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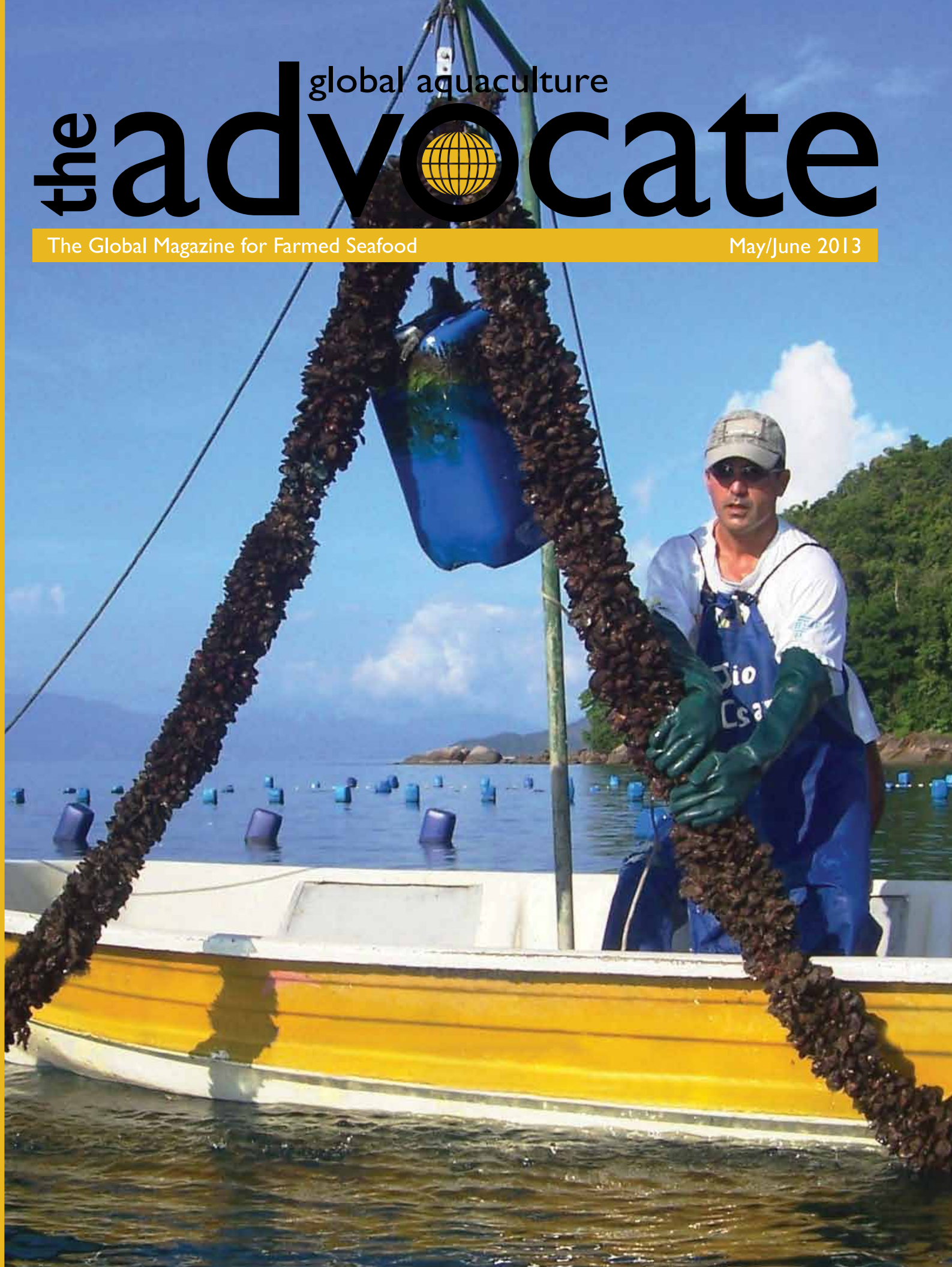
May/June 2013



NEW BAP STANDARDS

GLOBAL AQUACULTURE ADVOCATE

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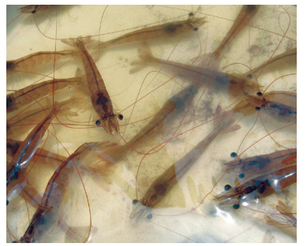
the advocate global aquaculture

production

marketplace

On the cover:
Researchers are examining stocking density and methods to improve mussel culture in Brazil. Photo courtesy of Helcio Luis de Almeida Marques.

DEPARTMENTS



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Impacts Of EMS/ AHPNS
As efforts continue to find a solution for acute hepatopancreatic necrosis syndrome in shrimp, expect changes in supply and pricing as production dynamics shift.

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Global Campaigns Promote Seafood
Seafood promotions are finding success around the world. Many involve governments working with industry to communicate the benefits of seafood. Price reductions help, too.

innovation

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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Another Step Toward Finding Ourselves

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In the words of Mahatma Gandhi, "The best way to find yourself is to lose yourself in the service of others." This has been the path of the Global Aquaculture Alliance, which began in 1997 with broad intentions to serve the aquaculture industry, but with an initial focus on the priority issues of the time. Recalling the mid-1990s, "Shrimp Tribunals" had been convened in the United Nations building in New York, the Supreme Court of India had ruled against shrimp farming, and moratoriums, embargoes and boycotts of farmed shrimp had been threatened. The shrimp-farming industry needed an advocate and a guide.

With its limited resources, GAA began with "Guiding Principles for Responsible Aquaculture" in 1997, distributed *Codes of Practice for Responsible Shrimp Farming* in 1999 and finally released Best Aquaculture Practices certification standards for shrimp farms in 2003. While these standards were important, it was their adoption by major retailers and foodservice companies like Wal-Mart and Darden Restaurants that led to their widespread acceptance. It's remarkable to look back upon the troubled past of shrimp farming as compared to its vastly improved practices today.

In its mission to serve the broader aquaculture industry, GAA continued to develop additional standards. It released seafood-processing standards in 2003, shrimp hatchery standards in 2004, tilapia and channel catfish farm standards in 2008, feed mill and *Pangasius* farm standards in 2010 and salmon standards in 2011.

This April, two major initiatives moved us closer than ever to our initial intention of serving the entire aquaculture industry. In the first, BAP standards for mussel farms were completed by the Mussel Technical Committee and approved by the Standards Oversight Committee for public comment.

It's remarkable to think that BAP standards now apply to any finfish, crustacean and, soon, bivalve in any culture system.

Please download the standards from the GAA website at www.gaalliance.org/bap/comments.php and help us improve them with your comments. Once the technical committee incorporates these comments, and the mussel standards are approved, a subsequent body of work will build on them to broaden their application to other bivalve molluscs.

In the second initiative, the Standards Oversight Committee was expected to approve release of new finfish and crustacean farm standards. These standards are the culmination of two years of effort in combining existing individual species standards into a single combined set of standards.

This accomplishes several important goals. It updates all the farm standards to the latest benchmarks for environmental, social, food safety and traceability compliance. The new standards apply to any culture system, including cages, ponds and raceways. In addition, they enable certification of any finfish or crustacean species except salmon, which have unique BAP farm standards.

It's remarkable to think that BAP standards now apply to any finfish, crustacean and, soon, bivalve in any culture system. With your support, we've come a long way since our early years as a "shrimp" organization. Yet, we are still only at the beginning of our journey. The longer we lose ourselves in service to others, the closer we get to finding our true identity and our full potential.

Sincerely,

George W. Chamberlain

Let's Be Leaders – Use Freshwater More Efficiently

Darryl E. Jory, Ph.D.
Editor, Development Manager
Global Aquaculture Advocate
editorgaadvocate@aol.com

GAA's last two GOAL conferences – Santiago, Chile, in 2011 and Bangkok, Thailand, in 2012 – revolved around the five major challenges we must effectively address to reach the objective of responsibly doubling production in a decade: disease management, feed supply, environmental limits, financing and market acceptance. At both events, these topics were addressed by speakers who provided participants with new insight into the development of better strategies to effectively answer the challenges.

One area of concern within the environmental limits challenge that is not often discussed is freshwater availability, which in several geographic regions has the potential to significantly hinder industry development. However, in 2011, Drs. Claude Boyd and Li Li reviewed the intensity with which 172 countries use freshwater for aquaculture. By dividing annual freshwater aquaculture production by the annual renewable freshwater volume, they determined the production:water use ratios varied among countries from 0 to 15,000 mt/km^3. One of their conclusions: "There seems to be adequate renewable freshwater to allow considerable expansion of freshwater aquaculture – especially outside Asia."

But according to the United Nations, about 1.2 billion people, or some 17% of the world's current human population, live in areas of physical water scarcity, and an additional 1.6 billion people face what can be called economic water shortage. This situation is expected to get worse with population growth, shortfalls in investment and management, and inefficient use of existing resources. By 2025, the Worldwatch Institute projected, an estimated 1.8 billion people will live in regions with absolute water scarcity, with almost half of the world living in conditions of water stress.

Aquaculture is the fastest-growing food-producing sector globally despite all the challenges we consider. Continuous innovation is key to maintain this growth and increase industry sustainability and profitability. Practically every day, news services report on incredible advances in many areas – genetic improvement and seedstock production, nutrition and aquafeeds, health management, production systems, product quality, safety and marketing – all of which are areas relevant to increased industry efficiency, sustainability and profitability.

Let's be innovative in how we use all resources, including freshwater. In the words of the late Steve Jobs, "Innovation distinguishes between a leader and a follower." Let's always keep innovation present in our daily industry activities, and let's be leaders every day.

In every issue, the *Global Aquaculture Advocate* addresses elements of the "five challenges" in articles devoted to covering the latest developments in the critical areas of farmed seafood production, market issues and innovation. We hope you will continue to find our content informative and interesting.

As always, we encourage your suggestions for topics you would like us to cover, as well as your contributions of short articles aligned with our content. Please contact me at your convenience for article guidelines. Your critical comments have significantly improved our magazine from its inception, and I urge you to continue sending us your comments on how we can best represent and serve our industry.

Sincerely,

Darryl E. Jory

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World Aquaculture Society
World Renderers Organization

BAP Multi-Species Farm Standards Finalized

Standards Expand Program For New Finfish, Crustaceans

The Global Aquaculture Alliance has expanded the Best Aquaculture Practices (BAP) certification program with the completion of new BAP standards for finfish and crustacean farms. The standards were expected to be implemented in late April.

The new multi-species farm standards apply to all types of production systems for finfish and crustaceans, excluding cage-raised salmonids, for which separate BAP standards exist. The standards they are replacing were separately tailored for shrimp, salmon, tilapia, *Pangasius* and catfish.

The addition of the multi-species farm standards represents a significant advancement for BAP, as it opens up the program to a number of species not previously covered, including sea bass, sea bream, cobia, seriola, trout, grouper, barramundi, perch, carp, flounder, turbot and striped bass.

The new finfish/crustacean standards also address environmental and social responsibility, food safety, animal welfare and traceability more rigorously than the standards they're replacing. For example, the new standards contain 33 clauses relating to worker safety and employee relations, compared to as few as 12 clauses in the previous standards.

"The new standards clearly show how the BAP program is evolving to meet changing market expectations, stricter compliance criteria and the diverse needs of producers," BAP Standards Coordinator Dan Lee said.

"The multi-species farm standards are a logical step for the BAP program," GAA Executive Director Wally Stevens said. "This is a very robust set of standards, and it opens up the BAP program to an even greater range of finfish and crustacean species."

The new farm standards were initially developed through a careful amalgamation of the existing BAP standards by Jeff Peterson, director of quality control for the BAP program. The species-specific standards were developed by specialist technical committees.

The BAP Standards Oversight Committee (SOC) – whose members represent a balance of stakeholders from industry, NGOs and academia – recommended refinements to the standards in November 2012.

The 60-day public-comment period ended January 31. Comments were received from respondents that included fish farmers, academics and non-governmental organizations from Australasia, Asia, Europe and the Americas. Comments are published on the GAA website along with the BAP responses.

The SOC then met at the International Boston Seafood Show in March before going on to approve the standards for implementation.

BAP Seeks Comments On Mussel Farm Standards

A draft of the Best Aquaculture Practices (BAP) standards for mussel farms is now available for public comment at www.gaalliance.org/bap/comments.php.

To submit comments, use the electronic form, e-mail BAP Standards Coordinator Daniel Lee at dangaelle@aol.com or send a fax to +44-1248-716729. The deadline to submit comments is June 8.

The BAP mussel farm standards address social and environmental responsibility, food safety, animal welfare and traceability. They encompass all production systems for mussels, including cultivation on the seabed or on poles, and suspended methods such as long-line culture and raft-and-rack culture. They also encompass various mussel species, including blue mussels, Chilean mussels, Mediterranean mussels, New Zealand Greenshell mussels and Asian green mussels.

The addition of mussel farm standards represents an important advancement for the BAP program, as it expands the number of species covered. The mussel farm standards will be used as a template for broader mollusk farm standards that cover other commercially important species, including clams, oysters, scallops and abalone.

The draft of the BAP mussel farm standards represents the outcome of an exhaustive process that addressed marketplace expectations and existing BAP elements while recognizing that mussel production systems differ significantly from the finfish and crustacean systems the BAP program already targets.

"I would like to express my gratitude to the dedicated technical committee members who have worked so hard on these standards and created something that addresses the needs of both producers and evolving markets," Lee said.

BAP's mussel farm standards will address varied mussel species and culture systems.

The technical content of the BAP mussel farm standards was honed by a technical committee under the direction of Dr. Andrea Alfaro of Auckland University of Technology in New Zealand. The BAP Standards Oversight Committee (SOC) – whose members represent a balance of stakeholders from industry, NGOs and academia – recommended refinements to the mussel farm standards before approving them for release.

"We extend our most sincere appreciation to Andrea Alfaro and the members of the technical committee, who put in a lot of time diligently addressing all aspects of mussel farming – a job well done," GAA Executive Director Wally Stevens said.

Commitment To Excellence

Seajoy Positioned For Future

Editor's Note: This is the first in a series of profiles recognizing companies for their commitment to responsible aquaculture and the Best Aquaculture Practices program. The "Commitment to Excellence" seal denotes the number of years a company has been committed to the BAP program.

Seajoy was an early supporter of BAP certification, as well as the program's first three-star company. Certification has helped the company grow.

Ask Peder Jacobson, administrative president for the Seajoy Group, about his company's commitment to environmental and social responsibility, and he sums up his answer in six words: "It is in our corporate DNA."

Established in 1979 when a group of aquaculture entrepreneurs opened a shrimp farm on Ecuador's Gulf of Guayaquil, Seajoy is now one of Latin America's leading shrimp farmers and processors, with operations in Ecuador, Honduras and Nicaragua.

The company has been farming and processing shrimp responsibly since its inception. Then, in the early 2000s when the concept of third-party certification was just taking off, Seajoy jumped on the opportunity to prove its commitment to responsible aquaculture to its buyers by pursuing Best Aquaculture Practices (BAP) certification.

"We saw early on that it was far better to be proactive in matters of sustainability rather than taking a defensive position," said Jacobson, an original GAA board member and former president of the Aquaculture Certification Council, which has since been folded into the BAP management team.

Best Practices, Good Business

Aquacultura Fonseca and Biomar, both located along the Gulf of Fonseca in Honduras, were Seajoy's first two shrimp farms to attain BAP certification in 2003, followed by Aquacultura Torrecillas in Nicaragua in 2004. Then came Seajoy's Empacadora Deli processing plant, located just outside Choluteca, Honduras, earning BAP certification in 2004. Seajoy was also the first company to achieve three-star BAP certification.

"It was apparent to our buyers that their customers were becoming aware of environmental and social issues and were demanding product that addressed these issues," Jacobson said. "It made good business sense. It was a win-win proposition.

"Our production was sustainable, and our buyers' customers were happy. We also gained the reputation of being trustworthy, and our many recertifications are an indication of our commitment to growing shrimp responsibly."

Currently, Seajoy operates 2,700 ha of farms in Honduras and Nicaragua and 550 ha of farms in Ecuador. In addition to owning and operating the 560-m^2 Choluteca plant, Seajoy has access to the Langostinos del Golfo plant in Chinandega, Honduras. In a good year, Seajoy produces approximately 9,000 mt of head-on shrimp, with products exported to markets in North America, Europe and Asia.

Environmental, Social Programs

The company is also dedicated to the communities in which it operates, and its list of environmental and social stewardship initiatives is long. Seajoy's environmental activities include a turtle conservation and reproduction program in Nicaragua, whereby 15,000 baby turtles were protected and released into the sea; a mangrove reforestation program in which 150,000 mangrove seedlings were planted in Honduras and Nicaragua; and an ark clam restoration initiative, whereby 4,500 breeders were tapped to restock the bivalves in Estero Real, a nature reserve in Nicaragua.

As for social activities, Seajoy has helped build school classrooms in communities near its farms and provided educational supplies, with 12 schools currently receiving support in Honduras and Nicaragua. Seajoy also organizes a health brigade, dispatching doctors to underprivileged communities.

The governments of Honduras and Nicaragua have repeatedly recognized Seajoy for its environmental and social stewardship, with the Honduran government twice naming Seajoy the country's "Exporter of the Year."

Seajoy has helped build classrooms and provide educational supplies in communities near its farms.

Growth Through Diversification, Research

The accomplishments mean little, however, if Seajoy isn't positioned for the future. So what do the next five to 10 years hold for the company?

"We want to survive and thrive in this challenging business, doing what we can to ameliorate the effects of disease," Jacobson said. "We also need to develop shrimp families that grow faster with less fish protein and are more resistant to pathogens and temperature fluctuations.

Seajoy's environmental stewardship includes mangrove reforestation and clam restoration in Honduras and Nicaragua.

"We also hope to carefully grow the business while diversifying and looking for additional value-added products. And we want to explore every possibility for reducing energy and operational costs, both in processing and at the pond level."

For the aquaculture industry as a whole, Jacobson points toward the need to invest in research and development. "We will also start to see a shift in financial resources for aquaculture-based research as large buyers and retailers realize that a large percentage of the shrimp growers do not have the resources for the type of R & D that is necessary to grow this industry," he said. "Increasing the supply side of the industry is going to remain a serious challenge."

GAA Welcomes Newly Certified BAP Facilities

A steady flow of new names has been added to the list of facilities certified under the Best Aquaculture Practices program. The new operations reflect aquaculture farms, hatcheries, feed mills and processing plants on three continents.

Chilean salmon producer **Trusal S.A.** has achieved three-star certification in the BAP program. Its Bajos Lami and Renihue farms were certified in late March.

The family business handles rainbow trout, coho salmon, Atlantic Salmon and Chinook salmon. Its vertical production integration ranges from broodstock and eggs to the processing of raw materials and final seafood products.

The Alitec Pargua S.A. and Biomar feed-manufacturing plants, certified in August 2012, were the first BAP-certified feed mills in Chile. Biomar sources marine raw materials from regulated fisheries and is working to reduce its use of marine ingredients via vegetable protein and oil alternatives in feeds.

Within the Trusal group, the Comercial Y Servicios Sur Austral Ltda. (Comsur Ltda.) processing plant completed BAP certification in January. With a daily production capacity of 120 mt, Comsur is the only salmon plant in Chile with facilities that receive, process and store product in a continuous flow.

In early April, **New Zealand King Salmon Co.** became one of Australasia's first salmon-farming companies to attain BAP certification. The two-star certification encompasses N.Z. King Salmon's entire operation – five farm sites in Marlborough Sound and three processing plants in Marlborough and Nelson.

CEO Grant Rosewarne said receiving third-party certification will help the company educate the public about responsible aquaculture and advance its standing in the marketplace. Certification gives N.Z. King Salmon "a license to operate in the premium end of the market," Rosewarne said. Its retailer and food-service customers were increasingly pushing for certification.

N.Z. King Salmon produces around 8,500 mt of salmon annually, representing about 70% of New Zealand's salmon production and 55% of the world's farmed king salmon harvest. About half of the company's production is exported, with primary markets in Australia, Japan and North America. The remaining production is sold domestically.

Tropical Aquaculture partner tilapia producer **Piscicola New York** has received two-star BAP certification of its processing plant. The Colombia-based producer, which utilizes a cage system in the Betania Reservoir on the Magdalena River, received BAP certification at the farm level in May 2010.

As part of the BAP program, the company constantly monitors water quality at three stations. Additionally, all aquaculture activity in the reservoir is managed by the Colombian government.

Table 1. Recent BAP certifications around the world.

Facility	Location	Country	Species
Farms			
Charoen Pokphand Foods Public Co., Ltd. – Sawee Farm 1	Sawee, Chumphon	Thailand	Shrimp
Hai Viet Joint Stock Co. – Khanh Hoa Branch	Cam Ranh City, Khanh Hoa Province	Vietnam	Shrimp
Salmones Blumar (4 farms)	Puerto Montt	Chile	Salmon
S.P. Enterprises	Iskapalli, Andhra Pradesh	India	Shrimp
Stapimex IOM Group 1	Soc Trang	Vietnam	Shrimp
Tassal Operations Pty. Ltd. (2 farms)	Battery Point, Tasmania	Australia	Salmon
Hatchery			
Sharath Industries Ltd.	Nellore, Andhra Pradesh	India	Shrimp
Feed Mill			
Salmofood S.A.	Castro, Chiloe	Chile	Feed
Processing Plants			
Europe Joint Stock Co.	My Tho, Tien Giang	Vietnam	*Pangasius*
Febin Marine Foods	Alappuzha, Kerala	India	Shrimp
New Zealand King Salmon Co., Ltd. (2 plants)	Nelson	New Zealand	Salmon
P.T. Sekar Bumi, Tbk.	Sidoarjo, East Java	Indonesia	Shrimp
Trang Corp.	Ho Chi Minh	Vietnam	Shrimp

GAA Gains New Global Corporate Members

Global Aquaculture Alliance membership is comprised of hundreds of seafood producers, processors, marketers and retailers as well as feed and equipment suppliers that support the aquaculture industry. Membership is also open to NGO groups and regional and international aquaculture, seafood and trade organizations.

Member dues support research and development, and the economic, ecological and social systems that surround aquaculture throughout the globe. Corporate member benefits include discounts on GOAL registration, advertising in the *Global Aquaculture Advocate* and online links to company websites. Companies that have recently joined GAA are listed below.

In a new program, companies that become Best Aquaculture Practices Registered Buyers are granted GAA Sustaining Membership, as well. BAP Registered Buyers demonstrate support for responsible aquaculture products and are recognized as preferred sources on the BAP website, www.bestaquaculturepractices.org.

Companies whose business reflects trade in seafood from BAP-certified facilities may also join GAA as Sustaining Members, with complimentary BAP Registered Buyer status available.

Governing Members

New GAA Governing Member **Megasupply** creates value in the distribution of equipment, supplies and services to the aquaculture industry. Its main offices in the United States, Venezuela and Central America serve companies around the world.

Megasupply provides a wide range of aquaculture solutions, including nutrition products for hatcheries, maturation and grow-out; feed ingredients and supplements; specialized chemicals; pump and aeration equipment and supplies; test gear; publications; and monitoring and control software.

Marine Technologies is also a Governing Member. Based in Chennai, Tamil Nadu, India, Marine Technologies has been a project consultant in developing and operating aquaculture projects in India, Malaysia, Sri Lanka, Tanzania and Saudi Arabia since 1989. It played a key role in technology transfer in India during the "boom days" of aquaculture in the early 1990s.

The company's chief executive, S. Santhana Krishnan, is a longtime friend and supporter of GAA. He is involved with the investment community in India and various Southeast Asia countries, and is also a Best Aquaculture Practices certification auditor.

Alltech has moved up from Sustaining to Governing Member status with GAA. Alltech, a global leader in the animal health and nutrition industry, is focused on natural scientific solutions to agriculture and food industry challenges. Its aquaculture divison looks at the whole production process – from broodstock nutrition and egg quality to growth performance and final flesh quality. Alltech's nutritional solutions improve production by optimizing performance, maintaining gut health and building natural defenses.

New Sustaining Members

BioMar Group is a leading supplier of high-performance fish feed. Its main business areas are feed for salmon and trout in Norway, the United Kingdom and Chile; and feed for trout, eels, seabass, and sea bream in Continental Europe. The BioMar Group supplies 60 countries with products that cover the full life cycle of fish, including larvae feed, fry feed, smolt feed, grower feed and broodstock feed.

Seafood Industry Development Co. Ltd. is a new Sustaining Member of GAA. SIDC is an entity whose mandate is to work with all stakeholders to ensure that the seafood industry of Trinidad and Tobago attains sustainable viability. Through collaboration and partnerships, its goals are to develop appropriate resource management strategies, explore new supply sources, and build capacity and infrastructure in the sector.

Seacore Seafood, Inc. is a wholesaler of quality fresh and frozen seafood products. Based near Toronto, Ontario, Canada, the company sources sustainable seafood whenever possible. Its wide variety of products includes crab legs from Alaska, barramundi from Australia and salmon from Ireland. Seacore's established partnerships support sourcing a full variety of seafood.

New BAP Buyers/GAA Sustaining Members

In the initial phase of dual GAA/BAP status, GAA now includes the following on its list of Sustaining Members.

Channel Catfish Processing Co., Inc.
Boston, Massachusetts, USA
Processes fresh and frozen seafood, including value-added and retail products. Offers standard and "dry" packaging.

Direct Source Seafood – Bellevue, Washington, USA
Services restaurants and retailers with quality frozen seafood. Specializes in shrimp, Brazilian lobster tails, crabs and fish fillets.

DNI Group – Novato, California, USA
Japanese-inspired seafood and appetizers. Value-added shrimp and soft shell crab products form the core of its product line.

Gorton's Seafood – Gloucester, Massachusetts, USA
America's leading seafood company provides innovative frozen products through chain grocers across the U.S. and Canada.

Great American Seafood Imports Co.
Los Angeles, California, USA
Importing/marketing division of Southwind Foods services high-end supermarkets. Separate Hispanic division.

Hai Yang International, Inc. – Toronto, Ontario, Canada
Vertically integrated seafood company serves retail and foodservice. Fish and scallops in IQF/BQF portions and fillets.

Odyssey Enterprises, Inc. – Seattle, Washington, USA
Treasures From the Sea brand frozen seafood features locally developed recipes. Partners with global processing companies

Ore-Cal Corp. – Los Angeles, California, USA
Importer/processor distributes Harvest of the Sea brand raw, cooked and value-added shrimp, several fish species.

Quirch Foods – Miami, Florida, USA
Distributes refrigerated and frozen foods to retailers and foodservice throughout the Southeastern U.S. and the Americas.

Rubicon Resources – Culver City, California, USA
Leading importer/distributor of sustainable fish and shrimp in North America. Founding Supporter of BAP program.

Tampa Bay Fisheries, Inc. – Dover, Florida, USA
Privately held company specializes in quality private-label fresh and frozen seafood. Founding Supporter of BAP program.

Zhangzidao Fishery Group – Oakville, Ontario, Canada
Vertically integrated seafood farming and processing conglomerate and one of the largest scallop farmer/producers in the world.

BAP Auditor Course Set For June In Vietnam

The Global Aquaculture Alliance invites aspiring auditors, returning auditors requiring refresher training and observers to attend the Best Aquaculture Practices (BAP) Farm and Shrimp Hatchery Auditor Training Course to be held in Ho Chi Minh City, Vietnam, June 19 to 21.

The course will cover BAP standards for shrimp hatcheries and select farm culture methods, including land-based ponds and fresh- and brackish water cage culture. Species such as shrimp, tilapia and *Pangasius* will be covered, while mussels, salmon and other marine species will not be covered.

The course will be taught by Jeff Peterson, BAP director of quality control; Ken Corpron, BAP Asia-Pacific region coordinator; and Murali Krishna Bujji, BAP trainer.

For detailed information about how to apply, competency requirements and fees, click the "BAP Auditor Course Info" link at the top left of the BAP website at www.bestaquaculturepractices.org. Please follow the instructions carefully. Improper submittals will be rejected. Candidates are encouraged to apply as soon as possible, as participants are admitted on a space-available basis.

EMS, Buyer-Supplier Relationships Among Topics At Mini-GOAL

Travis Larkin (left) talked about the need for the investment community to better understand aquaculture. George Chamberlain gave an encouraging update on EMS.

At its annual Mini-GOAL seminar during the International Boston Seafood Show, the Global Aquaculture Alliance covered EMS, investment, social responsibility and the marketplace – topics discussed in detail at GAA's GOAL 2012 conference in Bangkok, Thailand – via presentations and a panel discussion with three prominent U.S. retailers.

EMS Update

In front of a packed room of about 90 attendees, GAA President George Chamberlain kicked off the March 11 seminar with a presentation on the origin and spread of early mortality syndrome (EMS) in shrimp in Asia. EMS and its impacts on the global shrimp supply, which are expected to be significant this year, were hot-button topics in Boston.

The disease was first reported in China in 2009. Then it spread to Vietnam in 2010, Malaysia in 2011 and Thailand in 2012. Recently, it spread to Thailand's productive southern region. Losses due to EMS now exceed U.S. $1 billion annually.

But there's good news. "We now know that this disease is infectious," Chamberlain said. Dr. Donald Lightner and his team at the University of Arizona recently confirmed that a pathogen is the cause, not an environmental toxin, he explained. The discovery provides an experimental model for identifying the infectious agent and is expected to lead to rapid progress in developing diagnostic tools and better understanding of techniques for managing EMS.

Investment, Social Responsibility

Following Chamberlain's presentation, Travis Larkin, president of the Seafood Exchange, a North Carolina-based seafood importer and distributor, talked about for the need for the investment community to better educate itself on aquaculture – and for the aquaculture industry to facilitate and accelerate the learning process. GAA Communications Manager Steven Hedlund addressed the rising awareness of social responsibility in the seafood-farming and -processing sector.

Peter Redmond, vice president of development for the Best Aquaculture Practices program, rounded out the first half of the Mini-GOAL seminar with a presentation on a variety of challenges faced by the marketplace.

Market Panel

The second half of the Mini-GOAL seminar featured a panel discussion with Kim Taylor, category director of meat and seafood for Delhaize America, which includes Hannaford, Sweetbay and Food Lion supermarkets; Scott Williams, manager of quality assurance and product development for B.J.'s Wholesale Club; and Carl Salamone, vice president of seafood for Wegmans Food Markets. Topics ranged from the sustainability of the global fish feed supply to weighing the advantages and drawbacks of ecolabeling and opportunities to grow seafood consumption.

But no matter the topic, the need for seafood buyers and suppliers to work together to better educate themselves was a recurring theme.

"As retailers, we must belly up to the bar if we truly want sustainable seafood," Salamone said. "We cannot ask suppliers to add cost to their operations if we are not willing to pay some extra."

Taylor encouraged suppliers to more proactively educate buyers, and not to assume that buyers are up to date on issues. "We spend most of our time in our stores or at our desks," Taylor said. "So the only place we can learn about the issues … is from our suppliers, or at conferences and trade shows."

GAA Holds Membership, Board Meetings In Boston

The GAA board shared program updates on BAP standards and market expansion.

The Global Aquaculture Alliance held a membership meeting and a board of directors meeting at the International Boston Seafood Show in Boston, Massachusetts, USA, in mid-March.

At the membership meeting, GAA and Best Aquaculture Practices (BAP) staff and the board of directors provided program updates to members and other attendees. Of particular interest was the status of the new BAP standards for finfish and crustacean farms, and the BAP standards for mussel farms.

The BAP Standards Oversight Committee – which met at the New England Aquarium on March 9 – made "major progress" in advancing both sets of standards, BAP Standards Coordinator Dan Lee said. A few procedural steps remain, noted Lee, but the new multi-species farm standards were on track to go live in the spring, and the mussel farm standards were on track to be released for public comment. *(Continued on page 11.)*

Chamberlain Addresses North Atlantic Seafood Forum

George Chamberlain said seafood market dynamics may be volatile as new farming areas are developed. Photo by Gorm K. Gaare, EUP – Berlin.

Global Aquaculture Alliance President George Chamberlain gave the opening keynote speech at the 2013 North Atlantic Seafood Forum (NASF), the world's largest annual seafood business conference. Titled "Major Solutions Needed to Sustainably Expand Global Aquaculture," Chamberlain's March 5 speech at the event in Bergen, Norway, was part of the Marine Innovation aquaculture seminar organized by MareLife.

Chamberlain told his audience that rising global demand for seafood, driven mainly by a growing middle class in China and other Asian nations, is putting new pressure on the aquaculture industry to find sustainable ways to increase productivity. Hence, producers are seeking improved technologies to sustainably produce more seafood with fewer resources.

Chamberlain identified the major challenges constraining aquaculture growth as disease management, feed supplies, environmental issues, investment capital and market acceptance. Genetics represents a major driver for enhanced productivity, he said.

Top areas for potential aquaculture expansion include Brazil, Russia, the United States, Australia and several countries in Africa. Volatile market dynamics can be expected, Chamberlain said, as consolidations occur and capital investment structures shift. Market demand will drive certification needs.

This was the first time a GAA staff member gave a keynote speech at NASF.

"GAA's presence at the event is representative of aquaculture's growing importance to the global seafood supply," said NASF Managing Director Jørgen Lund.

"GAA will provide an essential bridge between the advanced, high-tech salmon sector in the North Atlantic and the demand regions in the Far East, where we in Europe can provide support through cooperation, knowledge transfer and capital investments."

NASF was expected to attract around 600 participants from more than 30 countries. The conference was organized by MareLife, Pareto Securities and the United Nations Food and Agriculture Organization.

GAA Meetings... *(Continued from page 10.)*

Peter Redmond, BAP vice president of business development, said nearly 100 retailers and foodservice operators now endorse the BAP program. This year, the BAP business development team is pushing to increase the number of foodservice operators in the BAP program and boost BAP's presence in the European marketplace.

A contingency of officials from the Malaysian government sat in on GAA's membership meeting, accompanied by Bill Herzig, GAA vice president and senior vice president of purchasing for Darden Restaurants. The contingency included Dato' Ahamad Sabki Bin Mahmood, Malaysia's director general of fisheries; Dr. H. J. Mazuki B. Hashim of Malaysia's Ministry of Agriculture and Agro-Based Industry; and Azini Bin Mohd Shahid, also of the agriculture ministry.

Day 2 of the Boston Seafood Show kicked off with GAA's board of directors meeting. Among the highlights were GAA welcoming two new members to its board: Jeff Sedacca, president of the shrimp and aquaculture division at National Fish and Seafood Inc., and Robins McIntosh, senior vice president of Charoen Pokphand Foods.

BAP Quality Director At Aquaculture 2013

Jeff Peterson, director of quality control for the Best Aquaculture Practices (BAP) program, outlined the roles and advantages of third-party certification in "Understanding Aquaculture Certification," his February 23 presentation at Aquaculture 2013 in Nashville, Tennessee, USA.

"We're all generally familiar with the term certification," Peterson said. "The important thing is that certification is an assessment against a standard or a set of standards."

The cornerstone of any certification program is the auditors' role in the process, he explained. Auditors must be unbiased, observant, objective and experienced in the field. Among other qualifications, auditors for the BAP program must have at least five years of aquaculture experience, complete a recognized auditor course and, initially, be shadowed by the certification bodies with whom they work.

Certification is not consulting, noted Peterson. "Auditors and certification bodies are strictly prohibited from offering suggestions on how to resolve non-conformities," he said. "But applicants can contact BAP for suggestions."

Peterson also addressed the advantages of certification. It helps fill an "information void" in communicating with the marketplace and consumers, and can add value and differentiate farmed seafood products in the marketplace.

Peterson said certification is complex and can be expensive, and therefore is easier for larger, integrated facilities to pursue. However, to be credible and transparent, certification requires multiple layers of oversight, which adds cost.

Aquaculture 2013 drew around 4,000 attendees from more than 90 countries. The event included a trade show, where the Global Aquaculture Alliance and its BAP program were exhibitors.

GAA Repositions BAP Marketing Team


Peter Redmond

The Global Aquaculture Alliance is repositioning its international marketing team with the move of Peter Redmond, vice president of development for GAA's Best Aquaculture Practices (BAP) program, from the United States to the United Kingdom to focus on development in Europe.

Redmond has been instrumental in expanding BAP's presence in North America. Around 75 supermarket and restaurant companies in the United States and Canada endorse the BAP program and offer seafood from BAP-certified facilities. Increasing BAP participation in Europe is among GAA's 2013 priorities.

"We are very pleased with the results of Peter's work with retail and foodservice businesses in North America," said GAA Executive Director Wally Stevens. "With the upcoming launch of the BAP finfish/crustacean farm standards, we hope to attain increased marketplace endorsements through Peter and his team's outreach in the United Kingdom and European Union."

Molly Metcalf will continue as BAP business development manager for North America, while Emil Avalon will remain BAP's manager for Europe. Roy Palmer represents BAP in Australasia.

Redmond joined GAA full time in mid-2009. He previously worked for Walmart for 17 years, serving as vice president and divisional manager for deli and seafood and then as director of sustainability before leaving to consult. A native of Ireland, Redmond was raised in England.

Ali MacMartin Joins GAA As Administrative Assistant

The Global Aquaculture Alliance has hired Alaina "Ali" MacMartin as a part-time administrative assistant reporting to GAA Executive Director Wally Stevens. Based in New Hampshire, USA, MacMartin will work directly with Stevens, handling administrative tasks as needed. MacMartin holds a bachelor's degree in social work from Plymouth State University in Plymouth, New Hampshire. In addition to working with GAA, MacMartin owns and operates All Things Green Cleaning LLC, an eco-friendly residential cleaning service.

GOAL 2013 JOIN THE JOURNEY October 7-10

PARIS, FRANCE — HOTEL PULLMAN PARIS MONTPARNASSE

Hotel Pullman Paris Montparnasse

The Pullman Paris Montparnasse is an upscale, 957-room hotel located in the heart of Paris' historic Left Bank district. It's one of Europe's largest business hotels, with 4,153 square meters (45,370 square feet) of meeting space and 49 meeting rooms. The hotel is just a stone's throw from the Montparnasse Métro station and only 10 minutes by train to the Eiffel Tower. It's located about 37 kilometers (23 miles) from Charles de Gaulle International Airport.

The hotel has two dining options — Justine, a full-service lunch and dinner spot, and Café Atlantic, an ideal location for a quick bite or drink, or a casual business meeting.

Networking With Leaders

GOAL 2013 is expected to draw upward of 400 seafood professionals representing many of the world's leading retailers, foodservice operators, suppliers, producers, academic institutions and environmental and social organizations. There will be many opportunities to network with industry leaders and set up meetings with existing and potential suppliers and buyers.

GOAL 2013 is conveniently held just days after the CONXEMAR International Frozen Seafood Products Exhibition in Vigo, Spain, and before the Groundfish Forum and Seafood Barcelona.

Offsite Tours

GOAL 2013 will include a pre-conference tour of Rungis Market in Paris, the world's largest wholesale food market, which handles more than 1.4 million metric tons (1.5 million U.S. tons) of food a year. Rungis Market has an annual turnover of about €7.8 billion (U.S. $10.4 billion), features over 1,200 companies and employs 11,683 workers. As for seafood, the facility's 55 seafood vendors handle more than 169,000 metric tons (186,290 U.S. tons) of fresh, frozen and smoked finfish and shellfish a year.

GOAL 2013 Online

For more information on signing up for tours or for event and registration information, please visit the GOAL 2013 web pages at www.gaalliance.org/GOAL2013. Photos, videos and profiles of speakers from previous GOAL events are also posted here. More information about GOAL 2013 will be added as it becomes available.

Global Aquaculture Alliance
Feeding the World Through Responsible Aquaculture
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www.gaalliance.org/GOAL2013

global aquaculture the alliance

GOAL 2013 JOIN THE JOURNEY October 7-10

PARIS, FRANCE — HOTEL PULLMAN PARIS MONTPARNASSE

CONFERENCE PROGRAM

MONDAY, OCTOBER 7

Registration

Welcome Reception

TUESDAY, OCTOBER 8

MORNING PROGRAM
9:00 a.m.-1:00 p.m.

Opening Remarks

Keynote Address

Lifetime Achievement Award

Production Data
Forecasting global supplies of Atlantic salmon, shrimp, *Pangasius*, tilapia, sea bass and sea bream

International Trade
Weighing the impacts of E.U.'s Generalized System of Preferences on global seafood supplies

Health Management
Update on early mortality syndrome in shrimp, infectious salmon anemia and other diseases

LUNCH
1:00-2:00 p.m.

AFTERNOON PROGRAM
2:00-5:00 p.m.

Breakout Sessions
In-depth discussions on production data, international trade and health management

BAP Meetings
Topics to be determined

WEDNESDAY, OCTOBER 9

MORNING PROGRAM
9:00 a.m.-1:00 p.m.

Keynote Address

Lifetime Achievement Award

Opportunity Africa
Identifying aquaculture growth opportunities in Africa

Fish Feed
Presenting the latest innovations in feed formulations and debating the effort to increase feed efficiency and reduce dependency on marine proteins

Aquaculture Innovation Award
Sponsored by:

NOVUS

LUNCH
1:00-2:00 p.m.

AFTERNOON PROGRAM
2:00-5:00 p.m.

Breakout Sessions
In-depth discussions on investing in Africa and fish feed

BAP Meetings
Topics to be determined

Gala Dinner
Time and location to be determined

THURSDAY, OCTOBER 10

MORNING PROGRAM
9:00 a.m.-1:00 p.m.

Keynote Address

Fish Feed
A retailer perspective on the issues surrounding the growing demand for fishmeal/fish oil

European Marketplace
Dissecting Europe's complex marketplace and meeting the needs of Europe's discerning buyers and consumers

Product Quality
Defining product quality for farmed seafood and meeting Europe's product quality expectations

Closing Remarks

OFFSITE ACTIVITIES

Rungis Market
Tours of Rungis Market to be held late Monday, Tuesday and Thursday; time, pickup location and registration information to be determined

GOAL REGISTRATION NOW AVAILABLE!

Visit www.gaalliance.org/

GOAL2013

for program details and full registration information. Link to make hotel reservations, too.

Impacts Of Acute Hepatopancreatic Necrosis Syndrome

Short-Term Market Dynamics Affect Long-Term Practices

Although APHNS/EMS may continue to spread, as with other diseases affecting farmed shrimp, there will likely be a moderation of impacts in years to come.

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Summary:
Research continues in the global efforts to identify the cause of acute hepatopancreatic necrosis syndrome in farmed shrimp and find solutions to stop the major losses caused by its spread. Prices will likely continue to increase as supply fails to meet demand, and production dynamics will shift, as they have due to other diseases. Will such shifts result in long-term changes in production paradigms and development of new shrimp-producing areas?

Few of those involved in the shrimp-farming industry are not familiar with acute hepatopancreatic necrosis syndrome (AHPNS), also known as early mortality syndrome (EMS). The disease has been well characterized, and it has been suggested that the early damage to the shrimp is a result of some form of hepatotoxic material. Work under way to determine the cause will hopefully result in a solid idea about how the problem can be controlled.

Meanwhile, the specter of the disease is weighing very heavily on global shrimp markets. Prices are up, with serious drops in production in the world's leading shrimp-farming countries. There are concerns that, with no immediate solutions in sight, the problem will continue to spread and further erode the stability of the market.

Disease Part Of Aquaculture

As most knowledgeable aquaculturists know all too well, disease is a natural component of aquaculture. Some outside the sector use this fact to try to defame aquaculture as being environmentally disruptive and essentially non-sustainable. However, the absence of disease is unnatural, and there are no agricultural practices that do not, at the very least, occasionally suffer from the impacts of disease.

While it should be the goal of all science-based aquaculture to prevent diseases to the maximum extent possible, the unfortunate truth is that this ideal is not achievable or perhaps even ultimately desirable. Even those production systems that minimize the variables and optimize production are prone to disease outbreaks, and each environment can create conditions that allow what may not have been pathogens under some circumstances evolve into pathogens.

An ideal production environment would be one in which animals were not prone to stressors that impact their integral physiologic mechanisms. These do not exist, however, and while genetic selection will allow the production of animals that tolerate stressors without noticeable negative impacts, we are still in many respects in the early stages of shrimp domestication. We can expect to continue to see periodic widespread disease outbreaks, but with the hope they will become less frequent as we learn how to operate in a truly sustainable manner.

As more is understood about the nature of AHPNS, we will be able to more narrowly define what actually constitutes this disease. Many farmers experience mortality post-stocking, which can be the result of many different issues. AHPNS results in a classic pathology, which must be present to define the disease process. It is clear that secondary pathogens may play a role in the ultimate death of affected animals.

Disease Spread

Controlling the underlying cause may not be simple or straightforward – and we will not know until the cause is identified what will turn out to be the case. There is little reason to believe the disease will suddenly become self-limiting. It appears to be spreading in a slow and inexorable manner. This does not bode well for the short-term prospects of limiting its impacts without significant paradigm changes.

Anecdotal observations suggest that stocking animals at much larger sizes, which would entail the widespread use of nursery systems, can stave off the worst part of the problem, although some claim to see impacts on larger shrimp, as well. Others report that polyculture with fish can also lessen AHPNS impacts.

The scientific veracity of these observations has yet to be proven. It is likely that unless drastic steps are taken to stop the disease progression geographically, we may see AHPNS move into areas that probably are currently free of it. It remains to be seen how much a barrier the Pacific Ocean will be in keeping farms in the Americas free of the disease.

Effects On Industry

In the interim, since a large portion of the global farmed shrimp crop originates from a handful of Asian countries, we can expect to continue to feel the impacts of AHPNS in the marketplace. Prices will likely continue to increase as the supply fails to meet the demand, and the production dynamics will shift, as they have in the past due to other diseases. What remains to be seen is whether this will result in long-term changes in production paradigms and to what extent new shrimp-producing areas will be developed.

In many parts of the world, shrimp farming has the potential for significant growth, and the temptation will be for it to occur without stringent regulation. While this may alleviate short-term supply issues, it is not likely to change the nature of shrimp farming in the long run.

Poverty-driven farming has been a component of shrimp culture for many years, and while the industry is slowly evolving away from this, the temptations for underdeveloped nations with aquatic resources to allow unregulated development are still strong. Such expansion could set off a new round of diseases and other problems, as well.

Perspectives

Unfortunately, it appears the lessons learned from coping with prior disease outbreaks have not been particularly useful in preventing this problem. The author believes that EMS/AHPNS is here to stay, and we have yet to see its full impacts. It will continue to spread, but as with other diseases affecting farmed shrimp, there will likely to be a moderation of the impacts in years to come.

The main clinical sign of IMNV infection is the appearance of white, opaque areas in the tail muscles of affected shrimp. Broodstock are individually analyzed for IMNV and other pathogens prior to entering maturation to produce disease-free nauplii and postlarvae.

Brazilian Shrimp Farm Performs Genetic Selection For IMNV Resistance, Growth

Summary:
The Queiroz Galvão Alimentos shrimp farm and hatchery in Brazil have been working with Concepto Azul to implement a disease-prevention and genetic-breeding program that addresses ongoing impacts from infectious myonecrosis virus and other pathogens. The program has focused on selecting broodstock resistant to IMNV as well as examining physiological stress factors and simultaneous pathogen-free certification. After multiple generations, the shrimp have much higher survival and improved growth.

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Since 2002, the epidemics due to infectious myonecrosis virus (IMNV) in the aquaculture of Pacific white shrimp, *Lito-penaeus vannamei*, in northeastern Brazil have caused severe impacts on production and still represent a threat to sustainable culture in most affected areas.

Queiroz Galvão Alimentos S.A. (QGA) owns a 960-ha shrimp farm, a hatchery with a monthly production capacity of 300 million postlarvae and a processing plant in Rio Grande do Norte, Brazil. In October 2004, QGA contracted technical assistance from the international team of Concepto Azul to implement a program for disease prevention and genetic breeding similar to those implemented against white spot syndrome virus (WSSV) and infectious hypodermal and hematopoietic necrosis virus (IHHNV) in other countries.

Due to severe mortalities caused by IMNV and other losses to IHHNV and the intracellular bacteria that cause necrotizing hepatopancreatitis (NHP), the program focused on selecting broodstock resistant to IMNV with simultaneous IHHNV- and NHP-free certification. It also examined several physiological stress factors and simultaneous pathogen-free certification.

QGA built a specific infrastructure for the program, including a molecular biology laboratory for polymerase chain reaction (PCR) analysis, individual spawning and larval culture units, an experimental pathology biosecure unit and broodstock culture units at the hatchery and shrimp farm.

IMNV Transmission

Pathogens such as viruses can be vertically and horizontally transmitted. Vertical transmission, mostly from infected females to their progeny, has been established for most of the viruses that impact shrimp production worldwide, including WSSV and IHHNV.

Postlarvae experimentally infected with IMNV at the biosecure facility.

In the case of IMNV, a preliminary study performed in 2005 showed that IMNV could be detected by nested PCR testing in broodstock ovaries, hemolymph and muscle. Disinfected eggs, nauplii and postlarvae produced from these naturally infected brooders were also detected positive. These data indicated that vertical transmission is very likely.

Horizontal transmission can occur by cannibalism or by host vectors. IMNV virus was detected in farm samples of zooplankton (77%), crabs (80%) and oysters (40%). Quantitative real-time PCR analyses for quantification of IMNV in water samples from the farm inlet canal showed high concentrations from 1.0 x 10^5 to 3.0 x 10^7 viral RNA molecules/mL.

Production Impacts

Considering the impracticality of sterilizing water and soils in the ponds of a semi-intensive system, total eradication of pathogens from the environment is almost impossible. Moreover, several abiotic stress factors that occur at the shrimp farm do affect production.

Eutrophic estuarine water can cause hypoxia and subsequent mortality. Due to adjacent river floods, low salinity values of 0 to 1 ppt and rapid drops in concentration cause higher susceptibility to pathogens. The mean survival rate in QGA's shrimp ponds in the winter of 2004 bottomed at 19%.

Specific pathogen-free postlarvae without selection for resistance to pathogens and stress factors would get infected at the farm due to contamination in the semi-intensive system. As a consequence, it was necessary to stock postlarvae selected for resistance, growth and certified free of disease to reduce the risks of pathogen transmission and mortality.

Genetic Breeding

The main criteria considered for the genetic selection program are resistance to IMNV and growth. The program relies on individual selection operations that permit a precise estimation of the genetic value of all broodstock candidates for each criterion.

Selected broodstock are used to establish pure lines through inbreeding, which increases homozygosity, in order to stabilize genes involved in resistance. For commercial production of nauplii and postlarvae, crosses are outbred between pure lines.

Production and selection of new generations are realized through directed crosses and artificial insemination. Nauplii are reared to the $P.L._{10}$ stage in the individual larval culture unit. Each family is submitted to high-pressure selection for 60 days after experimental infection with IMNV.

During these 60 days of challenge, all families also undergo several physiological stress factors, such as a salinity stress from 34 to 1 ppt, hypoxia and a temperature drop from 29 to 22° C in order to combine viral challenge with stress conditions that naturally occur at shrimp farms.

Then families and individuals are selected for growth. Selected individuals are tagged with elastomer markers and transferred to tanks and ponds for growth evaluation and selection. After reaching optimal weight, selected families are transferred to hatchery quarantine.

Preselected broodstock are individually analyzed for detection of IMNV, IHHNV and NHP by loop-mediated isothermal amplification, nested PCR or real-time PCR. All virus carriers are discarded. Only disease-free broodstock are transferred to maturation in order to produce disease-free nauplii and postlarvae.

Results: Controlled Conditions, Farm

In controlled conditions of challenge with IMNV for 60 days, mean survival rate increased from 3.2% in the F1 generation to 55.3% in F7 – a significant increase in the resistance factor of 17.3 times (Figure 1).

In 2007, a comparative study between selected and unselected postlarvae (P.L.) under farm production conditions was conducted. Forty ponds were stocked in April at a density of 30 P.L./m^2. The F3 IMNV-resistant postlarvae reached a final survival rate of 57.0%, while only 24.4% of the unselected control P.L. survived.

The growth rate under intensive conditions with a stocking density of 100 P.L./m^2 was tested during the winter months of 2010 in outdoor growout tanks. The mean weekly growth rate reached 1.1 g during 93 days with mean water temperature around 27° C.

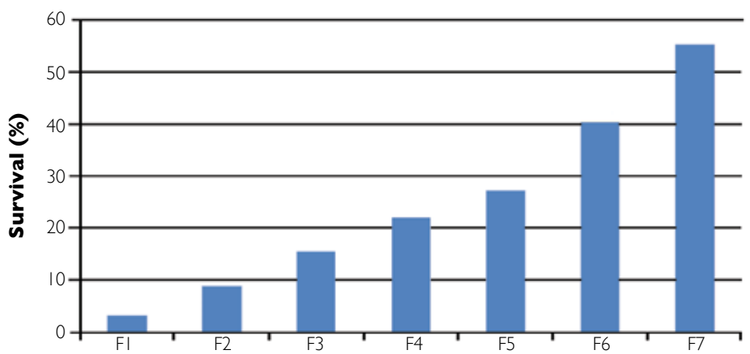

Figure 1. Mean survival rates for each generation at 60 days after IMNV challenge.

Immune Gene Expression

Quantitative real-time PCR allows quantifying gene expression at the mRNA level. The authors considered hemocyanin an interesting immune gene due to its double function of oxygen transport and antimicrobial activity.

They compared the constitutive expression of hemocyanin in two generations of selected shrimp for their resistance to hypoxia (control, F1 and F2). The F2 shrimp showed a constitutive expression of hemocyanin 5.6 times higher than in the control. These results could partly explain the higher survival rates in the F2 and following generations at the farm.

The genes Dicer and Argonaute, which are involved in the gene-silencing machinery through RNA interference, have been studied as antiviral gene candidates. IMNV injection in shrimp caused an up regulation of these two genes. A comparative study established that resistant asymptomatic shrimp surviving an experimental infection with IMNV had a 10,000 times lower load of virus than symptomatic susceptible shrimp. Dicer and Argonaute mRNA quantification by real-time PCR showed an almost two-fold higher expression level in resistant asymptomatic shrimp.

Perspectives

The QGA program has been successful in selecting and producing postlarvae significantly more resistant to IMNV and adapted to culture conditions in the shrimp farms in northeastern Brazil. Considering the impacts of pathogens in most shrimp-producing countries and at present of IMNV in Asia, the use of these selected lines could be of great importance to reduce the impacts of pathogens on the sustainability of shrimp aquaculture.

Updated Technologies Improve Efficiency, Reduce Costs For Mussel Seed In Brazil

Mussel seed on a continuous collector at Cocanha Beach.

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Summary:
The authors conducted research to improve the uptake of seed in artificial collectors and optimize the amount of seed used in mussel farming. The use of buoys to keep collectors at the air-water interface doubled seed volume. A modified Spanish seeding system using cotton socks and ropes made of discarded nets reduced seeding time by 30% in comparison to the French system. Stocking density could be reduced by half without decreases in productivity or the mean weight of mussels.

According to the Food and Agriculture Organization of the United Nations, Brazil is the second-largest producer of mussels in South America. The country produced 13,723 mt in 2010, mostly in the states of Santa Catarina and Paraná. Other states, including São Paulo, produced a total of 450 mt.

Mussel farming is carried out mainly by small producers, and particularly in São Paulo, it is conducted in a semi-artisanal way. The operations of mussel seed socking and mussel harvesting and cleaning are done manually or using rudimentary equipment. Therefore, labor represents a significant portion of the total costs of production.

Seedstock, Supply Issues

In Brazil, as in most tropical countries, mussel seed is not a plentiful resource due to continuous non-intensive reproductive activity throughout the year. Uptake of mussel seed on artificial collectors in São Paulo state occurs only in spring and, in some years, autumn.

The amount of seed obtained is quite variable from year to year due to climatic variations and occasional warm water flows in summer that cause seed mortality. The production of seed in hatcheries could be a solution to this problem, but producers will have to take into account the costs of acquisition, transport and handling of the seed.

Seed collectors are placed horizontally parallel to the sea surface to allow the uptake of seed. Consequently, they occupy a wide area that could be used to increase mussel production. Presently, each 1,000 m^2 of growing area requires an additional 500 m^2 for the placement of collectors.

Finally, the use of seed collectors has costs, mainly in labor. Observations have shown that the labor necessary for manufacturing the collectors, transport and placement on the sea, and removal and handling of seed in the socks, accounts for more than 50% of the total cost of labor in mussel production.

Mussel socks seeded using the French (top right) and Spanish systems. The Spanish system allows faster seeding.

Many artisanal seed collectors now employ buoys for flotation.

Seed Collectors

The authors recently conducted research in Cocanha Beach, Caraguatatuba, São Paulo, Brazil, to improve the uptake of seed in artificial collectors and optimize the amount of seed used in mussel farming without affecting the final yield through reduction of seeding density and modification of the seed sock system.

Seed collectors used in mussel farming in São Paulo are typically made of braided discarded nets with variable length. As a rule, these collectors remain submerged for five months, after which seed is removed and transplanted to mussel socks.

Research showed that the use of small buoys to keep the collectors placed horizontally at the air-water interface doubled the number of collected seed in the same period of time. These results stimulated the use of artificial collectors, and the higher amount of seed collected has mitigated the variability in seed collected from year to year.

Producers generally use two types of collectors: individual 2-m-long collectors and continuous collectors with length varying from 10 to 50 m. Transplanting of seed to growout socks only occurs if uptake is intense. Otherwise, mussel seed is kept in the collectors until reaching a marketable size over 6 cm in length. Commercial "Christmas tree" collectors are not used due to their high cost and the abundance of discarded material that can be used in the manufacture of artisanal collectors.

Seed Density Reduction

Traditionally in São Paulo, producers have adopted a seeding density of around 500 seed/m of sock using the French system of seeding in cotton socks inside polyethylene tubular nets. Research showed that this number can be reduced to 300 seed/m without any decrease in productivity or mean weight of mussels. Future research will evaluate the influence of density on the condition index of farmed mussels.

Other studies verified the technical and economic feasibility of replacing the French system of seeding by a modified Spanish system, using cotton socks involving the mussel seed in ropes made of braided discarded nets. The modified Spanish system provides greater economy in material, and the time spent in seeding the ropes is about 30% lower than for the French system. Thus, this has been the system preferred by producers for some time.

Presently, new research is under way to further reduce the density of seed. It was observed that it is possible to use as few as 200-250 seed/m of rope without reducing the final yield. At low densities, survival of the mussels is higher because the mussels remain firmly attached to the ropes and avoid detachment. In French systems or Spanish systems at higher densities, the mussels often attach to each other, and detachment is easer, increasing losses.

Perspectives

The authors believe that reduction in seeding density in mussel farming promotes lower labor costs for manufacturing seed collectors and handling seed mussels, as well as a reduced requirement for seed collection areas. Less space for seed collection corresponds to more space for mussel production.

The emergence of additional mussel seed produced in hatcheries or on artificial collectors helps increase the value of this resource. The results of these studies will allow the expansion of culture without increasing the demand for seed, improving economic profitability and enhancing the sustainability of the mussel sector as a whole.

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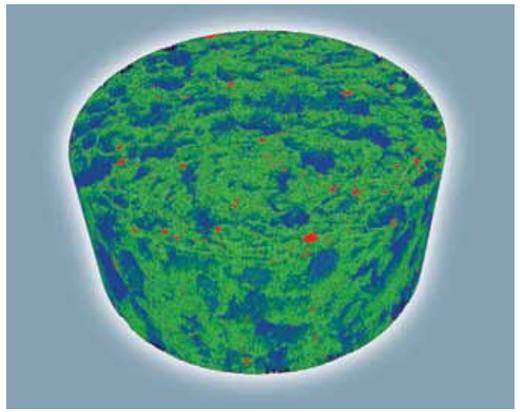
Alternative Feed Ingredients Support Continued Aquaculture Expansion



Skretting ARC is using X-ray microtomography to visualize pellets before and after coating, revealing the internal structure, the size of the pores and variation in size. This is important, as it affects physical properties and how the pellets behave in vacuum coating.

Summary:
As global demand for seafood rises, aquafeed production must rise without increasing demands for marine raw material resources and while maintaining the human health benefits of seafood. Researchers are looking for alternatives to fishmeal and fish oil that provide low feed-conversion ratios, maintain fish welfare and produce nutritious fish. Identifying sources for essential macro- and micronutrients is important, as well as understanding how best to manufacture feed to required physical specifications when using these new raw materials.

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According to the Food and Agriculture Organization of the United Nations, fisheries and aquaculture are vital to global food security and poverty alleviation. Research to increase the sustainability of aquafeeds is essential for aquaculture to fulfill its potential in providing high-quality protein for the global population of the coming decades.

A major challenge facing the continued growth of aquaculture is that most fish feed needs high levels of protein and energy. For carnivorous or omnivorous fish, these are traditionally provided mainly in fishmeal and fish oil, which also contribute to the health-promoting aspects of fish in the human diet – for example, with omega-3 fatty acids. The challenge lies in the need to increase feed production without increasing the demand for marine raw material resources and while maintaining health benefits.

Aquaculture today takes 60 to 80% of the fishmeal and 80% of the fish oil produced, mainly from the industrial pelagic fisheries and trimmings produced during processing for human consumption. The industry is, therefore, heavily dependent on marine resources, but production from these resources cannot be increased sustainably. At best, sustainably managed fisheries will continue to yield the current annual harvest of 5 mmt of fishmeal and 1 mmt of fish oil. Therefore, to meet the growing demand for fish, aquaculture must identify alternatives.

Research Progress

Researchers around the world are continually looking for alternatives that will provide low feed-conversion ratios, maintain high fish welfare and produce fish that are good to eat, both in terms of eating experience and nutrition.

Dr. Wolfgang Koppe, manager of the Nutrition Department at the Skretting Aquaculture Research Centre (ARC) in Stavanger, Norway, reported that the department has determined the nutritional value of more than 400 raw materials. In 2010, ARC researchers finalized what Skretting has dubbed MicroBalance technology, which has greatly reduced dependence on fishmeal.

Initially this was based on ensuring a correct balance of newly identified essential micronutrients in feeds for Atlantic salmon. Normally these are provided in fishmeal, but the researchers identified alternative sources. Identifying alternatives to fishmeal provides flexibility to adapt the raw material combinations in response to prices, lessening the impacts of price volatility on farmers.

Fishmeal levels in the average Atlantic salmon growout diet were previously around 25%. The ARC advances enabled Skretting to produce commercially successful feeds with just 15% fishmeal. Continuing research led to growout feeds with fishmeal levels of just 5 to 10%.

More Species

Researchers are now applying the technology to other established aquaculture species, including seabass, sea bream, rainbow trout, turbot and yellowtail. Skretting ARC is currently establishing a satellite research center in China to help address diets for marine species raised in Asia, which now typically receive feed with 20 to 30% fishmeal.

In 2011, the ARC recruited shrimp nutrition specialists and began research activities to transfer the MicroBalance technology to shrimp feed. The new research facility in China will play a key role in this project.

Feeds for crustaceans have traditionally used relatively high fishmeal levels of 20 to 30%. These inclusion levels vary with the shrimp species and the type of production targeted – semi-intensive or intensive.

Dr. Lenaig Richard, a researcher at Skretting ARC, said that considering the knowledge gained by the center in fish species, there is great potential for reducing the overall reliance on fishmeal in shrimp feeds, as well. However, Koppe said that identifying alternative sources of the essential macro- and micronutrients provided by fishmeal is only part of the story. The second part lies in discovering how best to manufacture the feed when using these new raw materials.

Manufacturing Challenges

Raw materials such as concentrated proteins from soybeans, wheat, peas or sunflowers are used in low-fishmeal feeds to provide the macronutrients normally delivered by fishmeal. They are supplemented with further ingredients to provide the essential micronutrients still required for complete nutrition.

Replacement of fishmeal is not straightforward in production terms. It is necessary to acquire knowledge about the functionality of plant proteins before such materials can be fully used in a commercial context.

To begin, the substitution of fishmeal by vegetable raw materials changes the physical properties of the raw material mix and therefore the way it behaves in the extrusion process involved in producing feed pellets. Skretting ARC has a pilot-scale feed plant in which researchers have been developing production methods that enable the operators to control the production process and the resulting physical properties of the feed pellets.

Physical Characteristics

In addition to providing the nutrients required by a particular species, the feed pellets must match a series of physical specifications. These vary among species and among growth stages within species.

Feed pellets should not crumble and must be sufficiently robust to withstand handling, for example, in transfer from one silo to another or storage in bags. They must be consistent in size, shape and density, and the density must be controlled precisely to give the required floating or sinking characteristics. Also, the pellets need to be stable during storage, especially at higher temperatures, to avoid loss of oils and other nutrients.

Vukasin Draganovic, a doctorate candidate at Skretting ARC, is exploring how suitable ingredients behave in terms of their processing, their interaction with other ingredients and the end physical qualities of the feed in a project being conducted with the Food Process Engineering Group at Wageningen University. Figure 1 is an example of one test of feed pellets.

With funding through the Industrial Ph.D. program facilitated by the Research Council of Norway, his work is also focusing on the impacts of the transition toward vegetable proteins on the energy consumption of feed plants and identifying options for more energy-efficient processes with lower carbon footprints. Draganovic reported that energy usage during feed processing can be greatly reduced by modifying the plant proteins to match the technological properties of fish protein.

Equivalent projects are addressing the need to reduce dependence on fish oil.

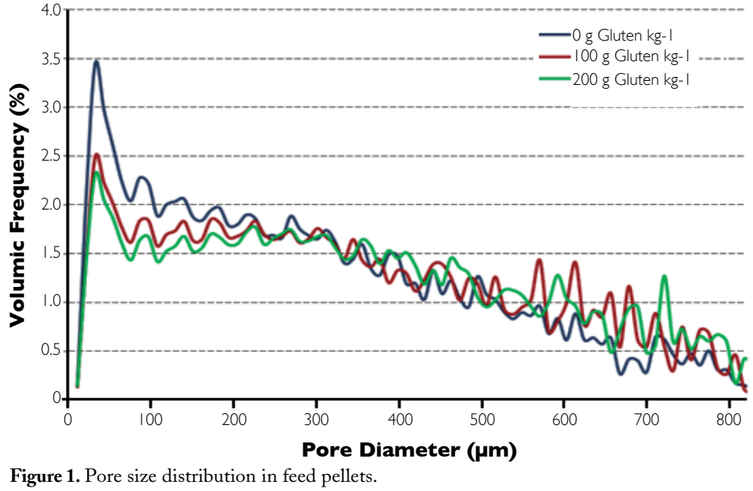

Figure 1. Pore size distribution in feed pellets.

Synthetic Products Replace Live *Artemia* In Shrimp Larviculture

The use of synthetic *Artemia* in shrimp hatcheries can help counter shortages of live *Artemia*.

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Summary:
To meet demand and maintain the sustainability of the shrimp aquaculture industry, commercial synthetic *Artemia* has been developed for use as a biosecure replacement for live *Artemia* in larviculture. The main benefits of artificial *Artemia* include a consistent nutrient profile, pathogen-free status and no storage or hatchout concerns. Artificial *Artemia* also has constant availability and pricing, and can be used as a vehicle for immunostimulants, enzymes and probiotics to improve animal health.

Artemia, or brine shrimp, have become a staple feed item in shrimp larviculture. They are a proven complete feed for shrimp that is easily seen and suspended in the culture water column. Their dormant eggs, or cysts, can be stored for long periods and hatched on demand to provide a convenient live feed for larval fish and crustaceans.

In years past, the aquaculture industry counted on adequate *Artemia* cyst harvests and inventories to allow *Artemia* suppliers to meet market demands. But for the last several years, the worldwide demand for *Artemia* cysts has risen to levels that exceed global supply. Today, as global demand increases, the combination of depleted inventories and unpredictable harvests has resulted in shortfalls in supply much sooner than the industry had anticipated.

Global Cyst Production

The Great Salt Lake in Utah, USA, has been one of the major suppliers of *Artemia* cysts. In 2011-2012, its cyst harvest reflected 70% of the wet weight of the 2010-2011 harvest, but only 55% of the dry, processed weight. Cyst harvests in Russia and China were also low for 2011-2012. The cyst harvest in the Ariel Sea returned in 2011-2012, but was not enough to compensate for the overall shortage. There were few cyst reserves anywhere in the world.

In contrast, the 2013-2014 cyst harvest has been superior. Thanks to a drop in demand in Asia due to lower shrimp larvae production in areas affected by early mortality syndrome, this year may be the first in five to show inventories exceeding demand. However, the inconsistency of supply has kept prices at record levels.

Vietnam Situation

Vietnam has over 500,000 ha of shrimp farms and over 3,000 hatcheries. In 2012, the hatcheries produced an estimated 70 billion postlarvae of Pacific white shrimp, *Litopenaeus vannamei*, and black tiger shrimp, *Penaeus monodon*. This number was up from 25 billion two years previous.

At the start of the 2012 production year, there was no "in-country" *Artemia* cyst reserve from any source in Vietnam. Only cysts imported from Thailand, priced at U.S. $110-140/kg, and Vietnam-produced cysts at $200/kg were available in very limited quantities. Many facilities were unable to produce due to the lack of cysts.

For the sustainability of the shrimp aquaculture industry, it became apparent that hatcheries needed an alternative for *Artemia* cysts.

Artemia Use

To develop an artificial replacement for *Artemia* in hatcheries, an understanding of how *Artemia* is used in different parts of the word is needed.

In the Eastern Hemisphere, *Artemia* are traditionally fed according to visual macroscopic observations by the technician of available feed in the water. Microscopic observation is generally not used. Also, production tanks normally have flat bottoms and limited aeration, making artificial feed suspension difficult.

Parabolic tank designs help keep artificial feed suspended in the water column.

For these reasons, there is a very high dependence on live *Artemia*, which is a complete diet that is easily seen and maintained in suspension. The average consumption in Asia is 3-10 kg of 80% hatchout *Artemia* cysts/million shrimp postlarvae produced. To date, has been done little to reduce historic consumption rates.

In the Western Hemisphere, the use of artificial diets is considerably higher. Feeding is based more on frequent microscopic observations of the animals than the water column. Production is done in parabolic tanks with high center aeration specifically designed to maintain all feeds in suspension and reduce dependence on live feeds. Much has been done to lower historic *Artemia* consumption rates in the Western Hemisphere.

Species Differences

The majority of *Artemia* cysts are consumed to produce *P. monodon* and *L. vannamei* postlarvae (P.L.). Both have different feeding characteristics.

P. monodon are pelagic feeders through $P.L._{20}$, feeding up in the water column. They are mainly grown in flat tanks, but are not efficient at feeding off the bottom, making it difficult to feed dry diets to harvest. The shrimp can only feed on what stays in the water column, such as live *Artemia*. It is typical to use 5-10 kg *Artemia* cysts/million postlarvae produced. In 2012, hatcheries paid U.S. $1.00-1.50/1,000 P.L. for *Artemia* in Vietnam.

L. vannamei are pelagic feeders only through stage P.L.5. They become benthic feeders at $P.L._6$ and remain so to harvest, which permits heavy dry diet use in later stages and reduces the amount of *Artemia* needed. They are mainly grown in parabolic tanks until $P.L._5$.

After $P.L._5$, *Artemia* cysts are normally cut from feeding protocols, and shrimp feed at the bottom with heavier sinking diets, decapsulated cysts or *Artemia* biomass. In Vietnam, it is typical to use 1-5 kg *Artemia* cysts/million *L. vannamei* P.L., which cost hatcheries U.S. $0.40-0.60/1,000 P.L. in 2012.

Synthetic *Artemia*

To meet the requirements and sustainability of the shrimp aquaculture industry, commercial synthetic *Artemia* has been developed for use in larviculture. It has proven to be a 100% biosecure replacement for *Artemia.*

The main benefits of using an artificial *Artemia* replacement include a consistent nutrient profile, pathogen-free status and no storage or hatchout concerns. Artificial *Artemia* also have constant availability and pricing, and can be used as a vehicle for immunostimulants, enzymes and probiotics to enhance digestion and improve water quality and animal health.

Field tests have demonstrated high survival in shrimp fed synthetic *Artemia.* The liquid diet is almost neutrally buoyant and formulated to match the nutrient profile of enriched *Artemia* with high highly unsaturated fatty acids content. Artificial *Artemia* has been shown to extend the transport time of shrimp postlarvae by helping maintain good water quality and dissolved-oxygen levels. It is available in multiple particle sizes and can be fed from zoea 1 stage to P.L. at harvest.

Commercial Hatchery Trial

Two feeding protocols that took into account the types of tanks used in larviculture of *L. vannamei* were tested. In one study, flat-bottom Asian-style tanks and easily suspended liquid larval feeds with synthetic *Artemia* were used, while the other used low-cost dry diets and synthetic *Artemia* in parabolic American-style tanks. Performed in a Western hatchery that exclusively used synthetic *Artemia* for the past two years, the trials evaluated the dietary impacts of the protocols on shrimp growth and survival in a commercial production environment.

Table 1. Results of commercial hatchery trials comparing two *Artemia*-feeding protocols.

Treatment	Stocking Density	Survival (%)	Size (cm)
Liquid diet with synthetic *Artemia*, flat-bottom tanks	163.00[a] ± 6.76	66.8[a] ± 5.0	0.89[b] ± 0.03
Dry diet with synthetic *Artemia*, parabolic tanks	161.00[a] ± 4.43	62.9[a] ± 1.0	1.18[b] ± 0.11

The trial ran for 21 days from N_5 to $P.L._{15}$ status. Each of the two treatments had three replicates. The rectangular, 20-m^3 fiberglass tanks with parabolic design were stocked with nauplii at 160/L. Through $P.L._4$, the microalga *Thalassiosira pseudonana* was used at a density of 60,000-100,000 cells/mL. Water temperature was maintained at 30.8 to 31.8° C, and dissolved-oxygen concentrations were 4.5-5.0 mg/L. pH was stable at 8.2 during culture.

Table 1 shows growth and survival data for each treatment. Both treatments gave adequate to superior results for a commercial hatchery using no *Artemia* in feeding protocols. Slightly better growth was seen using dry diets, and better survival was achieved with liquid feeds.

Since the hatchery closed its *Artemia* department in 2010, the facility has noted increased survival, sustained improvements in water quality and increased hatchery productivity, which have led to decreased production costs and higher profitability.

Pond Testing

It is common for shrimp farmers to demand that hatcheries use a certain amount of *Artemia* to guarantee the quality of the shrimp seed. So the question arose: Do P.L. produced with synthetic *Artemia* have the same quality as those produced with live *Artemia*?

Two hatcheries produced 6 million postlarvae for a trial. Three million P.L. came from a protocol using synthetic *Artemia*, and the remainder came from a protocol using *Artemia* cysts. The postlarvae were kept in nursery tanks for seven to 12 days prior to stocking into 72 ha of growout ponds at a large shrimp farm in Ecuador.

The results in Table 2 show that the postlarvae grown on synthetic *Artemia* entering a nursery system could outperform postlarvae grown on live *Artemia*. There was no significant difference in growout pond performance between the two treatments.

Table 2. Pond results for postlarvae produced with *Artemia* cysts or synthetic *Artemia*.

Treatment	Days in Nursery	Average Survival (%)	Stocking Density (shrimp/m^2)	Days to Harvest	Survival (%)	Feed-Conversion Ratio	Harvest Weight (g)	Pond Yield (kg/ha)
Synthetic *Artemia*	10	92	10.1	93	65.9	1.03	11.3	748.9
Live *Artemia*	8	80	10.4	96	67.7	0.97	10.7	745.7

Study: Essential Oils Enhance Fillet Composition Of Channel Catfish

The inclusion of a phytogenic product reduced the fat content in fillets of pond-raised catfish.

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Summary:
Lab studies with channel catfish and rainbow trout have found that phytogenic feed additives can help improve weight gain, feed conversion and immunity to disease. A pond study in Mississippi, USA, that compared the performance of catfish fed a control diet or a diet with a phytogenic supplement found the fish in both groups had similar survival, weight gain and yield. However, the fat levels were lower and protein levels were higher in fillets from fish that received the supplement.

Plant extracts called phytobiotics are a group of compounds that have been examined primarily in the domestic livestock industry to replace antibiotic growth promoters. These plant extracts include essential oils (volatile plant compounds), oleoresins (extracts from non-aqueous solvents), herbal products (bark, leaves) and aromatic plants (sage, mint).

Researchers have examined various essential oil components alone and in combination to find possible synergistic effects. Many of these products have been tested in cattle, poultry and swine, and their use in fish is beginning to emerge. For example, phytogenic feed additives have been examined in channel catfish and rainbow trout with results showing improvements in weight gain, feed conversion and immunity to disease.

A 12-week pilot study conducted in tanks at the Thad Cochran National Warmwater Aquaculture Center showed that catfish fed products from essential oils in a commercial feed supplement gained 44% more weight than control fish. In addition, treated fish consumed about 30% more feed. Fillet proximate analysis revealed the treated fish had lower amounts of fat and higher amounts of protein.

The results of the pilot study provided the impetus to test the product in earthen ponds, the typical commercial production environment in the southeastern United States.

Pond Research

At the Delta Western Research Center in Indianola, Mississippi, USA, studies were conducted to investigate the effects of a phytogenic feed additive on the growth performance, processing yield, fillet composition and survival of pond-raised channel catfish, *Ictalurus punctatus*.

Eight treated and seven 0.4-ha control ponds were stocked with 14,820, 126-g catfish/ha. Fish in the control ponds were fed a 32%-crude protein commercial floating diet, while fish in the test ponds were fed the same diet supplemented with Digestarom PEP MGE, a commercial phytogenic product, at 200 g/mt.

In a second study, five treated and five control ponds with areas of 0.4 ha were stocked at a similar density with fish that averaged 68 g in weight. The ponds received the same diets described for the first study. Aeration for each pond was provided by a 3.7-kW aerator. Aerators were turned off in the morning, when dissolved-oxygen concentrations were 4 mg/L or higher. Water quality was maintained in ranges considered adequate for normal catfish performance.

At the end of the studies, three groups of 100 fish from each pond were counted and weighed to determine average fish weight. Thirty fish whose weight range was 683 to 717 g were selected from each pond for measurements of weight and fillet characteristics.

Results

At the end of the six-month study with the larger fish, there was no significant difference in the amount of feed fed or the amount of weight gained between the control fish and those that received feed supplemented with the phytogenic (Table 1). Feed-conversion ratios, net yields and survival were also similar between the two groups.

Processing results showed that carcass, fillet and nugget yields were similar (Table 2). Fillet proximate analysis revealed that fillet fat was significantly lower (31.3 vs 35.9%, $P < 0.01$) in treated fish, while fillet protein tended to be a little higher (62.4 vs 61.2%, $P < 0.10$).

In the second study, six months of feeding resulted in similar production characteristics between the two groups (Table 3). Processing and proximate analysis were not conducted in the second study.

Although improvements in weight gain and feed conversion were not seen in the pond studies, fillet fat levels decreased, and fillet protein increased with the addition of phytogenic feed additives to catfish diets. Such improvements in fillet composition are of commercial importance.

Survival was excellent in both studies, and it is not clear what effects these products had on catfish immunity. In order to evaluate the previously reported improvements in fish health, these phytogenic products need to be examined in experimentally infected or stressed catfish.

Table 1. Mean production characteristics for channel catfish of 126-g initial weight fed different diets in 0.4-ha ponds.

Treatment	Total Diet Fed (kg/ha)	Net Yield (kg/ha)	Weight Gain (g/fish)	Feed-Conversion Ratio	Survival (%)
Control diet	19,631	9,329	516	2.10	99.2
Control diet with phytogenic	19,274	9,430	548	2.00	99.2
Standard error	542	291	15	0.04	0.2

Table 2. Mean processing characteristics and proximate fillet compositions of channel catfish fed different diets in 0.4-ha ponds.

Treatment	Weight of Processed Fish (g/fish)*	Carcass Yield (%)*	Fillet Yield (%)*	Nugget Yield (%)*	Fillet Protein (%)**	Fillet Fat (%)**	Fillet Ash (%)**
Control diet	683	65.5	35.3	9.70	61.2	35.9[a]	3.80
Control diet with phytogenic	717	65.6	35.6	9.80	62.4	31.3[b]	3.80
Standard error	15	0.2	0.1	0.04	0.9	0.7	0.06

* Mean values for seven control ponds and eight ponds with treated fish, 30 fish/pond.
** Mean values for seven control ponds and eight ponds with treated fish, 10 fish/pond.
Values with different letters within columns are significantly different ($P < 0.01$).

Table 3. Mean production characteristics for channel catfish of 68-g initial weight fed different diets in 0.4-ha ponds.

Treatment	Total Diet Fed (kg/ha)	Net Yield (kg/ha)	Weight Gain (g/fish)	Feed-Conversion Ratio	Survival (%)
Control diet	422	294	436	1.67	96.6
Control diet with phytogenic	409	295	445	1.61	95.8
Standard error	9.5	8.4	13.0	0.02	0.9

Perspectives

As the popularity of feed additives increases, more products specific to aquaculture markets will emerge. These and other fish studies appear to show some performance gains. Feed additives such as the one tested in these studies must be cost effective and be easily incorporated into diets made at feed mills.

The cost for adding this phytogenic compound in the diet was less than U.S. $5/mt, and no problems were encountered at the feed mill. The presence of the compound was tested and confirmed, even after extrusion. Finally, the mechanisms of action of these phytogenic compounds are poorly understood, and future research will need to focus on defining how these products work.

Accuracy Of Custom Water Analyses Varies

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Lab equipment that utilizes spectrophotometry can simultaneously measure multiple elements at a reasonable cost, but results may not be consistently reliable.

Summary:
The reliability of trace element analyses reported by custom laboratories cannot be checked by simple techniques, and results may not always be accurate. One should check the reliability of major ion analyses by determining the charge balance and comparing the measured total ion concentration with the total ion concentration estimated from conductivity. The closer these ratios are to 1, the greater is the likelihood that the analyses are accurate.

Water quality data often are necessary for assessing the suitability of water supplies and water in culture units for fish, shrimp or other species. Analyses of pH, dissolved oxygen, total ammonia nitrogen and salinity can easily be conducted on site with hand-held instruments or water analysis kits, but data on concentrations of major ions and trace elements normally are obtained by sending samples to custom laboratories.

These laboratories usually analyze samples using atomic absorption spectrophotometry or, increasingly, by inductively coupled plasma atomic emission spectrophotometry (ICP-AES). The ICP-AES method typically provides data on concentrations of 16 to 20 elements measured simultaneously at a reasonable cost. Of course, alkalinity (bicarbonate plus carbonate) is measured by titration with a standard solution of acid.

Ion Concentration

Most laboratories have effective quality control programs to assure the reliability of results. Nevertheless, in the authors' experience, their reports on concentrations of major ions often are in error. Upon receiving the results for a water sample, it is possible to assess the probable reliability of the data. The usual procedure is to make an anion-cation balance evaluation.

Because of the principle of electrical neutrality, positive charges of cations balance negative charges of anions in a sample. The major ions typically account for more than 95% of the total ions in a sample. Thus, if the concentrations of major ions are converted from a weight basis (milligrams per liter) to a charge basis (milliequivalents per liter), the sum of the milliequivalents of cations (calcium, magnesium, sodium and potassium) very nearly equals the sum of the milliequivalents of anions (bicarbonate/carbonate, chloride and sulfate) in an accurate analysis.

Working Example

Suppose a sample is reported to contain 40 mg/L calcium, 12 mg/L magnesium, 10 mg/L sodium, 4 mg/L potassium, 120 mg/L bicarbonate, 33 mg/L chloride and 24 mg/L sulfate. The charge balance can be made as follows:

Anions

120 mg/L bicarbonate ÷ 61 mg bicarbonate/meq = 2.00 meq/L
33 mg/L chloride ÷ 35.45 mg chloride/meq = 0.93 meq/L
24 mg/L sulfate ÷ 48 mg sulfate/meq = 0.50 meq/L
Total negative charge = 3.43 meq/L

Cations

40 mg/L calcium ÷ 20.04 mg calcium/meq = 2.00 meq/L
12 mg/L magnesium ÷12.15 mg magnesium/meq = 0.99 meq/L
10 mg/L sodium ÷ 23 mg sodium/meq = 0.43 meq/L
4.0 mg/L potassium ÷ 39.1 mg potassium/meq = 0.10 meq/l
Total positive charge = 3.52 meq/L

The charge balance (meq anions ÷ meq cations) in the example is almost equal – 0.974 as compared to 1.0 for perfect balance – suggesting an accurate analysis. The charge balance, however, is not always proof of a reliable analysis.

For example, a sample of seawater the authors recently sent to a laboratory for analysis by ICP-AES was reported to contain 164 mg/L bicarbonate; 26,552 mg/L chloride; 3,763 mg/L sulfate; 575 mg/L calcium; 1,790 mg/L magnesium; 14,858 mg/L sodium and 733 mg/L potassium. These concentrations were all greater than would be expected for normal seawater.

The sample was reported to have a conductivity of 50,300 µmhos/cm, a typical conductivity for normal seawater. A check with a hand-held salinometer when the sample was taken gave a salinity of 36 ppt, a reasonable estimate for normal seawater. However, the reported concentrations of most ions were higher than expected for normal seawater, and the sum of the ions was 48,435 mg/L – normal seawater should contain about 35,000 mg/L of total ions. Thus, in spite of the ion balance being very good (0.987), the analysis was obviously in error.

To resolve the issue with the seawater sample, the major ions were measured by traditional methods with the following results: bicarbonate, 126 mg/L; chloride, 20,660 mg/L; sulfate, 2,677 mg/L; calcium 340 mg/L; magnesium, 1,276 mg/L; sodium, 11,260 mg/L; potassium 412 mg/L. The sum of these ions was 36,750 mg/L, and the specific conductance was 49,800 µmhos/cm – reasonable values for normal seawater.

For seawater and brackish water samples, conductivity multiplied by 0.7 is a relatively good estimate of total dissolved solids. In the seawater example above, the estimate of total ion concentration based on the reported conductivity of 50,300 µmhos/cm was 35,210 mg/L. This simple calculation could have alerted the analyst to the fact that the analysis was in error, because the concentrations of the major ions measured by ICP-AES totaled 48,435 mg/L.

The factor 0.7 is not as reliable for estimating the total dissolved-solids concentration from conductivity in many freshwater samples as it is for seawater and brackish water samples. The factor has been reported to range from 0.55 to 0.80 for freshwater. Nevertheless, the factor of 0.7 usually gives an indication of whether a particular analysis of freshwater might be in error despite having a satisfactory charge balance.

Synthetic Water Test

To assess the reliability of data on major ion concentrations measured by custom laboratories, the authors made a synthetic seawater sample, analyzed it by traditional methods and sent it to five custom laboratories (Table 1). The synthetic seawater had a measured conductivity of 49,800 µmhos, a reasonable expectation for normal seawater. The traditional methods of analysis provided ionic concentrations similar to expected concentrations, the charge balance was 1.03, and the total concentration of measured ions was similar to the estimated total ion concentration.

The custom laboratories reported conductivities ranging from 41,540 to 55,279 µmhos. The range in concentrations of individual cations was huge – 361-1,045 mg/L for potassium, 258-694 mg/L for calcium and 5,229-22,179 mg/L for chloride.

Table 1. Results of analyses of major ions in synthetic seawater measured by traditional methods and custom laboratories using ICP-AES.

Ion	Weighed Amount	Traditional Analysis	Laboratory				
			1	2	3	4	5
Bicarbonate (mg/L)	145	136	117	129	145	179	150
Chloride (mg/L)	19,488	20,660	20,000	22,179	19,500	5,229	5,260
Sulfate (mg/L)	2,719	2,677	2,700	3,077	2,698	2,464	2,172
Calcium (mg/L)	409	340	694	404	258	411	281
Magnesium (mg/L)	1,304	1,276	2,238	1,352	1,266	1,199	687
Sodium (mg/L)	10,853	11,260	27,487	10,172	9,343	10,050	11,105
Potassium (mg/L)	383	412	1,045	533	508	405	361
Total (mg/L)	35,301	36,761	54,261	37,846	33,718	19,937	20,016
Conductivity (µmhos/cm)	–	49,800	41,540	47,900	49,800	55,279	54,200
Total ions, estimated (mg/L)	–	34,860	29,078	33,530	34,860	38,695	37,940
Anions ÷ cations	0.999	1.030	0.431	1.178	1.135	0.356	0.349
$Total_m$ ÷ $total_e$	–	1.055	1.866	1.129	0.967	0.515	0.528

$Total_m$ = Measured total (sum of ions). $Total_e$ = Specific conductance x 0.7.

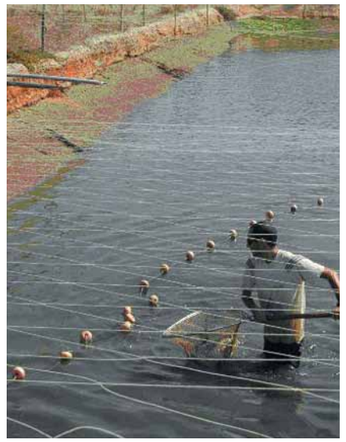
The charge balances for the results from the five laboratories ranged from 0.349 to 1.178, while the ratio of total measured ion concentration to estimated total ion concentration varied from 0.515 to 1.866. Only two of the laboratories provided results that reflected the actual composition of the sample.

Reliability Of Results

Although these findings do not bode well for the accuracy of ICP-AES analyses conducted by laboratories, most custom laboratories mainly run samples of a particular type – soil samples in the case of the laboratories used to test the synthetic water. In spite of the fact that these laboratories also do routine water analyses, they may not always adjust the ICP-AES methodology accordingly.

In fact, laboratory 1 that provided fairly reasonable results in Table 1 was the same laboratory that had earlier provided erroneously high results for the seawater sample discussed above. Before sending the synthetic seawater sample, the problem of the earlier seawater analysis was discussed with the lab director. Despite his icy response during the conversation, he apparently took heed, for the laboratory performed much better on the synthetic seawater sample.

In spite of the fact that these laboratories also do routine water analyses, they may not always adjust the ICP-AES methodology accordingly.



Captured meagre broodstock were adapted to captivity in a process that tends to take longer than for other farmed marine fish.

Portuguese Research Studies Meagre Production In Earthen Ponds

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Summary:
The meagre is a fast-growing fish species with good feed conversion that is a candidate for expanded aquaculture in the Mediterranean. The challenges of a lengthy adaption to captivity and susceptibility to external parasites are being addressed, and wild-caught broodstock now spawn regularly. Meagre grown out in earthern ponds were more resistant to diseases than more common farmed species, and attained almost 2 kg in two years, a higher yield than for other European marine species.

The meagre, *Argyrosomus regius*, is a fast-growing fish species with good feed-conversion rates that is a candidate for expanded aquaculture in the Mediterranean. Meagre production started in the late 1990s in France and Italy, but since then has spread to Spain, Egypt, Greece, Turkey, Malta and Portugal. Overall meagre production is still very limited, probably around 5,000 mt total annually, but it is expected to increase.

Meagre Production At IPIMAR

Studies to advance meagre production have been undertaken at the Instituto de Investigação das Pescas e do Mar (IPMA) Aquaculture Research Station, a 7-ha marine facility located in Olhão, southern Portugal, for research and technological development of species with potential value for the national aquaculture industry.

Meagre broodstock were initially captured in 2007 and adapted to captivity. The adaption took longer than for other farmed marine fish like sea bream and seabass. The meagre did not eat for more than three weeks upon capture, and afterwards ate only live mackerel, delaying the introduction of a frozen diet of sardines and squid. From 2009 onwards, five more breeders were captured, but their adaption to captivity was faster.

Meagre broodstock were also more susceptible to external Monogena parasites than other fish species. Altered behavior, such as fish holding their heads above the water surface, and skin darkening were often observed when parasitosis occurred.

Since 2009, the meagre spawn regularly during April and May, 48 hours after hormonal induction at the IPMA facilities. The fish spawn for only one to three days, with the egg volume higher on the first day. When the juvenile stage is attained, the fish are stocked in earthen ponds to evaluate their growth potential.

Pond Production

A shorter production cycle and lower investments, as well as a decrease in risk, are expected when farming a fast-growing species. Gilthead sea bream and seabass normally attain marketable sizes of about 400 g within 12 to 14 months, respectively, when farmed in earthen ponds from 20 g.

At the IPMA facilities, two farming protocols were used to evaluate meagre growth potential in 3,500-m^3 earthen ponds, monoculture and polyculture with *S. aurata* and *Diplodus vulgaris*. Fish had a consistent initial weight of 15 g when stocked, but in the monoculture treatment, meagre were prefattened in 18-m^3 outdoor fiber tanks before being transferred to earthen ponds at 300 g. In the polyculture

Meagre produced under monoculture reached 1 kg in earthen ponds at IPMA in Portugal. Fish raised in polyculture with sea bream were considerably smaller.

farming, meagre were directly stocked in the earthen ponds.

The meagre attained 563 ± 170 g (0.5 kg/m^3) within 15 months when farmed in monoculture and grew to above 1 kg five months later. When meagre were farmed with sea bream, it took 20 months to attain 300 g (Figure 1). The differences in fish weight at stocking, as well as the higher levels of water quality, cleaning and access to food in the tanks accounted for the observed differences in growth.

However, meagre feeding behavior and/or the initial stocking size, which was four times smaller than the size of the sea bream in the polyculture ponds, might have contributed to the magnitude of the growout weight difference. Sea bream have a more aggressive feeding behavior than meagre, which could have limited access to food for the meagre, especially during the first months.

Further studies with other species and different initial stocking densities are needed to confirm these observations, as well as improvements in feed distribution for greater growth. Increasing the number of meals and/or the number of automatic feeders could be a helpful strategy for the polyculture of meagre with sea bream.

Trial Results

Meagre farmed in polyculture and monoculture achieved different average weights after 29 months of growout: 879 ± 262.2 g and 1,968 ± 411.5 g (Figure 1), respectively. Differences in growth rates were mainly observed during the first 16 months, after which similar growth rates were observed for both production systems. At IPMA, meagre attained sizes above 1 kg faster than gilthead sea bream and seabass, which took 45 and 40 months, respectively, to reach 1 kg.

Meagre performance can still be improved, since the fish were fed commercial feeds for sea bream. During the prefattening period, feed-conversion ratios of 1.1 were obtained for meagre, suggesting that growth can be enhanced if adequate feed formulations are used. Water temperature greatly affected meagre growth, especially during the winter season.

As expected, the highest specific growth rates – 1.5-2.3%/day – were observed during the first 12 months of growout. It was also during this period that lower water temperatures had a higher impact on growth (Figure 1). Two periods of growth could be roughly identified: faster growth during May and October, and slower growth between November and April.

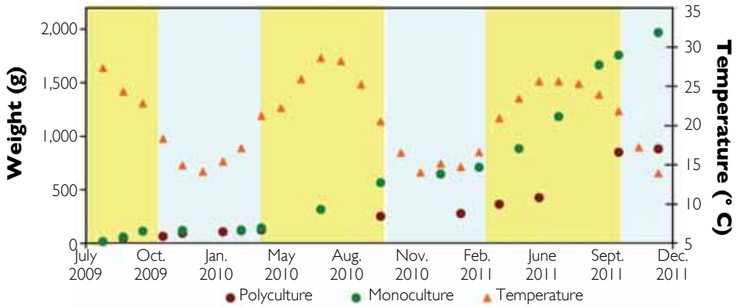

Figure 1. Influence of temperature on meagre grown in earthen ponds in monoculture or polyculture with gilthead and common two-banded sea bream.

Growth seemed to slow down when water temperatures fell below 22° C, but meagre feeding behavior was clearly depressed at temperatures below 17° C. Eating almost stopped below 15° C, whereas gilthead sea bream feed normally down to 13° C. Although southern Portugal has a mild winter on the coast, temperatures below 15° C are registered December through February.

During growout, meagre were more resistant to common diseases affecting other marine fish. At IPMA, the parasites *Amyloodinium ocellatum* and different *Lamelodiscus* and *Diplectanum* species were identified in meagre reared in polyculture, but mortalities were only observed where *A. ocellatum* was present. The meagre farmed under monoculture were not affected by *A. ocellatum*, suggesting the sea bream might have been a disease vector.

Although cultured meagre seem less susceptible to diseases than sea bream, seabass and sole, the intensification of production and/or polyculture with other species may result in disease outbreaks. It is important to follow the basic rules of hygiene and protect fish welfare by controlling density and water quality to prevent such outbreaks.

Market Acceptance

Although wild meagre that weigh 8 to 10 kg are common in the markets of southern European countries, where they are typically sold as portions, the taste and nutritional value of this species are unknown to consumers in other countries.

Farmed meagre in 600- to 800-g portion sizes priced below 4€/kg (U.S. $5.33/kg) were not well accepted by consumers due to the darker skin, larger bones and less flesh than those found in meagre above 1 kg. However, studies on portion-size farmed meagre found good overall acceptance by a sensory panel of 20 people.

About 70% of the panel moderately liked or very much liked cooked meagre fillets. In relation to sensory attributes, 72% of the panel liked slightly to moderately the taste of meagre, while its texture was a less-appreciated attribute. In fact, the fillets were considered somewhat soft – a perception confirmed by instrumental measurements. Nutritionally, the fish were found to have a low fat content in the range of 0.9 to 1.6%, but a balanced ratio of omega-3:omega-6 fatty acids.

The supply of Atlantic salmon increased dramatically over the past two decades. Salmon from Norway now claim a major market share in European countries.

Fresh Salmon Product Demand, Competition In Europe

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Summary:
Salmon production has long been dominated by Norway, while the United States, Canada and United Kingdom have experienced slow expansion in recent years, and Chile saw a fall and rebound in volume. Norwegian product leads fresh salmon imports in European markets, but increases in price can shift sourcing to Ireland and the U.K. However, most of the cross-price elasticities are insufficient to classify salmon from the other countries as a substitute for Norwegian salmon.

The supply of Atlantic salmon increased dramatically over the past two decades, with Norwegian producers driving much of the growth. While other salmon-exporting countries made minor expansions over the past two decades, Norwegian salmon production increased almost 600%. Chile was the only country with a similar rate of increase until infectious salmon anemia hit the sector. Although Chilean salmon is making a rebound, Norway continues to be the dominating producer in salmon production.

Figure 1 shows the production of Atlantic salmon over the past two decades. It reflects the slow expansion in the United States, Canada and United Kingdom during the second half of the period. It also shows the rise, fall and rebound of Chilean salmon, and the increasing dominance of Norwegian salmon production in recent years.

Global, Regional Positions

It is evident that Norwegian salmon is the market leader in the global market, followed by Chilean salmon. The European market, however, mainly demands Norwegian, British and Irish farmed salmon, with limited penetration of frozen Chilean salmon.

To what extent are global positions in the salmon market reflected in individual markets in Europe, and to what degree does the demand for fresh salmon products from the market leader Norway face significant price substitution effects from competing salmon supplier countries?

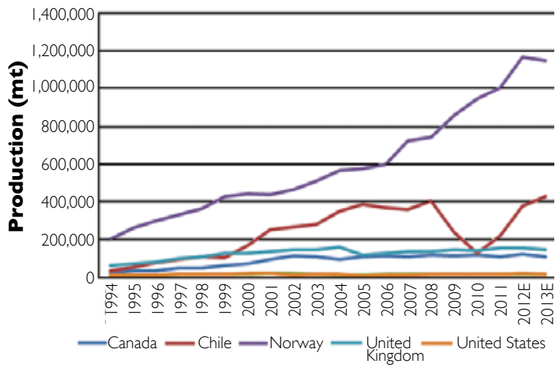

Figure 1. Atlantic salmon production.

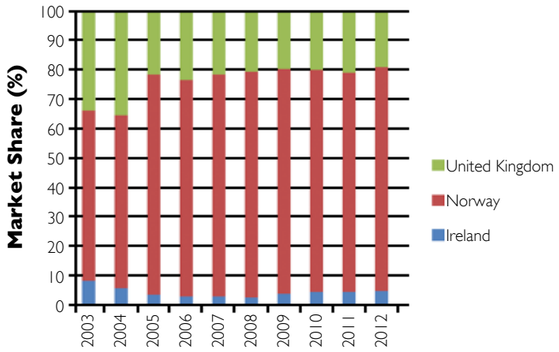

Figure 2. Market shares for French imports of fresh whole salmon.

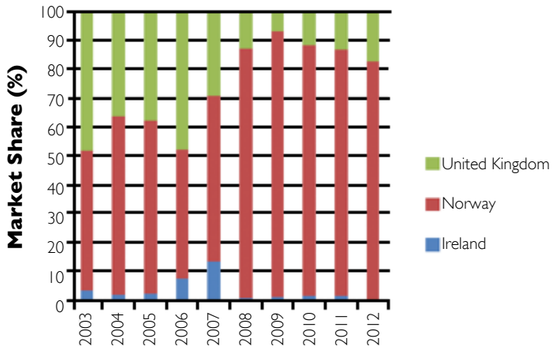

Figure 3. Market shares for German imports of fresh salmon fillets.

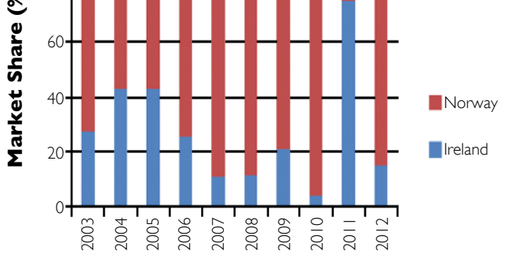

Figure 4. Market shares for U.K. imports of fresh salmon fillets.

French Market

In France, the market for fresh whole salmon products (Figure 2) is divided among fish from the U.K., Norway and Ireland. Although there were some changes in market shares in the past decade, major shifts among the three exporting countries were unnoticeable in recent years. Norwegian fresh whole salmon products maintained their leading market share, while British and Irish salmon kept their constant market shares after 2005.

Unlike the market for fresh whole salmon, where U.K. exports play a significant role, the French market for fresh salmon fillets was dominated by Norwegian imports, with their 90% market share since 2003. Norwegian production started to surpass British volume after 2000 and almost eliminated imports from Ireland in the last decade.

German Market

Although Norwegian salmon led in Germany's imports of whole and fillet salmon, they were more dominant in the fresh whole section. As for fresh salmon fillets, imports from the U.K. made their way into the German market after 2000 but declined after 2006 (Figure 3).

United Kingdom Market

In the British market for fresh whole salmon and fresh fillets, Norwegian and Irish salmon compete against each other as well as the domestic production. Although Norwegian salmon play a significant if not dominant role here, their dominance is less consistent than in the French and German markets.

Ireland plays a much bigger role in the U.K. market than in the French and German markets. Aside from the fact that U.K. has its own salmon production, and hence Norwegian salmon is at a disadvantage, another explanation can be the distance between U.K. and Ireland. Since Ireland and U.K. are much closer to each other, lower transportation cost and superiority in freshness can contribute to demand.

An interesting development in the U.K. market for fresh salmon filleted products occurred from 2011 to 2012 (Figure 4). The market was taken over by Irish salmon products for the first time, but lost again in the next year. Price played a major factor.

There was a price increase from €6.56 to €9.26 (U.S. $8.50 to $12.00) for Norwegian salmon from 2010 to 2011, where Irish salmon cost only €3.93 (U.S. $5.09) in 2011. However, Irish salmon filleted products rose to €12.59/kg (U.S. $16.32/kg) in 2012, when Norwegian salmon prices dropped to €4.92/kg (U.S. $6.37/kg). Although various factors contributed to the price shifts, the demand for salmon products in the U.K. market depends highly on prices.

Short-Term Elasticity

Short-term elasticities of demand for these importing markets can be estimated using econometric models. Separate models are estimated for fresh whole and fresh fillet salmon for the French, German and U.K. salmon markets.

French Market

Table 1 shows the short-term elasticities of Norwegian fresh whole salmon in the French market. It indicates that an increase in Norwegian salmon price will result in a -0.88 decrease in demand. And while insignificant, Irish and British salmon are substitutes for Norwegian salmon, because the increase in Norwegian salmon price results in higher demand for the salmon from these two exporters. The expenditure elasticity is significantly positive at 0.967.

When estimating the elasticities of Norwegian fresh filleted salmon in the French market (Table 1), an increase in Norwegian salmon price still results in a 0.870 decrease in Norwegian salmon demand. However, the cross-price elasticities for Irish and British salmon are highly insignificant, indicating limited substitution and competition with Norwegian salmon. The expenditure elasticity is significantly positive at 1.096.

German Market

In the German market for fresh whole salmon (Table 2), an increase in the price of Norwegian salmon results in a decrease of 0.86 in demand. The British Atlantic salmon is a substitute for the Norwegian salmon, because an increase in the Norwegian salmon price results in a higher demand for the British import. The Irish cross-price elasticity is not significantly different from

The American Fisheries Society's annual Larval Fish Conference covers the complete spectrum of research (from all habitats and geographic locations) related to fish early life history. The 37th annual meeting will focus on a list of topics of current relevance to larval fish scientists worldwide including advances and novel application of methods for the study of early life history stages of fishes, ecology of early life history stages of fishes, and the effects of ocean acidification and global environmental change on the early life history of fish. Anyone interested in this subject matter can attend the conference.

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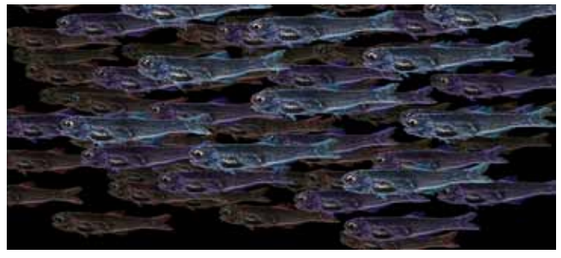

Table 1. Short-term elasticity in French market for fresh Norwegian salmon.

Variable	Coefficient	Standard Error	t	P > t
Whole Salmon				
Import price, Irish (€/kg)	0.090	0.059	1.530	0.128
Import price, Norwegian (€/kg)	-0.875	0.084	-10.440	0
Import price, United Kingdom (€/kg)	0.156	0.097	1.610	0.109
Total import value	0.967	0.064	15.080	0
Salmon Fillets				
Import price, Irish (€/kg)	-0.036	0.044	-0.820	0.414
Import price, Norwegian (€/kg)	-0.869	0.149	-5.830	0
Import price, United Kingdom (€/kg)	-0.021	0.083	-0.250	0.804
Total import value	1.096	0.236	4.630	0

Table 2. Short-term elasticity in German market for fresh Norwegian salmon.

Variable	Coefficient	Standard Error	t	P > t
Whole Salmon				
Import price, Irish (€/kg)	0.005	0.031	0.150	0.880
Import price, Norwegian (€/kg)	-0.862	0.082	-10.500	0
Import price, United Kingdom (€/kg)	0.231	0.058	3.990	0
Total import value	0.899	0.037	24.570	0
Salmon Fillets				
Import price, Irish (€/kg)	0.018	0.066	0.280	0.783
Import price, Norwegian (€/kg)	-1.217	0.329	-3.700	0
Import price, United Kingdom (€/kg)	-0.034	0.123	-0.280	0.780
Total import value	1.023	0.201	5.090	0

zero. The expenditure elasticity is significantly positive at 0.89.

In Table 2, an increase in the price of Norwegian fresh filleted salmon leads to a relatively elastic decline of -1.21 in demand. The cross-price elasticities of Irish and U.K. salmon are highly insignificant, suggesting very limited substitution. Norwegian fresh filleted salmon in the German market has significantly positive expenditure elasticity at 1.02.

U.K. Market

Since the main source of salmon in the U.K. market is naturally U.K, the competition for the import market is between Norway and Ireland. An increase in the import price of Norwegian fresh whole salmon caused a decline in its demand by 0.70 (Table 3). Irish salmon is a substitute, but the substitution effect is not statistically significant. The expenditure elasticity is significantly positive at 0.30.

Table 3 describes the short-term elasticities of Norwegian fresh filleted salmon products in the British market. Only the own price elasticity generated a significant result, where an increase in price generated a relatively elastic decline of -1.14 in the demand. The Irish salmon is not a significant substitute. As for the expenditure elasticity, it is positive but statistically insignificant.

Table 3. Short-term elasticity in U.K. market for fresh Norwegian salmon.

Variable	Coefficient	Standard Error	t	P > t
Whole Salmon				
Import price, Irish (€/kg)	0.047	0.111	0.420	0.674
Import price, Norwegian (€/kg)	-0.701	0.185	-3.780	0
Total import value	0.295	0.127	2.320	0.021
Salmon Fillets				
Import price, Irish (€/kg)	0.017	0.219	0.080	0.940
Import price, Norwegian (€/kg)	-1.141	0.506	-2.260	0.027
Total import value	0.137	0.487	0.280	0.780

Long-Term Elasticities

Long-term elasticities for salmon imports into the French, German, and British markets can also be estimated from the models. These estimates always have the same sign as the short-term elasticities, and the elasticity estimates are, as expected, similar in terms of statistical significance.

In summary, while an increase in Norwegian salmon prices always causes a decline in its demand, most of the cross-price elasticities are insignificant to classify salmon from the other sources as a substitute for the Norwegian salmon, with the exception of British fresh whole salmon in the German market.

Perspectives

The global position of Norwegian salmon is largely reflected in its market shares in the French and German fresh salmon import markets. Although there have been shifts, Norwegian fresh salmon remain dominant. In the U.K., the situation is a bit different, with the market having significant domestic production.

Overall, there is limited evidence of substitution between Norwegian fresh salmon and Irish and British product in terms of cross-price elasticities, both in the short and long run. To some extent, this probably reflects the inability of British and Irish salmon producers to respond to relative price changes with significant increases in supply, due to different restrictions on their production.

However, the intra-Norwegian competition among different Norwegian companies, as well as the competition with British and Irish salmon, means that prices for Norwegian fresh salmon products will not be allowed to rise to significantly higher levels in the long run.

Overall, there is limited evidence of substitution between Norwegian fresh salmon and Irish and British product in terms of cross-price elasticities, both in the short and long run.

Price Transmission In Seafood Value Chain

Case Study In Spain Shows Retailers Favor Farmed Products

Retailers focus interest on species whose prices decrease, allowing larger margins even with decreases in retail prices.

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Summary:
An FAO research project that studied value chains for wild and farmed seafood analyzed the impacts of varied market conditions on the transmission of prices from farms to consumers. Changes in retail prices were less pronounced than in producer or wholesaler prices, as retailers tended to flatten price variations. Value added by wholesalers was higher for wild species with limited imports. Retail farmed fish prices were more closely linked with the evolution of pricing across the value chain.

The profits and welfare of farmers and their communities are dependent on the ex-farm prices of their products. These prices are ultimately set by the retail demand for seafood. Under perfect competitive conditions along the different agents in the value chain, a shock in the prices at origin results in change in retail prices in the same direction and intensity. When this happens, it is said that perfect price transmission operates along the value chain of the commodity.

The assumption of perfect competition may be appropriate when applied to setting the prices of fish at the ends of the chain (origin/retail), but may be inappropriate for setting prices among agents participating in different stages and levels of the seafood value chain. In many industrialized countries, a few supermarket chains account for a very large share of retail sales of seafood products. Therefore, non-competitive pricing at the different stages of the seafood supply chain can have important implications for fishermen and fish farmers.

The consequences of imperfect price transmission not only affect the profits of farmers and fishermen, but also the demand of final consumers.

FAO/NORAD Project

Between 2010 and 2012, the Fishery Market Division of the Food and Agriculture Organization (FAO) of the United Nations led a research project with support from the Norwegian Agency of Development (NORAD) focused on the study of value chains of different wild and farmed seafood species in developed and developing countries. The main goal of the project was to test market competitive conditions along the different stages of the value chains and analyze the impacts of the varied market conditions on the transmission of prices from farms to final consumers.

Two alternative methodologies were used to study price transmission based on the availability of data. Structural data were used to test competitive equilibrium in a three-equation model measuring variations in the marketing margins, retail prices and ex-vessel/ex-farm prices. The independent variables used in these models were the supply quantities in origin, a retail demand shifter and marketing costs.

Data for all variables were not available in all the participating countries. Alternative reduced-form models based on cointegration analysis across the prices at the different levels of the chain allowed price transmission testing in those cases with no additional data.

Seafood Value Chain In Spain

The results for the Spanish case suggested that different species operated under different market conditions. Structural models differed from one species to another in terms of overall and parameter significances.

Price transmission was less effective in wild species dominated by local landings of fish like sardines, mackerel or blue whiting. In contrast, species with significant shares of imports like hake or anchovies were more competitive, and the inclusion of import prices in the analysis improved cointegration across all the prices. During the 2004 to 2011 period, the prices of wild species with significant shares of imports decreased or moderately increased even in periods of shortage in local supply. Prices for farmed species were more integrated than those for the wild fish.

Figure 1. Price changes at different levels of the value chain, 2004-2011.

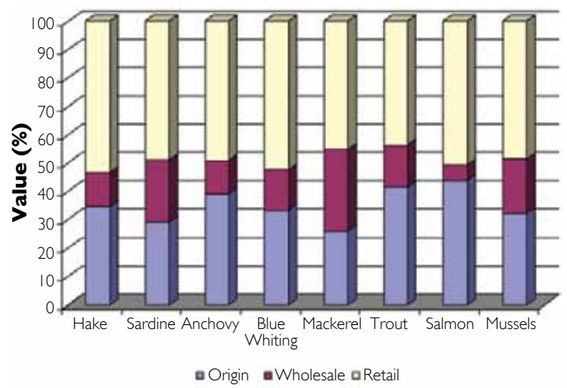

Figure 2. Contributions to final product value, 2004-2011.

Whether locally raised or imported, price transmission could not be ignored – even in the less-diversified models – excluding competition between local and imported products. Changes in retail prices were less pronounced than for producers or wholesalers. Retailers were flattening the variations of prices in the previous stages of the chain. But changes in farmed fish species were better linked with the evolution of prices in origin (Figure 1).

Value added by wholesalers was higher for wild species with low levels of imports. All the species showed a decrease in retailers' contributions to final value. Wholesalers' contributions to final product value were lower for farmed species than wild fish, with the exception of mussels. This level of value change lost importance when the market of the species was dominated by farmed fish. As wholesalers reduced their contributions in the value chain, retailers improved their profits (Figure 2).

Consumers' demand elasticity prevents significant rises in retail prices, making trade of species with large contributions from wholesalers less interesting for retailers. Although salmon and trout prices increased in the observed period, the impacts on retailers' profits were lower than for wild species. Even in periods with low stability in aquaculture prices, farmed products were more profitable for traders than wild species, especially if the former were dominated by local production.

Considerations For Farmed Species

Retailers focus interest on species whose prices decrease, allowing larger margins even with decreases in retail prices. Some farmed species increased their prices in the observed period, resulting in reduced profits for retailers. However, the decrease in retailers' margins was, in all cases, lower than the average decrease observed with wild species.

Retailers' decisions affect volumes of trade and consumption. In the observed period, species with decreasing prices and farmed fish were preferred over other wild species. But trends in prices are changing for some species, making them more or less attractive. In a perfect price transmission framework, farmed fish benefit from decreases in price, as this impacts retail prices and helps increase demand.

Asian Shrimp Buying 'Active and Building'

Imports from India, driven by the introduction of white shrimp, have steadily grown over the last several years.

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Summary:
Imports to the U.S. of most shrimp categories were lower in February. Asian buying interest continues to rise. Disease is affecting production in Vietnam and Thailand, and pending countervailing duties are clouding the market. In February, fresh whole salmon YTD figures continued the year with a decrease, while fresh fillet imports were 24% up from 2012 YTD. Imports of whole frozen tilapia rose in February, along with much higher figures for fresh fillets. Sales during Lent were rated normal, and pricing remained steady. Following a seasonal pattern, imports of frozen fillets declined. U.S. imports of channel catfish continue to struggle. Duties on *Pangasius* imports could potentially affect import volumes. Pricing levels have reached levels not seen since 2010. New shipments will cost more.

Imports of shrimp to the United States were down over 6% in February, pushing year-to-date (YTD) imports over 9% lower (Table 1). Peeled imports were higher in February, but all other categories were lower. Imports from India continued higher than a year ago. Vietnamese imports were also higher. The top five producing countries accounted for 62% of U.S. shrimp imports in 2012 and so are representative of the market and likely to dictate its course.

Although imports from Indonesia do not peak until later in the year, U.S. imports between March and May over the last two years have been significant. Through February, imports from Indonesia were down 10.5% but were significantly higher than in 2010 and 2011. Buying pressure from regions beyond the U.S. may curtail exports to the country.

Buying pressure has been on Ecuador recently as one of the only heavily active shrimp-producing regions. Asian buying interest has been particularly active and building, along with traditional European and U.S. buying.

Imports of Ecuador's shrimp were down almost 12% through February. The Latin American headless, shell-on (HLSO) market is currently dominated by Ecuadorian offerings. That market, which is sensitive to current spot conditions because of the short shipping time to the U.S., continued to see strength in April.

India will be the next major shrimp producer to come on line with production resuming in April and U.S. imports ramping up in May/June. Imports from India, driven by the introduction of white shrimp, have steadily grown over the last several years. Shrimp imports through February were 60% higher than in 2012. Last year, Indian product centered on 16-20 through 26-30 HLSO and also peeled shrimp.

U.S. shrimp imports from Vietnam through February were down almost 9.6%. However, as with Indonesia, imports were higher than in 2010 and 2011. Vietnam's shrimp production has been affected by disease and lack of investment. Concerns remain high regarding upcoming shrimp production.

Thailand is the United States' largest supplier of shrimp and the biggest unknown. Imports were down 20.7% through February and not expected to improve in the first quarter. Early mortality syndrome has had a significant effect on Thai shrimp production. In addition, buying interest from other Asian countries has further limited U.S. imports.

Steps are being taken to combat disease and production problems, but there is no certainty about the results. Many report there will be some indication by mid-April regarding the success of steps to rectify the disease situation. But imports will likely not begin to build until June under the best circumstances.

Table 1. Snapshot of U.S. shrimp imports, February 2013.

Form	February 2013 (1,000 lb)	January 2013 (1,000 lb)	Change (Month)	February 2012 (1,000 lb)	Change (Year)	YTD 2013 (1,000 lb)	YTD 2012 (1,000 lb)	Change (Year)
Shell-on	25,674	34,210	-24.95%	33,720	-23.86%	59,884	74,874	-20.02%
Peeled	32,471	42,940	-24.38%	29,044	11.80%	75,411	70,073	7.62%
Cooked	8,146	12,221	-33.34%	9,634	-15.45%	20,368	28,425	-28.34%
Breaded	5,213	8,662	-39.82%	4,398	18.53%	13,875	13,879	-0.03%
Total	71,504	98,033	-27.06%	76,796	-6.89%	169,538	187,251	-9.46%

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

Shrimp Market

The current U.S. shrimp market is strong when selling from inventory, but even higher offerings are noted when based on replacement. Inventories are dwindling, and overseas replacement offerings continue to indicate higher future spot market values. Trading among importers is active to fill holes in inventories. Supplies are closely held as buyers scramble to cover needs for the next several months until seasonal production is available.

Further clouding the outlook for the shrimp market is the May 28 deadline for the preliminary determinations of the Department of Commerce in the countervailing duty investigations of shrimp from China, Ecuador, India, Indonesia, Malaysia, Thailand and Vietnam.

Total YTD imports of salmon were up over 13% in February. Frozen fillets added significantly to the total.

Fresh Salmon Fillet Imports Up 24% From 2012

February year-to-date imports of salmon to the United States began the year with a 13.73% increase when compared to imports from the same time last year (Table 2). Fresh whole fish imports saw YTD figures decrease 6.74%. Fresh fillets were 24.53% up from 2012 YTD levels. Total February month-to-month data was down 9.64% when compared to January, although February imports were 5.39% higher than in February 2012.

Whole Fish

In February, fresh whole fish YTD figures continued the year with a decrease of 6.7% below February 2012 YTD figures. Similarly, a monthly comparison from January revealed a decrease of 13.6%. February imports were 13.8% lower than in February 2012. Imports from Canada were also lower – 7.9% down YTD.

The market during the beginning of April was steady to about steady after a very active start to 2013. Supplies in the Northeast were adequate for a moderate to fair demand. The undertone for the remainder of the month was somewhat unsettled. The market improved during the first part of 2013, and all sizes are now above their three-year price averages.

The West Coast whole fish market was full steady to firm on all sizes in March. April was initially steady to about steady. Supplies in the West Coast market ranged adequate to fully adequate. The undertone going forward was unsettled. Similar to

the Northeast market, most sizes were at or above their three-year averages.

Fillets

In February, YTD figures for U.S. imports of fresh salmon fillets revealed an increase of 24.5%. Monthly overall fillet imports, however, showed a February total of 18.4 million lb – 0.2% lower than in January.

In contrast, February imports were 19.1% over February 2012 levels. The U.S. imported 15.3 million lb from Chile during the month of February. Imports from Chile were 40.4% higher YTD, as 30.2 million lb have been imported thus far for 2013.

In early April, the market ranged about steady to weak. Since the end of Lent, supplies on the spot market improved, and demand ranged moderate to quiet. The undertone for the balance of the month was unsettled. All sizes were above their three-year price averages. The European fillet market remained unchanged with supplies adequate for moderate to fair demand.

Table 2. Snapshot of U.S. salmon imports, February 2013.

Form	February 2013 (lb)	January 2013 (lb)	Change (Month)	February 2012 (lb)	Change (Year)	YTD 2013 (lb)	YTD 2012 (lb)	Change (Year)
Fresh whole fish	16,040,453	18,556,248	-13.56%	18,611,115	-13.81%	34,596,702	37,098,490	-6.74%
Frozen whole fish	401,118	240,271	66.94%	512,643	-21.75%	641,389	977,209	-34.37%
Fresh fillets	18,431,930	18,466,835	-0.19%	15,477,825	19.09%	36,898,767	29,630,421	24.53%
Frozen fillets	6,481,657	8,501,676	-23.76%	4,638,959	39.72%	14,983,332	8,896,713	68.41%
Total	41,355,158	45,765,030	-9.64%	39,240,542	5.39%	87,120,190	76,602,833	13.73%

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

Frozen Whole Tilapia, Fresh Fillet Imports Pop

Imports of tilapia fillets rose to levels not seen since 2008.

Frozen Whole Tilapia

February's U.S. imports of whole tilapia increased over 10% from the previous month, a behavior that has not been historically seasonal. On a YTD basis, imports were off 15%, while compared to February 2012 levels, imports managed to surge by 12% (Table 3).

Fresh Fillets

Contrary to what has been noted on the frozen market, the fresh fillet market saw levels for January and February not seen since 2008, when imports reached record highs. An early Lenten season this year could have spurred larger volumes to the U.S., but relatively weaker prices compared to those seen in December proved supplies were fully adequate.

The Lenten season was adequately supplied, according to many traders in the U.S., with slight to negligible price variations throughout. Figures from Costa Rica will be published as reported by the U.S. Department of Commerce, but they will continue to be revised for errors. Although pricing adjusted slightly lower in December 2012, sales during Lent were rated normal, and pricing remained steady at listed levels.

Frozen Fillets

Following a clear seasonal pattern, imports of frozen fillets in February declined from the previous month. However, similar to the *Pangasius* market, imports in February were down when compared to the same month a year ago. Pricing in the U.S. has moved modestly higher over the course of the last three months amid rising replacement costs. At the moment, the market is full steady with traders testing the market with higher asking prices.

Table 3. Snapshot of U.S. tilapia imports, February 2013.

Form	February 2013 (lb)	January 2013 (lb)	Change (Month)	February 2012 (lb)	Change (Year)	YTD 2013 (lb)	YTD 2012 (lb)	Change (Year)
Fresh fillets	5,277,076	5,045,902	4.58%	4,709,084	12.06%	10,336,993	8,099,213	27.63%
Frozen whole fish	7,617,430	6,816,250	11.75%	6,801,177	12.00%	14,433,682	16,989,311	-15.04%
Frozen fillets	27,269,248	38,154,811	-28.53%	28,388,013	-3.94%	65,424,058	75,341,577	-13.16%
Total	40,163,754	50,016,963	-19.70%	39,898,274	0.67%	90,194,733	100,430,101	-10.19%

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

U.S. Import Duties Could Affect *Pangasius* Markets

Channel Catfish

In February, U.S. imports of frozen channel catfish were lower than those for the first two months of 2012. The imports in 2013 have been well below the three-year average.

Pricing has continued to trend lower as sellers try to move carried inventories. In addition, February figures showed lower replacement costs, which according to many sellers, gradually permitted asking prices to adjust lower. However, a few importers recently reported that replacement costs could be reaching a floor based on current offerings from packers.

Although U.S. imports of *Pangasius* ended 2012 on a record high, prices and supplies are shifting for 2013.

Pangasius

Although U.S. imports of *Pangasius* ended 2012 on a record high, a downward trend during the last quarter of 2012 could signal a change. To start with, January imports were notoriously lower than those in January 2012, falling over 30%. However, imports in February were the highest recorded for that month. These positioned figures for January and February 20% below those registered a year ago.

In addition, recent developments regarding duties, in which several packers were hit by a substantial increase, could potentially affect import volumes, according to many U.S. sellers. In December 2012, combined imports to the U.S. and Europe of *Pangasius* from Vietnam reached the lowest level since 2010. Data from Europe is only available since then.

From a pricing perspective, levels reached prices not seen since 2010. Trading prices in the U.S. represented by Urner Barry quotations reached the lowest point since May 2010, when prices averaged U.S. $1.68. However, recent developments on the duties issue caused the market to rise overnight. Replacement offerings showed that February imports averaged $1.38, a figure not noted since September 2010. In terms of pricing, at least for now, the new duties mean most new shipments will cost at least $0.35 more per pound.

Table 4. Snapshot of U.S. catfish imports, February 2013.

Form	February 2013 (lb)	January 2013 (lb)	Change (Month)	February 2012 (lb)	Change (Year)	YTD 2013 (lb)	YTD 2012 (lb)	Change (Year)
Pangasius	13,477,860	15,780,231	-14.59%	13,209,837	2.03%	29,258,091	36,598,141	-20.06%
Channel catfish	554,869	816,921	-32.08%	1,267,985	-56.24%	1,371,790	3,159,260	-56.58%
Total	14,032,729	16,597,152	-15.45%	14,477,822	-3.07%	30,629,881	39,757,401	-22.96%

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

As U.S. consumers seek more seafood in their diets, "USDA Organic" status for farmed products is still under government consideration.

U.S. Organic Aquaculture Update: Still Waiting

Summary:
Attendees at a recent conference session heard updates on the status of organic standards for aquaculture in the United States. Progress has been limited on standards recommended by the National Organic Standards Board with input from the Aquaculture Working Group. Petitions for the use of synthetic substances essential for aquaculture remain in process. Meanwhile, U.S. aquaculture producers are free to seek organic certification under third-party private standards or other country standards to legally sell certified products in the U.S.

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As evidenced in a well-attended special session during the Aquaculture 2013 conference in February, many within the United States organic aquaculture community have been experiencing frustration with a slow-moving government approval process and potentially challenging regulations. However, those who attended "Advances and Outlook for Organic Aquaculture – From Policies to Market" also heard that organic seafood can demand a substantial price premium in the U.S.

USDA Role

At the session in Nashville, Tennessee, USA, panel speakers who included officials from the U.S. Department of Agriculture (USDA) addressed the status of organic rule making, as well as the need for the workability of recommended rules.

The United States Organic Food Production Act of 1990 established the National Organic Standards Board (NOSB) to recommend standards for a National Organic Program (NOP) within USDA. The Aquaculture Working Group (AWG), 12 people with diverse expertise and experience in aquaculture appointed by USDA in 2005, advised the NOSB in the development of its 2010 recommendations.

The NOP is considering these recommendations and drafting a proposed rule that will be published in the Federal Register with a 60- to 90-day period of public review and comment. The public rule-making process will create new organic standards for the production and handling of aquatic animals and plants.

Session participants voiced concern about the limited progress since NOSB's recommendations, as well as a potential lack of certainty and consistency with USDA standards in the U.S. seafood market. It was reported that considerable work remains before the public review will occur. USDA has assembled an intra-agency team that is helping to draft the proposed regulations under the guidance of NOP.

Synthetic Essentials

Also of concern were delays by the NOSB in processing petitions for the allowance of 10 synthetic substances that are essential for organic aquaculture of aquatic plants and animals. Such substances include chlorine, vaccines, vitamins and trace minerals.

Under the Organic Food Production Act of 1990, any synthetic (not natural or agricultural) substance used in organic production must be placed on a "national list" by the NOSB. The AWG has had petitions for allowances pending for over a year without action. The petitioning process usually takes one year or longer for designated committees and the full NOSB to act.

Feed Issues

A panel on organic feed led by Ron Hardy of the University of Idaho discussed the proposed NOSB feed recommendations, as well as replacement of fishmeal and oil with wild fisheries by-products, insect meal and algae oil. While fish diets without fishmeal are possible with grain meal substitutes, they require synthetic amino acids for the healthy growth of fish. Unfortunately, organic management proscribes such synthetics.

International Standards

Uncertainties arose at the session about possible conflicts with European Union and Canadian organic aquaculture standards and their diluting effects on the organic standards recommended for the U.S.

NOP's Mark Bradley described how the United States has "equivalency agreements" with these jurisdictions that allow certified products grown and processed under their standards to be labeled as "USDA Organic" in the U.S. with some exceptions. U.S. aquaculture producers are currently free to seek organic certification under third-party private standards or other country standards, and legally sell certified organic products in the U.S.

Brad Hicks of Taplow Feeds and Ram Ramkrishnan of Quality Certification Services compared the European and Canadian organic standards. These standards are considerably simpler and not as restrictive as those proposed by NOSB for the U.S. For example, in the case of feed, the Canadians and E.U. allow fishmeal and oil from trimmings from wild fish caught in sustainably managed fisheries. This is very different from the proposed NOSB rule.

Price Premium

A panel with Carl Salamone, vice president for seafood with Wegmans; Linda O'Dierno of the National Aquaculture Association; and Dick Martin of Black Pearl Seafood presented perspectives on consumer preferences and seafood market information, as well as the rapid growth of organic food sales and the impacts of the "USDA Organic" label in establishing consumer value and trust.

A major positive development was the experience Salamone reported with the Wegmans program of selling E.U.-labeled organic salmon in the U.S. He said that over the past two years, Wegmans sold E.U.-certified salmon with price premiums 75% above the prices for conventional farmed salmon. This indicated price premiums for organic product can be significant and sustainable, so domestic producers of farmed fish and shellfish may be able to profitably operate organic aquaculture facilities.

U.S. aquaculture producers are currently free to seek organic certification under third-party private standards or other country standards, and legally sell certified organic products in the U.S.

Evolution Of Social Responsibility

Collaboration Key To Accountability

Social concerns are now taking center stage with environmental stewardship in the seafood industry.

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Summary:
Social responsibility has been slower to catch on than environmental stewardship in the world of seafood. Recently, however, governments have been increasingly pressured to enforce labor laws, and seafood suppliers are reviewing their supply chains for instances of wrongdoing and injustice. Third-party certification programs can help ensure compliance with labor laws and also bring various players together to address social concerns. Collab-oration will ultimately result in a more accountable seafood-production industry.

For years, social responsibility took a back seat to environmental stewardship.

Environmental stewardship has been at the forefront of the seafood sustainability movement since its emergence in the 1990s, evolving from political cause to corporate ethic and working its way into the farming, fishing and processing practices of the world's leading seafood producers. Care for the environment also became a common element in the procurement policies of seafood retailers and foodservice operators.

It makes good business sense to be environmentally responsible, and codes of practice are focused on the technical factors, which are easy to measure and not so contentious. For example, improved farming practices often lead to reduced incidence of disease, greater yields and increased profitability.

Social responsibility, however, has been slower to catch on than environmental stewardship. Social responsibility is a matter of governance of employment, with national, regional and local governments bearing the brunt of regulation and enforcement.

Limited Enforcement

As with many industries, the labor abuse that can occur within the seafood-production industry is often rooted in a lack of law enforcement. In most developing countries – where most of the world's aquaculture production occurs – the resources set aside for enforcement are limited. The result is that violators often avoid detection, according to Pedro Bueno, a United Nations Food and Agriculture Organization consultant and former director general of the Network of Aquaculture Centres in Asia-Pacific.

The lack of law enforcement could be rectified by self-governance and market-based incentives such as third-party certification, but those approaches have been slower to develop, too, Bueno said.

Bueno was one of six panelists who participated in a discussion on social responsibility at the Global Aquaculture Alliance's GOAL 2012 conference in Bangkok, Thailand. At the time, he said that as environmental responsibility improves, so does social responsibility.

"Being environmentally responsible is already being socially responsible," he said. "An adverse impact on the environment from a farm, such as pollution, and a health impact from a bad practice or unsafe product both translate to adverse social impacts."

Center Stage

But not until recently has social responsibility taken center stage along with environmental stewardship. Governments are being pressured to enforce their labor laws, and seafood suppliers are being pressured to review their supply chains for instances of wrongdoing and injustice.

"The treatment of workers is a natural extension of reviews, and certainly recent news reports – some deserved and some not – have pointed at seafood suppliers to focus on their social-compliance programs," said John Connelly, president of the National Fisheries Institute (NFI), a U.S.-based trade association representing many of the country's leading seafood suppliers.

"NFI has adopted a policy that all members should ensure that third-party audits are conducted on their first-level suppliers and make every effort to ensure those suppliers are going back in the supply chain to review their suppliers," Connelly said. "NFI is also working with distributors, retailers and restaurant operators to determine how to best share the fact that a company has conducted an audit."

Certification

While suppliers in the United States and other key seafood markets are taking the incentive to review their supply chains, third-party certification programs like Best Aquaculture Practices are addressing social responsibility more rigorously. The new BAP standards for finfish and crustacean farms – expected to go live in the spring of 2013 – contain 33 clauses relating to worker safety and employee relations, compared to 14 or fewer in the BAP farm standards they are replacing.

In a recent interview, BAP Standards Coordinator Dan Lee said, "What stands out now is that the requirements are spelled out in greater detail so that program participants can be under no illusions about the high standards needed to get a BAP certificate.

"Examples of topics that are now covered in more detail are child labor, forced or bonded labor, wages, benefits, holidays and overtime, deductions, migrant workers, sub contracted workers, piece workers, contracts and harassment," he said. "On top of all this, there are requirements relating to worker health and safety. So, in total, the requirements amount to a very comprehensive package of assurance."

Collaboration

Third-party certification programs can play a valuable role in ensuring compliance with labor laws. They can also be effective in initiating dialogue and bringing the various players together to deliver improvement.

And, ultimately, it's collaboration that will result in a more accountable seafood-production industry. While the onus often falls on governments to better enforce their labor laws, the world's leading seafood producers and suppliers need to set the tone and refuse to buy or sell seafood from facilities that mistreat their workers.

This means conducting thorough supply-chain reviews, pursuing third-party certification and working with governments, seafood-production organizations and labor interests to develop and implement guidelines that promote better working conditions.

Manoch Sangkeaw, director of problem solving and prevention for Thailand's Department of Labor Protection and Welfare, summed up the need for collaboration well at GOAL 2012, where he said: "Everybody needs to lend a helping hand in addressing labor rights together. If everyone complies, we will not be accused of violating labor rights. And you can say that the product you're exporting is the result of happy workers doing happy work."

While the onus often falls on governments to better enforce their labor laws, the world's leading seafood producers and suppliers need to set the tone and refuse to buy or sell seafood from facilities that mistreat their workers.

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Governments And Seafood Consumption

Part II. Global Campaigns Promote Seafood

Successful promotions can effectively increase the consumption of a variety of healthy seafood products.

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Summary:
Campaigns and promotions on seafood are proving successful in countries around the world. Many of them involve governments working with industry and other institutions to clearly communicate the benefits of seafood. Assistance with recipes and basic guidance on cooking and selection are helpful and informative. Associated seafood price reductions can enhance consumers' willingness to try seafood items and increase their overall consumption.

Campaigns focused on the health benefits of seafood consumption are regularly implemented around the world. Anna Child, an international consultant in the Products, Trade and Marketing Service of FAO Globefish, outlined a list of activities around the world that includes promotional fairs and pro-seafood campaigns of various types. Most incorporated education as well as promotion.

"Slow Fish" In Italy

Some events are especially designed for children, many of which are strongly related to fishing rather than aquaculture. For example, Slow Fish in Genoa, Italy, has been running since 2007 and includes activities on fish designed specifically for children, as these young consumers are often unfamiliar with seafood and how it comes to be on a plate.

The fairs displayed a variety of educational modules through which young consumers could learn about fish and fishing. The children also received hands-on experience about cooking and eating underutilized fish species like horse mackerel and blotched picarel. Educational resources such as guides, games and small aprons with the fish seasons on it were distributed.

Fish Week In Brazil

The Brazilian Association of Supermarkets and the Ministry of Fisheries and Aquaculture in Brazil have been collaborating to hold an annual Fish Week. The event aims to market the health benefits of fish consumption to Brazilian consumers through a large promotional campaign and discounted fish prices. In 2009, more than 300 supermarkets joined the event.

One facet of the program was to convince companies to slightly reduce their profit margins to obtain stronger and more long-term partnerships with markets and consumers. Supermarkets that participated in 2008 experienced a greater than 30% increase in their sales of fish and other categories of complementary products during the promotion period.

In Brazil, seafood consumption was only about 5 kg/capita. The Brazilian government made a number of decisions, not the least of which was the opportunity to farm tilapia. Tilapia production went from zero to 200,000 mt in five years, and not surprisingly, seafood consumption in Brazil is now around 9 kg/capita.

El Salvador Campaign

A joint campaign by the Food and Agriculture Organization of the United Nations and El Salvador's Ministry of Agriculture disseminated attractive and easy-to-read materials promoting seafood's health benefits, marketing fish as a "source of life" with "the nutrition that you need" and recommending eating seafood at least twice a week. The materials also provided helpful tips for home fish consumption. The project was called "Feed Your Stomach and Your Brain," and a number of promotional materials were created.

As consumers' experience in selecting and eating seafood grows, so does their interest in trying new species.

Indonesian Fairs

It is very important to get the seafood story out to young women, the mothers of the future. To that end, in 2011, the Indonesia Marine and Fisheries Ministry began holding a series of promotional fairs on the benefits of consuming fish, specifically targeting pregnant mothers.

These events were part of a government program aimed at increasing fish consumption nationwide. National annual fish consumption in 2010 was 30.47 kg/capita, but the government hopes to raise the figure to 38.00 kg by 2014.

The Indonesian maritime affairs and fisheries minister, Fadel Muhammad, said the government targeted pregnant mothers for the campaign because survey results found that many Indonesian children lacked omega-3s in their diets. The fatty acids are thought to strengthen infants' immune systems and prospects for healthy growth. Promotional fairs were held in villages across the country using local languages.

Bangladesh National Fisheries Week

Countries like Bangladesh understand the importance of seafood. In July of 2011, a National Fisheries Week was inaugurated in Bangladesh with a target to produce 3.5 mmt of fish by the end of 2013 and 4.2 mmt by the end of 2021. This is seen as a significant step toward Bangladesh achieving food security and sovereignty. Currently, the fish sector supplies 60% of the country's animal protein, 3% of export earnings and nearly 4% of the total gross domestic product.

The 2011 National Fisheries Week theme was "Produce Safe Fish to Change Bangladesh." The Fisheries and Livestock Ministry provided support with workshops and technical training. The week also aimed to increase awareness of fish in citizens through fish fairs, publication of supplementary information in national newspapers, telecasts, essay writing and a painting competition.

Poland: Mr. Carp

Following investments in seafood promotion made by the Czechs, Poland created the "Mr. Carp Campaign." The Inland Fisheries Institute in Olsztyn and the Fish Promotion Society conducted a promotional campaign for carp, the most traditional Polish aquaculture product. The campaign was largely a result of carp breeders facing growing competition from outside the European Union. Supported with funds from the E.U., the campaign sought to reassert carp's position in the market.

Denmark's Twice A Week

The Seafish Authority in the United Kingdom and the Danish government have both emphasized the "Twice a Week" approach.

When it was discovered that Danes do not eat enough fish, a campaign was coordinated by Fiskebranchen, an umbrella organization that brings together players in the fisheries and aquaculture sectors. In order to make the campaign successful, efforts were coordinated among the seafood industry, Denmark's Technical University, the Heart Foundation and most importantly, the retail segment.

Formative work by researchers from the university and the Danish Heart Foundation demonstrated several specific reasons for consumers not eating enough fish. These included the perception that fish was difficult to prepare and not readily available, as well as a lack of clarity about the amounts to eat and its benefits.

From this formative work, specific campaign messages were developed to achieve objectives, such as familiarizing consumers with the dietary advice of the Danish Veterinary Food Administration and encouraging retail chains to increase the range of fish sold. The campaign also sought to increase overall seafood consumption by educating consumers that fish is tasty and easy to prepare and motivating consumers to change their consumption habits.

The campaign also sought to increase overall seafood consumption by educating consumers that fish is tasty and easy to prepare and motivating consumers to change their consumption habits.

A website was developed to provide information about fish, including two new recipes each week. A link on the website allowed users to sign up for a weekly newsletter that would include recipes, and there are now over 52,000 subscribers. A cookbook with simple recipes for daily cooking and special occasions proved to be quite popular, with 1.7 million copies printed and distributed. Organizers noted that the most difficult part of the campaign was increasing awareness about the availability of fish and getting retailers to reduce their prices.

Researchers who analyzed the impacts of the campaign found that fish consumption, in fact, increased. They found that in 2009, sales of fish had increased by 14,000 mt and €21.5 million from pre-promotion levels in 2005, although some of the increase in value could be attributed to price increases for fish of over 20% between 2005 and 2009.

The analysis also found the campaign increased the visibility of fish at retailers, in discount catalogs, on the Internet and in public spaces, with consumers having more experience selecting and cooking fish. Lastly, the analysis concluded that the main existing barrier to fish consumption was that consumers still regarded fish as expensive.

The Twice a Week logo was widely used by producers, retailers and fishmongers and in all the promotional material. After running the campaign for two years, the logo was recognized by 76% of the population in Denmark.

Perspectives

These examples show that campaigns and promotions on seafood can be very successful. Many of them include governments working with industry and other institutions, and clearly they focus on the strengths of the benefits of seafood.

We need to challenge our own governments to get involved and follow these successful concepts. If we do that, we will not only make the world a healthier place, but also assist in creating more jobs and opportunities for young people. Let us work together on this.

By-Product Utilization For Increased Profitability

Part V. Fish Protein Hydrolysate Applications

Fish protein hydrolysates are used in antioxidants, emulsifiers, flavoring agents and antibacterial agents. They are also associated with the prevention of cardiovascular disease.

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Summary:
Fish protein hydrolysates have been used in the food industry for the development of antioxidants, emulsifiers, flavoring agents, antibacterial agents and feed. As natural products, they have a growing acceptance, since natural products are preferred by some consumers over industrial products. Also, hydrolysates have received interest in medical science for their prevention of cardiovascular disease and blood pressure-regulating function. Many hydrolysates are excellent nitrogen sources for industrial fermentation and microbial media.

Fish protein hydrolysates have extensive applications in food, medicine, feed and industrial products. As aquaculture operations continue to increase in size and number, the possibility of obtaining sufficient concentrations of by-products for commercial production of hydrolysates becomes economically feasible. Also, many of the hydrolysates are natural products and therefore have more appeal to consumers as the green movement continues to globally expand.

Antioxidants

Free radical modification of nucleic acids, proteins, lipids and small cellular molecules is associated with a number of diseases, including cancer, liver disease, Alzheimer's disease, arthritis, diabetes, Parkinson's disease, atherosclerosis and AIDS. In addition, radical-mediated lipid peroxidation negatively impacts the flavor, texture, nutritive value and shelf life of food products and even produces toxins.

In order to act against these deleterious oxidative-induced reactions in food and biological systems, many synthetic and natural antioxidants have been used. Fish protein hydrolysates have been reported to possess antioxidative and antihypertensive properties. The bioactive properties responsible for these properties are released upon endogenous or exogenous enzyme hydrolysis of fish proteins.

Antioxidant activity has been reported for protein hydrolysates from various fish sources, such as tilapia, shrimp, abalone, squid, echinoderms, capelin, mackerel, yellowfin sole, Alaska pollack, Atlantic salmon, hoki, conger eel, scad, tuna, grass carp, oysters, bigeye tuna, sardinelle, red snapper, mahi-mahi, scallops and channel catfish.

Emulsifiers

The degree of hydrolysis does not usually affect the emulsifying capacity, activity index or stability of fish protein hydrolysates. Emulsifying capacity higher than for sodium caseinate, used as a control, was obtained at pH 4 for most hydrolysates. The hydrolysates showed very low foaming capacity not affected by pH, but foam stability was equal or even better than in bovine serum albumin, except at pH 4. Research results suggested that fish protein hydrolysates can be produced with similar or better functional properties than the food ingredients used as standards.

Flavoring Agents

The practical application of mussel meat hydrolysate is its use as flavoring in products such as soups, sauces and special

beverages. In addition, the product is partially digested and has great nutritional value due to its good amino acid profile. It can thus be used as a food supplement in special diets.

Cardiovascular Disease

Significant research efforts on the prevention and treatment of cardiovascular disease have identified elevated plasma cholesterol as a primary risk factor. A hydrolysate produced from the freshwater clam *Corbicula fluminea* and marine red algae, *Gracilaria tenuistipitata*, was fed to rats and compared to several control diets. Plasma triacylgly-cerol levels were shown to decrease from 27.9 to 65.8% with a 16.6% hydrolysate, while cholesterol levels decreased from 17.1 to 16.1%. In the liver, triacylglycerol levels decreased from 21.0 to 28.0%, while total cholesterol levels decreased from 38.5 to 50.0%.

In a normal aerobic cell, reactive oxygen species (ROS) usually exist in balance with biological antioxidants. However, disruption of this critical balance can lead to oxidative stress and disease. Hydrolysates from alkali-solubilized red tilapia, *Oreochromis niloticus*, could be used as effective scavengers of ROS. In general, the ability of the hydrolysates to scavenge ROS rose with an increase in the degree of hydrolysis, so low-molecular-weight peptides were better scavengers than high-molecular-weight peptides.

Microbial Media

Fish peptone was produced from the heads of silver carp, *Hypophthalmichthys molitrix,* using alcalase hydrolysis to determine the ability to grow *Vibrio anguillarum* instead of the standard peptones used in the medium. According to the results, the degree of hydrolysis and protein percentage after 24 hours were 37.68 mg/mL and 20.74%, respectively.

An analysis of variance between the commercial media and the fish peptone substitute media was 0.930. This result showed that fish by-products modified by enzymatic procedures could be used as low-cost nitrogen sources for bacterial growth.

A peptone produced from mackerel, *Scomber scombrus*, and herring, *Clupea harengus*, and incorporated into bacteria media was tested against three lactic and three non-lactic bacterial strains. The results showed that culture media formulated with fish peptones, in most cases, could sustain efficient microbial growth and serve as an alternative to commercial media.

Antibacterial Activity

The antibacterial activities of half-fin anchovies, *Setipinna taty*, were digested by papain, pepsin, trypsin, alkaline protease, acidic protease and flavoring protease. Results showed the anchovy pepsin hydrolysate displayed higher antibacterial action that the other hydrolysates.

The optimized pepsin hydrolysate effectively inhibited the growth of *Escherichia coli, Pseudomonas fluorescens, Proteus vulgaris* and *Bacillus megaterium* with minimal inhibitory concentration values ranging 28.38-56.75 µg/mL. The cell integrity of *E. coli* was significantly destroyed after incubation for five hours, and cell membrane damage was also observed.

Recently, a snow crab by-product hydrolysate demonstrated antibacterial properties against *Escherichia coli* and *Listeria innocua*. Hydrolysates from capelin, mackerel and Alaskan pollock have also demonstrated antibacterial properties.

Fermentation

Industrial fish peptone was an excellent substrate from biomass production in solid and submerged fermentations. The maximal growth rates of several microorganisms were two to three times higher than for those grown on beef peptones, and the final biomass concentrations were almost twice as great as those grown on beef peptones.

Fish peptones did not increase the production of secondary metabolites relative to those produced on beef peptones in non-optimized media. Fish peptone has promising potential as a substrate for biomass production.

Antihypertensive Peptides

Angiotensin-converting enzyme (ACE) functions in the rennin-angiotensin system to increase blood pressure. ACE catalyzes the formation of angiotensin II, a potent vasoconstrictor, from angiotensin I and inactivates bradykinin, a vasodilator.

Inhibition ACE is a first-line therapy for hypertension and congestive heart failure. It was also found that peptide treatment upregulated the m-RNA expression of the cellular antioxidative enzymes superoxide dismutase, glutathione and catalase, thereby enhancing their intracellular antioxidative mechanisms.

The generation of ACE inhibitory peptides is dependent on the correct choice of exogenous enzymes. It has been shown that lower-molecular-weight hydrolysates have greater biological effects, since they are more readily absorbed in the digestive tract.

A protein hydrolysate from salmon, *Salmo salar*, was developed containing several angiotensin I-converting enzyme inhibitory peptides using protease s-amano and multifect neutral. Only protease s-amano had blood pressure-lowering activity. A single oral dose at 1,500 mg/kg body weight significantly lowered blood pressure in spontaneously hypertensive rats. The ability of the hydrolysate to lower blood pressure was due to a combination of ACE inhibitory tripeptides as well as additional unknown peptide species generated during digestion of the hydrolysate in the gastrointestinal tract.

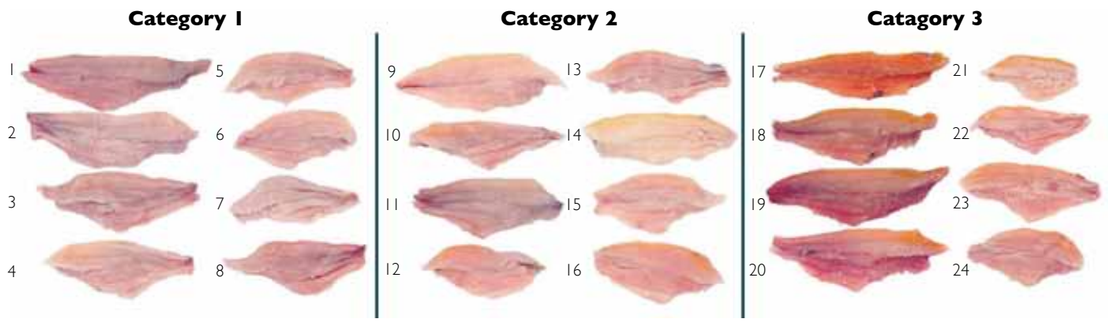
A single dose of shrimp hydrolysate produced with protease s-amano significantly decreased the blood pressure in stroke-prone spontaneously hypertensive rats. The antigenicity and allergenicity of the hydrolysate was very low.

Angiotensin-I-converting enzyme (ACE-I) inhibitory peptides were produced from seaweed pipefish, *Syngnathus schlegeli*, using papain, alcalase, neutrase, pronase and trypsin. Among them, the alcalase hydrolysate exhibited the highest ACE-I inhibitory activity.

ACE-inhibiting hydrolysates were produced from the skin of skates, *Raja kenojei*, using α-chymotrypsin, neutrase, pepsin, papain and trypsin. Among the six hydrolysates, the α-chymotrypsin hydrolysate had the highest ACE inhibitory activity. Antihypertensive peptides using thermoase have also been successfully produced from Antarctic krill, *Euphausia superba*; sea cucumbers; Pacific hake, *Merluccius productus*; Pacific cod, *Gadus macrocephalus*; and catfish using protamex.

Feed

A shrimp protein hydrolysate was incorporated at 6% into diets for Nile tilapia, *Oreochromis niloticus*. The inclusion produced no significant difference ($P > 0.05$) in final weight, survival, weight gain, average daily gain, specific growth rate, feed-conversion ratio, protein-efficiency ratio or apparent net protein utilization. However, the composition of the fish was slightly affected. Protein and ash contents decreased, and fat content increased. The results should be of special interest to aquaculture producers of tilapia and shrimp.



The catfish fillet coloration scale developed by Dr. David Cline shows the variations in color that occur in farm-raised catfish due to the presence of carotenoids.

Research Links Pond Production Practices To Yellow Coloration In Catfish Fillets

Summary:
The yellow coloration in catfish fillets caused by carotenoids does not affect flavor, but many consumers see the yellowish fillets as inferior. A study that correlated the occurrence of yellow fillets at processing plants with the farm practices used to produce the catfish indicated feed management that ensures all fish in multiple-batch pond systems receive their full daily ration and more efforts toward controlling algae blooms in catfish ponds can significantly reduce the occurrence of yellow fillet coloration.

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Catfish producers in the United States are going through a difficult time with high input prices and low selling prices. In the last several years, a significant portion of the U.S. market for frozen fillets has been lost to imports and other meat proteins. It is more important now than ever for the U.S. catfish industry to produce a consistent, high-quality product to remain competitive and regain lost market share.

Yellow Fillets

Yellow pigmentation in catfish fillets has been reported in research literature for decades, and in recent years, it has again become a major industry concern. There has been consumer push back for fillets that exhibit yellow coloration from species like catfish that are known as "white fish." This concern has especially expressed itself by buyers in the fresh market.

The yellow pigments in the fillets are carotenoids, which do not affect the flavor of the fish. However, when yellowish catfish fillets are presented next to white fillets in the same refrigerated cases, consumers see the yellowed fillets as old, spoiled or damaged in some way. Such variations have caused some major fresh fish buyers to look for alternative white fish products for their fresh seafood cases.

Study Setup

A study was developed to investigate linkages between the occurrence of yellow pigmentation in catfish fillets and on-farm production practices. As such linkages are defined, best practices can be developed to change producer management to diminish the occurrence of yellow fillet pigmentation. If there is cost involved in the new management strategies, an incentive-based price scale could be offered to encourage producers to adopt the new practices, and buyers of non-yellow fillets would need to pay a higher price, as well.

From December 2009 through December 2011, two processing plants in Alabama, USA, provided categorized data on the percentages of catfish fillets that exhibited sufficient yellow pigment to be considered "tainted" in the eyes of buyers. Data was collected on the first harvests to go through the plants each day, so the fillets could be identified with a specific farm and specific pond.

After receiving the yellow fillet information from the processing plants, a survey of production practices was conducted with each producer concerning the individual ponds from which the data was obtained. Surveys were conducted for 154 individual ponds spanning 28 farms in western Alabama, Mississippi and Arkansas.

The survey consisted of 25 questions having 126 production management variables. Correlation analysis was used to identify variables that were highly correlated with the occurrence of yellowness in the fillets. Those variables were then used as explanatory variables in regression models to identify the management practices most responsible for the occurrence of yellow fillets.

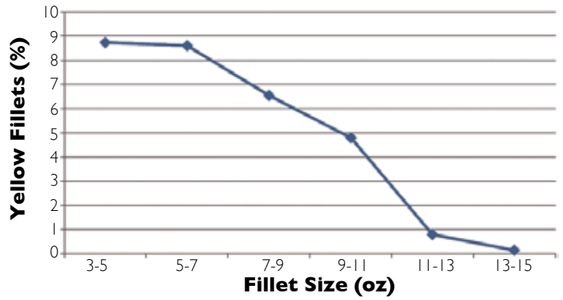

Figure 1. Occurrence of yellow pigmentation by fillet size.

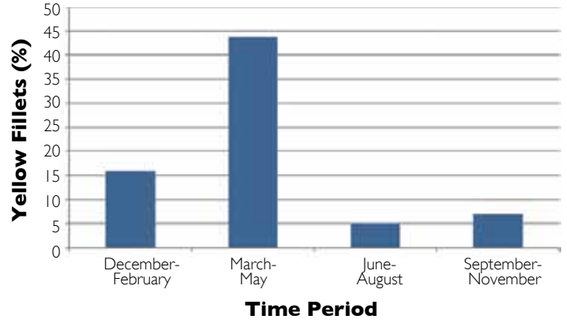

Figure 2. Occurrence of yellow pigmentation by season.

Results

The regression models with the best explanatory power included the management variables "days off feed before harvest," "average feeding rate in the summer," "number of batches of fish in the pond," "pond volume" and "alkalinity." These variables accounted for 63% of the model variation in the occurrence of yellow fillet coloration.

Considering the nature of the survey, which relied heavily on producers' memories of the practices used during the prior 18 to 24 months, explaining 63% of the variation was quite good. Variables such as "method of copper sulfate application," "fillet size" (Figure 1), and "season" (Figure 2), were highly correlated with yellow fillet coloration.

Feeding Strategies

The study indicated two areas of management that strongly affected yellow fillet coloration: feeding strategies related to multiple-batch production systems and algae control. It seemed essential to keep the fish fully fed on a commercial ration to discourage them from foraging on natural food items in the pond. The longer feed was withheld from fish before harvest, the greater was the occurrence of yellow fillets, indicating fish began to consume natural food soon after being taken off feed.

Through the winter months, it is common for fish to be left off feed for weeks at a time, if not the entire winter, causing them to forage for natural food items during warmer winter weather. A subsequent spike in the occurrence of yellow fillets was seen as the spring season began, most likely due to the long period of fasting from commercial diets over the winter.

Also, the fact that smaller fish demonstrated a significantly higher occurrence of yellowness in fillets is important when discussing stocking and feeding strategies. It is likely that some fish in multiple-batch production systems do not receive their full ration of commercial diets because of competition for the available feed, which is limited due to water quality concerns. Smaller fish are forced to forage for supplemental natural productivity, which is linked to yellow fillet pigmentation.

Algae Control

The other major area of management associated with the occurrence of yellow fillet coloration is related to algae control. Several significant regression variables addressed water quality, such as alkalinity, aeration, feeding rate and salinity. These variables can affect the type and quantity of algae present in ponds.

Management variables concerning "type of copper sulfate applied" and the pond water variable "alkalinity" showed that the ability to evenly mix the copper sulfate and its effectiveness in reducing blue-green algae had an important effect on yellow fillet occurrence. The method of algal control – such as frequent doses of copper sulfate to control the density of algal blooms and/or mixing of the ponds through aeration to discourage the growth of blue-green algae – may also help reduce the occurrence of yellow pigmentation in catfish fillets.

Perspectives

More research needs to be conducted to find threshold values for the variable "days off feed before harvest" in order to determine the number of "fasting" days before fish begin to forage enough to develop a yellow fillet problem. Also, focused studies to identify the exact effects of copper sulfate on the occurrence of yellow fillets are needed.

Blue Food Solutions

North Atlantic Forum Examines Sustainable Aquaculture Growth

At the North Atlantic Seafood Forum, major stakeholders reviewed the status of global aquaculture and examined the innovations needed to sustainably expand the sector. Photo by Gorm K. Gaare, EUR – Berlin.

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Summary:
Although state-of-the-art research has led to breakthroughs in cost efficiency, productivity and sustainability in aquaculture, further advances will be needed to support expansion of the industry to meet growing seafood demand. The North Atlantic Seafood Forum program identified challenges and proposed solutions for varied issues. Genetics represent a major driver for enhanced productivity, and alternatives for fishmeal will reduce dependence on wild-caught fish for feed. An "ecosystem" approach to aquaculture emphasizes siting that considers the social, economic, environmental and governance aspects of projects.

The North Atlantic Seafood Forum (NASF) drew major stakeholders and key players to Bergen, Norway, to review the status of global aquaculture and examine the pathways and innovations needed to sustainably expand the sector manyfold. Serious engagement by 200 manufacturers, solution providers, financiers, public authorities, consumer groups and non-governmental organizations made NASF a vibrant event in the spirit of shaping the future of aquaculture.

On Marine Innovation Day, March 5, presentations by expert speakers combined with an awards program and innovative "think tank" sessions in contributing to the knowledge of the participants and organizers.

Informative Speakers

In opening the forum, Christina Abildgaard, director of the Research Council of Norway, pointed out the immense untapped potential of the world's "blue" resources, and, as expressed by World Bank Group, its emerging importance for the world economy. She presented data on how state-of-the-art research and development have led to breakthroughs in improved cost efficiency, productivity and sustainability in global aquaculture.

Dr. George Chamberlain, president of the Global Aquaculture Alliance, gave an opening keynote on innovations needed to overcome the challenges constraining aquaculture growth.

Chamberlain said that rising global demand for seafood is largely driven by the global economy's "shifting center of gravity," as the growing middle class in Asia and elsewhere can now buy more seafood. Producers of shrimp and fish are seeking improved technologies for genetic enhancement, optimized feeding, disease control and infrastructure management.

Genetics represent a major driver for enhanced productivity, Chamberlain said.

Dr. Lara Barazi, chief executive officer of Kefalonia Fisheries, presented "Temperate Water Aquaculture – Potentials, Challenges and Solutions as a Future Key Global Food Supplier."

Barazi focused on the Mediterranean aquaculture sector, which has experienced dynamic growth over the past 30 years, but is still far from reaching its potential. The same elements that contributed to past growth – the recognized health benefits of fish together with the positive image of the Mediterranean diet and oceanographic and climatic characteristics of the region – will continue to do so, she said.

But to make the industry more competitive and viable, research into species diversification, genetics, disease prevention, feed quality, efficiency and sustainability must be encouraged. Better data, management and planning will help smooth out the volatility that has largely hampered its development so far.

Odd Magne Rødseth, chief executive officer of Aqua Gen A.S., spoke on the future contributions of cold water aquaculture to the global food supply. Rodseth said that in 2010, production of Atlantic salmon and rainbow trout, the main fish species raised in cold water regions, reached 2.5 mmt – about 6% of the global farmed fish production.

These cold-water carnivores' dependence upon finite capture fisheries as their major source for dietary protein and lipids has led to intensive research programs to find alternatives to fish oils. The most promising efforts include production of long-chain omega-3 fatty acids by yeast fermentation, extraction from algal sources or genetic modification of oilseed crops.

To counter the impacts of infectious diseases, scientists and industry have developed new technologies and management strategies based on better understanding of the genetic and physiological basis of immunity and disease resistance.

Dr. Doris Soto of the United Nations Food and Agriculture Organization (FAO) Fisheries and Aquaculture Department gave a plenary keynote on FAO's efforts to promote a global sustainable aquaculture agenda and an ecosystem approach to aquaculture.

Lara Barazi said better data and planning will help smooth out the volatility that has hampered further development of the Mediterranean aquaculture sector. Photo by Gorm K. Gaare, EUR – Berlin.

Soto said the main challenges to aquaculture growth include land and water availability, cost and energy-efficient productivity, ecosystem impacts, feed issues, biosecurity and health, finance and investment, and social impacts. FAO is assisting member countries with policies and planning, certification guidelines and compliance assessment, dissemination of investment tools for small farmers, and improvements in feeds, biosecurity and genetics.

Throughout, FAO promotes an ecosystem approach to aquaculture that emphasizes site zoning and locating that consider the social, economic, environmental and governance aspects of projects.

Innovation Awards

To highlight potential innovative and powerful aquaculture solutions, the Marine Innovation Day launched three awards. The 17 entries included ideas for biorefining chitin, lysis-based mussel meat production and even an optical-based system for sea lice treatment.

The award for Best Invention went to OxySolutions, which has developed and patented a radical new method for oxygenation of water. The technology can increase the amount of oxygen in water up to 1,000% under normal room temperature and pressure. This bubble-free solution makes it possible to oxygenate large tanks or recirculating facilities to the desired level based on fish type. This enhances food uptake, fish health and growth.

Under Best Solution, the award winner was Hortimare for its system to produce kelp, a valuable source of marine protein that is rich in essential amino acids, to be used in fish feed. Kelps cultivated near fish farms can use the valuable nutrients coming from the farms and bioremediate the sea at the same time. This results in a more stable ecosystem and less pressure on worldwide fish catches for fishmeal.

The Best Innovation selection examined system integrations of known innovations. The award winner was Novartis Animal Health for its work on nucleic acid vaccine technology for fish. This novel biomedical technology offers distinct advantages over conventional immunization or chemotherapy.

Think Tanks

Ahead of the conference, experienced chairs for seven "think tank" sessions outlined main issues upon which to guide the workshop sessions. The intense discussions that took place during the brief parallel sessions yielded interesting directives.

The "Race for Space" session sent one clear message: We need major innovations to find and utilize optimal sites for long-term, efficient aquaculture production. Where are the "super sites," and how can they be utilized in a sustainable manner?

Under "Science and Technology," the species question was debated. Session participants agreed that five species groups – salmonids, cyprinids, catfish, bass/bream and shrimp – will be the most likely contributors to aquaculture industry growth. To really contribute to food production, they said, innovations are needed to cut the time from egg to market by 50%.

"Brains, Money and Dialogue" focused on the need for aquaculture to become a major knowledge-based industry globally to attract talented young people. Related to this, "Engineering and Gear Solutions" discussed innovations for intelligent technology – the need for technologies that work perfectly, independent of human operating mistakes.

In "Human Health and Seafood" the importance of seafood as healthy food was addressed, along with the need for completely new sources of raw materials for feed. This was echoed in "Existing and New Bioresources," which called for the development of fully integrated systems for balanced, ecosystem-based harvesting and total utilization of all the catch.

From the "Market Innovation" thinkers, the concept of Total Brand Management together with a strengthened market orientation among the players came out as essential for further development and value creation.

Vision Paper

An international work group chaired by co-author Kjell Maroni is developing a vision paper focused on the major innovative breakthroughs needed to expand global aquaculture significantly. The group collected substantial inspiration and inputs from the forum program.

While still under development, the vision paper will likely address important components of the carbon footprint of the sector, as well as sustainable feed supplies, enhanced farming predictability through powerful disease control systems and accompanying regimes to manage environmental and wild stock impacts. Additional elements will focus on the recruitment of human capital, communications and market innovations.

The award winners (from left): Paul van der Heyden, Hortimare B.V. – integrated aquaculture of salmon and kelp; Jan Økern, OxySolutions A.S. – new oxygenation technology; Neil Robertson, Novartis Animal Health – nucleic acid vaccine. Photo by Thorvald Tande, Norsk Fiskerinæring.

Oyster Culture In Recirculating Systems

Contained Environments Support Research, Commerical Potential

The second author inspects oysters being cultured in a recirculating aquaculture system.

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Summary:
Environmental and other challenges have led to reduced harvests of wild oysters in the United States. In a study, the authors evaluated oysters cultured in a recirculating aquaculture system with zero water exchange for several months. Survival rates exceeded 99%, and the oysters had growth comparable to or higher than oysters of similar size deployed in the field. Closed system culture could support feeding studies and breeding programs, as well as offer a method for commercial farming.

In the United States, oysters are exclusively harvested and farmed in brackish rivers, estuaries, bays and oceans. The Eastern oyster, *Crassostrea virginica*, industry is an important multi-million-dollar industry that brought in nearly U.S. $100 million in 2009. However, the total landings in the U.S. dropped significantly over the past 60 years, from approximately 31,750 mt to 11,340 mt.

Numerous issues contributed to this decline, including overharvesting of stocks, loss of habitat, predation by cownosed rays and other species, and disease outbreaks due to *Perkinsus marinus* and *Haplosporidium nelsoni*. The oyster industry also faces numerous other challenges from anthropogenic pollutants, climate change, harmful algal blooms and various viral, bacterial and parasitic pathogens.

Culture Alternatives

This has prompted scientists and the oyster industry to determine ways to combat these issues through alternative culture techniques, programs and research. One possible solution would be culturing oysters in a closed system, isolated from environmental risks. However, there could be drawbacks, such as cost and potential risks associated with dense monoculture.

Even if production of oysters in closed systems is not realistic in terms of producing oysters intended for food, understanding of how to culture oysters in these systems could offer an opportunity for more toxicological research and feeding studies. This technology could also be useful for breeding and genetic programs.

Oyster RAS

In a study, the authors evaluated whether oysters could be cultured in a recirculating aquaculture system (RAS) with zero water exchange for several months. The study objectives were to manage suitable water quality parameters, monitor mortality rates and track growth.

The 12-week growout study was conducted in a closed-loop recirculating system with zero discharge using synthetic seawater made from well water and synthetic sea salt. Approximately 7,000 oysters were stocked in a single layer in four, 1.83-m-diameter tanks. The tanks were each partially filled with 3,200 L of water.

This culture system was outfitted with various filtration technologies and connected to a 4,000-L storage tank and 12, 1,000-L algae culture tanks. Two species of marine microalgae were grown as oyster feed: a *Chaetoceros* species diatom and a dinoflagellate, *Isochrysis* species.

The oysters were batch fed daily. The amounts of algae cells offered exceeded 300 million cells/oyster, which is the estimated amount an adult oyster can filter in a day. Ion chemistry was monitored and supplemented as required to maintain suitable water conditions. Oyster growth was monitored on a weekly basis.

Water quality parameters were within desired ranges for oyster culture. Observed mean concentrations of ammonia, nitrite and nitrate were all less than 1% of the lethal concentrations reported in scientific literature. Approximately 95% of oyster shells is calcium, so the animals have a high demand for calcium to grow. Accordingly, calcium was supplemented in the culture environment.

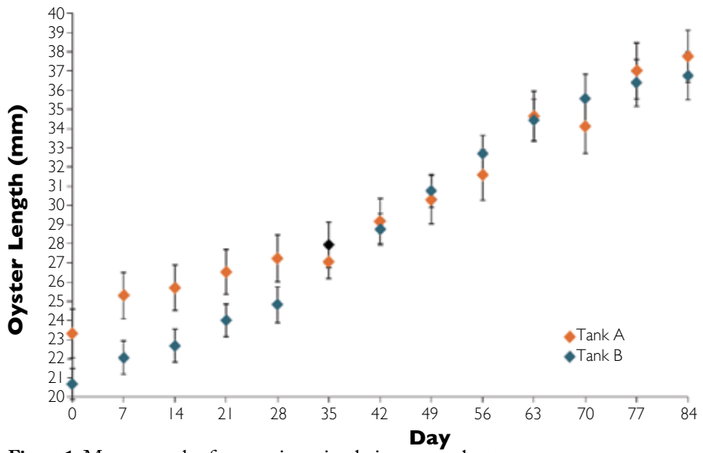

Figure 1. Mean growth of oysters in recirculating aquaculture systems.

Results

The two species of marine microalgae used in this study were selected because the blend has been demonstrated by others as an appropriate choice for bivalve culture. Survival rates for the study exceeded 99%, and the oysters grew an average 1.3 mm/week. Mean oyster mass increased an average of 0.39 g weekly.

The weekly growth in length was comparable to, and in some cases higher than, published growth data for oysters of similar initial size deployed in the field. Oysters in the ocean and bays typically grow 0.38-2.50 mm/week.

Factors that influence growth include the amount of feed in natural waters and temperature. Both factors can not be controlled in the natural environment, but can be controlled in recirculating aquaculture systems. Therefore, oysters grown in closed systems could offer distinct advantages over wild counterparts because high water temperatures could be implemented year round.

Perspectives

The good survival and growth of oysters in this closed system demonstrated that oysters can be potentially cultured in recirculating systems using synthetically derived seawater and live feeds. However there may be some potential issues to consider.

Concentrations of organics and potentially toxic waste products can negatively affect the growth of these organisms or pose a health concern for oysters intended to be consumed raw and unprocessed. While most recirculation systems allow for high stocking densities, the close proximity of animals could also allow the rapid magnification and dispersal of some infection agents.

Future studies are needed to investigate a longer culture period, alternative feeds and the safety and quality of oysters before oysters raised in closed systems can be considered for human consumption. However, this information can be useful today for those interested in culturing oysters for controlled studies, genetic and breeding programs. Other bivalves, such as clams, mussels and scallops, could also possibly be considered as candidates for culture using land-based recirculating systems.

Shallow Nursery System Uses Bioreactor Concept For Production Of Juvenile Shrimp

Each culture tank operated with a corresponding settling tank and belt feeder.

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Summary:
The authors tested the effects of sequencing autotrophic and heterotrophic dominance on water quality levels in a recirculating system raising shrimp. Culture tanks were inoculated with nitrifying bacteria, and chemoautotrophic dominance was maintained. After a biofloc level of 5 mL/L settleable solids was established by a high feed rate, the carbon:nitrogen ratio was increased by applying 15%-protein feed to promote heterotrophic bacteria. Acceptable growth and survival with 15%-protein feed indicated biofloc contributed to the shrimp dietary requirements.

Bioreactors are systems that utilize living organisms to enhance production processes. These systems can be designed to create a favorable environment for bacteria cell growth. Conditions within bioreactors can be controlled to optimize the production of microbial organisms.

Shallow nursery tanks with reduced water exchange that utilize recirculating aquaculture systems (RAS) can be inoculated to establish a desired microbial population. These biofloc-based RAS systems can be controlled for temperature, pH, alkalinity, dissolved oxygen, light level and water quality to optimize biofloc development. Organic carbon is limited or increased to enhance bacterial dominance and level.

Not enough biofloc results in poor water quality. Too much biofloc results in management problems such as reduced dissolved oxygen and anaerobic pockets that lead to the formation of hydrogen sulfide and a potential *Vibrio* problem.

Biofloc/Bacteria Balance

It is challenging to initiate a biofloc system in clearwater when bacterial populations and organic matter in the system are very low. Shrimp begin to excrete ammonia immediately after stocking. Heterotrophic bacteria require organic matter for both energy and carbon sources, and since biofloc is limiting, they cannot keep up with shrimp ammonia production.

Autotrophic nitrifying bacteria use ammonium and nitrites as sources of energy and nitrogen. However, these bacteria have very slow growth. It takes weeks for them to establish at a density great enough to maintain ammonia and nitrites at a safe, desired level.

Since nitrite nitrogen has been shown to inhibit the immune systems of *Litopenaeus vannamei* at levels as low as 5.15 mg/L, resulting in mortality caused by pathogenic bacteria, it is desirable to keep nitrite levels below that level. Nitrifying bacteria ultimately convert all the ammonia into nitrates. However, it has been reported that nitrate above 220 mg/L at low salinity can be detrimental to shrimp.

Although shrimp tolerance to high nitrate levels in low-salinity water is less than at high salinities, it is important to reduce and limit nitrates in the production system.

Objectives

The authors recently performed a study to test the effects of sequencing autotrophic and heterotrophic dominance through bioreactor-style technology on water quality levels.

One objective was to initiate a nursery biofloc-based RAS as an autotrophic-dominant system. Beginning with clearwater, they established chemoautotrophic-dominant biofloc with low carbon: nitrogen levels capable of maintaining desired water quality without detrimental spikes of ammonia or nitrites.

The authors also sought to convert the RAS from an autotrophic- to a heterotrophic-dominant system after biofloc reached a level of 5 mL/L settleable solids. Assimilation of inorganic nitrogen wastes to microbial proteins promotes heterotrophic bacteria.

Water exchange was minimized by manipulating feed rates, feed protein and carbohydrate levels, adding prebiotics as a carbohydrate source and bicarbonate to control alkalinity and/or pH, and regulating production water with a settling tank.

Materials, Methods

Four 1.5-m-square tanks were filled with filtered 28-ppt seawater to a depth of 20 cm. The tanks were stocked with *Litopenaeus vannamei* $P.L._{25}$ at an average density of 8,162/m^3.

Hydrological and water quality parameters were measured daily. Municipal freshwater treated by reverse osmosis was added as needed to replace water lost by evaporation. Settleable solids were determined with Imhoff cones. These values were used to define the biofloc levels.

Autotrophic Dominance

The tanks were inoculated with nitrifying bacteria, and optimal conditions for chemoautotrophic dominance were maintained. A commercial nitrifying bacteria inoculum (Fritz Turbostart 900) was applied at a rate related to the concentrations of ammonia and nitrite. The carbon:nitrogen ratio was kept at 7.17 by application of 45%-protein feed.

Application of sodium bicarbonate maintained alkalinity between 180 and 200 mg/L, and pH between 7.5 and 8.6. The dissolved-oxygen concentration was kept at 4.5 mg/L or greater. The light level was maintained at 36 lumens/m^2, except during system maintenance.

Heterotrophic Dominance

After a biofloc level of 5 ml/L settleable solids was established by a high feed rate, the carbon:nitrogen ratio was raised to 21.5 by applying 15%-protein feed to promote heterotrophic bacterial dominance.

Inorganic nitrogen was quantified, and the corresponding amount of organic carbon required to convert inorganic nitrogen to microbial protein was added to the seawater, using 40% microbial-conversion efficiency. The organic carbon source was short-chained fructooligosaccharide (FOS), a prebiotic that promotes proliferation of non-pathogenic bacteria.

Biofloc levels were controlled through feed administration. A feed curve based on optimal growth with a feed-conversion ratio (FCR) of 1.3 was used to determine the amount of feed applied daily. The expected weight gain was multiplied by the FCR to calculate the daily ration. The FCR was reduced proportionally to the amount of biofloc in the tanks. For each milliliter over 8 mL/L, the FCR was reduced by 0.1. The minimum FCR was predetermined at 0.85.

Biofloc was also controlled by a continuous bioreactor with recycle technology. Seawater was removed from the tanks with airlift pumps to an adjacent cone-bottomed tank in which biofloc settled out. Reduced biofloc supernatant was returned to the culture tanks. The rate of biofloc removal was adjusted according to the tank biofloc concentration. The goal was to keep the biofloc level between 10 and 15 mL/L.

Results

An average of 0.87 mL/L of bacterial inoculum was used to establish autotrophic dominance with nitrifying bacteria. Optimal alkalinity and pH were maintained by applying an average of 114 mg/L of sodium bicarbonate.

An average total of 1,139 mg/L of substrate (45%-protein feed) was applied to quickly establish 5 mL/L or greater biofloc. The settleable solids reached 5 mL/L or greater on the beginning of day 4, and the 45%-protein feed was replaced by a 15%-protein diet.

After the initial application, FOS was applied to the tanks for seven days in diminishing amounts, because inorganic nitrogen was reduced. Organic carbon from the FOS applied to convert inorganic nitrogen to microbial protein averaged a total of 285.9 mg/L.

The mean and peak total ammonia nitrogen, nitrite nitrogen and nitrate nitrogen levels were 0.31 and 2.89 mg/L, 0.20 and 0.91 mg/L, and 1.93 and 10.65 mg/L, respectively (Figure 1). The mean water temperature was 28.1° C. The mean, high and low dissolved-oxygen concentrations were 5.59, 6.04 and 5.14 mg/L, respectively.

After 20 days, mean harvest size was 0.87 g, and mean survival was 80.1% (Table 1). The average final shrimp biomass was 5.71 kg/m^3. The average FCR for the 15%-protein feed was 2.41. The overall average FCR including both protein levels was 2.61. The average daily water exchange was 0.81%. The mean daily biofloc level averaged 14.4 mL/L.

Table 1. Production trial results. Means of four observations.

Parameter	Value
Shrimp size (g)	0.87
Temperature (° C)	28.1
Dissolved oxygen (mg/L)	5.59
Survival (%)	80.1
Biomass (kg/m^3)	5.71
FOS application (mg/L)	285.9
Daily biofloc level (mL/L)	14.4
Daily water exchange (%)	0.81

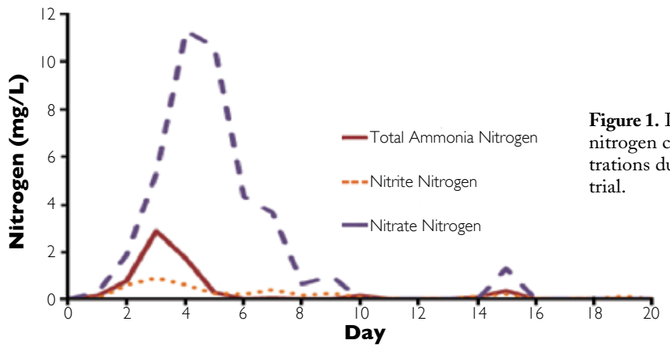


Figure 1. Inorganic nitrogen concentrations during the trial.

Discussion

The 45%-protein feed made up 10.84% of the feed applied, while the 15%-protein diet represented the remainder (Figure 2). Associated nitrogen levels are shown in Figure 3.

The overall carbon:nitrogen (C:N) ratio from feed application was 19.65, which including feed and FOS was 22.04. Once heterotrophic dominance was established, and inorganic nitrogen was removed, the 15%-protein feed seemed to provide enough organic material to serve as an energy and carbon source for heterotrophic bacterial dominance to maintain the inorganic nitrogen to levels near zero.

The FCR ended up much higher than expected. In checking the stocking data, an error was discovered with a factor used to compensate for moisture when the postlarvae were gravimetrically quantified. Thus, the number of animals stocked into the tanks was overestimated, resulting in more feed applied to the tanks than was needed.

Perspectives

Sequencing autotrophic and heterotrophic dominance through bioreactor-style technology maintained desired water quality levels. Spikes of ammonia and nitrites were successfully controlled during the autotrophic-dominant phase. During heterotrophic dominance, all types of inorganic nitrogen (ammonia, nitrite and nitrate) were greatly reduced or eliminated.

Acceptable growth and survival with 15%-protein feed indicated biofloc suspended in the water column contributed to the shrimp dietary requirements.

Establishing an initial biofloc level with excess 45%-protein feed to 5 mL/L and overestimating the number of shrimp stocked increased the expected FCR. Ratios less than 1.3 are expected in the future by using the correct moisture percentage when weighing live postlarvae.

A C:N ratio of 21.5 was adequate for maintaining heterotrophic bacterial dominance and desired inorganic nitrogen levels. The overall C:N ratio, including both feed and FOS, was 22.04, which implied the microbial-conversion efficiency for FOS was greater than 40%.

Settleable biofloc was kept at a sustainable level. Water exchange was low, but could likely be lessened with reduced feed application to about 0.6%/day.

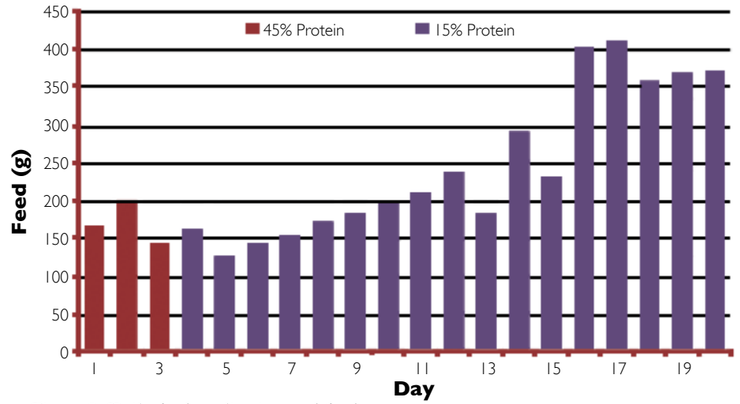


Figure 2. Daily feed application and feed type.

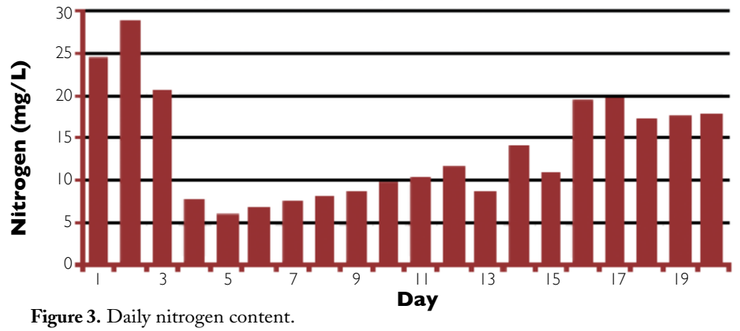
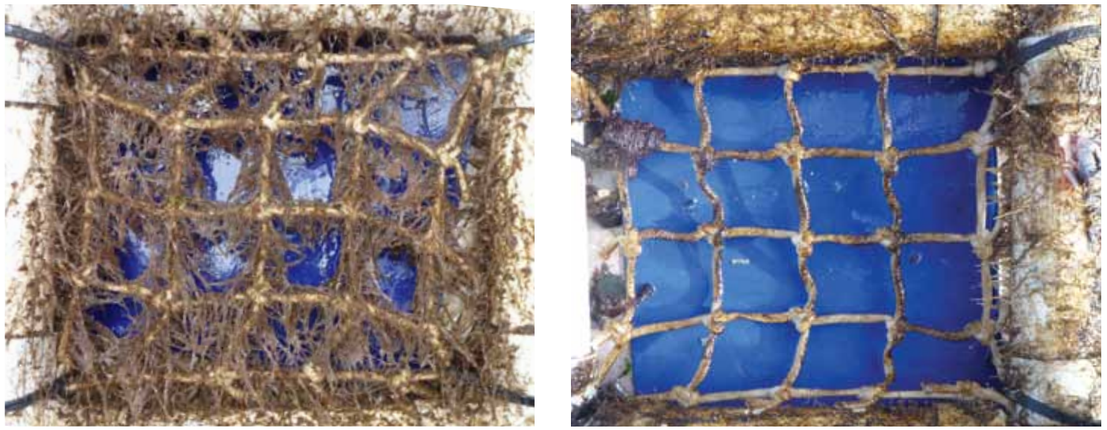


Figure 3. Daily nitrogen content.



The degree of net fouling varies considerably between summer (left) and winter (right) months.

Tasmanian Salmon Farms Examine Net Biofouling To Reduce Impacts

Summary:
Greater knowledge of fouling organisms and their settlement can help lead to greater effectiveness for cage net-cleaning machines. If cleaning is done regularly at certain times of the year, fouling organisms may be easier to remove or kept from settling on nets. A two-year study at salmon farms in Tasmania that observed experimental frames housing different net types found the amount of copper released during in situ cleaning of nets with copper-based coatings was within a comfortable range.

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Worldwide, the salmon aquaculture industry is addressing concerns regarding potential negative impacts on marine ecosystems by reducing its reliance on the use of copper-based anti-fouling coatings to control biofouling on nets. With the recent development of more efficient and economical in situ net-cleaning systems, the fish-farming industry in Tasmania, Australia, has committed to a strategy for the reduced use of copper-based anti-fouling coatings.

Two Tasmanian salmon aquaculture companies, Tassal Operations Pty. Ltd. and Huon Aquaculture Group Pty. Ltd., have embarked on an Australian government-funded project under the Caring for Our Country program to address potential water quality issues associated with in situ net cleaning. The results from this project will assist in developing best practice guidelines and promoting environmentally sustainable practices on farms that use in situ net cleaning within the greater salmon-farming industry in Tasmania.

CARING FOR OUR COUNTRY

Objectives

Upon adopting in situ net cleaning, it became apparent to Huon Aquaculture Group and Tassal Operations that little scientific information was available on the possible environmental effects of this cleaning method, both within lease areas and in the greater marine environments surrounding the farms.

To investigate the potential impacts of in situ net cleaning on water quality, the project has three objectives:

- Define the types of fouling organisms that grow on nets and determine their seasonality.
- Characterize the net wash material expelled by in situ net cleaning.
- Use deposition models to demonstrate the footprint of the net wash.

Fouling Organisms

Identifying the types of fouling organisms, their preferences for different net types, timing of settlement and seasonality allows for the alteration of operational procedures to maximize the effectiveness of cleaning machines. For example, some fouling organisms are harder to clean off than others, so if cleaning is done more regularly at certain times of the year, difficult types may be easier to remove or kept from settling on the net altogether.

To understand seasonality and net preference, a methodology developed by Dr. Simone Dürr of Liverpool John Moores University in the United Kingdom was employed. For a period of two years, experimental frames housing different net types were deployed at the

The authors identified *Ectopleura crocea* as a major net-fouling organism.

Huon and Tassal farms in southeast Tasmania. Each month, the frames were retrieved and sampled, with the selected net pieces replaced before redeployment.

The first year's data identified the dominant fouling groups on all net types as amphipod housings and the hydroid species *Plumularia setacea, Sarsia eximia, Obelia australis* and *Ectopleura crocea*, which together occupied 90% of the biological sample points. When looking at fouling assemblages among net types, the results indicated significant differences among net types and seasons.

Water Quality

To investigate potential impacts on water quality due to in situ net cleaning, the net wash was characterized by species composition and quantity. Analytes and size fractions were chosen based on the efficiency of previous sampling techniques and discussion with independent environmental chemists. The fates of copper, aluminum, phosphate, nitrate, nitrogen, carbon and ammonia were determined by quantifying analytes from a sample of net wash collected directly from the net cleaner.

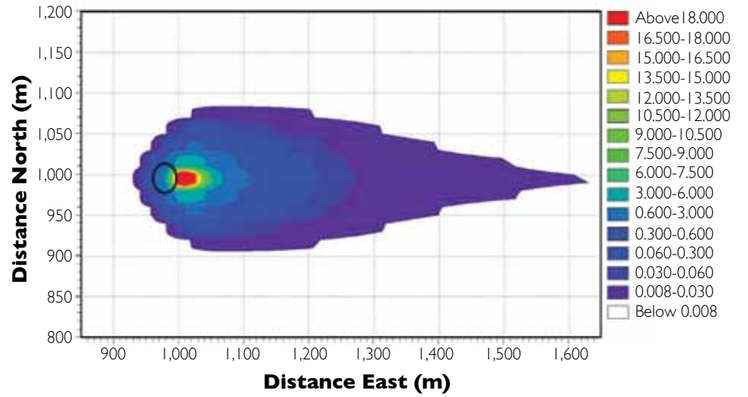

Figure 1. Copper deposition (mg/m^2) at a high-deposition farm site. The hydrodynamic regime plays a significant role in defining sediment impacts. Typically, a narrow footprint is observed in low-flow conditions, whereas the footprint widens under medium to high flow.

Of particular interest to state and federal regulators was the amount of copper released from the nets during the cleaning process. To investigate the relationships between the amount of copper released to the environment and the number of net cleans, net wash was collected from cages treated with copper-based paint that had undergone differing numbers of cleanings.

While there was no statistically significant relationship between the numbers of cleanings and amounts of copper release, Tassal and Huon provided descriptive statistics that were reported to regulatory bodies. The data demonstrated the amount of copper released was thought to be within a comfortable range.

Determining the destination of net wash materials released to the environment was achieved using settlement testing. This established the particle size and velocity of the net wash. In addition, hydrodynamic data was collected at sites with different flows. Both the settlement tests and hydrodynamic information were critical in modeling the deposition of copper within the farm lease.

To understand the copper footprint from in situ net cleaning, a deposition model was employed to demonstrate the movement of the analytes in the water column for high- and low-deposition sites. At the high-deposition site (Figure 1), interpretation of the model revealed that copper deposition reached 10.0 mg/m^2 and above directly downstream of the source, but quickly reduced to concentrations of approximately 0.3 mg/m^2 150 m from the release point.

Editor's Note: Since the time this article was written, Tassal Operations has stopped using copper-treated nets.

Experimental fish feeds containing different proportions of dried *Chlorella* in substitution for fishmeal.

Algae Alternative: *Chlorella* Studied As Protein Source In Tilapia Feeds

Summary:
Chlorella and other species have potential as protein sources in aquafeeds. In trials with tilapia fry raised in a recirculating system, the fish received a fishmeal-based control diet or feeds with portions of the fishmeal replaced by *Chlorella*. The fishmeal diet yielded the best performance, with results gradually deteriorating with increasing levels of *Chlorella*. The feeds with *Chlorella* were well accepted, but the fish could not consume enough feed to make up for its lower digestible protein and energy contents.

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In both aquaculture and agriculture, producers commonly rely on formulated feeds to ensure optimal growth, health and quality of the farmed animals. Fishmeal and fish oil from wild fisheries have traditionally been major constituents of aquafeeds, but their supply is finite. Therefore, raw ingredients other than fishmeal are being selected for their nutritive value, balance of amino acids, protein digestibility, quality of lipids and fatty acids, availability and cost.

Algae Alternatives

Algae biomass is being considered as one of the alternative ingredients of the future. The composition of micro- and macroalgae vary considerably among species, but also depend upon culture conditions. The average protein level in macroalgae is around 8 to 15% dry matter, while the average lipid content is only 1 to 3%. This compares to a protein content of 30 to 50% dry matter for microalgae, which have lipid contents as high as 40%.

Freshwater algae such as *Chlorella* and *Spirulina* seem to have good potential as protein sources, whereas marine microalgae are the fundamental source of the long-chain polyunsaturated fatty acids that are crucial for human health, as well as that of aquaculture animals.

In a study, the authors examined the efficacy and nutritional properties of *Chlorella vulgaris* as an alternative feed ingredient and protein source for the culture of all-male Nile tilapia, *Oreochromis niloticus.*

Experimental Setup

Genetically male tilapia sourced as fry and raised at the Centre for Sustainable Aquaculture Research at Swansea University in the United Kingdom were used for all the trials. The trials were set up indoors as part of a freshwater recirculation system, which included mechanical and biofiltration units, a protein skimmer and a sand filter. Water temperature was kept at 27° C, and photoperiod was set at 12 hours of light daily. Temperature and dissolved-oxygen levels were measured daily, while total ammonia nitrogen, nitrite, nitrate and pH were measured weekly.

Feeds were prepared by mixing the dry ingredients with binder and water, and extruding the feed through a meat grinder, followed by thorough drying. The resulting pellets had a diameter of 2.5 mm and were stable up to 24 hours in water.

Table 1. Apparent digestibility coefficients of *Chlorella* and fishmeal in tilapia.

	Dry Matter (%)	Protein (%)	Organic Matter (%)	Energy (%)
Fishmeal*	73.6	90.5	82.1	83.4
*Chlorella***	50.1	63.5	58.1	59.1

* Composition of fishmeal/kg as fed: dry matter 944 g, crude protein 645 g, lipid 99 g, ash 194 g, gross energy 18.82 MJ.
** Composition of *Chlorella*/kg as fed: dry matter 983 g, crude protein 472 g, lipid 82 g, ash 82 g, gross energy 21.14 MJ.

Table 2. Formulation (g/kg as fed) and composition of experimental feeds.

Ingredient	Fish-meal	30% *Chlorella*	60% *Chlorella*	100% *Chlorella*
Formulation				
Fishmeal	640	420	210	–
Chlorella	–	260	520	780
Corn starch	300	250	180	120
Vitamins, minerals	10	10	10	10
Dicalcium phosphate	–	10	30	50
Vegetable oil	20	20	20	20
Binder	30	30	30	20
Composition				
Dry matter (g)	930	920	930	930
Ash (g)	119	101	95	96
Lipid (g)	84	85	87	88
Crude protein (g)	413	394	382	377
Gross energy (MJ)	18.01	18.19	18.10	19.15
Digestible protein* (g)	374	323	279	239
Digestible energy* (MJ)	14.86	13.70	12.46	12.00
Digestible protein/ Digestible energy ratio (g/MJ)	25.1	23.6	22.4	19.9

* Incorporating results from digestibility trial.

Table 3. Performance parameters of tilapia after 31 days of growth at 27° C.

Treatment	Initial Weight (g/fish)	Final Weight (g/fish)	Specific Growth Rate	Feed Intake (%/ day)	Feed-Con-version Ratio
Fishmeal	35.3	101.6	3.40	3.56	1.00
30% *Chlorella*	35.2	97.5	3.29	4.50	1.31
60% *Chlorella*	35.3	89.9	3.00	4.42	1.44
100% *Chlorella*	36.0	84.5	2.75	4.49	1.58

Digestibility Trial

Digestibility studies of the algae biomass were performed by adding an indigestible marker (chromic oxide) to the feed and collecting the fecal matter by siphoning. By assessing the ratio of marker to energy or nutrient in the feed compared to their ratio in fecal matter, the digestibility of the feed could be established.

Fishmeal was used as the reference ingredient with the test diet mixed at 50% fishmeal and 50% *Chlorella*. Fifteen tilapia weighing on average 250 g each were stocked per tank. Fecal matter from each tank was pooled over the trial period until sufficient fecal matter had been collected for analyses. The digestibility of the ingredients, calculated using well-established equations, is presented in Table 1.

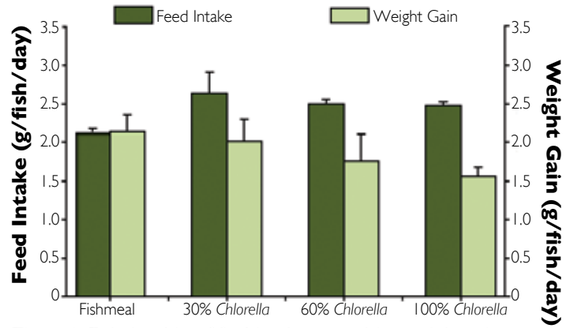

Figure 1. Relationship of feed intake to resulting weight gain in tilapia.

Growth Trial

Fifteen tilapia of 35 g initial size were stocked in 150-L tanks. Feeds were formulated to contain 40% protein and 9% lipid, and to gradually include *Chlorella* at the expense of fishmeal (Table 2). Fish were fed manually to apparent satiation up to four times daily. Any uneaten pellets were collected at the end of the day.

Feed intake was quantified and evaluated in relation to growth response. Fish were sampled initially and at the end of the 31-day growth trial for further chemical analyses. Through comparative body composition of fish carcass, the relationships between dietary protein and energy intake, and protein and energy deposition were assessed, which allowed estimation of the utilization efficiency of *Chlorella*.

Results

Results indicated that feed efficiency and growth performance were best for the fishmeal control and gradually deteriorated with increasing inclusion levels of *Chlorella* (Table 3 and Figure 1). The feeds containing *Chlorella* were well accepted by tilapia, and feed intake was initially increased to make up for the low contents of digestible protein and energy (Table 3). However, the tilapia were apparently reaching the limit of how much feed they could consume.

The daily feed intake and daily weight gain of fish fed the experimental diets are illustrated in Figure 1. Despite the higher feed intake for the feeds with algae, daily weight gain decreased with increasing dietary inclusion of *Chlorella*. The result was rising feed conversion, meaning more feed was needed to produce one unit of weight gain.

Perspectives

Chlorella vulgaris shows some potential as an alternative feed ingredient in aquaculture. Although the algal feeds were not utilized as efficiently as the fishmeal feed, *Chlorella* was well accepted. Overall, tilapia were able to achieve satisfactory growth on the feed with algae, and feed-conversion efficiency was comparable to that for a soybean-based feed.

A possible means of increasing the nutritional value of algal biomass would be to break down the cell wall fragments by mechanical treatment or even removal of most of the fiber, although such additional processing steps may be too expensive. At present, the costs of fishmeal and fish oil are steadily increasing. However, all categories of algal products are currently much higher in cost than the commodity feedstuffs used in aquafeeds.

Salmon Testes Meal Potential Ingredient For Pacific Threadfin Diets

The authors are researching ingredient alternatives that can help lead to a more species-specific commercial feed for Pacific threadfin.

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Summary:
A study evaluated the potential of pink salmon testes meal, a fisheries by-product, as a feed ingredient to replace fishmeal in diets fed to juvenile Pacific threadfin. Results showed the salmon testes meal contained high levels of protein, taurine and arginine. It can replace up to 55% of fishmeal protein without adversely affecting growth performance. This study suggested testes meal can enhance feed efficiency and protein utilization in Pacific threadfin fed a diet containing 25% soybean meal.

Pacific threadfin or moi is a tropical marine fish found in Hawaii, USA, and other Pacific regions that is being grown in different culture systems, including flow-through tanks, raceways and offshore submerged sea cages. It takes about six to eight month to raise this fish to market size.

Currently, aquaculture of Pacific threadfin depends on imported commercial feed containing 45 to 50% protein and 14 to 18% lipid. Recent studies by the authors estimated the optimal protein requirement to support growth performance of this fish is 40%. Thus, the current commercial feed has been overformulated with protein and is not optimally cost effective. More research is needed to investigate the nutrient requirements of this fish and look for alternative feed ingredients.

Fishmeal Replacement

Recent research has shown that some fishery by-products are promising as alternative ingredients in aquatic feeds. One of the by-products from the salmon fishery in the U.S. state of Alaska, pink salmon testes meal, has been shown to be highly digested by Pacific white shrimp and able to replace up to two-thirds of the fishmeal protein in a diet containing 15% fishmeal.

The application of this by-product in feeds for tropical marine fish has not been investigated. Therefore, in a study, the authors investigated the potential of using pink salmon testes meal as a feed ingredient for juvenile Pacific threadfin based on growth performance and feed utilization. Funding for this study came through a grant from the U.S. Department of Agriculture Agricultural Research Service and a USDA-ARS cooperative agreement with the University of Alaska Fairbanks.

Experimental Diets

Pink salmon testes meal was obtained from a commercial processing plant in Kodiak Alaska, dried at 71° C for 24 hours, mixed with the antioxidant ethoxyquin at a concentration of 150 mg/kg and stored at -30° C until use. Six test diets were prepared to contain 37% protein and 13% lipid with varied levels of fishmeal replacement (Table 1). A commercial feed containing 50% protein and 14% lipid was used as a reference diet.

Table 1. Dietary formulation of test diets fed to juvenile Pacific threadfin for eight weeks.

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Fishmeal protein replacement (%)	0	11	22	33	44	55
Pollock meal (g/kg)	350	310	270	230	190	150
Pink salmon testes meal (g/kg)	0	30	60	90	120	150
Dextrin (g/kg)	190	198	207	215	223	232
Menhaden oil (g/kg)	100	102	103	105	107	108
Soybean meal (g/kg)	250	250	250	250	250	250
Other (g/kg)	110	110	110	110	110	110

Fish Maintenance, Data Collection

While acclimating to laboratory conditions for seven days, the juvenile Pacific threadfin received the commercial feed prior to the beginning of the feeding trial. Three tanks were randomly assigned to each dietary treatment with 20 fish/tank. Fish were hand fed three times daily with total daily feeding volume based on 5 to 7% of body weight. Animal care, maintenance, handling and tissue sampling followed the protocols approved by the Oceanic Institute Animal Care and Use Committee.

At the end of eight weeks, total weights were recorded for each tank. Five whole fish from each tank were homogenized, freeze-dried and stored at -80° C until analysis for proximate composition.

Results

Nutritional Compositions

The testes meal contained a higher level of protein but a lower level of ash than the pollock fishmeal (Table 2). All test diets contained similar levels of protein, lipid and gross energy. The commercial diet had a higher level of protein and energy than the test diets. The total amino acid level (g/kg ingredient) was highest in the testes meal, followed by the pollock meal and lowest in the soybean meal (Table 3).

The amino acid levels of the testes meal were lower in methionine, glycine, glutamine + glutamate, and asparagine + aspartate than in the pollock meal. Taurine, lysine and arginine, however, were higher in testes meal than pollock meal. The amino acid composition of the test diets showed an increasing level of arginine and a decreasing level of methionine with the increasing amount of testes meal added. The taurine level was also increased with the replacement of testes meal for fishmeal.

The growth trial was conducted indoors in 150-L flow-through tanks with 31 g/kg seawater.

Growth Performance

No mortality was observed in any treatment during the growth trial.

Table 2. Proximate composition of major protein ingredients and test diets fed to juvenile Pacific threadfin.

	Testes Meal	Pollock Meal	Soybean Meal	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Commercial
Fishmeal protein replacement (%)	–	–	–	0	11	22	33	44	55	–
Dry matter (g/kg)	924	945	925	936	932	933	932	915	925	954
Crude protein (g/kg)	77.5	670	478	373	369	359	367	360	369	539
Crude fat (g/kg)	64	79	19	127	128	130	131	128	132	136
Ash (g/kg)	117	185	68	98	95	91	91	86	85	81
Gross energy (kcal/kg)	4,587	4,428	4,233	4,646	4,647	4,643	4,641	4,570	4,621	5,222

Table 3. Essential amino acid and taurine profiles of protein ingredients used in test diets.

Amino Acid	Testes Meal	Pollock Meal	Soybean Meal	Testes Meal	Pollock Meal	Soybean Meal
Arginine (g/kg)	109.1	54.0	35.6	144.7	87.0	82.6
Histidine (g/kg)	17.1	15.4	14.2	22.8	24.8	33.0
Isoleucine (g/kg)	40.3	32.9	24.0	53.4	53.0	55.7
Leucine (g/kg)	61.4	49.5	34.1	81.5	79.8	79.2
Lysine (g/kg)	65.6	49.9	30.4	87.1	80.4	70.6
Methionine (g/kg)	10.3	19.3	6.3	13.7	26.4	9.9
Phenylalanine (g/kg)	27.4	23.0	24.7	36.4	37.0	57.3
Threonine (g/kg)	44.3	38.0	17.6	58.8	61.3	40.8
Valine (g/kg)	44.1	33.1	22.7	58.5	53.3	52.8
Total	753.5	623.9	428.6	1,000.0	1,000.0	1,000.0
Taurine (g/kg)	30.1	6.7	0.4	40.0	10.7	1.0

Table 4. Growth performance of Pacific threadfin fed different diets.

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Commercial
Fishmeal protein replacement (%)	0	11	22	33	44	55	–
Weight gain (%)	934 ± 14[a]	990 ± 22[a]	959 ± 40[a]	924 ± 15[a]	953 ± 25[a]	934 ± 42[a]	983 ± 24[a]
Feed-conversion ratio	1.20 ± 0.01[b]	1.15 ± 0.01[c]	1.14 ± 0.01[c]	1.16 ± 0[ab]	1.16 ± 0[ab]	1.17 ± 0.02[ab]	1.32 ± 0.02[a]
Protein efficiency ratio	1.98 ± 0.02[c]	2.06 ± 0.01[b]	2.14 ± 0.02[a]	2.06 ± 0.02[b]	2.07 ± 0.01[ab]	2.03 ± 0.05[bc]	1.27 ± 0.02[d]
Protein retention (%)	35.6 ± 0.1[bc]	36.5 ± 0.4[bc]	38.8 ± 0.3[a]	36.9 ± 0.6[b]	36.2 ± 0.4[bc]	35.0 ± 1.2[c]	22.5 ± 0.3[d]

Replacement of fishmeal protein by the testes meal did not cause any adverse effect on fish weight gain ($P > 0.05$, Table 4). Feed-conversion ratios (FCRs) were lower for the fish fed diets 2 and 3 than those fed diet 1 with no testes meal included ($P < 0.05$).

Protein efficiency ratios (PERs) were increased by the supplementation of testes meal, except PERs were similar for fish fed diets 5 and 1. Protein retention was the highest for fish fed diet 3. Among all treatments, fish fed the commercial feed had the highest FCRs and lowest PERs and protein retentions. The proximate composition among fish fed the test diets was similar.

Perspectives

This study showed that pink salmon testes meal can be an effective protein source as well as a valuable feed additive in feeds for Pacific threadfin. The testes meal replaced up to 50% of the fishmeal protein in the test diet without any detrimental effect on the growth performance and proximate composition of fish. At a low level of supplementation with 22% fishmeal protein replaced, the testes meal reduced FCR and improved PER and protein retention of fish.

Both taurine and arginine were high in the testes meal compared to the fishmeal. Taurine is a conditionally essential nutrient for some marine species that has been shown effective in stimulating growth and decreasing FCR in fish such as cobia, Japanese flounders and red sea bream.

Arginine is an indispensable amino acid for optimal growth of fish as well as a precursor for creatine. Supplementation of arginine has been shown to increase growth, feed efficiency and protein deposition in fish.

Taurine is normally absent or found at very low levels in plant proteins. Arginine levels are low in some plant protein concentrates, such as canola meal (0.49 to 2.32%), corn gluten meal (1.90%) and safflower meal (1.20 to 1.90%), compared to the arginine levels in most fishmeal (3.60 to 6.80%)

As a result, a diet with a high level of plant proteins could easily become deficient in taurine or arginine. In this study, the increased values of PER and protein retention, and decreased FCR observed for the diet with 22% fishmeal protein replaced may be partly due to the increased levels of dietary taurine and/or arginine contributed by the supplementation of the testes meal.

On the other hand, the level of methionine was relatively low in testes meal when compared with fishmeal. When 55% of the fishmeal protein was replaced by the testes meal, the dietary methionine level was 0.81%. This level of methionine was within the published 0.7 to 1.2% diet range of methionine requirements for most species that have been studied.

It is possible that complete replacement of fishmeal with the testes meal could result in a methionine deficiency in diets for Pacific threadfin. Supplementation of methionine should be considered if a higher level of replacement (more than 55% fishmeal protein) is needed. However, this warrants further investigation.

industry news

Chile Quickly Responds To ISA Detection

The salmon-farming association SalmonChile, A.G. has announced that appropriate measures are being taken in response to reports of infectious salmon anemia (ISA) at two companies in the remote Aysén region.

SalmonChile said the farms have taken strong measures as indicated by Chile's new ISA Control Program. Some of the measures in Chile include early harvests, special monitoring in affected areas, biweekly sampling, stocking prohibitions and vessel transit bans within 10 km of affected areas. In addition, the industry has intensified health campaigns at all farms.

The ISA mortalities average under 2%/month, compared with the 14%/month experienced during the worst of the 2007-2010 ISA crisis.

"While the ISA virus cannot be eradicated, occurrences are normal and can be expected from time to time," said Maria Eugenia Wagner, SalmonChile president. "What is important is how the situation is addressed."

Through its technical "arm" Intesal, SalmonChile has established a working group that includes key representatives of the salmon cluster along with the Chilean Navy and Sernapesca to ensure full compliance with all sanitary measures.

For more information, contact Alejandra Pinhiero, apg@salmonchile.cl, 566-525-6666.

People, Products, Programs

Please send short news items and photos for consideration to:
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Alltech Launches Mycotoxin Management Program

Molds and mycotoxins made headlines in 2012 when they showed up in feed bunks and silage piles in the aftermath of drought and the devastating Sandy surge. Many producers were left with little information on the risks associated with these toxins.

To bring the latest research to the farm level, Alltech launched the Mycotoxin Management Program. This control program for feedstuffs is designed to reduce risk and improve safety, while ensuring mycotoxins do not limit livestock performance and profitability, or pose a threat to the food chain.

Alltech's program offers key components for farms concerned with mycotoxin contamination. The 37+ Program analyzes for multiple mycotoxin contamination, provides a risk assessment and calculates the toxic equivalent quantity in a given feed sample. The Mycotoxin Hazard Analysis Program (MIKO) is designed to improve production systems at farms and feed mills

by performing an audit, defining critical control points and limits, monitoring procedures and checking protocols for information recording.

The mycotoxin management team provides a contamination report and recommendations for management and nutritional applications that assist with mycotoxin prevention and control.

For more on the mycotoxin program, call the Mycotoxin Hotline at +1-866-322-3484. For further information on Alltech, visit www.alltech.com.

Merger Yields Top Seabass, Sea Bream Producer

An agreement has been reached to merge Selonda S.A. and Dias Aquaculture S.A. to form the largest seabass and sea bream producer worldwide. Under the corporate name Selonda, the new entity will have a 15% share of the global market for seabass and sea bream, Greece's top food exports in terms of total value.

The production facilities of the new company will include 72 sea cage farms, seven hatcheries, 14 packing stations, two processing plants and two distribution centers. The corporation created by the merger will have 12 subsidiary companies and total personnel of approximately 1,500 employees. The total annual volume of exports of fresh Greek sea bream and seabass to over 20 countries will surpass 35,000 mt, amounting to approximately 87% of total sales.

"The merger is the first step in the now-mandatory consolidation of the industry," Selonda CEO Stefanos Manellis said. "Dias and Selonda together have to exploit our competitive advantages to create a powerful corporation that can effectively manage the formidable challenges that our industry is currently facing. I am optimistic that we have the required infrastructure and human resources to achieve the desired results."

For more information, visit www.selonda.gr.

BioMar Invests In Feed Trial Unit In Chile

The BioMar Group has announced the construction of a new feed trial unit located near one of its factories in Pargua outside Puerto Montt, Chile.

Paddy Campbell, global R & D director for BioMar Group, said the unit will consist of 148 tanks divided into three different recirculation systems. It will be the largest of its kind in Chile and substantially increases the trial capacity available for BioMar's global research.

"With the new unit we gain a greater flexibility," Campbell said. "We will have a better possibility to perform precise benchmark trials for different diets and evaluate their biological and economic performance for our customers."

The new feed unit will enable BioMar to perform simultaneous trials with both freshwater and seawater in closed systems with controlled culture environments. Campbell said the facilities will primarily be used for trials with salmon and trout of various ages. The unit will allow BioMar to test new diets for recirculation systems and further investigate the link between nutrition and fish health.

For further information, contact Campbell at pcampbell@biomar.com or Michael Adler at madler@biomar.com.

Scottish Salmon Tops For Animal Welfare

The world's largest animal welfare organization, the Royal Society for the Prevention of Cruelty to Animals (RSPCA), has reported that 70% of Scottish farmed salmon is "Freedom Food" approved. The charity forecasts that 90% of Scottish producers will participate in the scheme by 2014.

Scotland is the world's third-largest producer of farmed salmon. Its industry has been working with the RSPCA over the last 11 years, said Scott Landsburgh, chief executive of the Scottish Salmon Producers Organization. "With growing signs that good animal welfare equals good business, Scottish farmers are set to continue to make animal welfare a high priority," he said.

Bob Waller, agricultural manager for Freedom Food, said: "It became clear at an early stage that there were tangible commercial benefits from adopting the welfare standards – improvements in fish health and biosecurity, a reduction in mortality and an increase in efficiency." Proper handling also improved flesh quality and shelf life.

For more, visit www.sdi.co.uk.

Skuna Bay Implements Carbon Offsets

Effective immediately, Vancouver Island, Canada-based Skuna Bay Salmon will neutralize carbon emissions for all freight shipments with carbon offsets purchased through Terra Pass. Adopting this policy further advances Skuna Bay's commitment to protect the environment through responsible stewardship and practices.

"Climate change and carbon emissions are critical issues in today's world, and Skuna Bay is committed to finding solutions and continuous innovation," said Stewart Hawthorn, head farmer.

Terra Pass, considered the world's most credible facilitator of carbon emission offsets, operates projects with carbon credits verified under the Climate Action Reserve and Verified Carbon Standard.

"It is important to us that we maintain our commitment to ocean-caught freshness while practicing environmental stewardship," said Dave Mergle, Skuna Bay Salmon director. "Offsetting our freight carbon emissions allows us to grow, service chefs and remain carbon neutral for our freight."

For more, visit www.skunasalmon.com.

calendar

MAY

Asian Fisheries and Aquaculture Forum/International Symposium on Cage Aquaculture in Asia
April 30-May 4, 2013
Yeosu, Korea
Phone: +82-42-535-8600
Web: www.koference.org

University of Virgin Islands Aquaponics Workshop
May 8-10, 2013
St. Croix, Virgin Islands
Phone: +1-340-778-1620
Web: www.uvi.edu/sites/uvi/Pages/AES-Aquaculture-International_Aquaponics.aspx

National Restaurant Association Show
May 18-21, 2013
Chicago, Illinois, USA
Phone: +1-312-580-5410
Web: http://show.restaurant.org/Home

Alltech Annual International Symposium
May 19-22, 2013
Lexington, Kentucky, USA
Web: www.alltech.com/symposium

VIV Russia 2013
May 21-23, 2013
Moscow, Russia
Phone: 704-365-0041
Web: www.imexmanagement.com/show/55/viv-russia-2013/

World of Seafood
May 22-26, 2013
Bangkok, Thailand
Phone: 66-2507-7999
Web: www.worldofseafood.com

Aquavet I, II, III
May 26-June 21, 2013
May 26-June 7, 2013
June 24-July 27, 2013
Bristol, Rhode Island, USA
Phone: +1-607-253-3000
Web: www.vet.cornell.edu/aquavet

Sustainable Diet and Food Security Conference
May 28-29, 2013
Nouveau Siècle, Lille, France
Phone: +33(0)1-40-78-38-14
Web: www.sustainable-diet2013.fr

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
Fax: +1-314-293-5525

Aquarama 2013
May 30-June 2, 2013
Singapore
Phone: +65-6592-0891
Web: www.aquarama.com.sg

JUNE

Aquaculture Canada 2013
June 2-5, 2013
Guelph, Ontario, Canada
Phone: 506-529-4766
Web: www.aquacultureassociation.ca/meeting/aquaculture-canada-2013

Annual Larval Fish Conference
June 2-6, 2013
Miami, Florida, USA
Phone: +1-305-421-4069
Web: www.rsmas.miami.edu/LFC2013/

Future Fish Eurasia 2013
June 6-8, 2013
Izmir, Turkey
Phone: +90-212-347-10-54
Web: www.future-fish.com

FENACAM
June 10-13, 2013
Natal, Brazil
Phone: 84-3231-6291
Web: www.fenacam.com.br

Water and Fish Conference
June 12-14, 2013
Belgrade, Serbia
Phone: +381-11-2615-315
Web: www.cefah.agrif.bg.ac.rs/conference/conference.html

Best Aquaculture Practices Auditor Course
June 19-21, 2013
Ho Chi Minh City, Vietnam
Phone: +1-352-563-0565
Web: www.bestaquaculturepractices.org

International Aquaponics Conference
June 19-21, 2013
Stevens Point, Wisconsin, USA
Phone: +1-800-898-9472,
+1-715-346-3838
Web: www.uwsp.edu/Aquaponics Conference

VIETFISH 2013
June 25-27, 2013
Ho Chi Minh City, Vietnam
Phone: +84-08-62810442
Web: www.vietfish.com.vn

Pescamar
June 26-28, 2013
Mexico City, Mexico
Phone: +1-55-56-01-77-73
Web: www.pescamar.com.mx

JULY

Crustacean Society Summer Meeting
July 7-11, 2013
San Jose, Costa Rica
Phone: 506-2222-2022
Web: www.crust-costarica2013.org

International Symposium on Sturgeon
July 21-25, 2013
Nanaimo, Canada
Web: http://iss7.viu.ca

AUGUST

Aquaculture Europe 2013
August 9-12, 2013
Trondheim, Norway
Web: www.easonline.org/component/content/article/226

Aqua Nor
August 13-16, 2013
Trondheim, Norway
Phone: +47-73-56-86-40
Web: http://nor-fishing.no/en/aqua-nor/aqua-nor-2013/

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