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STATUS OF TROUT CULTURE

IN PERU

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1.0 ITINERARY

May 12	Arrived Lima, Peru Conferences with officials of U. S. A. I. D. and Ministry of Fisheries
May 13	Conference with officials of Ministry of Fisheries and visit to Santa Eulalia Hatchery
May 14	Travel to Huaras
May 15	Visit to Pariac River and evaluation of Huaras trout hatchery
May 16	Visit to Olleros River
May 17	Visited Buin River, Ranrahirca River and Lake Llanganuco
May 18	Visited Auqui River and Marcara River
May 19	Evaluated site of proposed trout farm on Marcara River
May 20	Travel to Lima
May 21	Conference with officials of Ministry of Fisheries and with officials of U. S. A. I. D.
May 22	Travel to Huancayo
May 23	Visited market in Huancayo and evaluated Junin Hatchery
May 24	Continued evaluation of Junin Hatchery and visited a small trout farm near Huancayo
May 25	Visited small trout farms near Alcopalca, Jauja and Tarma
May 26	Travel to Junin
May 27	Evaluation of sites for trout farms along the Chaca-Chimpa River near Junin and travel to Lima
May 28	Conferences with officials of Ministry of Fisheries and with officials of U. S. A. I. D.
May 29	Travel to Cusco and Sicuani
May 30	Evaluation of Lancui-Layo Hatchery and visit to site of proposed egg collecting station on the Pallajchuma River
May 31	Continuation of the evaluation of Lancui-Layo Hatchery and travel to Cusco

June 2	Travel to Lima
June 3	Conferences with officials of U.S.A.I.D., the Ministry of Fisheries and FAO
June 4	Final conferences with U.S.A.I.D. and Ministry of Fisheries officials and conference with manager of Purina Feeds
June 5-6	Preparation of report
June 7	Travel to Fortaleza, Brazil

2.0 RECOMMENDATIONS

2.01 Trout Hatcheries

Steps should be taken to protect the water supply of all hatcheries. A system should be developed for collecting pertinent data on hatchery operation. Hatchery procedures should be standardized. The present stocking policies for hatchery trout should be studied and probably revised.

2.02 Site for the Location of Demonstration Trout Farm in Ancash

It is recommended that the proposed demonstration trout farm to be constructed in the Department of Ancash be located near the confluence of the Marcara and Santa Rivers. The best site in that area is a 10- to 12-hectare plot of land a few hundred meters south of the Marcara River and between the highway and the Santa River. The water for the farm should be taken from the Marcara River. It is further recommended that a program be initiated to encourage the use of good soil and water conservation practices in the valley of the Marcara. As the population of both people and grazing animals increases in the valley, unless good soil and water conservation practices are used by the inhabitants of the valley, the quality of water in the river may deteriorate to the point that the proposed trout farm will have to be abandoned.

2.03 Construction Plan for the Trout Farm at the Junin Hatchery

The water supply, soil and topography at the Junin Hatchery are adequate for the construction of the proposed trout farm. The utilization of space by the proposed construction is optimal. The plan calls for construction of rather wide raceways of clay. Because of the rocky nature of the soil, it may be necessary to construct narrower raceways of concrete and rock.

2.04 Collection of Rainbow Trout Eggs at the Mouth of the Pallajchuma River on Lancui-Layo Lake

The plan to obtain trout eggs for the developing trout farming industry in Peru from fish entering the Pallajchuma River from Lancui-Layo Lake is a good one. Once the population is re-established, there should be little difficulty in obtaining 20 to 30 million eggs from fish entering the stream. The one disadvantage of the plan is that the life history characteristics (rate of growth, wariness, resistance to disease, etc.) that evolve in the population of rainbow trout that develops in Lake Lancui-Layo may not be the characteristics that are best for trout farming.

2.05 Establishment of a Community Trout Farm on the Chaca-Chimpa River near Junin

The soil, water and topographical characteristics on public lands adjacent to the Chaca-Chimpa River near the town of Junin are adequate for the construction of a large trout farm. The area that is already in small ponds should be developed first. It is not recommended that the river itself be partitioned by screens for growing trout.

2.06 Small Trout Farms

There is an excellent potential for trout farming in Peru. The potential is extremely good in the southwestern part of the Department of Junin near Huancayo and Jauja. There is suitable soil, water and topography plus considerable interest in trout farming; however, if the trout farming industry is to grow in Peru, immediate attention should be given to providing management advice, credit, feeds, processing facilities, transportation facilities, marketing advice and marketing facilities to the trout farmers.

3.0 STATUS OF TROUT CULTURE IN PERU

by
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3.01 Introduction

A survey of trout hatcheries and trout farms in Peru was conducted May 12 to June 6, 1971, under the sponsorship of U.S.A.I.D./Peru and the Ministry of Fisheries. The purpose of the survey was to evaluate the potential for trout farming in Peru and to evaluate certain aspects of the Ministry of Fisheries' proposed program for the development of the trout farming industry.

3.02 Evaluation of Trout Hatcheries

Trout hatcheries can be evaluated according to a number of characteristics. Some of the most useful of these characteristics are the following:

(1) Weight of trout produced per m^3 of water flow per minute through the hatchery.

(2) Weight of trout produced per m^3 of raceways and ponds.

(3) Weight of trout produced per man-year of labor at the hatchery.

(4) Conversion of feed into trout.

(5) Cost per kg of trout produced when all production costs are considered.

Generally speaking, there were not sufficient data available at the hatcheries visited to make an evaluation on the basis of all criteria described above. Evaluation of the four hatcheries visited was restricted to an evaluation of the production procedures in use at each. Comments on the procedures observed at the

different hatcheries are presented in this section. These comments are offered in the hope that they will form the basis for improving the practices presently in use and not as criticism of the personnel operating them.

3.021 Santa Eulalia Hatchery

The Santa Eulalia Hatchery is located in the outskirts of Lima and in a rather densely populated area. The hatchery grounds are rather restricted in area and there is no space available for expansion. The hatchery is relatively small for efficient operation. With such a small facility, efficient use of supervisory personnel and labor is difficult.

The most serious problem encountered at Santa Eulalia was poor water quality. Most of the 1970 spawn of trout grown at the hatchery have died, and death of the remaining fish is continuing. According to information obtained at the hatchery, there is currently a relatively large mining operation on the river upstream. According to reports, the water becomes brown in color during certain periods of the year. At the time of the visit, the water was discolored with a fine, gray silt. Visibility in the raceways was rather poor. A cursory examination of trout that had died recently revealed that they were in good condition with an accumulation of fat in the body cavity. The color and appearance of internal organs, of the gills and of external surfaces were normal. The records of mortality for the past ten months indicate that the fish continued to die at a rather constant rate during the entire period. Only a small portion of the number of trout started at the hatchery in 1970 were alive at the time of the visit.

The diet being fed at the hatchery is a variation of the diets developed at Cortland, New York, utilizing freshly ground beef liver plus fish meal and various vegetable meals. As with the original formulation, salt is added to the mixture to solidify the ground beef liver, thus binding the diet. A similar diet was used at all of the hatcheries visited with the exception of the one at Lake Lancui-Layo where beef liver alone was utilized. The ingredients utilized in the diet along with the percentage of each and the cost is included in the following table:

Ingredient	Percentage in diet	Cost (soles*/kilogram)
Beef liver	50.0	26.00
Fish meal	16.7	7.00
Cottonseed meal	16.7	1.06
Wheat by-products	16.7	2.50
Salt	2.0**	1.00

* 43.38 soles = 1 U.S. dollar.
**Enough salt is added to the above organic ingredients to make up approximately 2 per cent by weight of the total feed being mixed.

The feed is prepared by first mixing all of the meals together and then adding the beef liver which has previously been ground in a meat grinder. Mixing of beef liver and the meal mixture is accomplished in a small cement mixer. Normally the bound feed would be fed at this stage, but at Santa Eulalia, the feed is passed through the meat grinder once again. A plate with large holes is used in the grinder which forms the mixture into long "strings". These strings are then broken to form pellets. According to data obtained at the hatchery, the cost of ingredients per kilogram of feed was 14.55 soles. This price does not include

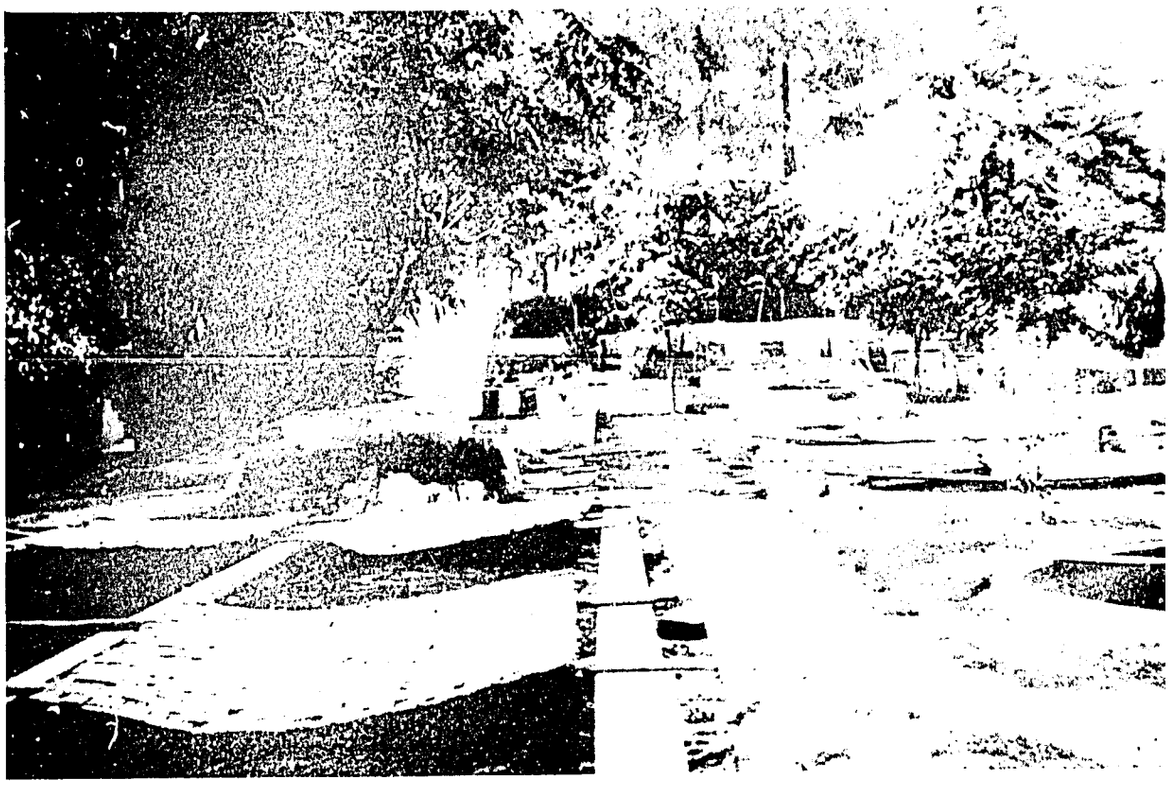
the cost of preparation or the cost of daily transportation to obtain the fresh liver. There are no storage facilities for liver.

Unless the cause of the mortality at the Santa Eulalia Hatchery can be determined and unless some means can be found to prevent similar losses in the future, the hatchery will have to be abandoned.

3.022 Huaras Hatchery

This hatchery is located in a rather densely populated area within the city of Huaras (Department of Ancash). Water is supplied to the hatchery via an open canal from a small river nearby. The water canal is used for general household purposes by many of the families. A considerable amount of trash (orange peels, beer cans, sticks, grass, etc.) is thrown into the canal and is carried into the hatchery.

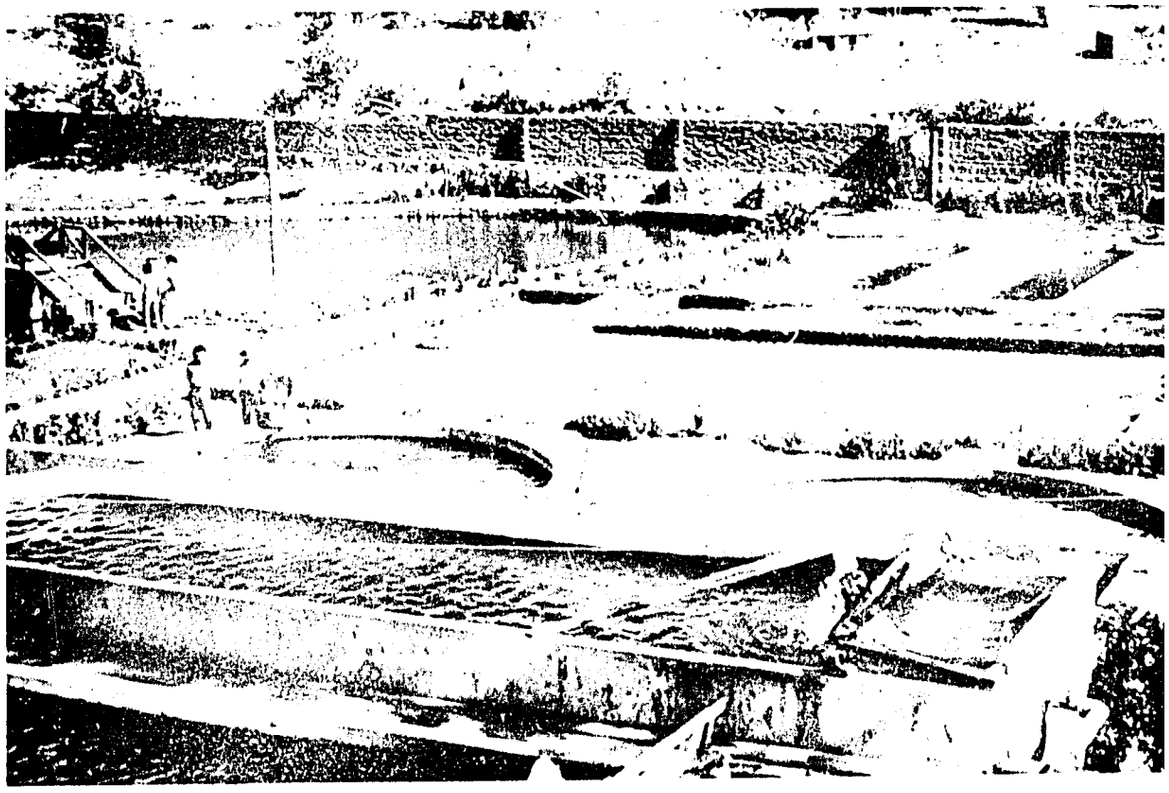
Although the river supplying the canal seems to be relatively free of silt, siltation is a major problem at the hatchery. The large pond on the station which is being used to hold brood stock is approximately half filled with silt and unless the present rate of silt accumulation is reduced considerably, this pond will be virtually useless in a few years. It appears that most of the silt comes from the yards of the homes adjacent to the canal.



(Criadero de truchas Santa Eulalia)

Figure 1. Santa Eulalia trout hatchery.

Figure 2. Raceways and pools at the Ministry trout hatchery at Huaras.



(Canales y albercas en el criadero de truchas del Ministerio en Huaraz)

Doubtlessly, as the population of Huaras increases, the pollution of the water in the canal will also increase. Unless some means is found to protect the water supply, this hatchery will probably have to be abandoned in the future. It is suggested that the installation of a pipe to carry the water from the river to the hatchery be considered.

Because of the location of the hatchery, there is little opportunity for expansion. This hatchery is also rather small for efficient operation.

The river supplying the hatchery arises from the snow-melt in the mountains east of Huaras. The river is relatively short; consequently the water temperature is relatively constant and also relatively low for efficient production of trout. Data in the following table includes average monthly temperatures (^{o}C) collected over a three-year period at the hatchery. The data in the table indicate that the water temperature at the hatchery remains near 10 C year-round. This is at the lower extreme of the range (10 - 19 C) where good growth of trout can be expected.

Month	Year		
	1967	1968	1969
January		10.4	10.4
February		11.3	
March		10.4	
April		10.0	
May		10.0	
June		8.4	
July	8.3	9.1	
August	----	----	
September	10.6	----	
October	10.4	9.5	
November	10.4	9.8	
December	10.5	10.0	

There are no records at the hatchery of the weight of trout in each raceway. Records are being maintained on the number of trout in each raceway.

There are approximately 450 kg of trout being grown for the market at the hatchery. These fish are near market size (20 cm), but are almost three years of age. The reason for the slow growth could not be determined with the available data. Although the water temperature is relatively low, it is not sufficiently low to account for such slow growth. Since there are no records on feeding rates or growth rates, it is not possible to determine whether under-feeding is responsible for the low growth rate.

The diet being used at the Huaras Hatchery is a variation of the meat and meal combination that is used at the other hatcheries. The following table lists ingredients, the percentage of each ingredient in the diet and the cost of each.

Ingredient	Percentage in diet	Cost (soles/kg)
Beef liver	16.0	0.00*
Blood	11.0	0.00*
Fish meal	16.0	7.00
Cottonseed meal	8.0	2.40
Wheat by-products	48.0	4.40
Salt	2.0	0.50

*Beef liver and blood are now being obtained free-of-charge.

As a result of being able to obtain the beef liver and blood free-of-charge, the cost of the diet at Huaras is much lower than at the Santa Eulalia Hatchery. The cost of the diet at Huaras is approximately 3.4 soles/kg.

The feed is prepared in a similar manner to the method employed at Santa Eulalia. Because of the relatively low percentage of liver in the combination, the binding of the diet at Huaras is not as good as at Santa Eulalia. The binding effect of salt on blood is not as dramatic as the effect of salt on freshly ground liver; consequently, where so much blood is used in the mixture, binding is not as effective as when liver alone is used.

Approximately 63 kg of the feed is prepared daily. This amount of feed is fed without any effort to relate the weight of the feed given to the weight of fish in the raceways. There are no records being kept on the amount of feed being given to a raceway of fish; consequently, it was not possible to determine the feeding rate or the conversion rate of feed into trout. Apparently the amount of feed being fed at the present time (63 kg) has not been changed for several months.

Most of the raceways probably contained an adequate weight of trout commensurate with the amount and quality of water being supplied; however, apparently there was no stocking policy followed in arriving at the quantity of fish stocked in each raceway. Apparently the quantity and quality of water were not primary considerations in the stocking rates utilized.

The growth of brook trout at the Huaras Hatchery is considerably better than the growth of rainbow trout. The brook trout were approximately 50 per cent larger than rainbow trout of the same age.

At least a few trout have died at the station of what appears to be hepatoma. There are no records on how extensive this mortality might be since only those trout with grossly obvious symptoms are examined. These fish have received a diet relatively high in cottonseed meal (8 per cent) for almost three years.

Hepatoma in rainbow trout in the United States has been reported following the feeding of cottonseed meal. The cause-effect relationship is not well understood, but a toxic substance called Aflatoxin produced by the mold, Aspergillus flavus seems to be involved in elaboration of the hepatoma. Aflatoxin is apparently produced in improperly processed and stored cottonseed meal.

Six, three-year-old trout were examined for gross symptoms of hepatoma. Except for being relatively pale in color compared to the livers of younger trout, the livers of these fish appeared normal.

There is relatively little evidence of disease at the hatchery. There is apparently no furunculosis, ulcer disease, infectious pancreatic necrosis or "whirling" disease on this or any of the other hatcheries. The incidence of "fin rot" is considerably lower at Huaras than at many trout hatcheries in the United States.

In the process of examining the three-year-old trout for evidence of hepatoma, it was noted that all of the fish were sexually mature. Milt flowed freely from the

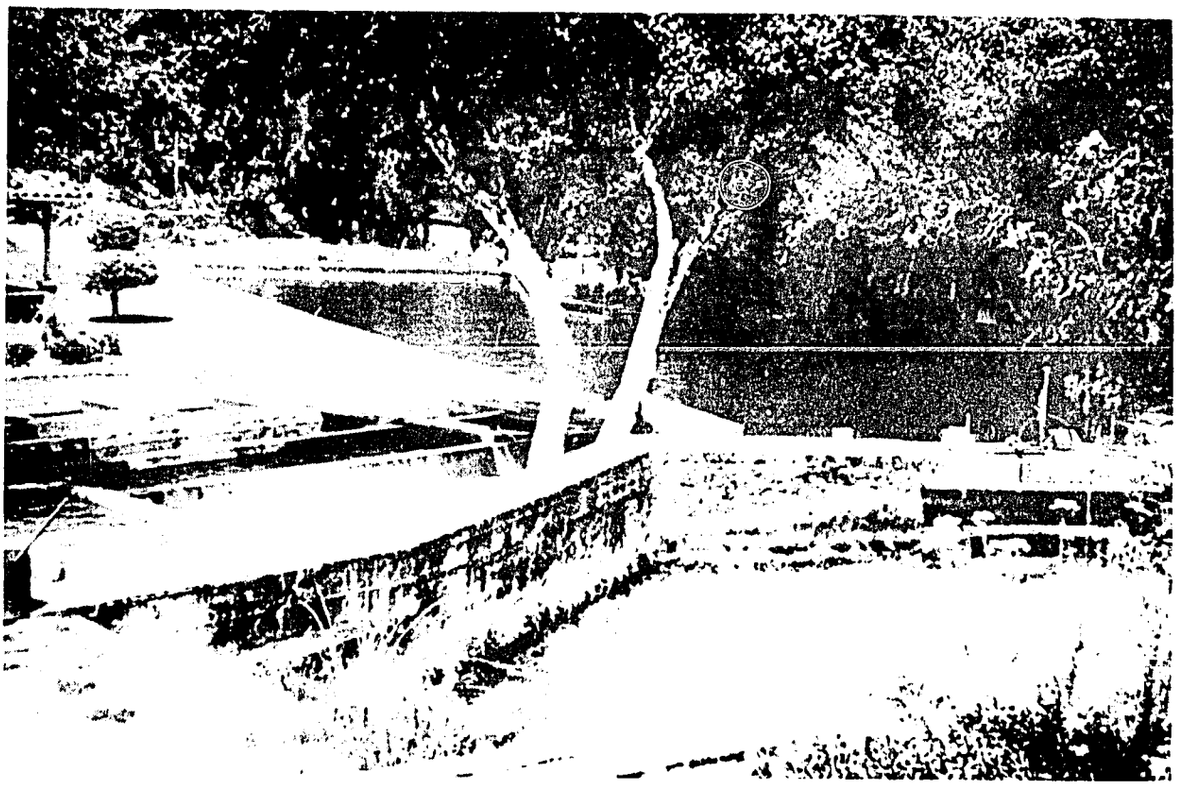
males and the abdomens of the females were filled with eggs. In all of the females, it was obvious that the eggs were very poor in quality. Almost 50 per cent of the eggs were white and many others were opaque. Few of the eggs had the characteristic shape and color that rainbow trout eggs should have this close to the beginning of the spawning season.

3.023 Junin Hatchery

This hatchery is located near the town of Ingenio in the Province of Huancayo. The hatchery has an excellent water supply which comes from springs a few kilometers away. The Chiapuquio River flowing from the springs is relatively short and flows through a narrow valley with a steep gradient. The hills on either side of the river are mostly covered with grass. There is little evidence of the over-grazing problem that characterizes the hills along the rivers near Huaras.

The water in the river is clear. There is little evidence of any siltation or movement of silt either in the river or in its relatively narrow flood plain. Flooding apparently does not occur or occurs rather infrequently.

As the nature of the exposed rocks on the hills and in the stream indicates, the water in the river is relatively hard. Downstream, below the hatchery, there is considerable evidence of carbonate precipitation on rocks in quiet places in the river. A few of the physical and chemical characteristics of the river water are shown in the following table.



(Criadero de truchas del Ministerio en Ingenio)

Figure 3. Ministry trout hatchery near Ingenio.

Figure 4. Ministry trout hatchery at Lake Lancui-Layo.

(Criadero de truchas en el Lago de Lancui-Layo)

Characteristic	Quantity or value
Temperature	11.0C (at 9:30 AM)
Total hardness*	250 ppm
pH	8.4
Oxygen	9.0 ppm

*EDTA titration with Hach Kit.

The raceways appeared to be well stocked; although there were apparently no guidelines based on quantity of water or space used to determine stocking rates. There was considerable variation in the size of trout in several raceways. There was no evidence of grading for size at the hatchery.

As was the case of the hatcheries at Santa Eulalia and Huaras, there was relatively little concern with weight inventory in the various ponds and raceways. In one pond stocked with 40,000 (310 kg) fingerlings, the fish had not been weighed or estimates made of the weight of trout in the pond since being stocked in February; consequently, virtually nothing is known of the growth rate or conversion rate of the trout in that pond during a four-month period. In this particular pond, the amount of feed being fed each day was being increased at monthly intervals. The amounts of feed fed per day in each of the months was 16 kg in February, 20 kg in March, 25 kg in April and 30 kg in May.

The mesh of the screens in the water control structures of most of the raceways is much too small which results in the expenditures of far too much labor in keeping them clean. With larger mesh, much of the material now clogging the screens would pass through with the water. Clogging of screens is primarily a

problem where diets containing a relatively high percentage of liver are fed. Despite considerable care in the grinding of liver, a large amount of connective tissue passes through without being cut into small pieces.

The diets utilized at the Junin Hatchery are more varied than at any of the other hatcheries visited. Beef liver, blood, meat, wheat by-products, chicken feed and hog feed are used in various combinations to prepare the diets. The typical diet is apparently composed of the following ingredients:

Ingredient	Percentage in the diet
Liver, blood or meat	50
Wheat by-products	25
Hog feed or chicken feed	25

In preparation of the feed used at the hatchery, liver or meat is used three days per week and blood is used the remaining four days. As a result, there is considerable variation in the quality of diet from one day to the next. A diet which contains 50 per cent whole blood (by weight) would be considerably lower in total nutritive value than a diet which contains 50 per cent liver instead. Probably two kg of the feed containing 50 per cent blood would be required to provide the same amount of nutrients as one kg of the ration when it contained liver.

According the the hatchery manager, the conversion rate of feed into harvestable trout at the hatchery is 3.5. Thus, 3.5 kg of feed is required to grow approximately eight alevins to an average size of 125 g each. A conversion rate of 2.5 should be obtained with proper management and with a good quality feed.

The use of chicken or hog feed as an ingredient for fish feeds is a rather unusual practice. Although these animal feeds are excellent for the purpose for which they are intended, they are not intended for trout. For example, an examination of the tags providing information on the contents of Purina "Startina" (chick starter), "Egordina" (broiler feed), and "Cerdina" (hog feed) revealed that these feeds contained a variety of drugs, antibiotics and additives. The "Startina" contained among other things, a drug to prevent coccidiosis, a hydroxyphenyl arsenical, a furazone and penicillian. The "Ergordina" contained a similar array of drugs, antibiotics and additives. The "Cerdina" contained aureomycin.

These drugs, antibiotics and additives included in the diets of farm animals serve very useful purposes; yet it has not been shown that similar benefits are to be obtained by feeding these materials to fish. In some cases, the feeding of drugs, antibiotics or additives that result in no adverse effects in warm-blooded animals may have a very toxic effect on a cold-blooded animal such as the trout.

Terramycin is included in the diet of the brood stock on the hatchery each day. The terramycin used is a material that is purchased from a farm supply store for use in farm animal feeds. In trout nutrition, the use of antibiotics on a daily basis in the absence of a specific disease is not recommended. The use of an antibiotic increases the cost of the feed; also continued feeding of an antibiotic may result in toxic effects such as reduced growth rate, poor quality eggs or even death of the fish; finally, daily feeding of antibiotics may lead to the evolution of drug resistant forms of disease-causing organisms.

When the small trout begin to feed at the hatchery, they are given a diet of liver for two or three months. One disadvantage of using liver only as a diet

for small alevins is the difficulty of grinding it into small enought particles for the size of the mouth of the small fish. Liver is a rather soft, flaccid tissue and does not grind well into tiny particles; consequently, most of the feed is too large for the mouths of the fish. Most of the trout in the United States are first fed finely ground mixtures of fish, meat and vegetable meals that contain a relatively high level of protein plus vitamins and minerals.

Initially, the small alevins at the hatchery are fed four times per day. In general, most trout culturists prefer to feed the small fish more often than this if it is practical to do so. Because of the small size of the mouth and stomach, it is questionable whether these small fish can eat enough feed in four feedings per day to provide adequate energy for their high rate of metabolism and still have enough protein, fat and energy left to promote maximum growth.

Trout produced at the Junin Hatchery are stocked widely throughout central Peru. The stocking rates used are arbitrary and do not seem to be related in any way to the physical, chemical and biological characteristics of lakes, rivers, private ponds and raceways being stocked. Stocking is apparently carried out without any consideration for the utilization of trout. Lakes are stocked with 300, 6-cm trout per hectare every two or three years. Some lakes are stocked less frequently. Rivers are apparently stocked with 5,000, 6-cm trout. The same rate is apparently used regardless of the amount of fishing on the river, the size of the river, the amount of natural reproduction, the productivity of the water, etc.

Stocking policies for private trout raceways are even more arbitrary than those for rivers and lakes. The results of this arbitrary stocking policy were

apparent when visiting the small private trout farms near Acopalca and near Molinos. On one such farm with an excellent water supply and with excellent facilities, the raceways received only one-tenth of the number of trout that could be grown to commercial size. On another small farm, small earthen ponds with a relatively poor water supply were stocked with several times more trout than could be grown to harvestable size when quantity and quality of water were considered.

3.024 Lancui-Layo Hatchery

This hatchery is located approximately 20 km south of the town of Sicuani in the Department of Cusco. It was constructed as a research station for experimentation with a species of catfish (suche), Trichomycterus rivulatus, found in Lake Lancui-Layo. In 1970, the station was converted to a trout hatchery. The primary purpose of the hatchery at the present time is to re-establish the rainbow trout population in the lake. There are no brood stock on the station. In 1970, eggs were brought from the Huaras and Junin hatcheries.

The hatchery was not constructed for trout production. It has a number of features that do not lend themselves well to the culture of trout. The raceways are much too deep. The depth of the raceways is much greater than the width. Proper circulation and water exchange is difficult to obtain. Fresh water pouring onto the surface of the raceways probably does not reach the bottom.

The size of the pipes supplying water to the raceways are probably not large enough to provide a sufficient flow of water required for maximum production of trout. At the present time, the water supply to the hatchery provides only 720

liters per minute. The source of the water is a spring in the mountains. The water is used for irrigation and stock water before it reaches the hatchery; consequently, it contains a considerable amount of silt. Because of the high elevation and cold climate, the water temperature is lower when it reaches the hatchery than when it emerges from the spring.

The station is scheduled for renovation in the future. Also, an egg collecting station will be constructed on the Pallajchuma River, the primary source of water for Lake Lancui-Layo. It is expected that when the population of trout in the lake is re-established at an optimum level that 20 million eggs will be collected at the new station. The present hatchery will be enlarged to provide space for the first 20 days of incubation for the eggs before they are transported to other hatcheries in Peru.

When the present hatchery is renovated, the water supply will be increased. Also the water will be piped directly from the spring, eliminating the problem of siltation. Before installation of the pipe, it should be determined that the water is of suitable quality when it flows from the spring. In some cases water flowing from springs contains too little oxygen, too much carbon dioxide, or too much iron in solution. These problems are normally corrected as the water flows downstream; however, if the water is piped directly from spring to hatchery, it will arrive at the hatchery with essentially the same characteristics as that of the spring where it flowed out of the earth.

Some of the physical and chemical characteristics of the hatchery water supply are shown in the following table.

Characteristic	Quantity or value
Temperature	6.7 C (at 10:00 AM)
Total hardness	75 ppm*
pH	7.9
Oxygen	8.0 ppm

*EDTA titration with Hach Kit.

The only feed used at the hatchery is ground liver. Apparently liver alone is used because of the difficulty encountered in purchasing fish meal, wheat by-products and cottonseed meal. The price of the liver is 15 soles/kg. This is the most expensive feed fed at any of the hatcheries. Also, since liver is some 70 per cent water, the conversion of feed to fish is probably the poorest of any of the hatcheries. The cost of producing a kg of trout at this station is also probably the highest of any of the hatcheries.

3.025 General Recommendations

In the evaluation of the four hatcheries visited, a number of problems were noted that if solved would likely lead to more efficient hatchery operation and to

increased production of trout at a lower cost. In this section a number of recommendations are made that should aid the solution of a number of these problems.

(1) Steps should be taken to protect the water supply of all hatcheries. At three of the four hatcheries visited, there is considerable evidence of pollution of the water supply. At Santa Eulalia, most of the trout have died as a result most likely of water pollution from mining operations upstream. At Huaras, silt has virtually filled the largest pond on the station. Screens have to be placed under the water supply inlets in many of the ponds to catch the garbage and trash before it enters the ponds. At Lancui-Layo, the water is turbid from silt picked up as it passes through irrigation canals. Presently, there is little evidence of water pollution at the Junin Hatchery. It may be expected that the pollution of the water at all hatcheries will increase in the future unless steps are taken now for the protection of the water supplies.

(2) A system should be developed for collecting pertinent data on the most important aspects of hatchery operation and for maintaining these data. Good records are the only basis for the evaluation of hatchery operation and hatchery efficiency and are the basis for continued improvement of hatchery management procedures. Ministry of Fisheries personnel should develop a uniform system for making number and weight inventories including instructions on procedures to be followed and forms

developed through consultation with the Chiefs of the several hatcheries. Once these procedures are established, each hatchery should follow them. Each hatchery should maintain records on its inventory. Summaries of the data from each hatchery could be maintained in in Lima and periodically evaluated.

Some of the types of data that should be recorded for each raceway, pond, or pool of fish each month and maintained in an accessible form are the following:

(a) Number and weight of trout in each raceway or pond at the beginning and at the end of the month.

(b) Daily record of mortality.

(c) Percentage of fish dying during month.

(d) Composition of feed fed during month.

(e) Amount of feed fed each day and for the month.

(f) Amount of feed given each day as a percentage of the weight of fish at the beginning of the month.

(g) Rate of growth during month.

(h) Conversion of feed into fish for that month.

(i) Daily temperature records and an average temperature for the month.

(j) Flow rates of water entering the raceways and ponds.

Sample data sheets that might be used to record the recommended data are shown in the Appendix.

(3) Hatchery management procedures should be standardized among the several hatcheries. There is wide diversity among the hatchery management procedures employed and not all of the diverse ways of accomplishing the same objective are equally effective. The Chiefs of the hatcheries and personnel from the Ministry should decide together on the best methods for spawning, hatching, rearing alevins, preparing feed, weighing fish, and determining feeding rates. These methods should be written up in manual form and each station should follow the same procedures unless there is a specific local reason not to do so.

(4) Rational stocking policies should be developed for lakes and rivers that take into consideration productivity of the water, flow rates, size of the lake or river, rate of removal of trout, amount of natural reproduction, and the mortality rate of the trout stocked.

3.03 Evaluation of Proposed Projects

One of the reasons for the visit to Peru was to assist personnel of the Ministry in evaluating several proposed projects. All of the projects are part of a plan to provide Government leadership in the establishment of a viable trout farming industry in Peru.

3.031 Selection of a Site for a Demonstration Trout Farm in Ancash

As part of the Government of Peru's efforts to aid the people and the economy of the area affected by the earthquake in May, 1970, the Ministry of Fisheries plans to establish a large trout farm in the Department of Ancash. The purpose of this farm is to conduct experiments on the production of trout for market and to

demonstrate the principles of trout farming to private trout farmers. It is hoped that with the Ministry trout farm as a nucleus that a sizeable trout farming industry will be developed in the Santa River valley.

In addition to conducting research on trout farming, the Ministry trout farm will produce approximately one-half million kg of trout per year for market. To produce this quantity of trout, approximately 7,600 m^3 of raceways will be required, assuming that trout can be produced at a density of 66 kg/m^3. This is a reasonable, even low, estimate of potential production if adequate water is available. With raceways 1 m in depth, 7,600 m^2 or 0.76 hectare of raceways will be required for the production.

It is desirable to plan on 1.5 complete water changes per hour in the raceways; thus a water supply would have to be capable of providing slightly over 3 m^3/second of flow during periods of peak production. Obviously a river of moderate size is needed to supply this quantity of water. Further, a rather large canal will be required to carry this amount of water from the river to the trout farm.

Since the station will require almost one hectare in water, a rather large area of land with low to moderate gradient will be needed. A number of buildings (shops, feed storage rooms, laboratories, hatching houses, etc.) will also be needed to support a trout farm of this size. There will probably also be a need for houses for technicians and research personnel. The total space requirement for a trout farm of the size planned by the Ministry (raceways, buildings, yards, etc.) will be approximately 10 to 12 hectares.

There are few springs in the valley of the Santa River in Ancash; consequently, trout farms in that area will have to be constructed with access to the numerous

smaller rivers that arise in the high Andes to the east and that flow to the Santa River. All of these smaller rivers receive some snow water and are therefore relatively cold. They are all short and flow through narrow "V" shaped valleys. The gradient of all of the rivers is extremely high. There are few pools, except plunge pools, on any of the rivers. With few exceptions the only land suitable for the construction of large trout farms is found where the smaller river valleys join with the valley of the Santa.

Visits were made to all of the permanent tributary rivers flowing into the Santa River from the Pariac River in the south to the Ranrahirca River on the north to evaluate possible sites for the location of the demonstration trout farm. Other rivers visited were: the Olleros, the Buin, the Auqui and the Marcara.

3.0311 Pariac River

The Pariac River is located south of the town of Huaras. There are a number of places along the river where small trout farms could be established. There is an area east of the main power generating station where possibly 1.0 hectare of raceways and ponds could be established. The canal carrying water to the hydroelectric plant runs along one side of the area. That particular piece of land is currently serving as a pasture and a soccer field. Although the area is suitable for a trout farm, it is not large enough for the type or size of station being planned by the Ministry. Also, access to the area is relatively poor.

Some physical and chemical characteristics of the river water are given in the following table:

(Valle del Rio Buin; típico valle en forma de "V" situado en las montañas de Hua

Figure 5. Buin River Valley; typical "V"-shaped valley of the mountains near Huaras.

Figure 6. Road construction along the Pariac River near Huaras.

(Obras de construcción de carretera cerca del Río Pariac en Huaraz)

Characteristic	Quantity or value
Temperature	12.0 C (at 11:00 AM)
Total hardness	50 ppm*
pH	7.8
Oxygen	10.0 ppm

*EDTA titration with Hach Kit.

3.0312 Olleros River

The Olleros River is also located south of Huaras. This river flows through a very precipitous "V" shaped valley. For several kilometers up the river valley there was virtually no land suitable for trout farms that would not require a long canal. Most of the land that has a suitable gradient for trout farms is 200 to 300 feet above the river.

Previous analysis of the river water indicated that the pH was near 6.0. The appearance of the water and rocks indicate a rather sterile environment. There are no algae growing on the surface of any of the rocks. Instead the rocks have an acid-washed appearance and where the rocks come in contact with the wa they are reddish-brown in color.

The Olleros River is relatively cold. Apparently it is somewhat shorter or runs a shorter distance from the area of snow melt to the River Santa than the other rivers visted. The water temperature in a small canal near the river was 8.5 C at 10:00 AM. Probably the river was even colder.

3.0313 Buin River

The Buin River is located north of Huaras. It runs through a typical valley for the area; although there is more relatively flat land adjacent to the river along the valley than is the case on either the Pariac or Olleros Rivers. There are a number of areas alongside the river and one or two meters above the level of the river that could be developed for small trout farms. There are 10 to 15 hectares of land suitable for the construction of trout ponds and raceways north of the river and adjacent to the highway from Huaras to Yungay; however, this land is some 10 meters above the level of the river which would require that a rather long canal be constructed to divert water to the area. There is already a canal that provides some water to the area, but it would have to be enlarged and improved before it would be a dependable source of water for trout farming. The temperature of the river in the general area where trout farms could be established was 12.8 C. Approximately three km upstream, the water temperature was 10.5 C.

According to the biologists from the Ministry, this river becomes turbid following rains in the area. If the silt load is heavy enough following rains, this would limit the potential of this particular river as a source of water for trout farming.

3.0314 Auqui River

The Auqui River runs through the city of Huaras. This also is a relatively short river which arises in the snow fields in the mountains just east of the town. The water is cold. A smaller river which joins the Auqui in the edge of the city

is the source of water for the Huaras Hatchery.

There is a large area near the confluence of the two rivers that could be developed into small trout farms. The area is relatively flat. It was formed by an avalanche. There are many large rocks on the area, but there is sufficient area free of rocks for the establishment of a number of small trout farms. At this point, the land is only two or three meters above the river level. Canals constructed to provide water would not need to be very long. The disadvantage of establishing trout farms on this river is the low temperature of the water.

3.0315 Ranrahirca River

This river flows through the valley near what remains of the town of Yungay that was devastated during the earthquake and avalanche in May, 1970. This is one of the largest rivers visited in the area, but according to the biologists, it is not permanent. The river originates in the mountains near one of the highest peaks in Peru. It flows through several small lakes (one of these is Lake Llanganuco). In the upper valley that was not affected by the avalanche, there is considerable farming and there are several places where small trout farms could be developed. At present, access to these upper valleys is very poor.

3.0316 Marcara River

Of all of the rivers and valleys visited in Ancash, the valley of the Marcara contains the best area for the development of trout farms. From the standpoint of stream evolution and valley development, this is the most advanced one visited in the area. The valley contains a relatively flat plain that varies in width from approximately 100 meters to almost a kilometer in places. The plain is never

very high above the level of the river. There are numerous areas where rather large trout farms could be established.

The Marcara River is the major river of that particular valley, but approximately two km east of the highway from Huaras to Yungay the Marcara is joined by the smaller Copa River. The Copa contributes a volume of water equal to approximately one-fourth the volume of the Marcara. Some of the physical and chemical characteristics of the two rivers at their confluence are given in the following table:

Characteristic	Quantity or value	
	Marcara River	Copa River
Temperature	12.4 C (2:30 PM)	12.0 C (2:00 PM)
Total hardness	75 ppm*	80 ppm*
pH	7.3	7.2

*EDTA titration with Hach Kit.

The amount of algae growing on the surface of the rocks in the Copa River indicates that it is a relatively rich river. There is less algae on rocks in the Marcara River, possibly as a result of its silt load. The water of the Copa River is very clear; while that of the Marcara carries a heavy load of dark gray, very fine sand. The visibility was little more than 25 to 30 cm during the time of the visit. The origin of this material is not certain, but it probably enters the river as a result of irrigation of the agricultural land upstream. The biologists say that the river has been this color since the earthquake in 1970.

At the point where the valley of the Marcara intersects the valley of the Santa, there are probably a hundred hectares of land on either side of the Marcara River

that have excellent potential for trout farming. The best site in that area is the parcel of land (10 to 15 hectares) south of the river and west of the main highway. The land is bound on the west by the Santa River and on the east by the highway. This is the area that is recommended for the construction of the large trout farm by the Ministry.

There is already a canal from the Marcara River that provides water to the area that is recommended for construction of the trout farm; however, it will have to be enlarged and improved before it will provide the amount of water required. The total length of canal that will be required to provide water to the entire area in question is approximately 0.5 km. A shorter canal will be required to reach the best site for a series of raceways and ponds.

The area appears to be relatively free of the danger of avalanches. The hills to the east are relatively low, rounded and mostly covered with vegetation. There is also little danger of the Santa River flooding the area. The river is 10 to 15 meters below the level of the plain where the farm is to be constructed. The slope from the plain to the river bed is a vertical one, but there is little evidence of continued erosion.

Much of the area is presently in cultivation. The soil appears to be very good for agriculture. It has very good compaction qualities as the permanence of the unfired bricks used for home construction in the area would attest. Unfortunately, the soil is permeated with rocks of all sizes. Some small plots on the area are so rocky that they cannot be used for agriculture except as pasturage. Other plots appear to be relatively free of larger rocks, at least at the surface.

The clay in the area is certainly of sufficient quality that the production ponds could be constructed of clay; however, there may be too many rocks underneath the surface of the soil for this to be possible. It will probably be cheaper when all costs are considered to use concrete raceways rather than ponds or raceways constructed of clay.

Some physical and chemical characteristics of the Marcara at the point where the canal would divert water to the trout farm are shown in the following table:

Characteristic	Quantity or value
Temperature	11.0 C (at 10:45 AM)
Total hardness	80 ppm*
pH	7.7

*EDTA titration with Hach Kit.

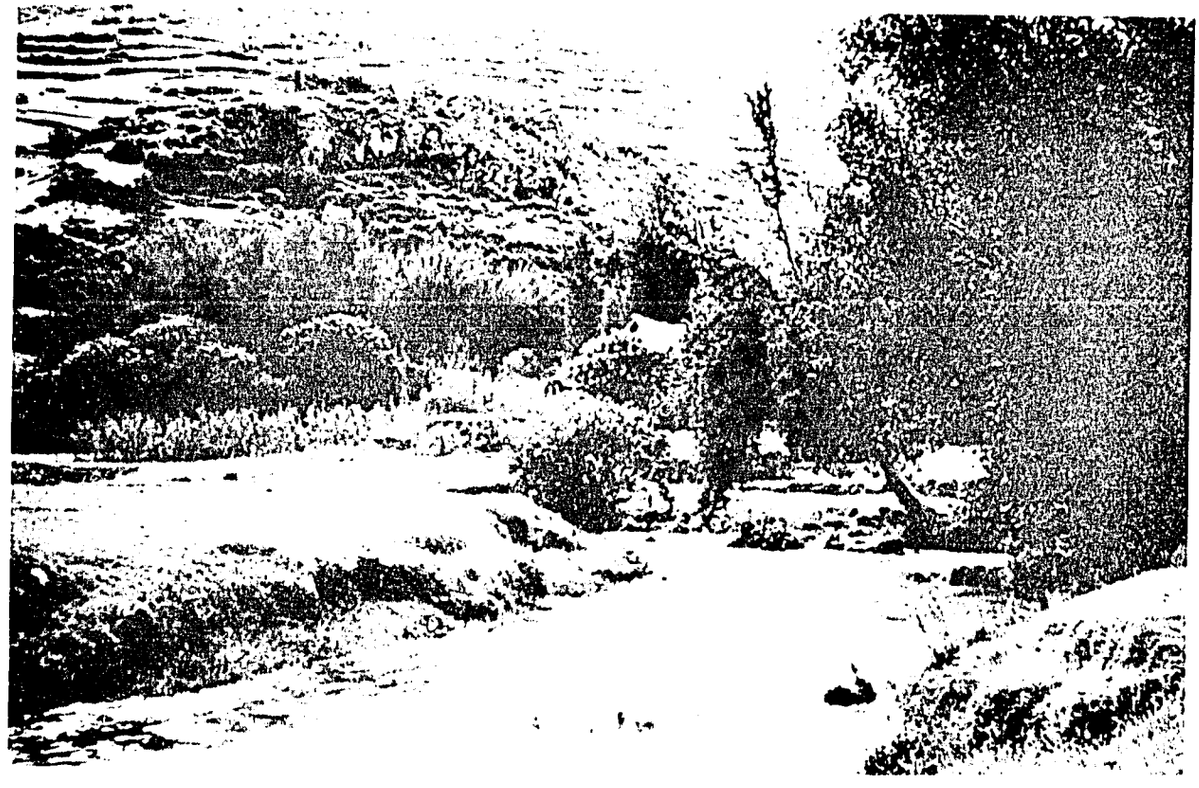
The temperature of all of the rivers in the area are in the lower part of the range for optimum trout growth (10 to 19 C). The Marcara is no exception; although because of its size and length, it may warm up a little more in the summer than the other rivers visited.

The area near the Marcara recommended for the construction of the Ministry's trout farm is certainly the best of all of the rivers visited; however, the area is not without its disadvantages. The very characteristics which make the valley of the Marcara suitable for trout farms also make it suitable for homes, farms, schools, and towns. In fact, except for the valley of the Santa itself, this is the most hospitable

(Lugar escogido por el Ministerio para su criadero de truchas cerca al río Marcara)

Figure 7. Site of the proposed Ministry trout farm adjacent to the Marcara River north of Huaras.

Figure 8. The Chiapuquio River; water supply for the Ministry trout farm near Ingenio.



(Río Chiapuquio; abastecimiento de agua para el criadero de truchas cerca a Ingenio)

valley in the area for human habitation. There is already extensive farming in the valley and there are a number of villages located along the river. Within 10 years, there probably will be two times as many people living in the valley of the Marcara as now. Farming will certainly increase, as well as the number of villages. There is already considerable evidence of overgrazing on the slopes of both sides of the river. Some of the slopes are virtually bare of vegetation. As the population increases, the number of grazing animals will also increase, putting a greater burden on the overgrazed hills. It is probable that erosion and siltation will increase in the future. At the present time the quality of water in the Marcara is adequate for the production of trout. Only time will tell whether it will be possible to maintain this quality. Unless steps are taken to establish good soil and water conservation practices and to prevent the contamination of rivers by mining, there is a possibility that all of the rivers in this area will become as polluted as the Santa River. Trout farming under these conditions will be difficult if not impossible.

3.032 Evaluation of the Construction Plan for the Trout Farm at the Junin Hatchery

As part of its overall plan to encourage the development of trout farming in Peru, the Ministry of Fisheries plans to construct a series of ponds for the production of trout of marketable size at the Junin Hatchery. The planned construction will include 39 ponds, 30 m in length, 7 m in width, and approximately 1 m in depth. Those ponds will be used entirely for commercial production of trout. A number of smaller ponds will also be constructed for rearing alevins, and for use in research on various aspects of trout farming.

The water supply for the Junin Hatchery is Chiapuquio River. The river is formed by springs in the mountains east of the hatchery. The present hatchery utilizes only a small portion of the volume of that river. There is sufficient flow in the river to provide an adequate amount of water for the proposed ponds.

The site of the proposed construction east of the present hatchery is a very good one for trout ponds. The north-south gradient is relatively low. Terracing in past years has divided the east-west gradient into a series of rather flat fields of approximately 0.5 hectare each. The drop between adjacent fields in some cases is rather abrupt, but this should offer few problems in constructing the waterways and canals.

The original plan was to construct the ponds of clay; however, test holes dug by the firm of consulting engineers responsible for the final design of the project indicated that there is probably too much soft, crumbly, pervious rock in the area. There is a shallow layer of good clay over most of the entire area of proposed construction; however, the test holes indicate that this extends downward only about 30 to 50 cm; consequently, it will probably be necessary to construct the ponds of concrete or a combination of concrete and rock.

As noted previously, it is planned to construct ponds 30 m in length and 7 m in width. Without specially constructed water control structures, it is difficult to obtain good water circulation in a pond 7 m in width. Usually there will be poor water circulation in the corners and along the sides of the pond. Most of the trout grown in the United States are grown in raceways that are two to three m in width. Circulation is much better in these narrow raceways; consequently, all areas of the raceway contain water of equal quality. Also, because of equal circulation,

the raceways tend to be self-cleaning. Feces and uneaten food tend to be moved toward the lower end of the pool; whereas, in wide pools these materials tend to collect in the corners where water circulation is poor. There is little doubt but that production of trout per unit volume and per unit of water will be higher in narrower raceways.

3.033 Evaluation of the Plan for Collecting Rainbow Trout Eggs at the Mouth of the Pallajchuma River on Lancui-Layo Lake

If the Ministry's program to develop a strong trout farming industry in Peru is successful, a large number of rainbow trout eggs will be needed. It is proposed that this need will be met by establishing an egg-collecting station on the Pallajchuma River near the point where it enters Lake Lancui-Layo, which is southeast of the city of Sicuani in the Department of Cuzco.

Lake Lancui-Layo is a 6,000-hectare lake located at an altitude of 3,942 meters. It has only one permanent tributary, the Pallajchuma River. The lake was first stocked with rainbow trout in 1940. After the initial stocking, a good population of trout developed in the lake. Five years ago there were 150 fishermen fishing the lake for rainbow trout with gill nets. Fishing was apparently not restricted in any way; consequently, the population has been virtually eliminated. There were few trout remaining in the lake prior to the stocking of 255,000 fingerlings in 1971. The plan of the Ministry of Fisheries is to re-establish the population by stocking and to maintain it by stocking if necessary.

An egg-collecting station will be constructed on the Pallajchuma River. As the rainbows move into the stream to spawn they will be trapped and held until they can be spawned artificially. It is anticipated that 20 million eggs will be

collected at the station each year and transported approximately 20 km to the Lancui-Layo Hatchery near the outlet of the lake. The eggs will be given their first 20 days of incubation at that hatchery and then transported to other hatcheries (Puno, Junin, Huaras, Huanuco, etc.) in the country.

The plan to collect most of the rainbow trout eggs at one location and transport them to other locations is a good one. Other hatcheries will not have to assign valuable hatchery space to hold brood fish. The one possible disadvantage of the plan is that the population of trout that may develop or evolve in Lake Lancui Layo may not have the characteristics that are needed, for example, in trout farm raceways of Huancayo. The trout in Lake Lancui-Layo must survive in a hostile, natural environment. Those that survive to spawn will be those best adapted to survival in that particular environment. It can be anticipated that their offspring will have some of the same characteristics; however, these characteristics that are valuable to survival in the lake may be detrimental to trout farming or even to survival in a stream in Huanuco. For successful trout farming, a semi-domesticated strain of trout is needed; trout that grow fast, that readily take artificial food, that convert feed to fish at a high rate, that are disease resistant, that are not easily frightened by the presence of man, etc. It is not likely that the population of trout that develops in Lake Lancui-Layo will have those characteristics.

The present plan is to prohibit fishing in the lake once the population is re-established in order to protect the spawning stock. It is my opinion that fishing should be allowed in the lake. Lancui-Layo appears to be a rather rich lake and it is probably capable of sustaining a catch of at least 20 kg/ha (120,000

kg total) per year and still provide an adequate run of spawning trout to provide 20 million eggs. To prohibit fishing in the lake would deprive the people of that region of a large quantity of excellent quality fish; however, it will be necessary to limit the fishing in some manner to guarantee the escapement of sufficient fish, both in quantity and size to provide the required number of eggs. Fishing regulations must be promulgated that will guarantee the escapement of sufficient fish that are sexually mature and that are of optimum size for egg production. Probably the only way to do this is through the use of regulations on the minimum size of mesh that may be used.

Assuming that sexual maturity is related to size (body girth), regulations can be established that will prohibit the use of a mesh that will catch fish until they reach a size where they are sexually mature. The exact methods of determining mesh sizes necessary to accomplish the desired objectives is beyond the scope of this discussion. Considerable research will have to be conducted before the regulations can be set.

With proper regulations relating to fishing in the lake and with protection for trout allowed to spawn in the Pallajchuma River, it should be possible to establish a self-sustaining population of rainbow trout that would provide a catch of 120,000 kg per year of marketable trout, 20 million eggs for distribution to other hatcheries and yet require relatively little stocking from the Lancui-Layo Hatchery.

3.034 Evaluation of the Plan to Establish a Community Trout Farm on the Chaca-Chimpa River near Junin

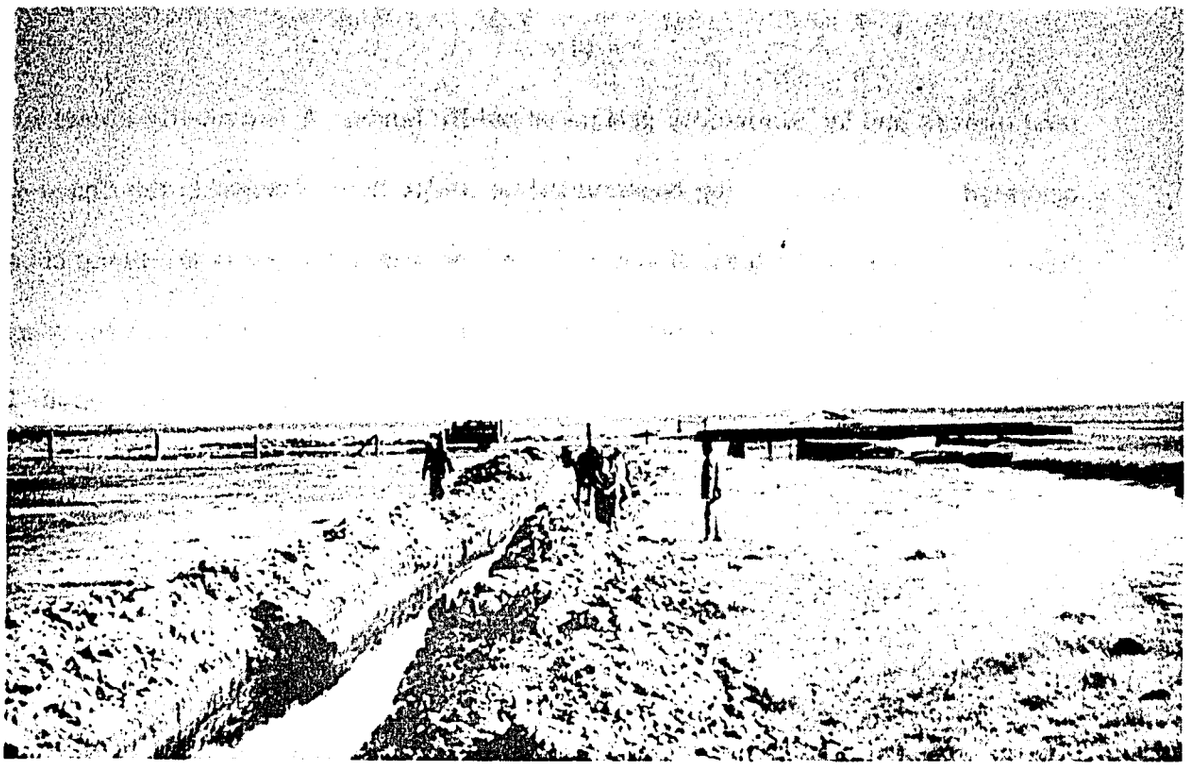
The Ministry's plan to establish a trout farming industry in Peru involves the construction and development of large numbers of small trout farms by private

land owners and by community groups on public lands. A community owned and operated trout farm is being constructed on public land adjacent to the Chaca-Chimp River just north of the town of Junin. The land where the ponds are being construct is in an area that was set aside for an experiment station on frog culture. A numbe of small ponds were constructed there several years ago, but they have since been abandoned. Now, four of the large ponds are being reconditioned for use as a smal trout farm. The Chaca-Chimpa River arises at the south end of the Lake Junin basin from springs flowing from the surrounding hills. The river has a relatively large flow. It flows across what is probably reclaimed lake or solidified bog. The land is relatively level; yet there is sufficient gradient for a good flow of water. The water has the characteristic brownish color of bog streams. It is very clear. The stream bed is virtually filled with an aquatic plant that resembles Certatophylli

A group in the community wished to place screens across the river and to use these sections for trout culture. I would not recommend this for the following reasons.

(1) With the abundance of plants in the stream, it is likely that the screens would become clogged resulting in flooding around the screens and the loss of trout.

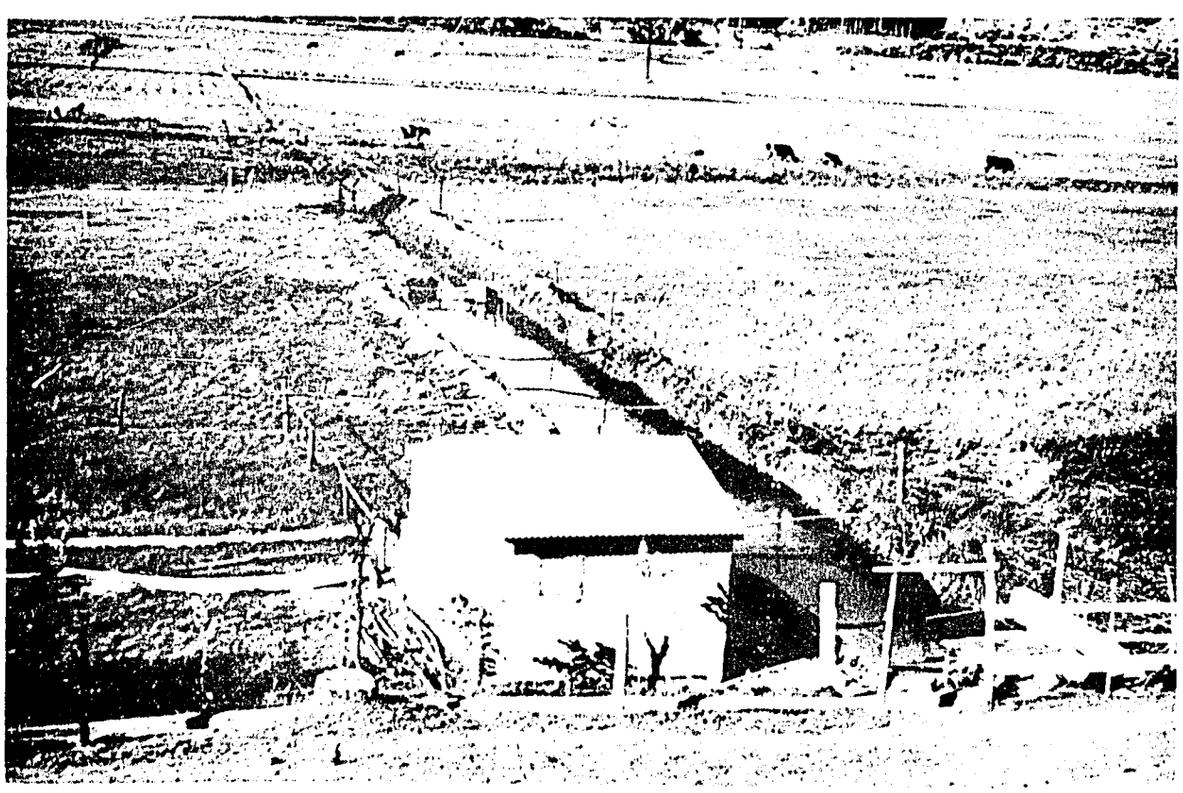
(2) There would be no way to control the flow of water. The flow through the rearing units would be equal to the flow of the entire river. The flow rate of the river is probably excessive for good trout production. The fish would utilize too much energy just maintaining their position in the stream.



(Canal de agua para las pozas del criadero de truchas cerca al Río Chaca-Chimpa

Figure 9. Water supply canal for the trout rearing ponds adjacent to the Chaca-Chimpa River near Junin.

Figure 10. Private trout farm near Huancayo.



(Criadero de truchas de propiedad privada en Huancayo)

(3) The small mesh screens needed to keep fingerlings in the ponds would likely be torn out by the force of the current.

(4) Harvesting the fish would be difficult since the rearing units could not be de-watered.

(5) The Ministry wishes to prevent the introduction of trout into Lake Junin in order to preserve the local fauna. If trout are placed in enclosures in the river, they will almost certainly escape and enter the lake sooner or later.

3.04 Evaluation of Small Trout Farms

As a result of the Ministry's efforts to promote trout farming, a number of small trout farms have been established in the Provinces of Huancayo, Jauja and Tarma in the Department of Junin. It is certainly encouraging to observe the interest in trout farming in the Department. In several locations trout farmers who had produced only one or two crops of trout previously are enlarging their production areas. One farmer is converting a part of his agricultural land into trout ponds.

Although there is considerable interest in trout farming in the district, it is obvious that all of the farmers visited will need a considerable amount of technical assistance if they are ever to produce more than a token amount of trout and if they are going to be able to produce trout for the competitive market that will develop as the industry grows.

Following are some of the technical problems that were observed in visiting the small trout farms in the district:

(1) Ponds constructed so that they cannot be drained or so that fish could be removed only by seining.

(2) Ponds poorly constructed, banks crumbling into water. Some ponds are little more than excavated holes.

(3) Poorly constructed water control devices.

(4) Some ponds were badly overstocked with fingerlings. Others contained only one-fifth enough fish needed for optimum production in the pond.

(5) Use of poor diets, and poorly bound diets. Some of the diets in use immediately disintegrated when thrown into the water.

(6) Most operators seem to have no knowledge of feeding rates for trout. They just prepare feed and put it in the pond without any concern for the amount of trout in the pond.

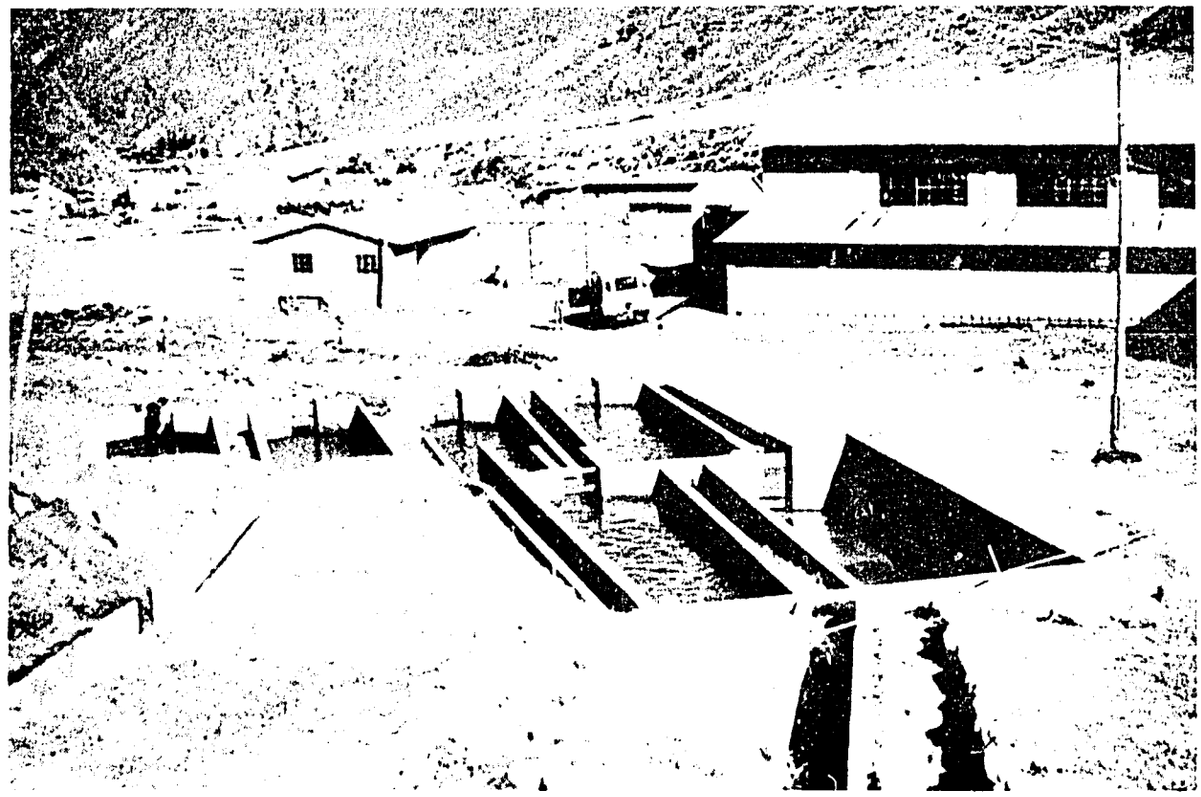
(7) Most of the farmers have no idea of their inventory in terms of weight.

(8) In some ponds the mud was quite deep. The water became muddy as the trout fed.

(9) Few of the farmers have any knowledge of the cost of producing trout.

(10) Construction of ponds where they are likely to be destroyed by floods.

There is excellent potential for the production of trout in the Provinces of Huancayo and Jauja. There are numerous springs that provide an abundance of clear, unpolluted water with a relatively constant temperature. There are literally thousands of hectares of land adjacent to these springs and to the rivers flowing from



(Criadero cooperativo de truchas en Alcopala)

Figure 11. Cooperative trout farm near Alcopalca.

Figure 12. Private trout farm near Jauja.

(Criadero de truchas de propiedad privada en Huancayo)

them with suitable characteristics for the construction of raceways and ponds for trout farming. There is also considerable interest in trout farming, but water, land and interest by themselves are not a trout farming industry. Many other things are needed, and if trout farming in those Provinces is to reach its potential, many other inputs and services will be needed.

Following is a somewhat simplified list of the requirements for a viable trout farming industry:

(1) Water

(2) Land

(3) Good Management

(4) Services

- (a) Management advice
- (b) Credit (to finance the building of ponds, etc.)
- (c) Feed (readily available, good quality, low price, etc.)

(5) Marketing

- (a) Processing facilities
- (b) Freezing facilities
- (c) Location and development of distant markets
- (d) Transportation to distant markets

All of the items in the above list are vitally important if the trout farming industry in Peru is to develop. Almost anyone of the items can prevent or impede the growth of the industry if it is lacking.

4.0 APPENDIX

4.01 Forms to be Used for the Collection of Pertinent Data for Trout Hatcheries

Table 1. Daily Records of Fish Production and Feeding

Date	Water Temp	Number of fish (shipped) (added)	Weight of fish (shipped) (added)	Mortality	Disease Control	Pounds of feed used	Daily total
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
Total							

Table 2. Monthly Summary Report

Station _____ Month _____ 19 _____

Species _____ Indicate Whether:

Lot _____ Sample Count _____

Date Started _____ Inventory _____

1. Number of fish per pound first of month _____
2. Number of fish per pound 15th of month _____
3. Number of fish per pound end of month _____
4. Number of fish on hand first of month _____
5. Number of fish on hand end of month _____
6. Weight of fish at end of month _____
7. Weight of fish (shipped) (added) during month _____
8. Adjusted weight of fish at end of month _____
9. Weight of fish first of month _____
10. Gain in weight of fish _____
11. Diet composition _____

_____

12. Cost per pound _____
13. Pounds of feed per pound of fish gained _____
14. Food cost per pound of fish gained _____
15. Weight of fish per cubic foot of water _____
16. Gallons per minute flow _____
17. Percent gain in weight of fish _____
18. Amount of food fed in percent of body weight _____
19. Mortality in percent _____