TROUT FEEDS AND FEEDING

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Bureau of Sport Fisheries and Wildlife
Circular 159

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Bureau of Sport Fisheries and Wildlife
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CORRECTION:

Circular 159, Trout Feeds and Feeding

Through editorial error, a statement on page 3 of Circular 159 is incorrect. The sixth paragraph on page 3 should read as follows:

It has been shown experimentally that the chemical content of waters affects the metabolic rate of trout. Fish transferred to low-calcium waters from high-calcium waters increase their metabolic rate to oppose mineral losses from the body. This condition may adversely affect growth or even cause death.

UNITED STATES DEPARTMENT OF THE INTERIOR, STEWART L. UDALL, SECRETARY
Frank P. Briggs, Assistant Secretary for Fish and Wildlife
Fish and Wildlife Service, Clarence F. Pautzke, Commissioner
Bureau of Sport Fisheries and Wildlife, Daniel H. Janzen, Director

TROUT FEEDS AND FEEDING

By

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TABLE OF CONTENTS

FOREWORD

This circular is a combination of "Trout Feeds and Feeding" (Fishery Leaflet 423 of the Fish and Wildlife Service) and parts I and V of "The Nutrition of Trout," a series of articles in the Progressive Fish-Culturist.

TROUT FEEDS AND FEEDING is the outgrowth of work at the Trout Nutrition Laboratory at Cortland, N. Y., instituted in 1932. Nutrition of trout has been studied there over the years, in a cooperative program of the Bureau of Sport Fisheries and Wildlife (of the U. S. Fish and Wildlife Service, preceded by the former U. S. Bureau of Fisheries), the New York State Conservation Department, and Cornell University. Ancestry of this circular is in the following publications that issued from the Cortland Experimental Hatchery:

Tables Applicable to Hatchery Operations, by A. V. Tunison, Fish Culture No. 2, May 1936.

Trout Feeds and Feeding, by A. V. Tunison, December 30, 1940.

Trout Feeds and Feeding, Supplement 1, by A. V. Tunison, December 31, 1942.

Feeding Tables for Trout (Revised), by Charles R. Deuell and A. V. Tunison, February 1944.

Trout Feeds and Feeding, by A. V. Tunison, revised February 1945 (reprinted April 1955 as the Fish and Wildlife Service's Fishery Leaflet 423).

The Nutrition of Trout, in the Progressive Fish-Culturist:

Part I, General Feeding Methods, by Arthur M. Phillips, Jr., vol. 18, No. 3, July 1956.

Part V, Ingredients for Trout Diets, by Arthur M. Phillips, Jr., and George C. Balzer, Jr., vol. 19, No. 4, October 1957.

INTRODUCTION

he health of all animals depends upon the fulfillment of physical and hysiological requirements for normal growth, development, and mainte- ance. Of the factors that govern growth and development, nothing can e done to change inherited characteristics once the animal has been onceived. Many other factors that control growth, however, are condi- ions of the environment, and in a controlled husbandry the efficiency f growth becomes dependent upon the skill and knowledge of the husbandman. n fish hatcheries these environmental conditions are numerous. Among he more obvious are water chemistry, flow, temperature, volume, and hanges per hour; sanitation; disease and disease control measures; and astly, but far from least in importance, the nutrition of the trout.

utrition is not solely a matter of diet composition. It is true that trout cannot grow or even exist if essential elements are lacking in he diet, but it's equally true that a complete diet cannot produce fish nless the diet is properly fed. The conversion of food into fish flesh s the measure commonly used to judge efficiency of a feeding program in fish hatchery. If conversion is a measure of efficiency, what can be one to ensure good conversions? Feeding methods, the protein, mineral, arbohydrate, fat, and vitamin requirements and the ingredients used in rout diets all have an effect on food conversions. In all probability, o one factor is more important than another, and it is a combination of ll of them that results in an efficient feeding program for hatchery rout. It is a common error to overemphasize either feeding methods or iet composition to the detriment of the other. The application of all vailable knowledge, physical and physiological, will result in a healthy, ast growing trout at a low production cost.

ood supplies the energy and raw materials that are essential to carry on he processes of life from the time of conception until death. Only that aterial which is absorbed into the body proper may be considered food, or cnly after absorption is the material available to the body. After bsorption, the nutrients are distributed throughout the body to serve any purposes.

he utilization of food in the animal body is described by the word metabolism." Metabolism includes all the chemical processes that food ndergoes to satisfy the requirements of the living body (growth, activity, eproduction, etc.). Metabolism occurs every instant of life, but the rate aries with body activities. Metabolism is at a low level during sleep nd at a high level during peak activities. Food is supplied to the body or the sole purpose of allowing normal metabolism to occur. Hunger is a ignal to the body that the materials for metabolism have been reduced and hat it is time for the supply to be replenished.

etabolism is classified as anabolism (constructive) or catabolism destructive). Anabolism is the building of materials useful to the body. he end products are new tissues (growth and repair), enzymes, red blood

TABLE OF CONTENTS

cells, reproductive products, and many more. Catabolism is the burning of carbohydrates, fats, and proteins to produce energy and represents a loss to the animal in the sense that the food is not directly utilized to produce body substances. For the most part the end products of catabolism are carbon dioxide, water, and nitrogen, which leave the body through the excretory system, and energy which is lost through radiation. Life cannot exist without energy, and catabolism furnishes the energy used for all body processes and activities. Catabolism always accompanies anabolism, for energy is essential for the conversion of foods into body materials.

Body activities that either increase or decrease the rate of metabolism alter the dietary requirement. Heavy work increases the energy requirement, and there must be an increase in the consumption of energy foods to meet the need or body tissue will be utilized. During reproduction the levels of protein, vitamins, and minerals must be increased to meet the growth requirements of the developing young, and the levels of fats and carbohydrates increased to provide energy for the processes within the developing young. If the needs of the embryo (or egg) are not met by the diet, the materials will be removed from the mother's body.

Basal metabolism is the minimum amount of energy required to maintain life when the body is at complete rest. Because metabolism is a chemical process, the rate of basal metabolism varies with body temperature. The body temperature of warm-blooded animals is relatively constant for a given species, and therefore the rate of basal metabolism is relatively constant. The warm-blooded animal can change the rate of metabolism under adverse environmental conditions. In extreme coldness the rate of metabolism is increased by the involuntary act of shivering which provides additional energy from the increased activity, to maintain normal body temperature. During illness, with accompanying fever, the basal metabolism of the body is increased by approximately 10 percent for each degree centigrade increase in body temperature.

The body temperature of cold-blooded animals is almost identical to that of the environment. There is a basal metabolic rate for each temperature normal to each species of cold-blooded animal. If body temperature influences the basal metabolism of cold-blooded animals to the extent it does warm-blooded animals, and there is evidence that this is the case, there is a tremendous range of normal metabolic rates for cold-blooded animals with changes in environmental temperatures. The normal body temperature of a trout may vary from just above freezing to 70°F. The basal rate of metabolism would be exceedingly high at 70°F., in comparison with the rate at 34°F. It is safe to assume that more food would be required to meet the basic energy needs of fish held in the higher water temperature.

Diet composition has an effect upon the metabolic rate of an animal. Feeding an amount of protein in excess of the protein requirements of the body results in the formation of fat from the excess protein. Sixteen percent of protein is nitrogen, which is wasted when fat is formed.

The metabolic rate of the animal increases to provide energy to eliminate this waste nitrogen. Similarly, feeding excessive amounts of minerals may increase metabolism to provide energy to excrete the excessive minerals and thus prevent toxic accumulations in the blood and tissues.

Nutritional deficiencies occur more rapidly in periods of increased metabolism vitamin deficiencies occur more quickly in trout living in warm-water than in those living in cold water because cold-blooded trout increase their metabolism as the water temperature increases. It is often impossible to rear trout in the summer months on diets that are satisfactory during the winter months.

An animal's age is a factor governing metabolic rates. The metabolic rate of a young, rapidly growing animal is higher than that of adults that have ceased to grow. Trout fingerlings have a higher rate of metabolism than larger trout as evidenced by their higher percentage growth rate. The trout-feeding tables based on trout size and water temperature are actually tables based upon metabolic rates of the fish.

Disease alters the metabolism of the body. For example, furunculosis and kidney disease in trout destroy the kidney, the organ for excretion of some end products of catabolism. The destruction of this excretory organ prevents normal excretion, eventually disrupts other phases of metabolism, and may cause the death of the animal. Any disease or nutritional deficiency that affects a single phase of metabolism may eventually affect other phases, as each separate phase of metabolism is in some degree dependent on every other phase.

Because increased body activity increases the metabolic rate of the animal, it's safe to assume that trout living in fast waters have a higher metabolic rate than those living in ponds. The trout must expend more energy to maintain themselves in swift waters. Trout living in fast waters, therefore, require more food for energy than those living in the calmer environments.

It has been shown experimentally that the chemical content of waters affects the metabolic rate of trout. Fish transferred from low-calcium waters to high-calcium waters increase their metabolic rate to oppose mineral losses from the body. This condition may adversely affect growth or even cause death.

GENERAL FEEDING METHODS

Feeding has been considered one of the simplest tasks assigned fish-culturists. It has been a matter of feeding all that the fish would consume and then a little more to assure an abundant supply. Consistency of the food has been disregarded; though given more food than necessary, trout have been underfed because the food was unavailable.

The availability of food to the fish is dependent upon diet consistency, and the control of this characteristic alone will result in a lower conversion of food into flesh. There are several methods of ensuring maximum food intake by trout.

In the 17 years since the last revision of Trout Feeds and Feeding there have been revolutionary changes in the foods fed to trout and the feeding methods used in hatcheries. The diets have progressed from all-meat mixtures, to those composed of meats and dry concentrates, to those manufactured in the form of pellets and/or crumbles from all-dry components. The pelleted types of food are fed either with or without meat supplementation, depending upon the pellets used and the conservative or aggressive nature of the hatchery manager. The majority of hatcheries at present are feeding at least a part of their foods as pellets, and as these diets are improved the moist type diets will disappear from hatchery use. For completeness, however, this paper will discuss the various types of foods that are still fed so that the reader may have a general survey of feeding practices.

Unbound diets

These diets may be fed as initial foods to trout fry and consist of finely ground meat (preferably through a 5/64-inch plate). The food is distributed in the water with a feather, spoon, or screen-bottomed dipper. The screen-bottomed dipper is the most efficient of the three feeding methods. Little or no water is added to the meat, and the weight of the meat on the screen bottom forces the food through the perforations as the dipper is gently shaken. Leaching of the nutrients is kept to a minimum.

However, loss of nutrients from these diets is inevitable and they should be fed for as short a period as possible.

Bound diets (mush or dough feeds)

Many years ago E. W. Fentress discovered that the addition of salt to a diet composed of pork spleen and dry meals resulted in a rubberlike mixture that resisted disintegration when placed in the water. Subsequent experiments established a satisfactory salt level as 2 percent of the diet. Bound diets result in increased fish growth, not because of the salt itself, but rather from increased intake because less food is lost in the water during feeding.

To obtain maximum efficiency from bound diets, the meat binder should be slightly frozen (ice crystals present) when ground. The best binder with salt is pork spleen followed in order of efficiency by beef spleen, horse spleen, beef liver, and beef lungs.

Simply binding the diet does not necessarily increase conversion efficiencies. The tightly bound mixtures are stiff and must be fed properly. There are several satisfactory methods of feeding these diets:

1. With a modified potato ricer (Bryant, 1949).
2. With a pond ricer (Burrows, 1947).
3. With a compressed-air feeder (Pelnar, 1947).
4. With a spoon or by hand feeding.

A bound diet is satisfactory for fish in troughs and in ponds if properly fed and/or if special feeding devices are employed (pond ricer or compressed-air feeders).

There are two types of bound diet mixtures, all-meat diets and meat-meal mixtures.

The all-meat diets are usually composed of liver and spleen with added salt. These are fed to trout following the unbound meat mixtures, after the fish are vigorous and feeding well, and range from 3/4 to 1 inch in length. This diet should be fed with the modified potato ricer, equipped with 1/16-inch plate holes.

The meat-meal mixtures are fed to trout over 1.5 inches in length. The incorporation of dry meals in the diet depends upon fish size, the amount of dry meals used, and the experience of the fish-culturist. These diets should be fed with the modified potato ricer and with as little added water as possible to prevent pollution.

The amount of dry meal in the diet may vary from 25 percent in fry diets to as much as 60 percent for the larger fingerlings (over 3 inches in length).

Blower feeds

Blower-mixed feeds are fed to fish held in ponds and raceways. These foods are prepared by passing the mixture of meat and meal through a centrifugal blower, similar to that used for room ventilation. The blower, which is equipped with long shaving fan blades, is mounted under a table with the outlet of the fan pointing toward the floor and the intake projecting toward the table top. The blower is driven by an electric motor. In the mixing operation the food is fed from the table into the fan, whipped by the blades and expelled into the tub. The resulting product appears as moist sawdust and is fed by scattering over the water at a rate that allows the fish to consume the food as it passes through the water. These mixtures usually consist of 45 percent meat and 55 percent dry meals.

Depending on the size of food particles desired, the food may be passed one or more times through the blower (more times through, the smaller the particles).

Blower feeds are satisfactory for trout held in ponds until the fish reach a size of 3 to 4 inches in length. Because of the small particle size these feeds are not efficiently utilized by larger trout.

Cement mixer prepared foods

Foods prepared by means of a cement mixer may be fed to fish from 3 inches in length to the size of brood stock. The food particles are larger than those of blower feeds, and the food is more completely consumed by the larger fish.

These foods are prepared in an ordinary cement mixer (either a nontilting-drum mixer or the tilting-drum type). The mixer is operated by an electric motor at a mixer speed of about 17 r.p.m. The diets mixed by this method are usually composed of 55 percent meat and 45 percent dry meals and should contain a minimum of 15 percent beef liver. The rest of the meat may be spleen. No water is added. The mixer is run for a period of 10 to 15 minutes. This method of diet preparation requires less labor and attention than the preparation of blower feeds.

Cement mixer prepared food is fed in the same manner as blower feed.

Pelleted foods

Several years ago pelleted types of trout food became available. These foods are manufactured in a manner similar to the methods for manufacturing pellets for rabbits and chickens. Since the appearance of the original trout pellet, dozens of brands have appeared on the market. Pelleted foods have captured the imagination of both fish-culturist and researcher, and tremendous amounts of time have been spent in their development. Many hatcheries throughout the country feed only all-dry diets from the time the fry start to feed until the fish are planted. The pounds of pellets fed has increased each year, and in 1961 approximately 70 percent of the food fed in National Fish Hatcheries consisted of pellets (table 11). The majority of commercial hatcheries are reported as using this type of food.

For economy, ease of feeding, and efficiency of food preparation, the pellet program is the best yet devised.

There is no published open-formula pellet that can be fed as a complete trout food without meat supplementation. However, many commercial pellets are advertised as complete trout foods and are so fed successfully at many hatcheries. Some workers believe that pellets should not be fed over long periods without meat supplementation, and they suggest meat at intervals of once or twice a week. The usual meat supplementation is equal parts of beef spleen and liver with 2 percent salt.

Pellets are readily stored and easily fed to the fish, and the tedious and time-consuming task of mixing diets and diet ingredients is eliminated. A number of experiments have shown that pellets produce fish at about half the pounds required for the more conventional hatchery diets. Although it requires fewer pounds of pellets to produce a pound of fish than it does of the conventional types of trout foods, the calories required to produce a pound of fish are similar with both types of diets. Pellets contain more calories per pound of food and hence fewer pounds are required to produce trout in comparison with meat-meal mixtures. For a true comparison of the efficiency of foods in fish flesh production the conversions must be related to the calorie contend of the diet (table 10). To determine the economy of a given type of diet, the conversion is related to the food cost per pound.

Most commercial manufacturers of pellets prefer the feeding of fry with crumbled pellets, and these foods replace the usual fry meat diets. For trout up to 3 and 4 inches, a small pellet (3/32 inch in diameter and 1/8 inch in length) is used; for fish over 4 inches, a larger pellet (1/8 x 1/4 inch); and for brood fish a still larger pellet. Table 12 lists Federal specifications for particle size of dry fish foods.

Pellets are fed by scattering over the water's surface. Automatic feeders are on the market, and the full development of these feeders along with increased efficiency of pelleted foods through research and development offers an almost foolproof and ideal method of feeding hatchery fish. There is almost no loss of nutrients from the pellets to the water, and if fed properly food consumption is nearly 100 percent. Difficulty may be experienced in starting trout to feed on pelleted foods, particularly if the fish have been fed meat or meat-meal mixtures prior to the use of pellets. Careful, slow feeding will usually overcome this difficulty. If the fish have previously received meats in their diet, coating the pellets with a mixture of beef liver and spleen may be helpful in acclimating the trout to the taste of the pellets.

In many cases a pellet that is successful as a complete food at one hatchery fails at another. The reasons for these results are unknown, but before placement of any all-pellet feeding program into operation the program should be tested on a small lot of fish during periods of rapid growth (fingerling fish during the summer months).

Pelleted fish foods may not be considered complete foods until more is understood of the nutritional requirements of trout. Trial-and-error experiments may produce an apparently complete food, but additional knowledge is required from sound nutritional studies before a complete and entirely satisfactory food pellet can be compounded. Eventually a nutritionally complete and balanced pellet will be available, and the feeding of all-meat, even by the conservative fish-culturist, will be eliminated.

The State of Oregon has developed a moist pellet composed of meats and dry meals that are stored in a frozen condition (Hublou et al., 1959). This food has proved successful and satisfactory in the Oregon State Hatcheries and overcomes some of the disadvantages of the dry pelleted foods.

Amounts to feed

The most common errors in a trout hatchery feeding program are overfeeding and underfeeding. Overfeeding is wasteful in terms of unconsumed food; underfeeding is equally wasteful in terms of lost production. To obtain maximum production during a growing season, careful daily attention must be given to the amount of food fed the fish. Tables 1, 2, 3, and 4 (Deuel et al., 1952) show the amount of food fed as an expression in terms of percentage of the body weight of the fish. For a given fish size, the amount to feed increases with increasing water temperature and for a given water temperature the amount of food decreases with increasing fish size. The variables (water temperature and fish size) are determining factors of the metabolic rate of the fish's body. With an increase in body temperature (water temperature) there is an increase in metabolism, indicating increased growth potential, and more food is required. As the fish size increases, the metabolic rate decreases, indicating a decrease in growth potential, and less food is needed. In a feeding program full advantage should be taken of the growth potential, thus assuring maximum dietary efficiency.

The feeding tables at best are guides for determing the amounts to feed. If the exact amount shown in the tables is fed, fair to excellent results should be obtained. However, there are situations in which these amounts should be increased or decreased, as determined by the specific conditions of the hatchery. As the water warms in the spring, the fish indicate, by their activity and feeding zeal, an acceleration of metabolism. At this time of the year, experience has shown that it is possible to feed in excess of the table values and increase fish production without adversely altering the conversion. As the temperatures drop in the fall, there is an apparent depressive effect on metabolism, and feeding less than the suggested table values can result in more efficient conversions of food into flesh.

The best measure of overfeeding or underfeeding is not the amount that is fed, but rather the conversion values observed. A fish-culturist must learn the "water habits" of his station for maximum efficient production.

The feeding tables of (Deuel et al., 1952) were established for the conventional type of trout diets (bound, blower, and cement-mixer diets). Pellets should be fed at levels determined from tables supplied by the feed manufacturer or at levels equivalent to 60 percent of the amounts in Deuel's tables. Only 60 pounds of pellets should be fed, according to the latter method if the amount of conventional diet to be fed is 100 pounds. Most pellets contain approximately 1,200 calories per pound, and the conventional diets of meat and meal approximately 720. Sixty percent of 1,200 calories approximates the calorie content of conventional diets.

Deuel's feeding tables group the fish by numbers per pound and length in inches. There is a wide range in numbers per pound within each inch size grouping. Judgment must be used to determine the amount of food for a specific size fish. At a water temperature of 47°F., 7.8 percent of the body weight is suggested as food for brook trout in the 1- to 2-inch size group, (2,542 to 304 per pound) and 6.2 percent the amount for the 2- to 3-inch group (304 to 88 per pound) (table 1). It would be poor judgment to feed 7.8 percent of the body weight of trout weighing 310 per pound since 6 fewer fish per pound would place them at a 6.2 percent level. The fish-culturist should ascertain the range position of his fish and feed accordingly. A level of perhaps 7.0 percent would be a proper compromise in the foregoing example. The final decision must be based upon trout size, water temperature, and good judgment.

The conversion factor serves to evaluate the level of food fed, allowing adjustments in the present growing season and establishing a basis for judgment for future seasons.

Haskell (1959) developed an equation for the estimation of the amount to feed trout that is based upon the conversion of food into fish flesh and the daily increase in body length of the trout. The equation assumes the acceptance of the premises that hatchery trout remain reasonably constant in body form for at least 1.5 years; increase in length at a constant rate; and a definite rate of increase in length may be derived for each temperature for each species of trout. Haskell has presented data in previous works to support these premises. The equation was derived as follows:

(1) Daily percent gain in weight $= \frac{3}{L} \times \Delta L \times 100$

In which:

L = length in inches

ΔL = daily increase in length in inches

3 = A constant derived from the usual weight-length relation equation ($W = KL^3$)

(2) Percent to feed of body weight daily $= \frac{200 \times \text{conversion} \times \text{percent gain in weight}}{200 \times 1 \text{ day}}$

The above is simplified to:

(3) Percent to feed of body weight daily = Conversion x daily percent gain in weight

Combination of equations 1 and 3:

(4) Percent to feed of body weight daily $= \frac{3 \times \text{conversion}}{L} \times \Delta L \times 100$

For a complete discussion of these equations the reader is referred to Haskell's original article (1959).

To use this equation, an average monthly gain in length in inches is established from previous year's records, and from this value an average daily gain in length is calculated by dividing the average monthly gain by the number of days in the month. An expected conversion is assumed or obtained from previous records. With these two estimates (daily gain in length and assumed conversion) Haskell's equation may be used to calculate feeding levels. Table 6 permits the establishment of the length and the increase in length over any period if the average number of fish per pound are known at the start and end of the period (from Haskell, 1959).

This method of calculation, if properly used, will help assure optimum feeding levels. Since the calorie content of the diet is reflected in the conversion of food into flesh this method will determine the feeding level of diets regardless of their calorie content.

The method is best suited to hatcheries supplied with constant-temperature water but is applicable to other hatcheries if changes in growth rate associated with changes in water temperature are recognized. For all practical purposes, the average daily water temperature over a several-year period would sufficiently smooth out temperature variations and permit a reasonably reliable application of the method, providing wide fluctuations of water temperature do not occur.

The usual method of application of the equation is to calculate the feeding levels between two time intervals of known fish lengths and then feed the fish from one calculated feeding level toward the other with passage of time. The interval is the choice of the hatcheryman and may be a day, a week, or a month. Probably a two week or monthly interval would be the more practical, unless temperature changes are a major factor.

Application of Haskell's equation:

From past year's records: (sufficient number of years to establish sound average figures).

June 1st fish inventory = 308 per pound
June 30th fish inventory = 158 per pound

From Table 6:

June 1st fish = 2.00 inches in length
June 30th fish = 2.499 inches in length

or:

A gain of 0.5 inches in length per month

or:

$\frac{0.5}{30}$ = 0.0167 gain in inches per day

Assume a diet of pellets:

Past records establish a conversion of food into flesh of 1.8 pounds.

Substitute in Haskell's equation:

$$\text{Percent to feed on June 1st} = \frac{3 \times 1.8}{2.0} \times 0.0167 \times 100 = 4.5$$

$$\text{Percent to feed on June 15th} = \frac{3 \times 1.8}{2.25^{*}} \times 0.0167 \times 100 = 4.0$$

$$\text{Percent to feed on June 30th} = \frac{3 \times 1.8}{2.5} \times 0.0167 \times 100 = 3.6$$

* Since increase in length is at a constant rate and the lengths on June 1st and 30th are known, it is possible to calculate the length on June 15th.

These calculations assume a relatively constant water temperature for the month of June, established from previous hatchery records. If the water temperature is constant or other monthly averages are similar to that of June, the monthly gain of 0.5 inch in length may be used to estimate the food allowance for additional months. If the water temperature fluctuates widely, the gain in inches must be calculated for each interval affected.

Once the daily gain in inches has been established for a given period of relatively constant water temperature, it is possible to estimate the length of the fish on any selected future date during this period by multiplying the daily gain by the number of days and adding this value to the length of the fish at the start. This calculated length is used to estimate the number of fish per pound by referring to table . After the number of fish per pound has been established, the weight of the lot may be estimated by dividing the number of fish by the estimated number per pound. This total weight of the fish may then be multiplied by the percent to feed in terms of the body weight to arrive at the number of pounds of food to feed on the selected date. With the proper manipulation of the data, this is also a convenient way to estimate the total growth and/or the growth rate of a lot of fish for any future date.

Frequency of feeding

There is little experimental evidence on which to establish the number of feedings per day for trout. It is generally believed that trout starting to feed should be fed small amounts at hourly intervals throughout the 8-hour working day. After trout reach a size of 1 to 1.5 inches in length, daily feedings are reduced to four, and this schedule is continued until the trout are placed in ponds. Trout 2 to 4 inches long in ponds are usually fed 3 times a day; later the feedings are reduced to twice a day. Brood stock are fed once daily. The foregoing is neither ideal nor absolute, but the Cortland workers believe that it is a satisfactory schedule. The efficiency of feeding frequencies cannot be measured solely by growth and conversion. Uniformity of fish size, sharing of the food by individuals, and many other factors too difficult or almost impossible to evaluate enter the picture. As in any husbandry, the fish should be fed 7 days a week.

Experiments have shown that feeding fingerling trout over a 24-hour period, either with or without extended light periods, did not increase fish growth or efficiency of food conversions (Phillips et al., 1958). These workers found no valid reason for extending the period of feeding beyond the normal work day. Haskell (1959) expressed the opinion that 24-hour feeding did increase the gains of fish above 1,000 per pound (smaller than 1.3 inches) but did not appear beneficial for larger fish.

Quality of food products

The products fed to trout must be of good quality. Meats should be preserved by freezing until ground. Meats that have been allowed to stand for extended periods are as unfit for trout as they are for human consumption. A standard practice that assures good quality of meats at feeding time is to grind sufficient meat for no more than a 2-day period and keep the meat chilled until used. Before grinding, excess fat should be trimmed or, if the product is fed to small fish, all fat removed. The trimmed fat should be discarded and not fed to larger fish.

Dry meals used for trout diets should be finely ground and the best available grade for animal feeding. It is unwise to feed meals that are coarse to small fish. Dry meals should be stored in a cool, dry area. Few hatcheries have the proper facilities for long periods of dry meal storage. It is advisable to purchase these products for no more than 6 months' requirement.

Pelleted types of food are best stored for periods not to exceed 3 months. When possible, it is desirable to store pellets in a cold-storage area. To prevent crushing and crumbling, pellets should not be stacked, unless on racks. The highest quality ingredients must be used in their manufacture.

Any food that has a rancid odor or shows indications of spoilage must not be fed. The practice of feeding old and rancid foods to brood stock is nutritionally unsound. Brood fish are the source of future generations and must have the best possible food and care. The quality of any animal or its reproductive product can be only as high as the quality of the food.

Food preparation

Food preparation is an important operation of a hatchery program. The best obtainable ingredients are useless without proper preparation.

Meat should be ground to the proper texture for the size of fish fed, by passing several times through the grinder if necessary. Required water should be added slowly, and the food should be tested frequently during the addition to avoid excess water and assure proper consistency. Excessive water lessens the bind of the diet and causes loss of nutrients by leaching.

Meat-dry-meal mixtures should be prepared in amounts no greater than required for 2 days and refrigerated (40°F.) between feedings. Because of an interaction between ingredients, mixed diets often deteriorate after even short periods of standing.

Feeding fish

Feeding is a slow process and should be done at a rate that allows the fish to consume the food as it falls through the water. Some fish-culturists prefer a floating food, but a floating food is not necessary if care is taken during feeding. The food should be scattered in such a manner that all fish have an opportunity to feed. Accumulations of food on the pond bottom should be avoided. Even though the fish may eventually consume the accumulated food, all foods leach some of their nutritional elements upon standing in water, and their quality is reduced. Feeding should take priority over all other hatchery operations and should be routine. Daily operation schedules must allow ample time and labor for carefully feeding.

Storage of prepared foods

Mixed foods should be refrigerated between feedings. It is undesirable to leave a day's allotment of food in the sun or warm shade between feedings. Pelleted types of food should not be left in the heat of the day between feedings.

Temperature and feeding

Daily fluctuations in water temperature should be considered when feeding trout. The greatest amound of food should be fed during the period of water temperature rise, and the least amount during periods of temperature decrease. In most hatcheries the heaviest feeding can be given in the morning. In a few hatcheries, supplied by mountain waters, the water temperature drops until 10 or 11 a.m. In these hatcheries the fish should be fed larger amounts in the afternoon, after the water temperature begins to rise. Attention to such details has a beneficial effect on the food conversion rate.

Many fish-culturists believe that fish should be fed heavily in the morning because of hunger caused by overnight starvation. This reasoning applies to warm-blooded animals with a more or less constant basic metabolic rate, but will apply to fish only if they are held in hatcheries supplied with constant-temperature water since the fish's metabolic rate changes with changes in water temperature. A drop in water temperature at night decreases the metabolic rate and reduces the desire to feed. The longer this drop continues, the greater the reduction in metabolic rate. As the water temperature increases, the metabolic rate increases and the appetite of the fish should be greater.

Daily as well as seasonal changes in water temperature accelerate or depress the metabolic rate. Fish feed best during periods of accelerated metabolism. The difference between satisfactory and excellent conversions of food depends on attention to the small refinements of fish feeding.

Accuracy of food weights

Trout nutrition suffers if the ingredients of the diet are inaccurately weighed or if improper amounts of food are fed. An accurate scale is essential for weighing both the diet ingredients and the allotted prepared foods. An error of 10 percent in weighing 100 pounds of food causes overfeeding or underfeeding by 10 pounds.

Each unit of fish population (pond, raceway, or trough) should have its food allowances weighed into a separate container to ensure uniformity of feeding throughout the hatchery.

Adverse feeding conditions

It is not possible in this article to cover all the adverse conditions that affect feeding practices in the hatchery. Some of these are overcrowding of the fish, unsanitary conditions, extreme variation in fish size, and disease control measures. This article presupposes the prevalence of near-ideal conditions. However, because insufficient water flow and low oxygen content of the water are common/and unavoidable adverse conditions in many hatcheries, these will be discussed.

Insufficient water flow -- The products of metabolism increase when trout growth increases. A fish disposes of the undesirable products of metabolism into the water in which it swims. Water flow and water volume combine to dilute the products to nontoxic levels. If the products are not diluted, the growth rate of the trout will be reduced and mortality increased, and the amount of food fed must be reduced.

The dilution of these products depends on the water flow into and the volume of water in the pond. If the flow cannot be increased, the volume of water may be reduced, thus increasing the number of water changes per hour through the unit and often permitting continuation of an optimum feeding program. Flow of water is not necessarily the limiting factor, but rather the relation of flow and volume that determines the water changes per hour. In hatcheries that re-use their water several times, the reduction of food intake by the fish may be the only solution for reducing the accumulation of metabolic products.

Low oxygen content of the water -- Many hatcheries suffer a low oxygen content of the water during the summer months. Low oxygen may be caused by a combination of insufficient water flow, warm water, and overcrowding of the fish.

A depleted oxygen situation may occur in dirt ponds containing large amounts of aquatic vegetation. Mortalities of fish occur at night, approximately 4 hours after feeding, the period of maximum oxygen use by feeding trout that is concurrent with the period during which plants withdraw oxygen instead of supplying it. This combination of pond metabolism necessitates the recirculation of the water to increase the oxygen content.

Proper feeding methods will often carry the trout through the critical period without the necessity of water recirculation. Feedings should be scheduled so that photosynthesis of the plants is maintained during the hours of maximum demand of oxygen by the fish. It may be necessary to feed only partial rations and on dark, cloudy days, eliminate feeding entirely. The reduction in fish mortalities more than offsets the decrease in fish growth caused by reduced or eliminated feedings.

REARING CAPACITIES OF HATCHERY UNITS

Since the size of hatchery rearing units vary from hatchery to hatchery, the carrying capacity is best stated in terms of pounds of fish per cubic foot of water. The establishment of the fish weight that may be carried per cubic foot of water depends upon, among other things, the water flow, volume, and temperature, the size of the fish, accumulation of metabolic products, the oxygen content, and the re-use of the water. The number of water changes per hour appears to be the best means of correlating many of these factors and a reliable statistic to use in establishing the carrying capacity of hatchery units. The capacity can then be expressed in terms of pounds of fish per cubic foot.

A number of years ago Kenneth Nichols of the New York Conservation Department devised table 5 to determine the pounds of trout to be carried in ponds and troughs, based upon practices in New York State Hatcheries. The table assumes a flow of 8 to 12 gallons of water per minute in troughs and a satisfactory amount in ponds. It has been widely used as a guide for many years.

In order to place stocking of ponds and troughs on an orderly basis, Haskell (1955) developed a formula for the determination of the pounds of fish carried per cubic foot of water. Haskell stated that if it is assumed that the accumulation of metabolic products and the consumption of oxygen are the factors that limit holding capacities of hatchery units, then the metabolism of food is the actual limiting factor since both the utilization of oxygen and production of metabolic products are dependent upon the metabolism of food. If, therefore, the carrying capacity of a unit is known for any particular size and species of trout at any water temperature, then safe capacities for other temperatures and sizes of the same species of trout would be the quantity of fish that would consume the same weight of food. Haskell's principle is described by the following equation:

$$\text{Weight of fish} = \frac{\text{Weight of food} \times 100}{\text{Percent fed in terms of body weight}}$$

For example Haskell determined that at the Rome, N.Y., Hatchery, brown trout, 1 inch in length, may be carried in troughs at a density of 1.75 pounds per cubic foot of water at 53°F. These fish are fed at the rate of 7.6 per cent of their weight (table 2). The amount of food fed per cubic foot of water is:

$$1.75 \times 7.6 \text{ percent} = 0.13 \text{ pound of food.}$$

The safe weight of brown trout that can be carried at any other water temperature of any size would be that weight requiring 0.13 pounds of food per cubic foot of water or:

$$\text{Permissible weight} = \frac{0.13 \times 100}{\text{Percent fed in terms of body weight}}$$

Haskell found that the weight of the same size brown trout held in ponds at the same water temperature was about one-sixth that of troughs, or 0.02 pounds per cubic foot of water. Haskell's formula is a sensible approach to the problem and has worked well under test. Each hatchery must determine its own values of food that can be fed per cubic foot of water. After this initial determination, the stocking of hatchery units is routine.

INGREDIENTS FOR TROUT DIETS

The food of man is composed of both plant and animal products, and he varies his diet according to his likes and dislikes as well as according to his income. The largest part of food for our animals comes from the plant kingdom, although carnivorous animals like the dog eat raw meat. Fish are both omnivorous and carnivorous. Various species have characteristic choosings; certain forage fish are largely plant feeders whereas the pike is a meat eater. In nature, trout feed largely on aquatic and terrestrial animals. Under domesticated conditions the trout's diet in the earlier years of fish-culture consisted mainly of organs of warm-blooded animals. Science has since discovered that these organs are valuable in human nutrition, and the cost has risen beyond the reach of trout hatcheries. Cheaper meat products (organs condemned for human consumption and dried plant and animal products have been substituted. Fresh fish have been used, but in some cases the use of these foods has been disastrous.

Diets today are compounded on a more sound basis than in the earlier days of fish-culture because many more of the trout's nutritional requirements are known. Some formerly serious disease problems have been brought under control through diet. It is still not possible to outline a nutritionally complete diet, and the fish-culturists must rely on certain products to furnish unknown, but essential ingredients. The past 20 years have seen great strides, but there is still much to learn.

The material that follows contains suggestions for the hatcheryman relative to the nutrition of trout. The diets suggested have been used successfully at this and other hatcheries. It is upon these successes that the suggestions are made.

Rations for livestock vary in different sections of the country depending on the availability of feeds. This applies equally well to trout diets. The dry mixtures described herein may of necessity be modified to conform to other sections of the country. However, before extreme modifications are made, the hatcheryman should conduct preliminary mixing and/or feeding trials to assure himself of the wisdom of the change. Feeds should not be chosen because of low cost alone. Gold dust would be economical if one could rear trout with a production food cost of a cent a pound. This implies that the fish-culturist should keep records of his hatchery production in terms of food required to produce a pound of fish and the food cost of this production. Such practices are obviously necessary if one is to make progressive improvements.

The nutritional requirements for hatchery trout are satisfied through the food that is fed. The efficiency of a hatchery diet is a direct reflection of the skill and knowledge of the fish-culturist. In a discussion of the dietary ingredients that may be used to satisfy the needs of trout, two questions are apparent: (1) What ingredients should be used? and (2) How is the efficiency of a hatchery diet measured? In the discussion that follows, these questions are discussed separately.

<u>What ingredients should be used?</u>

The sole requirement of an animal's diet is that it contain all of the ingredients required to satisfy all of the metabolic needs of the body. If the nutritional requirements of an animal are known, a satisfactory diet may be selected from the chemical composition of various ingredients. If the nutritional requirements are incompletely known, actual testing of a diet mixture is necessary through feeding trials. Unfortunately the design of trout diets, for the most part, must be achieved through feeding trials.

Trout diets may consist of all-meat mixtures, combinations of meats and dried meals, or all-dry diets composed of plant and animal concentrates.

Dietary ingredients are selected on the basis of nutritional value, availability of the product, and cost per pound.

The nutritional value of an ingredient is determined from the chemical composition of the product as compared with known dietary requirements and then verified through trial-and-error experiments in which the ingredient has proved satisfactory. Some ingredients are fed for specific purposes such as sources of protein (fish meals) or vitamin content (dried brewer's yeast), or for their growth promoting qualities (poultry feeding oils). Tables 7 and 8 list the chemical composition of a number of foods that have been used in trout diets.

The availability of a product is important in any decision to include it in a trout diet. The best food available is of little value if the supply is limited. Some products (salmon meal for example) have proved useful in trout diets but are not used because the supply is limited.

The cost of an ingredient determines the economical value of a product for trout diets. The cost must not be measured in terms of purchase price alone but rather in terms of the cost to produce a pound of trout (cost per pound of food times the conversion). The use of an expensive ingredient is not justified if a less expensive one produces equal results, and the use of cheap ingredients is not justified if a more expensive product is superior in terms of the cost of producing a pound of fish.

Food ingredients may be grouped into the following classes: (1) Fresh meats, (2) fresh fish, (3) plant concentrates, (4) animal concentrates, (5) dietary supplements.

1. Fresh meats -- Many of these products are excellent sources of vitamins and are fed for this purpose. At present, conservative fish-culturists advise the inclusion of some fresh meats in all dietary programs. This opinion is not shared by all and, as mentioned previously, success has been reported by many hatcheries that have placed their trout on all-dry diets. The most common meats fed are beef liver (condemned for human consumption) and beef spleen. Some liver should probably be included in all meat-feeding programs to provide supplemental sources of of the B vitamins. Spleens have the added value of being excellent binders when combined with salt.

2. Fresh fish -- Diets containing fresh fish should be fed with caution since these may cause a thiamin deficiency and high mortality. Among the species of fish known to produce a thiamin deficiency in trout are whitefish, bullheads, carp, goldfish, suckers, buckeye shiners, salt-water herring, and creek chubs. Cooking the fish prior to feeding eliminates the antithiamin factor but adds to production costs. The inclusion of ground fresh fish that do not cause a thiamin deficiency usually results in a high rate of conversion of food into flesh. The low cost of the fish products is not an advantage if the production cost of the trout is higher than the cost when other types of trout diets are fed.

3. Plant concentrates -- These products are mainly sources of carbo-
ydrate although some contain a high percentage of protein and others may e excellent sources of vitamins. They are the cheapest ingredients in out diets. Since the carbohydrate in plant products is mainly in the orm of raw starch, poorly digested by trout, they serve principally as ulk and "fillers" in the diet. The most common plant products used are ottonseed meal (high protein), wheat middlings, red-dog flour, and tandard wheat middlings, distiller's solubles, and a byproduct of the utyl alcohol industry, BY-100. Soybean meal has been used with variable esults in mixed diets. There appeared to be an obnoxious taste factor o the fish. It would be desirable to determine the value of soybean eal in pelleted types of foods. If taste is the factor in moist diets, t may not be a factor in dry diets.

4. Animal concentrates -- Some of these products are excellent ources of protein, whereas others have little value. Fish meals are he best and blood meals the poorest. Vacuum-dried whitefish meal is uperior to all others tested but is difficult to obtain. Menhaden, ardine, and the poultry-feed types of fish meals are useful substitutes or whitefish meal. Dried skim milk is excellent as a trout food and as a relatively high vitamin content. However it is expensive and there- ore usually used at a relatively low level. Meat meals, meat-scrap eals, and meat scrap and bone meals have been substituted for fish meal ut at best are poor substitutes. Meat-scrap meal is preferred to the thers in this group. All animal concentrates are artificially dehy- rated, and the method of dehydration determines to a large extent heir nutritional quality. In general, products dried under vacuum, with ow heat, are superior to those dried in air over flame.

5. Dietary supplements -- There is an inclination to utilize some f the commercial supplements in trout diets that have proved successful n the diets of higher animals. There is little experimental evidence f benefit from the inclusion of these products in the moist type of atchery diets. Even the antibiotics that have been of such value in he husbandry of higher animals have failed in trout diets as promoters f growth or reducers of conversions. Only three supplements: salt, ried brewer's yeast, and poultry feeding oils have produced results in oist diets that justify the additional expense. Poultry dietary salt ontaining trace elements is used in trout diets in place of the formerly uggested dairy salt. Highly fortified vitamin packages are added to ost commercial and many open-formula pellets.

t is not practical to specify one diet mixture that may be fed at all rout hatcheries. The cost and availability of the ingredients vary rom one section of the country to another, and a mixture satisfactory n one area may be too expensive in another. A number of diet mixtures ave been developed that produce satisfactory results when fed to trout. able 7 lists some of these mixtures. Changes in mixtures are possible, nd in some cases desirable. Many combinations of the listed ingredients ould be satisfactory. It is wise to follow the literature for suggested changes in diet formulas. Products change, and current evaluations may be obsolete at future dates. Any new mixture (either moist or dry) that has not been tested should be evaluated under hatchery experimental conditions before it is put in use in a hatchery. None of the listed pelleted formulas are considered complete diets; all therefore should be fed with supplemental meats.

How is the efficiency of a diet measured?

The efficiency of a hatchery diet is based upon the results obtained. This does not mean that testing must be conducted under laboratory supervision, as any hatchery can evaluate new products and diet mixtures if the work is carefully controlled. All precautions must be taken to assure an unbiased evaluation of the diet.

The efficiency of hatchery diets is usually measured by the growth of the fish, conversion of food into flesh, fish mortality, and the cost to produce a pound of fish. Under some conditions the effect of the diet on body chemistry is studied. Of these measures, all but the body chemistry may be evaluated satisfactorily under ordinary production hatchery conditions. These first four measures are usually sufficient to establish the value of diet mixtures.

The assurance of vigorous fish, without internal damage, must be established, and in some cases this requires the assistance of personnel trained especially for this type of work.

All experimental fish should be of the same age and from the same lot of eggs. The testing units should be stocked at a uniform rate of fish per cubic foot of water, and the water flow should be similar through each unit. The food must be accurately weighed, and one food container assigned to each experimental unit. For most experiments, each group of fish should be fed the same percentage of food in terms of their body weight. In some experiments (pellets vs. moist diets for example) the amount fed must be adjusted according to the calorie content of the diet for a fair evaluation.

The experimental groups must receive priority over all other hatchery activities, and when possible it is preferable to assign one reliable man to care for the fish throughout the experimental period.

All diets should be tested at least in duplicate and preferably in triplicate. Replication of diet mixtures allows normal variation and produces a basis for judgment of results. The experimental diets are compared to a standard diet (control). The comparison diet must be fed concurrently and under identical experimental conditions as the test diets.

he experimental trout should be weighed bi-weekly. The entire group of sh must be weighed. Sample counts will not suffice for experimental udies. By total weighing, the inherent error of sample counting is minated.

f the weights of the fish exceed the carrying capacity of the unit during he experimental period, trout may be removed. The fish removed are ran- omly selected by being crowded into a small area and taken while in motion. uring transfer of the fish, the addition of water to the tared weighing ontainer must be avoided. One cubic centimeter of water weighs 1 gram, nd it does not take many cubic centimeters to invalidate weighings.

he numbers of fish per experimental unit are usually established at the tart of the experiment by sample counting and relating these values to he total weight. As all judgments (except mortality) are based on the otal weight of fish, inaccuracy in numbers is relatively unimportant.

he experiments must be run for a period of time sufficient to establish alid conclusions. In warmer water (above 50°F.), with small fingerling rout, the period of experimentation is usually 16 to 20 weeks. In colder ater the experiments may have to be run for 6 months or more. Some types f diet experimentation are continued throughout the growing season regard- ess of fish size or water temperature. To determine possible pathological hanges in the fish's body, major changes in diet ingredients or feeding rograms may have to be evaluated over a 2- or 3-year period.

or greatest sensitivity, the experiments should be conducted when the fish re growing at their fastest rate (fingerling fish in warm water). Rapid abolism is required to measure nutritional deficiencies and overabundances, d the most rapid metabolism occurs in small fish that are held in warm ater. It can be disastrous to apply experimental results from larger fish eld in cold water during the winter months to fingerling fish in the warm ummer waters.

or experimental records, the hatchery management chart may be used to ecord data. Diets producing sufficiently large deviations in growth, ortality, conversion, and production costs from the comparison diet may e considered equal to, better than, or poorer than, the comparison diet. he replicate troughs must agree, or significance of differences will be nvalid. When the variation between diets are significantly greater than ariation within diets, there is a difference caused by the diet itself, nd the variation is not due to chance alone. It is difficult to establish ctual differences that must occur for significance. In the laboratory, athematical methods are used to measure significance. Under hatchery onditions, good judgment must be used without bias.

Any major change in diets for trout hatcheries should be substantiated by experiments. At present there is no other basis for knowing whether untried products will be satisfactory for trout. Even after such testing has been completed, there is danger of pathological conditions developing over extended periods. The fish husbandman must be on the alert for such conditions.

A comparison of the growth, conversion, and calories required to produce a pound of trout, following the feeding of several types of diet mixtures, is shown in table 10.

USE OF PRODUCTION CHARTS IN HATCHERY OPERATIONS

Successful businesses almost invariably maintain records of expenses and receipts. In livestock production the farmer has records showing produce sold and the cost of production material purchased. In dairying many farmers feed their cows in proportion to the amount of milk given, and the poultry husbandman keeps only the good layers for egg production. In rearing trout, better results will be obtained if records are maintained of the weight, growth, mortality, disease treatment, weight of fish held per volume of water, water flow, and conversion of food into fish flesh. It stands to reason, of course, that the records alone are of little value unless they are wisely used. After accumulating these records for a few years, the hatcheryman is in a position to predict operations for the year. He sould know when to expect disease; overcrowding can be prevented; food requirements can be estimated; and the food cost of production can be determined with a fair degree of accuracy.

Since 1934 the New York State hatcheries have used what is known as the Feeding Chart. Daily records have been maintained along the lines mentioned above. A number of tables have been prepared for use in hatchery operation of the feeding chart as well as for use in the general hatchery operation. A description of the feeding chart and methods for its operations, together with the various tables, has been published by New York State in bulletin form (Deuel et al., 1952).

In addition to the statistics of the production charts there are other desirable methods of evaluating the production efficiency of a hatchery. Tunison (1957) has discussed these methods and shown how they may be applied and interpreted.

Table 1

BROOK TROUT: THE AMOUNT OF FOOD TO FEED PER DAY, IN PERCENT OF BODY WEIGHT, FOR DIFFERENT SIZE GROUPS HELD IN WATER OF DIFFERENT TEMPERATURES

ater emp. (F.)	Number of Fish per pound										
	-2542	2542-304	304-88.3	88.3-37.8	37.8-19.7	19.7-11.6	11.6-7.35	7.35-4.94	4.94-3.47	3.47-2.53	2.53-
	Approximate size in inches										
	-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-
6	5.8%	4.9%	3.9%	2.9%	2.1%	1.7%	1.4%	1.2%	1.1%	1.0%	0.9%
7	6.0	5.1	4.0	3.0	2.2	1.8	1.5	1.3	1.1	1.0	0.9
8	6.3	5.3	4.2	3.2	2.4	1.9	1.6	1.3	1.2	1.0	0.9
9	6.6	5.6	4.4	3.3	2.5	1.9	1.7	1.4	1.2	1.1	1.0
0	6.8	5.8	4.6	3.4	2.6	2.0	1.7	1.5	1.3	1.1	1.0
1	7.1	6.0	4.8	3.6	2.7	2.1	1.8	1.5	1.3	1.2	1.1
[illegible]	7.4	6.3	5.0	3.7	2.8	2.2	1.9	1.6	1.4	1.2	1.1
3	7.8	6.6	5.2	3.9	2.9	2.3	2.0	1.7	1.5	1.3	1.2
4	8.1	6.9	5.5	4.1	3.0	2.4	2.0	1.7	1.5	1.3	1.2
5	8.4	7.2	5.7	4.3	3.2	2.5	2.1	1.8	1.6	1.4	1.3
6	8.8	7.5	6.0	4.4	3.3	2.6	2.2	1.9	1.7	1.5	1.3
7	9.2	7.8	6.2	4.6	3.5	2.7	2.3	2.0	1.7	1.5	1.4
8	9.6	8.2	6.5	4.9	3.6	2.9	2.4	2.1	1.8	1.6	1.4
9	10.0	8.5	6.8	5.1	3.8	3.0	2.5	2.1	1.9	1.7	1.5
0	10.5	8.9	7.1	5.3	3.9	3.1	2.6	2.2	2.0	1.8	1.6
1	11.0	9.3	7.4	5.5	4.1	3.2	2.7	2.3	2.0	1.8	1.6
2	11.4	9.7	7.7	5.8	4.2	3.4	2.8	2.4	2.1	1.9	1.7
3	11.8	10.1	8.0	6.0	4.4	3.5	3.0	2.5	2.2	2.0	1.8
4	12.3	10.5	8.4	6.3	4.6	3.7	3.1	2.6	2.3	2.1	1.8
5	12.9	10.9	8.7	6.5	4.8	3.8	3.2	2.7	2.4	2.1	1.9
6	13.5	11.4	9.1	6.8	5.0	4.0	3.4	2.9	2.5	2.2	2.0
7	14.1	11.9	9.5	7.1	5.2	4.2	3.5	3.0	2.6	2.3	2.1
8	14.7	12.5	9.9	7.4	5.5	4.4	3.7	3.1	2.7	2.4	2.2
9	15.3	13.0	10.3	7.7	5.7	4.6	3.8	3.2	2.8	2.5	2.3
0	16.0	13.6	10.8	8.1	6.0	4.8	4.0	3.4	3.0	2.6	2.4

eeding Tables for Trout (Revised), Deuel and Tunison, February 1944

Table 2

BROWN TROUT: AMOUNT OF FOOD TO FEED PER DAY,
IN PERCENT OF BODY WEIGHT, FOR DIFFERENT SIZE GROUPS
HELD IN WATER OF DIFFERENT TEMPERATURES.

Water Temp. (F.)	Number of fish per pound										
	-2542	2542-304	304-88.3	88.3-37.8	37.8-19.7	19.7-11.6	11.6-7.35	7.35-4.94	4.94-3.47	3.47-2.53	2.53-
	Approximate size in inches										
	-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-
36	4.9%	4.1%	3.3%	2.4%	1.8%	1.5%	1.2%	1.0%	0.9%	0.8%	0.7%
37	5.0	4.2	3.4	2.5	1.9	1.5	1.3	1.1	1.0	0.9	0.8
38	5.2	4.4	3.5	2.6	2.0	1.6	1.3	1.1	1.0	0.9	0.8
39	5.4	4.5	3.7	2.7	2.0	1.6	1.4	1.2	1.0	0.9	0.8
40	5.6	4.7	3.8	2.8	2.1	1.7	1.4	1.2	1.1	1.0	0.9
41	5.8	4.9	3.9	2.9	2.2	1.8	1.5	1.3	1.1	1.0	0.9
42	6.0	5.1	4.1	3.0	2.3	1.8	1.5	1.3	1.1	1.0	0.9
43	6.3	5.3	4.2	3.2	2.4	1.9	1.6	1.4	1.2	1.1	1.0
44	6.5	5.5	4.4	3.3	2.5	2.0	1.6	1.4	1.2	1.1	1.0
45	6.8	5.7	4.6	3.4	2.5	2.0	1.7	1.5	1.3	1.1	1.0
46	7.0	5.9	4.7	3.5	2.6	2.1	1.8	1.5	1.3	1.2	1.1
47	7.3	6.1	4.9	3.7	2.7	2.2	1.8	1.6	1.4	1.2	1.1
48	7.6	6.3	5.1	3.8	2.9	2.3	1.9	1.6	1.4	1.3	1.1
49	7.9	6.6	5.3	4.0	3.0	2.4	2.0	1.7	1.5	1.3	1.2
50	8.2	6.8	5.5	4.1	3.1	2.5	2.0	1.7	1.5	1.4	1.2
51	8.5	7.1	5.7	4.2	3.2	2.6	2.1	1.8	1.6	1.4	1.3
52	8.8	7.4	5.9	4.4	3.3	2.7	2.2	1.9	1.7	1.5	1.3
53	9.1	7.6	6.2	4.6	3.4	2.8	2.3	2.0	1.7	1.5	1.4
54	9.5	7.9	6.4	4.8	3.6	2.9	2.4	2.0	1.8	1.6	1.4
55	9.9	8.3	6.7	5.0	3.7	3.0	2.5	2.1	1.9	1.7	1.5
56	10.2	8.6	6.9	5.2	3.9	3.1	2.6	2.2	1.9	1.7	1.5
57	10.6	8.9	7.2	5.4	4.0	3.2	2.7	2.3	2.0	1.8	1.6
58	11.0	9.2	7.4	5.6	4.2	3.3	2.8	2.4	2.1	1.8	1.7
59	11.5	9.6	7.7	5.8	4.3	3.4	2.9	2.5	2.2	1.9	1.7
60	11.9	10.0	8.0	6.0	4.5	3.6	3.0	2.6	2.2	2.0	1.8

Feeding Tables for Trout (Revised), Deuel and Tunison, February 1944.

Table 3

RAINBOW TROUT: AMOUNT OF FOOD TO FEED PER DAY, IN PERCENT OF BODY WEIGHT, FOR DIFFERENT SIZE GROUPS HELD IN WATER OF DIFFERENT TEMPERATURES

Water Temp. (F.)	Number of fish per pound										
	-2542	2542-304	304-88.3	88.3-37.8	37.8-19.7	19.7-11.6	11.6-7.35	7.35-4.94	4.94-3.47	3.47-2.53	2.53-
	Approximate size in inches										
	-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-
36	5.3%	4.4%	3.5%	2.6%	2.0%	1.6%	1.3%	1.1%	1.0%	0.9%	0.8%
37	5.5	4.6	3.7	2.8	2.1	1.7	1.4	1.2	1.0	0.9	0.8
38	5.8	4.8	3.9	2.9	2.2	1.7	1.4	1.2	1.1	1.0	0.9
39	6.0	5.0	4.0	3.0	2.3	1.8	1.5	1.3	1.1	1.0	0.9
40	6.3	5.2	4.2	3.1	2.4	1.9	1.6	1.4	1.2	1.0	1.0
41	6.6	5.5	4.4	3.3	2.5	2.0	1.7	1.4	1.2	1.1	1.0
42	6.9	5.7	4.6	3.5	2.6	2.1	1.7	1.5	1.3	1.1	1.0
43	7.2	6.0	4.8	3.6	2.7	2.2	1.8	1.5	1.3	1.1	1.1
44	7.5	6.2	5.0	3.8	2.8	2.3	1.9	1.6	1.4	1.3	1.1
[illegible]	7.9	6.5	5.3	4.0	3.0	2.4	2.0	1.7	1.5	1.3	1.2
46	8.2	6.7	5.5	4.1	3.1	2.5	2.1	1.8	1.5	1.4	1.2
47	8.6	7.1	5.8	4.3	3.2	2.6	2.2	1.8	1.6	1.4	1.3
48	9.0	7.5	6.0	4.5	3.4	2.7	2.3	1.9	1.7	1.5	1.3
49	9.4	7.8	6.3	4.7	3.5	2.8	2.4	2.0	1.8	1.5	1.4
50	9.9	8.1	6.5	4.9	3.7	2.9	2.5	2.1	1.9	1.6	1.5
51	10.3	8.5	6.8	5.1	3.8	3.1	2.6	2.2	1.9	1.7	1.5
52	10.7	8.9	7.1	5.3	4.0	3.2	2.7	2.3	2.0	1.8	1.6
53	11.2	9.3	7.5	5.6	4.2	3.4	2.8	2.4	2.1	1.9	1.7
54	11.6	9.7	7.8	5.8	4.4	3.5	2.9	2.5	2.2	1.9	1.8
55	12.2	10.1	8.2	6.1	4.6	3.7	3.0	2.6	2.3	2.0	1.8
56	12.7	10.5	8.5	6.4	4.8	3.8	3.2	2.7	2.4	2.1	1.9
57	13.4	11.0	8.9	6.7	5.0	4.0	3.3	2.8	2.5	2.2	2.0
58	14.0	11.5	9.3	6.9	5.2	4.2	3.5	3.0	2.6	2.3	2.1
59	14.5	12.0	9.7	7.2	5.4	4.4	3.6	3.1	2.7	2.4	2.2
60	15.1	12.6	10.1	7.6	5.7	4.6	3.8	3.2	2.8	2.5	2.3

Feeding Tables for Trout (Revised), Deuel and Tunison, February 1944.

Table 4

LAKE TROUT: AMOUNT OF FOOD TO FEED PER DAY, IN PERCENT OF BODY WEIGHT FOR DIFFERENT SIZED GROUPS HELD IN WATER OF DIFFERENT TEMPERATURES

Water Temp. (F.)	Number fish per pound										
	-3492	3492-435	435-133	133-56.7	56.7-29.0	29.0-17.0	17.0-10.5	10.5-7.09	7.09-4.94	4.94-3.66	3.66-
	Approximate size in inches										
	-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-
36	5.7%	4.6%	3.4%	2.6%	2.1%	1.7%	1.5%	1.3%	1.2%	1.0%	1.0%
37	5.9	4.8	3.6	2.7	2.1	1.8	1.5	1.3	1.2	1.1	1.0
38	6.1	4.9	3.7	2.8	2.2	1.9	1.6	1.4	1.2	1.1	1.0
39	6.4	5.1	3.8	2.9	2.3	1.9	1.6	1.4	1.3	1.1	1.1
40	6.6	5.3	4.0	3.0	2.4	2.0	1.7	1.5	1.3	1.2	1.1
41	6.8	5.5	4.1	3.1	2.5	2.1	1.8	1.5	1.4	1.2	1.2
42	7.1	5.7	4.3	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.2
43	7.4	5.9	4.4	3.3	2.7	2.2	1.9	1.7	1.5	1.3	1.2
44	7.6	6.1	4.6	3.5	2.8	2.3	2.0	1.7	1.5	1.4	1.3
45	7.9	6.4	4.8	3.6	2.9	2.4	2.0	1.8	1.6	1.4	1.3
46	8.2	6.6	5.0	3.7	3.0	2.5	2.1	1.9	1.7	1.5	1.4
47	8.5	6.9	5.1	3.9	3.1	2.6	2.2	1.9	1.7	1.5	1.4
48	8.9	7.1	5.3	4.0	3.2	2.7	2.3	2.0	1.8	1.6	1.5
49	9.2	7.4	5.5	4.1	3.3	2.8	2.4	2.1	1.8	1.7	1.5
50	9.5	7.6	5.7	4.3	3.4	2.9	2.4	2.1	1.9	1.7	1.6
51	9.9	7.9	5.9	4.5	3.6	3.0	2.5	2.2	2.0	1.8	1.7
52	10.2	8.2	6.1	4.6	3.7	3.1	2.6	2.3	2.0	1.8	1.7
53	10.6	8.5	6.4	4.8	3.8	3.2	2.7	2.4	2.1	1.9	1.8
54	11.0	8.8	6.6	5.0	4.0	3.3	2.8	2.5	2.2	2.0	1.9
55	11.4	9.1	6.8	5.2	4.1	3.4	2.9	2.6	2.3	2.1	1.9
56	11.8	9.5	7.1	5.3	4.3	3.6	3.0	2.7	2.4	2.1	2.0
57	12.2	9.8	7.3	5.5	4.4	3.7	3.1	2.8	2.4	2.2	2.0
58	12.6	10.1	7.6	5.7	4.6	3.8	3.2	2.9	2.5	2.3	2.1
59	13.1	10.5	7.9	5.9	4.7	4.0	3.4	3.0	2.6	2.4	2.2
60	13.6	11.0	8.2	6.2	4.9	4.1	3.5	3.1	2.7	2.5	2.3

Feeding Tables for Trout (Revised), Deuel and Tunison, February 1944.

Table 5

ELATION OF WEIGHT TO LENGTH FOR BROOK TROUT, BROWN TROUT, AND RAINBOW TROUT

(From Haskell, 1959)

ber r nd	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches
0	0.744	4000	0.851	2000	1.072	1200	1.271
0	0.745	3950	0.855	1980	1.076	1180	1.278
00	0.748	3900	0.858	1960	1.079	1160	1.285
0	0.750	3850	0.862	1940	1.083	1140	1.293
0	0.752	3800	0.866	1920	1.087	1120	1.302
0	0.754	3750	0.870	1900	1.091	1100	1.309
00	0.756	3700	0.873	1880	1.095	1080	1.317
0	0.758	3650	0.877	1860	1.099	1060	1.325
0	0.761	3600	0.881	1840	1.102	1040	1.334
0	0.763	3550	0.886	1820	1.107	1020	1.342
00	0.765	3500	0.890	1800	1.111	1000	1.351
0	0.768	3450	0.894	1780	1.115	990	1.355
00	0.770	3400	0.898	1760	1.119	980	1.360
0	0.772	3350	0.903	1740	1.123	970	1.365
00	0.775	3300	0.907	1720	1.128	960	1.370
0	0.777	3250	0.912	1700	1.132	950	1.374
00	0.780	3200	0.917	1680	1.136	940	1.379
[illegible]	0.782	3150	0.922	1660	1.141	930	1.384
0	0.785	3100	0.926	1640	1.146	920	1.389
50	0.788	3050	0.932	1620	1.150	910	1.394
00	0.790	3000	0.937	1600	1.155	900	1.399
50	0.793	2950	0.942	1580	1.160	890	1.405
00	0.795	2900	0.947	1560	1.165	880	1.410
50	0.798	2850	0.953	1540	1.170	870	1.415
00	0.801	2800	0.958	1520	1.175	860	1.421
50	0.804	2750	0.964	1500	1.180	850	1.426
00	0.806	2700	0.970	1480	1.085	840	1.432
50	0.809	2650	0.976	1460	1.191	830	1.438
00	0.812	2600	0.982	1440	1.196	820	1.443
50	0.815	2550	0.989	1420	1.202	810	1.449
00	0.818	2500	0.995	1400	1.208	800	1.455
50	0.821	2450	1.002	1380	1.213	790	1.461
00	0.824	2400	1.009	1360	1.219	780	1.468
50	0.828	2350	1.016	1340	1.225	770	1.474
00	0.831	2300	1.023	1320	1.231	760	1.480
50	0.834	2250	1.031	1300	1.238	750	1.487
00	0.837	2200	1.039	1280	1.244	740	1.494
50	0.841	2150	1.047	1260	1.251	730	1.500
00	0.844	2100	1.055	1240	1.258	720	1.507
50	0.848	2050	1.063	1220	1.264	710	1.514

Table 5 (Continued)

Number per pound	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches
700	1.522	450	1.763	340	1.936	260	2.117
690	1.529	445	1.769	338	1.939	258	2.122
680	1.536	440	1.776	336	1.943	256	2.127
670	1.544	435	1.783	334	1.947	254	2.133
660	1.552	430	1.790	332	1.951	252	2.139
650	1.560	425	1.797	330	1.955	250	2.144
640	1.568	420	1.804	328	1.959	248	2.150
630	1.576	415	1.811	326	1.963	246	2.156
620	1.584	410	1.819	324	1.967	244	2.162
610	1.593	405	1.826	322	1.971	242	2.168
600	1.602	400	1.834	320	1.975	240	2.174
595	1.607	398	1.837	318	1.979	238	2.180
590	1.611	396	1.840	316	1.983	236	2.186
585	1.616	394	1.843	314	1.988	234	2.192
580	1.620	392	1.846	312	1.992	232	2.198
575	1.625	390	1.849	310	1.996	230	2.205
570	1.629	388	1.852	308	2.000	228	2.211
565	1.634	386	1.855	306	2.005	226	2.218
560	1.639	384	1.859	304	2.009	224	2.225
555	1.644	382	1.862	302	2.014	222	2.231
550	1.649	380	1.865	300	2.018	220	2.238
545	1.654	378	1.869	298	2.023	218	2.245
540	1.659	376	1.872	296	2.027	216	2.252
535	1.664	374	1.875	294	2.032	214	2.259
530	1.669	372	1.878	292	2.036	212	2.266
525	1.675	370	1.882	290	2.041	210	2.273
520	1.680	368	1.885	288	2.046	208	2.280
515	1.686	366	1.889	286	2.051	206	2.288
510	1.691	364	1.892	284	2.055	204	2.295
505	1.697	362	1.896	282	2.060	202	2.303
500	1.702	360	1.899	280	2.065	200	2.310
495	1.708	358	1.901	278	2.070	199	2.314
490	1.714	356	1.906	276	2.075	198	2.318
485	1.719	354	1.910	274	2.080	197	2.322
480	1.725	352	1.913	272	2.085	196	2.326
475	1.732	350	1.917	270	2.090	195	2.330
470	1.738	348	1.921	268	2.095	194	2.334
465	1.744	346	1.924	266	2.101	193	2.338
460	1.750	344	1.928	264	2.106	192	2.342
455	1.757	342	1.932	262	2.111	191	2.346

Table 5 (Continued)

Number per pound	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches
[illegible]	2.350	149	2.548	108	2.837	83.5	3.090
[illegible]	2.354	148	2.554	107	2.846	83.0	3.097
[illegible]	2.358	147	2.560	106	2.854	82.5	3.103
[illegible]	2.362	146	2.566	105	2.863	82.0	3.110
[illegible]	2.367	145	2.572	104	2.873	81.5	3.116
[illegible]	2.371	144	2.578	103	2.882	81.0	3.122
[illegible]	2.375	143	2.584	102	2.892	80.5	3.128
[illegible]	2.379	142	2.590	101	2.901	80.0	3.135
[illegible]	2.384	141	2.596	100	2.910	79.5	3.141
[illegible]	2.388	140	2.602	99.5	2.915	79.0	3.148
[illegible]	2.393	139	2.608	99.0	2.920	78.5	3.155
[illegible]	2.397	138	2.614	98.5	2.925	78.0	3.162
[illegible]	2.402	137	2.620	98.0	2.931	77.5	3.169
[illegible]	2.406	136	2.627	97.5	2.935	77.0	3.176
[illegible]	2.411	135	2.633	97.0	2.940	76.5	3.182
[illegible]	2.415	134	2.640	96.5	2.945	76.0	3.189
[illegible]	2.420	133	2.647	96.0	2.950	75.5	3.196
[illegible]	2.424	132	2.654	95.5	2.955	75.0	3.204
[illegible]	2.429	131	2.660	95.0	2.961	74.5	3.211
[illegible]	2.434	130	2.667	94.5	2.966	74.0	3.218
[illegible]	2.439	129	2.674	94.0	2.971	73.5	3.225
[illegible]	2.443	128	2.681	93.5	2.977	73.0	3.233
[illegible]	2.448	127	2.688	93.0	2.982	72.5	3.240
[illegible]	2.453	126	2.695	92.5	2.987	72.0	3.248
[illegible]	2.458	125	2.702	92.0	2.993	71.5	3.255
[illegible]	2.463	124	2.709	91.5	2.998	71.0	3.262
[illegible]	2.468	123	2.717	91.0	3.004	70.5	3.270
[illegible]	2.473	122	2.724	90.5	3.009	70.0	3.278
[illegible]	2.478	121	2.731	90.0	3.015	69.5	3.286
[illegible]	2.483	120	2.739	89.5	3.020	69.0	3.294
[illegible]	2.488	119	2.746	89.0	3.026	68.5	3.302
[illegible]	2.493	118	2.754	88.5	3.031	68.0	3.310
[illegible]	2.499	117	2.762	88.0	3.037	67.5	3.318
[illegible]	2.504	116	2.770	87.5	3.043	67.0	3.326
[illegible]	2.510	115	2.778	87.0	3.049	66.5	3.334
[illegible]	2.515	114	2.786	86.5	3.055	66.0	3.343
[illegible]	2.521	113	2.794	86.0	3.061	65.5	3.351
[illegible]	2.526	112	2.803	85.5	3.067	65.0	3.360
[illegible]	2.531	111	2.811	85.0	3.073	64.5	3.369
[illegible]	2.537	110	2.820	84.5	3.078	64.0	3.378
[illegible]	2.543	109	2.828	84.0	3.084	63.5	3.387

Table 5 (Continued)

Number per pound	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches
63.0	3.395	43.0	3.857	33.2	4.203	25.2	4.608
62.5	3.404	42.5	3.872	33.0	4.211	25.0	4.620
62.0	3.413	42.0	3.887	32.8	4.220	24.8	4.633
61.5	3.422	41.5	3.902	32.6	4.228	24.6	4.646
61.0	3.432	41.0	3.918	32.4	4.238	24.4	4.659
60.5	3.441	40.5	3.934	32.2	4.247	24.2	4.670
60.0	3.450	40.0	3.950	32.0	4.255	24.0	4.684
59.5	3.460	39.8	3.957	31.8	4.264	23.8	4.697
59.0	3.470	39.6	3.963	31.6	4.273	23.6	4.710
58.5	3.480	39.4	3.970	31.4	3.282	23.4	4.724
58.0	3.490	39.2	3.977	31.2	4.292	23.2	4.737
57.5	3.500	39.0	3.984	31.0	4.301	23.0	4.750
57.0	3.510	38.8	3.991	30.8	4.309	22.8	4.764
56.5	3.520	38.6	3.997	30.6	4.319	22.6	4.779
56.0	3.510	38.4	4.004	30.4	4.329	22.4	4.792
55.5	3.541	38.2	4.011	30.2	4.338	22.2	4.806
55.0	3.552	38.0	4.018	30.0	4.348	22.0	4.821
54.5	3.563	37.8	4.026	29.8	4.358	21.8	4.835
54.0	3.574	37.6	4.033	29.6	4.368	21.6	4.850
53.5	3.585	37.4	4.040	29.4	4.378	21.4	4.867
53.0	3.597	37.2	4.047	29.2	4.388	21.2	4.881
52.5	3.608	37.0	4.055	29.0	4.398	21.0	4.897
52.0	3.619	36.8	4.062	28.8	4.408	20.8	4.913
51.5	3.631	36.6	4.069	28.6	4.418	20.6	4.929
51.0	3.643	36.4	4.077	28.4	4.428	20.4	4.943
50.5	3.655	36.2	4.084	28.2	4.438	20.2	4.961
50.0	3.667	36.0	4.091	28.0	4.448	20.0	4.978
49.5	3.679	35.8	4.099	27.8	4.460	19.9	4.985
49.0	3.692	35.6	4.106	27.6	4.470	19.8	4.994
48.5	3.705	35.4	4.114	27.4	4.481	19.7	5.002
48.0	3.718	35.2	4.123	27.2	4.493	19.6	5.011
47.5	3.730	35.0	4.130	27.0	4.503	19.5	5.018
47.0	3.743	34.8	4.138	26.8	4.514	19.4	5.028
46.5	3.756	34.6	4.145	26.6	4.526	19.3	5.037
46.0	3.770	34.4	4.154	26.4	4.537	19.2	5.045
45.5	3.784	34.2	4.162	26.2	4.549	19.1	5.054
45.0	3.798	34.0	4.170	26.0	4.561	19.0	5.064
44.5	3.812	33.8	4.179	25.8	4.572	18.9	5.071
44.0	3.827	33.6	4.186	25.6	4.584	18.8	5.081
43.5	3.842	33.4	4.196	25.4	4.595	18.7	5.090

Table 5 (Continued)

Number per pound	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches
18.6	5.098	14.80	5.503	12.80	5.776	10.80	6.113
18.5	5.108	14.75	5.510	12.75	5.783	10.75	6.121
18.4	5.117	14.70	5.514	12.70	5.791	10.70	6.130
18.3	5.127	14.65	5.521	12.65	5.798	10.65	6.141
18.2	5.137	14.60	5.528	12.60	5.806	10.60	6.149
18.1	5.145	14.55	5.535	12.55	5.813	10.55	6.160
18.0	5.154	14.50	5.539	12.50	5.821	10.50	6.169
17.9	5.164	14.45	5.546	12.45	5.828	10.45	6.180
17.8	5.174	14.40	5.553	12.40	5.836	10.40	6.189
17.7	5.184	14.35	5.560	12.35	5.846	10.35	6.200
17.6	5.194	14.30	5.567	12.30	5.854	10.30	6.209
17.5	5.204	14.25	5.573	12.25	5.861	10.25	6.220
17.4	5.214	14.20	5.578	12.20	5.869	10.20	6.229
17.3	5.224	14.15	5.585	12.15	5.876	10.15	6.240
17.2	5.234	14.10	5.592	12.10	5.884	10.10	6.249
17.1	5.244	14.05	5.599	12.05	5.892	10.05	6.260
17.0	5.253	14.00	5.606	12.00	5.902	10.00	6.272
16.9	5.265	13.95	5.613	11.95	5.910	9.95	6.281
16.8	5.275	13.90	5.620	11.90	5.918	9.90	6.293
16.7	5.286	13.85	5.624	11.85	5.925	9.85	6.301
16.6	5.296	13.80	5.631	11.80	5.933	9.80	6.313
16.5	5.306	13.75	5.639	11.75	5.944	9.75	6.325
16.4	5.317	13.70	5.646	11.70	5.951	9.70	6.334
16.3	5.327	13.65	5.653	11.65	5.959	9.65	6.346
16.2	5.340	13.60	5.660	11.60	5.967	9.60	6.358
16.1	5.350	13.55	5.667	11.55	5.978	9.55	6.367
16.0	5.361	13.50	5.674	11.50	5.986	9.50	6.379
15.9	5.372	13.45	5.681	11.45	5.994	9.45	6.391
15.8	5.385	13.40	5.688	11.40	6.002	9.40	6.409
15.7	5.395	13.35	5.696	11.35	6.012	9.35	6.412
15.6	5.406	13.30	5.703	11.30	6.020	9.30	6.424
15.5	5.419	13.25	5.710	11.25	6.028	9.25	6.436
15.4	5.430	13.20	5.717	11.20	6.039	9.20	6.449
15.3	5.441	13.15	5.724	11.15	6.047	9.15	6.458
15.2	5.454	13.10	5.732	11.10	6.056	9.10	6.470
15.1	5.465	13.05	5.739	11.05	6.066	9.05	6.483
15.0	5.478	13.00	5.746	11.00	6.075	9.00	6.495
14.95	5.483	12.95	5.754	10.95	6.083	8.95	6.508
14.90	5.490	12.90	5.761	10.90	6.094	8.90	6.520
14.85	5.496	12.85	5.768	10.85	6.102	8.85	6.533

Table 5 (Continued)

Number per pound	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches	Number per pound	Length in inches
8.80	6.544	7.30	6.964	5.85	7.498	4.40	8.245
8.75	6.555	7.25	6.982	5.80	7.519	4.35	8.276
8.70	6.568	7.20	6.996	5.75	7.541	4.30	8.308
8.65	6.581	7.15	7.014	5.70	7.563	4.25	8.340
8.60	6.593	7.10	7.029	5.65	7.585	4.20	8.374
8.55	6.606	7.05	7.047	5.60	7.608	4.15	8.407
8.50	6.619	7.00	7.062	5.55	7.631	4.10	8.441
8.45	6.632	6.95	7.079	5.50	7.654	4.05	8.476
8.40	6.645	6.90	7.096	5.45	7.677	4.00	8.511
8.35	6.658	6.85	7.113	5.40	7.701	3.95	8.546
8.30	6.672	6.80	7.131	5.35	7.724	3.90	8.583
8.25	6.685	6.75	7.148	5.30	7.749	3.85	8.620
8.20	6.701	6.70	7.166	5.25	7.773	3.80	8.657
8.15	6.715	6.65	7.184	5.20	7.798	3.75	8.696
8.10	6.728	6.60	7.202	5.15	7.823	3.70	8.735
8.05	6.741	6.55	7.221	5.10	7.849	3.65	8.774
8.00	6.755	6.50	7.239	5.05	7.874	3.60	8.815
7.95	6.768	6.45	7.257	5.00	7.901	3.55	8.856
7.90	6.782	6.40	7.277	4.95	7.927	3.50	8.898
7.85	6.799	6.35	7.296	4.90	7.954	3.45	8.941
7.80	6.813	6.30	7.315	4.85	7.981	3.40	8.984
7.75	6.827	6.25	7.334	4.80	8.009	3.35	9.029
7.70	6.840	6.20	7.354	4.75	8.037	3.30	9.074
7.65	6.858	6.15	7.374	4.70	8.065	3.25	9.121
7.60	6.872	6.10	7.394	4.65	8.094	3.20	9.168
7.55	6.886	6.05	7.414	4.60	8.123	3.15	9.216
7.50	6.903	6.00	7.435	4.55	8.153	3.10	9.265
7.45	6.917	5.95	7.455	4.50	8.183	3.05	9.316
7.40	6.932	5.90	7.476	4.45	8.214	3.00	9.368
7.35	6.949						

Table 6

POUNDS OF TROUT THAT MAY BE CARRIED PER CUBIC FOOT OF WATER

(From Kenneth Nichols, State of New York Conservation Department)

Size of trout in inches	Pounds per cubic foot of water	
	In troughs	In ponds
- 1	0.6	---
1 - 2	1.0	---
2 - 3	2.0	0.3
3 - 4	3.0	0.7
4 - 5	4.0	0.8
5 - 6	---	0.9
6 - 7	---	1.0

Table 7

CHEMICAL COMPOSITION OF SOME FOODS FOR HATCHERY TROUT

	Percent					
ood	Protein	Fat	Carbohydrate	Ash	Fiber	Water
esh Meats:						
Heart, beef	14.8	24.7	0.9	0.9	---	53.3
Kidney, beef	13.7	1.9	0.4	1.0	---	74.0
Liver						
Beef	20.2	3.1	2.5	1.3	---	72.3
Pork	21.3	4.5	1.4	1.4	---	72.8
Sheep	23.1	9.0	5.0	1.7	---	61.2
Lungs, beef	16.4	2.8	---	1.0	---	79.7
Spleen						
Beef	18.0	2.3	---	1.4	---	75.2
Pork	17.0	1.9	---	1.4	---	78.0
esh fish						
Alewife	10.0	2.4	---	0.8	---	72.0
Carp	10.0	15.0	---	0.5	---	73.0
Herring	11.2	3.9	---	1.6	---	72.0
Whiting	18.8	4.0	---	5.4	1.7	71.0
imal meals						
Buttermilk, dried	33.8	5.6	41.9	10.5	0.3	7.8
Liver, dried	67.2	14.6	2.4	7.5	1.9	10.0
Meat	55.0	12.0	1.2	25.0	2.2	10.0
Skim milk, dried	34.8	0.9	50.1	8.0	---	6.2
nt meals						
BY-100	25.0	0.5	40.0	12.0	5.0	8.0
Cottonseed	38.0	8.0	39.9	6.4	10.5	10.0
Kelp	5.6	0.7	43.7	33.2	7.5	10.0
Red-dog flour	16.8	4.1	65.5	2.5	2.4	10.0
Soybean (expeller)	49.9	6.2	26.4	5.5	5.1	10.0
Solubles, distiller's	25.0	5.0	48.0	7.5	4.0	----
Wheat middlings	17.8	5.0	62.8	3.7	4.4	10.0
Wheat shorts	17.4	4.9	62.8	4.4	6.2	10.0
sh meals						
Menhaden	62.0	7.0	0.8	21.0	2.4	10.0
Salmon	55.0	---	---	---	---	10.0
Sardine	64.5	9.8	3.8	15.2	0.2	10.0
Whitefish	54.5	8.8	4.6	22.0	1.0	10.5
Whitefish	68.0	2.0	3.6	19.0	0.7	10.0
Redfish	57.0	6.0	---	26.0	1.0	10.0

Table 8

VITAMIN CONTENT OF SOME FOODS FOR HATCHERY TROUT

Food	Milligrams per 100 grams of food								
	Thiamine B1	Pyridoxine B6	Riboflavin B	Pantothenic acid	Biotin	Folic acid	Niacin	Choline	B1[illegible]
Fresh meats									
Heart, beef	0.61	0.24	1.76	1.80	0.008	0.11	7.0	170	0.[illegible]
Kidney, beef	0.51	0.44	0.20	3.70	0.022	---	10.0	360	0.[illegible]
Liver									
Beef	0.27	0.85	4.05	5.53	0.131	0.29	0.29	320	0.[illegible]
Pork	0.52	0.33	5.40	5.00	0.044	---	19.0	470	0.[illegible]
Sheep	0.14	0.37	5.20	5.34	---	---	15.0	---	---
Lungs, beef	0.20	0.07	0.49	1.80	0.003	---	6.2	---	0.[illegible]
Spleen									
Beef	0.16	0.12	0.45	1.10	0.011	0.15	7.5	---	0.[illegible]
Pork	0.24	0.12	0.76	1.60	0.004	0.12	4.3	208	---
Fresh fish									
Alewife	---	---	---	---	---	---	---	---	---
Carp	0.01	---	0.02	---	---	---	0.9	---	---
Herring	0.12	---	0.31	---	---	---	3.0	---	---
Whiting	---	---	---	---	---	---	---	---	---
Animals meals									
Buttermilk, dried	0.28	---	3.30	4.40	---	---	1.7	111	---
Liver, dried	1.20	---	10.20	15.40	---	---	98.3	---	---
Meat	0.12	---	0.60	0.80	---	---	6.8	189	---
Skim milk. dried	0.35	0.45	2.05	3.30	0.039	0.03	1.1	160	-
Plants meals									
BY-100	0.32	1.06	10.00	48.00	0.15	0.11	22.0	52	0.[illegible]
Cottonseed	1.30	0.69	0.40	1.14	0.05	0.07	2.3	266	---
Kelp	---	---	---	---	---	---	---	---	---
Red-dog flour	2.18	---	0.24	1.40	---	---	5.5	100	---
Soybean (expeller)	1.35	0.35	0.33	2.00	---	0.33	3.9	244	---
Solubles, distiller's	0.55	0.90	1.10	2.20	0.03	0.11	12.1	550	---
Wheat middlings	1.32	0.73	0.31	1.20	0.06	0.07	4.3	100	---
Wheat shorts	1.70	---	0.26	1.10	---	0.08	9.5	100	---
Yeast, brewer's	11.00	3.00	4.40	11.00	2.50	2.00	47.0	440	0.[illegible]
Fish meals									
Menhaden	---	---	0.46	0.89	---	---	5.5	311	---
Salmon	---	---	---	---	---	---	---	---	---
Sardine	---	---	0.70	0.28	---	---	6.7	289	---
Whitefish	0.09	0.21	0.96	1.22	0.04	0.05	6.7	155	---
Redfish	---	---	0.80	0.66	---	0.03	4.1	311	---

TABLE 5

A FEW SUGGESTED DIET MIXTURES FOR HATCHERY TROUT

Ingredient	Mixtures for "mush", blower and cement-mixer feeds 1/ Cortland number				Pellet mixtures 1/			
	6	6a	6b	6g	Cortland	Minneapolis	New Jersey	New York
Dried skim milk	12	---	---	---	7	11	8	3
Whitefish meal	12	12	12	---	40	16	25	24
Cottonseed meal	12	12	12	12	15	24	15	15
Wheat flour middlings	12	12	---	12	25	24	20	24 3/
Distiller's solubles	---	12	12	12	---	11	15	21
Red-dog flour	---	---	12	---	---	---	---	---
Menhaden fish meal	---	---	---	12	---	---	---	---
Poultry feeding oil	---	---	---	3	3	---	3 2/	3
Dried brewer's yeast	---	---	---	5	10	10	10	10
Salt	2	2	2	2	---	4	4	---
Pork spleen	30	---	---	---	---	---	---	---
Beef spleen	---	30	30	42	---	---	---	---
Beef liver	20	20	20	---	---	---	---	---

1/ Amounts of ingredients are in percent.

2/ 1.5 percent vitamin A and D powder and 1.5 percent of stabilized fat are substituted for the feeding oil.

3/ Red-dog flour may be substituted for wheat flour middlings.

Table 8

VITAMIN CONTENT OF SOME FOODS FOR HATCHERY TROUT

Food	Milligrams per 100 grams of food								
	Thia-mine B1	Pyri-doxine B6	Ribo-flavin B	Panto-thenic acid	Biotin	Folic acid	Nia-cin	Cho-line	B1
Fresh meats									
Heart, beef	0.61	0.24	1.76	1.80	0.008	0.11	7.0	170	0.
Kidney, beef	0.51	0.44	0.20	3.70	0.022	---	10.0	360	0.
Liver									
Beef	0.27	0.85	4.05	5.53	0.131	0.29	0.29	320	0.
Pork	0.52	0.33	5.40	5.00	0.044	---	19.0	470	0.
Sheep	0.14	0.37	5.20	5.34	---	---	15.0	---	--
Lungs, beef	0.20	0.07	0.49	1.80	0.003	---	6.2	---	0.
Spleen									
Beef	0.16	0.12	0.45	1.10	0.011	0.15	7.5	---	0.
Pork	0.24	0.12	0.76	1.60	0.004	0.12	4.3	208	--
Fresh fish									
Alewife	---	---	---	---	---	---	---	---	--
Carp	0.01	---	0.02	---	---	---	0.9	---	--
Herring	0.12	---	0.31	---	---	---	3.0	---	--
Whiting	---	---	---	---	---	---	---	---	--
Animals meals									
Buttermilk, dried	0.28	---	3.30	4.40	---	---	1.7	111	--
Liver, dried	1.20	---	10.20	15.40	---	---	98.3	---	--
Meat	0.12	---	0.60	0.80	---	---	6.8	189	--
Skim milk. dried	0.35	0.45	2.05	3.30	0.039	0.03	1.1	160	-
Plants meals									
BY-100	0.32	1.06	10.00	48.00	0.15	0.11	22.0	52	0.
Cottonseed	1.30	0.69	0.40	1.14	0.05	0.07	2.3	266	--
Kelp	---	---	---	---	---	---	---	---	--
Red-dog flour	2.18	---	0.24	1.40	---	---	5.5	100	--
Soybean (expeller)	1.35	0.35	0.33	2.00	---	0.33	3.9	244	--
Solubles, distiller's	0.55	0.90	1.10	2.20	0.03	0.11	12.1	550	--
Wheat middlings	1.32	0.73	0.31	1.20	0.06	0.07	4.3	100	--
Wheat shorts	1.70	---	0.26	1.10	---	0.08	9.5	100	--
Yeast, brewer's	11.00	3.00	4.40	11.00	2.50	2.00	47.0	440	0.
Fish meals									
Menhaden	---	---	0.46	0.89	---	---	5.5	311	--
Salmon	---	---	---	---	---	---	---	---	--
Sardine	---	---	0.70	0.28	---	---	6.7	289	--
Whitefish	0.09	0.21	0.96	1.22	0.04	0.05	6.7	155	--
Redfish	---	---	0.80	0.66	---	0.03	4.1	311	--

TABLE 9

A FEW SUGGESTED DIET MIXTURES FOR HATCHERY TROUT

Ingredient	Mixtures for "mush", blower and cement-mixer feeds 1/				Pellet mixtures 1/			
	Cortland number							
	6	6a	6b	6g	Cortland	Minneapolis	New Jersey	New York
Dried skim milk	12	---	---	---	7	11	8	3
Whitefish meal	12	12	12	---	40	16	25	24
Cottonseed meal	12	12	12	12	15	24	15	15
Wheat flour middlings	12	12	---	12	25	24	20	24 3/
Distiller's solubles	---	12	12	12	---	11	15	21
Red-dog flour	---	---	12	---	---	---	---	---
Menhaden fish meal	---	---	---	12	---	---	---	---
Poultry feeding oil	---	---	---	3	3	---	3 2/	3
Dried brewer's yeast	---	---	---	5	10	10	10	10
Salt	2	2	2	2	---	4	4	---
Pork spleen	30	---	---	---	---	---	---	---
Beef spleen	---	30	30	42	---	---	---	---
Beef liver	20	20	20	---	---	---	---	---

1/ Amounts of ingredients are in percent.

2/ 1.5 percent vitamin A and D powder and 1.5 percent of stabilized fat are substituted for the feeding oil.

3/ Red-dog flour may be substituted for wheat flour middlings.

Table 10

COMPARISON OF GROWTH, CONVERSION, AND CALORIES AND PROTEIN REQUIRED TO PRODUCE A POUND OF BROOK TROUT FED DIFFERENT DIETS

Diet composition (percent)	Number of observa-tions	Avg. total % gain	Avg. total conver-sion	% protein in the diet	Total cal. per lb. of diet	Calories required per lb. of fish produced	Grams of protein req. per lb. of fish prod.
	Water temperature 47°F.; 20-week experimental period 1/						
Pork spleen 48 Beef liver 50 Salt 2	10	1,717	2.9	18.3	415.0	1,204	238.6
Pork spleen 50 Dry meal 50 2/	13	1,854	2.9	27.6	722.3	2,095	359.6
Pork spleen 30 Beef liver 20 Dry meal 50 2/	2	2,160	2.7	27.3	744.0	2,088	334.8
	Water temperature varied with season (40°F. to 60°F.); 6-month experimental period 3/						
Beef spleen 32 Beef liver 16 Dry Meal 52 4/	2	562	2.9	27.4	744.3	2,158	357.6
Pellets, 5 days weekly Meat mixture, 2 days weekly 5/	2	634	2.1	35.3	930.7	1,954	333.5
Pellets, 6 days weekly Meat mixture, 1 day weekly 5/	2	535	2.0	40.6	1,094.1	2,188	363.8

1/ Average weight of fish at start 0.5 to 0.8 gram.

2/ Equal parts of cottonseed, wheat midds, dried skim milk, fish meal, and 4 percent salt.

3/ Average weight at start approximately 12 grams.

4/ Equal parts of red-dog flour, cottonseed, fish meal, distiller's solubles, and 4 percent salt.

Table 11

TYPE OF FISH FEED PURCHASED AT NATIONAL FISH HATCHERIES IN 1961

Area	Total Fish Feed Purch.	Pellet Type (complete diet)		Other Type (meats, meal, suppl. pellets)	
		Lbs. Used	%	Lbs. Used	%
gion 1	1,523,942	1,501,099	98	22,843	2
gion 2	678,502	317,480	47	361,022	53
gion 3	521,243	205,553	39	315,690	61
gion 4	1,143,997	595,550	52	548,447	48
gion 5	1,123,916	860,200	77	263,716	23
TOTAL	4,991,600	3,479,882		1,511,718	
erage			70		30

Table 12

TROUT FOOD SPECIFICATIONS, PARTICLE SIZES

e following particle sizes will be standard for all dry trout food purchased r National Fish Hatcheries through competitive bidding.

umble sizes are gauged by U. S. Sieve Series Standards.

es		Standard Designation (sieve opening)
arter	To Pass Through	595 microns
	To Pass Over	420 microns
. 1 Crumbles	To Pass Through	841 microns
	To Pass Over	595 microns
. 2 Crumbles	To Pass Through	1.19 mm
	To Pass Over	841 microns
. 3 Crumbles	To Pass Through	1.68 mm
	To Pass Over	1.19 mm
. 4 Crumbles	To Pass Through	2.83 mm
	To Pass Over	1.68 mm

llets, 3/32 inch diameter
llets, 1/8 inch diameter
llets, 3/16 inch diameter

ngth of pellets may be specified according to need.

llets 5/32 inch diameter may be accepted as an alternate size in lengths signated by the ordering hatchery.

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