NEW YORK AQUACULTURE INDUSTRY: STATUS, CONSTRAINTS AND OPPORTUNITIES

A WHITE PAPER

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EXECUTIVE SUMMARY

The capture of fish from the ocean has peaked and the demand for fish continues to rise. Aquaculture is the only sustainable method for supplying fish to the world's population. The worldwide market for fish is over $200 billion of which approximately $61 billion is supplied by aquaculture. It is estimated that by 2010, population growth alone will create an additional $36 billion per year of new demand for fish that will have to be supplied by aquaculture.

Aquaculture continues to increase its share of the world's supply of seafood, currently supplying 29% of the total seafood consumed. This is an increase from 10% about 15 years ago. Seafood imports are the second largest contributor (behind oil/energy) to the US trade deficit (over $7 billion, US Department of Commerce (DOC)) and this deficit continues to grow. The United States imported over $10 billion of seafood in 2000, of which $4.6 billion was for imported shrimp, salmon, and tilapia. The US continues to increase the percentage of seafood consumed that is imported, with it now being over 70%. New York State, surprisingly, imports nearly all the seafood consumed within the state. The total wholesale value of seafood in the US in 2002 was $26 billion. A major economic development opportunity exists in New York for aquaculture production, which would be consumed locally.

The future of New York's aquaculture industry must also embrace and support the present industry, which is significant, particularly the shellfish industry on Long Island. The shellfish industry contributes $17 million to the NY State economy of which $11 million is from aquaculture, while currently the finfish aquaculture industry contributes $2 million per year. The state ornamental fish industry is non-existent, yet New York State moves $150 million (retail value) of aquarium fish through its ports every year.

In the early part of the 20th century New York was a major shellfish producer, dominating the oyster industry, and a major national producer of hard clams through the middle of the century. Today the industry suffers for a number of reasons including poor water quality, lack of access to underwater land and dockage, and state public policy regarding underwater lands that currently discourages shellfish aquaculture. The opportunity exists for major increases of shellfish production in the marine waters of New York.

Some of the first finfish culture in the US was initiated in New York by the mid 19th century and the state was a leader in trout breeding by the time of the Civil War (Benson, 1970). NY has yet to reach anywhere near its potential in finfish production. Outdoor ponds, although subject to all the vagaries of weather and other issues, such as water quality, are used to raise fish for stocking purposes and baitfish production. Additional opportunities for utilizing ponds, for these purposes, exist today and the additional production of baitfish, for sale within New York, would have a positive economic impact in the state. There is also the potential opportunity to raise finfish in offshore pens in the marine environment, which has yet to be fully examined.

The type of aquaculture that currently has the most major potential economic impact is indoor food fish aquaculture in a controlled environment, similar to how the broiler industry has evolved. Today the finfish of greatest promise appears to be tilapia, which are currently being successfully raised and marketed in upstate NY. Tilapia accounts for more than 50% of the economic output for finfish production in New York State.

New York State has numerous inherent advantages in the indoor aquaculture industry, including its central location near significant population densities, the existing infrastructure of academic and business institutions, and the consumption patterns of its inhabitants. This type of aquaculture is also not dependent on scarce coastal resources. Government assistance is required for indoor aquaculture to become a driver of economic development in this state.

New York State has already begun to develop an industry centered around both finfish and shellfish aquaculture. With proper assistance and public policy support from the state and utilizing academic institutions to supply the necessary research and extension education, aquaculture in New York can over the next 10 to 20 years become a $1.5 billion per year industry, creating 15,000 new jobs with further growth expected beyond.

EXPANDED SUMMARY

New York State has already begun to develop an industry centered around aquaculture (the farming of fish for human consumption). With proper support and execution, aquaculture in New York can over the next 20 years become a $1.5 billion per year industry, creating 15,000 new jobs with further expansion expected in future years.

In New York State there were 15,000 dairy farms in the late 1980s, and today only 7,200 remain. The alarming trends in New York agriculture are highlighted in a recent White Paper "The Future of American Agriculture and the Land Grant University: Toward a Sustainable, Healthful and Entrepreneurial Food System,"[1] prepared after a yearlong study by a group of Cornell University agricultural scientists and economists. The Cornell group voices its belief that in the future agricultural entities in the United States either will be high value or local niche marketers, and few, if any, will be of medium size. They also point out that government subsidies will continue to play a critical role in supporting and encouraging local/state/regional agriculture. Their prediction supports the validity of establishing an aquaculture industry in New York, since seafood is considered highly perishable, vulnerable to alteration (food security issues), and of highest value if sourced locally. NY producers will garner further market advantage as the result of the US Department of Agriculture's Country of Origin (COOL) proposed rule that was published in the Federal Register on October 30 2003. In the case of farm-raised fish and shellfish, the proposed rule states that a covered commodity can only be labeled as "Product of the U.S." if it is hatched, raised, harvested and processed in the United States.

The capture of fish from the ocean has peaked and the demand for fish continues to rise. Aquaculture is the only sustainable method for supplying fish to the world's population. The worldwide market for fish is over $200 billion of which approximately $61 billion is supplied by aquaculture. It is estimated that by 2010 population growth alone will create an additional $36 billion per year of new demand for fish that will have to be supplied by aquaculture.

Aquaculture continues to increase its share of the world's supply of seafood, currently supplying 29% of the total seafood consumed by weight and 39% by value. This is an increase from only 10% about 15

[1] Report is available online at http://www.cals.cornell.edu/polson/faawhitepaper.pdf

years ago. Seafood imports are the second largest contributor (behind oil/energy) to the US trade deficit (over $7 billion, US Department of Commerce (DOC)) and this deficit continues to grow. The United States imported over $10 billion of seafood in 2000, of which $4.6 billion was for imported shrimp, salmon, and tilapia. To put this in perspective, the value of these three aquaculture products in 2000 was equal to the combined exports of the US broiler and hog industries (US Department of Agriculture (USDA), LDP-AQS-14, Oct. 14, 2001). The US continues to increase the percentage of seafood consumed that is being imported, with it now being over 70%. New York State, surprisingly, imports nearly all the seafood consumed within the state. The total wholesale value of seafood in the US in 2002 was $26 billion. Large opportunity exists here in New York for aquaculture economic development.

The US Department of Interior in August 1999 approved an aquaculture policy[2] to address the imbalance of seafood production and the opportunities for growth. Their vision statement reads:

> *To assist in the development of a highly competitive, sustainable aquaculture industry in the United States that will meet growing consumer demand for aquatic foods and products that are of high quality, safe, competitively priced and are produced in an environmentally responsible manner with maximum opportunity for profitability in all sectors of the industry.*

And the DOC's primary objective was to:

> *Increase the value of domestic aquaculture production from the present $900 million annually to $5 billion, which will help offset the $6-billion annual US trade deficit in seafood.*

New York State has long recognized the opportunity presented by the seafood industry. In 1988 the Honorable Michael J. Bragman (then Chairman of the Assembly Agriculture Committee) submitted a Special Report "Aquaculture in New York State: Technology, Research and Economic Development Prospects" to the New York Speaker of the Assembly, the Honorable Mel Miller. The Bragman report recommended:

[2]Complete policy statement is included in the Appendix.

a) Regulatory changes,
b) Increased extension support and technical information,
c) Development of an advocacy group for market structure development,
d) Development of co-generation projects, and
e) State financing of aquaculture expansion (access to capital).

The New York Sea Grant Institute in both 1985 and 1999 held conferences to address constraints and opportunities for NY aquaculture. Considerable progress has been made relative to the 1985 Bragman recommendations, yet aquaculture in NYS has remained basically stagnant for the last 20 years. Why? The 1985 Sea Grant report identifies a variety of factors (biological and technical) but states that:

> *Constraints on orderly development of aquaculture tend to be political and administrative, rather than scientific and technological ... development of aquaculture in general has been constrained by limited public support.*

An article by M.E. Porter (Harvard Business Review, November-December 1998) entitled "Clusters and the New Economics of Competition" provides an analysis of why certain industries emerge and thrive in certain localities, e.g., the California wine industry, Silicon Valley, the pharmaceutical industry in NJ/PA, the leather industry (Gucci and Ferragamo) in Italy, the paint industry in Cleveland, the salmon industry in Porte Monte, Chile, etc. A cluster promotes both competition and cooperation. Cooperation tends to be vertical, i.e., involving other companies in related industries. It is this cooperation that makes the site specific area competitive and able to out-compete other areas that seemingly might have more inherent advantages, e.g., low labor costs. New York could become a cluster setting for in-land seafood production using recirculating aquaculture system (RAS) technology.

There are several aquaculture methods for producing fish, including coastal farming (shrimp, shellfish), ponds (catfish, tilapia), ocean net-pens (salmon, sea bass), and indoor aquaculture (tilapia). Indoor aquaculture uses RAS technology to recirculate (reuse water instead of discharging to the environment) water to grow high quality fish in a controlled environment. Indoor aquaculture has advantages over other production methods because the fish are grown under optimized conditions and production facilities are not geographically constrained. The fish produced are pollution-free, disease-free, of consistent size, and can be harvested at any time. Because indoor aquaculture is not constrained by geography, fish can be produced in large quantities near urban centers. This means consumers, regardless of location, can enjoy premium quality fish that are same-day fresh.

The future of NY's aquaculture industry must also embrace and support the present industry, which is significant, particularly the shellfish industry on Long Island. The shellfish industry contributes $17 million to the NY State economy of which $11 million is from aquaculture, while currently the finfish aquaculture industry contributes $2 million per year. The state ornamental fish industry is non-existent, yet NYS moves $150 million (retail value) of aquarium fish through its ports every year. Again, the potential for new aquaculture industrial development is large. An ornamental fish growing industry in NYS would almost certainly require use of RAS technology.

While the shellfish industry is much larger than the current finfish industry in NY, future large-scale potential seems likely to concentrate on some form of food fish production. Tilapia is the most probable candidate. Tilapia is a firm white fish that is similar in appearance to sunfish. It is easily prepared, and considered by many to be superior to catfish in flavor and texture. Tilapia is ideally suited for large-scale production, as it is hardy, grows quickly, requires inexpensive plant-based feed, and converts feed to body mass very efficiently. (For example, it takes approximately 1.2 pounds of feed to produce one pound of tilapia, compared to 6-8 pounds of feed to produce one pound of beef on feedlots or 1.8 pounds of feed to produce one pound of broiler chicken.) Tilapia is an extremely popular fish worldwide, and in 2002 was the 9th most consumed fish in the US. Approximately 400 million pounds (whole fish basis) were consumed in the US in 2003, approximately five-times the volume of trout consumed. Tilapia in New York State contributes more than 50% of the finfish economic output.

Consumption of tilapia in the US is increasing by over 35% per year and industry experts project that US tilapia consumption will over the next 3 to 4 years be larger than the US catfish industry (catfish is currently 660 million pounds per year, USDA 2003). Based on growth rates and using industry statistics, we forecast that over the next 10 years the tilapia industry will grow to over one billion pounds per year, generate $1.5 billion of revenues per year, and create 15,000 new jobs. In predicting the growth of the tilapia industry, one can compare it to the US chicken industry, which grew to a 30 billion lb/yr industry over 40 years, or the

US turkey industry, which increased production by 2 billion lb/yr over a 15-year period.

Government support was a key ingredient to the success of the poultry and catfish industries, as exemplified by the support that Mississippi provided for the catfish industry. New York State has numerous inherent advantages in the indoor aquaculture industry, including its central location near significant population densities, the existing infrastructure of academic and business institutions, and the consumption patterns of its inhabitants. With government assistance, New York State can become the leader in indoor aquaculture just as Mississippi has become the leader in outdoor raising of catfish. A lack of action by New York will result in other states or countries taking advantage of the opportunity.

Growing a large-scale indoor aquaculture industry in New York State will require strong support and coordination from the state government. The potential to create 15,000 jobs and the tax revenues generated from a $1.5 billion industry justify the short-term assistance needed. The goal is for New York State to dominate the indoor aquaculture industry. Assistance could be reduced or eliminated once dominance by New York industry is established. Success will require support in at least three areas including grants, research, and access to capital, as follows.

a) **Grants and Subsidies.** Indoor aquaculture produces the highest quality fish because the growing environment is maintained under optimized conditions. This maintenance entails numerous expenses including electricity, heat, equipment and real estate. Indoor aquaculture is already cost-competitive with outdoor systems and ocean-caught fish if done at large scale, e.g., 1000 metric ton per year of production. However, to be as competitive as possible, costs must continue to be driven down. New York State can help the aquaculture industry by assisting with access to low-cost electricity, heat for water (for instance waste heat from cogeneration or manufacturing facilities), and equipment and real estate (i.e., help in using abandoned or underutilized buildings, or brownfield sites).

b) **Research.** Indoor aquaculture and, in particular, tilapia aquaculture would benefit greatly from more comprehensive research related to the nutrition, genetics, animal health management, and animal husbandry of tilapia. Fish raised under controlled conditions indoors grow differently than the same animals grown outdoors in their more natural environments. Improved understanding of the basic physiology of tilapia will drive economic efficiency. New York State can help by funding research into tilapia aquaculture, and the state already has numerous academic and business institutions that have aquaculture expertise, including Cornell University, Cornell Cooperative Extension, CUNY Brooklyn College, Hofstra College, and SUNY Brockport, Morrisville, Cobleskill and Stony Brook.

c) **Access to Capital.** Every pound of production capacity will require approximately $1.50 of capital investment for equipment and facilities. Given the newness of the indoor aquaculture industry, farmers are currently required to either provide all the equity for construction or to provide personal guarantees to secure debt financing. New York State can help by working with farmers and the private financial industry to provide a loan guarantee program or access to capital through state-backed industrial revenue bonds.

Growing the indoor aquaculture industry in New York State will require a collective effort among our farmers, research institutions, and political leaders. Already, the NY AgriDevelopment[3] Corporation is supportive of such development and has participated in early discussions of how to promote a greatly expanded aquaculture industry in New York State.

This is a rare opportunity to create a new industry, one that will create jobs, supply low-cost food, improve the US trade balance, and be environmentally sustainable. New York State should seize this opportunity.

This report will document the current status of the shell and finfish industries. Overcoming the constraints that would ensure the future growth of the shellfish aquaculture industry appears promising, particularly the removal of some of political constraints. A review of the

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[3]The NY AgriDevelopment Corporation (affiliated with the Metropolitan Development Association, Tom Blanchard, 1900 State Tower Bldg., Syracuse, NY 13202, Phone: (315) 477-0184) is made up of the following companies: Dairylea Cooperative Inc, P.L Richer Co., Agway Inc, HSBC Bank USA, NBT Bank, Granite Capital Holdings Inc, G&L Davis Meat Co., Northeast Dairy Producers Association, Green & Seifter PC, Bond Schoeneck & King LLP, G&C Food Distributors, First Pioneer Farm Credit, Shur Gain USA, NYSEG, J.R. Simplot Company, Agrilink Foods.

ornamental fish industry is provided and a description of its processing and marketing needs is given as well.
The economic benefits of expanding an indoor finfish and ornamental fish industry are described.

1.0 BACKGROUND TO AQUACULTURE

Internationally recognized business management expert and Nobel Laureate Peter F. Drucker predicts that aquaculture, or fish farming, will be one of the three major economic opportunities in the new millennium. Aquaculture has been identified as a major economic opportunity due to the diminishing supplies of wild caught species in the oceans and the inability of this natural supply of seafood to meet the increasing demands of the consuming public for healthy, nutritious, and, tasteful products, and concern for the rampant accumulation of pollutant chemicals.

Clearly the potential to create a major new agricultural industry in NY is before us. We have the large and unique advantage of our largest markets being within our state. No other producers can say that their product was produced within New York State. Consumer surveys always place freshness and source of product as one of their primary, if not number one priority, on qualifying their purchase of seafood. A consumer given a choice between a fresh fillet from Central America or a fresh fillet from upstate New York and/or New York City will choose the NY product and even pay a slight premium for their choice. Further, the general consensus and perception that fresh fish are fragile and spoil quickly will only enhance NY's competitive advantage of producing fresh fillets within the state targeted to NY consumers. It is also obvious that expanding into the greater northeast markets is an available option to further expand potential markets. Residents of Vermont, Massachusetts, Connecticut, New Jersey, Pennsylvania, and other states in close proximity to NY will also quickly and readily identify the NY produced fillet as the product of choice in the fresh fish markets.

THE SEAFOOD INDUSTRY STILL RELIES ON HUNTER-GATHERER PRODUCTION

The demand for animal protein in the US is supplied primarily from chicken, beef, pork, turkey and fish. All of these foods except fish have evolved into efficient industries where farm-raised products ensure consistent quality and pricing. Fish remains the last mass marketed food that is being supplied to consumers using the "hunter-gatherer" method.

The result is inconsistent supply and relatively high prices. Evidence is mounting that the world's fisheries will not sustain even the current levels of production.

OCEAN FISHING HAS PEAKED

Wild capture from the ocean has been the historical method of providing the seafood we eat. As the world population has increased, many fisheries have been over fished, resulting in poor production and the depletion of many fish species. For example, in March 2003 Nature Magazine reported that over 90% of the large fish in the ocean have been harvested, and may never be regained. In June 2003 US News and World Report reported that many depleted species, like the North Atlantic cod, might never recover because their habitat has been destroyed or too few survivors remain to find mates. Statistics show that the amount of fish harvested from the ocean has peaked at approximately 200 billion pounds per year.

Governments have attempted numerous ways to better manage our natural fisheries. Even if successful, the resources from the natural catch are biologically limited and we are close to that limit. So additional supplies of seafood will need to come from other sources, i.e., aquaculture.

Wild capture is a poor way to mass produce fish. Ocean-caught fish cannot be guaranteed to be fresh or of high quality by the time they reach the consumer. A typical fish catch is stored on ice in the boat until the boat returns to shore, so for most consumers the harvest date is uncertain. Furthermore, the oceans have become increasingly polluted, and many fish concentrate pollutants in their flesh. Recent reports regarding high mercury concentrations in numerous fish including swordfish, shark and mackerel have been of concern to consumers, and the FDA recommends that pregnant women avoid eating these species. Many consumers have historically avoided other fish, such as shellfish and catfish, because of the perception that these animals are scavengers that feed off the ocean floor or pond bottom. Because of this lack of quality assurance, fish, and particularly ocean-caught fish, are not generally part of a branded product line.

AQUACULTURE FILLS THE GAP

With continuing increases in world population and the well-publicized health benefits of eating fish, there continues to be a strong demand for fish. Because ocean fishing has peaked, this demand is being met through aquaculture. Today, aquaculture is the fastest growing segment of agriculture and supplies 29% of the volume and 39% of the value of the seafood consumed worldwide.

1.1 AQUACULTURE MARKET SIZE

According to the Food and Agriculture Organization of the United Nations (FAO) approximately 72 billion pounds of fish were produced by aquaculture in 1999. Industry sources generally use an average of one pound of fish equals $1.00 at wholesale, resulting in an aquaculture market of approximately $72 billion per year. Over the period from 1994 to 1999, the aquaculture market grew at approximately 9% per year.

As shown in Table 1.1, the worldwide per capita supply of fish has stayed fairly level at 15 to 16 kg per person over the past 5 years. Assuming approximately 16 kg per person going forward, population growth alone will create a demand for over 36 billion pounds per year by 2010. Because ocean fishing has topped out (some argue that the ocean catch is actually dropping), increased demand will have to be met with aquaculture.

Table 1.1 Contributions of the Wild Catch and of Aquaculture (FAO, 2002)

Production	**Billion Kilograms**						
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2010 Estimated**
Capture	91.4	91.6	93.5	93.6	86.3	92.3	93.0
Aquaculture	20.8	24.6	26.8	28.8	30.9	32.9	49.1
Total	112.3	116.1	120.3	122.4	117.2	125.2	142.1
% Aquaculture	18.5%	21.2%	22.3%	23.5%	26.4%	26.3%	34.6%
World Population, billions	5.605	5.685	5.764	5.844	5.923	6.002	6.812
Per Capita Food Fish Supply, kg	14.3	15.3	15.8	16.1	15.8	15.4	16.0

FISH CONSUMPTION TRENDS

As ocean fishing has leveled off and aquaculture has become more prominent, the popularity of the fish species that are produced by aquaculture has also increased. As shown in Table 1.2, only those fish that are aquaculture species have increased in consumption and rank over the last 10 years.

Table 1.2 Current Levels of US Seafood Consumption (lb/capita) by Fish Species (Seafood Business November 2003, US National Fisheries Institute)

	2002		1990	
Species	**Rank**	**lb/capita**	**Rank**	**lb/capita**
Shrimp	1	3.70	2	2.20
Canned Tuna	2	3.10	1	3.70
Salmon	3	2.02	5	0.73
Pollock	4	1.13	4	1.28
Catfish	5	1.10	6	0.70
Cod	6	0.66	3	1.39
Crabs	7	0.57	7	0.29
Clams	8	0.55	10	0.62
Tilapia	9	0.40		
Flatfish	10	0.32	8	0.57

This is also true on a worldwide basis. As shown in Figure 1.1, three aquaculture species (salmon, tilapia, and catfish) have had remarkable increases in production.

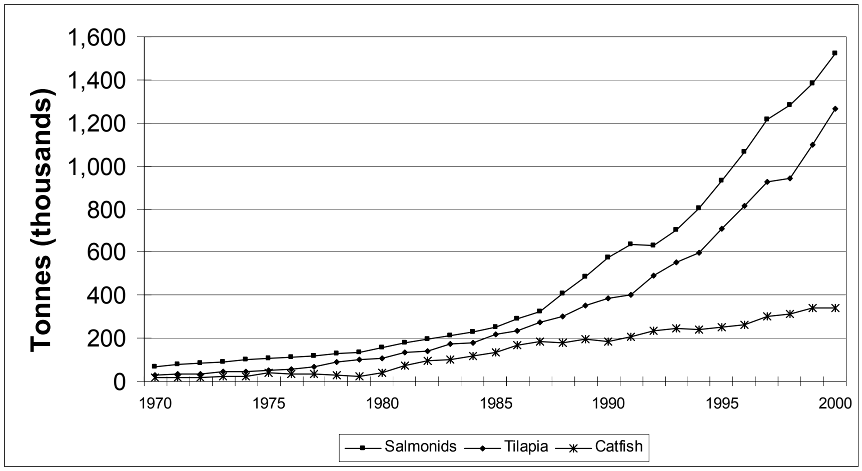

Figure 1.1 World Yearly Production of Salmonids, Tilapia and Catfish (FAO, 2002).

Changing US Demographics. Changing US demographics favor the increased consumption of fish. Worldwide per capita seafood consumption is approximately double US consumption, and the US continues to grow through immigration. In addition, the Hispanic population has now become the largest minority in the US, with over 45 million people. The Hispanic population is at the high end of the per capita consumption of fish. In addition, purchasing patterns are varied among the Hispanic population, with many seeking to buy fish live, dead on ice, or as fresh filets. This allows a wide variety of production processes to be used to satisfy consumer demand.

1.2 GROWTH DRIVERS

Indoor aquaculture is not a new industry, but a combination of recent developments has created the environment for explosive growth, including a) technology development, b) the popularity of tilapia, c) changing US demographics, d) increased documentation and reporting of ocean over fishing, e) growing awareness of the health benefits of adding more fish to the US diet, and f) concern about pollution in ocean-caught fish.

TECHNOLOGY DEVELOPMENT

In the past fish that were grown through indoor aquaculture were relatively expensive compared to fish that were ocean-caught or pond-raised. However, recent advances in production technology have brought the cost down to the point where similar pricing can be achieved. In particular, research conducted by Cornell University and applied by private industry has led to the development of an inexpensive and energy efficient water filtration technology. This technology has been patented by the Cornell Research Foundation and is in use at Fingerlakes Aquaculture (Groton, NY). Data indicate that the technology lowers total tilapia costs of production by as much as 30%.

1.3 NEW YORK STATE HAS SIGNIFICANT ADVANTAGES FOR INDOOR AQUACULTURE

The New York tilapia industry can mimic the successful catfish industry of the southern US, particularly Mississippi, and can do so on an accelerated schedule. The catfish industry has developed into a 630 million pound per year industry over the last 20 years. This whole industry was created as a concerted effort to transform poorly performing cropland into productive fishponds. A collection of bankers, farmers, and entrepreneurs created this industry.

To a large degree the catfish industry was patterned after the chicken broiler industry. In 40 years the broiler industry grew from a few million pounds per year to a 15 billion pound per year industry. The success of the broiler and catfish industries are attributed to their vertical integration of breeding, growing, processing, and distribution operations under a single business structure. These same opportunities, and at a similar economy of scale, are now available to New York State. The beauty of the opportunity for New York State is that a new agriculture industry can be created that creates jobs, produces low cost food, helps the US trade balance, and is environmentally sustainable. New York State has many advantages that allow it to capitalize on this opportunity.

NY's competitive advantage is the ability to grow the highest possible quality tilapia product on the doorstep of the consuming market. Nearly all fresh tilapia fillets being sold in the US today are imported from Latin America, the Caribbean, or the Far East. These importers face considerable transport costs and higher feed costs, which NY producers will avoid due to their "home field" advantage, and the abundance of grains and grain by-products in the US. Already, commercial-scale tilapia farms are producing tilapia for less than $1.00 per lb on a whole weight basis. If these same technologies are implemented on a large scale or as a collection of farms that supply fish to a central processing facility, the FOB price of tilapia fillets is competitive with Central American imported products, e.g., $3.50/lb wholesale for fillets. As the normal increased efficiencies associated with a developing industry are obtained, tilapia fillets produced using RAS technology will be produced at costs less than our Central American competition. And at this point, tilapia fillets will be competitive with the premium forms of chicken, beef, and pork. Then, American consumers will start to choose tilapia fillets instead of beef, pork, and chicken (collectively these add up to 160 lb per capita per year) making a 2 to 3 lb per capita tilapia consumption level an achievable and realistic goal. This could be achieved over a 10 year period with strong support within New York State. A three lb per capita consumption of fish flesh, when expressed on a whole fish basis, for the US translates into a 3 billion lb per year production industry (assuming a 30% yield from whole fish to fillets). A realistic goal for New York State's immediate production goal of 1 billion lb per year by 2030 becomes quite realistic in this context.

LOCATION

New York State has the inherent advantage of a central location with large population densities within or contiguous to the state. Approximately 73 million people, or 26% of the US population, live within a 10-hour drive of New York State. This means a truck loaded with fish that were freshly harvested in the early morning can easily reach the major metropolitan centers of New York City, Boston, Toronto, Cleveland, Pittsburgh, Philadelphia, Baltimore and Washington DC by dinnertime.

Presently, nearly all the fresh tilapia filets being sold in the US are imported from Central and South America, the Caribbean, or the Far East. New York production of fresh tilapia filets has numerous advantages over imported filets, including freshness, cost advantages, and branding.

a) **Freshness.** Consumer surveys always place freshness of product as one of the highest priorities in qualifying a seafood purchase. Production in close proximity to the consumer means that filets can be delivered same-day fresh to the public. By contrast, filets produced in Central and South America are typically shipped to Miami, transferred to a distributor, shipped to the relevant city, transferred to another distributor and ultimately sold to a market or restaurant. Producing fish in New York State and selling direct yields a 4 to 7 day freshness advantage over filets produced overseas.

b) **Low Cost.** New York producers will have lower costs compared to overseas producers using outdoor aquaculture systems for numerous reasons, including the following:

- Lower transportation costs (due to proximity to the market);
- Cost-effective and sustainable environmental treatment of fish waste (compared to ocean net pens and ponds);
- Automated seafood processing techniques that can be optimized for specific fish and production capacities (to minimize disadvantages of higher labor costs);
- More efficient feed conversion ratios (in comparison to outdoor aquaculture, due to optimizing conditions through indoor technology); and
- Lower US feed costs.

Feed represents the single largest component of fish production costs. Because of lower domestic feed costs compared to overseas producers that must import much of their grains, there is a production price floor protecting the United States from domination by imported product. Low US feed costs coupled with high productivity per unit worker enabled by continually improving RAS technology will make NY producers cost competitive with overseas producers. These simple facts of commerce combined with the overseas producers' higher shipping costs, position NY to prevail long term against overseas suppliers of farmed seafood in much the same way the US poultry and hog industries have dominated the US marketplace for those commodities. New York State can move aggressively to implement an infrastructure to support this new industry so that NY producers can be the dominant supply source for this increasingly popular fish.

c) **Branding.** Many consumers believe that agricultural products grown in the US are of higher quality and safer than imported products. This is particularly true of fish, where consumers are already sensitive to issues of pollution and disease. New York producers will be able to brand their fish and sell it based on freshness and quality. Consumers have shown a preference for foods of local origin and are willing to pay a premium for a properly differentiated product.

Over the long term, New York State production of fresh tilapia filets can dominate foreign production, just as domestic production of poultry, dairy, pork and turkey is dominant in the US.

EXISTING NEW YORK INFRASTRUCTURE

New York State already has numerous academic and business institutions that have aquaculture expertise. Cornell University, CUNY Brooklyn College, Hofstra College, and SUNY Brockport, Cobleskill, Morrisville and Stony Brook have led successful aquaculture efforts for many years. In particular, Cornell University and Cornell Cooperative Extension have had extensive experience raising tilapia.

Several other universities have been active in research focused on indoor aquaculture systems, such as North Carolina State University, the University of Maryland, the University of California at Davis, and Louisiana State University. The Freshwater Institute, a division of the Conservation Fund (Shepherdstown, WV), and the Harbor Branch Oceanographic Institute (Ft. Pierce, FL) are private foundations that are leading major efforts in indoor aquaculture. If New York State dedicates resources to developing the industry now, these institutions could provide significant assistance. Otherwise, other states may develop the opportunity.

In addition, New York has existing tilapia production farms located in Groton, near Cornell University and in the Bronx in New York City. Fingerlakes Aquaculture and Inner City Oceans own these facilities, respectively. Combined production from these two farms is over one million pounds of tilapia per year. The infrastructure is already in place to grow, distribute, and sell tilapia, primarily to the live markets in New York City and Boston.

Furthermore, state and local sponsorship is already beginning to take place in the tilapia industry, including programs supported by the NY State Energy Research and Development Authority, the Empire State Development Corporation, and the New York State Department of Agriculture and Markets' Grow New York Initiative.

CONSUMPTION

The people of New York State have a higher per capita consumption of seafood than the US average. In addition, New York City has a large and growing number of Black, Asian and Hispanic residents, all of whom consume fish at the highest end of the per capita spectrum. There is currently a very active market for live tilapia in the Chinatown area of New York City, and the Hispanic population consumes a significant amount of whole, dead on ice tilapia.

Over 70% of seafood consumed in the US is eaten in restaurants, and New York City has a significant restaurant industry. The Fulton Fish Market sells a substantial amount of tilapia, much of it purchased by the large number of restaurants in New York City. In 2004, the US will import the equivalent of over 400 million lb of whole tilapia.

1.4 CURRENT NEW YORK AQUACULTURE FINFISH PRODUCTION AND ECONOMIC OUTPUT

A survey was conducted in 2003 by the Cornell Program Work Team to quantify current aquaculture output in the state. A copy of the survey instrument is provided in the Appendix. Results are shown in Table 1.3, not including the shellfish industry. Note that while the economic output shown for the New York trout industry is comparable to the USDA data (shown in Table 1.4), the reported mass of product is less (88,175 lb. versus 144,000 lb. from the USDA data). Over 50% of the non-shellfish economic output is from indoor RAS tilapia farms ($1.2 million from a total of $2.08 million) and this was only three farms, indicating that larger scale operations are the major contributors to economic output in the state.

Table 1.3 Survey Results of Aquaculture Production in NY, not Including Shellfish (data collected by Cornell Aquaculture Program Work Team, 2003)

Species	Type	Number Sold	lbs.	Unit Value	Total Value/yr.
Crayfish	Bait	3,400,000	13,600	$20.00/lb	$306,010
Salmon-Trout-Char[1]	Food/ stocking		88,175	$6.28/lb	$554,072
Tilapia	Food	451,905	812,300	$1.45/lb	$1,201,335
Others[2]					$22,624[3]
Total (from survey only)					**$2,084,041**

[1]USDA statistics are more complete on trout production in NY.
[2]Other fish sold in NY: baitfish, catfish, crappie, shiners, large mouth bass, koi, perch, pike, sunfish, walleye.
[3]The majority of this revenue was generated by walleye producers.

Development and expansion of NY's aquaculture industry should embrace and support the present industry, which primarily consists of the shellfish industry on Long Island. The shellfish industry contributes $17 million to the NY State economy of which $11 million is from aquaculture, while in contrast the finfish aquaculture industry contributes only $2 million per year. The finfish production is summarized in Table 1.4.

Table 1.4 USDA Statistics on NY Trout Production (data summarized by Dr. Tom Field, Fernwood Limne Trout Hatchery, Gansevort, NY)

Year	2002	2000	1998	1996	1994	1992	1990
Total Trout Sold							
Number (1000's)	390	377	510	546	475	679	789
Pounds (1000's)	144	139	228	233	164	202	219
$ (1000's)	$567	$615	$921	$1015	$734	$876	$897
Avg. wt.	0.37	0.37	0.45	0.43	0.35	0.30	0.28
$/lb	$3.94	$4.42	$4.04	$4.36	$4.48	$4.34	$4.10
# of Producers	30	27	30	29	35	37	41
Average Number	13,000	13,963	17,000	18,828	13,571	18,351	19,244
Average Pounds	4,800	5,148	7,600	8,034	4,686	5,459	5,341
Average $	$18,900	$22,778	$30,700	$35,000	$20,971	$23,676	$21,878
Average $/lb	$3.94	$4.42	$4.04	$4.36	$4.48	$4.34	$4.10

The state ornamental fish industry is virtually non-existent, yet NYS moves $150 million (retail value) of aquarium fish through its ports every year. Again, the potential for new aquaculture industrial development is large. An ornamental fish growing industry in NYS would almost certainly require use of RAS technology.

1.5 NEW JOBS FOR NEW YORK STATE

The establishment of a one billion pound indoor aquaculture industry will create jobs in three primary areas: a) growing the fish, b) processing the fish, and c) associated jobs including selling, general and administration (SG & A), feed production, and distribution.

Industry data generated from Fingerlakes Aquaculture's experience indicates that a typical large-scale tilapia production facility to grow 5.5 million lb of fish per year will create approximately 22 jobs. Industry data from a food processing machine manufacturer indicates that a typical processing facility with an 8 million lb capacity will create approximately 47 jobs. Data from industry sources and Mississippi State University regarding the catfish industry indicate that associated SG&A, feed production, and distribution created approximately 5 jobs for each one million lb of fish produced. Therefore, in total, we estimate approximately 15 jobs are created for every one million lb of tilapia produced. (Data about the 2001 Mississippi catfish industry indicate 18.3 jobs per million lb of catfish produced.) We estimate that a one billion lb indoor aquaculture industry will create **15,000 new jobs** for New York State.

The jobs will be a combination of engineering, technology, management, and skilled and unskilled labor. The skill sets needed for maintaining fish year-round are skills that are transferable from underemployed sectors of the economy, e.g., skills such as attention to detail, high daily responsibility, cleanliness, and conscientious attitudes. In addition, many of the jobs at the production level and processing level can be adapted to handicapped and challenged laborers.

More importantly, these are new jobs to satisfy increased demand, not jobs that cannibalize other industries. Using an average wage of $20,000 per year per job, the indoor aquaculture industry will generate direct wages of over $300 million per year, with a wage-based economic multiplier effect of at least two times that amount on the overall economy.

Table 1.5 Brief Comparison of the Existing New York State Agriculture Industry to the New Indoor Aquaculture Industry

New York Agriculture Industry	
Jobs in livestock farming (dairy, poultry, etc.)	35,000 people
Other jobs in farming	35,000
Jobs in agricultural food manufacturing	70,000
Total employment in NY agriculture	140,000 people
Total number of NY farms (with more than $1,000 yearly revenue)	32,000
Total farm gross sales	$3 billion
The Indoor Aquaculture Industry in 10 Years	
Jobs in indoor aquaculture production	4,000 people
Jobs in indoor aquaculture processing	6,000
Associated SGA, feed, and distribution jobs	5,000
Total employment in NY indoor aquaculture	15,000 people
Total number of NY indoor aquaculture farms	200
Total indoor aquaculture gross sales	$1.5 billion

THE ROLE OF CLUSTERS

An article by M.E. Porter (Harvard Business Review, November-December 1998) entitled "Clusters and the New Economics of Competition" provides an analysis of why certain industries emerge and thrive in certain localities, e.g., the California wine industry, Silicon Valley, the pharmaceutical industry in NJ/PA, the leather industry (Gucci and Ferragamo) in Italy, the paint industry in Cleveland, the salmon industry in Porte Monte, Chile, etc. A cluster promotes both competition and cooperation. Cooperation tends to be vertical, i.e., involving other companies in related industries. It is this cooperation that makes the site specific area competitive and able to out-compete other areas that seemingly might have more inherent advantages, e.g., low labor costs. New York State could become a cluster industry for in-land seafood production using recirculating aquaculture system (RAS) technology.

New York State can choose to politically support the creation of an aquaculture industry because of the arguments of clustering. NY has the markets. No other state or country can take that away from us. With the ever increasing issues of food safety and traceability, NY will be further positioned to take advantage of local production of an identifiably safe fish fillet. In Puerto Mont (Chile), an entire salmon industry has been created that over a 10 year period has come to provide 50% of the world's salmon supply. The town of Puerto Mont is in part support by the supporting industries around the salmon base. Similar growth could be politically encouraged in New York State for an indoor tilapia industry. The beauty of this scenario is that creation and expansion of this industry would not compete for any established customer base for NY's other agricultural industries. Creation of this industry would be a win-win-win scenario.

1.6 HOW NEW YORK STATE CAN HELP

Growing a large-scale indoor aquaculture industry in New York will require support from the state government. The 15,000 jobs created and the tax revenues generated from a $1.5 billion industry justify the short-term assistance needed. The goal is for New York to dominate the indoor aquaculture industry, and assistance could be reduced or eliminated once dominance by the New York State industry is established. Success will require at least three areas of support including grants, research, and access to capital, as follows:

GRANTS

Indoor aquaculture produces the highest quality fish because the growing environment is optimally maintained. This maintenance requires numerous expenses, and while indoor aquaculture is already cost-competitive with outdoor systems and ocean-caught fish, to be as competitive as possible, these costs must continue to be driven down. New York State can help the aquaculture industry by assisting with access to low-cost a) electricity, b) heat for water, and c) equipment & real estate.

a) **Electricity.** Indoor aquaculture uses a system of pumps and filters to clean and recirculate the water in which the fish grow. Approximately 1.5 kWh of electricity is required to produce each lb of tilapia. New York State can help by providing access to inexpensive electricity or a direct subsidy of the electrical energy cost. As an example, making electricity available to the farmer at 1 cent per kWh (assuming the market rate is 9 cents per kWh and a one billion lb tilapia industry) implies the following:

1 billion lb/yr * ($0.09 - $0.01)/kWh * 1.5 kWh/lb = $120 million per year

This subsidy would be spread over 15,000 jobs, and therefore cost $8,000 per job. The New York Job Development Authority (JDA) supports the creation of jobs in New York. Through a variety of programs, the value assigned for jobs is on average $3,889 (range of $995 to $14,861) per year for each direct job created and on average $1,849 (range $520 to $4,898) for total jobs created. Using a loan life of a JDA loan of 20 years suggests that jobs are worth an average of $77,780. The Rural Development Program of the USDA uses an average of $15,000 per job created as an estimate of job value when developing loan programs.

b) **Heat.** Indoor aquaculture systems require water to be maintained at particular temperatures depending on the species of fish being grown. Tilapia is a tropical fish that requires warm water. Access to low cost heat helps keep production costs low. Just as insulation helps to reduce heating costs for residents in northern winter climates, so does the use of insulation in buildings used for raising a tropical fish. Minnesota is still a leading producer of turkeys from enclosed buildings and turkeys require several weeks of their growout cycle to be in the tropical temperature range. Numerous cogeneration or manufacturing facilities have waste heat that can be used to grow fish. New York State can help the tilapia industry by assisting with access to facilities that can provide heat.

c) **Equipment & Real Estate.** Indoor aquaculture is a capital intensive business that requires substantial investment in equipment and real estate. New York State can help by providing grants for equipment purchases, and potential sites for production facilities. The fish can be raised in almost any location that can sustain a manufacturing facility. In fact, abandoned or underutilized buildings could be used, as well as brownfield sites. These sites are often in neighborhoods where job creation is also an important consideration.

RESEARCH

Indoor aquaculture and, in particular, tilapia aquaculture would benefit greatly from additional research related to the fish's nutrition, genetics, animal health management, and animal husbandry needs. Fish raised under controlled conditions indoors grow differently and require different diet formulations than the same animals grown outdoors. Improved understanding of the basic physiology of the fish will also aid economic efficiency. New York State can help by funding research into tilapia aquaculture, and at the many State institutions that already that already have aquaculture expertise.

ACCESS TO CAPITAL

Every pound of production capacity will require approximately $1.50 of capital investment for equipment and facilities. Given the newness of the indoor aquaculture industry, farmers are currently required to either provide all the equity for construction or to provide personal guarantees to secure debt financing. New York State can help by working with farmers and the private financial industry to provide a loan guarantee program or access to capital through state-backed industrial revenue bonds.

1.7 SUMMARY OF ECONOMIC OPPORTUNITY

Clearly there is a large potential to make indoor aquaculture a major new agricultural industry in New York State. Creating a one billion pound tilapia industry will have the following economic impacts:

Jobs Created	15,000
Capital Investment in NY	$1.5 billion
Annual Sales	$1.5 billion per year
Wages Generated	$300 million per year
Conservative Multiplier Effect	2x (wage based)
Total Economic Impact (2x wage + sales)	$2.1 billion per year

If New York State can provide assistance, there is no doubt that New York farmers can seize the current opportunity. Working together, New York's farmers, research institutions, and political leaders can establish New York State as the national leader in indoor aquaculture and create the state's next large agriculture industry.

2.0 POTENTIAL TILAPIA INDUSTRY

Tilapia is being emphasized as a large-scale growth opportunity. We are not trying to minimize the importance or potential of the shellfish industry. Currently the shellfish industry is five-fold larger than the existing finfish industry. The opportunity for aquaculture development and growth, however, is much more likely to be centered around a commodity type of product/production, such as the case for the poultry industries (broilers and turkeys) elsewhere in the US. In New York State creation of a tilapia industry through pro-active support by the New York State government could add more than a $billion to the economy of the state over the next 10 years. Just as poultry and turkey market growth was driven by each industry focusing on a single species so that genetic and nutritional research could be focused more sharply, it would be beneficial if such a focus could be made on a single finfish. Tilapia is the clear choice if large-scale impact is to be achieved in the near future. While other fish species could be chosen, e.g., cobia or monkfish, tilapia is already an accepted fish in the US market place (number 9 in the lists of most-consumed seafood) and market growth is continuing at 35% per year with no decline in site. The ornamental fish industry could also be a major contributor to an aquaculture industry, if only a fraction of the current value of aquarium pets being imported through NY ports were captured for NY growers.

What is tilapia? Tilapia is a firm, white fish that is similar in appearance to sunfish. It is easily prepared, and considered by many to be superior to catfish in flavor and texture. It is an extremely popular fish worldwide, and according to the University of Arizona, over 3.3 billion pounds will be harvested in 2003. Tilapia was the 9th most consumed fish in the US in 2002, and approximately 400 million pounds (whole fish basis) were consumed in the US in 2003, approximately five-times the volume of trout consumed. Tilapia has long been a favorite in North America's Asian communities and is becoming increasingly popular among chefs, chain restaurants and mainstream consumers. Until the past several years, a large supply of good quality tilapia was not available in the US. Although tilapia is one of the most popular fish worldwide, only now is the American consumer becoming aware of its superior taste and texture. As the fish has become more widely available, it has continued to increase in popularity.

Tilapia is ideally suited for large-scale production, as it is hardy, grows quickly, and requires inexpensive plant-based feed. Additionally, tilapia is very efficient in converting feed to body mass. For example, tilapia requires approximately 1.0 to 1.2 pounds of feed to grow by one pound. This is contrasted with beef in feedlots that require 6 to 8 pounds of feed to grow by one pound, hogs that require 2.3 to 2.5 pounds of feed, poultry that require 1.8 to 2.2 pounds, and salmon that require 1.2 to 1.8 pounds.

CURRENT AND PREDICTED TILAPIA MARKET

The US market for fresh and frozen tilapia filets is already large and growing rapidly. Approximately 56 million pounds of fresh and frozen tilapia filets were imported into the US in 2002 (NMFS), and the market has been growing over 35% annually. Approximately three pounds of live fish are required to produce one pound of filet. Therefore, approximately 168 million pounds of live fish were required to produce last year's supply of filets. In addition, approximately 10 million pounds of live tilapia were sold in the US last year. Therefore, the total market size in 2002 was approximately 178 million pounds.

Demand for tilapia has grown by almost 400% in the past 7 years, while per capita consumption of seafood in general has remained level. This growth in the demand for tilapia is driven by continuing consumer demand for a fish with a firm, white flesh that tastes good and is easily prepared, and by the decline in the availability of traditional wild white-fish species such as cod, haddock, pollock, halibut, flounder, trout and perch. Tilapia per capita consumption in the US ranked in the top 10 for the first time in 2001, at 0.35 pounds per year, just ahead of scallops and is currently ranked 9^{th} ahead of flatfish at 0.40 pounds in 2002.

Tilapia can be sold to a wide variety of consumers at several price-points, ranging from high value added to low, including: a) live, b) whole, dead on ice, c) organic, d) branded, e) fresh fillets, and f) commodity products. Changing demographics favors the higher price points, as the live and dead on ice markets are particularly appealing to the rapidly growing Asian and Hispanic population. Additionally, changes in consumer dietary patterns and food safety concerns favor the branded and organic segments. Tilapia is one of the few fish that can be sold at this wide variety of price points.

We forecast that the US tilapia industry will grow to over one billion pounds per year over the next 10 years, which would equate to roughly one pound of filet per capita per year. The US catfish industry is a ready example of how fast aquaculture fish markets can grow. This market has grown rapidly, and according to the USDA's National Agriculture Statistic Service, currently sells over 630 million pounds per year. Most food industry professionals agree that tilapia has a greater market potential than catfish due to tilapia's superior texture and flavor.

Since 1997 the US tilapia market has grown from approximately 40 million pounds to over 178 million pounds in 2002. This annual growth rate of 35 percent is expected to continue for at least the next 5 years. As shown in Table 2.1, assuming an average annual growth rate of only 20% over the next 10 years yields an estimate for the US tilapia market of over one billion pounds by 2013.

Table 2.1 Estimated US Market Growth for Tilapia

Growth Rate	10 Years (2013) Live Weight	US per Capita Filet	Predicted Fish Consumption Rank
15 percent	720 million pounds	0.8 pounds/year	#6, ahead of cod
20 percent	1.1 billion pounds	1.2 pounds/year	#5, equal to catfish
25 percent	1.66 billion pounds	1.8 pounds/year	#4, ahead of pollock
30 percent	2.45 billion pounds	2.7 pounds/year	#3, equal to salmon

Fresh tilapia filets currently sell for between $4.99 and $7.99 per pound in supermarkets. Because three pounds of fish are required to generate one pound of filet, this translates to $1.66 to $2.66 per pound of tilapia on a whole fish basis. This is roughly the same price range for the sale of live tilapia in markets. Tilapia sold as meals through restaurants are obviously priced much higher. Assuming an average wholesale price of only $1.50 per pound of tilapia 10 years from now calculates to a total industry market size of $1.5 billion to $3.7 billion.

3.0 SHELLFISH AQUACULTURE IN NEW YORK STATE[4]

HISTORICAL BACKGROUND OF THE SHELLFISH INDUSTRY

Oyster Industry

Historically, the oyster industry represented one of the most commercially important shellfish resources in New York State dating

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back to the 1800's. The beginning of oyster culture in New York State involved the movement (transplanting) of natural seed oysters from "setting" (spat) areas to planting areas, which provided optimum growth and fattening for market. The natural seed (spat) beds were mainly located in the mouths of rivers in Connecticut and the Hudson River, and areas around Staten Island in New York. Seed oysters were transplanted to leases, franchises or underwater grants located in Long Island Sound, and Peconic and Gardiner's Bays for grow-out. Matured oysters were moved to areas in Great South Bay, Raritan Bay and Jamaica Bay for fattening prior to market.

New York dominated the oyster industry in the late 1800's through early 1900's. In 1911, a peak production of about 25 million pounds of oyster meats was harvested in the State. The Great South Bay on Long Island was once famous for its production of the Blue Point Oyster. The oyster industry observed a steady decline in production after its peak due mainly to a lack of an adequate supply of seed oysters and irregular sets in Connecticut and pollution from urbanization that led to the closure of shellfish lands in Raritan Bay, Jamaica Bay, and areas around New York Harbor. Other factors contributing to the decline in the oyster industry were diseases, predation, changing hydrographic patterns, over-fishing, etc. During the period from 1915 through 1921, more than twelve thousand acres of leased shellfish grounds were surrendered back to the State by growers due to a lack of cheap and reliable sources of seed.

The short supply of oyster seed and the unreliability of spat collectors led to research on the artificial propagation of oysters. The artificial propagation of oyster larvae, which was first reported by Brooks (1879) and later successfully demonstrated by William Wells of the New York State Conservation Commission in 1920 at an experimental hatchery at the Bluepoints Oyster Company, West Sayville, New York, was a significant breakthrough in the oyster industry. The artificial hatchery rearing techniques developed by Wells and Joseph Glancy (New York Conservation Commission) and researchers at the federal government's Milford, Connecticut laboratory led to the establishment of commercial shellfish hatcheries on Long Island in the 1960's. In 2001, oyster landings in New York State were reported to be only 243,575 pounds of meats with a value of $2.1 million. However, farmed raised (cultivated) oysters accounted for approximately 85 percent of the State's oyster landings.

Oyster farming, which involved planting seed, cultivating the bottom, putting down shell material (cultch), transplanting and harvesting marketable product, required some mechanism that allowed access to public underwater lands for private use. In 1887, Chapter 584 of the Laws of New York, provided for the granting of franchises of State-owned underwater lands, in perpetuity, for the purpose of oyster cultivation. In 1893, this law was repealed and a system of leasing of underwater lands for shellfish cultivation with specific term periods was established for the first time (Chapter 321, Laws of 1893).

During the period from 1887 through 1967, approximately 50,000 acres of State-owned underwater lands were allocated to the shellfish industry under franchises or lease agreements. Currently, there are only 1,694 acres of underwater lands held by franchises in Long Island Sound and all leases have reverted back to the State of New York for public use. Between the dates of 1885 and 1914, a total of 45,081 acres of underwater lands in Peconic and Gardiner's Bays were granted by the County of Suffolk to individuals in perpetuity for the purpose of oyster cultivation (Chapter 385, Laws of 1884, L 1896 Ch 916, L 1906 Ch 640, L 1923 Ch 191). They were required to pay annual taxes on the grants to avoid reversion to the County and the grants were also required to be in continuous use for oyster culture.

Suffolk County has reclaimed the majority of the oyster grants due to tax arrears and only about 3,400 acres of these oyster grants are currently privately held for oyster cultivation. Various municipalities (towns) on Long Island also leased underwater lands for oyster cultivation dating back to 1829 (Town of Brookhaven), but only one shellfish culture lease is currently in existence. Unfortunately, past abuses in the leasing program that were undertaken by large companies and strong opposition by baymen led to the termination of leasing programs by the towns. Frank M. Flower and Sons, Inc. of Bayville, New York represents the last remaining large-scale oyster company that operates a hatchery and plants millions of seed oysters and clams on leased lands from the Town of Oyster Bay. The NYS Department of Environmental Conservation (DEC) has the authority to adopt regulations to lease state-owned underwater lands but does not have an active leasing program at this time.

Hard Clam Industry

The growth of the hard clam industry on Long Island occurred in the 1930's as a result of declines in oyster abundance and loss of oyster grounds. Hard clam landings peaked in 1947 with a record harvest of more than 10 million pounds of meats having a value of over $6 million. The landings declined in the late 1940's through early 1950's and began to increase significantly in the 1960's through 1970's due to new sets in Great South Bay reaching a second maximum in harvest in 1976 at about 9 million pounds of meats.

In the 1970's, the hard clam fishery in Great South Bay accounted for approximately 94% of the hard clams landed in New York State. Wild hard clam stocks have continued to decline in New York State and the fishery in Great South Bay is almost non-existent. The Bluepoints Company, which held title to more than 13,000 acres in Great South Bay and operated a marine hatchery and extensive on-bottom grow-out operation, was forced to go out of business due to the poor water quality and unsuitable growing conditions in Great South Bay. In 2001, hard clam landings dropped to a low of 1.8 million pounds of meats valued at $13.5 million.

The total hard clam production in New York State is currently at less than 20% of its peak landings and only a few new sets have occurred in some of the north shore embayments in the Towns of Huntington and Oyster Bay. The steady decline in population of hard clams can be attributed to over-harvesting, recruitment failure, changes in water quality, poaching of seed clams, loss of suitable habitat and pollution. Although hard clam landings are at very low numbers relative to historical abundance, it is still the most commercially important marine resource in New York State.

Shellfish Transplant Programs

The dramatic decline in wild hard clam stocks in certified waters has resulted in a significant increase in participation in the shellfish transplant program by wild harvesters and culturists over the past fifteen years. The shellfish transplant program involves the harvesting and relay of shellfish from designated uncertified (polluted) waters to certified (clean) waters for cleansing and subsequent marketing as a food product. As a result, the annual shellfish transplant harvest in Raritan Bay off Staten Island, New York increased from 44,040 pounds of meats in 1987 to 933,768 pounds of meats in 2001. This program allowed for the participation of about 200 individuals, including on average four shellfish culture cleansing operations. In 2001, the shellfish transplant program accounted for approximately 45 percent of the annual hard clam production in New York State and was valued at almost $6 million.

However, this program was cancelled in 2003 by the DEC due to the discovery of the hard clam parasitic disease QPX (Quahog Parasite Unknown) in the harvest area in Raritan Bay. Without the transplant program harvest, New York State's annual hard clam landings will continue to significantly decline and likely reach an unprecedented low for 2003. Table 3.1 describes the shellfish transplant production as compared to the total hard clam landings for New York State during the period 1980 through 2001.

Table 3.1 Shellfish Transplant Production vs. Total NYS Hard Clam Landings

Year	Transplant Harvest (bu)	Transplant Reharvest[1]	Total NYS Landings (bu)	% of Total
1980	10,383	-----------	403,684	2.5
1985	19,365	-----------	183,382	10.5
1990	54,084	-----------	205,230	26.4
1995	36,594	39,226	218,930	18.0
1996	57,951	62,972	229,502	27.4
1997	68,739	68,168	234,239	29.1
1998	76,256	78,882	208,313	37.8
1999	82,176	84,655	220,585	38.4
2000	88,543	76,529	192,840	39.7
2001	77,814	64,535	152,127	42.4

Landing figures reported in bushels (conversion to pounds = bu x 12).

[1]Transplant Reharvest data used to determine percentage of total NYS Landings.

Table Note 1: Transplant harvest in this table refers to the total quantity of clams in bushels that were harvested from designated uncertified waters and relocated to certified waters for cleansing and eventual marketing as a food product. These figures are not included in the NYS Landings data until the shellfish are reharvested and sold. Transplant reharvest refers to the total quantity of clams in bushels that were reharvested from the transplant cleansing sites and sold for food consumption. Total NYS Landings in bushels refers to the annual production figures for the total quantity of shellfish landed and sold in New York according to production figures from NYSDEC. Transplant reharvest figures are accounted for and reflected in the Total NYS Landings data.

Table Note 2: Data taken from NYSDEC Annual Production Figures and Transplant Program.

Bay Scallops

Historically, the bay scallop represented a commercially important shellfish resource in New York State, particularly in Peconic and Gardiner's Bays located on the eastern end of Long Island. The bay scallop fishery was conservatively estimated to produce over 300,000 pounds of meats annually worth in excess of $1 million in landed value. In 1985, an usual bloom of the alga, *Aureococcus anaphagefferens*, also known as the brown tide, devastated bay scallop populations in the Peconic Bay system. Since the onset of brown tide, landings fell to an unprecedented low of 250 pounds of meats in 1988 and have risen only slightly to an insignificant level of 3,793 pounds in 2001. There have been several unsuccessful efforts to revitalize bay scallop populations by planting scallop seed (bugs) from local and out-of-state hatcheries and establishing spawner sanctuaries in the Peconics. Marine hatcheries will continue to play an important role in any efforts to rehabilitate scallop resources in New York State.

GROWTH OF SHELLFISH FARMING (1980 TO PRESENT)

In the past twenty years, there has been an increase in public and private mariculture operations in response to the decline in wild shellfish populations. In New York State, shellfish cultivation involves the transplanting of seed and/or legal-size animals from one area to another for grow-out to market size or cleansing, as appropriate, and raising of larvae and seed in marine hatcheries and nursery systems. The two main shellfish species being cultured are hard clams and oysters. There are public (town) and private (commercial) marine hatcheries and on/off-bottom culture operations conducted in New York State. Public mariculture programs are designed to augment and increase harvestable stocks for public use. Private mariculturists are obviously in business for economic gain, but provide an important and necessary service to the public mariculture programs by providing shellfish seed for nursery or grow-out systems.

Section 13-0316 of the New York State Environmental Conservation Law authorizes the cultivation of marine plants and animals in marine hatcheries or through on-bottom and off-bottom culture with permits from DEC. On-bottom culture is defined in Part 48, 6 NYCRR, as "the raising, breeding, growing or planting of marine plant or animal life on, or in, any natural underwater lands of the State." Off-bottom culture means "the raising, breeding or growing of marine plant or animal life, including containment on, or in, any raft, rack, float, cage, box or other similar device or structure in any natural waters of the State." The term marine hatchery refers to "any building, pond, tank, raceway or other structure, excluding hobby aquariums and natural bodies of water, in which marine plant and animal life is bred or otherwise cultivated, whether located on land or water, anywhere in the State."

Town managed shellfish programs, including the construction and operation of marine hatcheries and initiation of seed planting programs, have developed on Long Island in response to the decline in wild shellfish stocks, particularly, hard clams. Twelve of the thirteen Nassau and Suffolk towns use hard clam seed planting as part of their shellfish management programs. The number of marine hatchery permits issued to both private and public interests have increased in the past few years due to the development of new nursery systems called FLUPSY's (floating upwelling systems), which are considered floating marine hatcheries in the permitting process. Many of the towns raise small seed clams and oysters in FLUPSY's for one growing season and plant the shellfish in the late fall on public lands. Table 3.2 describes the number of aquaculture permits (on/off-bottom culture and marine hatchery) issued by NYS DEC in 1980, 1990, 2000 and 2002.

Table 3.2 Aquaculture Permit Types by Year

	On/Off-Bottom Culture		**Marine Hatchery**	
Year	**Total (Private & Public)**	**Public (Town)**	**Total (Private & Public)**	**Public (Town)**
1980	12	7	11	1
1990	18	7	16	6
2000	50	10	16	6
2002	51	10	23	9

There has been a significant increase in both private and public marine hatchery and on/off-bottom culture permits issued by DEC during the past twenty years and specifically, in the 1990's to the present. An increasing number of baymen have become interested in shellfish culture due to insufficient wild shellfish stocks, restrictions imposed on most fisheries, die-off of lobsters in Long Island Sound and as a means of subsidizing their livelihood on the water. Also, the attitudes of baymen toward aquaculture have changed and many that had opposed aquaculture in the past have turned to aquaculture as another source of income. In 1982, NYS DEC developed a Temporary Marine Area Use

Assignment Program that involved the issuance of 5-acre circular parcels of state-owned underwater lands for the purpose of off-bottom culture of shellfish. This program was designed to promote the growth of small-scale shellfish culture in New York State and at the same time address the concerns of wild harvest baymen. The culturists are required to grow their shellfish in containers (bags, trays, cages, racks) and cannot restrict access to the assignment site by wild harvesters and fishermen provided that they do not interfere with their aquaculture operation. Table 3.3 is illustrating the number of off-bottom culture permits and associated Temporary Marine Area Use Assignments issued by NYS DEC for the same period mentioned above.

Table 3.3 Off-Bottom Culture Permits and Temporary Assignments by Year

Year	Off-Bottom Culture Permits (Private)	Temporary Marine Assignments (5 Acres)
1982	6	1
1990	11	7
2000	40	28
2002	41	32

The dramatic increase in the number of off-bottom culture permits and Temporary Marine Assignments from 1990 to present has been very positive for the shellfish industry. Private marine hatcheries in New York have benefited from the increase in number of shellfish growers and have observed a significant increase in sale of seed clams and oysters for both private and public use. The shellfish culture industry is currently comprised of small-scale growers operated mainly by individuals rather than large companies. There is still a tremendous potential for growth of the shellfish culture industry in the future.

With the help of the New York State Department of Environmental Conservation, Cornell Cooperative Extension of Suffolk County initiated the S.P.A.T. program in 2001. This program, an acronym for Southold Project in Aquaculture Training, trains oyster gardeners, who grow shellfish off their dock or at a community garden at Cornell's Marine Learning Center. Although the participants cannot sell or barter the shellfish they grow, 50% of the seed they receive comes back to Cornell Cooperative Extension for resource enhancement, which along with having cages of shellfish acting as spawner sanctuaries in area creeks, potentially adds to the commercial wild harvest.

A few S.P.A.T. members have gone on to commercial shellfish farming; those that have continued to garden have a new respect for the work commercial shellfish farmers do. In 2002 there were nearly 400 participants growing shellfish in five towns; the program may expand to other towns in Suffolk County in 2003.

REQUIRED CHANGES TO IMPLEMENT GROWTH

The rapid growth of shellfish aquaculture in the past ten years has resulted in an environment where current legislation is out-of-date and does not reflect today's practices and needs. The complexion of the shellfish farming industry in the past was primarily large-scale operators who held vast acreage. Most of the product was bottom-planted and there was a dependency on wild product to varying degrees. The current industry is more intensive, and with the exception of those who relay wild clams in the transplant program, it has little or no dependence on the harvest of wild populations. In the past thirty years the conflict between those who harvested wild product and those who aquacultured discouraged small-scale operators from entering the industry. Today, wild populations have declined. The number of individuals holding permits to harvest shellfish has also declined to nearly 1/4 the level of the early 1980's.

Baymen who once opposed aquaculture are looking to shellfish cultivation as a way to sustain a living on the water. In 1995 Cornell Cooperative Extension (CCE) of Suffolk County received monies from the East End Institute (a state-funded agency) for a Mariculture Training Program for East End commercial fishers. This one-year program was extended and expanded in 1996 with a federal Fishing Industry Grant administered by the National Marine Fisheries Service. This second grant was awarded to the East End Institute with CCE-Suffolk and the East Hampton Shellfish Hatchery performing the work. Those who were successful at cultivating shellfish through these projects fostered a wave of interest in shellfish aquaculture among baymen.

The laws most in need of revision are those dealing with access to underwater land; the farmland needed by shellfish culturists. The County of Suffolk has had the right to lease underwater land since 1969. The County has not leased any land due to the cumbersome survey and mapping requirements, and due to negative reactions by wild harvesters to the leasing of underwater land to private individuals. The State of New York has also not moved forward on a leasing program. This is due, in part, to the practice of one baymen's group on the North Shore of

Long Island to aggressively use litigation and lobbying to push its agenda opposing the leasing of underwater land.

Laws dating back to the late 1880’s deal mainly with the older cultivation practices used by oyster farmers. From the 1880’s to the 1970’s seed oysters were transplanted from productive setting grounds in Connecticut and transplanted to growing grounds in New York State. Disease, pollution and over-harvesting reduced the productivity of the setting grounds. Many of these older oyster companies were out of business by the mid-1970's. The cultivation of seed shellfish in land-based hatcheries and nursery systems has become economically feasible as a way to produce large crops of oysters and hard clams. Bay scallops are also being produced commercially, but in smaller numbers. Laws regarding the access to underwater land through leasing and the harvest of aquacultured product need to be updated to reflect current practice and allow for managed growth. In 2003 and again in 2004, legislation was introduced in the State Senate and Assembly to modernize the 1969 law that gave Suffolk County the right to lease State-Owned underwater lands in the Peconics/Gardiners Bay system. While there is a good chance the bill will become law in 2004, there is no certainty of that at this time. This is due in part to a change in attitude by local baymen who now see aquaculture as an opportunity to sustain a living on the water.

In some cases the harvest of aquacultured product is impeded by regulations that address the conservation needs of a wild fishery. Size and season restrictions for aquaculturists result in lost revenue and market opportunities. Size restrictions on oysters and bay scallops will insure the wild populations reach sexual maturity and spawn before they are harvested. However, such restrictions are detrimental to aquaculturists.

The National Aquaculture Act of 1980 was the first federal law to address aquaculture development. The purpose of the act was to promote aquaculture in the US by establishing a national aquaculture policy as well as an aquaculture development plan. The act also encouraged increasing aquaculture programs in both governmental agencies and the private sector. The national aquaculture policy developed from the 1980 Act is:

> "Congress declares that aquaculture has the potential for reducing the United States trade deficit in fisheries products, for augmenting existing commercial and recreational fisheries, and for producing other renewable resources, thereby assisting the United States in meeting its future food needs and contributing to the solution of world resource problems. It is, therefore, in the national interest, and it is the national policy, to encourage the development of aquaculture in the United States."

Another result of the National Aquaculture Act was the formation of the Joint Subcommittee on Aquaculture (JSA) whose mission is to serve as an interagency coordinating group to improve the overall effectiveness and productivity of federal aquaculture research, technology transfer, and assistance programs. There are a dozen federal departments represented on the JSA, including Agriculture, Commerce and Interior.

In New York State, Chapter 128 of the Laws of 1985 added "aquaculture" to the powers and duties of the Commissioner of the New York State Department of Agriculture and Markets. This department currently does not have the funds needed to manage a new and complex segment of the farming industry. Article 25AA of the New York State Agriculture and Markets law does, however, define aquaculture as agriculture. To date, though, none of the acreage farmed for shellfish lies within the Agriculture Districts of New York State. The Department of Agriculture and Markets is an agency that promotes the agriculture industries as well as regulates them. The DEC is a regulatory agency that has authority over aquaculture permitting in New York State in accordance with Articles 11 and 13 of the Environmental Conservation Law.

The DEC is also in charge of the very critical task of monitoring water quality as required by the US Food and Drug Administration for sanitary control over the harvest of shellfish. There needs to be a stronger tie between these two agencies concerning the management and the fostering of the shellfish aquaculture industry. Most states that have a thriving and productive shellfish aquaculture industry have that industry under the authority of the state's agriculture department. Yet, transferring management of the shellfish aquaculture industry to the Department of Agriculture and Markets in New York State would be disruptive to the industry due to loss of experienced personnel and problems inherent with shifting responsibility from one agency to another. A strong linkage between the two agencies is possible, preferable, and recommended.

CURRENT CONSTRAINTS TO GROWTH

The biggest constraint to the development of shellfish aquaculture in New York State is access to underwater land, the waterfront, and dockage. Access to underwater land has always been a contentious issue in New York State as it involves setting aside areas in the public domain and privatizing them for shellfish farming. The practice of giving underwater land to individuals or companies dates back to colonial times. In modern times this practice has been vigorously opposed by individuals in the wild harvest fishery who see granting or leasing land as a way for one individual to monopolize the resource. Unfortunately there is little wild resource left. Many wild harvesters are turning to aquaculture to sustain a living on the water. The resistance to leasing public lands is diminishing as more wild harvesters come into the industry. A recent survey conducted by the East End Marine Farmers Association targeted those individuals who may be interested in leasing, such as aquaculturists, baymen and shellfish gardeners. The survey was not widely distributed due to its cost. However, twenty-nine people responded to the survey indicating a desire to lease a total of 872 acres (30 acres/person). All respondents had an interest in cultivating oysters on leases; over half wanted to also grow hard clams. About one third of the respondents wanted to cultivate bay scallops. Decision-makers need to be aware of this interest and promulgate policy that facilitates the access to underwater land.

Underwater land control in New York State involves several different ownership interests and may be under the jurisdiction of municipalities (towns), county, federal, state or private entities. Some towns will lease underwater land to private companies, but others do not and have adopted town code to prohibit leasing of town lands for private aquaculture. The state and county both have statutes (laws) that allow them to lease underwater land. Neither does so, mainly because the practice has been so contentious over the past thirty years.

In order to allow access to underwater lands for the culture of shellfish, the DEC has implemented a Temporary Marine Area Use Assignment Program (Temporary Assignment Program) that allowed for the temporary granting of 5 acre state parcels of underwater lands for the off-bottom culture of shellfish only. DEC has administered a Temporary Assignment Program which allows for the small-scale off-bottom cultivation of shellfish to be undertaken on state-owned underwater lands in the Marine and Coastal District including the waters of Long Island Sound and Peconic and Gardiner's Bays.

The Temporary Assignment Program was developed in 1982 under an agreement with the New York State Office of General Services and a Memorandum of Agreement with Suffolk County for those underwater lands located in Peconic and Gardiner's Bays. This Program was designed to be an interim program until a leasing program for the cultivation of shellfish could be developed by Suffolk County. Temporary Assignments are issued for one year and must be renewed annually as compared to multi-year leases that afford more security and access to long term financing.

In 2001, the DEC conducted a survey of all Temporary Assignment permittees; thirteen responded and commented on their practices and concerns. Nearly all permittees reported growing oysters (85%) while only ~35% were actively growing hard clams and scallops. This is primarily due to the current suitability of oysters as an aquaculture product and includes factors directly related to off-bottom culture such as mortality, growth rate, theft and availability of markets. Several of these factors would be mitigated by the option for on-bottom culture of which ~25% reported a desire to do so. Over 50% indicated that 5 acres was sufficient for their needs, and 35% felt it was too little. Also, a large group, nearly 50%, strongly asked for changes to environmental regulations that would allow special dispensation or exemption in the environmental conservation laws for the marketing of smaller sized aquacultured shellfish.

Access to waterfront and dockage may be a more difficult problem to solve. The suburbanization of the coastal zone means more recreational and residential use of the estuary. All segments of the fisheries are finding themselves squeezed out of waterfront access in favor of expensive summer homes and dockage for yachts. There is also the potential for stakeholder conflicts as the coastline changes from a working waterfront to one that is capable of generating large amounts of capital from recreation and pleasure activities.

REGULATORY ISSUES

The regulatory needs of the shellfish aquaculture industry boil down to the need to resolve the discrepancies between the management, regulatory and enforcement needs of a wild fishery versus an industry that relies on cultivated product. This need increases as more wild harvesters enter aquaculture in an effort to sustain a living on the water. This shift in the shellfish industry must be facilitated to create opportunity and economic viability. Growth should be managed to optimize the benefits of shellfish aquaculture and eliminate conflicts that will arise from inappropriate use of gear and impingement upon the rights of other stakeholders.

Aquaculture exemptions are needed for aquacultured product whose harvest restrictions are mandated by the need to protect wild populations of shellfish. Bay scallops and oysters are the two species that currently are cultivated and fall into this category. There is no State size limit currently regulated for oysters but many of the towns have adopted size limits involving a combination of 5 inches (2 inches wide x 3 inches high). However, to protect wild populations a size limit of 2 ½ inches wide was proposed by baymen on the North Shore of Long Island.

The New York State Shellfish Advisory Committee recognized the need to protect the resource without impacting the ability of aquaculturists to sell "petites" (oysters 2 – 3 inches wide). The law change was proposed to adopt a state size limit on oysters and allow for an aquaculture exemption. Bay scallops may not be harvested in New York State until they are 2 1/4 inches in length and have an annual growth line (survived one winter). Aquaculturists are beginning to cultivate bay scallops in large numbers. They can produce a portion of their crop to market-size in one season. The remainder of the crop is smaller, but marketable as an in-shell product that can be steamed like mussels. None of these can be harvested and sold in New York State, but can be harvested and sold in neighboring states. This results in a loss of revenue and an increase in risk due to mortality of over-wintered product. These restraints result in fewer individuals cultivating bay scallops because they cannot cost effectively cultivate without the option to sell a portion of their crop at the end of the first season.

A regulatory system supported by a sound statutory framework and adequate enforcement will aid in resolving conflicts between wild harvesters, other stakeholders and aquaculturists. The first task of this framework should be to delineate all areas in state, county and town waters that are appropriate for shellfish aquaculture and describe the type of aquaculture suitable for these areas. Work has already begun to collect the information needed to set aside aquaculture areas or zones. The Southampton Town Trustees have recently completed an aquaculture feasibility study to look at areas within the town that would be suitable for transient, off-bottom culture gear in Shinnecock and Moriches Bays. The County of Suffolk has also been re-evaluating their role in the management of underwater lands in Peconic and Gardiner's

Bays and considering the legal requirements that need to be undertaken to lease underwater land in the Peconics and Gardiner's Bays.

Two committees have met to look at this issue. Suffolk County formed the Suffolk County Aquaculture Committee to examine their management of underwater lands in the Peconic Estuary System and whether that management should include an active leasing program as provided for in NYS Law 1969, Chapter 990. The Peconic Bays Aquaculture Advisory Committee was an *ad hoc* group put together by The Nature Conservancy to resolve some of the current controversial issues surrounding leasing of underwater lands for shellfish culture. This group consisted of baymen, public and private aquaculturists, county, state, town, environmental groups, academia, and Cornell Cooperative Extension, and made recommendations regarding the establishment of leases to reduce stakeholder conflicts. The New York State Environmental Conservation Law addresses the cultivation rights held by those who lease or privately hold underwater lands. The Peconic Estuary Program is funding a benthic mapping project being conducted by The Nature Conservancy and the Marine Science Research Center at SUNY-Stony Brook. This information will be helpful in the establishment of leases.

To prevent the aquaculture industry from being regulated into a monoculture farming industry, the right to cultivate all species of shellfish in an environmentally responsible, economically viable manner must be maintained. The right to cultivate species other than oysters on underwater land grants in the Peconics and Gardiner's Bays has been questioned in recent years. Those who hold Temporary Marine Area Use Assignments may only culture off-bottom in transient gear. Pigeon-holing the industry into an oyster only industry by disallowing the cultivation of other species or the methodology to cultivate other species, leaves a thriving industry vulnerable to failure as has been demonstrated in the past. The shellfish farming industry in the last century was heavily dependent upon moving wild oyster populations to privately controlled growing grounds. The source of the seed oysters declined due to disease, pollution and over-harvesting. The industry consequently declined as well. Today, we can depend on other crops through shellfish hatchery production and relaying of wild harvest shellfish. However, each species has different conditions under which it thrives. Culturists must be able to bottom plant those species, such as hard clams, which grow best in the bottom. The ability to relay (transplant) hard clams is also important to the shellfish farming industry and employs wild harvesters and farmers alike. Hard clam farming will not thrive on Long Island unless farmers are permitted to bottom plant and mechanically harvest this species.

With the right to use the bottom for cultivation of species such as hard clams comes the responsibility to do so in an environmentally sensitive manner and to operate within the rules and regulations adopted by the NYSDEC. There are areas (site locations) that are not suitable for mechanical harvest during certain times of the year. Some areas are not suitable for mechanical harvesting or hand raking due to the presence of Submerged Aquatic Vegetation (SAV). Adequate enforcement by the NYSDEC will prevent abuses of the privilege to cultivate shellfish on leased or granted public land.

A growing industry needs to be protected to thrive. Although New York State Agriculture and Markets Law Article 25 AA recognizes aquaculture as agriculture, no underwater land lies within the Agriculture Districts of New York State. The main advantage of an agriculture assessment on one's property is a reduction in property tax. This is minimal for underwater land as it is valued the same as highly productive farmland. An agriculture assessment does give the farmed property protection under the Agriculture and Markets Law. This law will also protect the farmer from nuisance complaints from neighboring stakeholders.

Enforcement to protect the shellfish farmer from theft and vandalism needs to be undertaken and on a par with land-based farmers. The NYSDEC should enforce any theft of aquaculture products from underwater farms to the same extent as compliance issues on underwater property. Enforcement officers should be trained not only to observe operations on underwater land for possible infractions, but also to enforce theft of product by others off of those grounds and vandalism of gear. These issues are covered in Article 13 of the NYS Environmental Conservation Law (ECL). The onus to protect the product and gear from theft and vandalism, however, lies ultimately with the farmer.

ECONOMIC POTENTIAL

The economic potential of the industry is constrained by a number of factors such as poor water quality in areas that used to be productive, access to underwater land and resistance to modern cultivation methods by wild harvesters and other stakeholders. Resolution of these issues would allow for an increase in productivity, the responsible cultivation of all species and prevent dependency on monoculture. F. M. Flower and

Sons in Oyster Bay, Long Island is an example of a company that has thrived because they have the ability to cultivate two species of shellfish on their leased underwater land in an area with good water quality. They plant about 50 million seed oysters and 30 million seed hard clams each year. This has helped them stay in business in spite of crop loss due to oyster diseases.

Today's shellfish aquaculture is unique in that most operators are small-scale and will self-invest in their operations. This means that they carry little or no debt and are not beholden to investors who often have unreal expectations of returns. When these operations become profitable, all of the profit remains with the farmer, who can either enjoy the fruits of his/her labor or, invest in the growth of their business. The result of this business structure is that the farms grow in accordance with the operator's success in cultivation. It also grows in accordance with market demand for the product.

Growth of the industry would be further fostered by campaigns to market locally produced seafood. Shellfish farmers need to link up with other seafood producers and local farmers to influence consumer-buying habits. Price is the main component that influences consumer-buying habits. Their choice can, however, be influenced by a perceived benefit that will justify a higher price. The benefits to buying locally produced shellfish can easily be spelled out. In the case of hard clams an increase in market price would also benefit wild harvesters. Cultivated oysters are currently sold at a high price due to the marketing efforts of shellfish farmers in the fall and winter months.

Critical Needs of the Industry

The critical needs of the industry are: improvement of water quality, prevention of crop loss due to disease and Harmful Algal Blooms (HAB's), legislative changes to facilitate opportunity, a document outlining Best Management Practices, and public outreach/education.

The Marine Disease Pathology and Research Consortium at SUNY-Stony Brook has recently been established. It would be most useful to the industry if the Marine Disease Consortium could provide a diagnostic service to the aquaculture industry in New York State that is similar to that of the State of Connecticut, Department of Agriculture, Bureau of Aquaculture. Dr. Sunila, Shellfish Pathologist with the State of Connecticut has tested oysters and hard clams from various locations along the Connecticut shore. She has developed a management plan for

Connecticut oyster farmers to help prevent the spread of disease and manage around disease in areas where pressure exists. Dr. Sunila often makes site visits to discuss disease problems with shellfish farmers. This insures that they contact her as soon as they see a problem with their crops. The Marine Disease Pathology and Research Consortium was designed to conduct research on disease issues which are affecting marine organisms in the State and conduct diagnostic analyses on wild and cultured marine organisms as necessary. It would be invaluable to the shellfish culture industry if the Consortium could address diagnostic issues on a site-specific basis and meet the diagnostic needs of this industry.

HAB's are also a concern for shellfish farmers. The brown tide algae devastated the bay scallop population in the Peconic Bay estuary during the mid- to late eighties. This algae most severely affects bay scallops, but can also affect the growth rates of hard clams and oysters. No management plan has evolved that can prevent this algae from blooming again. However, preliminary experiments suggest that hard clams can graze down the algae bloom before it becomes the dominant species in the bay.

Gymnodinium splendens is a dinoflagellate that can also cause problems for aquaculturists. Unlike the brown tide algae, it does not announce its presence by turning the estuarine waters into one large monospecific algae culture. It is devastating to small oyster seed. Mortalities can be as high a 95% in nursery systems that rely on ambient water. This bloom can go unnoticed unless there is a shellfish farm affected.

Consistent monitoring of the estuary waters will not only detect HAB's, but may also record conditions that predict algae blooms. Monitoring will also create a database that can indicate periods of high productivity and good shellfish growing conditions. It would also yield the base-line data necessary to make sound decisions regarding steps needed to improve the water quality in Long Island's embayments and estuaries.

Changes in both the law and regulatory practices that constrain the development of shellfish aquaculture will create an environment where this growing industry can thrive. These changes will allow farmers access to areas suitable for shellfish aquaculture. They should also adapt regulatory practice to include the management of farmed product without treating cultivated product the same as wild harvest product. Including farmed underwater land in the Agriculture Districts of New York will further protect shellfish farms.

A document created from the input of members of the industry, extension educators, regulatory agencies and other stakeholders that outlines Best Management Practices (BMP) and Codes of Conduct is needed for shellfish aquaculturists in New York State. In this respect New York is behind Massachusetts, Maine, the West Coast and several southern states. A BMP document will educate newcomers to the industry regarding how and where to cultivate to minimize impact on the environment (where applicable) and to other stakeholders. It will also demonstrate to those unfamiliar with the industry our commitment to stewardship and our concern for the environment in which we work. This document should describe cultivation methods that will not impact the environment or wild populations. It should address importation of shellstock or seed shellfish, proper gear management, description of areas suitable for mechanical harvest of shellfish, and concerns often expressed by other stakeholders.

Public outreach is necessary for the community at large to understand the shellfish aquaculture industry. Most people are unaware of how their food is grown and where it comes from. Unfortunately, most people who live along the coast are unaware of how their actions affect water quality in the estuary. Facilitating interactions between the public and the industry will help foster mutual understanding. This can be achieved by having aquaculturists visit schools to educate children about the importance of water quality for all marine life. Their parents and grandparents can be reached through community based programs that involve people in shellfish cultivation and wetland restoration activities. Tours of shellfish cultivation facilities are always interesting to adults and school children alike.

Public outreach can also go a long way to prevent stakeholder conflicts. When one group understand the needs and contribution of another there is less room for misunderstanding. Meetings between stakeholder groups, especially within the fisheries community are needed to help the various groups find common ground. All segments of the marine fisheries industry would be better serve by cooperation as opposed to competition. Members of the fisheries industry should work together to improve water quality and market opportunities for their products.

4.0 ORNAMENTAL AQUACULTURE[5] AND BAIT FISH

Ornamental fish aquaculture is the controlled culturing of aquatic organisms strictly for artistic, decorative or personal pleasure reasons. This particular industry comprises a major component of the overall aquaculture market. As with consumable aquaculture products, most of the resources come from outside of the US. The retail value of this industry nationally is estimated to approach $3 billion annually (Davenport, 1996). The importation of this product is reflected in loss of economic and job market potential. Technology, market demand and ease of culturing, demands our immediate attention and action with the purpose of developing this industry here “at home”. As is the situation with other commercial aquaculture ventures, this market will not be realized without programs of education and promotion leading to the strong support of our policy makers and power brokers.

INTRODUCTION

The fascination with ornamental fish is worldwide and as old as civilization. Early Egyptians kept fish for pleasure, and the Sung dynasty Chinese raised goldfish and koi for their aesthetic value, much as many do today around the world. Special fish are found in the legends and histories of many cultures, and reference can be found in the Old Testament. Today, keeping ornamental fish in aquariums is a popular and burgeoning pastime. In the US, the aquarium hobby is second only to photography in popularity. Estimates in the mid-1990s of the total value of the wholesale trade in ornamental fish were about $900 million (Bassleer, 1994) with retail trade of live animals for aquariums valued at about $3 billion (Davenport, 1996). Since the 1980s these figures have been increasing, and fish keeping today is a hobby that has become institutionalized as a standard consumer commodity for millions of people around the world. Tropical ornamental fish are one of the leading cash crops in the aquaculture industry.

Ornamental fish for aquariums were originally collected from the wild. Holding areas evolved into production areas, and the aquaculture of ornamentals was born. Breeders have created and commercialized many varieties of fish that display dazzling color combinations and a vast array of fin conformations. Commercial production of freshwater ornamental

[5]Primary author of this section is Martin P. Schreibman, Professor, Department of Biology, Brooklyn College-CUNY.

fish and plant varieties in ponds and tanks is relatively new, and expanding.

Few definitive and recent studies on this industry are available and they are blatantly needed. Since 1982, the recording of US import and export data has been the responsibility of the U.S. Bureau of the Census. These data are obtained from the declarations of shipments (Form 3-177) recorded with U.S. Custom's officials, as required by law for nearly all overseas transfers. Prior to 1989, however, no specific category was established to represent the imports and exports of ornamental fish. Ornamental fish data were grouped in the general category, "fish or shellfish-live-other than for human consumption." Only in 1989 did the Bureau adopt a detailed coding system, with ornamental fish data being placed in a separate category, "fish-ornamental-live." Therefore, while we cannot be certain of the actual numbers for ornamental fish in the pre-1989 period, we can assume that imports and exports of ornamental fish accounted for the majority of the totals for the live fish/shellfish category.

Thus, this review will be based on currently available information. Worldwide, the ornamental (or aquarium) fish hobby is a multi-billion dollar industry, and the US is considered the largest market for ornamental fish in the world. In 1994, 56% of US households (estimated at 94.2 million in total) had pets, and 10.6% owned ornamental freshwater and saltwater fish, with an average of 8.8 fish per household (APPMA 1994). The US pet industry in 1993 was estimated at $3.6 billion, and the retail value of the fish hobby was worth $0.91 billion. Sales associated with the ornamental fish hobby included aquarium accessories (57.7%), reef products (3.8%), freshwater livestock (30.8%) and saltwater livestock (7.7%).

Unlike the food fish industry, where a relatively small number of species are cultured (approximately 95), the trade in ornamental fish is believed to number into the thousands of species, including their varieties.

From 1989 to 1992, almost 79% of all US ornamental fish imports arrived from Southeast Asia and Japan. Singapore, Thailand, the Philippines, Hong Kong, and Indonesia were the top five exporting nations. South America was the second largest exporting region accounting for 14% of the total annual value; Colombia, Brazil and Peru were the major suppliers. The remaining 7% of ornamental fish imports came from other regions of the world. Prominent exporting countries included Costa Rica, Trinidad, and Haiti in Central America and Nigeria and Zaire in Africa. A few imports arrived from Australia and other Pacific Islands (primarily the Marshall and Fiji Islands). Europe played only a minor trade role.

The US Fish and Wildlife Service, Division of Law Enforcement has designated 11 ports of entry for live ornamental fish (Federal Register 1992). Shipments originating in Canada and Mexico may enter other specified ports. Patterns of import and export trade activities indicated that Los Angeles (39%), Miami (22%), New York (16%), Tampa (6%), and Honolulu (6%) were the major ports for entry of ornamental fish into the US during 1992. The 16% component of the imports directly into New York indicates a $150 million dollar industry could easily be supported or could be as high as $480 million is we use the $3 billion estimate from Davenport (1996). Regardless of which estimate used, the economic opportunity exceeds $100 million annually.

Freshwater fish accounted for approximately 96% of the total volume and 80% of the value of the imports. Most freshwater ornamental fish were farm-raised and imported from Southeast Asia. Over 90% of US exports of ornamental fish were cultured in the State of Florida. Of the 1,539 species declared as ornamental fish, 32 species dominated the trade. These were all of freshwater origin. The guppy (Poecilia reticulata) and neon tetra (Paracheirodon innesi) were the most popular ornamental fish kept in US households. These two species accounted for 37% of the total number of fish imported and were valued at approximately half a million dollars. These species with four others, the platyfish (Xiphophorus maculatus), betta (Betta splendens), Chinese algae-eater (Gyrinocheilus aymoniere), and goldfish (Carassius auratus), account for half the total number of ornamental fish imports. In addition, the top five species of these ornamental fish (except for the algae-eater) were valued at above $100,000 for each species. Although saltwater fish had a high market value (20% of the declared value of the imports), the volume of these fish was only 4%. The majority of the imported and exported saltwater ornamental fish were collected from the wild.

Approximately 90% of freshwater ornamental fishes are captively bred (Dawes, 1998) and have an estimated price per pound of US$35 to US$60 (Hoff, 1996). By comparison, marine ornamentals draw a much higher price ($400 to $600 per lb), however their captive breeding and culture is much less advanced. The culture of ornamental fish and invertebrates is now recognized as a feasible alternative to the wild harvest of specimens. In addition, many collecting localities around the world limit either the number of fish or the number of species taken, or both (Tlusty, 2002). The environmental challenges to aquatic ecosystems, coupled with poor animal husbandry after capture and pressure from conservation groups and governments, have also challenged the success of the ornamental fisheries business (cf., Corbin, et al., 2003, Green, 2003). These problems can be successfully addressed and hopefully resolved by employing the technology and programs proposed by RAS-driven urban aquaculture.

With the exception of a few fish that had significant price ranges (e.g., arowana, discus, goldfish, Celebes, rainbow fish, and oscar), the average price declared for an imported fish was between 26 and 28 cents (an individual fish will weigh 0.5 to 3 grams, hence the high price per lb). The average prices paid for imported egg layer and livebearer fish were 45 and 22 cents, respectively. The most commonly imported fish, the guppy (a live bearer) and neon tetra (an egg layer) were, however, valued similarly at about 14 cents. The neon tetra had less price variability. The most highly priced ornamental freshwater fish were all egg layers and included the goldfish, discus, arowana, clown loach, black ghost knifefish, and Celebes rainbow fish. The least expensive (commonly) imported freshwater fish was also an egg layer, the Chinese algae-eater Gyrinocheilus aymonieri with an estimated value between 5 and 7 cents. The average prices paid for imported ornamental freshwater fish were 45 cents for egg layers and 22 cents for livebearers. The results of this study document the importance of the ornamental fish industry and identify the most valuable species in the trade for potential domestic culture and protection in the wild.

Imported saltwater fish number approximately 809 species belonging to a variety of families. Saltwater ornamental fish species with high monetary value were imported from the Philippines (44.1%), Indonesia (25.5%), the Marshall Islands (6.2%), Nigeria (3.7%), Costa Rica (3.6%), Sri Lanka (3.2%), and Australia (2.6%). Average prices for saltwater fish were not estimated due to the great variability in individual prices.

The more prominent domestic exported ornamental fish included guppies, mollies, swordtails, platyfish, gouramies, barbs, tetras, armored catfish, and a variety of cichlid species. Ornamental saltwater fish originated primarily from the coastal waters of Florida and Hawaii. Only a handful of saltwater fish species were cultured and only those of the genus Amphiprion were exported in consistent numbers. The largest volume of annual exports went to Canada (29.0%), followed by Southeast Asia (25.3%), Europe (20.3%, primarily to England, the Netherlands, and Germany), Japan (17.6%), Central America (6.4%), and South America (1.0%). Annual exports to the Middle East, Africa, and Pacific Islands combined were less than 1% of the total export value.

Although the majority of the freshwater ornamental fish are now cultured, the vast majority of ornamental marine specimens continue to be collected from the wild. With improvements in aquarium technologies, interest in vertebrate and invertebrate marine ornamentals around the world is growing as never before. However, there is a concern that the continued capture of saltwater ornamental organisms will have irreversible effects on the ecosystem, particularly in developing nations where capture methods have often led to the severe depletion of species and severe reef damage.

Advances in the artificial propagation of marine food species have led to the belief that aquaculture can alleviate some of fishing pressure on wild stocks, as well as create viable industries. Because of the relatively high prices that saltwater aquarium organisms command, propagation of marine ornamentals, especially, can be a lucrative enterprise. In reality, however, the artificial propagation of many marine aquarium species is constrained because rearing protocols have yet to be developed that can achieve captive spawning, successful first feeding of the larvae, larval mass culture and growout in an economically viable manner.

It becomes blatantly apparent that the demonstrated demand for ornamental aquatic organisms and our current reliance, for the most part, on a foreign market dictates the development of this industry here at home. The national demand is mirrored in the Northeast. Newly developed RAS technology, with heretofore limited application to ornamental aquaculture, makes it feasible to conduct this industry in geographic regions not previously considered. New York State with its large population, a proportionally large segment of popular aquarists, a large labor force and an infrastructure for distribution, could serve in this capacity. The “appropriate” political and financial support and stimulation could make it happen.

BAIT FISH

The recreational fishing industry in New York State is important and thriving. However, NY imports almost all of the baitfish sold within our borders, importing primarily from Arkansas and other Midwestern states. Precise economic data is not available, but wholesale value is estimated at $3 to $5 million per year; total retail sales of baitfish in the US is around $1 billion, but farmgate sales are less than $100 million. Assuming that the size of the recreational fishery industry will remain fairly static, the potential for baitfish sales is somewhat bracketed into the $3 to $5 million range.

Pertinent references used to prepare this section of the White Paper Report:

Bassleer, G. 1994. The international trade in aquarium/ornamental fish. Infofish International #5, p. 15-18.

Chapman, F.A., S.A. Fitz-Coy, E.M. Thunberg, C.M. Adams, J.R. Rodrick and M. Andre. 1997. United States of America trade in ornamental fish. J. World Aquacult. Soc., p. 1-10.

Corbin, J.S., Cato, J.C and Brown, C.L. 2003. Marine ornamentals industry 2001: Priority recommendations for a sustainable future. In: Marine Ornamental Species. Collection, Culture and Conservation, p. 3-10. (J.C. Cato and C.L. Brown, eds.) Iowa State Press.

Davenport, K. E. 1996. Characteristics of the current international trade in ornamental fish, with special reference to the European Union. OIE Revue Scientifique et Technique. 15:436-443.

Dawes, J. 1998. International experience in ornamental marine species management. Part 1: perspectives. Ornamental Fish Int. J., 26, February 1999.

Florida Aquaculture Website (USDA): http://www.nass.usda.gov/fl/aqua4.htm

Fifth International Conference on Marine Ornamentals. Website: http://imina.soest.hawaii.edu/seagrant/marine_ornamentals99/index.html

Green, E. 2003. International trade in marine aquarium species. In: Marine Ornamental Species. Collection, Culture and Conservation. p. 31–48. (J.C. Cato and C.L. Brown, eds.) Iowa State Press.

Hoff, F.H. 1996. Conditioning, Spawning and Rearing of Fish with Emphasis on Marine Clownfish. Aquaculture Consultants, Dade City, FL, 212 pp.

Market Situation for Hawaii-Farmed Ornamental Fish. Cooperative Extension Service Economic Fact Sheet 26. August 1998.

Olivier, K. 2003. World trade in ornamental species. In: Marine Ornamental Species. Collection, Culture and Conservation, p. 49–64. (J.C. Cato and C.L. Brown, eds.) Iowa State Press.

Pet Industry Advisory Council, Pet Information Bureau. Internet website: http://petsform.com/PIJAC

Tlusty, M. 2002. The benefits and risks of aquacultural production for the aquarium trade. Aquaculture 205: 203-219.

5.0 MARKETING AND PROCESSING[6]

One of the most significant impediments to the development of aquaculture in New York State is the issue of marketing aquacultured fish competitively. Although New York State is close to many major markets, i.e., the many large cities of the Northeast with large populations and a particularly rich diversity of ethnicities, the challenge is how a grower of fish can reach these audiences in a cost-effective way so that the benefits of locally grown, very fresh fish can be realized.

Helping local producers reach local markets is a legitimate role for the State's Agriculture and Marketing Department to support with assistance from the academic community within the state. The focus needs to be on providing useful information that growers can use in their marketing programs.

What are some of the possibilities?

1. An educational campaign to teach growers about the technical aspects of the food preparation part of the operation
    a. How to ship fish to the live markets
    b. How to prepare fish for the market
        i. Purging
    c. How to prepare the various forms of fish in the most efficient manner. (Some research to improve this aspect is also needed.)
        i. Whole
        ii. Gutted
        iii. Headed and gutted
        iv. Filleted
    d. How to properly store fish
        i. Proper use of chilled water
        ii. Proper use of ice

[6]This section was written primarily by Joe M. Regenstein, Professor of Food Science, Cornell University.

2. An educational campaign on potential marketing aspects
    a. Finding and working with Dealers/Brokers
        i. What NY State laws protect the farmer
        ii. How to decide if you want to use a Dealer/Broker or do your own sales
    b. Finding direct markets
        i. Farmers markets, CSA, and other alternate marketing sources
        ii. Traditional retailers
            1. Supermarkets
            2. Fishmongers
            3. Restaurants
            4. Other foodservice
        iii. Ethnic markets
    c. Understanding the ethnic markets
        i. Where are they?
        ii. What types of fish and in what forms do they use them?
        iii. What do you need to know about the culture to be more comfortable working with these groups?
        iv. Learning to "bargain"

Much of the above material could easily be put up on a web site. The concept is similar to Cornell's sheep and goat marketing program and the associated web sites that have helped these farmers find more markets and learn more about marketing of their products.

Using modern technology one ought to be able to put up various other learning materials, including lectures, demonstrations, and PowerPoint presentations that would help the small aquaculturist with respect to marketing. Without some support in this area, it is highly unlikely that aquaculture will reach its potential in New York State.

Other activities that may be beneficial include "marketing trips," where a group of farmers are taken into one or more cities to learn more about the user communities and assistance with "cooperative" selling -- marketing pools can often play a very valuable role in helping small farmers target a market that any one of them cannot do on their own.

6.0 AQUACULTURE METHODOLOGIES

Economic expansion in NY of aquaculture will include a variety of production management methods. With proper implementation, many approaches may be implemented effectively. Each should be properly evaluated in a context that optimizes its chance of succeeding. With proper implementation, each can be implemented effectively. Traditions within the state and historical production methods and their supporting communities should be protected where possible. However, large scale expansion of production, particularly for food fish, will need to be done in a way that is both sustainable and environmentally conscious. We will start by providing a brief review of different management technologies.

There are several aquaculture methods for producing fish, including outdoor methodologies such as coastal farming, pond farming, and ocean net-pens, and also indoor recirculating aquaculture systems ("RAS"). Each methodology is particularly effective for different types of fish.

Coastal Farming. Coastal pond farms are primarily located along the seashores on both the Atlantic and Pacific coasts. The fish are fed by distributing the feed within the farm area, and harvesting is accomplished through draining the ponds. Issues specific to coastal farming include the high volume of ocean water used, and potential contamination of the water with fish waste, uneaten feed, and disease. Shrimp and shellfish are often raised through coastal farming.

Pond Farming. Inland pond farms are primarily located in warmer climates. The fish are fed by spreading feed on top of the pond. The pond is harvested by dragging a net across the pond, crowding the fish into a specific area. The fish are then lifted in nets out of the pond. Issues specific to pond farming include the high levels of fish waste and uneaten food left in the pond, and the attraction of birds and other predators to the high fish concentration in the pond. Catfish and tilapia are often raised in ponds.

Ocean Net-Pens. Large net-pens are placed in the ocean or in streams and stocked with fish. The fish are fed by spreading feed over the area encircled by the nets. The fish are harvested by raising the nets from the ocean. Issues specific to ocean net-pens include fish escaping through holes in the nets or over the top of the nets. Additionally, predator fish and animals can get into the nets, and birds are attracted by the high fish concentration. Ocean net-pens may have a negative environmental impact on the surrounding area due to high levels of fish waste and uneaten food. Salmon and sea bass are often raised in ocean net-pens.

Indoor RAS. Fish are raised indoors in tanks within a controlled environment. Production water is circulated through filtration systems and reused. Feed, oxygen and heat are provided based on the requirements of the fish, and wastes are filtered and removed. Issues specific to indoor RAS include the costs associated with maintaining the environment. Tilapia is often raised with indoor RAS.

Faculty at Cornell University, along with colleagues at CUNY and SUNY, have been focused on aquaculture for the last 15 years. A few other universities have been active in research focused on recirculating aquaculture systems (RAS), e.g., North Carolina State University, the University of Maryland, the University of California at Davis, and Louisiana State University. The Freshwater Institute, a division of the Conservation Fund-Shepherdstown, WV, and the Harbor Branch Oceanographic Institute (Ft. Pierce, FL) are private foundations that are leading major efforts in RAS. These institutions have contributed to an industry beginning to form around aquaculture production using recirculating aquaculture system (RAS) technology. RAS is still viewed as being most appropriate for high value aquaculture species, but in the last 5 years farms using RAS have become competitive with traditional aquaculture production in the production of tilapia.

COMPARISON OF OUTDOOR VS. INDOOR AQUACULTURE

Indoor RAS technology offers numerous advantages over outdoor systems, primarily because the growing environment can be totally controlled and production facilities are not geographically constrained. This means that consumers, regardless of location, can enjoy premium quality fish that are same-day fresh.

Pollution-Free. A major drawback of outdoor systems is that because the environment is not fully controlled, the fish can be exposed to pollution, both man-made (such as mercury or other heavy metals) or as a result of the system itself. High concentrations of fish result in high concentrations of fish waste and uneaten feed, which linger in the growing environment and the surrounding areas. Additionally, waste from predator birds pollutes the growing environment. By contrast, these are not issues with indoor RAS.

Disease-Risk. Outdoor systems are subject to uncontrollable vectors of disease transfer, e.g. water birds, amphibians, uncontrolled entry of other fish, lack of biosecurity. Indoor systems use filtered water and control the entry of new fish into the culture system. This allows the aquaculturist to exert a much greater degree of control and the ability to limit the entrance of pathogens into the culture environment resulting in a lower incidence of disease and losses to disease. If there is a disease event, effective treatment is more manageable and generally more economical than an outdoor pond system, primarily because of a much smaller quantity of water that must be treated.

Environmentally Clean. Outdoor systems may have a significant impact on the surrounding environment due to high levels of fish waste and uneaten feed. Indoor RAS provides for environmentally safe waste management through filtration and sewage treatment systems. There are no environmental limitations to the size of the RAS system to be built. The low environmental impact of these systems means that they can be built close to the consumer and replicated rapidly.

Free from Predation. Outdoor systems risk fish loss either to other fish or to birds and other predators. By contrast, indoor systems have no such issues.

Genetically Safe. In outdoor systems, issues related to fish escapement are of major concern, because the best fish to use for aquaculture are hardy and grow quickly. If released into the environment, these fish may come to dominate naturally occurring species. This is particularly problematic in the case of genetically modified species. According to the Pew Oceans Commission 2003 report, nearly one million Atlantic salmon escaped from farm pens on the western coast of North America in the last 15 years. The species is now successfully reproducing in British Columbia rivers and diluting the gene pool of native species by hybridizing with Pacific salmon. Fish cannot escape an indoor RAS and will, therefore, not have any impact on the natural populations.

Consistent Size. Outdoor systems result in a bell-curve distribution of fish size, with the result that some of the harvest is too small to be marketable. While the bell-shaped curve is present for most populations, the range or variance in the population becomes larger with increased variation or lack of control in the rearing environment. Indoor RAS provide the capability to closely maintain ideal environmental conditions that result in a fish population growing more uniformly throughout the year. Further, indoor RAS more easily than outdoor systems allows for culling of the harvest over its growth cycle, so that the end product is of consistent size.

Consistent Supply. In outdoor systems, growth cycles are impacted by weather and seasonality. This can result in inconsistent supply and swings in pricing. Indoor RAS can be managed to produce fish consistently throughout the year.

Efficient Feed Conversion. Outdoor systems are more difficult to monitor and feed, which results in poorer feed conversion and increased waste and pollution. By contrast, fish raised through indoor RAS are closely monitored to maximize feed conversion and limit feed waste.

Geographically Flexible. Outdoor aquaculture systems must be located within a suitably large water source. The environmental impact of these systems can be significant and therefore permitting can be difficult. By contrast, indoor RAS facilities are less dependent on natural resources and have less of an environmental impact. With indoor RAS, fish production can be located at the doorstep of the consumer.

Small Footprint. With indoor RAS, high concentrations of fish can be raised in a small area using relatively little water. As shown in Table 6.1, indoor RAS uses substantially less land and water than outdoor methodologies.

Table 6.1 Water and Land Requirements to Produce Seafood (Timmons et al., 2002)

Species and System	Production Intensity (kg/ha/y)	Water Required (Liter/kg)	Ratio = Land or Water Use to RAS Use	
			Land	Water
Tilapia in ponds	17,400	21,000	77	210
Catfish in ponds	3,000	3,000-5,000	448	400
Trout in raceways	150,000	210,000	9	2,100
Shrimp along coast	4,200-11,000	11,000-21,340	177	160
Tilapia in RAS	1,340,000	100	**1**	**1**

From Timmons, M.B., Ebeling, J.M., Wheaton, F.W., Summerfelt, S.T., Vinci, B.J., 2002. Recirculating Aquaculture Systems, pp. 760. Cayuga Aqua Ventures, Ithaca, NY.

Scaleable. Outdoor systems are constrained by the natural water resource in which they are based. Indoor RAS technology can be reproduced in numerous production pods within several facilities in a relatively small area, allowing effective economies of scale. Indoor RAS has higher production per unit area and per unit worker compared to outdoor aquaculture systems.

Species Adaptable. Indoor aquaculture can be used to grow a variety of fish. Because of its favorable characteristics, tilapia should be the first species to create a major industry comparable to the broiler or hog industry. However, indoor aquaculture adoption would allow farmers to follow market trends for seafood preferences and produce varying species, such as shrimp, caviar (sturgeon), striped bass, and other popular species, all of which can be produced using indoor aquaculture.

Cost Effective. Indoor RAS combined with new technology has now become cost-effective versus outdoor systems and ocean fishing. Historically the costs associated with controlling the fish environment have been high, despite all the other advantages of the indoor RAS. However, technology and fish management practices have now lowered costs to the point where aquaculture can become an efficient industry. This is similar to the experience of the domestic poultry industry, where chickens were brought indoors and the cost of environmental control was more than recovered by higher growth rates, improved feed conversion and more efficient use of labor.

7.0 APPENDIX

THE CAFO EVOLUTION INCREASED THE SIZE OF THE ANIMAL PROTEIN MARKET

Over the past 40 years the American consumer has increased its consumption of meat (not including seafood) from 75 to 97 kg per year, in part because of greater availability of product and lower pricing. This was made possible by the advent of confined animal feeding operations ("CAFO"), which increased efficiency and lowered prices in the poultry, dairy, hog and turkey industries.

Table 7.1 lists the per capita consumption of various types of meat since 1960. Per capita consumption of seafood grew through 1985 and then flattened out as ocean fishing peaked. Per capita consumption has been steady in the face of population growth only because aquaculture has filled the gap.

The US population has increased from 181 million to 280 million people since 1960. Assuming 104 kg of total meat (including seafood) per capita, the overall US market for meat is over 64 billion pounds.

Table 7.1 US per Capita Consumption (kg) of Various Meat Products 1960 to 2001 (Delmarva Poultry Industry 2002, and Economic Research Service/USDA)

Year	Chicken	Beef	Pork	Turkey	Total	Fish
1960	12.7	28.7	26.8	2.9	75.3	4.7
1965	15.3	33.9	23.5	3.4	79.5	4.9
1970	18.3	38.4	25.3	3.7	88.2	5.4
1975	17.7	40.0	19.5	3.8	83.5	5.5
1980	21.8	34.8	26.0	4.7	88.6	5.7
1985	24.1	36.0	23.6	5.3	90.4	6.9
1990	27.9	30.8	22.6	8.0	90.4	6.8
1995	32.0	30.6	23.8	8.1	95.5	6.8
2000	35.4	28.5	23.2	7.9	98.1	7.1
2001	35.2	30.1	22.8	7.9	96.8	7.0

Explosive Growth Occurred in the Poultry, Salmon, and Catfish Industries

Within the overall market, certain subsections such as chicken, salmon and catfish have grown dramatically and contributed to the overall growth of the sector. For instance, as Table 7.2 shows, the growth of the chicken broiler industry was dramatic once birds were brought indoors and a growing technology was perfected.

Table 7.2 Historical Increase in US Broiler Production (Economic Research / USDA)

Year	Production (million kg, ready to cook)	Compound Annual Growth Rate (percent)
1950	627	
1955	1,095	11.8
1960	1,968	12.4
1965	2,668	6.3
1970	3,490	5.5
1975	3,641	0.9
1980	5,147	7.2
1985	6,138	3.6
1990	8,367	6.4
1995	11,271	6.1
2000	13,713	4.0
2001	14,046	2.4

Similarly, Table 7.3 lists the dramatic growth of the salmon industry over the last 20 years. Again, this is an example the potential for explosive growth once a technology is refined, in this case net-pen aquaculture for salmon.

Table 7.3 Farmed Salmon Growth (Holder, industry sources)

Year	Production (mm kg per year)	CAGR
1980	20	
1985	50	20.1%
1990	250	38.0%
1995	550	17.1%
2000	1,100	14.9%

More recently than the broiler and salmon industries, the catfish industry has developed into a 630 million pound per year business, adding nearly 100 million pounds of production in only the last 2 years. The catfish industry was created as a concerted effort to transform poorly performing cropland into productive aquaculture pond farming. A collection of entrepreneurs, farmers, and bankers created this industry, modeled in part on the poultry industry.

GENETICS ADDED EFFICIENCY TO THE POULTRY INDUSTRY

To date, tilapia have not been genetically improved to any significant degree. There is ample opportunity for improvement in the growth, meat yield, and feed conversion of tilapia. Table 7.4 lists the productivity increases obtained by the poultry industry.

Table 7.4 US Broiler Performance From 1925 to 2000 (National Chicken Council)

Year	Market age average days	Market weight kg, live weight	Feed to meat gain kg of feed to kg of broiler, live weight	Mortality percent
1925	112	1.14	4.70	18
1935	98	1.30	4.40	14
1940	85	1.31	4.00	12
1945	84	1.38	4.00	10
1950	70	1.40	3.00	10
1955	70	1.39	3.00	7
1960	63	1.52	2.50	6
1965	63	1.58	2.40	6
1970	56	1.64	2.25	5
1975	56	1.71	2.10	5
1980	53	1.78	2.05	5
1985	49	1.90	2.00	5
1990	48	1.98	2.00	5
1995	47	2.12	1.95	5
2000	46	2.28	1.95	5

Combining the effects of reduced market age and increased harvest weight, there was a 19% gain in productivity expressed as rate of gain over a 10-year period from 1950 to 1960. The improved feed efficiency of the bird due to genetic selection and nutrition was 13% in this same period. It would be reasonable to assume that similar improvements or even better could be made in the tilapia industry.

TILAPIA IS CAPABLE OF BEING LOWER COST THAN MEAT BECAUSE OF LOWER FEED COSTS

The anticipated $36 billion of new aquaculture demand anticipated by 2010 dwarfs what can reasonably be expected to be produced in the near term. However, in the long run, farm raised tilapia has numerous advantages which will allow it to compete against other types of meat products (poultry, beef, pork and turkey), opening up the entire 64 billion pound flesh food market.

Being competitive long term in the commodity market for meat will depend to a large degree on two variables: a) the cost of feed used to grow the animals, and b) the associated efficiency of converting the feed energy into meat flesh. Ultimately, these two variables will dominate the cost of production because all other cost inputs can be reduced by economies of scale and by obtaining associated production efficiencies.

Table 7.5 lists current ingredient prices for feed mixes for hogs, poultry, tilapia and salmon. Feed to gain ratios describe the dry weight of feed necessary to produce a pound of animal weight gain. Feed to gain ratios are roughly 2.5, 2.2, 1.2 and 1.8 for hogs, poultry, tilapia and salmon. The ability of tilapia to efficiently convert a large amount of a low-cost diet into meat flesh is a major long-term advantage.

Table 7.5 Relative Cost of Feed for Various Commodity Animals (Timmons, industry estimates)

Component	Cost $/ton	Hogs	Poultry	Tilapia	Salmon
Fat (bulk)	$260	6%	6%		
Corn	$112	70%	62%	15%	
Soy	$187	23%	21%	40%	20%
Wheat	$153			20%	
Fish Meal (62% Protein)	$550		3%	10%	50%
Fish Oil	$508			2%	12%
Other (inexpensive)		1%	8%	13%	18%
Blended Ingredient Cost $/ton		$137	$138	$187	$373
Feed to Gain Ratio		2.5	2.2	1.2	1.8
Feed cost/lb of animal produced		$0.17	$0.15	$0.11	$0.34

THE FEDERAL GOVERNMENT HAS RECOGNIZED THE AQUACULTURE OPPORTUNITY

The aquaculture industry fulfills several federal, state and local objectives, including inexpensive food production, job creation, improvement of the US trade balance, and environmentally stable food supply. The US imported over $10 billion of seafood in 2000, of which $4.6 billion was for imported shrimp, salmon, and tilapia. To put this in perspective, the value of these three aquaculture products in 2000 was equal in to the combined exports of the US broiler and hog industries (USDA, LDP-AQS-14 Oct. 14, 2001). The total trade deficit related to seafood is $6.2 billion (US DOC).

Currently, the US aquaculture industry generates about $1.5 billion each year, with 70% of this being from catfish production. The US DOC (approved August 10, 1999) promulgated an official Aquaculture Policy to increase the value of domestic aquaculture production to $5 billion. Six other related goals were established followed by a series of policy implementation efforts. DOC was to develop a partnership effort with USDA, Department of the Interior, and other federal, state and local agencies to achieve these goals. This document is included in the Appendix to this report.

INDOOR AQUACULTURE WILL BE THE NEXT LARGE AGRICULTURE INDUSTRY

Although we have forecast a one billion pound US tilapia market in the next 10 years, this may prove to be a conservative assumption. As production of tilapia increases and the price drops, tilapia filets will be competitive with the other types of meat. Then, American consumers will start to choose tilapia filets instead of chicken, beef, pork, and turkey, which collectively add up to 213 pounds per capita per year. We have assumed only one pound per capita consumption of tilapia! A 2 to 3 pound per capita tilapia consumption level is an achievable and realistic goal. Three pounds per capita when expressed on a whole fish basis for the US translates to a 3 billion pound per year production industry, and 45,000 new jobs. In 10 years the US tilapia industry will be large, the only question is, will New York State be a leader in production? With assistance from New York State, we believe the answer can be yes.

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May 2, 2003

Aquaculture Production Survey

Cornell University has established a Program Work Team (PWT) that is made up of private industry, academic institutions, Cooperative Extension and NY Sea Grant. The PWT wants to update this survey information. The overall goal of the PWT is to document the current status of NY Aquaculture economic strength and to establish the historical trends in the industry.

This survey is being conducted to obtain estimates of aquaculture production for all species in New York State. Previous surveys have been limited to trout production. The data will be used for estimates of sales.

Response to this survey is voluntary. Your cooperation is extremely important to the success of this study. All information submitted will be kept confidential. Survey results will be made available for all categories where aggregate totals are large enough to protect the anonymity of the respondents.

If you have any questions regarding this survey, please do not hesitate to contact me at (607) 255-1630.

Thank you for your time.

Michael Timmons

PWT Co-Chair

Name:______________________________________

1. Please fill out the following table for your 2002 production year. For type, please use the following:

Bait	–	Finfish Bait	Orn	–	Ornamentals
Eggs	–	Eggs	Other	–	Other (please specify)
Fing	–	Fingerlings	Shell	–	Shellfish
Food	–	Food Fish	Stock	–	Stockers
NFBait	–	Non-finfish Bait (please specify)			

*For number, live weight, and price, if appropriate, use other unit measures and indicate what those unit measures are.

Example

Species	**Type**	***Number of Fish Sold**	***Average Live weight**	***Average Price Per Unit Measure**
Crayfish	NFBait	500	2 oz.	Price each or per 100
Hard Clams	Shell	500 bushels	-----	Price/bushel
Oysters	Shell	300 bushels	-----	Price/bushel
Rainbow Trout	Food	10,000	14 oz.	$2.50/pound

Species	**Type**	***Number of Fish Sold**	***Average Live weight**	***Average Price Per Unit Measure**

2. For each of the types listed below, please estimate the percentage of your sales volume for each of the categories listed on the left for your 2002 production year. (Each column should sum up to 100%).

	Bait (All Types)	**Eggs, Finger, Seed, Stocker**	**Food**	**Ornamental**	**Other**
A. Consumers					
B. Fee Fishing					
C. Government					
D. Live Haulers/ Wholesale					
E. Other Producers					
F. Processors					
G. Restaurant & Retail					
H. Other (please specify)					
	100%	**100%**	**100%**	**100%**	**100%**

3. For your 2002 production year, please estimate the number and weight of product lost before sale. If the number and pounds are not appropriate for your type of operation, please use other measures and indicate what those measures are.

	Number	Unit (pounds, bushels, etc.)	Percent Total Crop
A. Disease			
B. Flood or Drought			
C. Predators			
D. Theft or Vandalism			
E. Other (please specify)			
Total % Lost			

4. What are your primary methods of production? Please indicate percentages.

A. Fresh water indoor recirc. system	
B. Fresh water ponds, rivers, lakes	
C. Marine culture	
D. Other (please specify)	

5. Comments, suggestions or explanations:

Please mail the survey back in the self addressed, stamped envelope to:

Brenda Marchewka
Cornell University
312 Riley-Robb Hall
Ithaca, NY 14853

U.S. DEPARTMENT OF COMMERCE AQUACULTURE POLICY

Approved August 10, 1999

Vision for U.S. Aquaculture. To assist in the development of a highly competitive, sustainable aquaculture industry in the United States that will meet growing consumer demand for aquatic foods and products that are of high quality, safe, competitively priced and are produced in an environmentally responsible manner with maximum opportunity for profitability in all sectors of the industry.

DOC Aquaculture Mission. A mission of the Department of Commerce (DOC) is to create sustainable economic opportunities in aquaculture in a manner that is environmentally sound and consistent with applicable laws and Administration policy. This mission complements and is an integral part of the Department's effort to restore and maintain sustainable wild stock fisheries in order to maximize the benefits of U.S. coastal resources for its citizens. Aquaculture in the United States can make major contributions to the local, regional, and national economies by providing employment in a new and diverse industry and by creating business opportunities both here and abroad. The United States can lead the world in the development of aquaculture technologies and advance international guidelines for the industry in order to maintain a healthy environment.

Definition. Aquaculture is defined as the propagation and rearing of aquatic organisms in controlled or selected aquatic environments for any commercial, recreational, or public purpose.

DOC Aquaculture Objectives. The DOC and its agencies, working in partnership with USDA, DOI, other Federal agencies, state, local, and tribal governments, environmental organizations, industry, academia, and other stakeholders at the national and regional levels will create a business climate and technological base for industry to develop environmentally sound aquaculture. The specific objectives by the year 2025 are to:

1. Increase the value of domestic aquaculture production from the present $900 million annually to $5 billion, which will help offset the $6 billion annual US trade deficit in seafood.

2. Increase the number of jobs in aquaculture from the present estimate of 180,000 to 600,000.

3. Develop aquaculture technologies and methods both to improve production and safeguard the environment, emphasizing where possible, those technologies that employ pollution prevention rather than pollution control techniques.

4. Develop a code of conduct for responsible aquaculture by the year 2002 and have 100 percent compliance with the code in Federal waters.

5. Double the value of non-food products and services produced by aquaculture in order to increase industry diversification.

6. Enhance depleted wild fish stocks through aquaculture, thereby increasing the value of both commercial and recreational landings and improving the health of our aquatic resources.

7. Increase exports of U.S. aquaculture goods and services from the present value of $500 million annually to $2.5 billion.

Policy Implementation. To achieve these objectives, the Department of Commerce and its agencies, working in partnership with USDA, DOI, other Federal agencies, state, local, and tribal governments, environmental organizations, industry, academia, and other stakeholders at the national and regional levels will:

- Develop a set of aquaculture guidelines for DOC aquaculture activities by the end of the year 2000 and ensure that all subsequent DOC activities conform to these guidelines.

- Conduct research and help develop guidelines for an environmentally sound and sustainable aquaculture industry and promote domestic and international compliance with the guidelines.

- Consistent with these guidelines, conduct basic and applied research to domesticate additional species, giving preference to high-value species and to those that are least likely to create problems for the environment.

- Deliver U.S. government aquaculture services, assistance, and research to state and local governments and industry in a comprehensive and coordinated manner.

- Hold national and regional meetings with aquaculture constituents to inventory present resources and issues and set priorities for the future.

- Develop an efficient and transparent permitting process for aquaculture.

- Accelerate the implementation of new aquaculture production methods by developing both pilot scale and demonstration projects where necessary.

- Develop effective enhancement strategies, where appropriate, for aquatic species to help wild stock fisheries recover and to provide additional recreational opportunities.

- Integrate aquaculture development with wild fish stock management and environmental stewardship to maximize the value of our aquatic resources for the benefit of the nation.

- Minimize the adverse impacts of aquaculture on protected species through proper design and siting of facilities and the application of appropriate deterrent technology.

- Provide financial, marketing, and trade assistance to the aquaculture industry.

- Provide extension, training, and education programs to ensure a competitive, safe industry.

- Provide an information clearinghouse and information dissemination system.