# FLORIDA POMPANO *Trachinotus carolinus* IS AN ALTERNATIVE SPECIES FOR LOW SALINITY SHRIMP POND FARMING.

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**Presented at Aquaculture America 2006, Las Vegas, February 14, 2006**

## ABSTRACT

As the world production of farm raised shrimp slowly shifts to the countries that have the lowest cost of production, many of the original western hemisphere shrimp farming firms are finding it almost impossible to compete. These western firms must modify their methods and products quickly or they will perish. The shrimp farmers of Taiwan were faced with crippling out breaks of disease but they recovered their businesses by shifting product choice from shrimp to finfish.

Over the past three years, the technical staff of Mariculture Technologies International, Inc. has been testing the limits of salinity tolerance of the Florida Pompano (T. carolinus). We have determined that the pompano will grow as well in 19 ppt salinity well water as they do in normal seawater (35 ppt). It appears to be the opinion of many observers in the mariculture industry in North and South America that to have a profitable operation one must produce a product that has an ex-farm gate value of over $4.00 per pound. Over the last decade, the Florida Pompano has established a wholesale market value of $4.50 to $6.00 per pound depending on time of year and size of product.

## INTRODUCTION

This presentation is the fourth paper in a recent and on going series regarding Florida pompano (*T carolinus)* farming. All of the work presented here has been accomplished at the marine finfish experimental facility owned and operated by Mariculture Technologies International, Inc (M.T.I., Inc.) in Oak Hill, Florida, USA. All previous papers in this MTI series can be found at www.PompanoFarms.com. An extensive review of the subjects already reported in previous papers covering the last 30 years of our work with the Florida Pompano will not be made.

New findings reported deal with our initial understandings for proper pond design, low salinity tolerances, and appropriate geographical locations for successful earthen pond farming of the Florida pompano. Further, data will be presented demonstrating the pompano's attractive market value and to expand on the obvious commercial opportunities that now exist as a result of our studies on low salinity tolerance of the Florida pompano.

## BACKGROUND

Our motivations to conduct this work have been two fold. First, for over 30 years as mariculturists, we have heard from both the State of Florida and the Federal Government telling our industry that they are working on the permitting process for off shore sea cage mariculture and it should happen any year now. However, warm water sea cage culture still has not happened in the USA. Therefore, we set out to determine whether the Florida pompano can be commercially farmed in low salinity ponds. Second, MTI has received numerous inquires over the last fifteen years from shrimp farming companies asking us if the Florida pompano can tolerate low salinities and grow in earthen ponds. Until recently, we have had to reply that we suspect they can tolerate lower salinities to some level but we did not know what that level is. This second motivation is purely market driven.

Briefly, the technical history of our group's understandings regarding the artificial and year round production of the Florida Pompano started back in 1972 (McMaster, M.F. et al, 1988,2003,2004,2005 and Wagstaff, R.K., 1975). It is important to note that all of our previous developments with this fish have eliminated critical technical road blocks which have plagued other marine species currently being considered as mariculture candidates (McMaster, M.F., 1988, 2003).

Starting in 2002, M.T.I., Inc. established a corporate plan to investigate whether the Florida pompano, post ten grams, could tolerate reduced salinities without negative impacts on growth, survival, and condition. The starting age, post ten gram fry, is based on what is known of this fish's natural life history (Gilbert and Parsons 1986, Watanabe 1995, Finucane 1971, and others) and our knowledge of this fish. Small pompano fry, less then 10 grams, have only been found in surf zones or exclusively in normal ocean salinities. The hatchery production as practiced by M.T.I., Inc. uses normal seawater salinities. There remains the question of how soon after metamorphosis (1 gram) this fish can transfer to lower salinities. In any event, we concluded that it would be safe to start them into reduced salinity acclimation starting at the ten gram size.

In the spring of 2004 the company produced from its hatchery the pompano fry needed for its first low salinity pond trial. In late July this batch of 10 gram fry was placed into the 19 ppt. salinity pond without acclimation. Acclimation rates had already been established (McMaster, M.F., 2004) and there is no harm from an instant drop of salinity from 32 ppt to 19 ppt at like temperature. We were, we thought, off to great start until the second week of August and then again in the first week of September, 2004 when two of the largest hurricanes ever reported to hit central Florida came right over our Oak Hill, Florida farm. That ended the experiment. Considerable over flooding of the salt pond with freshwater coupled with no electricity or ability to even reach the property for four days left the salt pond anoxic. This situation caused the death of all fish in the salt pond.

Fortunately, there were approximately 300 pompano juveniles (F1) residing in our broodstock facility and they survived the hurricanes. These fry had been selected as larger fry to be grown indoors for future spawning work. In October of 2004 the 300 juvenile population was sorted down to 25 of the largest fish in the group. Approximately 187 juveniles were released to the low salinity pond. Therefore, this paper presents work that was salvaged from the original goal. Unfortunately, our data in regards to adequate numbers of test fish has been compromised.

However, we believe the experience, data collected, and results are in a practical way, definitive and very encouraging.

There is a scarcity, if not a total lack of Florida pompano pond farming trials and experiments reported in the literature for over the past 27 years. Prior to 1978 and starting in 1957 through 1964 a few attempts were made in St. Augustine where wild pompano fry were placed in 1/8 to 1/4 acre (0.08 hectors) ponds using natural water for growing (Berry, F. 1967). One of the more successful attempts, in that time period, to pond farm the Florida Pompano was done by John Finucane near St Augustine, Florida (Finucane, J.H. 1971). These trials were done in apparently dammed off natural lagoons or tidal ponds using normal strength salinities. The source of juvenile pompano was reported to be natural stock captured on North Florida Beaches. Results were reported to be poor but encouraging. However, there is no record of on going work by John Finucane after the 1970 report. In 1978 a team of researchers (Tatum and Trimble) in Alabama carried the pompano pond farming experience a little further (Trimble, W.C. 1978). This work utilized wild caught juveniles and reportedly stocked brackish water ponds at the rate of 8,750 or 10,412 fish per hector. These fish were fed 40% protein trout chow for 95 to 191 days. Pond yields averaged 564 Kg./ha; survival (42%) was low, and a FCR (3.0) was high. Further trials with polyculture of shrimp with pompano eventually yielded about the same results for pompano production. Pond sizes were 0.08 ha. with a depth of 0.5 to 1.5 meters. The project utilized pumped water from an adjacent estuary/river that reportedly had a salinity of 13 to 18 ppt. Dr. Trimble's 1978 report is the last U.S.A. pompano pond trials we found. It is of interest here to point out that the State of Florida banned the collection of juvenile pompano from its beaches in the very early 1970's thus effectively stopping further research on pond farming in Florida. Other States followed that lead soon after. To this date only private sector companies have completed the spawning through hatchery production for this species thus limiting government's participation.

A very similar fish to the Florida Pompano that is indigenous to Asia is the snub-nosed or silver pompano (T. blochii). This species has reportedly been brackish water pond farmed for many years (C.T. Chu, Team Aqua Corporation). There is reportedly a small number of hatchery produced snub-nosed pompano while most of the fry available are from wild stocks. We have seen articles suggesting that 40 million snub-nosed pompano fry are being farmed per year (Yeh, S-P. 1998). Also, these general articles suggest that the majority of these fish are farmed in brackish water ponds with the balance farmed in floating sea pens (C.T. Chu, Team Aqua Corporation). As of this date we have not been able to find definitive information regarding pond production data and success for comparison purposes. It is of interest to note that the mature size of the silver pompano is reported to be above three pounds while the Florida Pompano is mature at 1 ¼ pounds.

## POMPANO MARKET CONSIDERATIONS

Why is the Florida pompano the right fish for today's brackish warm water pond mariculture? This is the salient question regarding the future of this species if it is to be considered a prime mariculture candidate. Today, we believe essentially the same as we did 30 years ago, there is no better candidate for modern warm water mariculture be it in ponds or cages. This opinion has now been enhanced by our recent observations on low salinity earthen pond farming of this species. We believe there is an attractive economic potential in sea cage farming this species, but it remains to be demonstrated. The sea cage model is still buried in government red tape and thus this method at present does not offer a business opportunity here in the USA.

The Florida pompano is a beautiful and classic appearing marine specimen. This fish presented side by side with any other species by far and away attracts the attention of consumers of all nationalities.

Photo 1. Florida Pompano, December 2005

The ice counter appearance is generally enough to make the species a top seller. Additionally, if one needs another reason to purchase Florida pompano we have uncovered a very interesting consumer nutritional reason to purchase pompano. In today's modern world of diet awareness and the negative results from poor dietary choices as it impacts cardiac health, the Florida pompano should be a fish of first choice. When one considers the benefits of oil content of marine fin fish and its resultant health benefits, the average aware consumer would seek out fish with high oil content that tasted good as well. If oil per pound of filet is part of the consumer's decision making process, then pompano and salmon win the contest.

The table below demonstrates that per fillet serving (85 grams) (3 ounces) pompano is equal to salmon in total fish oil content. In fact, pompano and salmon are the highest fat content of all consumable fish listed by the USDA (USDA-SR17)(www.nutritiondata.com/facts).

| Species | Total Fat Content/Portion |
|---|---|
| | |
| Pompano | 10 grams |
| Salmon | 10 |
| Trout | 6 |
| Tuna | 5 |
| Swordfish | 4 |
| Tilapia | 2.55 |
| Channel Catfish | 2 |
| Grouper (mixed species) | 1 |
| | |
| Portions are constant at 85 grams for each species and cooked with dry heat. | |

Table 1. Total fat Content for Consumable Fish

Clearly, the Florida pompano has shown itself to be an excellent table quality fish for years. The next question would be, does it have market value? Mr. Nils Stolpe, an independent commercial fisheries consultant contributed the following graphic analysis of ex-vessel values of some selected "premium" species. This comparison is very revealing. Starting in 1950 the Florida pompano has enjoyed the nation's highest ex-vessel value. Further, this graph says that the Florida pompano has been an accepted commercial species for quite some time and that translates into market recognition.

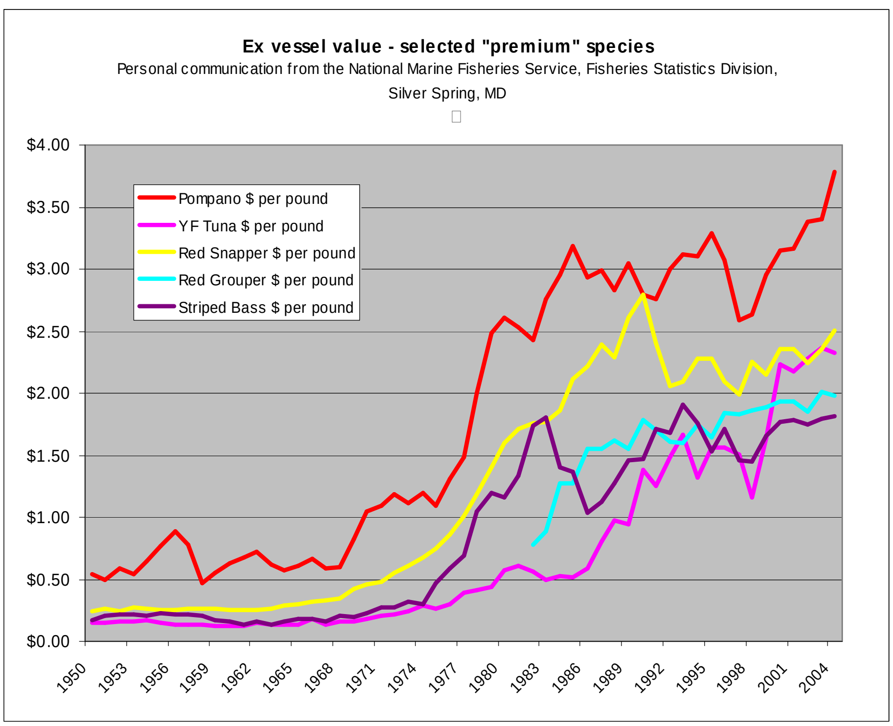


Figure 1. Ex Vessel Value for Selected Species.

The retail value at the fish counter is quite variable. Occasional spot checking by our staff in Florida and Georgia (Atlanta) has seen fresh and whole Florida pompano range from $6.00 per pound to $10 per pound. Prepared pompano dishes at up scale restaurants offer the Florida pompano in the range of $20.00 to $32.25 per dish. Some popular southern restaurant offerings:

| | | |
|---|---|---|
| Arnauds's – New Orleans | | |
| | Pompano Duarte | $31,50 |
| | Pompano David | $28.95 |
| | Pompano En Croute | $27.95 |
| | | |
| Antoine's – New Orleans | | |
| | Pompano Grille | $28.00 |
| | Pompano au "Buster" grille | $32.25 |
| | Pompano a la mariniere | $29.00 |
| | | |
| Court of Two Sisters – New Orleans | | |
| | Pompano Pontchartrain | $25.00 |
| | Pompano en papillote | $25.00 |
| | | |
| Broussard's – New Orleans | | |
| | Pompano Napoleon | $29.50 |
| | | |
| Joe's Riverside Grill - Fort Lauderdale | | |
| | Pompano grilled | $20.00 |
| | | |

Table 2. Some Popular Southern Restaurant Offerings.

## POMPANO POND FARMING

After the 2004 hurricanes had killed our pond fish we decided to modify our original experimental design. The 187 pompano juveniles that we put in the pond in October, 2004 were going to be considered an "endurance" experiment. The question was, can the Florida pompano survive and grow with no human intervention, except to mitigate catastrophic physical events like flooding, in our 19 ppt salinity pond? We did not add any artificial feed to the pond (McMaster, 2005).

The Florida pompano can tolerate a wide range of temperatures extending between 50 F. (10 C.) to 95F (35C.). However, we believe that for the purpose of commercially farming this species the temperature range for best growth and least operational problems is 80F. (27C.) to 84F (29 C.).

The location of our experimental farm is north central Florida on the Atlantic side. The property sits at the very northern tip of the Indian River Lagoon and is approximately 20 miles inland from the Atlantic Ocean. The site was previously a commercial orange grove. A ground water well (6 inch diameter and cased) was drilled to 480 feet (146 meters) where we obtain clear water with a salinity (total dissolved solids) of 19 ppt. This well has been pumped continuously for four years now at the rate of 60 gpm (227 liters per minute) and with no measurable salinity change. Salinities are measured with a hand held refractometer. On an annual cycle we send a well water sample to a commercial water testing laboratory (ABC Labs.) for metals and organic analysis (Appendix 1). Our group has had many experiences with saltwater wells in many different geographical locations and not one of them is the same when it comes to the portions of major ions. It is important we think to understand the impacts of differing well water chemistries in relation to what you are growing.

In July, 2005 we installed a continuous temperature monitor/logger into the pond. The graph below is the temperature record for July 5, 2005 to December 20, 2005. The rapid excursions in temperature were due to the removal of the sensor from the pond for down loading data.

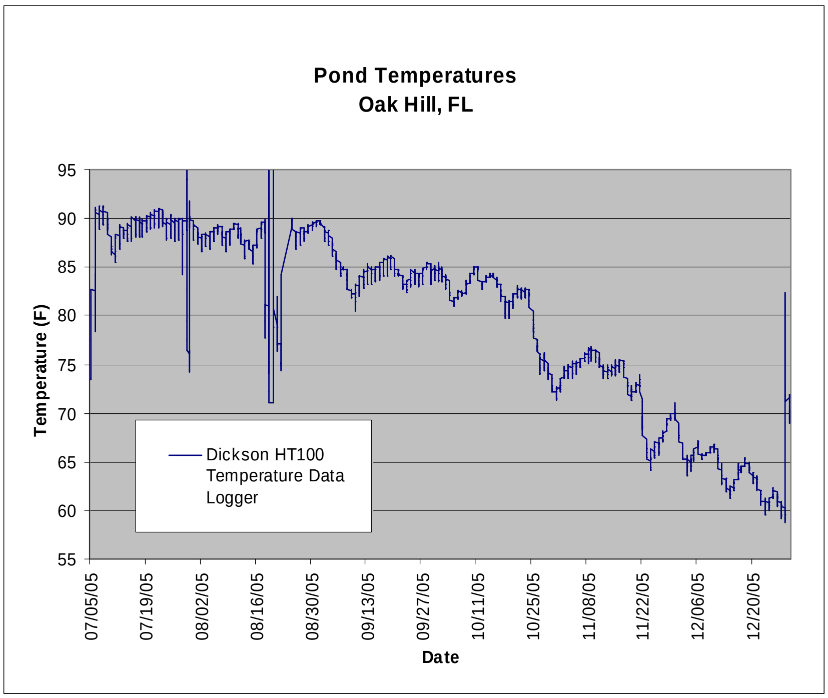


Figure 2. Pond Temperatures, Oak Hill

It is apparent from this graph that good growing temperatures existed from July through October, 2005. We suspect that June of that year would have been above the 80F. (27 C.) mark as well. In Oak Hill, Florida, for the year 2005 there was an optimum range of good growing temperatures for five months. This is not to suggest however that pompano stop growing at temperatures below 80F (27 C.)

Salinity variations were minimal over the test period. Only during large rain events (rain over 3 inches (7.62 cm.) per 24 hours) would salinities reduce measurably. The reason for this is primarily due to the slope of our 2.5 acre (1 ha.) building area that drains all surface water directly to the pond. After major rain events, typically the salinities would go down to 12 ppt at the normal extreme with major rain events causing salinities to drop to 15 ppt.. Normal salinity recovery rate, back to 19 ppt., took about a week. Salinity recovery was facilitated by constant well water input of approximately 60 gpm (227 lpm). The test pompano experienced extreme dilution of the pond on October 24, 2005 which is the date Hurricane Wilma hit our area. The temperature profile demonstrates a significant down turn in pond temperature starting on that date. Hurricane Wilma produced 15 inches (38 cm.) of rain over two days. The farm did not lose electrical power or sustain wind damage during this storm. However, the property and pond flooded over again with freshwater. This time our staff was able to keep the pond water turning over with submersible pumps to prevent freshwater to saltwater stratification and hence anoxia of the lower saltwater zone. This mixing however caused the entire pond water to drop in 24 hours to 2.0 ppt salinity. By October 28, 2005 the pond was back in its banks and the salinity had recovered to 12 ppt.. By November 3, 2005 salinities recovered to 15 ppt. It took about 15 days for the pond salinity to recover back to 19 ppt. using the well water supply. Interestingly, there were no pompano mortalities observed during this extremely low salinity period.

Continuous pond aeration is supplied via four diffusers (six inches long)(15cm. long) which are spaced out along one side of the pond. These diffusers are in approximately three feet of water (1 meter). Oxygen measurements were taken at irregular intervals. Generally, samples were taken once per month or when conditions suggest there maybe a potential for oxygen depletion. For over two years on this testing regime we have not found oxygen to be below saturation.

In addition to water exchange and aeration we apply probiotic bacteria (Alken Murray Corporation, culture # 1006 & 1002) on regular weekly bases. We attribute a significant improvement in water condition to the use of these bacteria. The pond is four years old and has never been drained for cleaning. By the end of the first year massive amounts of filamentus green algae (Enteromorpha intestinalis) was taking over the pond. Primary nutrient input to the pond is due to the pond continuously receiving all effluents arising from an adjoining Artemia Bio-mass farm. Six months after the commencement of applying probiotic bacteria the water cleared, the filamentus algae disappeared. The water remains clear with a light sandy silt soil on the bottom.

The M.T.I., Inc. test pond is used for various purposes concurrently with the pompano project. Other polyculture species co-inhabiting the pond are broodstock fish specimens such as Lookdowns (Selene vomer) , Pigfish (Orthopristis chrysoptera), Spot Croaker ( Leiostomus xanthurus), Pinfish (Lagodon rhomboides) Mud Minnows (Fundulus grandis), saltwater adapted Florida Flag Fish (Jordanella floridae ) and Sailfin Mollies (Poecllia sp.). The introduced invertebrate specimens are marine grass shrimp (Palaemonetes vulgaris), small cluster mussels (unknown identity), assorted species of small crabs and a few large blue crabs (Callinectes sapidus) .

We did find that our 300 foot X 150 foot X 8 foot deep (91meters X 46 meters X 2.44 meter deep) pond might not be the best configuration for pompano grow out. There is one difficult behavior of the Florida pompano, they like to jump. In fact, the only mortalities that we witnessed were pompano that had jumped out of the pond onto the pond banks. We acknowledge that there surely were other predatory causes for mortalities, but nothing other then one osprey catching one fish was observed. Never did we witness mortalities that could be associated with disease.

Photo 2. Oak Hill Pond

Our pond has a shallow slope on three sides with no embankment. The fourth side had a steep slope and high (6 foot)( 2 meter) embankment. All jumping deaths were found on the no embankment sides of the pond. We believe that some fish certainly jumped out on the high embankment side but they were able to roll and flop their way back down to the water. Future pond designs must take into account configurations that limit deaths due to jumping. Another important pond design parameter for the Florida pompano is water depth. We believe that the minimum water depth for behavior reasons is 3 feet (1 meter). For climate reasons, deeper ponds are necessary for temperature areas such as Oak Hill, Florida which is north of the Florida frost line.

## POND FARMING RESULTS

A definitive measure of survival rate and growth rate would require draining the entire pond and this would have interrupted operations with respect to other test species in the pond.

After the pompano had been in the pond for nine months and over wintered from late October 2004 to late July 2005 a seined sample was taken (McMaster, 2005). That sampling showed an average weight of 330 grams (11.63 ounces) and a fork length of 25 cm (9.69 inches). This growth rate was considerably below our standard long term growth rate of one pound in nine months (McMaster, 1988).

In late December, 2005, pond pompano were again sampled. This time sampling was done by hook and line using circle hooks. The December, 2005 population of pond pompano were 14 months old and experienced normal growing temperatures from June, 2005 until late October, 2005. The sample size was 20 fish. The average weight was 669 grams (1.25 pounds) and the average fork length was 29.19 cm. (11.49 inches). We estimate that the fish would have attained the market size of one pound by late October, 2005. In this natural pond case it took the pompano roughly one year to reach one pound market size. Our standard growth curve indicates that pompano farmed in tanks at 80F would reach market size of one pound in 9 months (McMaster 1988). Clearly, the slower growth of the pond fish was caused by over winter temperatures.

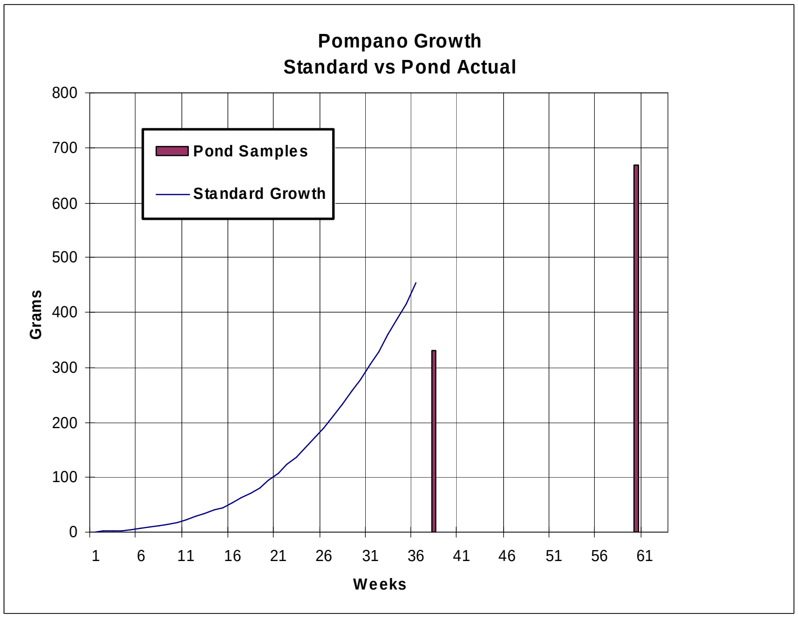


Figure 3. Pompano Growth, Standard vs Pond

There was no supplemental feeding of any kind provided for the entire test period. There remains the question that if they had been fed would they have grown faster? We believe they would have. Sibling fish from this same F1 spawn that were selected for future spawns and kept indoors are considerably larger at the same date. The indoor fish were climate controlled during the over winter period and fed twice daily with prepared foods. However, the pond results are very encouraging in that pompano survive and grew reasonably well while left to forage on their own. What they ate is open to debate as no effort was made to sample existing fauna on a monthly bases or do gut content analysis. Further, it is our opinion that the salinity of 19 ppt had no adverse effect on the Florida Pompano. We do not have adequate data to say that lower long term salinity exposure would have a negative effect on growth and survival. Our test fish did experience 15 ppt salinities for as much at 25% of the summer rainy season (June to October).

Upon both fish sampling occasions the observed condition factor of these pond fish was excellent. Normal skin and eye condition, normal girth appearance of a properly fed pompano was apparent and no signs of any disease on any fish. Long term low salinity (19 ppt.) exposure appeared not to have any negative effects on the Florida pompano.

Finally, one might ask if the taste of pompano raised in low salinity water was altered in any way. For both samplings we sacrificed 5 pompano for dinner testing. This is not a scientific taste testing regime, but, we have been growing pompano and consuming pompano for thirty years and we found these low salinity raised pompano to be excellent and in fact no different than any other pompano we have tasted.

## ABBREVIATED LOOK AT COMMERCIALIZATION

The Florida pompano was commercially farmed in the Dominican Republic in the years 1972 to 1975 (McMaster, M.F. 1988 and Wagstaff, .R.K., 1975). Year round and monthly production of eggs, fry, and market fish was accomplished. The primary cause of business failure was a fuel oil shortage caused by the first world oil embargo. Pompano in this project were grown in tank farms that required massive amounts of water pumped from diesel driven hydraulic pumps. If there is no fuel for the pumps there is no water for the fish. However, there was a huge amount of practical and applied pompano farming business experience gained from this project. The technical development of the Dominican pompano project was led by Michael F. McMaster who held the dual position of V.P. for Research and Development and General Manger of juvenile pompano production. Our work with the Florida pompano in one fashion or another has been on going since 1972.

We have an excellent understanding of what the costs and expected rewards would be for intensive, high capitalization tank farming systems. We do not have a good understanding as of yet on the capitalization and operational costs of pond farming the Florida pompano. However, we believe that low intensity pond farming of the Florida pompano will be much less equipment capital intensive and much less operationally intensive. Both these cost categories will give rise to a better bottom line opportunity.

We have heard many pundits declare that in the USA one must be able to sell maricultured fish for in excess of $4.00 per pound in order to be successful (Goethel, David, 2005, National Fisherman). I am not sure the catfish farmers of America would agree with that. However, in 2004 US seafood consumption has risen to 16.6 pounds per person according to NMFS. This equates to Americans consuming 4.8 billion pounds of seafood in 2004 (National Fishermen, Feb., 2006). These numbers clearly suggest there is a continuing market for seafood. However, can new seafood supplies be produced for a profit? Yes, if you keep your costs down and product price high.

The Florida pompano has demonstrated that it enjoys a high market price. The question is what does it cost to make it? Economy of scale is key to farming success. The economics of growing 50,000 pounds of pond grown pompano is significantly different from 1,000,000 pounds of pond farmed pompano. It would be an entirely different paper if we were to spend the time here to analyze all cost centers of a one million pound per year pompano pond farm. We can give reasonably good and conservative cost estimates of major cost centers. The pompano plant flowchart (Appendix 2) shows some of these major cost centers.

For the brief purposes of this presentation the major cost centers and project costs are for a projected one million pound per year pond farm operation are:

| **Project Costs for Major Cost Centers (Costs per pound of Market Fish) (Equipment, Operational Labor, Energy Included)** | | |
|---|---|---|
| | | |
| 1. | Water Supply @ $0.10 | |
| 2. | Pompano eggs @ $0.15 | |
| 3. | Live food production @  $0.25 | |
| 4. | Pompano fry @ $0.25 | |
| 5. | Pompano juveniles (10 grams) @  $0.25 | |
| 6. | Pompano food @ $0.50 per pound X conversion of 2.2 = $1.10 | |
| 7. | Processing and packaging @ $0.25 | |
| | | |
| | Estimated direct costs of operation | $2.45 per pound |
| | | |
| (Data source from multiple in-house business prospectus's on pompano farming) | | |

Table 3.  Pompano Farm Economics

Considerations for land and pond construction are virtually impossible to estimate do to the wide variety of locations for such a business. The direct operational costs are indeed still high in comparison to other established finfish pond farming operations. However, one million pounds per year is a fledgling beginning and thus the starting costs tend to be high. On the other side of the balance sheet, it has been demonstrated that the Florida pompano ex-gate wholesale value here in the USA for fresh iced fish is closer to $6.00 per pound.

## POND FARMING CONCLUSIONS

Upon comparing our Florida pond farming results with historic attempts we did not suffer the same fate. Clearly, pond design in relation to geographical locale is quite important as is the use of subterranean low salinity water.  We believe that a major reason for the survival success of all species of finfish in our experimental pond is largely do to the 19 ppt and 78F (25.5 C.) well water. Further, ground water is brought to the surface without evidence of pathogenic organisms found in the natural ocean.

As we have reported in the past (McMaster, 1988), there is one disease that this thin skinned Florida pompano cannot tolerate and that is marine ich (Cryptocaryon irritans). When the pompano is grown in tanks at 32 ppt sea water the ich organism is a continuous threat that can wipe out the entire population nearly over night. It would appear that the life cycle of marine ich is interrupted by 19 ppt salinity water. However, further studies need to be done to confirm this opinion.

In our view the next step for this project is commercialization. The preferred location would be a more tropical area for obvious reasons. However, temperate geographic areas are strong candidates as long as the project is properly designed. The grow-out time in temperate zones will be longer. However, we have shown that the Florida pompano still will attain a one pond market size in one year even though the pond temperature fluctuated in the 60's (16 to 20 C.) for six months out of the growing year.

Lastly, the Florida pompano as a new species candidate and a alternative species for consideration by shrimp farming companies that are looking to diversify their crop, we believe we have shown here that this fish is worthy of serious consideration.

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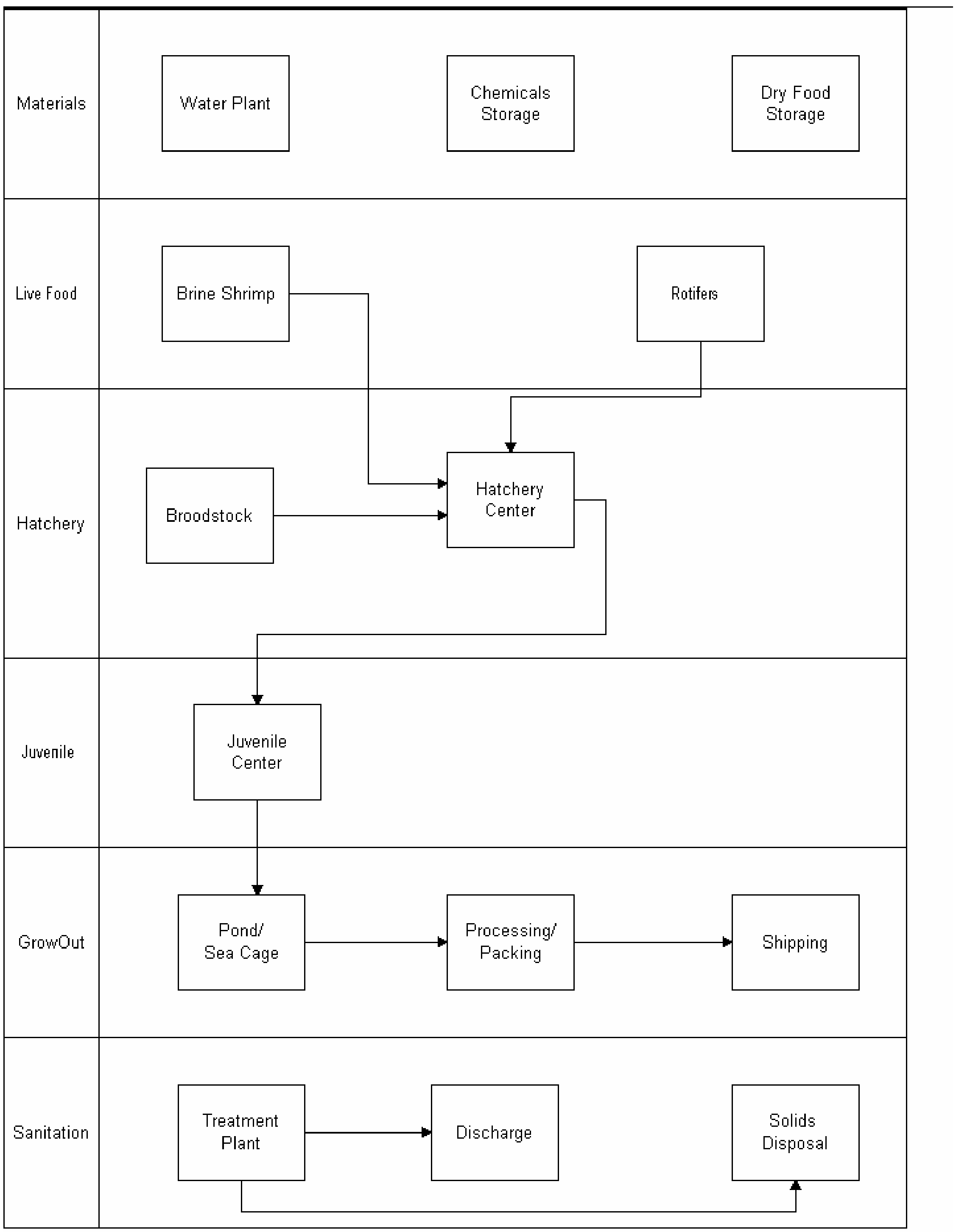
# Appendix 1

## Pompano Plant
## Process Diagram



# Appendix 2



## ABC Research Corp.

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A Better Company For Your Professional Analytical Needs

Sample #: 05013417
Received: Oct 7 2005
Description: Seawater

Finalized: Oct 28 2005
Print Date: Oct 31 2005

MIKE MCMASTER
MARICULTURE TECHNOLOGIES INTL., INC.
P.O. BOX 1020
OAK HILL, FL 32759

Client #: 14446
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## ANALYTICAL RESULTS

Results are representative of the sample(s) as submitted

| ANALYSIS | RESULT | UNIT | METHOD REFERENCE |
|---|---|---|---|
| Sample 1 *Seawater* | | | |
| ALUMINUM<br>Analysis started on 10/13/2005 | 0.022 | mg/L | EPA 200.7 |
| ANTIMONY<br>Analysis started on 10/13/2005 | 0.023 | mg/L | EPA 200.7 |
| ARSENIC<br>Analysis started on 10/13/2005 | <0.005 | mg/L | EPA 200.7 |
| BARIUM<br>Analysis started on 10/13/2005 | 0.057 | mg/L | EPA 200.7 |
| BERYLLIUM<br>Analysis started on 10/13/2005 | <0.005 | mg/L | EPA 200.7 |
| BISMUTH<br>Analysis started on 10/13/2005 | <0.005 | mg/L | EPA 200.7 |
| BORON<br>Analysis started on 10/13/2005 | 0.678 | mg/L | EPA 200.7 |
| CADMIUM<br>Analysis started on 10/13/2005 | <0.005 | mg/L | EPA 200.7 |
| CALCIUM<br>Analysis started on 10/13/2005 | 228 × 2 | mg/L | EPA 200.7 |
| CHROMIUM<br>Analysis started on 10/13/2005 | <0.005 | mg/L | EPA 200.7 |
| COBALT<br>Analysis started on 10/13/2005 | <0.005 | mg/L | EPA 200.7 |
| COPPER<br>Analysis started on 10/13/2005 | 0.013 | mg/L | EPA 200.7 |
| IRON<br>Analysis started on 10/13/2005 | <0.005 | mg/L | EPA 200.7 |
| LEAD<br>Analysis started on 10/13/2005 | <0.005 | mg/L | EPA 200.7 |
| MAGNESIUM<br>Analysis started on 10/13/2005 | 312 × 2 | mg/L | EPA 200.7 |
| MANGANESE | <0.005 | mg/L | EPA 200.7 |

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Report Continues

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## ANALYTICAL RESULTS

Results are representative of the sample(s) as submitted

| ANALYSIS | RESULT | UNIT | METHOD REFERENCE |
|---|---|---|---|
| Sample 1 *Seawater* | | | |
| Analysis started on 10/13/2005 | | | |
| MOLYBDENUM | <0.005 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| NICKEL | <0.005 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| PHOSPHORUS | <0.005 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| POTASSIUM | 79.4 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| SELENIUM | <0.005 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| SILVER | 0.112 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| SODIUM | 2,824 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| STRONTIUM | 5.50 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| SULFUR | 273 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| THALLIUM | <0.005 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| TIN | 0.027 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| VANADIUM | <0.005 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| ZINC | 0.048 | mg/L | EPA 200.7 |
| Analysis started on 10/13/2005 | | | |
| CHLORPYRIFOS | < dl | ppm | PAM I 3RD 302 E1 |
| Analysis started on 10/13/2005 | | | |
| DIAZINON | < dl | ppm | PAM I 3RD 302 E1 |
| Analysis started on 10/13/2005 | | | |

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Report Continues