

# **TILAPIA FARMING**

A Manual for Commercial Tilapia Production  
in Trinidad and Tobago

by

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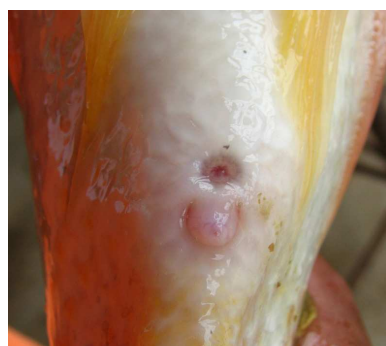
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## **PREFACE**

There is a need for a compilation of general information on various aspects of tilapia culture in Trinidad and Tobago. Although tilapia production in Trinidad and Tobago is not significant, there has been renewed interest in the area which offers great potential. It is hoped that this manual will complement the previous ones on Pond Construction and Cascadura Farming, and as well as assist in enhancing overall fish production. The basic needs for fish farmers, students, entrepreneurs, and other groups are hopefully filled.



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## 1. INTRODUCTION

### 1.1 History and Background

Tilapia culture has been part of aquaculture history since the late 1940s to early 1950s. Tilapia was described as a "wonder fish" and introduced to most parts of the world as "African perch", "Java tilapia" and "miracle fish".

Probably the most well known and widely distributed of the tilapias, *Oreochromis mossambicus* has been grown worldwide and cultured in Trinidad since the early 1950s. The fish were first stocked in ponds at the Bamboo Grove Experimental Station, Valsayn, but quickly escaped to the Caroni Swamp where they flourished and established themselves as wild stocks.

Tilapias were also stocked in previously existing ponds, and ponds that were dug primarily as watering holes for cattle. These ponds were difficult to harvest and the resultant fish production was low and uncertain. These subsistence levels of production gave little profit or economic return to the farmer.

There were many constraints to the commercial production of tilapias. Tilapia was stocked in ponds based on a "mixed-sex" system of males and females and the attractive feature of rapid breeding of the fish in ponds soon became a major management problem. The result was overpopulation of the ponds with large numbers of small, stunted fish of little market value. There was also an associated "muddy taste" and off-flavour of the flesh of the fish and insufficient marketing information.

Since the available technology and culture practices were not able to resolve these shortcomings, the fish was soon looked upon as a pest. The future of tilapia farming looked dim.

### 1.2 New Developments

Research in aquaculture over the last thirty years has made significant contributions to

commercial tilapia culture, helping to overcome some of the biological constraints in the culture of the fish. This included the modification of the culture animal through applications of genetic principles such as hybridization of species to produce larger, hardier offspring, higher percentage of males and faster growth rates.

Commercial production of tilapia has significantly improved. Production of formulated feeds and supplemental rations for tilapia, coupled with improved genetics and hybridization have produced stocks with better consumer acceptance and marketability. Since the advent of these new stocks and production technologies, tilapia farming has increased rapidly worldwide.

Commercial tilapia farming in Israel, Jamaica, Colombia and the United States has been successful. There is still some harvesting of wild stocks in South East Asia and small-scaled artisanal farming in Africa, the Caribbean and the Far East.

Regrettably, Trinidad and Tobago has not kept pace with world trends and culture practices are still behind current technologies. However, there has been a resurgence of interest and enthusiasm for tilapia farming.

### 1.3 Biology and Behaviour of Tilapias

Tilapias belong to the cichlid family, the same family as the local freshwater fishes, the blue coscarob *Aequidens pulcher*, the brown coscarob *Cichlasoma bimaculatum*, and the matawal or pike cichlid *Crenicichla alta*.

They are found worldwide but were initially introduced from Africa. Tilapias inhabit a wide range of water conditions including different salinities (freshwater, brackish water and seawater) and survive low dissolved oxygen (DO) conditions.

Tilapias are a diverse group with different species feeding on a range of available food types. They are classified according to their feeding and reproductive habits such as mouth-brooders, egg-layers, nest-builders, phytoplankton feeders and algae eaters. The

males are usually larger and are more brightly coloured than the females. Natural reproduction of cultured tilapia species occurs in one of two ways. The species *Oreochromes aureus*, *O. mossambicus* and *O. niloticus* are mouth-brooders. The female incubates and hatches her eggs in her mouth after they are laid and the male fertilizes them.

#### 1.4 Attributes of Tilapias

There are many factors which make tilapias excellent for aquaculture. Tilapias are attractive, easily bred, hardy and resistant to disease, and can live in a wide range of water conditions. They can be stocked at high densities and feed on both prepared rations and natural foods. The flesh is firm and is of excellent eating quality.

Tilapias cultured in Trinidad are the "black tilapia", "silver tilapia" and various red hybrids (Figure 1). The biology of the various species and the culture techniques used are similar, but because of the enhanced marketability of the red hybrid it is strongly recommended as the preferred fish for culture.



**Figure 1: Adult Black Hybrid Tilapia**

#### 1.5 Silver Tilapia

Also known as the silver tilapia, *Oreochromis niloticus* was introduced to Trinidad from Jamaica in 1985 by the Institute of Marine Affairs (IMA). They are silvery coloured and deeper bodied than *O. mossambicus* and are

widely used in polyculture systems with carp, catfish, mullet and fresh-water prawns.

Brood stocks were developed at the Institute of Marine Affairs (IMA), Chaguaramas, then at the Sugarcane Feeds Centre (SFC), Longdenville and the Bamboo Grove Fish Farm (BGFF), Valsayn. Silver tilapias are not widely cultured in Trinidad at present (Figure 2).



**Figure 2: Silver Tilapia harvested at the Institute of Marine Affairs. Note red hybrid on right.**

#### 1.6 Red Tilapia Hybrids

Red tilapias are obtained through genetic crossing of at least two different species of tilapias. They have been bred specifically for their bright red and orange hues and have been marketed as "red snappers", "orange snappers", and "St. Peter's fish" (Figure 3). Red tilapia hybrids have probably been the single most successful aspect of commercial tilapia research and production over the last twenty years. These hybrids are stronger and faster growing than their pure-line parents. More importantly, is the bright-red colour of the fish that makes it more appealing and attractive to the consumer than their wild-caught relatives. They also have the most commercial potential.





**Figure 3: Adult Red and Yellow Hybrid Tilapia**

Red tilapia hybrids were introduced to Trinidad from Jamaica in 1985 and several generations of hybrid crosses have been grown since. Research at the IMA and the Sugarcane Feeds Centre (SFC) indicate good polyculture potential with the armoured catfish or cascadura *Hoplosternum littorale* and giant fresh-water prawn *Macrobrachium rosenbergii* (Figure 4).



**Figure 4: Sampling polyculture ponds with red tilapia, prawns and cascadura at the IMA, Trinidad**

## 2.0 TILAPIA CULTURE TECHNIQUES

### 2.1 Mixed-sex Culture

There are several culture techniques used in tilapia production that have changed rapidly over the last fifteen years. Early attempts at tilapia farming used the method of mixed-sex culture where ponds were stocked with both male and female fingerlings. However, mature tilapias in a normal population have a high reproductive capacity and this led to overcrowding and resulted in the production of small, stunted and commercially useless fish. Mixed-sex culture is not recommended for commercial tilapia production. Monosex culture of males is the management practice most widely used to prevent overpopulation of ponds and simultaneously capitalizes on the superior growth rate of males.



## 2.2 Monosex Culture

Tilapias are best cultured on a semi-intensive level based on a monosex-culture technique. Fish production ponds are stocked with all-male fingerlings that are reared for final growout and marketing. A number of methods are used to produce male fingerlings for growout in monosex culture. These include manual sexing, hormonal sex reversal, and a combination of genetic manipulation and hormone treatment.

### 2.2.1 Manual Sexing of Tilapia

Manual or hand-sexing of tilapia is the process by which the males are identified and separated from the females. A male population may be produced by growing fry to a size at which males can be selected by the visual examination of the external uro-genital papillae or external sex organs of the fish. It is a very simple process and with practice the skill is quickly learnt. There is some degree of error involved especially in small fish less than 20 grams, but this should be kept to a minimum of less than 5 percent.

### 2.2.2 Hybridization

A high percentage male population may be produced by hybridization. For example when *Oreochromis niloticus* is crossed with *Oreochromis aureus* the offspring produced is predominantly male. For commercial production systems, this method requires proper management practices to maintain separate pure lines of the brood stock. Back-crossing or breeding of fish with the parents is also to be strictly avoided.

There is also a combination of genetic manipulation and hormone treatment to produce "supermales" by a combination of sex-reversal and genetic manipulation to produce all male brood stock which would then produce all male fingerling progeny.

### 2.2.3 Hormonal sex reversal

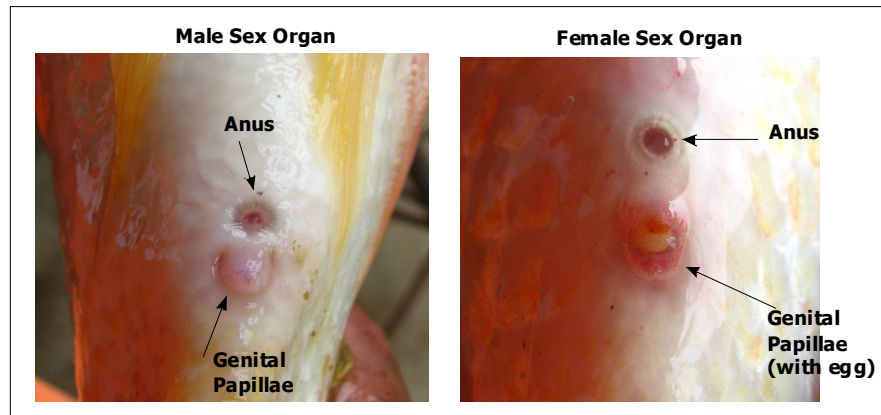
Artificial sex-inversion or sex-reversal of gonadally undifferentiated fry is achieved by feeding very young fish with a specialized diet containing male hormones. This method produces 95-100% males and its technical feasibility depends on precautions taken to reduce potential sources of error. Artificial sex-inversion or sex-reversal of fry is the most efficient means of producing male fingerlings for monosex tilapia production in commercial aquaculture systems.

## 2.3 Identifying the male

Adult males can usually be easily identified by their larger size and brighter colour. At the fingerling size, 15 to 25 grams, they are much more difficult to identify. The genital papillae of the male are quite pronounced and there is only one opening which is at the tip of the papilla. The other opening is the anus (Figure 5).

## 2.4 Identifying the female

Females are smaller than males and less brightly coloured. At the fingerling size, the genital papillae are used for identification. There are two (uro-genital) openings, one at the tip of the papilla and the other more pronounced and slit-like. The other opening is the anus. In sexually mature females release of eggs is a confirmation of the sex (Figure 5).



**Figure 5: Identifying the Male and Female**

## 2.5 Systems of culture

There are different levels of intensity as it relates to aquaculture production. The old system of fish farming relied on extensive production. Extensive tilapia production involved large ponds, low stocking densities, very little inputs of feed or fertilizer, and expected low volumes of fish. The subsistence or backyard farmer has much smaller ponds, but does not produce fish to make a profit.

Intensive systems rely on smaller ponds (<0.4 ha), tanks or raceways, more inputs of feeds, aeration, large volumes of water and higher production of fish. The risks are much higher but the resultant profits are usually greater. The unavailability and high cost of suitable land in Trinidad make semi-intensive systems more attractive. They rely on smaller areas, and can produce substantial quantities of fish that could realize a profit for the farmer. There are several culture techniques used to enhance tilapia production.

## 2.6 Phases of Production

Culture techniques for tilapia farming involves three main stages, the hatchery or brood phase, the nursery phase, and the growout or production phase. It is sometimes difficult to determine distinct differences between the phases and in some cases different stages are combined or omitted.

### 2.6.1 The Brood Phase

The brood or hatchery phase involves the actual production of the young fish or fry. This is achieved in specially selected ponds called brood ponds.

Selecting or purchasing red tilapia brood stock for your farm or aquaculture enterprise is probably the most important decision you will have to make concerning your venture. There are number of different hybrid crosses which have resulted in the red tilapia that we know today. In addition to those pure lines, there are strains. Strains are a particular group which belong to the same species but have different or specific features relating to that group. For example, one might have a fast growing strain of tilapia, another a disease-resistant strain, although both strains belong to the same species *O. niloticus*. However, greater care must be taken with the breeding programme to prevent in-breeding and 'throwbacks' to the original unwanted characteristics of the parents.

Typical characteristics of good brood fish include:

- Good body conformation traits (small head: body ratio, deep body, relatively thick, good dress percentages)
- Free from pathogens and disease
- Bright even colour
- Good egg production
- From good genetic pool

Brood ponds are stocked with sexually mature male and female fish (brood stock) at low stocking densities of 10,000 to 15,000 per hectare. Sex ratio of three females to one male (3:1) is common but up to a 4:1 ratio can be used.

After about two weeks the young fry are observed at the pond edges and are removed with a fine-meshed seine (knot-less nylon 2.5 mm). This is done once or twice per week. Fry at about 1 to 5 grams are then transferred to the nursery ponds.

### 2.6.2 The Nursery Phase

The nursery phase involves growing the young fry to fingerling size in nursery ponds (Figure 6). The nursery ponds are larger than the brood ponds but are significantly smaller than production or growout ponds. They are approximately 0.4 –0.6 ha. Nursery ponds are stocked at very high densities of 240,000 to 300,000 per hectare. Fry are fed a floating pelleted supplemental ration in a regime based on percentage of body weight for a period of 6 - 8 weeks. Table 1 shows a proximate analysis of the pelleted fish ration used for tilapia culture in Trinidad.



**Figure 6: Fingerling from nursery pond**

**Table 1: Proximate analysis of pelleted supplemental fish ration used at the IMA**

Ingredients	Percentage
Tuna Fish Meal	15.3
Soya Bean Meal	51.2
Corn	17.3
Rice Bran	5.0
Brewers Grains	7.5
Animal Fat	2.0
Di-calcium Phosphate	1.5
Vitamin Premix	0.2
<b>TOTAL</b>	<b>100.0</b>

The fish achieve fingerling size, 15 to 25 grams, at which time they are hand-sexed and the males stocked in the growout or production units.

In some cases, where there is a limitation of available ponds, brood stock can be removed from the ponds with a large mesh seine (4 cm). The fry are then allowed to undergo the nursery phase in the brood ponds.

## 3.0 SEX-REVERSAL TECHNIQUES

### 3.1 Sex-reversal

Sex reversal (or sex-inversion) is the oral administration of male hormones through feed to recently hatched fry before their sex organs are fully developed. This is sometimes used to produce all male fingerlings for stocking in growout ponds. This technique has been used worldwide in Jamaica, Israel, Panama, Ecuador, Colombia, Philippines and the United States in commercial systems.

Hormonal sex-reversal of tilapia fry is a relatively inexpensive technique and has several advantages over manual sexing. These include the following: -

- Large numbers of fry are available for growout.
- There is less wastage of fish and food since no females are discarded.

- Decreased labour and effort to produce male fingerlings.
- There is usually less breeding in production ponds.
- Less demand on pond space.
- Less expense in terms of food costs.

### 3.2 Production of sex-reversed populations

Female brood tilapia release young fry, which are gonadally undifferentiated. For effective sex reversal, the fry should be at most 2 days old. The male hormone treatment must be continued until the gonadal tissue of the developing fry has differentiated into testes. Genetic females develop into phenotypic males. The sex-reversed males are functionally male but remain genetically female and the breeding of these males will result in a larger percentage of females in their offspring.

### 3.3 Brood Ponds

Before filling brood or reproduction ponds, 3 cm nylon mesh netting should be draped in the harvest sump. The brood fish are then stocked at a 1:3 male to female ratio respectively. The stocking density of the brood pond should be approximately 10-12,000 per hectare. The spawning cycle lasts approximately 19 to 21 days.

At the end of this period the pond is drained and the brood stock are removed by lifting the 3-cm mesh. The mouths of parent females are checked for incubating eggs. Any eggs present are washed out and retained for later incubation in hatchery tanks. The free-swimming fry of a suitable size for sex-reversal remaining in the pond are netted out using a mosquito net.

### 3.4 Feed Preparation

The sex-reversal diet is prepared by an alcohol evaporation method. Ordinary fish ration (a filler) is mixed at a ratio of 40 to 60% with a high protein fishmeal substitute of approximately 60% protein, which is used as base. The hormone, alpha-methyl-testosterone

is dissolved in a solvent of methanol or ethanol at a rate of 60-70mg of hormone to 1 litre of solvent. This is added to the feed at a rate of 60-70 mg of hormone to 1kg of feed, hand-mixed, and allowed to dry by air. This is done 3 to 4 days prior to usage. This mixture should not be stored for more than 4 days.

### 3.5 Tank culture and cage culture

There are various types of sex reversal techniques, but two practices have been most successful each with its own advantages and disadvantages. Tank culture uses "clear water" and aeration and is usually done indoors (Figure 7) while cage culture is confined to cages in outdoor earthen ponds.



**Figure 7: Flow-through clear water system at the Institute of Marine Affairs, Chaguaramas**

#### 3.5.1 Tank culture

Fry are brought into the wet laboratory from brood ponds, and sorted using a 2.5 mm mesh. Those passing through the mesh are used for sex-reversal and range from approximately 7-11 mm in length. They are stocked in treatment tanks where they are chemically treated for diseases and parasites, which they may acquire from the outdoor ponds. They are then transferred to the culture tanks by siphon at stocking densities of approximately 5-6,000 per cubic metre.



**Figure 8: Concrete tanks used for sex-reversal of tilapia fry at a fish farm in Jamaica**

The fry are maintained in a circulating stream of biologically filtered water at a temperature of 23-26°C and fed at a rate of 20% body weight per day 4 times daily. The sex-reversal cycle is approximately 28-30 days and the feed is gradually reduced to 10% body weight per day at the end of the cycle. Weekly sampling of the fry facilitates determination of feeding rates.

Ecto-parasitic infections can cause diseases during the feeding treatment and these have to be carefully monitored and controlled with the use of effective prophylactic agents.

During the treatment period, the growth of fry is slow because of the high densities and relative low treatment temperatures maintained. Upon completion of the sex-reversal treatment, fry are stocked in nursery ponds for rapid growth prior to their stocking in production ponds. Fish ration of about 28-32% protein is used for the nursery and production cycle.

### 3.5.2 Cage culture

Fry from the reproduction ponds are passed through a 3.1 mm mesh grader to remove fry larger than 14 mm. The smaller fry are stocked in cages of mesh size 1.5 mm and stocked at stocking densities of approximately 2-3,000 per square metre.

The fry are fed on the sex-reversal ration 4 times daily starting at 20% biomass per day at the start of the cycle and reducing to 10% at

the end. The fry in the cages show more substantial growth than those sex-reversed in 'clear' water. The fry are then removed from the cages at the end of the cycle and stocked in nursery ponds and fed on a normal fish food diet. The disadvantage of this technique is its exposure to the elements and possible loss of thousands of "partially sex-reversed fry" in the event of damage or removal of nets or cages. Figure 6 shows tilapia fry in cages being fed with hormone treated feed.



**Figure 9: Tilapia fry being fed in net-cage with hormone-treated feed at a fish farm in Jamaica**

## 4.0 TILAPIA PRODUCTION

### 4.1 Monosex Production

Tilapias are best cultured on a semi-intensive level based on a monosex-culture technique. Fishponds are stocked with all-male fingerlings that are reared for final growout and marketing.

### 4.2 Growout or Production Phase

The growout or production phase is probably the most important phase and is the stage where the fish farmer should be most concerned about survival, growth rates and feed conversion. These are the factors that will most likely affect the viability and profitability of the project.

Stocking densities for the growout phase may vary and depend on the intensity level of the



particular system. Densities may range from 35,000 to 100,000 per hectare from semi-intensive to intensive levels respectively.

Survival is usually expressed as a percentage of the initial stocking density and will vary from pond to pond. An average of 75% survival is acceptable but with good management, up to 85% can be anticipated.

Tilapia will grow at an average of 2 grams per day with much faster growth in the early stages and slowing down towards the end of the production cycle. Growout period for tilapia, from fingerling size to a plate size or food fish size, (300 to 400 grams) is 3 to 4 months and may extend to 6 months depending on the final size required for the market. The average target size is about 380 grams.

#### 4.3 Feeding the fish

Fish are usually fed twice daily for a minimum of 6 days per week. More frequent feedings are desirable, 3-4 times/day, if possible. Fish should be fed slowly, with the food broadcasted over a sufficiently large area. This will allow easy access to the food by a large number of fish. Fish will not “overfeed” but putting too much feed in the pond may result in poor water quality conditions such as low dissolved oxygen.

Fish should be fed based on the estimated body weight obtained from sampling the pond or from a theoretical growth curve. The amount of feed per day is a percentage of the total body weight of the fish varying from 20% at stocking to as low as 3% just prior to harvest. For example if a pond is stocked with 1,000 fish weighing an average of 300 grams (estimated from sampling) and is to be fed at 3% body weight per day, then the daily feed rate would be 9 kilograms. This amount would be divided in 2 or 3 equal portions for each feeding. Table 2 shows a typical feeding guide for tilapias raised in fish ponds.



**Figure 10: Red tilapia hybrids at surface of water at feeding time. Note high density of fish.**

**Table 2: Feeding guide for tilapia in fish ponds**

<b>FISH WEIGHT (GRAMS)</b>	<b>FEEDING RATE % BODY WEIGHT/DAY</b>
0 - 1	30 - 15
1 - 5	15 - 10
5 - 25	10 - 5
5 - 150	5
150 - 250	3
250 - 450	3

#### 4.4 Handling of fish

The handling of live fish should be done without undue stressing of the animals, especially fry and fingerlings. This may mean seining and transporting fish to a covered or shaded area for the actual handling process such as manual sexing or brood selection. Aeration and frequent water changes reduce stress to the fry and fingerlings.





**Figure 11: Sampling ponds to estimate feed rates at the Institute of Marine Affairs, Chaguaramas, Trinidad**

When manually sexing fish, males should be identified and placed in clearly marked containers, tubs, buckets or cages well away from containers with the females. This prevents any unplanned mixing of the sexes. This method may be labour intensive, time consuming, and wasteful of the approximately 50% female component. Nevertheless, it has proven to be an economically feasible technique in many countries or circumstances with skilled and inexpensive labour. It is also used on small farms.

For indoor exercises, a prophylactic treatment of potassium permanganate to give a slightly pink colour (approximately 3 mg/l) or salt (15 g/l of sodium chloride for 30 minutes) is advisable, especially if fish sustain cuts and bruises during handling. In any event, it is good practice to use prophylactic methods.

#### 4.5 Hatchery or Brood Phase

Brood ponds should have a firm bottom and good drainage. The feeding rate is 1-3 % body weight per day using a supplemental feed ration with crude protein of about 26-35 %.

It is a good practice to maintain brood stock separate from your other fish and to prevent inbreeding. This is usually achieved by not allowing brood ponds to continue for long periods. They should be drained and restocked every 2 to 3 months when possible.

#### 4.6 Nursery Phase

The major problem encountered in nursery ponds is high mortality due to poor handling during stocking and harvesting. By following good fish handling procedures at this stage, unwarranted mortalities are reduced. Nursery ponds should be completely drained, allowed to dry out and all water puddles poisoned with a fish toxicant like Rotenone, lime ( $\text{Ca}(\text{OH})_2$ ) or household bleach (e.g. Clorox®).



**Figure 12: Nursery pond being treated with bleach after a total harvest, Institute of Marine Affairs, Chaguaramas, Trinidad**

#### 4.7 Growout Phase

After 6 months, the growth rate slows significantly and feed conversion becomes less efficient. It is at this point that the fish farmer must make the decision to harvest and sell his fish or risk losing money for a few extra grams. In the final analysis, it is the possible profit that will influence the exact timing of harvest and the marketing of the product.



**Figure 13: Growout Ponds under construction at the Sugar Cane Feeds Centre, Longdenville, Trinidad**

#### 4.8 Harvesting

Harvesting of fish for the market is usually with a seine. Two methods are employed, a partial harvest or total drain-down harvest. Partial harvest involves pulling a seine to remove the larger marketable fish and leaving the smaller ones to grow. A total harvest is achieved by draining the pond and removing all of the fish. This usually follows several seine hauls or a partial harvest. Typically, the period between a partial harvest and a total harvest is about two weeks.

Fish should be harvested in the cool of the morning or evening to prevent undue stressing of the fish. Care should also be taken to keep fresh water in the pond, especially at the drain end. Fish should be quickly transported either to a holding area or to processing facilities. Sometime fish are placed in cages for holding just prior to market.



**Figure 14: Harvesting of tilapia pond, Institute of Marine Affairs, Chaguaramas, Trinidad**



**Figure 15: Cages for temporarily holding fish after harvesting. Note legs on cages prevent sinking in pond-bottom mud**

#### 4.9 Marketing of fish

Marketing of your fish farm products is probably the most important aspect of your aqua-business and should be distinguished from a mere sale of fish. Since aquaculture products will be a relatively new and non-traditional commodity, ingenious and aggressive marketing strategies must be employed.

The major competition for the market will be from marine fish sales. Farm-raised tilapia has the distinct advantage of being available for market as needed, thereby guaranteeing a fresh product.

Farm-raised tilapia can also be sold live, by transporting the fish to the market site in tanks and actually displaying the live fish. This method had very good success in a preliminary market survey of retail fish markets in Trinidad done by the IMA, the results of which showed that there is a definite demand for the fish at a price that can generate a profit for the farmer. The attributes of taste, texture and price were very good when compared to marine products.



**Figure 16: Marketing “live red tilapia” at the Tunapuna Market, Trinidad**

Other methods include retail markets such as supermarkets where red tilapia has been sold for \$35.00 per kilogram and frozen fillet for \$50.00 per kilogram. The farmer must be able to guarantee good quality, consistent supply and the appropriate volumes of fish to satisfy customers and to even consider an export market. For large-scale production of tilapia, exports markets are a definite possibility. The United States imports chilled or frozen whole fish as well as chilled or frozen fillets.

## 5.0 SUGGESTED READING

**Fish farming handbook: food, bait, tropicals and gold fish.** Brown, E. Evan; Gratzek, John B. Westport: AVI, 1980. 391 p.

**Fish Farm Ponds. Design, Construction and Maintenance.** Gabbadon, Paul and de Souza, Gregory. IMA Aquaculture Series 1. Institute of Marine Affairs, Trinidad. 1990. 21 p.

**Cascadura Framing: from hatchery to production.** De Souza, Gregory and Gabbadon Paul. IMA Aquaculture Series 2. Institute of Marine Affairs, Trinidad. 1990. 22p

**A Guide to the Farming of Tilapia.** Hanley, Fred. 1990. Master Blend Feeds. Jamaica. 20p.

**Textbook of fish culture: breeding and cultivation of fish.** Huet, Marcel; Timmermans, J. A.; Kahn, Henry, trans. West Byfleet, Surrey: Fishing News Books, 1975. 436 p.

**International conference on warmwater aquaculture.** Finfish. Proceedings. Hawaii: Brigham Young University Office of Continuing Education, 1985. 711 p.

**Second international symposium on tilapia in aquaculture.** Pullin, R. S. V.; Buhukaswan, T.; Touguthai, K.; Maclean, J. L. Bangkok, Thailand 16-20 March 1987. Bangkok and Manila: Department of Fisheries and ICLARM, 1988. 623 p.

**Tilapia genetic resources for aquaculture.** Pullin, R. S. V., ed. Proceedings of the workshop on tilapia genetic resources for aquaculture 23-24 March 1987, Bangkok, Thailand. Manila: International Center for Living Resources Management, 1988. 108 p.

**Marketing the Red Hybrid Tilapia: A Pilot Survey of Retail Fish Markets in Trinidad.** Manwaring, Garret; de Souza, Gregory; Gabbadon, Paul W. and Titus, Addison. IMA Research Report. 21p.

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\* **Note:** Publications available at IMA Library

## **APPENDICES**



## APPENDIX I

### GLOSSARY OF TERMS

<b>brackish water</b>	a mixture of fresh and salt water
<b>fertilizer</b>	a substance added to water to increase the production of natural fish food organisms.
<b>fry</b>	recently hatched fish which weigh less than 1 g or measure less than 2.5 cm in total length.
<b>grow-out pond</b>	a pond used to grow aquatic animals to marketable size.
<b>integrated aquaculture</b>	Aquaculture systems integrated with livestock and/or crop production. For example, using animal manure to fertilize a pond to enhance fish production and water from the pond to irrigate a garden.
<b>male hormone</b>	a substance that, when fed to tilapia fry, induces undifferentiated tissue to develop into male gonads (testes). Hormone used is testosterone.
<b>manual sexing</b>	examining a fish to determine its sex.
<b>manufactured or supplemental food</b>	commercially processed food for fish that will allow good growth in fish ponds.
<b>mixed-sex culture</b>	culture of males and females in the same ponds
<b>monosex culture</b>	culture of all-male fish for market.
<b>mouth-brooder</b>	a fish that hatches its eggs in its mouth.
<b>oviduct</b>	a tube serving as the passage for eggs from the ovary.
<b>papilla</b>	a small fleshy appendage which projects from the underside of a fish and through which a female passes eggs and urine and a male passes sperm and urine.
<b>partial harvesting</b>	periodic harvesting of a portion of the fish from a pond during a culture cycle.
<b>plankton</b>	the various, mostly microscopic, aquatic organisms (plants and animals) that serve as food for larger aquatic animals and fish.
<b>polyculture</b>	simultaneous culture (in the same pond) of two or more aquatic species with different food habits.
<b>Spawning</b>	the act of depositing eggs and producing young.
<b>Substrate spawner</b>	a fish that lays its eggs on some form of substrate or surface where they will hatch.
<b>uro-genital pore</b>	an opening for passage of urine and sperm outside the body.
<b>Zooplankton</b>	the animal component of plankton.

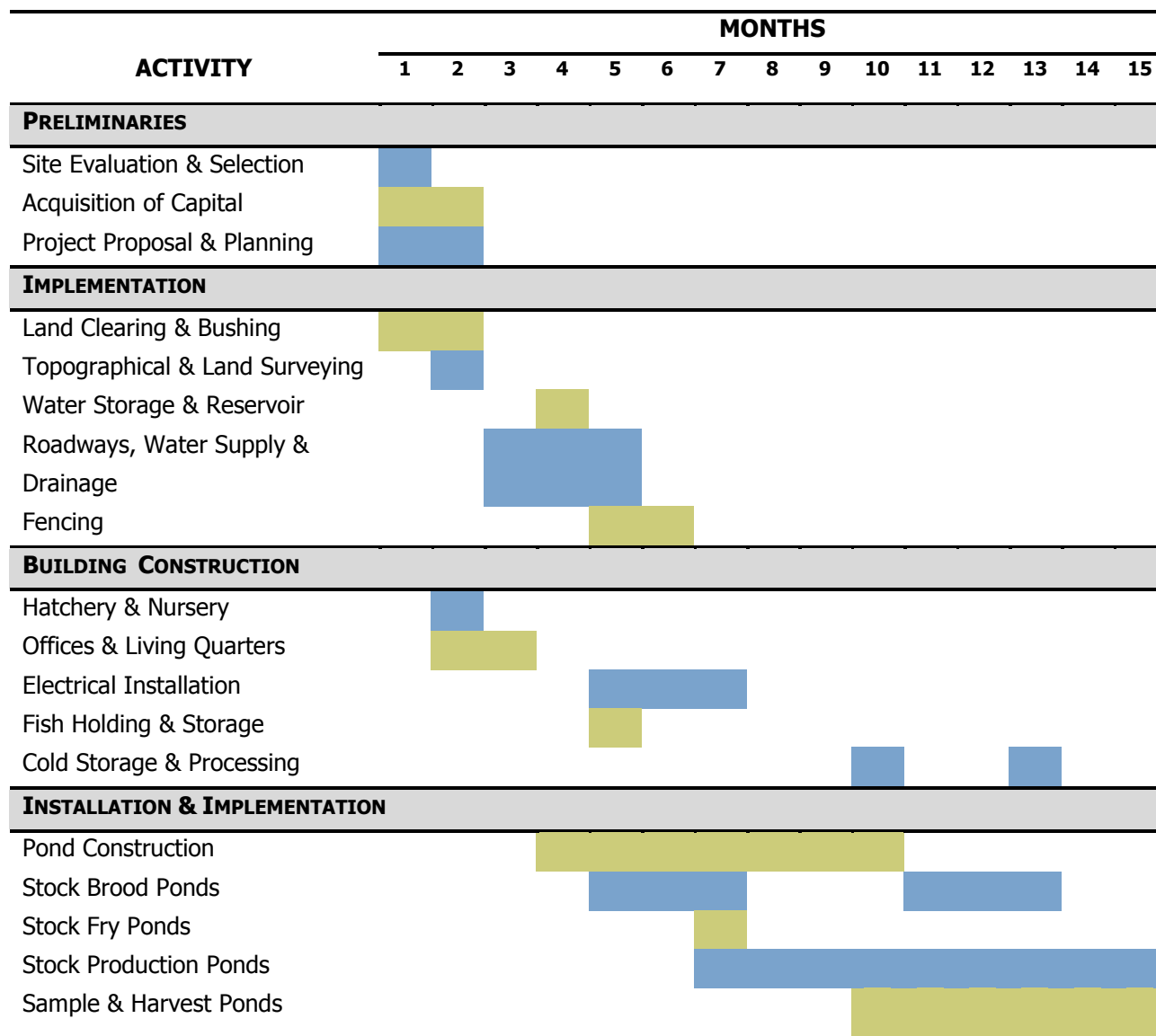


## APPENDIX II

The following Table shows a schedule of activities and outlines the major tasks necessary for project implementation.

### Schedule of Activities:

#### Typical Activity Schedule of Tilapia Farming Project for the First 15 Months



## NOTES