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Progress Report on Fisheries Development in El Salvador

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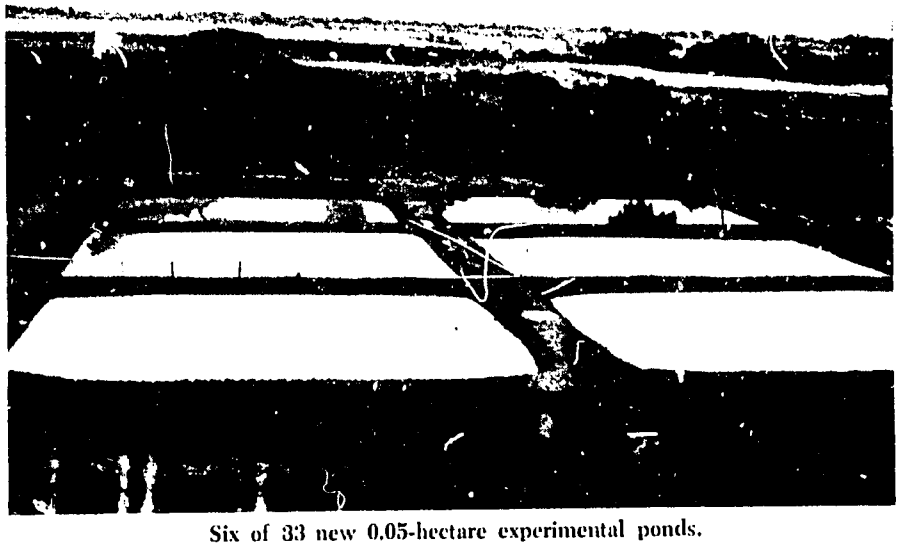
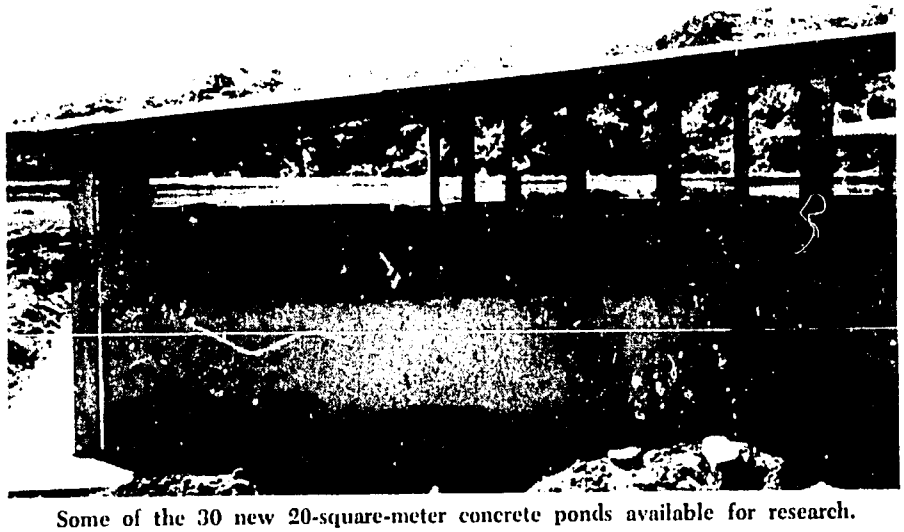
R. DENNIS ROUSE, Director AUBURN, ALABAMA

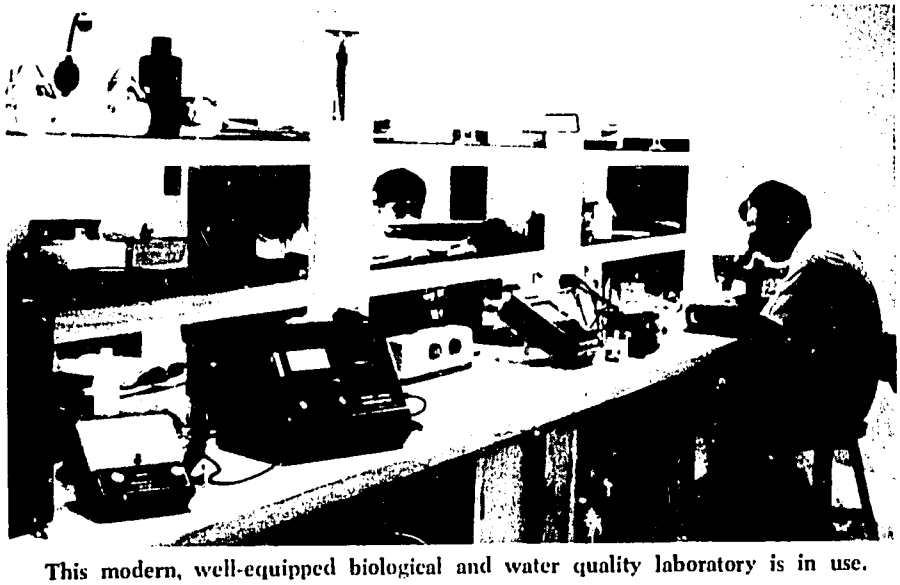
FACILITIES OF FISHERIES STATION, SANTA CRUZ, PORRILLO



Six of 33 new 0.05-hectare experimental ponds.



Some of the 30 new 20-square-meter concrete ponds available for research.



This modern, well-equipped biological and water quality laboratory is in use.

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COVER PHOTO. Laguna de Olomega, one of the five largest lakes in El Salvador and the most fertile of the five, contributes almost half of total fish production of the nation's large lakes.

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Progress Report on Fisheries Development in El Salvador

DAVID R. BAYNE*

INTRODUCTION

In February 1971, at the request of USAID Mission El Salvador, Dr. Donovan D. Moss, of the International Center for Aquaculture at Auburn University, conducted a survey of the inland fisheries of El Salvador. He was assisted by personnel of the Fisheries Section, Department of Forestry and Fisheries, Ministry of Agriculture and Livestock (MAG), El Salvador. Purpose of the survey was to review facilities and activities of the Fisheries Section and to determine if sufficient potential and need existed to justify accelerated development of inland fisheries and, if so, to recommend a program of inland fisheries development for El Salvador. Concluding that increased fish production could offer an abundance of relatively inexpensive, high quality animal protein to diets known to be deficient in animal protein, Moss[1] recommended the following:

1. Improvement and expansion of research facilities at the Fisheries Station located at Santa Cruz Porrillo so that an effective research program could be launched.
2. USAID Mission financial support for the purchase of laboratory and field equipment.
3. USAID Mission support in obtaining technical services from the International Center for Aquaculture in the form of a full-time resident fisheries advisor and short-term technical assistance.

Mission and USAID Washington acceptance of these recommendations resulted in Contract No. AID la-688, under which the author was employed as the resident fisheries advisor beginning January 1, 1972. Following Washington and on-campus orientation and Spanish language training in El Salvador, all efforts were devoted to coordinating and advising in the development of an effective inland fisheries program. Efforts were concentrated in the following work areas:

1. Renovation and expansion of research and supporting facilities at the Fisheries Station, Santa Cruz Porrillo.
2. Aquacultural research.
3. Aquacultural extension.
4. Investigations of the fisheries resources of major lakes and other natural waters of El Salvador.

STATUS OF THE FISHERIES PROJECT

Administration and Personnel

Anticipating increased emphasis to inland fisheries in the near future, the MAG administratively elevated the Fisheries Section to full departmental status January 1, 1972. This provided the Fisheries Department (since changed to Fisheries Service) a separate operating budget and a more efficient administrative alignment. At that time, there were six host-country technical personnel, none of whom had completed university degrees, four Peace Corps Volunteer biologists, and a supporting staff of two. During 1972-73, a biologist with an M.S. degree was appointed Head of the Fisheries Service, five new Salvadoran technicians (four with university degrees in biology) were hired, and two additional supporting staff were employed. Of the four Peace Corps Volunteers whose normal duty tours terminated in 1972, three were replaced and one extended for another year. The new volunteers all possessed B.S. degrees in fisheries and one had the M.S. in limnology. The Fisheries Service also contracted the full-time services of two civil engineers, a geologist, and a topographer to direct the site selection and construction of earthen ponds and related facilities both at the Fisheries Station and for the community fish pond development project.

Increased emphasis and support for the Fisheries Service has led also to increased responsibilities. In addition to inland waters, the Service has been charged with management and development of fishery resources of brackish and marine waters.

Financial Input

Financial support for the Inland Fisheries Development Project by the Government of El Salvador (GOES) was vastly improved during 1972 and 1973. Capital improvement funds allocated for the renovation of existing and construction of new facilities at the Santa Cruz Porrillo Fisheries Station are summarized as follows:

Year	*Funds budgeted by MAG*	*Project use*
1972 (Jan.)	¢ 15,000[1]	Construction of six earthen ponds and drilling of deep well
1972 (Dec.)	135,000	Additional pond construction, renovation of existing building, and construction of "wet lab"
1973 (Jan.)	119,000	Additional pond construction, construction of shop-warehouse-feedroom complex, drilling of second deep well
TOTAL	¢269,000 ($107,600)	

[1] One colon (¢) is equivalent to $0.40.

In addition to the capital improvement budget, the Fisheries Service operating budget was increased from ¢110,000 in 1972 to ¢227,000 for 1973. The approved budget for the 1974 fiscal year was ¢288,360. GOES has also initiated a community fish pond development project that calls for construction of 100 community owned and managed fish ponds throughout the country. The ponds are being constructed and technical assistance provided by the Fisheries Service.

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[1] Moss, D. D. 1971. Inland Fisheries Survey Report for El Salvador. Project: AID/csd-2270. International Center for Aquaculture, Auburn University, Auburn, Alabama.

An initial budget of ¢131,250 was appropriated for this project in 1973 and an additional ¢162,310 has been approved to continue this work in 1974. A special fund of ¢222,000 was appropriated for the investigation and inventory of all aquatic habitats, which was to begin in 1974.

Renovation and Construction at Fisheries Station

Renovation and expansion of research and supporting facilities at the Fisheries Station at Santa Cruz Porrillo are nearing completion. Progress in this area was extremely slow in 1972 due primarily to lack of funding. The ¢15,000 available in January 1972 was expended by June 1972, and the additional ¢135,000 that had been appropriated was not released until December 6, 1972. As a result, approximately 6 months' working time was lost. Progress during 1973 has been steady though not spectacular. The fact that only a minimum of heavy equipment was available, and this in generally poor condition, delayed completion of the 33 earthen ponds under construction.

Nineteen new 0.05-hectare earthen ponds have been completed and are in use. The remaining 14 ponds are nearing completion. Two deep wells have been drilled to provide an abundance of good quality water for these ponds, as well as for other facilities at the Station. The first well has been tested and found to yield in excess of 800 gallons per minute. Chemical analysis and bio-assay indicated excellent water quality.

Thirty concrete ponds, each having a surface area of 20 square meters and a depth of 1 meter, were constructed and are in use. These ponds greatly increase the number of experimental units available for research and provide area for holding fish, which frees more earthen ponds for research. Each pond can be filled and drained independently and is supplied with well water.

Two new buildings, a wet laboratory and a shop-warehouse-feedroom complex, are virtually complete. The wet laboratory contains small concrete holding tanks, aquaria, and facilities to maintain and culture eggs and fry of experimental animals. A small air-conditioned room provides laboratory working space within the building. The shop-warehouse-feedroom building contains offices, storage space, a workshop, and a fish feed preparation area.

Renovation of the existing office-laboratory building was completed. Necessary structural repairs were made, broken windows and damaged screens replaced, offices were partitioned, and the entire building was painted. Sanitary facilities were repaired and new sewage lines laid. The chemical/biological laboratory was completely refurbished, insulated, air-conditioned, and equipped. The electrical system for the entire Station was re-designed, with new lines and transformers provided to assure adequate electrical power to accommodate the increased demand. Night lights have been placed in strategic locations on the grounds to protect against theft.

Aquacultural Research

An active program of aquacultural research has been conducted at the Fisheries Station over the past 2 years. The program was designed to provide practical information to Salvadoran fish growers and to develop technology that would lead to increased production and profits.

Yield trials to compare production of two fish species (*Tilapia aurea* and *Tilapia mossambica*) were conducted under different test conditions at the Fisheries Station. The former consistently produced greater yields than the latter in ponds receiving organic and inorganic fertilizers. This was attributed to the higher growth rate of *T. aurea* females. Growth of males of the two species was approximately equal, and the males always attained a larger size than females of the same age. Growth of the originally stocked *Tilapia* in all trials ceased after approximately 3 months, indicating that pond carrying capacity was being approached.

Research was begun to systematically evaluate the culture potential of native species of aquatic organisms. Results with the most popular freshwater food fish, mojarra negra (*Cichlasoma macracanthus*), eliminated it as a possible culture species for El Salvador. In replicated fertilized pond trials, the fish grew slowly, reproduced prolifically at an early age, and total annual production was extremely low (440 kilograms per hectare). In progress are earthen pond trials with five other fish species, juilin (*Rhamdia guatemalensis*), guapote pando (*Cichlasoma motaguense*), tepemichin (*Agonostomus monticola*), mullet (*Mugil cephalus*), and the bagre (*Arius guatemalensis*), as well as with freshwater crustaceans, crab (*Pseudothelphusa magna*), and shrimp (*Macrobrachium tenellum* and *Macrobrachium americanum*).

Tilapia have been successfully cultured in 0.01-hectare fish pens and in 1-cubic-meter fish cages. Using these techniques permits intensive culture of fish in natural waters and in man-made ponds and reservoirs that are generally considered difficult to manage. Annual yields in excess of 12,000 kilograms per hectare in pens receiving a pelleted feed and 4,000 kilograms per hectare in pens receiving only fertilizer were obtained in trials at the Fisheries Station.

A pelleted supplementary feed containing coffee pulp, an inexpensive, commonly available by-product of the coffee industry, is being evaluated for use with *T. aurea* in cages, pens, concrete pools, and earthen ponds. The feed ingredients include:

Ingredient	*Percentage*
Coffee pulp	30
Corn meal	24
Molasses	20
Cottonseed meal	14
Wheat bran	10
Bone meal	1
Urea	1

All of these ingredients are readily available and the low cost of coffee pulp results in a total feed cost of only $1.72 (¢4.30) per 100 pounds. Although the ration contained only 21 per cent total protein and no animal protein, high annual yields (4,025-12,504 kilograms per hectare of pen) of *T. aurea* have been obtained in replicated fish pen trials, Table 1. At a stocking rate of 400 *T. aurea* per 100-square-meter pen, feeding the supplementary ration more than doubled production of treatments not receiving the ration. A feed cost of $0.067 (¢0.17) to produce each additional pound of fish proved to be both economical and practical.

In research to determine the most desirable fingerling stocking rate of *T. aurea* when cultured alone, rates of 5,000, 10,000, and 15,000 fingerlings per hectare were tested in fertilized ponds for a 4-month period. Both total yield and yield of marketable sized fish (14 centimeters and larger) were used as criteria to judge which of the rates should be recommended. Highest average total production per year, 3,249 kilograms per hectare, was realized at the 15,000 rate. The rate of 10,000 fingerlings per hectare produced only 1,943 kilograms per hectare per year; however, it yielded the highest percentage of marketable sized fish (85 per cent)

TABLE 1. RESULTS OF FEEDING TRIALS CONDUCTED IN 100-CUBIC-METER FISH PENS WITH *Tilapia aurea* RECEIVING A 21 PER CENT PROTEIN, PELLETED RATION CONTAINING 30 PER CENT COFFEE PULP

Treatment	Feed used	Fish stocked	Replicates	Survival of stocked fish	Duration of trial	Av. net gain per stocked fish	Projected total fish production/ha./yr.[1]	Food conversions	Av. cost for each add. lb. of fed fish[2]	
		No.	*No.*	*Pct.*	*Days*	*g.*	*Kg.*		*$*	*¢*
1	Ch. manure	300	2	66	156	83	3,600	3.25		
2	Pellet	300	2	56	150	124	4,025	3.70	0.2743	0.6857
3	Pellet	400	2	100	160	102	9,982	2.29	0.0672	0.1680
4	Pellet	600	2	100	160	90	12,504	2.85	0.0655[3]	0.1637
Control	None	300	2	47	156	77	2,790			
Control	None	400	1	97	160	48	4,124			
Control	None	600	1	18	160	65	1,536			

[1] Projected yield based on 351 growing days.
[2] Based on a feed cost of ¢4.30 per 100 pounds.
[3] Based on estimated production in control with 600 fish.
Note: Market value of fish at pond site was ¢0.40 per pound.

TABLE 2. COSTS AND RETURNS OF FISH PRODUCTION IN EL SALVADOR[1]

Cost or return item	Amount	
	¢	$
Initial costs		
Estimated cost of construction (1.5-ha. pond)	8,000.00	3,200.00
Seine net (locally made)	300.00	120.00
Containers for transporting fish	50.00	20.00
TOTAL	8,350.00	3,340.00
Fixed annual costs		
Amortization of pond construction (20 years)	400.00	160.00
Amortization of seine nets and other equipment (5 years)	70.00	28.00
TOTAL	470.00	188.00
Costs of production		
Fingerlings, 15,000 @ ¢0.015	225.00	90.00
Fertilizer		
Chicken manure, 15,185 lb. @ ¢0.03/lb.	456.00	182.40
$(NH_4)_2SO_4$, 66 lb. superphosphate	11.00	4.40
Labor, ¢2.63/day/man		
Stocking	118.00	47.20
Fertilizing	24.00	9.60
Sampling	37.00	14.80
Harvesting and marketing	108.00	43.20
Repairing of the pond	168.00	67.20
TOTAL	1,147.00	458.80
Annual gross return		
7,772 lb. @ ¢0.40/lb.	3,109.00	1,243.60
737 lb. @ ¢0.20/lb.	147.00	58.80
TOTAL	3,256.00	1,302.40
Annual gross return	3,256.00	1,302.40
Fixed annual costs	470.00	188.00
Annual costs of production	1,147.00	458.80
Annual net profit	1,639.00	655.60
EQUIVALENT TO: ¢1,092.00 = $436.08/ha./year or $177/acre/year		

[1] Based on the production of male *Tilapia* and guapote tigre culture during 6 months in a 1.5-hectare pond located at the Fisheries Station, Santa Cruz Porrillo, 1972-73.

and the largest total quantity of marketable sized fish (1,650 kilograms).

Some ponds at the Fisheries Station were managed as commercial production units to gain insight into routine problems and to test alternative systems of management, such as total harvest versus partial harvest. One large pond was managed for commercial production to obtain information on production costs and returns on investment. It was stocked per hectare with 10,000 male *Tilapia* and 5,000 guapote tigre, *Cichlasoma managuense*, and received daily applications of chicken manure (10-20 kilograms per hectare). Total annual fish production was in excess of 3,000 kilograms per hectare, and over 1.5 tons of fish were sold to people coming to the Fisheries Station within a 3-day period. An economic analysis of this trial is presented in Table 2.

One of the most serious problems encountered in *Tilapia* culture is overcrowding of the population because of early, prolific, and frequent reproduction of these fish. A solution to this problem has been the stocking of a predatory fish in combination with the *Tilapia* to control the number of young surviving. The piscivorous guapote tigre, *C. managuense*, was found to be excellent for this purpose. Subsequently, research was done to determine which stocking rates and ratios of *Tilapia* and guapote tigre yielded the highest production and greatest profits in fertilized as well as fertilized and fed earthen ponds. Preliminary results indicated that, in ponds receiving the supplementary ration with 30 per cent coffee pulp, stocking rates of 12,000 *Tilapia* per hectare at a *Tilapia* to tigre ratio of 4:1 were most productive, Table 3. This stocking produced greatest total yield (3,864 kilograms per hectare per year) and the highest annual yield of marketable sized fish (3,526 kilograms per hectare).

TABLE 3. PRELIMINARY RESULTS OF TRIALS IN PONDS RECEIVING FERTILIZER AND FEED CONDUCTED TO DETERMINE MOST DESIRABLE STOCKING RATES AND STOCKING RATIOS FOR *Tilapia aurea* AND GUAPOTE TIGRE COMBINATIONS

Treatment	Tilapia stocking rate/ha.	Tilapia:tigre stocking ratio	Duration of trial	Replicates	Projected production per hectare per year		Av. size of orig. stocked fish	"S" food conversion
					Net[1]	Net marketable[1]		
	No.		*Days*	*No.*	*Kg.*	*Kg.*	*g.*	
1	6,000	4:1	150	1	2,545	2,148	121	1.8
2	9,000	4:1	150	1	3,738	3,277	138	1.9
3	12,000	4:1	150	1	3,864	3,526	126	2.3
4	6,000	8:1	150	1	2,959	1,980	108	1.6
5	9,000	8:1	150	1	3,630	2,546	104	1.8
6	12,000	8:1	150	1	3,280	2,773	102	2.4

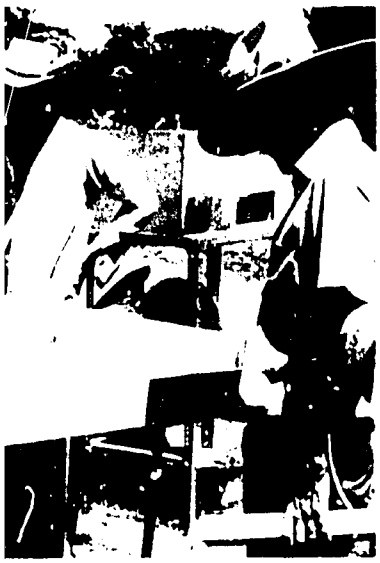
[1] Projected production based on 365 growing days.

ABOVE. The small catfish, *Rhamdia guatemalensis*, grew well in pond trials at the Fisheries Station and may prove valuable in mixed cultures with Tilapia. Further research is needed to develop spawning techniques.

BELOW. Research with cubic meter cages (shown) and 100-cubic-meter fish pens evaluated the feasibility of using these enclosures in natural waters of El Salvador.

ABOVE. The freshwater shrimp, *Macrobrachium tenellum*, grows well in ponds, but more research is needed so that it can be successfully spawned and reared in captivity.

RIGHT. Practical and inexpensive fish smokers like this were used in experiments aimed at finding alternative methods of fish preservation for small producers and artisan fishermen.



ABOVE. This counting table, constructed at the Fisheries Station, greatly facilitated the orderly collection and processing of data from research pond sampling and harvesting.

ABOVE. Fisheries Service biologists collected vital fishery statistics at sites where lake fishermen sold their catch. Cast net fishermen of the reservoir La Presa 5 de Noviembre were always happy to cooperate.

BELOW. Research was done to find effective, practical, and economical means of controlling aquatic weeds like the water hyacinth, *Eichhornia crassipes*, which pose a serious problem to many lake fisheries.

Another method of controlling reproduction of *Tilapia* is the use of all male hybrid fish. Certain crosses of different *Tilapia* species yield only male offspring. Not only are these fish unable to reproduce, but faster growth of male *Tilapia* compared to the female is an added advantage. The Fisheries Station will soon acquire from Brazil stocks of *Tilapia honorum* and *Tilapia nilotica*, which produce the all-male hybrid there. Hybrid culture will surely add a new dimension to fish culture in El Salvador.

Aquacultural Extension

Promotion of fish culture throughout the country is an essential step in the future development of an effective inland fisheries program, and ultimate success will depend on how soon and how well this can be accomplished. Because of this need, considerable efforts have been spent over the past 2 years to establish a fisheries extension capability within the MAG. Progress has been slow, however, due primarily to the following factors:

1. The type of fish culture being promoted is new to El Salvador. There is no tradition within the existing Agricultural Extension Service for offering the type of technical assistance needed, and there had been no training available to extension personnel or students of agriculture.

2. Although aquaculture is similar in many ways to more traditional forms of agriculture, the aquatic environment offers some unique problems not encountered in terrestrial culture.

3. The inability and unwillingness of the Agricultural Extension Service of MAG in the early stages of the project to accept the responsibility for fish cultural promotion and extension was a complicating factor, as was the fact that the Fisheries Service was prohibited from providing this service.

A farm pond evaluation study on the current status of fish culture and the needs that exist was conducted to provide information in the following areas:

1. Number, size, location, condition, and current use of all existing farm ponds in El Salvador.

2. Fish species being used and management practices employed.

3. Major problems limiting fish production.

4. An estimate of actual annual production.

5. An estimate of potential annual production based on production obtained in selected farm ponds that were stocked, managed, and harvested by biologists of the Service.

6. Processing and marketing techniques employed.

Results of this study emphasized the great need for a sound promotion and extension program. The 450 farm ponds in the study had a combined surface area of 53 hectares, yet only 10 per cent of the area was being utilized to produce crops of fish. The annual production from these waters was estimated to be less than 7,000 kilograms. Owners of almost half of the unused ponds expressed strong interest in fish culture but lacked the knowledge of how to pursue it. If promotion efforts could get only 40 hectares of the existing 53 brought into production, annual yield could easily rise to 140,000 kilograms. This 20-fold increase in production assumes the construction of no additional ponds and no improvements in culture techniques.

In addition to the farm pond evaluation study and the research program underway at the Fisheries Station, other studies have sought information related to commercial and subsistence pond fish production. Most fish are marketed in a fresh state, being captured or produced close to consumer markets. Fortunately, El Salvador is small and densely populated so this system is practical in a large number of cases. Aside from frozen fish that appear exclusively in the few supermarkets of the country, salting and sun-drying is the only method being used to process fish for delayed sale. Studies were conducted to determine if smoking of fish would be practical and economical in El Salvador, and if the product would be acceptable to consumers. Improvised fish smokers were demonstrated in several fish producing areas and attracted a great deal of attention.

Anticipating problems that might arise as a result of increased pond fish production, the Fisheries Service has initiated a country-wide fish marketing survey. Information is being gathered on:

1. Actual and potential demand for fish and fish products.
2. Sources and quantities of fish sold throughout the country.
3. Seasonal fluctuations in supply and demand.
4. Geographical distribution of fish markets and products.
5. Problems encountered in the marketing system.
6. Price structure of the fish market and seasonal variations in fish prices.

In addition to other valuable information, this study revealed that El Salvador was not meeting the domestic demand for fish and has been importing salted and dried fish in considerable quantities from both Nicaragua and Guatemala.

Compiling all pertinent information gathered over the past 2 years of research and study, members of the Fisheries Service have prepared a "Manual of Fish Culture" for El Salvador. Designed to provide practical and specific information on pond culture of fishes to Salvadoran growers, the manual contains sections on the importance of fish culture, pond construction, pond management, biology of culture species, processing and marketing, and the possibilities of forming owner cooperatives. Two other shorter publications also were prepared to assist in the extension effort.

The Agricultural Extension Service, which comprises a Department within a completely separate division of the MAG, has an extensive network of field offices throughout the country. Short courses, demonstrations, and workshops have been conducted by Fisheries Service personnel for the benefit of the extension agents. Short courses and demonstrations have also been presented to students of the National Agricultural School where a large majority of the future extension agents study. Present plans call for similar training to be offered to technicians of FOCCO, one of the country's largest community development organizations.

In cooperation with the U.S. Peace Corps, the Fisheries Service assisted in the construction and management of a demonstration fish pond on a model farm in the northern sector of the country. In October 1973, approximately 800 farmers from surrounding areas visited the demonstration pond while attending a field day sponsored by the Peace Corps. Written and oral information concerning fish culture were presented to the farm group.

The most encouraging development within the past 2 years concerning promotion of fish culture has been the commitment by MAG to establish two fish cultural specialist positions within the Agricultural Extension Service beginning in 1974. In addition, Fisheries Service personnel will be allowed to conduct extension activities and to provide technical assistance directly to pond owners who request it. A planned training program for the new extension specialists

will include in-country orientation and study, as well as exposure to a successful commercial, hybrid *Tilapia* operation at the Cantonal Agricultural Center, Turrialba, Costa Rica.

Lake Fisheries

Major natural and artificial lakes of El Salvador have been studied over the past 3 years. This series of studies was designed to provide data needed to manage each lake's fisheries so that the maximum sustained yield of aquatic organisms could be harvested by the local artisan fishermen. Studies carried out in 1971-72 were aimed primarily at gathering fisheries statistics. In 1973, emphasis was shifted to include studies on the limnology and fisheries biology of each area. Both studies included the five largest lakes of El Salvador: Lake Ilopango (70 square kilometers), Lake Guija (42 square kilometers), Lake Coatepeque (25 square kilometers), Lake Olomega (24.2 square kilometers), and the reservoir La Presa 5 de Noviembre (20 square kilometers). Smaller areas receiving attention were Laguna Verde (7.5 hectares), El Espino (100 hectares), Chalchuapa (5 hectares), Laguna de Metapan (312 hectares), and Laguna de Jocotal (110 hectares).

The gathering of fisheries statistics during 1971-72 usually included two, 1-month visits to each lake, one during the dry season and the other during the wet season. Smaller lakes were visited only once, and the duration depended on size of the lake and complexity of the existing fishery. Major objectives of the work were to:

1. Estimate total harvest of each lake in 1972.
2. Determine average length, average weight, and percentage by weight of each species in the catch.
3. Evaluate various fishing techniques and types of gear and determine catch per unit effort and fish size distribution with the gear being used by local fishermen.
4. Gather information on fish processing and marketing and estimate market value of catch.
5. Establish a census on each lake, with selected professional fishermen paid to collect and record catch data each month.

Formal reports have been prepared for each lake and selected portions of the information have been published. Tables 4 and 5 summarize some of the more interesting information resulting from these studies. Estimated annual pro-

TABLE 4. ESTIMATED ANNUAL CATCH, ESTIMATED VALUE OF CATCH, AND CATCH COMPOSITION FOR THE FIVE LARGEST LAKES OF EL SALVADOR

Lake and year	Surface area	Estimated total annual catch	Estimated catch/ha./yr.	Estimated value of catch: Total value		Estimated value of catch: Value/hectare		Catch composition by weight
	Ha.	*Kg.*	*Kg.*	*$*	*¢*	*$*	*¢*	*Per cent*
Ilopango[1] 1958	7,052	130,400	18.49	38,640	86,600	5.48	13.70	cichlids (86), sardine (14)[2]
Ilopango 1971	7,052	107,304	15.22	59,054	147,635	8.37	20.92	cichlids (95), catfish (3)[3], sardine (2)
Olomega 1971	2,420	470,908	194.60	100,317	250,792	41.45	103.62	cichlids (42), sardine (41), catfish (17)
Olomega 1972	2,420	524,166	216.60	67,933	169,832	28.07	70.17	catfish (54), cichlids (25), sardine (20)
Guija 1971	2,940	259,014	88.2	51,938	129,845	17.67	44.17	catfish (58), cichlids, sardine
Guija 1972	2,940	194,040	66.0	53,083	132,707	18.06	45.15	catfish (55), cichlids, sardine
Coatepeque 1971	2,500	113,517	45.4	40,379	100,947	16.15	40.37	cichlids (86), freshwater crab (13)
Coatepeque 1972	2,500	199,872	79.9	79,531	198,827	31.82	79.55	cichlids (93), freshwater crab (6)
5 de Nov., 1972	1,600	121,872	76.2	32,457	81,142	10.18	25.45	catfish (52), cichlids (38)

[1] Lin (1958).
[2] Group includes primarily *Astyanax fasciatus* and *Mollienesia sphenops*.
[3] Group includes *Rhamdia guatemalensis*, *Arius guatemalensis* and *Arius taylori*.

TABLE 5. AQUATIC ORGANISMS ENCOUNTERED IN FIVE LARGEST LAKES OF EL SALVADOR BY YEAR (NUMERALS INDICATE POSITION OF ORGANISMS IN CATCH, PLUS OR MINUS INDICATES OCCURRENCE)

Scientific and common name	Coatepeque				Ilopango				Olomega		Guija			5 de Nov.	
	1924-56-71-72-73				1924-58-71-73				1957-72		1924-63-71-72			1924-72	
Cichlasoma dowii, ceba[1]	—	—	—	—	—	—	—	—	—	—	—	—	+	—	+
Cichlasoma guttulatum, mojarra azul[1]	—	—	2	2	—	—	—	—	—	—	—	—	—	—	—
Cichlasoma macracanthus, mojarra negra	—	—	—	—	—	1	2	+	+	+	—	—	3	+	2
Cichlasoma managuense, guapote tigre[1]	—	—	1	1	—	—	1	1	—	2	—	—	2	—	3
Cichlasoma meeki, mojarra	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—
Cichlasoma motaguense, guapote pando	1	+	+	+	1	—	—	+	—	—	+	—	—	—	—
Cichlasoma nigrofasciatum, burra	+	+	3	3	2	+	3	2	+	+	+	—	+	+	+
Cichlasoma trimaculatum, istatagua	+	+	—	—	—	2	6	3	+	+	—	+	—	+	+
Tilapia mossambica, tilapia negra[1]	—	—	—	—	—	—	4	+	—	+	—	—	—	—	+
Arius guatemalensis, bagre (catfish)	—	—	—	—	—	—	—	—	+	1	+	1	+	+	+
Arius taylori, wicho (catfish)	—	—	—	—	—	—	—	—	—	—	—	—	+	—	1
Rhamdia guatemalensis, juilin catfish	—	—	+	+	—	+	5	+	+	+	+	—	+	+	+
Astyanax fasciatus, sardina	—	—	+	+	—	+	8	+	+	3	+	—	+	+	+
Mollienesia sphenops, chimbola	+	+	+	+	3	+	7	+	+	4	+	—	+	+	+
Roeboides salvadoris, alma seca	—	—	—	—	—	+	+	—	+	—	+	—	·	—	—
Priapichthys letonal, chimbola	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—
Thyrina guija, monjuda	—	—	—	—	—	—	—	—	—	—	+	—	+	+	+
Poecilopsis salvadorus, chimbola	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—
Profundulus guatemalensis, chimbola	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—
Anableps dowii, cuatro ojos	—	—	—	—	—	—	—	—	+	—	+	—	+	+	+
Pseudothelphusa magna, cangrejo (crab)	—	—	—	+	—	—	—	—	—	—	—	—	—	+	+
Agonostomus monticola, tepemechin	—	—	—	—	—	—	—	—	—	—	+	—	—	+	—
Centropomis sp., robalo (snook)	—	—	—	—	—	—	—	—	—	—	+	—	—	+	—
Macrobrachium tenellum, camarones (shrimp)	—	—	—	+	—	—	—	—	—	—	—	—	—	+	+

[1] Introduced species.

duction was 1,109,934 kilograms and returns to fishermen were ¢702,302 ($288,121). It is noteworthy that Lake Olomega, the most fertile of the five, contributed almost half of the total production. This lake had a comparatively high annual yield per hectare of 206 kilograms. Only five fish species were common to all of the five lakes: two cichlids, *Cichlasoma nigrofasciatum* and *Cichlasoma managuense*, a small catfish, *Rhamdia guatemalensis*, a characid, *Astyanax fasciatus*, and the top minnow, *Mollienesia sphenops*. The piscivorous guapote tigre, *C. managuense*, is the only non-native species. It was introduced from Nicaragua in June 1958 and has since attained a prominent place in the commercial catch of each lake, Table 5.

Two lake survey teams began studies in 1973 to provide more information on the commercially important aquatic species, to gather more detailed data on the biological and physical characteristics of each lake, and to test and evaluate new types of fishing gear and capture techniques. This work will continue through 1974.

Growth of noxious aquatic plants in some lakes and reservoirs of El Salvador hampers, and in some cases completely eliminates, the fishery. The water hyacinth, *Eichhornia crassipes*, is the most serious pest. Research trials conducted in 1972-73 revealed that the use of 2,4-D amine at rates varying between 10 and 15 pounds per hectare was an effective and economical means of controlling this plant.

Information resulting from these studies and surveys is being used to better manage important aquatic resources. Presently under consideration is the first fisheries law ever, with jurisdiction over inland waters. Efforts are being made to incorporate new knowledge of the fisheries of each lake into this new law so that the fishery is adequately protected and wisely managed. Also as a direct outcome of the lake studies, the Fisheries Service has begun a carefully planned stocking program. Lake Olomega and Laguna de Jocotal were both found to have large plankton populations but lacked fish that could directly utilize this portion of the food chain. Monthly stocking of the plankton feeder, *Tilapia aurea*, in both lakes during 1973 has resulted in breeding populations of the fish. Objective of this stocking was to increase both total production and production of a more desirable commercial species.

Participant Training

The Head of the Fisheries Service, Jose E. Cabrero, although trained academically as a biologist and with considerable working experience in botany and plant physiology, had had no formal or practical training in fisheries. It was recommended that USAID El Salvador provide funds for him to participate in a study tour of the International Center for Aquaculture, Auburn University, and other selected fish culture research and training facilities. This would allow Mr. Cabrero, who has the responsibility for directing and administering the Inland Fisheries Project, to observe the various facets of an on-going aquacultural training and testing facility, and visit selected commercial food fish production operations. This training was carried out during May 1973.

In June 1973, Cesar Abrego Funes began study toward a B.S. degree in fisheries management at Auburn University. Mr. Abrego had had 2 years of study in biology at the University of El Salvador. He had served as a biologist and as the acting Head of the Fisheries Service.

Two additional candidates have been selected and approved for fishery training at Auburn University. Cecilio Garcia Ramirios, who will complete his B.S. degree at the University of El Salvador in May 1974, will enroll the following month at Auburn University to work toward an M.S. degree in fisheries. Mr. Ramirios worked as a biologist for the Fisheries Service for over 2 years and has been receiving intensive English training for the past 8 months. Mr. Cabrero, the Head of the Fisheries Service, will enroll in the Graduate School of Auburn University in March 1974, to study for the Ph.D. degree in fisheries management. At the time of his enrollment, Mr. Cabrero will have served as Head of the Service for over a year. He has had excellent training in biology and is fluent in English, having received both the B.S. and M.S. degrees at the University of New Hampshire. With the return of these and perhaps other trainees, El Salvador will have the trained technical personnel needed to carry out an effective and imaginative fisheries development program.

Peace Corps Participation

The assistance of the U.S. Peace Corps in providing volunteer biologists to work with Salvadoran counterparts in the Service has been an integral part of the development project. These volunteers bring technical knowledge, leadership ability, and initiative to the job. They have contributed significantly to the progress made over the past 2 years, and their continued participation is most desirable.

Short-Term Technical Assistance

A project review of the El Salvador Inland Fisheries Development Project was conducted February 3-10, 1973, by Dr. Moss, of the International Center for Aquaculture, Auburn University. Results and conclusions of this visit were reported that year.[2]

November 18, 1973, Dr. E. W. McCoy, an agricultural economist with the Agricultural Experiment Station, Auburn University, arrived to conduct a general economic analysis of Salvadoran inland fisheries with emphasis on fish culture. Results of this study have been published and distributed to USAID, El Salvador.[3]

USAID Equipment Grants

Laboratory and field equipment made available to the inland Fisheries Development Project through USAID equipment grants has greatly increased the technical capability and self sufficiency of the Fisheries Service. Little could have been accomplished without this important input.

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[2] Moss, D. D. and D. R. Bayne. 1973. Review of El Salvador Fisheries Project AID/la-688. International Center for Aquaculture, Auburn University, Auburn, Alabama.

[3] McCoy, E. W. 1974. Economic Analysis of the Inland Fisheries Project in El Salvador. International Center for Aquaculture, Auburn University, Auburn, Alabama.

Fisheries Publications

Although there has been some activity in the field of inland fisheries for approximately 25 years, few technical publications were available prior to 1971. Much of what is known of research and evaluation conducted earlier was passed along by word of mouth. Efforts have been made to establish regular channels for publishing important research findings and for distributing extension and promotion literature. The following have been published over the past 2 years of the project:

Extension Literature

SERVICIO PISCICOLA. 1973. Manual de Piscicultura. Direccion General del Recursos Naturales Renovable. Ministerio de Agricultura y Ganaderia. El Salvador.

SERVICIO PISCICOLA. 1973. Informacion general sobre algunos aspectos importantes para la piscicultura salvadorena. Direccion General de Recursos Naturales Renovables. Ministerio de Agricultura y Ganaderia. El Salvador.

SERVICIO PISCICOLA. 1973. Que es piscicultura en El Salvador? Direccion General de Recursos Naturales Renovables. Ministerio de Agricultura y Ganaderia. El Salvador.

Research Related Literature

SANCHEZ Y DOMINGUEZ, CARLOS. 1972. Embriologia del camaron del rio. Agricultura en El Salvador. 12(2):11-13.

BOWMAN, DAVID. 1972. Cultivo de la tilapia en agua dulce y salada. Agricultura en El Salvador. 12(2):24.

GARCIA RAMIRIOS, CECILIO. 1972. Investigacion sobre algas. Agricultura en El Salvador. 12(2):25.

JOHNSON, K., A. ARGUMEDO Y M. RAMIREZ HIDALGO. 1972. Evaluacion de los principales lagos de El Salvador. Agricultura en El Salvador. 12(2):26-32.

RAMIRIOS, C. G. AND D. R. BAYNE. 1973. Cultivo de *Tilapia aurea* (Steindachner) en corrales de 100 m², alimentado artificialmente con gallinaza y un alimento preparado con 30% pulpa de cafe. Servicio Piscicola. Direccion General de Recursos Naturales Renovables. Ministerio de Agricultura y Ganaderia. El Salvador.

BAYNE, D. R. AND E. C. BUTTER. 1973. Un metodo practico y economico para el control quimico de jacinto de agua, *Eichhornia crassipes* (Mart.) en El Salvador. Servicio Piscicola. Direccion General de Recursos Naturales Renovables. Ministerio de Agricultura y Ganaderia. El Salvador.

BOWMAN, DAVID. 1973. Comparacion entre *Tilapia aurea* (Steindachner) y *Tilapia mossambica* Peters como peces de estanque en El Salvador. Servicio Piscicola, Direccion General de Recursos Naturales Renovables. Ministerio de Agricultura y Ganaderia. El Salvador.