

Farmer to Farmer Program

TILAPIA AQUACULTURE IN HAITI

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The goal of the Farmer to Farmer Program is to provide training and support to fish farmers who request education and advice on sustainable aquaculture practices. Farmer to Farmer volunteers provide on-site information and training in small-scale sustainable aquaculture techniques in developing countries. The focus is on the training of farmers and extension personnel in aquaculture Best Management Practices (BMPs). Accompanied by Bill Mebane, of the Marine Biological Laboratory Sustainable Aquaculture Initiative, the Aquaculture without Frontiers volunteer visited tilapia aquaculture production sites and fish farmers in Haiti. Activities were focused on Lake Azuei, a hatchery near Croix de Bouquet, and a hatchery near Leogane.

Taino Aquaculture, S.A. (8-9 April 2011)

Taino Aquaculture, S.A. is a recently established aquaculture business initiated by two Haitian-American brothers (Hans and Patrick Woolley) to culture tilapia in cages in Lake Azuei. The brothers own land on the lakeshore and are using this land to support cage operations in adjacent waters (18° 30.170'N 71° 57.683'W). Currently there are two cages in operation. Each cage is 10 ft x 10 ft x 5 ft and is stocked with 8000 tilapia fingerlings. The first cage was stocked on 18 February and the second cage was stocked on 7 March. A sample of from the first cage indicated that the fish were about 100 g, although the size range was quite variable.



Recommendations

Expand the scale of the operation to 12 cages within six months. The current operational scale is too small to allow demonstration of proof-of-concept and the timeline for project development should be accelerated.

Establish permanent structures on the shoreline to support aquaculture operations. Current storage facilities are inadequate and insecure.

Provide an alternative location for bathing and laundry for local residents. Currently local residents must pass through land owned by Taino Aquaculture to access these traditionally used

sites. Conflict with local residents over open access to the site may have profound negative implications for cage operations and site security.

Develop brush-park fisheries along the shoreline where depth permits.

Establish a record-keeping system to demonstrate proof-of-concept to support efforts to obtain investment capital. Specifically, records of feeding and fish inventory should be maintained.

Secure commitments for marketing of fish produced at Taino Aquaculture. The goal of selling fresh fillets into Miami will be difficult in the context of well-established marketing channels enjoyed by producers in Central America and Ecuador.

Caribbean Harvest (9-11 April 2011)

The project includes a for-profit business and a non-profit foundation managed by Dr. Valentin Abe. The business addresses critical nodes in the cultured fish value chain. It produces fingerlings for sale, transports fingerlings to growers, provides feed for sale, buys fish from growers, and transports and sells fish at market. The non-profit foundation secures funding for infrastructure, such as cage materials and hatchery construction. Beyond fish farming as an income-generating activity, and in partnership with other supporting NGOs, notably Operation Blessing, the project is also involved in providing other badly needed social services to residents of some extremely impoverished communities. These services include education, school meals, and construction of community centers, among others.

***Croix de Bouquet Hatchery* (18° 33.493'N 72° 12.586'W)**

The hatchery was started in 2006 and currently produces 1.2 million red tilapia fingerlings annually. Water is provided by a groundwater well that is 115 ft deep; the pump can deliver 150 gpm. There are 18 large 12,000-gal tanks used for spawning and 18 smaller 6,000-gal tanks used for fry production. Tanks are constructed of grain-silo sections embedded in a poured concrete floor sitting atop a raised base constructed with block and earth-fill and containing drain lines. Diesel generator power is available to pump water and operate other equipment.



Egyptian and Israeli strains of red tilapia are used for broodfish. Apparently the Israeli strain has greater salt tolerance but the Egyptian strain has a smaller head. Broodfish are used for four

years, then retired. Broodfish are stocked into spawning tanks at 60 females and 30 males. After 3-4 spawning cycles, females are rested. After 30 days, spawning tanks are drained, broodfish are moved, and the fry production cycle begins anew.

Fry are collected by dip net around the circumference of spawning tanks twice daily. Fry are counted by weight and 30,000 are stocked into fry rearing tanks. Fry are not sex-reversed because nearly all fish will be stocked in cages. Fry are cultured for two months at the hatchery to a size of two inches (3-5 g), a suitable size for stocking cages. The cost of production is \$0.12/fingerling and the sales price is \$0.14/fingerling.

During our visit, we constructed a prototype in-tank biofilter to support the goal of production intensification. The biofilter consists of a plastic barrel, floating Kaldnes media, and an airlift pump for water movement through the media bed.



Hatchery near Carrefour Peligre (18° 54.812'N 72° 7.024'W)

Caribbean Harvest has recently completed construction on a satellite hatchery near Lake Peligre and also near a large new clinic under construction near Mirebalais. The hatchery has six 12,000 gal tanks and a water storage tank that receives water pumped from the adjacent river, a tributary of the Artibonite River. The storage tank also includes a small treatment capacity to render the water potable. By 2012, the hatchery will have 15 tanks. The goal of the hatchery is to produce 40,000 small (2-in) fingerlings per month, doubling in the next two years. The fingerlings will be used to stock cages placed in Lake Peligre, using the model that has been successfully applied in Lake Azuei. The hatchery also has a training center that includes sleeping quarters for trainees. Funding support for construction of the hatchery and training center was provided by Partners in Health and the Clinton Global Initiative.



Cage sites

Caribbean Harvest began project work in Lake Azuei and now works with four of the seven villages around the lake. We visited two communities where the project is active. One is a community of Haitian migrant workers forcibly repatriated from the Dominican Republic located on the lakeshore near the border ($18^{\circ} 29.577'N$ $71^{\circ} 56.246'W$) and the other is an extremely impoverished and isolated village on the southern lakeshore ($18^{\circ} 33.015'N$ $72^{\circ} 2.474'W$).



We also visited the dam at Lake Peligre ($18^{\circ} 54.052'N$ $72^{\circ} 2.323'W$) to view potential areas for expansion of the project and implementation of cage culture. There are currently six cages in production now, towards a goal of 250 cages. Observation of the current reservoir stage indicates that wide variation (15-20 m) in water level occurs between dry and wet seasons, possibly complicating siting and access to cage culture areas. Nonetheless, the large number of small coves on the lake indicates high potential for cage culture or pen culture in coves.



Funding from the Clinton Global Initiative and Operation Blessing allowed the purchase of materials to construct 240 cages, sufficient for 120 families. Cages are 4 m³ and production ranges from 800 to 1200 pound/cage after 4 months of grow-out. Caribbean Harvest “sells” fingerlings and feed to farmers and then buys the market-sized fish at a price that is greater than the cost of fingerlings and feed but less than the sales price. Average production costs are \$0.90/lb, Caribbean Harvest buys fish from farmers for \$1.40/lb and sells fish for \$2.40/lb. Thus, revenue is shared between the cage farmer and Caribbean Harvest.

About half the production cost is feed, which is imported from the United States. The main feed used in production (30% protein) is manufactured by Southern States in Valdosta, GA. The base price for the feed is \$12.00 per 40-lb bag. Port fees and transportation to the hatchery adds \$8.83/bag. Feed is sold for \$22.00/bag.

Farmers receive training on swimming and water safety, fish feeding, harvesting protocols to preserve quality, and money management.

Recommendation

The goal of increasing production output of the Croix de Bouquet will require intensification of water use. The focus of increasing production intensity should be on increasing the supply of dissolved oxygen, primarily by diffused aeration. A blower system, powered by a photovoltaic array and battery storage system, should be installed and operated during nighttime hours. The blower should provide sufficient air to support a diffuser array in each tank. Addition of biofiltration capacity using simple, in-tank filters operating with air-lift pumps should be a secondary effort.

Damien Fish Culture Station (11 April 2011) (18° 35.871'N 72° 17.627'W)

With Jean-Robert Badio, Director of Fisheries and Aquaculture in the Ministry of Agriculture and Natural Resources, we viewed the Damien Fish Culture Station. The station was constructed in 1950 with financial and technical support from the FAO. Fingerling production at the station declined in the 1970s, due to lack of government support. The station was revitalized with the assistance of UNDP in the mid-1980s, but has once again fallen into disrepair. During our visit to the station, we observed several intact concrete raceways and small tanks. All ponds were dry and most had crops, especially bananas, growing inside. Although the land is ostensibly owned

by the Ministry of Agriculture, people have established residence in the area, which is not secured.



Recommendation

Securing funds for rehabilitation and revitalization of the Damien station will be difficult. Given the repeated pattern of activity and inactivity, it is hard to see how international donors would be willing to support the station. Furthermore, one of the main activities of the station—the production of fingerlings for distribution to farmers—may be better served by the private sector or smaller government-operated facilities closer to areas of production. If the Ministry of Agriculture and Natural Resources views rehabilitation of the Damien station as a priority, then a good-faith demonstration of the government's commitment might spur international donors to support the effort. One option that might serve as a confidence-building measure is construction of a wall or fence around the facility in order to control access. Obviously this would also include the disruption associated with removing and relocating the people that have taken up residence on the station grounds. Once the facility is secure, international donors or even private-sector investors may be more inclined to support a revitalized Damien station.

Christianville (12 April 2011) (18° 31.491'N 72° 33.375'W)

We were shown a series of 13 concrete ponds of variable size (most around 200-300 m²) by a resident agronomist, Christian Jean-Pierre. The facility is supplied by an excellent surface water source. Ponds are clearly producing far below potential although we were told that 1600 fish are harvested weekly. Red tilapia fingerlings (5 g) are produced in a set of small concrete tanks and then stocked at about 1/m² in concrete ponds and cultured for 3-5 months. The productivity of the water (as indicated by green color intensity) is quite low in most ponds. It appears that water exchange rates are too high. Water exchange is likely used to manage water quality as a way to reduce the risk of oxygen depletion. Water exchange is not very effective as a technique to manage low dissolved oxygen concentration, but remains widely used. The high tolerance of tilapia for low dissolved oxygen concentration should also be considered in using water exchange. Furthermore, oxygen depletion is rarely the cause of tilapia fish kills unless fish are held at very high densities, which is not the case in the ponds at Christianville.

Undesirable tilapia reproduction was observed in at least seven ponds. Given the production system at Christianville, tilapia are reaching sexual maturity and spawning before harvest.

The ponds at Christianville have considerable potential to provide food for the 2000 children at the facility. To fully realize that potential, further intensification of the pond production system should be considered.



Recommendations

Fish in all ponds are clearly underfed. The reservoir water adjacent to the chicken houses contains abundant nutrients that can be applied to the concrete tilapia ponds to raise fertility levels in those ponds. Alternately or additionally, consider adding substrate for periphyton production and grazing by tilapia. Periphyton is a preferred natural food for tilapia.

Reduce the rate of water exchange in ponds. Water should be allowed to become more intensely green before exchanging pond water with spring water. This should increase fish production by allowing pond fertility to increase.

Two options to address undesirable tilapia recruitment in production ponds are 1) culturing fish in stages, where fish are manually separated by sex at about 20-50 g between stages or 2) provide newly hatched and collected fry testosterone-treated feed for 28 days to produce a preponderance of males. Alternative, sex-reversed male fry can be obtained from the nearby CODEP hatchery.

Kiskeyi Aqua-Farm (13 April 2011) (18° 32.343'N 72° 37.190'W)

This farm is owned by a Haitian-American entrepreneur and medical doctor who is a resident of Boston, MA. The farm, in the Sheridan area near Leogane, has fish ponds, pigs, chickens, rabbit, and vegetable crops such as tomatoes, eggplant, peppers, and fruit trees such as bananas and papaya. The fish component consists of eight earthen ponds, each of which ranges from about 600 to 800 m². Red tilapia fingerlings (~5 g) are purchased from the national hatchery at Point Sonde for 2 goude/fish. Fish are marketed locally in Leogane and often directly from the farm. The market price is 75 goude/lb (\$1.87/lb). There are about seven people who work on the farm, with specific individuals responsible for specific areas, although all workers help in each area. None of the workers have had any formal training, with the exception of the farm manager, who is a trained agronomist. The person responsible for the fish ponds was not present during our visit.



Recommendations

Ponds did not appear to be particularly well-managed, despite the resources and investment made to construct them. Although a few bags of feed were present, obtained from Caribbean Harvest, feed was not stored properly, nor did it appear that fish were fed regularly and in sufficient quantity. Vegetation growing on levees and at pond margins was tall and thick. Regular cutting of vegetation on pond levees reduces the risk of fish loss from predators that seek refuge in the thick plant growth, especially at the water edge. Basic improvement in pond management is needed and would allow improvement in the production potential of the ponds.

Although fingerlings were obtained from the Point Sonde hatchery, the quality of these fingerlings is unknown and it appears unlikely that the fish were sex reversed. Consider purchasing sex-reversed fingerlings from the nearby CODEP hatchery.

CODEP (12-15 April 2011)

CODEP (Comprehensive Development Project) is mainly a reforestation program that is active in the hills between Leogane and Jacmel, but the project also includes an aquaculture component.

Hatchery

A small tilapia hatchery is located at the CODEP guest house in L'Acul (18° 26.547'N 72° 41.350'W). There are eight tanks for spawning and ten small tanks for fry rearing. Diffused aeration is provided continuously and water is pumped intermittently. The hatchery provides tilapia fingerlings for 50-60 small, family- or group-owned concrete ponds in the hills.

During our visit, each tank was drained, fish were separated by species/color, sex, and size. All tanks were thoroughly cleaned. The aeration system was renovated by servicing the blowers, repairing air manifolds and valves, replacing brittle tubing, and cleaning air diffusers. Tanks with no fish were emptied, cleaned, and left dry.

Four of the eight larger tanks were stocked with broodfish with the intention of initiating multiple cycles of spawning and fry collection. Two tanks were stocked with white hybrid tilapia and two tanks were stocked with Nile tilapia. The first fry collection occurred after ten days.



Recommendation

Continue with one-week collections of fry for each species. After one week of collection, start stocking another fry tank. After fry collection, provide hormone-treated feed to fry for 3-4 weeks, depending on the day collected. Feed small amounts of feed throughout the day.

After sex-reversal, grow the fry for another month in the larger tanks. Production intensity will be limited by water exchange or treatment. The goal should be a small (5 g) fingerling.

Hill Ponds

As indicated previously, the CODEP hatchery is used to provide fingerlings for small (50 ft x 50 ft) concrete ponds constructed on the saddles of steep hills in the area between Leogane and Jacmel. Examples of these ponds can be found at 18° 24.207'N 72° 38.288'W and 18° 23.109'N 72° 36.443'W. The ponds appeared to be receiving a variable degree of management attention. Some ponds contained active compost piles that included cut grass and animal manure in pond corners. These ponds had moderately dense phytoplankton blooms. Other ponds were obviously not well-managed, as indicated by relatively clear water. Few ponds visited included substrate for periphyton, despite this technique being promoted as a method to improve productivity. Ponds produce approximately 50 pounds every 6 months. Although this appears to be a paltry production level, project participants are very enthusiastic and pleased with the results.



Recommendations

Make a vigorous and sustained promotion and demonstration of the benefits of periphyton-based tilapia aquaculture. Provide strings of bamboo substrate to all fish farmers in the project. Some bamboo culms can be modified by packing them with chicken manure.



Select a few key farmers to provide ponds that will serve as demonstration sites for periphyton-based tilapia aquaculture.

Most of the ponds visited were shaded to a variable degree by trees planted as part of the reforestation project. These trees should be cut back to increase the availability of sunlight to drive plant growth in ponds.

Zanmi Beni orphanage (15 April 2011)

The Zanmi Beni orphanage is operated by Operation Blessing International, an NGO providing disaster relief, health and medical services, community water systems, and support for aquaculture projects in Haiti, among other services. The orphanage includes an aquaponics system manufactured by Nelson & Pade, Inc.



Recommendations

Experience with groundwater and calcareous soils in Haiti suggests that the salt content and hardness of groundwaters will complicate efforts to grow plants in aquaponics systems. Operation of the system might require increased water exchange to maintain salt levels below thresholds that reduce plant growth, essentially defeating the purpose of having a water-efficient system. One option is to collect rainwater for use in the aquaponics system. Rainwater has a very low salt concentration and the nutrient composition can be easily manipulated to desired levels for good plant growth.

Analyze a sample of well water to determine the following constituents: total dissolved solids, conductivity, hardness, alkalinity, specific cations (sodium, potassium, calcium, magnesium), specific anions (bicarbonate, sulfate, chloride), and micronutrients (iron, copper, molybdenum, and boron). In addition, pH should be measured in a water sample as soon as it is collected from the well. This will allow judgment of the suitability of the water source for aquaponics.

If the salt content of the water is too high, consider transforming the aquaponics system into a fish-only system. This will require additional biofiltration capacity, which can be accomplished by adding media to at least two of the four fine-solids removal tanks. These could be in the form of simple moving bed reactors with floating plastic media. Fish could be cultured in stages with one stage in the tanks currently designated for plant growing and the other stage in the existing fish tanks.

The following recommendations should be implemented regardless of the decision to fundamentally modify system management:

Add additional support beneath fish rearing tanks. The current framework is inadequate and is causing pinching and buckling of the plastic tank bottom.

Move air blower to the perimeter and provide a designated shelter to allow some noise shielding. Replace the existing pipe that is currently connected to the blower outlet with a length (18 to 24") of galvanized pipe to allow heat dissipation. Add air pressure relief on the blower outlet line. The valve can be a T in the line connected to a gas valve connected to a 8-12" ceramic diffuser. The valve should be opened until line pressure begins to decline below selected operating pressure (ca. 48").

Modify plumbing on outlet pipe from solids collection tank (clarifier). To collect sludge in buckets, add a short section of riser pipe, a horizontal leg, and a downturn.

Build bins for composting of fish sludge with bagasse. Be sure that bin construction allows drainage and collection of water beneath the pile. Alternatively sludge can be added to burlap bags for dewatering and thickening.

Remove the bag filters from the pipes supply water to the final stage of the treatment system (i.e., degassing tank). Filter fabric has already begun to tear. These filters would not be needed in a fish-only system.

Plant tomatoes in bins along the perimeter of the aquaponics facility. Tomatoes are recommended because they are reasonably salt-tolerant. Use determinate (bushy) varieties.

Comments on other facilities and sites visited:

Lake Azuei

Lake Azuei, also known as Etang Saumatre, is the largest lake in Haiti (22,000 acres). It is about 22 km long and a maximum width of 12 km. The maximum depth is reported to be about 30 m, with an average depth of 8 m. Salinity in the lake ranges from 10-15 ppt; at the time of our visit, measured salinity was 5.6 ppt. Primary productivity of the lake appears to be low and the current trophic status is oligotrophic to weakly mesotrophic.

Water is provided by numerous springs arising in the surrounding mountains. Lake water level has been increasing since 2008. After 2008, there was an abrupt increase in water temperature and water level (~2 m). We observed a pond aquaculture facility at the eastern end of the lake that was completely inundated by rising lake levels. Numerous residences have been abandoned and the main road connecting Port au Prince with the Dominican Republic had to be modified by the addition of fill to allow continued use of this vital transportation link.

Wind velocity and direction have a distinct annual pattern in the lake.

<u>Time period</u>	<u>Velocity</u>	<u>Direction</u>
November to February/March	Strong	From the east
March to June	Light	Variable
June to late August	Strong	From the east
Late August to November	Light	Variable

Little is known about the physical and chemical dynamics in the lake. This is of particular importance in the context of fish kills that occur periodically, such as occurred in late December 2010. Although a definitive explanation is not possible given that the event has passed, some reasonable speculation can be made. Combining knowledge of the lake salinity, depth profile, and annual wind pattern, it seems probable that the fish kill was a result of an oxygen depletion or sulfide toxicity following a lake destratification event. The elevated salinity of lake water suggests that sulfate concentration is high, indicating an elevated potential for sulfate reduction to sulfide under the anaerobic conditions that may occur during lake stratification. Lake Azuei is likely stratified during the period of low-velocity winds from late August to November. As surface waters cool in November and December, the temperature difference between surface and bottom layers narrows. Thus, when winds become strong in November and December, the energy required to completely mix the lake is minimized. In a lake the size of Lake Azuei, the depth of the mixed surface layer is about 10 m. Given that the average depth of the lake is about 8 m, most of the lake area is mixed most of the time. However, the deepest, main channel areas of the lake likely remain stratified until they become mixed with surface waters in November or December. This hypothesis can be tested or verified by sampling lake temperature profiles periodically at multiple stations near the deepest lake areas and at times corresponding to changes in wind velocity. Such sampling will not prevent future fish kills from occurring, but

can help cage fish farmers prepare to move cages to areas where water quality is better, if possible.

The initial stocking of the lake with *Oreochromis mossambicus* and common carp was conducted by FAO in the 1950s. The lake has been stocked with tilapia twice since 1999. Tilapia reproduction and recruitment in the lake is limited by salinity. The lake includes a native cichlid, *Cichlasoma hatiensis*, that is of conservation concern. The predaceous bigmouth sleeper, *Gobiomorus dormitor*, is also present in the lake.

There are about 3000 people living around the lake. For about 60% of this population, the sole source of income is fishing, usually with gill nets. For 33% of the population around the lake, income is derived from fishing and animal husbandry (goats, cattle).

Artibonite River Valley (10 April 2010)

The Artibonite River Valley is a rural area in central Haiti with considerable potential for pond aquaculture. The river flows out of Lake Peligre and flows in a northwesterly direction to Point Sonde. There are numerous sites in the river valley that appear to be good places for large-scale commercial pond aquaculture as well as small-scale mixed agriculture that includes fish ponds. Some of the places with high potential include the area near the town of Verettes, which is currently planted with corn, and the rice fields near Liancourt. The rice field area of the lower Artibonite River valley is quite extensive and represents a large area with high potential for development into pond aquaculture or rice-fish farming.



Point Sonde National Fish Hatchery (10 April 2010)

(19° 9.003'N 72° 36.611'W)

This fish hatchery is managed by the Government of Haiti through the Artibonite Valley Authority (ODVA). Although the Ministry of Agriculture and Natural Resources has authority over aquaculture matters, it does not control aquaculture activities of the ODVA, such as the Point Sonde hatchery. The hatchery was constructed in 1988 with funds from the UNDP and produces tilapia and common carp fingerlings for distribution to farmers. The facility includes 14 earthen ponds, concrete raceways, spawning tanks, and holding tanks. The facility appears to be under-utilized and not well maintained, although well designed.

