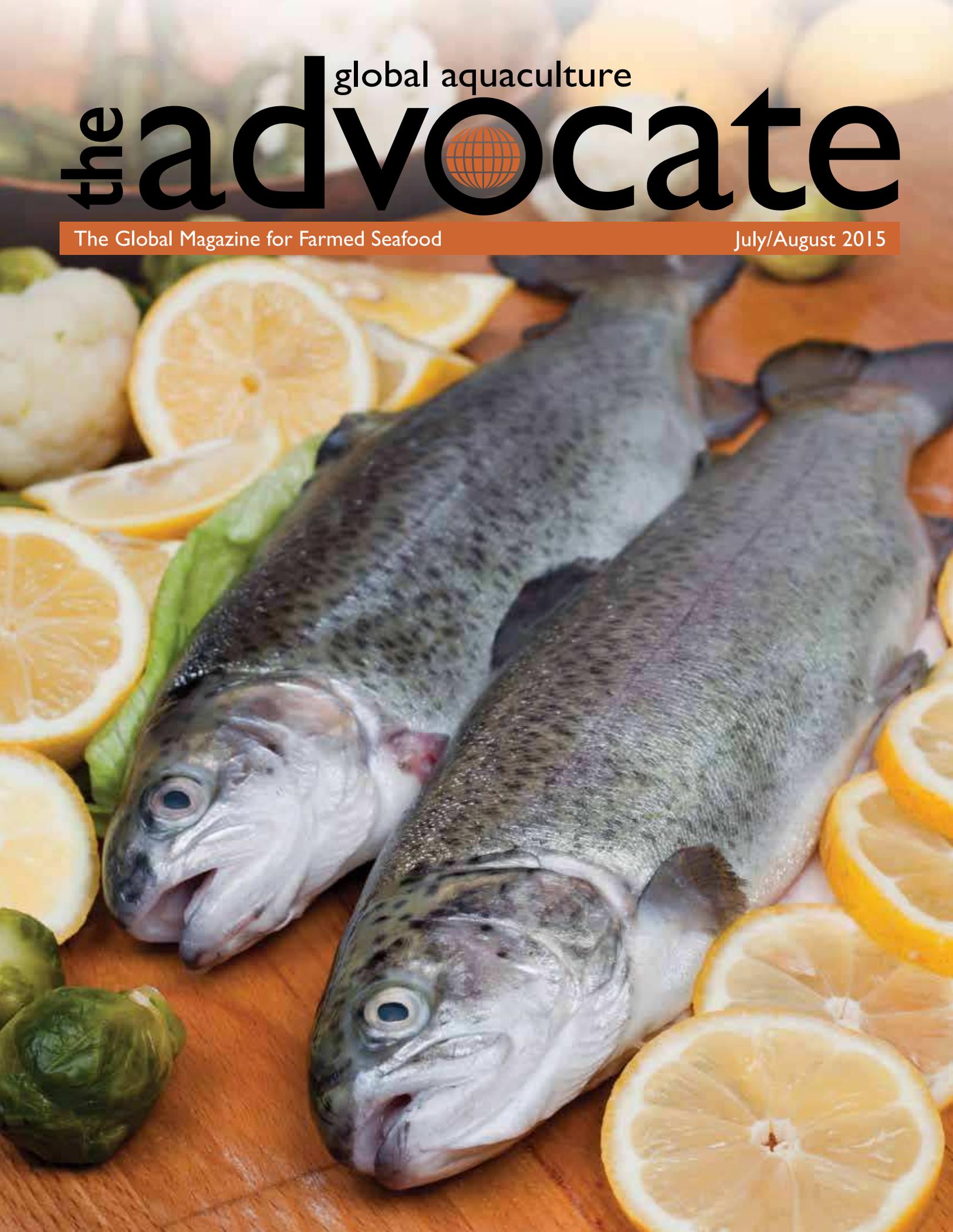


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The Global Magazine for Farmed Seafood

July/August 2015





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## GLOBAL AQUACULTURE ALLIANCE

The Global Aquaculture Alliance is an international non-profit, non-governmental association whose mission is to further environmentally responsible aquaculture to meet world food needs. Our members are producers, processors, marketers and retailers of seafood products worldwide. All aquaculturists in all sectors are welcome in the organization.

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## Advocate, Educate, Demonstrate

In my opening remarks at the Global Aquaculture Alliance's GOAL 2014 conference in Vietnam, I announced the organization had adopted a new mission statement: "The Global Aquaculture Alliance advocates, educates and demonstrates responsible aquaculture practices to feed and employ future generations."

Eight months later, GAA has clearly embraced its new mission statement.

Last month, GAA's Best Aquaculture Practices (BAP) third-party certification program reached a milestone, surpassing the 800-facility mark. Currently, more than 800 aquaculture facilities worldwide – processing plants, farms, hatcheries and feed mills – are BAP-certified. That's a 15% increase in less than six months.

While the 15% increase is a credit to the on-the-ground work of the BAP team and the suppliers who back BAP, it's also a tribute to the marketplace. Responsible aquaculture is no longer an expectation. It's a necessity. Retailers and foodservice operators worldwide are demanding that more product come from third-party-certified facilities.

While GAA is demonstrating responsible aquaculture through the growth of its BAP program, it is educating through the work of the Responsible Aquaculture Foundation (RAF) and its GOAL conferences.

RAF is on the cusp of rolling out a curriculum on the prevention and management of early mortality syndrome (EMS) in shrimp. The curriculum will be delivered online in a mobile-friendly format to Vietnamese farmers, processors, feed manufacturers, extension educators, regulators and government personnel.

On the opposite end of the seafood spectrum, The Fishin' Co. partnered with GAA to administer a consumer survey consisting of more than 40 questions on a variety of topics. More than 500 U.S. seafood consumers nationwide were polled.

Nearly half of the survey respondents had a negative perception of farmed seafood due to product quality, food safety or environmental concerns. However, a negative perception of aquaculture didn't necessarily translate to purchasing behavior, as a mere 5% of the respondents indicated they bought only wild seafood.

The full survey results will be presented at GOAL 2015 in Vancouver, Canada, in October, and a report will be available to conference attendees. Also, GAA is using the survey results to improve its marketing approach.

Finally, GAA is advocating responsible aquaculture through a variety of new initiatives. The latest is with Preferred Freezer Services and the University of Massachusetts Dartmouth on a project to build a global database of aquaculture facilities. The project is championed and funded by John Galihier, chief executive officer of Preferred Freezer Services, a GAA board member and a 1984 U-Mass Dartmouth graduate.

The data will provide focus for the advocacy work that GAA undertakes. The more facilities GAA reaches, the more impactful its advocacy work will be.

All would not be possible, however, without the dedication of the GAA staff. The quality of the men and women at GAA allows the organization to carry out its mission of advocating, educating and demonstrating responsible aquaculture.

With that, please join me in welcoming Chris Keller and Steven Hart to the GAA staff. Keller will act as BAP's market development manager-retail for North America, while Hart will serve as GAA's vice president of education and outreach. Both possess the knowledge, leadership and passion necessary to help GAA fulfill its new mission statement.

Sincerely,



Wally Stevens



**Wally Stevens**

Executive Director  
Global Aquaculture Alliance  
wally.stevens@gaalliance.org

## Facing The "F" Word

In a recent editorial, I discussed how to better tell our great story that farmed seafood makes sense in many ways. This was a central part of GAA Executive Director Wally Stevens' opening remarks at our GOAL 2014 meeting in Ho Chi Minh City, Vietnam, where he added consumer education as the seventh major challenge to aquaculture industry growth.

I would like to share with you two relevant experiences I had in recent weeks. Both involve dining experiences – one at a seafood restaurant catering to middle-class families and the other at a sushi bar.

At both places, I made it a point to talk to those preparing the meals, the chef and the itamae (sushi chef), respectively. From both, I got the same reaction regarding the dreaded "F" in the seafood world: Both denied their seafood had a farmed origin and stated they only source wild-caught seafood.

Why is this happening? Our industry has been under media attack for many years by those who have a different agenda or are simply uninformed or not interested in the facts. But the result is the same: A large proportion of the public has negative perceptions about farmed seafood, which are typically based on emotional, one-sided arguments and not grounded on solid, scientific facts. Among these people, unfortunately, are those who make seafood-buying decisions at food-serving establishments and elsewhere.

What can we do about it? On a personal level, this is an area where we can all contribute to change those negative perceptions into the positive realities of our industry by explaining the many benefits of farmed seafood. These include, among others, the known origin and traceability of the products. Also, that responsible aquaculture practices are available, widely implemented and continually growing – and that a significant proportion of farmed seafood production is carried out in a socially and environmentally sustainable manner.

All businesses along the farmed seafood production and marketing value chain benefit from increased consumer awareness and increasing demand and consumption. The health benefits of eating a seafood-rich diet are well documented, and the list of these benefits grows every day.

### The "F" for farmed seafood is actually a sign of quality, wholesome products produced in a responsible and sustainable manner.

Our industry truly has a great story to tell and a major role to play to help produce the food needed to sustain our growing global population. The next time you eat out at a seafood establishment, let the staff know about our industry and that you support farmed seafood. That the "F" for farmed seafood is actually a sign of quality, wholesome products produced in a responsible and sustainable manner.

We encourage your suggestions for current "hot" topics you would like us to cover, as well as contributions of short articles. Please contact me at your convenience for details and guidelines regarding article submissions, and let us know how we can best represent and serve our industry.

Sincerely,



Darryl E. Jory



**Darryl E. Jory, Ph.D.**

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## Alliance, Vietnam Directorate Sign Agreement



BAP development manager Carson Roper (left) and Dr. Pham Anh Tuan, deputy director general of Vietnam's Directorate of Fisheries, signed the MoU in Brussels, Belgium, in April.

advance responsible aquaculture in Vietnam and globally. The groups agreed to benchmark the Best Aquaculture Practices (BAP) finfish and crustacean farm standards to the VietGAP standards, and vice versa, using a mutually agreed upon methodology, followed by a parallel audit to determine equivalence. GAA agreed to offer training to help Vietnamese *Pangasius* producers comply with the VietGAP standards as part of a stepped approach to pursuing BAP certification.

The two organizations also agreed to share information and research pertaining to production, disease management and other aquaculture-related matters.

"We are delighted to formally recognize the collaboration between GAA and the Directorate of Fisheries to promote responsible aquaculture in Vietnam," said Carson Roper, BAP international business development manager. "This benchmarking project will build a solid foundation for VietGAP as a stepping stone toward BAP certification for *Pangasius* and shrimp farms in Vietnam."

## Varied Facilities Enroll In iBAP Program

A variety of aquaculture facilities are taking advantage of the Global Aquaculture Alliance's new iBAP program. Launched in February, iBAP is designed to assist companies interested in pursuing Best Aquaculture Practices (BAP) certification.

China's ProGift was the first hatchery to enroll in iBAP. Located on Hainan Island, Progift has until May 2016 to complete the program. The Fishin' Co. sponsored the hatchery with the assistance of the Hainan Tilapia Sustainability Alliance.

Recently, China's God Bless Tilapia Bao Fang Farm became Asia's first aquaculture operation to enroll with iBAP. The farm is one of the many farms that receive fingerlings from ProGift. With the support of the Hainan Tilapia Sustainability Alliance, The Fishin' Co. also sponsored God Bless Tilapia in iBAP.

God Bless Tilapia is located in Wenchang, Hainan, China. Its tilapia, which is exported to the U.S. market, is processed at the Eternal Spring and Tongwei plants.

"The iBAP program gives the entire supply chain an incredible opportunity to step up and do something that is vital for the industry – engage the highest standards of food safety, traceability and sustainability," said Manish Kumar, chief executive officer of The Fishin' Co.

Also enrolled in the iBAP program are Empacadora Dufer, a shrimp farm in Ecuador, and Salmoprocesos S.A., a salmon-processing plant in Chile.

"It has always been GAA's mission to bring small-farm production into the certification fold," said Peter Redmond, BAP vice president of market development. "iBAP has become an integral piece of this, and we look to enroll even more facilities in the iBAP program in short order."

Facilities that enroll in iBAP agree to a step-by-step, deadline-driven improvement plan. iBAP incentivizes facilities to make the improvements necessary to apply for BAP certification.

For more information on iBAP, including how to apply, e-mail [iBAP@gaalliance.org](mailto:iBAP@gaalliance.org).

The Global Aquaculture Alliance has signed a memorandum of understanding (MoU) with Vietnam's Directorate of Fisheries in which the two organizations will work collaboratively to

## GAA Partners With Preferred Freezer, UMass To Build Facility Database

The Global Aquaculture Alliance is partnering with Preferred Freezer Services and the University of Massachusetts Dartmouth on a project to build a global database of aquaculture farms, hatcheries, processing plants and feed mills.

The project is championed and funded by John Galihier, chief executive officer of Preferred Freezer Services, a member of the GAA board of directors and a 1984 UMass Dartmouth graduate. Preferred Freezer Services is a GAA Governing Member, a sponsor of GAA's GOAL 2015 conference and the sponsor of the 2015 Global Aquaculture Innovation & Leadership Award.

A four-person student team led by Dr. David Koop, a UMass Dartmouth computer and data science professor, will collect, organize and analyze the data and populate the database for the proprietary use of GAA and Preferred Freezer Services. UMass Dartmouth recently added a data science program. The project officially kicked off May 26.

"This project is both an incredible gesture by John Galihier and the folks of Preferred Freezer Services and a reflection of the program and student excellence of the UMass Dartmouth data science program," GAA Executive Director Wally Stevens said. "The data will serve to provide focus for the educational work that GAA undertakes with aquaculture producers around the world. GAA strongly believes in the role of education to make improvements in aquaculture."

## Red Lobster's Griffin Joins GAA Board



Nelson Griffin

Nelson Griffin of Red Lobster Seafood Co. has joined the board of directors of the Global Aquaculture Alliance.

As vice president of supply chain for Red Lobster, Griffin leads all supply chain-related activities for the world's largest casual-dining seafood restaurant company. He also oversees food safety and product quality. Griffin previously served in key supply chain roles at Darden Restaurants and also worked for Kellogg's and Cracker Barrel Old Country Store.

"Red Lobster's former parent company, Darden Restaurants, was a Founding Member of GAA and has always been represented on our board," GAA Executive Director Wally Stevens said. "We look forward to gaining from Nelson a greater understanding of his company's extensive supply chain for aquaculture products."



Steven Hart



Chris Keller



Norm Grant

## Alliance Expands Staff Education, Outreach

Dr. Steven Hart will join GAA as vice president of education and outreach, effective June 29. He will perform a range of functions involving communications, coordination, and program development and management.

Hart's duties will include developing educational materials on responsible aquaculture practices, investigating issues and working with GAA constituents in response, expanding activities with other seafood groups, and generating content for GAA communications.

"As GAA looks to increase both its advocacy and education outreach, it is critical to start with a solid grasp of the issues and the work already underway to address those issues," GAA Executive Director Wally Stevens said. "Steven will add strength to the incredible leadership that George Chamberlain has provided to the aquaculture industry for many years in the areas of knowledge creation and applied research."

Hart has been executive director of the Soy Aquaculture Alliance since 2011. He also helped form the Coalition of U.S. Seafood Production and was director of aquaculture for the Indiana Soybean Alliance.

## BAP Market Development

GAA's BAP division has expanded its marketing team with the addition of Chris Keller as market development manager-retail for North America.

(Continued on page 8.)

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# BAP Plant Standards Strengthened In Issue 4



Revisions to BAP's processing plant standards have clarified requirements and guidelines on worker rights, product sampling and other elements of certification.

The early-May release of the updated Best Aquaculture Practices (BAP) standards for seafood processing and repacking plants will help protect program integrity due to the clearer and/or more rigorous treatment of drugs, supplier monitoring, social responsibility and multi-star traceability.

As outlined in the Issue 4 processing plant standards, aquaculture drugs shall not be used unless they are approved by both the country of operation and the countries to which product is exported. Facilities are required to enforce this with their suppliers. There is also an additional clause requiring a risk analysis for drugs known to have been used or abused in the past. A statement was added to address secondary/value-added processors with regard to drug testing.

## GAA, ASC, GlobalGAP Combining Audits

The Global Aquaculture Alliance, Aquaculture Stewardship Council and GlobalGAP have taken a significant step forward in executing their memorandum of understanding (MoU) by agreeing to combined audit checklists for farms pursuing more than one aquaculture certification.

A combined checklist minimizes duplication of audit points among the certification programs and comprises all audit points of one group's standards, supplemented by specific add-on clauses for other standards. A farm pursuing multiple certifications can choose any one of the three programs and then select the desired add-ons.

The latest agreement was announced during a April 22 ceremony at Seafood Expo Global in Brussels, Belgium.

Since signing the memorandum two years ago, the three certification standards-setting organizations have been working collaboratively to increase efficiency and reduce duplication in the auditing process. The goal of the MoU is to make certification more accessible and create greater value to farmers and processors.

The definitions and rules surrounding the production of seafood at multi-star facilities and associated claims were clarified. Each certified farm, hatchery and/or feed mill must be identified, as well as the quantities of raw material and final product they handle. Seafood lots must carry unique codes or lot numbers for every star category.

To keep up to date with current issues and international norms, several standards related to social responsibility were added or revised. Wages must cover workers' basic expenses with some left over for discretionary spending. The issue of deductions from wages was expanded to include recruitment and other fees that have the effect of forced labor/debt bondage. The anti-discrimination clause was expanded, as well as the standards addressing freedom of association and collective bargaining.

The requirements for product sampling were clarified in Issue 4. A representative of a third-party lab is required to be at the facility during the certification audit to take samples from lots identified by the auditor. Testing for antibiotics and microbial contaminants is more clearly defined for all raw and cooked primary product forms.

Non-compliant samples are better defined, and regulatory detention/alert/refusal is added as a non-compliant criterion. Tolerance for test results were modified according to more updated regulatory authority criteria. Testing frequency remains monthly, quarterly and semi-annually, but the conditions for reduced sampling are better explained.

The new Issue 4 standards are posted online at <http://bap.gaalliance.org/bap-standards/>. For currently certified processing plants and those already in the process of application, the new standards will be mandatory for recertification beginning November 1.

## GAA Staff...

(Continued from page 7.)

Keller has more than 20 years of retail experience. Keller held numerous positions at Walmart, eventually acting as senior buyer. He won the Walton Entrepreneur of the Year award in 2007 for leading Walmart's seafood sustainability team. Subsequently, he worked for Quirch Foods and also launched his own consulting company.

"Chris Keller brings a wealth of experience in several areas, including retail and supply," said Peter Redmond, BAP vice president of market development. "He was also instrumental in driving sustainability in his retail career. This will really enhance our outreach in the North American marketplace while providing excellent care to our supporters."

BAP's market team also recently gained Norm Grant and Kent Inglis as business development managers for Australia and New Zealand, respectively.

Grant is executive chairman of the Seafood Importers Association of Australasia. He leads trade missions to Southeast Asia to familiarize government and industry with food safety and biosecurity standards. Previously, Grant operated businesses in fishing, marketing, and research, and published *Seafood Australia*.

Inglis has acted as the international marketing manager for New Zealand's largest mussel processor and held roles in the Pacific oyster and salmon industries. He gained substantial knowledge of the salmon sector and new species such as seriola and snapper through 10-year ownership of a finfish venture.

# BAP Program Tops 800 Certified Facilities

The Global Aquaculture Alliance's Best Aquaculture Practices (BAP) third-party certification program recently passed the 800 milestone. More than 800 processing plants, farms, hatcheries and feed mills have been certified worldwide.

That total reflects nearly 100 new certifications since the end of 2014. The number of companies with two-star, three-star and four-star BAP certification status is also on the rise.

## 4-Star Operations In India

In April, **Suryamitra Exim Private Ltd.** became India's second group to gain four-star BAP status for shrimp. The status was achieved once it was confirmed that Suryamitra's I. Surya Rao farm sourced its feed from the BAP-certified Avanti Feeds Ltd. feed mill. Also certified is the company's Siddardha Hatcheries Private Ltd. hatchery.

The effort was coordinated by U.S.-based National Fish & Seafood, which sources shrimp from Suryamitra.

"This four-star certification ... has made a significant contribution in advancing responsible aquaculture in India," said Jeff Sedacca, president of the shrimp division at National Fish. "We expect to expand our Suryamitra/National Fish four-star supply dramatically and ... jointly continue our work to help farmers, small and large alike."

**Avanti Feeds Ltd.** became India's third group to achieve four-star status for shrimp in late April.

"Avanti Feeds has always promoted sustainability and reliability in aquaculture, and as part of this effort, had its processing plant and feed mills BAP certified," the company said in a statement.

In early May, **Apex Frozen Foods Pvt. Ltd.** also claimed

four BAP stars for shrimp in India. Apex sources feed from the Avanti Feeds Ltd. mill. Also BAP certified are the company's processing plant, two integrated operating module farm groups and the NSR Aqua Farms Private Ltd. hatchery, from which it sources seed.

The farm sites consist of more than 200 ha of ponds, and the company intends to pursue BAP certification for another 200 ha within the next year, so the majority of its shrimp would originate from BAP-certified farms.

## Mussel Facilities

**Pesquera Apiao S.A.** became the world's first group to achieve two-star Best Aquaculture Practices status for mussels in May. Its processing plant in Quemchi, Chile, and seven mussel farm sites in the same area earned BAP certification on May 7. Pesquera Apiao processes about 50,000 mt of mussels annually, which are marketed in Europe, Asia and the United States.

**Blue Shell S.A.** recently became Chile's first mussel-processing plant to attain BAP certification. Located in Dalcahue, Chiloe, the plant has an annual production capacity of about 10,000 mt of mussels and 1,300 mt of clams. Blue Shell's mussel products are marketed in South America, North America, Europe, Africa and Asia in a variety of forms.

"BAP certification is a great contribution to the entire production chain, as it allows us to maintain our leadership and provide the best products to our customers," Blue Shell said in a statement.

### Recent BAP certifications around the world.

Facility	Country	Species
<b>Farms</b>		
Cermaq Canada Aquaculture Ltd. (4 farms)	Canada	Salmon
Cypress Island Icicle Acquisition (American Gold Seafoods)	United States	Salmon
Paraiso Springs Aquaculture Guatemala Cia. Ltda.	Guatemala	Tilapia
P.T. Permata Citranusa	Indonesia	Shrimp
Wushangxian Farm – Hanping Reservoir	China	Tilapia
<b>Hatcheries</b>		
Australis Aquaculture Vietnam Ltd.	Vietnam	Barramundi
Cooke Aquaculture (11 hatcheries)	Canada	Salmon
<b>Processing Plants</b>		
BMR Industries Private Ltd.	India	Shrimp
Guangdong Universal Aquatic Food Co., Ltd.	China	Shrimp, Tilapia
Kim Anh Co. Ltd.	Vietnam	Shrimp
Nam Viet Fish Freezing Factory	Vietnam	Tilapia, Pangasius
Narong Seafood Co. Ltd.	Thailand	Shrimp
Premier Marine Products Private Ltd.	India	Shrimp
Process Plant Trapen – Ventiqueros	Chile	Salmon
P.T. Windublambangan Sejati	Indonesia	Shrimp
Salmones Aucar Ltda.	Chile	Mussels
Zhangzidao (Rongcheng) Food Co., Ltd.	China	Shrimp
<b>Feed Mills</b>		
Cargill de Honduras S. de R.L.	Honduras	
Cargill de Nicaragua S.A.	Nicaragua	



# Bali BAP Course Sets Attendance Record



The course covered the BAP standards for all types of facilities and included a seafood HACCP course.

include the BAP processing plant standards.

The course was taught by BAP Asia-Pacific Coordinator Ken Corpron, BAP Vice President Lisa Goché and BAP Training Coordinator Jeff Peterson. The course covered the BAP standards for all types of facilities and included a seafood HACCP course for processing plant auditor candidates.

Ten countries were represented at the course: Bangladesh, Canada, China, India, Indonesia, Malaysia, Philippines, Thailand, the United States and Vietnam. "It's like a mini United Nations with so many folks from so many countries working together," Goché said.

Also of note was the number of industry observers in attendance, as industry interest in the BAP program continues to grow. Observers included representatives from P.T. Lola Mina, P.T. Lestari Magris, P.T. Central Pertiwi Bahari and DDT Konstrakt Inc. in Indonesia; Dataj Aquafarm and Mida Trade Ventures of the Philippines; Rubicon Resources of the United States; and Indepesca Aquaculture of India.

"Observer participation is a triple-win situation," Peterson said. "Observers get to learn firsthand about the BAP standards development and implementation process. They also provide valuable input on their experiences as the 'auditees.' Returning auditors and new auditor candidates also greatly benefit from their perspective on industry-related issues."

Goché provided valuable information on the recently released Issue 4 of the BAP seafood processing plant standards. "Issue 4 clarifies and consolidates the information formerly contained in the interpretation guidelines to issue 3," she said. "Annex 2, the social responsibility, traceability and aquaculture drug sections, have also been expanded."

Corpron provided up-to-date information on implementation and interpretation of the recently launched BAP finfish and crustacean hatchery and nursery standards, which can be applied to all species and species groups.

The Best Aquaculture Practices (BAP) auditor training and industry observer course held May 11 to 16 in Nusa Dua, Bali, Indonesia, broke records.

It was the best-attended course to date, with 26 returning auditors and new auditor candidates and 16 industry observers. Many returning processing-plant auditors came to extend their competencies to include BAP's farm and/or BAP feed mill standards. Likewise, some returning farm auditors extended their competencies to

## Jory Attends Workshops With Latin Focus

Dr. Darryl Jory, GAA development manager and *Global Aquaculture Advocate* editor, participated in the "Aquaculture Opportunities In Latin America and the Caribbean" aquaculture investment workshop at the University of Miami in Miami, Florida, USA, in late April.

Sponsored by the U.S. Soybean Export Council (USSEC), the by-invitation event brought together 90 industry leaders representing production, retail, research, insurance and financing. The status and concerns of the aquaculture industry in Latin America were actively discussed with much emphasis on opportunities and the need for more investment.

Jory also participated in the May 18 to 22 Regional Animal Production Course, at Auburn University in Alabama, USA.

Sponsored by USSEC, the event was attended by around 55 representatives of the farming and feed-manufacturing industries from several Latin American countries. Jory gave presentations on the status, issues and perspectives of the global farmed shrimp and fish industries.



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The RIU3 will accept multiple input types (4-20mA/ 0-5 V/ Modbus RS485) and contains 2 SPDT 4amp relays which can be setup for up to six control blocks. Control blocks are configured directly via the keypad, or through a PC using a computer connection cable; allowing users to setup local control, configure alarm conditions or even perform PID function. Another important feature of the RIU3 is tank side probe calibration and configuration which is easily performed using the weatherproof 4 button keypad.



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GOAL 2015 will feature four days of information and analysis on the farmed seafood value chain, with sessions in the mornings and afternoon breakouts. Topics such as animal welfare, environmental and social responsibility, food safety, marketplace accessibility, leadership and consumer education will be among the themes addressed.

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### Reserve Your Room Now!

GOAL 2015 will convene at the luxurious Four Seasons Hotel in Vancouver. Take advantage of the special conference room rate of CAD \$190 – book online now before the room block sells out.



### Key Production Data

Exclusive to GOAL, Drs. Jim Anderson of the World Bank and Ragnar Tveteras of the University of Stavanger will present the latest global production data on shrimp and finfish. Among the species in the international survey contributing to their data are shrimp, tilapia, *Pangasius*, catfish, salmon, trout, barramundi, seabass and sea bream. Which species are trending now?

### Zone Management Seminar

GOAL's initial sessions on October 26 will focus on zone management. As shown by disease outbreaks that affected whole regions in recent years, cooperation and oversight among facilities within production areas helps lessen disease risks, conserve resources and improve market potential. Peter Marshall of R.S. Standards will lead the discussions.

### Multiple Tours

On October 26, shuttle to Target Marine Hatcheries, Canada's only organic white sturgeon producer, for a tour and caviar tasting. Or tour the processing and distribution facilities of western Canada's largest seafood distributor, Albion Fisheries Ltd.

A post-conference tour will head to the wine country in Okanagan Valley to visit an arctic char farm as well as three wineries. Companion registration includes a half-day "Taste of Vancouver" tour featuring the city's culture, crafts, foods and markets.

### GOAL Gala

Prepare for a memorable experience at this year's gala dinner at Grouse Mountain, a short transfer from the Four Seasons. Enjoy the unbeatable view and fine cuisine from our private dining room. And get the latest gear or perfect souvenir of your visit to the Peak of Vancouver – the shops will be open!

### Preferred Freezer Services Innovation & Leadership Award

The winner of the Preferred Freezer Services Global Aquaculture Innovation and Leadership Award will present at GOAL 2015. The competition recognizes innovative practices that overcome production challenges or mitigate negative environmental or social impacts. The competition also recognizes leadership.

Innovations can span the full range of aquaculture activities. To enter, download the application at <http://gaalliance.org/wp-content/uploads/2015/05/innovationform151.pdf> and return it to BAP Standards Coordinator Dan Lee at [dangalle@aol.com](mailto:dangalle@aol.com).

### Program Schedule

#### MONDAY, OCTOBER 26

Subject
Zone Management Sessions

#### TUESDAY, OCTOBER 27

Subject
Keynote Presentation
Animal Health and Welfare
Antibiotics in Aquaculture
Shrimp Production: Breaking the Boom/Bust Cycle
Global Shrimp Production Data and Analysis
Global Finfish Production Data and Analysis

#### WEDNESDAY, OCTOBER 28

Subject
Keynote Presentation
Consumer Education, Social License and Community Relations
Pioneers of North American Aquaculture
Feed Sustainability
Retail Roundtable #1
Retail Roundtable #2
Presentation of Lifetime Achievement Award

#### THURSDAY, OCTOBER 29

Subject
Presentation of Aquaculture Innovation and Leadership Award
Role of Education in Aquaculture Improvement
First Nations' Role in Aquaculture
Understanding and Accessing China's Marketplace
Retail Roundtable #3
Retail Roundtable #4
Retail Roundtable #5

# Non-SPF Shrimp Breeding In Ecuador

## Alternative Approach Successfully Addresses Localized Conditions



By enabling direct, high-intensity selection of broodstock from ponds, non-SPF approaches facilitate breeding schemes specifically designed to minimize the impacts of genetic-environment interactions.

### Summary:

Following its devastation by white spot syndrome in 1999, Ecuador's shrimp aquaculture industry took a unique approach to recovery. When the specific pathogen-free paradigm was standard for global shrimp production and health programs, local programs began deliberately breeding from infected white spot survivors. This article reports on a breeding program focused only on the improvement of growth rates at associate farms. By applying a localized breeding strategy, the program has yielded an average 7.8% annual phenotypic gain for commercial growth rates, while survival has remained fairly constant.

While operating under extensive production system models at low stocking densities, Ecuador's shrimp-farming industry was devastated by white spot syndrome in 1999. Discouraged by the poor results and susceptibility of specific pathogen-free (SPF) animals to the diseases present, many in Ecuador believed that breeding from disease survivors, without particular concern for their disease carrier status, would be the only way forward if their shrimp industry was to rebuild around the same extensive production models and ideals.

More than a decade later, Ecuador's unconventional and non-SPF approach to shrimp health and breeding seems to have been successful (Figure 1), yielding the development of shrimp lines that cope well with diseases. This enabled the full recovery

### João L. Rocha, Ph.D.

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Rafael Verduga Hugo Mario Armijos Texcumar and Productores de Camarón de El Oro Centro de Reproducción y Mejoramiento Genético de Camarón

of the national industry under conditions where white spot virus is consistently present, especially when the temperatures drop below 24° C in the designated summer season.

These robust shrimp lines are in high demand from many parts of the world to improve the disease tolerance/resistance and robustness of the more susceptible SPF stocks. This trend has gained partic-

ular momentum after the emergence of early mortality syndrome in Asia and its recent expansion to Mexico.

### New Disease Hypotheses

New hypotheses on the acquisition of natural disease resistance/tolerance mechanisms by shrimp have recently been proposed by Dr. Timothy Flegel. These new hypotheses postulate that for natural mechanisms of shrimp disease tolerance/resistance to take place, direct exposure to the pathogens is a necessary condition – one that is obviously not present and even specifically precluded in the context of the SPF model.

Ecuador's unconventional shrimp health and breeding path seems to have anticipated these new hypotheses, and its results seem to corroborate the postulates.

### Non-SPF Breeding

This article reports on a specific breeding program initiated four years ago and established through a synergistic association between the largest maturation facility in Ecuador and a group of shrimp producers with a total of nearly 5,000 ha in production.

To keep the program as simple and low-cost as possible, its genetic objectives were defined by the shrimp producers to focus only on the improvement of the growth rates at their farms. Survival was considered strictly a management issue not requiring specific genetic strategies. The program adopted a localized line-based breeding strategy, with stringent mass selections for growth at commercial harvest end points for the different associates.

Genetic selections are done directly from commercial ponds. Different lines have been developed, with inbreeding levels mon-

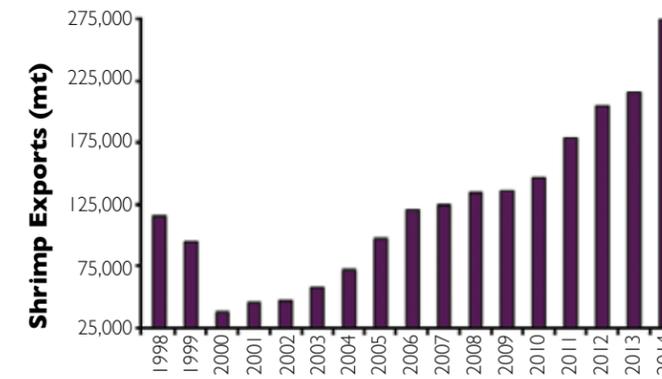


Figure 1. Shrimp production trends in Ecuador.

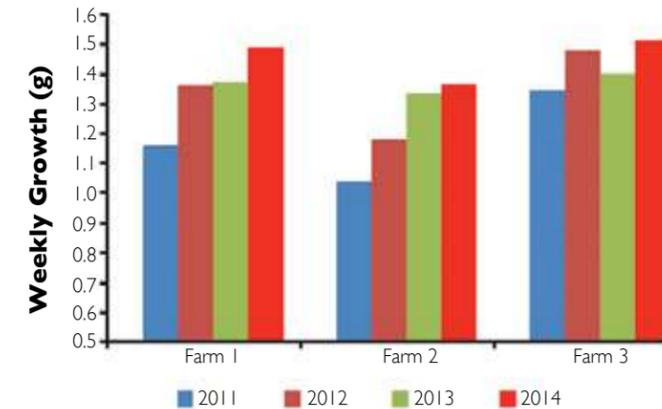


Figure 2. Weekly growth rates for three model farms.

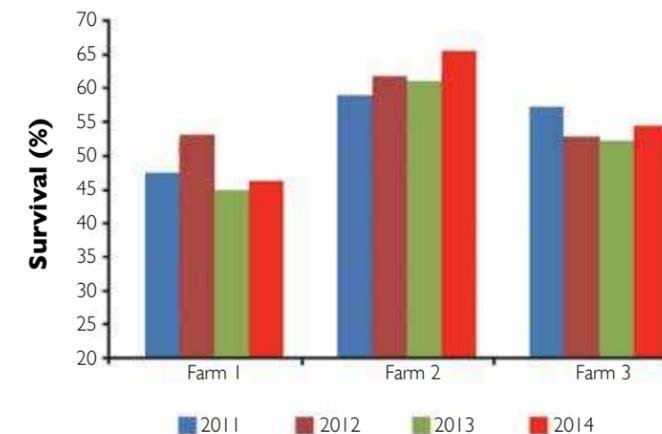


Figure 3. Survival trends for three model farms.

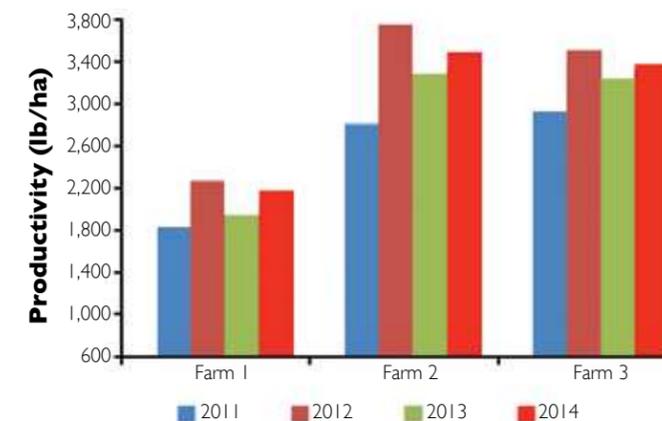


Figure 4. Productivity trends for three model farms.

itored through genetic marker approaches. Interactions between genetics and the environment (G x E) are addressed by the development of different commercial products for the shrimp producers. At any time, each associate has at least one maturation room stocked with broodstock derived and selected from its own farms. Female broodstock are screened for infectious hypodermal and hematopoietic necrosis virus, with a number of products certified from IHHNV-free females.

### Program Results

With these approaches, the genetic program has been able to yield a positive phenotypic trend with an average 7.8% annual phenotypic gain for commercial growth rates, while commercial survival rates have been kept fairly constant. Figures 2 through 4 document the growth, survival and productivity trends registered for three model farms in the program since it was initiated in 2011. These three farms formed the benchmark against which the breeding progress was evaluated.

Most farms served by the breeding program operate under a three-phase growout system. Average growth rates in 2011 were nearly 1.18 g/week (Figure 2), with an average survival of 54.5% (Figure 3) at 12 shrimp/m<sup>2</sup> and an average productivity of 2,515 lb/ha/cycle (1.14 mt/ha/cycle, Figure 4). In 2014, at 12.5 shrimp/m<sup>2</sup>, the average growth at the model farms was 1.45 g/week, with an average survival of 55.3% and average productivity of 3,006 lb/ha/cycle (1.36 mt/ha/cycle).

Productivity at the model farms increased from 24.8 lb/ha/day (11.25 kg/ha/day) in 2011 to 28.0 lb/ha/day (12.70 kg/ha/day) in 2014. Assuming a pricing standard of U.S. \$0.11/g, sales increased from \$48.60/ha/day in 2011 to \$65.90/ha/day in 2014. Average commercial harvest weights were 17.8 g in 2011 and 21.3 g in 2014.

### Perspectives

The Ecuadorian non-SPF extensive production system is a model that so far has served well in a very specific economic and production context. It is certainly not suitable for a number of other economic and production scenarios, so is not a universal panacea for shrimp production elsewhere. But non-SPF breeding approaches may have merits that warrant further consideration, especially concerning the breeding of animals better adapted to specific local conditions.

By enabling direct, high-intensity selection of candidate broodstock from commercial ponds – the real target of all breeding programs – non-SPF approaches have the additional merit of facilitating the implementation of breeding schemes specifically designed to minimize the impacts of G x E interactions. Tackling these interactions under SPF constraints can be complex and expensive.

High-density, intensive shrimp production systems are likely incompatible with non-SPF approaches, but are certainly an imperative within some economic contexts. The authors encourage aquaculturists to recognize the existence of different tools and approaches for different situations and contexts.

Which approach is the most vulnerable to the emergence of new diseases, and which can most rapidly recover from them? Could the development of robust and more tolerant or resistant local shrimp lines preclude the need for wide-ranging, permanent, international broodstock movements and thus constitute a safer path with respect to the recurrent introduction of new diseases in shrimp production? Ultimately, are highly intensive shrimp production systems really sustainable in the long run for wide national areas, when all the compounding environmental, economic, social and biological issues are considered?

# Rapid On-Site Diagnostic Tool For AHPND Management



Hand-held PCR devices are now available for rapid on-site detection of shrimp diseases.

## Summary:

To help minimize economic losses caused by acute hepatopancreatic necrosis disease, timely detection of its pathogenic *Vibrio* etiological agent plays a critical part in disease management. On-site pathogen detection tools enable farms of various scales to implement timely biosecurity measures. To diagnose AHPND, detection of both the AHPND-associated plasmid and *toxin 1* gene is recommended. A portable device with accompanying polymerase chain reaction assays can quickly identify the AHPND markers in shrimp, water, live feed or other sources.

Growing rapidly in recent decades, shrimp aquaculture is now one of the major global agriculture industries. In parallel, emerging shrimp diseases have also been on the rise, largely because shrimp are cultured at high density, exposed to environmental stress and traded globally.

Since 2009, early mortality syndrome, also termed acute hepatopancreatic necrosis disease (AHPND), has caused large-scale shrimp deaths and huge economic losses for shrimp farmers in China, Vietnam, Malaysia and Thailand.

AHPND can affect *Penaeus monodon*, *P. chinensis* and *Litopenaeus vannamei*.

The highest mortality rates for shrimp with AHPND are found during the first 20 to 40 days of culture in growout ponds. Typical signs of AHPND infection, which are found mainly in the digestive tracts of shrimp, include an empty gastrointestinal tract and abnormal shrunken, whitish hepatopancreas, which result in weakness and death in shrimp. AHPND infection is defined by histological changes in the hepatopancreatic system, particularly sloughing of hepatopancreas tubule epithelial cells.

In 2013, the causative agent of AHPND/EMS (AHPND *V.ph*) was identified as a unique pathogenic strain of *Vibrio parahaemolyticus* containing a virulence-associated plasmid. *V. parahaemolyticus* has been in marine environments worldwide.

## Molecular Identification

Recently, *toxin 1*, a homolog of an insecticidal toxin, has been shown to play a critical role in hepatopancreas damage caused by AHPND bacteria in diseased shrimp. *Toxin 1* consists of two genes, *pirA* and *pirB*, and *pirB* alone could cause the typical histological changes associated with AHPND in shrimp hepatopancreas.

Virulence factor genes, including *toxin 1*, have been found within "pathogenic islands" flanked by inverted repeats

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of transposase genes in the so-called AHPND-associated plasmid. Therefore, both *toxin 1* (*pirA* and *pirB*) and the AHPND-associated plasmid are potential markers to allow identification of virulent AHPND bacteria. The AHPND-associated plasmid could be identified by the presence of certain unique markers.

Various molecular methods targeting *toxin 1* and/or the AHPND-associated plasmid are available to help AHPND diagnosis. However, different *Vibrio* species readily exchange genetic materials among themselves through genetic transfer mechanisms, including homologous recombination, transposition, conjugation or transformation. Transposases can move genes horizontally from one location to another location.

So far, non-virulent *V. parahaemolyticus* strains containing truncated AHPND-associated plasmids with *toxin 1* deletion have been found in the environment. Therefore, detection of *toxin 1* alone is not recommended, since *toxin 1* is located in an unstable region.

Although no evidence has been reported yet, it is suspected that the *toxin 1* gene region could be transferred to another bacteria. And the new *toxin 1*-harboring bacteria might not be virulent, because AHPND pathogenesis may need other virulence factors.

On the other hand, it has been reported that 98% of the samples tested AHPND-associated plasmid positive by polymerase chain reaction were found to

show AHPND symptoms. Therefore, detection of the plasmid alone could help detect a potential AHPND threat. Thus, to diagnose AHPND, detection of both the plasmid and *toxin 1* gene is recommended.

When simultaneous performance of the two assays is not possible, due to cost concerns, for example, it is recommended to perform screening for the plasmid first to identify a potential threat. In case of plasmid-positive results, the *toxin 1* assay could be used to provide further evidence of AHPND.

A good AHPND detection method also should not cross-react with host DNA, any irrelevant plasmids and other microorganisms. Because not much bioinformatics information is available for *toxin 1* homologs, probe-based molecular methods should offer better specificity than conventional methods to detect targets of this nature.

## On-Site Molecular Detection Tools

Without vaccines and effective treatments for shrimp diseases, the shrimp industry relies greatly on biosecurity measures to prevent the introduction of pathogens or risk factors to facilities to reduce the spread of pathogens throughout the culture environment.

Polymerase chain reaction (PCR) assays, with their high sensitivity and specificity, have been employed commonly at various large-scale aquaculture facilities for pathogen surveillance or disease diagnosis. This approach has proven to help detect pathogens at early stages to facilitate timely implementation of measures to control the spread of major shrimp disease agents such as white spot syndrome virus, improving overall shrimp production in the long run.

However, due to the challenging requirements for sophisticated equipment and highly trained personnel to perform PCR, small-scale farms in general have been reluctant to include PCR assays in their biosecurity measures. Therefore, user-friendly, field-deployable detection methods are now available to monitor and improve biosecurity at small-scale farms.

Optimal on-site detection systems should be rapid, inexpensive, sensitive and easy to maintain and perform for anyone with minimal training. In addition, the reagents should be provided in a format that allows easy shipping and storage.

## Current On-Site Method

A molecular diagnostic assay based on insulated isothermal polymerase chain

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reaction (iiPCR) testing, working on a specific field-deployable device, is currently available for on-site detection of AHPND. The reliability of the iiPCR system has been demonstrated by a similar system certified by the World Organisation for Animal Health (OIE) as validated for detecting white spot syndrome virus in shrimp in 2013.

The portable device can amplify target sequence, detect fluorescent signals and display simple readouts within one hour. Two iiPCR assays, targeting either the most stable region of the AHPND plasmid or the virulence-related *toxin 1*, have been developed to monitor the markers in shrimp, water, live feed or other sources to help evaluate risks for AHPND.

The assays detect their targets sensitively and specifically. For example, the sensitivity of both iiPCR assays were comparable to that of real-time PCR assays, based on results of an endpoint dilution study using serial dilutions of a virulent AHPND *V.ph* strain (Table 1).

For specificity evaluation, cultures of 18 of the AHPND strains were tested. The *toxin 1* iiPCR reacted positively with all eight *toxin 1*-positive strains and negatively with all 10 *toxin 1*-negative strains identified by a reference *toxin-1* PCR assay from

**Table 1. Sensitivity performance of iiPCR assay for the virulent AHPND *V.ph*.**

DNA Dilutions	toxin 1		AHPND Plasmid	
	Real-Time PCR	iiPCR Assay	Real-Time PCR	iiPCR Assay
-1	2/2	2/2	2/2	2/2
-2	2/2	2/2	2/2	2/2
-3	3/3	2/2	3/3	2/2
-4	0/3	0/3	0/3	2/3
-5	0/3	0/2	0/3	0/2

National Cheng Kung University in Tainan, Taiwan, indicating this reagent has excellent specificity in detecting the virulence marker of the AHPND *V.ph*.

### Perspectives

Good diagnostic systems are mostly built on well-established technology and research results. Reagents should be manufactured under controlled environments with quality controls following international standard procedures and pass stringent validation procedures.

Application of these systems in pathogen detection can often be performed only on specific samples at specific time points. However, shrimp cultures generally involve huge shrimp populations associated with dynamic conditions over long periods of time. There-

fore, to get the most of these tools, the users should also pay attention to sampling site, size and timing. Furthermore, for correct diagnosis of a disease, it is best to analyze the samples using multiple test methods based on different technologies, such as microbiology, histopathology and qualitative/quantitative PCR.

On the whole, bacteria such as the AHPND *V.ph* are hard to eliminate and could have long-term impacts on shrimp farms once they are introduced into the facilities. Screening and removal of potential AHPND threats from shrimp, water, live feeds or other sources is critical in biosecurity. On-site diagnosis should make the implementation of this important measure possible at shrimp culture facilities of different scales at any location.

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# Breaking The 20% Soy Barrier In Fish Feed

## Improved Trout Line Boasts Good Growth, No Distal Enteritis



After 14 years of selective breeding, a line of rainbow trout grows rapidly on a high-soy diet and also does not develop distal enteritis. The trout phenotype can be a tool to further explore mechanisms of fish growth and health.

### Summary:

Reduced performance in fish fed high-soy feeds has been blamed on antinutrients, low methionine content and palatability issues. Pretreatment to inactivate antinutritional compounds and supplementation with amino acids improves soy-based feed performance, but not to control levels. After 14 years of selective breeding, a line of rainbow trout grows rapidly on a high-soy diet and also does not develop distal enteritis. Combined with advanced bioinformatics, the trout phenotype can be a tool to further explore mechanisms of fish growth and health.

The 20% soy content barrier in fish feeds has been an impediment to the development of more sustainable feeds for many farmed fish species for the last two decades. Many published papers

describe the results of short-term feeding trials that show soybean meal can exceed 20% in feeds for salmon, cobia, trout, seabass, sea bream and yellowtail. However, when such diets are fed for longer periods in commercial production, the results are often reduced fish growth, lower feed efficiency, increased mortality rates and distal enteritis.

Several lines of research on factors in soybean meal responsible for low fish performance have been explored, starting with assessing the effects of antinutrients in soy proteins, such as trypsin inhibitors, lectins, saponins and non-soluble carbohydrates. Phytic acid, the storage form of phosphorus in seeds, has also been blamed for reducing the performance of fish fed high-soy diets. Although phytic acid is not an antinutrient per se, it interacts with calcium ions to form insoluble complexes that reduce zinc digestibility, causing a conditional deficiency in salmonids.

Other research has focused on identifying nutrients that are lacking in soy protein ingredients compared to fishmeal, such as cholesterol, taurine, phosphorus

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or trace minerals, and fortifying high-soy diets to increase their levels. Finally, fishmeal contains androgenic steroids, unlike soy, which contains estrogenlike substances. Androgenic steroids in fishmeal increase growth rates in salmonids.

### Unsuccessful Research Lines

Fishmeal and soybean meal are complex products containing hundreds of compounds that are biologically important. In fish feed formulations, the usual approach is to ensure that all essential nutrients are present at levels above the minimum dietary requirements of fish. In practice, this means supplementing high-soy feeds with DL-methionine.

When feeds are formulated in this manner, the performance of fish improves, but not to control diet levels. Similarly, formulating high-soy feeds with supplemental amino acids to approximate the amino acid pattern of fishmeal improves performance, but still not to control feed levels.

Soybean meal can also be pretreated with heat to inactivate antinutritional factors. Pretreatment improves the nutritional value of soybean meal, but not enough to overcome reduced fish growth.

These research lines have been explored for many years in fish nutritional research without achieving breakthrough results. They are no longer considered the research avenues of preference likely to achieve them.

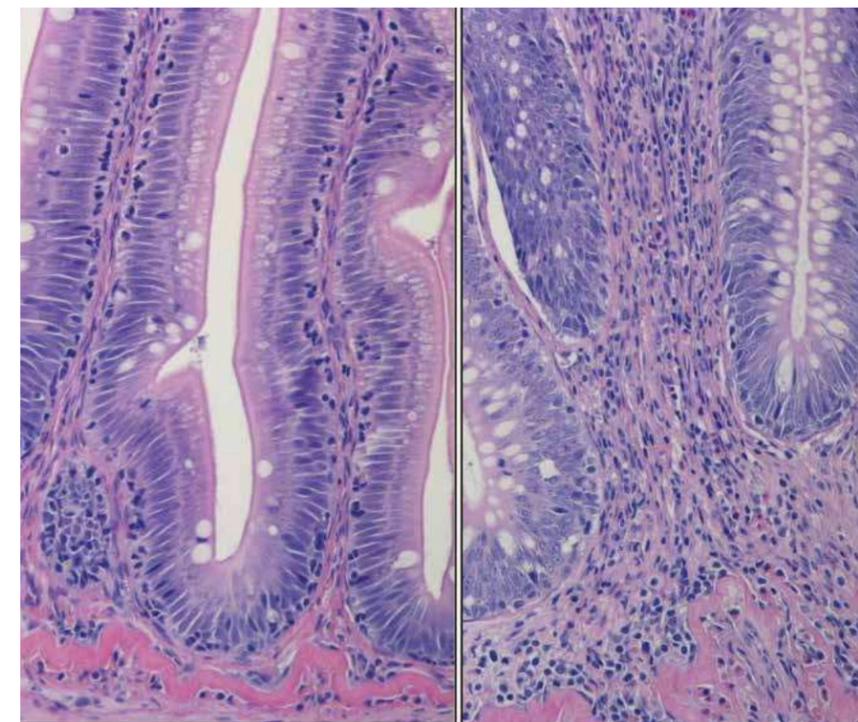


Figure 1. Grade 2 (left) and grade 4 (right) histological slides of distal intestine. In the grade 4 photo, note the increased inflammation, as well as expansion of lamina propria and an increased number of goblet cells in the epithelium.

### Trout-Breeding Program

In 2001, a selective-breeding program for rainbow trout was started at the Hagerman Fish Culture Experiment Station in Idaho, USA, by the Agricultural Research Service and the University of Idaho. Focusing mainly on enhancing growth and dietary utilization, the program fed rainbow trout a plant protein-based diet.

After 14 years of selective breeding, the selected line of trout produced grows

rapidly when fed an all-plant-protein, high-soy diet. However, another notable outcome of the program was a second trait linked with soy-based plant protein diets – the selected line does not develop distal enteritis. These results led the research team, with financial support from the soybean checkoff program through the Soy Aquaculture Alliance, to apply an alternative approach to studying soy-induced distal enteritis.

The selected line of trout exhibits a specific phenotype that can be used as a unique research tool to explore the mechanisms of distal enteritis development and other aspects of growth and health when combined with high-throughput sequencing and advanced bioinformatics.

For the first time, a fishmeal diet would not be considered the standard control diet. By comparing the genetic and physiological responses of the selected trout with those of non-selected trout when fed the all-plant-protein, high-soy diet, the mechanisms associated with the response of trout to high-soy feeds could be explored in an entirely new manner.

### Distal Enteritis

Many carnivorous fish species exhibit distal enteritis when fed high-soy feeds. The condition is best described as an inflammatory process typically located in the first section of the distal intestine that alters the cell structure and morphology of intestinal villi. The incidence and degree of enteritis increases with the soybean meal level in feed and duration of feeding.

In rainbow trout, distal enteritis is not always evident after 12 weeks of feeding, but can become full blown after 24 weeks. The severity of distal enteritis is visually judged by scoring histological slides using a scoring system based on evaluation of mucosal folds, goblet cells, supranuclear vacuoles, eosinophilic granulocytes, sub-epithelial mucosa and the lamina propria. An additional criterion for scoring the severity of distal enteritis is total inflammatory cells.

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Figure 1 shows histological slides of distal intestine. The left image shows a grade 2 sample, while the other reflects grade 4. In the grade 4 photo, note the increased inflammation, as well as expansion of lamina propria, both between and below the crypts. There are also a loss of supranuclear vacuoles in epithelial cells and an increased number of goblet cells in the epithelium.

### High-Throughput Sequencing

The development of high-throughput sequencing technology has changed the ability of researchers to investigate genomic differences, changes in global gene expression and the roles of the microbiome in humans, livestock, companion animals and now fish. The roles of the intestinal microbiota of fish in digestion and disease resistance have only recently come under investigation. Results suggest that gut microbiota are involved in key processes, including nutrient metabolism, innate immune responses, epithelial proliferation and overall fish growth and health.

Next-generation sequencing has proven to be a very powerful tool to identify all microorganisms in a sample based on unique genetic sequences in each bacterial class, family, genera or species. Initial findings by the authors evaluating the intestinal microbiota of selected and non-selected fish raised on either plant- or fishmeal-based diets revealed distinct changes in microbial populations linked specifically to diet, strain of fish and intestinal region.

### Responses To High-Soy Diets

Research has been under way for several years at the Aquaculture Research Institute in Hagerman, Idaho, USA, to characterize the responses of selected and non-selected trout to a high-soy diet. Initial results confirmed that the selected strain of rainbow trout indeed adapted to the high-soy diet and was distinctly different from non-selected fish, thus validating the use of this genetic line as a model organism.

Selected and non-selected trout strains differed in their capacity to grow on the high-soy diet, and this trait appears to be linked, in part, to differences in efficiency of digestion. Differences between strains in plasma amino acid levels following a single feeding were found in the hepatic portal veins of the fish. Differences were also found in plasma amino acid patterns in samples taken from caudal veins, which suggested differences among strains in amino acid metabolism in peripheral tissues and in post-hepatic processing.

The selected strain did not exhibit distal enteritis after 28 weeks of consuming the high-soy diet, in contrast to a high incidence of enteritis in the non-selected trout strain. Surprisingly, histological examination of distal intestine tissue samples revealed a biofilm containing cocci in samples from non-selected fish, whereas none were found in tissue samples from the selected strain. This finding suggested a link between the fish gut microbial community, particularly the microbiome associated with intestinal mucosa, and distal enteritis.

### Perspectives

Ongoing research is currently focused on integrating data from strain single-nucleotide polymorphism identification, transcriptomic and proteomic analysis of individual tissues, and microbial population changes with physiological responses to determine the roles of diet, microbiome, host and their interactions associated with the increased efficiency of selected fish in utilization of all-plant, soy-based aquaculture feed.

The next step will be to identify genetic and physiological markers in selected fish fed high-soy diets associated with resistance to development of distal enteritis, rapid weight gain and improved protein efficiency. These biomarkers will be used to improve the performance of commercial rainbow trout strains. The outcome of this research will lead to a new understanding of how selected fish adapt to high-soy diets.

This information will facilitate accelerated selection in other farmed species and identify specific microbial species in the gut microbiota that are associated with high tolerance of soy and improved fish performance, potentially leading to candidate probiotics specifically designed for high-soy feeds.

**Trout strains differed in their capacity to grow on the high-soy diet, and this trait appears to be linked to differences in efficiency of digestion.**

## production

*the bottom line*

# Use Caution When Predicting Profitability With Feed Cost/Unit Gain Metrics



In determining profits, a close economic relationship exists between the cost inputs of aquaculture – with feed a major expense – and the output revenues. There is risk in making decisions that consider only one side of the equation, such as costs.



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### Summary:

Feed cost per unit gain (F.C./U.G.) is a metric frequently used in animal production systems to evaluate the effects of feed costs on production profitability. F.C./U.G. is calculated by multiplying the feed-conversion ratio by the unit cost of feed. In many cases, F.C./U.G. does not correlate to profitability in specific systems because all of the relevant data for costs and sales must be used to evaluate the effects of feed on profitability.

Feed cost per unit gain (F.C./U.G.) is a metric frequently used in animal production systems to evaluate the effects of the cost of feed on production profitability. With feed making up between 40 and 70% of the total production costs, it is easy to understand why this metric is frequently used in publications and presentations, and by farm owners and managers to help analyze and manage costs

toward the overall objective of improving profitability.

F.C./U.G. is calculated by multiplying the feed-conversion ratio (FCR), the units of feed required to produce a unit of gain, by the unit cost of feed. See example below.

$$1.42 \text{ (FCR)} \times \text{U.S. } \$1.04 \text{ (Feed cost/kg)} = \$1.48 \text{ (Feed cost/unit gain)}$$

When F.C./U.G. is used to evaluate costs, it is usually assumed that as the number increases, profits decrease, and as the number decreases, profits increase. However, upon a more detailed analysis, it can be seen that these assumptions can be fundamentally flawed. In many cases, F.C./U.G. does not correlate to profitability in specific animal production systems. This is especially true in aquaculture.

### Profit Equation

Profits are correctly calculated by subtracting all expenses from all revenues. This equation tells us three factors are involved in increasing profits: increasing revenues, decreasing expenses or a combination of both. In aquaculture production

systems, expenses are normally incurred with the anticipation of creating a crop with a value in excess of all such expenses. A close economic relationship exists between the cost inputs and the output revenues. Therefore, there is risk in making decisions that consider only one side of the equation, such as costs.

The value received for a crop can reflect multiple factors. At harvest, these include the biomass sold, price per unit, animal size and coefficient of variation. Processing efficiency, product shrinkage and shelf life, and consumer values such as pigmentation and flavor come into play during or after processing.

The costs to produce a crop are many, including outlays for feed, labor, aeration, pond preparation, water quality management, animal health management and risk management. Fixed expenses also include fees for insurance, property taxes and administration.

### Roles Of Feed

On the income or value side of the equation, feed directly affects all of the items listed. By improving survival and growth rate, the size of the crop is increased. By improving the size of the animals, the price per unit received for

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**Table 1. Economic modeling for low-density shrimp production.**

	Low-Density Stocking				
	Control	L-1	L-2	L-3	L-4
<b>Input Data</b>					
Pond size (ha)	1.0	1.0	1.0	1.0	1.0
Stocking density (m <sup>2</sup> )	15	15	15	15	20
Weekly gain (g)	1.50	1.50	1.75	1.75	2.00
Average market weight (g)	18	18	18	18	18
Survival (%)	70	75	75	80	80
Feed-conversion ratio	1.60	1.60	1.50	1.40	1.50
Postlarvae cost/1,000 (U.S. \$)	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
Initial weight (g)	0.001	0.001	0.001	0.001	0.001
Market value (U.S. \$/kg)	\$4.00	\$4.00	\$4.00	\$4.00	\$4.00
Feed cost (U.S. \$/kg)	\$0.90	\$0.99	\$0.99	\$1.04	\$1.17
Overhead/pond/day (U.S. \$)	\$20.00	\$20.00	\$20.00	\$18.00	\$25.00
<b>Calculations</b>					
Days in cycle	84	84	72	72	63
Postlarvae stocked	150,000	150,000	150,000	150,000	200,000
Total weight marketed (kg)	1,889.90	2,024.89	2,024.89	2,159.88	2,879.84
Value at market (U.S. \$)	\$7,559.58	\$8,099.55	\$8,099.55	\$8,639.52	\$11,519.36
Postlarvae cost (U.S. \$)	\$750.00	\$750.00	\$750.00	\$750.00	\$1,000.00
Feed fed (kg)	3,023.83	3,239.82	3,037.33	3,023.83	4,319.76
Cost of feed fed (U.S. \$)	\$2,721.45	\$3,207.42	\$3,006.96	\$3,144.79	\$5,054.12
Overhead cost (U.S. \$)	\$1,679.91	\$1,679.91	\$1,439.92	\$1,295.93	\$1,574.91
<b>Results</b>					
Fingerling cost/kg marketed (U.S. \$)	\$0.397	\$0.370	\$0.370	\$0.347	\$0.347
Feed cost/kg marketed (U.S. \$)	\$1.440	\$1.584	\$1.485	\$1.456	\$1.755
Overhead cost/kg marketed (U.S. \$)	\$0.889	\$0.830	\$0.711	\$0.600	\$0.547
Total cost/kg marketed (U.S. \$)	\$2.726	\$2.784	\$2.567	\$2.403	\$2.649
Total profit/kg marketed (U.S. \$)	\$1.274	\$1.216	\$1.433	\$1.597	\$1.351
<b>Profit</b>					
Income over fingerling, feed and overhead costs (U.S. \$)	\$2,408.22	\$2,462.22	\$2,902.67	\$3,448.81	\$3,890.33

**Table 2. Economic modeling for high-density shrimp production.**

	High-Density Stocking				
	Control	H-1	H-2	H-3	H-4
<b>Input Data</b>					
Pond size (ha)	1.0	1.0	1.0	1.0	1.0
Stocking density (m <sup>2</sup> )	150	150	150	150	200
Weekly gain (g)	1.50	1.50	1.75	1.75	2.00
Average market weight (g)	18	18	18	18	18
Survival (%)	70	75	75	80	80
Feed-conversion ratio	1.60	1.60	1.50	1.40	1.50
Postlarvae cost/1,000 (U.S. \$)	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
Initial weight (g)	0.001	0.001	0.001	0.001	0.001
Market value (U.S. \$/kg)	\$4.00	\$4.00	\$4.00	\$4.00	\$4.00
Feed cost (U.S. \$/kg)	\$0.90	\$0.99	\$0.99	\$1.04	\$1.17
Overhead/pond/day (U.S. \$)	\$60.00	\$60.00	\$60.00	\$54.00	\$80.00
<b>Calculations</b>					
Days in cycle	84	84	72	72	63
Postlarvae stocked	1,500,000	1,500,000	1,500,000	1,500,000	2,000,000
Total weight marketed (kg)	18,898.95	20,248.88	20,248.88	21,598.80	28,798.40
Value at market (U.S. \$)	\$75,595.80	\$80,995.50	\$80,995.50	\$86,395.20	\$115,193.60
Postlarvae cost (U.S. \$)	\$7,500.00	\$7,500.00	\$7,500.00	\$7,500.00	\$10,000.00
Feed fed (kg)	30,238.32	32,398.20	30,373.31	30,238.32	43,197.60
Cost of feed fed (U.S. \$)	\$27,214.49	\$32,074.22	\$30,069.58	\$31,447.85	\$50,541.19
Overhead cost (U.S. \$)	\$5,039.72	\$5,039.72	\$4,319.76	\$3,887.78	\$5,039.72
<b>Results</b>					
Fingerling cost/kg marketed (U.S. \$)	\$0.397	\$0.370	\$0.370	\$0.347	\$0.347
Feed cost/kg marketed (U.S. \$)	\$1.440	\$1.584	\$1.485	\$1.456	\$1.755
Overhead cost/kg marketed (U.S. \$)	\$0.267	\$0.249	\$0.213	\$0.180	\$0.175
Total cost/kg marketed (U.S. \$)	\$2.104	\$2.203	\$2.069	\$1.983	\$2.277
Total profit/kg marketed (U.S. \$)	\$1.900	\$1.800	\$1.930	\$2.020	\$1.720
<b>Profit</b>					
Income over fingerling, feed and overhead costs (U.S. \$)	\$35,841.59	\$36,381.56	\$39,106.16	\$43,559.56	\$49,612.69

the crop is increased. Feed also influences shrinkage during processing, processing efficiency and shelf life.

On the expense or cost side of the equation, it is important to consider that feed is the primary contributor to a decline in water quality, either from feed metabolic waste products excreted by the shrimp or wasted feed that results from improper feeding methods. When feed is selected and managed in a way that reduces a decline in water quality, the costs associated with water quality management can be significantly reduced.

Faster-growing animals, associated with better feeds, can be harvested sooner. Less time in containment results in lower operating costs per unit produced. In addition, production risks are reduced when growout time is shortened.

Feed drives the production system. Therefore, all the relevant data from both sides of the profit equation must be used to evaluate the effects of feed on profitability.

### Economic Modeling

It is possible to explore the assumption that profits decrease as F.C./U.G. increases by using economic modeling (Tables 1 and 2). Although this modeling focuses on the feed economics for shrimp culture, the same principles can be used to evaluate production systems for fish or other animals.

Five production scenarios are presented for each of two stocking densities, 15 animals/m<sup>2</sup> and 150 animals/m<sup>2</sup>. The input data defines the production unit, operating and economic parameters. It considers all costs in three separate line items: postlarvae cost/1,000, feed cost/kg and overhead, which includes all other fixed and variable operating costs.

Overhead costs can be estimated by

adding together all of the annual fixed and variable costs, except for feed and postlarvae, for a specific farm or production unit, divided by the number of days the farm is operated each year. By dividing this number by the number of production modules or hectares, one can calculate a reasonable estimate of the daily overhead cost per module or hectare.

### Cost, Profit Data

The results sections of the tables provide economic data on cost and profit expressed on a per kilogram shrimp marketed basis. The results-profits sections report profit as the difference between all income less all expenses, per production unit, which in the illustration is 1 ha.

The two control columns are intended to represent average production conditions. In the other four columns for each stocking density, reasonable changes were made to the input data in order to measure the changes to the profit-oriented data at the bottom.

In the L-1 and H-1 columns, feed cost was increased by U.S. \$.09 a kilo or 10%, and survival was increased from 70 to 75%. In the L-2 and H-2 columns, feed cost was again increased by \$.09 a kilo or 10%. Survival was increased to 75%, growth rate or weekly growth was pushed to 1.75 g, and the feed-conversion ratio (FCR) was reduced from 1.6 to 1.5.

In the L-3 and H-3 columns, feed cost was increased by U.S. \$.14/kg or 15%. Survival was increased to 80% and weekly weight gain was 1.75 g. FCR was reduced to 1.4, and overhead decreased by 10% to \$18 or \$54 a day to account for a shorter growing season and better water quality as a result of improved FCR.

In the final columns, L-4 and H-4, feed cost was increased by 30% or U.S. \$.27/kg. In addition, stocking density was

increased by 33%, survival rose to 80% and growth rate was increased to 2 g/week. The overhead/day was increased by 25 and 33%, respectively.

As the cost of the feed increased for all the examples shown in Tables 1 and 2, so did the feed cost/kg shrimp marketed (F.C./U.G.). Although this value rose, the bottom line profit was increased in this economic modeling. These data strongly suggest that (F.C./U.G.) is not a reliable predictor of profitability.

### Regression Analysis

Another way of determining the relationship between F.C./U.G. and profitability is to treat crop economic data by regression analysis (Figure 1). These 2011 data represent one crop from a farm with 27 ponds and average pond size of about 3.5 ha.

In this case, the correlation coefficient of 0.0007 shows practically no correlation between the two factors compared, pond profitability and F.C./U.G.

### Perspectives

Clearly, these examples demonstrate that feed materially affects parameters on both sides of the profit equation. To better understand feed economics, also consider the ratio between the selling price of shrimp and the cost of feed expressed in similar units.

If shrimp sell for U.S. \$4.00/kg, and feed costs \$0.90/kg, the ratio is 4.44. Because of the significant impacts feed has on crop yield, unit value, days of containment and water quality, it only requires a small improvement in these parameters to more than equal incremental increases in feed costs.

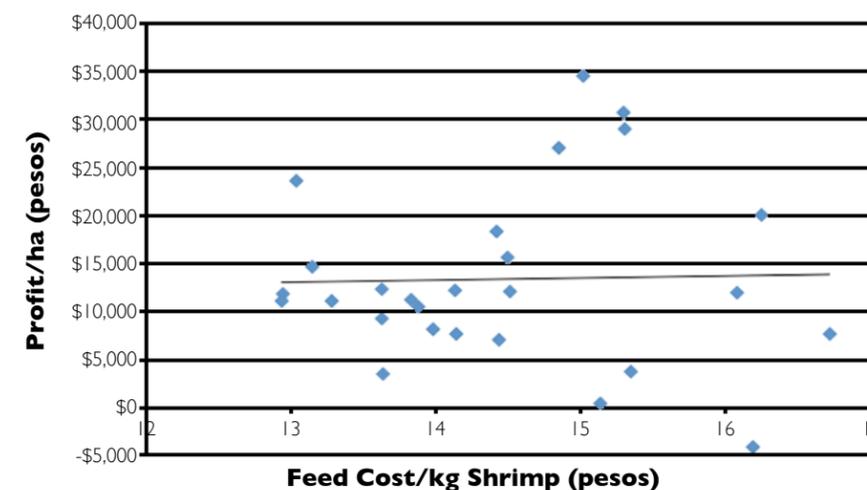


Figure 1. Comparison of profits and feed costs.



**Bottom Line:**  
Feed cost/unit gain  
evaluations are  
inappropriate for  
predicting profitability.

# Use Of Functional Diets Improves Survival Of *Vibrio*-Infected Shrimp



White shrimp infected with *Vibrio harveyi* had better growth and survival when they received feed supplemented with betaglucans and organic acids.

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was maintained between 20-25 ppt and temperature was kept constant at 29 ± 1 °C with heaters.

## 2.2. Experimental Feeds

Two 35% protein pelleted diets were produced in the Nicovita feed production plant in Trujillo-Peru, they were processed considering the additive inclusion as follows, betaglucans and organic acids (Nicovita Prevence<sup>®</sup>) and organic acids only (Nicovita Terap<sup>®</sup>). A commercial pellet diet from Thailand was used as the control diet.

## 2.3. Experimental Design

Before beginning the feeding trial, a virulent strain of *Vibrio harveyi* which had been cultured in Tryptic Soy Agar (TSA) with 1.5 % NaCl (w/v) was added into the tanks at the dose of 1x10<sup>3</sup> CFU/ml before stocking.

Five experimental groups; consisting of two control groups which shrimp were fed with commercial feed from Thailand and three treatment groups which were fed the experimental diets according to Table 1, were used for this experiment. Each group was carried out with four rep-

## 1. Introduction

New market opportunities for the shrimp industry have increased the aquaculture production volume; simultaneously the risk for the spread of diseases has increased as well. Vibriosis is one of the major problems in shellfish and finfish aquaculture being responsible for mortality in cultured shrimp worldwide. Outbreaks may occur when environmental factors trigger the rapid multiplication of bacteria already tolerated at low levels within shrimp blood.

Several methods to treat diseases have been used in the last years such as the inclusion of antibiotics in shrimp feed. It has been demonstrated that the abuse of antibiotics has given rise to multiple resistance among microbial populations associated with shrimp production. As a consequence, diseased shrimp will sometimes not respond to antibiotic treatments and the mortality will continue until a more suitable treatment is applied.

For these reasons the industry has sought alternative treatments for this disease. Functional additives such as betaglucans and a variety of organic acids have demonstrated efficacy in promoting shrimp health through the stimulation of the immune system and their antibacterial effects against Vibrios.

Functional diets using these ingredients have been developed and are cur-

rently being used in the industry, in countries such as Ecuador, Peru and Honduras, with good results; improving survival by regulating the immune system and reducing the presence of pathogenic *Vibrio* (Figure 1).

In this study we tested 2 diets with the inclusion of betaglucans and organic acids to evaluate their efficacy in improving survival against an infection with *Vibrio harveyi* in Pacific White Shrimp, *Litopenaeus vannamei*.

## 2. Materials and Methods

### 2.1. Experimental Animals

A total of 600 juvenile white shrimp weighting 2-3 g were stocked in 12 tanks at the Aquaculture Business Research Center (ABRC), Faculty of Fisheries, Kasetsart University, Thailand. Each tank had a 500 liter capacity and the stocking density was 50 shrimp per tank. Salinity

Table 1. Treatments and feeding protocol of experiment.

Treatment	Diet Administered	
	Days 1-14	Days 15-30
Negative Control	Commercial Feed	Commercial Feed
Positive Control	Commercial Feed	Commercial Feed
Nicovita Prevence <sup>®</sup>	Nicovita Prevence <sup>®</sup>	Commercial Feed
Nicovita Terap <sup>®</sup>	Nicovita Terap <sup>®</sup>	Commercial Feed
Nicovita Prevence <sup>®</sup> + Nicovita Terap <sup>®</sup>	Nicovita Prevence <sup>®</sup>	Nicovita Terap <sup>®</sup>

licates. The shrimp were fed *ad libitum* four times a day throughout the experiment. Survival and body weight were recorded on day 30. Hepatopancreases were delicately removed from several specimens from each tank for histological study at the end of the experiment.

## 2.4. Statistical Analysis

The final body weight and survival of treatment groups was statistically compared using Analysis of Variance and Duncan's New Multiple Range.

## 3. Results

After 30 days of the feeding trial, survival rates of shrimps in Negative Control, Nicovita Prevence<sup>®</sup>, Nicovita Terap<sup>®</sup> and Nicovita Prevence<sup>®</sup> + Nicovita

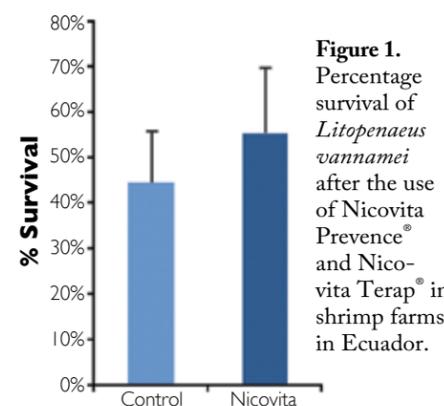


Figure 1. Percentage survival of *Litopenaeus vannamei* after the use of Nicovita Prevence<sup>®</sup> and Nicovita Terap<sup>®</sup> in shrimp farms in Ecuador.

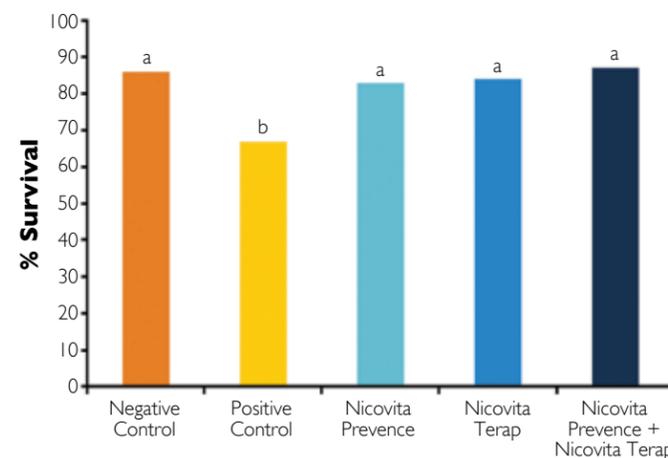


Figure 2. Percentage survival in *Litopenaeus vannamei* infected with *Vibrio harveyi* after 30 days of treatment.

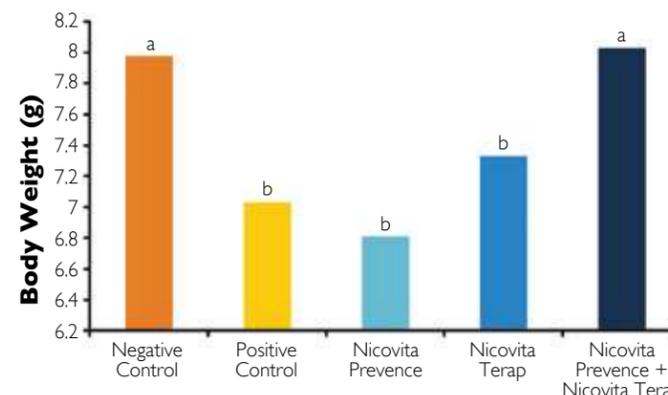


Figure 3. Body weight in grams of *Litopenaeus vannamei* infected with *Vibrio harveyi* after 30 days of treatment.

Terap<sup>®</sup> groups were not significantly different among each other, being 86.0 ± 4.0, 82.7 ± 2.3, 84.0 ± 0.0, and 86.7 ± 3.1% respectively. However, survival rates of these experimental groups were significantly higher than those of Positive Control (67.33 ± 3.06%). Statistical differences P<0.05 indicated by small letters (Figure 2).

Throughout the feeding trial, the highest body weight was seen in Negative Control and Nicovita Prevence<sup>®</sup> + Nicovita Terap<sup>®</sup> groups (7.98 ± 0.77 and 8.03 ± 0.82 g respectively), which were significantly higher than all other groups; whereas, the body weight of Nicovita Prevence<sup>®</sup> and Nicovita Terap<sup>®</sup> groups were comparable to those of Positive Control group, being 6.81 ± 0.56, 7.33 ± 0.62, and 7.03 ± 0.77 g respectively. Statistical differences P<0.05 indicated by small letters (Figure 3).

## Histological Study

Histological study of the hepatopancreas revealed signs of bacterial infection – indicated by granulomatous lesions and necrosis of hepatopancreatic cells – in Positive Control. In contrast, hepatopancreas of shrimps in Negative Control, Nicovita Prevence<sup>®</sup>, Nicovita Terap<sup>®</sup> and Nicovita Prevence<sup>®</sup> + Nicovita Terap<sup>®</sup> groups were apparently normal (Figure 4).

## 4. Discussion

The bacteria-infected shrimp fed Nicovita Prevence<sup>®</sup> + Nicovita Terap<sup>®</sup> had similar growth and survival responses as the group of uninfected shrimp; suggesting that the treatments applied in Nicovita Prevence<sup>®</sup> + Nicovita Terap<sup>®</sup> were capable of controlling the infection as shown in the structure of the hepatopancreas. The organic acids in Nicovita Terap<sup>®</sup> effectively kill bacteria improving the survival rate on the infected shrimps, while Nicovita Prevence<sup>®</sup> prepared the immune system for the upcoming infection.

The betaglucans in Nicovita Prevence<sup>®</sup> have an important role in this experiment's results as it is demonstrated in several studies that indicate how they improve health, growth and general performance of many different animal groups including farmed shrimp and fish.

Betaglucans have also demonstrated to up regulate immune parameters such as hemocyte count and phenoloxidase activity in charge of defending the organism against pathogens. Studies show that betaglucans stimulated phenoloxidase activity in hemocytes of Black Tiger Shrimp, *Penaeus monodon*. Activation of hemocytes as indicated by increased respiratory burst activity following treatment with betaglucans has been recorded by Song and Hsieh (1994). Murthy (2009) demonstrated that Pacific White Shrimp fed diets with betaglucans had significantly higher respiratory burst values than shrimp fed a basal diet.

On the other hand organic acids have demonstrated effectiveness in enhancing the growth performance and the nutrient availabilities in various aquatic species; they reduce the pH of the digest of the stomach and the foregut, which in turn stimulates the pepsin activity, improving protein digestibility and mineral absorption. Trypsin and chymotrypsin are the most abundant proteolytic enzymes in the midgut gland of shrimp, and are responsible for more than 60% of total protein digestion in the midgut gland of penaeids. Thus, the lowering of the gastric system's pH unchains the proteinases enzymatic activity allowing a better digestion of the protein in the feed.

Organic acids enhance gut health since they are generally absorbed through the intestinal epithelia by passive diffusion, providing energy for renewing the intestinal epithelia. Organic acids and their salts exert their growth inhibiting effects on stomach and gut microbes through pH reduction, anion and proton

(Continued on page 32.)



The most effective way of reducing the water pollution potential of feed is by using high-quality feed applied in a manner that assures culture animals fully consume it.

## Aquaculture Feed Composition Helps Define Potential For Water Pollution

### Summary:

A study found that feed for salmon and trout had higher organic carbon concentrations than did catfish, shrimp and tilapia feeds. Nitrogen and phosphorus concentrations were similar among salmon, trout and shrimp feeds, and higher than those in catfish and tilapia feeds. Whole body concentrations of organic carbon were greater in salmon and trout than in the other species. Salmon and shrimp had the highest whole body nitrogen concentrations. Phosphorus concentrations were greater in catfish and tilapia than in the other species.

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Losordo Intensive aquaculture relies on manufactured feeds to promote animal growth. Through the addition of supplementary feeds, production can be increased many times more than by fertilization alone. However, with an increase in feed use without proper management in aquaculture, there is a corresponding increase in the potential for water pollution caused by organic matter and nutrients originating in feed.

In commercial feed-based production, only a portion of the applied feed – usually 70 to 95% – is eaten by the culture species. The uneaten feed, feces and metabolic wastes enter the water and can adversely impact water quality. Manufactured feeds can lose nutrients by leaching immediately after immersion in water. Hence, some nutrient loss occurs even before the feed is eaten. It has been estimated that 60 to 80% of the nitrogen and phosphorus in feeds passes into the water column.

Nutrients from feeding waste can lead to a number of problems, including dense phytoplankton blooms, low dissolved-oxygen concentrations and increased concentrations of ammonia and other nitrogenous substances. Impaired water quality stresses fish and shrimp, potentially affecting their appetites and predisposing them to parasites and diseases.

The nitrogen content of feed can be estimated from information reported on feed bags, but manufacturers do not normally provide the concentrations of carbon, phosphorus and other elements of interest in water pollution assessments. Hence, a study was recently initiated at Auburn University to obtain detailed data on the chemical composition of feeds from several countries and for a variety of aquaculture species.

### Information Needed

Currently, the greatest need related to aquaculture and water pollution issues is more information on the concentrations of organic carbon, nitrogen and phosphorus in feeds. The concentrations of these compounds in feeds and whole bodies of culture animals are provided in Table 1 for five aquaculture species. Typical feed-conversion ratios for the animals are also included in the table.

Feed for salmon and trout had higher organic carbon concentrations than did catfish, shrimp and tilapia feeds. Nitrogen concentrations, as well as phosphorus concentrations, were similar among salmon, trout and shrimp feeds, and higher in these types than in catfish and tilapia feeds.

**Table 1. Typical feed-conversion ratios, whole body compositions and feed compositions for selected aquaculture species.**

Species	Typical FCR	Feed (% air dry weight)			Feed BOD (kg/kg feed)	Culture Species (% live weight)		
		Carbon	Nitrogen	Phosphorus		Carbon	Nitrogen	Phosphorus
Ictalurid catfish	2.0	39.73	5.59	1.32	1.11	12.75	2.38	0.68
Salmon	1.1	45.60	8.07	1.50	1.05	16.80	2.96	0.40
Trout	1.2	43.40	8.12	1.56	1.09	15.60	2.50	0.35
Shrimp	1.5	39.44	7.54	1.54	1.16	11.00	2.86	0.32
Tilapia	1.7	39.23	5.95	1.28	1.08	11.70	2.22	0.72

**Table 2. Biochemical oxygen demands (BODs) and loads of nitrogen and phosphorus associated with feed used to produce 1 kg of five common aquaculture species.**

Species	BOD (kg oxygen/harvest kg)	Nutrient Load (g/harvest kg)	
		Nitrogen	Phosphorus
Ictalurid catfish	2.22	88.0	19.6
Salmon	1.16	59.2	12.5
Trout	1.31	72.4	15.2
Shrimp	1.69	84.5	19.9
Tilapia	1.84	79.0	14.6

Whole body concentrations of organic carbon were greater in salmon and trout than in the other three species. Salmon and shrimp had the highest whole body nitrogen concentrations. Phosphorus concentrations were considerably greater in catfish and tilapia than in the other species.

Results from the study indicated that the crude protein concentrations reported for the feed by manufacturers were similar to the protein values estimated from the nitrogen content of feeds measured in the study.

### Oxygen Demand

The organic carbon and nitrogen in feeds that are not converted to the biomass of the culture species exert an oxygen demand. Part of the oxygen demand results from oxidation of organic carbon by the culture species and of organic wastes (feces and uneaten feed) by bacteria. The remainder of the oxygen demand is caused by nitrification.

Ammonia nitrogen from metabolism by the culture species and microorganisms of decay release ammonia that is oxidized to nitrate by nitrifying bacteria. The feed oxygen demand can be calculated as follows:

$$BOD_f = [C_f - (FCE \times C_c)] \times 2.67 + [N_f - (FCE \times N_c)] \times 4.57$$

Where  $BOD_f$  = Biological oxygen demand of feed (kg oxygen/kg feed)

$C_f, C_c, N_f, N_c$  = Decimal fractions of carbon and nitrogen in feed and live weight of the culture species, respectively

FCE = Feed-conversion efficiency.

### BOD Calculations

The biological oxygen demand (BOD) values were calculated for feeds for each of the five species (Table 2). The values ranged from 1.05 kg oxygen/kg feed for salmon to 1.16 kg oxygen/kg feed for shrimp. The average for the five species was 1.10 kg oxygen/kg feed.

The total oxygen demand per kilogram of production can be estimated by multiplying the feed BODs by the feed-conversion

ratio (FCR). The total oxygen demand for production of the five species ranged from 1.16 kg oxygen/kg for salmon to 2.22 kg oxygen/kg for channel catfish (Table 2).

The quantities of nitrogen and phosphorus entering culture systems can be estimated by subtracting the amounts of each element removed in the harvesting of 1 kg of the culture species from the quantity of each element applied in feed necessary to produce 1 kg of biomass. The equation for this calculation is illustrated below using nitrogen:

$$N_w = [(N_f \times FCR) - N_c] \times 10^3 \text{ g/kg}$$

Where  $N_w$  = Nitrogen waste in g nitrogen/kg culture species

FCR = Feed-conversion ratio

$N_f$  and  $N_c$  = Decimal fractions of nitrogen in feed and culture species, respectively.

Waste loads for nitrogen ranged from 72.4 g/kg for trout to 88.0 g/kg for ictalurid catfish, with an average value of 76.6 g/kg. For phosphorus, values ranged from 12.5 g/kg for salmon to 19.9 g/kg for shrimp, with an average of 16.4 g/kg. Estimated percentages of the two nutrients added in feed that would enter the waters of culture systems ranged from 66.7% (salmon) to 78.7% (ictalurid catfish) for nitrogen and from 86.1% (shrimp) to 67.3% (tilapia) for phosphorus. Averages were 73.2% for nitrogen and 76.9% for phosphorus.

In ponds, a large portion of the feed BOD and waste nitrogen and phosphorus are assimilated within the system and not discharged in effluent. In raceway culture, some of the wastes may be removed by sedimentation in the ends of raceway units and disposed of on land. In cage culture, the entire waste load enters the receiving waters directly.

### Perspectives

The most effective way of reducing the water pollution potential of feed – both within culture systems and in the water bodies receiving aquaculture waste – is through attention to feeds and feeding practices. High-quality feeds that contain no more nitrogen and phosphorus than necessary should be used. Feed should be applied in a manner to assure that culture animals eat essentially all of it. Good water quality should be maintained in culture systems to avoid stress that adversely affects the appetite of the culture species.

Presently, the digestibility of feed ingredients and processing technology play significant roles in improving feed quality and making feed more friendly to the environment. The addition of highly digestible ingredients in feeds can increase absorption and retention, as well as reduce wastage by reducing nutrient excretion.

Extrusion technology contributes significant positive impacts to the aquatic feed industry. Extrusion pellets have high stability and are durable, which reduces leaching and results in less wastage of nutrients and environmental pollution.

# Water Composition: Dissolved Inorganic Solids



Interest in inland aquaculture is growing, but inland waters can have ionic imbalances that affect the growth and survival of cultured species.



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All of these substances influence the quality of water for use in aquaculture, but this article focuses on dissolved inorganic solids.

### Salinity

A few anions, bicarbonate, carbonate, sulfate and chloride; a few cations, calcium, magnesium, sodium and potassium; and, largely, un-dissociated silicic acid represent the largest fraction of dissolved

inorganic solids in water. The total concentration of ions in water is called the salinity and is typically reported in either milligrams per liter or parts per thousand. It is inconvenient to measure the major ion concentrations and add them to obtain salinity.

Salinity can also be measured with a hydrometer, because the density of water increases with greater salinity. Salinity affects the refractive index of water, an effect that allows salinity to be measured with a hand-held refractometer. The ability of water to conduct electricity increases with greater ion concentration, so the conductivity of water provides another way of estimating salinity.

The salinity of freshwater varies from near 0 to 1,000 mg/L. Average seawater contains 34,500 mg/L salinity. Saline inland water and estuarine water can have lower or higher salinity than ocean water. The conductivity of seawater is around 50,000  $\mu$ mhos/cm, and in seawater and estuarine water, multiplying the factor 0.69 times conductivity provides a reasonable estimate of salinity in milligrams per liter.

Seawater has relatively constant proportions of major ions, but freshwater and saline inland waters do not. The factor for relating conductivity to salinity in these waters ranges from about 0.55 to 0.80. Thus, conductivity is not as accurate for estimating salinity in freshwater as in seawater.

### Total Dissolved Solids

The total dissolved-solids (TDS) concentration often is measured in freshwater by filtering water through a 0.45- $\mu$  filter, evaporating the filtrate and weighing the residue. The concentrations of dissolved organic matter and unionized substances usually are low, and the weight of these substances tends to be offset by loss of carbon dioxide from bicarbonate when water evaporates.

Thus, TDS concentration usually is roughly equal to salinity in freshwater. Salts are hygroscopic, and TDS concentrations cannot be measured accurately from the weight of the residue after evaporation for waters with concentrations above 2,000 or 3,000 mg/L.

### Major Ions

Global average concentrations of major ions in river water and seawater are presented in Table 1. Calcium and bicarbonate are dominant ions in river water, but sodium and chloride are the dominant ions in seawater. Magnesium also is more abundant than calcium in seawater, while the opposite is true in freshwater.

Unlike seawater, freshwater varies greatly both in salinity and in the proportions of individual ions. The lowest salinities are found in humid areas with highly leached, acidic soils, while the greatest salinities are found in areas with limestone deposits and in arid regions. In arid regions, sulfate and chloride often are present in greater concentrations than bicarbonate. This is especially true in saline inland waters, where sodium is often at higher concentration than calcium, and magnesium and potassium often are at low concentrations.

Bicarbonate and carbonate in water often are titrated with standard sulfuric acid and expressed as total alkalinity in milligrams per liter of calcium carbonate. Calcium and magnesium concentrations are often titrated collectively with the chelating agent ethylenediaminetetraacetic acid and expressed as total hardness, also in milligrams per liter of calcium carbonate.

Freshwater fish tend to grow best at salinities of 1,000 mg/L or less, but some species grow well in water with salinities of 5,000 mg/L or even more. Estuarine species such as marine

**Table 1. Concentrations of major ions and silicate in world average river water and normal ocean water.**

	River Water (mg/L)	Ocean Water (mg/L)
Bicarbonate/carbonate	58.0	142.0
Sulfate	11.2	2,700.0
Chloride	7.8	19,000.0
Calcium	15.0	400.0
Magnesium	4.1	1,350.0
Sodium	6.2	10,500.0
Potassium	2.3	380.0
Silicon as silica	13.1	6.4

shrimp can grow well across a wide range of salinity – from 1,000 mg/L up to full-strength seawater or higher. Of course, marine species grow best in full-strength seawater.

There is considerable interest in growing marine and estuarine species in inland saline water that is an unused resource in many regions. Sometimes, inland waters have ionic imbalances that affect the growth and survival of culture species, especially shrimp.

The most common ionic imbalance is a shortage of potassium that results in an excessive sodium:potassium ratio. Also, magnesium concentration sometimes may be too low. Mineral amendments such as muriate of potash (potassium chloride) and potassium magnesium sulfate can be used to correct ionic imbalances.

Low alkalinity and hardness are associated with acidic water, and liming often is done to increase their values. Alkalinity should exceed 60 mg/L in freshwater fish culture and 100 mg/L in shrimp and other crustacean ponds. The hardness should equal the alkalinity, but greater concentrations are acceptable.

### Summary:

A few anions and cations, and un-dissociated silicic acid represent the largest fraction of dissolved inorganic solids in water. The total concentration of ions is called the salinity. The total dissolved-solids concentration usually is roughly equal to salinity in freshwater. Unlike seawater, freshwater varies greatly in salinity and proportions of individual ions. Calcium and bicarbonate are dominant ions in river water, but sodium and chloride are dominant in seawater. Water contains many other inorganic substances, as well as many trace elements.

In spite of being commonplace, water has a chemical complexity that is seldom fully appreciated. Pure water probably exists only in water vapor – even rainwater contains dissolved substances. Water for aquaculture comes from surface runoff, streams, underground aquifers, reservoirs, estuaries and the sea.

Freshwaters come in contact with soils and other geological formations, and are influenced by climate, so they are much more chemically complex than rainwater. Freshwaters also vary in chemical composition from one location to another. Of course, seawater composition has developed over millions of years, and the ocean is so vast that its composition is similar from place to place.

Water used in aquaculture contains an array of dissolved gases, dissolved inorganic and organic solids, and particulate inorganic and organic solids. The particulate organic solids include both living organisms and their decomposing remains.

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## Other Inorganic Substances

Water contains many other inorganic substances. The plant nutrients phosphate, ammonium and nitrate are usually present at low concentrations of less than 0.5 mg/L phosphate-phosphorus, 2.0 mg/L ammonium-nitrogen and 0.5 mg/L nitrate-nitrogen, but these nutrients are extremely important because of their effect on phytoplankton productivity. Concentrations of silicon, an element important for the growth of diatoms, are usually between 2.0 and 10.0 mg/L.

Nitrogen and phosphorus fertilizers often are applied to promote phytoplankton growth in ponds without feeding or during the initial stages of culture in ponds with feeding. Silicon fertilization sometimes is practiced in shrimp ponds to promote diatom growth, but the benefits of this practice are unclear.

## Trace Elements

Water also contains a multitude of trace elements. Some, such as iron, manganese, zinc, copper, boron, cobalt, molybdenum and iodine, are nutrients. Others, such as lead, chromium and cadmium, are not nutrients and can be toxic.

Of course, even nutritive trace elements can be toxic at excessive concentrations. Trace elements, particularly iron, are some-

times added to fertilizers for saline-water ponds, because a shortage of iron is thought to limit phytoplankton growth in the ocean.

## pH

Water dissociates slightly, yielding hydrogen and hydroxyl ions. These two ions do not contribute significantly to salinity, but pH – which is extremely important in aquaculture – is related to concentrations of these ions.

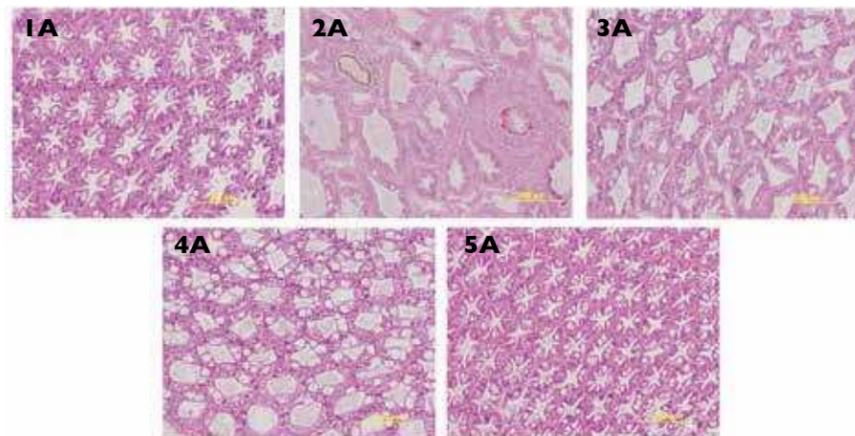
The pH is defined as the negative logarithm of the hydrogen ion concentration. Pure water has a pH of 7.0 and is considered neutral. The acidity of water increases with decreasing pH below 7, and basicity increases with increasing pH above 7.0. Most aquaculture species do best at a pH between 6.0 and 8.5.

## Perspectives

The chemical nature of a water source has a strong influence on the suitability of the water for aquaculture. Therefore, the chemical compositions of water sources for aquaculture should be known and monitored occasionally for possible changes so that appropriate measures may be taken to remediate the water, if necessary.

## Functional Diets Improve Survival...

(Continued from page 27.)



**Figure 4.** Hepatopancreas of Negative Control (1A: 100x), Positive Control (2A: 100x), Nicovita Prevence® (3A: 100x), Nicovita Terap® (4A: 100x), and Nicovita Prevence® + Nicovita Terap® (5A: 100x) groups.

effects in the microbial. Furthermore, the use of an acidifier rather than antibiotics means that there is no chance of contributing to antibiotic resistance in bacteria, nor are there any antibiotic-related effects on the food supply.

The combination of these additives allowed better growth and survival since they were able to improve digestion and kill bacteria efficiently; in addition it proposes a safe strategy to fight *Vibrio* infections without the risks implied by the use of antibiot-

ics. Nicovita Prevence® should be used 14 days prior to a mortality event to build up the immune system, following its administration Nicovita Terap® should be administered for 14 days if the mortality event is due to *Vibrio sp.* Alongside the dietary treatment water quality and environmental parameters should be evaluated and adjusted, if necessary, to create a better media for the growth of shrimp and to maximize the potential of the diets being used.

## Acknowledgments

Aquaculture Business Research Center (ABCR), Faculty of Fisheries, Kasetsart University, Bangkok, Thailand.

References available from first author.

**Nicovita's Veterinary Technical Staff can assist you in any adjustments made to this protocol and according to the type of stocking used in your facility.**

**Table 2. Protocol for use of Nicovita's products.**

	Microbiological analysis <i>Vibrio sp.</i> (Shrimp Larvae)	Growout Period				
		Day 0-14	Day 15-30	Day 31-45	Day 46-50	From Day 51 To Harvest
Direct Stocking	Vibrios < 1*10 <sup>3</sup> CFU/g	KR 1/2	Prevence 1.2 mm	Terap 2.0 mm	Classic 2.0 mm	Classic 2.5 mm
	Vibrios > 1*10 <sup>3</sup> CFU/g	Day 0-14 Terap 1.2 mm	Day 15-30 Prevence 1.2 mm	Use Nicovita Terap as needed according to bacteriological analysis of <i>Vibrio sp.</i>		

# production

## Pond Aeration And Aerators: Second Thoughts



Essentially the same aerators have been used for decades. Is this because the present aerators are so good?

## Summary:

Aerators, especially paddlewheels, are often used to mix the water and address oxygen stratification in ponds. However, most aerators do not provide the most efficient and power-conscious service. Due to thermal and oxygen stratification in ponds, the efficiency of paddlewheel aerators is low, and other present-day aerators have other problems. Emerging designs should better address effective mixing and aerating of pond water.

Aeration of aquaculture ponds, especially intensive ponds, is an essential requirement. Proper aeration is needed to obtain expected production, while on the other hand, it is an appreciable component of production cost.

An adequate aeration system should fill several roles while minimizing energy consumption. Aeration must supply enough oxygen to overcome oxygen limitations and enable high stocking and production levels. It must distribute the oxygen in the pond, both horizontally and vertically, and mix the water at the water-sediment interface. Proper aeration also minimizes sludge piles on pond bottoms and eases pond drainage.

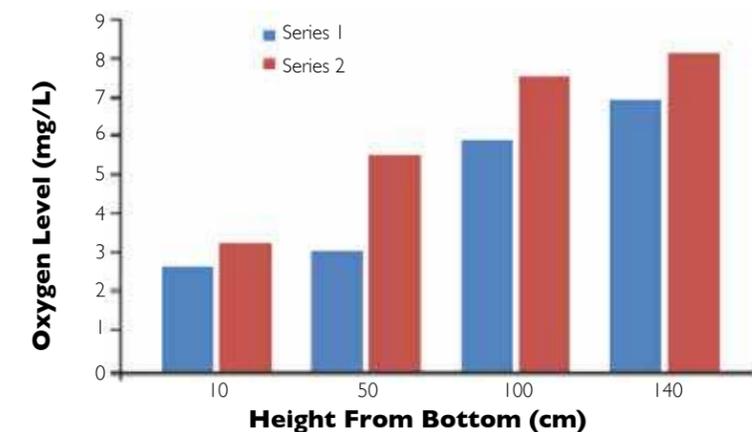
Reviewing the technical publications as well as field practice, one may be

astonished by the fact that essentially the same aerators have been used for decades. During this period, aquaculture production rose dramatically, feeds were greatly improved, and new species were cultured.

Is this because the present aerators are so good?

## Oxygen Stratification

One of the major factors affecting aeration efficiency is the development of thermal and oxygen stratification in aquaculture ponds. Thermal solar radiation is adsorbed by the superficial water layers, raising the temperature and forming a stable warm and light water layer. Moreover, algae photosynthesis and oxygen release preferentially take place in this superficial layer. Thus, during daytime – and often in the early nighttime – the top layer of pond water is relatively enriched with respect to oxygen, while the bottom layer and the water-sedi-



**Figure 1.** Late-morning oxygen profiles in a commercial shrimp pond.

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ment interface have limited oxygen.

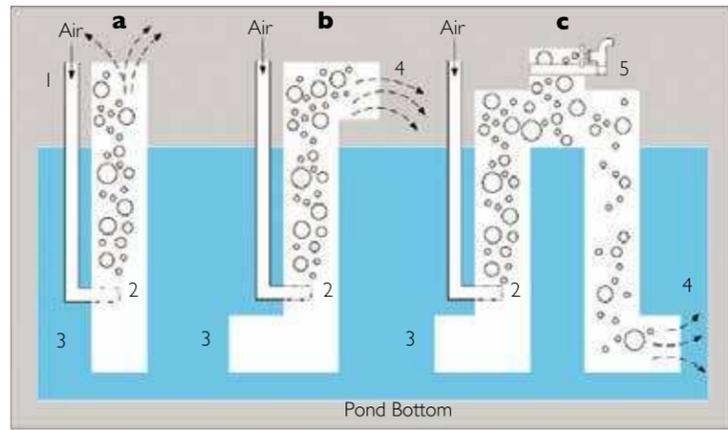
As an example, oxygen profiles in a commercial shrimp pond are shown in Figure 1. They were monitored across the pond at about 11:00 a.m. on a sunny day, when oxygen supply was likely to be optimal. At 6-8 mg/L, the oxygen concentrations in the surface layers were very high – in fact, super-saturated. However, at about 10 cm above the pond bottom, oxygen concentrations were very low, in the range of 2-3 mg/L. Oxygen is practically zero in the soil-water interface. It is important to mention that the bottom water layer is the zone where shrimp live and harvest feed and natural food.

This typical oxygen stratification is an important limitation in pond productivity, not only due to oxygen limitation for shrimp and fish in the bottom pond water, but also due to the development of anaerobic conditions in the sediment-water interface. To minimize this, one has to maximize mixing of this layer and direct the accumulated organic sludge toward the pond's drainage outlet.

## Paddlewheel Aerators

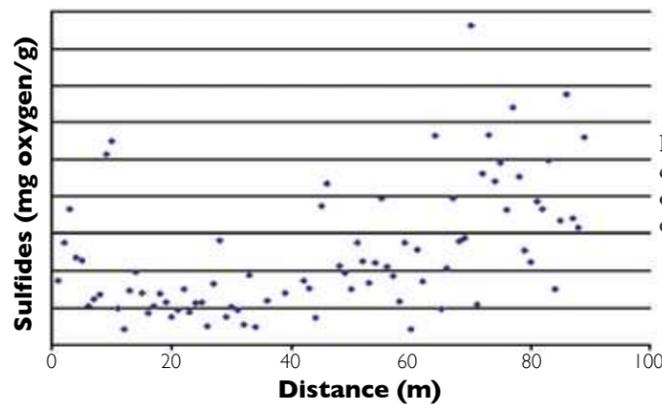
Paddlewheel aerators of different kinds are the most commonly used aerators. With these designs, aeration is achieved by splashing water in the top 20 cm of the water. As mentioned, this layer is the rich-

# Stocking Density Affects Super-Intensive Biofloc Nursery Shrimp Production



**Figure 2.** Standard airlift design and proposed modifications.

- 1 = Air Source (Blower)
- 2 = Air Inlet (Fine Bubbles)
- 3 = Water Inlet
- 4 = Water Outlet
- 5 = Valve Controlling Return Air



**Figure 3.** Effects of water circulation on the bottom of an intensively stocked earthen pond.

est with respect to oxygen concentrations.

The efficiency of aerating oxygen-rich surface water is very low when compared to the possible aeration of the oxygen-poor bottom water. Assuming a freshwater pond in which the oxygen concentration in the surface water is 5 mg/L and that of the bottom water is 2 mg/L, the aeration efficiency (as calculated following Dr. Claude Boyd's 1998 method for defining standard aeration efficiency) for the surface water will be about 45% of standard and 70% for aerating the bottom water. An aeration device that aerates the bottom water will be much more efficient, supplying almost twice as much oxygen for the same power consumption.

In addition to their low aeration efficiency, paddlewheel aerators deliver oxygenated water to the surface layer, while oxygen is badly needed by the bottom water layers. Paddlewheel aerators do a poor job with respect to vertical water mixing. The paddlewheels provide momentum to the water, pushing it horizontally across the pond. Yet, this momentum is given to the surface water and only partially used to move and mix the bottom water layers.

To raise aeration efficiency and aerate the bottom water, a different approach is required. A simple suggestion made by Dr. John Colt was to modify the paddle-

wheel aerator to a skirted paddlewheel design. By inserting a plastic or metal sheet barrier on the upstream side of a paddlewheel, the water would be pulled from the bottom.

## Vertical Mixing

Some commercially available aerators are designed to provide vertical mixing by pulling water from deeper layers. However, the oxidized water is released at the surface of the pond. Aspirators apply the oxygen to water of the topmost water layers, yet have the advantage of sending the aerated water jet downward. However, the effect of the jet is limited to only a portion of the pond bottom.

Diffused-air systems as such do not have efficient mixing potential and, unless placed in deep parts of the pond, loose efficiency due to the rapid rise of the diffused bubbles. It seems possible to use airlift technology to improve aeration systems.

## Airlift Enhancement

Airlifts are made by injecting air bubbles into tubes inserted in the water. The bulk density of the water with air bubbles inclusion is lower than that of the pond water, thus water outside flows into the lift and pumps the water upward (Figure 2a). The airlift unit pumps water from the pond bottom, an important advan-

tage. If 90° inlet and outlet tubes are utilized, the same unit induces horizontal water movement in both bottom and surface layers (Figure 2b). These units can be very useful in aerating and mixing relatively small intensive tanks.

In 2012, William Wurts suggested the use of modified airlift units that include an attached blower for commercial-scale ponds. The airlift design may be further developed, so as to pump water from the bottom layer, release the aerated water into the bottom layer and generate a horizontal flow at the bottom of the pond (Figure 2c).

The unit is made of an intake arm, roughly an ordinary airlift. A controlled air valve is placed in the horizontal part, and an outlet arm follows. The air valve releases part of the rising air bubbles, and thus, the water in the outlet arm is heavier than that in the inlet arm. If the air release valve is fully open and releases most of the air bubbles, water flow through the system is maximal. On the other hand, with limited release, the flow is lowered, but the downward-moving bubbles further release oxygen to the water.

The unit can effectively act as a double-length airlift that almost doubles the oxygen uptake efficiency. The system has a number of advantages: It aerates the oxygen-poor water close to the pond bottom, releases the oxygenated water to the pond bottom and induces water flow that mixes the pond bottom stratum. It also does not have any corrodible components in the water.

Water circulators, used often to destratify lakes, are equivalent to the fans we often use at home. These units move water using a very low hydraulic head, thus consuming very little energy to move large volumes of water across the pond.

Figure 3 shows the effects of a 2.5-hp circulator on redox indicators in the bottom of a highly stocked tilapia pond. Sulfides, indicating the dominance of anaerobic conditions, are very low in most samples up to 60 m downstream from the circulator.

## Perspectives

Aerators, especially paddlewheels, are often used to mix the water and address oxygen stratification in ponds. These units consume energy to splash surface water up in the air, which is often accompanied by the loss of oxygen from the top layer of over-saturated water.

Presently, most aerators do not provide the most efficient and power-conscious service. Mixing of water can be done in a more efficient way by using the modified airlifts described above or employing water circulation units.



At the end of the experiment, shrimp reared in the biofloc system had significant differences in mean final weight among the treatments.

## Summary:

The authors performed a study to determine the tolerance of shrimp postlarvae to the crowding effects of high-density stocking in terms of production performance. Postlarvae were stocked in heavily aerated microcosm tanks with biofloc at 1,500; 3,000; 6,000 or 9,000 shrimp/m<sup>3</sup>. High survival was observed at all densities. Final biomass values increased with higher stocking densities, but there was no significant difference between the 6,000 and 9,000 shrimp/m<sup>3</sup> treatments or the 1,500 and 3,000 shrimp/m<sup>3</sup> treatments.

Super-intensive production of shrimp is gaining increased attention worldwide as a potential means to improve aquaculture production via its application as a transitional nursery system between the hatchery and growout ponds. However, a significant increase in stocking density in the nursery phase can decrease the growth and survival of the shrimp because of the decreased space and availability of natural food, cannibalism, degradation of water quality and accumulation of organic matter on the bottoms of tanks.

This situation can require approaches such as culture systems with biofloc technology. These systems include predominantly aerobic and heterotrophic bacteria,

protozoa, metazoans, microalgae, exoskeletons, feces and the remains of dead organisms.

The ability of shrimp to obtain additional nutrients from biofloc has been suggested as one of the reasons for the improved growth of Pacific white shrimp, *Litopenaeus vannamei*, reared in biofloc systems.

## Study Setup

To evaluate the effects of stress caused by population density on *L. vannamei* postlarvae under high-density biofloc culture, the authors performed an experiment in the indoor tank facilities of the Marine Aquaculture Station of the Federal University of Rio Grande, Rio

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Grande do Sul, Brazil. The biological material used was acquired from the Aquatec Ltda. laboratory in Canguaretama, Rio Grande do Norte, Brazil.

After the *L. vannamei* nauplii arrived, they were kept in the sector of the hatchery for marine shrimp until reaching the P.L.<sub>25</sub> postlarval stage. With mean initial weights of 0.009 ± 0.002 g, the shrimp postlarvae were subsequently transferred to the experimental tanks, where the experimental design was randomized with treatments reflecting four stocking densities: 1,500; 3,000; 6,000 and 9,000 shrimp/m<sup>3</sup>. Three replicates were randomly assigned to each stocking density.

The shrimp were fed twice daily with commercial 40%-protein feed. Initially, the feeding rate was established according to other authors. Later, the feed was adjusted daily according to the consumption of the shrimp. The study lasted 42 days.

The study system included 12, 0.15-m<sup>3</sup> circular microcosm tanks that received intense aeration with blowers. Each experimental tank received water pumped from a 4-m<sup>3</sup> macrocosm tank. This water returned via gravity to a drain directed to the macrocosm tank. The water was completely recirculated from the macrocosm matrix tank to the microcosms about 20 times each day.

The tanks were filled with water pumped from a beach and filtered through a sand filter and cartridge filter. Before starting the study, the matrix tank

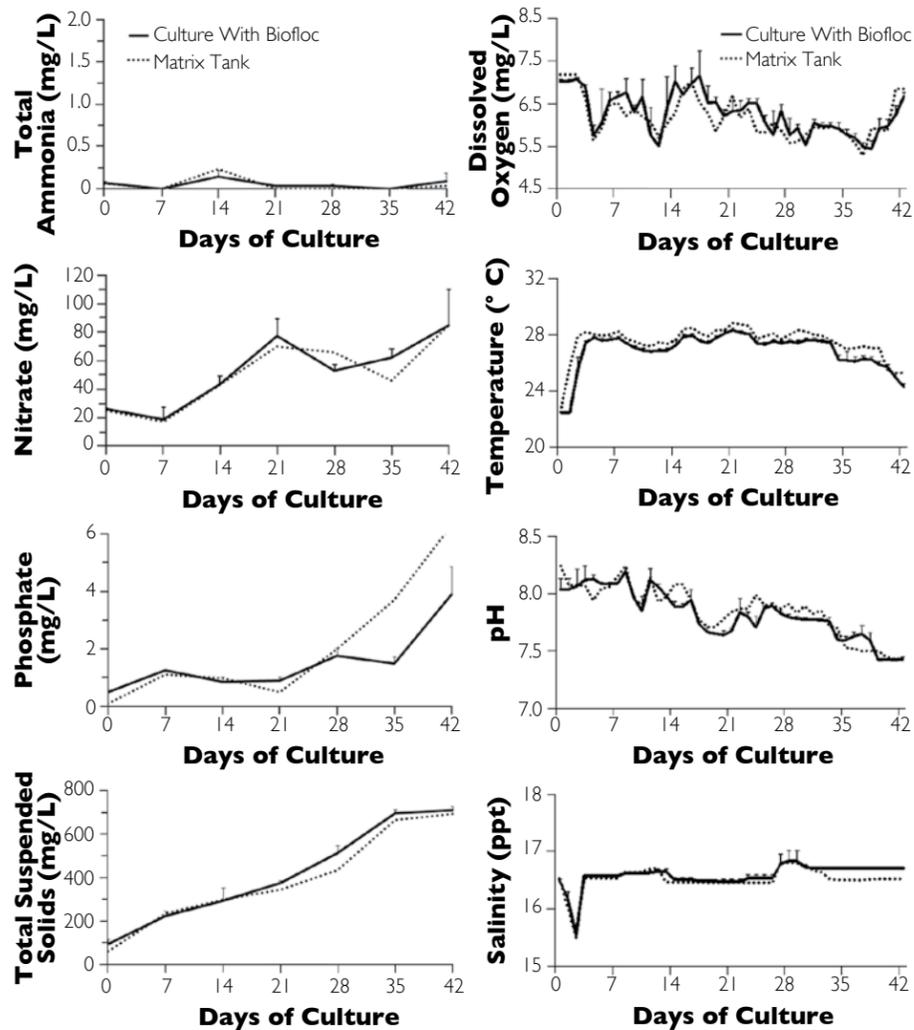


Figure 1. Mean water quality parameters in the matrix tank and biofloc culture system.

of the system was inoculated with water containing bioflocs from a rearing system for shrimp used in another experiment. It was stocked with 34 shrimp/m<sup>3</sup> to enhance the formation and maintenance of bioflocs.

There was no renewal of water during the study, only replacement of what was

lost due to evaporation by adding dechlorinated freshwater. During the experiment, the use of sugar cane molasses as a source of organic carbon was not necessary because the levels of total ammonia did not reach 1 mg/L.

The chosen photoperiod for the experimental room was 12 hours of light

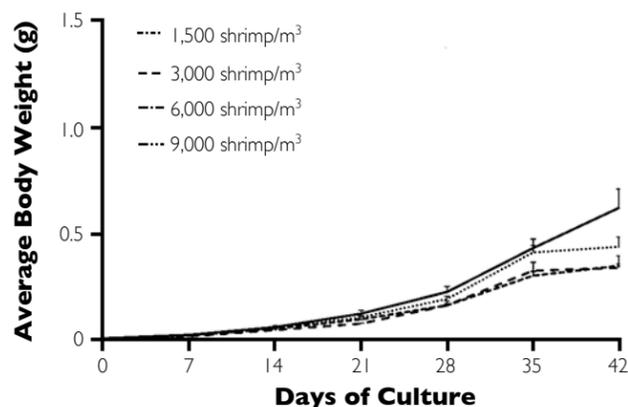


Figure 2. Growth of *L. vannamei* postlarvae reared in nurseries at different stocking densities.

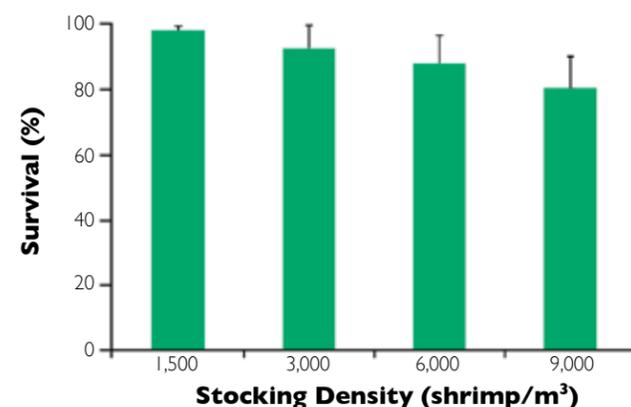


Figure 3. Survival of *L. vannamei* postlarvae reared in nurseries at different stocking densities.

and 12 hours of darkness, maintained by artificial lighting. The water temperature was maintained with two heaters immersed in the matrix tank. During the study development, physicochemical parameters were monitored in both the matrix and experimental tanks.

During the study, 50 shrimp from each experimental tank were weighed individually using a digital balance. The shrimp were returned to their original tanks after weighing. At the study end, the surviving shrimp were weighed and counted to evaluate their growth and survival.

### Results

Figure 1 shows the fluctuations of the water quality in the matrix tank and biofloc culture system. The physicochemical parameters monitored throughout the study did not present significant differences among the treatments and their respective matrix tanks. During the study, the total ammonia concentration did not exceed 1.5 mg/L. High nitrate ( $85.0 \pm 24.9$  mg/L) and total suspended solids ( $711.0 \pm 58.7$  mg/L) concentrations were seen in the biofloc culture system.

At the end of the experiment, the shrimp reared in the biofloc system had significant differences in mean final weight among the treatments (Figure 2). But there was no significant difference between results for the treatments at 6,000 and 9,000 shrimp/m<sup>3</sup>. High survival was observed and there was no significant difference among the stocking densities (Figure 3).

The produced biomass values were significantly different among the treatments. At the lower densities of 1,500 and 3,000 shrimp/m<sup>3</sup>, no significant difference occurred. The biomass values did increase with an increase in stocking density. The productivity range was 0.9-2.5 kg/m<sup>3</sup>.

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# Flow Rate Estimation For RAS



Even if a facility has a properly sized or even oversized biofilter, as in this large moving-bed biofilter with ultraviolet treatment, yet the flow between the biofilter and culture tank is too slow, the biofilter capacity will never be fully utilized, and ammonia nitrogen can build up in the culture system. Photo courtesy of Mote Marine Lab.



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tem. The first operating parameters that need to be determined are the tank volume and maximum allowable stocking density.

Stocking density is determined by the species being cultured and its life stage. As an example, assume fish are in the growout stage of life and will reach market size at an average 680-g weight in a 50-m<sup>3</sup> culture tank. For the species in question, the maximum culture density is assumed to be 80 kg fish/m<sup>3</sup> of tank volume. Hence, the maximum cultured biomass in this tank would be 80 kg/m<sup>3</sup> x 50 m<sup>3</sup> = 4,000 kg or 4 mt. Assume the daily feed rate at this maximum density is 1.5% of the fish body weight. In this example, the maximum daily feed rate will come near the end of the production cycle and peak at 4,000 kg fish x 1.5% of biomass/day = 60 kg feed. Assume for this example that the protein content of the feed is 40%.

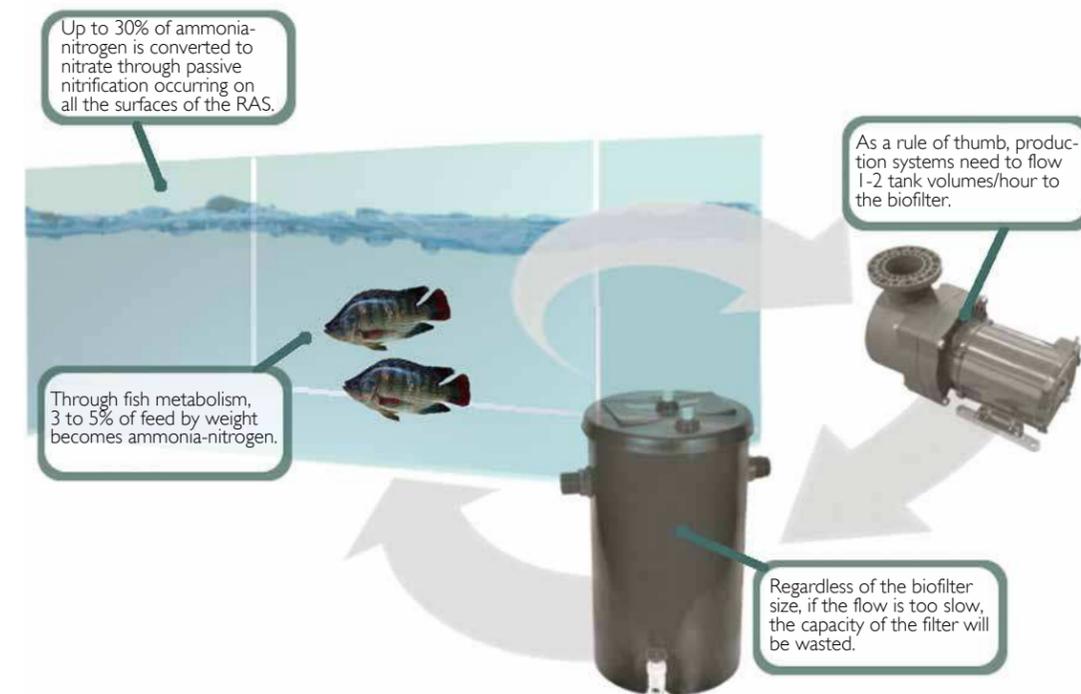
## Ammonia-Nitrogen Production, Conversion

Ammonia-nitrogen is excreted from the gills of fish as they assimilate feed and is also produced when bacteria decompose organic waste solids within the tanks and other components of the RAS. The amount of ammonia produced in an RAS is directly related to the rate of feed additions to the system, the protein content of the feed and an estimate of the nitrogen being wasted, which is related to the culture species and system design.

In general, estimate that 50% of the nitrogen added to the system via feed is not utilized by the fish and is a source of total ammonia-nitrogen (TAN). Given that 16% of protein is nitrogen and there are 1.2 g TAN/g nitrogen, the production of TAN in the example production system can be estimated as:

$$\begin{aligned} \text{TAN produced (kg/day)} &= 60 \text{ kg Feed/day} \times 40\% \text{ Protein} \times \\ &50\% \text{ Nitrogen wasted} \times 0.16 \text{ g Nitrogen/g Protein} \times \\ &1.2 \text{ g TAN/g Nitrogen} \end{aligned}$$

$$\text{TAN produced} = 2.3 \text{ kg TAN/day}$$



In general, an RAS requires water to flow from the culture tank to the biofilter once or twice an hour, depending on the desired tank TAN concentration and biofilter efficiency.

This formula estimates that roughly 4% of the feed becomes TAN within the RAS. In general, with feed protein content varying from 30 to 55%, this equation estimates TAN production rates as 3 to 5% of the weight of the feed, a reasonable estimate that is often cited.

The next step is to estimate the amount of TAN lost from the system in effluent. First estimate the volume of daily effluent from the system in liters and the TAN concentration desired in the culture tank. In this example, assume the TAN in the effluent is the same as in the tank, which is not always the case. The amount of TAN lost in the effluent can be estimated as:

$$\text{TAN discharged in effluent (g/day)} = [\text{Tank TAN concentration (mg/L)} \times \text{Effluent volume (L/day)}] / 1,000 \text{ (mg/g)}$$

For this example, assume the desired TAN concentration is 1.5 mg/L, and the amount of effluent is 10% of the system volume per day or 5,000 L. This calculating is not really necessary in a typical RAS due to the minimal discharge volumes and low TAN concentration. Only 7.5 g of TAN would be discharged in the effluent in this example.

However, there is a secondary ongoing process in the RAS called passive nitrification. This is due to the nitrifying bacteria within the system growing on all of the surfaces of the system. These bacteria, like their "cousins" on the biofilter surfaces, can convert as much as 30% of the TAN to non-toxic nitrate-nitrogen. In this example, assume 20% passive nitrification. As such, the biofilter would need to nitrify 80% of the TAN produced within the system or 1.84 kg of TAN.

## Estimating Biofilter Flow Rate

Mass balance can be used to estimate the flow required to go from the culture tank or tanks to the biofilter to maintain the desired TAN concentration. The efficiency of a biofilter depends on the TAN concentration of the water entering the biofilter, biofilter type and flow rate through the biofilter.

For most biofilters used today, approximately 50% of the TAN is removed per pass through the biofilter. Using this esti-

mate and the numbers above yields an estimate of the daily flow required to go to the biofilter as:

$$\text{Recycle flow to biofilter (L/day)} = \text{TAN available to biofilter (kg/day)} / \text{Biofilter efficiency (\%)} \times [\text{Desired tank TAN concentration (mg/L)} / 1,000,000 \text{ (mg/kg)}]$$

In the example, the TAN available to the biofilter after accounting for passive nitrification is 1.84 kg/day. The desired tank TAN concentration is 1.5 mg/L, and the biofilter removal efficiency is estimated at 50%.

Using the numbers given for this example in the equation, the flow rate from the tank or tanks to the biofilter can be estimated at 2,453,333 L or 2,453 m<sup>3</sup>/day, which is 102,000 L or 102 m<sup>3</sup> hourly. Note that in the 50-m<sup>3</sup> tank, this equation estimates the total volume of the tank will need to flow through the biofilter more than twice every hour.

It is instructive to note that if the concentration in the tank is allowed to be higher, say up to 3 mg/L, the flow rate to the filter would be cut in half to roughly one hourly exchange. Hence, the lower the required TAN concentration, the higher the required biofilter flow.

Therefore, carefully specifying the required maximum TAN concentration in the tank can be instrumental in reducing the energy use in pumping water to the biofilter and back to the tank. Coldwater RAS for salmonids commonly operate with tank turnover rates of 30 minutes or less, while warmwater RAS often operate with 60-minute turnover rates. The difference can be attributed to the lower TAN concentration required to grow coldwater species.

*Editor's Note: This article was based in part on research conducted by the author and Alexander Hobbs at North Carolina State University and published in the Volume 23, 2000 journal of Aquacultural Engineering. The spreadsheet in that publication presents all of what is described here in spreadsheet format.*

## Summary:

The water quality in recirculating aquaculture systems is generally a function of the tank size, biomass, feed inputs and waste treatment efficiency. Adequate biofiltration can control the build-up of ammonia-nitrogen and nitrate-nitrogen in the systems. Mass balance can be used to estimate the water flow required to go from the culture tank or tanks to the biofilter to maintain the desired total ammonia-nitrogen concentration. Carefully specifying the required maximum TAN concentration can be instrumental in reducing energy use for pumping water.

The production of aquacultured species in land-based systems using tanks and recirculating aquaculture system (RAS) technology is expanding globally. This trend is driven by the need for intensified production while using less water, combined with the requirement to reduce the volume and strength of system effluent.

One important element of the unit processes involved in RAS technology is estimating the flow rate requirements for the water recirculated from the culture tanks to the biofilter. Using mass balance analysis, an estimate of the flow requirements can be made in order to control the build-up of ammonia-nitrogen and nitrite-nitrogen in the system.

## Operating Parameters

The water quality in a recirculating system is generally a function of the tank size, the biomass in the tank, the rate of feed input, and the waste removal and treatment efficiency of the sys-

# Aquaculture Planning, Development In Brazilian Federal Waters



A key strategy of Brazil's More Fishing and Aquaculture plan is the development of aquaculture in federal waters. A variety of freshwater fish are raised in the floating cages.

## Summary:

The aquaculture industry in Brazil is moving toward further expansion with the support of the federal government. A key strategy of the More Fishing and Aquaculture plan is the development of aquaculture in federal waters. The plan promotes sustainable development of fisheries and aquaculture by linking those involved and consolidating state policies addressing social inclusion, security and food sovereignty. Tilapia is the main farmed fish, although tambaqui and others have potential for large-scale production due to their wide acceptance by consumers.

Aquaculture in Brazil is worth around 3.0 billion Brazilian reais (U.S. \$987.4 million) in business and provides a million direct and indirect jobs, and feed production around 900 mmt annually. According to the Brazilian Ministry of Fisheries Aquaculture Institute of Geography and Statistics, this agribusiness produced around 476,000 mt in 2013, representing a growth rate of 56% in the past 12 years. Thus, the aquaculture industry is consolidating as the main source for fisheries production, a trend

observed in other countries of the world, like China, Norway and Chile.

The Brazilian Institute of Geography and Statistics reported that among the species produced in the country, freshwater fish such as tilapia, *Oreochromis niloticus*, accounted for 43.0% of the Brazilian aquaculture production in 2013. Farming of tambaqui, *Colossoma macropomum*, reflected 22.6%, and the hybrid "tambacu" (female *C. macropomum* x male *Piaractus mesopotamicus*) made up 15.4% of the production.

Still, other species have potential to be produced on a large scale, mainly due to their wide acceptance by consumers. These include arapaima, *Arapaima gigas*; surubins, the spotted catfish *Pseudoplatystoma corruscans*; and cachara, *Pseudoplatystoma fasciatum*. However, these species still require further research and development of specific technologies for production on a commercial scale, which happened earlier for tilapia.

## Aquaculture In Federal Waters

The current annual world fish production is estimated at 158 mmt, and according to United Nations Food and Agriculture Organization projections for 2030, it is expected to increase around 100 mmt/year. With an estimated

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potential annual yield of 20 mmt, Brazil could help to meet this demand.

Given these projections, Brazil's federal government – with the participation of the production sector and civil organizations – drafted the sustainable development plan entitled "More Fishing and Aquaculture" in 2008. The objective of the plan was to promote the sustainable development of fisheries and aquaculture by linking all those involved with the sectors, thus consolidating sustainable state development policies addressing social inclusion, security and food sovereignty in Brazil.

The use of reservoirs for multiple uses, including aquaculture, in Brazil was established by the National Water Resources Policy act in 1997. This legal framework was complemented by federal directives regulating the use of Brazilian waters and public spaces for the practice of aquaculture. Up to 1% of the area of federal waters is available for aquaculture, which corresponds to at least 55,000 ha in freshwater reservoirs.

## Reservoir Studies

A key strategy of the More Fishing and Aquaculture plan is the development of aquaculture in federal waters. Therefore, the Ministry of Fisheries and Aquaculture has invested in studies for

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**Table 1. Estimated production for demarcated aquaculture parks.**

Area	Reservoir/ State	State	Estimated Production (mt/year)	Most Important Species
Reservoir	Furnas	Minas Gerais	35,702	<i>Oreochromis niloticus</i>
Reservoir	Três Marias	Minas Gerais	25,748	<i>Oreochromis niloticus</i>
Reservoir	Ilha Solteira	Mato Grosso do Sul/	50,422	<i>Oreochromis niloticus</i>
Reservoir		São Paulo/ Minas Gerais		
Reservoir	Castanhão	Ceará	33,080	<i>Oreochromis niloticus</i>
Reservoir	Itaipu	Paraná	2,920	<i>Piaractus mesopotamicus</i>
Reservoir	Tucuruí	Pará	8,518	<i>Piaractus brachypomus</i>
Reservoir	Lajeado	Tocantins	21,856	<i>Colossoma macropomum</i>
Reservoir	Serra da Mesa	Goiás	31,356	<i>Oreochromis niloticus</i>
Reservoir	Cana Brava	Goiás	10,140	<i>Oreochromis niloticus</i>
Reservoir	Manso	Mato Grosso	7,192	<i>Piaractus mesopotamicus</i>
Coastal	Santa Catarina	Santa Catarina	306	<i>Crassostrea gigas</i> , <i>Perna perna</i> , <i>Nodidipeten nodosus</i>
Coastal	Paraná	Paraná	57,538	<i>Crassostrea rizophora</i>
Total			284,778	

Source: SINAU/MPA, 2015

the demarcation of aquaculture parks in many reservoirs, as well as the coastal areas of Santa Catarina and Paraná.

These studies were based on criteria that addressed issues of environmental, social and economic sustainability. These 10 reservoirs have potential for the implementation of 100 aquaculture parks with a total area over 1,920 ha for fish culture and production capacity estimated at 227,000 mt/year of fish. This number would rise to more than 284,000 mt if the two studies in coastal areas are included (Table 1).

Currently, studies are being finalized and/or aquaculture parks are being implemented in 36 reservoirs: five in the Midwest, eight in the Northeast, five in the North, eight in the Southeast and 10 in the South. This development represents at least 210 parks. Of these, about 100 will be allocated to aquaculture on a family scale.

Furthermore, in recent years, studies

have been conducted to set up additional marine aquaculture parks in several states where parks for the production of fish, oysters, scallops, mussels and algae are already occupied by producers/entrepreneurs. The parks already identified may contribute increases of 59% over the current national aquaculture production and 37% in the present national fisheries production.

### Carrying Capacity

The granting of permission to use freshwater bodies for aquaculture projects in Brazil is carried out by the National Water Agency, which sets the maximum permissible value of fish in a given reservoir by calculating the carrying capacity using the hydrodynamic model developed by Peter J. Dillon and Frank H. Rigler in 1974. However, new research and pilot projects are being developed by University of Brasilia with Guelph University under a collaborative project involving the Brazilian Ministry of Science and

Technology's National Council for Scientific and Technological Development, and International Science and Technology Partnerships Canada to improve the methodology and input data through the integration of a nutritional bioenergetics model described by C. Young Cho and Dominique P. Bureau in 1998.

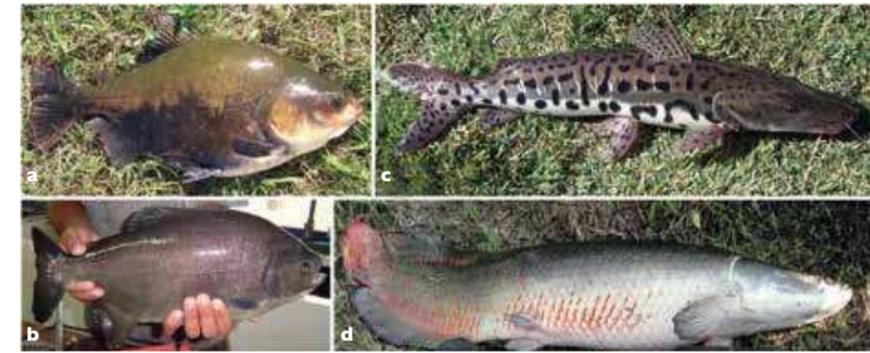
The hydrodynamic model projects waste dispersion simulations for the use of commercial diets with different total phosphorus percentage. This model allows more compartmentalized analysis of aquaculture parks, assigning technical, environmental and nutritional aspects for each region and increasing the security and reliability of estimates of environmental carrying capacity.

To enable the safe and environmentally responsible implementation of aquaculture in federal waters, mechanisms will be established to support supervised management of fish culture areas and define maximum productivity indicators, safe phosphorus levels in feed and distances between culture areas to allow appropriate dilution of waste in the environment.

### Aquaculture Potential, Challenges

Brazil is a country with great climatic diversity, great species diversity and an abundance of water resources for the development of aquaculture in federal waters. Aquaculture activity in lakes and reservoirs has expanded in the last 10 years, and hence the volume of projects and farms registered by the Ministry of Fisheries and Aquaculture.

However, despite this potential, there are a number of challenges to overcome for consolidation of the Brazilian aquaculture program. The main challenges are the lack of standardization of environmental licensing procedures across the



Although tilapia is the primary species farmed in Brazil, tambaqui (a), pacu (b), cachara (c) and pirarucu (d) are also cultured to meet consumer demand.

states of the federation, bureaucracy and the limited preparation of environmental agencies to review projects and issue environmental licenses.

These problems have increased the risk of investment in aquaculture, especially when factors such as global climate change, localized water scarcity and depletion of reservoirs, eutrophication and animal health problems are also considered.

An important point to examine is the absence of specific biosafety and health policies for aquaculture in federal waters, since

the aquaculture parks program groups together entrepreneurs, family farmers and government projects with different objectives and different degrees of knowledge and concern. Thus, there is a need to implement management committees and programs for monitoring and control of the reservoirs and the Brazilian coast.

Finally, integrated and sustainable development of the production chain in these regions – with tax exemption in the acquisition of supplies and equipment – is needed, along with coordination across the

production chain to minimize the economic, social and environmental risks of these projects in Brazilian federal waters.



## Article Submissions

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Brazil's great climate, considerable species diversity and abundance of water resources have combined to support aquaculture expansion in the last 10 years.

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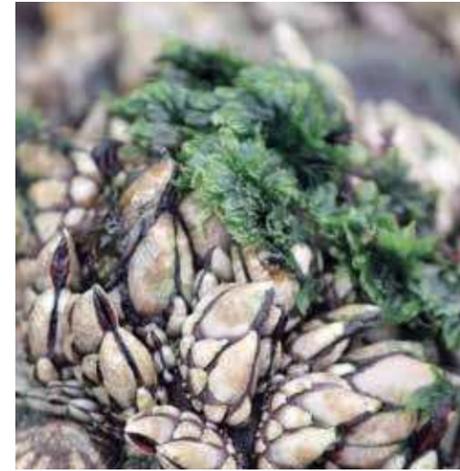
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Consumed cooked or raw, the percebes are economically important and valued highly in Portugal and Spain.

## Stalked Barnacles Hold Aquaculture Potential, But Face Bottlenecks

### Summary:

Interest in the aquaculture of stalked barnacles has risen in recent years as a response to increasing market demand and concern over the conservation of natural stocks. Is there enough knowledge, however, to establish the culture of stalked barnacles? Prospects are promising, but eventual success will require resolution of the main production bottlenecks, which include larval settlement and spat collection, as well as the optimization of reproduction and larval development in culture.

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Some of the economically relevant barnacle species hold high potential for aquaculture. These include the picoroco, *Austromegabalanus psittacus*; cracas, *Megabalanus azoricus*; and stalked barnacles, which are considered the most important for consumption. Of the latter, the percebes, *Pollicipes pollicipes*, is of particular interest.

Unlike most barnacles, stalked barnacles have a characteristic fleshy stalk, which has made them a delicacy. Consumed cooked or raw, the percebes are economically important and valued highly in Portugal and Spain. Other stalked barnacle species have local significance in Peru, Canada and Japan. In the Iberian countries, the percebes enter the market at U.S. \$25-40/kg, occasionally reaching \$100/kg, and consumer prices can be as high as \$200/kg.

### Fisheries, Aquaculture Potential

These prices have been mostly related to product availability, as the collection of wild percebes has been historically insufficient to meet the market demand. The percebes have been subjected to intensive collection in Portugal and Spain since the 1970s, which caused a decrease in standing stocks of up to 12

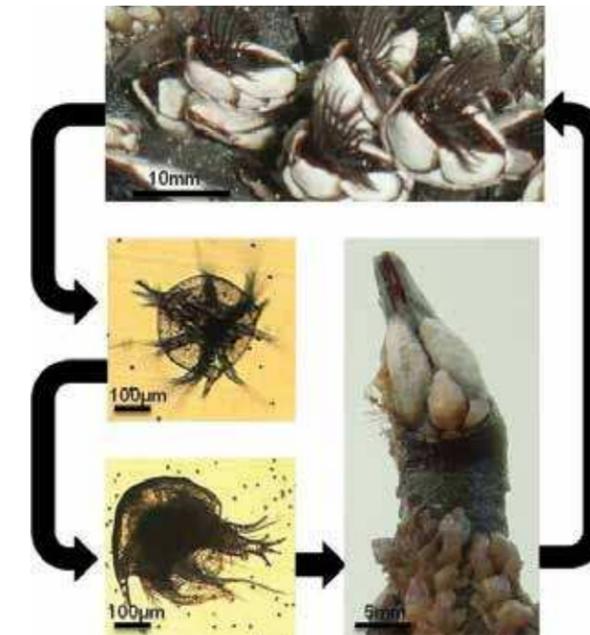
times in some areas. Collection has been estimated to have dropped from 2,000 mt over time to 300 to 500 mt annually. Moreover, harvesting is a risky activity dependent on seasonal and sea conditions, which causes the market supply to be variable and unreliable.

Concern over the exploitation of stocks has led to strict conservation measures. In spite of the positive effects of such regulations on stock recovery, this scenario has renewed interest in the search for new sustainable alternatives, such as the aquaculture production of percebes.

Percebes is a species whose biological and ecological characteristics make it highly suitable for culture. However, much remains unknown about production practices and optimized culture conditions. Research undertaken in recent years has focused on closing this knowledge gap and making available essential biological and ecological data on the percebes.

### Life Cycle

Percebes are intertidal invertebrates, which are sessile throughout most of their life cycles. As juveniles and adults, they live gregariously attached to the rocky shore, but disperse freely



Adult percebes release their free-swimming larvae, which develop in the water until returning to settle on the coast.

in the water column during their larval stages until a suitable settlement site is found.

During the breeding season, adults copulate and brood embryos until the release of the free-swimming larvae. These molt through six naupliar stages until they reach the cypris stage and start searching for a settlement site. This is usually the stalk of adult barnacles, where they attach and molt to juveniles. The juveniles then develop into sexually mature adults over the course of several months and reproduce themselves, closing the life cycle.

### Reproduction, Larvae Collection

Broodstock of percebes can be easily maintained in captivity, provided that cultures are kept in highly hydrodynamic recirculating or flow-through systems, since adults are dependent on currents to feed. Increased feeding response and rapid growth have been reported with diets of *Artemia* nauplii in comparison to non-living diets. However, much remains unknown regarding diet optimization.

Some authors recommend the use of artificial tidal cycles as a way of maximizing feeding and improving growth, although this can involve additional costs. Percebes is an intertidal species that tolerates periods of emersion as well as a wide range of temperature, salinity and humidity – a further advantage for husbandry purposes.

Optimal rearing conditions are still to be identified, but good results have been obtained using natural regimes of temperature and salinity while assuring strong hydrodynamics and water renewal. Broodstock have been conditioned in culture for periods of less than a month by temperature cycling in systems with barnacles subjected to emersion periods, and cultures have subsequently provided a continuous supply of larvae.

However, the number of larvae obtained from releases can vary considerably, as the percebes are multiple brooders that spawn asynchronously. Nevertheless, several researchers have reported the presence of triggering factors, such as tidal cycles, photoperiod and food availability, that can potentially be used to initiate spawning events. In fact, the number of larvae released has been observed to vary in response to periods of feeding and tidal emersion.

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One alternative to broodstock conditioning is the collection of larvae by direct egg lamella extraction from the adults, followed by egg incubation until hatching. Incubation can take up to three weeks, depending on lamella maturity and environmental conditions. Embryo culture has been accomplished for this species using techniques that largely resemble those already described for other barnacle species.

Although unsustainable, the attractiveness of this option comes from the fact that mature adults can produce thousands of eggs per brood, so there is no requirement for a large number of lamellae to start a significant culture of larvae, even with high mortality.

### Hatchery Production

The hatchery larval production of the percebes encompasses two phases: larval development from nauplii to cyprid and cyprid settlement on the provided surface. The larvae of percebes can be reared on microalgae diets in captivity with high growth rates, reaching the cyprid settlement stage in two to four weeks.

Methods for larval culture, already established for other barnacle species, have been used as a basis for the development of hatchery techniques for the larval rearing of percebes. Recent research has shown promising results for larval culture, with a recommendation to use a mid-range temperature of 15 to 20° C and mixed diets (e.g., *Tetraselmis* and *Skeletonema* species) to improve survival and growth rates.

### Larval Settlement

Unlike larval rearing in captivity, which can be easily accomplished even in suboptimal conditions, larval settlement under culture conditions remains the main bottleneck to continuous culture. The settlement stage of percebes, the cyprid, is known to be highly discriminating and tends to select as substrata the peduncles of adults of the same species, previously colonized substrata or surfaces in the vicinity of the adults. Settlement in captivity on substrata other than the adults has been reported to be negligible by several authors.

To date, no artificial substratum provided in captivity has proven to be suitable for larval settlement, with high larval mortality occurring at this phase. This represents a major challenge, since, as for many bivalves, settlement is a critical phase in their development. One option, if this bottleneck persists, is to use live adults as settlement inducers or use previously colonized sur-



An option to larval settlement in captivity is barnacle seed collection from the wild, after natural larval settlement using artificial substrata.

faces as attractants.

Other barnacle species have long been shown to respond to protein complexes, produced by the adults and that induce settlement, which might also constitute a potential route forward with percebes. Environmental conditions during settlement, substratum selectivity and suboptimal larval viability might also explain the poor results achieved to date. Further research is therefore essential.

A more mainstream production method – with considerably lower costs – would be the collection of seed from the wild after natural larval settlement using artificial substrata. Such an approach is not new for barnacle species, but seed collection can be highly variable and dependent on larval availability, larval selectivity and post-settlement survival. These variables can be affected by an array of factors, such as natural larval production, offshore transport, surface characteristics, chemical cues and cyprid condition.

Although preliminary attempts to collect settled cyprids using artificial substrata such as tufnol, plastic, rubber or sisal ropes had poor results and massive system loss, ongoing studies are investigating the biological and economic viability of the use of collector systems followed by growout in the field and should provide new insights into the potential of such an approach. For other barnacle species, such as the picoroco, spat collection has been shown to be an interesting alternative for production.

### Juvenile Growout

Juveniles have been grown successfully in captivity in closed and semi-closed systems for long periods with good results under conditions similar to the ones described above for broodstock rearing. However, extended growth periods in culture can lead to alterations in morphology, and a finishing growout period in the wild might be necessary.

In fact, the growout of juveniles in the wild is a promising alternative to growth in tank systems, which benefits from decreased costs for feeding and infrastructure. Potential options include the use of on-coast panels or suspended systems of racks or ropes currently in use for other commercially produced species.

Growout trials carried out on floating offshore systems north of Spain have reported the growth of juveniles to be higher than that achieved on the coast and with low mortality. System loss due to adverse sea conditions was the main setback encountered. Site selection and system design are therefore of massive importance, since factors like tidal level, light, productivity, temperature, predation, hydrodynamics and currents can impact the growth and survival of the individuals, as well as structure integrity.

The growth to commercial size in the natural environment has been estimated to take one to two years, varying with site and seasonal environmental conditions.

### Perspectives

In spite of promising prospects, the establishment of percebes aquaculture as a viable industry is still in its infancy. Future challenges include the resolution of the main production bottlenecks, securing larval settlement in captivity and spat collection from the wild. Other areas, such as captive reproduction, larval development in captivity and juvenile growth in the wild, would benefit from further studies and consequent culture optimization, but are currently not limiting production.

Investment in future research, both at scientific and commercial levels, toward establishing aquaculture of percebes is economically promising, mainly due to the current positioning of the product in the market and the type of sustainable low-cost production from which it could benefit.



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# Seafood Demand And Aquaculture Growth

## Relationships Vary In Developed, Emerging Markets



Recent research confirmed that seafood consumption in almost all developing or emerging countries is related to aquaculture supply.

### Summary:

An analysis of the relationships between aquaculture development and its consequences on seafood consumption found both similarities and differences across countries and species. Developing and emerging producing countries coincided across seafood consumption and the share of local aquaculture in total supply. The relationship between consumption and local supply was weak in developed importing countries. Developed markets were important as drivers for aquaculture expansion in developing countries. Consumption in northern countries somewhat drove development of the production of certain species in the southern world.

Aquaculture production has been significantly increasing its contribution to the worldwide seafood supply in the last two decades. Such an increase would be expected to have impacted seafood consumption and food security. On the other hand, it should also be expected that aquaculture growth

may be driven by seafood demand, whether at a national or global level.

### Relationships

An analysis of these potential relationships was conducted for a group of selected countries divided according to the importance of aquaculture in local seafood supply and the relevance of imports in domestic seafood consumption. This classification also coincided with the level of economic development.

The first group, which accounted for countries in which aquaculture represented around 50% of total seafood supply, included Brazil, India, Indonesia, Thailand and Vietnam. The other group accounted for countries in which imports represented at least 50% of total seafood consumption. These included the United States, Spain, Australia, Italy and Germany.

Despite significant differences across countries, some general ideas could be extracted and applied to explain the relationships across aquaculture and seafood consumption in the majority of the 12 countries analyzed.

### Data, Methods

A proxy for seafood consumption at the national level was taken from the food balance sheets of the Food and



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Agriculture Organization of the United Nations using the indicator of total fish supply (code 141). Regarding aquaculture supply and growth, several indicators were computed using Fishstat data at national and global levels for every year between 1990 and 2011. The share of aquaculture in total seafood production was determined by dividing aquaculture production by total seafood production, resulting in indicators for domestic and global production.

Another indicator measured the interannual rate of growth in aquaculture production by computing the yearly change rates with regard to the previous year for local and global production.

A vector autoregressive model was applied in two cases. One of the analyses explored the relationships between seafood consumption and the share of aquaculture in total seafood supply. The other case studied the relationships between seafood consumption and the yearly rate of growth in aquaculture production.

Granger causality testing analyzed whether one of the variables was a cause or effect of changes in the others.



More-developed global markets drive the expansion of industrial aquaculture in developing countries.

### Results

While results generally pointed in a similar direction in every group, there were differences among countries with regard to the relevant indicators. Developing and emerging producing countries significantly coincided across seafood consumption and the share of local aquaculture in total supply. For Vietnam and Thailand, the association was stronger with global aquaculture share than with local. This exception was mainly due to the relevance of exports in the aquaculture production in both countries and will require specific further analysis.

This relationship between consumption and local aquaculture supply was weak or insignificant in the case of developed importing countries. The causal links with the growth in global aquaculture were the dominant result, reflecting the importance of the developed markets as drivers for the development of indus-

trial aquaculture in developing countries.

To some extent, consumption in the northern countries during the observed period acted as a driver for the development of the production of certain species in the southern world. The exception was Germany, which with low seafood consumption was a major importer and exporter of processed fish and shellfish, resulting in inconsistent parameters and lack of significance in the relationships above.

Table 1 shows the different categories in the results of the analysis, with differences in the directions of the causal relationships and significance of the models. However, the links between aquaculture production and consumption in the producing countries, and growth of aquaculture supply and demand in the importing countries stand in almost all the observed cases.

### Related Information

Some facts help explain the results

**Table 1. Main results analysis of relationships between aquaculture growth and seafood demand.**

Country	Local Aquaculture	Global Aquaculture	Implications
Brazil	C → A.Q. F = 10.7000 [0.0042]	C → A.Q. F = 0.6147 [0.5539]	Increasing consumption in Brazil is a major driver for the local industry, but does not impact global industry growth.
India	A.Q. → C F = 5.0892 [0.0368]	C → A.Q. F = 0.3020 [0.5894]	An increase in consumption is caused by an increase in local production. Local demand does not cause changes in the global industry.
United States	C → A.Q. F = 0.0125 [0.9120]	C → GAQ F = 6.6501 [0.0189]	There is no linkage between the local industry and local demand. Although there is also no evidence of linkages between demand and the global share of aquaculture, there is a causal link between U.S. demand and the rate of growth in global aquaculture
Spain	C → A.Q. F = 4.0662 [0.0598]	C → A.Q. F = 20.1560 [0.0003]	Local aquaculture supply is weakly influenced by domestic seafood demand. Global aquaculture growth is also caused by Spanish demand.

C = Consumption, A.Q. = Aquaculture production, GAQ = Global aquaculture production

showed in the table. Brazil is not a significant importer or exporter of aquaculture products. Aquaculture is mainly developed for the domestic markets there. Hunger is still a dramatic issue in India. Besides cultural and religious factors, any additional supply of food will be locally consumed.

The United States is a major importer of aquaculture species such as shrimp and tilapia. Domestic aquaculture is concentrated in specific regions and species, with high production costs. Spain is another major importer of aquaculture species such as shrimp and *Pangasius*. Its domestic aquaculture faces an important market crisis, however. Shellfish culture is a traditional activity in a specific region that supplies the whole country at low prices.

### Perspectives

Although some results can be replicated in almost all countries, a general conclusion can not be presented. There are several particular cases. Consumption in almost all developing or emerging countries is related to aquaculture supply. However, in Thailand and Vietnam, global supply appears to have a stronger influence than local supply.

This is difficult to explain with the available data, variables and models. Developed countries appear to spur the growth in the global aquaculture industry. However, the levels of association were lower than 50%. Differences across species and their focus on international or domestic markets could be behind this weak predictive ability. U.S. consumption, for example, is highly significant in the case of shrimp industry growth, but it is totally insignificant for other large farmed species like carp, for which there is no relevant market in the country.

Further research will require more qualitative information from the field in order to understand the different cases. Analysis at the species level will help identify what groups are affected by the observed relations and which behave in a different way. Country-to-country analysis is needed to identify international trade flows and which species depend on specific developed markets.

Finally, it will be of high interest to investigate the potential impacts on the global aquaculture industry of the increasing south-south trade versus the traditional south-north flows.

*Editor's Note: This article is part of the work currently undertaken by the first author during his stay as a visiting expert at FAO in Rome.*

# Seafood Benefits Nutrition Health

Need For Constant, Clear Communications Continues

**YOU NEED MORE OMEGA-3S**  
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There are more than 27,000 published studies on omega-3s, making them some of the most studied nutrients in the world.

As expressed in this Global Organization for EPA and DHA Omega-3s artwork, seafood is an excellent source of the healthy omega-3 fatty acids we all need.

## Summary:

Are consumers fully aware of the health benefits of seafood? Many consumers do not act as if they are. It seems they do not have the information they need about the positive impacts the omega-3 fatty acids in seafood make on heart, brain and eye health. While fatty fish are especially good sources, any seafood is a better source of omega-3s than red meat. The need remains for clear communication and education about the health benefits, nutritional value and sources of omega-3s.

Many seafood people, especially those in marketing, remark that seafood promotion has got to go beyond just the health aspects. They suggest that consumers are fully aware of the health benefits of seafood, and we do not need to keep pushing those important aspects.

However, according to recent research by the Global Organization for EPA and DHA Omega-3s (GOED), more than a third of the adults in the United States have had a heart health scare, yet many have not made changes to better support their

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hearts. Amazingly, 66% of those who received a heart health scare did not start taking heart-healthy nutritional supplements like omega-3s, and nearly half (46%) did not change their diets.

Highlighting the need for consistent reinforcement, 77% of respondents did not know that low omega-3 levels can be harmful to health, and 44% were unaware that omega-3 intake can help lower blood pressure. Seafood marketing gurus say that everyone knows fish is good for you, but a staggering 92% of survey respondents could not accurately name the types of fish that provide high levels of omega-3s.

## Seafood Supports Health

While a lot of dietary promotion says that only some fish varieties – specifically fatty fish like salmon, mackerel, sardines, anchovies and certain types of tuna – are good sources of omega-3s, they forget to say that any seafood is far better than red meat on the fatty acid scale.

It was reported that GOED Executive Director Adam Ismail said: “Most people don’t have the important information they need about omega-3s as it relates to heart, brain and eye health, as evidenced by this survey. This underscores the strong need for clear communication and education about the health benefits, nutritional value and sources of omega-3s.”

If anyone is in any doubt, the facts based on numerous gold-standard research studies are that the omega-3s eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) support heart, brain and eye health. Evidence consistently shows that they help maintain healthy blood pressure, support healthy triglyceride levels and manage heart disease risks. The evidence is overwhelming that there is a positive correlation between increased omega-3 intake and heart health benefits.

Add to this that for many years, we have known omega-3s positively impact brain function and cognitive development. A diet deficient in DHA may deprive the nervous system of a critical nutrient and impair the brain’s ability to function optimally and play a role in eye health and infant visual development.

## Nutrition Guidelines

The human body does not efficiently produce its own EPA and DHA. That is why it is critical to get these nutrients through diet. To maintain healthy omega-3 levels, health authorities recommend that everyone should eat at least two weekly servings of omega-3-rich seafood. Some say we should consume up to four servings per week.

As mentioned in this column previously, although the

**HEALTHY EATING PYRAMID**

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Enjoy a variety of food and be active every day!

Nutrition Australia

Fish and other protein sources form an important part of the “Healthy Eating Pyramid” distributed by Nutrition Australia.

Dietary Guidelines for Americans from the U.S. Office of Disease Prevention and Health Promotion recommend eating two servings (226 g) of fatty fish per week, the average U.S. resident eats just 99 g—less than half of what they need. Is it any wonder that Americans’ health is going downhill?

In Australia, a new food pyramid has been promoted to create a simple visual guide to the types and proportions of foods that Australians should eat every day for good health. The Healthy Eating Pyramid from Nutrition Australia aims to convey key information about how to have a nutritious diet, based on the Australian Dietary Guidelines of the National Health and Medical Research Council, but it goes to some pain to point out that it does not replace the guidelines, nor tailored advice from accredited dietitians.

The revised Australian Dietary Guidelines were released in February 2013 with an increased focus on foods and food groups, instead of nutrients, making them more user-friendly. They also have an increased focus on the effects of food on health outcomes, in particular weight gain, heart disease and some cancers.

The guidelines recommended the consumption of an increased number of servings from the lean meat and poultry, fish, eggs, tofu, nuts, seeds and legumes/beans food group for all ages, but it is hard to see how that is reflected in the new pyramid. Additionally, the guidelines highlight that the “Eat Moderately” category contains dairy foods and meat, but do not specifically highlight fish. Do people really think “fish” when they see the word “meat”?

## Nutrition Education

The messages are not clear, and when you consider it, the vast majority of reasons for which people go to doctors are preventable. In addition to major heart concerns, 25% of Westerners have gut issues, and up to another 50% have a variety of conditions ranging from depression and painful period to acne, asthma and cancer.

Perhaps some 75% of all conditions that drive people to visit doctors could be prevented if good nutrition was promoted better. If these people had better education and changed their diets earlier in life, their chances of healing would be better. Think how much cheaper healthcare would be if we all were better educated about correct nutrition and firmly had the right messages about seafood.

## Nutrition Regulation

Just recently, it was reported that following its controversial regulation proposal on beef, the U.S. Department of Agriculture (USDA) was proposing regulations for seafood, specifically, new standards for farmed organic fish by 2016.

U.S. Representative Kevin Cramer criticized the USDA for its proposed regulations on beef. He was concerned that the regulation strayed “from purely nutritional evidence, venturing into areas like environmental sustainability and tax policy.” Along with 70 other congressmen, Cramer issued a letter to the U.S. Department of Health and Human Services and USDA to ensure the final 2015 Dietary Guidelines for Americans comply with guidelines previously passed by Congress and are based on sound nutritional science.

## Constant Message

Who is pushing the fish/seafood story? Are we as an industry doing enough to ensure a clearer focus on the unique benefits for health that fish/seafood can bring?

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# Human Enteric Viruses In Shellfish

## Part II. Noroviruses



Since many of those who consume shellfish contaminated with noroviruses become ill, sanitation programs attempt to control the viruses through growing, harvesting and processing standards.

### Summary:

Since bivalve shellfish filter large volumes of water to feed, they can accumulate and concentrate bacteria and viruses from various pollution sources. Among enteric viruses, noroviruses are the leading cause of gastroenteritis in humans who consume affected shellfish. Current wastewater treatments fail to ensure the complete removal of viral pathogens that can be discharged into fresh, marine and estuarine waters and therefore contaminate shellfish-growing waters. The detection of noroviruses in food relies on molecular techniques.

Bivalve molluscan shellfish filter large volumes of water as part of their feeding activities, and in doing so can accumulate and concentrate bacteria, viruses and other types of pathogens from human fecal pollution and other sources.

### Norovirus Infections

Among human enteric viruses, noroviruses are the leading cause of epidemics or sporadic cases of gastroenteritis in all age groups of humans. Victims typically exhibit diarrhea and vomiting for 24 to 48 hours after an incubation

period of 18 to 36 hours.

Members of the Caliciviridae family, noroviruses are characterized into five genogroups: GI through GV. Three groups – GI, GII and GIV – cause disease in humans. Within genogroups, they are further characterized into clusters (eight for GI and 17 for GII), and within clusters, the individual norovirus assigned to an outbreak is referred to as a strain. GII.4 cluster strains are the most common in outbreaks.

Attack rates are relatively high, often exceeding 50%, meaning that over half the people who consume the contaminated food became ill. Only a limited number of attack rates worldwide have been reported for molluscan shellfish. Attack rates of 30, 58, 63, 68 and 78% have been reported in shell oysters; with 58% in frozen half-shell oysters and 74% in mussels. Ill people shed norovirus at high levels in waste. Additionally, post-symptomatic virus shedding can continue for some time after disease resolves. For example, norovirus shedding in an experimental human infection model lasted a median of 28 days, with a range from 213 to 56 days, and most subjects were no longer symptomatic by day 4.

### Viral Detection

Strains of human noroviruses do not grow or poorly grow in vitro, and their detection in food matrices relies on molec-



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ular techniques. However, further standardization of molecular methods will be necessary before they are widely adopted within regulatory frameworks and routinely implemented in food analysis. A standard method for virus detection and quantification in molluscan shellfish is currently available via the International Organization for Standardization (ISO/TS 15216-1:2013, 2013), and adoption of the viral standards into European Union legislation is being considered.

### Norovirus Control

Shellfish sanitation programs worldwide attempt to reduce the incidence of norovirus illness through the establishment of growing water standards, harvesting and processing sanitation standards, distribution controls and consumer educa-

tion programs. However, human activities such as swimming, land runoff, heavy rain and storms, commercial and recreational boating, marinas and sewage discharges from commercial and domestic sources can rapidly introduce noroviruses to molluscan shellfish-growing areas.

By the time a regulatory agency can identify a potential or actual public health problem and implement corrective action, shellfish may have been harvested and entered commerce. Attempts to identify the location of the contaminated shellfish and initiate a complete product recall are usually difficult.

An example of the difficulty in identifying norovirus contamination prior to harvest occurred in the United States in 1993. The outbreak, which involved oysters from an approved growing area, had a 63% attack rate. Microbiological sampling showed the growing area met all standards. There was no environmental source of pollution identified. Sanitation procedures at the oyster-processing facilities where seafood dealers purchased the oysters met all state and federal health standards.

Incorrect assessment has also caused problems. It has been known for over 40 years that bacteria and viruses exhibit differences in terms of concentration, accu-

mulation and depuration from contaminated shellfish. As a consequence, the absence of virus contamination cannot reliably be deduced from the failure to detect bacterial contamination. However, risk management assessment and the management of harvesting areas continue to rely on bacteriological standards like *Escherichia coli* values, despite the fact they have been proven unreliable for indicating viral presence.

### Norovirus Outbreaks

Current wastewater treatments fail to ensure the complete removal of viral pathogens that can be discharged into fresh, marine and estuarine waters and therefore contaminate shellfish-growing waters. Viral elimination depends on a wide array of factors, including temperature, solar radiation, adsorption, enzymatic destruction and predation by bacteria and protozoa. The filter-feeding nature of bivalves and their often raw or slightly cooked method of consumption make molluscan shellfish one of the most common vehicles of foodborne illnesses.

Investigations of disease outbreaks linked to molluscan shellfish have been reported in the scientific literature, but only a few countries systematically collect

and report such data through a disease surveillance system. A systematic review was conducted by scientists in Greece to investigate viral outbreaks associated with mollusks and explore their distribution in different countries.

Six databases – Medline, Embase, Scopus, PubMed, Eurosurveillance and SpringerLink – and the ProMED global electronic reporting system were searched. From 1980 to July 2012, about 360 molluscan-borne viral outbreaks, alongside nine ProMED reports involving shellfish consumption, were identified.

More than half of the outbreaks, 63.6%, were reported in Japan. The rest were reported in Italy (7.7%), the United States (4.6%), France (4.1%), New Zealand (2.7%), Sweden (1.6%), Spain (1.6%), United Kingdom (1.4%), Singapore (1.1%) and Australia (1.1%). In 8.2% of the outbreaks, the country of the epidemic was not reported.

The most common vehicle of infection was norovirus, which was involved with 83.7% of the incidents. The shellfish species implicated in the viral outbreaks by the scientific literature and ProMED were oysters (58.4%), clams (22.6%), mussels (0.5%) and cockles (1.1%).

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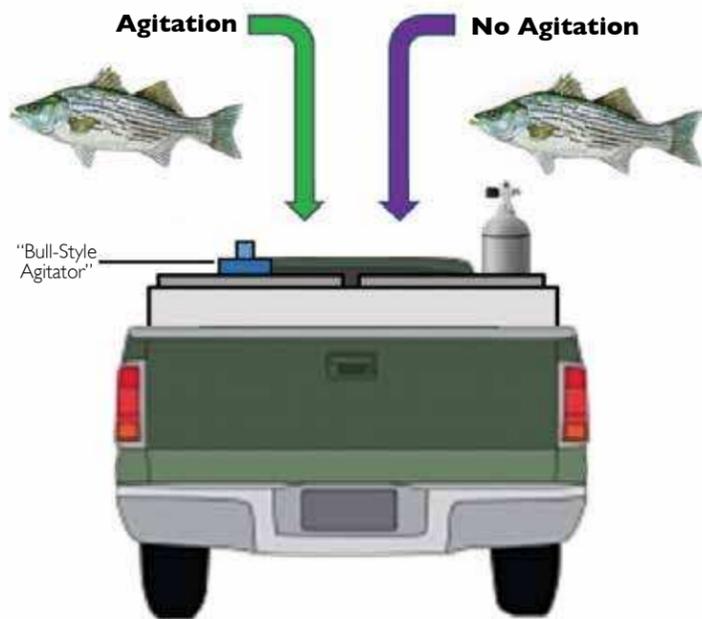
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# Improving Transportation Of Live Hybrid Striped Bass



Although continuous agitation improved some water quality parameters, its use did not substantially attenuate the stress responses of the fish.

## Summary:

Anecdotal information has suggested that pond-reared hybrid striped bass are more vulnerable to transportation-related stressors than cage-reared fish. Study results suggested that accumulation of carbon dioxide and decreasing pH levels may contribute to this phenomenon. Agitation during simulated transport mitigated the carbon dioxide accumulation and stabilized pH, but shifted the total ammonia nitrogen equilibrium in favor of un-ionized ammonia nitrogen. Ultimately, the agitators did not substantially attenuate the stress responses observed in the fish.

A majority of the U.S. production of hybrid striped bass – a cross of female white bass, *Morone chrysops*, with male striped bass, *M. saxatilis* – is associated with farms located in the states of Texas, North Carolina and Florida. According to the U.S. Department of Agriculture, these farms were responsible for nearly

75% of the 5,634 mt of market-size fish produced in 2013. Although Illinois is a relatively minor contributor to domestic production, hybrid striped bass are the second most cultured fish in the state and represent a significant portion of its aquaculture industry.

Hybrid striped bass have been raised in a variety of culture systems in Illinois, including earthen ponds and floating cages. Most Illinois growers market their fish live, but these lucrative markets are typically in major metropolitan areas such as Chicago and New York City, which are located hundreds of kilometers from the majority of farms in southern Illinois. Transport times often range from six to 24 hours, so long and stressful live hauls are common. The results can include mortality, morbidity and fish in generally poor condition upon arrival.

Anecdotal information from Illinois growers has suggested that pond-reared hybrid striped bass are more vulnerable to transportation-related morbidity and mortality than cage-reared fish. To verify these reports and explore ameliorative strategies, the authors conducted two experiments to simulate live hauling of market-size hybrid striped bass.

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## Live Transport Of Pond-, Cage-Reared Fish

In one experiment, market-size fish with individual weights of  $650 \pm 13$  g were harvested by seining from earthen ponds and dip netting from floating cages, then stocked at a rate equivalent to 97 g fish/L in a two-compartment, insulated aluminum live hauler and held for eight hours to simulate transport. About 60 pond-raised and 65 cage-raised bass were stocked. The procedure was repeated on four replicate days.

Water chemistry was measured and blood samples were taken from three fish at zero, one, two, four and eight hours (Figure 1). Since blood samples from one trial were improperly stored, the blood chemistry results reflected only three of the four replicate trials.

Changes in plasma cortisol, glucose, lactate and osmolality indicated all fish underwent an acute stress response following harvest and transport, but subtle differences in performance and conditions experienced by the pond- versus cage-reared fish suggested greater accumulation of carbon dioxide during transport of pond-reared fish may be problematic (Figure 1).

## Agitators Manage Water Quality

In a second experiment with three replicate days, market-size fish with individual weights of  $812 \pm 12$  g were seine harvested from earthen ponds and stocked in the same live hauler used in the first experiment. The bass were again held for eight hours of simulated transport. For this experiment, however, the live hauler was fitted with “bull-style” agitators powered by a 12-volt battery to provide continuous agitation during the simulated transport.

Although agitation mitigated the carbon dioxide accumulation and stabilized

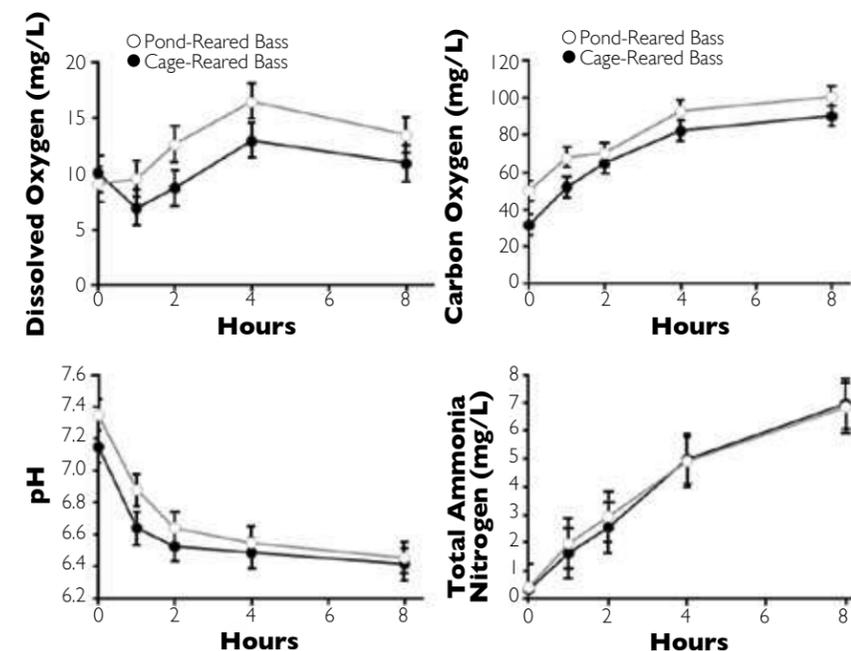


Figure 1. Water chemistry during simulated transport of hybrid striped bass in the first experiment.

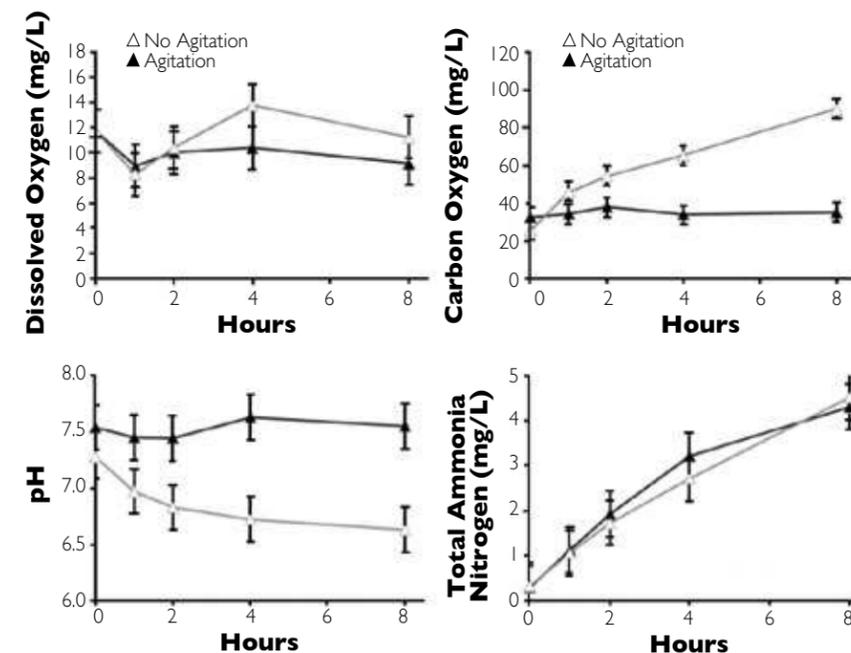


Figure 2. Water chemistry during simulated transport of hybrid striped bass in the second experiment.

pH, the total ammonia nitrogen equilibrium shifted in favor of un-ionized ammonia nitrogen (Figure 2). Minor differences in blood chemistry were noted, but the use of agitators did not substantially attenuate the stress response observed.

## Transport Limitations

The authors' work suggested the anecdotal reports of pond-reared hybrid striped bass performing poorly during and after live transport were accurate.

However, blood chemistry analyses failed to reveal significant differences between pond- and cage-reared fish. The only mortalities observed during the experiments were among the pond-reared fish, suggesting some distinction between these two “populations” of fish.

Increasing carbon dioxide and decreasing pH levels were identified as potential causal factors. The experiment with agitation to mitigate the carbon dioxide accumulation was successful in

terms of these two aspects of water quality, but presented another challenge in terms of nitrogenous waste management. Such interactions among water quality parameters can complicate attempts to mitigate water quality-related stressors and achieve ideal transport conditions.

## Perspectives

Experimental results suggested harvest-related handling can be a greater stressor than others experienced during transport, and seining may contribute to poorer condition of pond-reared fish during and after transport.

The authors recommend further research to identify strategies – allowing fish to recover between primary harvest and transport or the use of water treatments to neutralize ammonia, for example – to reduce stress and improve live transport of hybrid striped bass, particularly those raised in ponds.

*Editor's Note: This article was derived from a paper by the authors to be published in the forthcoming issue of the North American Journal of Aquaculture.*

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# Shrimp Volumes From Ecuador, India Rise In Unsettled Market



As Thailand continues to stage a comeback in shrimp production, much of its product is sent to the U.S. in cooked form.

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Headless, shell-on (HLSO) imports for March were even with a year ago. Count sizes were under 15 through 31-40, with most in the 21-25 and 26-30 categories. Peeled imports were 15.0% higher in March, but only 3.3% higher YTD. Cooked shrimp imports rose sharply, but volume was limited.

Through the first quarter of 2015, India was the third-largest supplier of shrimp to the United States behind Indonesia and Ecuador. Imports from Indonesia were down 8.5% in March, but Indonesia remains the top supplier to the U.S. in 2015, and YTD imports were 16.0% higher. HLSO imports (easy-peel) were down marginally, but remained over 42.0% higher for the year. Count sizes were spread. Peeled imports were down about 20.0% for March and down 5.5% YTD, while cooked imports were higher.

Imports from Ecuador were up some 52.0% in March. YTD, imports were 4.6% higher. Most of the imports were HLSO, which were 71.4% higher in March. The balance of imports – peeled shrimp – were 11.6% higher. HLSO import counts were mostly 26-30 through 51-60 and centered on 31-40 and 41-50.

Imports from Vietnam continue a down trend, off 47.6% for March and 23.7% YTD. Both HLSO and peeled imports were down sharply, as well as cooked shrimp. Production issues as well as a high tariff were likely affecting Vietnamese imports. However, 16-20 HLSO shrimp imports from Vietnam were up.

Imports from Thailand continue to improve from a poor production year in 2014. Imports were up 52.3% for March compared to a year ago and 21.6% YTD. Imports in all categories were higher.

Shrimp imports from Mexico rose dramatically by percentage, but volumes reflected the off season. HLSO imports were mostly 31-40 count and larger, centered on under 15 and 16-20 shrimp. Mostly in breaded form, the March imports of Chinese shrimp were up in March but down YTD.

## Shrimp Market

The Latin American HLSO market is generally steady with some offerings of 41-50 and larger shrimp trending to the higher

## Summary:

Although imports from Indonesia slowed in March, Indonesia remains the top shrimp supplier to the U.S. in 2015. Imports from Ecuador were up sharply in March. Indian product also increased in volume. Production and tariff issues likely affected Vietnamese imports. Headless, shell-on imports continue about even with 2014 levels. Peeled shrimp levels varied. The market undertone was somewhat unsettled, as seasonal production and imports were expected to ramp up in June. Importers burdened with high-priced inventory will be cautious moving forward.

March imports of shrimp to the United States were up 8.5% for the month, pushing year-to-date (YTD) imports 5.3% higher (Table 1). Imports from Ecuador were up sharply at 19.7 million lb versus 12.9 million lb a year ago – a 52.0% increase and likely source of weakness in the market in April.

Shrimp imports from India were up 10.4% in March compared to a year ago and 15.3% higher YTD. Imports from Vietnam were down sharply in March and YTD. Thailand continues to stage a comeback, with imports from that country up 52.0%, much of it cooked shrimp.

Table 1. Snapshot of U.S. shrimp imports, March 2015.

Form	March 2015 (1,000 lb)	February 2014 (1,000 lb)	Change (Month)	March 2014 (1,000 lb)	Change (Year)	YTD 2015 (1,000 lb)	YTD 2014 (1,000 lb)	Change (Year)
Shell-on	41,413	33,568	23.4%	35,609	16.3%	121,764	104,940	16.0%
Peeled	36,622	30,483	20.1%	40,783	-10.2%	104,339	114,691	-9.0%
Cooked	12,637	9,748	29.6%	9,958	26.9%	36,774	31,483	16.8%
Breaded	7,971	7,605	4.8%	5,321	49.8%	25,877	23,215	11.5%
Total	98,643	81,404	21.2%	91,671	7.6%	288,754	274,329	5.3%

Sources: Urner Barry foreign trade data, U.S. Department of Commerce.

side of our range, with a few premiums on 26-30 through 41-50 count. Smaller-count shrimp were steady in March. West Coast markets appeared to be discounted versus those on the East Coast.

Asian white shrimp were mostly steady, and 16-20 count shrimp in all categories were full steady with a few premiums asked. Under-15 count remained under some selling pressure. The 21-25 count and smaller shrimp were mostly steady except where they may have competed with lower-priced Latin American product.

The undertone was somewhat unsettled, as seasonal production and imports were expected to ramp up in June. Importers burdened with high-priced inventory throughout a long market correction will necessarily be cautious moving forward. Many look for demand to improve at the lower price points.

Black tiger shrimp have been weak and under selling pressure. Lower-priced white shrimp have put downward pressure on the market. High-priced inventories are cleared ahead of seasonal production. Also, an influx of Bangladesh offerings into the U.S. is having an effect.

## Domestic Shrimp

A line was drawn between 21-25 and 26-30 HLSO shrimp in recent weeks. Larger-count shrimp continued firm amid supply concerns, while smaller-count HLSO shrimp values have declined, given holdings and impending new season production. Values for both peeled and deveined, and peeled and undeveined shrimp also declined. Adequate on-hand supplies, an approaching season and a generally dull demand are weighing on the market.

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# Aquaponic System Produces Red Drum, Saltwater Vegetable Species



Water from the plant raceways in the rear of this photo is pumped, filtered and reused in the fish culture tanks (right foreground.)

## Summary:

Aquaponics offers a way to produce fish – and plants – in a controlled environment while minimizing water use and discharge. A project in Florida, USA, is studying the feasibility of a marine aquaponic system containing red drum and two native saltwater species. Water that exits the plant raceways is filtered and recirculated to the fish tanks. In tests, sea purslane grew rapidly, while saltwort took almost four months to adapt. The fish exhibited high survival and achieved a feed-conversion ratio of 1.2.

Interest in and development of aquaponic systems has grown rapidly in the last 10 years. Aquaponics offers a unique way to produce fish in a controlled environment while minimizing water use and waste discharge. Aquaponic systems vary in size from small-scale designs appropriate for households to larger commercial operations with yields able to supply farmers markets and high-end restaurants.

Many of the systems in operation are designed to produce freshwater fish and vegetables that grow well hydroponically. While there is great interest in marine aquaponics, development of marine sys-

tems has been constrained by limited land-based production of marine fish species and the selection of appropriate edible plant species that grow in saltwater.

Mote Aquaculture Research Park (MAP), the University of South Florida Civil and Environmental Engineering program, and Morningstar Fishermen partnered to design and study a marine aquaponic system. Building on past joint research on an integrated multi-trophic aquaculture system, the goal of the current project funded by Florida Sea Grant is to demonstrate the feasibility of a marine aquaponic system and explore its environmental and economic sustainability.

## Species Selection

Florida red drum, *Sciaenops ocellatus*, was selected for the fish species because of its heartiness and ability to tolerate conditions with only 12 to 15 ppt salinity. While harvests of wild-caught red drum have declined in recent years, the species is a popular sport fish, and farm-raised fish can be sold commercially.

Certain species of plants can tolerate low-salinity conditions. However, the use of halophytes, plants that naturally grow in saline conditions, was preferred over forcing freshwater plants to adapt to saline conditions.

Two saltwater vegetable species – sea purslane, *Sesuvium portulacastrum*; and saltwort, *Batis maritima* – were selected.

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Saltwort is a locally grown halophyte similar to the commonly consumed *Salicornia* species used in European cuisine and as animal fodder. Sea purslane is also native to Florida and has a European counterpart known by similar common names that in fact reflect different species.

Both sea purslane and saltwort are typically harvested from the wild. Research suggests they have numerous health benefits, including high omega-3 fatty acid, vitamin A and vitamin C content. A local nursery that produces both species for coastal restoration projects provided cuttings for the aquaponic system.

## System Design

Construction began during the summer of 2014, and the system was stocked with red drum fingerlings in September 2014. A schematic of the system is presented in Figure 1. The system consisted of three, 3.3-m<sup>3</sup> round fish tanks initially stocked with red drum at a density of 4.23 kg/m<sup>3</sup>.

Solids were removed first through a swirl separator then through an upflow media filter for fine solids removal. A moving-bed bioreactor was used to ensure enough nitrification capacity and subsequent fish health.

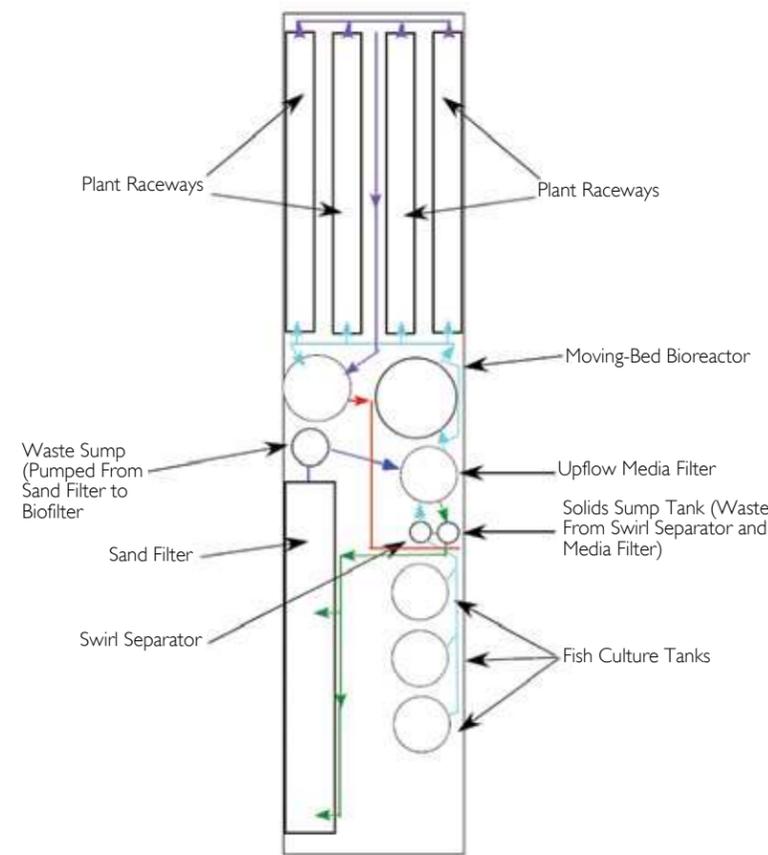


Figure 1. Schematic of the marine aquaponic system at MAP.

Four plant raceways with dimensions of 12.8 m x 1.2 m were constructed from wood and lined with polyethylene. Cuttings for the two saltwater plant species of 7- to 10-cm length were stocked in the raceways in early October. The saltwater vegetables were hydroponically grown in net pots packed with coconut fiber and supported on polystyrene rafts floating in the raceways. Once water exited the plant raceways, it flowed to a holding tank before being recirculated back to the fish tanks.

Due to the presence of salt in the solids, they could not be discharged to the environment or used as a soil amendment, as commonly practiced in freshwater aquaponics. For this reason, the MAP system was equipped with a sand filter to collect backwash from the radial flow filter and upflow media filter. The solids collected will be used in another project exploring their potential for methane production through anaerobic digestion and as a fertilizer for wetland plants grown for restoration.

## Water Quality Data

During the first three months, water samples were collected weekly from six points throughout the system and ana-

lyzed for ammonium-nitrogen and nitrite-nitrogen. Nitrate-nitrogen was analyzed twice weekly. The ammonium-nitrogen concentration fluctuated during the first 50 days, but remained below 1 mg/L (Figure 2). While there was no change in fish feeding behavior, by day 60, the ammonium-nitrogen level rose above 1 mg/L.

Three changes were made to improve ammonia removal: increasing the flow rate, reducing the biomass density and adding alkalinity to improve nitrification.

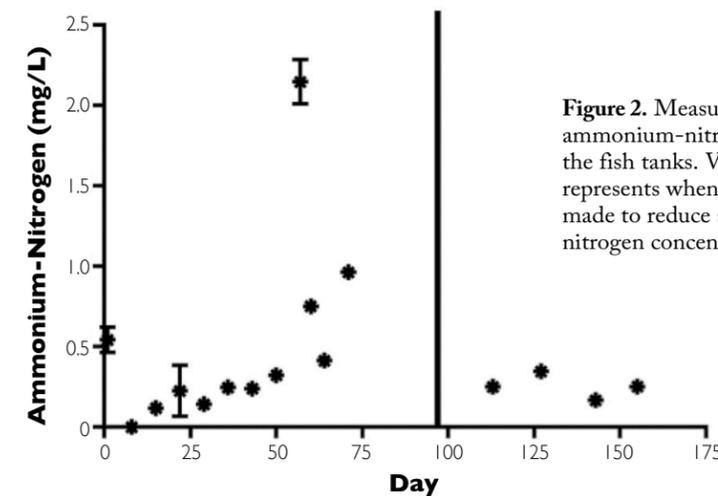


Figure 2. Measurements of ammonium-nitrogen exiting the fish tanks. Vertical bar represents when changes were made to reduce ammonium-nitrogen concentrations.



The project combined culture of two saltwater vegetable plant species with red drum.



**Figure 3.** Growth of one sea purslane plant. Day 1 represents the first day the plant was added to the system.

anaerobic conditions were created. These conditions, combined with the high nitrate-nitrogen concentration and high levels of organic carbon in the backwash, allowed improved denitrification. Once the changes were made to the sand filter, the nitrate levels decreased.

### Plant Growth

During the first three months, plant samples were collected twice monthly for later analysis of nitrogen and phosphorus content. The sea purslane grew rapidly and performed well in the aquaponic sys-

tem (Figure 3). Harvesting of sea purslane began in January. The plants are currently being sold in 0.25-lb (0.11-kg) bunches for U.S. \$3.50 at a local farmers market and directly to a local restaurant.

The saltwort did not perform as well initially. However, after five months, it appears to be growing better.

### Fish Growth

The red drum have performed well in the aquaponic system, with a survival rate of 98%. The average weight of fingerlings stocked in September 2014 was 46.5 g.

On day 100, the average weight was 294.0 g, and the feed-conversion ratio was 1.2. It is anticipated the fish will be ready for harvest late this summer.

### Perspectives

According to the Food and Agriculture Organization of the United Nations, the current global food system fails to sufficiently support the nutritional needs of over 870 million people worldwide. Meeting these needs has become increasingly difficult as water scarcity and decreased availability of arable land have begun to constrain agricultural production. Collapsing fish stocks have reduced wild-caught harvests for decades.

Novel methods of food production like marine aquaponics are key to meeting the future nutritional needs of the growing population. This research is just a beginning, and additional work on optimizing marine aquaponic systems and developing markets for the saltwater vegetables will be necessary to ensure the success of this industry.



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# Developmental Transcriptomes From Penaeid Shrimp



Since elite genotype shrimp (right) reflect much higher performance than wild-caught shrimp (left), breeders hope to develop a mechanism for genetic copyright.

## Summary:

To develop an alternative mechanism for genetic copyright of improved shrimp lines, the authors used a bioinformatics approach to identify germ line genes that could be potentially targeted to ablate the germ line. This approach has also resulted in the production of developmental transcriptomes for penaeid shrimp. The mesoderm/muscle gene sequences and molecular tools should be useful in further understanding the basic biology of mesoderm and muscle development in shrimp, for example in detecting cellular changes in faster-growing genetic lines.

Australian shrimp farms primarily grow black tiger shrimp, *Penaeus monodon*, for which elite genetic lines have been successfully produced by selective breeding. As reported by Brett Glencross and co-authors in *Aquaculture Nutrition* in 2013, these elite lines provide harvest yields

more than double that of unselected lines and have improved survival and growth performance, and lowered metabolic rates and energy requirements.

The demand to access these genetically improved lines is strong from the countries of Southeast Asia. However, the Australian shrimp-farming industry is highly motivated to prevent unlicensed breeding. As there are currently no mechanisms to confer failproof reproductive sterility and thus genetic copyright on a commercial scale in penaeid shrimp, this has precluded the sale of elite stocks beyond the individual farm enterprises that breed them. Remarkably little is known about the underlying biochemical and genetic processes that control fertility, sex and germ line determination, or other aspects of shrimp development.

To develop an alternative mechanism for genetic copyright, the authors used a bioinformatics approach to identify germ line genes that could be potentially targeted to ablate the germ line. This approach has also resulted in the production of developmental transcriptomes for penaeid shrimp.

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## Preparing Embryos For Genetic Sequencing

The kuruma shrimp, *Penaeus japonicus*, is readily spawned at one of the research stations of Australia's Commonwealth Science and Industrial Research Organisation, so this species was used as a model. It was first demonstrated by Takao Kajishima in 1951 that when *P. japonicus* embryos were separated by a sharp needle at the two-cell stage, the "animal" half only developed into a hollow ball of cells, while the "vegetal" half continued developing.

By utilizing this technique, researchers had the opportunity to look for embryonic genes differentially expressed in animal or vegetal half-embryos. They predicted that germ line genes might be enriched in the vegetal half, since the primordial germ cell was hypothesized to arise from vegetal determinants.

*P. japonicus* embryos were separated at the two-cell stage and allowed to develop until the animal and vegetal half-embryos could be distinguished. The animal and vegetal half-embryos were pooled separately, total ribonucleic acid was isolated and reverse transcribed to complementary DNA, and the resulting transcriptomes were sequenced.

Reads from each library were assembled, annotated and screened for known germ line and mesoderm genes. Pre-existing *P. monodon* ovary and nauplius

transcriptome libraries were also screened for developmental genes of interest.

## Germ Line Genes

The germ line genes *vasa* and *nanos* were previously found in shrimp by cloning methods, but neither *vasa* nor *nanos* appeared in the embryo transcriptomes. The authors found other candidate germ line genes, including *pumilio*, *germ cell-less*, *staufen* and *tudor*, in both animal and vegetal transcriptomes. All four of these were more highly expressed in ovary and/or testes than in other adult tissues and could be detected during embryonic development. Next, the authors looked for where the selected germ line genes were expressed in the developing embryos.

Custom monoclonal antibodies were generated to examine the protein expression of shrimp *vasa*, *nanos*, *pumilio*, and *germ cell-less* genes by immunoblotting and immunolocalization. The *vasa* and *nanos* antibodies labeled a structure in embryos previously hypothesized to be a germ granule. This structure has been detected in several shrimp species and is inherited by embryonic cells hypothesized to give rise to the primordial germ cell. The *pumilio* and *germ cell-less* antibodies are still being characterized.

## Mesoderm Genes

The mesoderm genes *twist*, *snail*, *mef-2* and *brachyury* were found in the *P. japonicus* half-embryo transcriptomes. These all function as transcription factors, which activate or repress other genes in mesoderm, muscle or related tissues. The *twist* and *brachyury* genes were found only in the vegetal transcriptomes, while *snail* and *mef-2* were found in both animal and vegetal transcriptomes.

Recently, five developmental transcriptomes – embryo, nauplius, zoea, mysis and postlarva – from the Pacific white shrimp, *Litopenaeus vannamei*, were published in the gene databases by Jianhai Xiang's laboratory. The *L. vannamei* versions of these mesoderm genes were identified, and primers were developed in collaboration with the Xiang lab to study their expres-



After five hours of development, shrimp "animal" half-embryos (left) form a hollow ball of cells, while "vegetal" half-embryos (right) undergo gastrulation and abnormal segmentation.

sion by quantitative polymerase chain reaction in this species.

The expression of the mesoderm genes is consistent with their known functions as transcription factors in other organisms. For *twist* and *snail*, expression was not detected until later embryonic stages and continued into the larval and postlarval stages. The *mef-2* expression was detected at all stages of development from zygote to postlarva. For *brachyury*, expression was highest during gastrulation – consistent with its known role in promoting cell movements during embryogenesis.

The next step will be to study the expression patterns of these genes in embryos and larvae, and antibodies to shrimp *twist*, *mef2* and *brachyury* are in production. In the model amphipod crustacean *Parhyale hawaiiensis*, work by Nipam Patel's laboratory has shown that *twist* and *snail* proteins are expressed in the posterior mesoderm, while *mef-2* protein is expressed in posterior mesoderm and persists in developing muscles.

## Application: Germ Line Knockdown

The availability of germ line gene sequences and antibodies to detect their protein products allows for experiments to ablate the shrimp germ line by targeted gene knockdown.

RNA interference is a powerful and highly accurate natural biological pathway in shrimp that can be utilized for such studies. This can be performed by administration of double-stranded RNA via tail-muscle injection or oral delivery.

The mesoderm/muscle gene sequences and molecular tools developed in parallel should be useful in further understanding the basic biology of mesoderm and muscle development in shrimp, for example in detecting cellular changes in faster-growing genetic lines.

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# Probiotics Improve Nursery Performance Of Juvenile Sea Cucumbers



In multi-phase testing, the addition of probiotics significantly increased the yield and robustness of juvenile sea cucumbers.

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gastritis, in the animals, which coincides with two difficult molting stages: the initial auricularia stage and 7- to 10-day-old juveniles. Subsequently, the young seed spends several months in the nursery tanks to reach lengths of 2 to 3 cm before they can be transferred to ponds for farming or to open sea. According to researcher Jiaxin Chen, the key to increased survival in the hatchery and nursery is to provide an appropriate feed and improve the overall management in the tanks.

## Probiotics

Microbial products are seen as, among other things, alternatives to the prophylactic use of chemicals. However, the presence of poor-quality probiotics in the market and the misunderstandings regarding their functions have given rise to doubts about their efficacy.

As discussed in numerous scientific reviews, selected microbial strains can perform a range of functions. These range from the control of pathogens, both in animals' digestive systems and the environment, by direct inhibition and competition for nutrients, to the stimulation of the animals' immune systems, enhanced feed utilization and the improvement of water quality.

## Selected microbial strains can perform functions that range from the control of pathogens in animals' digestive systems and the environment to stimulation of the animals' immune systems and improvement of water quality.

### Hatchery/Nursery Study

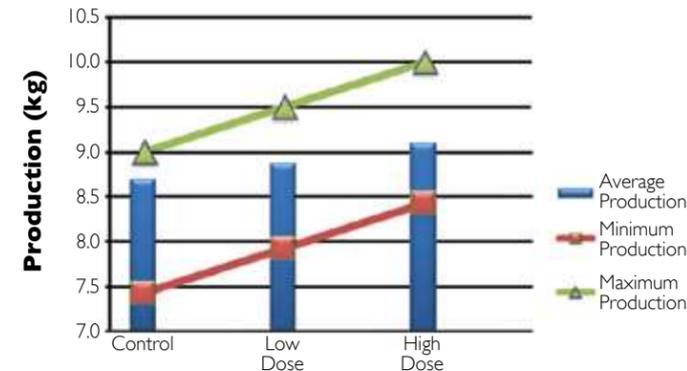
In a study, the authors tested the efficacy of a commercial mixture of selected *Bacillus* strains in the larviculture and/or grow-out of *Apostichopus japonicus*. Eighty-day-old juvenile sea cucumbers were stocked at 7.5 kg juveniles/18-m<sup>3</sup> tank.

A commercial probiotic mixture was applied during the nursery phase. The protocol is given in Table 1.

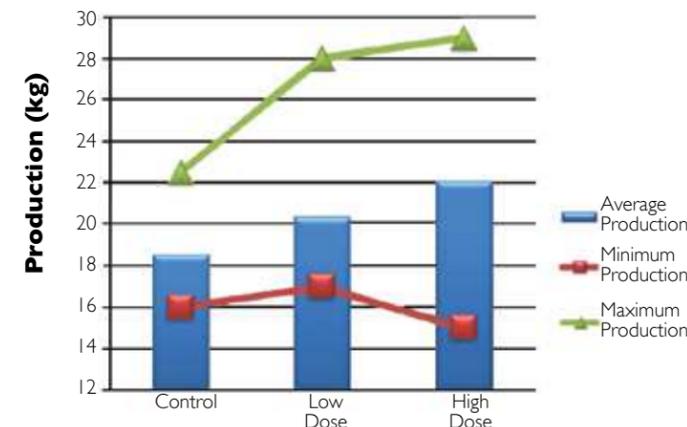
Ten, tanks containing prefiltered seawater were used as a control treatment. Five tanks each were used for the two treat-

**Table 1. Probiotic applications in test treatments with *A. japonicus* juveniles.**

Day(s)	Low-Dose Probiotics (g/tank)	High-Dose Probiotics (g/tank)
0	0	0
1	20	20
2-7	5	5
8-10	20	20
11-23	10	10
24-89	10	50
90-107	10	10



**Figure 1.** Average wet weights of sea cucumber juveniles after 55 days of treatment.



**Figure 2.** Average wet weights of sea cucumber juveniles after 140 days of treatment.

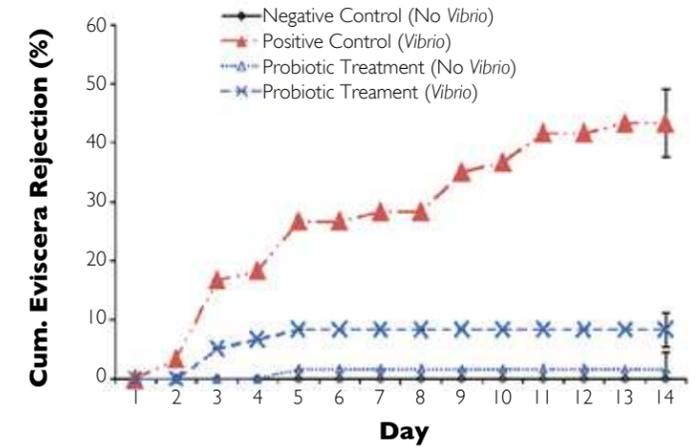
ments with probiotics, a low-dose protocol and a high-dose protocol. The tanks were aerated with air stones, and dissolved-oxygen concentrations were measured daily.

### Culture Phase 1

Juveniles of 0.13 to 0.17 g individual weight were distributed on the settlement substrates at a density of 2,500-3,300 individuals/m<sup>3</sup>. The sea cucumbers were fed in the morning and late afternoon with an artificial feed mixed with sea mud, at a rate of 5 to 8% of body weight daily.

Every day, 50% of the water was renewed. The tanks were cleaned every seven to 10 days by transferring the substrates and animals to new tanks. It took 55 days to finish the first phase of the cycle.

During this first phase, the yield of the tanks treated with the probiotics was better than that for the control treatment (Figure 1). The average harvested biomass volumes per tank were 9.1, 8.9 and 8.7 kg, respectively, for the high-dose protocol, low-dose



**Figure 3.** Eviscera rejection rates of sea cucumber juveniles during a challenge test with *V. splendidus*.

protocol and control treatment. An increased yield of 4.5% was noticed after 55 days of culture in the high-dose probiotic protocol. Moreover, 5 to 10% less feed was administered in the tanks with the probiotics compared to the control tanks.

### Phase 2, Nursery

After phase 1, the juveniles were removed from the settlement substrates. After weighing and sorting, the animals were distributed to new settlement substrates and tanks.

During the second phase, days 56 to 140, the probiotics were still administered on a daily basis in the two protocols. As a result, higher biomass yields were obtained. The average biomass harvested per tank after 140 days were 18.4, 20.4 and 22.1 kg for the control, low-dose and high-dose treatments. The average increase in yield was 18% after 140 days of culture in the high-dose probiotic protocol (Figure 2).

### Challenge With *Vibrio splendidus*

At the end of phase 2, the *A. japonicus* juveniles were graded and redistributed in new tanks reflecting their earlier treatments. Subsequently, the different treatments were restarted, and after two extra weeks of culture, *A. japonicus* juveniles from each treatment were transferred to the lab for a challenge test with *Vibrio splendidus* bacteria.

A negative control consisted of sea cucumbers that were not challenged with the *Vibrio*. A positive control group was exposed to *V. splendidus* during the culture period. Both treatments were done on animals selected from tanks treated with or without probiotics.

It was clear that the addition of the probiotics significantly increased the robustness of the juvenile sea cucumbers. A significant reduction of the eviscera ejection rate was noticed in animals treated with probiotics versus animals treated without probiotics (Figure 3). The use of probiotics might improve the culture performance of sea cucumbers, as it has an immediate effect against *Vibrio splendidus*, a well-known pathogen of *A. japonicus*.

## A significant reduction of the eviscera ejection rate was noticed in animals treated with probiotics versus animals treated without probiotics.

### Summary:

While sea cucumbers are one of the most prized seafoods in China and Asia, their production suffers from suboptimal juvenile production. The use of proper feeds and overall management in the nursery can improve yield and survival. In a study, juveniles in tanks that received a probiotic mixture performed better in terms of growth and feed conversion than those in control tanks. The sea cucumbers were also more robust, as demonstrated in a subsequent challenge test with *Vibrio splendidus*.

The history of the sea cucumber fishery dates back for more than 1,000 years. Over the last century, and especially the past 20 years, Chinese research projects have focused on the breeding and artificial culture of the species.

There are 134 species of sea cucumber identified in China seas, among which about 20 species have commercial value. As of 2005, *Apostichopus japonicus* was the only species cultured in China.

While sea cucumbers are one of the most prized seafoods in China and Asia, and aquaculture programs are being developed on a huge commercial scale, sea cucumber production still suffers from low and suboptimal juvenile production. The selection and use of proper feeds and the overall management practices in the nursery have been identified as the issues in the production process.

Apparently one of the main problems during the nursery phase comes from malfunction of the digestive ducts, especially



When drawn in, the V-shaped clamshell grader efficiently moves yellow perch to the side of the growout tank, where they pass to the sidewall box for harvesting.



A clamshell crowder/grader constructed of PVC pipe combines with an airlift pump to quickly harvest and grade 1.35-kg rainbow trout and Arctic char.

## Crowder/Grader Units Improve Harvest Efficiency In Large Circular Tanks

### Summary:

The use of larger and deeper tanks can reduce building, labor and other aquaculture production costs. However, the ability to grade and transfer large numbers of fish is more challenging when using large tanks. In a comparison of the effectiveness of a purse seine and a hinged clamshell to crowd fish in large tanks, the latter was easier to control and less stressful to salmonids. With a slotted bar rack in a side panel of the clamshell crowder, fish were simultaneously graded in size.

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Larger and deeper circular tanks are being widely applied in aquaculture, particularly for the commercial-scale culture of trout and salmon in water-recirculating systems. The tank diameters typically range from 10 to 16 m, with sidewall depths of 3 to 6 m, particularly at farms targeting annual production levels of 400 to 1,000 mt or more.

Larger and deeper tanks can improve floor space utilization and reduce building costs. They can also reduce the cumulative fixed costs per unit of production for pumps, piping, water treatment equipment, fish feeders and dissolved-oxygen probes when compared to the use of many smaller and shallower tanks. The largest savings in variable costs realized by moving to larger tanks

is likely related to a reduction in labor.

The ability to effectively and safely grade and transfer large numbers of fish is much more challenging when using large and deep circular culture tanks. The technologies and practices used to grade and harvest fish should require little labor and minimal time, and allow rapid set-up and removal. The equipment should also minimize stress on fish and not compromise worker safety.

### New Technologies

At The Conservation Fund Freshwater Institute, the authors have developed and evaluated in-tank crowders and top graders,

as well as technologies to simplify the transfer of fish from the growout tanks to finishing/purging tanks. For example, in a comparison of the effectiveness of a purse seine and a hinged clamshell crowder to crowd fish in large tanks, the latter was found easier to control and less stressful (with lower mortalities) to salmonids.

When a slotted bar rack was used in one of the side panels of the clamshell crowder, fish were simultaneously top graded in size because the slotted panel allowed small fish to swim out of the crowder, while larger fish were crowded toward the fish transfer device. The majority of fish tended to self-sort into smaller and larger sizes within the culture tank, without lifting fish out of water.

The clamshell crowder/graders were fabricated from polyvinyl chloride pipe fittings or marine-grade aluminum and high-density polyethylene sheets. The crowder/graders used in the 9.14-m-diameter, 150-m<sup>3</sup> tanks weigh 75 to 150 kg when dry, so an electric winch attached to a steel beam above the tanks is used to lift the units into and out of the culture tanks. At larger farms, an I-beam is installed overhead to allow a trolley and hoist to move the crowder/graders to and from different tanks.

### Crowder/Grader Operation

To operate, the crowder unit is lowered into the tank with the ends of both crowder panels closed and pulled tight against the tank wall to exclude fish from the relatively small area enclosed by the closed panels. The end of the first clamshell panel is tied off and held tight against the culture tank wall. The other long clamshell panel is then pulled around the tank's perimeter to slowly crowd the fish.

When the clamshell is used for grading, the wing wall is pulled slowly in increments that can take 30 to 60 minutes, providing time for the smaller fish to swim past the grader bars. The grading process is not perfect, but the majority of smaller fish

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A fish transfer pipe can easily be set up to carry fish from the growout tank's sidewall harvest box to the finishing/purging tank.

### Dual-Drain Tanks

In North America, many fish farms now use large circular culture tanks with dual drains. A sidewall harvest box was developed to take advantage of the flow discharged through a sidewall drain box, which typically receives 90 to 95% of the flow through the tank and is relatively free of settleable solids.

To harvest fish crowded into this sidewall box, a normally vertical perforated door through the sidewall drain is opened, which allows crowded fish to rapidly flow into the sidewall drain box. A dewatering rack is also installed in the sidewall drain box to enable rapid fish harvest through the box while fish are dewatered. The fish outlet sluice channel,

located opposite the sidewall box entry gate, provides a slope to its lower end.

The fish outlet sluice channel is connected to a transfer hose of 20.3- to 30.5-cm diameter, which is used to slide harvested fish to another location, such as a finishing/purging tank or palletized transfer tote. Only a small flow, typically less than 38 Lpm, is used to slide fish to finishing.

The authors have successfully used this technique to harvest rainbow trout, Arctic char, Atlantic salmon and yellow perch. Particularly with smaller fish weighing less than 1.5 kg, tightly crowded fish generally self-transfer out of the tank and into the sidewall box.

However, to reduce stress on the fish and when transferring larger fish, such as the 4.5-kg Atlantic salmon, a large hand net is sometimes used to gently pull fish to the entrance of the sidewall harvest box. The last of the fish in the clamshell crowder also have to be netted by hand.

### Clamshell Grader

The clamshell grader has been applied often, sometimes with the sidewall harvest technology, at several new land-based aquafarms using recirculation in North America. To increase the distance the fish can be transferred, at least one of these commercial farms connected the sidewall harvest box to a fish pump. The farm crowds fish to the sidewall harvest box and uses a temporary cover to obscure part of the dewatering rack, which passes some water with the fish into the fish outlet sluice channel.

The outlet channel is connected to the intake of a fish pump, which pumps fish in water to finishing/purging tanks. The fish transfer water is then pumped back, or more ideally, flows by gravity back to the recirculating system after overflowing the finishing/purging system. Because accounting for water flow is critical in recirculation, the technologies to transfer fish and water from the growout to the finishing/purging system should be detailed during the design phase.

### Perspectives

These fish crowding, grading and transfer technologies are helping to overcome scale-up issues and improve land-based fish farm production per unit investment. For more details, look for an open-access paper by the main author published in 2009 in Elsevier's journal *Aquacultural Engineering*.



A wide range of control can be applied to LED lamps to change both their intensities and spectrums.

## LED Lighting Technology Provides Unique Benefits For Aquaculture

### Summary:

Environmental lighting, which synchronizes all stages of aquatic life, is an important consideration as more aquatic animals are produced indoors in highly controlled environments. Artificial lighting should deliver uniform light across the water's surface in rearing tanks and mimic not only photoperiod, but also light color and intensity. Traditional artificial light sources are limited in their ability to simulate natural environmental light. Light-emitting diode lights can be controlled to reproduce the full spectrum of natural sunlight – with substantial energy savings.

Research with fish has shown that environmental light synchronizes all stages of life, from embryo development to sexual maturation. In nature, light rhythms occur in a predictable unflattering pattern – a pattern that has not changed for thousands of years. Thus, light, not temperature, has been the steadiest of environmental influences in animal evolution. Fish respond to changes in temperature, but they are cued by changes in light.

In nature, light intensity gradually increases during the day and slowly decreases toward sunset. The quality of the light also changes during the day. Sunrise is characterized by a dominance of red light, high noon has a lot of blue color light, and gradually the light color changes to a dominant red again at sunset.

Due to the earth's changing orientation to the sun, the quantity and quality of light change on a seasonal basis, as well as a diurnal pattern. Furthermore, the quantity and color of light an animal experiences in nature are governed by its geographical location.

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### Animals' Perception Of Light

Fish have adapted to the changes in light in their natural environment by evolving a biological clock that is synchronized and driven by light stimuli from their environment. This clock entrains physiological and behavioral processes. On a daily basis, these cyclic processes are known as circadian rhythms, and scientists refer to a "circadian clock" within an organism.

In fish, circadian rhythms are controlled mainly by the release of hormones and establish times of sleeping, eating, movement and socialization. Light in an animal's environment also entrains on a seasonal cycle. Migration and reproduction are two processes that are highly regulated by seasonal light.

In humans, the main structure for photoreception is the eye, but many vertebrates have other structures, separate from retinal receptors, that monitor and respond to light in the environment. These structures are known as extra-retinal photoreceptors. In teleosts, the pineal gland and deep-brain photoreceptors are examples of these structures.

Research has shown that in fish, these structures can become functionally responsive to light before retinal photoreceptors develop and before the animal is born. In the zebra fish, the developing embryo is photo stimulated in the first day post-fer-

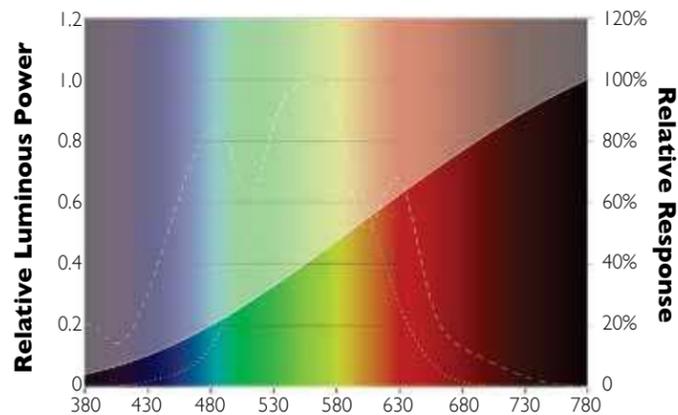
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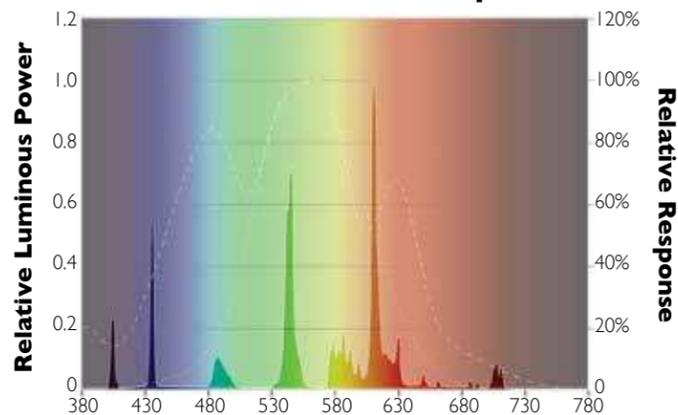
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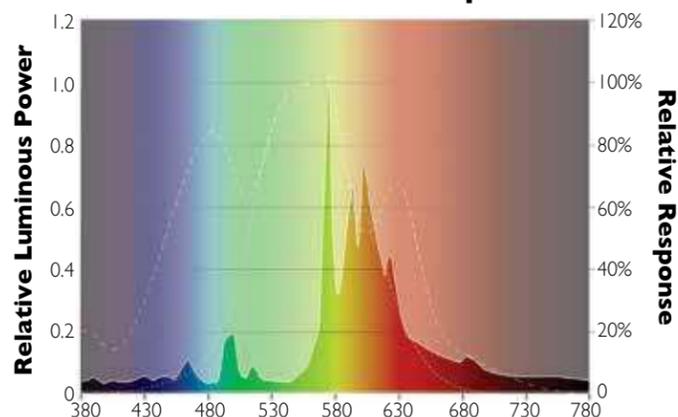
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**Wavelength (nm)**  
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**Wavelength (nm)**  
**High-Pressure Sodium Lamp**

In general, incandescent bulbs emit light with predominantly red wavelengths. Compact fluorescent lamps emit in the blue/green wavelengths, and high-pressure sodium lamps emit in the yellow/green wavelengths.

tilization, long before the development of the eye. The eggs of Atlantic halibut are photosensitive before hatch, allowing aquaculturists to synchronize the hatch time of the eggs by manipulating lighting conditions.

### Lighting: A Tool In Aquaculture

In recent years, there has been a push to move more and more of the growing and reproduction of aquatic animals

onshore and indoors into highly controlled environments. Situationally, when animals are reared in closed environments, the lighting they receive is more likely to be dominated by artificial light sources.

Traditionally, artificial light sources in aquaculture have been incandescent, fluorescent or metal halide bulbs. Unfortunately, these artificial light sources are very limited in their ability to simulate natural environmental light and therefore do not provide optimum rearing conditions for animals under culture.

In general, incandescent bulbs emit light with predominantly red wavelengths. Compact fluorescent lamps emit blue/green wavelengths, and high-pressure sodium lamps emit in the yellow/green range.

All of these light sources come in different, but usually fixed, intensities and fixed wavelengths, so once the choice of lamp has been made, the environmental light spectrum and intensity are also fixed. Dimming systems can be used with a few of these lighting systems, but the dimming capabilities are limited both in intensity and spectral range.

### LED Technology

A light-emitting diode (LED) light is comprised of one or more solid-state devices that convert electrical energy directly into light through a process called electroluminescence. The emitted light is usually blue or violet, but by passing it through a phosphor material, it can be modified to produce a broad spectrum of other colors.

The result can be a range of “white” light correlated with the full spectrum of natural sunlight and beyond. An LED lamp is basically a series of solid-state chips, and because of this, a wide range of control can easily be applied to the lamp to change both its intensity and spectrum.

### Light Intensity, Color

The perception of environmental light is very different for fish than for humans because of different light-sensitive structures in the eyes of fish and different structures in their bodies. When it comes to vision, humans are considered trichromatic, which means we see three colors – red, blue and green – with the cones in our eyes. Most fish can see color, but not all can distinguish the full color spectrum.

For example, bass have excellent color vision in clear, bright conditions, while walleye can only detect oranges and greens, with all other colors appearing as shades of gray. Many predator fish can also see into the ultraviolet spectral range.

The eyes of rainbow trout are sensitive to four different wavelengths. The retinal rods contain a visual pigment with maximum wavelength sensitivity at 512 nanometers (nm), a green color to humans. The retinal cone systems in adult trout consist of single and double cones with pigments having peaks at 453, 530 and 598 nm.

Zebra fish have a dark-adapted visual system that can be influenced by water temperatures. These fish have two spectral sensitivities, one when the water is “warm” (28 to 30° C) and another when the water is “cold” (22 to 25° C). Ultraviolet cones in the eyes of zebra fish contribute to the animals’ dark-adapted spectral sensitivity under both temperatures.

Some fish, like the walleye, have a tapetum lucidum, a structure on their retina that creates a reflective eye, similar to nocturnal land animals. This structure bounces light that has already passed the rods back for a second chance at detection. The fish’s sight is very slightly blurred, but very light sensitive.

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The fact that some species of fish have reflective eye structures can create problems in aquaculture when the fish are moved from low-light conditions to those with higher light intensities. Transfer without consideration of the changes in environmental light can shock the fish and cause them to become disoriented.

### LED Lighting Design

Energy savings are substantial with the use of LED lighting technology in indoor aquaculture operations. A farmer switching to an LED light source can reduce electrical energy use by 60%, while maintaining the same lighting intensity received from traditional light sources.

When considering transitioning to an LED-based lighting system, several factors are key to achieving an optimum lighting environment for fish.

First, choose the lamp wisely. Look for an LED lamp made for aquaculture applications, not just household use. An indoor aquaculture lamp must be robust and able to withstand the high humidity found in aquaculture environments. If used in a marine fish operation, lamps should also be able to withstand the corrosive effects of salt. A good aquaculture lamp will have a guaranteed life span of operation under aquaculture conditions.

Second, a properly designed lighting system should deliver uniformity of light across the water's surface in rearing tanks. The lighting system should be designed with animal lighting needs as the first priority, and human activity lighting needs secondary.

Unfortunately, it is common to see variability in light delivery in indoor aquaculture facilities, with some tanks receiving one mixture of wavelength and intensity of light, and others receiving a different mixture of wavelength and intensity. Yet the

reasons for "tank differences" are rarely associated with variances in environmental lighting. A properly designed lighting system supports the aquaculturist's goal of narrow grades of harvest animals with consistency in presentation.

Third, an LED lighting system must have versatility and not deliver only a single option of output. Natural light changes during the day, both in light intensity and light color. An indoor lighting system should be able to mimic the important light parameters for the animals under culture – not only photoperiod, but also color of light and intensity.

Most importantly, a lighting system should promote animal well-being by reducing stress. This can be as simple as programming a daily sunrise and sunset into the lighting treatment. However, much greater benefit can be achieved if the daily lighting treatment is in synchrony with the fishes' visual needs and cues for feeding, socializing and distribution in the tank.

**An indoor lighting system should be able to mimic the important light parameters for the animals under culture – not only photoperiod, but also color of light and intensity.**

## innovation

# Low Inclusions Of Krill Meal Replace Cholesterol In Diets For Juvenile Shrimp



Experimental diets manufactured at the LABOMAR facilities contained krill meal at varied levels.

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tent) at low dietary inclusion levels.

A study by the authors aimed to investigate the minimum dietary inclusion of krill meal able to replace a cholesterol supplement with 91% or more active cholesterol in growout diets for juvenile *Litopenaeus vannamei* shrimp.

### Study Setup

The study was carried out at the LABOMAR aquaculture facilities in north-eastern Brazil. Six diets were designed (Table 1): a reference diet (REF) formulated to contain high levels of fishmeal, combined with cholesterol supplementation and 2% krill meal; a positive control diet (POS) containing low levels of fishmeal combined with cholesterol supplementation, but no krill meal; a negative control diet (NEG) designed to be nearly equivalent to POS, but lacking cholesterol supplementation; and three experimental diets formulated to contain no cholesterol supplementation with dietary levels of krill meal at 1, 2 or 3% of the diets (1-K, 2-K and 3-K).

A total of 2,350 shrimp with body weights of  $2.00 \pm 0.14$  g were stocked at 45 shrimp/tank in 30 clearwater tanks of

**Krill meal is one of the few commercial protein ingredients that can deliver high levels of unsaturated fatty acids, cholesterol and phospholipids at low dietary inclusion levels.**

### Summary:

A deficiency of cholesterol in shrimp diets can result in slower growth and higher mortality rates. A study by the authors investigated krill meal as a partial replacement for a cholesterol supplement in diets for juvenile *Litopenaeus vannamei* shrimp. The results indicated that the inclusion of 3.0% krill meal in the growout diet improved shrimp performance parameters such as body weight, survival, yield, feed intake and feed conversion, and was able to reduce formula costs associated with cholesterol supplementation.

Cholesterol is considered an essential nutrient for penaeid shrimp that acts as a component of cell membranes and a metabolic precursor of steroid and molting hormones. Deficiency of cholesterol in shrimp diets can result in slower growth and higher mortality rates characterized by incomplete ecdysis. Cholesterol requirements in marine shrimp seem to be species-specific. Reported requirements range from less than 0.1 to as much as 1.0% of the diet.

In a 2000 report, Hui Gong and co-workers demonstrated an interaction

between dietary cholesterol and phospholipids for Pacific white shrimp, *Litopenaeus vannamei*. Cholesterol requirements in diets containing 1.5 and 3.0% supplemental phospholipids were reduced to 0.14 and 0.13%, respectively, compared to 0.35% in the absence of supplemental phospholipids.

### Cholesterol

Cholesterol and phospholipids may be present in feedstuffs such as rendered animal by-products and marine protein sources used in shrimp feeds. However, sterol supplements are often used to fully meet shrimp requirements and assure proper growth performance and survival.

There are few suppliers of cholesterol worldwide, and prices have skyrocketed in recent years. Cholesterol is extracted from wool grease obtained from farmed sheep, mainly in New Zealand. Therefore, prices can fluctuate depending on the use of wool by the clothing industry.

### Krill Meal

Krill meal is one of the few commercially available protein ingredients with a high fat content of 18 to 28% lipid that can deliver high levels of the unsaturated fatty acids docosahexaenoic acid and eicosapentaenoic acid (present at 5.5% of the meal), cholesterol (0.6 mg/kg) and phospholipids (40% or more of lipid con-

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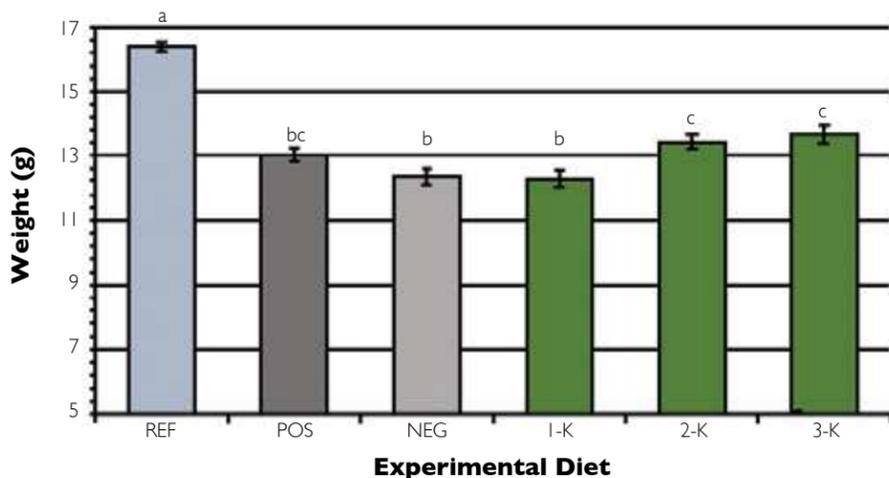
**Table 1. Composition of experimental diets.**

Ingredient	Dietary Inclusion (%)					
	REF	POS	NEG	1-K	2-K	3-K
Soybean meal	32.68	48.15	48.15	48.74	49.22	49.69
Wheat flour	30.35	27.00	27.00	27.00	27.00	27.00
Salmon by-product meal	18.00	5.00	5.00	5.00	5.00	5.00
Soy protein concentrate	5.00	10.18	10.18	8.84	7.58	6.33
Wheat red dog flour	4.00	0	0	0	0	0
Dicalcium phosphate	1.79	2.03	2.03	2.00	2.00	2.00
Salmon oil	2.48	2.00	2.00	2.00	2.00	2.00
Soybean oil	0	1.65	1.74	1.62	1.51	1.40
Krill meal	2.00	0	0	1.00	2.00	3.00
Soybean lecithin	1.67	1.83	1.83	1.74	1.64	1.55
Mineral-vitamin premix	1.00	1.00	1.00	1.00	1.00	1.00
Synthetic binder	0.50	0.50	0.50	0.50	0.50	0.50
Choline chloride, 60%	0.33	0.34	0.34	0.33	0.33	0.32
D,L-methionine	0.08	0.19	0.19	0.19	0.18	0.17
Cholesterol, 91%	0.08	0.09	0	0	0	0
Vitamin C	0.04	0.04	0.04	0.04	0.04	0.04
<b>Formula cost (U.S. \$/mt)*</b>	<b>\$1,017</b>	<b>\$837</b>	<b>\$744</b>	<b>\$758</b>	<b>\$772</b>	<b>\$786</b>
<b>Nutrient content (% dry matter basis) **</b>						
Crude protein	35.00	35.00	35.00	35.00	35.00	35.00
Methionine	0.70	0.70	0.70	0.70	0.70	0.70
Methionine + cystine	1.08	1.01	1.01	1.02	1.03	1.03
Lysine	2.02	1.98	1.98	1.98	1.99	1.99
Fat	8.00	8.00	8.00	8.00	8.00	8.00
Highly unsaturated fatty acids	0.50	0.36	0.36	0.39	0.42	0.44

\* FOB prices, northeastern Brazil  
 \*\* Projected/formulated values

**Table 2. Mean performance of juvenile white shrimp fed graded levels of krill meal in replacement of dietary cholesterol. Water salinity, pH and temperature were 35 ± 1 g/L, 7.67 ± 0.13 and 28.2 ± 1.0° C, respectively.**

Dietary Treatment	Final Survival (%)	Gained Yield (g/m <sup>2</sup> )	Feed Intake (g/shrimp)	Feed-Conversion Ratio	Growth (g/week)
REF	97.8 ± 11.2 <sup>a</sup>	1,106 ± 28 <sup>a</sup>	23.4 ± 0.5 <sup>a</sup>	1.67 ± 0.03 <sup>a</sup>	1.46 ± 0.10 <sup>a</sup>
POS	80.9 ± 9.0 <sup>b</sup>	674 ± 110 <sup>b</sup>	21.5 ± 0.9 <sup>b</sup>	2.56 ± 0.34 <sup>b</sup>	1.12 ± 0.07 <sup>b</sup>
NEG	73.8 ± 10.8 <sup>b</sup>	564 ± 123 <sup>b</sup>	20.8 ± 0.9 <sup>b</sup>	3.03 ± 0.71 <sup>b</sup>	1.05 ± 0.12 <sup>b</sup>
1-K	79.3 ± 6.8 <sup>b</sup>	611 ± 82 <sup>b</sup>	20.8 ± 0.2 <sup>b</sup>	2.71 ± 0.34 <sup>b</sup>	1.04 ± 0.04 <sup>b</sup>
2-K	76.3 ± 1.3 <sup>b</sup>	650 ± 8 <sup>b</sup>	21.2 ± 0.2 <sup>b</sup>	2.57 ± 0.01 <sup>ab</sup>	1.16 ± 0.03 <sup>b</sup>
3-K	81.5 ± 11.0 <sup>ab</sup>	721 ± 131 <sup>b</sup>	22.1 ± 0.8 <sup>ab</sup>	2.47 ± 0.39 <sup>ab</sup>	1.18 ± 0.09 <sup>b</sup>
ANOVA P value	0.004	< 0.0001	< 0.0001	0.002	< 0.0001



**Figure 1.** Final mean shrimp body weight of *L. vannamei* after 69 days of rearing.

0.5-m<sup>3</sup> volume with continuous water filtration and recirculation. Five replicate tanks were assigned for each dietary treatment. Shrimp were fed four times daily to satiation for 69 days.

**Results**

Shrimp performance was significantly

influenced by dietary treatment. Higher nutrient levels in the reference diet resulted in improved shrimp yield, weekly growth and final body weight at harvest (Table 2 and Figure 1). The lack of supplemental cholesterol in the NEG control diet caused a deleterious effect on final shrimp survival. Supplementation with 3.0% krill meal counteracted this effect, raising final shrimp survival from 73.8 ± 10.8% for the NEG treatment to 81.5 ± 11.0%.

The use of krill meal at 3% combined with 5% salmon meal was able to enhance feed intake at levels comparable to the REF diet with 18% salmon meal and 2% krill meal. While feed conversion was better for shrimp fed the REF diet, it was not significantly different when diets were supplemented with 2 or 3% krill meal. On the other hand, the lack of supplemental cholesterol depreciated shrimp body weight, which was only recovered when krill meal was supplemented at 2 or 3%.

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The World Aquaculture Society (WAS) has decided to hold the Annual Latin American & Caribbean Chapter, WAS meeting (Lacqua 2015) and the first Regional World Aquaculture 2015 (RWA'15) in Fortaleza, Brazil. The Associação Brasileira de Criadores de Camarão (ABCC) has decided to work with WAS/LACC to join LACQUA15/RWA'15 with FENACAM '15 including the XII International Shrimp Farming Symposium and the VIII International Aquaculture Symposium.

More info on  
[www.was.org](http://www.was.org)

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Pentair's new aquaculture center on its Florida campus supports the development of innovative culture technology.

## Pentair Opens Aquaculture Center Of Excellence

Mindful that fish farming has the potential to help meet the growing need for protein in a world with increasing water constraints, Pentair has opened the World Aquaculture Technology Engineering & Research Center of Excellence on the campus of Pentair Aquatic Eco-Systems in Apopka, Florida, USA.

Consisting of 1,150 m<sup>3</sup> of laboratories and fish culture systems, the center will be used for demonstrations, research and teaching activities. With full connectivity to the Internet, customers and educational institutions can monitor fish culture trials online.

The center showcases technologies in water reuse systems and solutions, including Pentair's energy-efficient pumps and filtration systems. The new center is "designed to allow development of innovative technology as well as showcase solutions for different environments."

"These systems can be put just about anywhere, as demonstrated by our work in the Middle East and our partnership with Urban Organics in a former brewery in downtown St. Paul," said Bob Miller, Pentair vice president of environmental systems.

Pentair delivers industry-leading products, services and solutions for its customers' diverse needs in water and other fluids, thermal management and equipment protection. For more information, visit [www.pentairaes.com](http://www.pentairaes.com).

## Paper To U.N.: Climate Change Impacts Aquaculture

Scientists need to better understand the impacts of climate change on aquaculture if we are to meet future seafood demand, said a paper submitted by WorldFish to climate talks at the United Nations.

"Climate Change and Aquatic Animal Disease," by WorldFish senior scientist Chadag Mohan, highlighted the risks of increased fish disease as a result of climate change and call for mapping of the potential risks and identification of suitable adaptation and mitigation strategies.

Fish farms in tropical zones, the paper noted, experience higher mortalities and faster progression of diseases, which could be exacerbated by climate change. With the threat of climate change bringing more disease, stronger biosecurity governance to manage risks associated with the spread of aquatic animal pathogens is needed.

## People, Products, Programs

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Stephen Hall, WorldFish director general, said: "About 4.5 billion people get at least 15% of their animal protein from fish. Given that projections suggest farming of fish will have to double to meet future demand, it is imperative that we gain a better understanding of how climate change will impact this valuable food crop."

The paper also highlighted increased salinity and seawater intrusion as issues with recommendations to invest in breeding programs for salinity adaptation.

The paper is available online at [http://unfccc.int/files/documentation/submissions\\_from\\_observers/application/pdf/517.pdf](http://unfccc.int/files/documentation/submissions_from_observers/application/pdf/517.pdf).



A camera-equipped ROV keeps Marine Harvest updated on farm conditions.

## ROVs Aid Salmon Farm Operations

As fish farms continue to gain prominence, the need to frequently inspect and monitor these farms is important to ensure the health of both the fish and the surrounding ecosystems.

Although professional divers are typically hired to check the underwater conditions at fish farms, tools such as remotely operated vehicles (ROVs) and underwater cameras have given farmers the ability to see below the surface from the comfort of land.

As Gerry Burry, site manager at Marine Harvest's Quatsino operating area, said: "Farms are like an iceberg. A person can only see about 10% of the farm floating on the surface, leaving the rest of the infrastructure underwater and out of sight."

Marine Harvest has invested in Deep Trekker DTG2 ROVs to act as their remote divers for an efficient view of their submerged infrastructure. The ROVs can help check nets and the status of adult fish and smolts, as well as monitor feeding activity.

Deep Trekker offers small, fully portable and easily maneuverable robotic underwater cameras in the form of an ROV. Multiple cages can be inspected in quick succession, and an optional bracket can be used to retrieve fish that die before harvest.

For additional information, visit [www.deeptrekker.com/aquaculture/](http://www.deeptrekker.com/aquaculture/).



The collaborative nature of the workshop will help move the industry forward.

## Workshop Supports Aquaculture Growth In Latin America

Representatives of the top aquaculture companies in Latin America and the Caribbean attended the April 29-30 Aquaculture Investment Workshop in Miami, Florida, USA, to discuss current challenges and opportunities related to growing the industry in the region.

Operators from established farms shared their success stories, and aspirational companies spoke of their technical and market particulars. Representatives from the investment, insurance and retail sectors also presented helpful advice for aquaculture growth.

Organized by the Global Soy in Aquaculture Program of USSEC and sponsored by the U.S. Soy Family and the Kansas Soybean Commission, the workshop has become one of the

most informative conferences in the seafood industry.

Francisco de la Torre, USSEC regional director and event organizer, said the collaborative nature of the workshop will help move the industry forward.

"When we first started this workshop, we couldn't find an aquaculture company who wanted to share their story," he said. "Now there's a clear understanding that we're all in this together, so we're willing to help each other. We need to have a critical mass of healthy, farmed seafood in the marketplace."

For more information, read the blog from Intrafish at [www.intrafish.com/free\\_news/article1411080.ece](http://www.intrafish.com/free_news/article1411080.ece).

## New Honduran Shrimp Hatchery Takes Natural Approach

Hatchery methods used to produce penaeid shrimp larvae have shifted away from open artisanal systems that permit exposure to natural microflora toward closed intensive systems that rely on disinfection, antibiotics and probiotics to kill everything in the incoming water and grow back only what you want.

Most hatchery managers consider high survival the most important outcome, but on the farm, survival at harvest is what counts. Artificially high survival in the hatchery may not be a good thing for the farm because it implies relaxed selection pressure on early stages that allows more unfit animals to survive and get stocked.

It makes more economic sense to take the mortality hit early instead of later, when the shrimp are cost loaded. For farmers, 30% survival in the hatchery and 70% on the farm is far better than 70% survival in the hatchery and 30% on the farm.

With this in mind, Grupo Granjas Marinas, an integrated shrimp producer in southern Honduras, has designed a new mega hatchery with larger, two-phase larval-rearing tanks to be stocked at lower densities and hold shrimp longer. This approach will produce larger, more uniform and stronger post-larvae at a much lower survival rate.

"The new system will encourage the proliferation of microalgae and other microorganisms in the larval-rearing tanks and depend much more on live feeds," said Brian Boudreau, GGM director of aquaculture operations.

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Web: [www.aquaculture-fisheries.conferenceseries.com](http://www.aquaculture-fisheries.conferenceseries.com)

## AUGUST 2015

### Aqua-Nor

August 18-21, 2015  
Trondheim, Norway  
Phone: +47-73-56-86-40  
Web: [www.nor-fishing.no/en/category/aquanor-en/](http://www.nor-fishing.no/en/category/aquanor-en/)

### Vietfish 2015

August 24-26, 2015  
Ho Chi Minh City, Vietnam  
Phone: +84-08-62-81-04-42  
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## SEPTEMBER 2015

### World Seafood Congress

September 5-9, 2015  
Grimsby, United Kingdom  
Phone: +44-0-1472-252300  
Web: [www.wsc2015.com](http://www.wsc2015.com)

### Seafood Expo Asia

September 8-10, 2015  
Hong Kong, China  
Phone: +1-207-842-5504  
Web: [www.seafoodexpo.com/asia/](http://www.seafoodexpo.com/asia/)

## Seafood and Aquaculture Events

Send event listings in English to: Event Calendar  
4111 Telegraph Road, Suite 302 • St. Louis, Missouri 63129 USA  
[homeoffice@gaalliance.org](mailto:homeoffice@gaalliance.org)

### Offshore Mariculture Conference Mexico

September 21-24, 2015  
Ensenada, Baja California, Mexico  
Phone: +44-1329-825335  
Web: [www.offshoremariculture.com/mexico](http://www.offshoremariculture.com/mexico)

### Seafood Expo Southern Europe

September 21-23, 2015  
Barcelona, Spain  
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Web: [www.seafoodexpo.com/southern-europe/](http://www.seafoodexpo.com/southern-europe/)

### NordicRAS Workshop on Recirculating Aquaculture Systems

September 30-October 1, 2015  
Molde, Norway  
Phone: +47-71400121  
Web: [www.nordicras.net/Workshop-2015](http://www.nordicras.net/Workshop-2015)

## OCTOBER 2015

### Aqua Fisheries Myanmar 2015

October 14-16, 2015  
Yangon, Myanmar  
Phone: +84-986-894-830  
Web: [www.myanmar-aquafisheries.com](http://www.myanmar-aquafisheries.com)

### Aquaculture Europe

October 20-23, 2015  
Rotterdam, Netherlands  
Phone: +32-59-32-38-59  
Web: [www.easonline.org/component/content/article/39-uncategorised/320-ae2015](http://www.easonline.org/component/content/article/39-uncategorised/320-ae2015)

### GOAL 2015

October 26-29, 2015  
Vancouver, Canada  
Phone: +1-314-293-5500  
Web: [www.gaalliance.org/goal/](http://www.gaalliance.org/goal/)

## NOVEMBER 2015

### China Fisheries and Seafood Expo

November 4-6, 2015  
Qingdao, China  
Phone: +1-206-789-5741, ext. 334  
Web: [www.chinaseafoodexpo.com](http://www.chinaseafoodexpo.com)

### International Symposium on Aquaculture Nutrition

November 11-13, 2015  
Hermosillo, Sonora, Mexico  
E-mail: [xiiisina@ues.mx](mailto:xiiisina@ues.mx)  
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Eligible to serve on committees	–	–	X	X	X
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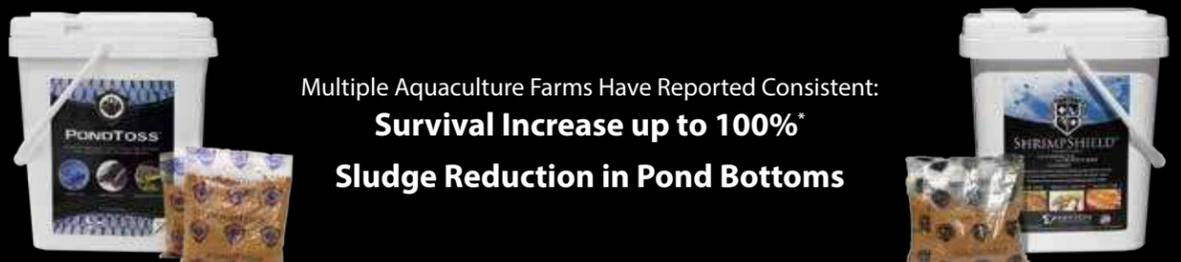
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