USMSFP

INDUSTRY BRIEFS

THE US MARINE SHRIMP FARMING PROGRAM

April 2004
Vol. 10 No. 2

The US Marine Shrimp Farming Program is a congressional initiative administered by the USDA / CSREES. It is an integral part of their aquaculture development effort and is executed by the US Marine Shrimp Farming Consortium.

2004 Boston Seafood Show Pages 2,5

Special Inland Issue!

Physiological challenges of culturing *Litopenaeus vannamei* in water containing low concentrations of dissolved solids

By Joe Tomasso, Heidi Atwood, and Craig Browdy. *L. vannamei* is capable of surviving and growing in a wide range of salinities. This ability has led many researchers and farmers to attempt to culture the species in inland, low-salinity environments. Successful efforts necessitate consideration of physiological requirements which can directly impact production costs.

When evaluating water for shrimp culture, two characteristics are important. First is the concentration of total dissolved solids (TDS), regardless of the constituent ions. Second is the specific ion composition of the dissolved solids. In our laboratories, we have successfully acclimated *L. vannamei* to salinities as low as 0.25 g/L (ppt)(salinity reflecting concentration of artificial sea salt). Acclimations to low concentrations of salts other than sea salt have not been as successful.

To better understand the importance of this assessment, first let us consider the role of dissolved solids in osmoregulation (water balance between the shrimp and its environment).

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Growth performance of selectively bred Pacific white shrimp, *L. vannamei* reared at different salinities

By Dustin R. Moss, Clete A. Otoshi, and Shaun M. Moss. Inland shrimp farming, under low-salinity conditions, is an attractive addition to traditional coastal farming for biosecurity, environmental, and economic reasons. This approach is now practiced in many shrimp farming regions around the world. Despite a global interest in low-salinity shrimp culture, little progress has been made to develop genetically improved shrimp for this type of environment. The objective of this study was to compare family growth performance of juvenile Pacific white shrimp, *L. vannamei*, cultured at 2 ppt and 34 ppt.

Six round, fiberglass tanks (8.8 m^2) were stocked with specific pathogen free (SPF) shrimp at a density of 78/m^2. Shrimp originated from the USMSFP breeding program at the Oceanic Institute. They were offspring from a lineage bred for rapid growth at 34 ppt. Each tank was stocked with shrimp from 47 full-sib families (11-15 shrimp/family/tank). Two treatments (3 replicates/treatment) were evaluated for 116 days and consisted of shrimp reared at 2 ppt and

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The US Marine Shrimp Farming Program is a congressional initiative administered by the USDA/CSREES. It is an integral part of their aquaculture development effort and is executed by the US Marine Shrimp Farming Consortium:

The Oceanic Institute
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School of Veterinary Medicine
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Inland Farming – The new face of US shrimp farming

The US shrimp farming industry is continually faced with new challenges that require innovative solutions to remain competitive. In 1990, the USMSFP, led by researchers at the University of Arizona, was the first to demonstrate the feasibility of low-salinity farming of *L. vannamei* at inland sites. Inland farms now account for about 25% of all the farmed shrimp in the US and are responsible for the geographic expansion of our industry from three to nine states since 1993. Inland farming represents an added dimension to the domestic industry that, in the future, will provide the ability for it to expand production beyond coastal zones and vertically integrate as it grows. Despite these successes, however, many problems still exist with inland farming. In this issue, we address some of the challenges associated with farming *L. vannamei* in low salinity waters and ways the USMSFP is working to provide a competitive edge in this area for our domestic industry, including:

- ***Joe Tomasso, Heidi Atwood, and Craig Browdy*** discuss the unique conditions associated with low concentrations of dissolved solids;
- ***Dustin R. Moss, Clete A. Otoshi, and Shaun M. Moss*** address growth performance of *L. vannamei* reared at different salinities; and
- ***Don Lightner, Hui Gong, Josh Wilkenfeld, and Craig Collins*** define diseases and their agents associated with low salinity water in Arizona.

The Boston Seafood Show - What can producers learn?

The Boston Seafood Show (BSS) is one of the most prestigious venues where seafood buyers and distributors can meet to promote and deal their products, exchange ideas, and get a feel for the international trends in seafood markets. It is also a good source of information for producers attempting to gauge the pulse of the industry and adjust their approaches to the demands and concerns of buyers. This can be accomplished by visiting the over 1,500 trade booths and engaging in discussions with buyers and sellers, but also by attending the Conference Program that focuses on current, key industry issues. This year was no exception. Presentations and panel discussions included traceability, the bio-terrorism act, and country of origin labeling (COOL)regulations.

Also timely was the annual Shrimp Forum meeting which focused on the shrimp anti-dumping suit. There is now growing tension in the buyer/distributor sector of the industry as COOL regulations, traceability, and impending tariffs are putting additional regulations and costs onto the shoulders of seafood retailers, buyers and distributors. The attitudes I felt emanating from the conference were important enough to convey to our domestic farming industry. We must be well informed to better prepare for the coming season and help provide insight for decisions being contemplated for the future.

Technical conferences are my normal venue, so I was a bit surprised at the relatively low audience turnout at most sessions in relation to the size of the BSS; most sessions only had 30 to 40 people. In contrast, attendance at the COOL session, including presentations by USDA, was so large (over 150), that it was moved to a bigger room. There was almost visceral condemnation of the regulations by the audience. The view from the retail community was that these regulations are unnecessary (voluntary labeling exists; consumers don't care where their shrimp comes from; price is what is important), unprecedented from a liability standpoint (liability is on retailers, not like other products where the liability is on the producers), costly (estimates are $1.79 billion to the retail sector in the first year alone), and have a disproportionate impact (the food service sector is not affected).

What was not discussed was the origin of the standards to prevent the introduction and spread of disease through shrimp imports, an effort promoted by the USMSFP for use on international animal health certificates. In fact, at one point an

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Syndromes associated with low salinity water in Arizona

By D.V. Lightner, Hui Gong, Josh Wilkenfeld, and Craig Collins. Shrimp farming in low salinity groundwater in the desert southwest has become a reality since USMSFP-funded work at the University of Arizona first demonstrated its technical feasibility in 1990-1992. In 2003, three farms produced crops of low salinity tolerant Pacific white shrimp *Litopenaeus vannamei*. However, development in Arizona has been hindered by some specific disease problems that may be linked to the low salinity of the waters used, and the farmers in southwest Arizona have complained about several diseases during the culture cycle (Table1).

Of significance has been the absence in Arizona of those diseases and their agents (eg. WSSV, TSV, YHV, IHHNV, NHP, and others) which are listed internationally or nationally by the OIE and USMSFP, respectively. The disease syndromes that have occurred in Arizona shrimp farms seem to be somewhat unique and are very likely related to such factors as high water temperature and deficiencies and imbalances of minerals such as potassium, magnesium and calcium.

Among these have been diseases like cramped muscle syndrome, various forms of focal cuticular, systemic and especially enteric vibriosis, hemocytic enteritis, and perhaps two other syndromes due directly to high temperatures and low salinity. Particularly troubling to the fledgling industry has been the onset and progressively increasing mortality during molting in large size (i.e., ~ $\geq$18g) *L. vannamei.* The relatively high frequency of this disease syndrome in 2001 and 2002 caused the farms to harvest some ponds earlier than would have been optimum for production of larger sized (and therefore higher value) shrimp just to prevent anticipated losses of large size shrimp during peaks of molting (usually coinciding with full and new moon).

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Figure 1. An aeration tower at Arizona Mariculture Associates. The tower contains multiple layers of screened plates which de-gas nitrogen from the supersaturated pumped groundwater, while increasing its oxygen content, as it falls through the screens.

Table 1. List of diseases and syndromes associated with gross signs of disease and with mortality episodes in Arizona shrimp cultured at farms using geothermal brackish groundwater.

Disease / Syndrome	Known or Presumed Etiology
Cramped Muscle Syndrome (CMS) and white muscle syndrome	Potassium and/or other trace mineral deficiency
Black gills and shell disease	Unknown toxicant(s) and bacterial agent(s)
Gas bubble disease	Inadequate degassing of pressurized (pumped) water
Bacterial infections: Septic HP necrosis Systemic vibriosis Shell disease/black spot Black gills	*Vibrio* spp., *Aeromonas* spp
Hemocytic Enteritis (HE)	Endotoxin producers (filamentous blue-green algae, certain bacteria)
Lethal temperature	Ponds too shallow
Molting mortality syndrome	Osmotic failure
Red HPs	Benthic blue-green algae (?)

Industry profile: Josh Wilkenfeld

Inland farming is the latest in a long professional life in the shrimp aquaculture industry for Josh Wilkenfeld. 1980 to 1984 saw Josh begin his career at Texas A&M University in the Shrimp Mariculture Project. From 1984 to 1994 Josh worked for Aquatic Farms Ltd. as Sr. Hatchery Biologist on *P. monodon* projects in Indonesia, India, and Burma, and then in the Philippines, where he worked with the Dole Food Company as Director of Hatchery Operations. In 1994 Josh became the Sr. Hatchery Manager at SuperShrimp and Maritech in Mexico, doing the prototype design for two new hatcheries constructed in Mazatlan, and increasing annual production at the El Golfo facility to over 730 million PLs per year by 1998.

However, Josh says his most challenging adventure so far in the shrimp industry has been his work with Arizona Mariculture Associates, LLC, where he has been the Operations and Farm Manager since 2000. Josh is shifting the farm strategy to bi-directional production efforts through dirt ponds as well as intensive lined ponds.

"Inland farming brings a unique set of benefits and challenges to the industry," says Josh. "Although brackish well water in this area of the Sonoran Desert is superficially similar to sea water, there are some significant chemical differences between the two. In order to successfully cultivate shrimp in Arizona, AMA personnel have compensated for critical differences by reformulating the shrimp feed used as well as by treating the water to make up for deficiencies of important seawater components."

Saline aquifers in West Texas (below) were devastating to West Texas farmers in the early 1900's. However, marine shrimp farming is taking advantage of this saltwater and providing new economic opportunities in the area.

Bart and Peggy Reid have created a showcase of well-managed inland ponds.Their company, Permian Sea Shrimp, is hard at work raising inland marine shrimp in close proximity to another famous Texas crop.

Inland Farms:
From coast-to-coast, inland marine shrimp farms are reviving rural areas!

Inland marine shrimp farms are established in California, Arizona, Texas, Arkansas, Alabama, North and South Carolina, and Florida. As we go to press, two new farms are beginning pilot projects in Georgia. Advances in technology allow farms to exist in areas previously out-of-bounds to marine shrimp farming. They provide a regional market for live shrimp to specialty markets, and furnish discerning consumers with a tasty, fresh, home-grown product.

location of inland Texas farms

An aerial view of Permian Sea Shrimp farm shows a well organized, efficient series of ponds.

Permian Sea Shrimp Company® farm is located just outside of Imperial in Pecos County, Texas on the northern edge of the Big Bend/Trans-Pecos area of West Texas and the northern end of the Chihuahua Desert. This unique area is well suited for growing marine shrimp.

The underground **Permian Sea** is an ancient saltwater sea. This is not some hard, freshwater aquifer, where the shrimp spend their whole lives trying to survive the marginal conditions. It is a real underground ocean ideally suited for shrimp. The natural flora of the area are salt tolerant so plants and grasses thrive around the ponds and the farm has created a wetland area with numerous estuarine birds. It is a healthy and diverse environment.

Shrimp are stocked in the ponds in the spring when the weather is warm. They are fed a specially made diet five times a day. The ponds are aerated with paddlewheel aerators to keep the oxygen content high. Chemicals and antibiotics are not used, and culture methods are 100% sustainable best management practices. Water is recirculated and conserved. Permian Sea Shrimp also cares for a population of threatened Pecos River Pupfish on the property under the supervision of the US Fish and Wildlife Service and the Texas Parks and Wildlife Department.

The Show

Every year, thousands of seafood professionals visit the Hynes Convention Center, continuing the IBSS reputation as one of the most important seafood events in North America.

Visitors attend the show looking for fresh, frozen, value-added, processed, and packaged seafood.

Low Prices - What does the future hold?

By Tony Ostrowski. The stress of low prices is now being shared by all industry sectors. The regulations being imposed on the seafood industry will change the face of shrimp buying and selling in this country. Traceability will add cost to all levels of the industry, including farmers who may be indemnified by buyers.

Even domestic shrimp will need the label **"Product of USA,"** if the regulations remain as currently written. Countries and even certain producers will begin to try to differentiate quality of shrimp, as some put it, "like we do wines, from country and even region."

But despite some of the costs, it can be a great opportunity and springboard for US shrimp farmers to promote their specific brand of shrimp and the advantages of a domestic product.

The US is the largest shrimp market in the world and domestically farmed shrimp offer consumers the freshest farm-to-market product. They are grown under the strictest health and environmental regulations anywhere in the world.

And what about prices? Partly because demand for shrimp in developing countries like Asia has increased in response to the Avian flu virus, prices have already been on the upswing.

It is expected that by December 2004 prices will be higher as a result of the tightening supply, good news for our domestic harvest season. After that, no one can predict. As Wally Stevens pointed out, there have been many examples in previous anti-dumping legislation where price has even decreased further. For our domestic farming industry, we need to take this knowledge and plan appropriately and proactively for the new era we most definitely are entering.

The Boston Seafood Show - What can producers learn? (continued)

audience member stated to the USDA representative present, that if the US government wanted to engage in protectionism, they should simply impose a much simpler labeling method – US product versus foreign product. The labeling issues do appear complicated, even USDA admits, but what is of more concern to producers is that buyers will begin to require from suppliers such items as a sticker or label of country of origin (including US produced), written certification of that origin and likely third party audit (i.e., traceability), recordkeeping of production, even down to pond, for a verifiable audit trail, and indemnification, liability insurance in case of potential law suits. The bottom line is the threat that costs will be passed down the supply chain, winding up on producers' laps. Referring to it as "onerous," the National Fisheries Institute is actively engaged in attempting to repeal the law and, at least delay its implementation.

The Shrimp Forum session focused solely on the anti-dumping suit, with panel discussion that included the presidents of the American Seafood Distributors Association (ASDA) and the Southern Shrimp Alliance (SSA). The bottom line from these discussions is tariffs will be imposed, and efforts to differentiate shrimp to increase price will be the thrust in industry. Despite the tariffs, Eddie Gordon, President of the SSA, acknowledged the US shrimp fleet is in transition to a smaller size and shrimp imports into the US will not be affected. He predicted rising imports from other countries not identified in the suit. The talk at the meeting was the increase in shrimp production targeted by Indonesia. Most interesting was the heated exchanges alluded to by the unfortunate title of the session, "Shrimp Summit 2004 - Let the Battle Begin." Eddie Gordon chastised the retail sector for gaining all the benefits of low prices while pitting producer against producer in a bidding war (even lamenting on the plight of farmers) when, "it's the buyers, not the producers who set the price." The heatedness ramped up when Wally Stevens of the ASDA countered in his presentation with a slide illustrating a bird of peace holding an olive branch followed by a slide of a boxing glove, symbolizing his interpretation of the SSA's response to ASDA's efforts to assist US shrimpers in marketing and other efforts to promote the wild catch. The exchange became uncomfortable when he directly accused Mexico of funding the suit filed by SSA to gain market advantage in the US He evoked the promotional campaign slogan, "The naked truth about shrimp," introduced by the prior speaker, Antonio Diaz, President and CEO of Ocean Garden Products, commenting he would indeed like to know "the naked truth." By the way, when asked by the moderator, Eddie Gordon did acknowledge that Mexico provided funds to the SSA, "after the suit was filed."

Arizona Mariculture Associates has constructed acclimation tanks to ensure a robust crop.

Arizona Mariculture Associates (AMA) was formed for the specific purpose of cultivating disease-free shrimp, working exclusively with SPF *L. vannamei*. Located on 1,200 acres in the Sonoran Desert near Dateland, Arizona, the inland site was selected to isolate operations from viral disease and bacteria devastating seaside farms. The land has sufficient brackish water to develop the entire 1,200 acres.

Although brackish well water in this area of the Sonoran Desert is superficially similar to sea water, there are some significant chemical differences between the two. In order to successfully cultivate shrimp in Arizona, AMA personnel have compensated for critical differences by reformulating the shrimp feed used as well as by treating the water to make up for deficiencies of important seawater components.

Shrimp farms in temperate areas are generally restricted to seasonal harvests. Located in an area known as Agua Caliente ("hot water" in Spanish), AMA is equipped to extend its growing season outside of the normal range. Thus far, ponds have been stocked as early as mid-February, and some harvests have taken place as late as early January. The extended culture period is particularly advantageous since, in the past, AMA has specifically targeted its production for the live-shrimp Asian markets in nearby California.

Arizona Mariculture Associates found a very willing product tester in Pugo the dog. Like the rest of America, Pugo finds a tasty shrimp meal irresistable.

Arizona Mariculture Associates continues to use the latest production strategies to produce a hearty, robust crop of marine shrimp for the domestic market.

Inland shrimp aquaculture in Texas offers a new type of crop to a former Kansas farm family

Before they settled near Imperial — a speck of a town in deep West Texas — Dale and Tina Schmidt raised corn, milo, wheat and soybeans in western Kansas. "There wasn't a future in it for us or our boys," Tina recalls. Commodity prices were perennially low, and "the water there was being depleted." In northern Pecos County, she says, they found that "the ground is cheap and there's plenty of water that nobody wants." The water is plentiful but salty, it has about the same salinity as the bays," Dale says, which is why the Schmidts' **D&T Shrimp Farm** is one of several commercial shrimp-raising operations in this corner of West Texas.

Inland shrimp farming in Alabama

Several years ago, a huge salt water aquifer (9 ppt salinity) was discovered under farmland in West/Central Alabama, about 160 miles from the Gulf Coast. Two enterprising men, Lee Jackson, Jr. and B.T. Durham constructed ponds and stocked them with Pacific white, pathogen-free, *L. vannamei* PLs.

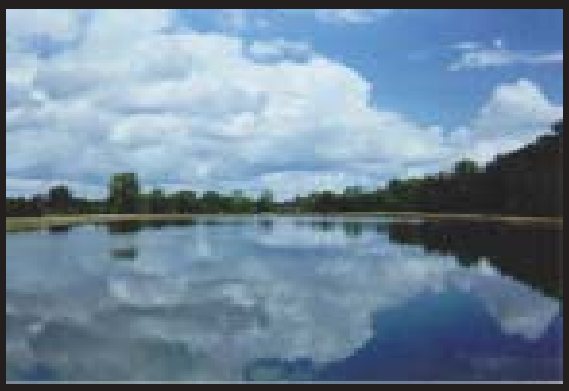
The four month growout of the stock produced a high quality, saltwater, jumbo shrimp. These shrimp were grown in an intensively managed environment with regards to oxygenation, water quality, soil conservation, temperature, predation avoidance, and feeding. The feeding regimen involved specially prepared, all natural feed, administered twice daily by the aquafarm staff. Gulf Inland/BayBoy Farms is one of only a select few of inland aquaculture producers in Alabama licensed by the USDA/Cooperative Extension Service and the Alabama Department of Conservation and Natural Resources for shrimp production.

Wood Brothers Farm (Desert Sweet Shrimp), less than an hour from downtown Phoenix, Arizona, has been cut from a swatch of parched desert land, with the Gila Bend mountains as a backdrop.

With the Wood Brothers product,no antibiotics,herbicides, pesticides, sodium tripolyphosphates or sodium bisulfites are used. Shrimp thrive on a high protein feeding regime. When shrimp are ready to be harvested, they are exposed to ice slurry, which quickly lowers the body temperature and preserves the quality of the meat.

For infrequent visitors to the farm, strict sanitation precautions are observed. Vehicles entering the property must travel through a dip filled with disinfectant. Once on the farm, guests don plastic booties over shoes to further protect the shrimp from contaminants.

Farm personnel also constantly monitor water temperature, algae count, ammonia levels and dissolved oxygen. Scientists from the Texas A&M University and the University of Texas are aiding in the development of the farm shrimp operation.



BayBoy Farms in Alabama. Using the area's natural artesian saltwater, along with the rich soil, hot climate, and newly constructed aquafarm ponds, BayBoy Farms has consistently produced high quality, farm raised, Pacific white shrimp.

Ocean Boy Farms (OBF) in Florida grows its marine shrimp inland, about 50 miles from the ocean, in artesian water from wells exceeding 1,000 ft. in depth. Ponds have high-density, polyurethylene liners to prevent seepage going into the ground and unwanted chemicals entering the ponds. In addition to the production ponds, the main farm site contains nursery greenhouses, a production office, a feed storage building, worksheds, production staff housing, and complete production laboratories. "OBF brings in indigenous flora like potted mangroves to place in our ponds as part of the water treatment process, later donating the plants to replenish valuable natural habitat throughout Florida," explains Eddy Daniel, manufacturing vice president. OBF use high-protein feed to produce a flock of aerobic bacteria that the shrimp feed on. In turn the aerobic bacteria in the flock feed on the anaerobic bacteria produced as waste by the shrimp, thus removing the waste product from the water in the grow-out ponds. This water is pumped through the mangroves and then recirculated to the ponds.

Biological treatment of shrimp aquaculture wastewater

By Quenton Fontenot. One of the problems associated with rearing shrimp at high densities is the rapid accumulation of waste products, such as nitrogen and carbon. Raceway aquaculture systems usually solve this problem by filtering waste products from the water and disposing them as a concentrated sludge. Research being conducted at Nicholls State University is focusing on methods to reduce the amount of nitrogen and carbon in the form of chemical oxygen demand in the sludge with a sequencing batch reactor (SBR). The SBR is a single container that can be operated aerobically or anaerobically, and the timed sequence of aerobic and anaerobic periods is the key to reducing nitrogen and chemical oxygen demand. During the aerobic periods, nitrification is occurring and ammonia is being microbially converted to nitrate. During the anaerobic periods, denitrification is occurring and nitrate is microbially converted to nitrogen gas. By using a bench-scale SBR, researchers at NSU have been able to reduce the nitrogen and chemical oxygen demand in shrimp sludge-water virtually to zero. Also, initial results have shown a 20% reduction in total sludge volume. Future research includes the development of a pilot-scale SBR suitable for commercial shrimp aquaculture wastewater treatment, and feasible methods to remove the salt from the sludge.

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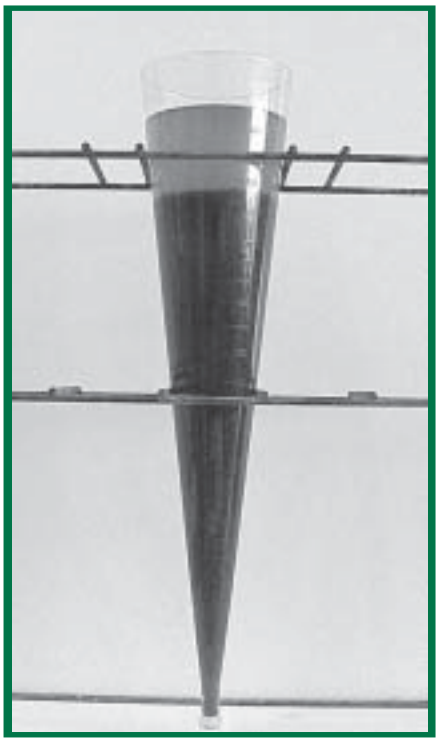

Wastewater studies are a critical step in good pond managment.

Growth performance of selectively bred Pacific White Shrimp... (continued)

34 ppt. All shrimp received a 35%-protein diet *ad libitum* three times daily and all tanks experienced a 200% water exchange per day. Water temperature, dissolved oxygen concentration, and salinity were measured daily in each tank. At the end of the study, all shrimp were identified by family (using internal elastomer tags) and weighed. Growth, survival, and water quality data were analyzed by ANOVA.

Final weight and growth rate of shrimp reared at 34 ppt were significantly greater (P <0.05) than for shrimp reared at 2 ppt. Survival was high and not significantly different between treatments. Temperature in the 34 ppt treatment (26.5ºC) was significantly greater (P <0.05) than in the 2 ppt treatment (25.1ºC), and this difference may have contributed to the growth difference. When growth data were standardized using degree days (DD), no significant difference in growth between treatments was observed. There were significant positive linear correlations (P <0.05) both for mean family weight gain and mean family survival between treatments. However, the coefficients of determination (r^2) were moderate at 0.64 and 0.46, respectively.

Treatment	Initial Wt ± SD (g)	Final Wt ± SD (g)	Growth ± SD (g/wk)	Growth ± SD (g/10 DD)	Survival ± SD (%)
2 ppt	2.06 ± 0.38[a]	19.29 ± 0.73[a]	1.04 ± 0.04[a]	0.21[a]	88.52 ± 4.64[a]
34 ppt	2.06 ± 0.38[a]	22.53 ± 1.41[b]	1.24 ± 0.09[b]	0.21[a]	91.20 ± 4.84[a]

<* values with different superscripts within each column are significantly different (P <0.05).

These results indicate that shrimp selected for growth at 34 ppt exhibited good growth and high survival when reared at 2 ppt. However, because linear correlations of mean family weight gain and mean family survival between treatments were not high, it is likely that further improvements in growth and survival at 2 ppt may be possible if selection occurs under low salinity conditions.

Dustin R. Moss, Clete A. Otoshi, and Shaun M. Moss, The Oceanic Institute, 41-202 Kalanianaole Hwy., Waimanalo, HI 96795 USA

Physiological challenges of culturing Litopenaeus vannamei... (continued)

During respiration water moves freely back and forth across shrimp gills. In hypertonic environments the concentration of dissolved solids is lower in the surrounding water than in hemolymph (the clear, bloodlike fluid in the circulatory system of shrimp), which causes water to cross the gills and move into the shrimp. In hypotonic environments the concentration of dissolved solids is higher than in surrounding water than in hemolymph which causes water to move across the gills, out of the shrimp. If water is moving into the animal, the excess is excreted as dilute urine. If water is leaving the shrimp, it is replaced by drinking. Both of these processes consume energy. Frank Castille and Addison Lawrence have determined that the salinity where environmental dissolved solids equals those in hemolymph in *L. vannamei* is about 25 g/L. It is reasonable to predict that culturing shrimp at salinities far above or below 25 g/L would require expenditure of increasing amounts of energy which might otherwise be partitioned into increased growth. Unfortunately, experimentation has not clearly shown this to be the case.

In addition to the concentration of dissolved solids, the specific elemental makeup of the dissolved solids in the environment is an important consideration—particularly when contemplating shrimp culture using inland well water. Seawater contains many elements in very specific ratios. Most inland well waters that contain relatively high dissolved solid concentrations do not contain all of the elements found in seawater, and the ratios of the elements that are present differ from that of seawater. Shrimp obtain most of the ions they need from the water in which they live. If required ions are not available in adequate concentrations, the animal can become impaired. Claude Boyd and others have focused on potassium as a probable ion in short supply in many brackish well waters.

Our research confirms that *L. vannamei* can survive and grow at salinities as low as 0.25 g/L. Mixed results were observed in environments containing mixtures of individual salts and artificial sea salt and results indicated that high levels of sodium may be toxic. Furthermore, results suggest that a minimum concentration of 1 g/L of artificial sea salt supplemented by an additional 1 g/L mixture of calcium chloride and sodium chloride may be adequate to support survival and growth at a level of interest to aquaculturists. Current research involves partial or total substitution of mixtures of simple salts (chlorides of calcium, sodium, potassium and magnesium) for sea salt to reduce production costs associated with using inland, low salinity water for marine shrimp culture.

One of the physiological implications of culture of *L. vannamei* at low salinities is increased susceptibility to nitrite toxicity. In a series of experiments, the uptake, depuration and toxicity of environmental nitrite was characterized at low concentrations of TDS. In 2 g/L artificial sea salt, nitrite was concentrated in the hemolymph in a dose-dependent and rapid manner (steady-state in about two days). When exposed to nitrite in 2 g/L artificial sea salt for four days and then transferred to a similar environment without added nitrite, complete depuration occurred within a day. Increasing salinity (up to 10 g/L) decreased uptake of environmental nitrite. Nitrite uptake in environments containing 2.0-2.3 g/L TDS composed of mixtures of simple salts rather than artificial sea salt was similar to, or lower than, rates in 2 g/L artificial sea salt. Toxicity was inversely related to TDS and chloride concentrations and was highest in 2 g/L artificial sea salt (96-h median lethal concentration = 8.4 mg/L nitrite-N).

These and other ongoing research efforts in our laboratories are directed toward a better understanding of the physiological implications of culturing *L. vannamei* at low salinities and toward identifying the minimum level of dissolved solids and specific ions required for economically viable production of *L. vannamei*. Once this understanding is achieved, farmers will have the information and tools needed to select appropriate sites for inland shrimp farms and develop realistic business plans and operating budgets that factor in the cost of augmenting ions in existing water sources.

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Syndromes associated with low salinity water in Arizona (continued)

Osmotic failure was identified as a possible cause of the high mortality rates observed in these large juvenile shrimp at the Arizona farms. Studies on the osmolarity capacity of large juveniles showed them to be less capable of maintaining their internal ionic balance than younger juveniles. Collaborative work carried out with Arizona Mariculture Associates and Desert Sweet Shrimp Farms showed that some of the low salinity diseases could be managed. This was accomplished by either supplementing the feed with the addition of certain trace minerals (K and Mg) and certain lipids, or by the use of fertilizers containing K and Mg applied directly to the ponds. Either method reduced the incidence and severity of cramped muscle syndrome, white muscle syndrome, and molting mortality syndrome and reduced production losses associated with these diseases. Refinement of the trace mineral content of feeds for inland low salinity shrimp culture, as well as well as better defining methods of pond fertilization to improve the trace mineral content of shrimp ponds, should further improve the management of low salinity disease syndromes.

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Coming in the July 2004 Issue...

There is probably no disagreement that marketing is playing a pivotal role in the ultimate economic success of shrimp farms in the United States. In our next issue we will examine various marketing strategies and their potential application to farmed shrimp products.

We will have articles from the research sector, market analyses, and much, much more. Don't miss this important and timely issue of Industry Briefs!

INDUSTRY BRIEFS

The US Marine Shrimp Farming Program

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