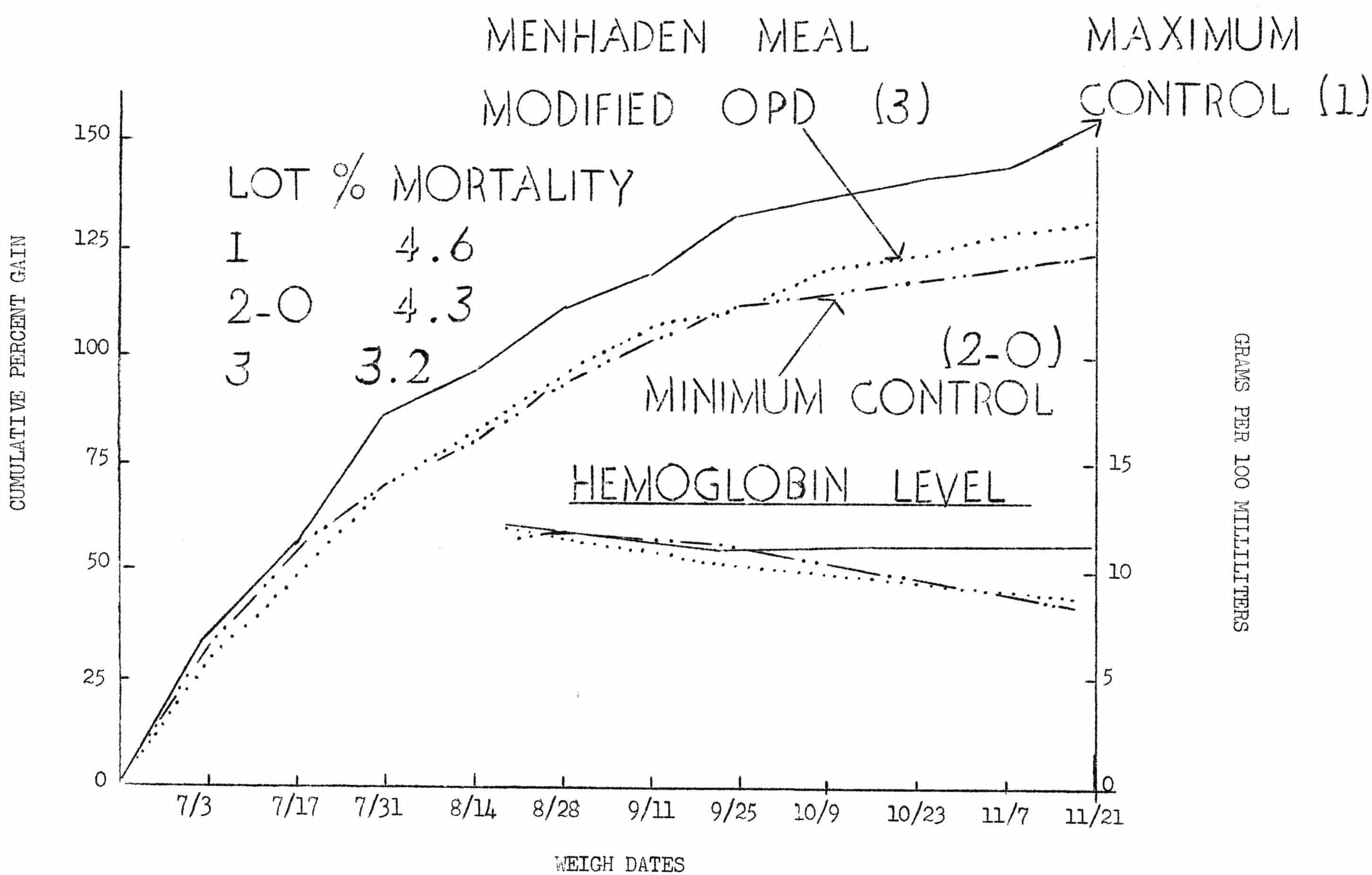
GRAPH IV



EXPERIMENTAL DIET STUDIES ON OAKRIDGE SPRING CHINOOK IN 1956



GRAPH VI


MENHADEN MEAL
MODIFIED OPD (3)
MAXIMUM CONTROL (1)
LOT % MORTALITY
1 4.6
2-O 4.3
3 3.2
(2-O) MINIMUM CONTROL
HEMOGLOBIN LEVEL
CUMULATIVE PERCENT GAIN
0
25
50
75
100
125
150
GRAMS PER 100 MILLILITERS
0
5
10
15
WEIGH DATES
7/3
7/17
7/31
8/14
8/28
9/11
9/25
10/9
10/23
11/7
11/21