UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE
Branch of Fish Hatcheries

Washington 25, D. C.

Leaflet FL-423
Revised February 1945

TROUT FEEDS AND FEEDING

A. V. Tunison
Cortland Experimental Hatchery
Cortland, N. Y.

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Introduction

The food of man is composed of both plant and animal products and he varies his diet in accordance with his likes and dislikes as well as in respect to his income. The largest part of the food for our animals comes from the plant world although a carnivorous animal like the dog eats raw meat. Fish are both omnivorous and carnivorous animals. Certain species have characteristic choosings. Various forage fish and carp are largely plant feeders whereas the pike is a carnivorous animal. In nature the trout's diet is composed largely of animal material such as aquatic and terrestrial organisms. Under domesticated conditions the trout's diet in the early years of fish culture consisted mainly of the organs of warm blooded animals. In recent years science has shown that these organs are very valuable in human nutrition and consequently their price has risen so that they are now rather prohibitive as trout food. The trout culturist has resorted to cheaper meat products and has used plant products as supplements with increasing success. He has also used carp, forage fish, herring and other marine fish for a part of his trout diet but in some instances the use of this type of food has led to disaster.

The production of trout in the hatchery is another phase of animal husbandry. Animals are raised for their meat or for their products such as eggs and milk. Trout are propagated for their flesh, either on the fish market or in the streams, and a few hatcheries specialize in the production of trout eggs. Just as in the case of other livestock trout must be raised cheaply and they must be vigorous and healthy when marketed. The food cost of producing trout is a major item and will vary in importance with the magnitude of such items as labor, investment in buildings and equipment, and various items of operation.

The diet of trout has undergone experimentation for a number of years. Emphasis has been placed on studies of the fundamental nutritional requirements of fish and the application of the results of such studies to the hatchery diets. Many feeding trials with various types of diets have been conducted in the hatcheries of the country. For the past 13 years this hatchery has been engaged in studying the nutrition of trout. The results of this research have been published by the New York State Conservation Department in bulletin form each year. "The Nutrition of Trout" (Annual Report of the Cortland Fish Hatchery) may be obtained from the Albany office of the Department at a nominal charge.

The following pages contain suggestions for the hatcheryman relative to the nutrition of trout. The diets that are recommended have been used successfully at this hatchery for several years. As far as we know at this time they are applicable to brook, brown, rainbow and lake trout. Since the preparation of food and the actual feeding operations are just as important as the diet itself, some time is spent in describing these details.

Rations for livestock will vary in different sections of the country depending upon the availability of certain feedstuffs. This will also apply to the trout diet. Diets which have proved to be successful at this hatchery and are suggested herein may be modified to conform to local prices. However, before modifying the diets the hatcheryman should prepare them as stated in order to observe their physical condition. Substitution of a granular feed such as some types of meat meal will markedly alter the physical state of a spleen-dry feed mixture and would not be satisfactory although the diet might cost less per pound. A hatcheryman should not use a feedstuff just because he can buy it cheaply. Gold dust would be an economical feed if one could raise his fish with a food cost of production of only a cent a pound. This implies that the fish culturist should keep records of his hatchery production in terms of pounds of food required to produce one pound of fish and cost of food to produce one pound of fish. Such a practice is obvious if one is to make progressive improvements.

It is suggested that the hatcheryman who attempts to introduce the meat-dry feed diets do so gradually and with a degree of experimentation. The feeder must gain experience in their preparation and use, and the local condition must be tested to determine the suitability of the meat-dry feed mixtures. We know of several instances where the successful use of this type of diet is prohibited due to local conditions of water supply, hatchery lay-out, or for some other reason. In time we hope to find ways of correcting these prohibitive factors.

During the present wartime emergency the fish food problem is serious. Feedstuffs which were formerly available are difficult to obtain. This applies not only to the fresh meat part of the diet but to the dry feeds as well. The reason for this is the increased requirements of the Army, Civilian, and Lend-Lease Programs. The fish culturist must resort to the use of substitutes whenever possible. Several years ago a Supplement was prepared for the original Trout Feeds and Feeding covering the use of substitutes for the trout diets and that material is included in the present revision.

Diets for Trout Fry

The diet of trout fry consists largely of fresh meat. Numerous experiments have been run to improve it nutritionally and economically but supplements of dry feedstuffs have usually been found of little benefit. The fresh meats commonly employed in hatchery diets are as follows:

Liver. Beef liver is the favorite food in most hatchery for the fry diets. Other livers such as sheep and pork are sometimes used but the growth is usually less. Pork liver when mixed up in diet form causes quite a milky pollution in the water. It is understood that two per cent of salt

in the diet will help to eliminate the milky condition of the pork liver diet.

Hearts. Beef heart makes a good food for fry starting to feed but after a week or ten days it can be omitted.

Melts. Pork melts are preferred. Beef melts can be used but because of their higher content of "fiber" more work is required in cleaning screens following their use. The beef melts should be skinned before feeding to small fish. When fed alone melts are a poor fry food.

Horse products. Horse liver has been tested as a fry food and found to be inferior to beef. However, it can be used as a substitute. Horse meat has been used in the diets of older fish in many hatcheries, particularly in the West. It is rather poor food, however, and other types of diets will produce better results.

Condemned livers. Livers condemned on account of fluke infestation and other parasites may be used as fish food provided they are first made inedible for human consumption in accordance with procedures outlined by the Bureau of Animal Industry. In the case of fluke-infested livers, they are slashed and then denatured by dipping in a hot solution containing one part of fast green F.C.F. in 5,000 parts of water, followed by washing in fresh water and then freezing. Cooking previous to denaturing is necessary when the livers are infested with certain other parasites. The condemned livers are sold at reduced prices and have found use in many hatcheries during the past few years.

Last year a number of experiments were conducted to determine the value of the condemned livers. The treated beef liver may be used satisfactorily. Over a 36-week period trout fed the condemned beef livers grew practically as well as they did when they received fresh beef livers.

Denatured sheep and pork livers cannot be recommended. Fry fed upon treated sheep liver developed swollen bodies (edema) and pop-eye in a very short period. Larger fingerlings when fed this diet became anemic and died. The exact cause of this is not known. Further experiments are under way to test the condemned products.

A diet composed of half beef liver and half pork spleen has been used at this hatchery for a number of years for the fry. This diet will produce about the same growth as beef liver and at a fair saving in cost. It is recommended for general hatchery use.

For fry beginning to feed, the meat is put through the finest plate (5/64") of the meat grinder several times. It may be fed to the fry in several different ways. Some men add water to the meat and beat it with an egg beater. A feather or spoon is then used to distribute it in the water. If this method is employed care should be exercised that the diet does not

contain too much water; otherwise a large portion of the food will be lost to the fish. Another method that appears advantageous is to feed the meat by means of a perforated bottom dipper. The perforations of the bottom areas are as small as the finest plate of the meat grinder, the size being increased as the fish grow. The dipper containing the meat is shaken on the surface of the water and the small meat particles drop through the perforated bottom into the trough.

Feeding utensils used for trout fry.

A modified potato ricer is probably one of the best implements to use for feeding fish. The regular potato ricer, obtainable in hardware stores, may be used but a good mechanic can make improvements upon it. The holes in the sides of the ricer cup should be sealed with solder. The bottom should be replaced with one of heavy gauge perforated metal, the holes being of the proper size for the fish which are to be fed. A rubber gasket held by a metal disc riveted or belted to the bottom of the plunger will help to prevent the food escaping past the plunger when the ricer is being operated. Feeding with this implement is simple. Little, if any, water is added in the preparation of the meat diet and the food is pressed out in the form of worms. One objection to the ordinary ricer is its size. However, a good mechanic can make a larger sized one which will work equally well or better. A good type of ricer can be purchased from Landers, Frary & Clark, New Britain, Connecticut. We were able to purchase blank cups for this ricer and thus drill holes in the bottom of the size desired. For detailed information on the construction of a modified potato ricer the reader is referred to the Progressive Fish Culturist, No. 55, November 1941, page 28.

Potato ricer -- a handy tool for use in feeding fish.

The fry diet of half beef liver and half hog spleen is continued until the trout have reached a size of about one to one and one-quarter inches in length. At this time two per cent of fine grade dairy salt is added. The salt combines with the spleen in the liver-spleen mixture and a rubbery consistency is formed. Hog spleen which has been allowed to completely thaw out does not work as well as when it is in a nearly frozen condition. It is

essential that the salted meat diet be fed with an implement similar to a potato ricer since it is practically impossible to break it into fine particles by any other known means. This diet can be started on fish smaller than indicated above provided the ricer cup has fine enough holes. The worms of meat which are formed as the diet is pushed through the ricer are somewhat larger than the holes themselves due to the swelling of the meat. The worms should be of such size that they are readily taken by the trout fingerlings. Water may be added in the preparation of the liver-spleen-salt diet but its early elimination is suggested. It is believed that the salted spleen prevents some loss of food nutrients in the water and any excess water in the diet would not add to this benefit.

The time at which dried meals may be incorporated in the diet depends upon several factors. Among others are--one, size of fish; two, amount of dry feed to be used; and three, the experience of the hatchery and personnel in the use of the meat-dry feed mixtures. Dried meals may be used as ingredients of fry diets if the level does not exceed 25 per cent and provided the diet is fed in such a manner that the fish are able to get the food. Pollution of the water with dissolved and suspended food materials is a serious problem with fry diets. The use of dried meals does not help to any extent and may be a hindrance in respect to pollution problem. If the dried meals are used in the diets for fry it is believed that the potato ricer is the best implement to use for feeding.

A great deal of experimentation needs to be done yet toward improving the diets for fry. In the light of nutritional requirements of farm animals the trout fry diet is deficient in certain respects and it is expensive. However, trout fry fed a meat diet do well, at least we think so, and the practice of feeding meat diets must continue until research shows us the advantages of changing.

The experience of the hatchery and personnel in the use of meat-dry feed diets is the third factor which will influence the time at which dried meals can be incorporated in the trout diet. Those who have had experience in the use of dried meals are in a better position to judge the time at which they may be started and the amounts that may be safely incorporated under their particular conditions. For those who are just starting the use of dry feed supplements it is suggested that they allow their fish to reach a size of 1-3/4 to 2 inches on the liver-spleen-salt diet before attempting the inclusion of high percentages of dry feed mixtures. The personnel at this hatchery are experienced in the use of the meat-dry feed diets and we have successfully used diets composed of 50 per cent hog spleen and 50 per cent dry feed on 1-1/4 inch brook trout. The use of such levels of dry feed for fish of this size is not recommended unless the personnel has previously used diets of this nature.

Dry Feed Mixtures

Mixtures of several feedstuffs are believed superior to one lone ingredient just as a mixture of fresh meats usually proves better than a single one. The reason for this is that a feedstuff may be potent in one single nutrient whereas another may furnish a different element and by combining a number of feeds the resulting mixture is well balanced and more complete. The different feeds have supplementary action. No single food is a complete diet for animals of all ages. Milk is the food of young animals but the cow cannot live on her own milk. One may say that beef liver is a complete food for trout. Liver is deficient in calcium. The trout corrects this by taking its calcium requirement from the water. Furthermore, trout will grow faster if two per cent of salt is added to the liver diet. Thus it is well to rely on a number of feeds when formulating animal diets.

A number of years have been required to formulate the following dry feed mixture. It has been tested for the last seven years and in our experience has proved to be satisfactory. It is a relatively high protein mixture when compared to a hog or poultry ration and because of this it is comparatively expensive. Carbohydrates could be used in place of some of the protein and thus reduce the cost but unfortunately trout are able to utilize only about 10 per cent of digestible carbohydrate. As new knowledge of trout nutrition becomes available the dry feed mixture will be modified accordingly.

Dry Feed Mixture No. 6

Dried skim milk, spray process	24
Whitefish meal	24
Cottonseed meal	24
Wheat flour middlings	24
Salt	4
	100 pounds

Dried Milk

Dried skim milk manufactured by the spray process is to be preferred. It is sold in paper lined barrels of 200 pound capacity. It will not lump on standing to any appreciable extent when purchased in this type of container. The dried milk can be purchased from many of the companies manufacturing milk products. If companies handling this commodity are not known in your community it is suggested that you write the American Dry Milk Institute, Inc., 221 North LaSalle Street, Chicago, Illinois, for such information.

Roller process dried skim milk and dried buttermilk may be used in place of the spray process skim milk. The powdered buttermilk is better than the granular type for the melt-dry feed mixtures. Dried whey is a possible substitute but it is low in protein. In using it for fingerlings a six per cent level in the diet is recommended. For yearlings that are being held over the winter for spring stocking the level may be increased to 12 per cent.

Fish Meals

White fish meal manufactured by the Dehydrating Process Company, Boston, Massachusetts, is the type of fish meal employed in the No. 6 mixture. This is a high grade fish meal. It is manufactured from the carcass resulting from the filleting operation. The meal which is vacuum steam dried has a protein content of 60 per cent. One objection to this meal is the high bone content. However, the bony material may be screened out for young fingerlings if desired.

Menhaden and sardine fish meals may be used as substitutes for the white fish meal. Fish and crab meal is another possible substitute.

Meal meal, meat scrap, and meat and bone scrap have been used as substitutes for the white fish meal but they are all rather poor. The scrap is preferred to the meat meal.

Cottonseed meal

The 41% and the 43% protein meals have been used and the latter is preferred. This feed can usually be purchased at a local feed store.

Both the 41% and 44% protein soybean meals have been tried as substitutes for the cottonseed meal in the No. 6 mixture. There is little if any difference between the two meals and neither are considered as good as the cottonseed meal although they may be used as substitutes.

Corn gluten meal, 41% protein, and peanut oil meal are also possible substitutes for the cottonseed meal in the No. 6 mixture.

Wheat middlings

Wheat flour middlings are preferred and can usually be purchased at the local feed store. Red Dog Flour, wheat flour middlings with screenings, and wheat standard middlings may all be used in place of the flour midds if necessary. Better mixtures result if the finer ground feedstuffs are used.

Oat meal and ground clipped oats are other possible substitutes for the wheat flour middlings in the No. 6 mixture.

Salt

Fine grade dairy salt is satisfactory and may be purchased locally.

The dry feeds may be mixed in small batches or one may wish to spread them out on a concrete or tight wooden floor and mix them with a shovel. In the latter case one could use a 200-pound barrel of milk, two bags each of fish meal, cottonseed meal, wheat flour midds, and add 33 pounds of salt. This proportion will give the composition listed for the No. 6 mixture. If one is fortunate enough to have a feed mixer it will save some hand labor. Local feed stores may be glad to do the mixing for a small charge. After mixing the feed may be stored in barrels or feed bins.

Three methods of feeding the meat-dry feed diets will be described separately.

Mush Type of Meat-Dry Feed Mixtures

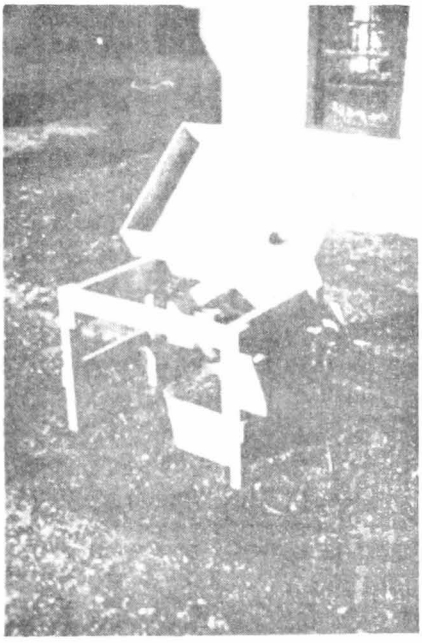
This diet is composed of 50 per cent by weight of hog spleen and 50 per cent of dry feed mixture No. 6. The spleen, or melts, should be ground while in a nearly frozen condition. For mixing, the meat and dry feed are placed in a tub or mixing box. About 30 pounds of water will need to be added for every 100 pounds of the meat-dry feed mixture in order to get a good physical consistency. This will vary somewhat with the moisture content of the dry feed and to what extent the melts are frozen. When thoroughly mixed, this diet will have a rubbery consistency which is due to the combination of salt and melts as previously stated. The diet should be prepared about every two days depending upon refrigeration. This diet is fed most advantageously by means of a potato ricer to fish held in troughs or narrow ponds. The holes in the ricer cup will have to be increased in size from time to time as the fish grow larger.

Meat-Dry Feed Diets Prepared by Blower Mixer

For the past seven years we have used a machine to mix some of our meat-dry feed diets. Machines manufactured by two companies have been tested. The one that has proved to be superior is made by the B. F. Sturtevant Company, Boston, Massachusetts. It is listed as Universal Monogram Fan - Design 3 - Fan size 00, and is equipped with the long shaving type wheel. The Company's catalogue No. 337-2 gives the specifications. A 1/2 H.P. motor with a V-belt drive is used to operate the blower fan at 3500 R.P.M. The Monogram Fan costs about $40.00. The motor can be purchased locally if one is not already available. The belt drive is to be preferred over the direct connection since the dust resulting in the mixing operation may get into the motor and cause trouble.

Last year a hatchery was visited that was using a No. 1 size fan of the above make of blower. It was operated at 2800 R.P.M. with a one H.P. electric motor. This larger size machine was quite superior in operation and the additional cost was well justified.

The Monogram Fan is a centrifugal air blower (or exhauster) which is used for ventilating various places and for removing sawdust, rags, shavings, etc. The fan wheel is of rigid construction and is enclosed in a metal housing. We have mounted the fan on a table 42" x 30" x 36". The fan with the outlet pointing toward the floor is bolted to the inside of one end of the table. The distance between the floor and outlet is sufficient to allow for a galvanized tub which serves as a receiver for the food. The motor is fastened with bolts to the same end of the table that supports the blower but is hung on the outside of the legs. The space between the motor and blower is sealed except for the bolt hole as this helps to prevent dust from getting into the motor. A cloth cover (salt sack) on a wooden frame is placed over the tub when the fan is operating so as to confine the dust and feed. The table top is the floor of the removable hopper. Six-inch sideboards are used. The inlet of the blower is connected to a hole in the hopper by means of a conductor pipe ell. In the mixing operation the feed is fed in through the hopper, whipped around by the fan blades, and expelled into the metal tub.



Blower used for preparation of meat-dry feed mixtures.

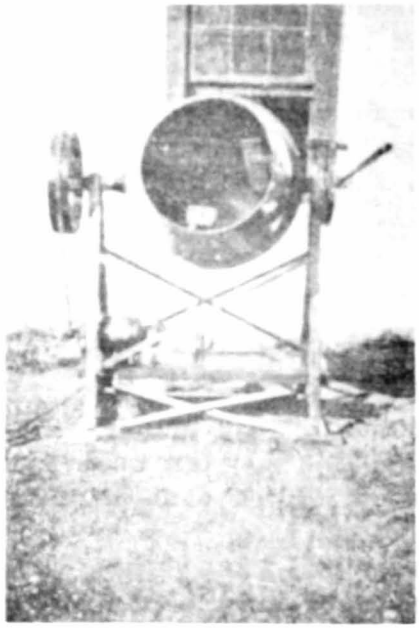
The diet which is prepared by this blower fan consists of 45 per cent by weight of hog spleen and 55 per cent of dry feed mixture No. 6. The melts are allowed to thaw some in this case as contrasted to the mush type of diet. No water is used in the preparation of this diet. The meat and dry feed are placed in a mixing box and the meat broken into pieces which are covered with dry feed. If the pieces of meat are not well covered with dry feed, the blower will become plugged and it will be necessary to take it apart and clean it. This is somewhat time consuming and it will be found advantageous to take a little more time in the preparation of the rough mix. A little experience will soon enable one to judge how well it must be mixed and how fast the feed can be fed into the blower without plugging it. After the feed is mixed roughly, it is dumped into the hopper and run through the blower. The feed is then placed in a cooler and allowed to set for about 24 hours. Depending upon the size food particles desired, it is run through the blower one or more times previous to feeding. For two-inch fish it may be necessary to put it through four times. As the fish become larger, twice is usually sufficient. We have

found this type of diet very satisfactory for fingerlings up to six inches in length. Fish larger than this may lose some of the finer food particles. The feed has the consistency of moist sawdust and is adapted to pond feeding since it is easily scattered.

Higher percentages of melts in this diet do not work satisfactorily because the blower becomes plugged too easily. Replacement of all of the melts with beef liver does not work well due to mixing problems. A part of the meat may be replaced with fish, such as herring, but this is not recommended for trout. We have not had experience with other kinds of meat and dry feed mixtures.

Meat-Dry Feed Diets Prepared by a Concrete Mixer

Within the last several years a few hatcheries have used a concrete mixer to prepare the meat-dry feed diets. These mixers have ranged in size from a two cu. ft. one used at this hatchery to one of a bag size employed at a larger station. The machines are operated with 1/3 or 1/2 H.P. electric motors. The ordinary speed of the concrete mixer has been reduced to about 17 R.P.M. by means of pulleys.



Feed mixer for meat-dry feed mixtures.

The feed prepared by this means can contain a higher percentage of meat which results in coarser particles more suitable for trout four inches or larger. The diet employed here has consisted of 55% of pork melts and 45% of the dry feed Mixture No. 6. In preparing the food the dry feed is placed in the mixer first followed by the meat which is "dusted" over with some of the dry material to prevent it from sticking to the sides of the mixer. No water is used in the preparation. The mixer is allowed to run for a period of from 10 to 15 minutes. It is well to allow the feed to set over night before feeding. This machine requires less labor and attention than the blower in the preparation of the diets and is superior for fish four inches or larger.

The concrete mixer may be used for preparing the rough mix for the blower machine described previously. In this operation the feed is mixed for a shorter time, five minutes or less usually being sufficient.

The mush type of diet and that prepared with the machines which have been described may be improved by substituting beef liver in place of 15

parts of the hog spleen. The hatcheryman might profit by incorporating this small percentage of liver even though the price of the diet is increased slightly.

Under our conditions at this hatchery we find that we can rear fingerling trout for about half the food cost of production on the meat-dry feed diets just mentioned as compared to a meat diet of beef liver - 50, hog spleen - 48, salt - 2. For the period May 1st to October 1st for three years it cost us about 22¢ to raise a pound of fingerling brook trout on the meat diet whereas the food cost of production on the meat-dry feed diets was about 12¢. The growth of the trout fed the meat-dry feed diets was equal to or greater than that of those trout fed the meat control diet. In some cases the mortality was higher when the dry feed was included in the diet and in others less. The hatcheryman will profit by the use of dry feeds provided he exercises care in incorporating them in the fresh meat diet and in feeding them.

The Use of Fresh Fish in Trout Diets

In the past we have not recommended the feeding of fish to trout. Reasons for this are that fish meal is a more economical feed, cold storage of fresh fish is a problem, and some hatcheries have experienced difficulty in feeding fish. Under the present wartime conditions the feeding of fish is recommended if certain precautions are observed and provided that the fish can be obtained at a reasonable price and cold storage facilities are available. Incorporating certain species of fresh fish in a diet and feeding it continuously to trout will result in a vitamin B1 deficiency. This can be avoided by feeding the diet containing the fresh fish for only short periods - a few days or a week at a time. On the other days the diet without the fish is fed. The factor in the fresh fish responsible for this vitamin deficiency can be destroyed by cooking but this is not practical in most hatcheries. The fresh fish can be used to replace part of the meat, dry feed, or both.

Feeds Unsuitable for Trout Diets

There are several feedstuffs that have caused trouble in trout. Linseed meal is toxic to trout and should not be fed. Certain lots of salmon egg meal and seal meal have been known to cause mortality in trout after a few weeks of feeding. Fish meal that contains any appreciable amount of roe should be fed cautiously.

Dry feed mixtures should contain some animal protein. It has been found that in all vegetable protein dry feed mixture composed of soybean meal, cottonseed meal, corn gluten meal, wheat flour middlings, and salt will cause gill trouble in brook trout which is due to a lack of pantothenic acid, one member of the Vitamin B Complex.

In general, feedstuffs that are suitable for other livestock can be fed safely to trout. In many instances where trouble develops with a certain diet it is not the fault of the ingredients but of the physical consistency of the diet and resulting "pollution." Sometimes this can be corrected by grinding the coarse feeds to a fine meal or flour.

Rearing Capacity of Troughs and Ponds

The number of trout that may be safely carried in troughs and ponds depends upon a number of factors. As far as is known, the size of the trough is not a great factor in rate of growth of trout if the troughs approximate the so-called standard sizes - hatching trough, 13'6" x 14" x 4" to 6" of water; rearing trough, 14' or 16' long x 22" to 28" wide x 4" to 6" of water. Ponds will vary in size in accordance with local conditions. Trout fingerlings, particularly brown trout, may do better in ponds than in troughs. Since the size of troughs and ponds will vary from hatchery to hatchery, it is best to standardize the carrying capacity by putting it in terms of weight of fish per cubic foot of water.

The volume of water per trough or pond will vary with the year, the time of year, the number of troughs and ponds taxing the supply, and the mechanical arrangement. In this region about 8 to 12 gallons of water per minute are used for hatching troughs when two or three are used in series. However, some hatcheries may use as much as 20 gallons for the larger size fingerlings. Rearing troughs are supplied with about 20 gallons per minute when several are used in series. No fixed rule can be given for the volume of flow needed but it is somewhat in the range of the figures just stated. Many hatcheries try to carry too much fish for their water supply. If the flow drops, as it does in some places in the summer, the number of fish carried should be reduced accordingly. The quality of water is the major factor in determining how many pounds of fish can be carried per cubic foot of water. One could write a book on the relationship of water supplies to fish hatcheries.

The following table gives the approximate weight of trout that may be carried per cubic foot of water in troughs and ponds. It is assumed that the flow is adequate and that the quality of water is average for good trout hatcheries. Fewer trout can be carried, of course, than is indicated in the table. However, when the number is very limited, it may be difficult to feed the fish so that no food is wasted. To what extent the values in Table 1 can be exceeded will depend upon local conditions. Overcrowding may be judged by some indicators as dropping off in the growth rate, increase in the mortality, as well as by the general appearance of the trout. Fish larger than seven inches held in ponds are usually not carried at more than about one pound per cubic foot of water.

Table 1

Pounds of Trout That May Be Carried Per Cu. Ft. of Water

Size of Trout	Troughs	Ponds
- 1 inch	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

Hatcherymen sometimes lose sight of the fact that their fish grow and their troughs must be thinned in order to prevent overcrowding. In May and June in many hatcheries it is common occurrence for trout fingerlings to double their weight in a month. This means that the weight of fish per cubic foot of water is doubled. If trout fingerlings up to four inches in length grow at the rate of 100 per cent increase in body weight per month, it requires more than a month for them to increase in length by one inch. Thus one can easily see that in order to keep within the limits of the table just presented, one must thin his fish occasionally depending upon their rate of growth.

Growth of Trout

As far as is known at the present time, no one has prepared a table showing the rate of growth of different species of trout of various sizes held at different water temperatures. The only data that approaches this, that is known to the author, are those of the New York State Feeding Chart. These show that for fingerling trout up to six inches in length, the fastest growth is made by brook trout followed by rainbow trout, brown trout, and lake trout in that order, the latter two being about the same. The hatchery man also realizes that as the trout increase in size, the rate of growth decreases. Thus two-inch fingerlings grow faster in proportion to their body weight than do their year old brothers and sisters. We also know that within certain ranges the rate of growth increases with an increase in water temperature. Water temperature in relation to the fish hatchery is seldom given the attention that it deserves.

This hatchery is supplied with three sources of water, one of which has a constant temperature of $47^{\circ} \pm 0.5^{\circ}$ F. The majority of our experiments are conducted with trout held at this temperature. Table 2 gives the

rate of growth of brook trout held in the 47° F. water for the period, April 12th to September 27th. The rate is given in terms of percentage increase in body weight for four-week periods. At the start of the experiment the trout were about 1-1/2 inches long and on September 27th they averaged about 4-1/2 inches. The other two sources of water for this hatchery fluctuate in temperature and average about 53° F. from May 1st to October 1st. Trout held in this water are appreciably larger at the end of the season. Table 2 is presented to show the growth rate that may be expected at this water temperature. It also shows the variability of the growth rate of four groups of trout fed the same diet and the negligible difference in the growth rates of trout fed a meat diet and a meat-dry feed mixture.

Table 2

Rate of growth of eight groups of brook trout. Four groups were fed a meat diet of beef liver - 50; hog spleen - 48; and salt - 2. The other groups received a diet of hog spleen - 50; dry feed mixture No. 6 - 50. Rate is given in terms of percentage increase in body weight for four-week periods.

Period (1940)	Meat Groups				Meat-dry Feed Groups			
	1	2	3	4	5	6	7	8
April 12 - May 10	118	125	122	126	131	126	131	128
May 10 - June 7	103	106	109	100	115	106	108	112
June 7 - July 5	81	85	86	89	79	86	85	88
July 5 - August 2	65	64	62	66	69	72	71	70
August 2 - August 30	57	58	52	61	57	54	59	51
August 30 - September 27	43	47	40	47	47	39	41	39

Food Allowance for Trout

Fish culturists follow different customs as to the number of times a day they feed their fish. All of them feed the small fingerlings more often than they do the older ones. For the first month or six weeks we like to follow the practice of feeding the fry and small fingerlings six times each day. The following month we usually feed only five times a day and when the fish have reached three inches in length, four feedings a day are thought to be sufficient. The number of feedings is reduced thereafter so that for eight-inch fish one feeding a day is allowed.

We believe that the amount of food allowed each day is more important than the number of feedings. Tables were prepared in 1936 suggesting

amounts of feed to allow various sized trout held in water of different temperatures. These tables were revised in February 1944 and will be found at the end of this report. The tables have been used for the past ten years in the trout hatcheries operated by the New York State Conservation Department and have been found to be satisfactory as an aide in regulating the amount of food allowed the trout. It will be noted that the amount of food allowed is decreased as the fish become larger. Increases in food allowance follow increases in water temperature. In practice the values are read to the nearest half. For example, a hatchery has 25,000 brook trout that weigh 25 per pound (total poundage is 1,000) and the water temperature is 48° F. The fish should be allowed about 40 pounds of food a day. As yet we have no proof that the amount of food allowed should be varied with the type of diet employed. In the example just given we would feed the 40 pounds of food whether it was beef liver or a diet of melts and dry feed. From the experience gained since 1936 it appears that if one keeps within 25 per cent of the values given in the tables, the amounts of food fed will be satisfactory.

The Use of Production Charts in the Operation of a Hatchery

Successful businesses almost invariably maintain records of expenses, receipts, and other items. In livestock production the farmer often has records showing purchases of feed and other items as well as receipt of produce sold. In dairying many farmers will feed their cows in proportion to the amount of milk they give. Likewise in poultry husbandry layers cannot be expected to produce unless they are housed properly and receive good rations and in quantity. In the case of rearing trout, better results will be obtained if records are maintained of the weight and growth, mortality, disease treatments, weight of fish per volume of water, flow of water, and pounds of food required to produce a pound of fish. It stands to reason, of course, that the records alone are of little value. They must be used wisely. After accumulating these records for a few years, the hatcheryman is in a position to predict operations for the year. He should know when to expect trouble in some cases, overcrowding can be prevented, food requirements for the year can be estimated rather closely and in normal times the food cost of production can be estimated 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 operation of the feeding chart as well as for use in general hatchery operations. A description of the Feeding Chart and methods of its operations, together with the various tables has been published in bulletin form entitled, "Fisheries Research Bulletin No. 3, the New York State Fish Hatchery Feeding Chart," Revised edition, by Charles R. Deuel, David C. Haskell, and A. V. Tunison.

The author is indebted to the staff of this hatchery for their assistance in the research and production work which has been the basis of this report.

The Cortland Experimental Hatchery is operated jointly by the New York State Conservation Department, the United States Fish and Wildlife Service, and Cornell University. December 30, 1940; Revised February 1945.

Table 3

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

BROOK TROUT

	No. of Fish per Pound										
Water Temp. (F.)	-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-
	Approx. Size in Inches										
	-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-
36	5.8	4.9	3.9	2.9	2.1	1.7	1.4	1.2	1.1	1.0	0.9
37	6.0	5.1	4.0	3.0	2.2	1.8	1.5	1.3	1.1	1.0	0.9
38	6.3	5.3	4.2	3.2	2.4	1.9	1.6	1.3	1.2	1.0	0.9
39	6.6	5.6	4.4	3.3	2.5	1.9	1.7	1.4	1.2	1.1	1.0
40	6.8	5.8	4.6	3.4	2.6	2.0	1.7	1.5	1.3	1.1	1.0
41	7.1	6.0	4.8	3.6	2.7	2.1	1.8	1.5	1.3	1.2	1.1
42	7.4	6.3	5.0	3.7	2.8	2.2	1.9	1.6	1.4	1.2	1.1
43	7.8	6.6	5.2	3.9	2.9	2.3	2.0	1.7	1.5	1.3	1.2
44	8.1	6.9	5.5	4.1	3.0	2.4	2.0	1.7	1.5	1.3	1.2
45	8.4	7.2	5.7	4.3	3.2	2.5	2.1	1.8	1.6	1.4	1.3
46	8.8	7.5	6.0	4.4	3.3	2.6	2.2	1.9	1.7	1.5	1.3
47	9.2	7.8	6.2	4.6	3.5	2.7	2.3	2.0	1.7	1.5	1.4
48	9.6	8.2	6.5	4.9	3.6	2.9	2.4	2.1	1.8	1.6	1.4
49	10.0	8.5	6.8	5.1	3.8	3.0	2.5	2.1	1.9	1.7	1.5
50	10.5	8.9	7.1	5.3	3.9	3.1	2.6	2.2	2.0	1.8	1.6
51	11.0	9.3	7.4	5.5	4.1	3.2	2.7	2.3	2.0	1.8	1.6
52	11.4	9.7	7.7	5.8	4.2	3.4	2.8	2.4	2.1	1.9	1.7
53	11.8	10.1	8.0	6.0	4.4	3.5	3.0	2.5	2.2	2.0	1.8
54	12.3	10.5	8.4	6.3	4.6	3.7	3.1	2.6	2.3	2.1	1.8
55	12.9	10.9	8.7	6.5	4.8	3.8	3.2	2.7	2.4	2.1	1.9
56	13.5	11.4	9.1	6.8	5.0	4.0	3.4	2.9	2.5	2.2	2.0
57	14.1	11.9	9.5	7.1	5.2	4.2	3.5	3.0	2.6	2.3	2.1
58	14.7	12.5	9.9	7.4	5.5	4.4	3.7	3.1	2.7	2.4	2.2
59	15.3	13.0	10.3	7.7	5.7	4.6	3.8	3.2	2.8	2.5	2.3
60	16.0	13.6	10.8	8.1	6.0	4.8	4.0	3.4	3.0	2.6	2.4

Feeding Tables for Trout (Revised), Deuel and Tunison, February 194[illegible]

Table 4

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

BROWN TROUT

Water Temp. (F.)	No. 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-
	Approx. 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 5

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

RAINBOW TROUT

	No. of Fish per Pound										
Water Temp. (F.)	-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-
	Approx. 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	1.4	1.2	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
45	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 6

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

LAKE TROUT

	No. Fish per Pound										
Water Temp. (F.)	-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-
	Approx. 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 7

THE RELATIONSHIP BETWEEN THE TOTAL LENGTHS OF TROUT AND THE NUMBER OF TROUT PER POUND (Subject to change as more data becomes available).

Size (in.)	No. Trout per Lb. Brook, Brown, Rainbow	Lake
0.75	5670	8250
1.00	2542	3492
1.25	1298	1815
1.50	740	1054
1.75	477	648
2.00	304	435
2.25	225	313
2.50	153	227
2.75	123	177
3.00	88.3	133
3.25	73.2	105
3.50	55.9	87.2
3.75	48.0	68.8
4.00	37.8	56.7
4.25	32.9	47.2
4.50	26.8	40.5
4.75	23.4	33.6
5.00	19.7	29.0
5.25	17.3	25.0
5.50	14.9	21.8
5.75	13.3	19.1
6.00	11.6	17.0
6.25	10.2	14.6
6.50	9.15	13.3
6.75	8.10	11.9
7.00	7.35	10.5
7.25	6.50	9.45
7.50	5.99	8.72
7.75	5.40	7.82
8.00	4.94	7.09
8.25	4.45	6.48
8.50	4.12	5.96
8.75	3.75	5.40
9.00	3.47	4.94
9.25	3.13	4.54
9.50	2.95	4.24
9.75	2.70	3.95
10.00	2.53	3.66
10.25	2.34	3.36
10.50	2.18	3.13
10.75	2.02	2.95
11.00	1.89	2.72
11.25	1.75	2.55
11.50	1.65	2.41
11.75	1.57	2.27

Table 7 (Cont.)

Size (in.)	No. Trout per Lb. Brook, Brown, Rainbow	Lake
12.00	1.45	2.11
13.0	1.13	1.67
14.0	0.91	1.33
15.0	0.73	1.08
16.0	0.61	0.88
17.0	0.50	0.74
18.0	0.42	0.62
19.0	0.36	0.53
20.0	0.31	0.45

N.Y.S. Cons. Dept., Bur. Fish Culture
January, 1936 /A.V.T.

Table 8

Mortality of Various Size Brook Trout

Size	Per Cent Mortality
Initial Feeding to 1 inch	6.0
1" to 2"	2.4
2" to 3"	1.1
3" to 4"	1.0
4" to 5"	0.1
5" to 6"	0.1

The above table was presented by Kenneth B. Nichols, Foreman, State Fish Hatchery, Warrensburg, N. Y., at a meeting of the State Fish Hatchery Foremen. The data are for a three-year period at the Warrensburg Hatchery.

Table 9

Composition of Various Fish Foods

Item	% Protein	% Fat	% Carbo-hydrate	% Water	% Ash	Reference
BEEF:						
Heart	14.8	24.7	---	53.2	.9	3,5
Liver	20.2	3.1	2.5	72.3	1.3	3,4
Melts	18.	2.3	---	75.2	1.4	1
PORK:						
Melts	17.	1.9	---	---	1.4	1,4
SHEEP:						
Heart	16.9	12.6	---	69.5	.9	1,5
Liver	23.1	9.	5.	61.2	1.7	1
Lungs	20.2	2.8	---	75.9	1.2	1,5
FRESH FISH:						
Carp	10.	.5	---	---	.5	1
Herring (sea)	11.	3.	---	---	1.5	1
ANIMAL MEALS:						
Buttermilk (Dried)	33.8	5.6	41.9	7.8	10.5	2
Meat meal	55.	12.	---	---	25.	1
Meat Crisp	75.	---	---	9.7	---	4
Menhaden	61.	7.	---	---	21.	1
Salmon egg (Neptune)	39.3	8.7	---	9.5	10.7	1
Skimmilk (Dried)	34.8	.9	50.1	6.2	8.	2
Whitefish	68.	2.	---	---	19.	1
Whitefish	54.5	---	---	10.5	---	4
PLANT PRODUCTS:						
Bran (Wheat)	15.8	5.	54.3	9.4	6.	2
Cottonseed meal	41.9	7.	27.2	7.2	5.9	2
Oat meal	16.3	5.9	64.1	8.5	2.4	2
Red dog flour	16.9	4.0	63.3	10.8	2.6	2
Wheat midds. flour	17.	4.9	59.9	10.4	3.4	2

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