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INLAND FISHERIES SURVEY REPORT

FOR EL SALVADOR

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 ITINERARY[1]

February 15	Arrived San Salvador, Republic of El Salvador
February 16	Initial meeting with officials of the U.S.A.I.D. Mission to discuss purpose of survey and organize work schedule
February 17	U.S.A.I.D. Mission and U. S. Peace Corps
February 18	Initial meeting with officials of the Ministry of Agriculture and Livestock; Department of Natural and Renewable Resources
February 19	Santa Cruz Porrillo Fisheries Station
February 20	Peace Corps Volunteer - Aquaculture Team
February 22	Lakes Coatepeque, Espino and Chalchuapa
February 23	Lake Guija
February 24	Lakes Ilopango and Apastepeque
February 25	Lakes Olomega and Jocotal
February 26	Santa Cruz Porrillo Fisheries Station
March 1	Peace Corps Volunteers - Fish Pond Survey and Extension Tea
March 2	U.S.A.I.D. Mission; Hydroelectric Commission Office
March 3	Final conferences with Assistant Director and Program Officer of the U.S.A.I.D. Mission
March 4	Sub-secretary, Ministry of Agriculture and Livestock; Directo General, Department of Natural and Renewable Resources
March 5	Final conferences with Director and Associate Director, Peace Corps; Chief of Agriculture, U.S.A.I.D. Mission Departed El Salvador

1. Dr. Glenn C. Holm, U.S.A.I.D. Mission, participated in all conferences held with various government divisions of El Salvador; Sr. Hector Hinds, Head of Fisheries Section, and Mr. Kenneth Johnson, Peace Corps Volunteer Lake and River Survey Team, accompanied the author on all field trips during the period of February 22 - 26.

2.0 SUMMARY OF RECOMMENDATIONS FOR INLAND FISHERIES DEVELOPMENT IN EL SALVADOR

2.01 The Santa Cruz Porrillo Fisheries Station facility is the only fisheries station operated by the Government of El Salvador. It is recommended that additional ponds and a new building be constructed. These new facilities not only would permit more rapid development of improved methods of fishculture that would reinforce the Government's efforts to establish a meaningful farm pond extension program for the country, but it also would allow the station to function more effectively as the national center or headquarters for all inland fishery investigations on natural waters.

2.02 Existing pond facilities, with a total water surface of 5.6 hectares, are suitable for production of fingerlings. However, many of the present ponds, due to their design, cannot be utilized to evaluate accurately the effects upon fish production of fertilization, supplemental feeding, or methods of stocking. A minimum of 32 additional earthen ponds, 0.05 hectare in size, and 30 concrete ponds, 10 to 20 square meters in surface area and 1 meter in depth, should be constructed. These facilities should be designed so that each earthen and concrete pond can be filled and drained individually at any time during the year and independently of all other ponds in the research facility.

2.03 A most urgent need for the station is an improved water supply. At present, water supplying the pond area is diverted a distance of 3 km by earthen canal from a stream. However, the fisheries station has access to the canal water only from 4:00 PM through the night since the adjacent Agricultural

Experiment Station has first priority in utilizing the water for irrigation in crop research. Also, the canal water cannot be used at certain periods in the year due to contamination with insecticides from cotton-spraying operations. Therefore, it is recommended that a deep well be drilled on the station to supply additional water for the Laboratory, Aquarium and ponds.

2.04 There are at present two buildings at the station: a combination laboratory, office and storage building; and a large aquarium building with 32 display tanks. Although well-constructed initially, the buildings now are in need of repair. For example, screens are rusted, some windows are broken, and the roof of the Laboratory leaks. Repairs should be made by the Department of Forestry and Fisheries as soon as possible to prevent further deterioration.

2.05 An additional building is required for housing field equipment and to serve as a shop for construction and repair of equipment. This building also should include space for fish feed preparation and storage.

Ultimately, a cold-storage facility with a capacity for holding 2 to 4 tons of fish will be required if the aquacultural program is to be expanded to include fish marketing and processing. A prefabricated, cold storage room with compressor would be satisfactory and these are available at moderate cost in the United States.

2.06 Basic laboratory and field equipment, including a tractor, mower, trailer, truck with distribution unit, boat and trailer and feed pelleting equipment, are needed to conduct the aquacultural program at the Santa Cruz Station and investigational projects on natural lakes, rivers and farm ponds. It is recommended that the U.S.A.I.D. Mission provide financial support for purchase of commodities that must be imported.

2.07 In view of the high interest evidenced by officials within the Ministry of Agriculture and Livestock in developing inland fisheries resources of El Salvador and the great need for high-quality animal protein within the country, it is proposed that the U.S.A.I.D. Mission support this program by obtaining technical services from the International Center for Aquaculture, Auburn University, Auburn, Alabama.

It is suggested that the U.S.A.I.D. Mission, through the International Center for Aquaculture, provide the following:

(A) A fisheries advisor to the Government of El Salvador for a two-year period, plus two-man months annually of technical services in specialized areas of aquaculture and fisheries as may later be determined to be most urgently needed. The resident fisheries advisor will have training and experience in both aquacultures and fisheries of natural waters.

(B) A special short-course training program of approximately one week in duration will be conducted annually for host-country fishery personnel, with appropriate Peace Corps Volunteers participating. The training program will be scheduled to coincide with in-country visits of short-term specialists from the International Center for Aquaculture.

3.0 INLAND FISHERIES SURVEY REPORT FOR EL SALVADOR

D. D. Moss
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Auburn, Alabama 36830

3.01 Introduction

An inland fisheries survey of El Salvador was conducted by the International Center for Aquaculture, Auburn University, from February 15 to March 5, 1971, at the request of the U.S.A.I.D. Mission. The principal objectives were: 1) to review the inland fisheries program of the Ministry of Agriculture and Livestock which includes the aquaculture project at Santa Cruz Porrillo Fisheries Station plus the Farm Pond Extension and Lake and River Survey projects; 2) to determine if sufficient potential and need exist within the country to justify accelerated development of inland fisheries resources, and, 3) to recommend to the U.S.A.I.D. Mission and host-country Government a program that would benefit El Salvador in terms of increased fish production for local consumption.

During the survey, several natural lakes were visited and two trips were made to the Santa Cruz Porrillo Fisheries Station. In addition, several conferences were scheduled with officials of the Government of El Salvador, U.S.A.I.D. Mission and U. S. Peace Corps. Also meetings were held with fishermen in various areas of the country. An itinerary giving the complete work schedule is included on preface page iii, while a map of the country is shown in Figure 1.

Excellent cooperation was received from various Government divisions of the Republic of El Salvador including: 1) the Division of Natural and Renewable

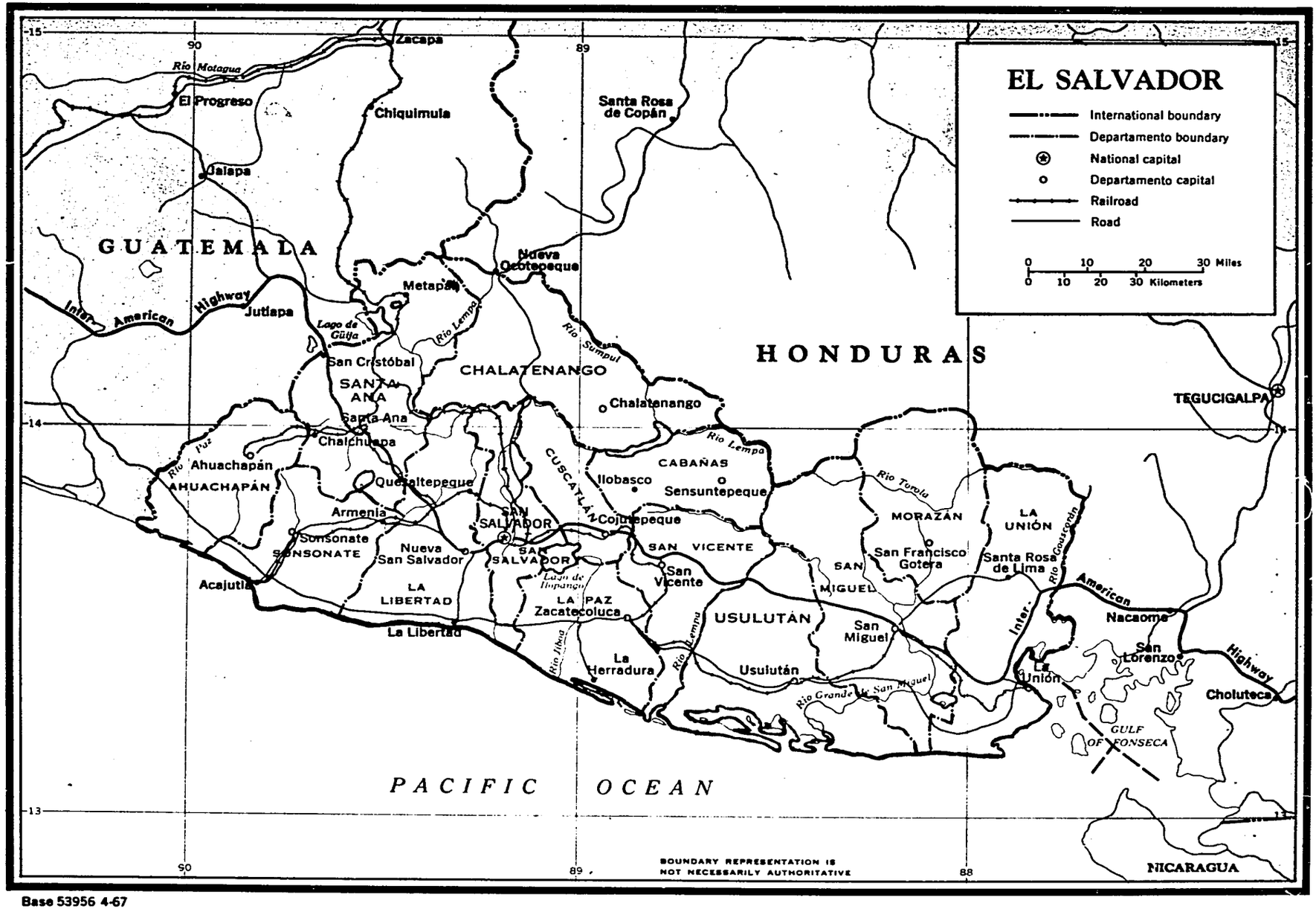

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Figure 1. Map of El Salvador

Resources; 2) the Department of Forestry and Fisheries; and, 3) the Fisheries Section. The Peace Corps Volunteers provided a great deal of assistance by making available copies of various fisheries reports. The U.S.A.I.D. Mission provided logistical support and evidenced high interest in the survey.

3.02 Geography and Climate

El Salvador, bordered by Guatemala and Honduras, is the smallest republic in the Western Hemisphere, with a total area of 21,393 square km (8,260 sq. mi.). It lies along the Pacific Ocean and has a coastline of 272 km (170 miles). Greatest land distances are: 256 km (160 miles) in an east-west direction and 96 km (60 miles) in a north-south direction.

Mountain ranges running east to west divide the country into three distinct regions: 1) a narrow coastal plain, 15 to 25 km in width, that extends the length of the country; 2) a large, central plateau with river valleys where population density is greatest; and, 3) the mountainous northern region. Approximately 90 per cent of the land is of volcanic origin.

The climate of El Salvador is tropical with air temperatures varying with altitude. Generally, it is warm on the central plateau, hot on the coastal plain and relatively cool in the mountain region. Temperature ranges from a high of 42 C in May to a low of 10 C in January at Santa Cruz Porrillo - elevation 30 m; 36 C to 8 C at San Salvador - elevation 700 m; and 27 C to 4 C at Volcan Sta. Ana - elevation 1,770 m. There is a distinct wet season, from May to November, followed by a pronounced dry season, from December through April. Average rainfall is 1,956 mm (77 inches).

3.03 Economic Status

The economy of El Salvador is based principally upon its agricultural resources. Coffee and cotton are the main cash crops accounting respectively for 44 and 8 per cent of the country's total exports. Other major products are beans, meat, sugar and corn. The most important fishery is shrimp, the great majority of which is exported. The Government, in an attempt to achieve greater agricultural diversification and to reduce food imports, is placing priorities on programs relating to increased domestic food production.

Total exports in 1969 amounted to $202 million while total imports for the same year were $214 million. Per capita gross domestic product or the value of total production of all goods and services, as determined by consultants (Battelle Memorial Institute, 1969) are as follows:

	1965	1970	1975	1980
Per capita gross domestic product (U.S. dollars)	260	297	346	414

3.04 Population and Nutrition

El Salvador, with a total land area of 21,393 square km (8,260 square miles) and a population of approximately 3.5 million in 1970, has the greatest population density of any Central American country. The average number of inhabitants for El Salvador is 164 per square km while for other countries in the region the population density per square km is as follows: British Honduras, 3.9; Guatemala, 36.9; Costa Rica, 26.7; Honduras, 17.4; Panama, 15.1; and

Nicaragua, 10.9.

Moreover, population growth rate presently is about 3.5 per cent and it is projected to increase to an even higher rate of 3.8 per cent in about 10 years (Robert R. Nathan Associates, Inc., 1969). This is well above the average annual rate of 3.2 per cent for all Central American countries. Population estimates as determined by consultants (Battelle Memorial Institute, 1969) are given below for the period 1965 to 1980:

	1965	1970	1975	1980
Population (millions)	2.921	3.524	4.183	4.832

Of the total population, over one-half is in the age category of 19 years and less, with 17.2 per cent less than 5 years of age; 27.6 per cent between 5 and 14; and 9.6 per cent between the ages of 15 and 19.

The diet in 1966 was 1,840 calories per capita per day, of which 63 per cent was supplied by cereals (U.S.A.I.D., 1970). In the United States in 1967, daily per capita calorie intake was 3,180, of which cereals provided 20 per cent.

The traditional diet of most families in rural areas consists of beans, tortillas and coffee, supplemented occasionally with rice and cheese. Compared with a minimum recommended daily food ration prepared by the Direccion General de Salud, the traditional diet is deficient by 900 calories and is noticeably deficient in animal protein. Per capita daily consumption of protein was estimated at 53.8 grams for 1959-61, with meat and fish supplying 9.5 and 0.2 grams, respectively, of the total (U. S. Department of Agriculture, 1964).

A nutritional study made in 1965, in which 30 rural communities in 14 departments were surveyed, indicated that consumption of animal protein was only 26 per cent of recommended levels, and that children under 8 years old were generally underweight and suffered malnutrition.(Nathan Associates, Inc., 1963).

3.05 Status of the Fisheries

The principal marine industry is the shrimp fishery which constitutes the country's third most important export, after coffee and cotton. Catch of shrimp and other crustaceans for 1965, 1966 and 1967 was reported at 5.0, 7.3 and 5.6 thousand metric tons respectively (FAO, 1968). In recent years, the catch of shrimp, most of which is exported, ranged in value from 3 to 4 million dollars annually. Various opinions were heard relative to the capability of this fishery to support a greater sustained annual yield. The Government, however, rigidly limits the total shrimp fishing fleet to 68 trawlers.

The catch of marine fish, which are harvested incidental to shrimp fishing operations, was estimated at 2.0, 2.0 and 2.7 thousand metric tons for 1965, 1966 and 1967, respectively. Freshwater fish catch for the same period was 2.6, 1.3 and 1.6 thousand metric tons, respectively (FAO, 1968).

Per capita consumption of fish in El Salvador is reported at 0.8 kg annually or 0.2 gram per person per day (U. S. Department of Agriculture, 1964). This figure is exceedingly low for a country with a coastline extending its entire length and several large natural lakes.

The fisheries of El Salvador are extremely important natural and renewable resources. Not only does significant economic gain result from fisheries,

but an excellent source of high quality protein is provided to a people critically short in this commodity. Greater effort should be placed in accurately assessing, developing and subsequently utilizing this renewable resource to the greatest extent possible without over-exploitation.

3.06 Government Divisions Responsible for Fisheries

Marine fisheries activities in El Salvador are directed by the Section for Fisheries and Maritime Activities under the Ministry of Economy. Programs in marine fisheries for the most part consist of collection of catch statistics, resource evaluation and coordination of activities of fishermen.

The Ministry of Agriculture and Livestock is responsible for all programs relating to inland fisheries, with the Fisheries Section carrying out the various research and extension projects. An abbreviated organizational plan showing the relationship of the Fisheries Section to the Department of Forestry and Fisheries, Division of Natural and Renewable Resources, is shown below:

MINISTERIO DE AGRICULTURA Y GANADERIA
Ministry of Agriculture and Livestock
(MINISTER)
|
(Sub-Secretary)
|
DIRECCION GENERAL DE RECURSOS NATURALES Y RENOVABLES
Division of Natural and Renewable Resources
(DIRECTOR GENERAL)
|
(Sub-Director General)
|
DEPARTAMENTO DE FORESTAL Y PISCICOLA
Department of Forestry and Fisheries
(CHIEF)
|
PISCICOLA SECCION
Fisheries Section

During recent years the Fisheries Section has been severely handicapped both by a lack of trained personnel and a very limited operating budget. Until recently there was a single biologist in the Fisheries Section. He had the primary responsibility of planning and supervising the research program carried out at the Santa Cruz Porrillo Fisheries Station, conducting field investigational projects on natural waters and extending a farm pond program within the country. Recently, however, additional biologists have been employed and renovation of earthen ponds at the Santa Cruz Porrillo Fisheries Station is in progress. Because of the Government's growing interest in aquacultures as a means for increasing supply of high quality protein in inland areas, it is likely that increased support will result.

3.07 Fisheries Training in El Salvador

The University of El Salvador has a limited marine biology program in the Department of Biology. Biological and fisheries investigations are undertaken at the University, but no vessels or laboratories are operated in conjunction with the program. The National School for Agriculture, with 6 major departments including Basic Science, Agricultural Mathematics, Agricultural Economics, Horticulture, Agronomy and Animal Science, provides basic agricultural training which would have value for inland fisheries biologists. It is suggested that serious consideration be given to expanding the Department of Animal Science to include at least one full time professor who has a graduate degree in inland fisheries biology or aquaculture. This would enable the Department of Animal Science to provide a few of the more essential fisheries courses to students interested in this area.

Fishery technicians employed by the Fisheries Section are generally college graduates, with a major in biology or other areas of natural science. They have had no formal training in fisheries or aquaculture. Hence, the first few years of employment are mainly spent in acquiring knowledge in fisheries through experience and self-study.

4.0 INLAND FISHERIES RESOURCES IN EL SALVADOR

For a country of its size, El Salvador possesses a relatively large number of natural lakes. There are approximately 20 principal lakes, one-third of which have areas in excess of one square km or approximately 0.4 square mile. Most are of volcanic origin. Lempa River is the largest river and the only navigable stream, draining roughly one-half of the total land area of the country. The majority of coastal rivers extend landward for a distance of 25 to 35 km and become very low during the dry season. Principal lakes and rivers of El Salvador are shown in Figure 2. There are presently in the country approximately 1,400 farm ponds, with 60 to 80 new ponds constructed annually.

Natural waters of El Salvador appear to support a relatively small number of fish species. Scientific and common names and distribution of the most important native freshwater fishes are given in Table 1. Several of those listed are important in the commercial and subsistence freshwater fishery although none apparently grow to very large size in natural waters. In an attempt to improve quality and quantity of the fishery, the Ministry of Agriculture and Livestock has introduced a number of exotic fish species over the past 20 years.

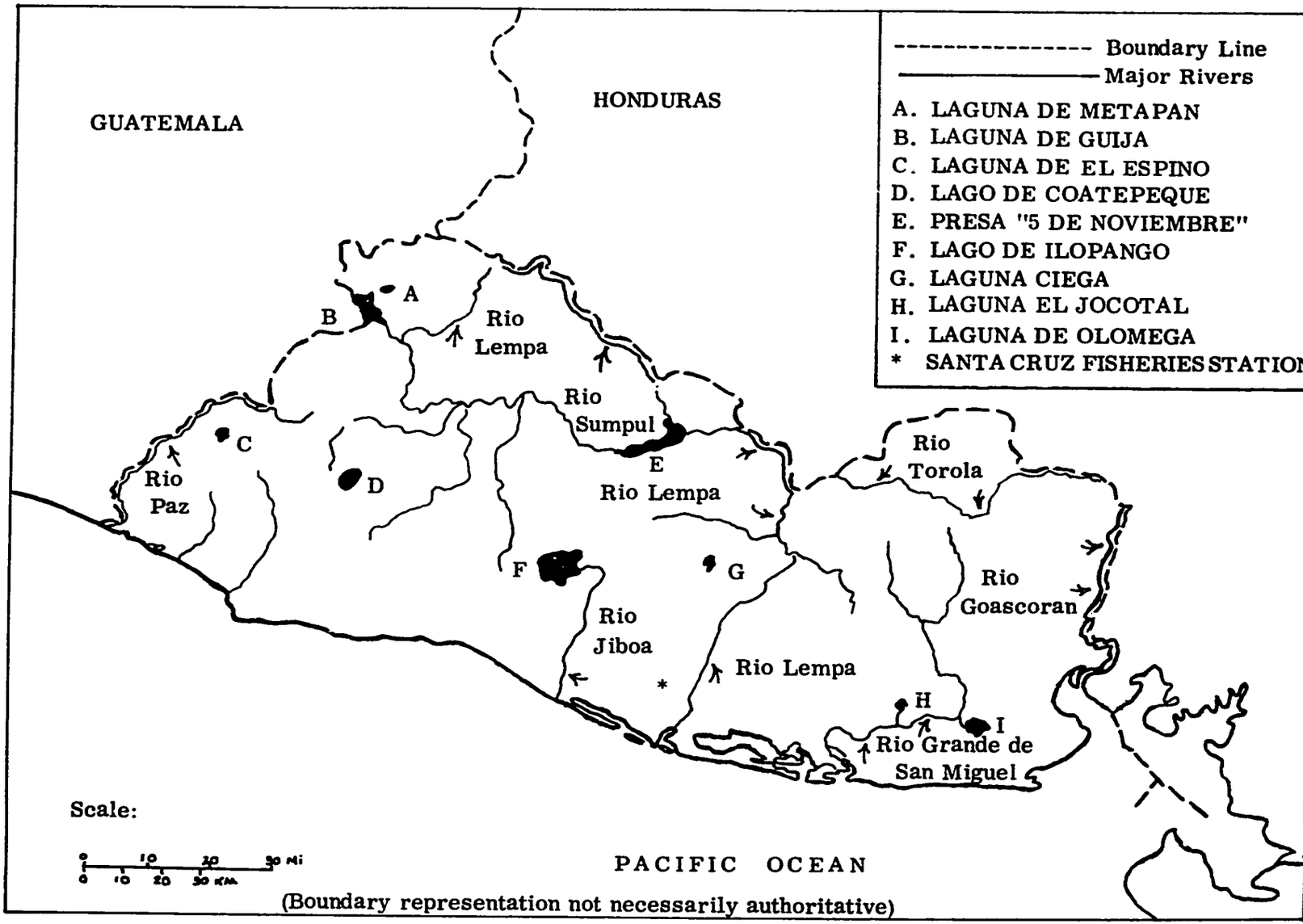


Figure 2. Map of El Salvador showing location of principal lakes and rivers.

Table 1. Distribution of important native and introduced freshwater fishes and crustaceans in El Salvador

Scientific Name	Common Name	Distribution[1]
Native Fish and Crustacean Species		
Cichlasoma macracanthrum	mojarra	O,G,I,A
C. trimaculatum	guapote	O,G.I
C. motaguense	guapote	O,G,I,C
C. nigrofasciatum	burra	Most lakes and rivers
Poecilia sphenops	chimbolo	O,G,I,A,C,E
Poeciliopsis turrubarensis	chimbolo	O,G,I,A,C,E
Roeboides salvadoris	sardina	O,G,I,A
Rhamdia guatemalensis	juilin	O,G,I,A
Astyanax fasciatus	plateada	O and most rivers
Dormitator latifrons	sambo	J and most rivers
Arius guatemalensis	bagre	O,G,I,A
Synbranchus marmoratus	anguila	O,C, and most rivers
Pseudothelphusa magna	cangrejo (crab)	C,G
Macrobrachium tenellum	camaron (prawn)	G,I and some rivers
Introduced Fish Species		
Cichlasoma managuense	guapote tigre	O,G.I,A,C,E
C. dovii	guapote blanco	A
C. guttulatum	mojarra azul	C
Tilapia mossambica	tilapia negra	G,I,A,C,E
Tilapia nilotica[2]	tilapia blanco	Santa Cruz Fisheries Station
Cyprinus carpio	carpa	Santa Cruz Fisheries Station
Micropterus salmoides	lobina negra	I,A

1. O = Laguna de Olomega; G = Lago de Guija; I = Lago de Ilopango; A = Laguna de Apastepeque; C = Lago de Coatepeque; E = Embalse 5 de Noviembre (reservoir); J = Laguna de Jocotal

2. Although commonly called T. nilotica at the station, this fish appeared to be T. aurea.

Scientific and common names of fishes introduced and the waters stocked are given in Table 1.

4.01 Natural Lakes

The natural lakes of El Salvador provide an important source of high quality protein for many people living adjacent to the lakes and in several small cities located in inland areas. Many of these lakes formerly were volcanoes with the central craters becoming reservoirs for collecting and retaining water. Volcanic lakes generally have small watershed areas. Productivity, therefore, is relatively low since the basic fertility of a lake is dependent upon runoff waters carrying soil nutrients into the lake. Nonetheless, the lake fishery provides gainful employment for a substantial number of full-time and part-time fishermen as well as a valuable source of animal protein for supplementing the high carbohydrate diet common to the people of El Salvador.

The sizes of the larger natural lakes and watershed areas are given in Table 2, while available data on chemical characteristics are listed in Table 3. Discussions follow in which several of the lakes visited during the survey are considered individually.

4.011 Lake Ilopango

Located at the juncture of Cuscatlan, San Salvador and La Paz Departments, Lake Ilopango is the largest lake of the country, having a surface area of 70.5 square km (17,420 acres) and a maximum depth of approximately 248

Table 2. The principal natural lakes of El Salvador

Name of lake	Area				Perimeter			
	lake		watershed		lake		watershed	
	km^2	acres	km^2	acres	km	miles	km	miles
Ilopango	70.5	17,420	204.8	50,606	52.5	32.6	71.5	44.4
Guija	44.1	10,897	1,989.0	491,482	42.0	26.1	277.0	172.1
Coatepeque	25.0	6,178	63.3	15,641	20.2	12.6	34.2	21.3
Olomega	18.6	4,596	252.0	62,269	24.0	14.9	94.0	60.3
San Juan	10.6	2,619	37.9	9,365	6.7	4.2	35.2	21.9
Espino	4.2	1,038	35.1	8,673	7.0	4.4	24.0	14.9
Jocotal	1.2	296	85.3	21,078	8.5	5.3	45.6	28.3

Table 3. Some chemical and physical data of lakes in El Salvador[1]

Name of lake	Depth of sample (meters)	pH	Oxygen (ppm)	Alkalinity HCO_3 (ppm)	Alkalinity CO_3 (ppm)	Cl (ppm)	Secchi disc reading (meters)
Ilopango	surface	8.4	6.8	210	---	635	6.5
	20	8.3	5.2	198	22	635	
Guija	surface	8.6	6.4	84	6	5	1.0
	6	7.3	4.5	90	---	13	
Coatepeque	surface	8.8	6.6	232	26	494	8.0
	15	8.5	---	232	26	494	
Apastepeque	surface	6.7	7.6	96	---	12	4.5
	20	---	---	---	---	---	
Metapan	surface	8.3	6.4	114	2	6	1.0
	4.5	7.3	4.5	112	---	6	
Espino	surface	6.7	6.6	32	---	11	0.2

1. Data are from Armitage, 1953. (See References, Section 7.0)

meters (813 feet). It was formed by tectonic subsidence of the earth's mantle accompanied by lava flows (Armitage, 1953). Although a deep lake, shallow areas are present in some areas near the shoreline in which dense beds of rooted vegetation occur. The watershed to lake area ratio is approximately 3:1. The lake drains by means of the Jiboa River.

In an attempt to improve the fishery, three fish species not native to the lake were introduced in the 1960's: guapote tigre (Cichlasoma managuense); tilapia negra (Tilapia mossambica); and lobina negra (Micropterus salmoides). The latter species, largemouth bass, apparently did not become established. The guapote tigre and tilapia negra, however, became quite abundant and these two species presently make up the most important fishery of the lake. Unfortunately, no studies were carried out on the fishery in terms of economic return and total fish harvest prior to introduction of the exotic fish species. Hence, it is not known to what extent, if any, the guapote tigre, a highly carnivorous species, may have reduced the native fish population. The second most important fishery of Ilopango Lake is provided by two other cichlids: mojarra (Cichlasoma macracanthum) and guapote de ilopango (C. trimaculatum).

Other native fish species including: burra (Cichlasoma nigrofasciatum); chimbolo (Poecilia sphenops); sardina (Roeboides salvadoris); and juilin (Rhamdia guatemalensis) make up the remaining portion of the fish catch.

Most fishing activity is concentrated in the southeastern area of Lake Ilopango where gill nets, the gear most frequently used, and cast nets are utilized. It was reported that illegal fishing with extracts of plants containing

rotenone compounds, dynamite and home-made explosive devices, is practiced to some extent. There are approximately 200 part-time and full-time fishermen harvesting the lake but no data were available on total catch or the value of the fishery.

4.012 Lake Guija

Located in the extreme northwestern portion of El Salvador in Santa Ana Department, Lake Guija extends into Guatemala. This lake, with a surface area of 44.1 square km (10,897 acres) apparently was formed by a lava flow that blocked off a valley. The San Diego volcano is located on its southeast bank and other smaller volcanic peaks are located around the lake. It has a rather large watershed, roughly 2,000 square km, resulting in ratio of watershed to lake area of approximately 44:1. Drainage is by the River Desague, which carries overflow water from the lake to the Pacific Ocean by way of the Lempa River.

Three exotic fish species: tilapia negra (T. mossambica); guapote tigre (C. managuense); and guapote blanco (C. dovii) were introduced into the waters of Lake Guija in 1960-1962. The tilapia negra and guapote tigre reproduced and established populations while the introduction of the guapote blanco apparently was not successful. Prior to introduction of the exotic fish species, the bagre (Arius guatemalensis) was the predominate species taken commercially. This species, however, was regarded as an inferior food fish and commanded a low market price. At present the guapote tigre, tilapia negra and bagre rank first, second and third, respectively, in the commercial fishery, with the guapote

tigre bringing the best price - about $0.30/lb. Gill nets, cast nets and hook and lines are utilized by fishermen, but the gill net is favored for those who can afford this gear. The fishing village of Desague is the largest in the area with some 300 full-or part-time fishermen. Some of the fishing gear utilized are shown in Figures 3 and 4. The catch of fish is transported daily by train to the city of Santa Ana. This journey requires from 3 to 4 hours arriving in Santa Ana at noon. Since no ice is available in the area, fish are not of the best quality when they reach the consumer.

4.013 Lake Coatepeque

This volcanic lake is located 15 km from the city of Coatepeque. It is the third largest natural lake in El Salvador having a surface area of 25 square km (6,178 acres), a depth in excess of 110 meters (360 feet) and a watershed to lake area ratio of 2.5:1. Of the larger lakes of El Salvador, Coatepeque is the only one having no surface drainage outlet.

The freshwater crab (Pseudothelphusa magna) is an important fishery of this lake. A photograph of the lake and of crabs being marketed are shown in Figures 5 and 6. Studies carried out in 1961 and 1962 indicated a total catch of 384,408 crabs weighing 34,705 kg (76,351 pounds) for the calendar year of 1961 (Lin, 1963). This is equivalent to a harvest of 12.4 pounds crabs per acre per year. During the first 7 months of 1962, 22,441 kg (49,370 pounds) were harvested which amounts to approximately 1.1 pounds per acre per month or 13.7 pounds per acre per year if expanded to an annual basis. At the prevailing market price of $0.50 per pound for crabs of large size, the total value

Figures 3. and 4. Fishing gear generally utilized in larger lakes of El Salvador include dug-out canoes, gill nets (stacked in bow of canoe in upper photograph), and a few outboard motors. Cast nets as shown in the lower photograph are widely used.

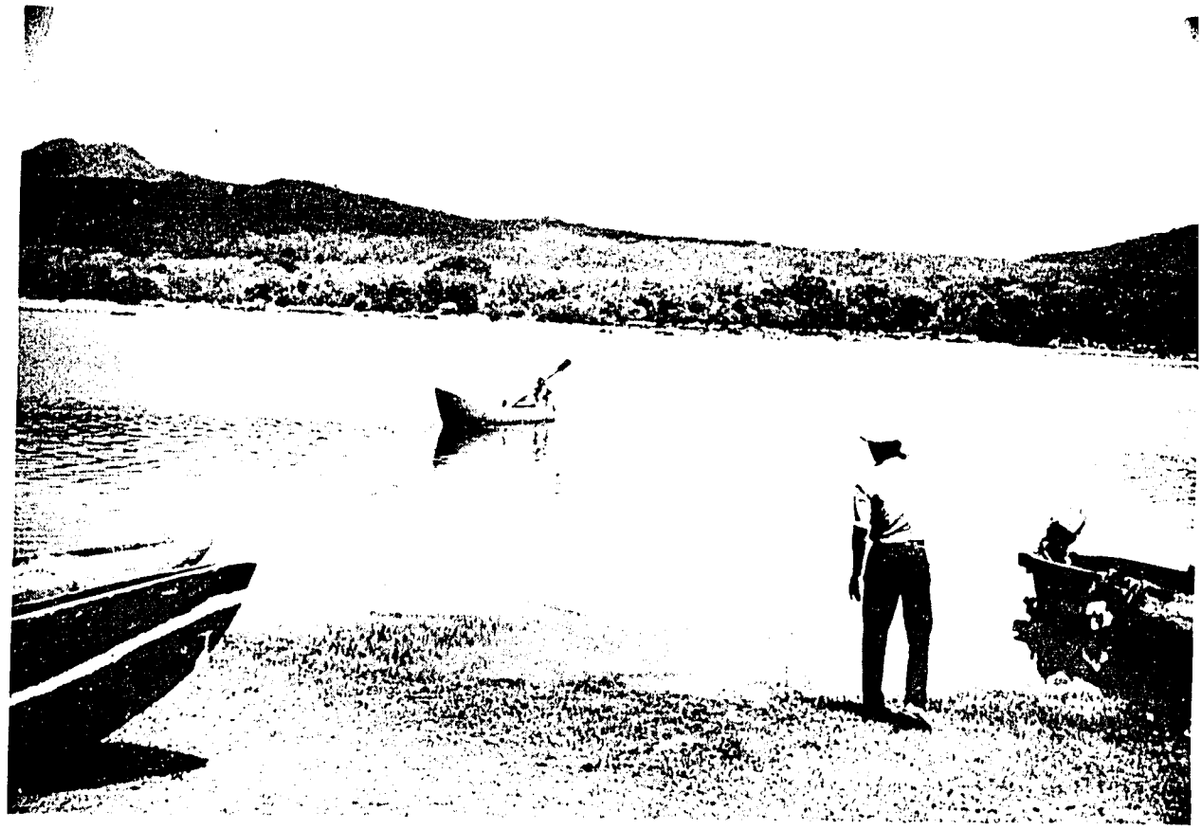


Figure 5. Photograph of Lago de Coatepeque, a 6,178-acre lake of volcanic origin with a relatively small drainage area to water surface ratio (2.5:1) and no surface outflow.

Figure 6. Photograph showing a purchaser bargaining for the freshwater crab, Pseudothelphusa magna. This crab lives for 3 days out of the water and is an important fishery resource of Lago de Coatepeque.

of the crab fishery alone amounted to approximately $38,170 in 1961.

A survey carried out by the Lake and River Survey Unit of the Fisheries Section indicated 1,600 kg crabs were harvested from Lake Coatepeque during March, 1971 (Johnson and Argumedo, 1971). This is equivalent to approximately 0.6 pound per acre, or about one-half the monthly harvest recorded in 1961-62.

In addition to the freshwater crab, a substantial fishery exists in Lake Coatepeque for the guapote tigre and mojarra (Cichlasoma guttulatum), both species of which were introduced. The guapote tigre was introduced in 1969 by individuals residing in the area, while 1,000 mojarra fingerlings were introduced in 1957 by the Government Fisheries Service. Also, about 1,000 tilapia negra fingerlings were introduced in 1970. It was reported that the fishery for guapote at present exceeds that of crab although the guapote sells at a lower price - $0.20 to $0.30 per pound. A total fish catch of 19,887 kg, approximately 4 pounds per acre, was recorded for the month of March, 1971. The guapote tigre and mojarra made up 59 and 40 per cent respectively of the total number of fish taken during March, 1971 (Johnson and Argumedo, 1971). Fish and crabs harvested by the 100 full-time and 200 part-time fishermen are transported 25 km by bus to markets at Santa Ana. It is likely that the guapote tigre, a top predator in the food chain, feeds upon small crabs. Food habit studies for this carnivorous species should be included in survey work presently being carried out by the Fisheries Section and the Peace Corps Volunteer of the Lake and River Survey Unit.

4.014 Lake Olomega

Lake Olomega, located in southwestern El Salvador, has a surface area of 18.6 square km (4,596 acres). Area of watershed is 252 square km (62,269 acres). Situated in a lowland sink area, it is the richest lake in the country in terms of total fish production. Depth of water is relatively shallow, varying from a maximum of 4 meters during the dry season to about 6 or 7 meters at the end of the rainy season. At the peak of the annual wet season, surface area of the lake is increased by approximately 50 per cent through inundation of lowlands surrounding the lake.

The water level drops progressively during the dry season, exposing large areas of lowlands that subsequently are utilized as pasture for livestock or for crop production, particularly maize. Fertilization of crops is rarely practiced in the area but yields are high due to the annual deposition of silt from flood waters.

High fish production of Olomega Lake, to a great extent, is due to the cyclic release of nutrients from decaying vegetation, cow manure, etc., as lowlands are inundated and to the minerals that are transported to lake waters through runoff from adjacent land areas.

From a study carried out by the Government Fisheries Service in 1957, it was concluded that the annual harvest was 504,000 kg or approximately 110 kg/ha/year (Lin, 1963). The bulk of the catch, however, consisted of plateada (Astyanax fasciatus), chimbolo (Poecilia sphenops) and bagre (Arius guatemalensis),

all of which commanded a very low market price. In 1959, a total of 110 guapote tigre (Cichlasoma managuense) was stocked in Lake Olomega. It was thought that the introduction of this carnivorous species not only would reduce the great numbers of less desirable species, but also would provide a fishery of greater economic importance. Results of studies carried out by the Fisheries Section on the fishery prior to and following introduction of the guapote tigre are summarized as follows:

Species	Price per kg (colones)[1]	1957 Harvest (kg)	1957 Value (colones)	1962 Harvest (kg)	1962 Value (colones)
Cichlids	0.60	162,000	97,200	217,300	130,380
Chimbolo, Plateada	0.15	270,000	40,500	15,932	2,390
Bagre	0.06	72,000	4,320	18,897	1,334
		504,000	144,020	252,129	133,904

1. Present value of one colon is $0.40.

In a period of 3 years following the introduction of slightly more than 100 guapote tigre, total harvest of fish decreased from 504,000 to 252,129 kg, or from approximately 98 to 49 pounds per acre per year. Decrease in total value of the fishery was 8,116 colones or $3,246. At the current rate of exchange the per acre value of the fish harvest was $12.34 and $11.64 for 1957 and 1962, respectively. Thus, the reduction in total weight of fish harvested following introduction of guapote tigre was compensated, to a substantial degree, by the higher selling price of the guapote.

Cichlasoma trimaculatum and C. macracanthum made up 70 and 30 per cent, respectively, of the total catch of cichlids in 1957. However, in 1962 the guapote tigre was the most important with this species comprising by weight 50 per cent of the entire catch of cichlids.

This provides an excellent example of the dangers associated with introducing piscivorous fish species. Such introductions should never be made unless a thorough study of existing fish populations is carried out with careful consideration given to the possible disadvantages as well as advantages of the introduction.

Since Lake Olomega has a severe weed problem including both water hyacinths and submerged, rooted aquatic vegetation, the introduction of fish species that consume weeds might be of substantial benefit. Again, however, it should be emphasized that no introductions should be made until adequate studies have been carried out. In this regard, it is suggested that a thorough study of the present fishery of Lake Olomega be made to determine what changes have occurred in the fishery since the last survey was carried out in 1962 and whether it would be advantageous to stock herbivorous fish species.

4.02 Rivers

The largest river in El Salvador is the River Lempa. Originating in Honduras, the Lempa River passes through the northwest corner of the country where it then flows eastward until impounded by the Fifth of November Dam. Several kilometers below this hydro-electric facility, the course abruptly changes to a southward direction where it flows into the Pacific Ocean.

The Lempa River, with a total length of roughly 300 km (186 miles), drains a large portion of the land area of El Salvador (Figure 2). Although it is a rather large river, very little is known of its fishery resource in terms of total production, quantity of harvest, relative abundance by species and economic value of the fishery. Species of fish and crustaceans known to be present are given in Table 4. Most marine species listed are commonly found in the lower reaches of the river while the freshwater species indicated are distributed throughout its entire length. Three crustacean species including the freshwater crab and two species of freshwater shrimp are found in certain sections of the river.

Smaller in size than the Lempa River, several other streams contribute to the country's total fishery resource. These are: Rio Paz, Rio Jiboa, Rio Grande San Miguel, Rio Goascoran, Rio Torola and Rio Sumpul (Figure 2). It is likely that most of the species found in the River Lempa also occur in the smaller streams.

4.03 Reservoirs

Embalse 5 de Noviembre, constructed on the Lempa River principally for production of electricity and water for irrigation, is the only large reservoir in El Salvador. The Government, however, is considering the alternatives of increasing the height of the existing dam or constructing a second reservoir immediately upstream from the present impoundment.

A number of small fishing villages or camps are located around the reservoir. The quantity of fish caught and composition of catch by species and

Table 4. Partial list of fish and crustacean species occurring in the Lempa River

Scientific Name	Common Name
Freshwater Species	
Cichlasoma macracanthum	mojarra
C. trimaculatum	guapote
Arius guatemalensis	bagre
Rhamdia guatemalensis	juilin
Astyanax fasciatus	plateada
Roeboides salvadoris	sardina
Poecilia sphenops	chimbolo
Poeciliopsis turrubarensis	chimbolo
Anableps dowii	cuatro ojos
Marine or Brackishwater Species	
Lutjanus novemfasciatus	pargo
Centropomus nigricans	robalo
C. robalito	robalete
C. pectinatus	robalo
Mugil cephalus	lisa
Menticirrhus undulatus	corbina
Promicrops itaiara	moro
Dormitator latifrons	sambo
Synbranchus marmoratus	anguila
Crustaceans	
Pseudothelphusa magna	cangrejo
Macrobrachium olfarsi	cacarico
M. acanthurus	camaron

weight are not known at present although plans are being developed to obtain such information.

Two exotic species of fish, guapote tigre and tilapia negra, have been stocke in the reservoir, but evaluation of these introductions has not been made to date.

4.04 Ponds

The Fisheries Service of El Salvador estimates that there are 1,400 farm ponds in the country with 60 to 80 new ponds being constructed annually. Many ponds are constructed for multi-purpose activities including: water for livestock, limited irrigation of vegetables and other agricultural crops, production of fish for food and, in some instances, sport fishing.

The potential of farm ponds as a means of increasing supply of animal protein should not be overlooked. For example, assuming an average size of one-fourth-hectare (0.6 acre) and an annual production of 2,000 kg per hectare (1,800 lbs/acre), total production from 1,400 farm ponds would amount to 700,000 kg (1,540,000 pounds) fish per year. Other positive attributes afforded through a progressive farm pond program are: 1) ponds can be constructed in inland areas which are deficient in production and availability of high quality protein; 2) ponds can be constructed in areas that may not be suited for agricultural crops; 3) the entire crop of fish can be harvested and marketed at one time or harvest may be extended over a longer period of time; and, 4) distribution of pond-cultured fish for consumption is relatively inexpensive since the bulk of the fish is consumed locally. The Fish Pond Survey Unit, consisting of two Peace Corps

Volunteers and two employees of the Fisheries Section, is carrying out a comprehensive survey of existing farm ponds in El Salvador.

5.0 INLAND FISHERIES RESEARCH AND EXTENSION PROGRAM

5.01 Research on Lakes and Rivers

To evaluate fisheries resources, the Ministry of Agriculture and Livestock has organized a unit to survey the natural waters of El Salvador. The Lake and River Survey Unit, consisting of a Peace Corps Volunteer and a technician of the Fisheries Section, is conducting studies principally to determine value of the fishery in terms of total production and economic return; composition of the fish catch; number of fishermen; types of gear utilized and marketing systems. The Ministry anticipates that such surveys will provide basic information for improved management and utilization of these fishery resources.

Under the original work plan some 16 lakes and 6 rivers were scheduled for investigation during a 2-year period. It is impossible for a 2-man team to complete such an ambitious work program within this time period -- that is, if data obtained are to be sufficiently reliable so as to provide a solid, scientific basis for managing the resource for maximum annual sustained harvest. It is suggested that the work plan proposed by the Lake and River Survey Unit be reduced to permit a more detailed investigation of a fewer number of lakes and rivers.

In any fisheries study, certain data on the physical and chemical characteristics of waters are essential. However, priority should be given to

investigation of the fishery proper. It is important that field studies be oriented toward assessing the economic aspects of the fishery and delineating status of the harvest. If the fishery is being inadequately harvested, improved fishing techniques can be introduced. In the event that the fishery is being over-exploited, regulations may be imposed limiting the type of gear used, size of fish harvested, or fishing season. With the exception of explosive devices and chemicals, there are at present no restrictions on type of fishing gear used or on the size of fish taken. Also, fishing activities are carried out throughout the year and licenses are not required.

5.02 Farm Pond Extension Program

To encourage production of fish in farm ponds throughout the country, the Ministry of Agriculture and Livestock has organized a farm pond extension project. Two teams, each consisting of a Peace Corps Volunteer and a Salvadoreno counterpart, are making a survey of existing farm ponds in El Salvador. Objectives are to compile statistics on the size of ponds, fish species present and harvest data, if available. Following completion of the survey, a number of ponds will be selected in various regions of the country to serve as demonstration ponds. Management programs will be drawn up for farmers desiring to cooperate in this program and periodic visits will be made by the Farm Pond Extension Team to collect records on growth of fish and to advise the cooperators on management procedures and particular problems that they may have encountered.

At harvest, crops of fish will be tabulated as will the economics of fish farming operations.

As of March 1, 1971, the Farm Pond Extension Team had visited about 125 of the approximately 1,400 farm ponds present in the country. It was estimated that 50 per cent of those ponds inspected were not suitable for fish-culture purposes because of small size or insufficient supply of water. Most of the ponds visited were less than one hectare in size with the average size being approximately 0.1 hectare. It was reported that 30 per cent of the pond owners interviewed were interested in utilizing their ponds for commercial fish production.

Apparently, most of the ponds stocked in previous years had received 250 tilapia negra and 250 guapote tigre per pond regardless of size of the pond. More recently, a greater number of ponds was stocked with tilapia only. As has been demonstrated at the Santa Cruz Porrillo Fisheries Station, high production of tilapia negra can be achieved with supplemental feeding. A very high percentage of the harvest, however, generally is made up of fish of very small size. Therefore, research is needed to develop cultural methods by which fish of large average size can be produced. As a means of supplementing the research program at Santa Cruz Fisheries Station, it is suggested that a testing program be initiated in selected farm ponds in which a piscivorous fish species such as the guapote tigre is stocked at various rates in combination with tilapia negra and tilapia blanco. Stocking and feeding rates should be based upon best production records attained to date in experiments carried out at the station.

An effective farm pond program would provide a significant quantity of animal protein in inland areas where protein intake is exceedingly low. If such a program is to be successful, it must be based upon proven management practices developed through research.

5.03 Santa Cruz Porrillo Fisheries Station

5.031 Background Information

This station was constructed in 1958 by the Ministry of Agriculture and Livestock under a program of cooperation with the Food and Agriculture Organization of the United Nations. Consisting initially of 15 ponds totaling 5.6 hectares of water, the station is located about 65 km southeast of San Salvador on the Pacific Littoral Highway in the Department of San Vicente. Facilities in addition to earthen ponds include a Laboratory, a large Aquarium and an elevated water storage tank. A drawing of the pond system and a view of the Aquarium are included in Figures 7 and 8, respectively.

Climate at Santa Cruz Porrillo is tropical as the elevation is only 30 meters above Mean Sea Level. Air temperature ranges from a maximum of 42 C (107 F) in May to a minimum of 10 C (50 F) in January. Water temperature of the ponds is less extreme with a maximum of 38 C (100 F) occurring in June and a minimum of 23 C (73 F) in January. Rainfall at the station ranges between 1,076 mm (42 inches) and 2,600 mm (102 inches) annually, with an average of 1,751 mm (69 inches). The major period for rain is from May through October with the remaining months being quite dry. Data on air and water temperatures and rainfall are given in Table 5.

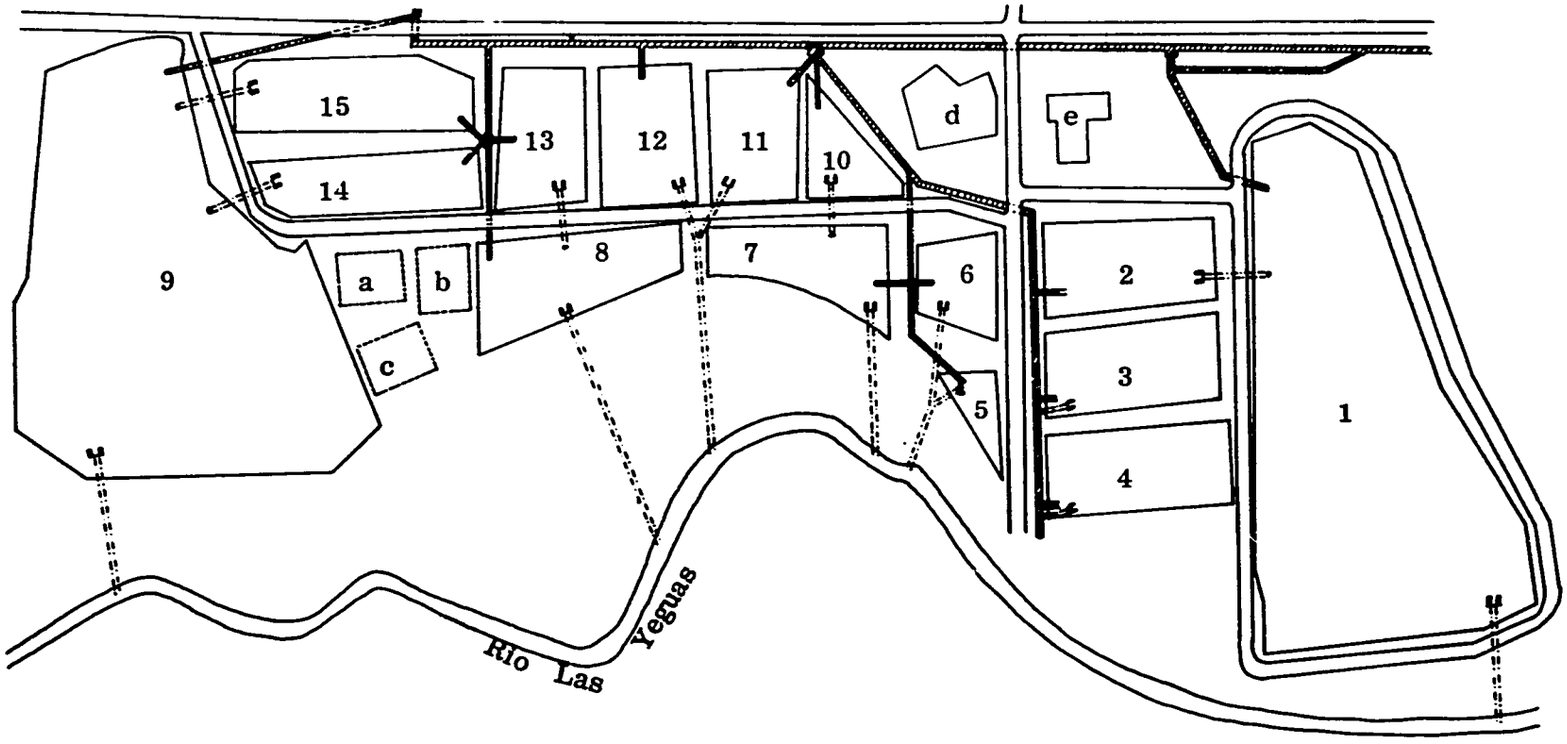


Figure 7. Drawing of pond system at Santa Cruz Porrillo Fisheries Station

LEGEND		POND SIZES (m^2)			
———	Road	1.	14,601	9.	15,553
//////	Water Supply Canal	2.	2,186	10.	970
-.-.-.-	Drainage Canal	3.	2,278	11.	1,737
a,b,c	New Ponds (each 500 m^2 in size)	4.	2,323	12.	1,976
d	Aquarium Building	5.	462	13.	1,762
e	Laboratory Building	6.	1,010	14.	1,989
		7.	1,901	15.	2,433
		8.	2,394		

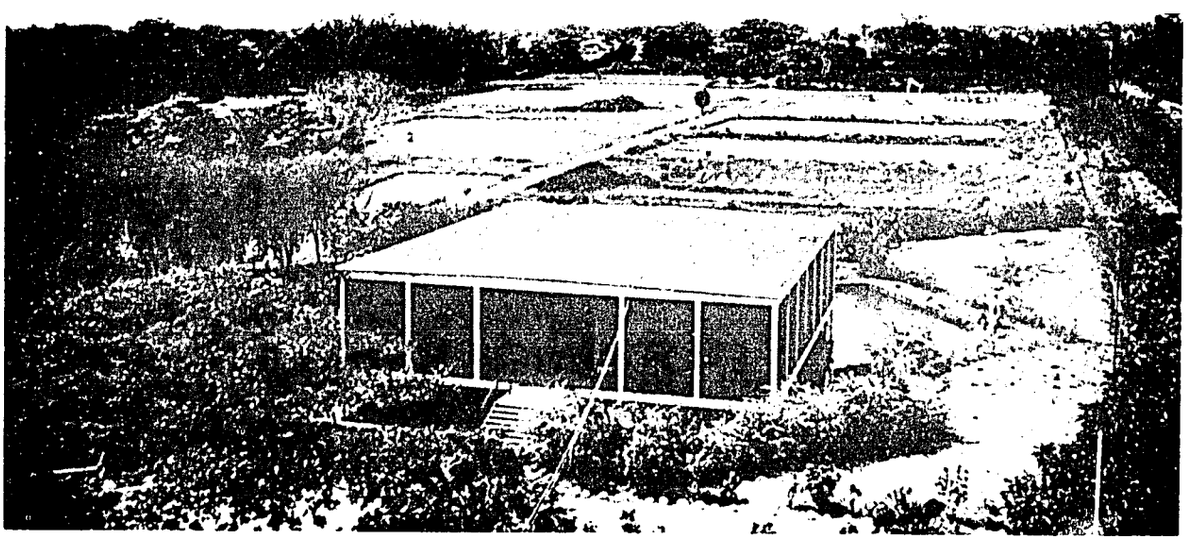


Figure 8. Shown above are production ponds at the Santa Cruz Porrillo Fisheries Station in process of renovation (February, 1971) to permit more effective utilization of the 5.6-hectare aquacultural facility. The Aquarium (foreground) houses 32 large display tanks for public exhibition of fishes.

Table 5. Data on air and water temperatures and rainfall at the Santa Cruz Porrillo Fisheries Station

Month	Air temperature*			Rainfall*	Water temperature**		
	Max. °C	Min. °C	Mean °C	mm	Max. °C	Min. °C	Mean °C
January	36	19	26	1	32	23	28
February	36	20	26	1	32	25	29
March	36	21	27	6	33	25	29
April	36	23	28	32	34	28	31
May	35	23	28	177	36	28	31
June	33	23	27	303	38	28	31
July	34	23	27	279	35	28	31
August	34	22	27	259	36	28	32
September	33	22	26	352	36	27	31
October	33	22	26	286	37	27	31
November	34	22	26	51	33	25	29
December	35	19	26	4	33	25	29
			Total	1,751			

*Almanaque Salvadoreno. 1971. Servicio Meteorologico Nacional. (air temperature and rainfall are from records gathered over a period of 20 years by Servicio Meteorologico Nacional, Ministerio De Agricultural Y Ganaderia, San Salvador.)

**Data are for the calendar year 1961 (Lin, 1963).

Apparently the Santa Cruz Porrillo Fisheries Station was constructed to serve a dual purpose for production of fingerlings and developing improved methods of producing food fish in farm ponds for human consumption. Success in attaining these goals has been less than spectacular, particularly in the latter effort. This has been due principally to: 1) inadequate number of trained fisheries technicians to carry out an effective program; 2) insufficient financial support for purchase of equipment and supplies necessary for operation and proper maintenance; and, 3) lack of an adequate number of experimental ponds suitable for replication of yield-trial experiments.

5.032 Existing Facilities

Physical facilities at Santa Cruz Porrillo Fisheries Station consist of two buildings, a water storage tank and 18 earthen ponds.

The Laboratory (3,200 sq. ft.) contains space that is presently being utilized as an office for the business officer, water chemistry laboratory, storage for feeds and equipment and living quarters for the Peace Corps Volunteer who is assisting in the aquacultural program.

The Aquarium (3,300 sq. ft.) contains 32 large, glass-fronted tanks that are utilized for display of live fish of various species. Also in the Aquarium are two large, rectangular concrete vats that may be used for holding larger numbers of fish for short periods.

To supply the station buildings with water, there is an elevated concrete tank with storage capacity of approximately 45 cubic meters (12,000 gallons)

and a shallow well. Water is supplied by gravity flow from a stream by means of an earthen canal. The canal, from the point of diversion, is 3 km in length; and it also supplies irrigation water to the adjacent Agricultural Experiment Station which is operated by the Ministry of Agriculture and Livestock.

5.033 Personnel

The work force at the station consists of 11 laborers, a foreman, 2 night watchmen and a skilled craftsman. In addition, there are the station administrator and a purchasing agent who handles the business affairs including acquisition of materials and supplies. The responsibility of planning and directing research programs and production of fingerlings is shared by the Head of the Fisheries Section and a Peace Corps Volunteer, with a Salvadoreno counterpart. The former, because of the responsibility of administering all inland fisheries programs in the country, has headquarters in San Salvador.

5.034 Work Program

The work program at the station consists principally of production of fingerlings for stocking farm ponds and natural waters and development of improved methods of fishculture.

The principal species cultured on the station include guapote tigre, tilapia blanco, tilapia negra and carpa (Cyprinus carpio). Photographs of the guapote and two tilapias are shown in Figures 10, 11 and 12.

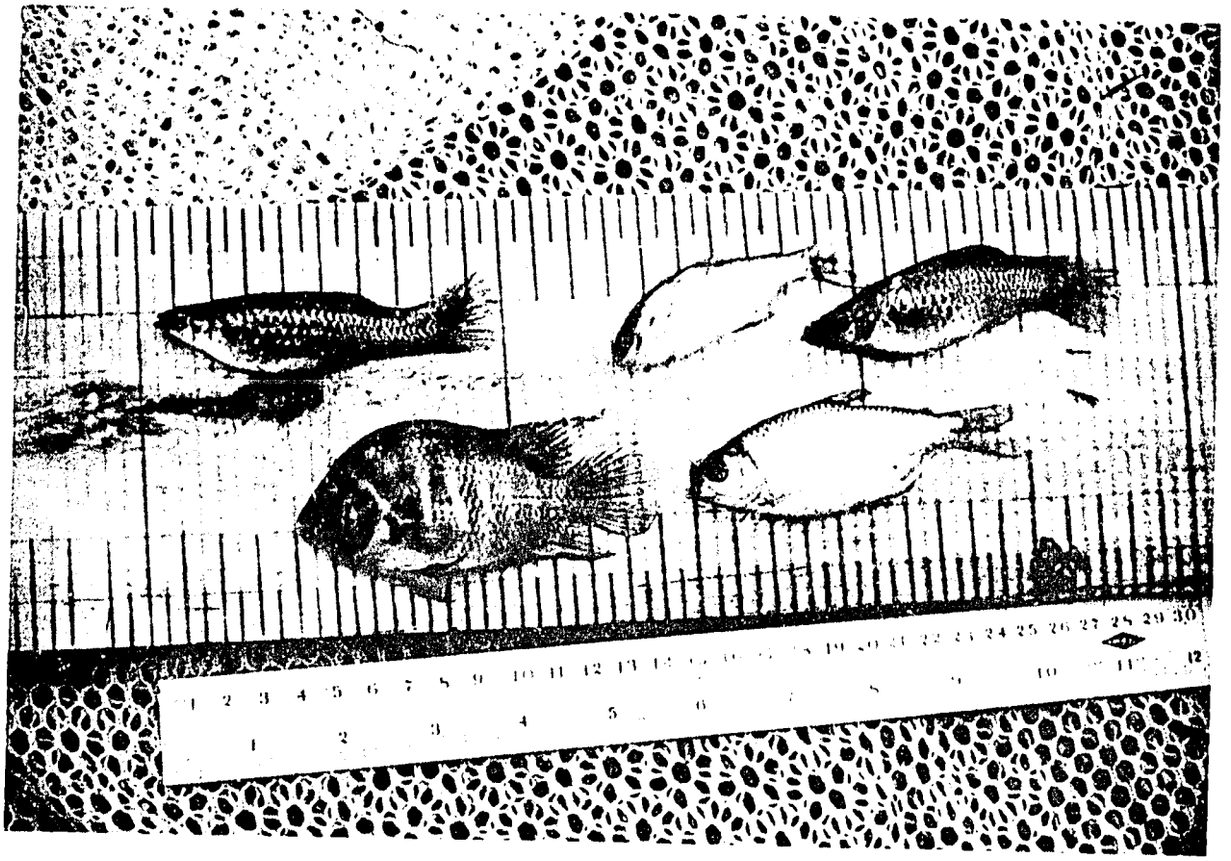
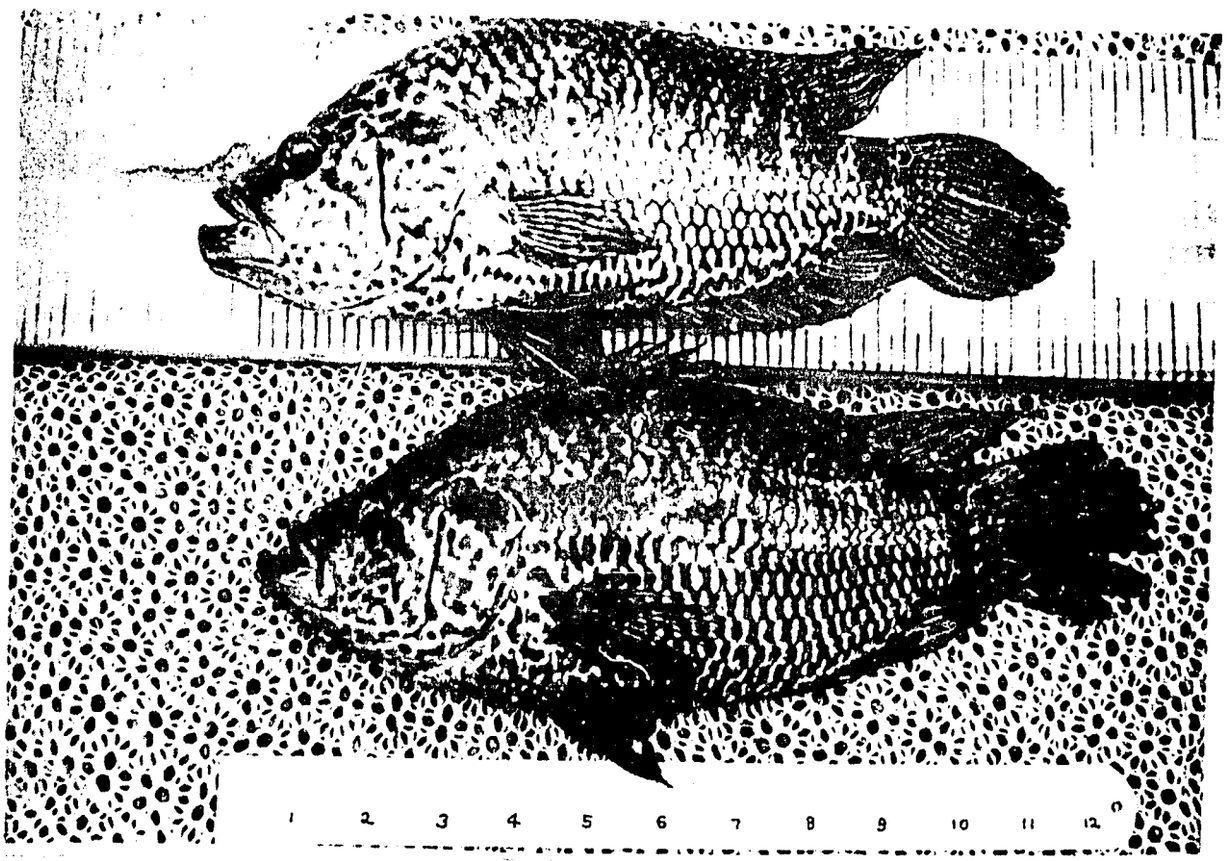


Figure 9. Photograph showing native fish species common to most natural waters in El Salvador. Largest fish is the burra, Cichlasoma nigrofasciatum; far left and far right are chimbolo, Poecilia sphenops; remaining are plateada, Astyanax fasciatus.

Figure 10. Photograph of the guapote tigre, Cichlasoma managuense, a highly carnivorous cichlid introduced from Nicaragua in 1959 and subsequently stocked in most of the larger natural lakes in El Salvador.



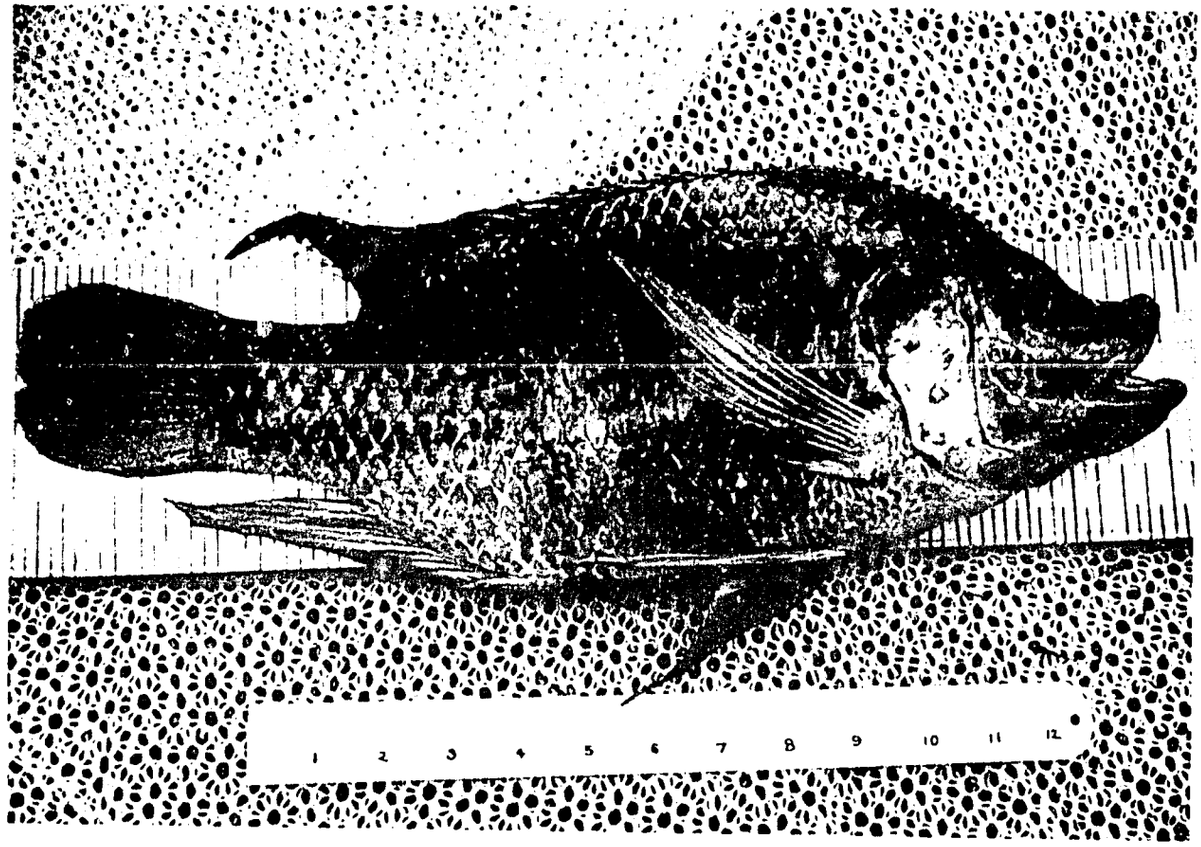
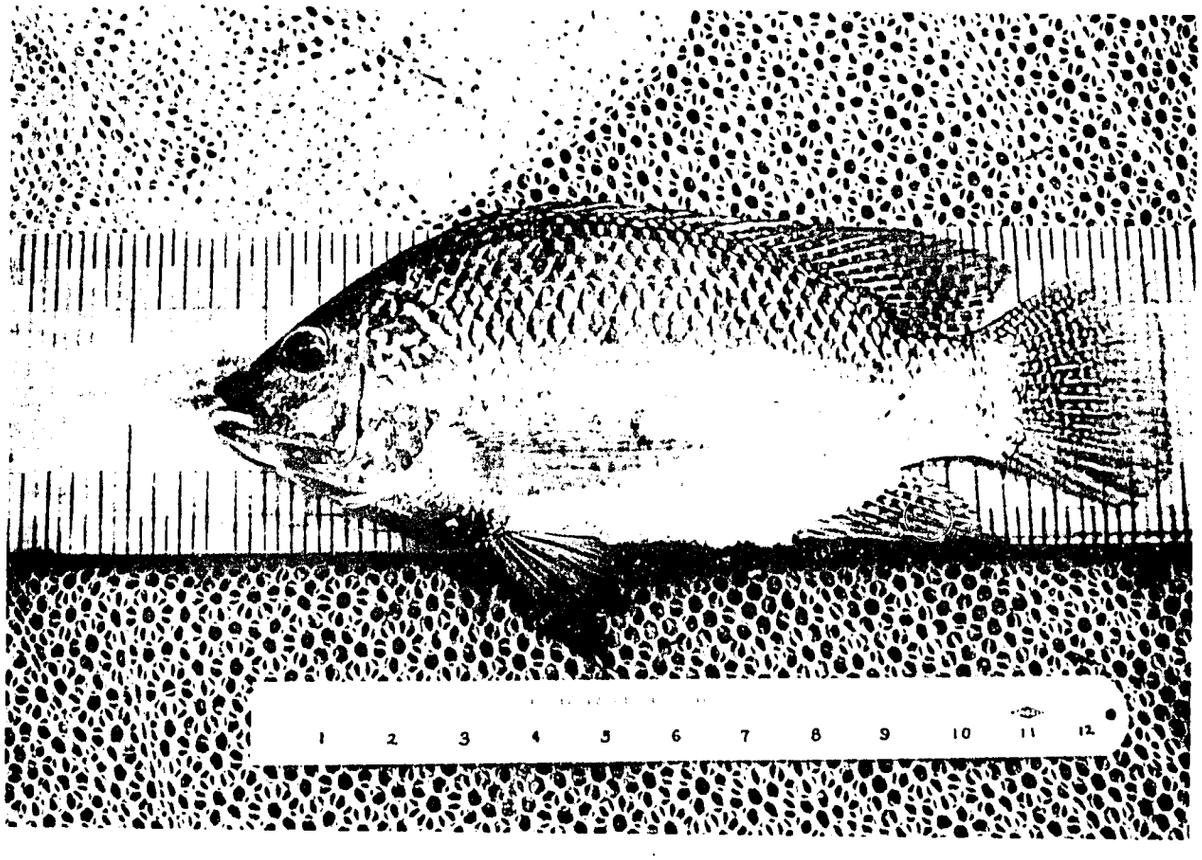


Figure 11. Photograph of tilapia negra, Tilapia mossambica, principal species propagated at Santa Cruz Porrillo Fisheries Station for distribution to farm ponds.

Figure 12. Photograph of tilapia blanco, Tilapia nilotica, another introduced species cultured at the Santa Cruz Porrillo Fisheries Station



Native fish species inhabiting the water supply canal and posing some problem in culturing preferred fish species, include the burra, plateada and chimbolo. These are shown in Figure 9.

Other fish species tested at the station in past years include mojarra azul, imported from Lake Amatillan, Guatemala, in 1958, and the lobina negra or largemouth bass. Early research with mojarra azul, carpa and lobina negra indicated these species had limited potential for culture due to slow growth or because of limited spawning success.

Tilapia negra is the principal species cultured at the station. It was estimated that from 3,000 to 5,000 fingerlings of this species were given to farmers coming to the station during the period November, 1970, to February, 1971. A total of 183,325 fingerlings was produced from July, 1969, to June, 1970, and these were stocked in 10 rivers, 3 lakes and 62 ponds.

In intensive culture experiments carried out in 1970, it was reported that total production of approximately 6,000 kg/ha was attained with tilapia negra using wheat bran as a supplemental feed and chicken manure as fertilizer. Additional experiments are in progress in an attempt to determine optimum rates of feeding, production at different stocking densities and rate of conversion of feed to fish flesh for the tilapia and guapote tigre.

5.035 Improvements and Additional Facilities Needed

The Ministry of Agriculture and Livestock has initiated a program of renovation for the station. For example, dams of earthen ponds are being repaired, pond bottoms are being sloped to effect proper drainage, drain and

water supply lines are being repaired. Also certain of the larger ponds are being sub-divided to afford a greater number of experimental units.

The renovation program should be expanded to include needed repair of the Laboratory and Aquarium and provide an improved water supply to these buildings. Rusted screens and broken windows should be replaced in the Laboratory. Also, the roof should be repaired to prevent damage during rains; a new lighting system is needed for the chemistry laboratory. This room in particular should be air conditioned as it is the most logical place to use and store microscopes, balances and other equipment susceptible to damage by high humidity. Glass display tanks in the Aquarium should be repaired to prevent water leakage and an air compressor installed in order that tanks containing fish can be supplied with air. When the station was visited during the survey, the water storage tank contained less than one-third of a meter of water. Also, it was reported that water is frequently muddy. Apparently, the walls of the shallow well have caved in and this has resulted in reduced volume of water available for pumping to the elevated tank. This condition must be corrected before either the Laboratory or Aquarium can function effectively.

In addition to repairing existing buildings and improving water supply, basic laboratory and field equipment are needed to conduct the investigational projects on natural lakes, rivers and farm ponds throughout the country. The Laboratory, for example, is inadequately equipped for carrying out even the most basic analyses, such as dissolved oxygen concentration and pH, as required in aquacultural or other inland fisheries research. The single dissecting

microscope is useless due to corrosion of optics. The 10-year-old refrigerator is in need of complete overhaul or possible replacement. A hot water heater, purchased some years ago, never was installed. Supplies, such as nets, seines, buckets, scales, measuring boards, counting tables, and other items used routinely in aquacultural operations were in short supply, if available at all. Field equipment including a tractor, mower, trailer, truck with fish distribution unit, boat and trailer, also is needed. It is recommended that the U.S.A.I.D. Mission provide financial support for purchase of commodities that must be imported.

Existing earthen ponds are suitable for production of fingerlings. However, several of the present ponds were constructed so that one drains into another, while others have a single pipe line which is utilized both for filling and draining the ponds. Such ponds cannot be utilized to evaluate accurately the effects of fertilization, supplemental feeding, or methods of stocking upon fish production. Because of the lack of an adequate number of experimental ponds suitable for replication of experiments,it is recommended that a minimum of 32 additional earthen ponds, 0.05 hectare in size, and 30 concrete ponds, 10 to 20 square meters in surface area and 1 meter in depth, be constructed. Concrete ponds are useful in aquacultural research for holding broodfish for relatively short periods, selective breeding and hybridization work, hatching of eggs and rearing of fry, growth studies, and fish nutrition studies.

These facilities should be designed so that each earthen and concrete pond can be filled and drained individually at any time during the year and independently of all other ponds in the research facility.

A most urgent need for the station is an improved water supply. At present, water supplying the pond area is diverted a distance of 3 km by earthen canal from a stream. However, the fisheries station has access to the canal water only from 4:00 PM through the night since the adjacent Agricultural Experiment Station has first priority in utilizing the water for irrigation in crop research. Also, the canal water cannot be used at certain periods due to contamination with insecticides from cotton-spraying operations. Therefore, it is recommended that a deep well be drilled on the station to supply additional water for the Laboratory, Aquarium and ponds.

One additional building is required to increase effectiveness of the station. Particularly needed is a building for housing field equipment and other materials used in fisheries research. One section of the building should be partitioned to serve as a shop for construction and repair of equipment. The building also should include space for fish feed preparation and storage. A pelleting machine will be needed to produce fish feed from locally available agricultural by-products such as cottonseed meal, wheat bran and maize.

Ultimately, a cold-storage facility with a capacity for holding 2 to 4 tons of fish will be required if the aquacultural program is to be expanded to include fish marketing, distribution and processing. For this purpose, a prefabricated, cold storage room with compressor would be satisfactory and these are available in the United States at moderate cost.

The Government of El Salvador, through the Ministry of Agriculture and Livestock, already has taken positive steps to increase the staff of the Fisheries Section. In recent months, several new fisheries personnel have been employed.

Most are college graduates with majors in biology, but with no formal training in fisheries. Hence, these technicians must acquire knowledge in fisheries through experience gained in the field and by a self-study program.

It is proposed that an annual program of specialized instruction in various subject-matter areas in aquacultures and fisheries be carried out at the Santa Cruz Porrillo Fisheries Station under the auspices of the U.S.A.I.D. Mission. Staff from the International Center for Aquaculture, Auburn University, with specialties in many areas including: aquaculture, pond construction, fish feeds and nutrition, fish parasites and diseases, fish taxonomy, fish technology, water chemistry, limnology and fish population dynamics are available to participate in such a training program. It is envisioned that Peace Corps Volunteers associated with the inland fisheries project would assist in the program and also serve as interpreters. Also, it is recommended that two selected host-country fishery personnel be trained in aquaculture and fishery management at the International Center for Aquaculture, Auburn University.

The four Peace Corps Volunteers associated with various inland fisheries projects for the most part are college graduates with majors in fisheries. However, they had very little or no work experience prior to accepting assignments in El Salvador. It cannot be expected, therefore, that the Volunteers can contribute a great deal during their tour toward training of personnel of the host country.

Such training is absolutely essential for development of an effective and progressive inland fisheries program. Moreover, the Peace Corps Volunteers indicated a definite need for guidance and periodic consultations with more experienced fisheries biologists.

It is recommended, therefore, that the International Center for Aquaculture, Auburn University, through sponsorship of the U.S.A.I.D. Mission, provide a fisheries advisor to the Government of El Salvador for a two-year period. Also, several man-months of technical services should be provided in specialized areas of aquaculture and fisheries for an annual short-course training program. The resident fisheries advisor will have training and experience in both aquacultures and fisheries of natural waters. He will assist the Head of the Fisheries Section in planning and carrying out the inland fisheries program in El Salvador.

6.0 CONFERENCES

Republic of El Salvador Government

Sr. Francisco Lino Osequeda, Sub-Secretary, Ministerio De Agricultura Y Ganaderia

Ing. Ernesto Martinez Menendez, Director General, Direccion General De Recursos Naturales Renovables, Ministerio De Agricultura Y Ganaderia

Ing. Joaquin Guevara Moran, Sub-Director General, Direccion General De Recursos Naturales Renovables, Ministerio De Agricultura Y Ganaderia

Ing. Jose Lazo Paz, Jefe, Departamento De Forestal Y Piscicola, Direccion General De Recursos Naturales Renovables, Ministerio De Agricultura Y Ganaderia

Sr. Hector Enrique Hinds, Jefe, Picicola Seccion, Departamento De Forestal Y Picicola, Direccion General De Recursos Naturales Renovables, Ministerio De Agricultura Y Ganaderia

Ing. Carol Ventura Montenegro, Jefe, Servicio E Investigaciones Hidrologicas, Departamento De Forestal Y Piscicola, Direccion General De Recursos Naturales Renovables, Ministerio De Agricultura Y Ganaderia

Ing. Francisco E. Granadino, Superintendente General, Comision Ejecutiva Hidroelectrica Del Rio Lempa

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7.0 REFERENCES

Anon. 1969. Projections of supply and demand for selected agricultural products in Central America through 1980. Battele Memorial Institute. 261 p.

Armitage, Kenneth B. 1953. Lagos volcanicos de El Salvador. Kansas University, Lawrence, Kansas. 15 p.

Chavarria, Hernan Romero. 1970. Investigation hidrologica de la cuenca del lago de Coatepeque. Unpublished thesis. Facultad de Ingenieria y Arquitectura, Universidad de el Salvador, San Salvador. December.

Food and Agriculture Organization of the United Nations. 1968. Yearbook of fishery statistics, catches and landings, 1967. Vol. 24, Rome. 408 p.

Food and Agriculture Organization of the United Nations. 1968. Yearbook of fishery statistics, fishery commodities. Vol. 25, 1967, Rome.

Johnson, K. L., and Antonio Argumedo. 1971. The fishery of Lake Coatepeque, El Salvador. A preliminary report. Ministry of Agriculture and Livestock, Division of Forestry and Fisheries, San Salvador, 1971. 13 p.

Lin, S. Y. 1963. Informe al Gobierno de El Salvador sobre un projecto de pesca continental. Basado en el trabajo. Rep. FAO/EPTA (1735): 27 p. Rome.

Ministerio de Agricultura y Ganaderia. 1970. Informe anual de labores: Julio de 1969 0 Junio de 1970. San Salvador, El Salvador.

Ministerio de Agricultura y Ganaderia. 1971. Almanaque Salvadoreno. Servicio Meteorologico Nacional, San Salvador, El Salvador.

Miller, Robert Rush. 1966. Geographical distribution of Central American freshwater fishes. Copeia, No. 4:773-802 p.

National Council on Marine Resources and Engineering Development. 1968. Marine sciences activities of the nations of Latin America. Washington, D. C. 76 p.

Robert R. Nathan Associates, Inc. 1969. Agricultural Sectoral Analysis for El Salvador. Prepared under contract for the Government of El Salvador and the U.S.A.I.D. Mission to El Salvador. 96 p.

U.S.A.I.D. 1970. Summary of Basic Data for El Salvador, A.I.D. (PPC/SRD). 12 p. In A.I.D. Economic Data Book - Latin America - PB 190 286. U. S. Department of Commerce/National Bureau of Standards, Washington, D. C.

U. S. Department of Agriculture. 1964. Food balances for 24 countries of the western hemisphere, 1959-61. Economic Research Service. ERS Foreign 86. 23 p. Washington, D. C.