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FISHCULTURE SURVEY REPORT

FOR COSTA RICA

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1.0 ITINERARY

- March 5** D. D. Moss arrived San Jose, Costa Rica from El Salvador
- March 6** R. T. Lovell arrived San Jose, Costa Rica from United States
- March 8** U.S.A.I.D. Mission Costa Rica, discussed purpose of survey and planned itinerary
Fisheries Section, Division of Forestry, Ministry of Agriculture
Central Market
Headquarters of Mas X Menos Supermarkets
- March 9** Agricultural Diversification Project at Turrialba
Zapote experimental fish ponds
- March 10** Inter-American Institute of Agricultural Science
Baja Chino experimental fish ponds
Demonstration ponds on private farms
- March 11** Returned to San Jose
Fish ponds at President's Home
U.S.A.I.D. Mission
- March 12** Extension Division, Ministry of Agriculture
University of Costa Rica: Departments of Biology and Agronomy
Mas X Menos Supermarkets
- March 13** Central Market
- March 15** Export and Investment Promotional Center
Forestry Division, Ministry of Agriculture
- March 16** International Development Bank
Meteorological Survey Office
- March 17** Forestry Division, Ministry of Agriculture
U.S.A.I.D. Mission; conference with research team from Turrialba
- March 18** U.S.A.I.D. Mission, debriefing
- March 19** Departed Costa Rica

2.0 SUMMARY

At the request of U. S. A. I. D. /Costa Rica, a team from the International Center for Aquaculture, Auburn University, made a 15-day visit to Costa Rica to survey the potential for fishculture in the country. The per capita consumption of fish in Costa Rica is only approximately 1 kg per year. Good quality marine fish were found in markets in San Jose, but the price limits its consumption by lower income groups. Quality red meat was available, but it also was expensive. Fish are not at present cultured for food on an applied basis in Costa Rica.

In 1968, the Extension Division, Ministry of Agriculture, initiated a program for farmers to grow tilapia in ponds. The program was generally unsuccessful because the tilapia, maturing at a small size, reproduced profusely and did not reach a desirable size for food. However, approximately 70 farmers participating in the program is evidence of significant interest in culturing the fish. The research station at Turrialba sponsored the construction of demonstration ponds on private farms and stocked them with a hybrid tilapia. When properly managed, the hybrids grew to suitable size and farmers appeared to be enthusiastic about culturing them for food.

Commercial production of fish on a large scale does not seem feasible immediately because markets for freshwater fish are uncertain at the present time and would have to be developed. The prospect for farmers to produce tilapia for family use and allow gradual expansion of the industry to commercial scale as markets develop shows considerably more potential. Personnel of the Fisheries Section of the Forestry Division and the Extension Division in the Ministry of

Agriculture showed enthusiasm toward the latter possibility and indicated definite interest in developing a fishculture program.

The following recommendations in regard to the development of fishculture in Costa Rica are discussed in this report.

- 1) The Government of Costa Rica should implement a fishculture program for farmers. The Fisheries Section of the Division of Forestry, Ministry of Agriculture, should contain the program supervisor and several fishculture specialists and the Extension Division should have responsibilities for working directly with the farmers.
- 2) Hatcheries and demonstration ponds should be established at regional agricultural centers.
- 3) An aquacultural research program emphasizing stocking rates, low-cost feed materials, and marketing for hybrid tilapia should be maintained. Other species as food fish should be evaluated. The station at Turrialba has good basic facilities and if it can be expanded, should be used as the primary research and training site for fishculture in Costa Rica.
- 4) A program should be set up in Costa Rica to train technical personnel to work in the fishculture program and to allow students to come to Auburn University to earn degrees in Fisheries Management.
- 5) Two to three man-months of technical services provided by the International Center for Aquaculture, Auburn University, should be made available to the Government of Costa Rica to assist with program organization, training, research planning, and hatchery design.

3.0 FISHCULTURE SURVEY REPORT FOR COSTA RICA

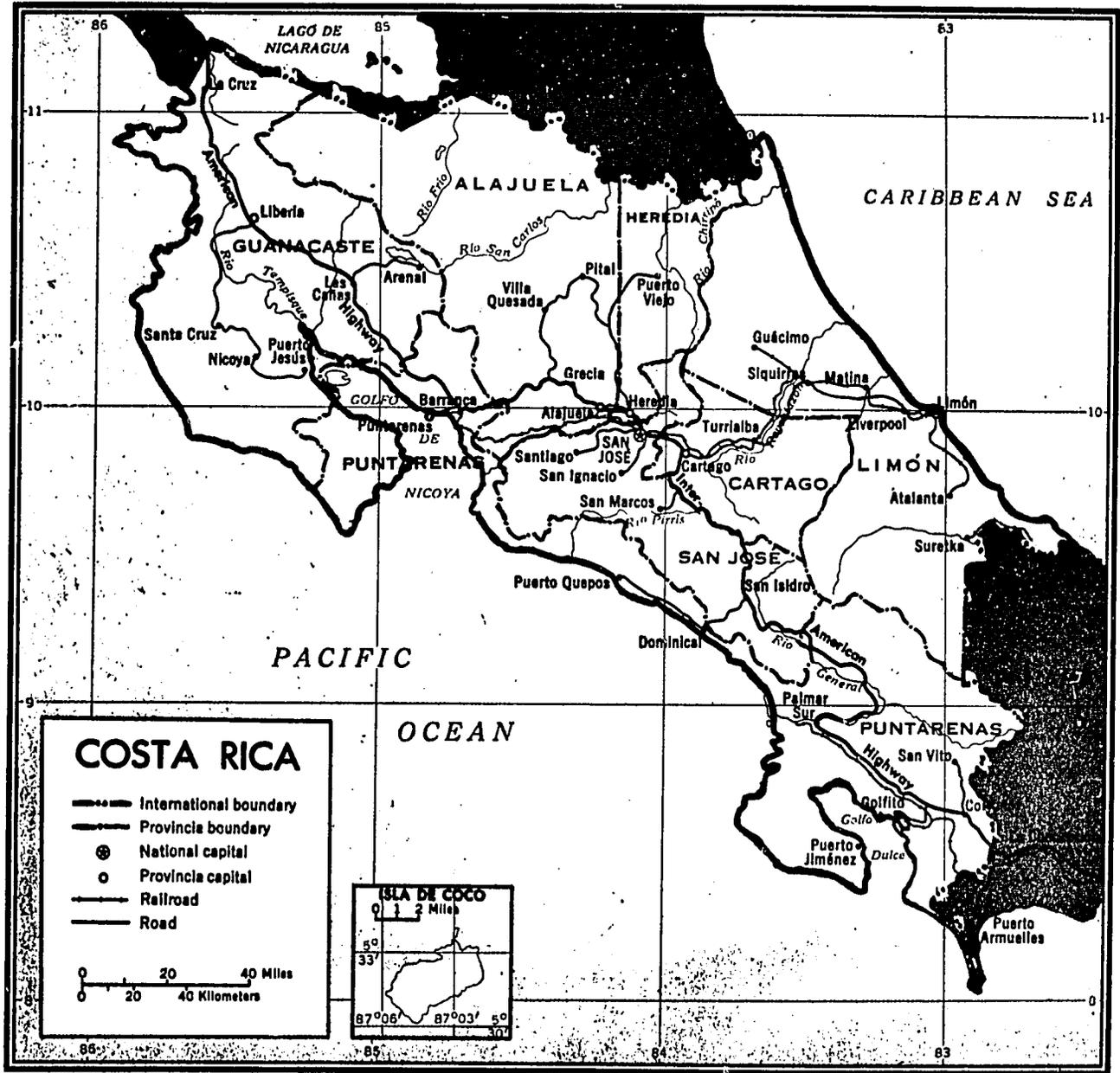
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Auburn University
Auburn, Alabama 36830**

3.01 Introduction

An inland fisheries survey of Costa Rica was conducted by a team from the International Center for Aquaculture, Auburn University, from March 15 to March 19, 1971. The visit, under sponsorship of U.S.A.I.D./Costa Rica, was for the purpose of providing technical advice on freshwater fisheries research programs in the country and on developing programs for the production of fish for food by farmers or commercial investors.

3.02 Geography, Topography and Climate

Costa Rica is located in southern Central America between Nicaragua on the north and Panama on the south. It is bound on the east by the Caribbean Sea and on the west by the Pacific Ocean. It is the second smallest country in Central America with a land area of approximately 51,023 square km (19,700 square miles). The country is comprised mainly of high, rugged mountains and hills drained by numerous streams and rivers. There is a relatively wide coastal plain on the east and a narrower plain on the Pacific Coast. Most of the population is located in the central plateau, with the coastal lands being considerably less populated.



Base 77667 10-70

Figure 1. Map of Costa Rica

Costa Rica has four distinct geographic regions:¹

- 1) The Caribbean Lowlands - hot and rainy all year, densely forested, comprising one-fourth of the country with only about 6 per cent of the population.
- 2) The Highlands - containing the volcanic mountain ranges and the Meseta Central, or the central plateau, where the capital city of San Jose is located. The Meseta has an elevation of 900 to 1,400 m and a pleasant climate that is usually between 23 and 28 C. Seventy per cent of the population live in and around the Meseta. The Highlands region contains rolling, well-drained, and fertile land. There are many streams and small rivers that flow the year round. The rainfall is 1,524 to 1,905 mm (60 to 75 inches) per year. The dry season is from December through April.
- 3) The Plains of Guanacaste, the hilly lands of the Nicoya Peninsula and the northern Puntarenas Provinces - contains regions where the climate is quite dry during part of the year; however, livestock is an important industry. Approximately 15 per cent of the population is located here.
- 4) Southeastern Costa Rica - contains about 9 per cent of the population. Rainfall is extremely high, exceeding 2,540 mm (100 inches) per year in sections. Bananas are a large export crop.

3.03 Population and Culture²

Costa Rica's population is estimated to reach 1.8 million, or about 86 persons per square mile, by the mid 1970's. More than 50 per cent of the people are

1. Republic of Costa Rica - Background Notes. U. S. Dept. of State Publication 7768. Revised October, 1970.
2. Ibid.

under 16 years of age. The annual population growth rate is 3.4 per cent, one of the highest in the world. Unlike its Central American neighbors whose population descends primarily from indigenous Indians, Costa Ricans are approximately 95 per cent of Spanish origin. A few Africans immigrated into the country from Jamaica. The literacy rate is approximately 85 per cent, one of the highest in Central America.

The social and economic development of Costa Rica can be traced to its settlement by Spaniards. In the absence of a large labor force of Indians to work the land, there evolved a system of small landholders cultivating their own land. With the development during the 19th century of coffee and banana industries and later sugar, beef and cocoa, a number of large agricultural enterprises has been established; however, a substantial number of people remains as small, independent farmers. Agriculture is the leading industry in Costa Rica with coffee and bananas being the main export products. Costa Rica has Central America's highest per capita gross national product, approximately \$466 U.S., according to a 1969 estimate.¹

3.04 Nutrition and Fish Consumption

Adequacy of the food supply for a population is indicated by the amounts of animal protein available per capita. The world-wide average minimum protein

1. Republic of Costa Rica - Background Notes. U. S. Department of State Publication 7768. Revised October, 1970.

requirement has been estimated to be 57.3 grams per day, of which 19 grams should be animal protein. An estimate by the U. S. Department of Agriculture showed that during 1959-61 the daily per capita consumption of protein was 63.1 grams of which 25.6 was animal protein.¹ Although the average protein intake appears adequate, it is probable that the consumption of protein, particularly from animal sources, is not evenly distributed among the population because of variation in incomes as well as unequal distribution of food throughout the country.

There is a good supply of meat and fish in San Jose where transportation and low-temperature storage facilities are available; however, the cost probably limits the purchase of these products to persons in the higher income groups. Because of deficiencies in preservation facilities, transportation and purchasing power, animal protein is extremely limited for the small farmers and other people in the lower income groups in Costa Rica.

The beef industry is developing rapidly on the grasslands in the western part of the country; however, export prices for beef are such that local prices are higher than a significant portion of the population can pay. Swine and poultry production are not large industries in Costa Rica because of the high cost of concentrated feeds. No freshwater fish are marketed in the country but marine fish were plentiful in markets in San Jose. The prices of meat, poultry and fish as observed in supermarkets and the fresh food markets in San Jose are shown in Table 1. These prices show why a relatively small percentage of the population consumes a significant amount of meat or fish.

1. Food Balances for 24 Countries of the Western Hemisphere, 1959-61. Economic Research Service, U.S.D.A., ERS Foreign 86. 1964.

Table 1. Prices of meat, poultry and fish in San Jose, March, 1971

<u>Supermarket</u>		<u>Fresh Food Market</u>	
Type	Colones/lb*	Type	Colones/lb*
<u>Meat</u>			
Sirloin steak	5.25	Beef filet	7.50
Round steak	4.95	Beef loin	6.50
T-bone steak	4.95	Beef round	4.50
Veal cutlet	3.50	Chopped beef	1.50
Pork chop	4.50	Beef tongue	3.00
<u>Poultry</u>			
Fresh, whole	2.75		
Fresh, pieces	3.90		
Frozen, whole	3.68		
<u>Fish</u>			
Corvina, filet	4.00	Corvina, filet	4.50
Corvina, whole**	2.50	Corvina, whole**	2.50
Shrimp	2.25	Shrimp, headless	3.00
Dorado, filet	2.50	Dorado, filet	2.50
Shark steak	2.50	Shark steak	2.50

*1 colon = \$0.15 U.S.

**Eviscerated

3.05 Status of the Fishing Industry

There are presently four shrimp processing plants and one tuna cannery on the western coast, all exporting most of their products. There is a frozen lobster export industry on the eastern coast. The catch of shrimp for 1967 was 1,500 metric tons.¹ The catch of marine fin-fish, which includes tuna and species utilized for domestic consumption, for 1967 was 1,300 metric tons.² There are no large lakes in Costa Rica, consequently, freshwater fishing is not a recognized industry.

A current estimate of the per capita consumption of fish in Costa Rica provided by FAO fish technology experts affiliated with the Fisheries Section, Ministry of Agriculture, was only 1 kg per year. All but a minor portion of the fish consumed in Costa Rica is marketed fresh. Most of it is harvested on the western coast and transported packed in ice to the central, populous areas of the country. Freezing, salting, drying or fermenting are not important methods of preserving fish for local consumption. The facts that most of the population in Costa Rica do not live by the sea and transportation and low-temperature preservation of fish are in short supply, have made Costa Ricans a non-fish-eating people.

3.06 Prospects for Developing Fishculture in Costa Rica

Costa Rica does not have a great wealth of natural inland resources for providing fish as food. Trout were stocked in several of the mountain rivers several years ago and sport fishing for trout is still good in some areas. The

1. Food and Agriculture Organization of the United Nations. 1968. Yearbook of Fishery Statistics, Catches and Landings, 1967. Vol. 24, Rome. 408 p.

2. Ibid.

Fisheries Section of the Division of Forestry, Ministry of Agriculture, has indicated interest in stocking more trout in mountain streams in the central part of the country for recreational and tourism purposes.

The prospect of culturing freshwater species of fish for food in Costa Rica was investigated. In 1968, the Extension Division, Ministry of Agriculture, initiated a program for farmers to produce tilapia in ponds. Approximately 70 ponds were built and stocked with tilapia to produce food for family use. However, uncontrolled reproduction by the fish resulted in numerous small fish and few large fish which made the program unpopular with the farmers. Hence, the Ministry stopped promoting it. The large number of farmers participating in the program during the short period indicates enthusiasm on their part for raising fish, but adequate information on methods of culture was not available.

The Turrialba station, through its Agricultural Diversification Project, supervised the construction of demonstration ponds on several farms and stocked them with tilapia hybrids. These hybrids were essentially all male, consequently, reproduction was minimal. When properly managed, the fish grew to suitable size for food and the farmers appeared to be very fond of the flavor of tilapia.

Commercial production on a large scale does not seem feasible immediately because markets for freshwater fish are uncertain at the present time and would have to be developed. The prospect for farmers to produce tilapia for family use and allow gradual expansion of the industry to a commercial scale as markets



Figure 2. Many Costa Rican farms have desirable locations for pond construction where relatively small amounts of earth can be moved and water diverted from streams.

Figure 3. Tilapia stocked in farm ponds are fed supplemental feed daily for several months until fish reach edible size. The farmer can remove fish from the large pond and place them in a small holding pond until eaten or sold.



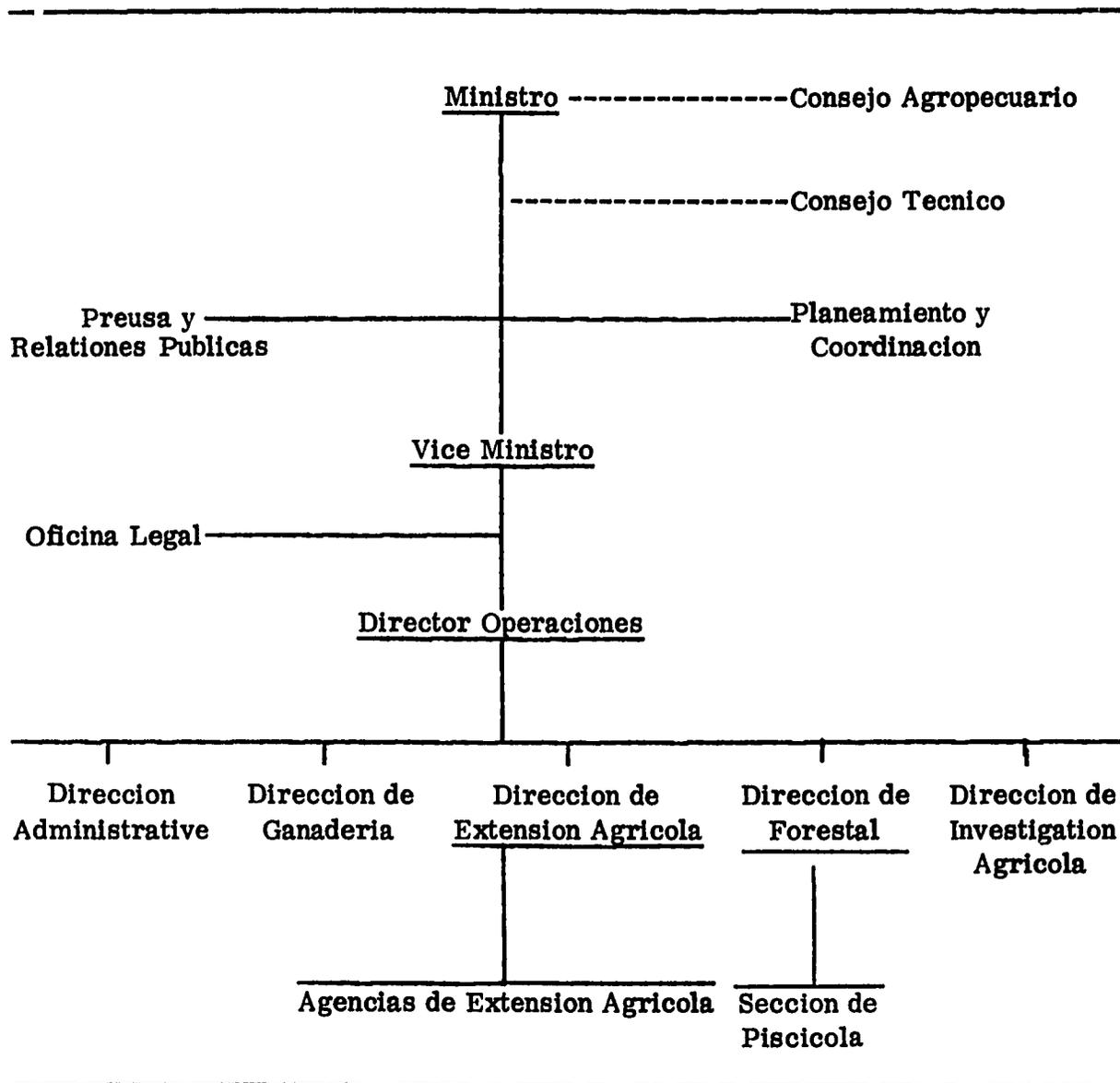
develop shows potential. Necessary are more research data on stocking, feeding and management and technical and financial assistance from the Government to get the program started. If a fish production program can be implemented in Costa Rica, it will provide two benefits: 1) it will give farmers more animal protein in their diets; and, 2) it can develop to commercial scale and provide an additional source of income as well as a new supply of animal protein for the non-farm population.

4.0 GOVERNMENT DIVISIONS RESPONSIBLE FOR FISHERIES DEVELOPMENT

The responsibility of development of fishery resources for food and recreation and compiling catch data is handled by the Fisheries Section in the Division of Forestry, Ministry of Agriculture. The organization of the Ministry is shown in Table 2. The primary concern of the Fisheries Section has been development of marine fisheries. It is interested in stocking mountain streams with trout for sport fishing to encourage tourism. It has had no experience with freshwater food fish. Conferences with administrators in the Forestry Division revealed serious interest in developing a fishculture program for the farmers.

The Extension Division, Ministry of Agriculture, which initiated the tilapia culture program in 1968, indicated interest in renewing the program now that the hybrid tilapia was available in Costa Rica. The office indicated that if a fish farming program could be developed, extension workers could be trained

Table 2. Organograma Del Ministerio De Agricultura y Ganaderia
(Organization of the Ministry of Agriculture and Livestock)



in fishculture and provide technical assistance to farmers in managing their fish operations.

5.0 FISHCULTURE RESEARCH AND TRAINING IN COSTA RICA

5.01 Research Station at Turrialba

The Turrialba Agricultural Diversification Project, an autonomous research organization supported by funds from a number of sources, has a research station and an active program in progress on the culture of tilapia for food. This research station is located on property pledged to the project by the Inter-American Institute of Agricultural Sciences (InterAmerican Instituto de Ciencia Agricultura - IICA) which is located near Turrialba. Tilapia research was first conducted in Costa Rica by Dr. Herster Barres while he was employed primarily in forestry research at the IICA. In 1968, Dr. Barres sought funds from various sources to establish a research project emphasizing diversified agriculture, or, new farm products to relieve overemphasis on coffee, sugarcane and bananas. The project was established and has since thrived emphasizing three products - timber, nuts and food fish. Currently (as of March, 1971) the program is being supported by the following agencies:

InterAmerican Development Bank

U. S. Agency for International Development

InterAmerican Institute of Agricultural Sciences

Municipality of Turrialba

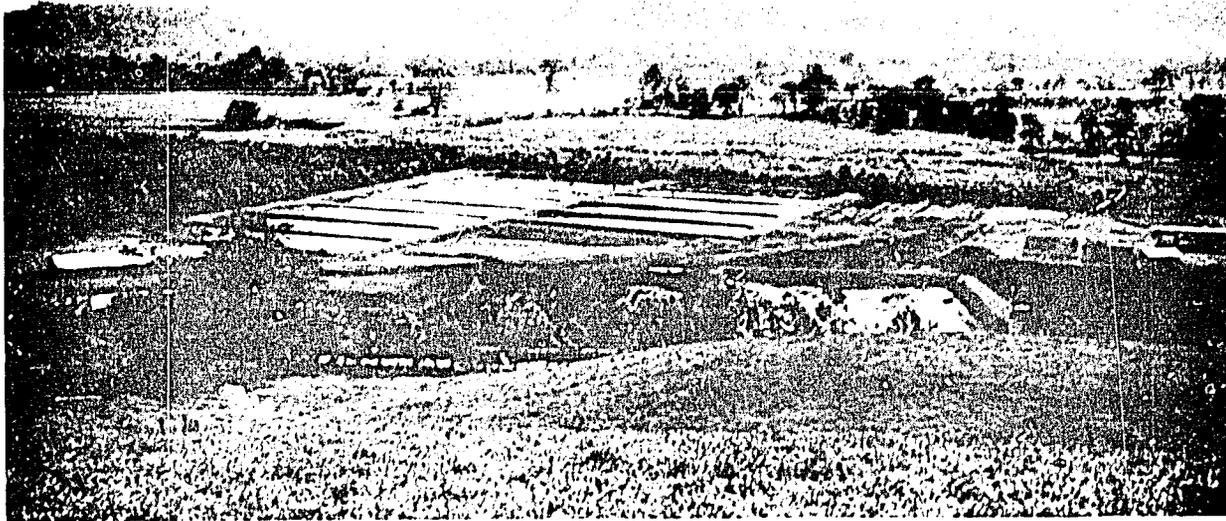


Figure 4. The Zapote Experimental Fishculture Station at Turrialba contains 23 ponds, with 18,500 m² of total pond surface. Several new ponds are presently under construction.

Figure 5. This experimental pond, under construction at the Turrialba station is divided by small-mesh screen which will confine broodfish but allow fry to move about the entire pond.

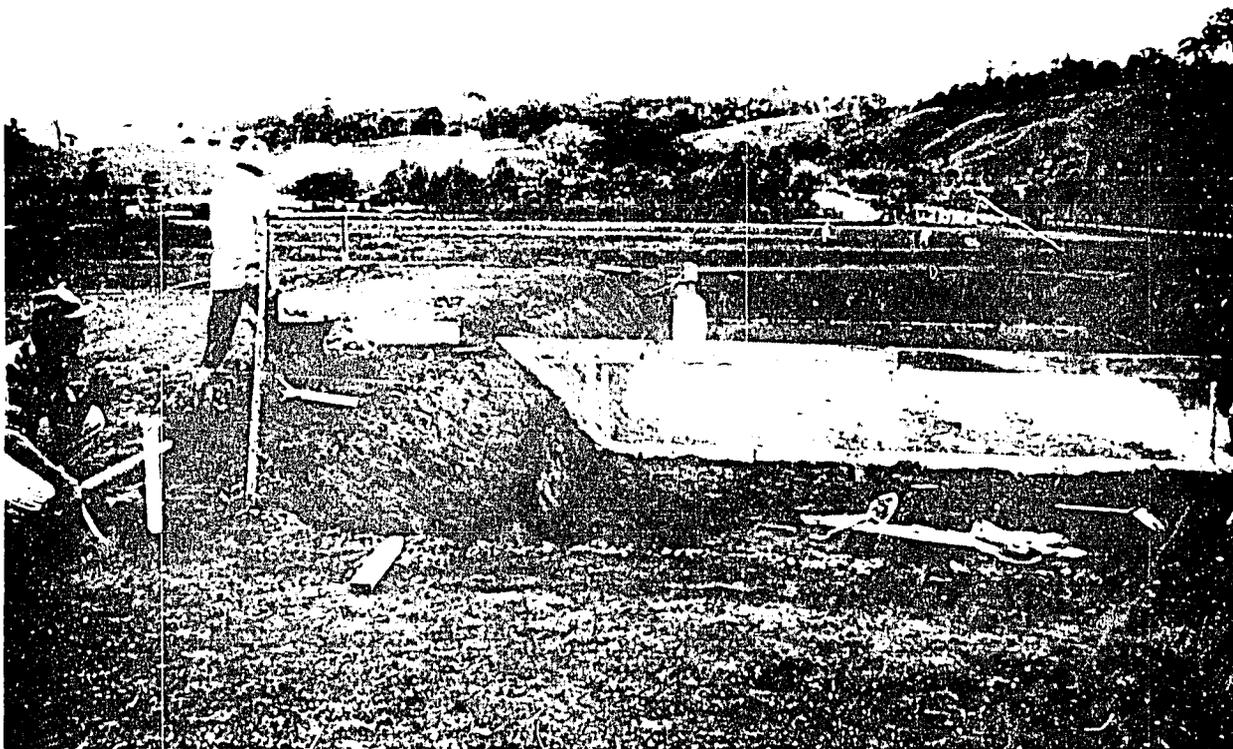




Figure 6. Hybrid tilapia are being fed several experimental feeds in 750 m² ponds at the Turrialba Station.

Figure 7. Raceways, with continuously flowing water, can be used to culture fish stocked at higher densities than in still-water ponds.



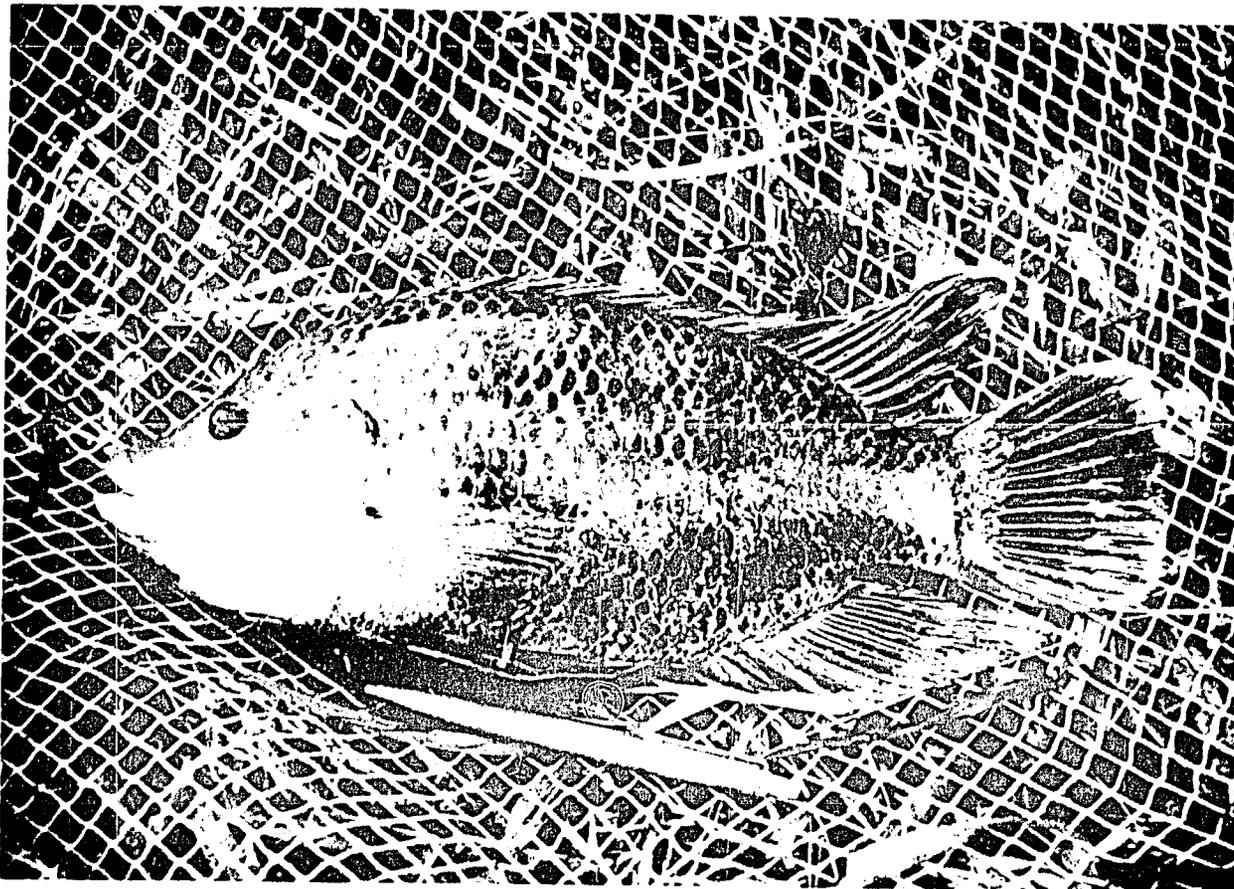
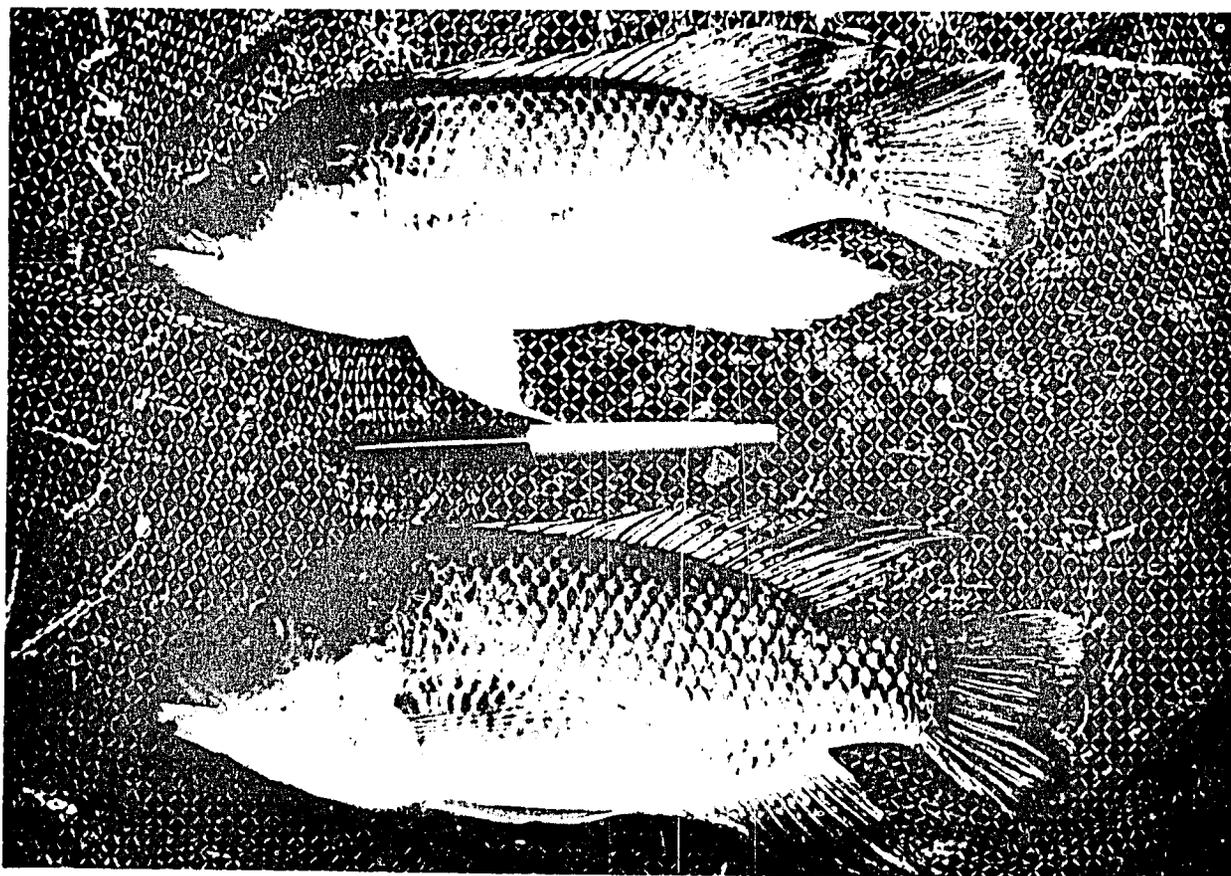


Figure 8. The hybrid tilapia, produced on the research station at Turrialba by mating T. mossambica ♀ with T. hornorum ♂, appears to be an excellent food fish to culture in Costa Rica.

Figure 9. Tilapia melanopleura, used in culture experiments at Turrialba, is an efficient plant feeder, but is also a prolific breeder in open ponds.



The local canton (township)

Food and Agriculture Organization of the United Nations

U. S. Peace Corps

International Coffee Office

The program personnel and their areas of training are as follows:

Director, Ph.D. in Forestry

Fish Culturist (Peace Corps Volunteer), M.S. in Fisheries

Fish Culturist, B.S. in Animal Nutrition

Marketing Specialist, M.S. in Agricultural Economics

Pond Superintendent

Clerical help

Farm laborers

The station facilities include a central office in Turrialba, office space at IICA, library and accessible laboratory facilities at IICA, 21 experimental ponds, 2 raceways, and other fishery research facilities on a 5-hectare plot at Zapote, and 13 experimental ponds on a small plot at Baja Chino. The experimental ponds at Zapote are generally well constructed and managed, although the amount of pond surface is small and the water supply, which is a small stream, is threatened by road construction on a mountain beside the stream. The ponds at Baja Chino have limited water supply during dry weather and they cannot be secured against poaching. The pond facilities are listed below:

<u>Location</u>	<u>Number of Ponds</u>	<u>Size of Ponds (m²)</u>
<u>Zapote Station</u>	13	750
	1	200
	2	275
	2	800
	1	1,000
	1	2,400
	1	3,000
	2	raceways
	<u>23</u>	<u>18,500</u>
<u>Baja Chino Station</u>	8	400
	<u>5</u>	<u>9</u>
	13	3,245

The fishery research program at Turrialba concerns only tilapia production as a food fish. The station has imported several species of tilapia, but the fish receiving most of the research emphasis is a hybrid which is being produced on the station from Tilapia mossambica females and Tilapia hornorum males. This hybrid has the advantage that essentially all of the F₁ offspring are males; consequently, reproduction is practically absent and food is converted into growth instead of reproduction.

The station has acquired the technology for producing the hybrid fish in large quantities. It has demonstrated that tilapia thrive well the year round under the conditions at Turrialba. The hybrids can be raised to the size of one pound in less than one year when fed any of a variety of supplemental feedstuffs. Variables which affect growth rate, namely stocking density and amount and type of feed, are being studied.

The station has developed a supplemental feed for use in its various research studies which is called the Turrialba A. The ingredient formula may

vary somewhat according to availability, but the general formula of the Turrialba A is shown in Table 3. It appears to be an excellent formulation for pond culture and growth responses have been satisfactory; however, it is probably too expensive for farmers to feed in their small ponds. A commercial (U.S.) catfish feed and some less sophisticated feeds, including wheat bran and a poultry feed, are being fed experimentally to hybrids. These feeding trials are presently in progress.

One-cubic-meter wire cages have been built and will be used soon in research studies to evaluate this method of culture for tilapia. Suitability of various feeds for cage-cultured tilapia will be investigated. The effect of cage confinement on tilapia reproduction will be studied.

Thirty-five demonstration ponds have been built by farmers around Turrialba and stocked with hybrid tilapia. The farmers were given directions for feeding, harvesting and weighing the fish. Most of the farmers did not keep accurate records on amounts of feed offered or fish harvested, although considerable enthusiasm has been shown by the farmers and they enjoyed eating the fish.

A marketing study was conducted at Turrialba by placing 80 live tilapia in a local restaurant in a tank, so the customers could select live fish. These fish sold well and had good consumer appeal. A larger marketing study is planned for the succeeding year with a larger supply of fish and in different markets.

Table 3. General formula for Turrialba A fish feed

Ingredient	Amount in Pounds per Ton
Fish meal	240
Oilseed meal (soybean, cottonseed, etc.)	400
Blood meal	200
Cereal byproducts (rice or wheat bran, fermentation byproducts, etc.)	1,060
Alfalfa meal	90
Vitamin premix ¹	<u>19</u>
Total	2,000

1. A highly fortified vitamin premix formulated for poultry feeds may be used. It should contain vitamins A, D, E, K, B₁₂, riboflavin, pantothenic acid, niacin, choline, folic acid, pyrodoxine, and an antioxidant.

5.02 FAO Fisheries Program

Although the Costa Rican Government has no formal research program in inland fisheries, it is participating in a joint FAO program in marine fisheries for Central America. The Ministry of Agriculture has a trained fish technology specialist, Mr. J. M. Trejos, who is working as the local counterpart with the FAO expert. The FAO program is directed toward supply, fishing areas and commercial utilization of marine fishes. The FAO program will terminate in 1972.

5.03 The University of Costa Rica

The University of Costa Rica offers no training program in fishculture or technology; however, there are several resources at the University which may be beneficial to fishculture development in the country.

Dr. William A. Bussing, an ichthyologist in the Department of Biology, has made extensive studies of freshwater fishes in Costa Rica.

Mr. Hernan Fonseca, an animal nutritionist and Associate Professor in the Department of Agronomy, has evaluated a number of high- and low-quality animal feedstuffs. He discussed with the survey team the potential value of these materials as components in fish feeds. His information and experience would be very useful in devising practical feeds for fish.

A Food Technology Laboratory is being constructed at the University. The design of the laboratory was provided by Dr. R. P. Bates, food scientist and special consultant from the University of Florida, and his counterpart from

the University of Costa Rica, Mr. L. F. Aris, who has an M.S. in Food Technology. This facility may be useful in training and research in fish processing.

Although a degree curriculum with emphasis in fishculture is not offered at the University, a degree in biology with other selected courses provides a favorable background for further training in fishculture. In this regard, courses available at the University which would supplement a biology curriculum are: animal nutrition, soil science, microbiology, and food processing technology. A student with this background may seek an M.S. degree in Fisheries at Auburn University or another university with a fisheries program, or, he may participate in short fishculture training programs in Costa Rica or abroad.

6.0 AVAILABLE INPUTS FOR FISHCULTURE IN COSTA RICA

6.01 Capital

Capital for fishculture developments will be scarce. The uncertainty of immediate commercial production of freshwater fish for food will discourage large-scale private investment. For this reason, family-size farm operations are recommended as the starting point for the program. The farmers participating in the program should have resources for paying for feed and fish and be able to obtain a loan for constructing a pond. Hopefully, credit for fish pond construction can be made available through government-sponsored programs with funds from the U.S.A.I.D. Agriculture Sector Program. As tilapia becomes a popular food

fish and shows commercial potential, private capital will find investment in fishculture more attractive. Mr. John Moretti, Vice President, and Mr. Enrique Uribe, President of Mas X Menos Supermarkets, are very enthusiastic about the potential for increasing fish consumption and are eager to conduct market tests with tilapia.

6.02 Land

Most areas of Costa Rica, except in the western section which has the long dry season, have enough rainfall the year round to keep sufficient water in fish ponds. The rolling terrain and numerous small streams provide many favorable sites for ponds less than one hectare in size. Small valleys may be dammed with a minimum of earth moving and water can be diverted from the streams to fill the ponds and to intermittently replace water in the ponds. On the other hand, there are few sites suitable for construction of ponds greater than one hectare in size.

6.03 Feedstuffs

Sources of feed will be an important factor in determining the practicality of farming fish for food in Costa Rica. Sophisticated feeds such as the Turrialba A formula probably will not be practical for small farmers. Less expensive feedstuffs and byproducts must be evaluated to derive feeding regimes that will provide economical conversions of feed to flesh. Appendix Table 1 shows relative values of some feed ingredients available for fish feeds in Costa Rica.

7.0 RECOMMENDATIONS FOR DEVELOPMENT OF FISHCULTURE IN COSTA RICA

Development and provision of a fishculture program for farmers in Costa Rica should be under the direction of the Ministry of Agriculture. The objectives of the program will be to provide the farmer with an opportunity to produce a nutritious and acceptable food with modest resources and expenses. Initial emphasis will be toward producing food to be used primarily by the family with only a limited amount to market; thence, commercial production will develop from this basis. Such a program will need to provide for technical assistance and loans for pond construction to farmers, hatcheries to produce fish fingerlings, and research and training facilities.

7.01 Support for the Program

New costs to the Government which will be on a continuing basis will include maintaining a research program, providing technical assistance for farmers in fishculture and loans for pond construction. Government costs which should not be continuous are those for building hatcheries and distribution centers, initial operation of these facilities, and initial training of personnel in fishculture. Operation of hatcheries should be self-sustaining after the first few years from receipts for fish purchased. It is anticipated that some will be operated by private investment as fishculture becomes widespread.

The Turrialba station has good facilities which may be expanded and serve as the primary research and training station in the country. The Government should be a major supporter of this station and, reciprocally,

the major aim of the fishery research station should be toward supporting the Government's effort to develop the fishculture program in Costa Rica.

7.02 Technical Personnel

Generally, the technical competence necessary for the fishculture program should include a specialist to supervise the program with several assistants who may be stationed at the regional agricultural centers in areas where fishculture is most abundant. Also, some of the agricultural extension agents in the various regions should have training in fishculture so that the farmer may have convenient access to technical advice on pond construction, stocking the fish, feeding, diseases, water quality management, and harvesting and handling the fish for personal use or commercial distribution. Existing personnel in the Extension and Forestry Divisions may be trained in fishculture and, likely, some new personnel will have to be employed.

7.03 Hatchery and Demonstration Stations

A hatchery for hybrid tilapia should be developed, perhaps at one of the regional agricultural centers. The location will be dependent upon the area where fishculture has best potential to develop most rapidly. Also, distribution centers must be developed where fish will be delivered from the hatchery to be picked up by farmers. In conjunction with the hatchery may be demonstration ponds where the farmers can be shown how to construct ponds and manage their fish. The hatchery should have a generous supply of water, spawning ponds, fingerling holding ponds, isolated ponds for holding the two species of

broodstock, and a building for storing feed and equipment and for counting fish. Specialists from Auburn University can assist in designing the hatchery and pond demonstration facilities. As fishculture increases, hatcheries will be built in other regions.

The station at Turrialba could possibly serve as the source of fingerlings for the initial phase of the program; however, if this is done, there will have to be additional ponds constructed because this station, already short on pond facilities, should function primarily as a research site.

7.04 Research

7.041 Production of Hybrid Tilapia

Previous research in Costa Rica has indicated that the hybrid tilapia appears to be the most promising freshwater fish for culture for food at the present time. High priority should be given to determining optimum stocking densities for hybrid tilapia cultured under various conditions. It is important to the farmer to know the most practical stocking rate for his pond, which may have flowing or nonflowing water, when using a particular feeding or fertilization regime.

Also important is the need for testing low-cost, conveniently accessible feedstuffs for tilapia in open pond cultures. These feeds may be evaluated singly or in simple combinations. Crude materials such as chicken or livestock manure should be evaluated. Inorganic fertilization of tilapia ponds should be investigated. Economics should be equated with production responses and serve as an important criterion for determining practical feeds. Preferably, feeds

should be evaluated in individual ponds.

Culture of tilapia in cages requires a more nutritionally complete feed than pond culture; consequently, it should not receive high priority until the feeding requirements of tilapia in this highly artificial environment are better understood. For example, in the United States, channel catfish did not grow satisfactorily under highly artificial conditions without feeds which were nutritionally adequate and quite expensive. For research purposes, a few cages of tilapia may be fed several feeds of known ingredient composition and the growth responses observed. It is possible that tilapia may be able to consume sufficient nutrients from plankton in the water diffusing through the cage to supplement the feed for satisfactory growth. On the other hand, it is possible that the nutritional needs of tilapia in cages cannot be met without feeds that are prohibitively expensive for practical fish production.

7.042 Culture of Other Species

Other indigenous species of fish should be evaluated for pond culture for food. Combination species with different feeding habits are needed to more completely utilize all the types of food produced in the pond. Suitable piscivorous fish species are needed for culture with tilapia or other species that reproduce in ponds. Culture of the local freshwater shrimps, Macrobrachium sp., that are present in rivers in Costa Rica, should be investigated.

7.043 Marketing

Marketing studies should be made with hybrid tilapia to ascertain their potential in various markets. These studies can be conducted by the personnel at the Turrialba station inasmuch as it has a marketing specialist on the staff and some experience in marketing tilapia. They can be tested in supermarkets in San Jose as dressed (scaled, eviscerated, head-on) fresh or frozen fish. Mr. John Moretti, Vice President of Mas X Menos Supermarkets of Costa Rica, has indicated that this company would be eager to cooperate in a marketing study by allowing tilapia to be marketed with other fish in their stores, and would provide advertisement and promotion for this new product. A large quantity of fish approximately one pound in size would be needed for this study, which should extend over at least a 12-week period. A long test period in one or two outlets would be more advantageous than a shorter test period involving a larger number of outlets. In this study, consideration should be given to price, promotion, method of display, and packaging. The price should be low enough to make tilapia competitive with marine fish but it must be high enough to return a profit over cost of production. The fish might be displayed frozen and nonfrozen, but the frozen fish should be displayed with the fresh fish and not in a frozen food case. The package for the frozen fish should have an attractive design.

Tilapia should also be test-marketed in the lower income markets. Price is important in these markets and the minimum price for which tilapia can be practically marketed should be used. Since acceptability of tilapia in these

markets is a totally unknown entity, various display forms may be tested, such as dressed fresh or frozen, or nondressed fresh. Salt-dried fish may be tested.

7.05 Training

If the Ministry of Agriculture plans for immediate implementation of fishculture in Costa Rica, a program should be set up to train specialists in a relatively short period of time who will initiate the program. The program supervisor should have a B.S. degree in fishculture or fishery biology and his assistants should have degrees in some area of biology. A four- to six-weeks training course should be set up for these persons. The Turrialba station can serve as the training site. if housing facilities for trainees and visiting lecturers can be provided. Personnel from Auburn University, Turrialba, and perhaps the University of Costa Rica can serve as lecturers for the course. A short-term training program should be provided each year for new personnel. A program of similar duration for the purpose of presenting new information to fishculture specialists should also be held annually.

A program should be provided for at least two persons to come to Auburn University for degrees in Fishery Management and return to Costa Rica to work with the fishculture program.

A program could be set up at the University of Costa Rica where a student receiving a degree in agriculture or biology may take selected courses and perhaps spend some time at the Turrialba station and develop a good background for additional training in fishculture. Fishculture courses could be

initiated at the university at some future date when sufficient interest is shown.

**7.06 Technical Services from the International Center for Aquaculture,
Auburn University**

Auburn University can provide two to three man-months of technical services to the Government of Costa Rica to assist in the following areas: organization of the fishculture program by the Ministry of Agriculture; part-time lecturers for the training program in areas such as fish parasites and diseases, nutrition, processing technology, marketing and hatchery management; design of the hatchery and demonstration station; and other areas such as trout propagation for sport fishing.

8.0 CONFERENCES

U. S. Government

Mr. Peter Kries	U.S.A.I.D. Affairs Officer, U.S. Embassy
Mr. Milton Lau	Rural Development Officer, U.S.A.I.D./Costa Rica
Mr. Paul Holden	Agricultural Officer, U.S.A.I.D./Costa Rica
Mr. Juan J. Castro	Agricultural Economist, U.S.A.I.D./Costa Rica

Costa Rican Government

Mr. Aroldo Madriz	Director, Forestry Division, Ministry of Agriculture
Mr. Carlos Arroyo	Director, Extension Division, Ministry of Agriculture
Mr. Mario Rodriquez	Subdirector, Forestry Division, Ministry of Agriculture
Mr. Eduardo Bravo	Subdirector, Fisheries Section, Forestry Division, Ministry of Agriculture
Mr. J. M. Trejos	Fisheries Technologist, Marine Fisheries Project

Agricultural Diversification Project at Turrialba

Dr. Herster Barres	Director
Mr. Jorge Zamora	Economics and Marketing Specialist
Mr. Robert Brown	Fish Culturist (Peace Corps Volunteer)
Mr. Eddie Gomez	Nutritionist

University of Costa Rica

Dr. William A. Bussing	Ichthyologist, Department of Biology
Mr. Hernan Fonseca	Animal Nutritionist, Department of Agronomy
Dr. R. P. Bates	Food Scientist, University of Florida, Consultant with U.S.A.I.D. program

International Development Bank

Mr. L. Felipe Vera	Representative, Costa Rica
Mr. Jacobo Stemple	Representative, United States

Promotion Center for Export and Investment

Mr. Humberto Esteve	Consultant, Arthur D. Little, Inc.
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Mas X Menos Supermarkets

Mr. Enrique Uribe	President
Mr. John Moretti	Vice-President

9.0 APPENDIX

9.01 Appendix Table 1. Materials available for fish feeds in Costa Rica

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Materials	Proximate Analysis					Digestibility to fish	Approximate cost/100 pounds
	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract	Ash		
Semolino de arroz (rice polishings)	10.08	13.07	4.16	53.28	6.55	Fair-Good	\$3.30
Harina de semilla de algodon Nicaragua (cottonseed meal)	38.84	6.76	13.38	20.90	6.95	Good	\$4.95
Harina de pescado de Puntarenas (fish meal)	40.32	8.78				Good	
Harina de pescado de Panama (fish meal)	49.47	4.81				Good	\$9.75
Gluten y cascara de maiz (corn gluten and husk)	10.81		4.42		4.78	Good	
Harina de semilla de algodon Costa Rica (cottonseed meal)	30.72	6.12	13.03	28.42	10.38	Good	\$4.95
Harina de carne y hueso (meat and bone meal)	33.43	17.89	0.94		38.27	Good	
Harina de banano (dried banana)	6.12	1.05	3.53	69.81	4.04	Fair	\$2.40
Melaza de Cana (cane molasses, dehydrated)	9.66	1.88	5.46	72.42	5.10	Fair	

Appendix Table 1.--continued

Materials	Proximate Analysis				Ash	Digestibility to fish	Approximate cost/100 pounds
	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract			
Puntillo de arroz (broken rice)	7.47	1.00	0.47	78.00	1.02	Good	
Harina de carne (meat meal)	36.61	15.25	1.49	4.84	35.07	Good	
Torta de mani	48.56	1.53	4.28	24.54	11.5	Good	
Salvado de trigo (wheat bran)	16.48	4.31	8.33	45.45	4.31	Fair-Good	\$2.25
Trigo adlaine (wheat)	9.39	3.08	1.45	65.14	9.24	Good	
Tankage (tankage)	38.89	17.35	1.00	3.73	35.64	Good	
Torula (yeast)	38.85	6.61	1.00	44.74	12.70	Good	
Sorgo inverniz (grain sorghum)	10.39	2.70	2.16	70.46	1.91	Good	\$4.13
Brozo de cafe (coffee hulls)	3.52	.72	60.31	25.73	0.95	Poor	

Appendix Table 1. --continued

Materials	Proximate Analysis					Digestibility to fish	Approximate cost/100 pounds
	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract	Ash		
Afrecho palma Africana (African palm meal)	15.22	6.79	13.44	51.25	2.96	Fair-Good	
Harina da tiburon (shark meal)	72.24	1.78	0.41	0	13.00	Good	
Harina de sangre (blood meal)	75.75	0.37	2.42	0.21	3.83	Good	
Maiz amarillo (yellow corn)	8.04	3.70	1.65	70.95	2.42	Good	\$4.95
Salvado de arroz ² (rice bran)	13.00	1.00	14.00	45.00	16.00	Fair-Good	\$3.30
Harina de coco, copra (coconut meal, copra)	20.00	6.00	14.00	75.00	8.00	Good	\$3.60
Banano fresco (fresh banana , wet basis)	3.50		0.60	14.00		Poor-Fair	
Yucca fresco (fresh yucca , wet basis)	2.75			15.00		Fair-Good	

1. Information in this table was provided by Professor Hernan Fonseca Z., Animal Nutrition Laboratory, Department of Agronomia, University of Costa Rica. Mr. Rudolpho Muvillo, assistant to the Agricultural Attache, American Embassy, provided some cost figures.

2. Estimated in the compilation of this table based upon U.S. analyses.