ECONOMIC FEASIBILITY OF UTILIZING SALINE GROUNDWATER OF WEST ALABAMA TO PRODUCE FLORIDA POMPANO IN A RECIRCULATING AQUACULTURE SYSTEM

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ECONOMIC FEASIBILITY OF UTILIZING SALINE GROUNDWATER OF WEST ALABAMA TO PRODUCE FLORIDA POMPANO IN A RECIRCULATING AQUACULTURE SYSTEM

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THESIS ABSTRACT

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Recirculating aquaculture systems hold great promise for producing large amounts of fish in a confined area, using significantly less water and land resources than conventional aquaculture. However, these systems require a large capital investment and are often not profitable due to the low price received for traditionally cultured specie such as tilapia and catfish.

In order become more profitable, high value marine species were evaluated to determine if the higher prices received would compensate for higher operating costs and capital oulays. To decrease the cost of producing these marine fish in recirculating systems, saline water from West Alabama aquifers was used to reduce or eliminate (depending on culture salinity) the cost of making seawater.

After evaluating numerous species such as grouper, snapper, and flounder, pompano was chosen as the specie for evaluation. This selection relates to the high prices it commands, as well as its suitability for culture in low salinity, recirculating systems.

Culture was evaluated at both 15 ppt salinity and 6 ppt salinity. The system was designed to harvest 92,625 pounds of fish per year in 67,102 gallons of water. Operating costs totaled $478,084 per year if raised at 15 ppt and $250,993 per year if raised at 6 ppt salinity. The total capital investment for the facility was $298,206 regardless of the salinity at which pompano were cultured, with annual depreciation of $40,462. Sensitivity analysis was conducted to evaluate the profitability of a pompano facility producing pompano at various salinities, with different feed conversion ratios (FCR), and at different prices received. Pompano production was found to be an attractive investment when raised at 15 ppt at 90 percent survival with an FCR of 3.1 and a market price of $7 per pound. If pompano can be successfully cultured at 6 ppt, as research suggests, production is an attractive investment at 95 percent survival with an FCR of 3.1 and a market price of only $4 per pound.

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INTRODUCTION

The world's reliance on food captured from or cultured in water is undeniable. The U.N. Food & Agriculture Organization (FAO) reports that in 2004, 2.6 billion people throughout the world derived 20 percent of their animal protein from fish (FAO, 2007). In many areas of the world, it is not uncommon that the entirety of one's protein intake comes from seafood. Often, this fact relates to the availability and abundance of fish, and hence, its affordability.

However, in other areas of the world, such as in the United States, fish have historically accounted for a much smaller percentage of the general population's protein intake. This relationship is changing. Many studies, such as those conducted by Dariush and Rimm, as well as marketing, may have changed the public's perception of fish. One such study indicates that modest consumption of fish results in a 36 percent reduction in deaths from coronary heart disease and a 17 percent reduction in the risk of death from any cause (Dariush and Rimm, 2006).

Studies such as these, as well as increased marketing by companies and organizations which represent the seafood industry, are working to significantly increase fish consumption in the U.S. Data from the National Oceanic and Atmospheric Association reports that from 2001-2006, per capita seafood consumption in the United States increased by 11 percent from 14.8 pounds to 16.5 pounds (NOAA, 2007).

However, one down side to the benefits realized by this increase in fish consumption is the ecological impact of more fish being harvested from the world's oceans. The FAO reports that early studies predicted that "the estimated maximum potential for traditionally exploited marine species is about 100 million tons per year". After adjustments made to this research, the number was amended to a maximum potential of around 80 million tons harvested per year (FAO 2005, p. 1).

Since the FAO estimates were released, data collected around the world have confirmed the earlier estimate of a maximum of 80 million tons to be quite on target. The U.N. FAO reports that the amount of seafood harvested from the world's oceans increased from 16.7 million tons in 1950, to a record high of 86.2 million tons in 2000, and then settled to 84.4 million tons in 2002. Throughout the 1990s until present, the amount of seafood harvested has remained relatively stable, suggesting that we have reached the cap on the amount of seafood that can be harvested from the world's oceans (FAO, 2005).

The FAO reports that in the 1970s, overexploited, depleted, and recovering stocks made up 10 percent of the total catch. By 2002, this number had climbed to 24 percent of the total catch. Also in 2002, seven out of the ten species of fish that account for 30 percent of the world's harvested seafood were classified as either fully exploited or overexploited, while 76 percent of fish populations for which information is available need to be either monitored and/or rebuilt to maintain sustainability objectives (FAO, 2005).

In summary, the world's human population is increasing, as well as its per capita demand for fish. Meanwhile, the amount of fish that can be harvested from our oceans has peaked and in some cases, even decreased. In order to meet the demand of consumers, aquaculture (fish/seafood farming) has emerged as a fast growing industry in agribusiness in the United States (Aquatic Network, 2005).

While increasing the amount of seafood available to consumers without increasing the amount of fish harvested from the wild and also providing economic benefits to the producer, aquaculture is not without its own problems and issues. The Secretariat of the Convention on Biological Diversity reported the ecological downfalls of many aquaculture ventures (Secretariat of the Convention on Biological Diversity, 2004).

The Secretary's report describes the negative impact of intensive salmon culture in raceways and cages. Ecological problems arise as a result of suspended solids being released into waterways, and an increased amount of organic material and nutrients that cause an accumulation of anoxic sediments, alteration of plant and animal communities, and rapid build up of algae in lakes. It also reports that large scale shrimp farming has harmfully altered coastal habitats through the conversion of mangrove forests and the destruction of wetlands. Shrimp culture has also increased the salinity of many agricultural and drinking water supplies and has led to land subsidence through the compaction of soil layers. Other ecological concerns include the misapplication of chemicals, by-catch of other species while collecting seed, and the use of fishery resources as feed inputs.

Another problem that the report addresses is the release of non-native species into local waterways. It states, "Aquaculture is the principle reason for the introduction of freshwater fishes and experience has shown that the introduced species will eventually enter the natural ecosystem (either through purposeful release or accidental escape)".

This introduction of non-native species can have harmful effects on local resources through "hybridization and loss of native stocks, predation and competition, transmission of disease, and changes in habitat" (FAO 2009, p. 1).

In order to combat the potential ecological hazards of aquaculture, a study by White, et al., stresses that methods of sustainable aquaculture be employed. The study states that, "sustainable aquaculture must consider the ecological, social, and economic aspects of development in a way that conserves land, water, plant and genetic resources, is environmentally non-degrading, technologically appropriate, economically viable, and socially acceptable" (White, O'Neill, Tzankova, 2004, p. 4).

An increasingly popular approach to sustainable and ecologically friendly aquaculture is use of closed recirculating systems. These systems can be built anywhere from an arid desert, to a booming metropolis, as long as there is a sufficient water source. A basic system consists of a tank to hold the fish, a biofilter to clean the water that returns to the tank, pumps that continually circulate the water throughout the system, and an effluent pond to dispose of waste properly. Through water reuse, these systems minimize water use, and since they are closed systems, diseases, organic material, and non-native species are not at risk to be introduced into local waterways.

Aquaculture already has a significant impact on the economy of the state of Alabama. The USDA reports in the 2005 Census of Aquaculture that Alabama has a total of 215 aquacultural production facilities, generating total revenue of over 120 million dollars. This is a significant increase from 1998 when 259 farms produced a total of only 59.6 million dollars worth of product. Most of this revenue is generated from catfish production, with 192 farms producing 98.4 million dollars of product in 2005 (USDA, 2007). In addition to the impact that aquacultural production has on the state's economy, other businesses rely on the fish that these farms produce and make significant contributions to the state's economy as well.

In 2005, three catfish processors in Alabama generated total sales of 151.2 million dollars and employed 1,290 people. It was estimated that 94.66 percent of this sales revenue was generated from sales outside the State of Alabama, meaning that 143.1 million dollars was new money entering the State's economy. All output impacts, "the total value of revenues or expenditures associated with an activity or event", of aquacultural production and processing combined in the State of Alabama generated an estimated 498 million dollars (Stevens, 2007).

Alabama is a leader in aquacultural production, it has abundant water resources (including higher salinity groundwater suitable for some marine species), and is a strong candidate to incorporate recirculating aquaculture systems to produce new, high valued species of fin fish for consumption.

High salinity groundwater has already been used for aquacultural production in West Alabama. In 1999, catfish producers in Greene County produced pacific white shrimp in abnormally saline ponds. These ponds consisted of water that ranged between 5 and 6 ppt salinity and was pumped from approximately 1300 feet below ground. Such groundwater is available throughout western Alabama (Coddington, 2002).

OBJECTIVES AND METHODS

The purpose of this study is to evaluate the feasibility of using the saline water from West Alabama aquifers in order to produce high valued, marine fish in a recirculating aquaculture facility. Traditional aquacultural producers in the United States have seen dwindling profit margins in recent years, and the ability to produce a high valued product may make aquacultural production a more profitable enterprise (Timmons, 2001).

Evaluation and modification of recirculating aquaculture systems that have been successful in the past were used in order to create a system that is capable of producing fish at high densities in a saline environment. Species of marine fish were evaluated based upon six criteria. These include their ability to tolerate low salinity conditions, their ability to be grown at high densities, the availability and use of a commercial feed diet, the availability of fingerlings, whether past research or commercial production shows a potential for the fish to be cultured successfully, and also their market price.

Investment costs associated with building a recirculating aquaculture facility increase when the system is designed to produce fish in a warm, saline environment. Operating costs are higher as well, especially when compared to catfish or tilapia production. Feed, fingerlings, and the cost of supplemental salt work to push these costs significantly higher. However, the premium received for producing high valued species of fish may be sufficient enough to outweigh the increased costs, making it a profitable enterprise. This study will use standard budgeting, break-even, and sensitivity analysis to evaluate the feasibility of producing a marine fish specie in the saline waters of West Alabama using a recirculating aquacultural production system. Technical and economical characteristics of the system are presented and evaluated. Alternative marine species are evaluated for production consideration.

LITERATURE REVIEW

The concept of producing fish in a recirculating aquacultural system is not new. M.B. Timmons wrote the publication that the authors of *Recirculating Aquaculture Systems* refer to as “the original aquacultural engineering bible” in 1977 (Timmons, et al 2001). Since that time, many aquacultural ventures started and then failed in trying to generate a sufficient profit from recirculating technology. In *Recirculating Aquaculture Systems*, the authors relay a story written by Peter Redmayne that points out significant failures in the aquaculture industry. These failures include an intensive tilapia operation, Simplot Co., which shut down their operations due to an inadequate biofilter, losing the company over $20 million. They also report that in 1991, the largest indoor catfish operation at that time was Blue Ridge Fisheries in Martinsville, Virginia. Their business failed because their Recirculating System was not cost effective. These cases highlight the difficulty that exists in raising fish in recirculating systems. The capital cost is very high, there is potential for catastrophic fish losses, and prices received for conventionally cultured species of fish are often low. Thus, fish produced in recirculating systems are generally not competitive price-wise (Timmons, et al 2001).

More recently, to improve feasibility, researchers and entrepreneurs have looked toward more valuable species of fish to culture in recirculating systems. This approach has led to an increased interest in the culture of marine fish species. While the cost of production is higher, there is the potential that the increase in revenue from selling the higher valued fish will outweigh the higher cost of production and generate a profit.

Mariculture is specifically defined as "the farming and husbandry of marine plants and animals in brackish water or marine environments." Mariculture is still far behind in tonnage of production when compared to freshwater aquaculture, but it is growing globally, from 9 million tons in 1990 to 23 million tons in 1999. Better feed conversion ratios enable farmers to produce fish with about the same feed input as is required for a terrestrial animal (CBD, 2004).

There is an additional benefit to producing marine fish in low salinity environments that was not mentioned by most researchers who conducted studies and have written papers in this area. An additional benefit to producing marine fish in low salinity environments is that in doing so, there is a significant decrease in the energy spent by the fish during osmoregulation, or the regulation of the salt and water balance within the fish's body (Delbeek, 1987). Researchers at the University of Texas report that studies have shown that between 10 and 50 percent of a fish's total energy intake is used during osmoregulation (Resley, Webb, Holt, 2006). By reducing the energy spent during osmoregulation, more efficient growth rates may be observed than in traditional net/pen culture.

Dr. Yanothan Zohar of the University of Maryland Biotechnology Institute (UMBI) has successfully raised Mediterranean gilthead seabream in an urban environment using recirculating aquaculture systems technology to turn a Baltimore basement into an intensive mariculture facility. He reports that in the Baltimore area, gilthead seabream bring retail prices around $20/kg, or about $9/lb. These fish are traditionally raised in net pens throughout the Mediterranean. Around 500,000 lbs. is imported to the United States each year. After conducting their own market research, it was decided that the fish could be sold at an ex-farm price of $12/kg in the live markets and around $9/kg fresh on ice.

In his study, Dr. Zohar pumped city water through charcoal filters and into a tank where saltwater ranging between 15 and 25 ppt was produced by adding sodium chloride and other essential minerals. This water was used to raise the fish at an initial density of 44-47 kg/m^3, or .392 lb/gallon with 7-10 percent water of the system's water exchanged daily. Later, the stocking density was increased to 60kg/m^3, or .5 lb/gallon. Growout time in the system (7.7 months) was roughly half of what is realized by culturing the fish in net pens (12.9 months) with overall survival exceeding 90 percent. This result was attributed to the optimal environment that was provided by being able to control photoperiod, temperature, and salinity (Zohar, 2005).

While overall the results of this study are encouraging, Dr. Zohar reports that by exchanging 10 percent of the water volume daily, 25 percent of the total cost of production derives from the expenses associated with producing seawater. Dr. Zohar and his colleagues at UMBI have since embarked on research that would significantly decrease the daily water exchange. Some of this research includes recovering salt that may be lost by removing solids, addition of a denitrification unit, and the identification of new bacteria that work to oxidize ammonia and nitrites (Zohar, 2005).

While this research shows promise, a possible solution to the problems associated with the cost of producing saltwater has already been addressed by aquaculturists throughout the country who have used and are using groundwater supplies that have a higher salinity, making the water unsuitable for conventional agriculture. In a 1993 paper published in

Aquaculture, Sandifer relates his study in which researchers attempted to produce red drum through intense pond culture using saline ponds averaging 28-ppt salinity. While parasite infestation and oxygen depletion caused significant losses in some of the fish populations, other ponds experienced survival rates between 88 percent and 94.9 percent (Sandifer, et al. 1993).

James Forsberg published a 1996 paper in the *Journal of World Aquaculture* in which he describes culturing red drum in the saline waters of West Texas. Red drum were raised in seven different locations that ranged between five and fifteen parts per thousand with varying levels of success. The most successful site produced red drum in 5 ppt groundwater with a survival rate of 85 percent (Forsberg, 1996). Utilizing the water from high salinity aquifers in a recirculating system may decrease production costs for the production of marine fin fish.

In addition to lowering the cost of production by utilizing high salinity groundwater and producing high value fish, a producer may also be interested in the potential for selling their product through live fish markets.

In an attempt to study the nature of live markets in the southeast, a trip was made in July of 2007 to Atlanta, Georgia to visit both the Dekalb Farmers Market, as well as the Buford Highway Farmers Market. While both markets had an extensive selection of seafood items, only the Dekalb Farmers Market had tanks in which to hold live fish for sale. These tanks consisted of both rainbow trout, listed at $3.99 per pound, as well as tilapia, also listed at $3.99 per pound. There were also tanks available to hold live shellfish for sale. A conversation with one of the managers in the seafood department revealed that they do not have the ability to hold live fish in a saline environment. It may be worthwhile to note that at Dekalb Farmers Market, whole red snapper on ice sold for $5.99, whole yellow snapper on ice sold for $5.29 per pound, and whole wild strawberry grouper on ice sold for $4.99 per pound. At Buford Highway Farmers Market, whole red snapper on ice sold for $4.99 per pound, whole grouper on ice was $5.99 per pound, whole flounder on ice was $4.99 per pound, and whole seatrout on ice sold for $2.44 per pound. Both of these markets rely heavily on a consumer base of Asian and Hispanic origins.

Many other attempts were made to acquire more information about live markets in the southeast, by calling Asian restaurants, speaking with producers, and by contacting researchers who have themselves attempted to describe the nature of live seafood markets in the Southeast. These attempts were unsuccessful due to either language barriers or unwillingness of producers to discuss live markets that they may be supplying. Dr. Benedict Posadas at Mississippi State University had earlier in his career attempted to study these markets but was largely unsuccessful because of their secretive nature (Posadas, 2007).

While my and other's attempts at studying Southeastern live markets seem to have been largely unsuccessful, a more scientific and in depth analysis of live seafood markets in the northeast was released in 2007. This study was conducted by the New Jersey Department of Agriculture and consisted of surveys sent out to restaurants and consumer retail markets, as well as surveys of customers who were visiting markets where live seafood was sold.

Generally, live seafood markets have been associated with areas that have a large Asian population. This is reflected in the New Jersey surveys in which 82 percent of respondents said that Chinese was the most common language spoken in their household. Also, 64 percent of the market managers surveyed in stores replied that Asians made up at least 50 percent of their customer base. This is a large amount but leaves room for other ethnic/racial groups to make up a significant portion of sales as well. One market reported that Caucasians generate 50-80 percent of live seafood sales, while another reported than Hispanics and African-Americans made up its largest consumer base. Eighteen percent of markets reported that Hispanics made up 20-50 percent of the consumer base, 15 percent of markets reported Caucasians constituted 20-50 percent of the consumer base, and 12 percent reported that African-Americans made up 20-50 percent of the consumer base. It was also reported that "increasing numbers of white tablecloth and gourmet restaurants are featuring live seafood (Myers, 2007). These variations in purchases by ethnic/racial groups show that the potential for live market sales exists in other areas outside those with a large Asian population.

No specific numbers were given in regards to the volume sold either of specific species, or in total, but an informative overview of the magnitude of the live seafood market in the area was presented in the New Jersey Study. It relates that 161.7 family units entered the store each hour and 23.8 (14.7 percent) of these purchased live fish. Of the seafood consumers who were surveyed, 6.2 live seafood purchases were made each month, with an average of $14.80 spent per visit. With an average household size of 3.7, the live seafood expenditure averaged $301.15 per person per year (Myers, 2007).

This demand was met by producers from in state (50 percent), out-of-state (44 percent), and even from foreign countries (6 percent), with considerable volume being shipped from the Southeastern United States. Thirty-eight percent of markets that sold live seafood used between one and three vendors of live fish. Ninety-one percent of market operators established a relationship with the vendor through word-of-mouth, or some other contact such as an in-store visit by the supplier. Fifty-five percent of markets relied on these vendors to supply over 500 pounds of live seafood for sale per week, while 45 percent sold between 100 and 500 pounds per week (Myers, 2007).

It is important to note that these surveys were conducted in large cities of the Northeast such as New York, Boston, and Philadelphia, as well as Washington D.C., and were accompanied by low response rates for restaurants (9.2 percent). However, this study highlights the potential that may exist to market live seafood in the southeast. A current example includes Mariculture Technology International in Oak Hill, Florida which sells live Pompano at $10 per pound.

Previous researchers have studied the economic feasibility of freshwater recirculating aquaculture systems (De Ionno, et al, 2006) to produce finfish and also that of flow-through seawater systems to produce spiny lobsters (Jeffs and Hooker, 2000). Jeff and Hooker used information from previous studies and information from commercial farms for other marine species, such as abalone, in order to design a hypothetical spiny lobster farm. Financial analysis was prepared through the use of computer spreadsheets. Production parameters such as growth and mortality rates were varied in order to determine the sensitivity of the hypothetical farm's profits to such changes. The researchers used straight-line depreciation and did not include tax on income "as the focus of the analysis was solely on the economic performance of the farming operation." Their results conclude that although biologically feasible, infrastructure and operating costs must be reduced significantly in order to be profitable, regardless of mortality and growth rates (Jeffs and Hooker, 2000).

De Ionno, et al used real industry data from a "commercial RAS facility located in Warrnambool, Victoria, Australia" that was collected over a three-year period between July 1, 2002 and June 30, 2005, and "incorporates the construction and start-up phase, the commission period (defined as the period to obtain maximum specified standing stock/and or feed rate), through to maximum output" (De Ionno, et al 2006, p. 317). The primary concentration of the facility was production of Murray cod. The income and expenditures of the facility were used to create both cash flow statements as well as profit and loss statements. Using the three years of data, projections were carried out to Year 10, "as it is unlikely that an aquaculture enterprise would be an attractive investment opportunity if it were not profitable after ten years." The reported and projected cash flows were used to generate cumulative cash flows, net present value (NPV), and internal rate of return (IRR) (De Ionno, et al 2006, p. 318).

Cumulative cash flows are defined as "a measure that represents the total, gross amount of the net cash flows (i.e. inflows less outflows) over a specific period. Cash inflows are netted out against cash outflows over the period, and hence a positive value indicates that inflows exceed outflows" (De Ionno, et al 2006, 318). It is important to keep in mind that, while a strong indicator of an operation's performance, a positive cash flow does not indicate profitability, just as a negative cash flow does not necessarily indicate that an operation is not profitable (Kay, Edwards, Duffy, 2004). Emphasis is often placed on cash flow statements when evaluating high-risk investments such as aquaculture ventures, as they are “widely recognized as the preferred technique” for analysis (De Ionno, et al, 2006).

Net present value (NPV) not only takes cash flows into account, but also the time value of money and the timing of the cash flows (De Ionno, et al, 2006). The NPV of an investment is “the sum of the present values for each year’s net cash flow (or net cash revenue) minus the initial cost of the investment” (Kay, Edwards, Duffy 2004, p. 285). Hence, a positive NPV shows that the present value of the future cash inflows, calculated at the project’s required rate of return, is greater than that of the initial investment (Ionno, 2006). The formula for the net present value of an investment is

$$NPV=P_1/(1+i)^1 + P_2/(1+i)^2 + ... + P_n/(1+i)^n - C$$

“where NPV is net present value, P_n is the net cash flow in year n, i is the discount rate, and C is the initial cost of the investment” (Kay, Edwards, Duffy 2004, p. 285).

“There are three components to calculating the discount rate and they include: uncertainty (the risk associated with the investment), alternative uses of capital, and inflation” (Thacker, Griffin 1994, p. 89). Thacker uses constant 1993 dollars in their analysis and so counts inflation as equal to zero. A savings account is used as capital’s minimum alternative use, and it is stated that “each individual has his own risk factor depending on his willingness to take a risk” (Thacker, Griffin 1994, p. 89).

Internal rate of return (IRR) is “the discount rate that yields an NPV of zero for an investment. Hence, a project evaluated according to IRR is accepted if its IRR is greater than or equal to the required rate of return.” De Ionno, et al used a discount rate of 15 percent for his study, citing that “this has often been used as a criterion for high risk investments of this type, with a higher IRR required as investment risk, market uncertainty, and the cost of capital increases" (De Ionno, et al 2006, p. 318).

De Ionno used straight line depreciation and a zero salvage value for equipment. He also excluded land values from the analysis in order to focus "on the profitability of the RAS system itself." As in the study conducted by Jeffs and Hooker, income was reported on a pre-tax basis (De Ionno, 2006).

In order to study the effects on profits due to fluctuations in variables, De Ionno, et al (2006) conducted a sensitivity analysis. The feed conversion ratio (FCR) of 1.2 was used as the base in the economic analysis. The reported FCR was found to be quite low for other commercial RAS located in Australia, and so an FCR of 1.5 and 1.8 were also used in the sensitivity analysis to study the effects of a lower feed efficiency on profits. Ionno also allowed other "key operating cost variables" such as feed, labor, and electricity costs to fluctuate by +/- 20 percent in order to evaluate their effects in the sensitivity analysis. Also, the effect of differing sales prices were evaluated at both $10/kg and $15/kg in order to capture volatility in the market (De Ionno, 2006).

Similar to Jeffs and Hooker, Ionno found that over the specified ten-year period, the facility was not economically viable. However, by continuing onward and using the real industry data with larger, but hypothetical farms, the feasibility was much improved by increasing the capacity to 50 tons per annum, and finally reaching commercial viability at 100 tons per annum (Ionno, 2006).

BACKGROUND FOR ANALYSIS

In searching for species that would grow successfully in a recirculating system, as well as bring a high market price, flounder production was analyzed early in the study but was eliminated as a potential candidate in this system. According to data provided by the National Marine Fisheries Service, wild caught flounder brought a six year average price of $1.31 per pound coming from boats in the Gulf of Mexico (NOAA, 2008). Other publications reported a higher price, such as a study by Daniels (2000) which reported that high quality fish weighing 1-2 pounds and bled on ice brought between $4 and $6 per pound.

Flounder's tolerance to low salinity environments also makes them an interesting species to evaluate for potential culture. In 2000, the Southern Regional Aquaculture Center reported that research on the culture of flounder had only started five years prior to the publication. While much information is available on Southern Flounder hatchery facilities, access to literature on their growout is sparse. However, Gregory Beckman of Water Management Technologies, made a presentation at the 2002 International Conference on Recirculating Aquaculture, where he reported that summer flounder were currently in commercial production. He went on to present evidence that summer flounder could be a profitable enterprise (Beckman, 2002). However, because summer flounder are a flat, bottom dwelling fish, they require different system parameters than the species of fish that were considered in this study. The density at which they can be stocked is calculated not on volume, but instead on culture tank area (Beckman, 2002). This characteristic significantly alters the design of the system and increases the area of the facility from 4,160 square feet to 12,107 square feet. This design makes the system species specific with entirely different system parameters. Due to the lack of available information on the production of Flounder past the hatchery phase, as well as the requirement of a different system for analysis, Flounder was eliminated from consideration in this study.

Grouper was also evaluated as a potential species candidate for culture but was eliminated due to lack of fingerling availability and satisfactory commercial feed. Grouper have been successfully farmed in Asia for many years. Rimmer, McBride, and Williams (2004) report that in 1997, Chinese farmers produced an estimated 8,256 tons of grouper, many of which brought high prices upwards of $70/kg wholesale in the live markets of Hong Kong and southern China. In 2001, Vietnamese farmers produced an estimated 2,600 tons of cultured fish, with a high proportion being grouper. However, their method for production was very different from that proposed, requiring much less technology and expertise. In the Chinese system, juvenile grouper are typically captured from the wild and then cultured in ponds or in floating net cages. These fish are then fed trash fish until they reach market weight (Rimmer, McBride, Williams, 2004).

The National Marine Fisheries Service reports that landings of grouper in the Gulf of Mexico brought a six year average price between $2.22 per pound and $2.86 per pound depending on the type of grouper (NOAA, 2008). However, magazine and newspaper articles report retail fillet prices ranging between $10 and $12 per pound after the grouper season ends in the Gulf of Mexico ends.

The Australian Centre for International Agricultural Research has shown significant interest in evaluating grouper for aquacultural production. They published an online book in 2004 titled *Advances in Grouper Aquaculture*. In this book, they highlight numerous problems with current grouper culture techniques and seek to develop ways to improve aquacultural production methods. One problem associated with making intensive grouper culture possible is the availability of fingerlings. The reason that current production methods use wild caught juveniles is that successful hatchery production of grouper has not occurred on a large scale basis. Average survival of larvae to fingerling stage is reported to be between 0 and 10 percent with high variability. Total mortality is not uncommon (Rimmer, McBride, Williams, 2004).

Another problem associated with the development of intensive grouper culture in tanks is that very little work has been done to develop an acceptable commercial, pelleted feed. Grow out in the Asia-Pacific involves the feeding of trash fish, which yields a very inefficient feed conversion ratio between 5:1 and 10:1. Also, the feeding of trash fish creates numerous environmental problems and increases stress on local fisheries. While the authors were able to develop a commercial diet that could replace most of the trash fish fed, improvements were not made that would be sufficient to produce grouper in intensive, recirculating tanks, thus eliminating them from the analysis (Rimmer, McBride, Williams, 2004).

Florida Pompano were also evaluated as a species for production, although the design of the system allows for culture of most any other specie that can be cultured in a range from low salinities all the way to seawater at 35 ppt (Zohar, 2005). The Southern Regional Aquaculture Center reports that pompano are commonly found in warm, shallow waters between Massachusetts and Brazil. They can grow to 25 cm in length and up to 8 pounds. They are a hardy fish that can withstand varying environmental conditions such as low levels of dissolved oxygen (4 mg/L) and salinities between 0 and 50 ppt. While very tolerant of fluctuating oxygen levels and water salinities, they are a warm water species that stresses easily when water temperatures fall. Death loss occurs when water temperatures are between 50 and 53 degrees Fahrenheit or when rapid water temperature changes occur. Optimal growing temperatures range between 77 and 86 degrees Fahrenheit (Main, 2007).

Pompano is one of the most valuable fish caught in the Gulf of Mexico. Charles Weirich (2006) reports that the average wholesale price of Pompano was $7.42 per kilogram ($3.09/lb) in 2003. M.F. McMaster (2003), reports a higher price in 2003, stating that “fair market values to the producer (fishermen) of between $3.50 and $5.50 per pound in the round” (McMaster 2003, p. 3). He also reports that live markets present more lucrative opportunities with prices of $10 per pound being offered.

As of May, 2008, Pompano Farms, LLC, is currently selling fresh, farmed pompano on ice at $8 per pound. Meanwhile, after taking prices paid to the fisherman from 2000-2005 as reported by the National Marine Fisheries Service, and adjusting for inflation, a six year average price of $3.75 was computed, with $3.25 being the lowest price reported, and $3.98 being the highest price (NOAA, 2008). This average price of $3.75 is the price used in the study, but price/yield sensitivity analysis was conducted to capture the possible range of prices reported by other sources and other markets.

Other reasons that Pompano was selected for culture evaluation include their ability to be grown at high densities. McMaster reports that previously, Pompano have been raised at densities of one pound of fish per gallon of water (McMaster, 2003). It is important to note that he goes on to say that he does not recommend culturing fish at such densities due to “mechanical limitations for maintaining proper water quality and feed delivery” (McMaster 2003, p. 10). However, recirculating systems are designed to produce fish at very high densities, and it is only at these densities that they can be profitable.

Tilapia at the North Carolina State Fish Barn are raised at densities of .66 pounds per gallon (NCDOA, 2002). It is not only freshwater systems that can handle this kind of biological load, but saltwater systems as well. Dr. Yonathan Zohar reports culturing Mediterranean gilthead seabream at 44-47 kg/cubic meter (almost .5 lb/gallon) in a recirculating system (Zohar, 2005). For the current study, Pompano were raised at a density of .5 pounds per gallon, a density that many successful aquacultural producers meet or exceed (Timmons, et al, 2001).

Another reason that Pompano were selected for culture is their tolerance of low salinity waters. McMaster (2005) reports that Mariculture Technologies International (MTI) in Oak Hill, Florida, has successfully grown Pompano in ponds fed by 19ppt saline groundwater, measured at 15ppt after heavy rain, with seemingly no adverse effects attributed to lower salinity. A slower growth rate was observed but it was attributed to the lack of climate control, as the water temperature plunged as low as 56 degrees Fareinheight. In a subsequent publication, McMaster (2006) reported having measured pond salinities as low as 2 ppt with no recorded Pompano mortality. Michael Nystrom conducted a study in which Pompano juveniles were cultured in both low salinity (5ppt) and high salinity (30ppt) conditions. He found no statistical difference in growth between the two groups of fish, although the group of fish reared in very low salinity waters (5ppt) had to be treated twice for infections, routinely had higher nitrite readings, and involved more water exchange (Nystrom, 2005).

Pompano are a fast growing species of fish. Weirich reports Pompano reached a market size of 450 grams (one pound) in as little as four to five months (Weirich, 2006). McMaster reports that the total growth time from one-gram hatchery fry to market size is seven months. However, by purchasing 10g fingerlings to grow out to a market size of 453 grams (one pound), the time is reduced to around 5 months, or approximately 140 days. Ten gram fingerlings are available from MTI at a price of $1.50 per fish (McMaster, 2008). While available at this price, significant savings are realized by purchasing one gram pompano from overseas at a price of $0.30 a piece (Chappell, 2008). An additional 8 weeks is required to reach market size and so fewer cohorts may be stocked and harvested in a year (6.5 rather than 8.6). However, the savings realized by purchasing the smaller pompano outweighs the increases in revenue that are realized by purchasing ten gram fingerlings. Using the base feed conversion ratio (FCR) of 3.1, as well as the stated market price of $3.75, break-even price for pompano production falls from $6.37 per pound when purchasing fingerlings at $1.50 a piece, to $5.93 per pound when purchasing one gram pompano for $0.30 a piece. Greater detail on how these numbers were generated is provided in ensuing sections.

One criticism of Pompano culture is that while they grow rapidly as juveniles, researchers are quick to point out that at around 250g, their growth stalls and feed efficiency becomes very poor. However, McMaster (2003) reports that while historically, feed conversion ratios (FCR) are 3.1:1, recently developed diets and culture methods have “significantly outperformed the standard diet”. However, Coburn and

McMaster (2007) report use of a FCR of 2.2:1 for pond culture (Coburn and McMaster, 2007). While this FCR improves the opportunity to be profitable, the lack of information to support this claim makes it unreasonable to use this FCR which is drastically different from previous studies, and is also vital to the feasibility of the aquacultural operation. The FCR used in this study is the previously reported 3.1:1, which is also reported by McMaster and lies within the scope of other studies such as those by Weirich (2006).

As in the study by De Ionno, et al (2006) a conservative approach was taken when evaluating the profitability of producing pompano in a recirculating system, as there are no definitive standards for feed conversion ratios, production cycles, or market prices, as is evidenced by the discrepancies in the literature.

Projections for the facility were carried out to Year 10, "as it is unlikely that an aquaculture enterprise would be an attractive investment opportunity if it were not profitable after ten years" (De Ionno, et al 2006, p. 318). All operating costs and biological parameters were held constant over the period of analysis. This assumes no fluctuation, positive or negative, in the price of expenses such as feed, energy, or juvenile pompano, as feed and energy are volatile markets and hard to predict, while there is no way of determining whether input costs of pompano hatcheries will significantly increase or if more producers will enter the market, increasing efficiency and supply, thereby reducing the price (Timmons, et al, 2001). This also assumes that no efficiency gains are made over the period.

Operating costs such as electricity and liquid oxygen were calculated by comparing usage per hour per pound of fish produced at other RAS facilities, assuming a steady state of production over 24 hours per day, 7 days per week and applying prices provided by local suppliers. Costs for natural gas were calculated by consulting equipment suppliers on power usage and consulting local suppliers for prices.

The industry standard, straight-line depreciation was used and incorporated a salvage value of $0. Ionno states that, “it could be expected that [a large facility] would obtain some salvage value at the expiry of the project” (De Ionno, et al 2006, p. 319). However, Timmons suggests that any amount received for used equipment is likely to be minimal, less than ten cents on the dollar, due to the specialized nature of the equipment (Timmons, et al, 2001).

As with many analyses of aquaculture ventures, land was presumed to be owned. This excludes the land value from the analysis so that the focus of the study will be only on the profitability of the RAS facility (Jeffs and Hooker, 2000).

It was assumed that 20 percent of the capital cost was assumed to be financed by the individual, while 80 percent of the investment is financed through a loan accruing interest at 8.5 percent over five years. An additional loan bearing interest of 8 percent was assumed to be taken to cover 50 percent of operating costs, with the remainder covered by the investor. These rates were chosen to reflect current credit markets for business investors (Adrian, 2008).

Cash flow budgets were created to analyze the liquidity of the facility using the base FCR of 3.1 at both 15ppt salinity, as well as 6ppt salinity. This depicts the cash on hand that the facility has in order to continue operation. Interest and principle payments were included, though depreciation was not, in order to strictly analyze the operation’s cash position at any given year. A minimum $1,000 cash balance was maintained at all times.

When calculating net present value, net cash revenues were calculated by netting cash expenses from cash receipts, ignoring depreciation, interest, and principle payments. Depreciation is assumed to be a noncash expense and "already accounted for by the difference between the initial cost and terminal value of an investment", while interest and principle are not included because "investment analysis methods are used to determine the profitability of an investment without considering the method or amount of financing needed to purchase it" (Kay, Edwards, Duffy 2004, p. 283).

A discount rate of 15 percent was used which incorporates a 5 percent return on capital as the minimum alternative investment, and a risk premium of 10 percent (Ionno, 2006). This closely parallels the risk free rate and risk premium of other investments, as well as the 15 percent standard used "as a criterion for high risk investments of this type" (De Ionno, et al 2006). Net present value was only calculated for scenarios that, through sensitivity analysis, showed the potential to provide positive cash flows, and hence, a positive NPV, as any scenarios that do not generate a positive NPV would not be considered an economic success (Thacker, Griffin,1994).

TECHNICAL SYSTEM

Research indicates that Pompano show potential to be successfully cultured in salinities of 6ppt, as is found in West Alabama (Nystrom, 2005). This level significantly decreases the costs associated with supplementing salt in order to increase the water salinity. Currently, Pompano are not cultured at salinities below 15ppt. The recirculating system described is designed to operate at varying salinities and situations at both 6 and 15 ppt were evaluated in this study.

The technical aspects of the system used in this analysis are based on an example system located at North Carolina State University that is used to produce tilapia (Losordo, 2000). The design of a system based on the North Carolina State System is described by Thomas Losordo while the economics of tilapia production in this system is evaluated by the North Carolina Department of Agriculture and Consumer Services. Figure 1 depicts the general layout of such a system (DeLong, 1999). Prices and exact specifications for equipment were derived from various industry suppliers and manufacturers such as Aquatic Eco-systems, Inc., Atlas Manufacturing, and Red Ewald.

The system used in this study resides in a 30’ by 112’ greenhouse. The greenhouse includes both a ventilation system with air flow fans, exhaust fans and shutters, as well as a gas heating system, and a thermostat for temperature controls between 30 and 110 degrees Fahrenheit. The system consists of two quarantine tanks and four grow-out tanks, each made of fiberglass, Figure 1. The tanks are round with sloping bottoms in order to facilitate easy cleaning, and also to generate a natural current that is desirable when producing marine fin-fish (Zohar, 2005). The first quarantine tank (Q1) is 750 gallons, the second (N1) is 4,200 gallons, and the four grow-out tanks each hold 15,538 gallons, bringing the total volume of the system to 67,052 gallons. This system is assumed to exchange 10 percent of its water volume each day (Zohar, 2005).

Water is supplied to the system by a well approximately 1,300 feet deep that delivers saline water of 6 ppt to four, above ground, polyurethane tanks that each hold 6,300 gallons of water. These tanks may be used to store four tanks' supply of 6ppt water, or if producing at a higher salinity, three tanks may be used to treat the water to desired salinity. This approach provides 25,200 gallons of water readily available to replace the 6,803 gallons that is lost each day during operations, and also to provide excess water in any emergency that might require additional water. If culturing fish in water at 6ppt, this method provides three and a half days of water supply in reserve. However, if producing at a higher salinity, only three tanks may be treated and will only supply two and a half days' supply of water. The flow rate for this system is 250 gallons per minute, or one tank exchange per hour, as described by Zohar (2005), and replaces 6,803 gallons of water from the system per day.

Water is drained from growth tanks using a center drain that runs through a particle trap to remove solids from the water, Figure 1. The water then travels through a drum screen filter and to the biosump. After leaving the biosump, water runs through an oxygen saturator, through the water heater, and then returns to the fiberglass tank it originated from. A monitoring system, composed of sensors wired to a computer, constantly evaluates and controls temperature, salinity, and dissolved oxygen, and is connected to a modem that will send an alert for any abnormalities detected. Any sludge and waste-water that is not treated and returned the tank is removed from the system to a one acre effluent pond. Other equipment purchased includes a bulk storage feed bin, automatic feeders, a generator, and a used truck.

ECONOMIC ANALYSIS

One gram pompano are to be purchased at a price of $0.30 each in lots of 15,000 every fifty-six days and stocked at an initial density of .045 lb/gallon, which after 8 weeks of growth to 10 gram fingerlings, becomes .44 lb/gallon, Table 1. A 95 percent survival rate is assumed. Fish are fed a diet of commercially available carnivorous fish feed available from Burris Mills/Cargill that is 46 percent protein, and is delivered at a price of $0.45 per pound ($900 per ton) every six weeks to a 24 ton feed bin. Fingerlings are maintained for 8 weeks in the first quarantine tank (Q1) and then moved into the second quarantine tank (N1) where they are held for an additional 8 weeks. They are then moved into one of the 15,000 gallon grow-out tanks (Growout 1 – Growout 4) for another 8 week period until the group is split into two separate batches in 15,000 gallon tanks, where they will remain for approximately four to five more weeks, or until they reach a harvest weight of approximately one pound. One tank is harvested every four weeks in weekly intervals with 1,781 pounds harvested each week.

The total investment associated with a system capable of producing 92,625 lbs of Pompano annually is $298,206 with annual depreciation of $40,462, using straight line depreciation and assuming a zero salvage value on all equipment, Table 2. The operation was evaluated assuming 20 percent owner equity and the remaining 80 percent financed over five years at 8.5 percent, reflecting current credit markets (Adrian, 2008). A loan to cover 80 percent of the initial investment is $238,565 and with an interest rate of 8 percent generates an annual interest payment of $11,021 for the facility. Land (5 acres) was assumed to be owned.

Recirculating systems are available for commercial aquaculture production at a significantly lower cost to the producer than that used in this analysis (Chappell, 2008). However, no available literature discusses their ability to produce marine finfish. If the cost of the recirculating system could be decreased by $200,000 to $98,206, annual depreciation would decrease by $27,135 to $13,325 per year. Interest expense would also decrease by $15,129. This is a total savings of $0.31 per pound assuming 95 percent survival and no loss of efficiency of the system.

Operating costs total $478,084 each year except for the first (Table 5), during which operating costs are only $396,196 (Table 4) while the system is building to full capacity. Fifty percent of the operating costs are financed through a short term (one year) loan at an interest rate of 8 percent, Table 3. This adds an additional $19,057 in interest expense each year. Labor was calculated at a rate of $10 per hour for eight hours each day (Timmons, et al 2001). Employment taxes were evaluated at 1.45 percent for Medicare and 6.2 percent for Social Security as specified by the Internal Revenue Service. Property taxes were evaluated as Class III property at the state average of 43 mills. Total operating expenses for the production of Pompano are $478,084 per year, Table 5. At this cost, and while receiving the stated price of $3.75 per pound, the operation generates total revenue of $347,344 and accumulates a substantial loss of $161,391 Table 5. The breakeven price of Pompano raised under the stated conditions is $5.92 per pound.

Sensitivity analysis was conducted to evaluate the profitability of Pompano production at different prices, yields, feed conversion ratios, and salinities, similar to that the analysis presented on an Australian aquaculture facility, Table 6 (De Ionno, et al 2006). Prices fluctuate widely, due to a lack of an established market, but reflect different reports of prices received for live pompano and pompano on ice. All prices below $8 per pound are assumed to be paid for fresh pompano on ice, and are the most likely prices a producer would expect to receive, based on evidence presented in this study. Prices of $8 per pound or higher were evaluated to show the potential profitability of marketing live fish. While live fish markets present a great opportunity for a lucrative outlet, it is doubtful that a producer could sell 92,000 pounds of pompano by only relying on live markets, due to the information that is available on the volume of live seafood sold in major markets (Myers, 2003). It is assumed that live markets exist and may be taken advantage of, as evidence presented suggests, but due to a lack of definitive information on details such as the volume of live pompano demanded, and information such as where and how to market large quantities, it is not reasonable to expect such returns without further information.

The sensitivity analysis shows that at 95 percent survival, FCR of 3.1, and a market price of $6 per pound, Pompano production is generates an annual return to land and management of $7,126, Table 6. At 95 percent survival, and FCR of 3.1, return to land and management is $99,751 when the market price is $7 per pound. If survival falls to 85 percent, with a market price of $7 per pound, return to land and management is $72,427.

If the feed conversion ratio is decreased to 2.75, then the operation returns $21,715 to land and management at a price of $6 per pound at 95 percent survival. If market price increases to $7 per pound, return to land and management is $58,155 at 85 percent survival and $114,340 at 95 percent survival, Table 6.

Further enhancing the feed conversion ratio to 2.2, as reported by Coburn and McMaster, the operation has positive returns of $20,215 at only 90 percent survival and a market price of $6 per pound (Coburn and McMaster, 2007), Table 6. At 95 percent survival, returns are $44,639 at $6 per pound. If the market price reaches $7 per pound, returns are $78,667 at 85 percent survival, and $137,264 at 95 percent survival.

Producing pompano in saline water of 15ppt incurs a significant cost from supplementing sea salt. At a cost of $227,091, it accounts for 44 percent of total operating expenses, Table 3. However, if pompano are produced in salinities of 6ppt, the need to supplement salt is no longer required and thus, the cost of production greatly decreases. Sensitivity analysis was conducted to evaluate prices received under prices and yields identical to those described above, but without the added cost of adding additional salt to the water, Table 7.

Under these conditions, and using a feed conversion ratio of 3.1, Pompano production has positive returns to land and management of $10,869 when survival is 80 percent and market prices are $4 per pound, Table 7. At 95 percent survival, return to land and management is $48,967 annually.

If the FCR is enhanced to 2.75, pompano production has positive returns of $9,687 at only 75 percent survival when the market price is $4 per pound, Table 7. At 95 percent survival, returns increase to $63,555 annually at a price of only $4 per pound.

Further enhancing the FCR to 2.2, pompano production has positive returns of $27,785 at 75 percent survival and a market price of $4 per pound, Table 7. At 95 percent survival, returns reach $86,480 annually.

While dockside prices paid to fisherman were used as the base price paid to producers in this study, other marketing avenues present an opportunity for much higher revenues. According to their website, Pompano Farms of Oak Hill, Florida sells whole, fresh pompano on ice at a price of $8 per pound, excluding shipping. At this market price, at 15ppt salinity, and using the FCR of 3.1, returns to land and management are $192,376 annually at 95 percent survival, Table 6.

While income statements and associated sensitivity analysis show the operations profitability potential, cash flow analysis is a more accepted tool of investment analysis when dealing with high risk investments such as pompano production in a recirculating system (De Ionno, et al 2006). A cash flow budget was created to portray the operation's liquidity over a ten year period using the specified FCR of 3.1 and the base market price of $3.75, under conditions of 15ppt salinity. Starting with a beginning cash balance of $806,369 at the start of Year 1, the operation generates a larger negative cash balance each year until reaching a cumulative cash balance at Year 10 of ($2,475,428), Table 8. The same facility evaluated under identical parameters but in salinity of 6ppt yields positive cumulative cash balance at Year 10 of $625,153, Table 9.

In order to evaluate at what point the operation becomes an attractive investment, net cash revenues were calculated at each specified price and feed conversion ratio used in the profitability analysis that showed a positive return to land and management, from which the net present value (NPV) of the pompano farm could be calculated in each scenario. Each point at which NPV becomes positive is reported, as that is the combination of price, feed conversion ratio, and survival rate at which the investment meets the expected return of at least 15 percent, and the point at which the operation would be considered an economic success (Thacker, Griffin1994).

In the case where production is in water of 15ppt salinity and using an FCR of 3.1, NPV becomes positive at a market price of $7 per pound with 90 percent survival, Table 10. If the feed conversion ratio is decreased to 2.75, NPV becomes positive at a price of $7 per pound with 90 percent survival. Using the minimum FCR of 2.2, NPV is positive at a price of $7 per pound and 85 percent survival.

Evaluating production at a salinity of 6ppt, NPV was calculated using all three FCRs, and at prices which show a positive return to land and management in the sensitivity analysis. At an FCR of 3.1, NPV is positive at a price of $4 per pound with survival rate of 95 percent, Table 11. If FCR is decreased to 2.75, NPV is positive at a price of $4 per pound, with survival of 85 percent. Using the minimum FCR of 2.2, NPV is positive at a price of $4 per pound and the minimum survival rate of 75 percent.

In order to add value to their product, some farms decide to process their own fish and market fillets. The Southern Regional Aquaculture Center reported in 1997, that small scale, on farm processing adds a cost of $ .44 per pound to the producer (Lazur, 1997). Adjusted for inflation, this is equal to $ .60 per pound in 2008. Websites such as CharlestonSeafood.com offer fillets of wild caught marine fish at prices ranging between $11.83 per pound for amberjack to $34.21 per pound for Chilean Seabass, with shipping costs added after the sale. Information on pompano fillet yields was not available, but catfish fillet yields are approximately 36 percent (Li, 2001). At such a yield, 2.7 pounds of live pompano would provide 1 pound of processed fillets. At a breakeven cost of

$5.92 per pound of live fish, and adding the $.60 per pound of processed fillets, this would equate to a break even cost of $17.04 per pound of fillets.

Live fish markets are another alternative to traditional marketing of fish to wholesalers. As stated earlier, Yonathan Zohar sold live guilthead seabream in the city of Baltimore at prices ranging between $12 per kilogram, or $5 dollars per pound. Their market research also shows that other high value species of marine fish such as grouper, snapper, and flounder bring prices ranging between $4.50 and $5.40 per pound (Zohar, 2005).

Currently, as far as is known, there are two producers of pompano on the market. One is the Pompano Farms, LLC, spawned from Mariculture Technologies International. They produce pond raised Pompano available for purchase in the months of November, December, and January, "or until supplies are gone." Prices are $8 per pound, whole on ice, which may be shipped, or $10 per pound live and may be picked up at the farm, as reported by their website. The other company in production of Pompano is Dyer Aqua. They provide fresh pompano year round, in the form of whole fish or filets. The company's website states that company has hatchery facilities located in Florida, but ships fingerlings to their ocean pen grow-out facilities in the Bahamas, Panama, and soon, Belize.

CONCLUSION

Recirculating aquaculture systems provide a method to partially control all the factors of aquacultural production as well as meet increasing demand for fish in an environmentally sustainable way. Pompano production cultured at a salinity of 15ppt and supplemented with 6ppt groundwater from Alabama's underground reservoirs shows the potential to be profitable, at prices of $6/lb and $4/lb respectively, particularly if the producer is able to take advantage of live markets, or adds value to their product by producing fillets and selling directly to individual consumers or restaurants. If pompano are successfully cultured at 6ppt salinity, without the need to supplement additional salt, as has been shown may be possible by previous research, then pompano becomes a much more attractive prospect for culture because the market price at which it is profitable falls from $6 per pound to $4 per pound.

Total investment costs for a facility capable of producing pompano is $298,206 with annual depreciation of $40,462. Operating costs are $478,084 annually, of which the largest components are sea salt, feed, and pompano fry, constituting 44 percent, 25 percent, and 6 percent of costs respectively.

Sensitivity analysis shows that pompano production becomes profitable between $4 per pound and $6 per pound, depending on salinity, and research into market prices shows that pompano often sells between $7 and $10 per pound.

By conducting cash flow analysis and computing net present value (NPV), exact parameter specifications were located at which the investment becomes economically successful. At a salinity of 15ppt, pompano production is shown to have positive returns at various survival percentages at a market price of $6 per pound. However, the operation only reaches a positive NPV at market prices of $7 per pound and with high rates of survival. It is doubtful that, unless highly confident of the ability to take full advantage of lucrative, high dollar markets, such an operation would be a successful investment.

If, as previous research indicates, pompano may be raised successfully in salinities of 6ppt, the investment becomes much more attractive. NPV becomes positive at a market price of only $4 per pound, indicating the facility to be a profitable investment.

Historically there has been only a minimal supply of pompano available to the consumers. At the beginning of this study, there was no company commercially producing Florida pompano. However, in recent months, both Pompano Farms as well as DyerAqua have started to culture and sell pompano commercially. Until recently, pompano were only available when caught from the ocean in limited amounts (less than 500,000 lbs per year) and at certain times of the year. While Pompano Farms only has pompano available for three months of the year, DyerAqua produces pompano year-round and is anticipating expanding production to two additional sites. With a large increase in the amount of pompano available, and also the fact that it is now available year-round, investment in an enterprise to produce pompano should be entered into cautiously. An individual's success may depend largely on their experience in aquacultural production, as well as their business management skills.

Techniques that allow for the capture and reuse of salt from wastewater would significantly decrease operating costs at 15ppt. UMBI has experienced success by implementing such methods (Zohar, 2005). Feed costs are substantial and any improvements in FCR significantly improve economic performance of the facility.

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TABLE 1:

Marine Recirculating Aquaculture System Parameters

Parameters for Pompano Production in West Alabama, 2008

Pompano

number of growout tanks	4
number of quarantine tanks	2
total water volume (gallons)	67,102
building size (sq ft)	3,360
fish stocked per cohort	15,000
cohorts stocked/harvested per yr	6.5
survival	95%
fish harvested per cohort	14,250
average size at harvest (pounds)	1
feed conversion ratio	3.1
avg. length of production cycle in days	252
pounds harvested per tank	7,125
lbs. Harvested, year 1(6.5 tanks)	46,312
lbs. Harvested, year 2 and on (13 tanks)	92,625
cost of one gram pompano (each)	0.30
electricity (kwh per pound of production)	2.54
bank credit line int. rate for annual op exp	8%
% of capital financed by owner	20%
bank interest rate for construction (5 yr)	8.5%
sale price ($/pound)	3.75

TABLE 2:

Capital Outlay & Depreciation

Marine Recirculating Aquaculture System for Pompano Production, West Alabama, 2008

Part	Price	# units	Total	Years	Depreciation
Quarantine 1					
Q1 Tank (750 gallons)	930	1	930	7	133
pumps (1hp)	565	1	565	7	81
particle trap (Ecotrap)	1,942	1	1,942	7	277
titanium heat exchanger	723	1	723	7	103
oxygen saturator (35-65 gpm)	688	1	688	7	98
foam fractitionator	1,417	1	1,417	7	202
biosump	584	1	584	7	83
bio sump media	235	1.92	451	7	64
media blower	208	1	208	7	30
regenerative blower	912	1	912	7	130
drum screen filter	8,825	1	8,825	7	1,261
subtotal			17,246		2,464
Quarantine 2					
Q2 Tank (4200 gallons)	2,710	1	2,710	7	387
pumps (1hp)	565	2	1,130	7	161
particle trap (Ecotrap)	3,258	1	3,258	7	465
titanium heat exchanger	832	1	832	7	119
oxygen saturator (65-90 gpm)	1,323	2	2,646	7	378
foam fractitionator	1,417	1	1,417	7	202
bio sump	812	1	812	7	116
bio sump media	235	4.34	1,020	7	146
media blower	208	1	208	7	30
regenerative blower	912	1	912	7	130
drum screen filter	8,825	1	8,825	7	1,261
subtotal			23,770		3,396
Growout System					
Tanks (15538 gallons)	6,920	4	27,680	7	3,954
pumps (2hp)	1,808	8	14,464	7	2,066
particle trap (Ecotrap)	4,387	4	17,548	7	2,507
oxygen saturator (150-260 gpm)	1,255	8	10,040	7	1,434
foam fractitionator	8,895	4	35,580	7	5,083
bio sump	1,460	4	5,841	7	834
bio sump media	235	15.4	3,619	7	517
media blower	309	4	1,236	7	177
regenerative blower	912	2	1,824	7	261
drum screen filter	12,600	2	25,200	7	3,600
subtotal			143,032		20,433

TABLE 2 CONT'D:

Capital Outlay & Depreciation

Marine Recirculating Aquaculture System for Pompano Production, West Alabama, 2008

Part	Price	# units	Total	Years	Depreciation
System-wide equipment					
building (30' x 112' greenhouse)	14,358	1	14,358	10	1,436
water heating units	6,800	2	13,600	7	1,943
feed bins	4,285	1	4,285	7	612
feeders	385	6	2,310	7	330
gas generators	8,289	1	8,289	7	1,184
oxygen monitor	2,046	6	12,276	7	1,754
airlift pumps (for harvest)	8,000	1	8,000	7	1,143
misc. harvest equipment (nets, etc.)	1,000	1	1,000	7	143
misc. equipment	1,000	1	1,000	7	143
well	17,500	1	17,500	15	1,167
water tanks	2,885	4	11,540	7	1,649
1 acre effluent pond	10,000	1	10,000	15	667
subtotal			104,159		12,169
System Total			288,206		38,462
Truck	10,000	1	10,000	5	2,000
TOTAL			298,206		40,462

TABLE 3:

Operating Expenses

Marine Recirculating Aquaculture System for Pompano Production, West Alabama, 2008

Operations	**Unit**	**Cost**	**Units**	**Total**
feed	lb	0.45	287,138	129,212
one gram pompano	fish	0.30	97,500	29,250
Instant Ocean Sea Salt	160 gallons	50.48	4,499	227,091
electricity	kwh	0.10	235,268	24,592
liquid oxygen	100 cubic ft	4.91	703,950	34,564
natural gas	ccf	2	1,518	2,417
hired labor	hrs	10	2,080	20,800
other (repairs, alarm, phone)				2,000
marketing, promotion/travel				4,000
insurance				2,500
property tax	43 mills	43		67
		6.2%		
employment taxes		1.45%		1,591
interest: annual operating capital				19,057
fixed capital				11,021
subtotal				508,162

TABLE 4:

YEAR 1 INCOME STATEMENT

Marine Recirculating Aquaculture System for Pompano Production, West Alabama,2008

Revenue:			
	1 lb Pompano @ $3.75/lb	106,875	
	Total Revenue		106,875
Expenses:			
	Purchased Feed	64,606	
	Purchased Fingerlings	29,250	
	Other Cash Operating Exp.		
	electricity	24,592	
	oxygen	17,282	
	natural gas	2,417	
	labor	20,800	
	sea salt	227,091	
	other (repairs, phone)	2,000	
	marketing, travel	4,000	
	insurance	2,500	
	property taxes	67	
	employment taxes	1,591	
	Total Operating Expenses		396,196
	Depreciation	40,462	
	EBIT		(289,321)
	Interest Expense	30,651	
	Net Income	(319,972)	

TABLE 5:

YEAR 2 ONWARD INCOME STATEMENT

Marine Recirculating Aquaculture System for Pompano Production, West Alabama, 2008

Revenue:			
	1 lb Pompano @ $3.75/lb	347,344	
	Total Revenue		347,344
Expenses:			
	Purchased Feed	129,212	
	Purchased Fingerlings	29,250	
	Other Cash Operating Exp.		
	electricity	24,592	
	oxygen	34,564	
	natural gas	2,417	
	labor	20,800	
	other (repairs, phone)	2,000	
	marketing, travel	4,000	
	insurance	2,500	
	sea salt	227,091	
	property taxes	67	
	employment taxes	1,591	
	Total Operating Expenses		478,084
	Depreciation	40,462	
	EBIT		(130,740)
	Interest Expense	30,651	
	Net Income	(161,391)	

TABLE 6:

Sensitivity Analysis for Pompano Production in Salinity of 15ppt, West Alabama, 2008

FCR: 3.1

		WHOLE ON ICE				LIVE		
Survival	**Yield (lbs)**			**Price/lb**				
		3.00	4.00	5.00	6.00	7.00	8.00	10.00
75%	73,125	(302,046)	(228,921)	(155,796)	(82,671)	(9,546)	63,579	209,829
80%	78,000	(294,222)	(216,222)	(138,222)	(60,222)	17,778	95,778	251,778
85%	82,875	(286,398)	(203,523)	(120,648)	(37,773)	45,102	127,977	293,727
90%	87,750	(278,573)	(190,823)	(103,073)	(15,323)	72,427	160,177	335,677
95%	92,625	(270,749)	(178,124)	(85,499)	7,126	99,751	192,376	377,626

FCR: 2.75

		WHOLE ON ICE				LIVE		
Survival	**Yield (lbs)**			**Price/lb**				
		3.00	4.00	5.00	6.00	7.00	8.00	10.00
75%	73,125	(290,529)	(217,404)	(144,279)	(71,154)	1,971	75,096	221,346
80%	78,000	(281,937)	(203,937)	(125,937)	(47,937)	30,063	108,063	264,063
85%	82,875	(273,345)	(190,470)	(107,595)	(24,720)	58,155	141,030	306,780
90%	87,750	(264,753)	(177,003)	(89,253)	(1,503)	86,247	173,997	349,497
95%	92,625	(256,160)	(163,535)	(70,910)	21,715	114,340	206,965	392,215

FCR: 2.2

		WHOLE ON ICE				LIVE		
Survival	**Yield (lbs)**			**Price/lb**				
		3.00	4.00	5.00	6.00	7.00	8.00	10.00
75%	73,125	(272,431)	(199,306)	(126,181)	(53,056)	20,069	93,194	239,444
80%	78,000	(262,632)	(184,632)	(106,632)	(28,632)	49,368	127,368	283,368
85%	82,875	(252,833)	(169,958)	(87,083)	(4,208)	78,667	161,542	327,292
90%	87,750	(243,035)	(155,285)	(67,535)	20,215	107,965	195,715	371,215
95%	92,625	(233,236)	(140,611)	(47,986)	44,639	137,264	229,889	415,139

TABLE 7:

Sensitivity Analysis for Pompano Production in Salinity of 6ppt, West Alabama, 2008

FCR 3.1

		WHOLE ON ICE					LIVE	
Survival	**Yield (lbs)**	**Price/lb**						
		3.00	4.00	5.00	6.00	7.00	8.00	10.00
75%	73,125	(74,956)	(1,831)	71,294	144,419	217,544	290,669	436,919
80%	78,000	(67,131)	10,869	88,869	166,869	244,869	322,869	478,869
85%	82,875	(59,307)	23,568	106,443	189,318	272,193	355,068	520,818
90%	87,750	(51,482)	36,268	124,018	211,768	299,518	387,268	562,768
95%	92,625	(43,658)	48,967	141,592	234,217	326,842	419,467	604,717

FCR 2.75

		WHOLE ON ICE					LIVE	
Survival	**Yield (lbs)**	**Price/lb**						
		3.00	4.00	5.00	6.00	7.00	8.00	10.00
75%	73,125	(63,438)	9,687	82,812	155,937	229,062	302,187	448,437
80%	78,000	(54,846)	23,154	101,154	179,154	257,154	335,154	491,154
85%	82,875	(46,254)	36,621	119,496	202,371	285,246	368,121	533,871
90%	87,750	(37,662)	50,088	137,838	225,588	313,338	401,088	576,588
95%	92,625	(29,070)	63,555	156,180	248,805	341,430	434,055	619,305

FCR 2.2

		WHOLE ON ICE					LIVE	
Survival	**Yield (lbs)**	**Price/lb**						
		3.00	4.00	5.00	6.00	7.00	8.00	10.00
75%	73,125	(45,340)	27,785	100,910	174,035	247,160	320,285	466,535
80%	78,000	(35,541)	42,459	120,459	198,459	276,459	354,459	510,459
85%	82,875	(25,742)	57,133	140,008	222,883	305,758	388,633	554,383
90%	87,750	(15,944)	71,806	159,556	247,306	335,056	422,806	598,306
95%	92,625	(6,145)	86,480	179,105	271,730	364,355	456,980	642,230

TABLE 8:

CASH FLOW BUDGET FOR 15ppt SALINITY (Year 1-5)

Pompano Production in a Marine Recirculating System, West Alabama, 2008

	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Beginning Cash Balance	806,369	1,000	1,000	1,000	1,000
Operating Receipts:					
Pompano sales	106,875	347,344	347,344	347,344	347,344
Total Cash Inflow:	913,244	348,344	348,344	348,344	348,344
Operating Expenses:					
Feed expense	129,212	129,212	129,212	129,212	129,212
1 gram pompano	29,250	29,250	29,250	29,250	29,250
Instant Ocean Sea Salt	227,091	227,091	227,091	227,091	227,091
Electricity	24,592	24,592	24,592	24,592	24,592
Liquid oxygen	34,564	34,564	34,564	34,564	34,564
Natural gas	2,417	2,417	2,417	2,417	2,417
Labor	20,800	20,800	20,800	20,800	20,800
Marketing, Promotion/Travel	4,000	4,000	4,000	4,000	4,000
Insurance	2,500	2,500	2,500	2,500	2,500
Property tax	67	67	67	67	67
Employment taxes	1,591	1,591	1,591	1,591	1,591
Other (repairs, alarm, Phone)	2,000	2,000	2,000	2,000	2,000
Total Cash Operating Expenses	478,084	478,084	478,084	478,084	478,084
Capital Expenditures:					
Building	14,358				
Recirculating System	246,348				
Truck	10,000				
Well and Pond	27,500				
Scheduled Debt Payments:					
Current Debt-Principal	238,213	191,072	406,854	639,898	891,585
Current Debt-Interest	19,057	15,286	32,548	51,192	71,327
Noncurrent Debt-Principal	58,734	58,734	58,734	58,734	58,734
Noncurrent Debt-Interest	11,021	11,021	11,021	11,021	11,021
Total Cash Outflow:	1,103,316	754,198	987,242	1,238,929	1,510,752
Cash Available	(190,072)	(405,854)	(638,898)	(890,585)	(1,162,408)
New Borrowing:					
Current:	191,072	406,854	639,898	891,585	1,163,408
Ending Cash Balance:	1,000	1,000	1,000	1,000	1,000

TABLE 8 Cont'd:

CASH FLOW BUDGET FOR 15ppt SALINITY (Year 6-10)

Pompano Production in a Marine Recirculating System, West Alabama, 2008

	Year 6	Year 7	Year 8	Year 9
Beginning Cash Balance	1,000	1,000	1,000	1,000
Operating Receipts:				
Pompano sales	347,344	347,344	347,344	347,344
Total Cash Inflow:	348,344	348,344	348,344	348,344
Operating Expenses:				
Feed expense	129,212	129,212	129,212	129,212
1 gram pompano	29,250	29,250	29,250	29,250
Instant Ocean Sea Salt	227,091	227,091	227,091	227,091
Electricity	24,592	24,592	24,592	24,592
Liquid oxygen	34,564	34,564	34,564	34,564
Natural gas	2,417	2,417	2,417	2,417
Labor	20,800	20,800	20,800	20,800
Marketing, Promotion/Travel	4,000	4,000	4,000	4,000
Insurance	2,500	2,500	2,500	2,500
Property tax	67	67	67	67
Employment taxes	1,591	1,591	1,591	1,591
Other (repairs, alarm, Phone)	2,000	2,000	2,000	2,000
Total Cash Operating Expenses:	478,084	478,084	478,084	478,084
Capital Expenditures:				
Building				
Recirculating System				
Truck				
Well and Pond				
Scheduled Debt Payments:				
Current Debt-Principal	1,163,408	1,387,221	1,628,938	1,889,993
Current Debt-Interest	93,073	110,978	130,315	151,199
Noncurrent Debt-Principal				
Noncurrent Debt-Interest				
Total Cash Outflow:	1,734,564	1,976,282	2,237,337	2,519,277
Cash Available	(1,386,221)	(1,627,938)	(1,888,993)	(2,170,933)
New Borrowing:				
Current:	1,387,221	1,628,938	1,889,993	2,171,933
Ending Cash Balance:	1,000	1,000	1,000	1,000

TABLE 9:

CASH FLOW BUDGET FOR 6ppt SALINITY (Year 1-5)

Pompano Production in a Marine Recirculating System, West Alabama, 2008

	Year 1	Year 2	Year 3	Year 4	Year 5
Beginning Cash Balance	806,369	37,018	63,614	90,209	116,804
Operating Receipts:					
Pompano sales	106,875	347,344	347,344	347,344	347,344
Total Cash Inflow:	913,244	384,362	410,957	437,552	464,148
Operating Expenses:					
Feed expense	129,212	129,212	129,212	129,212	129,212
1 gram pompano	29,250	29,250	29,250	29,250	29,250
Electricity	24,592	24,592	24,592	24,592	24,592
Liquid oxygen	34,564	34,564	34,564	34,564	34,564
Natural gas	2,417	2,417	2,417	2,417	2,417
Labor	20,800	20,800	20,800	20,800	20,800
Marketing, promotion/travel	4,000	4,000	4,000	4,000	4,000
Insurance	2,500	2,500	2,500	2,500	2,500
Property tax	67	67	67	67	67
Employment taxes	1,591	1,591	1,591	1,591	1,591
Other (repairs, alarm, phone	2,000	2,000	2,000	2,000	2,000
Total Cash Operating Expenses:	250,993	250,993	250,993	250,993	250,993
Capital Expenditures:					
Building	14,358				
Recirculating System	246,348				
Truck	10,000				
Well and Pond	27,500				
Scheduled Debt Payments:					
Current Debt-Principle	238,213				
Current Debt-Interest	19,057				
Noncurrent Debt-Principle	58,734	58,734	58,734	58,734	58,734
Noncurrent Debt-Interest	11,021	11,021	11,021	11,021	11,021
Total Cash Outflow:	876,225	320,749	320,749	320,749	320,749
Cash Available	37,018	63,614	90,209	116,804	143,399
New Borrowing:					
Current:					
Ending Cash Balance:	37,018	63,614	90,209	116,804	143,399

TABLE 9 Cont'd:

CASH FLOW BUDGET FOR 6ppt SALINITY (Year 6-10)

Pompano Production in a Marine Recirculating System, West Alabama, 2008

	Year 6	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Beginning Cash Balance	143,399	239,750	336,101	432,451	528,802
Operating Receipts:					
Pompano sales	347,344	347,344	347,344	347,344	347,344
Total Cash Inflow:	490,743	587,094	683,444	779,795	876,146
Operating Expenses:					
Feed expense	129,212	129,212	129,212	129,212	129,212
1 gram pompano	29,250	29,250	29,250	29,250	29,250
Electricity	24,592	24,592	24,592	24,592	24,592
Liquid oxygen	34,564	34,564	34,564	34,564	34,564
Natural gas	2,417	2,417	2,417	2,417	2,417
Labor	20,800	20,800	20,800	20,800	20,800
Marketing, promotion/travel	4,000	4,000	4,000	4,000	4,000
Insurance	2,500	2,500	2,500	2,500	2,500
Property tax	67	67	67	67	67
Employment taxes	1,591	1,591	1,591	1,591	1,591
Other (repairs, alarm, phone)	2,000	2,000	2,000	2,000	2,000
Total Cash Operating Expenses:	250,993	250,993	250,993	250,993	250,993
Capital Expenditures:					
Building					
Recirculating System					
Truck					
Well and Pond					
Scheduled Debt Payments:					
Current Debt-Principal					
Current Debt-Interest					
Noncurrent Debt-Principal					
Noncurrent Debt-Interest					
Total Cash Outflow:	250,993	250,993	250,993	250,993	250,993
Cash Available	239,750	336,101	432,451	528,802	625,153
New Borrowing:					
Current:					
Ending Cash Balance:	239,750	336,101	432,451	528,802	625,153

TABLE 10:

ANALYSIS OF NET PRESENT VALUE (NPV)~15ppt

Pompano Production in a Marine Recirculating System, West Alabama, 2008

FCR 3.1		**Year 1**	**Year 2-5**	**Year 6-10**	**Net Cash Revenues**	**NPV**
				Price/lb		
Survival	**Yield (lbs)**			7		
75%	73,125	(320,584)	33,791	33,791	(16,463)	(436,768)
80%	78,000	(310,084)	67,916	67,916	301,162	(286,046)
85%	82,875	(299,584)	102,041	102,041	618,787	(135,324)
90%	87,750	(289,084)	136,166	136,166	936,412	15,398
95%	92,625	(278,584)	170,291	170,291	1,254,037	166,120

		Year 1	**Year 2-5**	**Year 6-10**	**Net Cash Revenues**	**NPV**
FCR 2.75				**Price/lb**		
Survival	**Yield (lbs)**			7		
75%	73,125	(281,864)	72,511	72,511	370,734	(242,443)
80%	78,000	(277,397)	100,603	100,603	628,031	(121,998)
85%	82,875	(272,930)	128,695	128,695	885,328	(1,554)
90%	87,750	(268,463)	156,787	156,787	1,142,625	118,891
95%	92,625	(263,995)	184,880	184,880	1,399,921	239,336

		Year 1	**Year 2-5**	**Year 6-10**	**Net Cash Revenues**	**NPV**
FCR 2.2				**Price/lb**		
Survival	**Yield (lbs)**			7		
75%	73,125	(263,766)	90,609	90,609	551,718	(151,611)
80%	78,000	(258,092)	119,908	119,908	821,081	(25,111)
85%	82,875	(252,418)	149,207	149,207	1,090,443	101,389
90%	87,750	(246,744)	178,506	178,506	1,359,806	227,889
95%	92,625	(241,071)	207,804	207,804	551,718	(151,611)

TABLE 11:

ANALYSIS OF NET PRESENT VALUE (NPV)~6ppt

Pompano Production in a Marine Recirculating System, West Alabama, 2008

FCR 3.1		**Year 1**	**Year 2-5**	**Year 6-10**	**Net Cash Revenues**	**NPV**
Survival	**Yield (lbs)**			**Price/lb** 4		
75%	73,125	(160,993)	41,507	41,507	212,571	(265,979)
80%	78,000	(154,993)	61,007	61,007	394,071	(179,852)
85%	82,875	(148,993)	80,507	80,507	575,571	(93,725)
90%	87,750	(142,993)	100,007	100,007	757,071	(7,598)
95%	92,625	(136,993)	119,507	119,507	938,571	78,528

FCR 2.75		**Year 1**	**Year 2-5**	**Year 6-10**	**Net Cash Revenues**	**NPV**
Survival	**Yield (lbs)**			**Price/lb** 4		
75%	73,125	(122,273)	80,227	80,227	599,767	(71,654)
80%	78,000	(122,306)	93,694	93,694	720,939	(15,804)
85%	82,875	(122,339)	107,161	107,161	842,111	40,045
90%	87,750	(122,372)	120,628	120,628	963,283	95,895
95%	92,625	(122,405)	134,095	134,095	1,084,455	151,744

FCR 2.2		**Year 1**	**Year 2-5**	**Year 6-10**	**Net Cash Revenues**	**NPV**
Survival	**Yield (lbs)**			**Price/lb** 4		
75%	73,125	(104,175)	98,325	98,325	780,752	19,178
80%	78,000	(103,001)	112,999	112,999	913,989	81,083
85%	82,875	(101,827)	127,673	127,673	1,047,227	142,988
90%	87,750	(100,654)	142,346	142,346	1,180,464	204,893
95%	92,625	(99,480)	157,020	157,020	1,313,702	266,798

FIGURE 1

NCST Fishbarn Diagram