GREENHOUSE TILAPIA PRODUCTION IN LOUISIANA

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Introduction

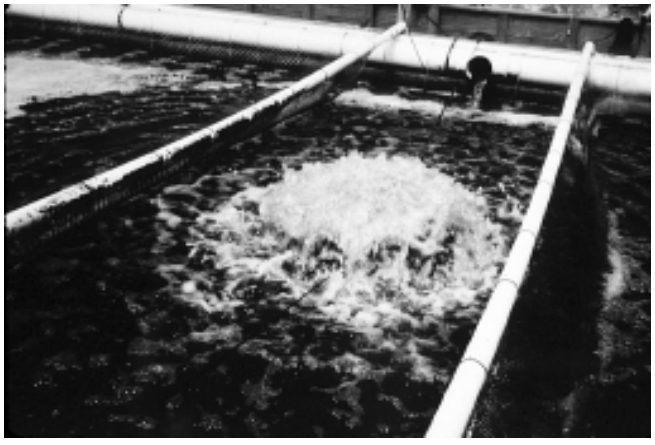
The term tilapia refers to several related fish species, all native to Africa and the Middle East. They were first grown thousands of years ago in ancient ponds and cages for the tables of Egyptian pharaohs. Today, these tropical, perch-like fish rank second only to carp in global aquaculture production and are one of the most rapidly emerging seafood products in the United States.

Tilapia are hardy and grow rapidly under crowded conditions, but their tropical nature is a major drawback for U.S. producers. Various species and strains of tilapia differ in cold tolerance, but growth is generally limited at water temperatures below 70 degrees F, and most tilapia become severely stressed at 65 degrees F. Death begins to occur at 60 degrees F, with few surviving temperatures below 50 degrees F for any period of time.

These characteristics limit production and marketing opportunities for pond producers in states like Arkansas, Texas, Mississippi and Florida, but many producers throughout the Southeast avoid these constraints by growing tilapia in indoor recirculating tank systems. In Louisiana, tilapia cannot be raised in outdoor ponds; their production is limited by the Louisiana Department of Wildlife and Fisheries to indoor recirculating systems under strictly controlled conditions to prevent accidental introduction of these species into natural waters.

Recirculating Production Systems

In any type of aquaculture, basic environmental requirements must be maintained for fish survival and growth. These include adequate dissolved oxygen (DO), acceptable water chemistry and the removal or neutralization of waste products. Waste products associated with fish production include ammonia and fecal solids. Additional wastes can result if feed goes uneaten. Recirculat-



ing or "re-use" systems rely on the continuous circulation of water through mechanical and biological filters to remove solids and neutralize ammonia. This allows water quality to be maintained at levels that promote growth and survival of the species being cultured.

Mechanical filtration involves the use of fine screens or submerged beds of gravel, sand or plastic beads to trap solids as water flows through the filter. Key features producers should look for in evaluating mechanical filters include solids removal efficiency, required back washing frequency, water loss through back washing, ease and cost of operation and capital cost per unit of capacity.

Ammonia is a toxic by-product of protein digestion, excreted from the fish's bloodstream across the gills. Neutralizing ammonia in recirculating systems requires biological filtration. Biological filtration uses commonly occurring natural bacteria to oxidize ammonia to nitrate, a relatively non-toxic compound. The process involves two separate stages, each performed by a specific type of bacteria. In the first step, bacteria belonging to the genus *Nitrosomonas* convert ammonia to nitrite. Nitrite is also toxic to fish, but as it begins to build up a second group of bacteria, *Nitrobacter*, converts it to nitrate.

Biological filters (or biofilters) are designed to push water across or through a variety of materials with lots of surface area for *Nitrosomonas* and *Nitrobacter* bacteria to grow on. Gravel, plastic beads, plastic rings and corrugated sheets of fiberglass or plastic are often used to provide surfaces for bacteria to colonize. As bacteria reproduce and solids accumulate, biofilters require back washing or some other form of cleaning to avoid reduced water flow. Key biofilter features producers should look for include operating costs, mechanical simplicity, ease of operation, self-cleaning tendencies and capital cost per unit of capacity (pounds of feed fed per day).

Although tilapia will survive and even grow at oxygen levels well below the acceptable range for most fish species, profitable tank production requires continuous aeration to maintain dissolved oxygen at optimum levels. Common types of aeration are easily adapted to tilapia tank production. Continuous turnover of the water column along the sides of the tank can be accomplished by forcing air through air stones or anchored pipe with holes drilled at regular intervals. Floating vertical pump aerators also can provide additional oxygen. Under certain conditions, pure oxygen can be used to increase production capacity, but pushing system capacities to these levels elevates the risk of catastrophic loss if equipment or power fails.

Fingerling Sources

Maintaining broodstock and rearing fry require good culture skills as well as special feed, tanks and other equipment. As a result, in many instances it is more economical to purchase fingerlings than to try to produce them on site. In either situation, the quality of fingerlings from a genetic standpoint can vary greatly. While mixed-sex culture of tilapia can be economically feasible with proper management and growout densities, predominantly male fingerlings produced from YY-male broodstock or through dietary sex reversal of newly hatched fry demonstrate distinct advantages in terms of

growth rate and uniformity. Improvements in growth appear to increase profitability in Louisiana greenhouse systems more than do improvements in feed conversion efficiency.

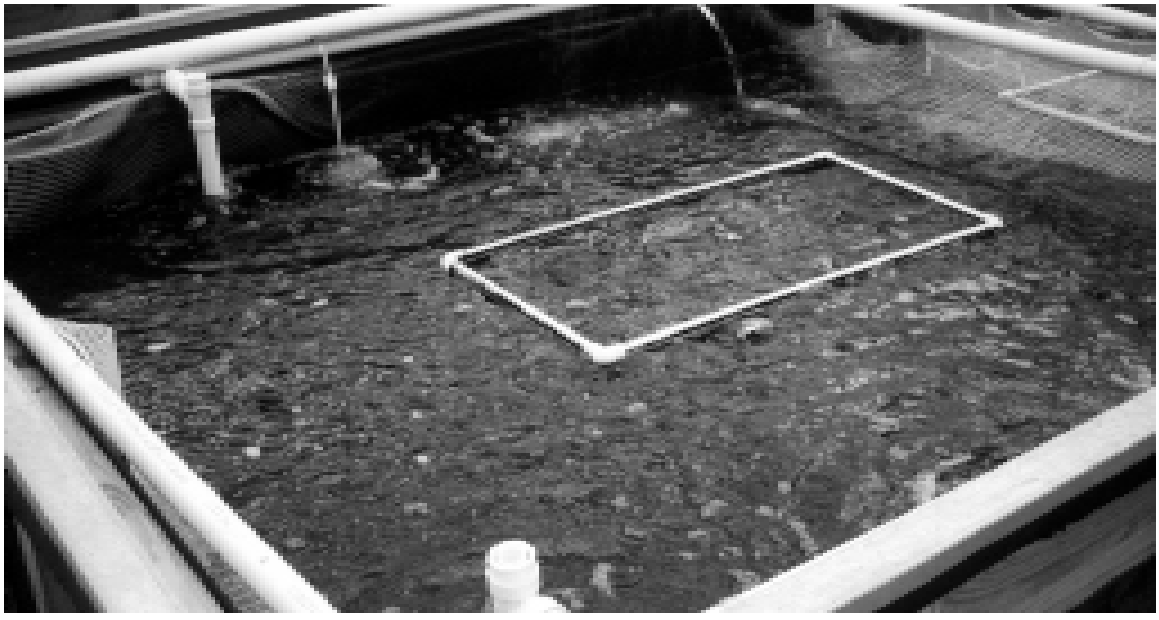
Temperature tolerance is also important when comparing tilapia species and strains. The wrong genetic background in tilapia fingerlings can have practical consequences in terms of increased growout time in the system, increased heating costs to maintain growth in cool weather and lower market value for fish that fail to reach 1 pound or more. Whatever the genetic background of any given production strain, the health status of every shipment of fingerlings entering a facility should be thoroughly evaluated. The potential risk of introducing diseases such as *Streptococcus sp.* dictates extreme caution in choosing a fingerling supplier. Once contaminated, recirculating systems may require thorough drying and disinfection before operations can be resumed.

Stocking and Harvest Management

A simple means of maximizing production in recirculating systems is to approximate the system's maximum carrying capacity at all times. This may be accomplished by physically adding and removing fish from individual tanks at frequent intervals as they increase in size, but a much easier method is to divide each production tank into four or more sections, each housing a different size of fish. As a group of marketable fish is harvested, small fingerlings can be added to the same tank in the empty compartment. In this way, the overall load on filters, pumps and aerators remains relatively constant.

Tilapia fingerlings tend to grow at slightly different rates, and initial size differences are rapidly magnified as larger fish compete for more than their fair share of the feed while smaller fish cannot eat enough to increase their size substantially. In both instances, the conversion of food to saleable fish is inefficient and unprofitable. For this reason, grading and separating tilapia by size classes can improve profitability.

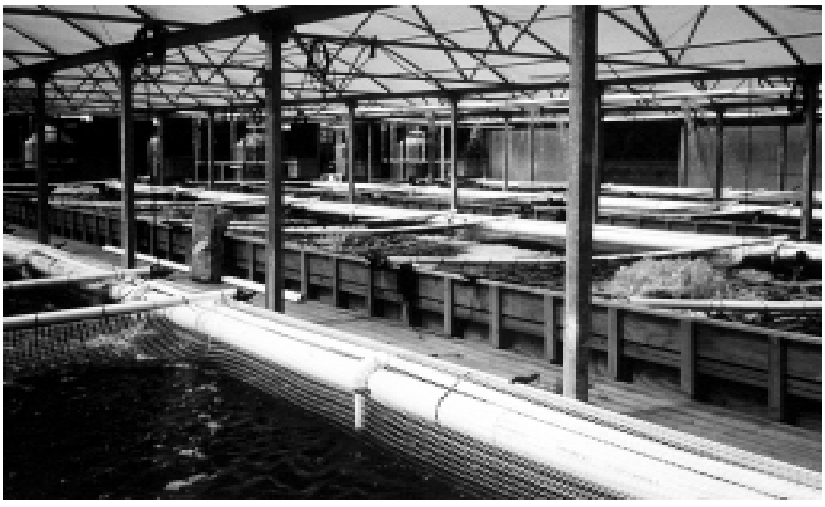
In round tanks, settleable solids can often be concentrated by means of a circular current and removed directly through a central drain, but using tank dividers to



separate size classes of tilapia effectively eliminates this advantage by disrupting the current. If solids can be kept in suspension until they are removed by mechanical filtration, rectangular tanks can be used for tilapia production. A series of net pens, each with an appropriate-sized mesh, can be suspended within a tank, allowing easy management of size classes throughout the growout period.

Commercially available greenhouses lend themselves easily to tank production of tilapia, especially if rectangular tanks are employed. Apart from efficient use of floor space and relatively low capital costs, greenhouses allow for the development of algae blooms in production tanks. A healthy algae bloom can reduce biological filtration requirements through the natural uptake of ammonia as a source of fertilizer. Algae also consume nitrate and use carbon dioxide from fish respiration as a carbon source during photosynthesis.

Another advantage derived from algal blooms in tilapia production is improved fish growth and feed conversion. In addition to consuming prepared feeds, most species of tilapia are filter feeders, removing algae from the water column throughout the day. As a result, algal blooms serve not only to reduce or convert waste loads in a recirculating system, but to recycle these nutrients to increase fish production.



Regulatory Considerations

The Louisiana Department of Wildlife and Fisheries allows for the culture of tilapia only under strictly controlled conditions. To avoid potential negative impacts to native species, tilapia must be grown only in indoor tanks, with a number of safeguards to eliminate the possibility of escape into the wild. The development of low water-use filtration systems has allowed several commercial production systems to go into operation in recent years. The following are highlights from the Rules and Regulations on Importation, Culture, Possession and Disposal of Tilapia in Louisiana, promulgated by the Louisiana Department of Wildlife and Fisheries:

• All aspects of tilapia culture systems and processing facilities shall be completely enclosed so that predation from birds, mammals, amphibians and reptiles is precluded.

• All water utilized in the culture of tilapia (adult fish, juvenile fish, fry or fish eggs) shall be accounted for and shall be filtered, screened and / or sterilized prior to leaving the culture system and the permittee's property in such a manner as the Department deems adequate to prevent any possibility of escape from the system.

• All aspects of tilapia culture facilities must be at least one foot above the 100-year flood elevation. Additionally, the Department may require a surface hydrological assessment of the proposed site at permittee's expense.

• Applicants must demonstrate to the satisfaction of Department officials that adequate security measures are in place at culture facilities to guard against vandalism and theft of tilapia.

• It shall be the responsibility of the permittee to have at

least one individual who is familiar with the culture system readily available for emergencies, inspections, etc.

• For each occurrence when the permittee wishes to import, export, transport, possess, transfer or sell live tilapia, the permittee must obtain, in writing, approval from the Department. In addition, if live tilapia are transported into or within the state of Louisiana, anyone taking possession of these live tilapia must also have a tilapia permit. Live tilapia showing signs of diseases shall not be transported into or within the State of Louisiana. Among other key points, approval requests shall include electrophoretic certification which must identify stock(s) to the species or hybrid level.

• The cost of a Tilapia Permit shall be $50.00, plus the actual cost of the on-site inspection. Qualified universities conducting research approved by the Department shall be exempt from the fee charge. In order for the permit to be valid, a Fish Farming License from the Department is required. Permits are valid for 12 months, and are not transferable from person to person, or property to property.

* The Department may employ whatever means it deems necessary to prevent the release or escapement of tilapia or their eggs into the environment. In the event that tilapia should escape or be accidentally released, the permittee shall agree to reimburse the Department for all costs including, but not limited to, man hours and materials utilized during corrective actions. In order to assure the Secretary that the permittee will fulfill their financial obligation, the permittee shall, at the option of the Department, post a $25,000 performance bond, or present a letter of credit from a financial institution stating that the $25,000 is available to the Department on a certificate of deposit.

Complete information on the permitting process in Louisiana can be obtained from:

Permits Supervisor, Inland Fisheries Division
Louisiana Department of Wildlife and Fisheries
P.O. Box 98000
Baton Rouge, LA 70898-9000

Economics

An economic model of greenhouse tilapia production has been developed based on a typical Louisiana recirculating system. Data from Louisiana greenhouse facilities with similar construction and management have been compiled to provide an economic characterization of this particular approach to tilapia production. Development and operating budgets presented here reflect costs and returns for an annual production level of 100,000 pounds (Table 1). The budgets include reasonable expectations of labor, management and capital contributed by owner operators.

The economic model is based on a facility with three 16 feet wide by 80 feet long by 5 feet deep grow-out tanks constructed of treated lumber, insulation board and a 40-mil liner. Land requirements total 0.9 acres, based on 150% of the required production tank and work area plus 0.5 acres to accommodate delivery and loading access and a sludge settling pond. Production tanks and surrounding work areas require a 5,990 square feet greenhouse for enclosure. A 2-foot

well is included to fill production tanks and supply daily make-up water. New construction of an office and restroom with an on-site septic system, as well as an adjoining storage area, is assumed.

Open-top automated air-washed bead filters are used in the model system. Aeration is accomplished through several means, including the use of air stones suspended at regular (0.3 - 0.5 m) intervals along tank walls and supplied with forced air from regenerative blowers. Floating vertical pump aerators are also used for supplemental aeration. A diesel generator sized to operate the entire facility in the event of a power outage is included. Net pens are required for segregating tilapia by size groups.

Equipment requirements include scales, dipnets, a monitoring and alarm system,

Table 1. Facility, equipment and operating costs for 100,000 pounds per year tilapia greenhouse facility in Louisiana.

Item, Unit	No. Units	Cost / Unit	Total
Facility and Equipment			
Land, Acre	0.9	$2,500.00	$2,248
Permits			$450
Greenhouse, sqft.	5,990	$3.25	$19,469
Heating / Ventl., sqft.	5,990	$.50	$2,995
Water Well	1		$3,200
Tanks / Decking	3	$4,224.00	$12,672
Electrical Installation	3	$550.00	$1,650
Filters / Pumps	6	$5,200.00	$31,200
Plumbing / Fittings	3	$720.00	$2,160
Blowers, 2hp	3	$580.00	$1,740
Aerators, ½hp	12	$625.00	$7,500
Generator, Diesel	1		$6,000
Net Pens w / hardware	18	$300.00	$5,400
Equipment, Tools			$5,180
On-Site Septic System			$1,980
Settling Pond			$1,000
Alarm System			$2,500
Storage			$2,000
Office / Restroom / Etc.			$6,000
Truck (3 / 4 ton), trailer			$26,000
	TOTAL		$141,344
Operations			
Feed, lb	180,000	$ .17	$31,429
Fingerlings, 4.5g	75,988	$ .21	$15,959
Electricity	3	$6,105.00	$18,315
Hired Labor	1.25	$20,000.00	$25,000
Other			
(repairs, alarm monitoring, phone svc., etc.)			$8,000
Marketing, Promotion, Travel			$4,000
Insurance			$2,500
	TOTAL DIRECT		$105,202
Estimated Depreciation			$14,143
Direct Expenses and Depreciation: $1.19 per pound of production			

feeders, an oxygen meter and water quality test kit, telephones, a fax machine and other necessary items for day-to-day operation. A 3/4-ton pickup truck and trailer are included for transporting construction materials, equipment, fingerlings and other items.

Operating cost estimates for the economic model are based on a feed conversion ratio of 1.8 pounds of 32% protein feed (at $340 per ton) to 1 pound of tilapia weight gain. Fingerlings are stocked at an average weight of 4.5 g, with assumed survival of 94% to a harvest weight of approximately 1.4 pounds. Growout is projected to take 8.5 months on average, with the fastest-growing fish reaching market size during their eighth month in the systems and the remainder harvested before the end of the ninth month. Electrical costs reflect $475 per month direct charges and $33.75 overhead charges (office use, security lighting, etc.) per production tank.

One full-time laborer at $20,000 annual salary and one quarter-time laborer paid at the same rate are required, in addition to owner-operator contributed labor and management. Owner-operators must determine the value of their contributed labor and management on a case-by-case basis. Repairs, alarm monitoring, office operations and related day-to-day expenses are estimated at $8,000 annually, with an additional $4,000 budgeted for marketing, promotion and travel. Annual insurance was estimated at $2,500.

Based on estimated costs for facilities and operations and prevailing 1996-1998 Louisiana farm-gate prices to live-haul markets, a cash flow illustration for the model facility *assuming the owner-operator supplies 100% of the required capital for facility development and operation and has an outside source of income to meet living expenses* is shown in Table 2. Under these conditions the model facility shows a cumulative return to the owner-operator's labor, management and contributed capital of almost $17,000 by the end of the fourth year of operation.

If the same economic model is modified to reflect the combined impacts of borrowing 60% of startup funds, annual financing of

Table 2. Cash flow illustration for 100,000 pounds per year Louisiana tilapia greenhouse facility, July startup. Values are for end of operating year, based on prevailing 1996-1998 Louisiana costs and farm-gate prices to live-haul markets.

	Year 1	Year 2	Year 3	Year 4	Steady State
Cash Outflows					
Construction	$55,135				
Equipment	$85,340				
Other Startup	$2,869				
Feed	$11,420	$31,428	$31,428	$31,428	$31,428
Hired Labor	$25,000	$25,000	$25,000	$25,000	$25,000
Utilities	$15,771	$18,315	$18,315	$18,315	$18,315
Fingerlings	$13,299	$15,959	$15,959	$15,959	$15,959
Other, Mkt.,etc.	$12,000	$12,000	$12,000	$12,000	$12,000
Insurance	$2,500	$2,500	$2,500	$2,500	$2,500
Total	$223,335	$105,202	$105,202	$105,202	$105,202
Cash Inflows	$35,566	$173,381	$173,381	$173,381	$173,381
Cumulative returns to operator labor, management and contributed capital	(187,769)	(119,590)	(51,412)	$16,767	

operating costs and a $24,000 annual salary draw for the owner-operator, however, the positive cash flow horizon more than doubles at 1996-1998 average market prices. These prices, in turn, are only slightly higher per pound of production than the total of direct costs, depreciation and interest.

Markets

Since recirculating systems are generally more capital intensive than other forms of aquaculture, very high yields or revenues per volume of capacity are required. Tilapia are the most suitable aquaculture species for recirculating system production in most areas of the U.S. because of prevailing market prices and their ability to withstand tank culture conditions. Tilapia consumption has increased steadily in North America in recent years, and the market is supplied by both imports and domestic production.

Variation in the quality of tilapia in North American markets is reflected in a wide range of prices. Market outlets demand everything from whole, preferably live, fish, especially among Asian-American consumers, to quick-frozen fillets for the restaurant trade. Although live-fish markets in large northeastern cities sustained most pioneers in the U.S. tilapia industry, new producers should be aware that these markets have already approached a point where only the lowest-cost producers will be able to compete for market share. Expanding markets for tilapia throughout the country include local restaurants, regional brokers, supermarkets, seafood dealers and other niche markets. Growers will have to emphasize superior quality to compete with imported fillets in these market outlets.

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