global aquaculture

the advocate

The Global Magazine for Farmed Seafood

November/December 2013

DEPARTMENTS

On the cover:
Long regarded as an international center for the arts, Paris became the center of the aquaculture world when it played host to 300 seafood professionals at GOAL 2013. Photo by Gail Hannagan, gh–studio.com.

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Exposure to ammonia nitrogen can reduce growth and increase disease issues in aquatic species. The best management is via conservative stocking and feeding.

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Novel Monosex Culture Of Prawns
New technology for producing all-male populations of freshwater prawns by silencing the androgenic gland insulin-like gene works without hormones or chemicals.

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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The Rest Of The Story

Wally Stevens
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Two years ago, at the GOAL 2011 conference in Santiago, Chile, the Global Aquaculture Alliance identified five major challenges to doubling aquaculture production in a decade – health and disease management, feed, environmental and social accountability, investment capital and marketplace support.

In October, at the GOAL 2013 conference in Paris, France, which more than 300 aquaculture and seafood professionals from 35 nations and six continents attended, the organization added a challenge to the double-in-a-decade target – leadership.

GAA doesn't shy away from the issues critical to the long-term sustainability of aquaculture, no matter how uncomfortable or controversial. This sense of leadership – and cooperation – was evident at this year's GOAL, where, after giving presentations in the morning, the conference's speakers willingly fielded questions from attendees in the afternoon, resulting in a productive dialogue.

Case in point: On Day 1 of GOAL 2013, a crowd of about 50 aquaculture professionals huddled around the world's foremost authorities on early mortality syndrome for a classroom-style discussion on the work that's being done to better manage a disease that has battered global shrimp production.

On Day 2, a bigger crowd of aquaculture professionals clustered around representatives of the feed ingredients sector for a question-and-answer discussion on everything from dependency on unsustainable marine proteins to the use of GMO vegetable proteins. No issue was ignored, and no question was disregarded.

This sense of leadership and cooperation is apparent in GAA's primary roles and everything it does. Those roles are GAA, the standards owner, and GAA, the voice for responsible aquaculture.

Through its Best Aquaculture Practices standards, GAA offers the world's most comprehensive third-party certification program for aquaculture facilities. Recognizing that the challenges faced by the industry do not stop at the farm level, the BAP standards encompass the entire aquaculture production chain, including processing plants. The standards address every key element of responsible aquaculture, including social responsibility and food safety. Additionally, GAA's market development team actively promotes the BAP program to retailers and foodservice operators worldwide on behalf of BAP-certified producers.

Through its communications vehicles, GAA advocates responsible aquaculture. At the annual GOAL conference, issues are debated, and solutions are identified. All the while, relationships are forged, and tomorrow's leaders are developed.

Through its public-relations work, GAA defends the practices of BAP-certified facilities, acts as a source of accurate, objective information for the media and promotes the work being done by the Responsible Aquaculture Foundation, a charitable organization established with the assistance of GAA to offer education and training in support of responsible aquaculture.

In the pages of this very magazine, GAA encourages the exchange of science-based information, providing farmers, processors and marketers with the research and evidence they need to be smarter professionals.

GAA offers the type of leadership and cooperation that's vital to the long-term sustainability of aquaculture. Through its BAP third-party certification program and various communications vehicles, GAA tackles the issues of the day head-on while advocating responsible aquaculture.

It's a powerful combination.

Sincerely,

Wally Stevens

How Do We Get There?

Time Again To Review…

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

With this issue, we close another successful year for the Global Aquaculture Alliance and its *Global Aquaculture Advocate* magazine. We are most grateful to our advertisers, contributors and readers, because without their significant and valuable support, we could not accomplish what we do.

At this time, I would like to again share with you my recurring message: We must produce more seafood, and we can only accomplish this by further developing our aquaculture industry in a responsible, efficient and profitable manner.

As outlined in previous end-of-year messages, let's ask ourselves some simple questions. Where are we? Where should we be? And how do we get there?

Let's look at available data for aquaculture production and current trends for most major species currently cultured – including freshwater and marine finfish and shellfish. As discussed in our recently concluded GOAL 2013 meeting in Paris, France, aquaculture growth now appears to be slowing down, and significant improvements in production growth are needed if we are to meet the challenge of supplying the growing human population with more seafood.

Where do we need to go? Most current predictions for future global seafood needs indicate we need to produce an additional 30 mmt to 40 mmt of seafood worldwide in the next few decades, depending on wild fisheries output and consumer demand trends.

How do we get there? I believe improving the efficiency of aquaculture production is the major strategy with the potentially largest impact. Ours is already a relatively efficient industry when compared to terrestrial livestock production. But we need to do much more.

Ours is already a relatively efficient industry when compared to terrestrial livestock production. But we need to do much more.

Increasing sustainable production will require more production from established species; development of new candidate species; expansion into new production areas like inland, near- and offshore; improved domestication and genetic selection; better aquafeeds and new feed ingredients; improved health management; new production technologies with increased control; and better risk management.

Also, we must attract professional investors, accelerate industry consolidation and address market perspectives. This will increasingly demand more efficiency, quality control and traceability through the entire production chain. In other words, we need to become "industrialized," as other major meat-producing industries have done.

GAA Executive Director Wally Stevens, who identified five major challenges to aquaculture growth at GOAL 2011 in Santiago, Chile, added a sixth challenge in his welcoming remarks at our recent GOAL conference: leadership. In the words of Prof. Warren Bennis, "Leadership is the capacity to translate vision into reality." We certainly have the vision, to better feed our growing population, but our industry needs visionary leaders to lead by example and make that vision a reality.

We hope you have had a great year, and offer our wishes for much success in 2014. Please let us know how we can best serve our industry.

Sincerely,

Darryl E. Jory

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Leadership Development, Cooperation Emphasized At GOAL 2013

Some 300 seafood professionals traveled to Paris to "Join the Journey" toward more responsible aquaculture.

The significance of leadership development and cooperation echoed throughout the opening remarks and two keynote addresses at the Global Aquaculture Alliance's GOAL 2013 conference in Paris, France. Held from October 7 to 10, the event carried the theme of "Join the Journey."

The audience of some 300 attendees reflected an international mix, with one-third of the participants from France, the United Kingdom and other countries in Europe. Nearly half the attendees came from North America, while Southeast Asia, Latin America, the Middle East, Africa and Australia were also represented.

GAA Executive Director Wally Stevens set the tone during his opening remarks with an emphasis on leadership development and cooperation, which he said are "critical to the long-term sustainability of aquaculture."

He pointed to GAA President George Chamberlain and GOAL 2013 guests Ole-Eirik Lerøy of Marine Harvest and aquaculture pioneer Bjørn Myrseth as individuals who succeeded in the industry, but not without receiving help along the way. He then challenged the audience to also assist others by mentoring tomorrow's leaders.

Stevens reviewed the aquaculture industry's five major challenges as health and disease management, feeds, environmental and social accountability, investment capital and market support – challenges that have been identified at previous GOALs. But, said Stevens, a sixth major challenge is emerging: leadership.

Stevens' messages carried over into Marine Harvest Chairman Ole-Eirik Lerøy's keynote address, titled "Leading the Blue Revolution." "We are a very young industry," Lerøy said. "We have a lot to learn, and we have to do it together."

There was a lot of positivity in Lerøy's presentation, acknowledging the seemingly endless opportunities for farmed salmon without ignoring the challenges faced by the industry. He said there's a need to use "a better-educated consumer as a tool to bring the industry forward."

In his keynote address on October 10, titled "Green Growth and Implications for Fisheries and Aquaculture," Carl-Christian Schmidt, head of the fisheries policies division at the Organisation for Economic Co-operation and Development, delivered a message similar to that of Lerøy.

Even though Schmidt is from the public sector, and Lerøy is from the private sector, both share the theory that aquaculture holds much promise if it grows in a sustainable, responsible manner.

Schmidt pointed to Norway as an example of a country that has embraced responsible aquaculture. Schmidt attributed the success in Norway to licensing of farms, regulated installation of aquaculture facilities, restrictions on the use of antibiotics, proper disposal of dead fish and maintaining good records.

In many countries, however, aquaculture growth is restricted by bureaucracy and the lack of a regulatory framework. There are too many agencies involved in aquaculture regulation, and the agencies "don't talk to each other," Schmidt said. "This is a serious problem."

In his keynote, Marine Harvest Chairman Ole-Eirik Lerøy acknowledged the many opportunities for farmed salmon without ignoring the challenges faced by the sector.

GOAL 2014 HO CHI MINH CITY VIETNAM

GOAL 2014 Goes To Vietnam

The Global Aquaculture Alliance's GOAL 2014 conference will take place in Ho Chi Minh City, Vietnam. The location was announced during the closing remarks of GOAL 2013 by Travis Larkin, president of The Seafood Exchange. Larkin also unveiled the GOAL 2014 event logo.

The dates, venue and theme of GOAL 2014 will be posted on the GAA website. The conference is expected to take place in October or November.

To view full GOAL 2013 program information, visit www.gaalliance.org/GOAL2013.

GOAL 2013

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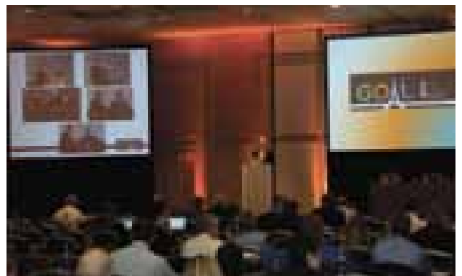











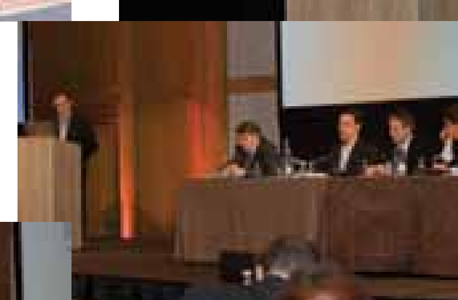
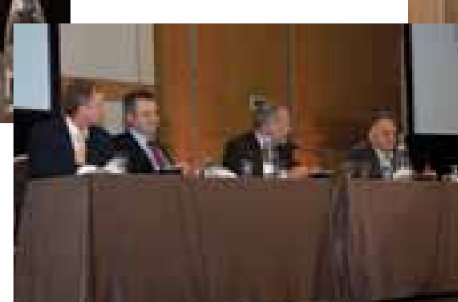

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PRODUCTION: Global Fish Review

Industry Growth Slowing For Multiple Species

Annual mussel production is expected to increase slightly for 2013.

Prof. Ragnar Tveterås
University of Stavanger

The experts who speak on global aquaculture production at GOAL refer to estimates based on figures from Kontali Analyse and information from a global survey coordinated by Dr. Darryl Jory for the Global Aquaculture Alliance. Production figures until 2010 are based on the United Nations Fish and Agriculture Organization's Fishstat database. The Norwegian Seafood Council has provided data on prices for several species. Table 1 provides a summary of finfish production volumes. Additional information on individual species and trends is provided below.

Mussels

The survey on mussels included the following species: Mediterranean mussels, *Mytilus galloprovincialis;* blue mussels, *M. edulis;* Chilean mussels, *M. chilensis;* cholga mussels, *Aulacomya ater;* and green mussels, *Perna viridis*. Annual global mussel production is fluctuating around 1.8 mmt. This year, production is expected to increase only slightly.

Figure 1 shows the development in the global production of these species. According to this figure, mussels have seen little growth in production since 2010.

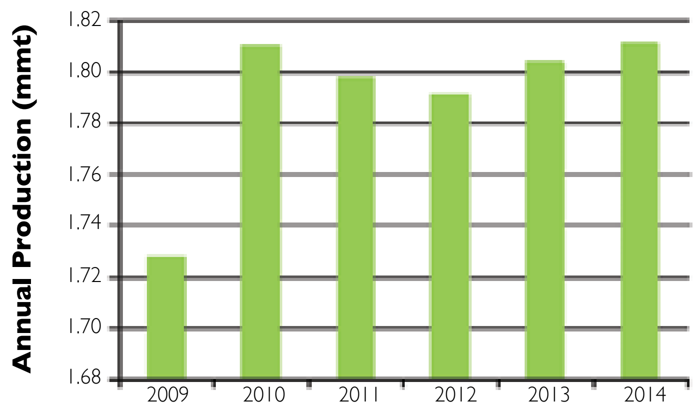

Figure 1. Global mussel production estimates and projections.

Tilapia

Tilapia have a diversified production base and market base, which makes culture of the species more resilient to all kinds of shocks than other species. The sector has therefore continued to add production over time.

Table 1. Production of surveyed species and regions (in 1,000 mt).

Species (Regions)	2009	2010	2011	2012	2013	2014
Freshwater Species						
Tilapia	3,109	3,497	3,958	4,208	4,400	4,500
Pangasius (Vietnam)	1,050	1,140	1,151	1,416	971	920
Catfish	2,703	3,200	3,366	3,635	3,685	3,690
Carp, China	11,034	11,528	12,125	12,971	12,420	12,940
Diadromous Species						
Atlantic salmon	1,469	1,446	1,623	1,980	2,013	2,074
Coho salmon	108	125	148	168	180	141
Rainbow trout	298	307	317	362	298	289
Trout, Latin America	24	23	35	34	36	37
Barramundi (Australia, India, Taiwan)	19	32	34	35	35	35
Milkfish (Philippines)	348	349	373	387	393	400
Marine Species						
Seabass and sea bream (Meditteranean)	295	294	291	320	343	335
Olive flounder (South Korea)	55	41	41	40	40	41
Turbot (excluding China)	10	10	11	13	13	12
Atlantic halibut	2	2	3	4	4	4
Atlantic cod	24	23	17	10	6	4
Bluefin tuna	29	29	27	30	31	30
Grouper (Indonesia, Taiwan)	22	22	24	26	26	25
Total (excluding carp, China)	9,563	10,540	11,416	12,669	12,473	12,507
Total	20,597	22,067	23,541	25,640	24,893	25,447

While Vietnam reported a 30% drop in *Pangasius* production from 2012 to 2013, production in other countries is expected to rise slightly in 2014.

Tilapia farmers are expected to produce 4.4 mmt in 2013, a 4.6% growth since 2012 (Figure 2). Next year, the total is expected to grow by 2.3% to 4.5 mmt. This is still significantly lower than the average growth rate over the 2003-2013 period, which has been 11.0%.

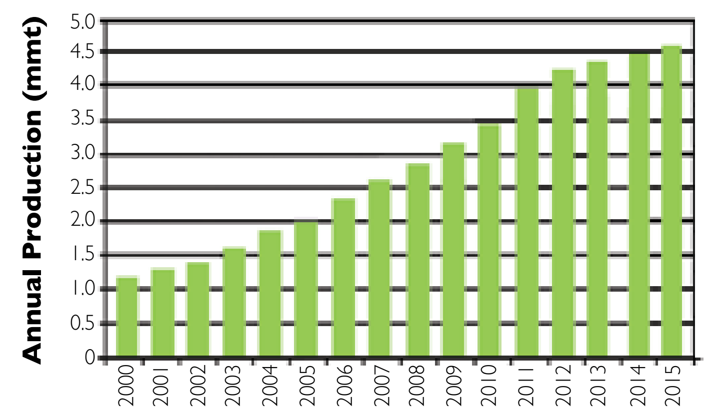

Figure 2. Global tilapia production estimates and projections.

Pangasius, Catfish

GAA is getting estimates on *Pangasius* from more countries than previously. Some years ago, we only had figures from Vietnam. As shown in Figure 3, the total production from those countries reporting is around 2 mmt in 2013, a figure projected to rise slightly in 2014.

Vietnam is experiencing a 30% drop in *Pangasius* production from 2012 to 2013, if we are to believe the figures. Annual production is now below 1 mmt and is expected to stay at that level next year.

GAA has just recently started to get data on catfish species. It showed that global production of catfish reflects a mixed bag. Vietnam, China, Indonesia and Bangladesh are among the largest producers. Total production in those countries covered has reached levels of 3.7 mmt in 2013, up by 1.4% from last year. Production is expected to increase only marginally next year.

To view full GOAL 2013 program information, visit www.gaalliance.org/GOAL2013.

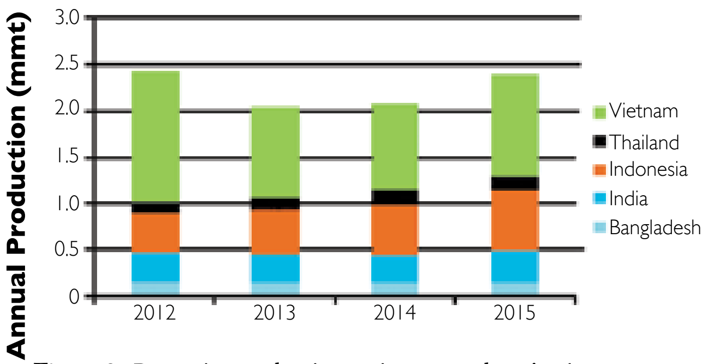

Figure 3. *Pangasius* production estimates and projections for select countries.

Salmonids

Atlantic salmon production reached about 2 mmt this year, up a bit since 2012. This is a much smaller increase than that seen in the previous two years, which provides some explanation for the upward pressure in prices this year. Next year, salmon production is expected to grow by 3%. Norway continues to dominate the producer field, but Chile has made a strong recovery from its 2010 low point.

Coho salmon production has grown by 7.1% to 180,000 mt in 2013. Next year, however, production is expected to decline by around 20.0%. Chile, the main producer, is driving this decline. We have seen a sharp drop in prices from Chile's 2011 levels.

Rainbow trout seems to have reached a production plateau in the last few years. There was a spike in production in 2012, but output is expected to decline by 17% in 2013 to 300,000 mt. Next year, production is predicted to decline further to 288,000.

Marine Species

Seabass and sea bream in the Mediterranean added significant production in 2012 and 2013 after a long period of stagnation. Production is estimated to reach 342,000 mt in 2013. Next year, however, output is expected to decline by 2%. The sector has experienced a long period of relatively stable prices. The production increases in 2012 and 2013 have been accompanied by some decline in prices on seabass and bream.

Flatfish represent relatively small production, with generally high unit values. For olive flounder in South Korea, annual production levels of around 40,000 mt were fairly stable in 2012 and 2013. This is predicted to continue in 2014.

For turbot, the estimates indicate that production (excluding that of China) declined by almost 30% to 9,300 mt in 2013, down from 13,000 mt in 2012. Production seems to have reached a plateau. Beyond China, for which we do not have estimates, Spain is the dominant producer of turbot.

Atlantic halibut is a high-value species produced in small quantities, primarily in Norway. Annual production is between 3,500 and 4,000 mt.

Cobia is a species that is hard to follow because country data coverage varies from year to year. Production levels for those countries providing data reflect around 5,000 mt total.

Atlantic cod have experienced an implosion of production in recent years, as the industry faced low prices and failed to solve technological bottlenecks. Production is now at levels around 6,000 mt and is expected to decline further next year.

Bluefin tuna output seems to have found some kind of equilibrium. It is expected to stay more or less stable around 30 mt/year.

Total Production

The total production of species (excluding carp) and countries covered by the surveys is shown in Figure 4. It indicates that production increased from 4.0 mmt in 2002 to 12.7 mmt in 2012.

The bad news is that for 2013 and 2014, production is expected to stay at or below that level. The rate of growth is declining, and in some years, growth has been close to zero. From annual growth in 2011 of 11%, it is predicted to be -1.6% in 2013 and only 0.5% next year.

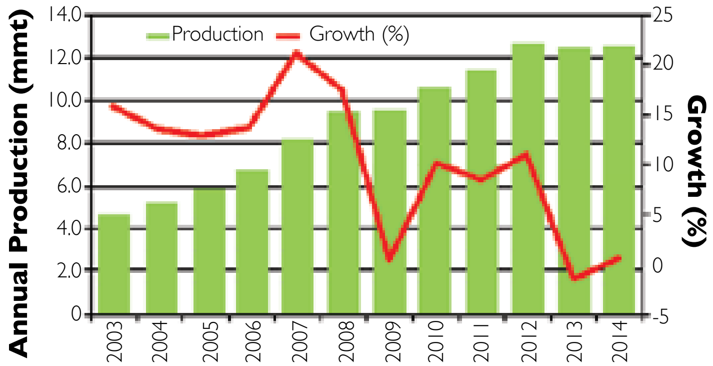

Figure 4. Global production estimates and growth rates, all species surveyed.

Species Groups

How is total production split among different species groups and farming environments? Freshwater fish represent the bulk of production. For 2013, the surveyed freshwater sectors are predicted to produce 9.1 mmt, while diadromous sectors will provide 3 mmt, and marine sectors will produce 0.5 mmt.

All three groups project a declining trend in growth rates for 2013. When carp in China are excluded from the freshwater sector, the growth average since 2003 has been 13.5%. With carp included, the freshwater sector has had average growth rate of 7.2%. The production of marine sectors grew on average by 6.9%, while diadromous species increased by 5.8% on average.

Double In A Decade?

Did the species covered by the survey double output in a decade? Some did, and some did not for the 2003 to 2013 period. Marine species grew about 89% during the period. Diadromous species increased by 72%. Production for freshwater species, however, increased by 243%. If we include carp in China, the freshwater sectors more or less doubled their production.

The total production of the surveyed species – when we include carp in China – is close to doubling with a 95% growth. Excluding carp presents a more impressive total growth of 171%.

So until this year, aquaculture has largely been able to double production in a 10-year period. But most of the growth happened in the first half of the 10 years. Unless these aquaculture sectors can pick up their pace of growth, we may see they have not been able to double in the next decade.

To view full GOAL 2013 program information, visit www.gaalliance.org/GOAL2013.

PRODUCTION: Global Shrimp Review

Disease Drops Production, But Recovery Anticipated

The near-future outlook for shrimp production varies considerably by region. Product forms are trending away from cooked and breaded shrimp, and generally toward smaller sizes.

James Anderson, Ph.D.
The World Bank

Diego Valderrama, Ph.D.
University of Florida

The 2013 Global Aquaculture Alliance survey of production trends in shrimp farming polled 39 respondents from Asia/Oceania, 29 from Latin America and two from Africa. Figure 1 summarizes the production estimates for the major producing nations in Asia. Data through 2011 are official statistics from the United Nations Food and Agriculture Organization (FAO) while 2012-2015 data are averages of the estimates provided by the survey participants.

Asian Production

According to FAO, shrimp production grew steadily in Asia through 2011, averaging a 5% annual growth rate from 2006 to 2011. This growth was slower than that recorded during 2000 to 2006, when annual growth rates averaged 18%.

The Asian respondents reported a large impact on production in 2012 and 2013 caused primarily by early mortality syndrome or acute hepatopancreatic necrosis (EMS/AHPN) in China, Vietnam and Thailand. Production in Asia is expected to bottom out in 2013 at 2.8 mmt, down 16% with respect to 2011. The largest production declines relative to 2011 levels are expected in Thailand (-48%), Vietnam (-43%) and China (-26%). Nevertheless, most of the respondents in these countries expected to see at least a partial recovery by 2014 and 2015.

In contrast, respondents from Indonesia, India, Bangladesh, Malaysia and Myanmar projected steady increases in production into 2015, with India and Myanmar achieving double-digit growth rates. By 2015, Indonesia, India and Myanmar are expected to reach annual outputs of 600,000; 300,000 and 100,000 mt, respectively. These forecasts assumed no major impacts from shrimp diseases in these countries. The expansion of shrimp farming in India will continue to be driven by production of the western white shrimp, *Litopenaeus vannamei.*

Latin America

Figure 2 presents estimates for the major producing nations in Latin America. Mexico was heavily impacted by EMS/AHPN in 2013, and as a result, respondents reported a 60% decline in production relative to 2012 – from 93,000 to 38,000 mt. A partial recovery is expected in 2014 and 2015. However, output in 2015 is expected to be 43% lower than the production levels in 2011.

The outlook for most other Latin American nations is much more positive, with Ecuador and Brazil reaching 250,000 and 100,000 mt annual production by 2015, respectively. The Ecuadorian estimates for 2012 are substantially lower than the official FAO statistics for 2011, which seems to indicate some disagreement about actual production levels in this country. These data inconsistencies may be corrected in the next few years as FAO revises its statistics based on information provided by the Ecuadorian government. Assuming no major impact from EMS/AHPN, steady increases in production through 2015 are forecast for most countries in Latin America with the exception of Colombia, where the industry is expected to contract by 90% between 2011 and 2015.

FAO indicated that global production of farm-raised shrimp reached 3.9 mmt in 2011. Due mostly to EMS/AHPN, the GOAL survey estimated that production decreased by 5.7% in 2012 and then again by 9.6% in 2013.

Considering that global farmed shrimp production grew at an average annual rate of 4.8% between 2006 and 2011, it is estimated that 2013 production is 23.0% below the level expected if the most recent disease crisis had been averted. Global shrimp production is expected to recover and grow at an average rate of 6.9% in 2014 and 2015, but 2015 output should still be about 4.0% lower than in 2011.

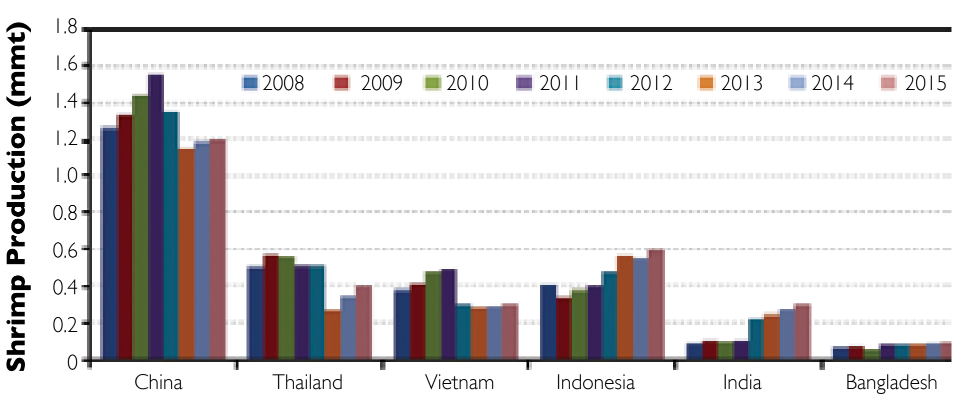

Figure 1. Production of farm-raised shrimp in major producing nations in Asia. Sources: FAO (2008-2011) and GOAL Survey (2012-2015).

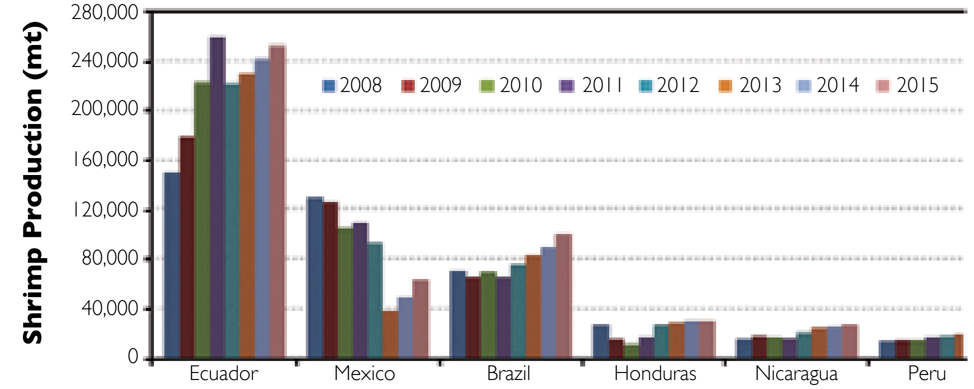

Figure 2. Production of farm-raised shrimp in major producing nations in Latin America. Sources: FAO (2008-2011) and GOAL Survey (2012-2015).

Product Form Trends

The GOAL survey also collected information on trends in size categories and product forms. A notable trend in Asia in recent years has been the increase of green shrimp relative to other product forms, such as cooked and breaded. While head-on and head-off green shrimp accounted for only 30% of production in the 2007 survey, it accounted for 43% in the most recent poll. These changes seem to reflect the growing importance of the domestic Chinese market, which may have a preference for green shrimp over other processed forms.

Production in Latin America continues to be oriented toward green shrimp. Head-off shrimp seem to be losing market share relative to head-on shrimp and other product forms. Green head-off shrimp accounted for 41% of production in 2007, but only 30% in 2012. Increased shipments of Ecuadorian shrimp to European and Asian markets are an important factor driving this trend.

Respondents in Asia and Latin America have reported a move toward production of smaller shrimp (51-60 and smaller) since 2011. Between 2010 and 2012, the share of small shrimp in Asia increased from 27 to 41% and from 30 to 42% in Latin America. The shift to smaller shrimp seems to have been driven by narrowing price margins between the small sizes and larger counts. Early harvests caused by EMS/AHPN also help explain this trend.

Disease Impacts

Diseases were once again identified by survey respondents as the most important challenge faced by the industry. Other disease-related issues, such as access to disease-free broodstock and seedstock quality and availability, were also ranked high (third and fifth positions, respectively). Feed costs and international market prices were ranked as the second and fourth most-important issues.

These perceptions have changed remarkably. In the 2007 survey, diseases were not mentioned among the top three challenges for Asian producers, who used to be more concerned about feed costs, international market prices and trade barriers. Disease issues have now moved to the forefront. In Latin America, access to credit recently emerged as an important challenge for the industry.

Opinions among Asian respondents were divided with regard to the impacts of global economic conditions on the shrimp market. Latin American respondents showed more confidence in the improvement of the global economy. Nevertheless, most Asian and Latin American respondents expected the upward pressure on feed prices to continue in 2014.

Expansion of shrimp farming will continue to be driven by production of *Litopenaeus vannamei.*

CHALLENGE: Health Management

Program Focuses On 'Perfect Killer' EMS

Dr. Donald Lightner described ongoing research to develop a commercial PCR test for the rapid detection of EMS.

George Chamberlain
Global Aquaculture Alliance

At the GOAL 2013 meeting in Paris, disease was once again identified as the primary challenge obstructing the growth of aquaculture. George Chamberlain moderated a panel on health management that reviewed the three disease case studies conducted by the Responsible Aquaculture Foundation and World Bank (RAF/WB).

Fred Kibenge reviewed the situation with infectious salmon anemia (ISA) in Chile, where the first case study was performed in 2011. He said ISA is unlikely to be eradicated in Chile, but the industry has advanced greatly in its surveillance and zone management procedures, and successfully managed ISA outbreaks this summer. Progress is also being made toward developing more effective vaccines.

Attention was then shifted to early mortality syndrome (EMS) in shrimp, which was the topic of the second RAF/WB case study in Vietnam in 2012. Chamberlain began the discussion with a review of the EMS epidemic, which began in China in 2009 and spread to Vietnam in 2010, to Malaysia in 2011, to Thailand in 2012, and to Mexico in 2013. The disease causes atrophy and dysfunction of the hepatopancreas.

After three years of industry speculation about possible causes of the disease, Donald Lightner's laboratory at the University of Arizona diagnosed the cause as a virulent strain of *Vibrio parahaemolyticus* that colonizes the stomachs of shrimp, produces a potent toxin and causes acute damage to the hepatopancreas organs. This results in massive secondary bacterial infection. The EMS pathogen does not affect humans and is deactivated by prolonged freezing.

Overcoming EMS

Chamberlain then introduced Lightner, Robins McIntosh and Noriaki Akazawa to discuss recent advances in overcoming EMS. Lightner described research at the University of Arizona to develop a sensitive polymerase chain reaction (PCR) test to allow rapid detection of the disease in broodstock, postlarvae and juveniles. The test is expected to be commercially available soon.

Akazawa described efforts to control the disease at Agrobest, a large integrated shrimp farm in Malaysia. He indicated that EMS first appeared at his farm in early 2011 in association with a batch of postlarvae purchased from an outside hatchery. It quickly spread, but not all ponds were equally affected.

The incidence of severe mortality was related to environmental conditions such as pH of the pond water. Progress was made in recovering productivity of the farm until May/June of this year, when a new wave of mortality occurred. Akazawa said that prevalence of EMS in postlarvae is a major uncontrolled variable, which will be difficult to control until the PCR test becomes available.

McIntosh described EMS as the "perfect killer" because it grows extremely fast and is a colonizer that adheres to surfaces. The colony coordinates release of a potent toxin through a process known as quorum sensing. He said recovery from the disease in Thailand will be complicated and likely require two to three years.

Environmental Conditions

During an informal breakout discussion following the panel, other helpful information about EMS emerged. For example, the pathogen does not grow in freshwater or nearly freshwater with up to 3 ppt salinity, but its growth increases from 4 to 11 ppt, above which growth is unaffected by salinity. While Akazawa's research showed that shrimp mortality is greatly accelerated at high pH, the pathogen itself seems unaffected by pH. This implies an interaction between pH and shrimp immunity.

Unlike viral pathogens, the EMS pathogen can grow in coastal waters and shrimp ponds outside the host. This challenges conventional methods for water treatment. Chlorination followed by addition of molasses or other nutrients has not been effective in controlling EMS, perhaps because chlorination kills competing bacteria, and the addition of nutrients stimulates the growth of *V. parahaemolyticus*. On the other hand, well water has yielded improved survival when compared to the use of surface water. These results suggested a greater role for filtration and probiotics in competing with and excluding EMS.

Although laboratory bioassays indicate that both *P. monodon* and *L. vannamei* succumb to an infective dose of *V. parahaemolyticus*, field results indicate *P. monodon* usually don't die of EMS in ponds. This suggests the feeding behavior of *P. monodon* is different than that of *L. vannamei*, which reduces its exposure.

Polyculture studies with fish such as tilapia have reduced EMS mortality in shrimp. This is thought to be caused by the blooms of *Chlorella* algae in tilapia ponds, which may disrupt the quorum sensing ability of *V. parahaemolyticus*.

The afternoon breakout sessions provided an opportunity to address specific questions about EMS/AHPN.

OPPORTUNITY: Africa, Middle East

Aquaculture Potential Varies By Country

Panelists agreed that Africa and the Middle East offer significant potential for additional aquaculture development.

Oman is open for business. That's the message that H. E. Dr. Hamed Al Oufi, Oman undersecretary for Fisheries, Ministry of Agriculture and Fisheries Wealth, delivered during his GOAL 2013 presentation, titled "Aquaculture's Potential in the Sultanate of Oman."

Day 2 of GAA's GOAL 2013 conference focused on aquaculture growth opportunities in the Middle East and Africa. Eight speakers – representing a cross-section of industry, government and academia – talked about their experiences in aquaculture in this part of the world, which accounts for less than 3% of global aquaculture production, according to the United Nations' Food and Agriculture Organization (FAO).

Middle East

There's a lot of potential. Oman is attractive for aquaculture start-ups, said Al Oufi, because of its biodiverse resources with 3,165 km of coastline, world-class infrastructure, investor-friendly environment, speedy permitting process and political stability. "We're looking for long-term business partners," he said. "Come talk to us."

Speaking after Al Oufi were aquaculture consultant Patrick White, who spoke about aquaculture opportunities in the United Arab Emirates, Kuwait, Bahrain and Qatar; and Tim Huntington, director of Poseidon Aquatic Resource Management Ltd., who spoke about aquaculture opportunities in Saudi Arabia and Yemen.

White said a number of aquaculture systems would work well in the region, including recirculation technology for marine fish hatcheries and intensive fish production, large-scale microalgae pond or tank culture for biodiesel, and freshwater, brackish-water and marine aquaponics.

Saudi Arabia

Meanwhile, Saudi Arabia is at a crossroads, with an established shrimp-farming sector that has been hit hard by white spot syndrome. The main impact of white spot has been to stimulate the growth of finfish farming in Saudi Arabia, including yellowish kingtail, or amberjack, and Red Sea bream, said Huntington. "Finfish cage farming offshore is a major area of potential development," he said.

Also speaking about the Middle East were aquaculture consultant Marcos Villarreal, who talked about his experiences in Saudi Arabia, and Jim Greenberg, co-founder and board member of Arabian Shrimp Co. Ltd. Greenberg gave the introductory remarks and moderated the panel.

Africa

In Africa, aquaculture production is dominated by Egypt, which yields about 1 mmt of farmed seafood annually, predominately tilapia, said Izzat Feidi, an aquaculture and fisheries consultant and former FAO official.

As Feidi outlined the status of Egypt, Libya, Tunisia, Algeria and Morocco, it was apparent that aquaculture opportunities in North Africa vary greatly country by country, even though the region has thousands of kilometers of coastline, rivers, lakes and man-made ponds. The same goes for Sub-Saharan Africa.

"You must be passionate about what you're doing, and you must be prepared to be there for the long-term," said Patrick Blow, one of three speakers who addressed aquaculture opportunities in Africa.

Blow is owner of Cowrie Associates Ltd. and a part-time consultant to Marks & Spencer PLC and African Century Foods Ltd. He founded Lake Harvest Group Tilapia Farming and Processing in Zambia, one of Sub-Saharan Africa's largest tilapia producers. However, it took years to get the operation off the ground.

"You basically have to start from scratch," said Blow, as he laid out the difficulties associated with fish farming in Africa, including political and economic instability and a lack of quality fish feed.

Also speaking about Africa was Chantal Andriamilamina, principal investment officer for International Finance Corp. One of the biggest challenges that Africa faces is a lack of risk capital. "Even we institutions have to cherry pick," she said.

CHALLENGE: Feed Sustainability

Diverse Ingredients Sector Fights Misinformation, Emphasizes Innovation

IFFO's Andrew Mallison said fishmeal has been shifting from a mere commodity to become a more specialized ingredient.

While no one issue dominated Day 2's discussion on aquafeed at GAA's GOAL 2013 conference, which featured a diverse mix of representatives from the feed-ingredients sector, it's apparent that each sector is working diligently to increase transparency and educate the marketplace.

"We're seeing a more transparent value chain," said Andrew Mallison, director general of IFFO, the trade association for the marine ingredients industry. "Fishmeal has moved from a commodity to a specialized ingredient, as demand outstrips supply. Our business strategies need to be transparent and responsible."

The fishmeal sector is still dogged by misinformation, especially when it comes to fish in:fish out ratios, he said. The conversion of wild feed fish to farmed salmon is 1.4:1, yet the outdated 5:1 ratio is still cited in the media and by the environmental community.

Mallison also noted that the amount of whole fish converted into fishmeal is declining. Currently, by-products and trimmings make up 35% of total fishmeal production, he said.

For Martin Alm, technical director of the European Fat Processors and Renderers Association, the misinformation is due to a 12-year hiatus. This year, the European Union lifted its 12-year ban on the use of feather meal in fish feed. And due to its absence, knowledge of feather meal is marginal. Re-education is required. Said Alm: "Someone asked me recently, 'What is feather meal?'"

Rising Demand

Misperception may be a challenge, but there's no question that demand for feed ingredients is through the roof. "Shrimp has the fastest growth rate of all animal protein sources at 4.6% annually," said Philippe de Lapérouse, managing director of HighQuest Partners LLC. "Demand for feed for fish is growing three times faster than feed for other proteins."

Demand for soy in aquaculture is projected to increase by 4 mmt by 2020, when it is expected to meet half of global aquafeed needs, said Michael Cremer, senior international aquaculture program advisor for the U.S. Soybean Export Council. The U.S. soybean industry has been quite supportive of aquaculture, investing more than U.S. $50 million in the sector to date.

Alternative Proteins

Antoine Hubert, associate partner and director of research and development for Ynsect, spoke about the potential of alternative protein sources, including insect meal. Currently, insect meal and other alternative protein sources like algae and krill represent a minute percentage of the ingredients used in aquafeed. Plus, insect meal is still too expensive to be used in aquafeed. But the potential is there.

"The industry is ready for this," Hubert said in an interview following the panel. "They ask for this kind of material, even naming insects or worms as a potential supply for them, as feed producers."

Also speaking about feed were Duncan Leadbitter, technical director of the Sustainable Fisheries Partnership; Steven Hart, executive director of the Soy Aquaculture Alliance; Laura Foell of the United Soybean Board; and Robins McIntosh, senior vice president of Charoen Pokphand Foods Public Co. Ltd.

Philippe de Lapérouse said the demand for fish feed is growing much faster than for other feeds.

Scott Williams (second from left) said that effective partnerships lead to better business plans.

MARKETING: Marketplace Issues

2013 Challenging Year For Seafood Retailers

One of the more popular features of GAA's GOAL 2013 conference was Day 3's retail roundtables, where some of the world's more influential seafood retailers talked about the challenges and opportunities they face as the industry's links to consumers.

Once again, the retail roundtables were moderated by Peter Redmond, vice president of business development for GAA's Best Aquaculture Practices program. Subjects ranged from sustainability and efficiency to partnerships and trust.

Partnerships Wanted

Partnering with transparent suppliers and third-party certification programs that communicate effectively is key to maintaining a steady flow of affordable seafood, especially during a supply crisis – like the one that's currently dogging the shrimp sector, where suppliers are faced with reduced supplies and increased prices due to early mortality syndrome.

"We have to have great partnerships," said Scott Williams, manager of quality assurance and product development for B.J.'s Wholesale Club, a U.S. East Coast club store chain. "We only sell best sellers, so we need to figure out how we can make them affordable. Let us know when there's a problem on the horizon. We need to know 30 to 45 days out. We need to be able to plan."

Lee French, vice president of seafood merchandising for Price Chopper Supermarkets in the northeastern United States, agreed. "It comes down to relationships," he said. Before the infectious salmon anemia outbreak of 2007 and 2008, one of French's Chilean salmon suppliers said: "There's going to be trouble. You need to find someone else for a couple of years." Nine months ago, a shrimp supplier said to French, "There's going to be an issue."

Supply, Price Issues

For retailers, 2013 has been a challenging year, marked by supply and price difficulties. Just how challenging? That's a question that popped up over and over again at the conference due to increased prices and tightening supplies for many farmed seafood species.

"It's been a challenge, because how do you manage each individual issue?" said Robert Fields, senior director of meat, seafood and gourmet for Sam's Club, a U.S.-based club store chain owned by Walmart. "Even though prices are on the rise, consumers want a high-quality product, and they're willing to pay a higher price as long as the eating experience delivers."

"There are going to be peaks and troughs, biological and supply challenges, but that doesn't change the way we approach things," Ally Dingwall, aquaculture and fisheries manager for Sainsbury's, Europe's third-largest retailer, said. "Sustainability drives efficiency."

Marie Christine Monfort confirmed the positive image farmed seafood holds in Europe.

Also speaking on the three retail roundtables were Huw Thomas, fisheries and aquaculture manager for Morrisons; Laky Zervudachi, group sustainability director for Direct Seafoods; Joe Zhou, senior director of purchasing for Darden Restaurants; Mike Berthet, director of fish and seafood for M & J Seafood Ltd./ Brakes Europe; Carl Salamone, vice president of seafood sustainability for Wegmans Food Markets; Chris Brown, head of ethical and sustainable sourcing for Asda; Beth Grant, commodities procurement manager for US Foods; and Kimberly Taylor, category director of meat and seafood for Delhaize America.

European Markets

Between the retail roundtables was a presentation on the complexity and diversity of the European marketplace, delivered by Marie Christine Monfort, senior consultant at Marketing Seafood and Sea-Matters. "Europe is not one market – it's a bunch of national markets," Monfort said.

Europe is a 13-mmt seafood market. Aquaculture provides 3 mmt of the total, with finfish and shellfish at 1.5 mmt apiece. Market size and consumption, consumer habits and preferences, distribution and sensitivity to environmental issues vary depending on the market, Monfort said.

But there are similarities, including the growing dependence on imports, large-scale suppliers and farmed seafood, she said. Also, species not traditionally consumed in a particular region are growing in popularity. For example, farmed salmon is becoming popular in southern Europe. Monfort referred to this trend as "the pink wave."

What's encouraging is that farmed seafood has an excellent image, Monfort said, due to its nutritional content, freshness, year-round availability, affordability and positive contribution to the conservation of wild resources.

"The demand for [inexpensive], quality protein is only going to increase," she said.

To view full GOAL 2013 program information, visit www.gaalliance.org/GOAL2013.

Ben Gurion University Professor Wins Novus Innovation Award

NOVUS global aquaculture the innovation award advancing aquaculture through best practices

Amir Sagi, Ph.D., a professor at Ben Gurion University of the Negev in Israel, received the Global Aquaculture Alliance's inaugural Novus Global Aquaculture Innovation Award at GOAL 2013 for his novel biotechnology application to produce all-male populations of giant freshwater prawns through temporal RNA interference

The six judges selected Sagi's innovation because it addresses a key obstacle in the production of *Macrobrachium rosenbergii* – manual sorting of juveniles by gender.

"The beauty of our biotechnology lies in the fact that it represents the first commercialization of temporal RNA interference with no use of chemicals, hormones or genetic modifications," Sagi said. "To sustain its rapid growth, the aquaculture industry will need to consistently introduce the latest scientific developments. I am confident the R & D community will propose many more such applications in the near future."

Sagi, who received an expense-paid trip to GOAL 2013 and a U.S. $1,000 cash prize, is a past president of the International Society of Invertebrate Reproduction and Development and former dean of the Faculty of Natural Sciences at Ben Gurion University. Twenty years of research on the androgenic glands of prawns are behind the biotechnology used to produce all-male crustacean populations.

Sagi's innovation supports the production of all-male prawn populations without hormones or chemicals.

Sagi's entry was selected over 15 other creative innovations to capture the award. The applicants dealt with nine species of marine and freshwater fish and shellfish and originated from 11 countries.

The Global Aquaculture Innovation Award is sponsored by Novus International, a global leader in developing animal health and nutrition solutions. It was launched at GOAL 2012 to recognize innovative practices that overcome production challenges or mitigate negative environmental or social impacts at aquaculture farms.

"The GAA Standards Oversight Committee recommended the Novus Global Aquaculture Innovation Award as a way of recognizing the integral role of creative advances in driving continuous improvements in aquaculture," GAA President George Chamberlain said. "The Best Aquaculture Practices standards are routinely revised to reflect these advances."

Aquaculture pioneer Bjørn Myserth (left) was recognized for his work with salmon and other species.

Donald Lightner (right) and his research teams have been key to identifying elements of diseases and developing commercial solutions to their spread.

GAA Honors Myrseth, Lightner With Achievement Awards

The Global Aquaculture Alliance recognized the work of aquaculture pioneer Bjørn Myrseth and renowned shrimp pathologist Dr. Donald Lightner through Lifetime Achievement Awards presented during GAA's GOAL 2013 conference.

"Bjørn is not only a long-time advocate for responsible and sustainable aquaculture," said GAA Executive Director Wally Stevens. "He has willingly shared his knowledge about hatchery and growout operations, always with the attitude that a rising tide lifts all boats. Bjørn is a real credit to the aquaculture industry."

Myrseth is best known as co-founder and chief executive officer of Stolt Sea Farm S.A. and Marine Farms ASA. Stolt Sea Farm pioneered Atlantic salmon smolt production in Norway in the 1970s and later expanded into salmon farming in the United States and Canada.

Marine Farms invested in successful aquaculture operations in Europe and Chile, where it developed cage, feeding and well boat technology. After being acquired by Morpol ASA, where Myrseth is a chairman, Marine Farms' operations included seabass, sea bream, cobia and pompano facilities. A founding member of the European Aquaculture Society, Myrseth has also worked with tropical fish in Belize and Vietnam.

Lightner is a shrimp and finfish pathologist in the University of Arizona's School of Animal and Comparative Biomedical Sciences. He directs the Aquaculture Pathology Diagnostic Laboratory, an international reference laboratory for shrimp diseases.

Dr. Lightner's research deals with virology, histology, toxicology and other tools for disease diagnosis, pathogen characterization and treatment. Lightner has played a major role in identifying the elusive pathogen causing early mortality syndrome in shrimp. He also has been instrumental in the prevention of disease through nutrition, immunology and development of specific pathogen-free stocks of white and black tiger shrimp.

"Disease epidemics have plagued shrimp farming for four decades, but Dr. Lightner and his dedicated team have been there every step of the way to help diagnose and overcome each outbreak, develop ever-improving tools to prevent and manage disease, and train health specialists around the world," GAA President George Chamberlain said.

SOC, BAP Meetings Held At GOAL 2013

Standards Oversight Committee Seeks New Members

Daniel Lee
Best Aquaculture Practices

Responsible sourcing of fishmeal and fish oil for aquafeed and zonal management were key discussion points during the meeting of the Best Aquaculture Practices (BAP) Standards Oversight Committee held just before GAA's GOAL conference in Paris, France. The SOC is also seeking new members.

The SOC had a long discussion on how the BAP feed mill standards should incentivize responsible sourcing of fishmeal and fish oil (FMFO). One problem area, members said, is Southeast Asia and the prevailing use of FMFO from multi-species trawl fisheries that are rarely operated sustainably. The intention is for the BAP program to indirectly encourage the formation of fisheries improvement partnerships by insisting that FMFO be obtained from sources certified under the IFFO Global Standard for Responsible Supply or plants participating in related improvement programs.

Zonal Management

Zonal management is viewed as an essential step in the development of sustainable aquaculture systems, particularly as a means of controlling biosecurity and disease outbreaks such as early mortality syndrome in shrimp and infectious salmon anemia. During the SOC meeting, the limitations of farm-by-farm certification were noted, and the need for collaboration with national and regional regulators was stressed.

The salmon industry is more advanced than more fragmented aquaculture industries like shrimp farming. GAA President George Chamberlain reviewed the disease outbreak case studies recently conducted by the Responsible Aquaculture Foundation (RAF) and the World Bank to show how the lessons learned are essential in developing viable strategies for tackling zonal management. The SOC resolved to build on the RAF approach of conducting carefully targeted case studies and formed a zonal management subcommittee under the chairmanship of Dr. David Little.

New Members Sought

The SOC will soon be placing notices welcoming candidates for several committee positions.

The committee is currently seeking applicants to fill the vacant seat for a representative of the academic or regulatory communities. A strong preference for candidates from Asia was expressed to reflect the growing dominance of this region in aquaculture and consumption of farmed seafood.

A chairperson to lead the BAP technical committee on finfish and crustacean farm standards is also needed. This new standard was created in 2013 by combining earlier standards for shrimp, tilapia, catfish and *Pangasius* and expanding its coverage to virtually all fish and crustacean production systems apart from cage-reared salmonids.

The SOC also seeks a chairperson to lead the technical committee developing standards for mollusc farms. This committee will modify the existing BAP mussel farm standard so they can be applied to all important mollusc farm systems, including those for clams, oysters, scallops and abalone.

Evolving Program

Wally Stevens opened the meeting with a round-up on how the BAP program is positioned with regard to other programs and initiatives, such as GlobalGAP, Global Seafood Sustainability Initiative, Aquaculture Stewardship Council and the recently announced Global Salmon Initiative. He stressed that the BAP program needs to evolve in a landscape that reflects shifting stakeholder engagement in the sustainable seafood movement.

Stevens described the work and plans of the Responsible Aquaculture Foundation. The RAF is becoming more active in its training and education role, for example, through the case studies funded by the World Bank. These studies have been well received by industry and policymakers. Stevens thanked the members of the SOC for their continued, multi-stakeholder guidance for the BAP program.

Program Update

BAP Director William More, BAP Vice President Lisa Goché and Director of Quality Control Jeff Peterson provided a status report on the expansion of the BAP program. Twenty-three countries now have BAP-certified facilities, with total annual output at 1.4 mmt, about half of which is also certified at the farm level. The total number of certified facilities stood at 618. However, supplies of shrimp from certified facilities have suffered as the industry contracted due to disease problems.

More reported that eight mussel farms in Canada that practice rope-grown culture are being audited to the new BAP mussel farm standards. He also said there is some interest in the new BAP multi-species farm standard for covering less-prominent aquaculture species. Goché explained that the reputation of the BAP program was built on the high quality of its auditors and described plans for the next round of auditor-training courses.

New recruits Cormac O'Sullivan and BAP Program Integrity Manager Murali Krishna Bujji have strengthened the training team, and a new certification body, FCI of Scotland, with strength in Europe and a seafood focus, has been approved for the program.

Goché also explained that the new multi-species farm standards will open up the processing plant standards to cover multiple new species. This will make BAP's plant certification an even better competitor to alternative food safety certifications.

Innovation Award

In Paris, SOC Chairman George Chamberlain gave an account of the applicants and the winner of the Novus Global Aquaculture Innovation Award presented at GOAL. Dawn Purchase of the Marine Conservation Society, who originally devised the award concept, received a vote of thanks.

BAP Dialogues

BAP Standards Coordinator Dan Lee and staff members of GAA's BAP Division held two open meetings during GOAL 2013 to discuss the evolution of the BAP program. The meetings provided program updates and an opportunity for wide-ranging question-and-answer sessions with attendees, who included journalists who posed general questions.

Discussions covered the subject of small-scale farmers and the practical difficulties of how they can gain full representation in certification programs. One participant said that various points contained in the BAP farm standards were being used in "due diligence" appraisals of shrimp farms seeking financial support, although without the farms completing the full certification process. This illustrates how, in codifying best practices, the BAP program benefits reach beyond farms that actually adopt BAP certification.

The BAP program needs to evolve in a landscape that reflects shifting stakeholder engagement in the sustainable seafood movement.

GAA Directors, Membership Meetings Report Continued BAP Growth

GAA's Best Aquaculture Practices (BAP) and administrative teams provided encouraging updates at the Global Aquaculture Alliance board of directors and membership meetings held in Paris, France, during the organization's October 7-10 GOAL 2013 conference.

Go BAP

BAP Program Manager Bill More gave an update on the BAP third-party certification program. As of August 31, there were 618 BAP-certified facilities – an increase of 123 from the 495 facilities at the end of 2012. In August, the combined annual output from BAP-certified processing plants totaled about 1.4 mmt, a 6.6% rise from the August 2012 output, while the combined annual output from BAP-certified farms came to about 704,000 mt, up 13.9% across the same 12-month stretch.

The bulk of the growth within the BAP program in 2013 has been attributed to salmon. The annual output from BAP-certified salmon-processing plants has more than quadrupled since August 31, 2012, to nearly 449,000 mt. As of August 2013, there were 119 BAP-certified salmon farms, up from just 28 in August 2012.

At the farm level, tilapia and *Pangasius* also experienced significant growth, with volumes up 24% and 17%, respectively, through the first eight months of 2013. However, for shrimp, it's been a different story. Early mortality syndrome hit shrimp farmers hard this year. As a result, the annual output from BAP-certified shrimp farms was down 21% through the first eight months of 2013.

New Standards

Also providing an update on the BAP program was BAP Standards Coordinator Dan Lee. The BAP mussel farm standards were completed in August, and the first audit was conducted at eight mussel farms in Prince Edward Island, Canada, in September. A mussel-processing plant in Canada has also been inspected, but the certification has not yet been finalized.

The addition of BAP mussel farm standards represents a key advance for the BAP program, as the new standards will be used as a template for broader mollusc farm standards encompassing clams, oysters, scallops and abalone.

Also, the BAP program has added Food Certification International Ltd. (FCI) to its team of BAP-approved third-party certification bodies. FCI joined SGS, Global Trust Certification and NSF International as the ISO/IEC Guide 65-accredited certification bodies designated to perform BAP audits, BAP Vice President Lisa Goché said.

Program Expansion

Peter Redmond, vice president of business development for the BAP program, reiterated that the BAP program is very strong in North America, where dozens of retailers have publicly endorsed the BAP program. However, there's a lot of room for growth among foodservice operators, who haven't been as quick to endorse the BAP program, and in Europe. Redmond said there is also much room for growth in Asia, where the perceived need for third-party certification has not been as prevalent among retailers and foodservice operators.

Early mortality syndrome hit shrimp farmers hard this year. As a result, the annual output from BAP-certified shrimp farms was down 21%.

Toronto Course Graduates New BAP Auditors

The new auditors represented home countries in Europe, South America and North America.

The Global Aquaculture Alliance's Best Aquaculture Practices (BAP) division held a successful three-day auditor training course in Toronto, Canada, from September 11 to 13.

The course covered the BAP finfish and crustacean farm standards for marine cages, BAP salmon farm standards and the new BAP mussel farm standards. In attendance were new and returning auditors from Argentina, Canada, Chile, Greece, Scotland and the United States. Observers representing producers, nongovernmental organizations and government agencies also participated.

The course was taught by BAP Vice President Lisa Goché, BAP Director of Quality Control Jeff Peterson and Cormac O'Sullivan of SAI Global in Canada. O'Sullivan was called on to share his extensive experience in auditing both salmon and mussel farms worldwide.

"With the launch of the BAP mussel farm standards in August and a number of facilities actively seeking BAP certification, we were fortunate to have Cormac join the instructor team – and even more fortunate with the number of mussel-qualified auditor candidates."

The next BAP auditor-training course was scheduled for October 22 to 26 in Guayaquil, Ecuador. The course covered all culture methods, including cage farming and land-based ponds, as well as the new BAP mussel farm standards and finfish and crustacean farm standards.

BAP Adds Food Certification International To Auditing Team

The Best Aquaculture Practices (BAP) division of the Global Aquaculture Alliance has added Food Certification International Ltd. (FCI) to its team of third-party certification bodies.

In a service agreement between the two organizations, FCI will conduct auditing and certification activities for aquaculture farms, hatcheries, processing plants and feed mills that apply for BAP certification.

"We are very pleased to welcome FCI as a BAP-approved certification body," said Lisa Goché, BAP vice president. "The company's expertise in seafood and aquaculture will be a very valuable addition for the BAP program, which continues to experience rapid growth globally in all sectors of the seafood production chain."

Founded in 1996 and based in Inverness, Scotland, FCI specializes in the certification of aquaculture, fisheries and related supply chains. It is accredited to multiple seafood certification systems. In June, FCI became part of Acoura, formerly known as the Certus Compliance Group.

FCI joins SGS, Global Trust Certification and NSF International as the ISO/IEC Guide 65-accredited certification bodies designated to perform BAP audits. The use of independent certification bodies complies with international requirements for the operation of credible certification schemes.

BAP Auditor Course Set For India

Registration Deadline: January 8

The Global Aquaculture Alliance invites new auditor candidates, returning auditors requiring refresher training, producers, government officials and other industry observers to attend a Best Aquaculture Practices (BAP) Auditor Training Course in Chennai, India, from January 18 to 23, 2014.

For detailed information about how to apply, competency requirements, fees and more, visit the BAP website at www.bestaquaculturepractices.org. The registration deadline is January 8.

The course will cover the BAP seafood-processing plant standards, finfish and crustacean farm standards (including land-based ponds and fresh/brackish water cage culture, but excluding marine cage culture), shrimp hatchery standards and feed mill standards. The BAP salmon farm standards and mussel farm standards will not be covered during the course.

Please follow the application 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. Payment for the course must be received in advance.

BAP Staffers Meet With Stakeholders During World Seafood Congress

Best Aquaculture Practices Standards Coordinator Dan Lee and Market Development Manager for North America Molly Jacques represented the BAP program at the recent World Seafood Congress in St. John's, Newfoundland, and took the opportunity to hold meetings with key Canadian retailers, NGOs, salmon farmers and other players in the aquaculture industry.

Lee gave a presentation titled "Aquaculture Certification: Meeting Expectations," in which he placed the BAP program in context and discussed the latest developments in the world of certification.

He said the BAP program is now expected to do much more than provide quality assurance. It is also expected to drive improvements, add value, facilitate trade and attract producers of all different scales. Lee provided evidence for these additional benefits and also discussed the collaborative work on certification resulting from the recent memorandum of understanding that GAA signed with the Aquaculture Stewardship Council and GlobalGAP.

Members of the audience asked about the new multi-species BAP hatchery standards, which are in an advanced stage of development, and wanted to know how much penetration aquaculture certification is achieving. Lee said independent assessments placed this penetration at 4.6% of global aquaculture production. Although this may appear low, note there is currently no demand for certification of seaweed and Chinese freshwater fish, which reflect over 80% of global aquaculture production.

On their first day in St. John's, Lee and Jacques were inducted as honorary Newfoundlanders, or Screechers, in a time-honored ceremony that involved consuming local delicacies, downing shots of rum and kissing a freshly defrosted cod on the lips!

Dan Lee expressed that BAP certification is increasingly recognized for aspects beyond quality assurance.

Tilapia Farming In Ghana

Breeding, Feed Advances Support Rising Output

The development of fast-growing strains of tilapia are increasing production in Ghana.

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Summary:
Natural factors, institutional support and a big appetite for fish have all contributed to the growth of aquaculture in Ghana, where about 80% of all farmed fish is tilapia. The introduction of river and lake cage technology, as well as genetic improvements and the establishment of a feed mill have been important factors in production increases. Although the government of Ghana strongly supports aquaculture, the private sector is still recognized as the primary driving force for development.

Ghana is a nation in which fish constitute about 60% of animal protein intake. The annual per-capita consumption of fish is currently about 26 kg, a figure that declined with decreasing fish harvests from 40 kg/capita in the 1970s. Fish are vital to Ghana's food security, with fisheries accounting for about 7% of gross domestic product and employing some 10% of the population.

Meanwhile, fish stocks are overexploited, with marine fisheries in terminal decline from intense fishing pressure by offshore trawlers and paired seines, artisanal beach seining and lagoon harvesting of juveniles. The Volta Lake, source of most of the harvest from inland fisheries, is also showing signs of overfishing.

Ghana's estimated fish requirement for 2012 was 968,000 mt, which was partially met by fish harvests totaling about 455,700 mt from marine and inland fisheries. To make up the gap, aquaculture contributed about 26,000 mt, and 175,341 mt of fish were imported, but this total still left a large deficit in supply (Figure 1).

Current figures indicate that annual fish farming output is about 24,250 mt from 2,278 cages and 1,770 mt from 4,749 ponds, which total about 700 ha. These figures, however, represent a 20-fold increase in five years. Over 80% of production is locally selected stocks of *Oreochromis niloticus,* while the remainder is mostly African catfish or mudfish, *Clarias gariepinus.*

Aquaculture Growth

Ghana's interest in aquaculture dates back to 1953, when fish ponds were built in northern Ghana by the Department of Fisheries to supplement national demand for fish and increase livelihood opportunities. These initiatives did not result in much success.

In the early 1980s, the government of Ghana began a massive promotion of aquaculture. According to a study, this effort resulted in the construction of about 2,000 ponds with an estimated total area of 350 ha. By the end of 2000, annual production was 750 mt, and it increased to 1,200 mt by 2004. In 2006, further developments emerged through private-sector investments.

Rapid increases in production can be attributed mainly to the introduction of floating cage systems in the Volta Lake and Volta River. By 2010, annual production increased to 10,000 mt and in 2012 hit 26,000 mt – indicating a 20-fold increase in five years (Figure 2). It is worth mentioning that a single farm contributed 6,400 mt to this production, and it continues to be a motivating factor and attraction to other investors. Current tilapia production is typically based on sex-reversed males in 125-m^3 cages, in which about 10,000, 5-g fish are raised to a size of about 300 g in five months.

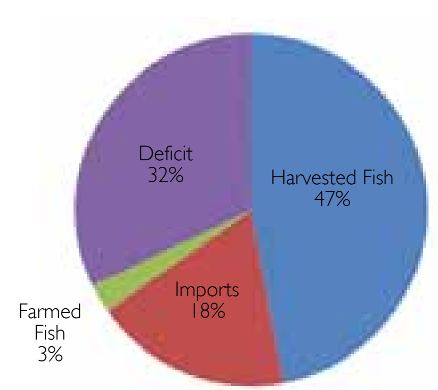

Figure 1. Fish availability in Ghana.

Favorable Conditions

A number of natural factors, as well as institutional support and a big appetite for tilapia, have contributed to the growth of aquaculture in Ghana. The Volta Lake covers an area of 8,500 km^2, and the Volta River stretches about 50 km below the Akosombo hydroelectric dam. Ghana has 11,000 ha of irrigated land spread across the country, with over 300 small dams and reservoirs in northern Ghana alone. In addition, there are 90 brackish water lagoons totaling about 40,000 ha along the 500-km coastline. Climatic conditions are suitable for tilapia culture throughout the year.

The huge national "fish deficit" results in high domestic demand for fresh tilapia. A growing middle class with a taste for tilapia is leading to rising prices despite increasing production. In fact, capable individuals in cities are investing in fish farming managed by others.

Government Support

In collaboration with international bodies and development partners, the government has initiated policies and regulations for the aquaculture industry in Ghana. The Ghana National Aquaculture Development Plan has the objective of producing 100,000 mt over a five-year period, thereby increasing the market share of commercially farmed fish in the country from 3 to 30% by 2018.

A new Ministry of Fisheries and Aquaculture Development was established in 2012 to emphasize the commitment of the government to aquaculture development. Government policy allocates 5% of irrigation areas to aquaculture to expand opportunities from planned irrigation schemes and hydroelectric projects.

Currently, the private sector is recognized as the driving force for the development of aquaculture in Ghana. The Water Research Institute (WRI), which has been carrying out aquaculture research related to production systems and genetic improvement since 1991, provides a range of technical support to the sub-sector. Currently, stocks of Genetically Improved Farmed Tilapia (GIFT) from the World Fish Centre are undergoing evaluation in comparison to the Akosombo stock in the Ghana Project supported by the Food and Agriculture Organization of the United Nations.

Licenses for aquaculture operations are issued by the Environmental Protection Agencies and Water Resources Commission. Other permits for operation are issued by the Fisheries Commission and

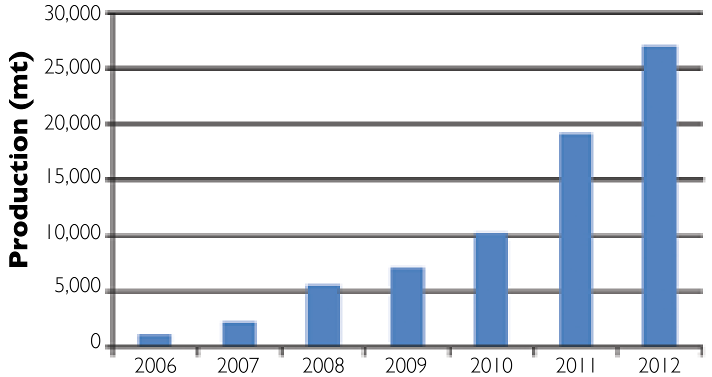

Figure 2. Aquaculture production of tilapia in Ghana.

district assemblies. These permits are especially necessary to regulate site selection for cages on Volta Lake.

Public universities and institutes provide courses in aquaculture and related areas to doctorate levels. Collaborations between universities and fish farms are leading to training and internships for students with mutual benefits.

Feed

Fish feed is mostly imported from Brazil, Israel, China and Southeast Asia. In 2012, an Israeli company established a modern fish feed mill near Accra. It is already producing 1,000 mt monthly using 70% locally sourced ingredients and inputs and supplying several other West African countries, including Togo, Benin and Nigeria. Other international fish feed companies are working hard for shares of the market.

Fish feed, however, continues to be a concern to farmers, as it constitutes 60 to 70% of the production costs for cage farmed tilapia. Nonetheless, the Ranaan fish feed mill in Ghana has reported it increased sales by four times in a single year. The cost of fish feeds ranges U.S. $1.00-2.50/kg, depending on source and brand.

Tilapia Fingerlings

Ghana has about seven hatcheries, with a few of them owned by the government. Prominent among them is Water Research Institute (WRI), which has been developing superior strains of *O. niloticus* over eight successive generations. It has produced a strain that grows about 30% faster than fish in the wild and has other improved characteristics.

Most of the other hatcheries use the new WRI strain as broodstock in producing fingerlings for the whole industry. Some private farms have also developed their own strains.

Domestic Market

Tilapia consumption in Ghana is largely defined by domestic production. Imports are illegal, and exports are minimal, although one farm aims to produce fillets for the export market. Tilapia are sold whole and fresh (degutted). Well-priced alongside demersal species of fish sold, fresh tilapia have retail prices of U.S. $3.70-4.00/kg.

Larger farms are more competitive due to the use of more modern practices.

There is demand for both small tilapia of less than 200 g and large sizes weighing over 350 g. Small fish sell quickly because of high patronage by low-income earners. However, the higher margins are made by the retailers and not at the farm gates.

Production Economics

Fish farmers are not forthcoming with farming information, but net margins of 30% are easily achievable by cage farmers. Mainly attributable to the high cost of feed, the overall cost of production in Ghana is higher than that of the low-cost leaders in other countries.

Large growout farms are known to be doing very well, but small-scale farmers are struggling due to limited economies of scale and production knowhow. The value chains of large-scale foreign investors tend to bypass local participants.

Challenges

Although tilapia farming is experiencing strong growth, overall output is minimal compared to that for other species. A number of factors account for this.

At the institutional level, regulations and farming zones tend to be inadequately enforced. Coordination among agencies is limited, and there are problems with access to land. At the enterprise level, costs are high for feed and quality fingerlings, and access to credit to pay for them – especially for small-scale farmers – is limited. Knowledgeable and experienced personnel are largely lacking.

Perspectives

A number of foreign commercial investors have set up in Ghana and drastically impacted the scale and practice of fish farming in the country. Ghana is in the initial stages of aquaculture production, and pioneering farms are taking advantage of available opportunities. Additional investors are welcome, as much more needs to be done for pond culture development and support to small-scale producers.

Going forward, greater enforcement of regulations will be required to ensure orderly growth toward a period of stabilization and consolidation. The government and fish farmers are on a course of collaboration for the continued implementation and enforcement of regulations, improvement of tilapia stocks and greater fish health management. Within the next five years, there will likely be a better story to tell.

Namibia Project Raises Tilapia In Former Mine

A farm project in the Namib Desert produces food fish through small-scale cage culture.

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Summary:
Sustainable development of aquaculture can help achieve social and economic benefits in Namibia. A farm project established at a lake formed by an old tin mine incorporates a hatchery facility and growout cages to raise tilapia. It utilizes an existing water resource to improve food security and ensures the participation of disadvantaged local communities. The project also aims to educate consumers on the nutritional benefits of freshwater fish and assist farmers in establishing additional growout facilities.

The development of aquaculture in Namibia is particularly important, since the government has established priorities on food security and poverty reduction. Sustainable development of this sector can help achieve social and economic benefits.

A unique fish-farming project in Uis, Namibia, is situated in a remote and arid region of the Namib Desert of southwestern Africa. The key objectives of this project were to utilize an existing water resource to produce food fish and improve food security, and ensure the participation of local communities.

The communities included marginalized women groups, especially those with human immunodeficiency virus infection/acquired immunodeficiency syndrome (HIV/AIDS), lactating women, youth groups and unemployed individuals. The project empowers the Uis village communities through organized training and capacity-building initiatives for both cage farming and eco-tourism development.

Infrastructure

A recirculating aquaculture system – the first RAS in Namibia – that supplies tilapia fingerlings is combined with cage culture at a nearby lake. This lake originated from a previous tin mine that eventually dug into an underground aquifer. The water quality of the lake is good, with analyses indicating levels of heavy metals below the detection limit of the analyzer. Dissolved-oxygen levels are maintained by prevailing winds.

The project also reflects the country's first implementation of cage culture. The 30 floating cages in the lake are anchored next to a floating walkway that serves as a platform for feeding and harvesting. The cages consist of 9-m² floating frames with nets suspended at a depth of 2 m. The current production of 4 mt/month is achieved by stock splitting and grading at a regular rate.

Feeding of fish and fry is done manually at a frequency of five times daily. Feed powder with 38% crude protein is used for the fry and juvenile fish. Fingerlings are fed 38%-crude protein pellets of 2-mm diameter, while adult fish (including broodstock) receive 4-mm pellets with 30% crude protein.

Fingerlings are produced continuously in a recirculating aquaculture system consisting of 11 pools that produce 25,000 fingerlings a month. Eggs are collected every two weeks. Fish are grown to 40 g, and the fingerlings are then supplied for growout.

Water from the pools is recirculated through an aquaponics system, where various crops are grown. Water returned

The lake formed when a tin mine eventually dug into an underground aquifer.

from the aquaponics is then pumped through a vortex and later biofilter system. Pool water is heated by solar panels during the daytime, while a heat pump maintains the temperature above 25° C during the night.

Product

The Mozambique tilapia, *Oreochromis mossambicus*, are harvested at weights of 200 to 250 g. Smaller fish are sold to the informal sector. Harvested fish are washed in clean water before packaging in 5-kg frozen cartons or 3-kg bulk plastic bags.

Further Development

The existing cage culture system occupies only about 10% of the water body available. The objective is to utilize the lake to its full projected capacity of 12 mt/month. A minimum depth of 3 m below the cage bottoms will be maintained. Water quality is regularly monitored to determine the ultimate stocking density.

Construction of a new hatchery and broodstock pool system that will be able to produce 60,000 fingerlings monthly is already under way. Another objective is to promote commercial aquaculture farming and assist farmers with the establishment of additional growout facilities. Market research has showed a need for the continuous supply of fresh and frozen filleted catfish. The initial annual capacity of a planned catfish facility will be 60 mt.

Aquaculture activities in Namibia are regulated by legislation overseen by the Ministry of Fisheries and Marine Resources. This project maintains a close relationship with the ministry while its knowledge and experience are shared.

Perspectives

Namibia is mainly a meat-eating country, but the government and especially the Ministry of Fisheries and Marine Resources have been trying to promote aquaculture at all levels. The consumption of tilapia is common in certain regions of Namibia, but seasonal. In general, the local market is oriented toward marine fish. The farm project aims to educate consumers on the nutritional benefits of freshwater fish consumption and establish a sustainable freshwater fish market.

Since most Namibian restaurants, lodges and hotels do not have tilapia on the menu, these markets will be targeted through the fish-farming initiatives. Furthermore, the establishment of additional cage culture will provide opportunities for women, youths and disabled people to improve their social livelihoods.

Incorporating aquaponics with recirculating aquaculture systems will make a significant contribution toward the profitability of this project and related supporting secondary industries. The hatchery will supply fingerlings to various communal areas throughout Namibia, where farmers must be trained and assisted to efficiently grow out fish to marketable sizes.

The cage project also has potential as an eco-tourism attraction. Potential farm tourism activities include general tours of the hatchery, nursery and growout facilities; seasonal angling competitions or even the establishment of a recreational water park. Students from universities and other institutions may apply for internships at the fish farm as part of their academic experiences.

Mahi Revisited

Aquaculture Prospects Improved By Ocean Option

In the wild, mahi can grow to 45 kg within four years. They exhibit very high growth rates in captivity, as well.

Summary:
Mahi is a fast-growing, high-value fish species with excellent potential for aquaculture. The technology for maturation, spawning, larval rearing, fingerling production and growout of mahi has been mastered, yet progress toward commercial development has been slow. Production challenges remain, and more basic research may be necessary to fully understand the physiology of mahi mahi, but recent advances in open-ocean cage culture and improved recirculation technology should improve its prospects for culture.

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Mahi, *Coryphaena hippurus*, is a top epipelagic predator widely distributed in tropical areas around the world. Also commonly known as mahi mahi, dolphin fish and dorado, the species is commercially important for fisheries wherever it occurs. Mahi has also long been recognized as a high-value fish with excellent potential for aquaculture.

Several researchers have showed the technological feasibility of mahi aquaculture since the early 1970s. The technology for maturation, spawning, larval rearing, fingerling production, nursery and growout of mahi has been mastered, yet progress toward commercial aquaculture development has been slow.

Mahi have been raised experimentally and in pilot-scale operations using a variety of culture systems, including floating net cages, recirculating systems and flow-through tanks and raceways. However, the economic feasibility of producing mahi commercially has not been realized.

With recent advances in open-ocean cage culture as well as improved recirculation technology, commercial mahi aquaculture may become a reality soon. One important remaining bottleneck is determining the nutritional requirements and digestibility of common aquafeed ingredients by this species to formulate ecologically and economically efficient practical diets.

Fast-Growing Fish

Mahi are tropical and subtropical pelagic predatory fish whose most important biological characteristic is their extremely rapid growth. In the wild, this species can attain a mass of over 45 kg within a life span of less than four years. They exhibit very high growth rates in captivity, as well, reaching 2 kg in six months and 5 kg in 12 months from eggs. They also spawn spontaneously in captivity with up to 200,000 eggs/female every other day year round.

Larval husbandry has been successfully conducted in Hawaii and Florida using traditional protocols with microalgae, rotifers, *Artemia* and copepods as feeds, as well as an innovative "clearwater-pulse feeding" technique developed at the Oceanic Institute in Hawaii. Advanced nursery techniques in Hawaii and Florida utilize raceways with high levels of water exchange, forcing the postlarvae and early juveniles to swim constantly against relatively strong water currents.

Further efforts to advance commercial mahi aquaculture must focus on increasing survival and lowering production costs.

Diets

Mahi mahi grow well when fed either mixed (raw) or practical (dry, semi-moist) diets. Adequate growout diets for mahi mahi can contain up to 30% moisture, over 50% crude protein, 10% crude fat and high caloric content of 5.0 cal/mg or greater.

Generally, fish are fed once or twice daily to satiation, corresponding to a total daily food consumption of approximately 4% of body weight (moist feed/wet fish) or 3% of body weight for dry feed. Feed-conversion rates ranging from below 1 to more than 3 have been reported for mahi mahi grown in captivity on fed pellets.

High Demands

Coupled with extremely high rates of somatic and gonadal growth, mahi mahi exhibit high levels of activity, as indicated by behavioral observations in captivity as well as in numerous natural history accounts of the species. This means mahi mahi have outstanding nutritional and water quality demands not easily met under aquaculture conditions.

In nature, they inhabit the epipelagic environment, the upper layer of the offshore area. In the open ocean, water parameters are of the highest quality, with dissolved-oxygen levels always at or above saturation levels. The water quality parameters found in the offshore environment can hardly be provided continuously in an aquaculture facility, and this is likely one of the main reasons mahi are prone to disease outbreaks when confined. This problem may be resolved by simply raising mahi in offshore cage systems.

Constraints

Survival rates during larval rearing range from 1 to 20% through metamorphosis. Overall survival rates from egg to market size remain low for mahi and represent one of the main hurdles to overcome for commercial aquaculture development. Mortalities of uncertain causes at developmental stages such as first feeding and metamorphosis often occur under rearing conditions. Also, agonistic behavior among juvenile cultured dolphin fish can result in cannibalism and stress-related mortalities.

Advanced nursery techniques force juvenile mahi to swim constantly against relatively strong water currents.

Another mortality-related phenomenon that is not completely understood is feeding-associated inflation of the abdominal cavity when juvenile mahi mahi are fed artificial diets. In addition, vibriosis and other diseases that often lead to mortality in mahi can be associated with handling stress. More basic research may be necessary to fully understand the biology and physiology of mahi mahi before commercial aquaculture can be developed.

Data on basic physiological requirements, such as metabolism and energy utilization during early developmental stages, remain scarce. In addition, the environmental requirements of mahi are still not fully understood. Disease outbreaks are often related to nutritional and environmental inadequacies.

Perspectives

Researchers have made steady progress in all stages of mahi aquaculture and agree that the problems can be resolved if they are tackled with appropriate resources. The technology is in place, but market forces will ultimately determine the success in renewing efforts to develop commercial aquaculture of this species. If good market demand and prices exist, mahi can be raised.

The main problems to be resolved are directly related to each other: high mortalities during the juvenile stages and economics. Current and future attempts at taking mahi aquaculture operations from the technological to the commercial level of feasibility must focus on increasing survival and lowering production costs.

Recently, mahi aquaculture has been revisited in Ecuador, where new broodstock were acquired and transported to Ocean Farm S.A., a private hatchery owned by one of the larger exporters of wild mahi to the United States and other markets. Its objective is to develop year-round business by filling in off-season supply with cultured mahi.

As of 2010, the University of Miami Experimental Hatchery resumed working with mahi throughout all life stages. Fish have been spawning almost daily since October 2010. More recently, countries such as Portugal and Mauritius have expressed interest in pursuing mahi aquaculture and are venturing into the activity with technological support from the hatchery.

It is nearly impossible to totally eradicate vibrios from ponds. Furthermore, since most vibrios are benign and serve useful purposes, eliminating them opens up niches for other species that may not be benign.

AHPN Inferences Based On Behavior Of *Vibrio* Bacteria

Summary:
Vibrio parahaemolyticus, a strain of which is the cause of acute hepatopancreatic necrosis (AHPN), has both virulent and benign strains. This strain colonizes the stomachs of shrimp by the formation of a biofilm, which protects it from antibiotics and other potential treatments. As with *V. cholera, V. parahaemolyticus* tolerates a range of salinities, pH and temperatures. Both species readily piggyback on marine plankton and may be spread by ocean currents. *Vibrio* species can also be spread by broodstock and postlarvae. The etiologic agent of AHPN occupies many niches.

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Vibrio is a genus of Gram-negative bacteria that inhabit most aquatic ecosystems, including freshwater. As of late 2013, there are at least 98 recognized species, with many more candidates. Vibrios serve critical functions in the recycling of nutrients, including polymeric n-acetylglucosamine, a molecule commonly known as chitin, the primary structural component of the exoskeletons of shrimp and other arthropods.

Most vibrios are benign. Many have the ability to degrade chitin by the production of chitinases and readily attach to chitinous invertebrates. They are also often associated with algae and zooplankton, which provide means of transport within aquatic environments and contribute to their ecological stability.

Disease-Causing Vibrios

Shrimp in the wild, contrasted with those at most farms, live at lower densities and can move when needed to environments of less stress. Stress is frequently an inherent component of the farming process.

A relatively small number of vibrios cause disease in farmed shrimp. Most are opportunistic pathogens that are able to cause disease because the host animals are stressed and impaired in their ability to fight them off. Only a few are obligate pathogens that cause disease in healthy and impaired animals just by being present. The most virulent of these kill shrimp at very low levels of exposure in the water or when consumed.

Since vibrios readily exchange genetic material with each other as well as other bacterial species, they undergo a constant process of evolution. Thus, rapid changes in antibiotic resistance are seen due to the acquisition of genes encoding for these traits. Other phenotypic characteristics can change, as well, including possibly those observed in the etiologic agent(s) of acute hepatopancreatic necrosis (AHPN) or early mortality syndrome in shrimp.

Dr. Donald Lightner and team identified the AHPN pathogen as a unique strain of a relatively common bacterium, *Vibrio parahaemolyticus.* Lightner determined that the vibrio may have been infected by a virus known as a phage, which could cause it to release a potent toxin.

V. parahaemolyticus is a common inhabitant of most marine, estuarine and some freshwater ecosystems. Most strains are not pathogenic and are harmless to ingest. However, toxin-producing strains of this bacteria, typically found as natural inhabitants in many fish species, are a major cause of seafood poisoning.

Genomic Taxonomy

The advent of genomic taxonomy has been instrumental in allowing differentiation among isolates that appear phenotypically and biochemically identical by conventional biochemical testing. Such characterization must occur, or there is significant risk of misidentifying some species. The group of bacteria that are etiologic agent(s) of AHPN are particularly prone to this.

Even very small differences that are consistent can be exploited to develop tools that are critical to the ability to localize a pathogen and come to a more complete understanding of where it is in the environment, from where it comes and how it might be controlled. Until these tools are available, care must be taken in ascribing all cases of AHPN to a single strain of bacteria – although the possibility exists that such a strain might be sufficiently unique to merit becoming a new vibrio species.

Farmers should appreciate that it is very difficult, if not possible, to totally eradicate any group of bacteria. Nor is this necessarily desirable. As most vibrios are benign and serve a useful purpose, eliminating them opens up niches for other species that may not be benign.

Vibrio cholerae

The vibrio bacteria that are etiologic agent(s) of AHPN exhibit characteristics similar to those of *Vibrio cholerae*, some strains of which cause cholera, a serious life-threatening disease in humans who drink contaminated water and ingest typically more than a million bacteria at one time. Treatment to restore the electrolyte imbalance along with common antibiotics to lessen the chances of complications can easily cure cholera and *V. parahaemolyticus* food poisoning.

These rather ubiquitous vibrio pathogens act primarily through the guts of their hosts. Like many other vibrio species, they form biofilms. Cholera typically becomes problematic when drinking water and sewage systems are not properly segregated. A parallel in aquaculture is reusing discharge water with limited treatment in production. Currents containing discharged waters can carry vectors far and wide.

In the early 1990s, cholera spread along more than 1,600 km of Peruvian coast in a very short time, and as it followed rivers and streams, much of Latin America was affected. There is evidence that the etiologic agent of AHPN is being spread similarly.

As with *V. cholera, V. parahaemolyticus* tolerates a wide range of salinities, pH, temperatures and nutrient conditions. Both species of bacteria readily piggyback on many potential vectors. For example, *V. cholerae* and *V. parahaemolyticus* are both commonly associated with many species of marine plankton. They readily attach to chitin, the surfaces of algae and other similar substrates.

Vibrio species can also be spread by broodstock and postlarvae. Clearly the etiologic agent of AHPN occupies many niches. This could explain how it seems to move so easily and why eradication and/or control will not be a simple matter.

Biofilms

Biofilms occur everywhere. Probably the biofilm most familiar to humans is why we brush our teeth. They are implicated in a myriad of disease states and are an effective mechanism for bacteria to spread.

A biofilm is an assemblage of organisms that have attached to a surface – such as detritus on shrimp pond bottoms or, in the case of AHPN, the stomachs of shrimp. The biofilm protects the bacteria within from the action of antibiotics and other bacteria that would seek to occupy the niche themselves.

In the formation of biofilm, the bacteria first attach to the chitinous stomach and gastric mill surfaces in the shrimp. The bacteria then form sticky exopolymers that "glue" the bacteria to the surface. As the biofilm subsequently matures and forms microcolonies, exopolysaccharides protect the bacteria against antibiotics, disinfectants, herbal extracts and other treatments while still allowing normal metabolic cell activity. In its final state, the biofilm begins to detach, and its cells disperse in the environment as a new biofilm develops.

AHPN Control

Efforts to control AHPN began long before its identity was established. What was probably AHPN was first reported in China four or so years ago and has spread to a number of other countries. In the author's opinion, this strain of vibrio will likely spread into those environments that

Because of the high stocking densities, stress is frequently an inherent component of the shrimp-farming process.

allow it to dominate at the expense of the other bacterial species present.

Given the complex nature of the vibrio taxon, a number of things make AHPN a less-than-straightforward problem to address. The pathogen is unusual in shrimp in terms of how it produces disease. Further analogies with cholera are apparent, as it appears as a toxin-based disease process where the bacteria colonize a limited surface, and the toxin does the damage. Most other pathogenic vibrios invade the animal and through various toxins and their cell wall structural component, lipopolysaccharides, overwhelm the ability of the animal to defend itself, with ensuing decline and death.

The strain of *V. parahaemolyticus* responsible for AHPN does not appear to be invasive in the sense of finding its way into the hemolymph of animals through injuries or other mechanisms. This explains why antibiotics do not stop the AHPN infection. If the antibiotics are not able to come in contact with the pathogen at sufficient levels to impact it, then they will not work.

Since the abuse of antibiotics in shrimp farming has been a point of concern for some years – although there is room for appropriate use of antibiotics – this is one example where any use of antibiotics would be inappropriate. Furthermore, if the pathogen is present in a biofilm in the stomach, this can protect it from the action of many other compounds that could theoretically kill it. This will pose a serious challenge to those trying to develop treatment modalities.

Editor's Note: This article is based on a longer paper by the author. To read the full text, visit www.sustainablegreenaquaculture.com/uploads/5/3/7/2/5372499/what_can_shrimp_farmers_do_about_ems.pdf.

Given the complex nature of the vibrio taxon, a number of things make AHPN a less-than-straightforward problem to address.

Suspended Solids Effects In Shrimp Biofloc Systems

The use of lined tanks increases the confinement of biofloc in the culture environment and restricts the organic particles in the water column from being recycled completely.

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Summary:
The use of biofloc systems for shrimp culture requires monitoring of water quality parameters, particularly suspended solids levels. When a production cycle begins with a well-stocked biofloc inoculum, the concentrations of ammonia and nitrite are relatively low, but concentrations of suspended solids tend to be higher in this phase. Generally, nitrite concentrations rise as suspended solids levels increase. At dissolved-oxygen concentrations above 5 mg/L, excess suspended solids were not a problem for shrimp respiration.

Marine shrimp aquaculture systems that incorporate biofloc technology often experience a high density of suspended solids within the systems. The injection of air at the bottoms of culture tanks promotes both the diffusion of oxygen in the water column and mixing of suspended material. The use of lined tanks increases the confinement of biofloc in the culture environment and restricts the organic particles in the water column from being recycled completely.

Suspended Solids

Suspended solids consist mainly of organic matter, which is comprised of microbial forms that when decomposing exert a high demand for oxygen. This demand can decrease the dissolved-oxygen concentrations in the culture system to reach levels below the recommended concentration for the cultivated species. An increase in suspended solids can also reduce the water quality within the system (Table 1). Overall, these less-than-optimal conditions reduce system performance.

These conditions can occur throughout the different stages of the marine shrimp production cycle, depending on whether the system starts a cycle with mature biofloc inoculum. However, the use of biofloc inoculum relates to the suspended solids concentration in the water column.

At the beginning of a cycle, interactions among the nitrogenous compounds, ammonia and nitrite are most notable when biofloc is forming in the culture. The reduction of ammonia occurs with the establishment of ammonium-oxidizing bacteria, which does not require the use of organic carbon, and with the absorption of heterotrophic bacteria. Therefore, the nitrite accumulation occurs due to the slow growth of nitrite-oxidizing bacteria.

Total suspended solids levels constantly increase, and consequently nitrite concentrations increase. In contrast, when a cycle begins with a well-stocked biofloc inoculum, the concentrations of ammonia and nitrite are relatively low. However, the concentrations of suspended solids are higher in this phase. Both situations require management of suspended particulate matter within the culture system.

Experimental Work

In experiments conducted with *Litopenaeus vannamei* shrimp in biofloc systems at the Marine Aquaculture Station of the Federal University of Rio Grande in southern Brazil, the best growth performance occurred in a study where suspended solids were removed for the maintenance and control of the total suspended solids concentrations in culture inoculated with biofloc.

In another experiment, concentrations of nitrogen compounds differed when compared to different total suspended solids (TSS) concentrations during the formation of biofloc. Higher TSS concentrations resulted in higher concentrations of nitrite.

In another experiment that used the biofloc inoculum, it was observed that when the concentration of dissolved oxygen was maintained above 5 mg/L, the suspended solids excess was not a problem for the respiration of the reared shrimp. Considering the interactions of water quality parameters listed above, maintenance of the suspended solids levels is required for better water quality. Values for common water quality parameters measured under two average TSS concentrations are shown in Table 2.

Table 1. Changes in water quality parameters with excessive suspended solids.

Parameter	Effect
Ammonia	Increase
Nitrite	Increase
Nitrate	Increase
Phosphorus	Increase
pH	Decrease
Alkalinity	Decrease
Dissolved oxygen	Decrease
Carbon dioxide	Increase

Table 2. Water quality parameter values with average total suspended solids concentrations.

Parameter	200 mg/L TSS	800 mg/L TSS
Dissolved oxygen (mg/L)	5.90	5.10
pH	7.95	7.40
Alkalinity (mg calcium carbonate/L)	160	100
Ammonia (mg/L)	3.50	2.50
Nitrite (mg/L)	1.00	15.50
Nitrate (mg/L)	5.00	80.00
Phosphate (mg/L)	0.50	6.00

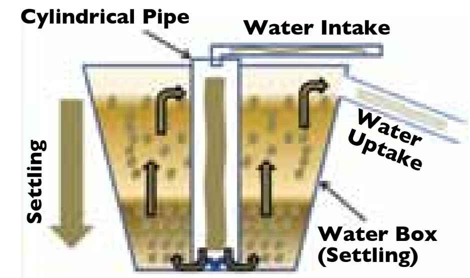

Figure 1. Settling chambers use gravity to settle particles. The arrows indicate water flow. Water from the culture tank enters via a central pipe, which reduces velocity and turbulence, and returns after settling.

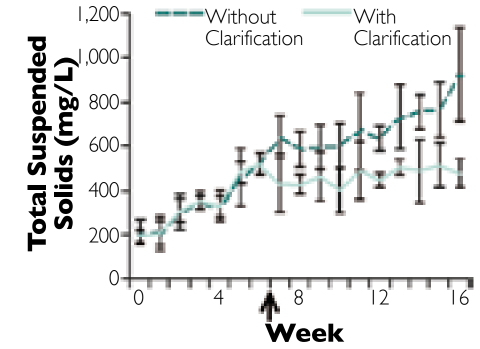

Figure 2. Total suspended solids concentrations in study with and without clarification. The arrow indicates the seventh week since the start of the solids removal process.

Monitoring, Intervention

Measurements of suspended solids were made using the gravimetric method, which measures total suspended solids and settleable solids within an Imhoff cone. Various techniques can be applied to reduce and maintain suspended solids concentrations, such as the use of a settling chamber or clarifier to remove solids. Set up in straightforward settling chambers, clarifiers rely on gravity to move particles to the bottom (Figure 1).

The radial water flow in the settling chamber can be adjusted based on prior analysis of biofloc sedimentation in an Imhoff cone, increasing the efficiency of the method. This method allows the control of TSS and keeps the concentrations near the recommended values (Figure 2). Another advantage of this method is maintaining a constant flow during the application of settling, so a small amount of water is sufficient for removing suspended solids.

Greenhouse shrimp production with linear tanks.

Ammonia Toxicity Degrades Animal Health, Growth

An NH_3-N concentration of 0.45 mg/L reduced the growth of five species of penaeid shrimp by about 50%.

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Summary:
Ammonia nitrogen occurs in aquaculture systems as a waste product of protein metabolism by aquatic animals and degradation of organic matter, or in nitrogen fertilizers. Exposure can reduce growth and increase susceptibility to diseases in aquatic species. Ammonia nitrogen concentrations vary with time of day, water depth and temperature, and increase as biomass and feed input increase. The best management is conservative stocking and feeding rates that minimize ammonia nitrogen and avoid excessive phytoplankton blooms that cause high pH.

Ammonia nitrogen consisting of un-ionized ammonia (NH_3) and ammonium ion (NH_4^+) occurs in waters of aquaculture production systems as a waste product of protein metabolism by aquatic animals and degradation of organic matter by bacteria and other microorganisms. Ammonia nitrogen also reaches ponds in nitrogen fertilizers such as ammonium sulfate, ammonium phosphate and urea that hydrolyze to produce ammonia nitrogen.

The proportion of ammonia nitrogen existing as NH_3 increases as water temperature and especially pH increase (Table 1). Salinity decreases the proportion of NH_3 at a given pH and temperature, but the effect is not great. For example, at pH 8 and 25° C, the contributions of un-ionized ammonia nitrogen (NH_3-N) to ammonia nitrogen at different salinities are: freshwater, 4.90%; 5 ppt salinity, 4.93%; 10 ppt, 4.78%; 15 ppt, 4.63%; 20 ppt, 4.48%; 25 ppt, 4.34%; 30 ppt, 4.20%; 35 ppt, 4.07%.

Most of the waste nitrogen in aquatic animals is transported in the blood to the gills, where it diffuses into the water as NH_3. When NH_3 concentration is low in the surrounding water, there is a high concentration gradient to facilitate loss of ammonia from animal blood to the water. An increase of NH_3 in the water decreases the gradient, resulting in a higher concentration of NH_3 in the blood and leading to adverse physiological consequences that can be lethal if the NH_3 concentration becomes excessive.

Toxicity Of Ammonia Nitrogen

The toxicity of ammonia nitrogen to aquatic animals results almost entirely from NH_3, because NH_4^+ is relatively non-toxic. Thus, NH_3 toxicity is highly dependent upon pH and is more likely in waters with pH above 8. Of course, in pond culture, water pH typically fluctuates daily, with lowest values in the early morning hours and highest values in the afternoon. In some weakly buffered, low-alkalinity waters with dense phytoplankton blooms, and in high-alkalinity waters, pH can be high throughout the day.

There has been much research on ammonia toxicity to aquaculture species under controlled conditions in the laboratory. Toxicity data have commonly been reported as the concentration of ammonia (reported as NH_3-N) lethal to 50% of the test organisms (LC50). The duration of tests have varied, but many were for 96 hours. Typical 96-hour LC50s found in the literature are presented in Table 2 for several aquaculture species.

The LC50s for NH_3 typically are less than 1.0 mg/L for coldwater species and 1.0-3.0 mg/L for warmwater species. There is not much difference in the 96-hour LC50 range for freshwater and marine species. Some of the reported variation in LC50s resulted from species differences in susceptibility to ammonia. However, much of the variation was the result of different conditions in the toxicity tests – especially water temperature, pH and salinity.

Table 1. Decimal fractions of ammonia nitrogen existing as un-ionized ammonia at various pH values and water temperatures.

	Temperature (° C)								
pH	16	18	20	22	24	26	28	30	32
7.2	0.004	0.005	0.006	0.007	0.008	0.009	0.011	0.012	0.015
7.6	0.011	0.013	0.015	0.017	0.020	0.023	0.027	0.031	0.036
8.0	0.028	0.033	0.038	0.043	0.049	0.057	0.065	0.075	0.087
8.4	0.069	0.079	0.090	0.103	0.117	0.132	0.149	0.169	0.194
8.8	0.157	0.178	0.200	0.223	0.248	0.276	0.306	0.339	0.377
9.2	0.319	0.352	0.386	0.420	0.454	0.489	0.526	0.563	0.603

Table 2. Examples of 96-hour LC50s for NH_3-N to common aquaculture species.

Species	96-Hour LC50
Freshwater	
Channel catfish	0.74-3.10
Tilapia	2.88
Rainbow trout	0.32-0.93
Cutthroat trout	0.50-0.80
Fathead minnows	0.20-3.4
Freshwater prawns	2.00-2.50
Marine	
Striped bass	0.64-1.10
Spotted sea trout	1.72
Southern white shrimp	0.69-1.20
Pacific white shrimp	1.20-2.95
Black tiger prawns	1.04-1.69
School prawns	1.39

A study on rainbow trout reported LC50s of 0.32-0.66 mg/L at temperatures of 10 to 13° C, but at 16 to 19° C, LC50s were 0.86-0.93 mg/L. This revealed that NH_3 was more toxic at lower temperature. This is somewhat unusual, because the LC50s of many toxins decrease with increasing water temperature, indicating greater toxicity in warmer water.

The pH is not only important in determining the percentage of ammonia nitrogen in NH_3 form, it also affects the toxicity of NH_3. In a study of channel catfish, the LC50 at pH 6.0 was 0.74 mg/L, but at pH 8.8 was 1.91 mg/L. In rainbow trout, the LC50 increased from 0.13 mg/L at pH 6.5 to 0.66 mg/L at pH 8.9. Although there is a smaller proportion of NH_3 at lower pH, NH_3 is more toxic at lower pH.

In studies, tilapia growth declined progressively at NH_3-N concentrations above 0.068 mg/L.

Increasing salinity lessens the toxicity of NH_3. In Pacific white shrimp, the LC50 increased from 1.2 mg/L at 15 ppt salinity to 1.6 mg/L at 35 ppt salinity. Similar results were reported for other species of shrimp and fish.

The effect of dissolved-oxygen concentration on NH_3 toxicity is unclear. One study did not find an effect, but another study revealed that NH_3 was more toxic to black tiger prawns at a dissolved-oxygen concentration of 2.3 mg/L than at 5.7 mg/L.

Sub-Lethal Effects

In aquaculture, producers are usually more concerned over sub-lethal effects of a toxin than about the LC50. A number of studies have revealed that chronic exposure to NH_3 produces physiological changes, causes gill lesions, reduces growth and increases susceptibility to diseases.

A study with channel catfish found that growth decreased linearly over the NH_3-N concentration range of 0.048-0.989 mg/L. Growth reduction was 50% at 0.517 mg/L, and no growth occurred at the highest concentration. Tilapia growth also was shown to decline progressively at NH_3-N concentrations above 0.068 mg/L.

An NH_3-N concentration of 0.45 mg/L reduced the growth of each of five species of penaeid shrimp by about 50%. Rainbow trout exposed continuously to NH_3-N concentrations up to 0.073 mg/L did not show reduction in growth, but histopathological lesions were noted at 0.04 mg/L, and protozoan infections increased above 0.02 mg/L.

Most toxicity studies were conducted at relatively constant concentrations of NH_3-N. In culture systems, and especially in ponds, the NH_3-N concentration varies with time of day and depth. For example, in a freshwater pond, the pH might be 7.4 in the early morning, when water temperature is 26° C, and 8.8 in the afternoon, when the water temperature is 28° C. At an ammonia-nitrogen concentration of 1.0 mg/L, the NH_3-N concentration in the morning would be 0.015 mg/L, but in the afternoon, the concentration would be 0.306 mg/L – 20 times greater.

Nevertheless, daily fluctuations of NH_3-N up to 0.37 mg/L that occurred in ponds did not cause a measurable decline in tilapia growth. The authors of that study concluded that exposure to sub-lethal ammonia concentrations probably has minimal effects on fish growth.

Fish and shrimp exposed earlier to sub-lethal NH_3 concentrations were less affected by high NH_3 nitrogen concentration than were animals not previously exposed. Ammonia-nitrogen concentrations tend to increase over time in culture systems as biomass and feed input increase. This may allow the culture species to acclimate to greater ammonia-nitrogen concentrations.

Safe Concentrations

The safe concentration for long-term exposure to NH_3-N and several other common toxins often is estimated by multiplying 0.1 or 0.05 times the 96-hour LC50. Using 0.05 as the factor, safe NH_3-N concentrations would range 0.015-0.045 mg/L for coldwater species and 0.050-0.150 mg/L for warmwater species.

Because of the great variations in NH_3-N concentrations, pH and water temperature over time, however, these calculations should be considered more as general guidelines than absolute values. Frequent, repeated monitoring of NH_3-N in culture systems – especially in ponds – is therefore not necessary.

Besides, there is no sure method for reducing ammonia nitrogen short of using a high rate of water exchange to flush ammonia out of culture units or lowering feed inputs and hence production. The common practices of inoculation with nitrifying bacteria or application of zeolite may be of limited value, so probably the best approach to ammonia nitrogen management is to adopt conservative stocking and feeding rates that minimize NH_3-N input and avoid excessive phytoplankton blooms that cause high pH.

Enough aeration should be applied to avoid low dissolved-oxygen levels and encourage oxidation of ammonia nitrogen to nitrate by nitrifying bacteria. Disturbance of surface water by aeration also encourages NH_3 diffusion into the air. Pond bottoms should be dried out between crops, and acidic soil should be limed to encourage oxidation of organic matter between crops to lessen ammonia nitrogen release into the water during crops.

Saturated Fatty Acids Limit Effects Of Fish Oil Replacement In Cobia Diets

Cobia fingerlings received diets with varied soy-based ingredient replacements for fish oil.

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Summary:
As ingredients in aquafeed, non-fish oil lipid sources contain few long-chain polyunsaturated fatty acids and can impair the growth of fish. In a study of juvenile cobia fed diets containing fish oil or soybean oils, results suggested that lipid sources with high levels of saturated fatty acids and low polyunsaturated fatty acids can replace a large percentage of fish oil in feeds if they are amended with DHA, yielding acceptable growth and maximizing the nutritional value of the final product.

Alternative, non-fish oil lipid sources contain few or no long-chain polyunsaturated fatty acids (LC-PUFAs). Growth performance may therefore be impaired in some fish fed diets with reduced or no fish oil.

The authors' research with cobia indicated that juvenile fish fed alternative lipid sources amended with docosahexaenoic acid (22:6n-3) generally exhibited growth equivalent to those fed fish oil, regardless of dietary phospholipid supplementation. However, alternative lipids high in saturated fatty acids, such as fully hydrogenated soybean oil, yielded superior LC-PUFA retention compared to those rich in C_{18} polyunsaturated fatty acids.

Fatty Acid Requirements

The fast growth, high market value and robustness of cobia, *Rachycentron canadum*, have led to interest in further development and expansion of commercial cobia aquaculture. However, as marine carnivores, cobia demand high levels of dietary lipids and require certain long-chain polyunsaturated fatty acids for proper growth and health. Fish oil is a palatable, digestible source of LC-PUFAs, although concerns regarding future availability and pricing incentivize using fish oil more judiciously in aquafeeds.

Terrestrial plant-derived lipids such as soybean oil are attractive as substitutes for fish oil because of their wider availability and lower cost. However, if these lipids replace a large percentage of dietary fish oil, LC-PUFA deficiencies can develop, as plant-origin lipids do not contain these critical nutrients.

Research on fish oil sparing in other aquaculture species suggests that alternative lipids high in saturated fatty acids (SFAs) or monounsaturated fatty acids have a beneficial effect on the efficiency of LC-PUFA utilization and may effectively reduce LC-PUFA "requirements." Furthermore, phospholipids, which are critical to the development and ontogeny of juvenile fish – especially fast-growing species such as cobia – may also exert some influence over the success of fish oil sparing.

The authors' objective was to assess the growth performance and tissue fatty acid composition of juvenile cobia fed diets containing fish oil or 22:6n-3-amended soybean oils containing different levels of SFAs versus C_{18} PUFAs with or without supplemental phospholipid (P.L.) (Table 1).

SFA-Rich Lipids Minimize Fatty Acid Profile Changes

After eight weeks of feeding, statistically significant differences were observed among treatments for feed conversion, weight gain

Table 1. Dietary formulation (g/kg) and proximate composition (g/kg) of test diets.

Ingredient	FISH ONLY	STD SOY	STD SOY + P.L.	HYD SOY	HYD SOY + P.L.	FULL HYD SOY	FULL HYD SOY + P.L.
Wheat bran	302.3	289.0	289.0	289.0	289.0	289.0	289.0
Menhaden fishmeal	245.5	245.6	245.6	245.6	245.6	245.6	245.6
Corn gluten meal	150.1	150.1	150.1	150.1	150.1	150.1	150.1
Soybean protein concentrate	137.0	137.2	137.2	137.2	137.2	137.2	137.2
Soybean protein isolate	79.2	79.2	79.2	79.2	79.2	79.2	79.2
Menhaden fish oil	53.1	0	0	0	0	0	0
Soybean-derived lipid	0	44.5	24.5	44.5	24.5	44.5	24.5
Carboxymethyl cellulose	20.2	20.2	20.2	20.2	20.2	20.2	20.2
Choline chloride	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Methionine chloride	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Stabilized vitamin C	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Vitamin premix	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Mineral premix	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Soybean lecithin	0	0	20.0	0	20.0	0	20.0
Algal meal	0	21.6	21.6	21.6	21.6	21.6	21.6
Proximate Composition							
Dry matter	944	951	950	959	959	945	960
Protein	486 ± 2	486 ± 3	487 ± 6	491 ± 5	485 ± 7	487 ± 4	489 ± 5
Lipid	94 ± 1	100 ± 1	94 ± 1	100 ± 7	102 ± 3	98 ± 5	102 ± 2
Ash	87 ± 4	98 ± 6	82 ± 4	80 ± 5	95 ± 7	78 ± 6	83 ± 2

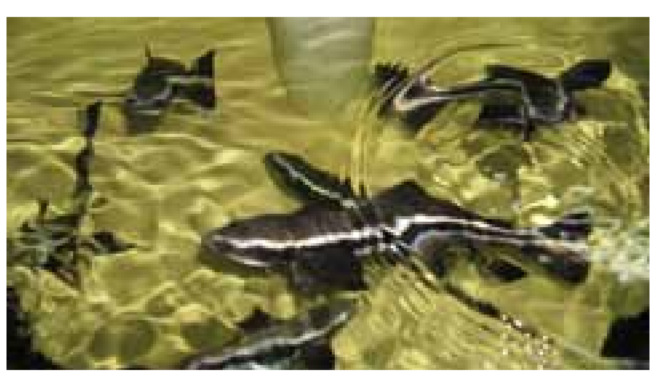
STD SOY = Standard soybean oil, STD SOY + P.L. = Standard soybean oil plus phospholipids
HYD SOY = Partially hydrogenated soybean oil, HYD SOY + P.L. = Partially hydrogenated soybean oil plus phospholipids
FULL HYD SOY = Fully hydrogenated soybean oil, FULL HYD SOY + P.L. = Fully hydrogenated soybean oil plus phospholipids

Table 2. Mean production performance by dietary treatment. Means with common letter labels are not significantly different (P > 0.05).

Parameter	FISH ONLY	STD SOY	STD SOY + P.L.	HYD SOY	HYD SOY + P.L.	FULL HYD SOY	FULL HYD SOY + P.L.	P VALUE
Survival (%)	97 ± 3	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	0.463
Initial weight (g)	55 ± 1	55 ± 0	55 ± 0	56 ± 0	56 ± 1	54 ± 1	55 ± 1	0.379
Final weight (g)	172 ± 9	177 ± 4	189 ± 9	169 ± 2	160 ± 3	176 ± 7	167 ± 1	0.078
Weight gain (%)	211 ± 17^{z}	220 ± 8^{yz}	241 ± 16^{z}	201 ± 7^{yz}	185 ± 4^{y}	224 ± 8^{yz}	206 ± 3^{yz}	0.039
Feed-conversion ratio	1.40 ± 0.05	1.42 ± 0.03	1.45 ± 0.02	1.45 ± 0.01	1.51 ± 0.01	1.55 ± 0.05	1.53 ± 0.01	0.036*
Specific growth rate (% body weight/day)	2.02 ± 0.10^{yz}	2.08 ± 0.04^{yz}	2.19 ± 0.08^{z}	1.97 ± 0.04^{yz}	1.87 ± 0.03^{y}	2.10 ± 0.04^{yz}	2.00 ± 0.01^{yz}	0.034
Feed intake (% body weight/day)	2.98 ± 0.07^{x}	3.12 ± 0.02^{xy}	3.37 ± 0.10^{yz}	3.00 ± 0.10^{x}	2.94 ± 0.03^{x}	3.44 ± 0.04^{z}	3.21 ± 0.04^{xyz}	< 0.001

STD SOY = Standard soybean oil, STD SOY + P.L. = Standard soybean oil plus phospholipids
HYD SOY = Partially hydrogenated soybean oil, HYD SOY + P.L. = Partially hydrogenated soybean oil plus phospholipids
FULL HYD SOY = Fully hydrogenated soybean oil, FULL HYD SOY + P.L. = Fully hydrogenated soybean oil plus phospholipids

* Although the one-way ANOVA indicated significant treatment effects, more conservative Tukey's HSD pairwise comparison tests indicated no significant differences among means.



The fatty acid profiles of fish tissues tended to reflect the fatty acid profiles of the dietary lipid sources.

and feed intake, although the magnitude of these differences was relatively small in most cases (Table 2). Only the HYD SOY + P.L. treatment group exhibited significantly reduced growth in comparison to the FISH ONLY control group.

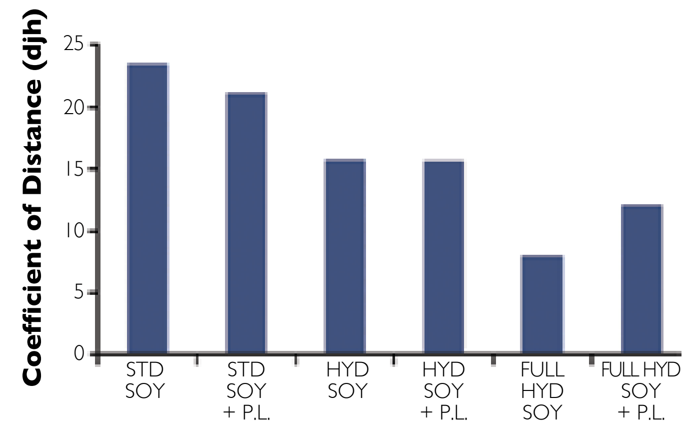
Feed intake was significantly increased relative to the FISH ONLY control only among fish fed the STD SOY + P.L. and FULL HYD SOY feeds. Dietary protein content and feed intake were both lowest in the HYD SOY + P.L. group, which may explain the impaired growth performance of this group, rather than P.L. supplementation or the lipid source used. Otherwise, neither P.L. supplementation nor alternative lipid source appeared to have any effect on growth performance.

Tissue fatty acid profiles tended to reflect the fatty acid profile of the dietary lipid source, but fillet profile distortion varied among the dietary treatment groups (Figure 1). Fillet LC-PUFA retention was best in the dietary treatments that contained the greatest amounts of SFAs and low amounts of C_{18} PUFAs – the fully hydrogenated soy treatments. This may be due to the selective catabolism of SFAs over LC-PUFAs for energy when they are provided in dietary surplus and also the tendency of C_{18} PUFAs to "compete" with LC-PUFAs for deposition in tissues.

Perspectives

These results suggested that high-SFA, low-C_{18} PUFA lipid sources can replace a large percentage of fish oil in feeds for juvenile cobia if they are amended with 22:6n-3, yielding acceptable growth performance and maximizing the nutritional value of the final product for the consumer.

Editor's Note: This article was based on "Saturated Fatty Acids Limit the Effects of Replacing Fish Oil With Soybean Oil With or Without Phospholipid Supplementation in Feeds for Juvenile Cobia," a paper recently published by the authors in the North American Journal of Aquaculture.



STD SOY = Standard soybean oil, STD SOY + P.L. = Standard soybean oil plus phospholipids
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FULL HYD SOY = Fully hydrogenated soybean oil, FULL HYD SOY + P.L. = Fully hydrogenated soybean oil plus phospholipids

Figure 1. Fillet coefficient of distance values by dietary treatment. Values compare overall fatty acid profiles between the experimental treatments and the FISH ONLY positive control treatment, with smaller values indicating greater profile similarity between the experimental treatment and the control.

Flatfish Conditioning For Stock Enhancement

Acclimation cages in Japan "zipper" closed so fish can be stocked and released easily.

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Summary:
For stock enhancement, the ideal end product is an individual that can survive in the wild until maturity. Conditioning fish for stock enhancement can increase survival and recapture rates. The degree to which they need conditioning before release depends on the type of fish and its ecological niche. Acclimation cages, the most implemented conditioning strategy for flatfish, are inexpensive and effective, but require site-specific adjustment. Live or lifelike diets show great potential in rearing stocked flatfish.

The most prominent countries conditioning flatfish for stock enhancement are Japan, Denmark and the United States. Wherever it is practiced, a successful stocking program requires high survival of released fish. Hatchery-reared fish must be able to adjust to their new environment, feed successfully and avoid predation when released. However, all reared fish are not equal. The end products of fish reared for aquaculture and those reared for stock enhancement vary greatly.

For aquaculture, the ideal end product is a large-sized individual that was grown most economically, both financially and temporally, and preferably has a pleasant flavor. For stock enhancement, the ideal end product is an individual that can survive in the wild until maturity. Conditioning fish for stock enhancement can increase survival and recapture rates of released fish.

Conditioning Strategies

The degree to which fish reared for stock enhancement need conditioning before release depends on the type of fish reared and its particular ecological niche and associated behaviors.

Conditioning can be implemented in the hatchery or in the wild. In the hatchery, fish can be exposed to rearing tanks with sediment, predator exposure and live or lifelike diets. In the wild, fish can undergo operant behavioral training, whereby fish learn to gather at a sound or light for feeding. Fish also can be released into acclimation cages before true release to the wild. The cages serve as a "halfway house" as the fish adjust to their new environment.

In the hatchery, providing rearing tanks with sediment allows flatfish to begin camouflaging pigment change and develop burying skills. In addition, this decreases the frequency of off-bottom swimming behavior, as seen with juvenile Japanese flounder, *Paralichthys olivaceus*, in tanks with sand compared to bare tanks.

In the United States, the survival of summer flounder, *Paralichthys dentatus*, was significantly higher for fish reared with an isolated blue crab, *Callinectes sapidus*, present in the tank than for fish reared without the predator conditioning. However, the increased survival of the conditioned fish was not as high as that for wild fish. In Japan, observational learning improved predator avoidance for hatchery-reared Japanese flounder that witnessed predation of their own species.

At the University of New Hampshire in the U.S., live diets for flatfish stock enhancement have been explored. Subadult brine shrimp, *Artemia salina*; white worms, *Enchytraeus albidus*; and common burrower amphipods, *Leptocheirus plumulosus*; have been cultured as feeds. The most promising feed is white worms, which have been reared in the former Soviet Union since the 1940s for hatchery-reared sturgeon.

In the field, hatchery-reared winter flounder, *Pseudopleuronectes americanus*, grown on white worms exhibited survival, diet profiles and RNA/DNA compositions similar to those for wild fish. In Japan, juvenile marbled flounder, *Pseudopleuronectes yokohamae*, at Hyogo Prefectural Center for Stock Enhancement are fed a mixture of minced frozen mysids with additional formulated feed to boost nutritional content. However, formulated feed is stopped two weeks before release to redirect fish to more natural feed.

From 2009 to 2011, the University of New Hampshire deployed floating cages of juvenile winter flounder at and just below the surface.

Operant behavioral training may be especially useful in sea ranching. Work conducted in Japan revealed Japanese flounder gathered when a sound cue was provided, even when food was not available.

Acclimation Conditioning

Acclimation cage conditioning allows hatchery fish to experience substrates and sediments, live food sources and a predator-free existence before actual release. Researchers in Denmark began cage conditioning turbot, *Psetta maxima*, in bottomless cages to expose fish directly to sediments. The fish were conditioned for three to six days in areas with a small tidal range of about 30 m. However, when this technology was transferred to Japan, there were problems with predators entering the cages through the open bottoms. To address this, cages were modified. Japanese cages now contain mesh bottoms, and sand is put inside. They also "zipper" closed so that fish can be stocked and released easily.

When this technology was transferred to the U.S., there were two problems. First, crab predators were more abundant and they ripped holes in the soft nylon cage mesh with their claws. Since crabs gather on the bottom, two types of floating cages – at the surface and 0.5 m below the surface – were deployed.

Survival in these cages was highly variable, and fish did not gain the benefit of experiencing sediments before release. So a new U.S. cage bottom design was constructed of more-durable polypropylene mesh. This material was too rigid to close with zippers, so cable ties were used.

The second problem was that due to the 1- to 5-m tidal range in New Hampshire, the fish swam to the surface of the cages and wedged themselves between the cable ties to escape when the tide rose. The newest design has a self-adjusting height that rises with the tide so the cage opening is never submerged. First used in September 2012, this design has been successful, with high fish survival and retention.

Implications For Stock Enhancement

Ensuring that released fish are morphologically, ecologically, genetically and behaviorally similar to wild fish is necessary for an effective release program. Nonetheless, conditioning strategies that are easy to implement, economically feasible and effective are still being developed and tested. The number of studies that monitor and track the fate of released conditioned fish is few.

A study in Japan found that non-conditioned fish, mostly non-feeding individuals, were caught more often than conditioned fish by boat beam trawl when researcher-initiated recapture efforts were applied. Similarly, a Danish study found that the catchability of non-conditioned turbot caught by beam trawl was 10% higher than that of cage-conditioned fish. This may indicate that intensive researcher recollection efforts at or near release sites disproportionately sample weak fish that are not feeding or moving.

Efforts and money for recapture may be better spent on involving more local fishermen, especially since cooperative efforts generate more interest and publicity in the stocking. Involving more fishermen also may promote the reporting of recaptured hatchery-reared catch by those not directly involved in the project, and thus amplify the level of monitoring conducted.

Monitoring

Even without implementing a conditioning strategy, one of the greatest difficulties of a stocking exercise is the level of post-release monitoring. In many cases, 1% recapture rates are the norm. Choosing a location that can be monitored adequately may be just as important as choosing a location where stocking is predicted to succeed, which is essential for stocking efforts to successfully influence future funding and resources support.

Stocking agencies have an obligation to conduct post-release monitoring to assess stocking effectiveness, especially if the stocking effort is funded by general taxes or fees from fishermen. In addition, there is a biological and ecological responsibility to evaluate what, if any, effect the stocking has on local fish populations and their habitats.

White worms (left) are a promising live feed for conditioning juvenile winter flounder. In Japan, juvenile marbled flounder at Hyogo Prefectural Center for Stock Enhancement are fed frozen shrimplike mysids (right).

Market Bottlenecks For Small-Scale Aquaculture

Even when they join cooperatives, small-scale mussel farmers face market challenges that often relate to a lack of product differentiation.

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Summary:
Due to their limited scale, small aquaculture producers largely have to accommodate the conditions imposed by the following links in the value chain in terms of prices and quality standards. Combining production improves scales in terms of transportation, processing and marketing costs, but quality inconsistencies, lack of professional managerial skills and limited promotional efforts often remain. Lack of product differentiation can be another challenge.

From a marketing point of view, the implications of scale go beyond the volumes of production, costs and efficiency. Scale also describes a firm's ability to affect its social, environmental and market conditions.

Frequently, the term small-scale in the agrifood business implicates that producers have to accommodate the conditions imposed by the following links in the value chain in terms of prices, quality standards and product differentiation, among others. Producers commonly face limitations related to their limited economic capacities, and even large-volume industries like tilapia aquaculture in developing countries or mollusc farming all around the world, frequently organized in small independent farms, have to deal with those limitations.

The ability of a company to influence the market is directly related to the volumes of supply it has under its own control. By definition, small-scale aquaculture implies that, even in an industry with huge production, private decisions affect small quantities of production.

Small farmers may combine their production, as in cooperatives, resulting in relevant volumes of supply and also scales in terms of transportation, processing and marketing costs. However, other variables escape small farmers' control and limit the development of markets, such as quality inconsistencies, lack of professional managerial skills and limited promotional efforts.

Varied Management Duties

Small-scale farmers' qualifications rarely exceed what is needed to run a farm at the operational level. Farmers know about the best feed for the fish, the optimal breeding periods and how to deal with parasites and pathogens. But they fail when managerial tasks need to be undertaken. Common business practices like budgeting, accounting and financial planning are usually not found within the skills of these farmers.

On the other hand, farm owners, who commonly also work at their farms, may take several different tasks under their responsibility that are not always compatible, resulting in inefficiencies in the use of managers' available time. They have to control the production, negotiate with suppliers and customers, make decisions on investments, and perform additional tasks that impede increased productivity derived from experience and adequate learning.

In the marketing field, overcharged managers may not have the time and skills to develop new products, explore alternative channels or make decisions regarding promotions or special pricing policies. Facing varied activities, managers tend to concentrate on those associated with direct economic inputs, such as production, purchases and sales.

Under these conditions, innovation is difficult, and farmers often copy newer techniques already used with other species or in different parts of the world. The same happens with marketing tools like advertising, which is often constrained to low-impact local efforts that do not continue over time.

Training programs are a common governmental initiative applied to improve the performance of local aquaculture. They may provide some knowledge and skills to managers, but the issue of available time and how managers allocate it according to immediate priorities are still barriers to effective use of the newly acquired knowledge. Frequently, training programs do not have the expected effects, and farmers keep on with their usual routines.

Product Quality

Another important issue in small-scale aquaculture is quality consistency. Since most small-scale producers sell an undifferentiated product, fish from different farms are viewed by consumers as if they were the same products with the same quality attributes.

When quality is inconsistent across producers of a same species or region, it affects the whole industry and results in negative product perceptions.

It does not matter if only one or a small group of producers provides below-standard quality. Since consumers are unable to discern whether a fish came from one producer or another, a failure in quality from one farm may be perceived as an industry failure. This is why it is so important that an industry follow consistent quality standards, especially when producers are not able to differentiate each others' products.

Pricing Policies

Lack of differentiation also affects the prices farmers receive for their fish. Traders may understand that all producers hold the same levels of quality and may be willing to pay the same price for any fish of the same species and region. But problems arise when one producer or group of producers decides to decrease prices – not due to increased efficiency, but to non-technical reasons, such as the need for liquidity or accumulation of stocks.

In such cases, traders try to apply the new prices to the rest of the producers, resulting in a reduction in the incomes of all farmers. Fragmentation on the side of farmers contrasts with concentration at the wholesale and retail levels, driving producers to reduce their market power to a minimum. Since market power also involves the ability to set product prices, it is unlikely that small-scale farmers can control the prices they get from the market.

Alternative Market Development

Industry fragmentation is the origin of the majority of the limitations referenced above. Producer aggregation may appear to be a solution to many of them and increase market power. However, it is not easy to consolidate an industry based on small-scale production without pushing a large number of farmers out of business. This solution may increase the profits of the remaining farming companies, but the social impacts may not be good for struggling farm neighbors.

Farm cooperatives may help concentrate sales and control prices, but may not be effective in terms of quality consistency and marketing strategy. Small producers need to coordinate their actions beyond concentrating supply. Cooperatives need to operate as a unified entity in the market. Quality standards need to be implemented and controlled. And skilled managerial professionals have to be hired to manage the process.

Small operations have a limited ability to control the prices paid for their harvests.

Cooperation Across Seafood Chain Can Counter Mercury Reports, Other Concerns

Additional training for seafood retailers could enhance consumers' purchasing experiences and increase seafood consumption.

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Summary:
Although seafood is the most nutritious, healthy and sustainable protein available, many consumers hold misguided perspectives about it. Risk-based advisories are scaring people away from eating fish. Often-referenced but outdated reports have raised concerns over mercury, while in reality, not eating seafood carries greater risk than the minute presence of such chemicals. By improving interfaces between aquaculture and consumers, and getting out consistently truthful, positive messages about seafood, the industry will see positive advances.

I had the great pleasure to visit Mexico and Brazil recently, where I had the opportunity to speak about standards, seafood consumption and increasing seafood capacity to many audiences. These elements are all inexplicably tied together.

In Mexico, I had a whirlwind tour of five very different areas of the country, while in Brazil, I was confined to beautiful Rio de Janeiro and the World Tilapia Conference. Throughout the journey, I had discussions with all sectors of the industry and government. These discussions simply hardened my thoughts on the way forward for all.

(In)accurate Information

Media negativity gets mentioned wherever you go in the aquaculture/seafood world. Unprofessional journalism seems happy to print anything based on opinions instead of getting the peer-reviewed science and facts. We all know that anyone can put anything they like on the Internet, and regrettably some of that takes hold. We must continue to criticize such behavior and take responsibility that we ourselves do not pass on false information, whether well-meaning or otherwise.

It seems some work has been done in Mexico and Brazil. Great start. But as we know, companies like McDonald's and Coca-Cola do not just advertise once to ensure their brands are kept at the tops of our minds. There is a constant flow of information utilizing all forms of media and, no matter what you think of such companies, they train their staff exceptionally well.

GILLS will continue to promote the concept that industry needs to adopt strict standards in all areas of its operations, empower staff through training/development programs, demonstrate that workers meet those standards and then promote the healthy products that come through from harvests.

Questions

During my trip, I asked the audiences three questions:

1. How many people do you know who have died from mercury poisoning from eating too much fish?
2. How much money does your business put aside for marketing your brand and products, or into a collective pool for joint promotion?
3. Who among you has had such a terrific, pleasurable experience when buying seafood at retail that you want to talk about it?

The answers were pretty much the same everywhere – none, nil and no one!

Mercury Issue

The mercury issue always astounds me but manages to keep arising when some group feels like venting at the industry or about seafood. Let us be blunt: It is a "furphy," Australian slang for a rumor or an erroneous story.

When the Codex Alimentarius Commission decision was made

Most mercury issues with seafood involve large predatory species like tuna and swordfish.

on mercury levels, it was based on two studies done by a joint United Nations Food and Agriculture Organization/World Health Organization (FAO/WHO) Expert Committee on Food Additives. One of these was on seafood consumption in the Seychelles, and the other was on seafood consumption in the Faroe Islands.

In the Seychelles, many studies have been done over many years by eminent nutrition scientists and researchers, but particularly Gary Myers and Sean Strain. More people need to read their reports, such as "The Seychelles Child Development Study of Methylmercury From Fish Consumption: Analysis of Subscales From the Child Behavior Checklist at Age 107 Months in the Main Cohort."

In all the years of testing, no evidence of adverse effects from prenatal exposure to methyl mercury by consuming a high-fish diet has been reported. Note that people in the islands have seafood consumption eight to 10 times higher than that of Americans.

Where people consume seafood in the Faroe Islands, it was highlighted, children have shown deficits in learning and memory that correlate with cord-blood mercury levels. The big difference is the tendency to eat pilot whales in the Faroes. In "Mercury: Selenium Interactions and Health Implications," eminent human and environmental health specialist Dr. Nicholas Ralston told us an answer lies in selenium, or the lack of it.

The most common-sense approach could have been to simply say: "Do not eat pilot whales." But the two studies were combined to find some middle ground on the figures relating to seafood consumption. As a result, we had major countries issuing warnings to pregnant mothers, which added considerable fuel to the anti-seafood lobby.

Benefits, Risks

Dr. Dariush Mozaffarian of the Harvard School of Public Health has said: "We have smart, well-meaning scientists who have been educated in a framework in which you assess risk and come up with tolerable intakes. But that's the wrong framework, because you don't eat pure contaminants, you eat fish, and you can't get the risks without the benefits."

What the enemies of seafood do not tell people is that not eating fish is also dangerous. Dr. Mozaffarian and other specialists point out that the risk of dying from heart disease is about 50% higher among people who don't eat seafood than those who get one or two servings of a high-fat fish each week.

Since the average American eats only about 7.2 kg of seafood yearly – a much lower quantity than the 18 kg/year for the average world seafood consumer – the risk of too little seafood seems to be the larger threat. But the risk-only advisories, even some of the more balanced advisories, are scaring people away from eating fish.

Additionally, these tests were done many years ago. Farmed fish are not as exposed to mercury issues as their wild cousins, yet we have not attempted to revisit these findings and get the standard guidelines changed. *Environmental Health Perspectives* and Science Daily are also coming to this view – see http://www.sciencedaily.com/releases/2013/09/130930211701.htm#! . We have learned from WHO/FAO that the benefits of eating seafood far outweigh any risks.

Marketing

Answers to my second audience question indicated that attempts at marketing are generally left to individuals, while a joint approach in sharing the burden may well be the better approach. This is not rocket science – invest in marketing and education, and you will reap rewards. Failing to do this will leave the industry languishing. Arguments always ensue when issues like levies are raised, but once addressed, the pain is generally forgotten, and used wisely, the effort is well rewarded.

Seafood is the most nutritious, healthy and sustainable protein you can put in your mouth. I believe the problem is that those within the aquaculture/seafood industry do not work together globally in the same way as the enemies of seafood do. Hopefully we can change that.

Consumer-Industry Interface

Regarding my third audience question, we do need to address the interface between the industry and consumers. Over the years, much work has been done in the harvesting and processing sectors, with massive gains through education, technology and standards. Yet we have tended to allow anyone to sell seafood.

Seafood retailing is the "window" of the industry. In order to increase seafood consumption, retailers must have certain skills and knowledge that, unfortunately, due to its nature of being an entry-level employer that seldom demands great skills, are lacking in the seafood industry.

Harvesters can have the best fully certified products in the world and great passion about their brands and products, but as soon as shipments leave their control, they are left to the mercy of the seafood chain and its end retailers.

In some countries, it is not possible to operate a butcher business without formal qualifications, as the slaughterhouses will not sell meat to unaccredited operators. But the supply chain for seafood is such that nearly anyone can start a fish retail business. This leads to poor practices, undercutting, waste, etc. I have first-hand experience with the difference training can make in retail and am constantly amazed that we allow untrained people to be the window of our industry.

Perspectives

Some potentially good news is on the horizon relating to this. If we can change the interface with the consumers and get out consistently truthful, positive messages about seafood through an education platform, ideally globally, then we will make a difference. If we can make shopping for seafood a pleasurable experience and empower consumers with sound advice, then the world is more than our oyster, it will be a shining pearl!

Certification Programs For Aquafeed Manufacturing

Planned cooperation among leading programs should streamline the certification process for feed mills.

Summary:
Private aquafeed certification standards have been developed to bring trust and demonstrate responsible industry practices among stakeholders. The primary certification programs have signed a memorandum of understanding with the goal of working together to streamline the audit process and reduce costs. Since the standards programs have many similarities, harmonization of control points could be a first collaborative step. To maintain the differences of the programs, only the points not harmonized would need to be additionally audited.

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Feed manufacturing is an important link in the production chain of aquaculture species. As the safe feed-safe food concept is pursued to minimize food safety risks to animals and people, other aspects such as the environment, biodiversity and worker health and safety are also taken into account to aid in the sustainability of the industry as a whole.

Private feed certification standards have been developed as a market response to bring trust and demonstrate responsible industry practices among stakeholders. There are currently more than five feed certification schemes, but only the Global Aquaculture Alliance Best Aquaculture Practices (BAP) feed mill standards and GlobalGAP Compound Feed Manufacturing (CFM) Standard include specific criteria to address important food safety, environmental and social issues and are of worldwide applicability. A third feed scheme for aquaculture feed producers being developed by the Aquaculture Stewardship Council (ASC) is projected to be available by December 2015.

Leading Programs

The BAP feed mill standards are solely intended for aquaculture feed production and have sections with control points addressing property rights and regulatory compliance, community relations, worker safety and employee relations, fishmeal and fish oil conservation, storage and disposal of supplies, waste management, HACCP process control, good manufacturing practices and traceability.

The GlobalGAP CFM Standard's scope is solely intended for mammalian/avian livestock and aquaculture feed production. It has sections with control points addressing official approvals; worker health, safety and welfare; quality management – HACCP; internal audits; feed ingredient management; storage facilities; processing; finished feed transport; site hygiene and management; quality control of finished feed; ingredients declaration; complaints; traceability; animal protein and responsible use of natural resources.

The ASC feed standard will be intended solely for aquaculture feed production, targeting production that will be environmentally sound and socially responsible. What control points will be included to achieve these objectives remains to be seen.

Cooperative Agreement

Representatives of the three above-mentioned programs signed a memorandum of understanding in April during the European Seafood Exhibition in Brussels with the goal of working together to achieve efficiencies that will benefit all stakeholders. This is really a laudable act that has as one of its first objectives to work on the harmonization of the feed standards.

Hopefully, this effort will translate to tangible efficiencies that reduce "audit fatigue" and costs associated with multiple certifications. It may also avoid yet another costly accreditation process for the ASC feed standard to certification bodies that are already accredited by International Accreditation Forum members and Multilateral Recognition Arrangements signatories.

A quick look at the sections content of the BAP and GlobalGAP feed standards suggests that harmonization of many of the control points is an achievable goal and could be a first collaborative step to take. Recognition of the harmonized standards by each standard's owner and market participants would then be desirable.

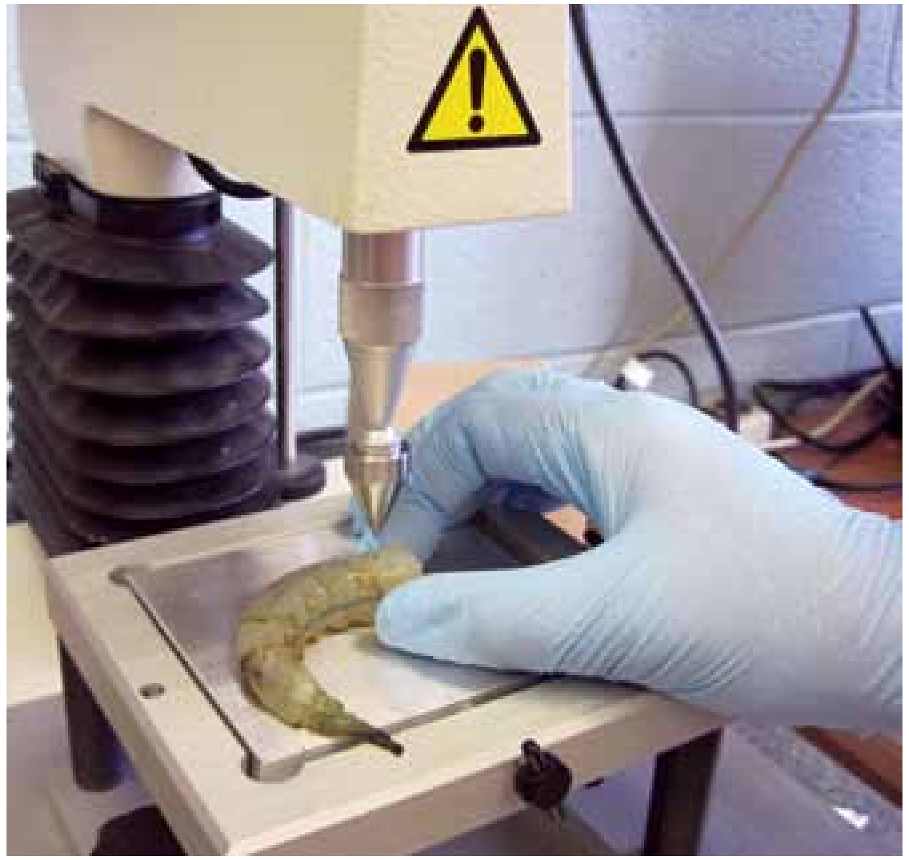
As each of the standard-setting organizations would want to maintain the unique differences of their programs, only the control points not harmonized – or riders for specific standards – would need to be additionally audited for feed mills wishing to be certified under more than one of the standards, thus streamlining the audit process and reducing costs and resources for all.

Perspectives

What this initial collaborative effort's final outcome will be remains to be seen. However, the industry is grateful for it and looking forward to reliable, efficient and effective certification systems. Ultimately, these advances will help bring trust and transparency among all market participants, regardless of size, and support further development of the industry to provide an excellent supply of protein to an increasing human population.

This effort will translate to tangible efficiencies that reduce "audit fatigue" and costs associated with multiple certifications.

Study Finds Texture Quality Of Head-On, Headless Shrimp Similar After Cold Storage



The texture analyses of head-on and headless shrimp evaluated the hardness, cohesiveness and springiness of shrimp tissue.

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Summary:
Mushiness of shrimp tails is often associated with head-on shrimp. Results from the authors' study, however, indicated that texture values did not vary much between headless and head-on shrimp stored over a two-week period at 4° C. Although the hardness of shrimp tissue generally decreased over time for all the shrimp, those with heads had 15% lower hardness values than headless shrimp. When comparing cohesiveness and springiness, there was little to no difference between shrimp with or without heads.

Shrimp, the most consumed seafood in the United States, is primarily marketed as frozen product. However, there is growing demand for locally produced fresh food that was never previously frozen. It is in the best interests of shrimp farmers to saturate their local and regional markets with fresh shrimp to increase the prices received for their products.

If farmers can market shrimp head-on, they can tap into an additional specialty value-added market and enjoy the benefits of selling whole shrimp versus headless shrimp. The advantages for selling head-on shrimp include higher pricing on a weight basis and not having to dispose of shrimp heads as waste or developing a use for this by-product.

Mushy Tails

Shrimp from wild fisheries are primarily deheaded soon after they are captured, because shrimp tails become mushy if the heads remain on for an extended period of time post-mortem. This is also common practice for farmed shrimp.

The mushiness of whole shrimp held on ice is not due to the action of enzymes indigenous to muscle tissue, but is attributed to the diffusion of proteolytic and collagenolytic enzymes that originate from the autolysis of the hepatopancreas. Mushiness for head-on shrimp has also been related to differences in genetics, rearing practices and animal stress.

In a study, the authors compared the textures of head-on versus headless farmed shrimp stored over time in a refrigerator.

Study Methods

Pacific white shrimp, *Litopenaeus vannamei,* were cultured in recirculating aquaculture systems, harvested and then euthanized in a freshwater slurry/ice bath with a temperature less than 4° C. To ensure the internal temperature of shrimp was less then 4° C, they were maintained in the ice bath for 20 minutes.

Head-on and headless shrimp were then placed on ice in single layers with alternating layers of ice and shrimp. The shrimp were held on ice for approximately two hours to simulate the time between being euthanized and processed. Shrimp were then packaged for fresh storage in vacuum pouches and stored at 4° C.

Head-on and headless shrimp were stored separately in seven bags, so on each sampling day, shrimp were removed from packaging that was under vacuum until the time of texture analysis. Texture analyses were performed on three head-

Mushiness of shrimp tails is often associated with head-on shrimp.

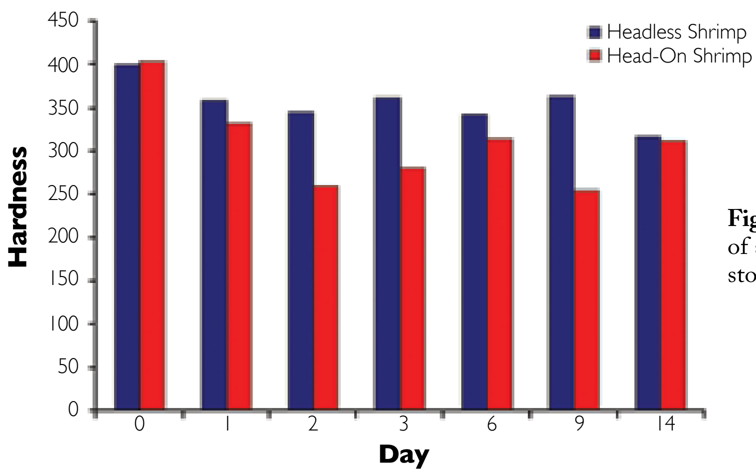

Figure 1. Hardness of shrimp tail muscle stored at 4° C.

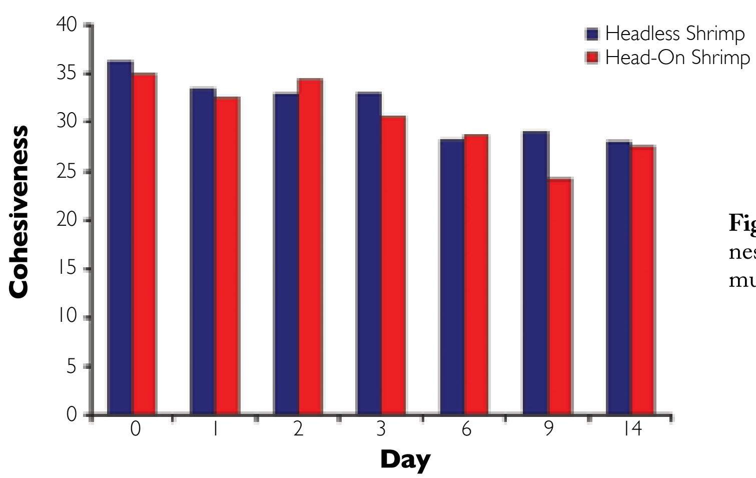

Figure 2. Cohesiveness of shrimp tail muscle stored at 4° C.

on and three headless shrimp on days 0, 1, 2, 3, 6, 9 and 14.

Analyses were performed using a texture analyzer calibrated for force and height at the start of each test day. Shrimp were removed from their bags one at a time and peeled. Texture analyses were performed on the first and fourth segments of each shrimp tail and averaged to provide an overall texture profile.

Results

Hardness is defined as the minimum compression force required to compact material by a given distance. In other words, the lower the hardness value, the softer the shrimp muscle will be. The hardness of shrimp generally decreased over time for both groups of shrimp (Figure 1). On average, the headless shrimp had a 15% higher hardness value than the values found in the head-on shrimp. It was expected that headless shrimp would have higher hardness values based on the enzymatic degradation of the tails from the head region.

Cohesiveness is defined as how well material withstands a second compression relative to how it behaved during initial compaction. Lower cohesiveness values indicate internal shrimp muscle bonds are not as strong. Generally, cohesiveness decreased over time for both groups of shrimp. Cohesiveness values for headless shrimp were, on average, 4% higher than those for the head-on shrimp (Figure 2). So compared to the first compression values, the second compression values were not as different between headless and head-on shrimp.

Springiness is a value that defines how well a material physically springs back after is has been deformed during initial compression. For shrimp, lower values show that shrimp muscle has less recovery to its normal state after force is removed. The springiness of both groups of shrimp did not vary over time and remained relatively consistent over the 14-day period of storage. The springiness of the headless shrimp averaged just under 2% lower than that of the head-on shrimp.

Perspectives

Mushiness of shrimp tails is often associated with head-on shrimp. Results from this study were somewhat surprising in that texture values did not vary greatly between headless and head-on shrimp stored over a two-week period.

Further studies should be conducted to determine the consistency of these observations, along with a comprehensive shelf life study A full shelf life study including microbial plate counts and a human sensory pane is planned in the near future to determine the overall potential for the head-on fresh shrimp market. If results are not favorable, product quality may be improved by enhanced post-harvest protocols or other good aquaculture practices.

Killing Methods, Post-Slaughter Quality

Part III. Fasting, Post-Mortem Changes, Transportation Effects

Studies have shown that fasting fish species such as Atlantic cod for several weeks did not greatly affect filleting yield, but prolonged fasting typically causes some physical changes in color and shape.

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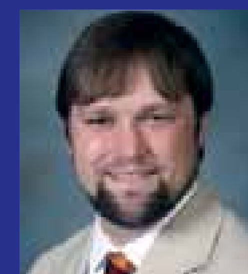

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Summary:
Slaughter methods can impact product quality. It is recommended that fish be fasted prior to slaughter to clean their digestive tracts. Fasting does not usually contribute to unacceptable odor, flavor or texture in processed fish, but prolonged fasting can decrease yield and change fish color and shape. Instant killing minimizes the degradation of tissue quality. Immediate bleeding is more important than the bleeding method. The implementation of comprehensive handling and transportation practices will help ensure high-quality fish.

The first two articles in this series reviewed various methods of fish slaughter and the effects on initial product quality. Also, ethical concerns with some of the slaughter methods were discussed. Part III of the series discusses how slaughter methods impact product quality from slaughter through consumption.

Effects Of Fasting

It has been recommended that fish be fasted for several days prior to slaughter to clean their digestive tracts, thereby minimizing the risk of muscle contamination during gutting and processing. However, since proper feeding is an important component of animal welfare, longer fasting periods are not recommended as a commercial practice.

For research purposes, varied studies have examined the effects of longer fasting on post-mortem fish quality. One finding, for example, was that if fish are subjected to prolonged fasting, weight loss is more pronounced during the first four weeks and less thereafter. However, various fish species reflect different weight losses.

Typically, most of the initial weight loss occurs in the viscera and can account for 50% of the total weight loss. After the visceral loss occurs, the remaining loss comes from the body. It has been found that product yield can increase in fish subjected to various fasting schedules. Some studies have shown that some fish species, such as Atlantic cod *Gadus morhua*, could be fasted for up to 10 weeks without affecting filleting yield. However, after prolonged fasting, processing yield decreases, and fish exhibit some physical changes in color and shape.

For many fish species, initial lipid loss during extended fasting occurs in the visceral fat and then in the liver and muscle tissue. As lipid is lost in muscle, it is replaced with water, since an inverse relationship exists between lipid and water. Lipid loss occurs at a slow rate during initial fasting but increases at a more rapid rate as the fasting period is extended. Also, saturated fat is lost first, resulting in a higher concentration of unsaturated lipid in the muscle tissue.

During extended storage, amino acids decrease within white muscle first, followed by red muscle and then connective tissue. Amino acid losses are similar to lipid content losses in that losses occur first in the viscera, then in the liver and finally the muscle tissue. While amino acid concentrations vary, in many fish species, protein content remains constant for an extended period. It has been observed that protein content in the white muscle may increase slightly before decreasing.

Depending upon the fish species, glycogen may or may not be metabolized before lipids and proteins. If glycogen is metabolized, the muscle tissue pH rises due to the production of lactic acid. When the glycogen content of muscle tissue is affected, fillets can become soft in texture, thus affecting product quality.

The external color of many fish does not change with fasting, except during extended storage times. However, the muscle tissue does undergo some changes in color, usually in the red range. The sensory quality of fish fasted for less than two weeks may exhibit only minimal changes in sensory appeal.

Post-Mortem Changes

In research, two fish species were killed by three different procedures: stabbing in the spinal hub (instant killing), dipping in cold water (temperature shock) and leaving in the air to die (struggled killing). After death, the fish were stored at 0° C for up to 34 hours.

The progress of rigor mortis; changes in concentrations of adenosine triphosphate (ATP), inosine monophosphate (IMP) and creatine phosphate; and shifts in the breaking strength of the dorsal muscles were the slowest in the instant killing group. The rates of change in the temperature shock group were similar to those in the struggled group. The differences were most pronounced during the first nine to 14 hours. After 14 hours, the rates of degradation were somewhat similar.

The total blood volume of fish customarily ranges from 1.5 to 3.0% of body weight. However, in some species, the blood volume can be up to 5.7% of the body weight. Only 20.0% of the blood is localized in muscular tissue, and the rest is in internal organs.

Because the white muscle is rather poorly vascularized, it has been assumed that blood distribution is little affected by exercise. However, when rested fish are exposed to stressors and exhibit escape behavior, blood flow is gradually redistributed from the viscera to the locomotory muscles to meet the increased oxygen demand of the white muscles. Moreover, when fish are subjected to handling stress, the plasma-clotting time is reduced. A 43% decline in blood clotting times has been observed 10 to 60 minutes after a stress incident.

This finding suggests that perimortem stress can lead to poorer blood drainage. However, it has been reported that stress during stunning normally promotes peripheral vasoconstriction thorough the action of catecholamines, resulting in a minimum of blood in the muscular tissues.

In further research, the bleeding efficiency of anesthetized and exhausted Atlantic salmon was studied. In all cases, the amount of residual blood in the fillets was modest, and blood was not considered a quality problem in terms of fillet appearance. Perimortem stress did not affect the residual blood content of prerigor filets. The low levels of residual blood were partly attributed to filleting shortly after killing, which allowed washing before the blood had time to coagulate.

It is a well-established fact that a beating heart does not play a significant role for effective blood drainage. Muscle activity during bleeding in not important to facilitate adequate drainage of blood. Although there is some disagreement as to what is the best bleeding method, it is apparent that immediate bleeding after capture or stunning is more important than the actual bleeding method. The major factor is that the blood should be removed prior to the initiation of coagulation.

In another study, rainbow trout, *Oncorhynchus mykiss*, were stunned by electrocution, exposure to elevated concentrations of carbon dioxide or a blow to the head, and subsequently bled. The fish were stored uneviscerated in ice for up to 15 days, after which the changes in the textural properties of the fish flesh were measured objectively and subjectively. The differences in lactic acid concentrations, pH, water-holding capacity in muscle metabolites and fillet texture were not greatly different over time.

Effects Of Transportation

Stress and muscle activity during the transport, netting and anesthesia of fish can shorten the time of rigor mortis onset, which is essentially triggered by depletion of glycogen and ATP in muscle cells. Handling and processing of fish during rigor mortis can result in a loss of quality and lower fillet yield. The prerigor period must be long enough to ensure that bleeding, gutting, washing, chilling and packing all occur before the onset of rigor mortis.

It has been shown that transport of salmonids for up to 11 hours at densities of 69-170 kg/m^3 had only a minor effect on physiological responses. Changes in muscle metabolites and fillet texture after road transport of rainbow trout for 10.5 hours at 167 kg/m^3 had a limited effect on quality.

In a study, Atlantic salmon with a mean weight of 5.1 kg were transported live at 125.0 kg/m^3 for 1.5 hours by a well boat from the sea cage to a processing facility and then kept in the well boat for four hours prior to slaughter. Anaerobic white muscle activity due to handling stress during fish loading at the cage, after shipment immediately before slaughter and after the fish had passed the slaughter line were evaluated using several biochemical parameters.

No dramatic effects of handling stress were found, indicating transport and slaughtering did not have an adverse effect on flesh quality. The results were attributed to the ability of the well boat to maintain acceptable seawater quality during transport, rapid netting of the fish from the well boat to the slaughter line and an efficiently maintained carbon dioxide anesthesia tank that minimized struggling prior to killing.

Duties Dead As Shrimp Prices, Supplies Settle Some

Several producing countries have stepped up shrimp exports to cover the gap left by Thailand, but shortages remain. Spikes in market prices are affecting overseas contracts.

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Summary:
In July, shrimp imports to the United States continued to reflect a steep decline. India has become a key supplier to counter production hit by early mortality syndrome elsewhere. The market has responded with continued strength as the U.S competes globally for the tight supply. July imports of whole salmon remained lower than last year in a moderate market. Imports of fresh salmon fillets continued a strong 2013 with increases. U.S. imports of frozen whole tilapia, especially from Taiwan, continued their upward trend. The market for fresh fillets has held a strong undertone, with high replacement prices for frozen fillets. Despite non-seasonal behavior, the market for Chinese catfish has been relatively steady. U.S. imports of *Pangasius* remained high, although there was uncertainty about future availability from Vietnam.

Editor's Note: Due to the temporary "shutdown" of the U.S. government, the authors of this column present import data for July, rather than August.

In July, shrimp imports to the United States continued to reflect a steep declining trend. Month-over-month (MOM) imports for the same period a year ago were down over 13%, pushing year-to-date (YTD) imports over 8% lower (Table 1). Keep in mind that these decreases in imports are being compared to a year ago, when imports were also lower in volume compared to the previous year.

Imports from Thailand continued their dramatic decrease with July imports 58% lower MOM and YTD imports 36% lower. Ecuador's shrimp, which are now even with the volume of Thai imports on a YTD basis, were also 13% lower MOM and almost 12% lower YTD. Shrimp imports from Indonesia, India and Vietnam were all higher MOM. YTD Indian imports were up over 69%, as India has become a key supplier in the battle to counter shrimp production restricted by early mortality syndrome elsewhere.

Imports from China were down moderately in July. Mexican imports were down sharply and not expected to improve seasonally on a farmed shrimp basis. Wild shrimp production in Mexico has begun.

Headless, shell-on (HLSO) shrimp imports including easy-peel product were down sharply, although import volumes from Indonesia and India were both higher. Most imports by count sizes were also lower. Peeled shrimp imports were down almost 19% MOM but about even on a YTD basis. Cooked shrimp imports were slightly higher MOM, but down over 20% YTD.

Markets

The market has responded to the constricted supply of shrimp with continued strength as the United States competes globally for the tight supply. While U.S. shrimp imports were down almost 8%, the value of those imports was down less than 2%. However, importers have recently begun to resist further increases in overseas offerings, particularly as seasonal spot demand in the U.S. slows during September and October.

On September 20, the International Trade Commission voted 4-2 to throw out the shrimp countervailing duty case based on the fact that injury to the domestic industry was not proven. This meant the countervailing duty suit on shrimp is over.

As a result of the duty decision and a quiet seasonal demand, the Latin American HLSO market – led by Ecuador – has recently held a weak tone, and market quotations have drifted lower, particularly on smaller-count shrimp. However, replacement offerings have continued generally firm by most reports.

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

Form	July 2013 (1,000 lb)	June 2013 (1,000 lb)	Change (Month)	July 2012 (1,000 lb)	Change (Year)	YTD 2013 (1,000 lb)	YTD 2012 (1,000 lb)	Change (Year)
Shell-on	34,041	27,296	24.7%	43,109	-21.0%	221,354	252,890	-12.5%
Peeled	33,114	29,655	11.7%	40,806	-18.9%	237,996	238,625	-0.3%
Cooked	11,616	9,822	18.3%	11,289	2.9%	68,632	86,006	-20.2%
Breaded	7,505	6,103	23.0%	6,824	10.0%	43,738	47,435	-7.8%
Total	86,276	72,876	18.4%	102,028	-15.4%	571,720	624,956	-8.5%

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

Importers with inventory have limited buying interest given the quiet demand, so the market undertone is unsettled.

Asian white shrimp in all categories continue full steady to firm. Here the market has been concerned mostly with securing product amid the tight global supply. The root of this shortage has been the curtailed production in Thailand due to early mortality syndrome. The U.S. market was further jolted by the general failure of farmed Mexican production that should have been offered at about this time.

Indonesia, Vietnam and especially India have stepped up exports recently to help fill the gap left by Thailand, but shortages remain. In addition, due to the unprecedented nature of the sharp spike in market prices, there have been issues with overseas packers fulfilling contracts.

Although concerns remain high, it appears some market participants have generally come to terms, as contracts have been renegotiated despite delays in shipments expected in some cases. Recently, some importers have reported a steadier undertone as the rate of increase in overseas replacement pricing has moderated.

Although this is a slower time of year for farmed salmon sales, prices have remained high.

Salmon Trends Continue: Fillet Imports Climb, Whole Fish Dip

July YTD imports of salmon to the United States showed a 3.8% increase in volume when compared to imports from the same time last year (Table 2). Fresh whole fish imports continued to see YTD figures decrease 9.7%. Fresh fillets remained up 14.6% from 2012 YTD levels. Total month-to-month data were down 7.3% for July when compared to June. Year to year, total July salmon imports were 8.7% lower than in July 2012.

Whole Fish

July's YTD whole fish import figures were 9.7% below July 2012 YTD figures. However, a monthly comparison revealed an increase of 4.0% from June to July. July 2013, on the other hand, had 7.7% lower volume than that of July 2012. Canadian imports were 16.8% down YTD.

The Northeast market in early October was barely steady on small fish and full steady to firm on mid- to large-sized fish. This situation contrasted with the previous month, when supplies of 14-up in the Northeast were fully adequate. Reflecting a historical trend, October has seen quiet demand.

The West Coast market, on the other hand, was steady to full steady on all sizes in early October. Like the Northeast market, September was barely steady to weak, especially on larger fish. In October, the market was more moderate, and there was a firming undertone.

Despite the downward pricing trend in September, both the Northeast and West Coast markets were well above their three-year price averages for all sizes of fish. The European whole fish market was also very weak during September, but saw a more moderate market in October. Supplies were adequate for a fair demand.

Fillets

Imports of fresh salmon fillets continue 2013 with increases. YTD figures for July revealed an increase of 14.6%. Monthly overall fillet imports – a total for July of 16.6 million lb – were 13.2% below June's imports.

The U.S. imported 12.7 million lb from Chile during the month of July. Volumes from Chile were 18.3% higher YTD, and 106.1 million lb have been imported thus far for 2013. Overall fresh fillet imports are at the highest levels to date at 133.3 million lb.

The market during September and October was barely steady to weak on all sizes. Overall supplies were fully adequate to ample for a lackluster demand. With the market trending lower, the undertone was barely steady to weak. Historically, this is a slower time of year for farmed salmon sales. However, pricing for all sizes was above the three-year averages. The European fillet market trended lower during September, but adjusted higher in October.

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

Form	July 2013 (lb)	June 2013 (lb)	Change (Month)	July 2012 (lb)	Change (Year)	YTD 2013 (lb)	YTD 2012 (lb)	Change (Year)
Fresh whole fish	16,185,118	15,562,098	4.00%	17,541,525	-7.73%	120,192,383	133,088,192	-9.69%
Frozen whole fish	626,910	579,561	8.17%	553,923	13.18%	3,374,423	3,398,326	-0.70%
Fresh fillets	16,673,796	19,219,984	-13.25%	17,014,922	-2.00%	133,334,561	116,364,052	14.58%
Frozen fillets	6,313,095	7,588,297	-16.80%	8,466,690	-25.44%	47,151,812	40,027,081	17.80%
Total	39,798,919	42,949,940	-7.34%	43,577,060	-8.67%	304,053,179	292,877,651	3.82%

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

Frozen Tilapia Fillets Jump, Fresh Fillet Imports Flat

Rising replacement costs for frozen tilapia fillets from China have pushed up prices across the distribution chain.

After re-analyzing the data from the U.S. Department of Commerce for fresh tilapia fillets, we noticed the ongoing error previously mentioned has been revised. However, data from April 2012 still reflects a large discrepancy between the two import codes previously mentioned. Going into the fall, the market is relatively quiet, but prices are holding steady.

Frozen Fillets

In July, U.S. imports of frozen tilapia fillets jumped 18% from the previous month, but remained 4% shy of the import level for the same month a year ago. On a YTD basis, imports were 18% below the figures registered during the first seven months of the year, which in terms of volume translated into 38.4 million lb less imported.

This situation caused inventories in the U.S. to be barely adequate throughout 2013. In addition, rising replacement costs from China, led by a shortage of raw materials, have also pushed prices up all the way across the distribution chain.

In early October, the market held a strong undertone with offering price levels holding firm. Importers have reported high replacement costs – and hence higher than those seen throughout last year – through 2013.

The import price per pound reported by the USDOC has risen over U.S. $0.30 since the low point seen in October 2012. This is an increase of almost 19% in a matter of nine months. Furthermore, many continue to report strong replacement offerings as they try to book shipments for last-quarter arrival.

Frozen Whole Fish

As indicated in July data, U.S. imports of frozen whole tilapia continued the upward trend they have seen throughout the year (Table 3). Imports of whole fish from Taiwan have increased significantly when compared to last year, where YTD imports revealed a 49% surge. Overall, imports advanced 10% for the January to July period when compared to the same period last year.

Fresh Fillets

Imports of fresh tilapia fillets in July decreased only 2% when compared to the previous month. Despite YTD imports being slightly ahead of last year due to the decreased availability of product from Ecuador, the market has held a strong undertone. Watch imports from Colombia, Mexico and Costa Rica as they try to fill the supply gaps left by Ecuador.

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

Form	July 2013 (lb)	June 2013 (lb)	Change (Month)	July 2012 (lb)	Change (Year)	YTD 2013 (lb)	YTD 2012 (lb)	Change (Year)
Fresh fillets	4,653,083	4,748,665	-2.0%	4,319,246	7.7%	35,851,385	33,159,291	8.1%
Frozen whole fish	8,374,690	7,757,500	7.9%	5,816,574	4.4%	50,204,023	45,503,753	1.0%
Frozen fillets	30,631,328	25,866,089	18.4%	31,926,125	-4.0%	171,542,381	209,983,149	-18.3%
Total	43,659,101	38,372,254	13.8%	42,061,945	3.8%	257,597,789	288,646,193	-10.7%

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

U.S. *Pangasius* Imports High, Catfish Remain Steady

U.S. imports of *Pangasius* remain at record-high levels.

Channel Catfish

Imports of Chinese catfish to the United States declined steeply in July from the previous month, falling below the 1 million-lb monthly mark (Table 4). Given the non-seasonal behavior of monthly imports throughout 2013, monthly comparisons against previous years tend to be skewed. Despite such odd numbers, the market has remained relatively steady throughout the year.

Pangasius

Although U.S. imports of *Pangasius* in July declined from the previous month, the figures were the second-highest on record. This translated into a 5% increase on a YTD basis, reaching over 131 million lb imported in 2013. That 131 million-lb figure for frozen *Pangasius* fillets related to 76% of the total imports of frozen tilapia fillets in 2013 – a proportion that in 2012 was about 60%.

In early October, however, there was some uncertainty about future supply availability from Vietnam. Some importers have reported tight raw materials for processing for the next few months.

The market trended lower in September, as record-high imports in June and July caused supplies to prove ample. Since importers have reported raw materials shortages overseas, the prices offered to processors have firmed.

Whether that translates into higher prices in the U.S. remains to be seen. For the time being, the undertone in the U.S. for this market has been generally mixed.

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

Form	July 2013 (lb)	June 2013 (lb)	Change (Month)	July 2012 (lb)	Change (Year)	YTD 2013 (lb)	YTD 2012 (lb)	Change (Year)
Pangasius	24,711,324	25,164,561	-1.8%	20,758,869	19.0%	131,629,228	125,388,957	5.0%
Channel catfish	720,073	1,658,715	-56.6%	71,656	904.9%	8,706,285	4,831,476	80.2%
Total	25,431,397	26,823,276	-5.2%	20,830,525	22.1%	140,335,513	130,220,433	7.8%

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

Monosex Culture Of Prawns Through Temporal Androgenic Gene Silencing

Since *Macrobrachium rosenbergii* males (right) grow faster and reach higher weights than females of the species, all-male culture improves harvests.

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Summary:
A newly developed technology for producing all-male populations of freshwater prawns by temporal silencing of the androgenic gland insulin-like gene marks the first RNA interference-based biotechnology to be commercialized in the field of aquaculture. This no-hormone, no-chemical and non-GMO method suggests a sustainable solution that involves the culture of non-breeding populations to increase yields.

Editor's Note: The author received the ***Novus Global Aquaculture Innovation Award*** *during GOAL 2013. This article reflects his award-winning work with all-male populations of freshwater shrimp. The technology is licensed to Tiran Shipping Ltd.*

Commercial production of freshwater prawns has been the subject of research and commercial enterprise in many countries for several decades. This species is native to the tropical Indo-Pacific region of the world and is an economically important crop in China, India, Vietnam and many other Asian countries. It has high demand as a food item and an export product.

Its relatively limited wild catch has resulted in a gradual increase in traditional culture of the prawns. The global market for freshwater prawns was growing annually until 2009. China, India and Vietnam together annually produced more than 200,000 mt of prawns with a value of U.S. $2.4 billion. To sustain growth of this sector, genetic, husbandry and biotechnological improvements are needed, including attempts to use approaches such as monosex culture.

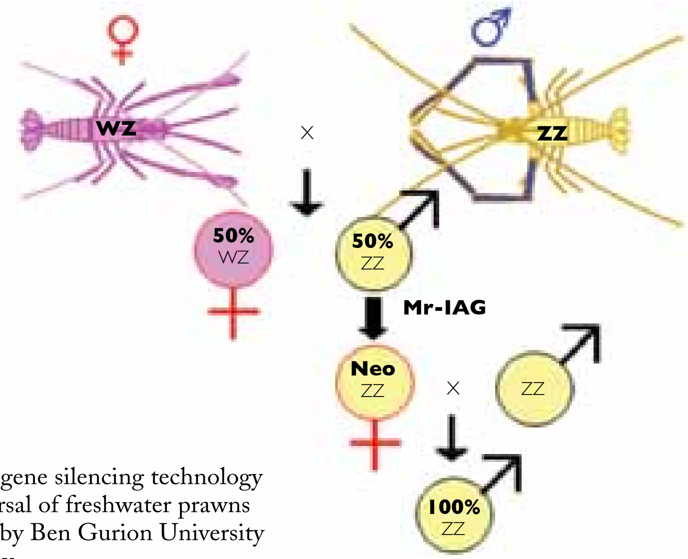
Monosex Culture

In many crustacean species, a sexual bimodal growth pattern is exhibited in which females grow larger than males of the species or vice versa. In two of the most economically important penaeid shrimps, *Litopenaeus vannamei* and *Penaeus monodon*, females grow larger than males. However, in cultured species such as the Australian red-claw crayfish, *Cherax quadricarinatus*, males grow faster and reach higher weights than females. This is also the case for the giant freshwater prawn, *Macrobrachium rosenbergii*, as males reach market size faster than the females.

Differences in growth rate, alimentary needs and behavioral patterns between males and females dictate the need to establish management procedures specifically adjusted to one sex or the other. Moreover, since a monosex culture population is inherently non-breeding, energy is focused on growth, and unwanted breeding is prevented – both in the pond and as an unwanted environmental impact. Reproduction can be carried out in such systems under separate, controlled conditions.

The monosex strategy has become a common practice in fish culture, and attempts have been made to apply it to crustacean culture. In a small-scale experiment conducted as early as 1986 in Israel, hand segregating *M. rosenbergii* monosex populations in hapa nets resulted in significantly higher yields when all-male populations were cultured.

More recently, an economic analysis of all-male culture in India showed an income increase of about 60% over mixed and all-female populations, taking into account expenses caused by labor-intensive hand segregation and related costs. Alternatively, all-female culture has been



The single-gene silencing technology for sex reversal of freshwater prawns is patented by Ben Gurion University of the Negev.

suggested as the choice for super-intensive culture of small *M. rosenbergii* prawns at high densities.

Microsurgical Sex Reversal

In *M. rosenbergii*, fully functional sex reversal can be achieved by microsurgical manipulation of the androgenic gland in early postlarval males. Although such manipulation dates back more than half a century, a biotechnological approach only recently devised for the generation of all-male populations involves the microsurgical removal of the androgenic gland from juvenile males. The microsurgery biotechnology for all-male monosex culture of prawns has been used in India, Thailand and Vietnam.

The author's research found that sex-reversed animals or "neo-females" are capable of mating with normal males to produce all-male offspring. Since *M. rosenbergii* males are the homogametic sex, bearing two homologous sex chromosomes (ZZ), sex-reversed males produce 100% male progeny.

Gene Silencing

Recently, a more advanced RNA interference (RNAi)-based biotechnology was developed in the author's laboratory at the National Institute of Biotechnology at Ben Gurion University (BGU) of the Negev in Israel. It is based on the recent finding of a patented new gene encoding an insulin-like androgenic gland hormone from *M. rosenbergii* termed Mr-IAG.

It was found that silencing this gene through RNAi at an early postlarval stage could cause complete sex reversal of a male into a functional neo-female. The technology includes the application of temporal RNAi in males of the BGU line of *M. rosenbergii* prawns. Through the use of specific molecular sex markers, the identified males are transformed through temporal RNAi into neo-females. The BGU neo-females are shipped, grown and bred with selected local lines of males at each locality to produce all-male populations.

Perspectives

The sex-reversal technology does not use hormones or chemicals, and it does not produce genetically modified prawns. The intervention is temporal, occurring during a short period at the early stages of the neo-females. The silencing agent is a naturally occurring sequence of RNA that degrades in a few days. It is not transmissible to future generations, and the manipulation is limited to the broodstock, with no manipulation necessary in growout populations.

This approach may be of tremendous application in the aquaculture industry. Moreover, it could also form part of a sustainable solution for the management of invasive and/or pest crustacean species, where the production of non-reproducing male or female populations is sought.

The silencing agent is not transmissible to future generations, and the manipulation is limited to the broodstock, with no manipulation necessary in growout populations.

Important Unit Processes In Recirculating Systems

Commercial drum-screen filters remove suspended solids from RAS production systems.

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Summary:
Recirculating aquaculture systems (RAS) are increasingly used to raise fingerlings for stocking large fish in mor bwd98avPS-g e traditional production systems. A number of unit processes are critical to the design of successful RAS systems. Right-sized, cost-effective water treatment components are key. The most popular method for removing suspended solids involves mechanical filtration. Foam fractionation, or protein skimming, is used to remove fine solids in RAS.

Recirculating aquaculture systems (RAS) offer an alternative production technology to flow-through tank-based aquaculture and pond-based aquaculture technology for the nursery culture and growout of farmed finfish. Through water treatment and reuse, these systems use a fraction of the water required by ponds or flow-through tanks to produce similar yields. Because recirculating systems usually use tanks for aquaculture production, significantly less land is required. While these systems are not going to completely replace other land based technologies, they are finding their way into the production of advanced fingerlings for stocking large fish in more traditional production systems.

This article is based upon United States Department of Agriculture fact sheets created for the aquaculture industry by the author, M. Masser and J. Rackocy in 1998. It contains important information that should be understood by individuals before moving into today's recirculating aquaculture industry.

Recirculating Technology

RAS technology involves a process by which the environment in an aquaculture culture tank is controlled through water treatment and recirculation. The technology has been developing for more than four decades. Although RAS systems can be costly, claims of impressive yields and the opportunity for year-round production in locations close to major markets using little water attract interest.

In recent years, the salmon industry worldwide has adopted RAS to produce larger smolts to stock into production net pens. We are seeing similar interest from managers of pond-based farms. While there have been some large-scale failures in this business sector, numerous small- to medium-scale efforts continue with success.

Critical Processes

Aquaculture production depends upon the delivery of high-quality diets to the fish within a culture tank while maintaining high water quality. The two do not necessarily go hand in hand. Higher feed rates lead to more waste production and the potential for uneaten feed or fecal material to degrade in the culture tank. Critical water quality parameters include the concentrations of dissolved oxygen, un-ionized ammonia nitrogen, nitrite-nitrogen and carbon dioxide, as well as pH and alkalinity values.

As feeds are introduced to the tanks, they are either consumed by the fish or left to decompose within the system. The by-products of fish metabolism include carbon dioxide, ammonia-nitrogen and fecal solids. If uneaten feeds and metabolic by-products are left within tanks or water filtration systems, they degrade and generate additional carbon dioxide and ammonia-nitrogen, while reducing the oxygen content of the water.

The carrying capacity of RAS production systems must be carefully designed to provide for the cost-effective production of fish. A number of treatment processes, or "unit processes," are critical to the design of successful production systems. These unit processes must be implemented in the right order, and the success of RAS systems also depends upon the correct sizing of the components involved.

If a component is too small, a barrier is created that can limit the productivity of the production system, often resulting in the inability to meet financial goals. Similarly, a component for a water treatment process can be oversized to the point where the capacity of the component is never reached. As such, the RAS technology is paid for but not used.

Unit Processes

As noted above, key to building and operating a successful recirculating aquaculture production system is the use of right-sized, cost-effective water treatment components. All recirculating production system technology must remove waste solids, oxidize ammonia and nitrite-nitrogen to nitrate-nitrogen, remove carbon dioxide and add dissolved oxygen to the water by aeration or the use of oxygen gas before returning it to the culture tank. More-intensive systems or systems culturing sensitive species or delicate larval and nursery life stages may require additional treatment processes, such as fine-solids removal, dissolved organics removal and/or some form of disinfection.

Solid Waste

One of the most important unit processes in RAS production technology is waste solids removal. Pelleted diets used in aquaculture production consist of protein, carbohydrates, fat, vitamin and mineral packs, and water. The portion of feeds not assimilated by fish is excreted as organic

It is imperative that waste solids are removed from the system as quickly as possible.

Propeller-washed bead filter.

wastes, fecal solids and urea. When fecal solids and uneaten feed are degraded by bacteria within the system, dissolved oxygen is consumed, and ammonia-nitrogen is generated. As such, it is imperative that waste solids are removed from the system as quickly as possible.

Waste solids can be classified into three categories: settleable, suspended and dissolved. In RAS, the first two categories are of primary concern. Dissolved solids can become problematic in systems with low water exchange. Settleable solids should be removed from tanks or filtration components quickly. They can be removed as they are deposited on tank bottoms through the proper design and placement of tank drains.

Solids Removal

The most popular style of tank drain today is the "double drain." In this configuration, only about 10 to 15% of the flow leaving the tank is removed at the bottom center. Solids are then typically removed from flow with a swirl separator or radial flow separator. The remaining water is removed from higher in the water column, which generally captures the suspended solids in the tank.

From an engineering point of view, the differences between suspended solids and settleable solids are practical. Under fish culture conditions, suspended solids do not settle to tank bottoms and therefore cannot be removed as quickly in the bottom drain. As a result, suspended solids are not always dealt with adequately and can significantly degrade water quality and limit system production.

The most popular method for removing suspended solids involves mechanical filtration. The most common approaches are drum-screen filtration and granular media filtration, usually with pelleted plastic media.

With both of these technologies, it is important to remove the solids from the water flow as quickly as possible. With the bead filter technology, that means backwashing frequently to eliminate the waste from the filter. Drum screens, on the other hand, move into a backwash cycle frequently, usually every few minutes, but generally waste more water than bead filters.

Fine Solids

Fine suspended solids with diameters below 30 µ contribute more than 50% of the total suspended solids that build up in RAS. Fine and dissolved solids are not effectively removed by sedimentation or

In this foam fractionation unit, one pump moves water through the unit for the treatment process, while the second pump drives a venturi that injects air into the base to create bubbles that rise and create foam at the top.

mechanical filtration technology. Foam fractionation, also called protein skimming, is used to remove these solids in RAS.

In foam fractionation, air bubbles are introduced at the bottom of a column of water, and foam is created at the top air-water interface. As the bubbles rise through the water column, solid particles attach to the bubbles' surfaces, forming the "dirty" foam at the top of the column. The foam bubbles collapse and flow out of the foam fractionator to a waste drain for disposal or treatment. Solids concentration in the waste flow can be five times greater than that of the culture tank.

Although the efficiency of foam fractionation is subject to the chemical properties of the water, the process generally is more effective in saltwater systems or those with high pH. Most modern foam fractionators utilize venturi devices to inject fine air bubbles at the base of the components.

Acoustic Control Improves Feeding Productivity At Shrimp Farms

The sound feeding system enables sensor-based control of multiple feeders within ponds.

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Summary:
In systems recently developed for shrimp farms, passive acoustic-based technology enables sensor-based control of multiple automatic feeders. Hydrophones installed in the water beneath the autofeeders detect shrimp eating sounds and send data to a computer, where software interprets the sounds to define feed consumption rates. The systems also monitor key environmental parameters and deliver alarms, as well. Improved growth and feed conversion have been recorded at commercial farms using the technology.

In intensive farming systems for chickens, pigs, lot-fed cattle and sea cage salmon, feeding control systems reflect fundamental production technology. These systems use micro tag readers, infrared sensors, cameras and other sensing methods to automatically deliver an optimum ration to the animals every day.

Shrimp farming, however, faces a variety of unique challenges to implementing such feeding controls. Shrimp are small animals that weigh less than 50g. They are grown in large numbers up to several million in ponds with areas up to 20 ha that have turbid waters that limit visual inspection. Counting and therefore biomass estimation can be very difficult.

Feeding Trays

After the pioneer years, when feeding strategies were based on individual feed intake measurements in laboratory experiments, the use of feeding trays represented a significant advance in improving feed conversion in small, as well as large ponds. Nevertheless, the implementation and daily use of feed trays bring an increased need for skilled labor and subjective feed tray analysis, which is a measurement of feed intake with an inherent lag that can lead to waste.

Automatic feeders without sensor-based control technology have become popular in Thailand and Malaysia. The feeders do contribute to lower labor costs and, for some diligent operators, lower feed-conversion ratios (FCRs), but they are still fully dependent on human decisions based on feeding tray readings and weekly growth sampling.

In the last five years, a passive acoustic feeding-control technology has been developed by AQ1 Systems. The sound feeding system enables sensor-based control through technology that has been commercially validated at shrimp farms with different species in different countries.

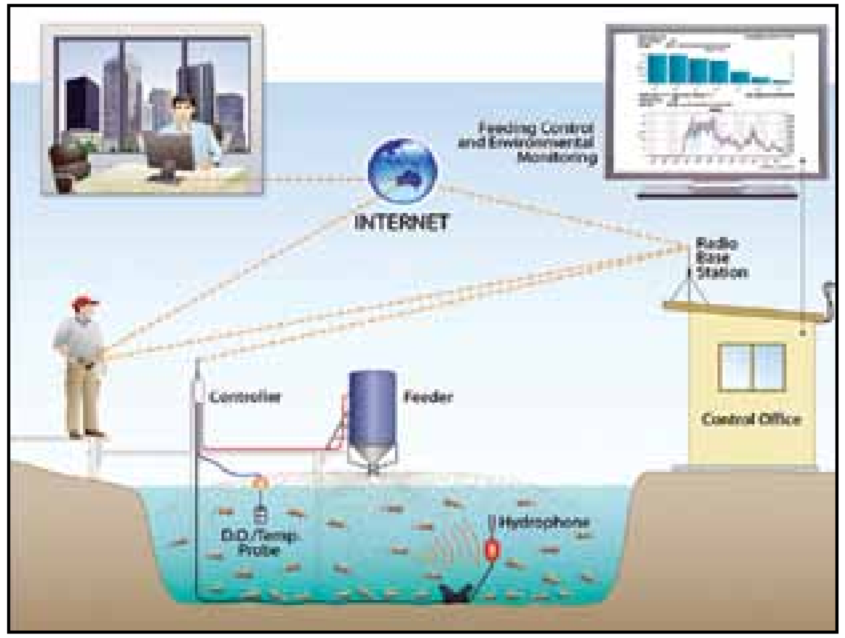
Sound-Based Technology

At the core of the system is a hydrophone, an underwater microphone that analyzes the many sounds that occur in the pond. These sounds are filtered by software that is capable of differentiating and recognizing specific noises made by the shrimp when they eat. A strong relationship between shrimp-feeding sounds and feed intake has been confirmed with feed trays, acoustic cameras and underwater cameras.

Once the shrimp-feeding intensity is known, the control algorithms in the feeding control decide when and how much feed is required and ensures it is all eaten. The latest sonic algorithms are self-learning, so the systems can be used for a variety of farm types and species.

In ponds, hydrophones are installed below the water surface in the distribution areas covered by the autofeeders, and the system controls feeding. The systems also monitor key environmental parameters and deliver alarms, as well.

System configuration is based on the number and size of the shrimp and the species grown. One hydrophone can monitor multiple autofeeders, and one control unit can monitor two hydrophones for two ponds. All data is communicated wirelessly to a computer in the farm office. The shrimp feeding activity and consumption rates are recorded, and the control software e-mails a daily feeding summary to the person in charge of the ponds. Additional information can be accessed remotely over the Internet.



Hydrophone and water condition data are sent wirelessly to a computer in the farm office that e-mails a daily report to farm management. Additional information can be accessed remotely over the Internet.

Feeding Studies

So far, detailed feeding studies have been carried out with *Penaeus monodon, Litopenaeus vannamei* and *L. stylirostris* shrimp weighing from 1 to 43 g. Additional studies with *Marsupenaeus japonicus* and *Fenneropenaeus indicus* are in progress.

In terms of pond size and stocking densities, positive tests have been run in 0.3- to 7.5-ha ponds. Stocking densities have varied 10-350 postlarvae/m^2 so far.

Shrimp Feeding Behavior

The usual feed rate reduction observed during the general molting cycle of the shrimp population is shown in Figure 1. A sudden drop of salinity in the ponds induced by heavy rains was also linked to a strong reduction of feed intake by shrimp in the following 12 to 36 hours.

Over a six-month cycle with *P. monodon*, the preferred time for feeding changed. Shrimp ate mostly at night in the warm season, but fed more during the afternoon as water temperatures fell. Not surprisingly *L. vannamei* were also seen to display preferential feeding patterns that related to such parameters as water temperatures and monsoonal activity in Asia.

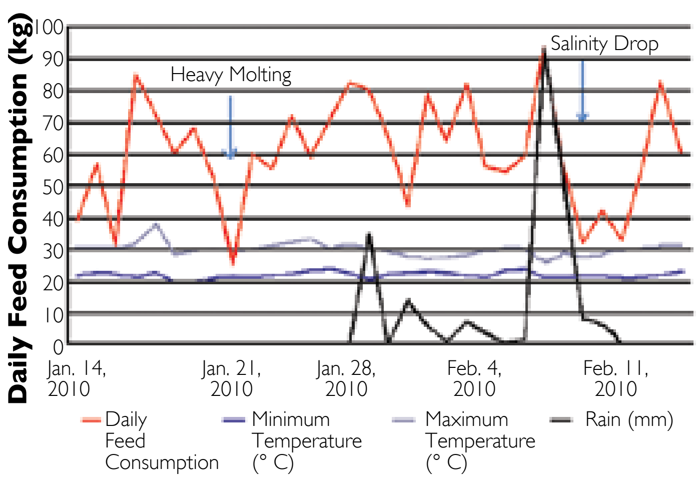


Figure 1. Daily shrimp feed consumption with related environmental parameters.

Table 1. Average productivity gains in commercial trials.

Species	Growth	Feed-Conversion Ratio	Feeding Method
L. vannamei	12.1%	12.3%	Auto feeder and hand feeding 4 times daily
P. monodon	15.2%	13.0%	Truck feeder 4 times daily
*L. stylirostris**	30.6%	-0.2%	Tray feeding 2 times daily

*FCR affected by large mid-crop mortality.

At a spatial level, research has shown strong relationships among where shrimp eat in the pond and the prevailing winds, pond depths and oxygen levels. Data also indicated shrimp dispersed quickly away from the automatic feeding zones in large ponds after feeding based on the lack of detritus build-up under the feeders and cast net samples taken around the pond during and after feeding.

In the end, many factors influence when, where and how much shrimp eat. Even the most skilled farmer using feed trays and auto feeders cannot hope to deliver the optimal ration instantly all day without a closed-loop control system managing feeding.

Results At Private Farms

Trials have been undertaken on well-managed private farms in Australia with *P. monodon* from 2010, in Thailand with *L. vannamei* from 2011 and in New Caledonia with *L. stylirostris* from 2012. The trial objectives were to determine the natural feeding patterns of these species over 18- to 24-hour cycles, investigate the impacts of changes in environmental conditions on feed intake and assess the economic benefits from better growth, total harvested biomass and FCR reduction.

Productivity gains reflecting growth increases and FCR reductions averaged 25 to 30% across all species. A summary of the commercial trial results is shown in Table 1.

Another significant benefit for automatic feeding control is improved pond bottom quality, especially in large ponds. Feed is no longer spread all over the bottom all cycle long. Instead, it is available only below the autofeeders and is consumed immediately when distributed, so that no excessive accumulation of feed is observed.

Perspectives

At today's shrimp prices, the value of faster growth is very high. The return on Investment for acoustic feeding control has been 3.5 times/2 crops in Thailand with white shrimp and 2 times/crop in Australia with black tigers. The labor savings and FCR gains reduce farm gate costs by more than 10%, which will be especially important when prices return to historical levels.

Salinity Tolerance Of Gulf Corvina, Prospective Aquaculture Species

Juvenile Gulf corvina. The species is being evaluated as a prospective species for aquaculture in northwest Mexico.

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Summary:
After six weeks of experimental culture, comparable growth and survival were recorded in juvenile Gulf corvina raised at salinities of 5, 15, 25 or 35 ppt. Coupled with stable plasma osmolality values observed in fish at the varied salinities, these results confirmed the euryhaline nature of this species, a trait that could enhance its status as a candidate for aquaculture. This study represented the first data gathered on the salinity tolerance of Gulf corvina.

The Gulf corvina, *Cynoscion othonopterus*, is a fish species of commercial importance that supports a fishery of over 3,000 mt annual production in the Gulf of California off Mexico. Because of the high quality of the fresh fillets and high consumer acceptance in a well-established local market, the Gulf corvina is currently being evaluated as a prospective species for aquaculture in northwest Mexico, where growout trials in sea cages and ponds are being conducted.

Euryhaline Species

The Gulf corvina is a relative of the red drum, *Sciaenops ocellatus*, for it belongs to the same family, Sciaenidae. Many members of this family of fish are recognized for being "euryhaline" or capable of tolerating wide ranges of environmental salinity. In this respect, the Gulf corvina is well known for performing a seasonal reproductive migration to the Colorado River Delta in the northern portion of the Gulf of California, where the freshwater Colorado River flows into the gulf and decreases environmental salinity to provide adequate spawning and nursing grounds for this species.

This physiological characteristic can be advantageous for the diversification of production sites at which the fish can be cultured. To evaluate the salinity tolerance of Gulf corvina, the authors exposed juvenile fish to varying levels of environmental salinity.

Experimental Study

A six-week study was conducted at the University of Sonora's Wet Laboratory of Aquaculture Nutrition of the Kino Bay Experiment Station at Kino Bay, Sonora, Mexico. Gulf corvina juveniles with individual mean initial weights of 17.2 g were stocked into circular 250-L tanks at a rate of 6 fish/tank. Salinity treatments of 5, 15, 25 and 35 ppt, each run in triplicate, were tested in a completely randomized design experiment.

Fifty percent of the water volume in each tank was replaced daily with new clean, filtered water of the corresponding salinity. The overall levels of dissolved oxygen, temperature and pH were maintained at 6.8 mg/L, 26.2° C and 7.6, respectively – all adequate for fish culture. All fish were fed a commercial feed with crude protein and lipid contents of 46 and 14%, respectively.

At the end of the trial, fish were group weighed and counted to estimate growth and survival rates. In addition. blood was drawn from the caudal veins of all fish and centrifuged to separate plasma from cells. Plasma osmolality, an estimation of the concentration of substances in the plasma, was measured with an osmometer. In addition, the osmolality of the culture water was measured.

Plasma osmolality has been shown to be a physiological indicator of osmotic stress in fish. For example, it can be altered rapidly and acutely in fish not able to adapt to changes in salinity, while it tends to remain relatively stable in fish that cope well with variations in salinity.

Testing at the University of Sonora measured plasma osmolality, a physiological indicator of stress in fish.

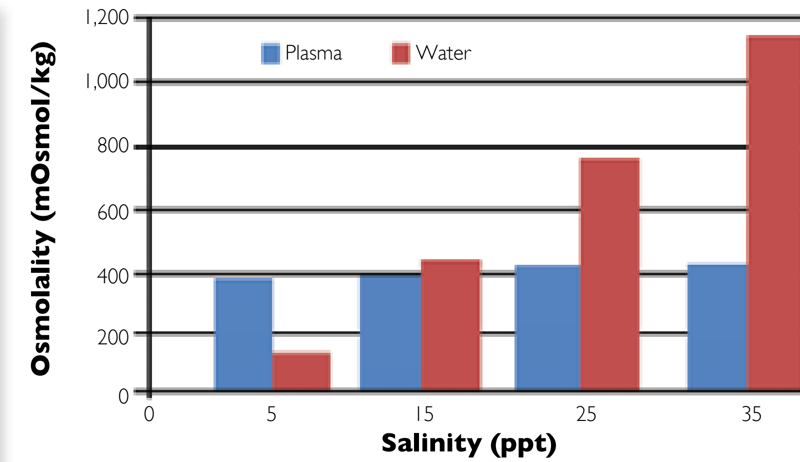

Figure 1. Osmolality values of culture water and blood plasma of Gulf corvina exposed to different salinities.

Results

High survival rates of 83, 89, and 87 and 100% were observed in fish held at salinities of 5, 15, 25 and 35 ppt, respectively, without statistical differences among them. The weight gains of the fish, which ranged from 46.4 to 73.3%, also reflected no statistical difference among treatments.

The fact that comparable growth and survival of fish were recorded at all salinities was indicative of adaptation to the varied conditions. This was further supported by the physiological response of the fishes' plasma osmolality, which, in spite of the increasing osmolality of the culture water at higher salinities, remained nearly constant, as shown in Figure 1. This pattern of stable plasma osmolality and unaltered growth and survival in response to salinity stress is typical of euryhaline fish such as salmonids and some flatfish.

The results of this study, to the authors' knowledge the first set of data gathered experimentally on the salinity tolerance of Gulf corvina, confirmed the euryhaline nature of the species. As related to aquaculture, euryhalinity offers the advantage of culturing fish at production sites where brackish or low-salinity water is available, either by the sea or even at facilities far away from coastlines.

However, before this becomes a reality, further aspects of the salinity tolerance of this species must be evaluated, such as long-term exposure to varying salinities, preferably with growout trials until fish of marketable are obtained, using floating cages or other infrastructure for commercial culture.

Kudzu Component: Stress Reliever For Fish?

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The fast-growing and invasive kudzu plant may provide a feed ingredient that improves stress factors in fish.

Summary:
A study was performed to determine the effects of puerarin, a biologically active ingredient in the roots of kudzu, on stress modulation in farmed salmon. Results from the study revealed that fish fed puerarin-supplemented fish feed had lower levels of blood glucose and better blood circulation than fish fed commercial feed – both indicators of reduced stress.

In the realm of aquaculture, the loss of productivity through infections and subsequent reductions in growth and development are major problems that require innovative methods for generating solutions. There are no commercially available vaccines against many aquatic pathogens, and further exacerbating the problem, the use of antibiotics for treatment of fish is not preferred due to the risk of developing antibiotic resistance within the bacteria and harming non-target species.

Further complicating the situation is the fact that in aquaculture, fish are raised in tanks with thousands of other fish under crowded conditions, which can negatively affect feeding behavior and other normal physiological functions such as growth, immune response and reproductive prowess.

Studying Effects

A study was developed to determine the effects of supplementing commercial fish feed with puerarin, the most biologically active isoflavone present in the roots of kudzu, *Pueraria lobata*, on modulating acute stress within salmonids. Salmonids are known for their upstream migration patterns, which have been reported to induce stress within the fish.

While kudzu powder has been used in Asian countries as a natural treatment for cardiovascular diseases, recent research has shown puerarin to reduce skeletal tissue blood glucose levels in diabetic mice over a period of one day. Moreover, puerarin helped restore GLUT-4 (the primary glucose transporter in skeletal tissue) mRNA expression levels in the diabetic mice to levels similar to those in non-diabetic mice within three days.

Since rainbow trout, *Oncorhynchus mykiss*, possess GLUT-4 transporter proteins, the authors chose Chinook salmon, *O. tshawytscha*, which belong to the same genus as rainbow trout and are a farmed species of Pacific salmon, for the study. In addition, Chinook salmon have been shown to elicit very high post-stress plasma cortisol levels, often reaching 400 ng/ml during upstream migration in the wild.

Performing stress response studies under laboratory conditions is difficult, since the fish are typically acquired from hatcheries where fish are reared with thousands of other fish. Therefore, it is harder to induce stress through crowding, as the fish are accustomed to being in close proximity to each other since birth.

Due to their capacity to be stressed, fingerling Chinook salmon provided a good model organism to determine the effects of puerarin on acute stress. Stress was induced through chasing and netting the fish, as those are conditions fish encounter in aquaculture facilities.

Stress Response

Within the aquaculture industry, the protocols for handling fish are well-documented acute stressors that lead to stress levels which are tolerated despite causing undesirable effects. In fish, stress response is marked by the stimulation of the hypothalamus-pituitary-interrenal axis, which leads to a shift in levels of plasma cortisol and the sympathetic-catecholamine cell axis that elevates catecholamine levels. Cortisol is an immunosuppressive agent, and increased occurrences of disease have been observed in stressed fish.

In addition to a suppressed immune response through cortisol, acute stress has been characterized by hyperglycemia, which has been associated with complications such as strokes in both animal and human models, along with increased susceptibility to infections in fish. Teleost fish have been well-documented for their reduced capacities to clear plasma glucose levels, and hence are more prone to suffer from stress-induced hyperglycemia.

A student processes fish macrophage cells to measure immune response.

Experimental Setup

The fingerlings were acquired from the Bodine State Fish Hatchery in Mishawaka, Indiana, USA, transported to the Life Science Resource Center at Purdue University – Fort Wayne campus and allowed to acclimate for two months prior to the start of the study.

The study focused on determining the consequences of puerarin supplementation on acute stress and chronic stress. Acute stress was induced by transferring all the fish randomly from their housing tanks into replicate tanks in which fish were fed a control feed and unstressed, tanks where the fish received puerarin-supplemented feed and were not stressed, tanks whose fish were fed a control diet and stressed, and tanks that received feed with puerarin and stressed the fish.

Five hours post-transfer, the fish were fed their respective feeds to satiation. Subsequently, the stress groups were chased with nets for five minutes. The fish were sampled prior to the initial transfer and then once more 24 hours following the transfer. The experimental conditions were maintained for eight more weeks to mimic chronic stress. The fish were sampled at two-, five- and eight-week intervals for plasma cortisol, blood glucose, hematocrit, plasma protein, spleen somatic indices, respiratory burst and condition factor.

Results

Results from the acute stress phase of the study revealed that the supplementation of puerarin lowered blood glucose levels while improving blood circulation, as the fish had lower levels of glucose, hematocrit and protein when fed feed with puerarin. Analyses for the chronic portion of the study revealed that puerarin helped improve blood circulation due to relatively lower levels of hematocrit and plasma proteins within the stressed groups than the fish given the control diet.

The results from this study were concurrent with prior studies with puerarin on mice. Puerarin in fast-acting and rapidly metabolized by the body, and its anti-hyperglycemic properties were best observed during the acute stress phase of the study. These results agreed with previous research, as puerarin's anti-hyperglycemic properties were most effective after 24 hours.

Perspectives

The results of this study – one of the first of its kind – illustrated the potential of puerarin supplementation in commercial fish feed. Further studies could test the effects of puerarin on salmonids for a period longer than eight weeks and at different concentrations. In addition, subsequent studies could focus on the financial viability of using kudzu roots to generate puerarin for feed supplementation.

Monterey Bay Seafood Watch Upgrades Farmed Salmon

Verlasso salmon made the grade as a "Good Alternative."

In a softening of its position on salmon aquaculture, the Monterey Bay Aquarium's Seafood Watch program recently ranked salmon from a Chilean farm as a "Good Alternative" for seafood consumers.

"There are many environmental problems related to farming Atlantic salmon," the Monterey Bay website says, "which means most are ranked 'Avoid.' However, efforts to reduce some of these environmental impacts have been successful."

By participating in the new Seafood Watch External Assessment Model, which requires rigorous third-party assessment, Verlasso salmon became the first ocean-raised farmed Atlantic salmon to receive the "Good Alternative" status. The Seafood Watch assessment of Verlasso's hatcheries, farms, processing plants and management took 16 months.

Some of the practices that helped lead to the buy ranking included an industry-leading fish in:fish out ratio, stocking at densities lower than at traditional salmon farms, long fallowing cycles and traceability through gill tag quick-response codes.

Verlasso is a brand of AquaChile, which has formed a collaboration with DuPont that blends the collective expertise of the companies to identify how to raise fish sustainably.

For more information on Seafood Watch, visit www.montereybayaquarium.com/seafoodwatch. For more on Verlasso, visit www.verlasso.com.

America's Tilapia Alliance Formed

A group of U.S. and foreign tilapia enthusiasts has formed America's Tilapia Alliance to help enable the various stakeholders within the tilapia value chain to become members and add value to the industry. A previous entity called the American Tilapia Association is in the process of dissolution.

The concept is for the ATA membership to share their experience, contacts and financial support to protect and promote an improved image of tilapia. The organization will focus on those aspects of the industry that impact all of its stakeholders, from farmers and feed suppliers to distributors and foodservice companies.

The benefits of participation in the ATA include networking and receiving information about production, certification, markets, regulations and other matters related to the industry. Information access will be determined by the level of membership fees. The ATA expects to coordinate its interests with those of other related organizations.

The ATA will rely heavily on Web-based communication. The alliance expects to develop websites, newsletters and chat forums among the various groups that contribute to the tilapia industry. For additional information, visit the group's website: www.americastilapiaalliance.org.

People, Products, Programs

Please send short news items and photos for consideration to:

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Regal Springs Expansion To Boost Tilapia Production In Mexico

Manuel Velasco Coello, governor for the state of Chiapas, Mexico, recently announced that Regal Springs Tilapia will invest U.S. $40 million in a five-year expansion plan to raise Mexico's overall tilapia production by as much as 60%.

The Malpaso Aquatic Park expansion goal is to increase Regal's fresh tilapia fillet production by 70,000 mt annually. About 50,000 mt will be exported to the U.S., 10,000 mt will be exported to the E.U., and the remaining 10,000 mt will be used domestically in Mexico.

Currently, Regal Springs operates 200 floating cages in Penitas. The company produces about four million fry a month and expects to boost production to 20,000 mt by the end of 2013.

"It is a pleasure for me to present this project," said Leopoldo Montoya Martinez, general manager of Regal Springs Tilapia Group. "Actually this is the beginning – our plans are to generate a top-level company. This will take the state to a very prominent position as a tilapia producer."

AwF Signs Agreement For New Aquaculture Center

The agreement will support food security and personnel training in Mexico.

Aquaculture without Frontiers (AwF) has signed a cooperative agreement with the Universidad Tecnológica del Mar de Tamaulipas Bicentenario (UTMarT) based at La Pesca, Soto la Marina, Tamaulipas, Mexico, to jointly develop food security and personnel training in the International Center for Innovation and Technology Transfer for Aquaculture.

UTMarT currently offers technical, bachelor and graduate programs in aquaculture and is building the new center in Tampico. Its programs will include visiting professors, joint research, participation in international training and other input from AwF specialists around the world.

"AwF is very keen to be involved in capacity building, engaging in projects and working with students," AwF Executive Director Roy Palmer said. "We hope to make a difference in the growth of aquaculture to assist the alleviation of both poverty and hunger, and we see this new partnership as a major step in this direction."

"This agreement will bring many benefits to UTMarT and its students in the long term," Chancellor Dr. Guadalupe Acosta Villarreal, said. "This agreement fulfills the university's goals of social awareness and extension, which are part of its mission."

The discovery is leading to practices that offset acidification effects at hatcheries. Photo by Lynn Ketchum, Oregon State University.

Ocean Acidification Inhibits Oyster Shell Formation

For the past several years, the U.S. Pacific Northwest oyster industry has struggled with losses due to ocean acidification that causes high larval mortality. A new study led by researchers at Oregon State University has found why the oysters appear so sensitive to increasing acidity.

It isn't necessarily a case of acidic water dissolving their shells, researchers say. Rather it is a case of water high in carbon dioxide altering shell formation rates, energy usage and, ultimately, the growth and survival of the young oysters.

The larvae must form shells solely based on the energy they derive from their eggs because they have not yet developed feeding organs. Increasing carbon dioxide in acidified water, however, increases the amount of energy needed to build shell.

The discovery may actually be good news, scientists say, because interventions at hatcheries may offset some of the effects of ocean acidification. Some hatcheries have begun "buffering" water for larvae. Selective breeding for tolerance of acidic water may be another strategy to improve survival.

For more information, contact study author George Waldbusser, +1-541-737-8964 or waldbuss@coas.oregonstate.edu.

High Liner Buys American Pride

High Liner Foods Inc. has acquired the principal assets and operations of American Pride Seafoods LLC from American Seafoods Group LLC. High Liner will operate American Pride – a value-added frozen seafood and scallop-processing business based in New Bedford, Massachusetts, USA – without substantial changes through 2014.

"Our vision is to be the leading frozen seafood supplier in North America," said Henry Demone, High Liner CEO. "Profitable growth through acquisitions like American Pride that complement our business should strengthen our leadership position within the seafood industry."

American Pride's branded and private-label products are primarily distributed to foodservice customers in the restaurant, healthcare and education markets, as well as some export and U.S. retail markets. For more information, visit www.highlinerfoods.com.

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INNOVATION DISTINGUISHES BETWEEN A LEADER AND A FOLLOWER.
—Steve Jobs
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How do you stay ahead in a sea of change?
Newly farmed aquatic species, changing raw material availabilities, and even controversial ecological issues have created serious needs for advancements in aquafeed processing. As a long-time leader in extrusion, Wenger is addressing these and other challenges with ground-breaking approaches. Consider these recent Wenger innovations: Oblique Tube Die and Diverging Cone Screw result in small diameter feeds at rates three to five times those of previous technology; Thermal Twin Screw Extruder permits high percentages of fish slurry, oil and high moisture ingredients; HIP preconditioner, with adjustable mixing intensity, addresses recipe challenges - especially those with varying content of starch, fiber and oils. And the list goes on.
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