Critical National Need Title:

Sustainable Shrimp Aquaculture Alternative: New Disruptive Technology

Contributing Organization:

Royal Caridea, LLC

603 S. Mays Street

Round Rock, TX 77864

Phone: 916-616-7038

Fax: 512-388-3960

E-mail: Meese404@gmail.com

Summary:

The technology described in the "white Paper" that follows has the potential of revitalize the shrimp farming industry in the U.S., increase jobs, help the economy and decrease the 4 to 7 billion dollar import deficit for shrimp. The technology is disruptive.

As part of the development Royal Caridea, LLC will work with Texas A&M to establish a fully functioning totally enclosed small scale "closed-system" super-intensive shrimp production facility at Texas Agrilife Mariculture Research Center in Port Aransas, TX. This facility will provide evidence that the system created by Dr. Addison Lawrence can be scaled up to produce shrimp that can meet market demands and that production can be sustainable. Based on the results from this study Royal Caridea, LLC will setup a fully closed industrial scale system to produce 1,000,000 lb of shrimp per year. The technology will be licensed from Texas A&M University that was invented by Dr. Addison Lawrence, Regent Professor Texas A&M University.

The “closed-system” to be constructed will serve as a model system and will be expanded worldwide under license. Dr. Lawrence and his students will participate in the design and have access to bring about improvements through further research.

Request:

As discussed in the “White Paper” (see below), Royal Caredia, LLC is looking to setup a “closed-system” super-intensive production system. As stated in the “White Paper” such systems are financially demanding but have significant financial reward if they are proven viable.

A financial analysis indicates setup and operation will require an investment of $3,000,000. Royal Caridea, LLC has commitments for $500,000 and we are working with investors to raise additional capital. In addition, we are seeking a grant to support development.

Sustainable Shrimp Aquaculture Alternative: New Disruptive Technology

Background

Current Methods of Shrimp Production are not Sustainable

The Rise and Fall of the Blue Revolution - by Alfredo Quarto, East Africa Wildlife Society's magazine *SWARA,* October-December 1998 (pp.16-21).

Beginning in the 1960s and 1970s, industrial processes were widely introduced into aquaculture to encourage commercial production. Then in the early 1980s, major improvements in hatchery production and feed processing allowed rapid advances in shrimp farming techniques, making it possible to produce dramatically increased yields. This "Blue Revolution" has in many ways retraced the steps of the "Green Revolution" in agriculture. The latter contributed to the growth of large-scale export-oriented agribusiness enterprises in developing nations, but it also generated widespread criticism for its environmental and social impacts. The new aquaculture techniques resulted in an explosive expansion of coastal shrimp aquaculture throughout developing nations in Asia and Latin America.

Over 85% of worldwide farmed shrimp is produced in Asia. Approximately two-thirds of it is exported to Japan and the United States, with the remainder divided among other foreign markets and luxury domestic markets. Though trawler-caught shrimp still dominate 2/3 of the world shrimp market, the rate of growth in farmed shrimp production will allow that sector to overtake, and even surpass, the wild-caught production by the year 2000. Farmed shrimp production has truly skyrocketed, rising from just 26 thousand metric tons of production in the 1970s to 100,000 metric tons in the early 1980s to over 700,000 metric tons in 1995.

Bankrolling a Bankrupt System

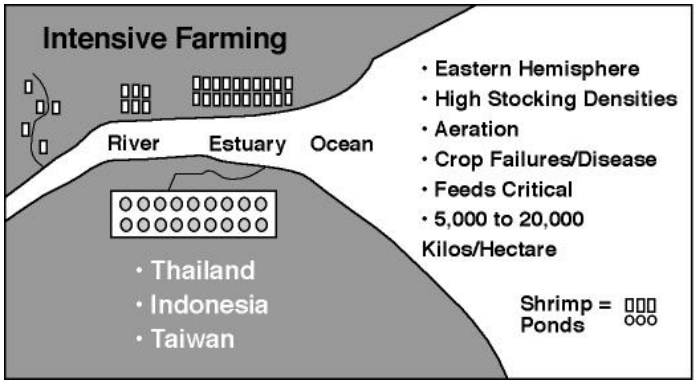
Shrimp aquaculture has become a global industry that has an annual farm-gate value of over $6 billion dollars, and an annual retail value of over $20 billion dollars. It has great profit potential for the astute investor and entrepreneur. Spurred on by governments eager for increased export dollars, shrimp aquaculture development has been aided by generous support and incentives from international lending institutes, including the World Bank, Asian Development Bank, and Inter-American Development Bank. One high profile rationale used by international lending

agencies to justify the investments in aquaculture has been its assumed importance as a tool to help meet food needs in developing countries, i.e. to "feed the poor". Ironically, the shrimp produced from these investments have been channeled exclusively to luxury consumers in domestic and international markets, and have never become a food source for those who are truly hungry. Meanwhile, the coastal poor are being robbed of their once sustainable food sources as their traditional agriculture and fisheries are being steadily despoiled by the shrimp industry's operations.

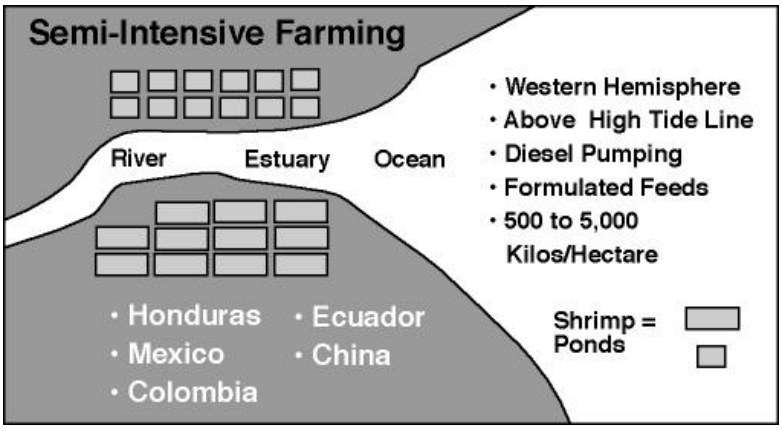
Over half the world's human population is concentrated along coastal areas. These important zones also support a vast array of other life dependent upon healthy ocean ecosystems. Yet, today our oceans are beleaguered by overfishing, pollution, and mass destruction of coastal resources via unsustainable forms of modern development. Serious declines in wild fish stocks amid increasing world consumer demands for more fish products have combined to present a dilemma on how best to meet these new challenges.

Proposed Solution—Aquaculture

Aquaculture is being highly lauded by governments, world lending institutes, and industry. Many see it as the next logical step towards solving the above problems, and offering a revolution in modern fisheries--the **"Blue Revolution"**. Following on the heels of agriculture's "Green Revolution", modern aquaculture promised to turn the tide on food production from the seas and waterways, delivering into the world's eager hands the key that unlocks the door to "farming the sea." However, there are major problems.



Aquaculture might be broadly defined as the establishment of man-made enclosures to raise aquatic life forms, such as shellfish, fish, and sea weeds for human consumption purposes. The aquaculture process itself is quite ancient, having appeared in traditional, less-intensive forms nearly 2000 or more years ago in Asia and other parts of the world. The Gei Wais of Hong Kong and the Tambaks of Indonesia, offer striking examples of traditionally derived forms of aquaculture which still exist today. Unfortunately, since the advent of more modern intensive and semi- intensive industrial aquaculture, serious



environmental and social issues have developed. Millions of indigenous coastal people are being adversely affected, many losing their livelihoods, homes, and cultures to unsustainable aquaculture development. Meanwhile, , in the cities and towns of the wealthy consumer nations, where imported fish products are sold in great volumes, little is known of the great hardships created by these "revolutions" in farming the land and the sea. Few consumers of aquaculturally raised products are aware of the many serious problems caused by the incoming tide of the aquaculture industry, where ruin and riches run simultaneously, like two parallel, yet opposing sea currents.

In the last 15 years, the rapid and largely uncontrolled expansion of the shrimp aquaculture industry has led to immense environmental and social problems. Among the most serious problems is the degradation and loss of natural coastal resources. Unsolved pollution problems plague the industry, despoiling once fecund waters of nearby estuaries and inshore coastal bays. Formerly rich fishing grounds are being impacted, and vital fish breeding and nursery habitat are being lost to the encroaching shrimp farms.

In 1982, only 60 percent of shrimp consumed in the United States was imported. Now, nearly nine of every 10 shrimp eaten in the United States comes from overseas, with Chinese shrimp accounting for a fast-rising proportion of that total. Currently, more than 80 percent of the seafood Americans consume is imported, and at least 40 percent of those imports are farm-raised seafood.

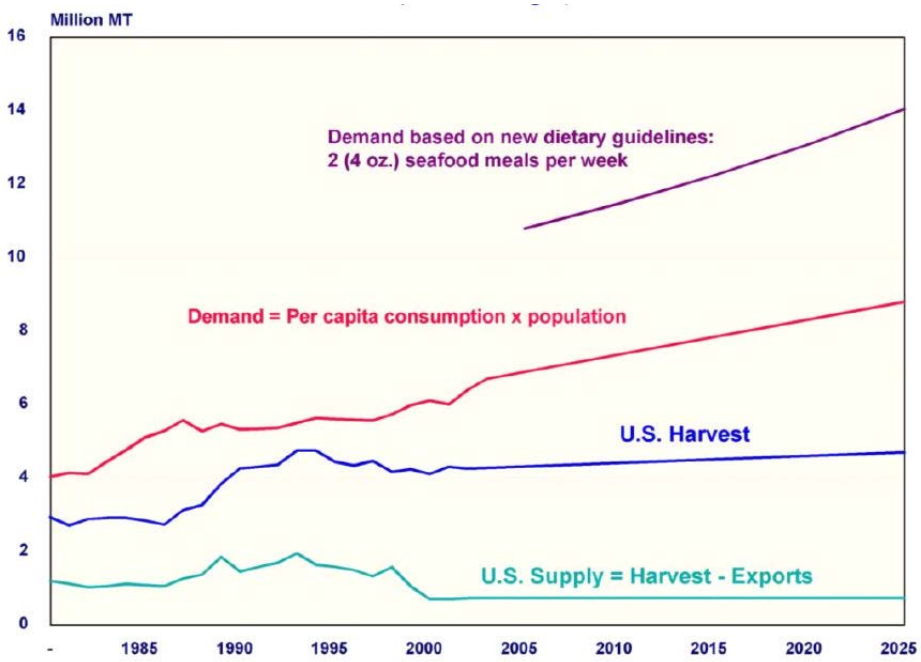
According to the National Marine Fisheries Service, the US imported 1.74 *billion* pounds of shrimp in 2006, versus domestic production of only 182 *million* pounds. Last year, one out of every dozen shrimp imported into the US came from China: a pile of farm-raised crustaceans weighing some 150 million pounds. And that total is expected to rise fast, with Americans eating more shrimp than ever … about 4.4 pounds per person annually.

In 2006, domestic seafood consumption saw a higher percentage from imported product, a trend that has been going on for some time. These imports stem in large part from foreign aquaculture or “farmed” production that has experienced issues with quality and chemical additives, for years. Almost all foreign countries are in the same situation as the U.S. with limited ways to increase their wild harvest seafood industry (see Figure below entitled **Global capture production of** *Litopenaeus vannamei*), so they are expanding their aquaculture production often times under less stringent controls then the U.S. The continued growth of shrimp in the marketplace provides a good example of how farm-raised product is being used to satisfy that need. In this industry most of the growth continues to come from Asian farm raised production.

In 2004, seafood total imports exceeded $11.2 billion. This is up from $6 billion in the late 1980’s. Today shrimp is now over 1/3 of the total value of all seafood imports. The United Nations is projecting a 40 million ton global seafood shortage by 2030, unless something is done. While NOAA works to end over fishing and rebuild wild seafood

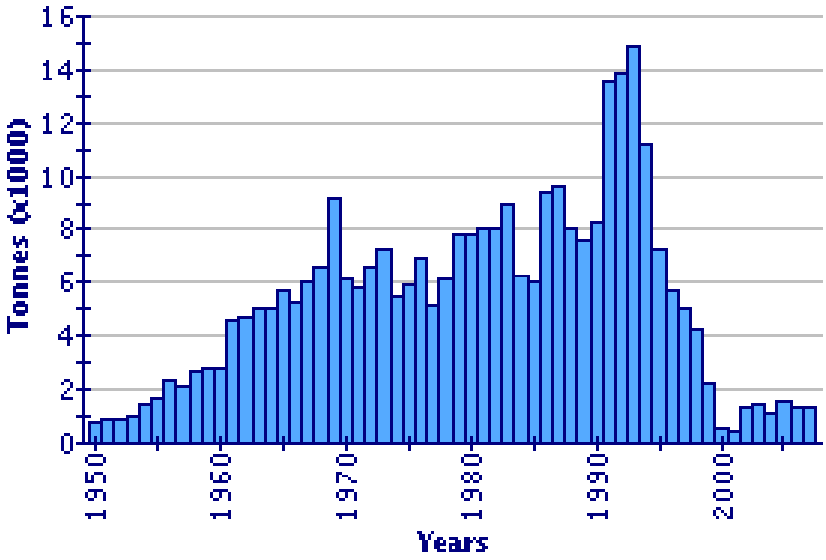
stocks, the United States still needs aquaculture to narrow the trade gap and to keep up with consumer demand. **Just to cite an example of the endangered United States**

U.S. Seafood Supply and Demand: Past and Projected



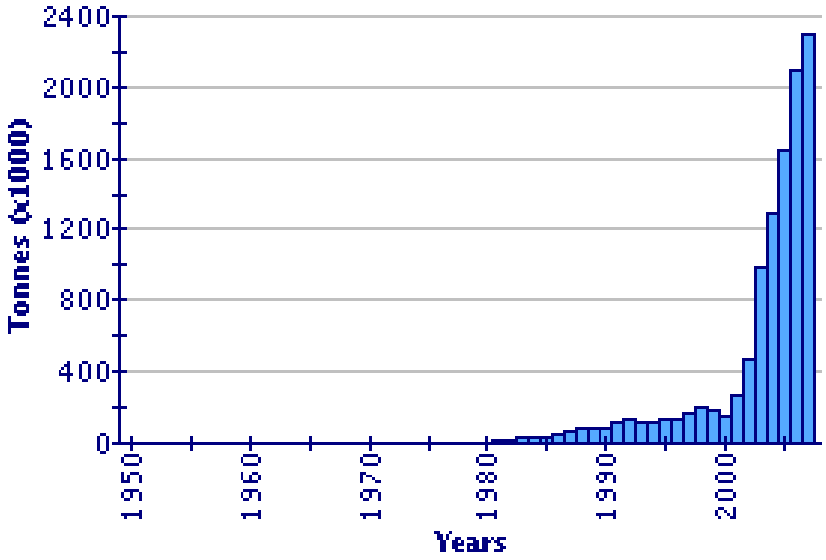
consumption, the casinos in Las Vegas go through 68,000 pounds of shrimp each year. Within 5 years the "American shrimp fisheries" will have totally collapsed. The collapse of shrimp fisheries is illustrated in the following figure.

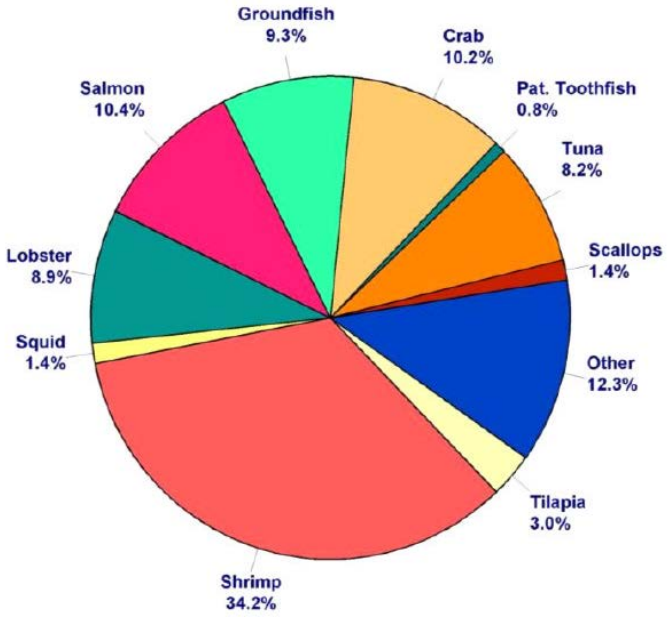
Global capture production of *Litopenaeus vannamei*



Despite collapse of the shrimp fisheries, demand has not gone down. Demand has been met by aquaculture in Southeast Asia and Latin America countries using intensive farming methods with the associated non-sustainable ecological production problems.

Global aquaculture production of *Litopenaeus vannamei*





Composition of Major U.S. Seafood Imports, 2004

Total Imports = $11.2 billion

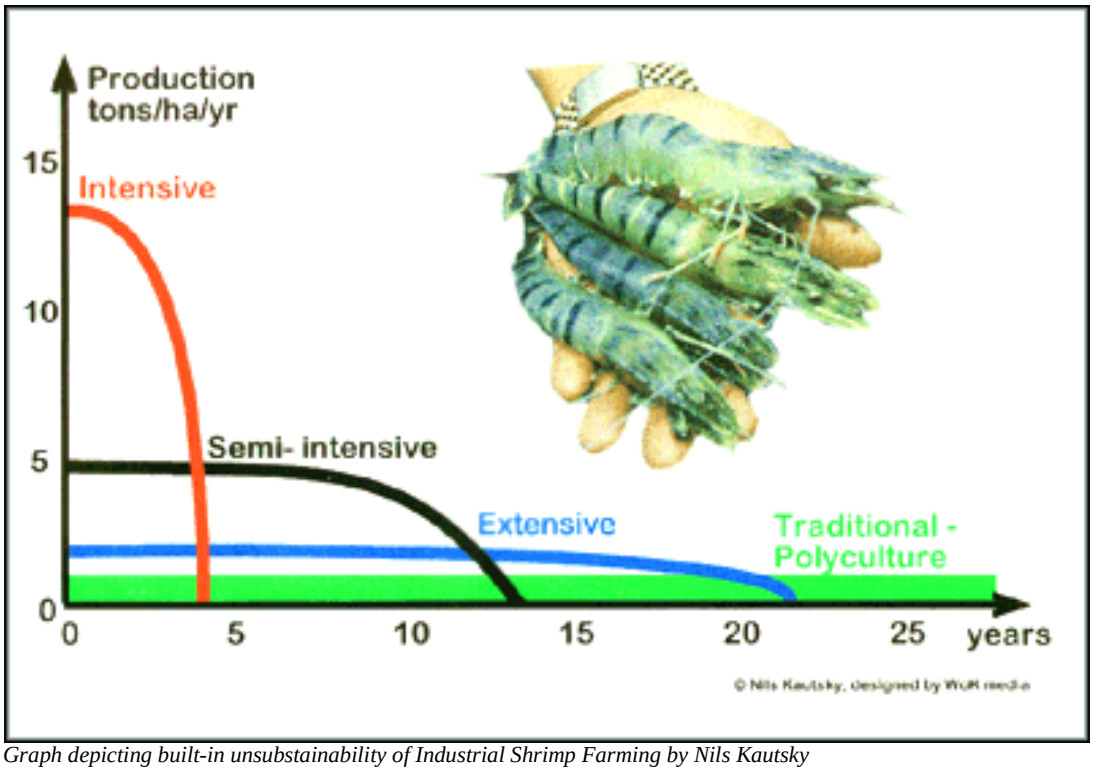
On a dollar basis, the United States imported in January 2009 over $301,000,000 of shrimp. **This is in a down economy.**

What Options are Available for Sustainable Shrimp Production?

In actuality there are very few options. The Mangrove Project points (http://www.mangroveactionproject.org/issues/shrimp-farming/sustainable-alternatives-of-shrimp-aquaculture) to traditional aquaculture. These forms of shrimp aquaculture are all currently being practiced in areas of the world today, and they all appear to meet most, if not all of the **criteria for sustainable shrimp culture** in that:

1. they maintain the integrity of affected ecosystems;
2. there is an equitable balance with natural resources and resource-users of affected coastal zone;
3. they are structured to promote social and economic equity within and between nations
4. they are economically viable.

However, as can be seen in the following figure, extensive and traditional polyculture aquaculture cannot come close to meeting world demand. Likewise, intensive and semi-intensive production methods will ultimately fail as well because they have major ecological and associated social problems. A way forward that meets ecolological specifications and is sustainable if shrimp is going to be a viable food product in the future must be found. The only real option is “closed-system aquaculture.



Graph depicting built-in unsubstainability of Industrial Shrimp Farming by Nils Kautsky

Closed-System Shrimp Aquaculture

In the US, Thailand, and other countries where industrial shrimp aquaculture is being competitively pursued using intensive and semi-intensive methods, a new alternative method is seen as more sustainable. This is the so-called "closed production system" approach. The aquaculture industry has itself been wrestling with those many insurmountable problems inherent in the so-called "open production systems,"i.e., the traditional, extensive, semi-intensive and intensive production models. This stems from the fact that these present-day methods of shrimp aquaculture pollute and degrade their surrounding environments, while at the same time depending on a healthy state of natural resources to maintain their own production. This reliance on the health of the external environment, such as the sea and fresh water sources, while at the same time degrading these very vital supporting systems with massive amounts of toxic effluents, classifies these self-degenerative open-cycle production schemes as "throughput systems."

The "closed-system" potentially eliminates many of the obvious failures of the modern "open-production system," by operating in a more environmentally "friendly" fashion. Recirculating production pond waters, which remove toxins from these fouled waters, are one step in the right direction. Recycling of the effluent waters emanating from the production ponds can be done in various ways, ranging from complex and costly water filtration systems to establishment of settlement ponds, or integrated secondary containment ponds.

High technology closed systems are being tested now. Dr. Addison Lawrence has run numerous studies to evaluate the effects of stocking density and water exchange on growth and survival in a closed-system. It has been demonstrated that shrimp can be raised at super-intensive levels at levels equivalent to 500 m^3. Taking it to the next level in a totally enclosed production system using shallow raceways is the subject of this submission.

There is hope that such an innovative closed-system aquaculture enterprise will succeed, where the open-cycle systems have so miserably failed. Water quality is obviously a major concern of any aquaculture facility, and elimination of antibiotics, pesticides, and fertilizers will help alleviate one of the major contributing factors leading to water quality declines during production. Improved feeds and feeding regimes are also important considerations in water quality control, as is regular careful monitoring and assessment of the internal pond environment. All of these factors have been considered.

In addition to the ecological advantages of an organic, closed-system approach, the pond operator can actually stagger harvests and sizes to produce whatever the current market demands on a year-round basis. The initial financial risk is steep; however the closed-system eliminates many of the production risks that are beyond the control of most shrimp farm operators such as: pollution and disease from coastal water exchange, natural predators, weather peculiarities, and the side effects or long-term effects of medicinal additives such as synthetic antibiotics. These drawbacks are increasingly unappealing to consumers who want to know how their food is produced.
Closed-systems, hold great potential to one day fill the current market demands of those numerous shrimp importing nations, especially when today's consumption demands far outweigh the current ability of the industrial aquaculturists to produce enough shrimp in environmentally and socially friendly ways.

As part of the development Royal Caridea, LLC will work with Texas A&M to establish a fully functioning totally enclosed small scale "closed-system" super-intensive shrimp production facility at Texas Agrilife Mariculture Research Center in Port Aransas, TX. This facility will provide evidence that the system created by Dr. Addison Lawrence can be scaled up to produce shrimp that can meet market demands and that production can be sustainable. Based on the results from this study Royal Caridea, LLC will setup a fully closed industrial scale system to produce 1,000,000 lb of shrimp per year. The technology will be licensed from Texas A&M University that was invented by Dr. Addison Lawrence, Regent Professor Texas A&M University. This new technology has the potential to revitalize the shrimp farming industry in the U.S., increasing jobs, helping the economy and decreasing the 4 to 7 billion dollar import deficiency of shrimp.

The "closed-system" to be constructed will serve as a model system and will be expanded worldwide under license. Dr. Lawrence and his students will participate in the design and have access to bring about improvements through further research.

The full project is delineated in the Royal Caridea, LLC business summary that follows:

Royal Caridea, LLC Business Summary:

Shrimp, once regarded as a luxury food by most people, has become more affordable and available as demand for it steadily rises in the major consuming markets of the United States, Japan, and various European countries. In 2007 the United States consumed over 556,000 tons (T) of shrimp at an estimated market value of $3.9 billion dollars, of this; the United States imported almost ninety four (94%) percent[1]. Fortunately, new technology developed by Dr. Addison Lawrence at the Texas AgriLife Research Mariculture Laboratory at Port Aransas, a Texas A&M System facility will permit vastly expanded production of high quality farmed shrimp in the USA, generating American employment, reducing foreign trade and opening the door for international export of this technology.

Royal Caridea, LLC (Caridea) is securing the exclusive license of the Dr. Addison Lawrence "Super-Intensive Raceway Shrimp Farming Technology".

The problem is simple, American demand for shrimp is far beyond the current American shrimp farming capabilities and domestic fisheries are not able to meet the need. Worldwide shrimp farming methods are failing. This is caused in part by a combination of factors including geographic and climatic conditions, water pollution, pond contamination, and most importantly disease caused by assorted shrimp pathogens. The most common disease is vibriosis caused by *Vibrio spp.* The direct economic implications of Vibriosis can be devastating, particularly when acute outbreaks occur. Shrimp infected with *Vibrio spp* become weak and disoriented and may have dark wounds on the cuticle. The mortality rate can exceed 70% [2]. Additionally, the inexorable global expansion of marine shrimp farming generated by market demand has brought with it ineffective intensive farming systems, rise in uncontrolled nomadic farmers, sociological disputes, loss of water quality and disease in many shrimp farming countries.

The “solution” is the Texas AgriLife Research Mariculture Laboratory commercial super-intensive raceway shrimp farming technology (SIRSFT), a true disruptive technology. SIRSFT can increase shrimp aquaculture production levels from a maximum of 20-25 metric tons (MT) per hectare (2.47 acres) per year to greater than 300 MT per hectare per year, an increase of more than twenty times the current shrimp aquaculture farming methods. This increase in production made possible by SIRSFT is related to implementation of biosecurity programs to prevent introduction of pathogens and the elimination of the need for chemicals (some toxic to humans) such as antibiotics commonly employed by Asian and Latin American aquaculture farmers (Nitrofurans, chloramphenical, etc.). SIRSFT also eliminates social and environmental problems associated with shrimp aquaculture. SIRSFT is a practice which will result in a sustainable manner with minimal environmental impact.

The result is daily production of a high quality, high yield product of marketable shrimp at locations close to customers with a focus on sustainable shrimp production using an environmentally friendly production approach.

Caridea will market and offer for sale three products: Fresh live, Fresh Dead and Frozen Head On shrimp (“Products”). The three products will be 30 to 35 gram shrimp selling as U15 (15 shrimp to a pound). Caridea will target the USA market initially and follow into the international opportunities.

Caridea will be a Delaware Corporation with its initial business starting in Texas. It will be based in Texas and will build its first sustainable aquaculture production shrimp farming facility in Texas. The location will be near a major metropolitan city, as close as possible to Port Aransas, Texas to allow for as much participation from Dr. Addison Lawrence and his student(s) (funded by Caridea) in the construction and startup of the SIRSFT system. Caridea will locate and lease warehouse space, that is readily available, and fund infrastructure necessary for installation and operation of a sustainable shrimp aquaculture production plant based on SIRSFT. The facility will be setup and outfitted to produce Products at the rate of at least 1,000,000 pounds per year. Caridea will also use this facility as its primary distribution site to deliver Products to customers including wholesalers, restaurants, and food chains and where appropriate other distributors.

This facility will not only serve as our proof of concept and provide initial Products-to-Market, but it will be the blue print for sustainable shrimp aquaculture worldwide.

As Caridea understands, SIRSFT was developed by Dr. Addison Lawrence at the Texas AgriLife Research Mariculture Laboratory at Port Aransas, a Texas A&M System facility. The technology is proprietary. A patent entitled “SYSTEM AND METHOD FOR SUPER-INTENSIVE SHRIMP PRODUCTION” has been filed by Dr. Addison Lawrence. The technology 1) has been validated in pilot studies, 2) delivers consistent weekly weight gains, 3) yields shrimp having mean weights in excess of 30 g in times as low as five months, 4) shrimp survival rates higher than that observed in pond raised shrimp, and 5) feed conversions of less than 1.5. All features listed in 1 through 5 can be accomplished indoors, in a controlled environment, minimizing environmental and social issues and misuse of land. Most importantly SIRSFT allows for a

significant increase in shrimp production and yield per square meter, minimal use of valuable water and therefore more saleable product that adds directly to the bottom line.

[1] US Shrimp Market Report 2008

[2] Wikipedia Shrimp Farm Diseases

Initial Market: United States of America:

Harvesting of wild ocean shrimp has hovered around two million T a year since the early 1980s. Shrimp fishing has not been able to keep up with world demand. As a means to expand shrimp production, shrimp farming has sprung up along vast stretches of tropical coastlines of many developing countries in an effort to meet the ever growing demand for shrimp. Shrimp output exploded from under 84,000 T in 1982 to more than 712,000 T in 1995, a nine-fold increase. **Today, more than one-quarter of the shrimp consumed worldwide is produced on farms, and the proportion of shrimp farming is predicted to rise to 50 percent as shrimp demand expands and wild catches from overfished shrimp fisheries decline.**

In the U.S., the world's leading shrimp consuming country, shrimp competes with tuna as the most popular seafood. The United States imports up to one-half of the total world production of farmed shrimp and restaurant chains such as Red Lobster, Bubba Gump, Shoney's Long John Silvers, etc., built reputations and market share by selling shrimp to millions of Americans. Red Lobster alone sells almost five percent of the farmed shrimp produced worldwide. According to the President of ICEC Seafood Corporation[3], "Red Lobster's advertising of shrimp has stimulated all consumption and in large part made possible the 250 percent increase in US shrimp consumption since the advent of aquaculture".

The U.S. consumption of seafood, particularly shrimp, continues to increase every year, while supplies from domestic producer's remains in decline. Therefore, more seafood shrimp products are imported every year to satisfy an increasing demand.

In 2004, seafood total imports exceeded $11.2 billion. This is up from $6 billion in the late 1980's. Today shrimp is now over 1/3 of the total value of all seafood imports. A division of the United Nations, Food and Agriculture Organization (FAO) is projecting a 40 million T global seafood shortage by 2030, unless something is done. National Oceanic and Atmospheric Administration (NOAA) is working to end over fishing and rebuild wild seafood stocks, but the United States still needs dramatic increases in aquaculture to narrow the trade gap and to keep up with consumer demand. Just to cite an example of the endangered United States consumption, the casinos in Las Vegas consume more than 68,000 pounds of shrimp each year. It is projected that within 5 years the American shrimp fisheries will most likely collapse without undergoing vast changes.

Beyond immediate demand there is an additional market that Caridea will target and that is the organic market. Every major food chain and niche marketplace now has an organic section. To address that highly profitable area, Caridea's aquaculture facility will be in strict compliance with

organic standards and will be ready for certification when the U. S. finally defines an organic seafood standard. This is anticipated to occur in late 2009.

It is worth noting that fresh imported shrimp amounted to less than $2,500,000 in sales in January 2009 and most of this came from Pakistan. Caridea using SIRSFT will take this market niche and dramatically expand this market opportunity.

[3] http://www.fao.org/docrep/007/y5767e/y5767e0j.htm

Problem: Shrimp demand is out pacing production and current shrimp farming methods are failing.

The problem is simple, the demand for shrimp is out pacing American production and current shrimp farming methods cannot meet demand domestically. Failing farming methods are caused by a combination of factors including climate, pollution, pond contamination, and most importantly disease caused by assorted shrimp pathogens. The most common disease is vibriosis caused by *Vibrio spp.* The direct economic implications of Vibriosis can be devastating, particularly when acute outbreaks occur. Shrimp infected with *Vibrio spp.* become weak and disoriented and may have dark wounds on the cuticle. The mortality rate can exceed 70% [2]. Additionally, the inexorable global expansion of marine shrimp farming generated by market demand has brought with it non-sustainable farming practices, rise in uncontrolled nomadic farmers, sociological disputes, loss of water quality and disease in many shrimp farming countries. Specifically:

- Domestic shrimp fisheries worldwide are in distress.
- Domestic shrimp farming in U.S, is failing due to climatic location, disease and other problems. It may soon to be non-existent.
- Imported shrimp distorts the U.S. trade balance and makes the U.S. increasingly more dependent on foreign sources of seafood products.
- Shrimp aquaculture as practiced in countries like India, Bangladesh, Thailand, Honduras and Ecuador causes both environmental and social problems that cannot be sustained and result in inappropriate loss of useable land and land resources.
- There are safety concerns with respect to imported shrimp from China and other Southeast Asian countries because of toxic chemicals and/or antibiotic residues associated with shrimp raised in these areas.
- The world needs **an alternative** protein rich **food** for an ever growing population. Countries have routinely turned to the sea to meet protein needs, however most

fisheries including shrimp fisheries worldwide are in collapse. Countries must turn to aquaculture to meet this need.

Solution: Commercial Super-Intensive Raceway Shrimp Farming Technology (a true shrimp farming disruptive technology)

The commercial super-intensive raceway shrimp farming technology, developed by the Texas AgriLife Research Mariculture Laboratory at Port Aransas, TX is truly ***a disruptive technology***.

Commercial shrimp farming industry as a whole is in the equivalent position to where the chicken industry was in the late 1960's and early 1970's. Basically this was a time when the chicken farming industry started to saturate the market, production cost for many commercial farms started to exceed farm gate value, disease was becoming a greater problem and many of the existing commercial farms were starting to fail. However, poultry producers that incorporated new technology through intensification, biosecurity programs and the development of higher quality and lower cost feeds resulted in increased predictability of production, increased production levels and decreased production cost that allowed the adopters to flourish and be profitable. This resulted in a change from chicken being more expensive than beef and a luxury food to being a reasonable cost stable source of high quality protein food for human consumption.

SIRSFT has the ability to:

1. Increase production to greater than 300 metric tons (MT) per year per hectare. Currently some shrimp farm operations in Southeast Asia achieve production levels of only 10 MT per hectare per year despite their efforts at intensive farming practices.
2. Stimulate shrimp growth with SIRSFT proprietary feed formula.
3. Effectively eliminate and/or control pathogens with its biosecurity programs.
4. Significantly reduce or eliminate toxic chemical and antibiotic abuse.
5. Minimize environmental and production costs as production is accomplished indoors and not in ponds.
6. Eliminate losses due to microbial pathogens by implementation of biosecurity measures.