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The Development of Commercial Farming of Tilapia in Jamaica 1979-1983

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BACKGROUND

A COMMON REACTION to the idea of commercial fish farming in Jamaica is to question its appropriateness in a small country surrounded by the sea. This island, however, has long been a heavy importer of fish. The clear inshore waters so attractive to tourists do not support a large marine capture fishery, and many of the productive offshore fishing grounds near Central and South American countries have been lost because of expanded territorial claims by many of these countries. From 1973 to 1978, Jamaica, with a total population of approximately 2 million people, annually imported an average of 15,000 metric tons of fish. Imports would likely have been even higher if foreign exchange had not been limiting. Thus, an economically viable, local fish farming industry becomes more attractive.

Tilapia (*Oreochromis*) *mossambica*, locally known as the African perch, was introduced to Jamaica in 1949. It flourished in irrigation canals, and a low-input subsistence level of management was attempted in a few small ponds. By 1977, a small hatchery and research facility were constructed, but the viability of commercial tilapia farming had not been demonstrated. In that year Auburn University was awarded a technical assistance contract (AID/la-C-1166) for a USAID-sponsored Fisheries Development Project (532-0038), with Ken Randolph serving as Auburn's first resident advisor in Jamaica. Project objectives were to evaluate the economic potential of commercial fish culture in Jamaica and to increase Jamaica's institutional capacity to implement a fish production program. An existing 16-pond complex, with approximately 10 hectares of water, was acquired at the beginning of the project. Upgrading and expansion to 32 hectares were begun concurrently with the first production trials with monosex (male) *Tilapia mossambica* fed a commercial poultry ration. During the period of 1978 to 1979, more then 50 tons of food-fish were produced at this farm and marketed mainly through the government-owned Agricultural Marketing Corporation.

Because of the high production and the promising economic analysis of the management system, a follow-up project (532-0059), jointly funded by the Government of Jamaica and the USAID, was begun in late 1979 to stimulate the development of warmwater fish culture in the private sector. The following sections describe the growth of commercial farming of tilapia during the first 4 years of that project.

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PRINCIPAL GOAL AND INPUTS OF THE PROJECT

Goal

The basic goal of the project was to increase food-fish production throughout the country, primarily through extension support to private producers. Founded on a training program for participating farmers, extension agents, and professional aquaculturists, production targets for end-of-project (August 1984) were 600 participating farmers producing 545 metric tons annually from 232 hectares of ponds. Approximately 80 percent of the farmers and 20 percent of the production should be from small-scale farms, each with less than 4 hectares of arable land.

Inputs

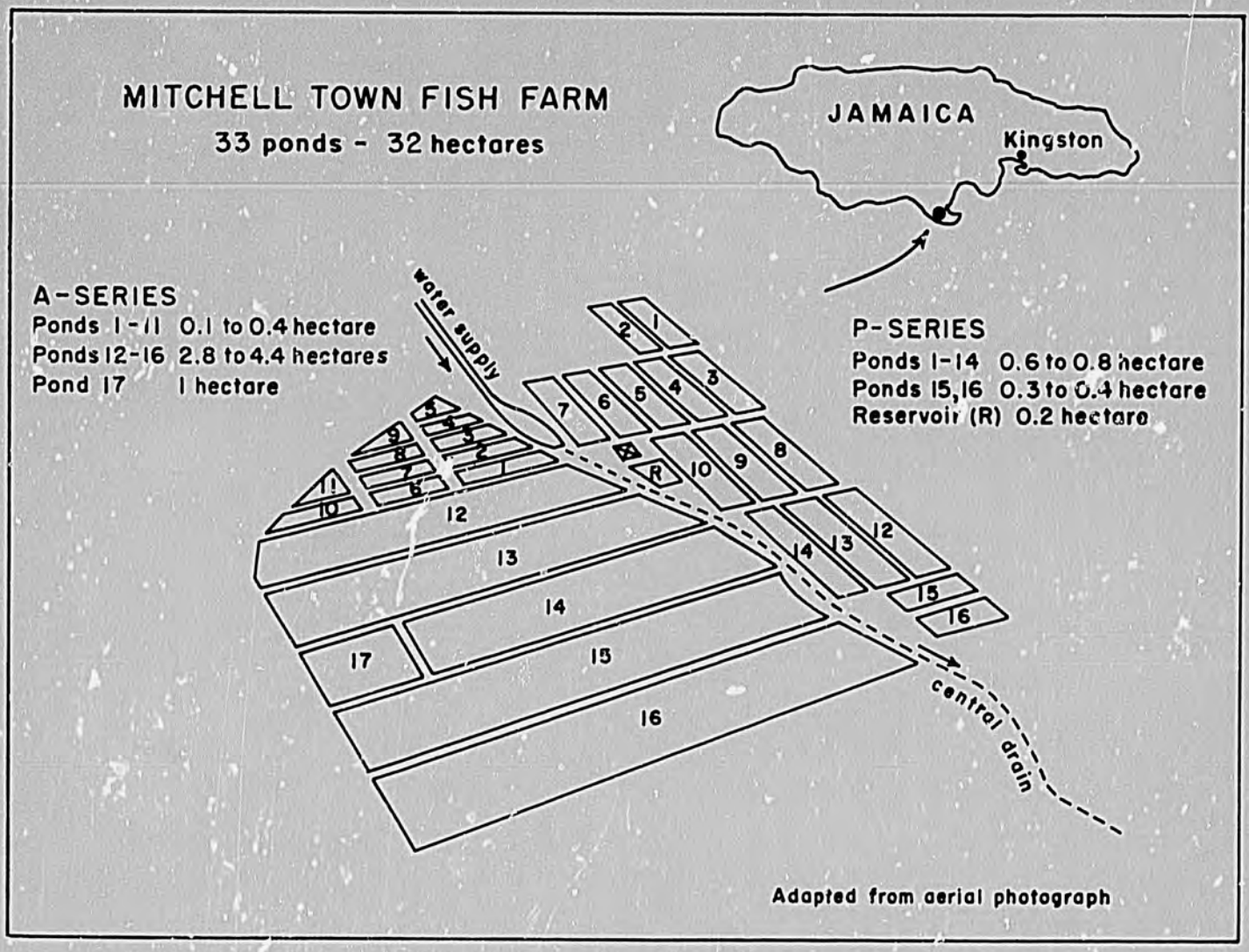
Funding. Total financial obligations for the 5-year project were nearly US$9 million, 54 percent of which was funded directly by the Government of Jamaica, with the remainder being financed via loan and grant agreements with the USAID.

Jamaican Staff. Emphasis was placed on the training of Jamaican personnel. More than US$600,000 has been committed for long- and short-term training. Planned manpower levels at end-of-project were 160 persons, including 24 professional staff members.

Technical Assistance. Auburn University continued to provide technical assistance under the original USAID grant-funded contract. A total of 13 person-years of long-term and 14 person-months of short-term technical assistance were provided under this contract. The resident consultants included a senior technical advisor and two extension specialists.

Support Hatcheries and Research Facilities. In the eastern region of the island, the Mitchell Town Support Facility, originally used to demonstrate the economic feasibility of tilapia farming, was upgraded and is now used principally for fingerling production. This farm now has 33 ponds with a combined surface area of 32 hectares. An office, a warehouse, feed storage bins, a seine room, a five-tank holding facility for live fish and other support equipment, and vehicles are now operational.

Initial development efforts were concentrated in the eastern half of the island, but in 1982, the construction of an additional facility in the western region permitted expanded extension activity. The Meylersfield Support Facility has 18 earthen ponds with a combined surface area of 6 hectares. Support equipment and buildings, similar to those at the Mitchell Town Facility, are also provided.



Practical research capabilities were increased by the addition of a 28-pond unit at project headquarters in Twickenham Park near Kingston. This facility is used to further refine the production technique currently practiced by farmers.

Farmers' Commodities. Included in the project are loan funds for the importation of essential fish farming equipment. This provision was included to permit a more rapid decrease in dependency on government support. This equipment is made available at cost to participating farmers. Money from the sale is to be put into a revolving account for purchase of additional equipment through the Jamaica Agricultural Society.

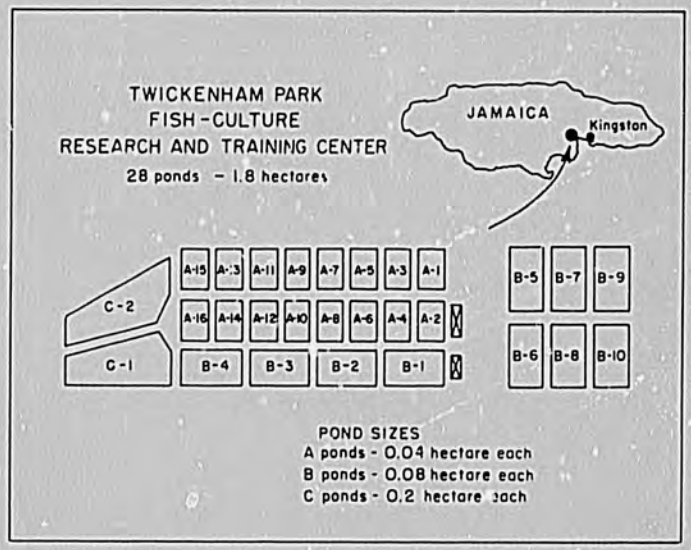
Vehicles. Mobility of extension and support personnel was enhanced by provisions to purchase 20 trail bikes and 24 four-wheel vehicles, including automobiles, pickup trucks, and vans. Three small bulldozers and two flatbed trucks for bulldozer transport were also purchased to facilitate the timely and more economical construction of farm ponds.

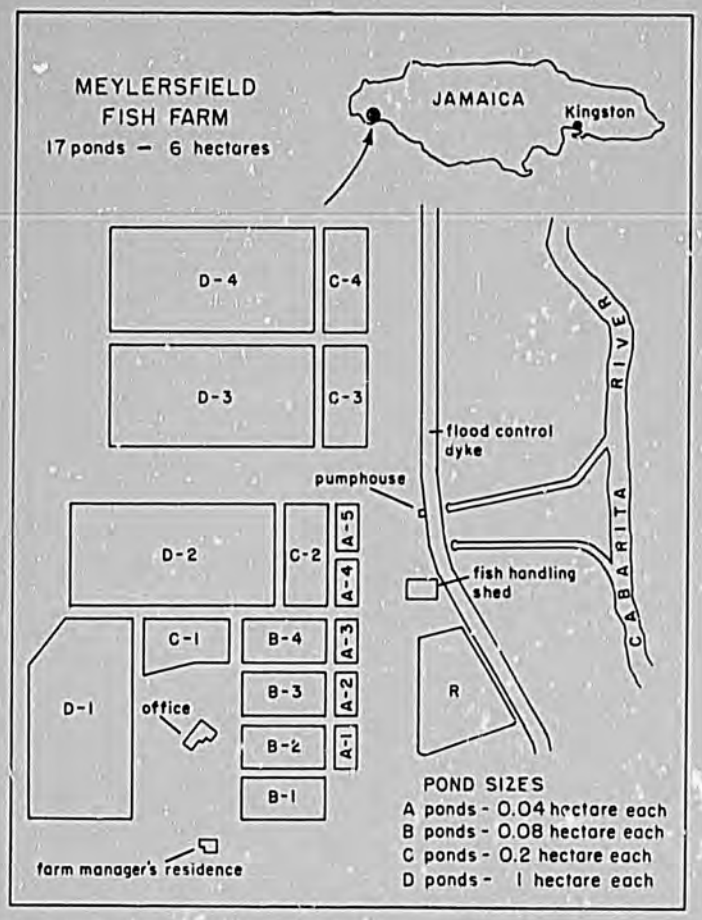
FISH FARMING METHODS PROMOTED IN JAMAICA

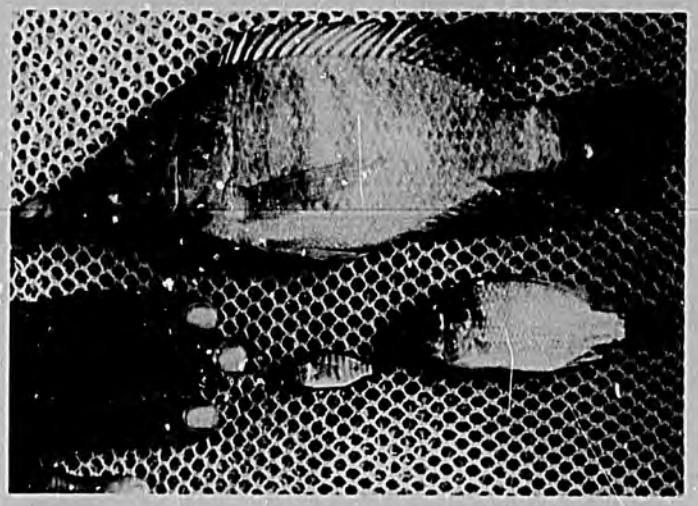
The following section is a technical description of the required inputs and the expected yields from the pond management practices currently promoted in Jamaica by project personnel. The rate of development in the private sector and the strategies used by the extension service to promote this management system will be described in the following two sections.

The economic justification for semi-intensive farming of tilapia in Jamaica was provided in 1978-79 during the original project, and

FIG. 1a, b, and c. The Mitchell Town Support Facility, above, is the largest of the three facilities, and is used primarily for fingerling production. The newest facility, Twickenham Park, below, is used to refine the production system used by farmers. The Meylersfield Support Facility, facing page, expanded the program to the western region of Jamaica.







Tilapia farming, as usually practiced in Jamaica, is a three-step procedure. Very small fish are first harvested from brood ponds and are then transferred to a second pond for rearing to the intermediate size required to visually determine their sex. Males are finally restocked into fattening ponds for grow-out to marketable size.

the same basic production system for food-fish ponds is still practiced today. To prevent excessive reproduction and overcrowding, food-fish ponds are stocked only with male fingerlings that have been manually separated from the females by visual examination of the genital papilla ("hand-sexed"). There have been, however, three fundamental modifications to the original production system: the species of culture fish and the supplemental feed have been changed, and a different technique for production of male fingerlings has been adopted.

The substitution of the original poultry feed with a specially formulated ration was the result of the interest generated during the initial project. Since 1979 a local feed manufacturer has produced a commercial fish ration using a formula designed by project personnel. The current formulation contains fish meal (11 percent), soybean meal (42 percent), wheat middlings (30 percent), corn, molasses, and mineral and vitamin premixes. It has a crude protein content of 28 to 30 percent, approximately one-fifth of which is of animal origin.

Tilapia mossambica was the original culture species since it was already present on the island. Although production results were favorable, its dark pigmentation negatively affected consumer acceptance. *Tilapia (Oreochromis) nilotica*, locally called the silver perch, with its faster growth and lighter color, was introduced in 1978 and first distributed to private farmers in late 1979. By late 1981, it had replaced *T. mossambica* as the preferred culture species.

Another modification to the original culture system was the method of producing male fingerlings to be stocked in food-fish production ponds. Fingerlings were originally obtained by periodic partial harvesting of brood ponds. Since 1981 small fry (recently hatched fish) are transferred from brood ponds to nursery ponds, and are later harvested as uniform-age fingerlings.

Over the past few years, a technology package for farming tilapia in Jamaica has been developed. The following is a more detailed description of suggested management practices and the yields normally obtained from the brood, nursery, and food-fish production ponds.

Brood Pond Management

Brood ponds are managed to produce small (1-gram) mixed-sex tilapia for subsequent rearing in nursery ponds. To accomplish this, sexually mature fish, ranging in size from 40 to 200 grams, are stocked in earthen ponds at a density of 7,500 to 10,000 per hectare. The sex ratio of the brood stock is approximately 3 females per male. Feed is offered at a daily rate of 23 kilograms per hectare during the first month and thereafter at a rate of 34 kilograms per hectare.

Frequent partial harvesting of the fry begins 5 to 7 weeks after stocking brood fish. Fry are collected weekly, using a nylon drag seine with 6-millimeter square mesh. In order to obtain uniform-size fish, the catch is usually graded through nylon netting with 12-millimeter square mesh into a partially submerged cage covered with 6-millimeter mesh wire or plastic screen. The average size of the fry that are small enough to pass through the 12-millimeter mesh netting and large enough to be retained in the 6-millimeter mesh cage varies from 0.6 to 1.1 grams.

Experience has demonstrated that frequent partial harvesting, usually once a week, is essential to the success of this management practice. If partial harvests are discontinued for an extended period, the average size of the fingerlings increases, resulting in increased cannibalism on small fry and a great reduction in the total number of fry. With an uninterrupted program of frequent partial harvests, some brood ponds have remained productive for a period of more than 8 months, but the usual productive period is 4 to 6 months.

Yield statistics for fry are based on results from six brood ponds with a combined surface area of 1.5 hectares. During an average production cycle of 26 weeks, 3.4 million fry, with an average size of 0.9 gram each, were harvested from these ponds. The average rate of production was 128,800 fry per hectare per week during the period of partial harvesting, table 1. The total weight of fry obtained from the six brood ponds was 1,983 kilograms per hectare during the average production cycle of 6 months. Approximately 1.7

TABLE 1. PRODUCTION OF FRY OF *TILAPIA NILOTICA* IN EARTHEN BROOD PONDS BY FREQUENT PARTIAL HARVESTING WITH A 6-MILLIMETER-MESH SEINE[1]

Item	$\bar{X}$	±	1 S.D.
Duration of complete cycle, weeks[2]	26	±	8
Total fry production during 6-month cycle, millions/ha	2.4	±	1.0
Average size of fry, g	0.9	±	0.2
Rate of fry production during period of partial harvests, thousands/ha/week	129	±	67
Feed consumption during 6-month cycle, metric tons/ha	3.3		

[1]Based on results from six ponds, 0.1 to 0.4 hectare each, at the Mitchell Town and Twickenham Park Support Facilities.
[2]The production cycle began with the stocking of brood fish. Partial harvesting of fry began approximately 6 weeks later.

kilograms of feed was used for each kilogram of fry harvested. Based on an analysis of major production costs, the break-even price for 1-gram fry was J$4.87 (about US$1.65) per thousand fry, table 2.

For planning purposes in Jamaica, 1 hectare of properly managed brood ponds stocked with *T. nilotica* will produce 1-gram mixed-sex fry at an annual rate of no less than 4 million fry with annual feed requirements of 6 to 7 tons. With present management practices for nursery and production ponds, 6 percent of the total water area dedicated to tilapia culture in Jamaica is required for fry production.

Because frequent partial harvests are essential to the success of this management system, the technique described is not appropriate for small operations that do not have a near-constant weekly demand for fry. Although it has proven satisfactory at the government hatcheries, small-scale producers must depend on the government support facilities or on larger private operations as a source of fry for their nursery ponds. However, since only 6 percent of all pond space must be used for fry production, this has not been a serious constraint to the development of tilapia farming in Jamaica. During the last 6 months of 1983, the total number of fry harvested islandwide exceeded 8 million.

TABLE 2. MAJOR PRODUCTION COSTS FOR 1-GRAM FRY FROM BROOD PONDS AT MITCHELL TOWN SUPPORT FACILITY DURING 1982[1]

Item	Cost, J$/0.4 ha (1 acre)[2]
Annual fixed costs	
Opportunity costs on construction capital (8%)	320.00
Pond maintenance	50.00
Depreciation (prorated):	
61-m seine, 6-mm-square mesh (3 years, life; 1/2 use)	413.00
2 tractors, 1 wagon, 1 pickup truck (7 yr. life; 1/50 use)	328.00
TOTAL	1,111.00
Annual variable costs	
Feed, 2,506 kg @ $0.604/kg	1,512.00
Pumping (19,736 m³ @ ¢6.08 per 100m³)	1,200.00
Tractor fuel and maintenance (8 km/wk @ $1.25/km)	520.00
Labor (1/50 of total labor budget)	3,283.00
Guard service (1/80 of total)	1,187.00
TOTAL	7,702.00
TOTAL ANNUAL FIXED AND VARIABLE COSTS	8,813.00
Per unit cost (J$/1,000 fry)	4.87
ANNUAL FRY PRODUCTION	1,810,000

[1]The Mitchell Town facility has 32 hectares of water. The cost of guard service is prorated accordingly. Labor is based on the normal division of work among the 30 pond operators employed there.
[2]In late 1983 an official devaluation set the exchange rate at J$3.15/US$.

Nursery Pond Management

The fry collected from brood ponds are transferred to nursery ponds for rearing to a size of 20 to 30 grams, at which time they are hand-sexed and the males subsequently stocked into food-fish production ponds.

Seed fish for stocking nursery ponds are harvested weekly from brood ponds at a size of only 1 gram. Each year nearly 5 million fry are harvested from each hectare of brood ponds.

Nursery ponds are currently stocked with 1-gram fry of *T. nilotica* at a density of approximately 180,000 per hectare. The suggested feeding schedule begins at a daily rate of 11 kilograms per hectare during the first week, and is gradually increased to 40 kilograms per hectare by the fourth week and 60 kilograms per hectare by the sixth week. Total feed consumption usually ranges from 1,400 to 1,900 kilograms per hectare per crop.

Harvesting of fingerlings begins as early as week 6, and is usually completed by week 9 or 10. Although the harvest begins by seining a full pond, the final portion of the crop is removed by draining. Before filling the pond with water for the following cycle, the pond bottom is usually allowed to dry for a few days and any remaining puddles are treated with rotenone to remove fish.

Expected yields are based on results from 23 earthen nursery ponds varying in size from 0.1 to 0.4 hectare. A total of 140,200 male fingerlings, with an average weight of 27 grams, was harvested from the 4.3 hectares of nursery ponds during an average cycle of 9 weeks, table 3.

Based on the average production of 34,200 male fingerlings per hectare during a 9-week crop and a turn-around time of 2 weeks between crops, the expected average annual yield from 1 hectare of nursery ponds is 161,000 male fingerlings, weighing 20 to 30 grams each. An additional annual production of 4,000 kilograms of female fingerlings is a by-product of marginal value. The annual feed requirements are 9 to 10 metric tons per hectare.

TABLE 3. REARING OF MALE FINGERLINGS OF *TILAPIA NILOTICA* IN EARTHEN NURSERY PONDS[1]

Item	X	±	1 S.D.
Initial stocking density	178	±	19
Initial size of fry, g	1		
Duration of cycle, weeks	9	±	2
Final size of male fingerlings, g	27	±	7
Recovery of male fingerlings, thousands ha cycle	34.2	±	10.0

[1]Based on results from 23 ponds, 0.1 to 0.4 hectare each, initially stocked with mixed-sex fry. At the end of the cycle males were separated from the females by visual inspection. The females were a by-product of marginal value.

Fry collected from brood ponds are reared in nursery ponds for approximately 2 months to a weight of 20 to 30 grams at which size an experienced pond operator can separate the males from females by visual examination. At the end of a rearing period more than 30,000 male fingerlings are normally obtained from each hectare of nursery ponds.

The hand-selection of male fingerlings for final grow-out is most efficiently and comfortably done in specially constructed facilities (top photo), but most privately produced fingerlings are "hand-sexed" in the nursery ponds (middle photo). Many small-scale farmers simply work on the pond bank where female fish (foreground of bottom photo) are discarded or used as animal feed and the males are temporarily maintained in water-filled barrels.

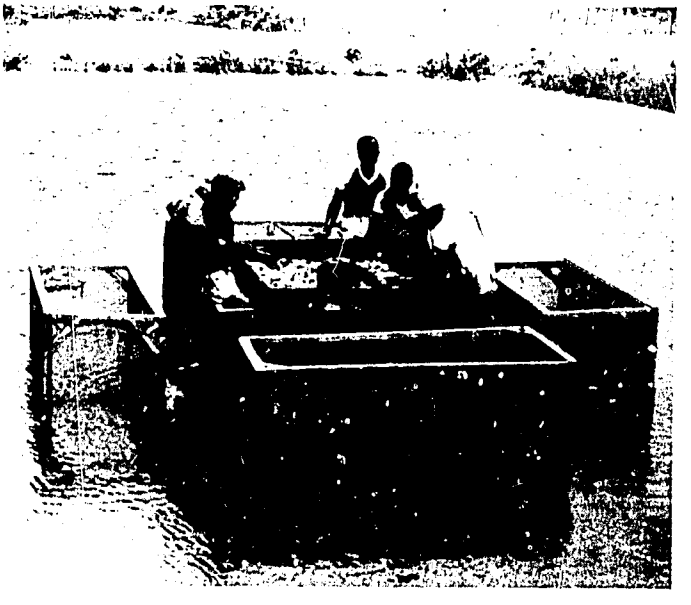


TABLE 4. MAJOR PRODUCTION COSTS FOR MALE FINGERLINGS FROM NURSERY PONDS AT MITCHELL TOWN SUPPORT FACILITY DURING 1982[1]

Item	Cost, J$/0.4 ha (1 acre)[2]
Annual fixed costs	
Opportunity costs on construction capital (8%)	320.00
Pond maintenance	50.00
Depreciation (prorated):	
76-m seine, 19-mm-square mesh (3 years life; 1/4 use)	336.00
2 tractors, 1 wagon, 1 pick-up truck (7 yr. life; 1/40 use)	410.00
TOTAL	1,146.00
Annual variable costs	
Fry (331,000 @ $4.87/1000)	1,612.00
Feed (3,814 kg @ $0.60/kg)	2,302.00
Pumping (29,600 m³ @ ¢6.08 per 100m³)	1,800.00
Tractor fuel and maintenance (8 km/wk @ $1.25/km)	520.00
Labor (1/30 of total labor budget)	5,472.00
Guard service (1/80 of total)	1,187.00
TOTAL	12,893.00
TOTAL ANNUAL FIXED AND VARIABLE COSTS	14,083.00
Per unit cost ($/100 males)	21.70
($/kg of males)	8.04
Annual production of male fingerlings	64,700[3]

[1]See footnote of table 3.
[2]In 1983 an official devaluation set the exchange rate at J$3.15/US$.
[3]The incidental production of approximately 1,600 kilograms of female fingerlings is assumed to have no economic value.

The total cost of producing male fingerlings in nursery ponds at Mitchell Town in 1982 was J$21.70 (about US$7.25) per hundred, table 4. Sale of the female fingerlings would have lowered cost, but attempts to market them as "soup-fish" for human consumption have not been commercially successful at this farm. At present some females are kept as future brood stock, but most are either sold cheaply to a local small-scale manufacturer of fish feed, converted to silage as an experimental protein supplement for swine, donated to a local zoo, or discarded.

By late 1983, one medium-scale farmer began selling small females from his nursery ponds for J$0.66 (about US$0.22) per kilogram to a food-fish distributor, who in turn received J$1.54 (about US$0.50) from consumers. If this trend continues, the sale of "soup-fish" will benefit lower income consumers, but will not change substantially the economics of fish farming. At present prices, the additional revenue would offset no more than 15 percent of the total cost of producing male fingerlings. Nevertheless, in spite of the low utility of nearly one-half of the yield from nursery ponds, male fingerlings are currently produced at a cost that allows food-fish production of monosex tilapia to be economically feasible for Jamaican farmers.

Management of Food-fish Production Ponds

In Jamaica, *T. nilotica* are produced commercially in earthen ponds ranging in size from less than 0.1 to 0.4 hectare. Males, weighing 20 to 30 grams each, are stocked at a density of 15,000 per hectare. With supplemental feeding the grow-out period ranges from 10 to 15 weeks. Because of occasional errors made in the visual identification of the males or contamination of the pond with females through the water supply, some reproduction occurs in most ponds. Although reproduction is limited, the percentage of unmarketable fish usually becomes unacceptably high after 15 weeks. By this time, however, the originally stocked fish have attained an average weight of 180 to 260 grams, with total production of marketable fish varying from 1,800 to 2,900 kilograms per hectare for most well-managed ponds. Recovery of initially stocked fish is seldom more than 90 percent, and usually varies between 60 and 80 percent. Neither agitators nor aerators are used, but some farmers manage water quality by an occasional flushing with fresh water. Major fish kills from oxygen depletion have occurred but are infrequent.

Small-scale commercial producers often fertilize their ponds with chicken manure, a practice which usually contributes to shorter production cycles (10 to 13 weeks) and decreased feed consumption. The amount of feed to produce a ton of marketable fish may be as low as 1.0 ton in manured ponds, but 1.5 tons is normal for well-managed unfertilized ponds.

Depending on marketing strategy, ponds may be harvested in a single operation or over a 2- to 3-week period. All ponds are completely drained, and any remaining puddles are treated with rotenone to eliminate all fish before refilling and beginning the next production cycle.

This generalized description of food-fish management practices is based on field data from private and government-owned ponds, table 5.

TABLE 5. FOOD-FISH PRODUCTION FROM PRIVATE AND GOVERNMENT-OWNED PONDS STOCKED WITH MONOSEX TILAPIA FINGERLINGS (ABOUT 15,000 PER HECTARE) AND RECEIVING SUPPLEMENTAL FEED

Item	Public sector			Private sector[4]	
	T.P.[1]	M.T.[2]	Average	Top 80%	All ponds combined
Final weight, g	184	247	216	220	216
Total production, kg/ha	2,568	2,116	2,342	2,419	2,137
Duration of crop, weeks					
At first harvest	15	12	13		
At final harvest	15	17	16	12	12
Recovery of initial stock, pct.	88	53	71	71	65
Feed conversion, kg feed/kg fish produced	1.54	1.54	1.54	1.25	1.39
Number of ponds	7	13	-	44	55
Manure	no	no	no	most ponds	most ponds

[1]Twickenham Park Training and Research Center. Data are from experimental ponds (0.04 hectare) operated under carefully controlled conditions in 1982.
[2]Mitchell Town Support Facility is used primarily as a fingerling production farm, but a few 0.7-hectare ponds were kept in food-fish production to provide a buffer against fluctuations in available fish supplies from private producers. Data are from ponds stocked in 1982.
[3]Data were taken from small-scale commercial ponds (with an average surface area of 0.3 hectare each) harvested between July and December 1982. It was the first crop for many farmers, and on occasions ponds were stocked at fish densities and/or harvested on dates that greatly deviated from suggested practices.
[4]The "top 80 percent" represents the average for reasonably well managed ponds and was calculated by eliminating the least productive 20 percent from the analysis.

Most farmers drain and harvest their food-fish ponds about 3 months after stocking. By that time, the weight of an individual fish exceeds 200 grams and the total crop is more than 2 metric tons per hectare of pond.

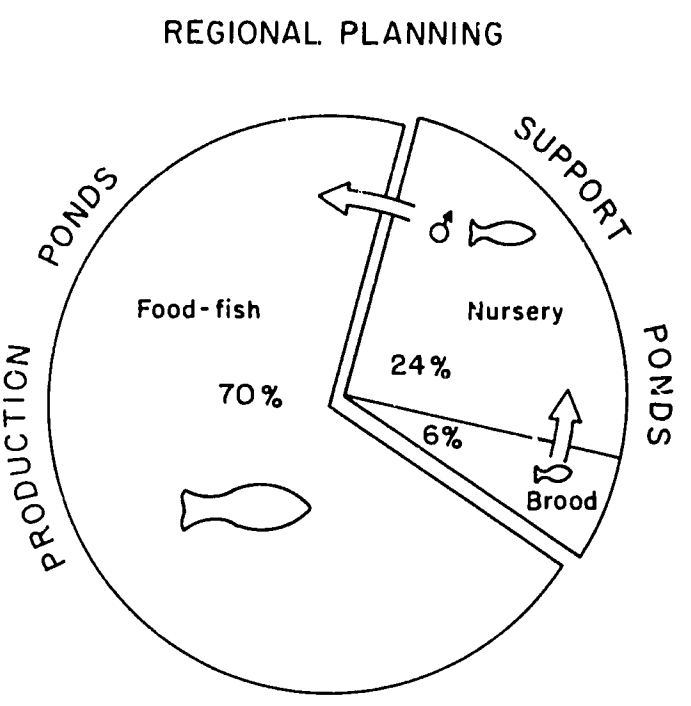


FIG. 2. On a regional or national scale, approximately 70 percent of pond space is used in the final grow-out of hand-selected male tilapia. The remaining 30 percent must be utilized either as brood ponds for production of initial seed fish or as nursery ponds for subsequent rearing to a sexable size.

Relative Size and Number of Brood, Nursery, and Production Ponds

For large-scale operations or for purposes of national or regional planning, a total water area of 100 hectares would utilize 24 hectares in nursery ponds and 6 hectares in brood ponds to support 70 hectares of production ponds, figure 2.

For the larger operations with sufficient production ponds to require a near continuous demand for male fingerlings, the relative size of nursery ponds, as compared to production ponds, is not critical. However, for small-scale operations with few production ponds, the stocking of male fingerlings is a periodic event. In this case, it is best if the size of the nursery ponds is such that the entire yield from one crop is just sufficient to completely stock a production pond. To accomplish this, nursery ponds should be approximately 40 to 50 percent as large as the production ponds. Since the production cycle in nursery ponds is shorter than that of food-fish ponds (about 11 versus about 16 weeks), the number of nursery ponds needed is less than the number of production ponds. Two nursery ponds, each about half as large as the production ponds, are needed to support three production ponds; 3 nursery ponds are needed for 4 production ponds, and 3 or 4 will be needed for a 5-production pond operation.

Since brood ponds must be partially harvested on a near weekly basis to remain productive, this type of pond is justified only when demand for fry is also on a near weekly basis. When justified, however, a minimum of two brood ponds is required for a continuous supply of fry. This is due to the 2-month unproductive period in each brood pond between the finalization of one cycle and the beginning of partial harvesting of fry in the following cycle.

Recent Introduction of a More Intensive Technology

The brood-nursery-production pond management system described above is practiced by most tilapia farmers in Jamaica. The level of sophistication is a compromise based on the desire for high production and maximum economic returns, and on the need to limit capital investment, energy dependency, and the required technical skills to levels compatible with a small- or medium-scale farmer with little previous experience in aquaculture.

By 1982, the basic infrastructure and certain marketing and production characteristics of tilapia farming had been sufficiently proven to attract the interest of private companies having the investment capital and technical expertise needed for more intensive production systems. In 1983, two such companies began construction of farms designed for a minimum of 100 hectares of water. Production at one of these farms is based on the polyculture of the giant freshwater prawn (*Macrobrachium rosenbergii*) and a tilapia hybrid (*T. nilotica* x *T. aurea*) produced from strains selected in Israel resulting in a nearly all-male hybrid progeny. The other farm is also designed for polyculture, but emphasis is on tilapia. It produced nearly all male tilapia hybrids from similar strains of the same two species but, in addition, is evaluating the market value of a "red" tilapia of uncertain origin (possibly *T. mossambica*/*T. nilotica*/*T. hornorum*). Male fingerlings of this red tilapia are obtained by "sex reversal" (oral administration of a male hormone through feed to recently hatched fry before their sex organs have formed). Plans at this farm are to grow the majority of the tilapia to a size of 500 grams in 0.1- to 0.2- hectare square earthen ponds stocked at fish densities exceeding 100,000 per

hectare. Each pond has two to four continuously operating electric paddle wheels arranged to keep the water flowing in a circular pattern. Approximately 10 to 15 percent of the pond water is removed by periodically opening the valve of a 150-millimeter drain pipe that extends to the center of the pond where the circular water flow has concentrated detrital material.

Both of these farms began production in 1984. Their technology is not being promoted by project personnel, but they will be closely monitored to evaluate the applicability of the production system for other Jamaican fish farms, and as a potential source of male fingerlings for small-scale farmers.

FISH PRODUCTION EXTENSION BRANCH

Organizational Structure

Prior to project implementation, some felt that General Agriculture Extension Agents having special training in fish farming might effectively transfer the new technology to farmers in the course of their traditional extension activities. Nevertheless, the project was organized with its own independent Extension Branch. This decision was based on two major considerations. First, since the technology was completely foreign to most farmers, new producers would require advice and reinforcement more frequently than for other agricultural activities. Second, because of the rapid evolution of fish farming and the relative inexperience of early extension agents, the opportunity for consultation with more experienced personnel should be increased by making an extension unit an integral part of the project.

The organizational structure of the Extension Branch and its relationship with other technical sections of the project are diagrammed in figure 3.

The extension staff includes the majority of the technical personnel assigned to the project. As of January 1983, 16 of the 26 Jamaican technical personnel were working full-time in extension. In addition to the Jamaican staff, each of the two regional extension officers served as counterparts to extension specialists from the technical assistance team, and 4 to 6 Peace Corp Volunteers were active as extension officers through most of 1982.

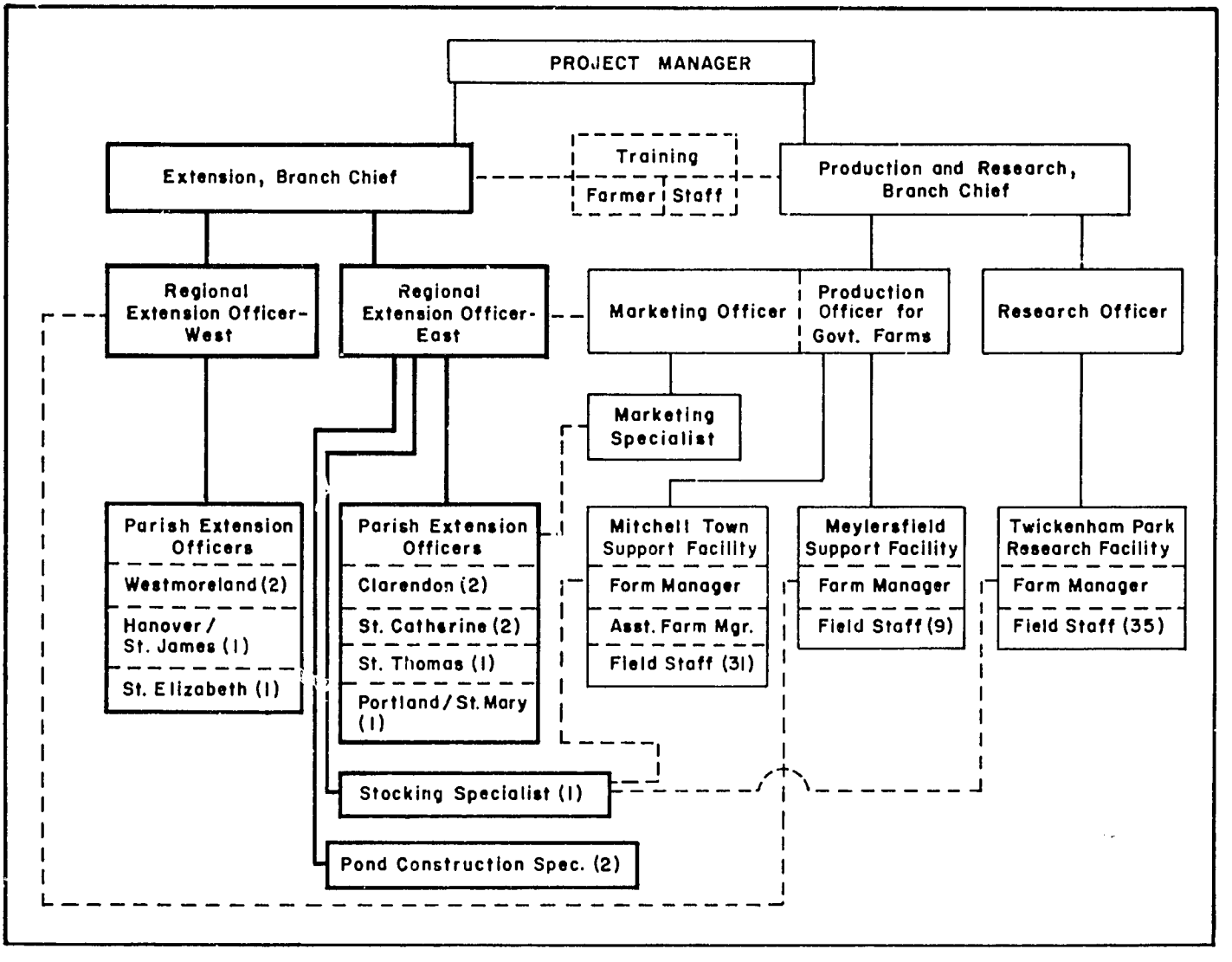


FIG. 3. Organizational structure of the fish production Extension Branch in 1983 and its relationship with other technical personnel in the project. (Solid lines indicate vertical hierarchy of authority. Dashed lines indicate critical horizontal lines of communication for routine operations.)

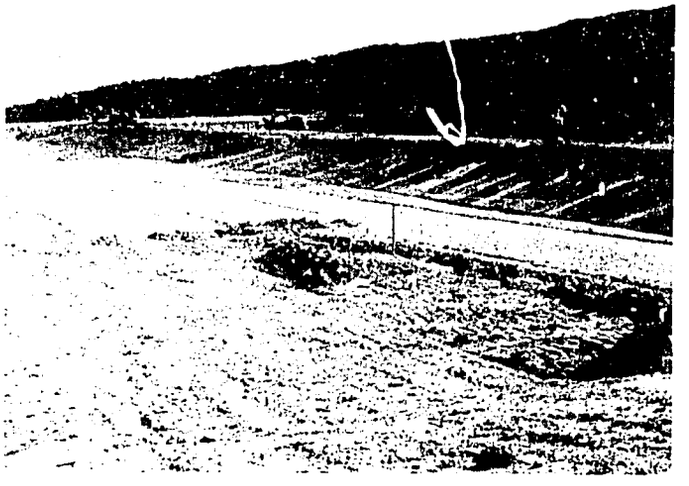
Extension Services Provided

The type and extent of extension services provided were adjusted during the life of the project in accordance with the rapidly changing state of development of fish farming in Jamaica.

Early subsidies and broad support were based on four major considerations. First, most farmers were reluctant to begin a relatively unknown and capital-intensive type of farming. Second, close supervision was required until producers had acquired the necessary technical skills. Third, several of the critical means of production were not available to farmers except through the project. Fourth, a reliable distribution system for pond-raised fish was not in place prior to this project.

With each successful crop, farmers gained confidence in fish farming, both technically and economically. Production inputs became more available and reliable. Further refinement of management systems and continued accumulation of production data provided additional proof of the farmers' capacity to assume greater independence. The overall strategy to accomplish this was not to suddenly eliminate a service but to impose or increase service charges and to create conditions that motivated greater private sector participation.

Site Evaluation and Pond Construction. This service changed little during the life of the project. Upon request from a potential fish farmer, a preliminary evaluation is made by an extension officer, who examines water supply, soil texture, and land topography. If the site appears favorable, a pond construction specialist surveys the land to further evaluate drainage characteristics and to define the most appropriate size and distribution of the ponds. The extension officer then makes arrangements for construction by one of three project bulldozers at an hourly rate set islandwide by the Ministry of Agriculture. If heavier equipment is more appropriate, the Extension Branch will arrange contact between the farmer and construction firms. Both farmer and contractor are informed of previous construction costs of other ponds, but the Extension Branch does not enter directly into the negotiations. Whether a private or public bulldozer is used, the pond construction specialist normally stakes out the pond and supervises construction. There is no charge for this service.



The Extension Branch places much emphasis on proper pond construction. Once a general extension officer makes a preliminary evaluation for an interested farmer, a pond construction specialist surveys the site, suggests an appropriate design, and supervises the construction.

Seed Stock. As the demand for male fingerlings increased, the role of the Extension Branch became more complex. In the early stages, all small-scale fish ponds were stocked with fingerlings produced at the project support facilities, and extension personnel made delivery in a project vehicle. The initial stocking of a private pond was without charge, and subsequent stockings were heavily subsidized, with payment often being at end-of-crop.

Since that early period, private farmers, motivated by fingerling shortages and the phased removal of the subsidy (completed by 1983), have accepted greater responsibility in the production of fingerlings. Since late 1982, a stocking specialist continues to make delivery on pre-paid orders of government-produced male fingerlings, but project thrust has been toward the development of the farmers' capacity to supply their own seed. Fingerlings, initially "hand-sexed" only by project personnel, are now also handled by some of the farmers themselves and by small groups, trained by project personnel, that contract their services to small-scale producers with nursery ponds.

Feed Supplies. Two locally manufactured fish feeds are now distributed through normal commercial channels. The Extension Branch was instrumental, however, in initially convincing local distributors to carry the product and in coordinating supply with demand.

Routine Farm Visits. The frequency of visits by an extension officer varies in accordance with the experience of the farmer. Weekly or bi-weekly visits are usually required for new farmers until they acquire an understanding and conviction about feeding and fertilization schedules and until they are able to adjust manuring regimes according to water quality conditions. After two or three fish crops, monthly visits are usually adequate.

Harvest Schedules. As the expected harvest date nears, ponds are sampled with a cast net or small seine by an extension officer and/or farmer to estimate fish size. The extension officer may help the farmer to contract, on an emergency basis, the use of a project water pump at a cost that covers amortization, operation, maintenance, and depreciation (J$6.08 per 100 cubic meters of water). He may also be involved in arrangements to contract-harvest the fish crop. Information on potential markets is available through the marketing specialist.

Training. The fundamental objective of the Extension Branch is training. Most small-scale farmers are unable to schedule relatively large blocks of time for formal training courses. These farmers acquire their skills on the farm on a one-on-one basis with extension officers and by discussion with other producers. The farmer-to-farmer communication is encouraged by monthly fish farmer meetings arranged by the Extension Branch.

As the agricultural sector gains confidence in fish farming, more producers enter the industry at a scale requiring additional hired labor. At the request of a farmer, these persons may receive training at no cost. Some formal training is scheduled, but emphasis is on field experience at the project support facilities. For 1 to 4 weeks they work alongside experienced laborers, acquiring skills in seining, fish handling, sexing, stocking, and harvesting. The project may provide transportation between project headquarters and support facility, but the private producer is responsible for any financial agreements for the trainees' time.

With the growth of private nursery ponds in 1982, the demand for skilled workers to differentiate male and female fish increased considerably. Persons receiving training in this field may be full-time employees of medium-scale producers or they may be landless laborers hoping to periodically contract their skills to small-

scale producers. Some of the earliest trainees were given a subsistence allowance during their 4-week period of training. Increasing numbers are now willing to forego a subsistence allowance to increase their employment opportunities. Extension Branch makes no employment commitments to these individuals, but most have obtained permanent positions on private farms or at least decreased their previous level of underemployment.

Large-scale fish farms have also benefited from training received by project personnel. Private producers are not discouraged from hiring experienced technical personnel from the project. The formal and on-the-job training which makes these employees increasingly valuable as project staff also prepares them as competent managers for private fish farms. By December 1983, four of the technical staff had left the project to accept management positions at medium- and large-scale fish farms.

FOOD-FISH PRODUCTION ON PRIVATE AND PUBLIC FARMS

Rates of Production

Rates of production from private commercial ponds are variable (CV = 37 percent in 1982). A producer has little control over some sources of variation, but other factors, such as feeding schedules, water quality, and theft, depend largely on his motivation and management skills. Reliable production data were obtained from 55 of 71 recorded private harvests in eastern Jamaica from July to December 1982. The median yield of marketable fish with average weights exceeding 200 grams was 2,100 kilograms per hectare. Approximately 20 percent of the harvests were less than 1,500 kilograms per hectare and more than 20 percent were greater than 2,600 kilograms per hectare, figure 4.

Annual rates of production are greatly affected by the duration of the unproductive period between harvest and subsequent restocking, especially for this type of farming with its short grow-out period. The median turn-around time between crops for the above group was 6 weeks for all ponds combined and 5 weeks for "reasonably well managed ponds" (the top 80 percent). Based on actual yields, crop duration, and turnaround time between crops, the annual rates of production were 6,100 kilograms per hectare for all ponds combined and 7,500 kilograms per hectare for reasonably well managed ponds. Annual yields from small-scale commercial ponds would have been 20 to 25 percent higher if the "down-time" between fish crops had been kept to 2 weeks, figure 5. The most common reasons for delayed restocking were fingerling shortages and delays in refilling ponds with water.

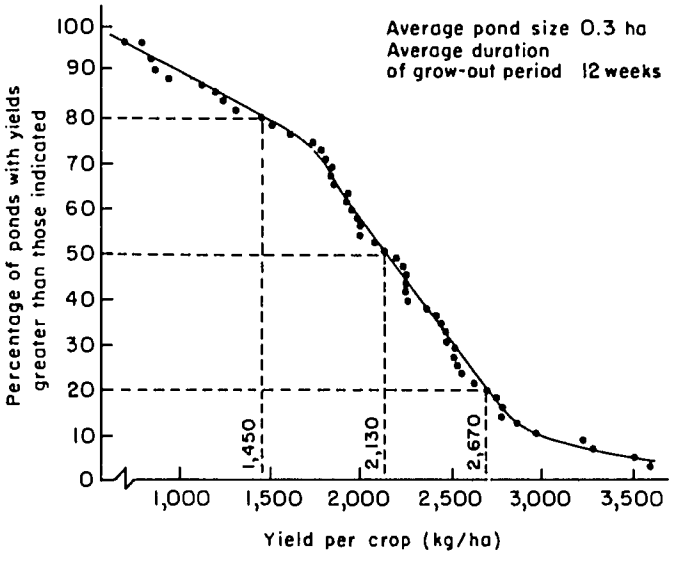


FIG. 4. Frequency distribution of fish yields from small-scale commercial ponds. (Based on data from 55 private ponds harvested between July and December 1982.)

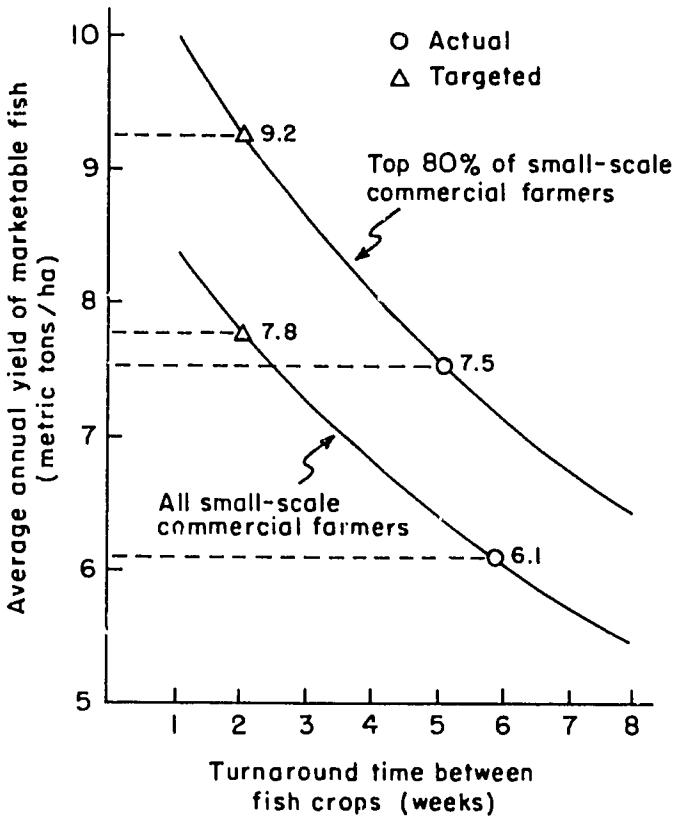


FIG. 5. Average annual rate of fish production, as affected by actual and targeted turnaround times between fish crops. (Based on actual crop duration and yields from 55 small-scale private ponds.)

Total Food-fish Production

Total annual production of tilapia in Jamaica from 1979 through 1983 from both public and private sectors is presented in figure 6. During the first years of the project, 1979 and 1980, there was little net growth. Total production held at 16 to 18 tons per annum as the public sector phased out of food-fish production at approximately the same rate as private producers entered the industry. In 1981, however, total production doubled to about 36 tons, with growth occurring in both public and private sectors. In 1982 the harvest of 126 tons more than tripled levels of the previous year, and in 1983 output increased by an additional 27 percent to 160 tons. Pond construction activity during late 1983 indicated that growth will continue at least through 1984.

Small-scale Private Producers. During the first 3 years of the project, 1979 through 1981, all privately produced food-fish came from small-scale fish farms, typically consisting of one or two production ponds less than 0.5 hectare each. Growth was relatively constant during this period, gradually increasing from less than 2 tons in 1979 to 27 tons in 1981. The most rapid growth of small-scale

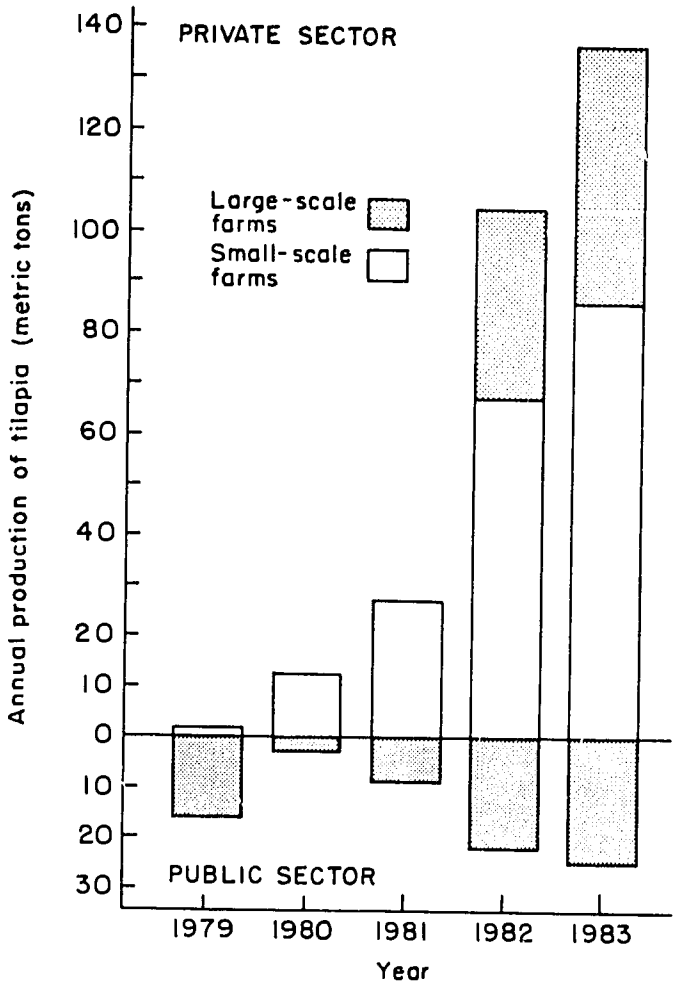


FIG. 6. Total production of marketable tilapia in public and private sectors from 1979 to 1983.

fish farming was registered in 1981-1982 when production increased from 27 to 66 tons. In 1983, production increased to 85 tons, accounting for nearly two-thirds of all privately produced tilapia. Much of this growth represented expansion of existing farms.

Large-scale Private Producers. The first large-scale fish farm with more than 30 hectares of water began production in early 1982. During the last 6 months of that year, nearly one-third of all production came from this farm. In 1983, most of the production from the large-scale category continued to come from that one farm, but during the latter half of the year construction on two other large-scale farms was begun and several medium-scale farms were reclassified into the medium- and large-scale category as they had expanded to more than 8 hectares of water. In 1984, the greatest growth in fish production occurred in the large-scale category of producers.

Government-owned Farms. The early decline in food-fish production at the government facilities, from an annual rate of near 20 tons in the first half of 1979 to less than 2 tons in the latter half of 1980, was due primarily to a change in emphasis from food-fish to fingerling production. Other factors that depressed food-fish production during this period were the disruptions resulting from a switch in culture species and the need to redevelop fish distribution channels when the government-owned Agricultural Marketing Corporation phased out its work in this area. During 1981 some government-owned ponds were returned to food-fish production, and output gradually increased to more than 30 tons from mid-1982 to mid-1983. The primary justification for rebuilding

Even with strict import limitations, annual per capita consumption of fish products in Jamaica is nearly 10 kilograms. The economic feasibility of tilapia farming is enhanced by enthusiastic acceptance of this fish. The occasional larger tilapia weighing more than a kilogram, as above, may be taken first, but pan size, 200-gram fish are readily accepted.

food-fish production at the government-owned farm was to provide stability to fish supplies for interested distributors. However, as private production expanded, this role became less important. Consequently, the annual rate of production during the second semester of 1983 declined to 18 tons, being largely replaced by expanded fry production to meet the demands from private nursery ponds. No future growth in food-fish production is planned for the public sector facilities.

ECONOMICS OF SMALL-SCALE TILAPIA FARMING

Costs and Returns for a Small-scale Fish Farm

By mid-1982, continued growth of small-scale fish farming hinged on increased fingerling production. Further expansion of the government-owned hatcheries could not have kept pace with growth in the private sector and would have conflicted with a general government policy to reduce its involvement in the purely production aspects of agriculture. Large-scale production of fingerlings was being considered by a few private individuals and companies, but this would have been a medium-range solution at best. At least for the near future, growth of small-scale fish farming will depend on the technical and economic possiblity of farmers producing their own male fingerlings. Fortunately, by early 1982 the nursery pond management system had been sufficiently tested at the government hatcheries to justify its extension to private producers. Once the farmers had realized economic gains from their production ponds and had experienced delays in restocking, many were willing to construct their own nursery ponds.

Expected costs and returns for a small-scale tilapia farm with both production and nursery ponds are presented in table 6. The land requirement is 2.4 hectares, including three 0.4-hectare production ponds, two 0.2-hectare nursery ponds, and 0.8 hectare of land for pond dikes and support area. At this scale of operation the farmer must buy the 1-gram mixed-sex fry to stock his nursery

ponds, but he produces all the male fingerlings needed for his production ponds. Annual production of food-fish from this farm is slightly less than 10 metric tons (about 4 tons per hectare of land). Unit costs are J$3.50 (about US$1.16) per kilogram of food fish. Approximately one-third of all costs is in fingerling production (about US$0.06 per male fingerling). Net annual returns to land and management are J$4,450 (about US$618/hectare of land). For family-operated farms, net returns to land, management, and labor (4.5 person-days per week) are J$10,388 (about US$1,440 per hectare). If ponds can be filled by gravity, instead of pumping, net annual returns are further increased by J$6,257 (about US$870 per hectare of land).

Fish Farming and Competitive Land Uses

Land use is influenced by physical and social factors, but economic considerations, such as initial credit outlay, operational costs, labor requirements, and net profits, are the prime motivators. In Jamaica, fish farming was originally emphasized as an alternate use for marginal or swampy crop land, but good returns and short crop times (12 to 15 weeks) enhanced the farm's cash flow, and made it a viable competitor with traditional farm crops. In table 7, the past and present economics of small-scale tilapia farming are compared with some common small-scale row crops and livestock enterprises.

Early profit margins were very high for fish farming due to subsidized material and labor inputs from the project to convince cautious farmers to enter the new industry. However, even after the gradual removal of most subsidies, tilapia farming continues to be competitive with other agricultural activities.

For relatively small-scale animal husbandry, tilapia farming is less capital-intensive than hog or broiler fattening. It requires more labor per unit of capital, but returns to labor and management are higher. Thus, tilapia farming has addressed one of the prime goals of the Government's agricultural development plan: a relatively low-capital but high-labor type of livestock enterprise.

TABLE 6. EXPECTED COSTS AND RETURNS FOR SMALL-SCALE PRODUCTION OF *TILAPIA NILOTICA* ON 2.4 HECTARES OF LAND CONTAINING THREE 0.4 HECTARE FOOD-FISH PONDS SUPPORTED BY TWO 0.2-HECTARE NURSERY PONDS[1]

Item	J$[2]		
	Nursery (2x0.2-ha)	Food-fish (3x0.4-ha)	Combined (2.4 ha of land)
INITIAL COSTS			
Pond construction	6,000.00	15,000.00	21,000.00
Equipment (seines, holding cages, bucket, scale, dipnets)	1,500.00	1,000.00	2,500.00
Water pump, 135 m³/hr[3]	3,000.00	9,000.00	12,000.00
Total	10,000.00	25,000.00	35,000.00
ANNUAL FIXED COSTS			
Average interest on loan for initial costs amortized at 12% per annum over 5 years	812.80	1,935.25	2,748.05
Depreciation on equipment (3 years' life)	500.00	333.33	833.33
Pump (7 years' life)[3]	428.57	1,285.71	1,714.28
Pond maintenance	100.00	300.00	400.00
Use of existing storage structure	400.00	400.00	800.00
Total Fixed Costs	2,241.37	4,254.29	6,495.66
ANNUAL VARIABLE COSTS			
Fry for nursery (@ J$5.00/1000)	1,654.54	-	1,654.54
Feed (@ J$600.00/ton)	2,059.20	9,652.50	11,711.70
Diesel fuel for pump (@ J$0.95/l)	609.08	1,476.27	2,085.35
Chemical fertilizer (@ J$3.50/ton)	165.45	341.25	506.70
Pump maintenance	390.00	1,170.00	1,560.00
Transportation for feed and fertilizer	180.00	420.00	600.00
Labor (@ J$25/man-day)			
Feeding (2.0 hours/day)	343.80	1,611.56	
Harvesting (2 man-days/pond)	472.73	487.50	
Hand-sexing (J$1.00/100)	647.00	-	
Misc. (40% of total)	975.69	1,399.37	
Subtotal, labor (237 man-days)	2,439.22	3,498.43	5,937.65
Subtotal Variable Costs	7,479.49	16,558.45	24,055.94
Interest on production capital (15% per annum)	1,124.62	2,483.77	3,608.39
Total Variable Costs	8,622.11	19,042.22	27,664.33
TOTAL ANNUAL FIXED AND VARIABLE COSTS	10,863.48	23,296.26	34,159.74
UNIT COST			
(J$/100 male fingerlings)	16.79	-	-
(J$/kg food-fish)	-	-	3.50
NET ANNUAL RETURNS (@ pond-bank selling price of J$3.96/kg)[4]			
To land and management[5]	-	-	4,450.26
To land, labor[6] management[5]	-	-	10,387.91

[1]The economic analyses (late 1982) are based on a production system in which each 0.2-hectare nursery pond produces an average of 6,850 male fingerlings in an 11-week production cycle (including 2 weeks turnaround time); annual production is therefore approximately 64,700 male fingerlings. This provides a 10 percent margin of safety in stocking each of the 0.4-hectare food-fish ponds with 6,000 male fingerlings every 16 weeks. Total annual production of 220 grams food-fish = 2500 k.lograms per hectare x 3.25 crops per year x 1.2 hectares = 9750 kilograms. Based on actual production statistics from 55 private ponds harvested between July and December 1982, an average annual fish yield of four out of five small-scale fish farmers would equal or surpass this level of production provided average "down-time" between crops did not exceed 4 weeks (i.e. ponds without fish more than 25 percent of the year).

[2]J$2.70 to 3.20/US$ for most business transactions; by late 1983, an official devaluation set the exchange rate at J$3.15/US$.

[3]Pump, costing $16,000.00, is used 75 percent in fish farming activities. Initial cost, depreciation, and maintenance are prorated accordingly.

[4]As of July 1983, most small-scale farmers were receiving J$4.40 per kilogram for fish at pond bank. Indicated net returns are therefore conservative. If pumping is not required, net returns are increased by J$6,257.00.

[5]Approximately 1/4 - time manager is needed at this scale of operation.

[6]An average of 4.5 man-days per week; 1/4 to 1/3 of the work is best accomplished by a team of 2 or 3 persons. Therefore, at this level, 2 or 3 *part-time* workers are needed to meet labor requirements.

TABLE 7. ANNUAL COSTS AND RETURNS FOR SMALL-SCALE PRODUCTION OF TILAPIA, SOME COMMON AGRICULTURAL CROPS, AND LIVESTOCK IN JAMAICA[1]

Item	Tilapia (1 ha)		Vegetable and root crops (1 ha)					Livestock[4]	
	Subsidized 1981[2]	Independent 1983[3]	Sugar cane	Sweet cassava	Negro yam	Red beans	Green corn	30-hog unit[5]	1000-broiler unit
Total costs, excluding labor (J$1000)	6.6	11.7	2.3	1.4	16.8	1.5	2.2	15.2	16.7
Net return (J$1000) to									
Land, labor, and management	6.9	4.3	1.1	2.6	5.5	8.0	2.9	2.8	2.0
Labor and management[6]	5.9	3.3	0	1.6	4.5	7.0	1.9	2.6	1.9
Labor requirement (man-days)	81	99	158	86	336	232	138	45	23
Net return per unit of labor: (J$/man-day)[7]	65	22	neg.	17	8	30	12	25	9
Crop duration (weeks)	15	15	52	52	26	26	18	26	13

[1]Cost analyses of row crops, livestock, and "subsidized 1981" tilapia budget are adapted from F.E. Ross, 1983. An analysis of the economic viability of the Government of Jamaica/USAID Inland Fisheries Project. Ph.D. Dissertation, Auburn University, Alabama. 193 pp.

[2]Based on a typical farm in 1981 with two 0.5-hectare production ponds that were stocked and harvested at a cost subsidized approximately 50 percent by the Government.

[3]Based on management practices promoted in late 1982 for a 2.4-hectare plot with 1.6 hectares of ponds constructed to produce its own fingerlings and harvest its own food-fish (see table 6).

[4]The scales of operation indicated are approximately the maximum if initial costs are to be kept in the range of eligibility for special low interest loans to small farmers.

[5]With purchase of 20-kilogram weaners and fattening to 90 kilograms.

[6]Assuming an annual return to land of 8 percent of equity value of J$12,500 per hectare.

[7]After subtracting a minimum return to management for risk of operating capital of 10 percent of total annual costs.

Tilapia farming is more capital-intensive and equally or less labor-intensive than most common plant crops, but if investment capital can be acquired, returns are generally higher. The significant exception to this generality is cultivation of red beans, which would seem more appropriate for small-scale farmers with limited capital and excess labor potential.

It should be pointed out that the two main economically competitive enterprises to fish farming, hog fattening and red beans production, have longer crop times, which can strain a small farmer's cash flow, and are very market-sensitive, with periodic gluts causing a fall in market prices of up to 30 percent. At current production levels tilapia has not been market sensitive. The low catch and high price of the inshore marine fishery, combined with the foreign exchange-related restriction on imported fish, have steadily driven up the price of pond-raised fish. Further, fish gluts are not expected in the near future.

Capital Availability for Fish Farming

Through the lobbying of the project, the Government of Jamaica has added small-scale fish farming to the list of enterprises eligible for low interest (9 percent) financing through an arm of the Agricultural Credit Bank. In these cases, a lien is taken on the crop, and the farmer has 5 years to repay the original loan.

The demonstrated profitability of fish farming has also convinced the commercial banks to provide loans for development of medium-scale fish farms. These loans attract a higher interest rate of 15 percent, but have a 10-year loan repayment period. A significant number of small-scale farmers have upgraded to the medium-scale category via this mechanism.

TREND TOWARD GREATER INDEPENDENCE OF PRIVATE PRODUCERS

Less than 5 years ago few Jamaican farmers seriously considered the prospect of semi-intensive fish farming. At that stage, special enticements were needed to convince serious farmers to transfer land from a traditional and proven agricultural use to a new high-investment type of animal husbandry. Therefore, during the early stages many inputs were supplied by the Project. However, as production gradually expanded, the capacity to provide the required inputs increasingly became the limiting factor for continued growth. Fortunately, by this time the farmers had developed confidence in the economic viability of fish farming and a willingness to participate in all aspects of production.

Fingerling Production in the Private Sector

During the first half of 1980, male fingerlings were produced at the government support facilities at an annual rate of 342,000. With the exception of the second semester of 1981, when *T. mossambica* was being replaced by *T. nilotica*, their output has steadily increased, surpassing 800,000 in 1983. From the beginning, however, this growth rate was not sufficient to meet demands. Fingerling shortages soon became the principal limiting factor to further expansion in the private sector. In spite of this shortage, in 1981 farmers were not encouraged to produce their own fingerlings since little production and cost data were then available on the newly adopted brood and nursery pond management practices.

By early 1982, sufficient data had been accumulated, and the subsidy on male fingerlings was reduced by doubling the charge from J$5.00 to $10.00 per 100. Where conditions permitted, farmers already in production were encouraged to include a nursery pond in their operation, and the policy was adopted that new farms with at least 0.4 hectare (1 acre) in food-fish production should be designed to produce their own male fingerlings. In 1983, the last of the fingerling subsidy was removed when the charge was again doubled to J$20.00 per hundred male fingerlings.

During 1982, more than 1.2 million male fingerlings were produced in the public and private sectors. This was more than double the levels registered in 1980 and 1981. By the last 6 months of 1983, the rate of production had climbed to 2.0 million male fingerlings per annum. Although production at the government facilities had increased, the principal reason for the sudden growth was the participation of private producers, figure 7. Based on the total number of male fingerlings stocked in production ponds, the contribution of the private sector increased from zero in 1980 to 14 percent in 1981, 43 percent in 1982, and 54 percent in 1983. The present response of private producers suggests that they will continue to accept greater responsibility in the area of fingerling production.

Harvesting of Private Ponds

Fish harvesting equipment was not initially available to farmers since there had been no previous history of commercial fish farming in Jamaica. This equipment was to be purchased by the project and resold to producers at cost. All larger producers were to harvest their own ponds, and the small-scale producers, lacking the econ-

By 1983, most small-scale commercial producers of tilapia were rearing their own male fingerlings. This farm was designed with two 0.2-hectare nursery ponds to provide the required fingerlings for three 0.4-hectare grow-out ponds.

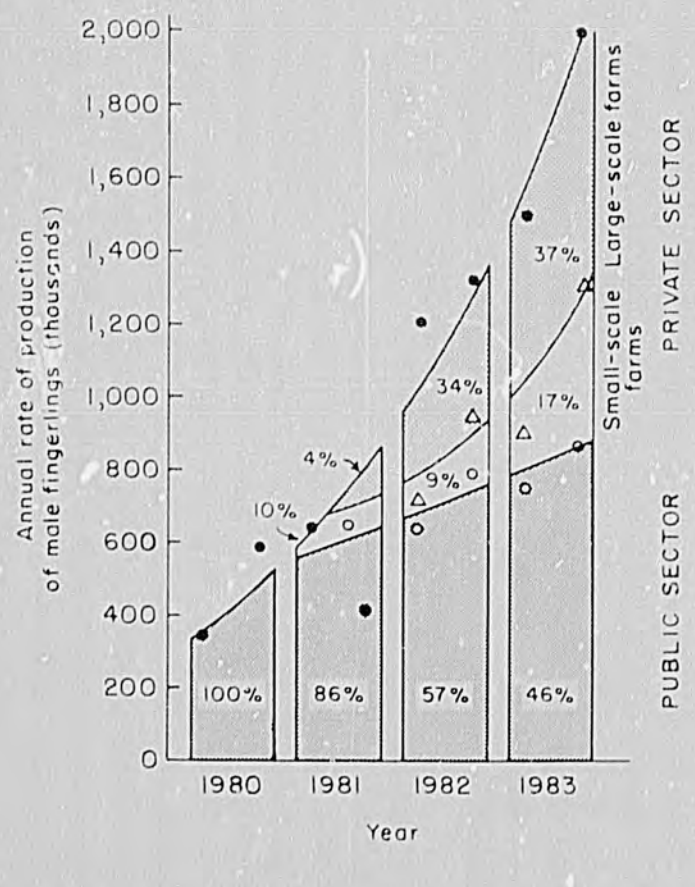


FIG. 7. Production of male fingerlings by public and private sectors from 1980 to 1983. (Figures within graph indicate percentage of total production during a given year.)

omies of scale to justify the purchase of harvesting gear, would either share the cost with other farmers or arrange to have their ponds harvested on a contract basis.

The first shipment of harvesting equipment arrived in late 1982. Prior to this, the three largest producers were sold or lent existing project gear on an emergency basis. Some small-scale producers harvested their ponds by draining, but most small commercial ponds were harvested with project equipment by project personnel. The capacity to provide this service was not seriously taxed until late 1982 when the weekly harvest schedules often included 3 to 5 production ponds.

For promotional reasons, small commercial production ponds were initially harvested free of charge. However, with the availability of additional harvest equipment and the practical necessity for greater private sector involvement in harvesting, a harvesting charge was imposed to economically motivate the purchase of equipment. The harvesting charge was based on expected costs, plus a 25 percent return on fixed and variable costs, for a potential small-scale processor-distributor who vertically integrates to include contract harvesting in his operation. Accordingly, the harvesting charge was set at J$22.00 (about US$7.50) per 100 kilograms of fish. Labor and transportation costs accounted for approximately 40 and 20 percent of this charge. Farmers who provide these inputs themselves paid a proportionally reduced charge.

A farmer with a well-constructed pond and an immediate demand for the entire fish crop can harvest at a considerably lower cost by simply draining his pond for a complete harvest. However, if marketing conditions require several partial harvests over a 2- or 3-week period, he must have a seine and minor related equipment. The purchase of this gear is justified only if the farmer has attained a minimum economy of scale. A farmer with at least 0.6 hectare of water can harvest using his own equipment more cheaply than by contracting for harvest.

The initiation of the harvesting charge, and the rate at which it was set, were part of project strategy to motivate private sector involvement. By late 1983 most of the equipment had been sold to fish farmers, and another shipment had been requested. Several producers now harvest their own fish, but a private contract-harvesting operation has not been established.

MARKETING FARM-RAISED TILAPIA

Related Supply and Demand Considerations

Jamaicans traditionally consume large quantities of fish. Per capita consumption in 1973 was 14 kilograms when 12,000 tons were harvested from local marine and freshwater sources (Ministry of Agriculture estimate) and an additional 19,050 tons of fresh and processed fish were imported (Jamaica National Planning Agency). By 1982, however, per capita consumption of fish had fallen to 9 kilos, as local catch fell to 8,000 tons and imports were held to 13,000 tons due to a deteriorating balance of payments situation, while the population increased by 9.2 percent over that 9-year period. Assuming that demand had been satisfied in 1973 and that it grew in proportion with the population, national demand for fish in 1982 was 34,000 tons, more than 12,000 tons greater than available supplies.

The inshore marine fishing grounds of Jamaica are considered to be overfished. This, in addition to the high foreign exchange requirements for fisheries imports (e.g. boats, outboard motors, fuel, and replacements parts), offers little hope that the capture fishery will fill the existing unsatisfied demand. Similarly, greatly increased importation of fish is unlikely in the near future as prices are rising on the world market and the foreign exchange deficit continues.

Increased annual production of tilapia, from 15 tons in 1980 to 160 tons in 1983, indicates that farm-raised tilapia larger than 150 grams have been well received by the Jamaican consumer. The freshness of the product has been an important factor since a high percentage is sold live with most of the remainder being marketed heads-on after gutting, degilling, and scaling. Local acceptance of tilapia was further reflected by a panel of local restauranteurs that rated it higher than imported snapper and grouper in odor, flavor, and texture, table 8.

TABLE 8. CONSUMER PREFERENCE TEST FOR THREE LOCALLY-AVAILABLE FISH AS JUDGED BY AN INDEPENDENT PANEL[1]

Item	Tilapia	Grouper	Red snapper
Impression before testing			
Color	7.1	7.4	7.6
Appearance	7.0	7.2	7.5
Taste results			
Odor	7.5	7.2	7.4
Flavor	7.6	7.5	7.1
Texture	7.9	7.1	6.6

[1]Taste test was conducted by *Grace Kitchen and Consumer Center*. The panel consisted of eight members, primarily restauranteurs. All samples were fried after adding usual quantities of salt and black pepper. Test characteristics were graded on a scale of 1 to 10, in ascending order of preference. The values indicated are the average from the eight panelists.

Approximately one-third of all fish imported in 1982, nearly 5,000 tons, was chilled or frozen fish, which can be considered as a first-order competitor with tilapia. This quantity was more than 25 times greater than the rate of production of tilapia at that time and nearly 10 times greater than targeted levels at the end-of-project in 1984.

With the stagnation of the fishing industry, continued import limitations, and an expanding population, the market potential for farm-raised tilapia is very favorable. Analyses of consumer response and the traditional sources and volume of fish products in Jamaica indicate the project goal of an annual production of 545 tons of tilapia (less than 3 percent of total national consumption of fish in 1982) is well below the level that would saturate national demand.

Problems with Pre-existing Distribution Channels for Fish

During project planning, the distribution and marketing of tilapia were not expected to be a problem. Much of the marine catch had traditionally been moved through a network of small-scale middlemen, termed "higglers," and this system was expected to readily absorb the production from small farmers. In addition, arrangements had been made with the central government marketing body, the Agricultural Marketing Corporation (A.M.C.), to purchase and collect fish from the larger farmers at the pond bank. As agreed, quantities of fish in excess of 500 kilograms were initially collected by A.M.C. in refrigerated trucks and delivered to its fish processing plant in Kingston.

Several factors had been overlooked or not anticipated in the early project planning. First, the capture, processing, and distribution of a high percentage of the inshore catch had been integrated into family operations, thus greatly reducing the risk of non-payment for fish taken on consignment. The families of most new fish farmers had no experience in marketing fish and no desire to do so, and, in addition, were often unwilling to extend credit to the highly mobile higglers. Second, the irregular harvest and widely scattered fish ponds made the organization of a timely and systematic distribution system difficult. Third, the A.M.C., which ran into a financial deficit in its general marketing operations, was closed down by the Government. Two other large wholesale/retail companies, Jamaica Frozen Foods and Grace Kennedy, although experienced in marketing fish, were geared to imported bulk fish purchased at a lower price. The initial low volume, inconsistent supply, and higher price of tilapia discouraged them from moving this product. It is probable that, as the fish farming industry grows and supplies are stabilized, these or similar large companies will begin marketing farm-raised fish. To date, however, most tilapia are processed and distributed by entrepreneurs who have begun operation only recently.

Development of Distribution Channels for Tilapia

The initial involvement of project personnel in the distribution process was substantial since semi-intensive fish farming requires heavy financial investment, and failure to reach a market, especially during the early stages of the industry, would have greatly retarded investment interest. The basic policy, however, has been to gradually withdraw support as confidence developed in the marketability of tilapia.

Prior to 1981, most fish producers were reluctant or unable to locate market outlets. Although project personnel were seldom involved directly in the sale of privately produced fish, they usually coordinated the negotiations between producers and buyers. A small fraction of a harvest was often sold live at pond bank, but the major buyers were institutions such as schools, hospitals, and prisons. These institutional markets received the fish directly from the farmer or through a middleman with a previous history of distributing marine fish. Another occasional outlet was a small local market where fish were bought directly by consumers or by small-scale middlemen in lots of 5 to 20 kilograms. In both of the above cases, project personnel generally participated in the transportation and handling of the fish.

The next stage of development was the establishment of a centralized distribution outlet. This was more practical than attempting to market at pond bank because production ponds were widely scattered and accessibility to public and private transport

LEFT: Fish that are not sold live at pond bank after harvest are transported live to a central distribution point where they are unloaded for immediate sale.

BELOW: Fish are weighed for customers at a central distribution point. The obvious demand for these fish has motivated larger-scale intermediaries to begin marketing tilapia.

was highly variable. Also, for reasons of security and general farm management, many farmers preferred that their planned harvest date not be widely publicized. As a temporary measure, limited marketing facilities were made available to small-scale producers at the project's headquarters at Twickenham Park. Farmers were allowed to use holding facilities on the farm and to sell their fish on the compound.

Two additional measures were taken to ensure the predictability of the supply of fish at this location. First, private sector harvests were scheduled so that fish would be available for sale every Thursday. Second, fish from the government production farms were used to buffer the market against periodic private sector shortages. The majority of the fish were sold by the producer or his designate directly to consumers or to small-scale distributors.

The initiation of a central distribution point resulted in increased farmer confidence and a growing interest among potential processor/distributors. By mid-1982, production was expanding beyond the capacity of this one-day market. However, small-scale distributors had expanded their capacity to 2 or 3 tons of fish per week.

To accelerate private sector involvement in marketing, a fee for the use of the distribution outlet at project headquarters was suggested. Private individuals expressed interest in setting up such outlets in two parishes, but the project site will remain available to farmers until such permanent central distribution areas have been developed.

The project at this time is concentrating on developing the local market. However, a pre-feasibility study on the export potential of tilapia, to be carried out by the Jamaica National Investment Promotions Limited, has been proposed. Export of tilapia would be especially significant for Jamaica, where a reduction in foreign exchange earnings from its traditional exports has generated strong interest in opening up new overseas markets for non-traditional export crops such as fish.