Introduction

Your business plan is a critical document in the development of a successful enterprise. The quality of your business plan may determine whether or not you get the financing you need in order to start or expand your business and whether or not you can manage your business for long-term success.

Lenders or venture capital providers may not have significant knowledge of the aquaculture business, but they know how to read a business plan and judge from that plan the risk involved in providing the financial resources you need.

Who will use your business plan?

Rule Number 1: Understand who will read and use your business plan and write it accordingly.

- Lenders will use the business plan as a major element in determining your eligibility for a loan
- Venture capital providers will use the plan to determine if they should invest in your enterprise
- You and your executive staff will use the plan to provide a road map for your long term goals and immediate milestones which will let you know if you are on track to meet your goals.

Questions answered by your business plan:

The business plan answers a number of questions categorized as who, what, where, how, and when.

Who:

Who are you?
Who will be running your business?
Who are your customers?
Who are your competitors?
Who are your suppliers?
What:
What is your business structure?
What are your (measurable) goals?
What is the time span of this plan?
What products and/or services will you offer?
What of resources will you already have?
What of resources will you need?

Where:
Where your business operate?
Where are your customers located?
Where are your competitors located?
Where are your suppliers located?

How:
How will the business acquire the resources it needs?
How will the business manage its finances?
How will the business manage its other resources?
How will the business manage its operations?

When:
When are the major decision points?
When will the business be fully operational?
When will it be profitable?

Business Plan Structure:
Following some boilerplate preliminary items (cover sheet, statement of purpose, table of contents), all business plans have three major sections; detailed information about the business, financial data, and supporting documentation.

Rule Number 2: Don't get creative with your business plan structure. Give the users the kind of plan they expect. It makes them comfortable.

The Business

Rule Number 3: Let your enthusiasm for the business show through.

In general, there are a number of sections to this part of the business plan. I will use the sections listed in the Small Business Administration's web site. Various pieces of business planning software will usually display a similar structure.
A. Description of business

This is a critical element to your plan. Just as a novelist has only a few pages (called "the hood") in which to capture a reader's attention, you must make a positive impression in the first few pages or risk losing your audience. You already start off with the disadvantage that the banker or potential investor you approach with your plan is probably not familiar with aquaculture, and even if they are, they are even less likely to be familiar with the concept of operating an aquaculture business in an urban center. You should briefly describe:

- The legal form your business will take
- Any licenses or permits you will need and how you will go about getting them
- Your products and/or services (i.e., fresh fish for the seafood trade, high quality ornamental fish for the pet shop trade, high quality fry for grow out by established aquaculture businesses).
- Whether this is a new venture, an expansion of an existing business, or a franchise
- A short list of reasons why your business will succeed.
- Why you have chosen aquaculture as the business you wish to enter and what knowledge and skills you bring that apply to this field. Include both work experience and academic resources.

Above all, show commitment and enthusiasm for the business in this section. This section is a sales pitch. While you may not enjoy writing the plan, unless your enthusiasm for the venture shines through, you will have a hard time convincing someone to risk their finances backing you. If you are not a good writer, get professional help.

B. Marketing and the Marketing Plan

What are you selling and why (from the customer's perspective) should they buy from you? This is what you must address in this section. Talk about the benefits you offer compared to your competition and how you will communicate those benefits to your customers.

When dealing with Urban Aquaculture, you have the opportunity to sell to a broader spectrum of potential customers than more traditional fish farms do. A single business could provide:

- Fresh seafood to grocery stores and restaurants, thus cutting out some of the middlemen.
- Fry and fingerlings to other aquaculture businesses for grow out.
- High quality tropical fish and aquatic plants to local pet stores.
- Direct specialty sales to the public.

This should be a major point used to offset the potentially higher costs of operating a business in an urban center rather than a rural area. Access to this diverse marketplace
should more than offset the costs of doing business in an urban center.

Most growers in traditional aquaculture grow a single product and sell to a small number of customers. In the urban marketplace you have many more choices. This will require the development of a complete **Marketing Plan** which will cover a number of detailed topics. These include:

1. Detailed descriptions of your customers, their requirements, and any cyclical factors which can be determined about the needs of those customers. If you are selling a variety of products, you will have to provide a separate section for each product segment.

2. Data indicating the current and projected health of your markets. You must make the case that your market will support you and that your potential market will remain large enough to support your desired business expansion.

3. Your strategy for gaining market share, including your advertising and marketing channels.

4. Your pricing strategy, which will take into account both your customers and your competition.

5. Your Internet strategy. In today's world, all businesses must look at the Internet as a major marketing channel. If you can't answer the question "How will you use the Internet?" you are ignoring a valuable resource.

**C. Competition**

You must take a realistic approach to your competition. Recognize that you have competitors and those competitors have the advantage of incumbency.

In the urban marketplace you will be dealing with both local and remote competitors. Against each of these groups you will have advantages and disadvantages, so be careful to differentiate your competitors by location, customer, and product. Try to develop a file on each major competitor and identify their strengths and weaknesses. Show how you will counter their strengths, exploit their weaknesses, and turn competition into an opportunity for your own enterprise. Attending conferences and obtaining price and product lists from your competitors is a good way to build your file on the competition.

**D. Operating procedures**

In order to convince potential lenders or investors that your business has a reasonable chance for success, you must show how your business will be run and that you have the requisite knowledge and skills to operate the firm. Areas you will need to address include:

- Your applicable business experience
• Your weaknesses and how you will compensate for them
• A description of your management team and the abilities they bring to the table
• Your plans for compensating for the loss of a key individual
• A clear description of the duties of each member of your management team

**E. Personnel**

In today's labor market, a staffing plan is an absolute necessity. You should be prepared to define:

• The knowledge and skills you will need
• How you will locate and hire the required staff
• Your plans for properly adhering to all applicable labor regulations
• Your employee training strategy
• Your salary and benefits plan

**F. Business insurance**

You will need a number of types of insurance for your business. Some of them are standard types of insurance, but others, such as crop loss insurance, are more specialized.

**Financial data**

*Rule Number 4: What impresses lenders are thoroughness, accuracy, and attention to detail.*

There are a number of financial documents you will need for a comprehensive business plan. Some of them include:

- Loan applications
- Capital equipment and supply list
- Balance sheet
- Break-even analysis
- Projected profit & loss for three years
- Projected cash flow for three years

**Supporting documentation**

There are a number of additional documents you will need to compete your package.

• Last three years of your tax returns and those of any partners
• Personal financial statement (all banks have these forms)
• Copies of any legal documents referring to the facilities you intend to occupy
• Copies of licenses and other legal documents
• Resumes of all principals
• Any other documents indicating agreements with suppliers, customers, etc...

Finding Help With Business Planning:

There are a number of web sites and pieces of software which may help you with this process. The following resources indicate help on the Internet:

US Department of Commerce (DOC), Minority Business Development Agency (MBDA) Aquaculture Center
http://www.mbdaw.gov/Virtual_Centers/Aquaculture/index.html

DOC Economic Development Administration
http://www.doc.gov/eda

Small Business Administration Business Plans page
http://www.sba.gov/starting/indexbusplans.html

Planware business planning software and information site
http://www.planware.org/

Palo Alto Software
http://www.palo-alto.com/

Plan Magic Software
http://www.planmagic.com/

CCH Business Owner's Toolkit
http://www.toolkit.cch.com/

EntreWorld Resources for Entrepreneurs
http://www.entreworld.com/
Designing a Research Protocol for Economic and Financial Analysis Phase I

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Introduction

As the demand for fish and shellfish grows, pressure on natural or wild stocks becomes intense. Aquaculture, the husbandry of aquatic organisms, can provide a consistent supply of palatable, high quality protein, and relieve pressure on the harvesting of natural resources. Recirculating aquaculture systems are relatively new to the arena of commercial aquaculture production. Only within the last few years have these systems proven to be economically competitive. To insure that usage of this method of fish production continues to expand, research on improving the efficiency of recirculating aquaculture firms is needed.

The purpose of this project is to provide economic and financial protocols for aquaculture research projects at Virginia Tech. This will allow physical data to be collected in a manner that facilitates subsequent financial and economic evaluation of the research upon its completion.

Specific objectives are to identify (the type and form) physical data that can be measured in typical aquaculture production projects and to match those data sets with the type and form needed for economic and financial analysis of the results from typical aquaculture

1 Please use Dr. Charlie Coale as the principal contact for information concerning this particular project.
production projects. Once these parameters are established, the project will proceed to
design financial and economic protocols for typical aquaculture projects that enhance the
transfer of information from the research phase to the industry in the form of an
economic analysis of the results obtained.

Virginia Tech has established one of the world’s premier centers for research on
recirculating aquaculture. Much of the work conducted at the center is focused on
improving the probability of success of firms using recirculating aquaculture technology.
Any given project may be associated with several different objectives. For example, a test
of a new biofilter configuration may involve students examining the efficiency of the
biofilter performance while other students are involved with evaluation of the candidate
species being grown in the system. Additional students may be involved in monitoring
and maintaining the health of the fish during the test while still others may be conducting
research on water chemistry and effluent makeup. As you can see the variety of research
possibilities produces a wealth of data. Most of this data is relevant to the economics of
the operation. The goal of the researcher should be to make the data applicable not only
in a research setting, but in an industry setting as well. This will allow the data to be
utilized to its fullest potential.

A standard set of economic and financial protocols for data collection would greatly
enhance the process of translating generated results into business terms. We propose to
examine the prototypical physical data generated by research projects, enumerate the data
required for economic and financial analyses, and derive a set of protocols that would
allow the physical data generated to be quickly and easily translated to an economic and
financial analysis.

Spreadsheet templates will be generated into which the physical data from research can
be entered into a computer and applied. Micro economic and financial management
principles will be applied to the aquaculture models for structuring spreadsheet analyses.
The spreadsheet display clarifies and answers the economic questions by illustrating
resulting budgets, unit cost, cash flow and operating statements, and balance sheets.
Further, the application of ratio analysis will show the relationship of a particular study to
obtainable results from other fish and shellfish industries.

The availability of economic and financial analysis based on solid scientific research will
enable aquaculture entrepreneurs to better judge the potential economic benefits to be
gained from various practices and equipment changes suggested by research conducted at
Virginia Tech and everywhere else as well.

**Physical Relationships of the Recirculating System**

The following is a description of a recirculating system where the main purpose is to
provide a healthy environment for fish while maintaining a way to minimize the total
amount of water consumed by recirculation.
Each recirculating system contains a series of grow-out tanks, a biofiltration vessel, a microscreen drum filter, an airlift distribution manifold, an airlift pump, biofilters, a regenerative blower, a vacuum line, air lines, a discharge pipe, and a supply of fresh water. There are four complete recirculating systems within the project’s physical design. Each recirculating system consists of two grow-out tanks, which are 20 feet long, 5 feet wide, and 3.3 feet deep. Each of these grow-out tanks holds 2468 gallons (9342 liters) of water.

There is one biofilter vessel in each recirculating system. The biofilter vessel is 22 feet long, 2 feet wide, and 2.25 feet deep. The vessel holds 740 gallons (2802 liters) of water and contains the filtration equipment.

The microscreen drum filter is 22 inches in diameter covered with a 120M stainless steel mesh screen. It contains a 10 inch diameter outlet pipe, stainless steel frame, vacuum suction head, and a 120 volt gearmotor. The microscreen drum filter removes solids from the water.

There is one airlift distribution manifold, also called an airlift header, per recirculating system. Each airlift distribution manifold contains one 6 inch PVC (poly vinyl chloride) pipe and one 6-inch in PVC tee. Each airlift tube provides 25 GPM (gallons per minute) of water. The airlift distribution manifold distributes water to the eight airlift pumps.

Each airlift pump uses 3 cubic feet of air per minute. Each airlift pump consists of eight PVC airlift tubes that are 2 inches wide and 30 inches long with 2 inch PVC long-sweep elbows, plastic, PVC pipes that pump the water. The airlift pumps move 200 gallons per minute of water per tank. The airlift pumps lift the water, carrying the water from the distribution manifold, returning it from the filtration area to the grow out tank.

There are four biofilters (rotating biological contactors or RBC) in a recirculating system. Each biofilter is 4 feet in diameter and 20 inches wide. The corrugated surfaces of each RBC provide a surface area of approximately 1500 square feet. The biofilters provide surfaces for nitrogen-fixing bacteria, which convert ammoniacal metabolic wastes to nitrite and then to harmless nitrate.

Two regenerative blowers are required for the four recirculating systems. Each regenerative blower has 1.5 horsepower and 96 Standard Cubic Feet per Minute (SCFM) at 30 inches of water. The regenerative blower produces energy that moves the water through the airlift pumps.

Each recirculating system has one vacuum line. The vacuum line uses the inlet port of the regenerative blower to provide suction for the microscreen drum filter vacuum head.

Two separate air lines are in each recirculating system. The air lines provide pressurized air from the regenerative blower to the airlift tubes and to the RBC’s.
A single discharge pipe works to remove effluent from the microscreen drum filter vacuum head and discharges the waste into the sewer system. The fresh water supply line is used for water replacement.

The pilot-scale project includes four Low Head Recirculating Aquaculture Systems (LHRAS). Each system consists of two grow-out tanks and one filtration vessel (See Figure 1 LHRAS). Water flows from each grow-out tank through an 8 inch diameter PVC pipe into the first section of the filtration vessel. The first section of the filtration vessel contains a 120 micron microscreen drumfilter. The microscreen drumfilter removes solid waste (i.e: feces and uneaten feed) from the system water. The waste material collected by the microscreen drumfilter is lifted by a vacuum head and then transferred to a sewer line. The water then flows into the second section of the filtration vessel after the solid waste removal. This section contains four Rotating Biological Contactors (RBC). RBC’s use nitrifying bacteria to convert toxic metabolic fish waste (ammonia) to a non-toxic form (nitrate). The filtered water then moves through a 6 inch

FIGURE 1: Top View of the Low Head Recirculating Aquaculture System
PVC pipe to eight 2 inch diameter airlift pumps. The airlift pumps lift the water from the biofilter vessel into the grow-out tanks. Each airlift pump provides 25 gallons of water per minute for a flow rate of 200 GPM’s per tank. The airlift pumps also add oxygen to the water and remove carbon dioxide. All of the system water passes through the filtration vessel six times per hour.

The water recirculation occurs simultaneously in opposite directions through the filter tank and both grow-out tanks. Water is constantly being recirculated by moving through the biofilter vessel and both grow out tanks.

**Standard Operating Procedures**

Standard Operating Procedures for the Virginia Tech Aquaculture Center will be used to evaluate the procedures and help those who work in the facility to train others. These procedures are used in most industries to keep the different processes working efficiently. Standard Operating Procedures are usually written by individual processing plants and facilities to meet the particular needs of those using the procedures.

Standard Operating Procedures are used to standardize the procedures used within any physical plant. These standard operating procedures are important because they provide any facility with regular, systematic procedures. These procedures help in avoiding research, production, or safety emergencies within the facility.

1. **Prechecks**
   1.1. Test water supply (both quality and quantity) by obtaining samples of all water sources (municipal, well, spring, surface) and sending these samples to certified laboratories for testing. These laboratories can be found by speaking with a county agent. The water supply should be tested every 1 to 2 years.
   1.2. Check utilities and drainage situation, site preparation.
   1.3. Investigate and obtain any necessary federal or state permits by contacting state aquacultural extension personnel and Game and Inland Fisheries Department for requirements.
   1.4. Choose particular species for specific environment and document the temperature for fingerlings. This must be decided by declaring which species (which can be obtained by doing a literature search) will meet the objectives of the research.
      1.4.1 Change species depending on availability.
      This information needs to be documented and kept on record.
   1.4.2 Ensure supplier certification.
      This information needs to be documented and kept on record.
   1.5. Analyze tank space and water volume, which can be accomplished once for the entire system, by measuring the physical dimensions of the tanks. It is important to decide the appropriate volume for the tank shape.
   1.6. Check system capacity.
      1.6.1. Calculate the stocking density which is the weight of fish per volume unit of water (lbs/gallon). Stocking densities are dependent upon two factors:
1. Oxygen recharge rates or the ability of the culture system to add oxygen back to the water per unit of time (mg O₂/gal/sec).
2. The oxygen consumption rate per unit weight of fish (mg O₂/pound of fish/sec).

When the ratio of factor 2 to factor 1 is equal to 1, there is a maximum stocking density of pounds of fish per gallon. Also note that oxygen consumption rates are dependent upon species and fish size.

1.6.2. Check the oxygen recharge rates. Investigate oxygen recharge rates by using standard methods to determine units of oxygen added to system per unit of time. This is helpful in determining stocking densities.

1.6.3. Check the feeding rates.

1.6.4. Check the filtering capacity and analyze the solids removal capacity.

1.7. Perform hydrodynamic testing.

1.7.1. Perform the flow test (gallons per minute / gpm): this should be done once on a new system and can be accomplished by measuring the water velocity through a pipe, measuring the outflow of a pipe or pump, or by water draw-down.

1.7.2. Test for leaks and repair those leaks once on a new system.

1.7.3. Perform the dye test. This is done by adding dye to the water at only one point and observing how the dye moves through the system. This is used to determine flow patterns of water through a particular system (called the water mixing patterns). This test should be done once on a new system.

1.8. Acclimate the biofilters to assure the nitrification process is occurring by adding an ammonia source to each system and recording the TAN, NO₂, and NO₃ concentrations.

1.9. Check feed.

1.9.1. Investigate feed composition for particular species by a literature search or inter-personal communication.

1.9.2. Determine the ordering schedule, amount, and source for feed supply. These decisions may depend on bulk or bag feed.

1.10. Establish parameters for water quality by doing a literature search for species requirements.

1.11. Take inventory of and test analytical equipment with standard solutions and obtain required reagents. Obtain additional equipment if needed.

1.12. Take inventory of emergency equipment. Obtain additional equipment if needed.

1.12.1. Develop a chemical and emergency action plan.

1.12.1.1. Develop a chemical hygiene plan.

1.12.1.2. Develop an emergency escape route.

1.12.1.3. Develop an emergency lighting system.

1.12.2. Install a generator and test it regularly.

1.12.3. Install a fire extinguisher.

1.12.4. Install a first aid kit.

1.13. Use approved chemotherapeutics. These drugs and chemicals used in the treatment of fish diseases should be researched for the particular species.
This information should be obtained through a literature search and contact aquatic medical specialist.

1.14. Conduct hazard analysis and develop Hazard Analysis and Critical Control Point plan (HACCP) to keep research facility clean and disease or pathogen free.
1.15. Develop marketing plan for fish.
1.16. Develop waste disposal plan.
1.17. Install and test alarm system.
   1.17.1. Install and test pumps.
   1.17.2. Install and test other equipment.

2. System Operations
2.1. Visit supply sites to analyze fish health and to ensure the quality and integrity of supplier.
2.2. Purchase eggs, fry, and genetic strains from a disease and pathogen free, reputable supplier. The source of these purchases needs to be documented; and this documentation can be provided by the supplier. The suppliers will be different for each species.
2.3. Obtain sample fish from delivery truck for examination by aquatic medicine lab. Have fish analyzed for a widespread number of diseases.
2.4. Quarantine stock for 45 to 60 days to ensure no health hazards to facility.
2.5. Hatch eggs (if not using fingerlings).
2.6. Stock tank.
   2.6.1. Record the size and number of count going in.
2.7. Perform periodic tasks.
   2.7.1. Obtain feed sample and store batches for examination of composition for hazards such as aflatoxins only if a problem arises with fish by observing their behavior.
   2.7.2. Check waste discharge.
   2.7.3. Perform harvesting.
   2.7.4. Perform sampling.
   2.7.5. Ship sample to veterinary offices for health analysis. Six fish should be sampled every month and sent for testing of diseases, infections, and health hazards. There should be histological, bacteriological, virological, and biological testing done on the samples.
   2.7.6. Enter data from hard copy (paper) into the computer system.
   2.7.7. Analyze solids and record data.
   2.7.8. Wash RBC monthly.
2.8. Perform the general tasks.
   2.8.1. Perform visual examinations and record data.
      2.8.1.1. Examine the water level.
      2.8.1.2. Examine the pump operations.
      2.8.1.3. Run biofilter.
      2.8.1.4. Remove dead fish.
2.9. Analyze water chemistry and record data.
   2.9.1. Perform daily tests.
      2.9.1.1. Measure pH.
2.9.1.2. Measure ammonia.
2.9.1.3. Measure temperature.
2.9.1.4. Measure dissolved oxygen.
2.9.2. Perform bi-weekly tests.
   2.9.2.1. Measure nitrates.
   2.9.2.2. Measure nitrites.
   2.9.2.3. Measure hardness.
   2.9.2.4. Measure alkalinity.

2.10. Perform feeding and record data.
2.10.1. Check label to ensure proper feed for species.
2.10.2. Determine the pre-weight of feed and record.
2.10.3. Administer feed.
   2.10.3.1. Determine feeding behavior. This information should be observed by a trained individual and recorded.
   2.10.3.2. Remove uneaten feed.
   2.10.3.3. Determine the post-weight of feed and record the amount of feed that was consumed by subtracting post-weight feed from pre-weight feed.

2.11. Perform preventative maintenance.
2.11.1. Perform daily maintenance.
   2.11.1.1. Flush vacuum filters.
   2.11.1.2. Wash screens.
   2.11.1.3. Clean tank lip (ledges of walls).
   2.11.1.4. Top up tank.
2.11.2. Perform weekly maintenance.
   2.11.2.1. Clean tank walls.
   2.11.2.2. Clean intake screens as needed.

2.12. Perform days end tasks.
2.12.1. Perform another visual inspection and record observations.
2.12.2. Control lighting for fish environment.

2.13. Measure the inputs into system.
2.13.1. Measure the electricity used by all equipment.
2.13.2. Measure water used.
2.13.3. Measure labor used.
   2.13.3.1. Measure it daily.
   2.13.3.2. Measure it weekly.
   2.13.3.3. Measure it monthly.
   2.13.3.4. Calculate it yearly.

2.14.3. Measure it monthly.

This manuscript is a work in progress and will not be complete until all three parts of the project are finished. An additional paper will be written to include the final part of the
project which is the data collection and analysis. These final parts will draw conclusions about the entire project and describe how the recirculating system’s physical plant, standard operating procedures, and data collection and analysis are pieced together to make a profitable system to grow fish, save water, and sustain the environment.

In summary, it is critical to success that operators of a recirculating aquaculture system plan and outline their financial and operational processes. Management and employees must follow the established protocols and fine-tune them as the operation grows and prospers.

**A Glossary of Terms Used**

*Airlift distribution manifold (airlift header)*
Number used within each system: 1
Equipment and dimensions: 1 6-inch PVC pipe, 1 6-inch in PVC tee
Capacity: 25 gallons per minute.
Purpose: To distribute water to the airlift pumps.

*Airlift pump*
Number used within each system: 8
Equipment and dimensions: 8 PVC airlift tubes (2 inches wide and 30 inches long) and 2-inch PVC elbows.
Capacity: 3 cubic feet per minute or air and 200 gallons per minute per tank of water, 25 gallons per minute.
Purpose: To lift the water from the distribution manifold to the grow out tank.

*Air line*
Number used within each system: 2
Purpose: To provide pressurized air from the regenerative blower to the airlift tubes and also to the RBC’s.

*Biofilter*
Number used within each system: 4
Dimensions: 4 feet in diameter and 20 inches wide.
Capacity: 1500 square feet in surface area per RBC.
Purpose: To convert the metabolic waste known as ammonia to nitrite and then nitrate.

*Biofilter vessel*
Number used within each system: 1
Dimensions: 22 feet long, 2 feet wide, and 2.25 feet deep.
Capacity: 740 gallons (2802 liters) of water.
Purpose: To contain the filtration equipment.
Discharge pipe
Number used within each system: 1
Purpose: To remove effluent from the drum filter vacuum head and discharge the waste into the sewer system.

Grow out tank
Number used within each system: 2
Dimensions: 20 feet long, 5 feet wide, and 3.3 feet deep.
Capacity: 2468 gallons (9342 liters) of water.
Purpose: To contain and hold the water and the fish.

Microscreen drumfilter
Number used within each system: 1
Equipment and Dimensions: 22 inch diameter drum with 120 micron stainless steel mesh screen, 10 inch diameter outlet pipe, a stainless steel frame, a vacuum suction head, and a 120 volt gearmotor.
Purpose: To contain and hold the water and fish.

Regenerative blower
Number used within each system: 2
Capacity: 1.5 horsepower and 96 SCFM at 30 inches of water per blower (533 gpm/hp).
Purpose: To produce energy that moves the water through the airlift pumps.

Vacuum line
Number used within each system: 1
Purpose: Uses the inlet port of the regenerative blower to provide suction for the microscreen drum filter vacuum head.
Economic Viability of an Aquaculture Producer/Processor Coop (APPC) in a North Central Location

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With this project and this report researchers evaluate the potential economic viability of an aquaculture producer/processor cooperative, here referred to as the APPC. The project is focused on a new APPC in Illinois, which has the distinction of being specifically authorized by state legislation and allocated substantial state sales tax revenues to support it. This project identifies and evaluates the issues important to new or improved cooperative business approaches for solving farmer-producer problems such as those the APPC might face.

A primary objective was to develop an operational and financial computer based simulation model of the APPC to evaluate alternative economic viability scenarios for the APPC and similar cooperative ventures. A goal of this research was to ascertain the most likely of the possible future scenarios for the APPC, taking into consideration the natural endowments, market opportunities, and constraints on production and processing the APPC might face. The results may be helpful to current and potential farmers as they look for ways to diversify, develop "value added" options and, in other ways, attempt to improve their survivability in an increasingly competitive, global and industrial agriculture industry and market.

The simulation model may assist aquaculture producer/processor cooperative ventures as they plan and as they evaluate their organization’s potential economic viability in a North Central location or other areas of the country with similar natural endowments as well as market opportunities and constraints on aquaculture production and processing.

Historically, the size of the fish farming or aquaculture producer industry in Illinois has been difficult to measure with any degree of accuracy. The first detailed Agriculture Census data on aquaculture producers in Illinois was published in February of this year. The Census of Aquaculture – 1998 reported 20 farms in Illinois sold aquaculture products with a total value of $2,871,000. Sixteen of those farms reported selling food fish with a total value of $1,546,000.
Previous efforts by the Illinois Department of Agriculture and the North Central Regional Aquaculture Center to describe commercial aquaculture production in Illinois also indicated that it involved a small number of producers and limited volume of commercial fish production. Additional production, most likely in the southern part of the region, may be necessary to support the economic viability of an APPC of commercial scale.
Economics of Shrimp Culture in a Freshwater Recirculating Aquaculture System

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A series of commercial-scale production trials were carried out at Harbor Branch Oceanographic Institution (HBOI) over a one-year period to develop information on the production parameters and costs associated with the production of Penaeus vannamei in a recirculating aquaculture system. These data were used to develop an economic model to analyze the commercial feasibility of producing shrimp in systems based on the designs developed at Harbor Branch.

A 10-year cash flow analysis was developed for a hypothetical commercial shrimp production facility using data gathered from a prototype system operated by Harbor Branch. The hypothetical commercial shrimp production facility consisted of twelve greenhouses, an acclimation/quarantine building, storage shed for feed and equipment, well and water pretreatment systems, and wastewater retention ponds. A twelve-greenhouse facility was modeled because this is the minimum facility size that could utilize a truckload of feed (20 tons) within the three-month shelf life of the feed.

System Description and Capital Requirements

The model assumed production takes place in a three-phase production system. In the three-phase systems the culture period was divided evenly into 60-day nursery, intermediate, and final growout phases. The culture tank was partitioned into three sections with 10% of the area allotted to the nursery phase, 30% to the intermediate phase, and 60% to the final growout phase. Annual productivity in three-phase production systems averaged 1.7 times the productivity of single-phase systems in the production trials carried out at Harbor Branch (Van Wyk, 2000). Construction and operating costs associated with the three-phase system were only marginally higher than for the single-phase system.

Each of the greenhouses in the hypothetical facility measures 9.15 m x 45.75 m and contains two three-phase production systems (188 m²). The culture tanks consist of a wooden frame supporting a black high-density 30-mil polyethylene liner and are set up in a racetrack configuration in which water is circulated around a center divider baffle. Shrimp are transferred between sections through 4" bulkhead fittings. The sections are stair-stepped to provide the elevation differences necessary for the shrimp to be transferred between sections by gravity.

Each three-phase culture tank is provided with a solids filter and a biofilter. The solids filter consists of a 1,000 L cylindro-conical tank filled with 0.5 m³ of Kaldnes biofilter
media. The water enters the filter near the bottom and flows up through static bed of filter media and exits by gravity through a slotted pipe near the water surface. The filtered water flows from the solids filter by gravity into a moving bed biofilter containing 1.0 m$^3$ of the Kaldnes biofilter media. A 1.25-hp low-head centrifugal pump returns water to the culture tank. A more complete description of the system can be found in Van Wyk (2000).

The initial capital investment required to purchase the land and build the facility was $533,500. An additional $212,500 must be spent over the ten year life of the project to replace worn out equipment. The model assumed the facility was built over a three-year period, with four greenhouses put into production in each of the first three years of the project. Each greenhouse cost approximately $35,000 to set up. This included the cost of the site preparation, greenhouse kit, construction labor, electrical installation, tanks, filtration equipment and a blower. The well and well water pretreatment system consisting of a degassing tower, biofilter, blowers, pumps, and water storage reservoirs cost approximately $22,000. Capital costs are summarized in Table 1.

Table 1: Summary of capital requirements for a hypothetical 12-greenhouse facility.

<table>
<thead>
<tr>
<th>Category</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Years 4-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Land</td>
<td>$25,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Buildings &amp; Improvements</td>
<td>$92,880</td>
<td>$84,380</td>
<td>$84,380</td>
<td>$60,000</td>
</tr>
<tr>
<td>Tanks &amp; Filtration Equipment</td>
<td>$50,300</td>
<td>$46,800</td>
<td>$38,300</td>
<td>$21,600</td>
</tr>
<tr>
<td>Machinery &amp; Equipment</td>
<td>$51,496</td>
<td>$28,846</td>
<td>$26,263</td>
<td>$127,520</td>
</tr>
<tr>
<td>Office &amp; Office Equipment</td>
<td>$4,850</td>
<td>$0</td>
<td>$0</td>
<td>$3,350</td>
</tr>
<tr>
<td><strong>Total Investment</strong></td>
<td><strong>$224,526</strong></td>
<td><strong>$160,026</strong></td>
<td><strong>$148,943</strong></td>
<td><strong>$212,470</strong></td>
</tr>
</tbody>
</table>

**Production and Marketing Assumptions**

The values used for key production parameters defining the performance of the system were based upon averages from the five three-phase production trials carried out in HBOI in 1999. Table 2 summarizes the key production assumptions.

Seed, feed, energy, and labor accounted for about 75% of the operating costs. Seed costs accounted for 18% of the total operating cost. The model assumed specific pathogen free (SPF) postlarvae were purchased at a price of $10/1000 PLs. Postlarvae were held in a quarantine/acclimation facility for one week, during which time they were acclimated to freshwater at a cost of $2.61/1000 PLs, assuming a survival of 85% in the acclimation system. Feed costs represented about 20% of all operating costs. A 35% protein grower pellet costs $0.30/lb delivered when purchased by the truckload. Labor and energy costs each accounted for about 19% of total operating costs.
The final phase of each culture tank was harvested six times per year, yielding an average of 271 kg/crop of 18 gram shrimp. In Years 4-10, when all 12 greenhouses were in production, the total annual production averaged nearly 39,000 kg/year (86,000 lbs/year). The total production cost per pound of shrimp was estimated to be $4.27/lb. Production costs were relatively high because recirculating systems are more capital-, energy-, and labor-intensive than semi-intensive pond production systems in the tropics. Because of this fact, shrimp produced in recirculating production systems can not compete directly with foreign-produced shrimp on the wholesale frozen tail market. Rather, these shrimp must be direct-marketed to restaurants and specialty seafood markets as premium fresh product in order to bring a higher price. While few detailed market studies have been carried out to indicate the volume of fresh, whole shrimp that can be sold at various prices, our experience suggested that significant volumes can be sold at prices in the range of $5.00-$6.00/lb. For the economic analysis it was assumed that the shrimp were sold for $5.25/lb of whole shrimp. At this price the annual gross revenues from shrimp sales averaged nearly $450,000 per year on sales of 86,000 lbs/year of whole shrimp.

**Cash Flow and Investment Analyses**

A pro forma cash flow analysis was carried out to determine the borrowing requirements and net cash income from the project over a ten-year period. The results of this analysis are summarized in Table 3. The cash flow analysis showed that the project would have to be financed through borrowing or investor paid-in capital during the first three years of the project, which are building years. Beginning in Year 2 all of the operating costs were covered by the revenues from shrimp sales, and some of the income from sales was available to apply against new capital investment. Nevertheless additional outside money was needed in Years 2 and 3 to cover new construction costs. A total of nearly $495,500 of borrowed capital was paid into the project.

### Table 2: Key production parameters

<table>
<thead>
<tr>
<th>Item</th>
<th>Nursery</th>
<th>Intermediate</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Days to Transfer or Harvest</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Acclimation Survival</td>
<td>85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Survival - Phase (%)</td>
<td>80%</td>
<td>85%</td>
<td>90%</td>
</tr>
<tr>
<td>Percent Survival - Overall (%)</td>
<td>80%</td>
<td>68%</td>
<td>61%</td>
</tr>
<tr>
<td>Stocking Density (shrimp/m$^2$)</td>
<td>1,351</td>
<td>348</td>
<td>150</td>
</tr>
<tr>
<td>Harvest Density (shrimp/m$^3$)</td>
<td>1.081</td>
<td>296</td>
<td>135</td>
</tr>
<tr>
<td>Harvest Densitu (kg/m$^3$)</td>
<td>1.68</td>
<td>2.43</td>
<td>2.46</td>
</tr>
<tr>
<td>Total Weight Harvested/Crop (kg)</td>
<td>29</td>
<td>137</td>
<td>271</td>
</tr>
<tr>
<td>Feed Conversion Ratio</td>
<td>1.72</td>
<td>1.77</td>
<td>1.76</td>
</tr>
</tbody>
</table>

The final phase of each culture tank was harvested six times per year, yielding an average of 271 kg/crop of 18 gram shrimp. In Years 4-10, when all 12 greenhouses were in production, the total annual production averaged nearly 39,000 kg/year (86,000 lbs/year). The total production cost per pound of shrimp was estimated to be $4.27/lb. Production costs were relatively high because recirculating systems are more capital-, energy-, and labor-intensive than semi-intensive pond production systems in the tropics. Because of this fact, shrimp produced in recirculating production systems can not compete directly with foreign-produced shrimp on the wholesale frozen tail market. Rather, these shrimp must be direct-marketed to restaurants and specialty seafood markets as premium fresh product in order to bring a higher price. While few detailed market studies have been carried out to indicate the volume of fresh, whole shrimp that can be sold at various prices, our experience suggested that significant volumes can be sold at prices in the range of $5.00-$6.00/lb. For the economic analysis it was assumed that the shrimp were sold for $5.25/lb of whole shrimp. At this price the annual gross revenues from shrimp sales averaged nearly $450,000 per year on sales of 86,000 lbs/year of whole shrimp.
Production and income stabilized in Years 4-10, with net revenues (before taxes) averaging $118,893/year. After tax net revenues averaged $91,656.

The net present value (NPV) of the investment was calculated based on before tax net revenues. A discount rate of 26% (6% opportunity cost for capital + 20% risk premium) was used to calculate the NPV. If the NPV of a stream of revenues from an investment were greater than zero, then the investor would be favorably disposed towards the investment. If the NPV was less than zero, the investor would reject the investment. In addition, the internal rate of return (IRR) was also calculated. The IRR is the discount rate for which the NPV would equal zero. Under the set of assumptions used in the baseline scenario, the NPV for the project equaled -$134,341, and the IRR equaled 12%. In order for this investment to earn an IRR of 26% (the minimum acceptable rate of return) the producer would have to be able to sell the shrimp for $6.04/lb. Based on the results of this analysis, this would not be a desirable investment unless the shrimp could be sold for greater than this price.

**Sensitivity Analysis**

While it is clear that we have not yet demonstrated the economic feasibility of producing shrimp in freshwater recirculating systems, there certainly appears to be room for improvement with respect to several important variables affecting the cost of production in the system. Two key production variables that could be improved upon are the survival rate and the growth rate of shrimp in the system. Four of the five crops used to calculate expected survival rates were carried out in systems with very shallow nursery tanks (depth = 20 cm). One production trial was carried out in a system with a deeper nursery tank (depth = 34 cm) with better water circulation. The survival in this trial was 81%. In some recent trials carried out at HBOI in which artificial substrates were placed in the nursery and intermediate sections of the culture tank, survivals have averaged better than 70%. Growth rates in the 1999 production trials at HBOI averaged only 0.7 g/week when temperatures were maintained above 28°C. However in ponds, growth rates of 1.0 g/week are generally expected at this temperature. The slow growth rates observed in the 1999 HBOI trials might be related to the fact that the greenhouses were shaded with 95% shade cloth to minimize algal growth. Moss et al. (1992) demonstrated that green pond water enhanced the growth rate of shrimp raised in aquaria. Moss (1999)
reported growth rates of 1.4 g/week in "greenwater" recirculating systems similar to the HBOI systems. Subsequent to this study the shade cloths covering the HBOI greenhouses were removed, and growth rates have improved.

A sensitivity analysis was carried out to determine the effect of improved survival and/or growth rates on the IRR of the hypothetical 12-greenhouse enterprise. The results are summarized in Table 4. This analysis showed that the profitability of the enterprise was very sensitive to growth rates. If the shrimp were grown to an average weight of 18 grams in 150 days (an average growth rate of 0.84 grams/week), the IRR improved to 29% (holding survival at 60%). If the shrimp were grown to 18 grams in 150 days at a survival rate of 70%, the IRR improved dramatically to 46%. Improving survival to 70% without any improvement in growth rates improved the IRR to 25%, or slightly less than the minimum acceptable return.

Table 4: Sensitivity of NPV and IRR to Survival and Growth Rates

<table>
<thead>
<tr>
<th>Item</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60%</td>
</tr>
<tr>
<td><strong>180 days to 18 grams</strong></td>
<td></td>
</tr>
<tr>
<td>Net Present Value @ $5.24/lb (Heads-on)</td>
<td>($152,310)</td>
</tr>
<tr>
<td>Internal Rate of Return @ $5.24/lb (Heads-on)</td>
<td>10%</td>
</tr>
<tr>
<td>Price Required for NPV to Equal 0</td>
<td>$6.04</td>
</tr>
<tr>
<td><strong>150 days to 18 grams</strong></td>
<td></td>
</tr>
<tr>
<td>Net Present Value @ $5.24/lb (Heads-on)</td>
<td>$27,864</td>
</tr>
<tr>
<td>Internal Rate of Return @ $5.24/lb (Heads-on)</td>
<td>29%</td>
</tr>
<tr>
<td>Price Required for NPV to Equal 0</td>
<td>$5.13</td>
</tr>
</tbody>
</table>

**Conclusion**

The commercial viability of shrimp production in freshwater recirculating systems is critically dependent on the ability to grow shrimp to at least 18 grams in 150 days, with consistent survival rates of better than 60%. Only efficient production systems are going to be successful, to minimize the capital cost per pound of production. The three-phase production system developed at HBOI allows system productivity to be increased without significantly increasing the capital costs of the system. Nevertheless, it is unlikely that shrimp grown in recirculating systems can be grown as cheaply as pond-reared shrimp, so they will need to be sold at prices significantly higher prices. The volume of shrimp that can be sold at these premium prices is presently unknown.

**Acknowledgements**

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References

