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October - November 2019 Volume 45 Number 5

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COLUMNS

Editor's Comments

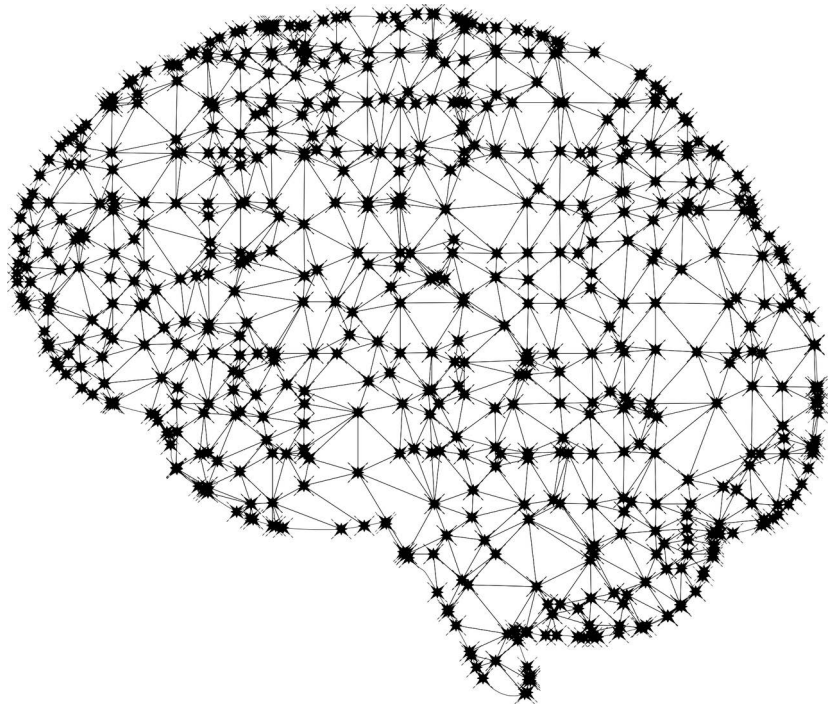
Aquaculture Intelligence... the New A.I.

*By C. Greg Lutz**
Louisiana State University Agricultural Center

I often find myself bouncing around the internet when I'm supposed to be 'working.' But, in a way, I really am working because I stumble on many aspects of modern life that relate to aquaculture in one way or another.

The pace of technological innovation seems to accelerate almost daily, and 'technology' (one of those catch-all terms, kind of like 'scientists') is advancing in too many areas to keep track of. Many times, these advances seem far removed from day-to-day life on a fish farm. To date, technology hasn't really impacted things like harvesting, loading out hauling trucks or workboats, or collecting, recording and disposing of mortalities. Nor has it eliminated the need to check the oil and radiator fluid in tractors or generators. Nonetheless, technology is increasingly offering us new ways to approach aquaculture production.

In the late 1980's, my friend Walter Landry told me that we would never be able to raise fish profitably with automation, because 'someone needs to be with them and observe them day in and day out.' Walter served as President of the Striped Bass Growers Association and the Louisiana Aquaculture Association, and also served on the Board of the National Aquaculture Association, so as a young Extension Specialist I took his opinion more or less as gospel.



Three decades back, when someone brought up the topic of Artificial Intelligence (AI) in aquaculture, more often than not they were referring to simple monitoring and control apparatuses, like an oxygen sensor that sent a signal to a computer, that in turn would open an oxygen bottle solenoid valve or turn on an aerator if DO values dropped below some pre-set level of concern. This type of 'innovation' fit in well with the traditional production process and reduced the potential for human error (um… err… or, at times, simply substituted that risk with the potential for technological/mechanical error).

Systems were soon developed that deployed any number of sensors that could be connected (by wires and state-of-the-art interfaces) to a computer, allowing a manager to monitor water quality and equipment performance from multiple systems in real time. With their bundles of wires reminiscent of sticky spaghetti, these packages were impressive to look at and fun to show off to visitors (especially when purchased with someone else's money), but they were still just data… just numbers and on/off signals.

The emergence of the internet allowed personnel to view real-time facility data from far away locations, but this was not much of an improvement (especially if you had to get up at 3 am and drive for an hour to try to respond to an emergency equipment failure). Tedious data entry, manipulation and interpretation was still required to turn the numbers generated by these monitoring systems into management tools for evaluation, troubleshooting and planning purposes.

But all the while, AI was evolving as it were. If you could pull together and package the mountains of data related to feeding rates, mortality patterns, water quality, growth rates, and equipment performance, programs that could gobble up the numbers and spit out enlightened conclusions were beginning to be available. This level of interpretation was perhaps not yet a practical tool, but all that would soon change… with the dawn of the Internet of Things (cue dramatic music…).

Yes, IoT. The Internet of Things. I still don't really grasp it but I guess my understanding of IoT involves someone asking Alexa to turn on the coffee maker…I guess. I ignored the whole concept (as much by ignorance as by choice) for as long as I could, but in addition to changing so many aspects of our modern life – IoT has opened up a whole new frontier of production (and business strategy) management for all sorts of manufacturing, including aquaculture. Look up the term "Industry 4.0" sometime.

The capacity for modern sensors and monitors to communicate through Wi-Fi and internet channels has reshaped the potential architecture for 'command and control' in aquaculture operations. And more importantly, the computational resources required for interpretation, decision making and long-term planning can now be fed a continual diet of all types of data, allowing subtle relationships between management factors and production strategy trade-offs to be clearly understood. There are two interesting pieces on these topics in this issue.

As advances in AI continue, many aquaculture production systems really will be able to operate with minimal human supervision. I'm not sure whether Walter would be sold on the idea that a computer could understand our fish better than we can, but we'll see how it all works out.

Dr. C. Greg Lutz has a B.A. in Biology and Spanish by the Earlham College at Richmond, Indiana, a M.S. in Fisheries and a Ph.D. in Wildlife and Fisheries Science by the Louisiana State University. His interests include recirculating system technology and population dynamics, quantitative genetics and multivariate analyses and the use of web based technology for result-demonstration methods. Professor and Specialist with the LSU AgCenter.

F3 Challenge Launches Carnivore Competition

The Future of Fish Feed (F3) announced on September 3 that its third contest— "F3 Challenge – Carnivore Edition" — is now open to companies that produce and sell "fish-free" feed for farm-raised carnivorous species. Contest registration is open until April 30, 2020. A US$35,000 prize will be awarded in each of three categories — salmonid, shrimp, and other carnivorous species—to the contestant that produces and sells the most feed made without using wild-caught fish or any marine-animal ingredient.

"We were told after our first contest that the real challenge was fish-free feeds for carnivorous species," said Kevin Fitzsimmons, F3 Challenge chair and Professor at the University of Arizona. "Fortunately, there's a lot of great research happening on alternative feed ingredients for carnivores, so we are excited to see what emerges from our third contest." Chinese aquaculture expert Ling Cao, an Associate Professor at Shanghai Jiao Tong University and affiliated research scientist at Stanford University, joined Fitzsimmons and Michael Tlusty, Associate Professor at the University of Massachusetts Boston, as a judge for this competition.

Each year, an estimated 16 million metric tons of wild fish are caught exclusively for use as fishmeal and fish oil in global food production. Fish farming or aquaculture, now provides well over half of the world's seafood and is the dominant consumer of these oil-rich fish, like sardines, anchovies and menhaden called "forage fish." Today, fish farm owners are looking for new and innovative ways to feed all those billions of fish in a way that doesn't rely on the limited wild fish supply from the ocean.

Salmon aquaculture, one of the fastest growing food production systems in the world, supplies roughly 70 percent, or 2.5 million metric tons, of all salmon produced. Salmon farms use over 20 percent of the fishmeal and 60 percent of the fish oil consumed by the aquaculture sector. Today, over half of the global shrimp supply is farmed. Global shrimp farming production, which reached nearly 4 million metric tons in 2018 according to the UN Food and Agricultural Organization, is also one of the dominant consumers of the global fishmeal supply.

This competition, which is designed to accelerate the development and adoption of alternative "fish-free" feeds for aquaculture, will accept aquafeed entries formulated in three categories: salmonid, shrimp, or other carnivorous species. Feeds submitted for the other carnivorous species category must be approved by the contest judges. Feeds for all categories must not contain any ingredients consisting of or derived from marine animals, including but not limited to, fish, squid, shrimp, or krill.

Forage fish are crucial sources of food for other commercial fisheries like cod, salmon, tuna, and marine mammals like whales, dolphins and seals, as well as seabirds. Without alternative oil sources, the world's oceans will not be able to keep up with the demands from the growing world population, which could result in major supply chain disruptions for the aquaculture industry and in an environmental crisis for wild fisheries.

The winner of the second F3 challenge, The F3 Fish Oil Challenge will be announced on Wednesday, Oct. 23 during a special ceremony at the Global Aquaculture Alliance's GOAL conference in Chennai, India.

For official contest rules and to register, visit: https://carnivore.f3challenge.org/.

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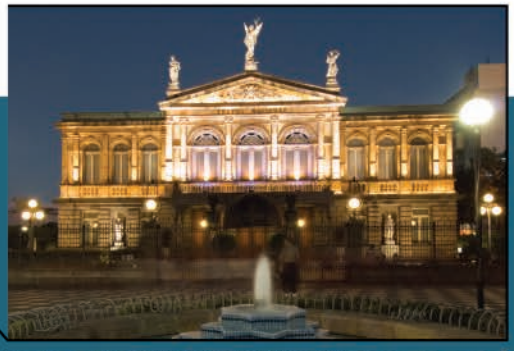

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National Aquaculture Strategy helps South Australian mussels with new markets in South East Asia and China

With the development of a new production facility and key partnerships, South Australia-based Eyre Peninsula Seafoods is embarking on a ground-breaking initiative to significantly increase the export of South Australian mussels throughout South East Asia and China. Eyre Peninsula Seafoods (EPS) was created in 2016 and is represented by three premium mussel brands - Kinkawooka Shellfish, Boston Bay Mussels and Spencer Gulf Mussels. Over the last three years the company has experienced significant growth, and the push into SEA and China as part of the government's National Aquaculture Strategy (NAS) will drive further success.

"The growth of the EPS business could see a further 20 jobs in regional South Australia, along with an increase in the demand for local resources, including packaging, freight, and fuel," said Andrew Puglisi, Executive Director, Eyre Peninsula Seafoods. "As the South Australian Mussel brand develops this will also create a growing awareness for the region and will have an influence on assisting to grow the international recognition for the region as a seafood capital. The aspiration, of course, is to create the awareness and recognition of South Australia as a premium mussel appellation, which can be used across all markets."

The new multi-million-dollar production facility in Port Lincoln will allow the company to increase mussel production from 2000T per annum to 3500T, providing the volume required to push into the South East Asian region, and potentially the US and Europe too. The NAS sets out to achieve the goal to double the current value of Australia's aquaculture industry to $2 billion a year by 2027. The Strategy details the actions government and industry need to take to meet this target through eight priority areas - Regulatory framework; Research, development and extension; Market access; Biosecurity; Public perception; Environmental performance; Investment; and Training and education.

A crucial partner supporting the push into China is Thomas Cappo Seafoods. Based on the huge success of their animal protein division, primarily premium beef products turning more than $2.6 billion in revenue, Thomas Cappo is a leader in Australian food distribution into the valuable market hungry for premium Australian foods. Partnering with Thomas Cappo allows Eyre Peninsula Seafoods to use the networks and relationships built up over many years, especially in China, where relationship marketing is the primary demand for market entry. Damian Cappo, principal of Thomas Cappo Seafoods is a third- generation fishmonger from Adelaide, with a deep and long history in trading seafood.

"China, and in fact that whole region, is not only important in regards to volume of mussels they consume naturally in their food culture, but it's a great platform into other markets too off the back of any success you might experience," said Cappo. "But anything into China is difficult because you're competing globally, but it's about getting on the ground and understanding the product, the requirements and matching with the correct customer channels and constantly massaging and educating so people understand the product and its value."

"On top of that, it creates an opportunity to move into Europe and the US who have their own blue mussel industries that are not in season while the South Australian Mussel is. This could allow year-round supply of blue mussels to those markets," he says. am

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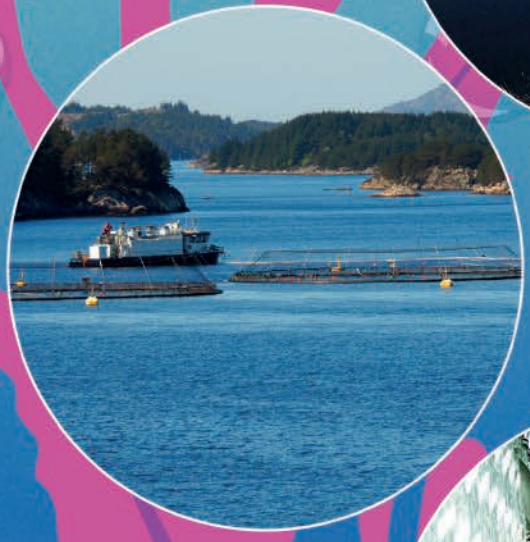

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Atlantic States Marine Fisheries Commission Awards Grants to 5 Aquaculture Pilot Projects

The Atlantic States Marine Fisheries Commission (Commission) has selected five aquaculture pilot projects to receive funding. Through these pilot projects, emphasis is being placed on promising but less commercially developed technologies for finfish and shellfish, and other industry needs like increased permitting efficiency. As part of its efforts to foster responsible aquaculture and seafood security in the US, NOAA Fisheries provided $575,000 in funding to the Commission to support these projects. Following a rigorous review, which included an evaluation of the technical aspects of the proposals as well as their compliance with environmental laws, the following five projects were selected. The projects, ranging from black sea bass production to aquaculture workforce development, will begin in August and are scheduled for completion in 2020.

FY2019 Atlantic States Marine Aquaculture Pilot Projects Grants	
Applicant	**Title**
Massachusetts Division of Marine Fisheries	The Massachusetts Aquaculture Permitting Plan Web Interface to Streamline Aquaculture Permitting
University of Maine	Aquaculture Workforce Development: Certificate in Applied Sustainable Aquaculture
University of North Carolina at Wilmington	Removing Technical Barriers to Sustainable Production of Black Sea Bass (*Centropristis striata)* in Recirculating Aquaculture Systems
North Carolina State University	Continued Evaluation of Bay Scallop (*Argopecten irradians*) Aquaculture in North Carolina as a Means for Industry Crop Diversification and Restoration of Wild Stocks: Building upon 2018 Results
Florida Fish and Wildlife Conservation Commission	Regional Pilot Project to Evaluate and Develop Sustainable Aquaculture of the Caribbean Spiny Lobster (*Panulirus argus*)

Salmon Group removes Brazilian soy from feed

After recently adopting an innovative new feed formula, Salmon Group, a Norwegian cooperative of small and medium sized salmon producers, announced that it would stop using Brazilian soy products in its fish feed last month. The Cooperative's Purchasing and Feed Manager stated that the "change we are making to the feed recipe has significant impact. In fact, the result of this change is twice as large as the impact of all the other measures put together."

"If you have the knowledge that something can be improved, you should go ahead and do it" said Salmon Group's CEO Anne-Kristin Øen. "Removing Brazilian soy is a direct consequence of the difference in climate footprint. It costs us a few millions, but the climate effect is just enormous."

Salmon Group had already recently begun using an alternative feed produced by Biomar Group. Key factors in the feed's production process, such as the use of microalgae oils and more by-catch based fishmeal, are said to result in a 20% reduction in carbon footprint. The replacement of Brazilian soy ingredients is expected to provide an additional 17% reduction, and Salmon Group believes that additional adjustments to management and production practices should result in an overall reduction of 50%.

Øen was quoted at that time in a press release. "Salmon Group works systematically with issues related to sustainability and fish welfare. Last year we launched our feasibility study: 'Sustainable Farming of Salmon and Trout – What is that?' In that report we point to fish feed as an important aspect. Now we take it one step further and get on with doing something about it."

According to the Cooperative's statistics, Salmon Group's combined annual harvest of roughly 135,000 tons of salmon and 20,000 tons of trout generates a total turnover of $980 million USD.

AI in aquaculture: shaping the future with Observe Technologies

Generally the most important task for aquaculture farmers is to maximize feed output while minimizing wasted feed. When feed is wasted, farm profitability, FCR, and local environment are all negatively impacted. Similarly, underfeeding slows farm growth.

Currently, aquaculture addresses this balance by relying heavily on human intuition and interpretations of existing data streams found on sites. Farmers spend their entire day monitoring their stock on video screens, looking for changes in fish behaviour to try and determine the fish's satiety. They then manually adjust the amount of feed released into the cage based on what they see. This requires constant concentration, as farmers combine their interpretation of visual data with a plethora of environmental data streams gauging oxygen levels and current rates, feed intensities, historic fish growth and many more factors.

At the moment, there is no way of monitoring and evaluating feeding strategies objectively. Feeding strategies are an 'art': a reflection of the farmers' spontaneous decision on how much food to put in a cage based on what they saw over the day. There are no unbiased measures of feed strategies to directly explain when a site produces good or bad FCR scores.

Observe Technologies aims to convert aquaculture processes from an art to a science by using Artificial Intelligence and data processing to identify measurable patterns in feeding activities and strategies to present to farmers. The system is built to be adaptable and empowering for farmers by seamlessly tapping into the existing sensors, feed systems and cameras on site. Data is collected through a multitude of AI algorithms to optimize farm performance; from the cost efficient use of feed to maintaining fish welfare.

Past innovations have focused on hardware and data collection; however the problem is typically not a lack of data, but the rigour and overwhelming pressure on farmers to consistently interpret that data and apply correlations with fish activity, feeding patterns, sensory data, food particles and other historical information in real time. The use of AI in aquaculture farms offers constant analytical and objective evidence of how fish growth responds to farmer input under different conditions, allowing meaningful data exploration of different feeding strategies.

Aquaculture Group Applauds WDFW for Fish Farm Proposal

The Northwest Aquaculture Alliance (NWAA), the leading trade association representing aquaculture producers and support businesses in Washington, Oregon, Idaho, Montana, and British Columbia, applauded the Washington Department of Fish and Wildlife (WDFW) proposal to issue a five-year Marine Aquaculture Permit to Cooke Aquaculture Pacific, LLC to grow rainbow trout (steelhead) in its existing commercial marine net pens in Puget Sound.

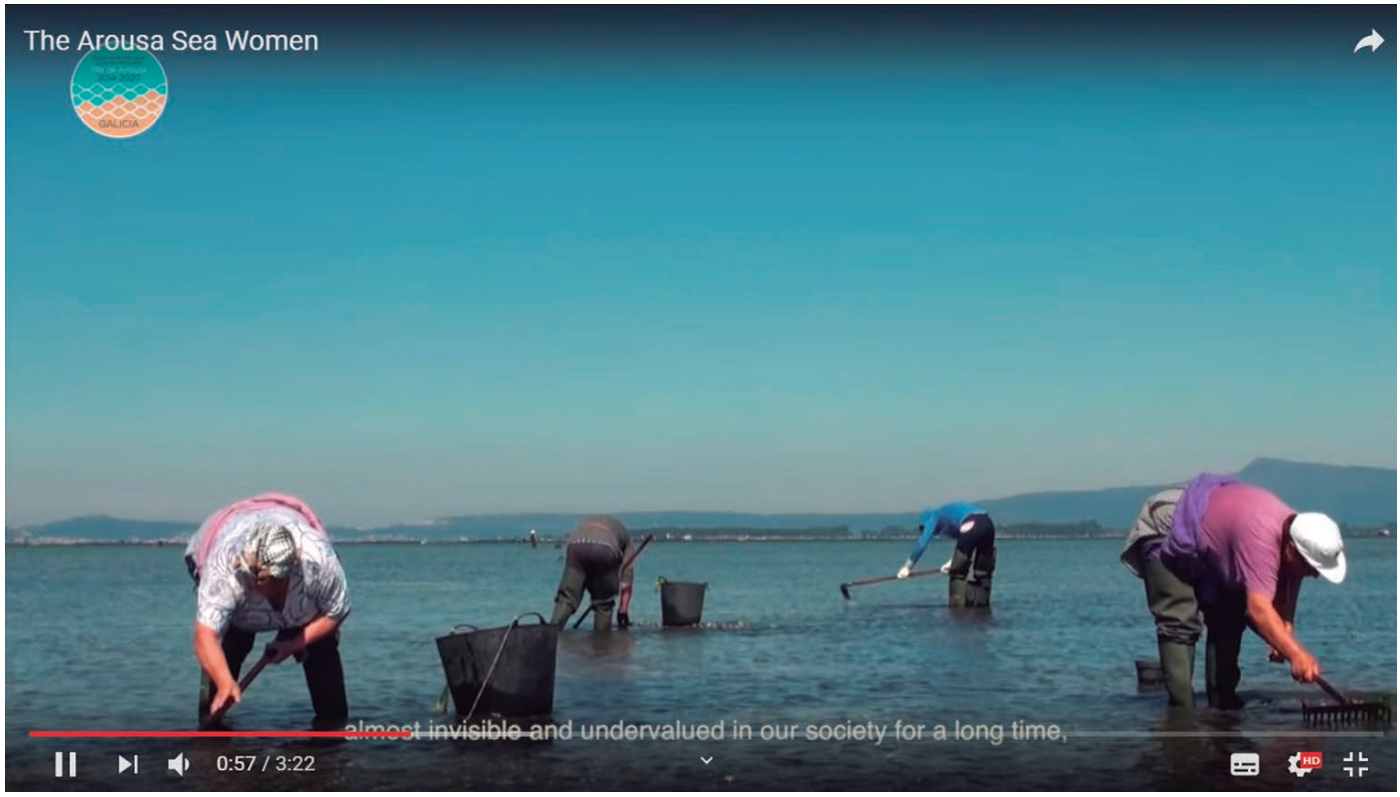
The WDFW proposal, would give Cooke a five-year permit to culture all-female triploid (non-fertile) rainbow trout—and much-needed certainty to continue operating in the state.

Cooke plans to partner with the Jamestown S'Klallam Tribe to raise native species in Port Angeles Harbor, once the aquatic farm lease in Port Angeles is reinstated, according to a press release issued recently.

"We commend the state, particularly WDFW, for 'going the extra mile' to ensure fairness in making this important decision," said NWAA Executive Director, Jeanne McKnight. "We are grateful that science has won the day over politics, and we are delighted that Cooke will be able to continue producing sustainable seafood in Washington State, particularly in areas where family-wage jobs

Source: Northwest Aquaculture Alliance

Women in Seafood announces Video Competition winners



The International Association for Women in the Seafood Industry (WSI), a not-for-profit organization created by seafood and gender issues specialists, highlights gender imbalance in the industry, sheds light on women's real contribution in the industry, and promotes greater gender diversity and inclusiveness. For its third edition the WSI video competition 2019 has hit a record with 32 entries from 14 countries, an 88% increase compared to 2018. The international jury including highly recognized professionals has awarded prizes to the three best video competition 2019.

First prize: Women of the Arousa Sea, (Galicia). "The best! Touching, Strong, positive, with context and showing diverse angles of women at sea" commented one jury member. https://www.youtube.com/watch?time_continue=1&v=_ZsfK-pctXlI

Second prize: Oyster farming in Wadatar (India). "Very interesting and positive initiative, where women overcame prior opposition and go in the water." https://www.youtube.com/watch?v=EL4uyn_SEsI

Third prize: Truchas arapa, or The Aquaculture women of Lake Arapa (Peru). "A promising aquaculture initiative where Reyna Callata Chaco a very inspirational role model provides good leadership to other women." https://www.youtube.com/watch?time_continue=1&v=z9R6Isziwa0

WSI Prize of Excellence 2019 Leadership des femmes transformatrices au Sénégal (Senegal): "Excellent video - great music and visuals, where women were at the front and innovations current and important." https://www.youtube.com/watch?v=ilL3413SiXg

WSI Prize of Excellence 2019 Women with tradition (Peru) "A one family business inspirational for other families in the community". https://www.youtube.com/watch?time_continue=2&v=reluoGzuC_o

Finally a Special WSI mention is awarded to: Special WSI mention to Mujeres del mar, (Mexico) "Very good example of the work of a community in which women share experiences" https://www.youtube.com/watch?v=IjvnV5jRGwM

And Special WSI mention to Mujeres a bordo (Spain, Galicia) "Highlights the key issue of prejudice on land not on board. Excellent lesson to those who do not believe a woman can do it!" https://www.youtube.com/watch?time_continue=1&v=5aDn77twYNU

"The standard of all the films was high, and they demonstrated the many ways in which women are active throughout the seafood industry. There were happy tales and sad tales, tales of bravery and perseverance, and tales of the struggle against circumstance. A couple of films even brought a tear to my eye. All the women should be congratulated on their outstanding efforts; they left me in awe." Nicki Holmyard, journalist, UK. All videos are available here: http://womeninseafood.com/videos-2019/

"We are happy to announce that the 2020 edition is open and we look forward to receiving new wonderful testimonies from all over the world, making visible the two often invisible yet paramount contribution of women to the seafood industry" said Marie Christine Monfort, WSI President. Email: womeninseafood@wsi-asso.org

Trade relations between Turkey and China continue to be developed

With a new Chinese aquatic products export protocol in place, Turkey's Ambassador to Beijing Abdulkadir Emin Onen said that a potential $ 250 million market has been opened for Turkish aquaculture producers.

China's General Administration of Customs of the Ministry of Agriculture and Forestry was in Ankara in early September. During the visit, a protocol was signed aimed at boosting the export of fishery products from Turkey to China such as rainbow trout, river trout, tuna and bluefin tuna. According to officials, the protocol is valid for 5 years from the date of signing.

Onen said in a statement on the subject that in the past year Turkey's exports of aquaculture products were worth 80 million dollars, while China's imports were some 250 million dollars. "So the door was opened to a potential $ 250 million market for Turkish producers" he added. Onen cited the initiative of cherry and pistachio exports from Turkey to China earlier this year, followed by poultry exports, fishery products and milk and said the government continues its efforts to begin exports of citrus products.

Ontario Provides Direction to Support a Strong and Sustainable Aquaculture Industry

Ontario is taking action to protect water quality in Ontario's lakes while supporting an environmentally sustainable and prosperous fish farming sector, as part of its Made-in-Ontario Environment Plan commitment.

Ontario released its final policy paper on lake-based cage fish farming that helps provide business certainty and enables long-term investment in the sector by finalizing the provincial water and sediment quality objectives for how fish farms should be situated, sized and managed.

Jeff Yurek, Minister of the Environment, Conservation and Parks, and Mike Harris, Parliamentary Assistant to the Minister of Natural Resources and Forestry, met with RJ Taylor, Co-owner of Cedar Crest Trout Farms, in Hanover on August 29 to talk about the province's fish farming policy and the industry's contribution to Ontario's economy.

"Ontario's aquaculture sector brings jobs and prosperity to rural, northern and Indigenous communities across Ontario," said Minister Yurek. "Setting this direction will provide greater clarity and certainty for investment. It's an important step in reducing barriers to industry growth and ensuring the industry continues to play an important role in providing our food, protecting our waters and strengthening the provincial economy for years to come."

"Ontario's fish farmers put more than 100 million meals of delicious and healthy trout on Ontario dinner tables every year. Aquaculture brings jobs and prosperity to Ontario's rural, northern, and Indigenous communities," said RJ Taylor, Co-owner, Cedar Crest Trout Farms. "Our farms are certified and internationally recognized for their environmental stewardship and best management practices. We are delighted to see the Ontario government embrace Ontario seafood farmers and help us create jobs, fuel our economy and feed Ontarians."

"Healthy locally grown fish are important to both Ontario families and to our economy," said John Yakabuski, Minister of Natural Resources and Forestry. "This policy supports Ontario's abundant wild fish populations and a healthy cage aquaculture industry."

"Businesses like Cedar Crest Trout Farm play an important role in providing a quality food product for Ontarians and new economic opportunities for our region and province, and so I'm pleased to see our government supporting our local business and the aquaculture industry. I'm excited about the potential to significantly expand this industry, jobs and the economy," said Bruce-Grey-Owen Sound MPP

Bill Walker. "Protecting and restoring water quality in our lakes is part of our Made-in-Ontario Environment Plan to ensure we balance a healthy environment and a healthy economy and that the province's pristine beauty and strong communities can be enjoyed now and in the future."

There are currently six provincially licensed commercial cage fish farm operations in Ontario and they are located in Lake Huron. In 2018, the market value for rainbow trout in Ontario was $29 million.

News from the Aquatic Animal Drug Approval Partnership

A Branch of the U.S. Fish and Wildlife Service's Fish and Aquatic Conservation Program.

Syndel announces Parasite-S (formalin) label extension

In April 2019, Syndel announced an indication addition for Parasite-S (formalin). The new indication allows use of Parasite-S to control mortality in freshwater-reared finfish due to saprolegniasis associated with fungi in the family Saprolegniaceae when administered at a dose of 150 ppm for 60 minutes per day on alternate days for three treatments in tanks and raceways. For more information on dosing, limitations, and treatment calculations of other Parasite-S (formalin) indications, refer to AADAP's Quick Desk Reference Guide to Approved Drugs for Use in Aquaculture.

AADAP needs your help!:

Check out the AADAP website for a list of AADAP's current research priorities/needs for efficacy studies (https://www.fws.gov/fisheries/aadap). AADAP is on the lookout for facilities with the following conditions/species combinations in which to conduct efficacy studies:

Aeromonas hydrophila in a coolwater species, as well as a warmwater species other than catfish (Oxytetracycline dihydrate-Terramycin® 200 for Fish)

Edwardsiella spp. in catfish (Oxytetracycline dihydrate-Terramycin® 200 for Fish)

Yersinia ruckeri in a salmonid species (Romet)

Columnaris in a coldwater species (Chloramine-T)

If you're aware of any facilities that may be able to help us, please have them contact Guppy Blair at: marily_j_blair@fws.gov

Approved Aquaculture Drug Fact of the Month:

Did you know Tricaine Methanesulfonate is approved for use in fish (of the families Ictaluridae, Salmonidae, Esocidae, and Percidae), aquatic amphibians, and other aquatic poikilotherms for temporary immobilization? For more information on dosing, limitations, and treatment calculations, refer to AADAP's Quick Desk Reference Guide to Approved Drugs for Use in Aquaculture.

Fish Bytes video added to the AADAP website:

Check out the Fish Bytes video that was recently added to the AADAP website. The 1-minute video showcases the overall goal of the Aquatic Animal Drug Approval Partnership Program.

EXAMPLE TREATMENT SCENARIO AND SUGGESTED FORMALIN TREATMENT CALCULATIONS*

Charged Flow-through Treatment

Example: You have a raceway containing a moderately high density of rainbow trout diagnosed with a *Costia* sp. infestation. The raceway measures 60 ft x 6 ft, with a water depth of 3 ft. Water flow into the raceway is 100 gpm. Management has prescribed a treatment regimen of 170 µL/L formalin for 1 hour, and has determined that stocking density is such that a charged flow-through treatment is recommended. How much formalin (mL) must be added to "charge" the raceway to the prescribed treatment concentration? How much formalin (mL) must be "metered" into the raceway inflow over the course of the 1 hour treatment duration to maintain the prescribed treatment concentration?

Additional information:
Formalin is considered 100% active ingredient, for it is a saturated aqueous solution of formaldehyde gas
The specific gravity (SG) of formalin = 1.08
Gallons per cubic foot = 7.48
Conversion Factor (CF) to convert gallons to milliliters = 0.003785

Calculations:

Volume of water (gal) in raceway = [length (ft) x width (ft) x depth (ft) x 7.48 gal/ft^3]
= 60 x 6 x 3 x 7.48
= 8,078 gallons

Formalin (mL) to "charge" raceway = [water volume (gal) x treatment concentration (µL/L) x CF ÷ SG]
= 8,078 x 170 x 0.003785 ÷ 1.08
= **4,813 mL**

Formalin (mL) "metered" into raceway = [water flow (gpm) x treatment duration (min) x treatment concentration (µL/L) x CF ÷ SG]
= 100 x 60 x 170 x 0.003785 ÷ 1.08
= **3,575 mL**

*Always refer to and follow all label instructions

EXAMPLE TREATMENT SCENARIO AND SUGGESTED TRICAINE METHANESULFONATE TREATMENT CALCULATIONS*

Static Bath Treatment

Example: Your resource management objectives include the production of 200,000 fin-clipped rainbow trout for stock enhancement. Management has prescribed the use of tricaine methanesulfonate (MS-222) at a treatment concentration of 80 mg/L to sedate fish prior to fin-clipping. Fish will be sedated in small lots utilizing "knockout" tubs containing 1.5 gallons of water. How much MS-222 (g) needs to be added to each knockout tub?

Additional information:
MS-222 is considered to be 100% active ingredient
Conversion Factor (CF) to convert gallons to grams = 0.003785

Calculations:

Amount of MS-222 to add to each knockout tub = [water volume (gal) x treatment concentration (mg/L) x CF]
= 1.5 x 80 x 0.003785
= **0.45 g**

*Always refer to and follow label instructions

Special Session at Aquaculture America 2020:

AADAP is planning to co-host a special session with the AFWA Drug Approval Working Group (DAWG) at Aquaculture America 2020, to be held in Honolulu, HI from February 9th-12th, 2020. The tentative session title is "Aquaculture Drug Updates". If you're interested in being a part of this session, please contact Julie Schroeter for more information by October 25th, 2019.

Shrimp Multipath;
providing a pathogen safeguard to Kenya's emerging integrated mangrove conservation and aquaculture enterprises

In March 2019, Kenya produced its first ever crop of farmed shrimp from hatchery reared animals grown in community-based, integrated mangrove conservation and aquaculture systems (IMAS).

*By: Iain Olivier, Melony Sellars and Nigel Preston **

This success was the result of a partnership including Mtoni Ltd, Kenya's only commercial shrimp hatchery, several Kenyan community-based IMAS enterprises, the Australian Commonwealth and Scientific Industry and Research Organisation (CSIRO), Kenya Marine and Fisheries Research Institute (KMFRI) and the Kenyan Department of Fisheries, with support from the Australian Department of Foreign Affairs and Trade (DFAT).

The first harvest of a mixed crop of *Penaeus monodon* and *Fenneropenaeus indicus* provided a significant source of income to the Mtepeni Community Mangrove Forest Conservation Group. This included the resources required to support community activities in mangrove conservation and restoration. The success of this project has provided the incentive for Mtoni Ltd to progressively increase the number of Kenyan coastal communities with access to the knowledge and technology to enable them to develop their own IMAS.

These coastal communities have all been committed to mangrove conservation activities for the past decade or more. However, mangrove conservation alone does not provide adequate levels of resources to offset the loss of community income from traditional fishing activities that have been so severely impacted by overfishing in these coastal areas. Faced with this challenge, these communities are now seeking to integrate mangrove conservation with sustainable shrimp aquaculture. The communities are acutely aware that poorly managed aquaculture enterprises can have negative impacts on mangroves and other marine ecosystems. Accordingly, they are committed to the application of IMAS knowledge and technology.

Hatchery seedstock.

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Pond-planted mangrove.

Integrated mangrove shrimp ponds – Ihaleni Kakuluni Conservation Group, Kilifi County, Kenya.

Broodstock transport.

All aspects of these systems are demonstrably sustainable and auditable, enabling significant improvements to community livelihoods whilst also conserving and restoring mangrove forests and reducing pressure on wild fish stocks. A key aspect of reducing pressure on wild fish stocks is to provide high-health, hatchery reared shrimp seedstock to these communities. This eliminates the need for women and youths to spend many hours capturing wild seedstock from local estuaries, which is unsafe and time consuming and places additional pressure on wild fisheries.

A new partnership between Mtoni Ltd and Genics is providing transformational capacity to detect and manage shrimp pathogens by providing critical access to the Shrimp MultiPath™ Platform. This platform is now commercially available through Genics with testing performed in NATA accredited ISO17025 Australian Service Laboratories. This has enabled Mtoni Ltd to screen broodstock, post larvae and pond stocks for 13 commercially impactful pathogens in a single assay, within 48 hours of samples arriving at the testing laboratories in Australia. Mtoni Ltd hatchery manager Sheban Mdzomba Hinzano put in long hours camping out in the fishing grounds in the Tana Delta and whizzing about on trawlers in order to collect shrimp broodstock samples.

Monitoring prawn growth.

Stocking community ponds.

Mtepeni community ponds.

Mtepeni community ponds.

Results have confirmed that Kenya's natural stocks of *P. monodon* and *F. indicus* will provide safe and reliable founder stocks for local domestication and selective breeding programs. Ongoing access to Shrimp MultiPath™ will be critical in optimising pathogen detection and management in the domesticated stocks, to the benefit of Kenya's IMAS enterprises. Achieving this goal will contribute to the growing body of evidence that internationally accredited, responsible aquaculture can have significant economic and social benefits whilst also conserving and restoring the health of adjacent ecosystems.

Iain Olivier, CEO Mtoni Ltd, Melony Sellars, Director Genics Pty Ltd and Nigel Preston, Honorary Professor, University of Queensland.

University of Wisconsin's One-of-a-Kind Aquaculture Research and Demonstration Facility

The UW-Stevens Point Northern Aquaculture Demonstration Facility (UWSP NADF) is a state-of-the-art, dynamic facility, showcasing new advances in aquaculture system technology such as sustainable land based recirculating aquaculture, while also providing traditional aquaculture systems such as flow through raceways and outdoor ponds for industry-based research projects.

*By: Emma Wiermaa and Greg Fischer **

A variety of aquaculture production systems and water sources provide the facility with the capability of raising various cool and cold-water fish species important to the industry, such as rainbow trout, brook trout, Atlantic salmon, arctic char, lake trout, lake herring, walleye, saugeye, lake sturgeon, yellow perch, baitfish and other species at various life stages.

The UWSP NADF is recognized as an international leader and promoter in recirculating aquaculture system (RAS) technology. Demonstration projects at the facility show how RAS technology can be more environmentally responsible and sustainable for the future of aquaculture. The facility is located on The Red Cliff Band of Lake Superior Chippewa Indians' reservation and was built as a partnership with the Tribal Natural Resources Department and with the Tribal Fish Hatchery Program.

The UWSP NADF is recognized as an international leader and promoter in recirculating aquaculture system (RAS) technology. Demonstration projects at the facility show how RAS technology can be more environmentally responsible and sustainable for the future of aquaculture.

History

After 10 years of planning and development, the facility became operational in 2002. The facility was originally constructed by the UW System and operated by the University of Wisconsin-Superior. In 2006, ownership was transferred to the University of Wisconsin-Stevens Point. The facility location was carefully chosen due to important geological information that was gathered to determine the best site for the facility. Determining factors included topography, aquifer capacity, water quality, and effluent management. While the land is leased by the tribe to UWSP, the facility also provides strong collaboration with the Red Cliff Tribe providing workshops and training for future industry workforce and project partnerships with the Red Cliff Fish Hatchery.

The overall mission of the facility throughout the years has been to advance sustainable aquaculture for a northern climate, focusing on species, systems and technologies that relate to Wisconsin and the Midwest. The facility focus is to perform industry applied research projects while demonstrating effective aquaculture systems, management practices, and technologies. The facility partners with private industry, tribal entities, state and federal hatcheries, other universities, K-12 Wisconsin schools, industry related companies and other organizations. With a professionally trained staff of dedicated aquaculturists and biologists the facility is able to maintain a high level of expertise for conducting a myriad of projects with many species of both cool and coldwater fish at various life stages.

ATS Tank Overview.

Scope

As a result of the ongoing research and demonstration projects at UWSP NADF, the facility is continually advancing to evaluate and assist in development of state-of-the-art technologies and new aquaculture species to improve efficiency and sustainability for aquaculture in the Midwest. Outcomes from various research projects and partnerships drive the best management practices and technological advancements currently demonstrated at the facility today. The facility has also filled the unique niche of assisting up and coming aquaculturists and businesses to begin to or better understand what is needed to be successful in rearing a variety of fish species for either food fish and/or conservation purposes.

The UWSP NADF is one-of-a-kind in the Midwest that joins a group of only a handful of similar facilities in North America. For the

past 18 years, the facility has continuously been involved in significant projects which have not only been ground-breaking but have also impacted aquaculture at a local and global scale.

Due to strong partnerships, collaborations and trusted applied research, the UWSP NADF has been awarded over $5 million in grants to support project funding. The facility has raised over 15 species of cool and cold-water fish in various systems at all life stages. This work has positively impacted private, tribal, federal and state hatcheries and organizations to advance their production and efficiency. Looking into the future, the facility strives to maintain high quality applied research, biological results, workforce training and effective outreach and education efforts. A few specific projects are highlighted below.

Highschool aquaculture.

Developing Atlantic Salmon Broodstock for US Commercial Supplies of Atlantic salmon Eggs

One example of industry impacts involves the facility's work with the Cascade strain of Atlantic salmon. In 2014, the facility was provided with some of the few remaining Cascade strain Atlantic salmon left in the world. The UWSP NADF collaborated with Riverence, LLC. of Washington state and with The Conservation Fund's Freshwater Institute in West Virginia to develop a broodstock of Cascade strain Atlantic salmon to supply eggs to the growing commercial food fish industry utilizing RAS technology. For over five years, the UWSP NADF worked with Riverence to collect and ship eggs to Washington for the development of a new broodstock. Riverence is now the first US commercial supplier of Atlantic salmon eggs to support the salmon food fish industry and the only supplier, globally, of Cascade strain eggs.

Partnering with World's Largest Aquaponics Facility

Among various partnerships, the UWSP NADF is also strongly associated with the world's largest aquaponics facility, Superior Fresh, LLC. of Hixton WI. Superior Fresh is currently raising Atlantic salmon, steelhead and various aquaponic greens. The UWSP NADF partnered with Superior Fresh to advance the company's sustainable production of Atlantic salmon reared in recirculating aquaculture systems. UWSP NADF provides technical assistance, demonstration and cold-water species

The facility location was carefully chosen due to important geological information that was gathered to determine the best site for the facility. Determining factors included topography, aquifer capacity, water quality, and effluent management.

The overall mission of the facility throughout the years has been to advance sustainable aquaculture for a northern climate, focusing on species, systems and technologies that relate to Wisconsin and the Midwest.

expertise to advance the company's facility and operations. UWSP is also partnering to provide interns, technicians and other support staff. Recently, UWSP NADF received federal funding through the NOAA Sea Grant college program for research to overcome barriers to sustainable, land based Atlantic salmon production with its partners WI Sea Grant, Superior Fresh, Riverence, and The Conservation Fund's Freshwater Institute. This project was selected to receive part of an $11 million aquaculture initiative, the only project in the Great Lakes region that was funded from this initiative.

Larval room tanks at UWSP NADF.

A Leading Research Facility for Intensively Reared Walleye for Food Fish Production

For nearly 10 years, the UWSP NADF has been raising both walleye and hybrid walleye (saugeye) in indoor, intensive systems on commercial feed. Based on the research and published work from Bob Summerfelt and colleagues in the Walleye Culture Manual, the facility has developed intensive systems to raise this species on commercial feed from hatching, starting in larval systems and on through grow-out in recirculating aquaculture systems. Although most walleye fillets are imported into the Midwest from Canada, this well-known species in the Midwest has a strong existing food fish market. Intricate system designs, management practices and prior research have enabled the facility to raise this species to an average of >1.0 lb in 12 months from egg to finished fish utilizing intensive systems at commercial density levels of 60-80kg/cubic meter. These indoor rearing techniques result in highly bio-secure fish, limiting issues of disease or infections. This also provides an additional market for providing pellet-trained fingerlings to companies utilizing aquaponics or recirculating aquaculture systems. UWSP NADF is the leading research facility advancing the commercialization of raising walleye intensively for food fish production.

A Leader in Aquaculture and Aquaponics Education in Wisconsin and Beyond

UWSP is the first accredited university in Wisconsin to offer an aquaculture minor and the first in the Nation to offer a full semester aquaponics course and aquaponics certificate program.

UWSP is the first accredited university in Wisconsin to offer an aquaculture minor and the first in the Nation to offer a full semester aquaponics course and aquaponics certificate program.

Walleye final harvest WWRAS.

Broader research initiatives over the next decade include broodstock research and development, year-round spawning of walleye, feeds and nutrition, and economic analysis of various aquaculture or aquaponic systems and species.

Walleye 1lb -1 year in RAS.

to offer a full semester aquaponics course and aquaponics certificate program. Each year the university supports various students to intern at UWSP NADF and other partnership facilities. These students meet workforce development needs for the aquaculture industry. Availability of a skilled and experienced workforce is currently a major bottleneck to the advancement of the industry. Every research or demonstration project also consists of strong outreach components through various avenues including workshops, trainings, tours and presentations. The UWSP NADF mission also involves public education, providing tours for all ages. Yearly, the facility directly outreaches to thousands of people through interactive tours, classroom visits and public presentations.

Crosscurrent

UWSP NADF has a strong mission to support and promote aquaculture education. One of the major opposing forces to the facility and aquaculture in general is negative public perception of aquaculture. To the general public, wild harvested fish continues to be viewed as superior over aquaculture raised fish in terms of quality and environmental sustainability. The facility works to educate those that are unaware of the benefits of sustainable aquaculture including food safety, preservation of wild populations, low environmental impacts with land-based systems, and the regulations on U.S. aquaculture and aquaponics.

UWSP NADF is an open-door-policy facility, therefore the research and results are publicly available.

Research done at UWSP NADF is evaluated by other highly reputable aquaculture facilities and organizations including tribal, state, federal and private groups. Research done at the facility is directly tied to grant or private industry funding, in which the results and outcomes are widely shared and extended to the intended audiences.

Outlook

Future research goals and objectives will be driven by environmental and economic sustainability with direct industry applicability. Current species and systems of high interest include Atlantic salmon, walleye and arctic char raised in recirculating aquaculture systems or de-coupled aquaponics systems for food fish markets. With continual technological advancements for indoor systems, there will also be continued research and demonstration projects around these developments. Broader research initiatives over the next decade include broodstock research and development, year-round spawning of walleye, feeds and nutrition, and economic analysis of various aquaculture or aquaponic systems and species.

Emma Wiermaa is the Aquaculture Outreach & Education Specialist at the NADF. Her duties include conducting tours for the facility, social networking and website building, connecting with and providing technical assistance to schools, private fish farms and tribal, federal or state organizations, assisting in research and data analysis, and writing reports and proposals. Greg Fischer is the NADF's Assistant Director & Research Program Manager. His responsibilities currently include overseeing applied research and demonstration projects, facility staff, interns, volunteers, and all day-to-day activities involved with the operation of the facility.
Email: ewiermaa@uwsp.edu

Potential of Genome Editing to Improve Aquaculture Breeding and Production

New breeding technologies such as genome editing using CRISPR/Cas9 have the potential to expedite sustainable genetic improvement in aquaculture. Genome editing can rapidly introduce favorable changes to the genome, such as fixing alleles at existing trait loci, creating *de novo* alleles, or introducing alleles from other strains or species.

*By: Remi L. Gratacap, Anna Wargelius, Rolf Brudvik Edvardsen and Ross D. Houston **

Fish production via aquaculture is now approximately equal to capture fishery production for the first time in history, will be the dominant source of seafood within a few decades, and is the fastest growing food production sector, predicted to grow by 31% over the next 10 years. Fortunately, development potential is huge, with only ~1% of suitable marine sites currently being used for aquaculture. Furthermore, aquaculture production is considered efficient in terms of feed conversion and protein retention compared with most terrestrial livestock, and seafood is the major source of long-

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chain polyunsaturated fatty acids, which are considered essential for human health.

However, relative to many crop and livestock production systems, most aquaculture is at a formative stage and is typically a high-risk activity. Sustainability can be hindered by an initial lack of control of the reproduction cycles of species, and periodic collapses due to infectious diseases. Upscaling and improving the reliability of production will require disruptive innovation in engineering, health, nutrition, and genetic improvement technologies, the latter being the focus of this review.

Genomic selection has become the state-of-the-art in several globally important aquaculture sectors, offering higher selection accuracies than selection based on phenotypic and pedigree records alone. However, genetic progress in selective breeding is limited by the heritability of the target traits, the generation interval of the species, and the need to target multiple traits in the breeding goal. In addition, advanced breeding programs are typically closed systems, and are limited to the standing genetic variation in the broodstock (typically sourced from a limited sample of wild populations), and new variation that arises from *de novo* mutations. Genome-editing technologies, such as CRISPR/Cas9, offer new solutions and opportunities in each of these areas.

In contrast to transgenesis, which involves the transfer of a gene from one organism to another, genome editing allows specific, targeted, and often minor changes to the genome of the species of interest. The CRISPR/Cas9 system was discovered in bacteria, and was engineered to enable easy, cheap, and efficient targeted editing of the genome. The system creates a double-strand break (DSB) at a user-defined locus, enabling imperfect or targeted repair to create alterations to the sequence of the genomic DNA. The platform functions by combining an endonuclease, the most commonly used enzyme derived from *Streptococcus pyogenes* (SpCas9), and an adapter RNA in two parts, the complementary RNA (crRNA) and the transactivating crRNA (tracrRNA).

Genomic selection has become the state-of-the-art in several globally important aquaculture sectors, offering higher selection accuracies than selection based on phenotypic and pedigree records alone.

Genome editing using CRISPR/Cas9 was recently successfully applied in vivo and/or in cell lines of several major aquaculture species such as Nile Tilapia (see table 1).

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Once annealed, the crRNA recognizes the target DNA sequence and the tracrRNA binds the Cas9 protein to enable targeted endonuclease activity. There are then two primary repair mechanisms, each of which can be used to introduce different types of edit to the target genome. First, the two adjacent strands of DNA can be repaired through a nonhomologous end-joining pathway (NHEJ), which is error prone and induces insertion or deletion of a few nucleotides. Second, if a repair template is present, homology-directed repair (HDR) can be used to insert desired mutations (from a single nucleotide swap to a whole chromosomal region insertion).

Over the past few years, technical developments have made genome editing more efficient, and raised new possibilities for biological discovery. Single guide RNA molecules (sgRNA) are routinely used instead of the crRNA and tracrRNA duplex, to facilitate synthesis from a polymerase III promoter (U6), which simplifies the process of CRISPR/Cas9 delivery. There have also been numerous innovations that have enabled improved precision of editing, with lower off-target rates, and broadening of the range of target sites accessible via alternative Cas9 proteins. Novel extensions of the CRISPR/Cas9 editing system now allow researchers to achieve gene activation or inhibition, without DSBs by using a 'dead' Cas9 (dCas9) fused to an activating (VP64, Rel A, and Rta proteins, known as the VPR system) or inhibiting complex (dCas9-KRAB). Furthermore, swapping of base pairs (base-editing) from C to T with a cytidine deaminase and A to G with an adenine deaminase using the same inactive Cas9 (dCas9) has the potential to target numerous single-nucleotide polymorphisms (SNPs).

Table 1

Successful applications of CRISPR/ Cas9 Genome Editing to Date in Aquaculture Species.

Species	Target gene[a]	Trait of interest	Notable features
Atlantic salmon, *Salmo salar*	*tyr/slc45a2*	Pigmentation	
	dnd	Sterility	
	elov-2	Omega-3 metabolism	
Tilapia, *Oreochromis niloticus*	*dmrt1/nanos2-3/foxl2*	Reproduction	Germline transmission
	gsdf	Reproduction	
	aldh1a2/cyp26a1	Reproduction	
	sf-1	Reproduction	Germline transmission
	dmrt6	Reproduction	
	amhy	Reproduction	
	wt1a/wt1b	Reproduction	
Sea bream, *Sparus aurata*	*mstn*	Growth	
Channel catfish, *Ictalarus punctatus*	*mstn*	Growth	Germline transmission
	icam1/rbl	Immunity	
	LH	Sterility	
Southern catfish, *Silurus meridionalis*	*cyp26a1*	Germ cell development	
Common carp, *Cyprinus carpio*	*sp7a/sp7b/mstn(ba)*	Muscle development	
Rohu carp, *Labeo rohita*	*TLR22*	Immunity	Homology-directed repair
Grass carp, *Ctenopharyngodon idella*	*gcjam-a*	Disease resistance	*In vitro*
Northern Chinese lamprey, *Lethenteron morii*	*slc24a5/kctd10/wee1/soxe2/wnt7b*	Pigmentation/development	
Rainbow trout, *Oncorhynchus mykiss*	*igfbp-2b1/2b2*	Growth	
Pacific oyster, *Crassostrea gigas*	*mstn*	Growth	

Advanced breeding programs are typically closed systems, and are limited to the standing genetic variation in the broodstock (typically sourced from a limited sample of wild populations), and new variation that arises from *de novo* mutations.

Current Status of Genome Editing in Aquaculture Species

Genome editing using CRISPR/Cas9 was recently successfully applied in vivo and/or in cell lines of several major aquaculture species of Salmonidae (Atlantic salmon, *Salmo salar* and rainbow trout, *Oncorhynchus mykiss*), Cyprinidae (Rohu, grass, and common carp, *Labeo rohita, Ctenopharyngodon idella,* and *Cyprinus carpio*, respectively), Siluridae (channel and southern catfish, *Ictalurus punctatus*), as well as Pacific oyster *(Crassostrea gigas)*, Nile tilapia *(Oreochromis niloticus*), and gilthead sea bream *(Sparus aurata)* (see Table 1 for details).

One major group of aquatic species where successful CRISPR/Cas9 editing has not yet been reported is shrimp (*Penaeus* sp.), which may be partly due to practical limitations, as discussed briefly below. The standard methodology to induce in vivo mutations in aquaculture species is injection of the CRISPR/Cas9 complex into newly fertilized eggs as close as possible to the one-cell stage of development. Typically, mRNA encoding the Cas9 protein is injected together with the guide (g)RNA, leading to the high efficiency of editing demonstrated in various species to date (Table 1). Using the Cas9 protein in place of mRNA is also effective. Successful germline transmission of edits has been reported in several studies to date (Table 1). Mosaicism is common in edited animals, implying that the Cas9-induced cutting and editing continues past the one-cell stage; this is an issue to tackle with future research.

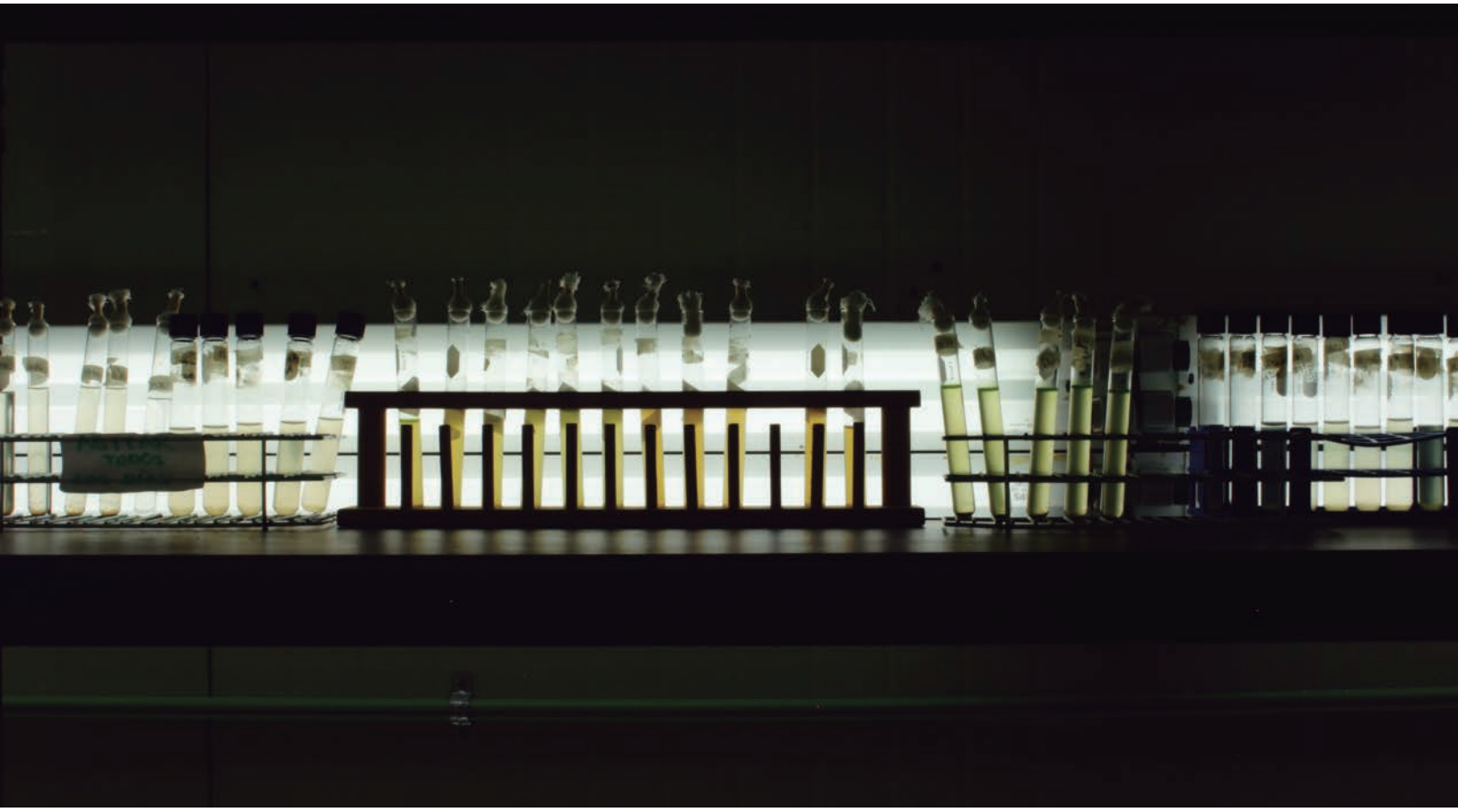
Target production traits for genome-editing studies in aquaculture species to date have included sterility, growth, and disease resistance. CRISPR/Cas9 has been used to induce sterility in Atlantic salmon and

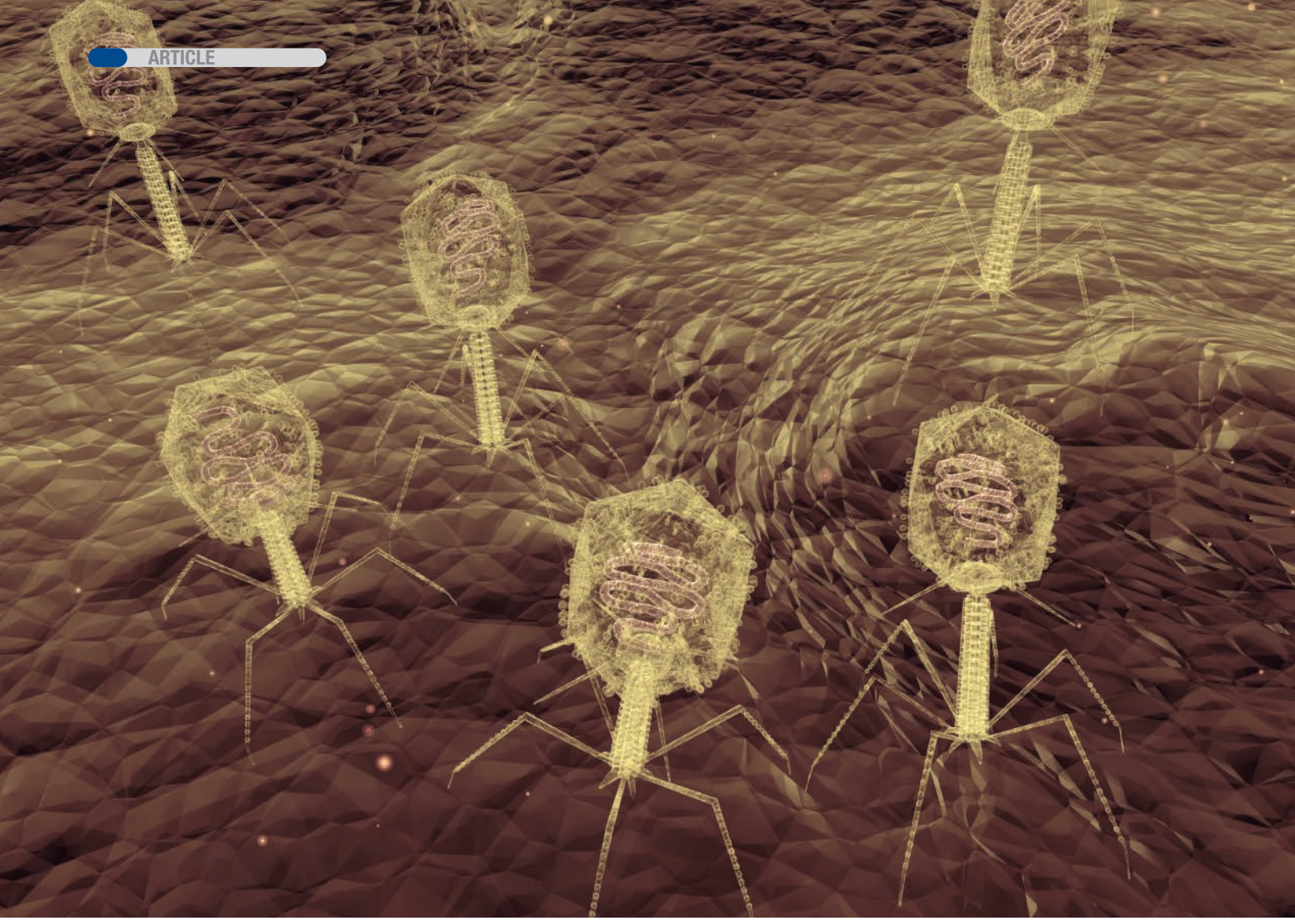
Catfish (Table 1). For growth-associated traits, several groups have edited the myostatin gene (famous for its role in 'double-muscled' cattle, such as the Belgian Blue), resulting in larger fish. To date, this has been performed in channel catfish and common carp (Table 1). Immunity and disease resistance have already been investigated using genome editing in Rohu carp and Grass carp, respectively, and it is expected that this area of research will flourish as a route to improving and understanding disease resistance as a key target trait for aquaculture. Genome editing can also be applied to develop models for studying host response to infection in fish. Along similar lines, it is plausible to use genome-editing technology to generate improved cell lines for fish species, for example by enabling more efficient production of viruses for future vaccine development by knocking out key components of the interferon pathway.

Some practical reasons why genome editing has such potential for research and applications in aquaculture species are the ease of access to many thousands of externally fertilized embryos, and the large size of those embryos facilitating microinjection by hand. The ability to use large nuclear families enables a degree of control of background genetic effects, with ample sample sizes achievable for downstream comparisons of successfully edited individuals with their unedited full-sibling counterparts. The ability to perform extensive 'phenotyping' is often also feasible, for example using well-developed disease challenge models to assess resistance to many viral and bacterial pathogens during early-life stages.

Finally, should favorable alleles for a target trait (e.g., disease resistance) be created or discovered, then there is potential for widespread dissemination of the improved germplasm for rapid impact via the aforementioned selective breeding programs. In parallel, high-quality, well-annotated reference genomes are available for most of the key species. A high-quality species-specific reference genome is essential for the effective design of target gRNAs with high specificity and minimum change of off-target editing.

Some practical reasons why genome editing has such potential for research and applications in aquaculture species are the ease of access to many thousands of externally fertilized embryos, and the large size of those embryos facilitating microinjection by hand.





Viral infections (and resistance to those infections) are high-priority target traits for in vitro studies using CRISPR/Cas9.

Applications of Genome Editing for Aquaculture Research and Production

Infectious diseases are one of the primary threats to sustainable aquaculture, with an estimated 40% of the total potential production lost per annum. Due to the formative stage of domestication of many aquaculture species, new selection and disease pressures in the farm environment may increase the possibility that standing genetic variation in farmed populations includes loci of major effect, which may represent potential 'low-hanging fruit' for genome editing to increase the frequency of the favorable allele. A well-known example of a major quantitative trait locus (QTL) affecting disease resistance is the case of infectious pancreatic necrosis virus (IPNV) in Atlantic salmon, in which a major QTL explains the majority of the genetic variation. Marker-assisted selection, which is based on the targeted use of molecular genetic markers linked to QTL, has been successfully applied to markedly reduce the impact of this disease. However, despite several QTL studies in aquaculture species and ample evidence for the heritability of disease resistance traits, only a handful of large-effect QTL have been detected, and most disease resistance and other production-relevant traits are underpinned by a polygenic genetic architecture.

The substantial opportunity for genetic improvement of disease resistance and other performance traits in aquaculture species, combined with initial success of in vivo genome-editing trials, opens exciting new avenues to improve aquaculture production and sustainability. There are three main categories by which genome-editing technology could be applied to make step changes in genetic improvement, and each requires different approaches to the underpinning research leading to discovery of functional alleles: (i) detecting, promoting, removing, or fixing targeted functional alleles at single or multiple QTL(s) segregating within current broodstock populations of a selective breeding program; (ii) targeted introgression-by-editing of favorable variants from different populations, strains, or species to introduce or improve novel traits in a population; and (iii) creating and utilizing *de novo* favorable alleles that are not known to exist elsewhere.

Fixing Alleles at Existing QTL

Detecting and utilizing causative variants for QTL affecting production traits is a fundamental goal of most animal breeding and genetics research, albeit with few success stories to date. Simulations have demonstrated that harnessing genome editing for favorable causative alleles at multiple QTLs as part of a breeding program, has the potential to expedite genetic gain compared with pedigree or genomic selection alone. However, a major challenge for the effective application of this approach is the successful identification of causative variation underpinning QTLs, particularly those of small effect. A challenge for polygenic traits is the need to edit multiple alleles simultaneously in the same broodstock animal(s) to achieve notable impact using this approach and, therefore, development and improvement of multiplex genome-editing approaches is required.

Introgression-by-Editing: Accessing Alleles from Different Strains or Species

One of the exciting possibilities of genome editing is to access genetic variation outside closed breeding populations, without the need for costly and time-consuming introgression programs, or in cases where introgression is impossible. It is common that a particular farm animal strain, or a closely related species, has a desirable characteristic. If the alleles responsible can be identified, then CRISPR technology potentially allows editing of the unfavorable allele in the target strain and/or species to correspond to the sequence of the favorable allele found in the related strain or species (i.e., introgression-by-editing). In other words, it offers new opportunities to bypass traditional introgression, thereby avoiding the downsides associated with linkage drag (e.g., negative effects on growth rate associated with introgressing alleles from wild strains), and it allows access to genetic variation in other strains and species that would not be possible using conventional selective-breeding methods.

From a pragmatic standpoint, the early applications of such introgression-by-editing approaches will need to hold promise for transformative impacts on production to justify the extensive research and development effort required. In Atlantic salmon, parasitic copepod sea lice (*Lepeophtheirus salmonis* in the Northern hemisphere and *Caligus rogercresseyi* in the Southern hemisphere) have a crippling impact on sustainable aquaculture, with an economic impact of over GBP £700 million (USD$ 880 million) per annum globally. A unique aspect of aquaculture is the proximity of farmed species to extant wild species and populations that may have desirable characteristics. For example, certain Pacific salmon species, such as Coho salmon *(Oncorhynchus kisutch)* and pink salmon *(Oncorhynchus gorbuscha)*, are largely resistant to sea lice and are able to mount a successful immune response against the parasite. It is plausible that there are key regulatory genes in the pathways underpinning differential resistance between the species that could be modified in Atlantic salmon to mimic the response to sea lice exhibited by the Coho salmon. This may be targeted editing of the coding sequence and/or modulation of the regulatory sequence to enhance or suppress the expression of these key host response genes. However, overall modification of expression may not achieve the desired effect.

Creating *de novo* Variants Based on Knowledge of the Trait

While genome editing based on existing genetic variation (either within the farmed strain, or via introgression-by-editing) gives rise to possibilities for major benefits in animal production, creating *de novo* favorable alleles (i.e., those that are distinct from any naturally occurring alleles, to the best of our knowledge) is another exciting avenue and has already resulted in potential solutions to animal production and welfare problems. In this approach, novel alleles can be created using CRISPR/Cas9 based on a priori knowledge of the biology of the trait of interest, or from genome-wide genetic perturbation approaches to identify candidate genes influencing the trait. An example of the former is the development of Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) resistance in pigs, where genome editing was used to knockout the *CD163* gene, resulting in a viable animal missing the entire receptor, or created a modified receptor by removing a specific exon and its associated protein domain. Similar approaches have been used in aquaculture, including modification of the *dnd* allele to induce sterility in Atlantic salmon and targeting the *mstn1* gene in several fish species to increase growth (Table 1). Alternatively, reverse genetic screens can facilitate the discovery of *de novo* alleles impacting traits of interest. Such genome-wide CRISPR/Cas9 screens can be performed in cell

The substantial opportunity for genetic improvement of disease resistance and other performance traits in aquaculture species, combined with initial success of in vivo genome-editing trials, opens exciting new avenues to improve aquaculture production and sustainability.

lines, and may provide *de novo* targets for downstream testing and potential editing in vivo, in particular for disease resistance traits (see below).

Pooled CRISPR Screens for Disease Resistance

A major bottleneck for aquaculture research is the lack of suitable, well-tested, and characterized cell lines for many species of interest. Indeed, for many crustacean and molluscan species, there are no well-established immortalized cell lines. Developing such platforms will make genome-wide screening approaches a more realistic possibility in major aquaculture species. Recently, medaka, carp, and chinook salmon cell lines were edited using CRISPR/Cas9. The embryonic chinook salmon CHSE-EC cell line is the only fish cell line with stable integration of Cas9, another important component of pooled CRISPR screens. Various aspects of in vitro genome editing need to be optimized in aquaculture species, including methods for the genomic integration of large inserts and optimization of which promoter to use to drive the expression of the gRNA in the different species and systems.

Viral infections (and resistance to those infections) are high-priority target traits for in vitro studies using CRISPR/Cas9, because the innate mechanisms of host response are usually cell-intrinsic and, therefore, amenable to interrogation in existing immortalized cell lines. Developing this technology would help facilitate an integration of large-scale genetic screens to inform the biology underpinning disease resistance and provide a pipeline of candidate alleles for application to commercial aquaculture breeding (Figure 1).

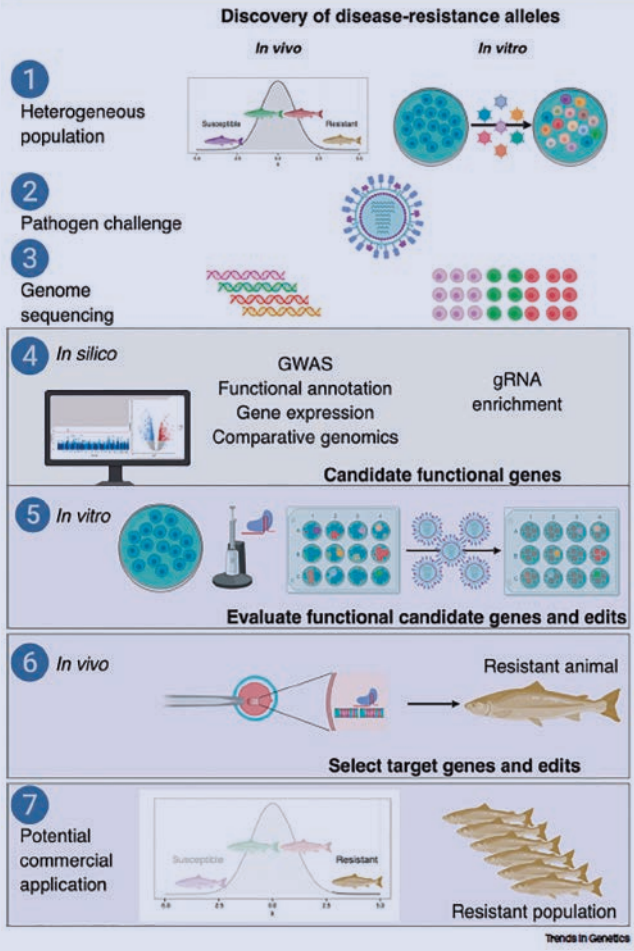
Factors Affecting Public and Regulatory Acceptance

Innovation in technology is essential to advance food production to address the increasing global demand. CRISPR/Cas9 technology has the exciting potential to contribute to the improved quantity, quality, and sustainability of seafood production globally. However, public and regulatory acceptance are key to its potential being realized. There is considerable debate about the definition of genetic modification (GM) and whether genome-editing approaches should be considered separately. If genome editing is considered separately, the different applications discussed earlier may be subject to different regulations. For example, genome editing animals could be created with just single base changes in their genome that correspond to existing polymorphisms within farmed and/or wild stocks. Alternatively, *de novo* alleles can be created that are absent in nature to the best of our knowledge (e.g., PRRSV resistance in pigs). The former may be more acceptable to the public and could feasibly be subjected to less stringent regulatory procedures. However, the ruling by the European Court of Justice that genome edited crops should be considered GM organisms is likely to hinder the commercial-scale application of genome editing in EU farmed species. Nonetheless, it is noteworthy that a GM salmon (the AquaBounty salmon with a transgenic growth hormone gene) has been approved

A major bottleneck for aquaculture research is the lack of suitable, well-tested, and characterized cell lines for many species of interest, such as crustaceans and mollusks.

Figure 1

Combining *In Vivo* and *In Vitro* Screening Approaches to Identify, Test, and Apply Disease Resistance Alleles in Aquaculture Species



for human consumption by the FDA and the Canadian Food Inspection Agency. Furthermore, a line of tilapia derived from genome editing by the same company has been exempted from GM regulation in Argentina. It is clear there will be longstanding uncertainty about the regulation of edited animals, and the process will vary considerably in different countries. Therefore, extensive engagement with the public and other stakeholders to facilitate knowledge-driven decisions about benefits and risks of the technologies is key. From a public acceptance standpoint, it is important to consider the nature of the target traits, and whether the potential benefits stretch beyond sustainable production and profit. For example, traits such as sterility also have downstream benefits for the environment and wild stocks, and traits such as disease resistance have substantial concurrent benefits for animal welfare.

This article was adapted from: Remi L. Gratacap, Anna Wargelius, Rolf Brudvik Edvardsen, and Ross D. Houston. Potential of Genome Editing to Improve Aquaculture Breeding and Production. Trends in Genetics, September 2019, Vol. 35, No. 9. In adherence with open access conditions outlined at https://creativecommons.org/licenses/by/4.0/

Enhancing aquaponics management with IoT-based Predictive Analytics for efficient information utilization

*By: Divas Karimanzira, Thomas Rauschenbach**

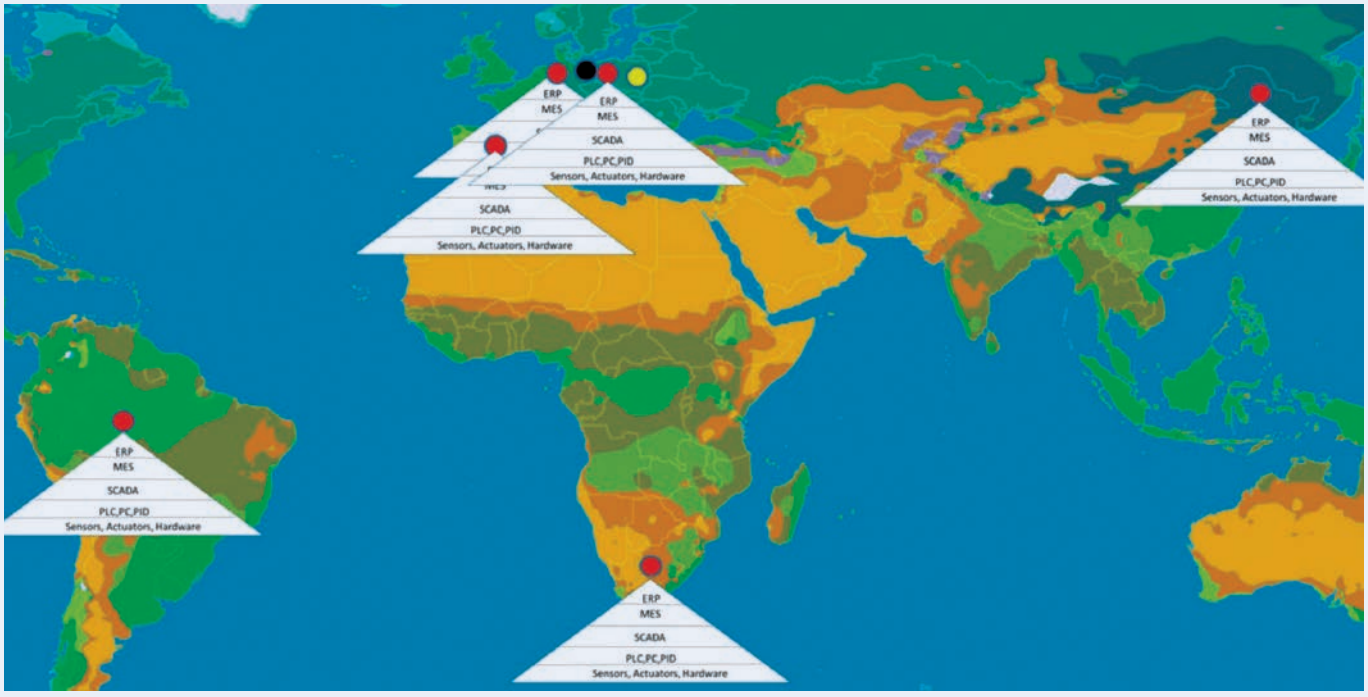
Modern aquaponic systems can be highly successful, but they require intensive monitoring, control and management.

The Automation Pyramid (AP) with its layers of Supervisory Control and Data Acquisition (SCADA), Enterprise Resource Planning (ERP) and Manufacturing Execution System (MES) is widely applied for process control. With cloud-based Internet of Things (IoT)-based Predictive Analytics at the fore marsh, it is worth finding out if IoT will make these technologies obsolete, or they can work together to gain more beneficial results. In this paper, we will discuss the enhancement of SCADA, ERP and MES with IoT in aquaponics and likewise how IoT-based Predictive Analytics can help to get more out of it.

Consider the problem in Fig. 1 for example, where the red dots represent aquaponic sites owned by an enterprise or a consortium with its own Automation Pyramid (AP). The classical automation pyramid does not suffice to intelligently and efficiently manage the complete system. Today's double recirculation aquaponics approach is a complex integrated production operation that encompasses recirculating aquaculture systems and hydroponics to produce fish and plants in a closed-loop system. The fish produce nutrient-rich effluent that is used as fertilizer for

Fig. 1

Problem illustration. Red dots: aquaponics sites. Black dot: aquaponics enterprise. Yellow dots: aquaponics hardware and software installer and service.



the plants. Fish waste is broken down by bacteria into dissolved nutrients that plants then utilize to grow in the hydroponic component. This nutrient removal not only improves water quality for the fish but also decreases overall water consumption by limiting the amount released as effluent.

Several processes such as mechanical and biological filtering, pumping, heating etc. are involved in the system. Evaporated water from the plant sector is regained via cooling traps and reintegrated into the fish tanks. The double recirculation aquaponics technology allows the setting up of optimum conditions both in the fish and in the plant units, thus ensuring high productivity and enhancing resource efficiency.

Aquaponics can be scaled from "mini" units for hobbyists to commercial production facilities. Further, the market increasingly demands individualized products. Product life cycles are getting shorter and average lot sizes are getting smaller. Considering this, cost-efficient production in a globalized and resource limited environment requires a highly flexible (IT-) infrastructure that also works well in cross-enterprise networks. All these features require new capabilities in system control, diagnosis for maintenance, and management. Once stabilized, the system should be able to run day and night with less human intervention. For the installation companies, flexible adaptation to special aquaponics configurations

as well as specific parameterization of the individual modules is a prerequisite. The diagnosis and maintenance of such systems requires an extensive knowledge of aquaponics. Therefore, a direct support for the aquaponics operator is indispensable, especially in the case of errors. In most cases the direct support is not on site.

Traditionally, systems such as aquaponics are managed using the automation pyramid as shown in Fig. 2.

The automation pyramid has five layers which can be divided into two distinct sections: production process at the bottom (i.e. sensors, actuators, hardware, Programmable Logic Controls (PLCs) etc.), while the enterprise resource planning systems for business management (i.e. the Supervisory Control and Data Acquisition (SCADA) network, Manufacturing Execution System (MES) and Enterprise Resources Planning (ERP)) comprise the top level. The least amount of data is featured at the top and as one goes down the amount of data increases, as the amount of information increases. At the bottom, where the sensors and actuators are, information is sent to the control level where they control the production process. The only data sent between the control level to the HMI level is that which the operator needs to be transferred, as such it is less frequently transferred and in bigger packets.

Fig. 2

The automation system pyramid.

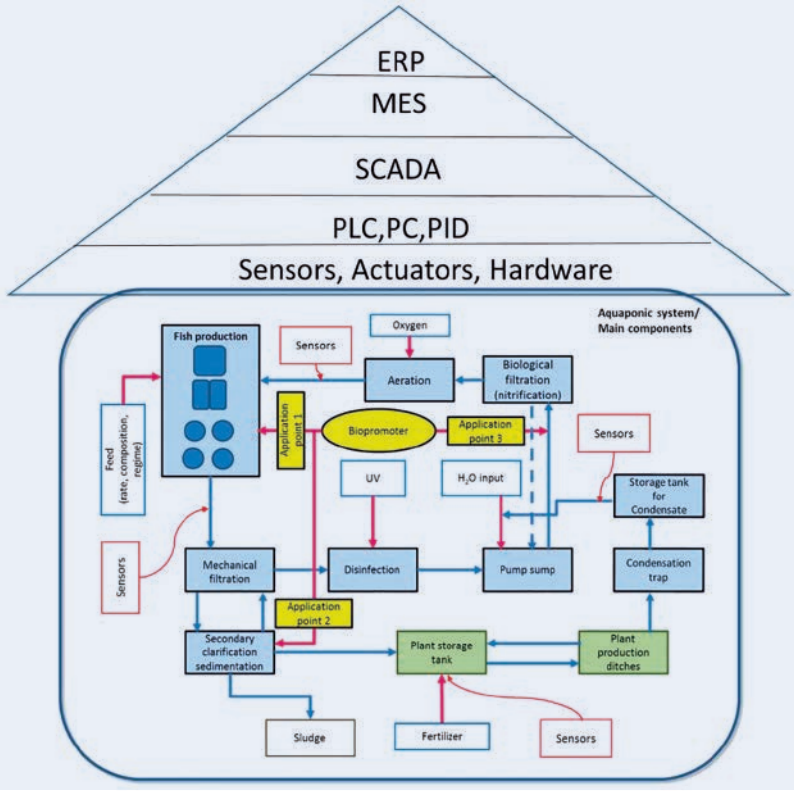
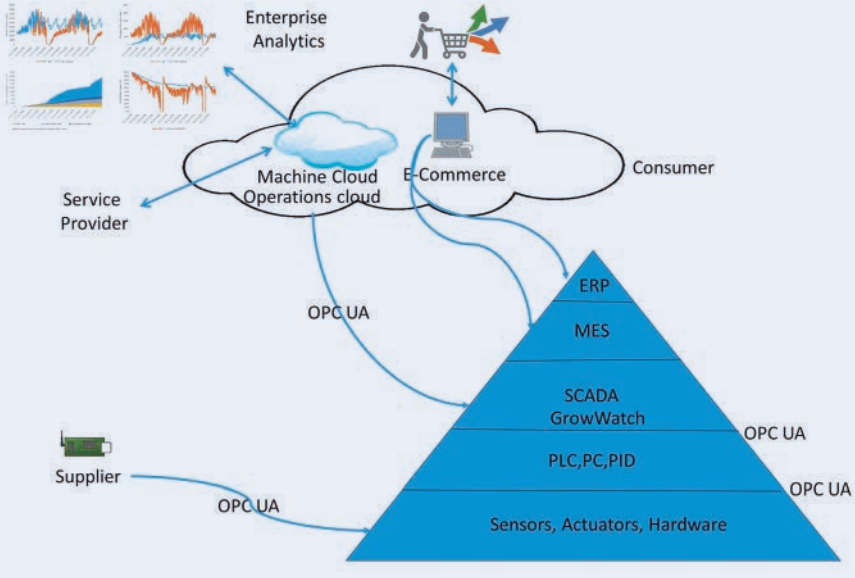


Fig. 3

The future for aquaponics process automation systems with IoT.



> **The double recirculation aquaponics** technology allows the setting up of optimum conditions both in the fish and in the plant units, thus ensuring high productivity and enhancing resource efficiency.

The classical automation pyramid paradigm is due to its strict well defined hierarchic separation in such a way that information flows upwards from devices to enterprise via levels of control, supervision and management. By analyzing the features of

Cost-efficient production in a globalized and resource limited environment requires a highly flexible (IT-) infrastructure that also works well in cross-enterprise networks.

the individual layers the enhancement which can be created by IoT can be seen. The connecting of physical things to the internet makes it possible to access remote sensor data and control the physical world from a distance.

Methodology

The main objective of the cloud-based IoT-based Predictive Analytics enabled Aquaponics is to bring the world of business data and the world of automation data much closer together in order to reduce the number of media breaks and the number of isolated aquaponics applications. In addition, the combined data will be the basis for completely new insights. After analyzing the classical automation pyramid in Fig. 1, a new structure is obtained as in Fig. 3.

SCADA is eminently a tool for supervisors, which is meant to help to make decisions for the production line, but it does not give a holistic view of the production floor to make top decisions. The inability of SCADA systems to connect to legacy computing systems, computer techniques with disparate communication protocols, has generated the demand for federated data storage of different data sets. Cloud-based IoT-based Predictive Analytics can enhance SCADA by providing real-time as well as analysis for available historical data which is the foundation for predictive analytics and informed decision-making.

For an enterprise to really flourish, its personnel, data and processes should be connected in a smart way. ERP provides a back office for all data within an enterprise as well as an integrated and continuously update-to-date view of key business activities. However, without data analytics and the adaptability provided by cloud-based IoT, ERP is only a large chunk of transaction data. While ERP gives a view of the current situation, IoT can provide insights into the root causes and grounds for actions to proceed forward. A large part of activities and processes can be automated to reduce trivial and repeatedly accomplished manual work such as the manual sensor reading done in most aquaponics.

MES provides a view of the production floor activity to the higher level decision makers, e.g., managers and provides a strong foundation for IoT application. One important feature of MES has always been that it uses external smart devices to collect data and processes the data to the system and controllers that MES can communicate with. With cloud-based IoT and the vast amount of data IoT pulls in the ecosystem, MES can become more flexible, easily tailored to suit different requirements of an enterprise. Non-cloud MES, without IoT, makes it very difficult for aquaponics operators to benchmark efficiency and productivity across different plants of the same group or other competitors. Connected to cloud-based IoT, the aquaponics management system will be able to communicate and work with different types of media devices such as mobile phones.

Use Case

Consider the aquaponics systems from the INAPRO project. The INAPRO partners have realized four INAPRO demonstration sites in Europe and one in China (Fig. 4). In general, the demonstration sites consist of a fish farm with the recirculating aquaculture system (RAS). Different hybrid energy systems can be utilized according to the geological location, e.g. combined heat and power plant (CHP), Photovoltaic etc. The aquaponics are of different scale, e.g. one has a total area of 573 m^2 and the site is expected to produce around 24 tons of African Catfish and 11 tons of tomatoes per year. Further, there is a fish and tomato manufacture at only one site. A control and management platform has been implemented at all the sites according to architecture of the classical automation pyramid.

For this platform several IoT services can be provided which include energy management, monitoring based on GrowWatch, diag-

Fig. 4

INAPRO aquaponics demonstration sites (Source: www.inapro.eu).

Table 1

Scenario specification and analysis.

Scenario	BF	MF	Stocking Density [g/liter]	Net Return [cents/liter/day]	Days to Harvest
Base	**1**	**1**	**0.13**	**0.034**	**265**
1	0.95	1.0	0.13	−12%	+14
2	0.95	0.5	0.13	+44%	+20
3	0.80	1.0	0.13	−80%	+86
4	0.85	0.5	0.07	−44%	+55
5	0.85	0.5	0.13	−70%	+77

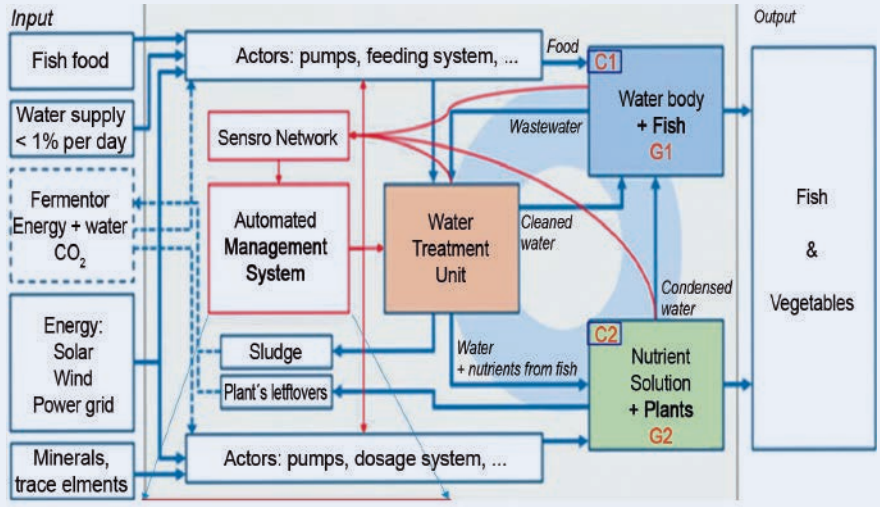
The base scenario in bold represent the ideal situation of the aquaponics system.

The classical automation pyramid paradigm is due to its strict well defined hierarchic separation in such a way that information flows upwards from devices to enterprise via levels of control, supervision and management.

nostics and maintenance assistance, econometric services and for the manufacturing component, a logistics tracking service to understand how the production is moving and being stored in real-time cold chain processes. Through an application program interface (API) made with MongoDB, the system tracks the status of various sensors and relays, e.g., water level in both, aquaculture and hydroponic tanks, pH of water temperature of water, turbidity/TDS of water, flow rate, and Greenhouse ambient conditions. The remote user can access the data being generated from this system using an interface. Like other distributed systems, this requires mapping each signal in the database once it has been connected. This is then visualized using a web front end which has a similar visualization as the physical system (Fig. 5). This can also be sent to a broadcast-like service such as Twitter for example to inform customers about the harvest dates.

Fig. 5

Control and aquaponic system material flow.



Enterprise: economic analysis service

As an example, the econometric service will be elaborated briefly here. For this module the platform collects data on fish size, water quality, feeding patterns, energy use and supply source and weather conditions using mobile devices, sensors and automated feeders. Combined with other data, the algorithms go to work to provide recommendations such as remote maintenance, feeding management strategies and optimal harvest dates.

The main objective of the cloud-based IoT-based Predictive Analytics enabled Aquaponics is to bring the world of business data and the world of automation data much closer together in order to reduce the number of media breaks and the number of isolated aquaponics applications.

With all the information entering the operation cloud from the SCADA, and other sources, models are adaptively used to predict the growth of the fish and the plants, food ration size, fresh water required as well as the yield and estimated harvest dates. Information from other aquaponics site is used to make the models robust. For example, the mechanical (MF) and the biological filter efficiency (BF) as well as the initial stocking density (S0) can be varied and every time the system re-optimized to get a 700 g tilapia. With changes in the biological filter efficiency more or less Ammonia is nitrified which leads to another growth rate. Thus, with a better filtering technique larger ration sizes and higher protein content of the feed are possible, the raising period is thus shorter and the profit greater as can be seen in the scenario analysis in Table 1.

Table 1 shows that a 700 g tilapia can be produced in 265 days with net return of 0.034 cents/liter/day using a 20 percent dietary protein feed. Scenarios 1–4 show the increase in days to harvest and declination in net return if the efficiency of the wastewater treatment units decreases with effects of the biological filter being predominant. In

Fig. 6

Fish growth in different tanks, stocking density and control parameters.

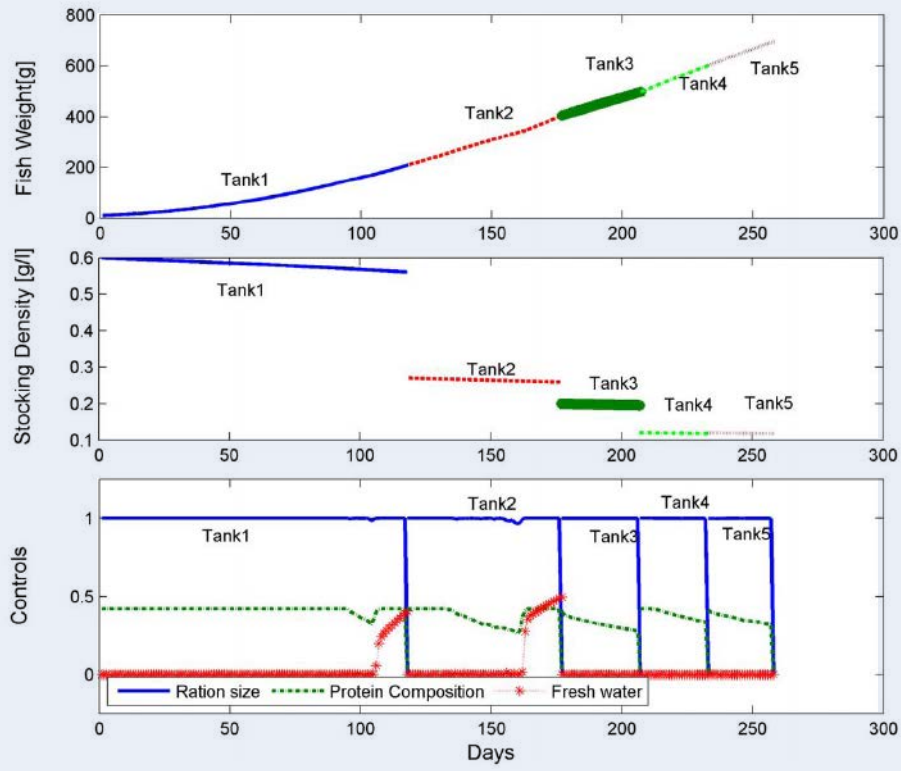


Fig. 7

Nutrient concentration/Fresh water supply.

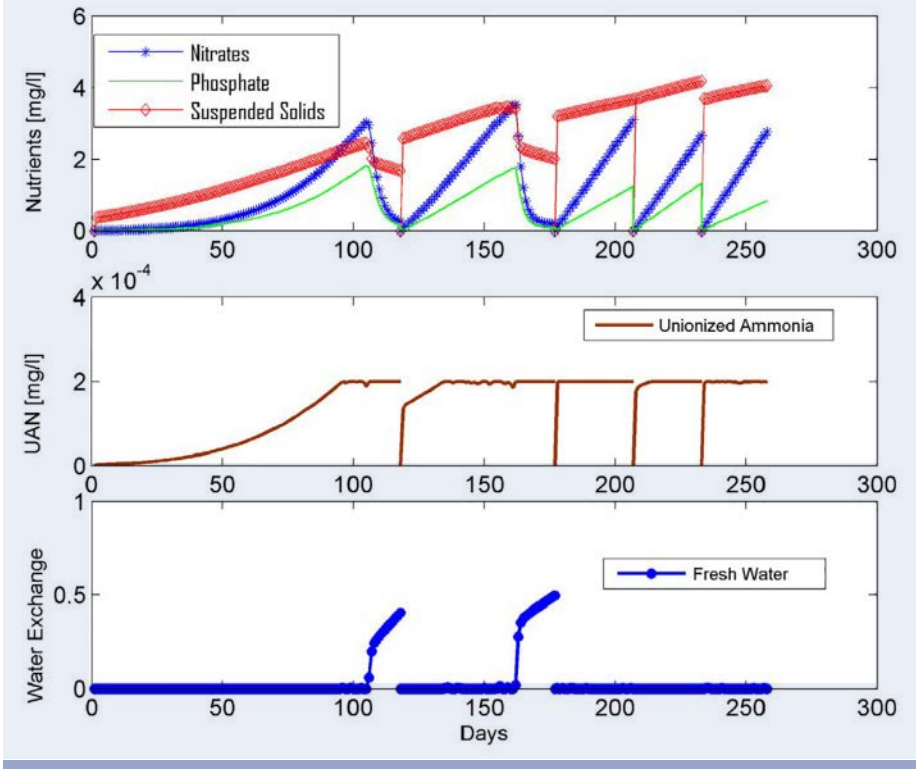


Table 2

Remote assist rules.

Nr.	Condition	Conclusion	Priority	Recommended action
1	$O2_{cM}$–$O2_{cBi} > 2$	The O_2 sensor from the tank i is faulty or the tank aeration is damaged	High	Switch emergency aerator; Check and eventually calibrate the sensor. Where $O2_{cM}$ is the maximum value of the oxygen concentration, $O2_{cBi}$ is the current value of the oxygen concentration.
2	$NO_{3c} > 100$ mg/l	**Fish tank i Nutrient controller failure**		**Check controller**
3	$NH4_{cC}$–$NH4_{mFB} < 0.5$ & $NH4_{cC}$–$NH4_{mFB} > 0$	Faulty evolution of the nitrification process	High	Check the biofilter operation (if the liquid flux is uniformly distributed on the biofilter section), where $NH4_{cC}$ is the current value of the ammonium concentration, $NH4_{mFB}$ is the ammonium concentration measured in the last hour inside the biological filter.
4	$pH_c \leq 6,5$	The pH is less than the admissible limit	Normal	Check if there is alkaline agent in the control loop AND increase the water recirculating flow OR increase the water refresh flow, where pH_c is the current value of pH.
5	{$GMI_i \in$ (50–700 g)} AND {SGR < 3%}	**The fish biomass in the tank i is not developing normal**	Normal	**Check the technological conditions AND/OR the food rate should be adapted, where GMI_i is the average weight of the individual in the tank i, SGR is the specific growth rate, $SGR_k = 100\ (\ln B_k - \ln B_{k-1})/t$, where t is the time between the last two weighing.**

the simulation attempt, tilapia production was staggered in five rearing tanks so that one rearing tank is harvested every 6 weeks after a year. Fish are moved from one rearing to the next after a certain period. Figs. 6 and 7 show as an example a detailed description of the optimization for which the biological filter and mechanical filter efficiencies of the system were set to 0.95 and 0.5, respectively. Both the ration quantity (R) as well as the protein content (D) were always as high as possible, but as soon as the ammonia concentration approached the critical limit of 0.2 mg/l, these values went down again. This is attributed to the relatively expensive water price of 2.27 Eur/l and the ammonia concentration is determined significantly by the amount of the protein consumed by the fish. Growth will thus be retarded but the profit is, however, greater than that of a high water exchange rate.

Installer: monitoring and remote service assistance

Another example service for use of IoT in the system is a monitoring and remote service assistance system. It uses historical failure data in the system and expert knowledge to remotely conduct a diagnosis of the system and produce some recommendations for service or automatically intervene for example in the case of aeration failure. Firstly, a list of potential problem areas and water quality parameters are compiled according to their relative importance and the required response time each will require. Life support priorities in aquaculture start with water, followed by adequate levels of dissolved oxygen. In response times parameters which require fast response time – minutes include electrical power, water level in tank, dissolved oxygen - aeration system/ oxygen system, moderate response time –hours include temperature, carbon dioxide and normally slowly changing – days include pH, alkalinity, ammonia- nitrogen nitrite nitrogen and nitrate-nitrogen. A fuzzy system for diagnosis is developed by rule extraction from collected data, i.e. data from the public cloud and the demonstration sites.

Based on variation of the monitored parameters, alerts and solution recommendations will be generated if the reading goes beyond the system's tolerances. Some selected rules of the system are shown in Table 2. The inference engine uses a forward-chaining strategy, based on the previous production rules and the reasoning is of deductive type, from the facts to the goal. Figures 8 and 9 show the results of this IoT service in automatic mode, rule 5 and 2, respectively. Alarms and corrective measures are triggered as can be seen in the Figures, for example on 04.11 in Fig. 8 were nitrate issues (in this case a controller outage was simulated), and in Fig. 9, the fish growth is predicted to be slower than expected.

Challenges

The benefits of deploying cloud-based IoT for flexible aquaponics have been shown but there exist some challenges which should not be neglected and need to be addressed. The first challenge "connectivity" has been already mentioned in the text. The lack of IoT standards causes less interoperability and all sorts of automation devices from different brands or even from one single brand with diverse protocols are being used which are incompatible at the data layer.

Another important element that should not be underestimated is

The benefits of deploying cloud-based IoT for flexible aquaponics have been shown but there exist some challenges which should not be neglected and need to be addressed, such as: connectivity, cost of implementation, adequate know-how, reliable electricity and mobile internet and security issues.

the cost of implementing the IoT solutions (initial costs, cost of IoT enabled sensors is relatively high, buying mobile data for real-time monitoring and storage to the cloud or remote centers for analysis). As an additional cost to already existing running systems, it is often perceived as overwhelming. Therefore, the choice of IoT platform should be based on the determinants such as ease of use and training and ready adaptability.

Further issues involve the lack of adequate know-how: Most aquaponic owners or operators are not IT educated. They can have all the

Fig. 8

Alarm nitrate concentration.

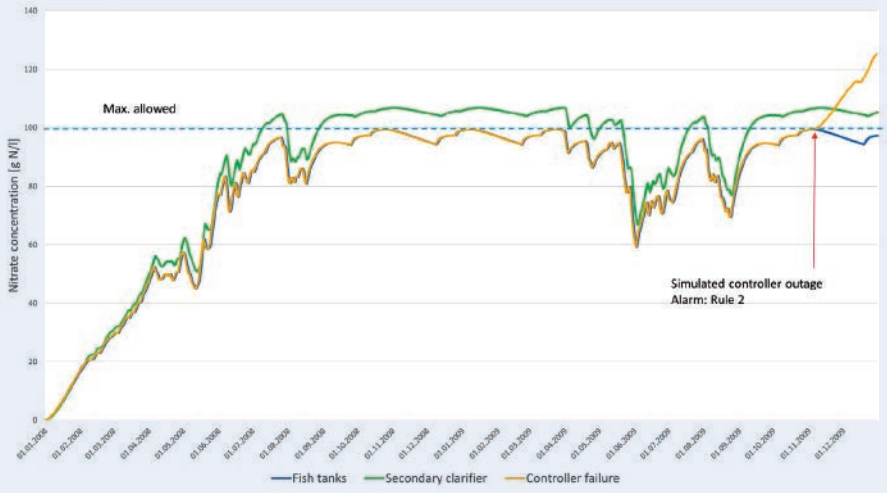
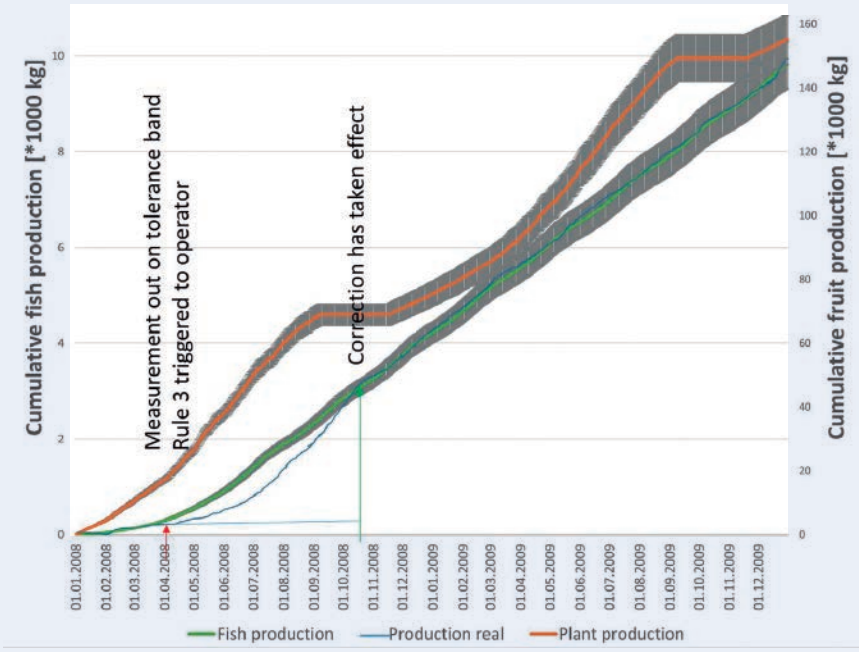


Fig. 9

Alarm fish growth rate.



information but cannot utilize it. More serious is also that in many places there is not enough skilled man power to deploy the IoT technology at its fullest. Another important factor is that the availability of reliable electricity and mobile internet to the aquaponics facilities is required. Last but not least, the well-known security issues. IoT devices communicate automatically with each other. In the absence of a secure and properly encrypted network, the adoption of IoT could lead to brand new security challenges and vulnerabilities.

Conclusions

An enhancement of the automation pyramid for an aquaponics system with cloud-based IoT Predictive Analytics was presented. It helps to automate real-time data collection and analysis, i.e., continually monitor and analyze the conditions of fish and plants at different sites, take automated corrective measures to balance the deviation based on ideal data from experts to increase revenue and reduce risks of false data and reduce manual human interactions. Various parameters can be viewed in real time and collected from systems (Temperature, pH, soil moisture, O2 content etc.). The operator connected to the operations cloud can control the various aquaponics system components such as heaters, lights and fish feeders, or change parameters of filtering equipment according to his/her system intervention rights, remotely. All the collected data can be analyzed to get an insight into the growth as well as the energy/systems utilizations, and can be used to make the models for Predictive Analytics increasingly robust.

IoT systems can produce unprecedented improvements in many areas of aquaponics system operations but require MES, ERP and SCADA to leverage their true potential and benefits. In the future, the services need to be integrated in to the online system for testing and we shall investigate the monetary benefits of IoT in aquaponics (installation and running costs) and issues of system/data security and sovereignty.

IoT systems can produce unprecedented improvements in many areas of aquaponics system operations but require MES, ERP and SCADA to leverage their true potential and benefits.

Africa Report: Recent News and Events

By: Staff / Aquaculture Magazine

International Fund for Agricultural Development (IFAD), the Republic of Kenya, and the country's aquaculture sector

In June 2018, IFAD announced that more than 35,000 rural households in Kenya would soon be eating better and earning more money thanks to a financial agreement signed by the Fund and the Republic of Kenya in support of the country's aquaculture sector. The agreement was to provide financial support to the Aquaculture Business Development Programme and related activities designed to promote fish production in an economically and environmentally sustainable manner in 15 target counties.

Courtesy USAID Southern Africa.

The total cost of the programme was reported as US$143.3 million, including a $40.0 million loan from IFAD. The programme was structured to be co-financed by the FAO of the United Nations ($400,000), the Government of Kenya ($31.4 million) and by the beneficiaries themselves ($43.6 million). The financing gap of $27.9 million will be covered from future IFAD financing rounds or by potential co-financing partners.

The financial agreement, signed in Rome by Gilbert F. Houngbo, President of IFAD, and Harriet M. Nduma, Charge d'affaires a.i. of the Embassy of the Republic of Kenya, will go a long way to improving food security and reducing poverty in rural areas where 75 percent of Kenyans live.

The programme's goals are to assist thousands of smallholder farmers in becoming profitable fish producers or village-level providers of support services within value chains in counties that already have aquaculture-related infrastructure, adequate water resources, marketing potential, and high poverty rates.

The proposed approach blends public- and private-sector investments in the aquaculture value chain with community-wide initiatives that promote good nutrition and food security through education and better access to affordable foods.

The new programme will pay special attention to women and youth. For example, while women are engaged in most areas of fish value chains, recent studies show that men receive a larger share of the benefits. Youth unemployment is also very high in rural areas and it's hoped the new programme will slow outward migration.

Since 1979, IFAD has financed 18 rural development programmes and projects in Kenya at a total cost of $819.3 million, with an IFAD investment of $376.3 million. These projects have directly benefitted more than 4.3 million rural households.

Fifteen county governments have been challenged to invest in aquaculture and build internal markets for fish to sustain an eight-year aquaculture project funded by an international agency to the tune of Sh15 billion.

The International Fund for Agricultural Development (IFAD) is funding the project which is being implemented in top aquaculture producing counties including Meru, Th-

araka-Nithi, Embu, Isiolo, Laikipia, Kirinyaga and Nyeri. Each county has been allocated at least Sh1 billion.

Fisheries Principal Secretary Prof Micheni Ntiba said the project will face serious challenges without a reliable local market, and urged the county governments to partner with private sector in implementing the plan. The PS said an aquaculture project that started in 2009 collapsed, noting that the current initiative is meant to revive it.

Courtesy West Africa Agricultural Productivity Program.

African Great Lakes workshop scheduled

The African Center for Aquatic Research and Education (ACARE) and its partners are holding a workshop: Strengthening Capacity in Research, Policy and Management through Development of a Network of African Great Lakes Basin Stakeholders (AGL Stakeholder Network Workshop) in Entebbe, Uganda on November 5-7, 2019. This is a rescheduling of a workshop that was planned to be held in Malawi in August.

The workshop is the first step of creating a long-term, collaborative process with global freshwater experts in order to address the biggest challenges facing the African Great Lakes. To do this, ACARE is developing a stakeholder network of lake-specific Advisory Groups to guide future research. Experts from Africa, Europe, and North America will be in attendance to provide guidance, structure, and ideas on how to move forward as a community on the African Great Lakes.

The motivation for this process comes from decades of disparate research approaches that have often lacked coordination to aggregate past or current research data. The outcome has often been weak data sets inadequate to positively inform policies and management. Without a harmonized approach, the African Great Lakes community often lacks the ability to prioritize research to tackle the biggest problems.

To address the challenges on the African Great Lakes, ACARE and its partners are creating lake-specific advisory groups to harmonize research efforts and garner the resources necessary to conduct this research. The overall purpose for this approach is to ensure strong, robust science with long-term, coordinated data to help influence positive changes in freshwater policy and management. Advisory groups will work towards collaborative efforts including:

- Aquaculture
- Education of Africa's next generation of freshwater experts
- Long-term, base-line monitoring

More information about the workshop, including a draft agenda and registration information, can be found at www.agl-acare.org/2019-workshop

Lagos scales up fish production

Lagos State Government says it is implementing programmes and projects that would upscale fish production and harness the enormous economic opportunities available in the agricultural value chains in the State.

The Permanent Secretary, Ministry of Agriculture, Dr. Olayiwole Onasanya shared this news in Lagos last month at the closing ceremony of the 15th Annual Executive Weekend Training on Investment Opportunities in Fish Farming organised by his Ministry, noting that these programmers and projects have significantly increased fish production, created jobs and stimulated economic activities in the State.

He identified the programmes and projects to include fish farm estates development; fish cage culture system; training/capacity building programmes; agricultural value chains empowerment and artisanal fisheries development among others.

"Lagos State with a population of 22 million people is structured to have a fish demand of 374,000 tons per annum as against the current fish production figure of 155,262 tons per annum. The deficit in supply is being met through importation which gulps enormous foreign exchange which the Federal Ministry of Agriculture has estimated at a total sum of USD 1 billion," the Permanent Secretary explained.

According to him, very wide investment opportunities exist within the Agricultural Value Chain both within the country and internationally, especially now that there is the need to increase export of non-oil commodities in order to earn foreign exchange for the financing of the nation's economy.

Courtesy Worldfish.

African catfish courtesy USAID.

Mukasa-Farms Courtesy Technologies for African Agricultural Transformation.

Onasanya explained that the 4-day Executive Weekend Training Programme has been carefully structured to equip participants that include aspiring fish farmers and retiring executives, both in the private and public sectors among others with relevant knowledge of best practices in aquaculture. The programme broadens participants' practical experience in fish juvenile and feed production as well as exposes them to investment opportunities available in fish farming.

"The training programme has a special focus on the overview of Fisheries development in Lagos State, Fish Culture Systems and Management, Water Quality Management & Disease Control, Prospects for Cage and Pen Culture System in Lagos State, Hatchery Management and Fingerling Production, Fish Feed Formulation and Nutrition, Fish Farming Insurance and Fish Preservation, Processing, Packaging, Marketing and Export Potentials," he added.

Onasanya urged the 43 participants to make good use of the lessons learnt during their training programme as well as to leverage available government extension services towards successful fish farming businesses. Since the commencement of the training programme in 2005, no fewer than 912 people have been trained which has contributed to the increased investments in the fish farming value chain in the State.

New online platform introduced to promote fish farming in Tanzania

An online platform called Jamvi has been introduced with the hope of promoting investments in aquaculture. The founder of Jamvi, Shadrack Kamfya, said a fishpond would be established in Bagamoyo with a production capacity of some 10,000 fish. Kamfya indicated that the company was collaborating with a fish consultancy firm. The stated goal would be to raise funds, create financial freedom and encourage rural empowerment.

Mr. Kamfya explained that "Anyone who wants to join our platform can sign on through internet and social media. After that, he/she will be required to invest a maximum capital of Sh1 million (USD 435) to Sh50,000 (USD 21.75)." He went on to state that registration had already begun through the online platform for persons interested in investing in a tilapia or catfish farm. "So far the registration process is going on well" he said. "We have at least 30 people registered and before the end of this month we expect to reach 200 people through an online system."

"By investing in fish farming, farmers contribute to food security" Kamfya continued. "We encourage people to invest in fish farming to fill the gap" referring to the shortfall in fisheries products that plagues Tanzania. The business hopes to attract $30,000 in the next 18 months in order to produce some 10 tons of tilapia and catfish. Mr. Obey Assery, Director of Policy and Planning in the Ministry of Agriculture, indicated that the platform initiative would enable a number of young people to venture into fish farming.

Latin America Report: Recent News and Events

First company to be granted with import license for tilapia genetic material to Colombia

Benchmark's Spring Genetics®, in a multilateral collaboration with the United States Department of Agriculture – Animal and Plant Health Inspection Service (USDA-APHIS), the Federación Colombiana de Acuicultura (FEDEACUA), and Acuacultivos El Guajaro were successful at completing all processes to obtain, for the first time in decades, a license to import greatly needed new tilapia genetic material to the country. Spring Tilapia®, brand name of the tilapia strain provided by Spring Genetics, has gone through 8 generations of selection at a breeding nucleus in Miami. Selection has focused on key traits such as fast growth, survivability and yield, and more recently, advanced genomic selection for resistance to *Streptococcus iniae* and *S. agalactiae*.

The tilapia genetics that will be available in the country, along with high biosecurity and continuous health surveillance at the breeding nucleus, will provide a significant opportunity for the Colombian tilapia industry to improve productivity and sustainability in their businesses.

First shipment with new Import protocol.

The first shipment of genetic material to Acuacultivos el Guajaro, Spring Genetics®' distributor for the Caribbean Region, began at the end of September. Ongoing negotiations with other Colombian companies are being held to secure a wider national reach. Spring Tilapia fingerlings will be commercially available in Colombia in 2020.

Expertise and Technology transfer.

With a nucleus in Florida, USA, Spring Genetics' breeding program is designed and supervised by its sister company, Norwegian based Akvaforsk Genetics (AFGC), a leading provider of genetic improvement services to aquaculture industries worldwide. AFGC has extensive experience from more than 15 large scale selection programs covering 15 species in 25 countries across Europe, Asia and the Americas.

Upcoming event: LACQUA19, updated information and details

SPECIAL SESSIONS During the upcoming congress a number of sponsored special sessions will take place, including "Ingredients for Aquafeed" (DSM), "Functional Ingredients for Aquafeed" (JEFO Nutrition and VYMISA), "Tilapia Health" (Merck), and "Innovation in Shrimp Farming" (Biomar). Additionally, there will be an industry forum for producers, where international and regional companies and entities will participate, sharing important information on the business of aquaculture.

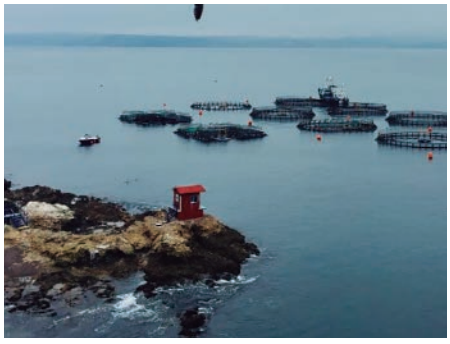
25 YEARS
WORLD AQUACULTURE SOCIETY
LATIN AMERICAN & CARIBBEAN CHAPTER

COMMERCIAL EXHIBIT The LACQUA19 is presented as a business opportunity for the sector, including commercial exhibits, with the presence of national and foreign companies representing the entire aquaculture value and supply chains. The organizers are pleased to confirm the participation of companies such as Jefo, VYMISA, Zinpro, Merck, Biomar, DSM, Intermas, Prilabsa, Kytola Instruments, Grupo Rolan, Zeigler, Darling, Aker Biomarine, Solacua, Faivre, Bayer, Tectron, Igusol, Feed Pro, Technoaqua, Flint Hill Resources, Willfort Aquaculture, Calitri Techonology, K-Nikom, Reed Mariculture, Magic Valley, Wenger, ESE Intec, and Grupo Trisan.

More information about this event can be found at: https://www.was.org/meeting/code/lacqua19

México has been designated to preside over the 11th meeting of the FAO'S Aquaculture Subcommittee, which will be held in the country in 2021

In the latest meeting of the FAO's aquaculture subcommittee held in Trondheim, Norway Mr. Giovanni Fiore Amaral, representative of Mexico, was elected as president for the next meeting, which will also be held in his country. To occupy the positions of first to fifth vice-presidents, Indonesia, South Africa, Fiji and Belgium were elected, respectively.



The Mexican delegation, present at the 10th meeting where the election took place, expressed that: "Mexico recognizes that public policies for fisheries and aquaculture, as well as their continuous improvement, must be based on existing tools such as the Code of Conduct for Responsible Fisheries, the Sustainable Development Objectives, and a holistic approach to aquaculture development and the blue revolution, among others. This is applicable to national legislation and international efforts being made by organizations such as the World Organization for Animal Health (OIE)."

In the 11th meeting, to be hosted by Mexico in 2021, the organization will include a forum and discussion panels oriented to dialogue and technical advice between FAO's Subcommittee of Fisheries and FAO's Subcommittee of Aquaculture.

USSEC held the first feed formulation seminar and workshop in Latin America to encourage use of the IAFFD

The aquaculture feed industry is made up of a multitude of larger and smaller feed manufacturers with very different scientific and technical capabilities and logistical and financial resources. The large number of aquatic species and life stages cultivated, the diversity of production systems used and the broad number of feed ingredients used in the production of feed combine to create a challenging environment for aquaculture feed formulators around the world.

The International Aquaculture Feed Formulation Database (IAFFD), previously known as the Asian Aquaculture Feed Formulation Database (AAFFD), is an open access, free of charge, database that answers some important needs of this industry. The IAFFD was developed by a consortium comprised of the University of Guelph's Fish Nutrition Research Laboratory (UG-FNRL Guelph, ON, Canada) and Seafood Consulting Associates (Bangkok, Thailand), with the support of the United States Soybean Export Council (USSEC), MITACS (Canada) and the Maximizing Agricultural Revenue through Knowledge, Enterprise Development and Trade (MARKET) Project, an initiative funded by the United States Agency for International Development (USAID).

Around 40 specialists from different Latin American countries attended this first seminar, which was held during August in Guadalajara, Mexico. The distribution of this free tool and related training to nutritionists and aquaculture feed manufacturers in Latin America responds to the effort put into the development of the data base during the last four years. Its dissemination, starting now in Latin American countries, should contribute greatly to the intensive development of cost-effective aquaculture feeds.

The IAFFD is comprised of two major modules: 1) the Feed Ingredient Composition Database (FICD) containing detailed information on the chemical composition and nutritional value of more than 500 ingredients, and 2) the Aquaculture Species Nutritional Specifications Database (ASNS) including nutrient specifications for over 30 species, or groups of species, that are commercially important in Asia and elsewhere.

Data in ASNS is derived largely from a nutritional modeling effort that is built on the standardized compilation, integration, and analysis of available scientific and technical data. Data in the FICD comes from the compilation of information from a variety of documents and databases on the chemical composition and nutritive value of about 400 feed ingredients that can potentially be used in aquaculture feeds.

All the data contained in this database are guidelines. These guidelines are intended to assist international aquaculture feed manufacturers in making informed decisions regarding the formulation of feeds for different species at different life stages or different weight ranges. The IAFFD is a reference tool and not a substitute for the research, analyses and due diligence that a feed manufacturer should carry out. The tool and all available information on the data base can be accessed freely at: www.iaffd.com . Workshops and seminars such as this one will continue to be held in Latin America during the upcoming year, and details will be available at USSEC's events website once the information has been confirmed. Link: https://ussec.org/events/

Aquaculture Stewardship Council

News from the Aquaculture Stewardship Council

China's Largest Abalone Producer First in Country to Achieve ASC Certification

China's largest abalone producer has also become the first in the country to achieve certification against the ASC Abalone Standard. Fujian China-Singapore Evervest Co., Ltd. (FCSE) celebrated the achievement with a certification ceremony at a national annual abalone symposium held in Rongcheng, Shandong Province.

FCSE is based in Lianjiang County of Fujian Province, known as the hometown of abalone in China. Over 20 years it has grown into China's largest abalone farming company, and operates across the entire supply chain, from breeding and farming, to processing and sales. China is the world's largest producer and consumer of abalone, making it an important region for efforts to reduce farming impacts and improve practices.

The newly certified farm is located in the waters surrounding Datan Island in the East Sea, which enjoys a number of natural advantages including moderate salinity and abundant dissolved oxygen. FCSE has made a number of innovations, including the replacement of Styrofoam floating rafts with sturdier wave-resistant alternatives, increasing safety and reducing plastic pollution. They have also teamed up with Shanghai Ocean University to develop a traceability system where, feed, marine environment and water quality changes are monitored.

Fujian abalone wave resistant rafts.

The density of abalone has been reduced over time to improve quality and working conditions for staff.

"We aim to provide high quality abalones to consumers and that's why we want to change the traditional extensive farming practices to the standardized modern approaches to abalone farming," said Wu Yongshou, the chairman of Fujian China-Singapore Evervest. "We seek to open up the high-end market through ASC accreditation and we also hope that ASC's high standards and rigorous requirements will help Chinese abalone farming companies review and improve their practices so as to increase their sustainability."

"Abalone is a high-end seafood that is very popular among the Chinese people. Fujian China-Singapore Evervest is the largest abalone farming company in China and the first to meet ASC standards," said Fang Qing, ASC China Country Manager. "This will provide strong support to upgrade the aquatic products for Chinese consumers."

"China is now vigorously promoting the green development of aquaculture," according to Mr. You Weiwei, Secretary-General of the Abalone Branch of China Aquatic Products Processing and Marketing Association and an associate professor at Xiamen University. "Abalone actually has the

natural advantages to become a model species for green aquaculture, due to its farming model and feed composition. The first ASC certificate for responsibly farmed abalone in China will sharpen the competitive edge and strengthen the credibility of the abalones produced in China. It will also bring Chinese experiences into the global practices in responsible aquaculture."

World's First ASC Certified Collagen Supplement Launched in Sweden

The ASC label isn't only found on food products, thanks to the many and varied uses of responsibly produced fish.

This was further highlighted this weekend with the launch of a new skincare supplement in Sweden which is the world's first ASC certified collagen product.

Launched by Inekogruppen at an annual event for the LIFE Europe health food store chain in Sweden under the brandname NORDBO Kollagen, the product will go on sale in Life stores, the biggest health food chain in Sweden, Norway and Finland. The product will also be sold at the health food chain Hälsokraft, Bodystore.com, Åhléns Lifestyle Stores, and the beauty store Lyko.se.

The supplement contains collagen, which promotes healthy skin, hair and nails. The collagen is sourced from ASC certified *pangasius* and co-developed by the Danish company Engredo ApS. The collagen is derived from the skin of the fish which is removed as a by-product of the filleting process. The skin is processed at the same facility, before being processed further into the finished collagen product by Engredo and sold as NORDBO Kollagen by Inekogruppen.

"We are very happy to have obtained our ASC chain of custody certification, finalizing full supply chain sustainability and traceability," said Henrik Uth, Director at Engredo ApS. "This means everything is certified, from farming and processing of single source, ASC certified *pangasius* by our partner Vinh Hoan to the final product on the shelf – five gram sachets of the worlds' first ASC certified finished collagen product."

"The NORDBO Kollagen product is our most exciting launch yet and the perfect addition to our ASC-certified Danish trout fish oil product," said Emil Andersson, Director of Product Development at Inekogruppen. "Scandinavian consumers are very aware and looking for responsibly-sourced options in all categories. That's why we are so proud to provide an option that we think is the most sustainable as well as the purest."

"The variety of ASC certified products is increasing all of the time, which is good news for consumers who want to promote responsible fish farming with as many of their purchases as possible," said Inger Melander, ASC Commercial Marketing Manager, Northern Europe. "It's also great to see products like this taking advantage of the many different uses of farmed fish and ensuring that the by-products don't go to waste."

Cromaris Obtains Certification for 100% of its Seabass, Seabream and Meagre Farms

Cromaris, a leading producer of Mediterranean white fish based in Croatia, has become the first producer to obtain ASC certification for all of its seabass, seabream, and meagre farms.

Cromaris has applied and successfully obtained ASC certification for all five of its seabass, seabream and meagre farms, certified by the independent auditor DNV GL Business Assurance Norway. The producer has also attained Chain of Custody (CoC) certification for its processing facility. CoC certification ensures that ASC seafood is properly handled and kept separate from non-certified food throughout the supply chain from farm to fork.

"We are proud to receive the ASC standard for all our farms. This reflects our strategy in terms of developing sustainable aquaculture of top quality and the freshest Mediterranean fish on the market. It is important to highlight that we have certified all our farms – 100% of the production. Our strategy is to guarantee these standards to all our customers and consumers. All customers working with Cromaris can be 100% certain they are going to get ASC certified fish. This is a principle we follow in implementing all our standards as well as with all characteristics of Cromaris branded products" said CEO of Cromaris, Goran Markulin.

"This is an impressive achievement for Cromaris and we're really pleased

to see their dedication to minimising the environmental and social impacts of their farms," said Esther Luiten, ASC Commercial Director. "Certifying all of their farms against the ASC Seabass, Seabream, and Meagre Standard means even easier choice of responsibly produced fish for their customers. The ASC Seabass, Seabream and Meagre Standard is still relatively new but we've already seen plenty of demand from producers wanting to demonstrate their responsible practices."

Cromaris operate five farms producing seabass, seabream and meagre, located off the Croatian coastline on the Adriatic Sea. Their main market is Italy, with strong growth in central European markets including France, Germany and Switzerland.

The ASC Seabass, Seabream, and Meagre Standard was launched in late 2018, and farms were able to arrange audits from March this year, following a six month effective period. Many farms around the Mediterranean have already achieved certification against the new standard, in Turkey, Greece, Croatia and Albania.

Shrimp Farm in Honduras.

French Supermarket Giant Carrefour Makes ASC Shrimp Commitment

French consumers now have even more choice when it comes to responsibly farmed shrimp, thanks to an ASC commitment from supermarket giant Carrefour.

The commitment means that 100% of the farmed shrimp sold in all Carrefour supermarkets' fishmonger counters and chilled seafood aisles is now ASC certified.

"ASC certified shrimp farmers work hard to ensure they minimise their environmental and social impacts, and by choosing to buy ASC products, consumers can reward this responsibility," said Camille Civel, ASC France Outreach Manager. "Now Carrefour has given consumers even more opportunities to reward responsible farming, helping our mission to drive up standards in aquaculture."

"ASC certification of all shrimp is Carrefour's strong commitment to a major product in our seafood product offering," said Gaëtan de Lamberterie, of Carrefour. "It is fully in line with Carrefour's ambition to become the leader in the food transition for all and contributes to the company's commitment to provide consumers with a wide choice of responsible farmed and wild-caught certified seafood products."

Carrefour's commitment will have a big impact, with the company operating over 1,000 stores in France.

The Shrimp Standard is one of ASC's most widespread, with almost 300 farms around the world currently certified, producing over 200,000 tons annually. Vietnam has the most ASC certified farms, with Ecuador, Honduras and Indonesia also important countries for the programme.

The standard contains over 100 requirements dealing with legal, social and environmental issues. These include the protection of mangrove forests and other critical habitats, prohibition on the use of antibiotics, fair treatment and pay for farm workers, and being good neighbours to local communities.

If you've bought some responsibly farmed shrimp from Carrefour or elsewhere but aren't sure what to do with it, you can visit ASC's recipe page for inspiration.

Fishing is Growing Old

What fishermen need is a pension program, not subsidies to continue fishing for what is no longer there.

*By: Salvador Meza **

Around the world, over 80% of fishermen are over 60 years old. The industry is growing old, and the figures indicate that each year a great number of people are abandoning fishing activities. The replenishment of new workers is called into question.

Of the 40.3 million fishermen in the world today, according to the FAO, 2 million correspond to Latin America, and of these, 283 thousand live in Mexico. In this country, 54% of fishermen are over 50 years old, and they average 63 years of age, which is why only one in 10 is between 16 and 25.

When fishing is unable to provide an adequate and stable income, fishermen postpone their retirement age, and this allows for the age average among fishing workers to increase even more. In this sense, the future increase in the age of fishermen is a sign of the environmental, economic and social instability of fishing communities. On the other hand, young people take interest in fishing only when fish populations are big and stable, and when they see in it an activity where they can generate an income and pursue a career. If young people don't see a profitable industry in fishing, they go seek other opportunities, and the age average for the fishing industry increases even more.

In spite of the above, most of the world's governments have paid little or no attention to the aging situation of the fishing industry. In fact, they continue to promise, using redundant remedial actions, justice to the fishermen with programs to sustain and increase fisheries production without having a complete picture of the ecological situation of the promised catches. They hand out budgets and subsidies for programs designed to elevate the production of fish and seafood, such as the purchase of fishing nets, motors or boats, when what they should be doing is creating a pension scheme for this vulnerable group of society, using exchanges and social assistance programs. Thus, most of the resources budgeted by governments to increase the production of fish and seafood could be redirected towards the growth of sustainable aquaculture, which, according to the FAO, will be the industry that will provide the world with most of its fish and seafood in the upcoming years.

In general, for instance, the level of access fisher-folk have to social security in the Latin American region is very low. In Peru, for example, 94.3% of artisanal fishermen and women do not pay contributions to any of the available pension funds, while in the case of Colombia, this figure goes up to 97%. In Chile, only 8% of the fishermen and women registered in the Artisanal Registry have any affiliation with social security. In the case of El Salvador, it is estimated that 93% of the people involved in fishing and aquaculture activities are from the informal sector, and therefore have no social security whatsoever.

To better understand the problem presented by the lack of a pension scheme for fishing workers in the world, we have to analyze the strong tendency of the latter to continue in this activity. This situation may be explained by different factors, one of which is the investment in time these middle-aged fishers would have to make in order to learn a new type of activity, as well as being accustomed to obtaining income in a short term. Another factor is the low level of schooling of the fishing population, which is an obstacle in allowing their involvement in productive activities other than fish capture in a quick, functional manner. And lastly, the ease with which the fishers become employed in this activity, and the quickness with which they obtain profits, are conditions which favor this minimal tendency to change livelihoods. The working conditions of the fishers, while not optimal, do allow them to have a certain margin of discretion and flexibility.

Currently, a family of four is considered in a situation of income poverty if their income is below US$25.75 per day, in accordance with the US 2019 Federal Poverty Guidelines. The fishers' incomes are not stable and are far from the figure proposed by The Department of Health and Human Services of this country. Which is why the majority of fishermen, without consideration to their advanced age, accept the government subsidies destined to fishing production programs, and thus also accept risks they perhaps shouldn't be still taking by going out to sea, when in reality what they need is a pension that allows them to lead a dignified life in their old age.

What we have here is a mix-up of programs which, at the end, are not going to increase the production of fish and seafood, plus an omission regarding the living conditions of the fishermen who have no pension scheme, and finally a lack of insight because of the failure to invest these subsidies in the growth of aquaculture, which would indeed generate rural employment for a population of young people who currently have to migrate to the city.

Salvador Meza is Editor & Publisher of Aquaculture Magazine, and of the Spanish language industry magazine Panorama Acuicola.

Offshore Macroalgae Culture

as a Balm for the Oceans and the Planet

*By Neil Anthony Sims**

Carbon dioxide's impacts on the oceans are indisputable, inescapable, and terrifying. Yet there is a disconcerting lack of public panic – or even attention - around ocean acidification. We need to find solutions – fast!

Courtesy University of the Sunshine Coast.

I have been gently chided, at times, for proposing offshore aquaculture as the cure for all that ails humanity, our oceans, and our planet. OK, I admit it's not quite a cure-all; offshore aquaculture can't fix varicose veins. But there may be potential for culture of seaweed offshore to solve – in some part – this most pressing crisis for our oceans.

There is no universal agreement on the causes and the impacts of global climate change – or rather, as it is now more correctly being identified – the global climate crisis. Despite the multitude of models and deluge of data, supposedly well-intentioned, seemingly honest scientists can and will disagree. Even my brother-in-law is a climate skeptic! Part of the problem is that global climate models are really, really complex. The models are – as the adage holds - always wrong, and sometimes useful, but the only ones that are truly useful are those that reinforce our own biases. There are also all sorts of intricate feedback mechanisms (the albedo effect of clouds, for example) and complex compounding factors (methane clathrates bubbling up from the permafrost) that multiply the uncertainties – or at least, increase the opportunities for sowing seeds of uncertainty in the mind of my brother-in-law, and other doubters. The fear of global climate change is thus more of a nagging disquiet for most of us.

Ocean acidification, however, is quite simple. No models are needed to explain it; it is a straight-out, straight-up-and-down equilibrium equation. More CO_2 in the atmosphere means more CO_2 is absorbed into the ocean. This then pushes the ocean's pH lower, down from its current level of 8.2, closer to the acid end of the scale (towards 7.0). As it falls - even while it is still not yet acidic - it makes it harder for animals to deposit calcium carbonate shells. At some point, the shells will begin to dissolve.

A mea culpa digression: I saw this effect, first-hand, some 30 years ago, but failed to recognize its significance. I was then working at Kona's Natural Energy Lab for a Japanese-funded pearl oyster project, striving to culture Mikimoto pearls in oysters grown in the OTEC (Ocean Thermal Energy Conversion) deep ocean water. This water, from 2,000 – 3,000 feet deep, is pumped to the surface at around 6 – 8ºC. It is also supersaturated with CO_2, and has a pH around 7.6. By degassing the deep seawater, and warming it to around 18ºC, we could push the pH up to 7.9 or so, but no higher. Our poor *Pinctada fucata* sat there, struggling to push their shell deposits up over the hurdle of the aragonite solubility co-efficient. Their shell diameters literally grew backwards! They were dissolving before our eyes.

As the seas start to acidify, the catastrophe that I witnessed at tank-scale in Kona will be visited upon all the oceans of the world. There will be no escaping it; marine organisms can't migrate around a global shift in ocean

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Macrocystis canopy, Chile. Photo credit: Alejandro Buschmann.

pH, the way that terrestrial flora and fauna might relocate in response to changes in climate. We, our children, and our grandchildren stand on the brink of bearing witness to a global mass-extinction event that would rival that of the Permian-Triassic, when over 96% of all marine species in the planet were wiped out. Even my brother-in-law cannot deny these inevitabilities.

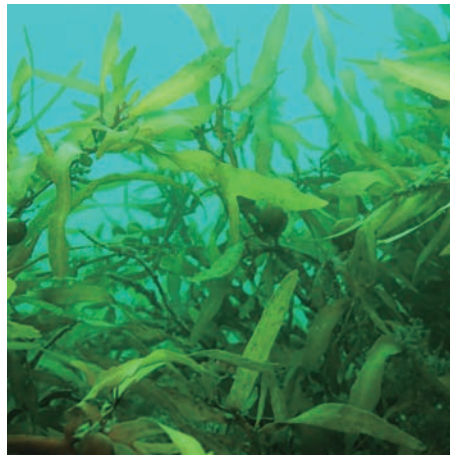
So … are you scared, yet?

A string of possible solutions have been posited – crush limestone and dissolve it in the ocean; add iron to the surface waters to stimulate phytoplankton blooms – but none of these are practical at any scale, and all of them would be horrendously expensive, and would require a hand be dipped into our collective public pocket. Ha! We cannot even get Joe and Jane Public to support a gas tax, so how are we possibly going to get them to loosen the purse strings to fund projects countering ocean acidification? Let's accept the truth - we can't.

I believe that the only viable option is to find some means for harnessing entrepreneurial incentives (a.k.a. the profit motive) to the ecological imperative, and have businesses solve ocean acidification for us. We need to find a profitable, scalable way to remove CO_2 from the oceans.

The simplest way to co-opt CO_2 to embellish a business' bottom line is through harnessing photosynthesis. Let's have the plants do all the work;

Ocean acidification is quite simple. No models are needed to explain it; it is a straight-out, straight-up-and down equilibrium equation. More CO_2 in the atmosphere means more CO_2 is absorbed into the ocean.



we can then reap the harvest. It has worked on land, pretty well, for feeding us for the last 10,000 years or so. In terrestrial agriculture terminology, this is called 'agronomy'. Unlike ag on land, offshore seaweed farming doesn't need forests to be cleared, and needs neither fresh water, nor (possibly) exogenous nutrients, yet it literally sucks CO_2 out of the sea for us to use or sequester as we see fit. Marine agronomy - the culture of marine plants and macroalgae (seaweeds) to produce the food, feeds and fuels that we crave – may then be a balm to counter the coming cataclysm of ocean acidification.

OK, outside of your local sushi bar, and Japan/Korea/China, seaweed isn't much craved, but that's just a matter of taste, and tradition. "Sit there and eat your seaweed salad, Johnny, or you won't get any seaweed icecream!" said no-one's Mother, ever, as she sipped on her kelp beer. Well, not yet, anyway … but people laughed at vegetarians, once.

Seaweeds could also be used directly as feeds for marine fish (many great-tasting coral reef fish are herbivores) or cattle (*Asparagopsis* has been shown to reduce the methane in cow burps by up to 70%). Alternatively, seaweeds could be used as feedstock for producing single-celled proteins (SCPs), which could then become protein powder for body-builders, or feedstuffs for 'carnivorous' fish (or for chickens, if you must). And the biodigestors producing the SCPs could be readily adapted to produce methane, or other biofuels, so we can leave more of the ancient other stuff in the ground.

This is not just your crack-pot correspondent talking. Conservation International, The Nature Conservancy, and World Wildlife Fund are all working on seaweed projects with localized nutrient removal, and mitigation of acidification, as key elements. However (and you knew I was going to get to this!) to truly scale this, we need to take it offshore. The U.S. Department of Energy seems to agree. Their Advanced Research Projects Agency – Energy (ARPA-E) just completed selection for Phase II awards for their MARINER Program (Macroalgae Research Inspiring Novel Energy Resources), with the long-term goal of developing culture systems for macroalgae for biofuels on offshore arrays, to allow production on the scale that is truly needed to make an impact on global energy demands.

There is also the tantalizing possibility of using macroalgae as a carbon

I believe that the only viable option is to find some means for harnessing entrepreneurial incentives to the ecological imperative, and have businesses solve ocean acidification for us. We need to find a profitable, scalable way to remove CO_2 from the oceans.

Seeded ulva lines for offshore.

> **"Sit there and eat** your seaweed salad, Johnny, or you won't get any seaweed icecream!" said no-one's Mother, ever, as she sipped on her kelp beer. Well, not yet, anyway…but people laughed at vegetarians, once.

Sugar kelp harvest - Long Island Sound. Photo credit: Charlie Yarish.

sequestration tool, where the seaweed could be cultured offshore, processed (to remove pigments, carageenans or other products of value) and then the inert equivalent of marine biochar could be dropped to the ocean floor. In 4,000 m deep water, that carbon won't see sunlight ever again; it will become part of the abyssal "ooze", and then eventually, some millions of years hence, be pulled down a subduction zone at the edge of the ocean, into the earth's crust. A couple of recent papers have recently shone some light on sequestration of macroalgae – natural or cultured - to the abyssal plain, and its capacity to mitigate global climate change. The science is sometimes encouraging (48 million sq km suitable for seaweed farming), but also always cautious ("Seaweed offsetting is not the sole solution to climate change").

Sugar kelp harvest - Long Island Sound. Photo credit: Charlie Yarish.

Beyond the culture technology, and the profitable products (which are both problems solvable by optimism), the nutrients (mostly N and P) represent the greatest limitation to offshore macroalgae scalability. There are, conveniently, abundant nutrients in deep seawater. Yes, it was just such deep seawater that dissolved the pearl oyster shells in Kona, but there could be some calculus to determine locations and depths at which nitrogen and phosphorus abundance exceeds

Sugar kelp longline. Photo credit: Charlie Yarish.

Sugar kelp production - Long Island Sound. Photo credit: Charlie Yarish.

Courtesy of Aquaculture without Frontiers.

the corrosiveness of the carbon. And with the oceans metaphorically awash in "Dead Zones" from eutrophication, there would seem to be possibilities to bring these nutrient-enriched waters literally to light.

We need to encourage ocean innovators and entrepreneurs to find the fundable non-fiction, from among the myriad futuristic proposals and the fanciful plans. And to do this, we need them to understand the scalability of the opportunities that are offered offshore. We need them to think beyond the blue horizon.

After all, the "No Action Alternative" is terribly grim … and otherwise inevitable.

Neil Anthony Sims is co-Founder and CEO of Kampachi Farms, LLC, based in Kona, Hawaii, and in La Paz, Mexico. He's also the founding President of the Ocean Stewards Institute, and sits on the Steering Committee for the Seriola-Cobia Aquaculture Dialogue and the Technical Advisory Group for the WWF-sponsored Aquaculture Stewardship Council.

Seafood Consumer Tendency and the Role of Aquaculture

With most of our world covered by water, why was our planet ever named Earth? Has this impacted our thinking with the emphasis of growth being focused on land? Would we have a different perspective if our planet was called OCEAN?

We have discussed previously in this column that the retailer is the window of the industry, yet how many producers know their retailers that well? And, is that a barrier to understanding more about the consumer and being able to inform and influence those important people? If you are not connected with your customer how can you understand the consumer's feelings towards your products?

You are locking yourself into commodity activity and unable to differentiate your brand if the consumers are not aware. And sadly, that is a pathway to marginal business.

Whilst each marketplace is different, one thing we are aware of is that we can gauge some perspectives from splitting the consumers into age groups – baby boomers (born between 1944 and 1964); Gen X (1965-1979); Millennials (1980 – 1994) and Gen Z (1995-2015). Each group shows some different tendencies in respect to their purchasing and eating of foods. Analysis from many experts enables us to have a greater understanding of such issues.

It is complex, and from a marketing perspective it can have major repercussions on your brand. The Millennial group has been impacting food trends over the last 10 years. Millennials are the largest U.S. age demographic, and as such they are key tastemakers. Their food preferences are helping determine what you'll find in retailers and restaurants across the country.

Most millennials are in college, starting new jobs, getting married or having kids and currently there are more millennials in the workforce than any other age bracket, and therefore their consumer choices matter. They are demanding truth from food manufacturers and many large food producers are starting to listen to consumer demands for transparency about ingredients and sources. There are benefits and risks for producers, but clearly change is happening.

While there are many positive changes in food and nutrition because of millennials, there is one cautionary issue that we need to be aware of. Research has indicated that about 40 percent of millennials say that friends and family are a top source of their nutrition information (only 21 percent of boomers give that answer — they trust doctors and dietitians more). Millennials rely heavily on websites, bloggers and social media fitness professionals for health information. This impacts on increased nutrition myths (like their love of organic food), and can be harmful for

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future generations, including their very well-fed babies.

"Karen on Facebook" may well have great intentions with her health/nutritional postings but there is no way to know how trustworthy such information is. This leads to misinformation and confused messaging, which makes marketing a nightmare. Of course, this is not assisted by NGOs and even aquarium groups trying to have their tuppence worth for their own 'donate now' causes, and adds to the muddle.

Given that farmed seafood has had public issues with regards to the environment and food safety in the past, misinformation and misconceptions have run rampant among consumers, adding more fuel to the fire and creating a lack in confidence in buying and eating seafood.

These three areas would appear to be the consumers' aquaculture perceptions:

1. Damages the environment;
2. Consumes more fish than it produces; and
3. Delivers poor quality food that is unsafe and less nutritious than what we could harvest from the sea.

People still use information from the past (especially the 'donate now' groups) to make their cases, which again does not assist in the overall campaign to promote seafood consumption and it is going to take a strong united approach to redress some of these matters and to win the war!

The issue has been further complicated by insecure fishermen who feared their products would no longer be required as aquaculture products came into their markets.

"Everyone is entitled to his/her own opinion, but not to his/her own facts" – Daniel Patrick Moynihan, American ambassador, senator and presidential advisor.

Negative stories are easy to promote – the shock/horror headlines are what the world's media thrives on and this is perpetuated through viral social media which survives on this negativity. We need to keep promoting FACTS and we need to get all our industry on the same song sheet, along with supporting scientific or government input.

Doomsayers are already predicting the end of commercial fishing so where will we be if we don't have aquaculture? The world's population is growing, and we need protein, especially scientifically proven nutritional food that we can deliver from our seas and oceans through farming.

Sadly, it has recently been reported that the Danish Government has announced that it is to put a halt to the development of fish farming at sea in a bid to protect the environment. The move will see an end to the development of any new sea fish farms in the country as well as a curb in growth for existing farms. Denmark is the eighth largest producer of sea farmed fish in the EU with around 19 sea fish farms currently in existence.

The main concern the Danes highlighted in reports were the levels of pollution associated with aqua-

culture, being the cause of significant criticism in the past. The resulting concentration of waste from the sector and its impact on the marine environment has been widely questioned, especially concerns about the combination of uneaten food pellets and waste which can pollute the water, smothering animals and plants on the seafloor. Other issues mentioned relating to aquaculture include the spread of diseases and parasites from farmed fish to wild fish.

According to the Allied Market Research Aquaculture Global Opportunity Analysis and Industry Forecast, 2014-2022, the aquaculture market valuation is forecast to reach $242 billion by 2022. The OECD and FAO Agricultural Outlook 2019–2028, recently published, predicts a 15 per cent increase in worldwide consumption and predicts prices for most commodities will fall by up to 2 per cent, but technology and genetics will increase yield. This highlights the need for aquaculture to invest in improved genetics. The outlook also shows a global urban population reaching 60 per cent of the total, up from 55 per cent in 2018.

Global trade tensions are also impacting agricultural investment and that is not assisted by political uncertainty, which means that our industry cannot rely on the same predictability of sales and will need more effort in engaging new markets into the future. That is why creating trade corridors to Asia is imperative, with over 60% of the world's middle class in that region by 2030 and a culture of eating seafood.

Resulting preferences for processed, transportable foods, particularly in the developing world, will see demand grow for certain commodities. Ninety-eight per cent of predicted demand will be coming from the developing regions of Asia and Africa.

The projected rise in production may increase global greenhouse emissions. Direct emissions from agriculture, mostly from livestock, as well as rice and synthetic fertilizers, are expected to grow by 0.5 per cent annually over the coming decade. FAO assistant director for general economic and social development, Maximo Torero Cullen, has said the climate challenge requires further emission cuts from the agri-food industry.

In order to move forward The Fishmonger promotes that we all make a commitment to work together to create our global agenda and focus on the important opportunity we have. The strategy should engage with the UN Sustainable Development Goals so that we have measurable outcomes.

Promotion efforts must focus on:
• factual health and wellbeing outcomes for women
• encouraging global retail standards
• collaborating on benchmarking
• building our Corporate Social Responsibility platforms on mangroves/sea grass, plastic alternatives and helping the poor.

From a corporate perspective, we need to invest in our people through education and development activities, invest in quality and technology, eliminate waste and develop a Blue Economy Growth Strategy in conjunction with governments.

There are strong messages for individuals, companies and associations and it will need all of us engaged in order to collaborate much more than we have in order make a difference and compete in such a difficult world of paradox.

The Fishmonger

The significance of SUFFICIENT WATER VELOCITY IN SALMON CAGES

*By Ashjørn Bergheim**

Water velocity is of profound impact on metabolism, performance and welfare of salmon and trout. Many reports indicate that higher velocity can boost fish growth due to increased feed intake and improved feed conversion.

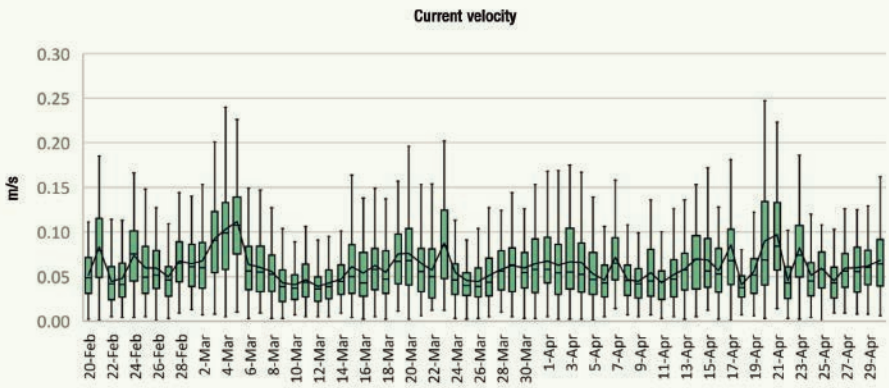
For example, a current speed of 0.4-0.6 BL (body length)/s (ca. 20 cm/s) has been shown to result in improved growth rate and feed utilization in post-smolt Atlantic salmon compared to 0.2-0.3 BL/s (Arve Nilsen, personal communication). The velocity of water also affects the behaviour and aggression of the fish stock as well as their flesh texture.

Currents normally fluctuate widely throughout the day, and from day to day as well. Horizontal motion of water along the coast and in fjords is associated with the rise and fall of the tide. Adequate water exchange through cages is essential for the replenishment of oxygen. To ensure the continuous supply of oxygen, there should be minimal periods of slack water. Current conditions are one of the key criteria for cage site selection. Good current scour at the seabed beneath cages reduces the risk of waste build-up. The Norwegian salmon industry is currently expanding to more exposed farming sites, which are associated with higher water current velocities.

At cage sites on the Norwegian coast, the current range is typically between zero and 20-30 cm/s from the surface to 10/20 m depth (Figure 1). The average velocity at cage sites was 6 – 8 cm/s which is considered sufficient to maintain adequate oxygen levels under most conditions. However, the current is reduced to some degree by cage nets, in particular when fouling causes a reduction of the mesh openings. Jellyfish blooms may

Figure 1

Current conditions outside at cage farm on the Norwegian coast during a three month period. Monitoring outside the cages (courtesy: Mowi ASA).



Some might find the generalization questionable, but most of the time the current velocity in most salmon cages appears to be suboptimal for growth and welfare of the fish stock.

completely clog cage nets and cause mass mortality in cages due to oxygen depletion and/or cage deformation.

Some might find the generalization questionable, but most of the time the current velocity in most salmon cages appears to be suboptimal for growth and welfare of the fish stock. Salmon farms in sheltered localities rarely experience current velocities above 20 cm/s. At such velocities the fish will often form a circular, one way directed uniform swimming pattern, possibly as a result of individuals actively avoiding collisions with each other and the cage wall. At these sites salmon typically swim at speeds of 0.3–0.9 BL/s, with maximum average values of 1.9 BL/s (Inst. of Marine Research (IMR), Norway, see Figure 2A).

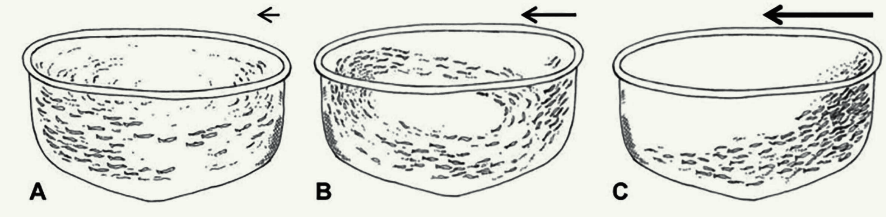
Under natural conditions in open sea, the constant swimming of salmon is associated with a congenital migratory tendency and the swimming speed approximates to 1 BL/s independent of age and size. The so-called critical swimming speed of adult Atlantic salmon, i.e. the highest swimming speed the fish can maintain for more than 20 minutes, is found to be in the range 1.8–2.2 BL/s.

When exposed to current, a net cage changes shape by deflection and deformation, and these deformations increase with increasing current velocity. In a detailed study on a farm site in the Faroe Islands, the Norwegian research centre SINTEF estimated a cage volume reduction of 40% at a current of 0.35 cm/s. At the time of harvest, when the stocking density of the cage was 36 kg/m^3, the fish density would have increased to about 60 kg/m^3. It has been reported that average stocking densities in cages greater than 22 kg/m^3 for more than 3 months resulted in lower welfare indicators than typically seen in fish kept at lower densities.

The deployment of skirts to reduce sea lice infestation in salmon cages is proving very effective for Scottish and Norwegian fish farms. Use of tarpaulin skirts of 5 – 10 m depth around the cages has been widely implemented over the last 5 years. However, the use of skirts also results in reduced water flowing through cages, affecting the flow patterns and reducing the oxygen levels in skirted cages. A reduced oxygen concentration of more than 30% in skirt shielded cages has been reported when compared with open control cages. Several attempts to increase water flow and the supply of oxygen in skirted cages are being implemented. Introduction of air-lift pumps lifting oxygen rich deeper water has recently been shown to raise the oxygen level in the upper part of the cages affected by the surrounding skirts. Injection of pure oxygen for longer periods is a more costly strategy.

Figure 2

Three observed swimming structures in a cage stocked salmon: A) Circular movements B) Circle and on current, C) Standing on current. The arrows indicate the strength and direction of the water current during the different group structures. Approximate current velocity: A 22 cm/s, B 38 cm/s, C 47 cm/s. Studies performed by IMR (courtesy: Stein Mortensen).



Dr. Asbjørn Bergheim is a consultant at Oxyvision Ltd. in Stavanger. His fields of interest within aquaculture are primarily water quality vs. technology and management in tanks, cages and ponds, among others.
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LIGHTING
IN AQUACULTURE FACILITIES

*by Amy Stone**

Lighting is generally an afterthought in many facilities but it can make a pretty important impact on production.

When I was first starting out in the red drum hatchery, we were just using standard fluorescent lighting. While we were successful, it's possible we could have capitalized on better lighting options. Of course, I was doing this work in the mid to late 90's before the availability of more efficient fixtures, so I will use that as my excuse.

Over the last decade, we have seen several significant advancements in lighting. One of the most prevalent is the LED (Light Emitting Diode) technology. LED's allow a greater variety of spectrum- or color-specific lighting and offer a completely new range of lighting options previously not possible with conventional lighting technologies.

This column will discuss the different types of lighting and controllers that are available for use in our industry. From traditional fluorescent lighting to the more efficient LED, there are several options that are available.

Before delving into the types of lighting, it is important to review lighting in general. Lighting can be species and life phase specific. For example, brood stock lighting, in my experience, has been more about the time that the light is on than wavelength and intensity. Larval rearing has been more specific to intensity and in some research, it has been shown that wavelength can also affect fish growth.

One of the bigger hurdles in lighting is finding lights that are UL approved in wet conditions. While not every facility requires UL listings, it is common enough that it narrows the available fixtures significantly.

In general, the testing mechanisms existing for many lighting options are such that it is hard to guarantee specific "colors" so the most common description for a lamp is its Kelvin output. According to Reef Brite, a lighting manufacturer, the word temperature is important when discussing Kelvin because it refers to the temperature of a theoretical black body or to an emitting body of light in degrees Celsius when heated to a given

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One of the bigger hurdles in lighting is finding lights that are UL approved in wet conditions. While not every facility requires UL listings, it is common enough that it narrows the available fixtures significantly.

temperature. Most of us are familiar with an incandescent lamp which has a filament (theoretical black body) made of tungsten. As current begins to pass through the filament it will begin to heat up. As the number of electrons (current) passing through the filament increases it will start to glow, producing light. If you were to measure the temperature of the filament and note the color it is glowing, you now have a fundamental idea of how color temperature (Kelvin) works.

We will cover the three most common types of lighting in this column. While there are other options available, it seems prudent to go with the more common options.

Fluorescent Lights

These are the most economical lights to purchase on the market, and they come in a variety of styles and sizes as well as wavelengths. Fluorescent lights are available virtually anywhere and can be installed quickly with standard outlets and switches. The most common is the T-5 lamp which is the newer version that replaced the T-8 and T-12 lamps. Fixtures for these are also available pretty much anywhere. Specific Daylight spectrum lamps are commonly available as well. Several brands of these lights allow the user to daisy chain the fixtures for easy installation.

This style of light is relatively efficient but has specific disposal requirements since they contain a small amount of mercury. It also can lose its wavelength over time so if the wavelength is critical, plan accordingly. Each manufacturer has a recommended replacement timeframe.

At the end of the day, the best possible option is to look at all the options and decide what is most effective for the species and system that needs the lighting.

Metal Halide Lights

These have been in use for many years. They were, and to a certain extent still are, the most popular for reliable wavelength and longevity. This style lamp often requires a pretty heavy ballast as well as quite a bit of energy. Luckily new electronic ballasts are coming into the market, which are lighter and smaller.

Metal halide lamps work by passing an electric arc through vaporized mercury and metal halides. The intensity of the light is determined by the mix of the metal halides that are present in the lamp itself. There is a start-up time required which can take several minutes for them to be fully lit. As an example, traditional sport field and parking lot lights are metal halide lamps.

Metal halides are most often used in applications where plant or algae growth is needed. They are also used in coral and bivalve farms. They have a significant initial investment as well as high operating costs, so analysis needs to be done on the application to make sure they are appropriate.

LED Lights

And now on to the latest and greatest fixture in the market. As with all the latest and greatest gadgetry, one must be very careful not to be taken down the garden path of gimmicks. The race for better LED technology has been on for over a decade and we are finally seeing some of the low-quality materials fall out of the market.

LED stands for Light Emitting Diode. That said, this technology allows the manufacturer to control the wavelength of the fixture by choosing specific diodes. Really efficient and effective LED lamps can be extremely expensive. This is especially true if UL listing and large fixture sizes are required.

One of the biggest advantages to LED technology is that it is more focused because the light is only shone in one direction. While the fluorescent and metal halide lamps produce light along the entire filament, which is round, light from these sources that is initially directed away from the target must be reflected down.

The more commercial the fixture, the more expensive and more testing the unit has undergone to prove the technology. The good news is that in most aquaculture applications the specific wavelength is not as critical as it can be in other applications.

At the end of the day, the best possible option is to look at all the options and decide what is most effective for the species and system that needs the lighting. What works for some facilities may not work in others, so this is one of the items that requires a lot of analysis.

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Shoot the Rhino

A colleague of mine was addressing a large gathering at World Wildlife Fund and told a story he called, "Shoot the Rhino." As you could imagine there were gasps from the audience. I don't know where the story originated and am happy to amend the column to give proper citation, but in summary, it goes like this…

*By Aaron A. McNevin**

Most of the animals on Earth have perished, there are only three individuals remaining – two male humans and a male rhinoceros. All three are in a field seeking the last scraps of natural resources left on the planet when one of the humans finds a single shot breach barrel rifle with one bullet left in it. The question before these two gentlemen is whether to shoot the rhinoceros or one of themselves. Both men agreed and shot the rhinoceros.

Seems almost silly to tell this story as it is second nature to do what the humans did. But that is the point, it is second nature, it is expected. Obviously, the story didn't require a decoder to understand the logic. The story is about the unimaginable odds that those seeking to conserve nature are up against. The planet's flora and fauna need the same natural resources as humans do, so in a world of increasing population and increasing consumption, are we destined to shoot the rhino?

Sustainable development, or in our context sustainable aquaculture, is the answer, no? This is the balancing of the social, economic and environmental pillars of sustainability to produce a healthy nutritious product. Yes, the balancing of the pillars – of course! This is where people are lifted out of poverty, the entire community benefits and the natural resources are present in perpetuity. Putting aside the seaweeds and filter

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feeders, which is not insignificant, I struggle in seeing the Jedi-like balancing of these pillars.

To be clear, I am using a fairly principled definition of sustainability – not the one that is on every presentation and in every pitch or proposal. This is not to say that there are not incredibly well-run aquaculture operations doing great things for livelihoods, social stability and environmental conservation, but sustainability is a very high bar and perhaps we should be holding our community to a higher standard. This is not an attempt to increase the height of the ivory tower. On the contrary, this is to increase the rate of advancement in the sector.

To be clear, it will be private business investment that will take us closer to sustainability. All other efforts in development are "projects" and by that, I mean subsidized. Of course, businesses don't all have the desire for sustainability – there are many examples of smash and grab operations that are quick to profit and quick to exit. Investment in long-term scaling, community development and efficiency are the attributes that would differentiate those businesses that intend to persist.

The others in the sustainable development space tend to be making a living off the inability of businesses to find this balance. There are environmentalists pointing to ecological challenges or unsustainable use of resources, the social activists seeking better compensation and conditions for workers, and grass roots activists that can be focused on both social and environmental considerations while seeking to protect the stability of local communities.

The planet's flora and fauna need the same natural resources as humans do, so in a world of increasing population and increasing consumption, are we destined to shoot the rhino?

The development institutions are equally challenged by the many layers of bureaucracy in the form of safeguards to protect institutional reputation. There are aquaculture research scientists struggling to obtain funding and develop novel experiments that will increase their impact factors and publication records. There are the academics that observe and report on aquaculture which can include viewpoints ranging from "never aquaculture" to "aquaculture can do no harm" as well as the "poverty journalists" that live the cushy life by describing the plight of the poor.

Then there are the donors – the public donors that develop research agendas but are so far removed from aquaculture that they cannot effectively evaluate what research is needed. There are also the private donors

There is no solution that an institution or organization will reveal that opens the doors to the balanced pillars of sustainability. If everyone is a leader, there is no one to do the needful tasks.

that fund research by esteemed institutions that have little experience in the aquaculture sector. Those same private donors often fund the NGOs engaged in aquaculture, along with the never-ending attempts to coordinate amongst NGOs - fundamentally fostering a thriving industry of mediation, consultation and strategy development.

Yet since I have effectively run out of stakeholders to critique, I thought I would turn a bit inward – yes, glass houses and such… The more recent ancillary processes and efforts by the environmental NGOs has gotten out of hand. It has slipped away much like the world of academic research into irrelevancy. I think that Rachel Mutter, from Intrafish, laid it out pretty clearly in her great article on the 2019 Seafood Summit meeting in Bangkok. She described a sort of fantasy land where the NGOs were so self-consumed in their toolkits and shiny partnerships and initiatives; they could not see that the audience they wanted to influence was out trying to solve the problems the NGOs thought they had solved.

To the point – there are many people that have roles and responsibilities that are beyond their skills. There is no solution that an institution or organization will reveal that opens the doors to the balanced pillars of sustainability. If everyone is a leader, there is no one to do the needful tasks. There is a greater need to be part of something and contribute all you can to a shared outcome, rather than your institution's best interest. There needs to be a better sense of selflessness, or better, "institution-lessness." I am no expert on sustainable development, and I don't believe those that claim to be.

I will advocate what I think is in the best interest of environmental conservation, and I would expect someone from the business sector will argue for what is best for business. Other stakeholders will advocate for community stability and development to alleviate poverty. It is this range of advocacy, for what we are good at or skilled at, which will ultimately tend towards the balance of the pillars of sustainability. Attempting to balance these pillars in one body or one institution will always result in the same outcome – the dead rhino.

Dr. Aaron McNevin directs the aquaculture program at the World Wildlife Fund (WWF). He received his MS and PhD from Auburn University in Water and Aquatic Soil Chemistry. Aaron has lived and worked in Indonesia, Thailand and Madagascar and currently manages various projects throughout the developing world. He previously worked as a professor of fisheries science, and is the co-author of the book Aquaculture, Resource Use, and the Environment.

TILAPIA, *PANGASIUS* AND CHANNEL CATFISH

UPDATES FROM URNER BARRY

*By: Lorin Castiglione, Liz Cuozzo **

Total tilapia imports for July gained 9.8 percent from the previous month. All categories saw increases, however, on a year-to-date basis total imports fell 5.1 percent below 2018 totals.

Pangasius **and Channel Catfish Intro**

July imports of *Pangasius* fell by 6.5 percent. Compared to the same month a year ago, imports fell almost 54 percent, while on a YTD basis 2019 volume tracked 24 percent lower than 2018. Frozen channel catfish fillet imports increased 49.9 percent from the previous month. However, compared to the same month a year ago, volume was down 20 percent. On a YTD basis, 2019 is trending almost 41.6 percent below the same 2018 timeframe.

Imports of Frozen Channel Catfish ***(Ictalurus)*** **Fillets**

Imports of frozen channel catfish fillets totaled 727,139 pounds. Imports have trended lower all year compared to the previous 5-year average. However, July finally peaked above that average of 418,547 pounds, by 73 percent. On a YTD basis, January through June totaled 3.8 million pounds and was the lowest on record since 2011, which saw 2.6 million pounds for the same timeframe. Shipments in July entered the U.S. with a declared value of $2.41 per pound, gaining $0.14 from the previous month, but falling by $0.24 cents when compared to the July 2018 value of $2.65.

Shipments into the U.S. are reportedly delayed as African Swine Fever is a contributing factor to product staying domestically within China, with this species being a protein substitution for the fallen pork production within the country. Because of this, as well as additional upwards pressure due to tariffs, pricing is increasing on all sizes.

Imports of Frozen ***Pangasius*** **(Swai) Fillets**

July imports of frozen *Pangasius* fillets fell from the previous month, down 6.5 percent and totaling almost 9.9 million pounds. Despite a slight uptick, July 2019 was the lowest-volume July since 2009 brought in 8.9 million pounds during the month. Looking at cyclical behavior of total imports, July falls 64.5 percent below the previous 3-year average for the month, which is 26 million pounds.

European data runs through June 2019, and it reveals imports fell for the second consecutive month, down 19.2 percent at 11.1 million pounds. On a YTD basis, the U.S. had fallen 18.1 percent while Europe was up

11.9 percent compared to the same timeframe in 2018.

According to data from the USDOC, replacement prices for July 2019 gained $0.04 per pound from the previous month, recorded at $1.70. Replacement prices have fallen month-over-month since February, with July breaking the downward trend. Please consider that the replacement cost we publish from the USDOC is not Delivery Duty Paid (DDP); therefore, if we are to properly assess this cost we must add extra to this price per pound. Prices continue to fall within the market, as sales are slow with falling demand.

Imports of Whole-Fish Tilapia

Imports of frozen whole fish increased 5.4 percent in July, totaling 8.7 million pounds. Monthly volume had been increasing month-over-month since March. On a YTD basis, 2019 imports were 0.7 percent above the same 2018 timeframe. Looking at cyclical behavior of import volume, July 2019 was 2.8 percent above the previous 3-year average.

Imports of Fresh Tilapia Fillets

Imports in July rose 3.7 percent from the previous month but fell 4.2 percent from the same month last year. Imports from Ecuador continued to fall, with YTD figures showing a 16.6 percent decline compared to last year. Imports from Honduras, the largest supplier of this commodity to the U.S. market, were 8 percent lower through July compared to the same period last year. Total imports of this commodity were 4.9 percent lower on a YTD basis through July. From a replacement cost basis, as well as the adjustments made to the weighted import price per pound (which includes only the top five suppliers), we found that the July figure of $2.70 decreased $0.07 per pound from the previous month. Replacement prices had fallen month-over-month since April. Some industry contacts reported slower sales and softer prices.

Imports of Frozen Tilapia Fillets

Imports of frozen tilapia fillets in July increased 12.8 percent from the previous month, totaling 22.2 million pounds. July 2019 import volume was ahead of the previous 3-year average of 20.3 million pounds by 9.6 percent, but fell 6 percent below the 10-year average of 23.7 million pounds. Looking at YTD totals, by July 2019 tracked 6.8 percent below 2018 volumes. Replacement prices fell $0.07 in July to $1.62 per pound. This is the lowest replacement price in almost 10 years, since October 2009 recorded $1.61 per pound. With replacement costs falling and wholesale prices steady, the ratio of these two numbers adjusted to 1.29. Wholesale prices are currently at an average of $2.08 per pound.

YTD weighted replacement costs registered $1.73 for the January to July timeframe, registering the same value from this same time last year. YTD import volume still fell below previous years and was the lowest on record since 2008, when volume was 114.2 million pounds for the same timeframe.

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Shrimp

UPDATES FROM URNER BARRY

*By: Jim Kenny, Gary Morrison **

U.S. Imports All Types, By Type

For the fifth straight month, July imports showed an increase in total volume imported. Shipments to the U.S. in July were 8.1 percent higher compared to July 2018, pushing the year-to-date figure into a slight positive of 0.8 percent, the first time in 2019 that that figure was in the green.

The trade flows were positive from most of the U.S.'s main partners. Increases were seen from India (+8.3%), Indonesia (+2.2%), Ecuador (+32.6%), Vietnam (+46.3%) and Mexico (+43.8%). Thailand (-0.4%) and China (-46.2%) shipped less in July compared to last year. The latter continues to battle African Swine Fever, with conservative estimates showing a thirty percent loss in hogs for the leading pork consumption country. This has led them to hold onto and look for all other proteins.

Increases were seen in all major categories except for cooked, a trend from June's figures as well. Shipments of Headless Shell-On increased, which includes easy peel, (+12.6%); peeled (+7.4%), and breaded (+43.7%) categories. Fewer cooked shrimp (-17.6%) were landed.

Monthly Import Cycles by Country (All Types)

India: At nearly 42 percent of shrimp imports for the month of July, and more than 2.5 times the next country, India remained squarely as the main trade partner with the United States. India shipped 8.3 percent more than July of last year, with total year-to-date volume at 311 million pounds.

Indonesia: There was a small increase, but an increase none the less, extending the positive streak to three months for imports from Indonesia. July shipments were 2.2 percent above last year which continued to shrink the year-to-date gap. Losses were seen in shell-on (-6.2%) and peeled (-2.2%) while cooked drove gains (+2.1%). Indonesia remains an important number two source of imported shrimp for the U.S.

Ecuador: It was another banner positive month for imports from the United States' third largest trade partner. July imports were up 32.6 percent and reached the double digits (+12.9%) for the year. This was driven again by shell-on (+34.8%) and peeled (+30.7%).

Thailand and Vietnam: Monthly imports for July edged lower for Thailand (-0.4%) while volumes from Vietnam (+46.3%) grew at an astounding pace.

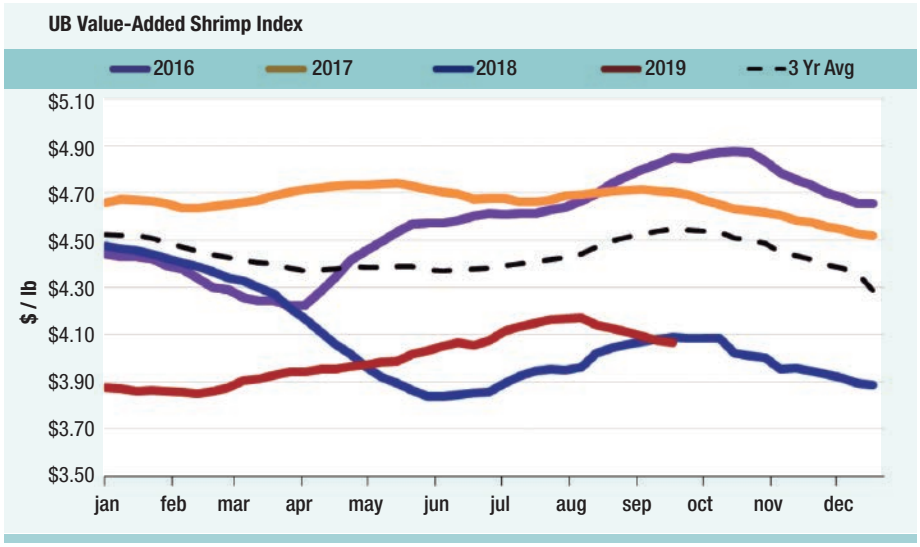
Shell-On Shrimp Imports, Cyclical & by Count Size

Headless Shell-On Imports, including easy peel, were 12.6 percent higher in July than the same month last year. The 51-60 count and larger, except for u/15, were all above last July. The 61-70 and o/70 counts were lower.

Replacement values (import $/lb.) for HLSO shrimp continued to be disjointed and the market took notice. They shot up in the month of July after a one-month decline. The average for the month was $3.68 per pound, up $0.06 per pound from the prior month, and $0.14 per pound above last year.

Value-Added, Peeled Shrimp Imports

Imports of peeled and deveined shrimp in the month of July increased at nearly the exact rate of June, at 7.4 percent. Gains in India, Ecuador, Vietnam, Thailand, Mexico, and now Honduras outpaced small losses seen from Indonesia (-2.2%).



Replacement values (import $/lb.) for peeled shrimp also increased sharply to $3.82 for July. This was $0.14 per pound higher than June.

Cooked (warm water) imports were again lower in July, to the tune of 17.6 percent, with declines noted from India, Vietnam and Thailand. Only Indonesia showed gains. Breaded imports outperformed, with July totals at 43.7 percent higher for the month.

Cooked, Breaded & Other Shrimp Imports

Despite some challenges sourcing overseas, replacement has been occurring and the market in the U.S. has become increasingly competitive. Movement has remained solid. The average value of all shrimp imports in the month of July was $3.77 per pound; $0.06 higher than June and $0.06 lower than July 2018.

Shrimp Price Timelines; Retail Ads

Retail: Retailers appeared to find shrimp a viable option to feature in July, as evidenced by the significant increase in buying opportunities from June. In fact, there were more than 27 percent more in July than June, and three percent above last year. The average ad price was $7.65 per pound. The economy remained strong in July, which helped some of the higher-end proteins, including shrimp.

U.S. Shrimp Supply & Gulf Situation

Supply concerns are price supportive throughout the complex. The National Marine Fisheries Service reported July 2019 landings (all species, headless) of 7.037 million lbs. compared to 7.923 million in July 2018. The landings for the first half of the year were 35.067 million pounds, roughly 10.55 million pounds below the same period last year.

Ecuadorian Shrimp Exports

Farmed White: The widespread price support gave way as sellers looked to keep product moving through the pipeline into a lower demand period. While weakness was not broad based there were some sizes and types that became more vulnerable. There was a willingness to discount where inventory and margin allowed.

Farmed Black Tiger: While most of what we have reported throughout the year remains, there are some new developments that may need closer attention. Larger black tiger remained strong amid limited offerings. As of July some smaller sizes were also experiencing the same. Mid-counts were also available.

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W: www.aquaculturemag.com

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W: www.was.org

XV INTERNATIONAL SYMPOSIUM ON AQUACULTURE NUTRITION
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W: www.was.org

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AUGUST 2020

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