

Cold Water Aquaculture
in Ecuador

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Introduction

In his report on Aquaculture Development in Ecuador (Aug 1981), Dr. Ronald P. Phelps of Auburn University states that there is a wide variety of aquaculture potentials in Ecuador based on the diversity of geographical and natural resources. He correctly cites an increasing per capita consumption and an unsatisfied demand for freshwater fish products. Because the freshwater supply of fish is largely seasonal, he suggests the most reasonable solution to be an increased emphasis on aquaculture.

The Auburn (Phelps) report is devoted primarily to the identification of agencies, including universities, that are currently involved in inland fishery programs and a description of suitable sites where aquaculture facilities could either be constructed or expanded on existing infrastructure. Although his emphasis is on warm water aquaculture he did visit areas where cold water fisheries would be best suited and stated that this resource area could be important to the overall aquaculture development.

This report is a "follow up" investigation to determine the degree to which cold water fishery development could contribute, and where a program might best be started. Because the author had the opportunity to explore the potentials for trout production in the southern and south central regions of Ecuador (PREDESUR) while serving as a senior scientist for the United Nations, it was possible to concentrate this time on central and northern sectors of Ecuador and generate specific recommendations and a plan of action rather than spend an inordinate amount of time in description of areas visited and an evaluation of local potentials. That material is available in a trip report left with the A.I.D. mission in Quito in November 1981.

The tenor of this report is that a cold water fishery program is not only potentially feasible, but that it is also desirable and a plan of action along with a set of alternatives is the next logical step.

Of all the agencies identified by Dr. Phelps (many of which were observed and studied on this and the previous U.N. visit) it would appear that the Departamento de piscicultura under the guidance of Captain Francisco Garcia N., would be the most logical organization for collaborative work. Captain Garcia and his associates appear to have a sincerity of purpose and have laid considerable groundwork toward a viable program.

Trout Culture in Ecuador A Plan of Action

Trout were introduced into cold water ecosystems of the South American Sierra in the 1940's. It is likely that the first introduction into Ecuador occurred at about that period, although the exact date is in doubt. Because of little competition from endemic fishes in the colder waters, trout flourished and have maintained natural populations in many regions.

Attempts at artificial propagation were made soon after the initial introduction but have met with marginal success at best. Although many reasons can be cited for individual failures, the overriding problem has been the failure to formulate and manufacture diets suitable for the several different life stage requirements of trout. If any attempt is made by USAID or any other agency to upgrade and expand trout culture in Ecuador it must start with nutrition and diet formulation. The suggestions by U.N. scientists and other fishery biologists that Ecuador is not sophisticated enough to use this internationally recognized approach to trout culture is to stymie progress. One need only to look at neighboring Peru, where in two or three years a nation with similar cultural and economic conditions has broken the barrier and is now not only producing trout for its own internal consumption but has become

an exporter of trout products largely on the basis of a USAID experimental project. The UN recommendation to use local feed products for local hatchery or pond production fails to consider the very specific nutrient requirements of trout and would, if adopted, keep cold water fish production in Ecuador decades behind its neighbors. The USAID has a unique opportunity to suggest and demonstrate a very appropriate and relatively simple technology with a high probability of success and the opportunity for replication. Rewards for Ecuador could come from local economic improvement as well as an important nutritional gain.

After observing the several locations in Ecuador where some infrastructure for trout culture exists and could be both improved and expanded, it is tempting to outline a series of projects in several areas. The best procedure, however, is to select the one most suitable location and build a demonstration facility where experimental activity could involve all stages of trout life history as well as techniques in handling, transport and utilization of fish products by the people of Ecuador. From this base, knowledge could be exported to other locations in Ecuador for replication.

This best alternative would not preclude the concurrent development of some cold water projects that are well along and need only simple modification or technical assistance. There are, for example, several private facilities that could be made economically viable by the provision of diets and extension type guidance. Another example might be the immediate stocking of a series of abandoned trout ponds in the AID demonstration area near Lbactaurcu (Salcedo) where an element of credibility might be important. This stocking would, of course, depend upon the availability of a suitable diet. A Peace Corps volunteer at this site, with a current assignment in human health, could and would look after the fish.

Site recommendation

The one best site for a demonstration facility of all those observed was at Papallacta where Captain Francisco Garcia has developed a general plan. This site, which is already under government ownership, has these several distinct advantages:

- (1) easily reached by an all season road slightly more than one hour driving time from Quito, and very central relative to Ecuador's cold water ecosystems;
- (2) stream water originates in a well protected watershed with little potential for pollution. This is unusual for much of the Ecuadorian Sierra where the majority of the streams are subject to severe silt or mining pollution;
- (3) the potential hatchery site slopes in such a way as to insure adequate fall between ponds and/or raceways. The soil is a clay type thus allowing potential for ponds which are much less expensive than concrete ponds or raceways;
- (4) there is sufficient stream volume (not measured but estimated to exceed 20 CFS at low flow) to insure a steady supply of water (potential capacity is far in excess of 200,000 lbs of trout annually);
- (5) records indicate minimal seasonal fluctuation in volume, temperature or turbidity;
- (6) stream temperature at the time of inspection was 11°C (51°F) almost ideal for cold water fish production;
- (7) there are several relatively large hot springs rising on either side of the main stream that could be used for mixing with the stream water. The hot springs flow at approximately 44°C (109°F) and could be

- introduced into experimental ponds by gravity flow. The opportunity to mix waters suggests a potential for almost unlimited experimental work on diets, growth, disease, etc.;
- (8) the hot water would allow parallel experimental work with warm water fish culture as well as the cold water species, thus allowing cost sharing opportunity;
 - (9) the warm water appears to be very low in sulphur or other mineral contaminants that would limit its use. Tests show that trout can and do live in areas where the cooled hot water enters the main stream;
 - (10) the residents of Papallacta know trout and are very anxious to have a source of fish for local consumption and for stocking nearby lakes and streams. The local mayor is especially interested in fish culture;
 - (11) a hydro-electric power station is located just below the hatchery site thus providing inexpensive lighting and power requirements;
 - (12) the Japanese government has offered funds for construction of some housing in this area even though they would not participate in hatchery design, construction or management.

Trout diet formulation and manufacture

As stated above, a program of cold water aquaculture would have little chance of success in Ecuador unless a source of diet ingredients was located and a facility for diet manufacturing was either built or approved from among the several existing feed mills in Ecuador.

After the completion of the above mentioned UN study, the author requested that a former Colorado State University student, Mr. David Gariques (then a Peace Corps volunteer with PREDESUR) compile a list of trout diet ingredients currently available in Ecuador along with costs, location of sources and nutrient content of each ingredient. Mr. Gariques was considering entering

into a private trout culture venture at that time and such information would be invaluable to him. Although Mr. Gariques was not able to obtain the resources for his venture, he remained in Ecuador and when contacted in November of 1981, was able to join the author for consultations and to produce his list of ingredients. This list along with a list of suggested milling plants allowed the opportunity to visit and observe the methods used by one facility that was not only well located in relation to ingredient sources but also central in relationship to a potential trout culture industry.

The milling and pelleting plant BALALFARINA in the city of Riobamba has most of the qualities and qualifications we need. The plant manager is very knowledgeable in diet formulation and his modern facility, equipped mostly with British pelleting machinery, has excellent capabilities. We were able to inspect the entire plant, examine and question his procedures and to sample products (pellets) produced for other animals.

At the time of inspection the manager had just prepared a trial diet for shrimp cultural interests. This diet was not only well formulated, but it was prepared in such a way that one would expect first rate results on a contracted program. The owner/manager was willing to allow open inspections at any time and would allow a fishery representative to be present at each milling run. This is important since it is essential that fish diets not be contaminated by other animal diets that had been run previously.

Should a cold water fishery program be established under the guidance of AID, it is recommended that a contract be made with BALAFARINA, Riobamba, on at least a trial basis. A tremendous cost savings would be had in not having to capitalize and construct a facility and private enterprise would be aided as well. Another not to be overlooked advantaged with BALFARINA is their possession of import/export licenses for ingredients such as mineral packs or vitamin packs that might not be available otherwise.

Because Mr. Gariques has spent hundreds of hours in preparation of ingredient and nutrient level lists, it would be a great cost savings to use his data (he has agreed to this). His lists could serve as a basis for preparing an array of cost effective formulas to be used. It is impossible to stress the importance of his tabulations. To generate this same data by hiring an in-country or out-of-country consultant would take at least six months to a year of time.

To be used most effectively at a rearing/hatching station such as Papallacta, diet formulas should include swim-up; #1, 2, 3, 4 and 5 fingerling as well as 3/32, 1/8, 5/32 and 1/4 inch production pellets. Because Balfarina does not have a full set of pellet dies to cover this need, it would require them to purchase the extra dies suggesting the need for a long term contract or AID purchasing the dies and offering them under a lease or use basis.

The milling company would likely do a good job of selecting ingredients for the diets. It would be best, however, to have a trained individual either at AID or from Captain Garcia's office to be involved in the acquisition. Fish meal, for example, is one of the most important diet components but in Ecuador most commercial fish meal is of very low quality, with much scale, bone and detritus mixed in. Serious problems could develop in prepared diets if fish oils, etc. were or became rancid or mold was allowed to develop on prepared products.

Personnel Training and Development

Although much, if not most, technical training in the planning, building and operation of a cold water production facility could be accomplished through in-country training programs, Peace Corps aid and/or occasional visits of technical assistance staff, there probably will be a need to send one or more

Ecuadorian biologist or administrator to the US (or elsewhere) for more advanced training such as nutrition, disease or management. In the development of any program, it is essential to time such visits and training in coordination with the entire project plan so that the individuals would be able to use their improved expertise in each stage. Replication in other areas can then be accomplished by Ecuadorian personnel with a minimum of wasted time or effort.

There appears to be an excellent Peace Corps program in place in Ecuador. This agency could be utilized very effectively in advancing a program in cold water aquaculture.

Extension and Local Training

In the development of a comprehensive trout water program for Peru it was decided that a Cadre of Peruvian trained biologists and other specialists should be brought into the program at an early date so that they could act in a sense as extension agents in preparing local communities and/or landowners for raising or marketing fish should the project be successful. This was a fortunate decision because their early contacts with locals made the expansion of hatcheries and lake stocking much easier. In Ecuador there is a scarcity of trained biologists as contrasted with Peru. Phelps reports that "there are four universities planning to offer training in aquaculture" and that although there appears to be a great deal of interest amongst university staff that he contacted, very few faculty members really have training in fish culture. Many of the fisheries personnel contacted in this evaluation visit received their training (if any) in other countries.

The establishment of a demonstration hatchery facility at Papallacta would likely advance the efforts of the universities and should in no way conflict

with their plans to build ponds or other aquaculture facilities near their campuses. There are many obvious potentials for collaborative projects culminating in the better preparation of needed extension personnel.

One of the most successful extension activities in Peru was the visitation by women nutrition specialists to remote communities where the rearing of fish could add a much needed source of new protein to the local diets. By actually demonstrating the preparation and cooking of trout and by open discussions of the nutritional value to children, pregnant and lactating women and the elderly, much good was accomplished. People who had participated in these demonstrations and lectures were willing to utilize much of the annual fish production for local food benefit rather than exporting it to larger communities for profit. This export of fish for economic gain is obviously important as a co-objective but it should not be allowed to become the dominant reason for developing local aquaculture.

There is already a great deal of interest in Ecuador in the rearing of trout and other fish as a private enterprise. Obviously this should be encouraged and it can be by the wise use of extension personnel. As an example, one large landowner had built a reasonably good trout hatchery and had paid for a Swedish National working there to travel to Europe to study methods of trout culture. Unfortunately there was no source of an adequate diet for this man to use upon his return and he had to revert to the traditional use of dried milk and/or chicken feed. The quality of the fish demonstrated the failure of the effort. Had an operating demonstration hatchery been in operation in Ecuador along with a good formulated diet, this operation could become economically viable in a very short period of time.

There were several other visitations to frustrated private landowners and in every instance the problem was directly related to the lack of an

adequate diet or knowledge about fish nutrition.

Marketing

A major mistake in the planning of a new or expanded enterprise in a developing country is the lack of emphasis on marketing and product utilization. This same mistake should not be made in any aquaculture program in Ecuador.

Local, regional and export markets need to be thoroughly investigated and nothing left to assumption. Although most cultures in developing countries utilize some fish products there is wide variation in how much and in what form they will accept it. The fact that fish are subject to rapid spoilage has not been lost on most societies and they are chary about its use.

Again using Peru as an example, marketing surveys turned up many surprising and important things. Color of trout, for example, was very important. Wild fish populations obtain fairly large amounts of carotene from plankton or other sources and the flesh is usually redish orange. In a hatchery prepared diet, carotene is normally low unless it is intentionally added for egg development in brood stock. That derived from animal sources (shrimp meal) is quite expensive. A private trout farm in Peru attempted to market fresh trout in Lima and found very low acceptance until they tried a small market sample with colored flesh. The results were immediate and supply could not keep up with demand despite an added cost. In time, it is quite likely that an "un-colored" trout will be acceptable but marketing will have to follow a change in consumer acceptance.

Another major problem is production in excess of immediate demand. Traditional smoking and salting or drying can accomodate many problems of surplus but the product is normally very inferior to the fresh and nutritional value is lost.

Any program of aquaculture in Ecuador should be accompanied by a program in new product development and utilization. For example, in Peru we have

suggested the blending of trout flesh with potatoes or cereal products through an inexpensive extrusion process. In this case we have used as much as 40% trout flesh with 60% potatoe and have produced an item that is not only very palatable and nutritious but also shelf stable at room temperature for several months. We have also demonstrated retort packaging, using low energy to produce a packaged product that retains its nutritional value, flavor and texture for up to two or three years, again requiring no refrigeration.

In Ecuador there is a frequent surplus of potatoes in rural areas. Habas is another product that would blend nicely with fish flesh to produce a nutritional, shelf stable food item.

Replication Planning

New programs in cold water aquaculture in Ecuador should be designed to accomodate replication in other sectors. Either in total or in part.

It should be recognized that any successful program or facility will be studied, and copied by others anxious to share in new sources of wealth and protein. Design of a demonstration hatchery should therefore be functional yet realistic in cost. Care must be used in incorporating materials that are obtainable in most localities at reasonable prices. When dirt ponds or raceways can be used in place of perhaps more functional concrete, for example, they should be built.

Although some sophisticated equipment might be needed to insure success of important research studies it should be placed and used in such a way that observers will not get the idea that it must be part of their facility.

This can result in a demonstration facility that may be less attractive than the widely circulated pictures of US Federal and State supported monstrosities but it will serve a better purpose. Appropriate technology is a widely expressed concept but too infrequently put into practice. Aquaculture is an area where appropriate technologies can and should be applied.

Recommended Sequence of Action

- I. Establish the format for a working relationship in cold water aquaculture development with Captain Francisco Garcia N. or a designated representative from the Direccion General de Pesca.
 - A. Clearly outline objectives, goals and limitations of AID participation as well as expectations from the Departamento de Piscicultura.
Suggested primary goals (1) to increase protein sources through aquaculture in rural areas; (2) stimulation of local rural economics by development of small private or community fish rearing facilities or related business enterprise; (3) develop marketing and fish utilization strategies to assist first two goals.
 - B. Identify key personnel, along with their responsibilities. Generate list of technical assistance needs and institutional sources. Contact Peace Corps or other support agencies.
 - C. Develop preliminary plans for potential funding.
- II. Initiate steps to obtain full use of and access to Papallacta hatchery site including first rights to water use; watershed protection insurance; utilities etc.
 - A. Using preliminary plans and data on Papallacta from Captain Garcia, draft final plans and develop a set of blueprints to include: water delivery and discharge systems; raceway and pond locations, design, construction; laboratory; feed and equipment storage; housing, etc.
 - B. Initiate phased construction starting with water systems, hatchery, fry fingerling ponds etc. Coordinate expansion with previously identified research and management needs.

- III. Negotiate contract with feed plant at Riobamba to provide rations for Papallacta station as well as extension needs and possibly for use in other government stations such as CREA, PREDESUR, etc. should they become interested in the project and need assistance.
 - A. Design a workable plan to test diet formulations for different sizes and species of trout at Papallacta.
 - B. Consider possibility of formulating and manufacturing diets for other fish or shellfish that may be part of AID sponsored projects such as those recommended by Auburn University in warmer waters. Savings are obvious.
- IV. Initiate training program in Ecuador and possibly in USA for key personnel. Among those selected could be: hatchery manager; nutritionist or disease/nutritionist; marketing specialist; extension specialist, etc.
- V. Designate communities, agency personnel, and private growers that might profit most from extension aid and start preparing literature, teaching aids and other materials that could be used to give them help.
- VI. Have a marketing program planned well in advance to absorb production that will accrue from expanding aquaculture efforts.
 - A. Select and train specialists to travel into rural areas to instruct in fish preparation, utilization and consumption. This could work well with ongoing Peace Corps programs in rural health.
 - B. Plan for a research and development sub-project to be headquartered at Papallacta to design and test fish based products that would use low energy sources, maintain nutritional qualities and offer long-term storage. Equip food technology laboratory for this purpose.

- VII. Host at least one or more demonstration schools at Papallacta. Invite interested people from government agencies, private enterprise and universities as participants. This should be done after the basic facility is established and at least one-year of operation is completed.
- VIII. Evaluate program for replication in other areas of Ecuador.

Alternate Plans

The above plan of action appears to this writer to be a sound and workable option to advance cold water aquaculture in Ecuador within a framework of minimal cost and maximum results that can be measured both socially and economically. Obviously, problems, constraints and differences of opinion will modify this basic plan and there should be alternatives available. Some of these, along with limitations are presented:

I. Update and expand existing government stations.

- A. Cotopoxi this station south of Quito is the most functional of the units under the supervision of Direccion General de Pesca. It has a small hatchery (using zinc coated pipes) with three or four troughs capable of hatching perhaps 100 to 200 thousand eggs. There are some relatively good concrete raceways for fingerling and a larger collecting pond for production fish or brood stock.

The station could be expanded by the development of a food supply.

The expansion is limited mainly by the quantity of the water supply.

Several small springs are collected for use but combined flow appears to be no more than 1 to 1.5 CRF (450 to 675 gpm). There is no additional water available from any known source. Maximum production of large edible fish could not exceed 15,000 lbs per year.

Recommendations: Assist by supplying trout eggs and trout diet from Riobamba. Limit the unit to a hatching and fingerling growing station.

Replace zinc pipe system with PVC and other non toxic materials.

B. Ototavalo Punyaro hatchery

The Departamento de Piscicultura maintains a relic station in this community. There is essentially no infrastructure at this site salvagable with the exception of the enclosed spring water source. The few tanks used for rearing an even fewer number of trout are of little or no functional value.

The spring water source (56° F) does have considerable potential value and by excavating accumulated silt and building a protective barrier to keep flooding stream waters away, the station could be useful. It is located near several lake systems that are presently stocked with trout and that could be aided greatly by a stocking and management program. Because this area has a considerable tourist appeal, recreational trout fishing could be considered as an economically viable alternative in the future.

There is enough land and water in the area that fairly large poundage of trout could be reared on the site. Perhaps as much as 70,000 to 100,000 lbs annually. Because the site is on the edge of the city limits of Otovalo, it is probable that all of the production not used for stocking nearby lakes could be sold locally.

Recommendation: Protect and improve the spring source as mentioned above. Construct a new small hatchery building for hatching trout eggs and fingerlings. Production ponds should be constructed with concrete and/or concrete and stonework because soil is too unstable to hold water.

C. Zuleta

The former hunting and fishing club at Zuleta is in the process of being renovated and expanded under the guidance of the Department. Most of the water source is from a small spring that rises a very short distance above the former hatchery building. Water temperature is good for trout culture (54° F) but the 12 L/S volume precludes any large scale production. There are well executed plans for a new hatching shed and several fingerling raceways. A small river above the site can be diverted into rearing ponds but its value is questionable until fluctuation and pollution of that river is better known.

There is considerable animosity on the part of native women who have used the area for washing for several years. They are not anxious to see any change.

Again there have been no plans for a food supply for the hatchery.

Recommendation: Assist primarily in the area of diets for trout. This station could produce several thousand fingerling for local stocking. If the river water is suitable there could be enough area for a new local protein source provide they can obtain the trout diet.

D. Aychupicchu

This is the site of a former Department hatchery and rearing area that was confiscated for army use. A good 56°F spring of approximately 4 CFS of flow formerly supplied a series of 10 dirt raceways and two larger ponds. The army is making no use of the

facility for aquaculture and the headboxes, etc. are falling into decay. The site is very close to Quito.

Recommendation: Inquire to see if some joint use can be arranged with the military. Again provision of a food source is the main problem.

E. Lbactaurcu Salcedo

This site of a former World Bank financed trout rearing area was mentioned previously. Because it is located within a zone that is being intensively rehabilitated by USAID, it would be logical to have it re-activated.

The five dirt ponds, approximately 50 x 30 feet in size are in relatively good condition. The water source is small but probably adequate to supply the ponds provided they are moderately stocked. Some headgate repair is needed but costs would be minimal. Temperature is very warm considering the elevation (66° F) but growth of introduced fingerling would be rapid.

Recommendation: Improve the ponds and stock with fingerling rainbow trout perhaps from nearby Cotopoxi. A food supply is obviously needed and could come from Riobamba which is not far away. Because the ponds are in an unguarded area, some provision will have to be made to prevent poaching.

F. Other area

In addition to these few alternatives there are many other areas that could be incorporated into an expanded program to substitute for Papallacta. These would include such areas as Lakes Cuicocha and Mojanda to name two. In addition there are numerous small ponds or

pond sites controlled either privately or by communities that certainly would profit from any type of aquaculture assistance. It would be much easier and logical, however, to bring them into their best use after the development of Papallacta or a similar facility.