Development of Organic Feeds and Production Techniques for Tilapia Fish Production in Ecologically Based Recirculating Aquaculture Systems.

Farmer/Grower Grant Final Report FNE02-448

Project Goals:

Our project goals were to identify organic feed sources and organic production techniques for tilapia fish raised in aquaculture systems. Such techniques and feed sources are badly needed to improve the health and quality of the cultured fish, reduce negative environmental impacts, and capitalize on the growing markets for both organic foods and aquaculture products.

Our production based goals were to achieve acceptable feed conversion ratios and growth rates without using antibiotics, steroids, growth hormones or high percentages of ocean-harvested fish meal that are commonly used in aquaculture feeds.

Farm Update:

Since receiving the farmer/grower grant, the Ocean Arks food group was renamed to Advanced Farm Ecosystems. The renaming was executed to better distinguish our work in the area of ecological food production. Advanced Farm Ecosystems is now the official name of the Ocean Arks food group. We now have two full-time employees and three part time employees that oversee our farm research operations located in a 7000 square foot greenhouse in South Burlington and a 1250 square foot greenhouse in the Intervale agricultural area of Burlington, Vermont. We are currently conducting research on aquaculture systems, dairy manure treatment and conversion to value-added products, winter produce production and mushroom production.

Cooperators and their role:

Our technical advisor, Dr. John Todd, assisted our project by sharing his many years of experience in aquaculture and marine biology. He helped us identify aquatic plants, algae and invertebrates that can be cultured within the aquaculture system for use as organic feeds. Dr. Todd also connected us with some of the most respected and well-known aquaculturalists in the world. These contacts led to a site visit by Steve Serfling (President of Sunwater Systems, Inc. in Sarasota Florida and former President/CEO of Solar Aquafarms in Southern California). Mr. Serfling has developed some of the worlds most advanced recirculating aquaculture systems for tilapia. We also visited the operations of John Reed of Bioshelters Inc., a successful aquaponic

operation (tilapia and basil) in Amherst, Massachusetts. These site visits provided valuable information on the industry and ideas on how to construct a system for organic production.

Summary of Opportunities, Advantages and Challenges of Tilapia Culture:

Opportunities:

- Aquaculture is one of the fastest growing sectors in the agricultural economy and the market for tilapia in United States is growing at 20% annually.

- New market opportunity for high quality, high value organic fish.

Advantages:

- Intensive production in a small footprint (up to 1/2 pound per gallon water).

- Recirculating systems are a highly efficient use of water resources (99% water reuse)

- Tilapia feed low on the food chain and consume a wide variety of natural feeds that can be cultured within the system. (Algae, duckweed, azolla, copepods, amphipods, red worms)

- Tilapia are hardy and respond well to fluctuations in water quality associated with recirculating systems.

- Nutrient rich water can be used to grow a variety of produce crops and giant freshwater shrimp.

Challenges:

- Organic Feed Production: the development of organic pellet-type feeds will require the sourcing of acceptable protein sources. The extrusion technology used to formulate floating feeds is generally accomplished on a very large scale. Small-scale technology must be located or developed to produce smaller batches of feed using only organic ingredients.

- Live Market vs. Fillet: the live market for tilapia is most active in ethnic communities around larger cities. This market is reaching saturation and has additional barriers to entry (language and cultural). Most consumers outside of these specialty markets prefer fillets. Fillets require more labor and equipment and reduce the mass of sellable product (fillet yield only 25-36% of live weight).

- Energy consumption and overall operating expenses: tilapia require water temperatures of 80-85° F for optimal growth. Recirculating aquaculture systems also require significant aeration and pumping to maintain acceptable water quality.

Project Summary:

Our project was separated between two components:

Part 1. Research into organic standards for aquaculture.

Beginning in March 2002, the project team investigated the current status of organic aquaculture in the United States. This included a review of existing practices, previously proposed standards, timelines for acceptance of organic standards under the new USDA certification program, and investigation into promising feed sources and culture techniques for organic production. As a result of this research, we produced a resource compilation entitled: "The State of Organic Aquaculture in the United States". This compilation is included with the final project report for this grant.

Part 2. Construct pilot system and conduct research to prove effectiveness of various organic production techniques.

In March of 2002, we began construction of a 2000 gallon recirculating aquaculture system. This system contained 4 culture tanks and an ecological filter system. In May 2002, 876 all-male tilapia were stocked into the system. Initial average weights and lengths were recorded at stocking time. The fish were fed a combination of cultured vegetative and live feeds as well as a grain-based pellet. The vegetative feeds included the aquatic plants duck weed (*Lemna minor),* azolla *(Azolla caroliniana*) and several species of algae cultured in the aquaculture system. The live feeds included copepods (a fresh water shrimp) grown in the aquaculture system and red worms cultured in a vermicomposting system. The fish were fed between 2 and 5% of biomass daily. The target weight of the finished product was 1 lb. (live weight). Harvest and filleting of the fish took place in November of 2002.

Results and Accomplishments:

The most significant result that we achieved was to reduce the amount of supplemental feed used to less than 1 pound per pound of live fish produced. The average feed conversion ratio (FCR) for the grain-based feed over the 25 week growing period was 0.97. This compares to FCR's of

1.5 to 2 for conventionally grown tilapia. Our low FCR result proves that the natural feeds present in our system significantly reduced the amount of supplemental feeds needed for production. See tables and charts below for data.

Table 1. Feed Conversion Ratios for Tilapia in Ecological Recirculating Aquaculture System. Please note that Ratios were calculated from supplemental feed amounts only.

Week	FCR
3.5	1.27
6	0.91
7.5	0.71
9	3.07
10.5	0.7
12	0.51
13	1.21
13.5	0.89
14.5	0.92
15.5	0.82
16.5	0.55
18.5	2.35
20	0.72
21	1.08
23	0.72
25	1.98
Cumulative	0.97

Table 2. Tilapia growth rates over 25 weeks in recirculating aquaculture system.

Week	Ave Weight (lbs)
1	0.00
4	0.00
6	0.01
8	0.02
9	0.03
10	0.05
12	0.09
13	0.10
14	0.11
15	0.13
16	0.16
17	0.20
18	0.18
19	0.22
20	0.26
21	0.27
23	0.31
25	0.34

Chart 1. Tilapia growth rates over 25 weeks in recirculating aquaculture system.

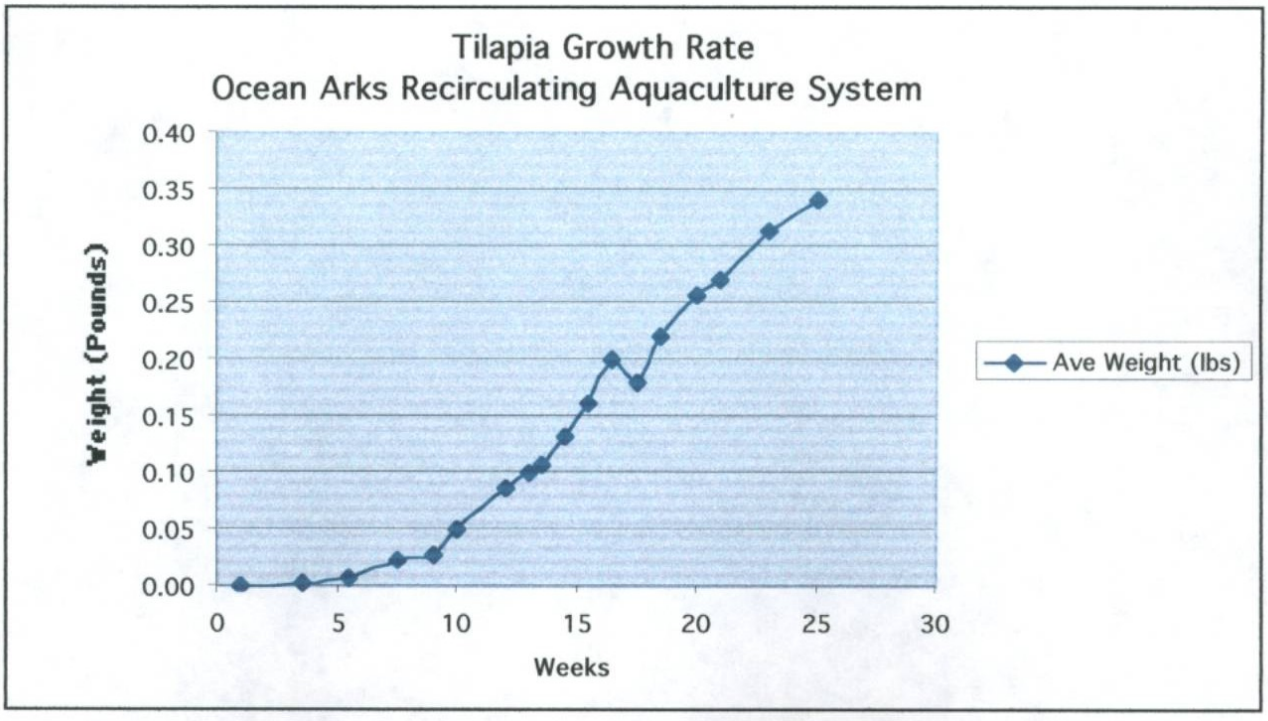

Table 3. Tilapia Harvest Data.

Tilapia Harvest Data	
	(lbs.)
total mass of fish harvested	242.5
total mass of filets	36.655
total mass of fish fileted	159.07
Avg. live weight on harvest	0.3166
% of weight as filet	0.2304

While we were successful in reducing the amount of conventional feeds required and improving the feed conversion ratio through the use of natural organic feeds, we failed to achieve the desired harvest size after 6 months of culture. After further investigation and discussions with other growers, we learned that a 1 lb. live weight yield is very difficult to achieve in only 6 months. In the Northeast region, 9 to 12 months would likely be required to achieve such results. We intend to continue using the natural feeds in our system as a viable supplement to conventional feed. The natural feeds (algae, aquatic floating plants, snails and worms) add stability to the system and serve the additional function of maintaining good water quality for the fish.

Project Continuation:

Our system was designed as a small-scale pilot and was never intended to be economically self-sustaining. In the next phases of this project, our challenge will be to scale the system in such a way as to produce a sufficient revenue stream to cover operating costs and return a reasonable profit to the small-scale diversified grower. The most promising technique for achieving this goal includes the use of aquaponic technolgy. Aquaponics involves the raising of hydroponic crops on the nutrient rich waste of the fish. In addition to removing nitrogenous waste from the fish culture tanks, the plants in the aquaponic system can provide up to 80% of the total revenues. We find exceptional quality and flavor profile of the fish and produce grown in an ecological aquaponic system based on natural feeds.

Outreach Program

Our facility is open to the public 5 days a week. During the duration of the SARE research project, we gave tours of our work to several hundred visitors including elementary and high school groups, college students and professors, farmers, natural resource professionals and the general public. In addition to the tours, we hosted a fish fry at the annual Intervale Festival which draws about 3,000 people. Hundreds of festival attendees were able to sample our fish and learn how it was raised. We have also provided several phone consultations with individuals

interested in learning more about our project. We were featured in one international trade magazine and as a feature article in the local (Burlington, VT) newspaper. These materials will be sent with the hard copy of the final report.

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2/7/03