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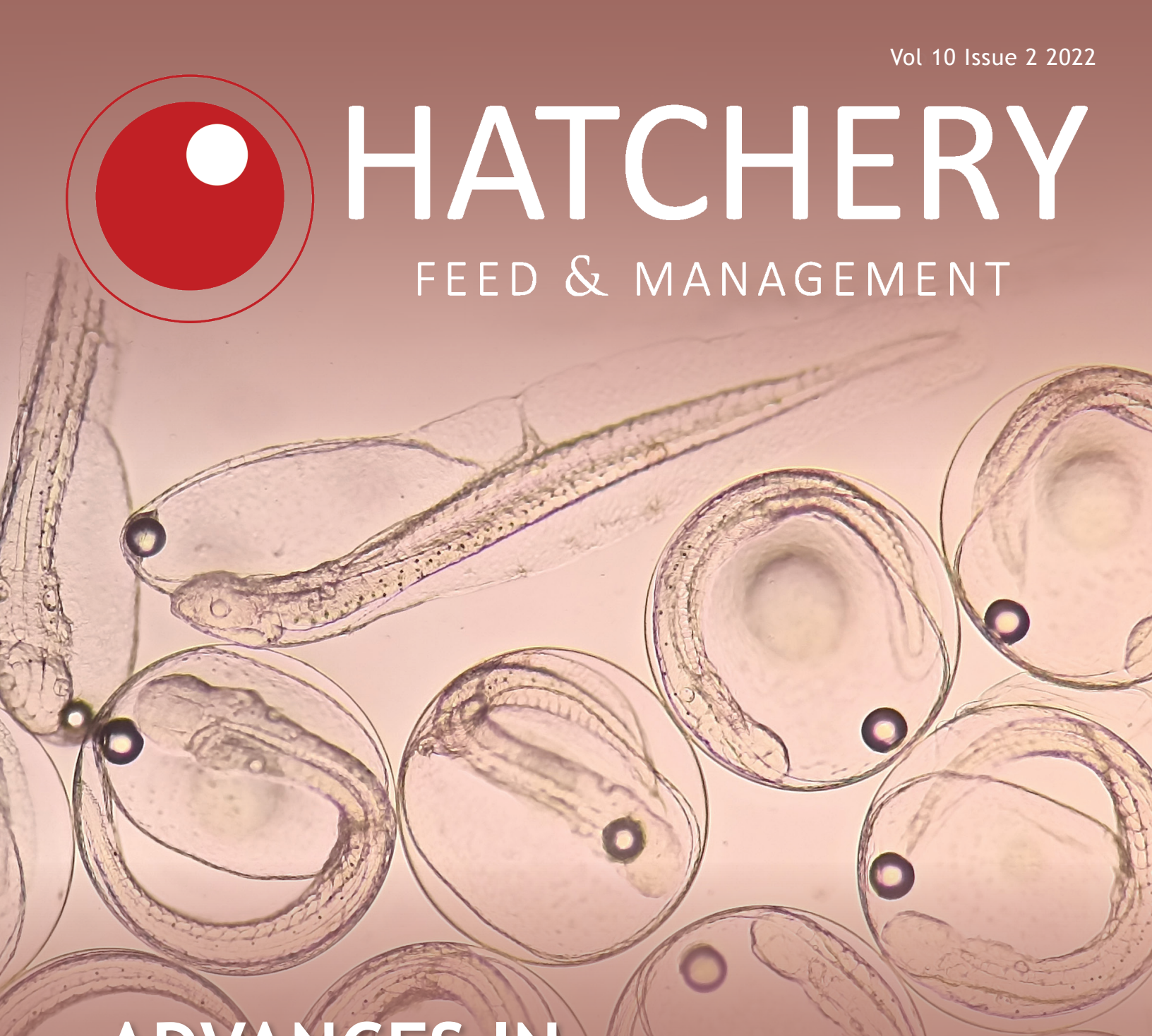
HATCHERY
FEED & MANAGEMENT



ADVANCES IN ROSE SPOTTED SNAPPER

Early Stage Nutrition

Vaccine Strategies

Indoor Closed System For Shrimp Broodstock

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HATCHERY FEED & MANAGEMENT

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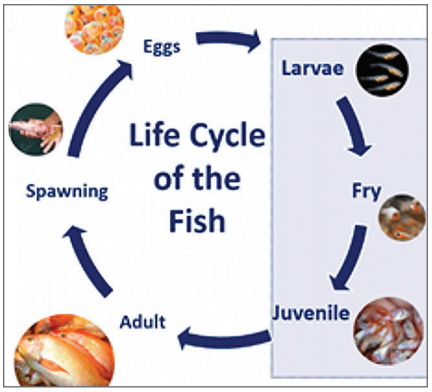
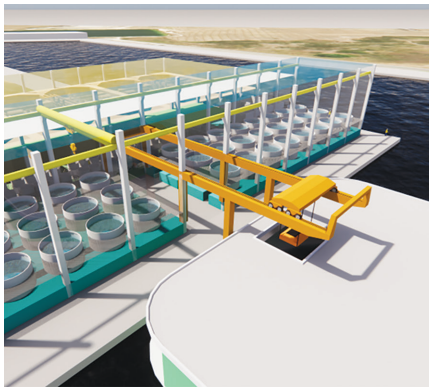




Tony Broadhurst is Technical Director for Aquaculture at Martec.

INTERVIEW *with* ***Tony Broadhurst***

HFM: Please tell us about yourself. What has been your journey in aquaculture?

TB: I was born in Britain in 1958 and studied marine biology at Liverpool University in the late '70s. I was granted a CASE postgraduate research studentship with Shearwater Fish Farming to look at issues with rearing turbot in the early '80s. Then I moved to Mars to help with the early field development of their Frippak line of products.

I moved with my family to Spain in 1986 to take on hatchery production of turbot, gilthead bream and seabass for Tinamenor. I've been doing pretty much the same ever since, but sometimes with different species and often for different companies.

I came to Costa Rica to work for Martec almost four years ago, and I hope to still be with the group for a few more years while we expand the snapper operation and diversify into other species. I am currently the company's technical director for aquaculture.

HFM: Grupo AquaFoods, the parent company of Martec S.A., recently acquired Grupo ACI. The company now runs two vertically-integrated fish operations in Costa Rica, one for tilapia and another for rose spotted snapper. Why did the company decide to invest in tilapia?

TB: Tilapia is a very different kettle of fish from snapper, of course, but there is also quite a lot of common ground between the two. For AquaFoods, the advantages are two-fold. First, Martec and GACI are both based in Costa Rica and currently export most of their production to North America, so there are

several opportunities for synergies. Second, Martec's shareholders have long held an ambition to expand in favor of aquaculture and rely less on extractive fisheries. Combining Martec with GACI was a perfect opportunity to pursue that goal and I expect we shall continue to move in the same direction in the future. We all believe very strongly in our motto, which is "Heathy food + life + planet", so we are absolutely committed to developing our industry sustainably. Martec and GACI are entirely compatible in this respect.

HFM: Let's go with the rose spotted snapper business. Martec is a pioneer in raising this species. How long did it take you to where you are today and what have been the main challenges?

TB: There was quite a bit of preliminary work beforehand, but we really only got started with the pilot industrial project about ten years ago, when we started to develop our hatchery. Aside from the practical difficulties of developing an operation in a remote tropical setting, I think the main challenge was changing from a research to an industrial mindset. I think that being able to import industrial experience from Europe, North and South America helped a lot in this respect, but we still need to keep reminding ourselves that the same technology doesn't always fit different species. It's been a process of learning and adaptation for everyone.

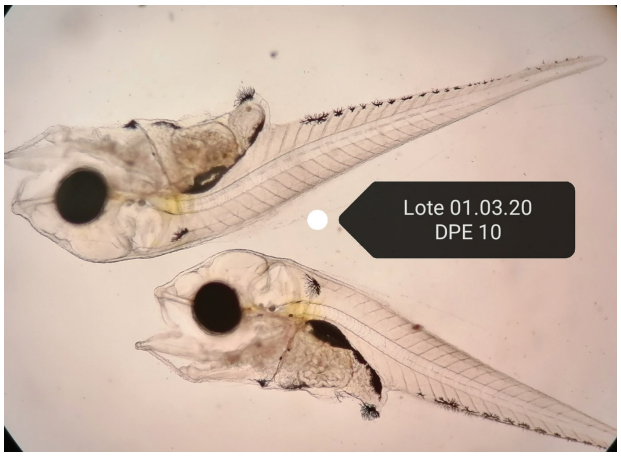
HFM: Martec recently partnered with Xelect to develop the first commercial rose spotted snapper genetic program. What has the company reached so far and what are the main targets?

TB: We're still at an early stage with this project, but we have characterized our current broodstocks and are about to begin smart selection to breed the next generation of offspring. It will probably be a while before we start to see the benefits in our ongrowing operation, but at least it's a start, and we now have a better idea of where we're going.

HFM: What are the key points for a successful snapper larval rearing process? What are the current hatchery and grow-out survival rates? Is there room for improvement?

TB: Early-stage survival from hatching to the start of weaning is around 20%, which is not at all bad for marine fish species. We cull out a portion of the survivors later, during weaning, and – factoring in post-larval attrition – usually end up delivering about 14% of the number of newly-hatched larvae stocked as juveniles to the cages. Of course, there is still room for improvement – particularly with respect to quality – but we are now a lot less concerned about survival, per se, than we were just a couple of years ago. As for how we achieve these results, there's no real mystery.

Rose spotted snapper eggs hatch on the same day that they are spawned.



Early-stage larvae look like many other marine fish species.

Three weeks after hatching they are more differentiated and are being weaned onto dry diets.

I think most people who work in a marine fish hatchery setting will already know the importance of broodstock conditioning, live feed protocols and fine attention to detail during the larval rearing process.

HFM: Martec runs a land-based hatchery and nursery facility. What have been the main challenges in setting a RAS for this species?

TB: Seawater RAS is quite different from freshwater systems, of course, but they are still very effective if they are designed correctly. I am pleasantly surprised and gratified that the system that we have chosen and adapted seems to be working nicely on our site within the design parameters that we set. I fully expect that we shall be setting up more – and larger – systems in the near future.

HFM: Costa Rica is a country without a strong aquaculture industry. How did the lack of skilled labor impact the development of the company?

TB: If we just look at the marine hatchery, many of our operatives have been with us for a fair number of years and have learned their trade through coaching on the job. I think we have achieved a critical mass of experience now, and this helps a lot when we introduce new recruits to the team at this level. We are also fortunate that the Costa Rican education system does train students to graduate level in zootechnology and similar disciplines, so there are more trained local candidates for technical posts available than perhaps one might imagine. However, for the time being, we still often have to look abroad to find people with sufficient industrial experience to take on roles of higher responsibility, though we hope that will change within the next few years.

HFM: What are the main targets in terms of markets for both businesses? When do you think the rose spotted snapper business will be consolidated?

TB: I think the global market for tilapia is pretty much satiated now, so our goal is probably to remain competitive within this and perhaps diversify product lines a little further.

The US market for snapper is still undersupplied so, clearly, our goal is to expand production of this species, both to satisfy that demand and be able to move into other markets, such as Europe and Asia. I doubt that the snapper business will be fully consolidated before I retire, but maybe I'm wrong. We'll just have to wait and see which happens first.

NEWS REVIEW

HATCHERY FEED & MANAGEMENT

Highlights of recent news from Hatcheryfm.com

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Global shrimp genetics suppliers merge to create Blue Genetics Global

International shrimp genetics suppliers, Blue Genetics Mexico and Sea Products Development, have merged to create Blue Genetics Global, a new player tailor-made to meet the major challenges in the shrimp industry around the world. Both companies merged under Groupe Grimaud, not only to share their experience and build on their strengths, but also to get access to the world's leading experts in animal genetics, and to the best technologies to increase the efficiency of their R&D.

Hendrix Genetics expands its shrimp breeding network to India

With the formation of a new company, Kona Bay India PVT Ltd, Hendrix Genetics and Sapthagiri Hatcheries will jointly establish a broodstock multiplication center for the benefit of the Indian shrimp industry. Beginning in early 2023, Indian shrimp hatcheries will be able to source high-quality, specific pathogen-free (SPF) broodstock, that has been locally reared. The newly constructed BMC will be based at an SPF facility in Kotapalem Village, Ranastalam Mandal, Srikakulam District, Andhra Pradesh.

SPAROS introduces two hatchery feeds for marine fish

The company launched two novel nutritional solutions for marine fish hatcheries within its Hatchery Feeds range, ENRico and WIN Wrasse.

ENRico is an all-in-one enrichment for Artemia and rotifers formulated with a balanced nutritional content for optimal larval development. It targets species such as Senegalese sole, turbot, halibut, seriola, meagre, seabass, seabream and ballan wrasse.

WIN Wrasse is a premium weaning microdiet tailor-made for ballan wrasse larvae. It is formulated specifically for ballan wrasse larvae, ensuring good growth and survival while combining high digestibility, high palatability and low impact on water quality.

SPAROS has also joined forces with PTAqua to offer fish hatcheries its custom-made nutrition. PTAqua will distribute WINFast - premium feeds for fish species such as seriola, meagre, seabass and seabream, WINWrasse - the first customized commercial earliest stage microdiet for ballan wrasse larvae, and ENRico - an all-in-one enrichment feed for artemia and rotifers.

WorldFish signs agreement to transfer GIFT to Nigeria

WorldFish signed an inclusive legal agreement with Premium Aquaculture Limited for the transfer of Genetically Improved Farmed Tilapia (GIFT) to Nigeria. The agreement also involves the establishment of a parental broodstock as well as breeding, propagating and disseminating fry and fingerling across Nigeria. This is the first private sector partnership between WorldFish and a hatchery operator. It reflects WorldFish's intention to commercialize its genetic assets, work toward financially sustainable operations and reduce its dependency on donor funding for its genetic R&D.

Hendrix Genetics, Coraqua partner for locally grown trout eggs in Peru

The companies signed a strategic partnership, securing access for Peruvian farmers to high-health, high-quality Troutlodge eggs. By growing elite Troutlodge stocks from egg to mature broodstock in Chichillapi, the eggs will be grown their entire life cycle in the unique conditions of the high Andean area. The first domestically grown eggs will be available to Peruvian farmers by November 2024.

Benchmark Genetics expands partnerships for ova supply

The company signed a three-year extension with Icelandic salmon farmer Landeldi where Benchmark will continue to fulfill Landeldi's ova needs for its ongoing expansion. Switzerland's first salmon farm, Swiss Alpine Fish AG, has also secured its ova requirements for five years through a long-term agreement with Benchmark Genetics.

Luminis Water Technologies introduces microbiome sampling kits for early disease detection

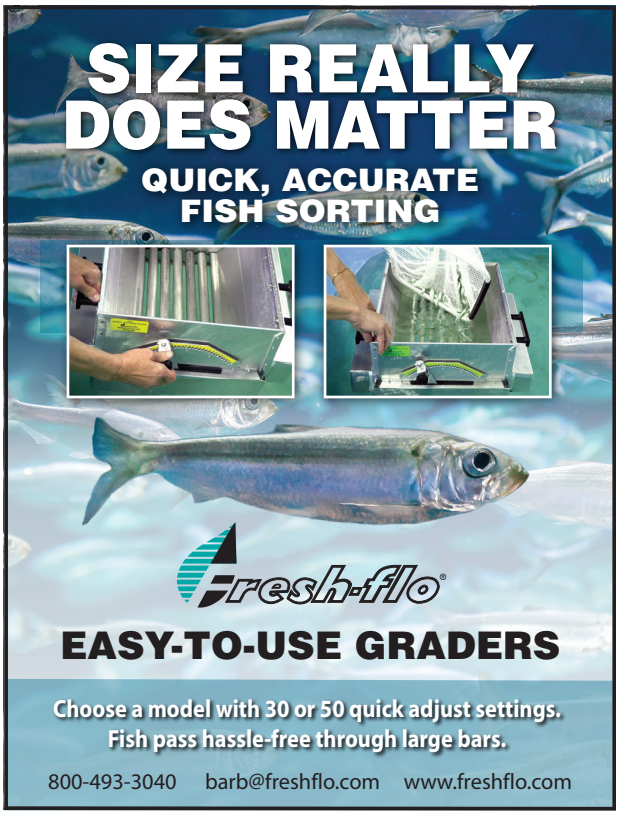
The company launched a range of NextGen microbiome sampling kits designed for easy sample collection, followed by AI-driven metagenomic analysis. The kits can take fresh and seawater samples and identify all pathogens, parasites, and viruses, both known and unknown. The kits can also provide insight into algae.

BactiQuant unveils fungal detection solution for hatcheries

The company introduced FungiCount, a new and innovative product designed to tackle and prevent fungal contamination in RAS aquaculture and hatcheries. FungiCount has been designed to quickly detect and generate results even in the earliest stages of fungal growth. Spores, hypha, and micro fragments can be detected, so fungal infections can be handled successfully before they even become a problem.

KYTOS, I&V Bio partnership makes microbiome management accessible to shrimp farmers

The companies joined forces to bring rapid sample logistics (I&V Bio) and local microbiome analysis (KYTOS) to the six of the most important shrimp-producing countries (Thailand, Indonesia, India, Vietnam, Ecuador and Bangladesh). The partnership will install local and independent KYTOS labs to serve aquaculture farms and hatcheries with cutting-edge high throughput microbiome management tools.



Nueva Pescanova Group adopts aquaManager digital solution for its shrimp hatcheries

Nueva Pescanova Group and aquaManager implemented a complete production management solution for the vanammei hatcheries of Promarisco and Camanica, part of Nueva Pescanova Group, located in Ecuador and Nicaragua respectively. This integrated project consists of the aquaManager system, customized to the needs of the group, mobile applications for real-time data collection, and an IoT device infrastructure. This digital ecosystem supports the complex processes of larval production, evaluates performance, and optimizes the results by promptly identifying patterns, trends, and areas of attention.

Zeigler introduces EZ Artemia Ultra in India

Zeigler Bros., Inc., in cooperation with Priyanka Enterprises, successfully launched EZ Artemia Ultra on March 29, 2022, at Golden Bay Resorts Koovathur, Tamil Nadu, India. The launch of the third generation of EZ Artemia was attended by over 50 participants representing 32 big hatcheries from the Chennai coastal region.

Originally developed as a synthetic substitute for Artemia, this complete and balanced diet has become a global standard for the industry, the company said. EZ Artemia Ultra formulation exceeds the attractability, digestibility and nutritional value of Artemia nauplii. Over the years, the best ingredients have been incorporated into highly digestible microparticle matrices, precisely manufactured and sized for maximum consumption. The microencapsulation process protects sensitive pigments, fatty acids, enzymes, vitamins and other nutrients in a soft moist easy-to-consume matrix. Shelf-stable, convenient, biosecure and cost-effective, sales of EZ Artemia have grown over the years with many hatcheries significantly reducing their use of Artemia nauplii and some eliminating Artemia nauplii completely.

Over the past few years, Zeigler R&D has improved the formulation to incorporate new powerful ingredients while removing terrestrial proteins. The second area of advancement was in the manufacturing process, enabling the incorporation of more nutrients into each microcapsule, improving digestibility, and making the capsules more buoyant while maintaining water stability. The third area of focus was on demonstrating performance improvement. Product development efforts focused on feeding EZ Artemia as the sole diet for PL 2-12, assuring maximum performance and improved larval fitness and gut health as demonstrated by higher survival and growth.

The event was hosted by Balaraman Radakrishnan, newly appointed general manager of Priyanka Enterprises. Mr. Balaraman is a seasoned technical and sales professional with more than 30 years of experience in the field of shrimp aquaculture for both hatcheries and farms.

Mark Rowel Napulan, sales manager of Zeigler Bros., Inc. for Asia led the event with his presentation entitled *EZ Artemia Ultra, the best just got better*. Napulan

From left to right: R. Balaraman, Mark Rowel Napulan, Muthukaruppan, VP AISHA, Padmanabha Reddy, Priyanka Enterprises, Panchu, Uni Bio SPF Monodon hatchery, Ravikumar, Golden Marine Harvest Group of Hatcheries, Kalraj, president AISHA, Tamil Nadu Chapter & MD Royal Shrimp Hatchery.

emphasized the importance of increased biosecurity and understanding potential pathogen carriers to produce clean post-larvae. He believes that there is a need to balance the risk between using live and fresh feeds versus post-larvae productivity.

"After three years of continued research and development work at our Z-ARC (Zeigler Aquaculture Research Center) in Florida, I am very excited to present to you the key distinguishing features of this improved product. This diet now comes with much-improved buoyancy making the particles remain suspended in the water column for an indefinite period with good aeration, maximizing productivity from flat as well as parabolic larval systems. We have incorporated our special blends of Rescue probiotics into the micro-capsules to promote gut health and help protect shrimp against pathogenic Vibrio. In the liquid fraction, we have incorporated our Remediate water quality probiotic blend designed for waste digestion and toxic gas control for a healthier tank environment. The formulation includes V-Pak, Zeigler's immune enhancement feed additive for stress and disease tolerance," Nauplan said.

EZ Artemia Ultra users can adopt different feeding strategies depending on their experience in using liquids. Some hatchery managers have found that continued feeding of EZ Artemia Ultra after discontinuation of Artemia nauplii helped reduce cannibalism and resulted in significantly higher survival.

Mark Rowel Naupulan, Sales Manager for Asia, Zeigler Bros., Inc.

Padmanabha Reddy, Priyanka Enterprises during open forum, R. Balaraman GM Priyanka enterprises (sitting behind).

As a partial Artemia replacement, laboratory and field studies have demonstrated improved lipid deposition, growth and survival compared to control tanks fed with 100% Artemia nauplii. In addition, production costs were reduced, and profits were increased, the company said.

"EZ Artemia Ultra has also been demonstrated to successfully replace 100% of the Artemia in the diet, eliminating the need for the additional capital and labor expense associated with Artemia hatching systems. Complete replacement of Artemia significantly reduces the risk of Vibrio and microsporidian contamination, while improving the gut health of the larvae and the environmental health of the larval rearing tank," the company concluded.

AquaBounty is scaling up its GE and non-GE salmon

AquaBounty broodstock.

AquaBounty's goal has been to bring fresh salmon to the market in a responsible and sustainable way. Its story is well known. Back in 1989, researchers microinjected a growth hormone gene from Chinook salmon, coupled with a promoter sequence from an antifreeze protein gene from ocean pout, into fertilized Atlantic salmon eggs. It resulted in a salmon that grows faster to market size (4.5 kg in 18-20 months), compared to conventional farmed Atlantic salmon. More salmon can be produced in less time and use 25% less feed than other salmon. After a long process in receiving FDA approvals to raise genetically engineered (GE) salmon, AquaBounty now raises salmon in two land-based RAS farms, located in Albany, Indiana, United States and Rollo Bay, Prince Edward Island, Canada, and is building a new one in Pioneer, Ohio, United States.

Breeding programs

Research to improve salmon did not end in 1989, Alejandro Rojas, chief operating officer at AquaBounty, told Hatchery Feed & Management in a recent interview. Breeding programs are part of the current developments of the company. The main focus is better growth performance of the fish in RAS systems and flesh quality, in particular, flesh color. "We are running an operation in Indiana and our fish is a mix of eggs produced by conventional females mixed with GE neo-males in order to produce all-female transgenic fish," Rojas added. The percentage of sterility reached by the company is 99.8%. "We could eventually reach 100% using new technologies that will be available in the market soon, together with gene-editing," Rojas said.

Non-GE salmon

AquaBounty also delivers conventional non-GE Atlantic salmon eggs. The company breeds them separately, both in Prince Edward Island in Canada, but in separate facilities following FDA recommendations to breed them in different facilities in different locations.

"AquaBounty does not sell GE salmon eggs," Alejandro clarified about the recent rejection of the project of American Aquafarms in Maine due to concerns about egg sourcing. "Any facility in the U.S. that farms GE salmon has to be approved by the FDA and American Aquafarms is not authorized. They never asked us for GE salmon," Rojas said.

Alejandro also said that AquaBounty aims to become a supplier of non-GE Atlantic salmon eggs. The company is currently selling conventional Atlantic salmon eggs to small farms in Canada and is developing breeding programs for non-GE salmon with the same focus as the GE, which is for better growth performance in RAS systems and flesh quality.

RAS challenges and technology

As the company increases the scale of its RAS operations, challenges arise. Alejandro said that the first challenge is having the right workforce. "RAS technology is not new; it has been used for the past 20-30 years. But having people with the right experience and know-how is very important. Equally important is having a good quantity and quality of water."

Feeding AQB's Atlantic salmon in grow-out.

Alejandro Rojas, chief operating officer at AquaBounty.

"The aquaculture sector in the U.S. is still small, considering the size of the RAS operations we are thinking of building. We have been in contact with technical institutes and universities, letting them know what kind of training profile we are looking for. We will also need to train our team members internally. It's challenging. We need highly qualified staff, so we are also starting to look at countries with a more consolidated (salmon) aquaculture industry, such as Norway, Scotland, Chile and Canada," Alejandro stated.

The RAS farm that the company is building in Ohio will be designed together with Innovasea. "We plan to build a state-of-the-art facility with the best technologies available in the market, not only from aquaculture but also from other industries which can be applied to our aquaculture business," Rojas mentioned. "We are also assessing the best option for sludge treatment, whether it can be used as fertilizer or to produce energy. We are evaluating what can be done with the blood or offal and if we can incorporate this into the circular economy concept. And we are also considering plastic and styrofoam usage and how we optimize/reduce their use in our different operating stages and processes."

The company is also testing RAS feeds. "The majority of our feeds are coming from Skretting and we are partnering with them to develop specific RAS feeds for our fish. The quality of the feeds and the water are the critical factors in a RAS system; therefore, we need quality RAS feeds," Alejandro said.

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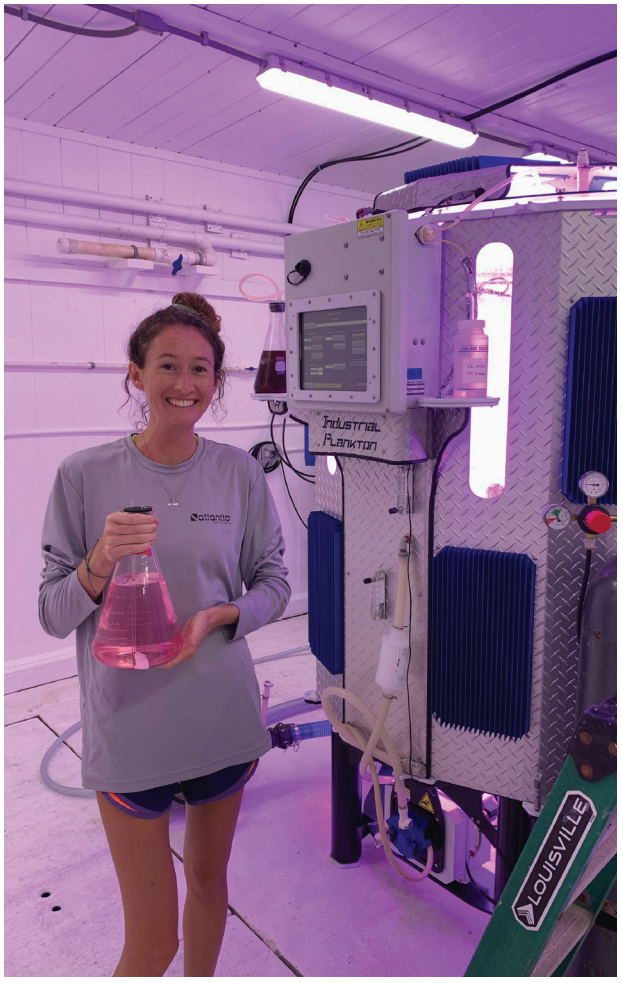
Industrial Plankton collaborates with HPU's Oceanic Institute to increase engagement in aquaculture for native Hawaiian students

The Oceanic Institute of Hawai'i Pacific University has been a cornerstone in aquaculture for decades. Their shrimp breeding program is world renowned, and their ornamental breeding facility is home to the first fully aquacultured yellow tangs.

Through a US Dept. of Education grant designed to increase native Hawaiian student engagement in STEM disciplines using aquaculture, Oceanic Institute was able to renovate an aquaculture teaching space and secure funding to install algae bioreactors from Industrial Plankton. The bioreactors came to Oceanic Institute at a critical time when their operations were looking at needing an algae lab expansion to support their increasing demands on their algae department.

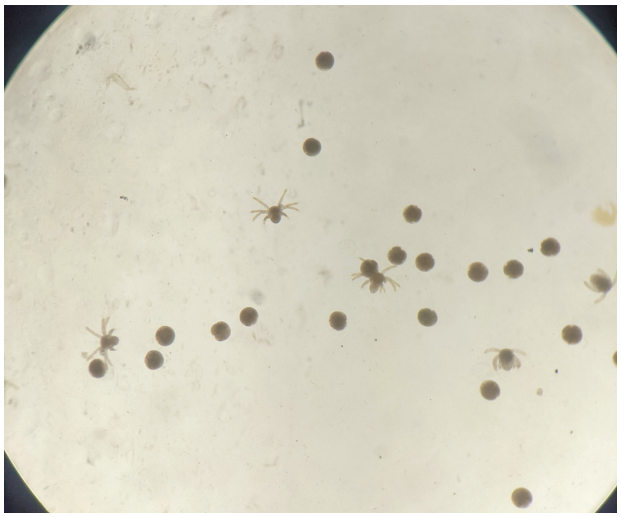
The two time-machine-like algae bioreactors landed in Hawai'i in April of 2022 and are growing two critical strains of algae for their programs: *Chaetoceros muelleri* and *Tisochrysis lutea*. *Chaetoceros muelleri* is required to feed the larval and post-larval shrimp that the shrimp research program uses to proliferate their family lines. Oceanic Institute pioneered the development of specific pathogen-free (SPF) shrimp stocks, which are used to enhance breeding programs worldwide. These family lines are the oldest continuously maintained lineages of *Litopenaeus vannamei* globally, so biosecure algae is a must.

Any *C. muelleri* which doesn't go to the shrimp will go to the ornamental breeding program to feed their *Parvocalanus* sp. copepods. When Dr. Chatham Callan's team first broke the code on raising larval yellow tangs, these copepods were critical as a first feed, and they continue to be vital in scaling up the production of their yellow tang. Since Hawai'i closed the ornamental fishery to protect their natural resource, the work of Dr. Callan's lab has become even more critical to the ornamental fish industry.

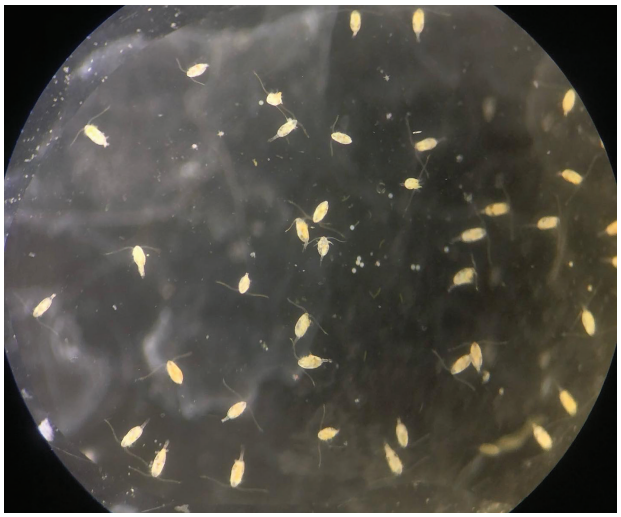


Carmen Hoyt, phycologist.

The *T. lutea* serves two functions: it is used as background algae (or "green-water") for the larval tanks or as a feed for the copepods. Using live algae



Freshly hatched *L. vannamei* nauplii and eggs.



Parvocalanus sp. copepods.

as "green-water" has the benefits of all green-water techniques in that it provides a backdrop for efficient feeding and lowers stress for the larvae, but it also provides an ecosystem service as live algae can consume nitrogenous waste in the water.

In addition to providing additional high-quality algae to fish and shrimp, these bioreactors will serve as invaluable teaching equipment.

Using these reactors, students at Hawai'i Pacific University will learn how the fundamentals of algae culture (light, nutrients, pH, etc.) are also crucial in the context of global ocean systems. The demonstration of these interactions in real-time will allow for a unique and dynamic learning experience that can impact students beyond the aquaculture space.

Industrial Plankton is thrilled to be working with the world-class shrimp and ornamental breeding teams at Oceanic Institute and overwhelmingly proud to be supporting two amazing missions, especially as they help increase the engagement of minorities in aquaculture.

More information:
www.industrialplankton.com
Hawai'i Pacific University

Optimizing aquaculture performance starts with early stage nutrition

Delphine Weissman, ADM

Proper nutrition is essential for a strong start and lifelong development in many animal species, from humans to fish and shrimp. Feed quality for early life stages affects not only growth and performance in the larvae to juvenile phases but also throughout grow-out stages to harvest (Fig. 1). Therefore, maximizing success and profit in aquaculture hinges on optimized early feeding.

Early stage growth and development

Organ development happens at different rates within young animals, with physiological changes occurring in relation to proportional changes in body size. This is known as allometry. In human babies, for instance, exponential brain growth during the first 1,000 days of life is a critical time when nutrients to maximize neural health and development must be prioritized (Valentine, 2020). Similarly, not all organs grow simultaneously in newly hatched fish (Osse *et al.*, 1997) and consequently, growth intensity is not distributed uniformly across the body (Fuiman, 1983). Postembryonic structural changes also exist in species that do not undergo metamorphosis, at varying degrees depending on the species (Fujimura *et al.*, 2007).

In fish, these changes enable the progressive transformation from recently hatched larvae to juvenile to adult. They are described in tilapia (Fujimura *et al.*, 2007) and mullet fish (Khemis *et al.*, 2013). Khemis *et al.* detailed three growth episodes distinguished by allometric inflexions in newly hatched mullet fish from dph1 to dph71. The first episode includes the development of the cephalic region. A fast allometry growth of the head is observed, with eye and vision development, increased mouth size and the transition from cutaneous to gill respiration. The second allometry episode includes the development of locomotion organs, such as the tail and fins. In the third episode, axial musculature develops: the fillets start to grow. All these developments enable the fish to better detect feed particles, ingest them, swim quickly and precisely, and have an efficient oxygen supply to swim toward feed particles.

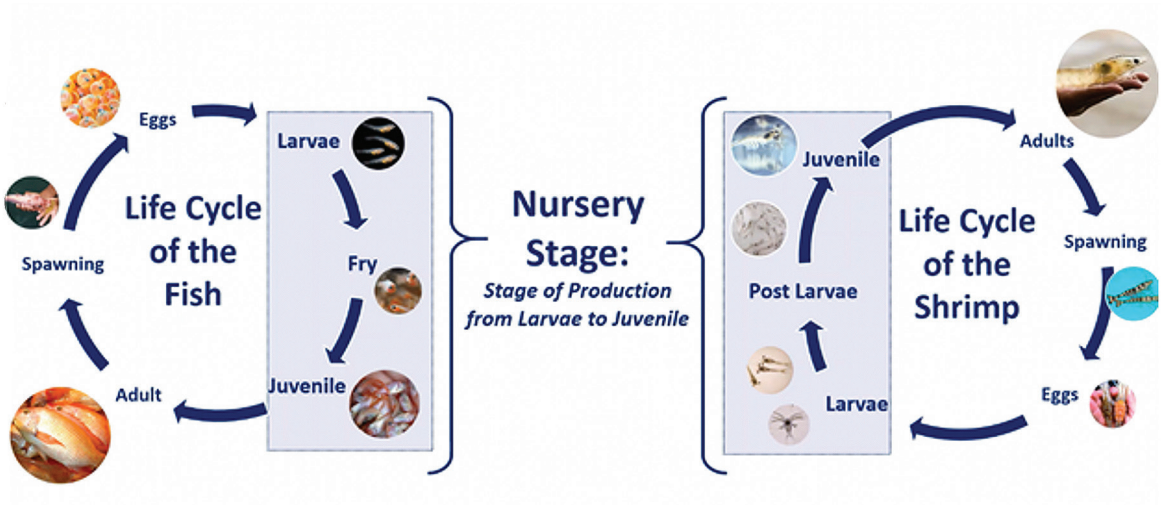


Figure 1. The nursery stage of aquaculture production includes phases from larvae to juvenile.

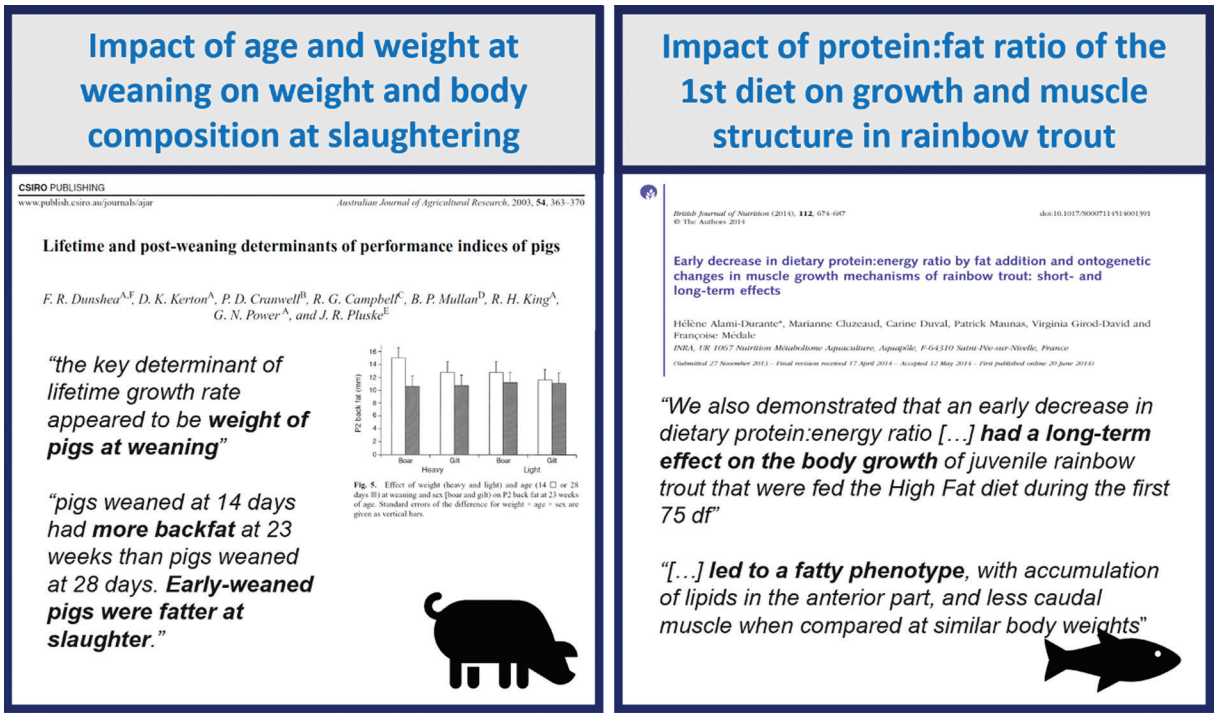


Figure 2. Impact of early life nutrition on phenotype and carcass quality at slaughter.

Given the crucial developments that happen in the early life of fish, it is essential to provide the right nutrients at the right time. In aquaculture, complete feed is the main source of nutrients, so the nutritional profile of the feed must be adapted to each life stage. Feed digestibility and quality of the raw materials must be fine-tuned, especially because fish intestines are still developing in the first weeks of life. Ensuring a good attractability of the feed will also help to provide nutrients in sufficient quantity. Additionally, appropriate feed particle size is critical for proper suction feeding and optimized fish development.

Early nutrition affects all life stages

The ways early nutrition can affect phenotype depends on animal species. An extreme example is found in bees, as larval stage nutrition will determine if the larvae become either a worker or a queen. More generally speaking, nutritional challenges during young stages may modify gene expression and cause metabolism modifications. Therefore, adjustments to nutrient profile at the juvenile stage affect animals during this young stage and later life stages, leading to different phenotypes at slaughter and variations in carcass quality.

In swine production, age and weight at weaning influence fat content and carcass quality at slaughter (Dunshea *et al.*, 2003) (Fig. 2). The demonstrated impact of early nutrition on fillet quality at harvest is also published in aquaculture. For example, a decrease in the dietary protein:energy ratio by adding lipids to trout juvenile feed during the first 75 days of life affects muscle and fillet quality later in life and presents a fattier phenotype. For similar body weight at slaughter, fat excess at early stages decreases muscle fillet deposition (Alami-Durante, 2014) (Fig. 2).

These findings indicate that early nutrition not only affects fish performance during the juvenile period but also overall fish performance and quality to harvest. So for better outcomes in commercial aquaculture, farmers must consider quality and calibrated early nutrition.

Lifelong muscle growth

Most fish continue to grow as they advance to later life stages and favoring muscle growth will increase fish size. Muscle growth includes hyperplasia, an increase in the quantity of muscle fibers, and hypertrophy, an increase in the diameter of muscle fibers (Kiesslingetal, 2006), as illustrated in Figure 3.

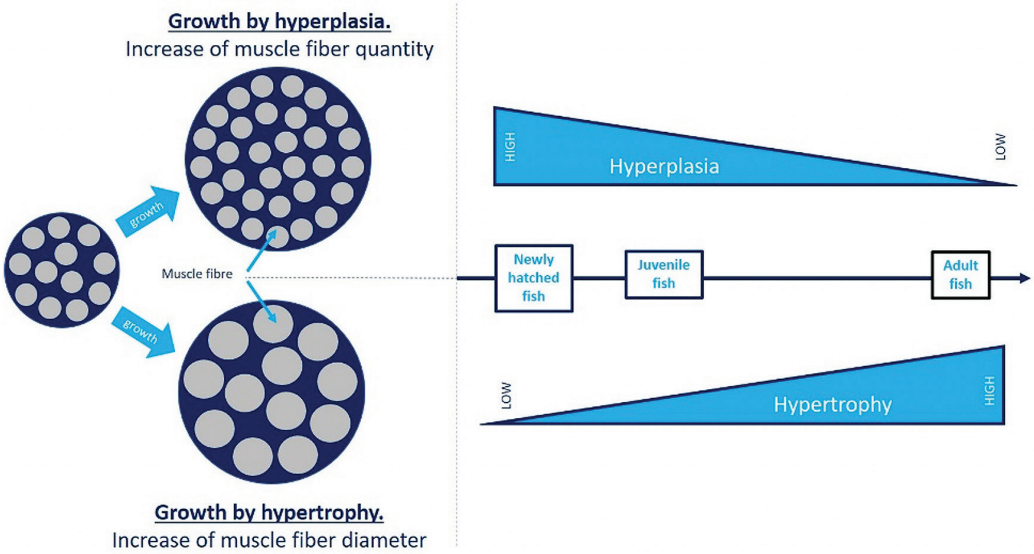


Figure 3. Growth muscle mechanism and its evolution through lifespan.

Research has shown that hyperplasia is the dominant growth process in recently hatched fish, and it gradually decreases as fish increase in size (Zimmerman, 1999), while hypertrophy continues after this stage. Kiesslingetal *et al*. (2006) have reported that hyperplastic muscle growth, which occurs primarily during the juvenile life stage, is of great interest in commercial aquaculture because it contributes to the final market size of the farmed fish. Moreover, a higher number of muscle fibers would also improve fillet quality (less gaping, better texture) due to the greater amount of connective muscle tissues (Kiesslingetal, 2006). To extrapolate, good growth in early stages, while the hyperplasia process is dominant, can improve fish growth in later stages and final body weight.

Optimize early nutrition for improved outcomes

Beyond the various growth and allometry events that happen in early life stages, young fish are exposed to numerous challenges. During a critical period in which the digestive system and the immune system are not fully mature, the developing animal is unprepared to efficiently defend against pathogens. At the same time, young fish in intensive production systems are often exposed to external stressors such as transportation, transfers, handlings and water quality variations. For more favorable technical and economical performances in aquaculture, farmers must carefully manage nutrition and development of young fish.

Much evidence suggests that high-quality nutrition supports the proper development of fish in the early stages and onward. Precisely formulated feed, with a balance of the proper nutrients and functional ingredients, may promote successful fish farm results. Key factors to optimize feed for early life stages include a complete nutritional profile, digestibility, attractability, water stability and particle size. In developing high-performance nutrition for hatchery and nursery phases, formulators must take each of these aspects into account.

For example, ADM's global brand, BernAqua, sources highly digestible raw materials and uses cold microextrusion processing technology for better behavior and stability in water, particle quality and digestibility. With a premium nursery stage feed, commercial fish farms are investing in precision nutrition that is adapted to very small animals and intensive conditions. This customized approach can support productivity and resiliency, helping more juveniles advance to the grow-out stages.

References available on request.

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Do high energetic needs mean high dietary lipid levels? The road to tailored diets for marine fish larvae

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Optimal dietary lipid levels are still unknown for most marine fish larvae

Although the quality of commercial microdiets has significantly increased during the last few decades, it is fair to say that our knowledge of the quantitative and qualitative nutritional requirements of fish larvae still remains at the tip of the iceberg. Still, it is generally accepted that fish larvae have high nutritional requirements, mostly due to their fast growth, which in some species/stages can reach over 50% per day, but also due to their energetic predatory and swimming behavioral pattern. Fish larvae have therefore a high requirement not only for proteins, which deposited in muscle tissues are the building blocks for growth, but also for lipids, which are mainly directed towards energy production and are a source of essential long-chain polyunsaturated fatty acids (e.g. docosahexaenoic acid - DHA), vital pieces for physiological balance, organogenesis and formation of cellular membranes.

In commercial microdiets for fish larvae, proteins account for the largest fraction, generally around 56-62% of diet weight. However, levels found in the lipid fraction are more variable, ranging between 9-20% of diet weight. This variability in dietary lipid levels of commercial microdiets may occur because determining an optimal dietary lipid level for a given species at the early developmental stages is extremely difficult. On one hand, the main metabolic fate of dietary lipids in marine fish larvae is towards energy generation. On the other hand, energy production is also dependent on the catabolism of amino acids, which belong to the protein fraction of the diet. Energy production in fish larvae is therefore largely affected by the protein and lipid fractions of the diet, and both factors cannot be dissociated in energy yielding.

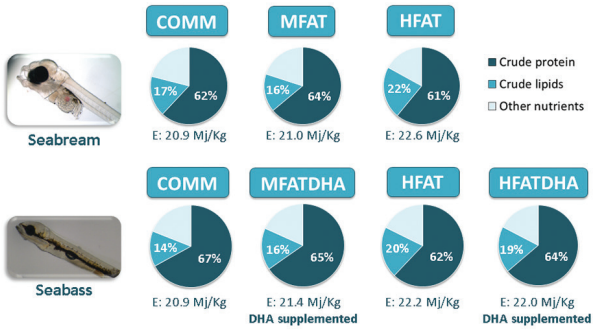

Figure 1. Proximal composition of microdiets tested in experimental trials with traditional species. Values expressed in diet wet weight basis; COMM: commercial diet; MFAT and HFAT: diets containing moderate and high fat levels, respectively; HFATDHA: diet containing high fat levels and supplemented with DHA; crude protein percentages are represented in white over the dark blue areas of the circles; crude lipid percentages are represented in white over the medium-light blue areas of the circles; E - crude energy values.

The term “lipids” is a generic noun for organic compounds that are grouped together on the basis of being soluble in organic solvents, including fatty acids,

phospholipids, sphingomyelins, waxes and sterols (NRC, 2011). Although there is considerable information on the requirements of essential fatty acids such as EPA (eicosapentaenoic acid) and docosahexaenoic acid (DHA) (Tocher, 2010), and the ratio of phospholipids to neutral lipids in marine fish larvae (Morais *et al*., 2007), dose-response studies including several dietary levels are extremely scarce (Hamre *et al*., 2013). Traditionally, these studies were impaired by technical difficulties related to the low acceptance of diets, nutrient leaching and low digestibility. However, with progress in feed production technologies and ingredient quality, we are now better positioned to increase our knowledge in larval nutritional requirements and optimal dietary levels. To this end, this study aimed at reviewing optimal ranges for dietary lipids levels in early life stages of traditional – gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*) – and emerging fish species, such as greater amberjack (*Seriola dumerili*), meagre (*Argyrosomus regius*) and Senegalese sole (*Solea senegalensis*), for European aquaculture.

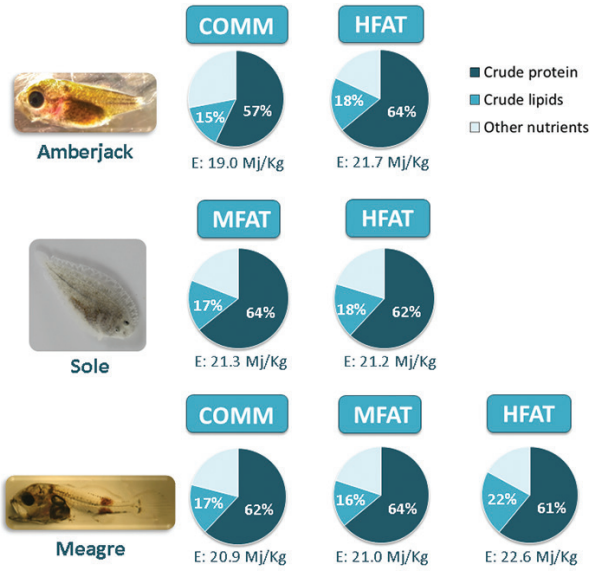

Figure 2. Proximal composition of microdiets tested in experimental trials with emerging species. Values expressed in diet wet weight basis; COMM: commercial diet; MFAT and HFAT: diets containing moderate and high fat levels, respectively; crude protein percentages are represented in white over the dark blue areas of the circles; crude lipid percentages are represented in white over the medium-light blue areas of the circles; E – crude energy values.

Response to diets containing high lipid and energy levels is species-specific

A series of experimental trials was conducted during the first few weeks of development of target species: gilthead seabream (22-58 days after hatching; DAH), meagre (20-46 DAH), European seabass (23-56 DAH;) – all at IPMA-EPPO –, greater amberjack [33-78 DAH; Futuna Blue España SL; data from Navarro-Guillén *et al*. (2019)] and Senegalese sole (31-65 DAH, SPAROS Lda). In these trials, larvae were reared in triplicate tanks under standard zootechnical conditions and fed ad libitum on diets containing different nutritional profiles, with experimental variables focusing on lipid and energetic values. Premium practical ingredients (e.g., squid meal, krill meal, fishmeal, wheat fish oil, DHA-rich algae products and soybean lecithin) were used to formulate and produce experimental diets according to the proximal composition shown in Figures 1 (traditional species) and 2 (emerging species). At the end of the trials, growth performance, survival, liver histology, feed conversion ratio and biochemical parameters related to oxidative stress were analyzed.

Results showed that the capacity to deal with high dietary lipid/energy levels varied among species. In comparison with MFAT, feeding on HFAT diets, which contained higher lipids/energy levels, represented a very relevant increase in terms of growth performance for seabream, meagre, amberjack and seabass larvae (Fig. 3). Conversely, Senegalese sole larvae fed on the MFAT diet had a significantly higher weight and a lower FCR (MFAT: 1.0 vs HFAT: 1.6) than larvae fed on the HFAT diet at the end of the trial. In addition, significant differences were found between treatments for survival in the seabream and meagre trials.

In seabream, the HFAT diet resulted in a significant increase in survival in comparison to the COMM diet (HFAT: 58% vs COMM: 43%). In meagre, the same trend was observed, with the COMM diet resulting in a survival of 14%, whereas values of 22 to 28% were found in the MFAT and HFAT treatments, respectively. In the remaining trials, no significant differences were observed between treatments for fish survival, with values of 75 to 80% being reached in seabass, 81 to 83% in amberjack (Navarro-Guillén *et al*., 2019) and 80 to 85% in Senegalese sole.

Interestingly, the differential effects of dietary treatments for target species were not limited to

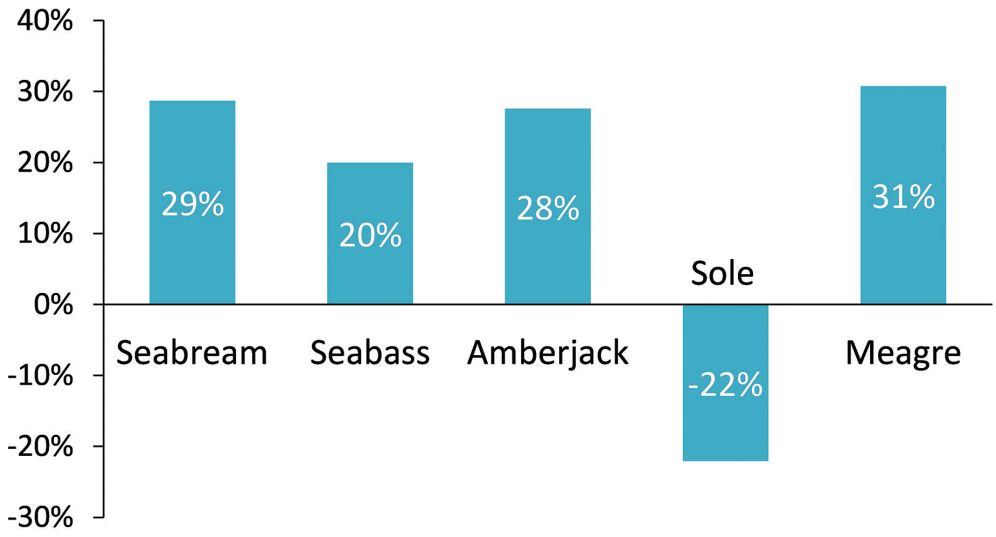

Figure 3. Variation in final weight in larvae of different species fed a diet containing high lipid levels (HFAT) versus a diet containing moderate lipid levels (MFAT). Positive values indicate a higher final weight variation in fish from the HFAT treatments, as opposed to negative values, which indicate a higher final weight variation in fish from the MFAT treatment.

traditional criteria such as growth, feed conversion ratio and survival. Namely, results for the seabass (Fig. 4) and amberjack trials showed a significant increase of vacuolization area in the liver of fish fed commercial diets. In seabass, liver vacuolization area reached 28% in COMM, as opposed to values reached in experimental diets (15 to 16%). In amberjack, lipid vacuolization reached 25 and 19% of liver areas in COMM and HFAT treatments, respectively. Although it should be made clear that these results do not represent signs of a severe steatosis, they still suggest that lipid metabolism and transport in fish larvae is highly dependent on the quality and form of lipids included in the diet and not only on its quantitative level. This conclusion can also be inferred from results obtained in oxidative stress biomarkers analyzed under the scope of this trial. For instance, analysis of oxidative stress biomarkers in fish from the HFATDHA treatment, which was approximately isoenergetic and isolipic to the HFAT treatment, showed a higher lipid peroxidation and a lower ratio of reduced to oxidized glutathione in whole larvae.

These findings indicate that supplementing DHA in a diet already containing high lipid levels may lead to an increase in oxidative stress. These findings were most likely verified because DHA is more susceptible to peroxidation due to its long-chain and high unsaturation degree.

Towards tailored nutritional profiles in microdiets for traditional and emerging species for European aquaculture

High lipid/energy diets resulted in beneficial effects for species with higher activity patterns and growth rates, such as greater amberjack (Navarro-Guillén *et al.*, 2019) and meagre. However, it can also be observed that these benefits were also observed in seabream and seabass, species that attain lower growth rates at early developmental stages, but also have a clearly active behavioral pattern. In the case of seabass, it was interesting to observe that dietary DHA supplementation did not bring additional benefits to those verified for larvae fed high dietary lipid levels. Such findings suggest that DHA levels in the HFAT diet already fulfilled seabass DHA requirements and an additional supplementation of this polyunsaturated fatty acid was likely not necessary. In fact, DHA supplementation had an impact on oxidative stress biomarkers, indicating that dietary DHA levels adopted in the HFATDHA diet were most likely above an optimal level.

Senegalese sole was the only species showing a lower growth performance when dietary lipid levels increased. Therefore, contrarily to the remaining species of the current study, there was no beneficial effect for sole to feed on a diet containing higher lipid levels. A previous

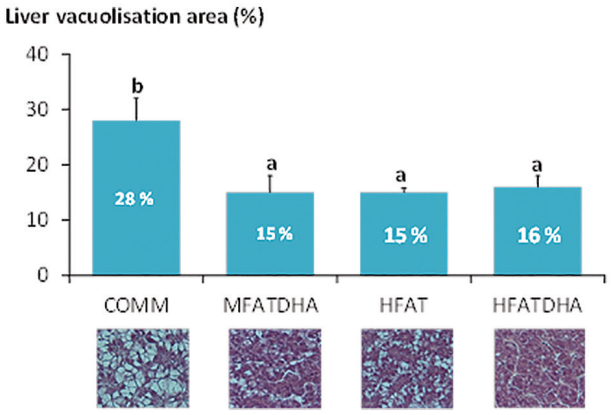

Figure 4. Liver vacuolization area in seabass larvae fed diets containing different lipid and energy values. COMM: commercial diet; MFAT and HFAT: diets containing moderate and high fat levels, respectively; HFATDHA: diet containing high fat levels and supplemented with DHA. Pictures below each dietary treatment illustrate the level of lipid vacuolization found in liver hepatocytes of fish from each treatment.

study by Pinto *et al.* (2016) showed that increasing dietary lipid and DHA levels increased Senegalese sole post-larvae growth performance. However, it should be taken into account that diets tested under the scope of that study varied in lipid composition from 6 to 13% (diet wet matter basis), with these levels being below those for both diets (MFAT and HFAT) tested in the current study. Interestingly, sole can be considered the least active species of those targeted in the current study, suggesting that high dietary lipid levels may be more adequate for species with a more active behavioral pattern. It is likely that a high energy input derived from dietary lipids may spare dietary proteins from being allocated for energetic purposes, being available for deposition in muscle tissues and growth purposes, as observed in juveniles of several fish species.

In general, results from the current study show that the nutritional profile of a single diet will not be optimized for the early stages of different species targeted for aquaculture. Hence, optimal dietary lipid levels and fatty acid profiles should be determined for the early-life stages of each species. Future endeavors should focus on the creation of tailored diets that comply with each species' nutritional requirements.

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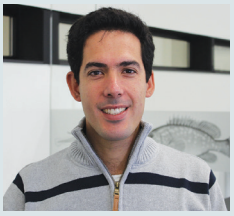

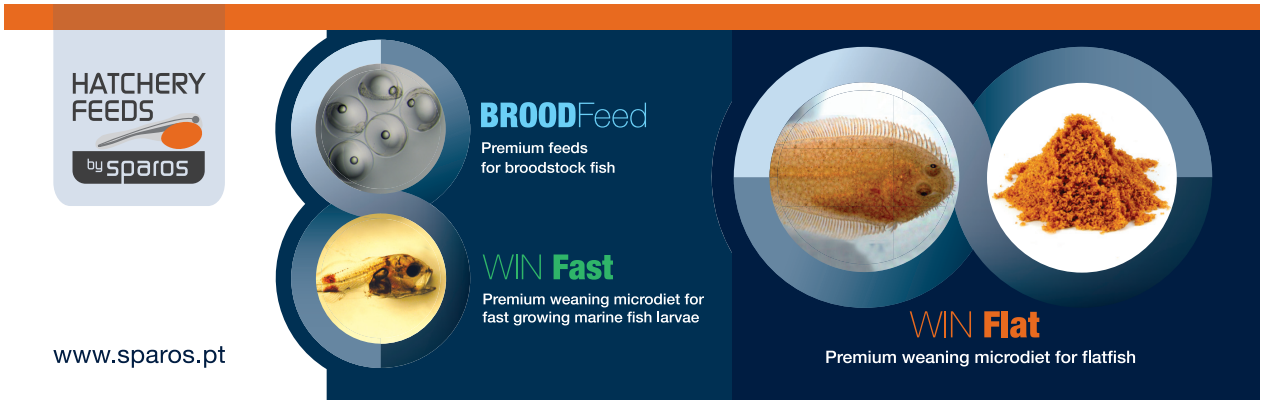

Developments in aquaculture from BLUEGent

Prof. Dr. Ir. Tom Defoirdt
Center for Microbial Ecology and Technology (CMET), Ghent University

Antivirulence therapy: Disarm your microbial enemies

Disease outbreaks are a major limitation to increasing aquaculture production. Vibrios are amongst the major bacterial pathogens of aquatic organisms, causing severe diseases, such as acute hepatopancreatic necrosis disease (AHPND). This results in up to 100% mortality, and losses of up to more than $1 billion per year in the shrimp industry alone. Antibiotics are still critically important as a first-line therapy for the treatment of bacterial infections, both in humans and animals. However, bacteria showing clinically relevant resistance to antibiotics consistently appear within as little as a few years after the first use, and bacteria have now developed resistance against all known antibiotics.

A major reason for this is that the modes of action of the currently available antibiotics are primarily variations on a single theme: bacterial eradication. Such mode of action imposes strong selective pressure for resistance development, i.e., a mutant that is resistant to an antibiotic will be able to multiply in the presence of the antibiotic, whereas its antibiotic-sensitive competitors will be killed. As a result, resistance is spreading rapidly, rendering antibiotic treatments ineffective.

As a consequence of the frequent use of antibiotics in order to control bacterial diseases in aquaculture, aquaculture is a major source of antibiotic resistance genes, and this is an important problem with respect to public health. Antibiotic resistance is common in aquaculture pathogens and in human pathogens that are associated with seafood. This is only the tip of the iceberg, since the pathogenic bacteria that are screened for antibiotic resistance are only a fraction of the total microbial community that is associated with seafood, and the other (harmless) bacteria can also contain antibiotic resistance genes. These genes can often be transmitted to other bacteria, including human pathogens.

It is clear that on the one hand, controlling bacterial diseases in aquaculture is essential to assure food security, whereas, on the other hand, the practice of using antibiotics for this purpose is causing major problems for food safety. Hence, there is an urgent need for novel methods to control bacterial diseases in aquaculture.

Antivirulence therapy

Infection by bacterial pathogens is caused by the production of different virulence factors, i.e., molecules or cell structures produced by pathogens that enable them to colonize or harm their host. As virulence factors are required for infection, preventing pathogens from producing them constitutes an interesting alternative strategy for the control of disease, and this strategy is called antivirulence therapy. Rather than killing, antivirulence therapy aims at “disarming” the pathogens, thereby preventing them from attacking their host. Importantly, little to no negative impacts on the harmless and beneficial bacteria within the host are expected. This is in sharp contrast to antibiotics, which not only kill the pathogens but also harmless and beneficial bacteria. This can result in problems associated with the loss of the functions performed by these harmless and beneficial bacteria (e.g., their contribution to digestion). These problems can persist for some time after ending the antibiotic treatment because beneficial bacteria have to recolonize the host again before their beneficial activity can restart.

As antivirulence therapy does not kill the harmless and beneficial bacteria, this kind of problem will be prevented. Another advantage of antivirulence therapy

is that it imposes less selective pressure for resistance development when compared to conventional antibiotics, i.e., a resistant mutant will have a smaller advantage over the sensitive competitors because antivirulence therapy does not kill these competitors.

Quorum sensing in aquaculture

Virulence factors and the activities associated with them are often metabolically costly to the cells that produce them, and therefore, their expression is tightly controlled by various regulatory mechanisms. Amongst the best-characterized virulence regulatory mechanisms are bacterial cell-to-cell communication systems, called quorum sensing. Quorum sensing is a gene regulation mechanism in which bacteria coordinate certain processes (including the production of virulence factors) in response to the presence of small signal molecules. Vibrios belonging to the *Harveyi* clade (i.e., *Vibrio harveyi* and closely related species like *Vibrio campbellii* and *Vibrio parahaemolyticus*) are model species in quorum sensing research. These bacteria contain a three-channel quorum sensing system (using three different signal molecules), that controls the expression of different virulence factors and that is required by these pathogens to attack their host.

During the past 15 years, several agents capable of inhibiting three-channel quorum sensing systems in aquaculture pathogens have been identified, and these agents have been proven to be effective in controlling disease in various aquatic host-pathogen systems. The agents tested in these studies included natural and synthetic compounds, and (metabolites produced by) micro-organisms. As a whole, these studies can be considered as a proof-of-principle for the concept of antivirulence therapy for aquaculture as they have proven that disease can be prevented by interfering with the three-channel quorum sensing system of the pathogens. However, in contrast to vibrios belonging to the *Harveyi* clade, the three-channel quorum sensing systems of other species such as *Vibrio anguillarum*, *Vibrio crassostreae* and *Vibrio tasmaniensis* have no effect on their virulence. Therefore, we need to develop novel inhibitors that target other molecular pathways.

Even though many bacteria have been known for a long time to produce substantial amounts of indole, its biological role as a signaling molecule has only relatively recently been revealed. We have recently shown that indole controls the virulence of vibrios belonging to the Harveyi clade. Adding indole significantly decreased motility, biofilm formation and exopolysaccharide production, which are virulence factors that enable the pathogens to attack their host. We also found that natural indole analogues that are produced by plants and (micro)algae (e.g., the plant hormone indole-3-acetic acid) have a similar effect as indole. Finally, we have shown that indole also controls the virulence of other *Vibrio* species, including *Vibrio anguillarum*, *Vibrio crassostreae* and *Vibrio tasmaniensis*. The current research now focuses on the further exploration of natural sources of indoles (bacteria, algae) as well as on identifying synthetic indole analogs with a stronger effect than indole to be used as novel virulence inhibitors to control *Vibrio* disease. Altogether these results show that disarming pathogenic bacteria by using virulence inhibitors is a valid alternative to the use of antibiotics.

Preventative fish health management in modern aquaculture

Terje Tingbø, PHARMAQ part of Zoetis

Figure 1. Manual vaccination of pangasius in Vietnam. Each fish is carefully vaccinated by trained operators using hand-held injectors.

Sustainable and healthy food for a growing global population

There is an increasing need for healthy and sustainably produced food driven by a growing global population. Many wild fish stocks are overexploited, and aquaculture is the solution to meet the rising demand for seafood. Aquaculture production has grown by 7.5% annually since 1970, and volumes of farmed fish have recently surpassed wild catch (FAO). Despite significant advances in farming practice and technology, the aquaculture industry is still facing challenges with regard to disease outbreaks, food safety and environmental footprint.

The aquatic environment

Intensified production increases the risk of outbreaks and the spread of disease for all farmed animals. Epidemiology in fish populations is similar to that of humans and other animals, but there is one important difference. Fish live in water which represents an optimal environment for the transmission of bacteria, viruses and parasites. Pathogens may be transferred between wild and farmed species, between fish inside the farm, or from one farm to another. When disease occurs, the whole population must be treated, with the risk of pharmaceutical residues influencing the farming system and reaching the surrounding aquatic

Figure 2. Automatic vaccination of tilapia in Brazil. The machine scans each fish, adapts the injection point and depth individually, gathers population data and grades the fish by size into different channels.

environment. Increasing efforts are therefore being made to reduce the use of therapeutics and chemicals, in order to ensure food safety, protect human and animal health and preserve the environment.

Understanding epidemiology

The best way to reduce the impact of disease in aquaculture is prevention, and the first line of defense is fish health and biosecurity. To create and maintain an efficient fish health management and biosecurity plan, a proper understanding of epidemiology and disease risks is required. Diagnostics can be used to screen populations prior to re-location, for routine health checks, or to investigate outbreaks of disease. A wide range of tests and assays are currently available for fish diagnostics, but these need a well-founded sampling strategy and evidence-based interpretation to optimize the return on investment. A screening study covering the whole cycle from hatching to harvest can provide valuable information on epidemiology and the impact of pathogens on production, and facilitate the implementation of measures to reduce the risk of disease. Co-infections, i.e., a disease caused by two or more pathogens, commonly occur in many farming environments. Various combinations of bacteria, viruses and parasites may be found, and it is often challenging to determine which ones are the primary and secondary causes of disease. The presence of certain parasites may, for example, suppress the immune system and could facilitate bacterial or viral infections that would not have occurred in healthy fish. A diagnostic investigation should therefore always be performed with an open mind, backed by a proper clinical evaluation and validated methods.

The role of fish vaccines

In the mid-eighties, Norwegian salmon farmers were the first to perform large-scale commercial vaccination of fish. Today, salmonids are routinely vaccinated against up to nine different bacteria and viruses. While production has grown to 1.4 million tons, the use of antibiotics in Norway has been reduced to nearly zero.

The continuous pipeline of new and improved vaccines has been crucial for this development, but factors such as improved biosecurity, nutrition, genetics, farming technologies, fish health knowledge and governmental regulation have also contributed significantly to the success. The experience and knowledge gained from salmon are today being employed to the benefit of other species, such as European seabass, seabream, barramundi, pangasius and tilapia, and vaccination is being successfully adopted. Many of the tropical freshwater species are however of low value and large parts of the production are done by hardly developed smallholder farms with limited ability to invest in new technologies. A holistic approach to improvement, involving farmers, academia, the supply industry, fish buyers and not least authorities will therefore be even more important to succeed in making these industries more sustainable.

Vaccine strategies and technologies

Delivery of vaccines to fish can be done orally (through feed), by immersion (dip or bath) or by injection (into the abdominal cavity or muscle). So far it has proved difficult to obtain significant and lasting protection after oral vaccination and immersion, and injection into the abdominal cavity remains the most common method.

The classic and well-proven approach is to cultivate the bacteria or viruses, inactivate them by heat or chemicals, and mix the antigens (inactivated pathogens) with substances called “adjuvants”. Adjuvants help improve the efficacy of the vaccine by strengthening the immune response and/or facilitating a prolonged release of antigen (depot effect). In injectable fish vaccines, antigen suspended in water is often mixed with oil into an emulsion which stimulates the immune system and creates a depot effect. The vaccine is injected into the abdominal cavity of the fish, it is metabolized over time and it is safe for both the fish and the consumer. The most complex commercial fish vaccines available today protect against as many as seven pathogens – two viruses and five bacteria. Other technologies that have been employed in recent years are DNA vaccines and live vaccines. A DNA vaccine is injected into the muscle and introduces a DNA sequence into the cells, whereby they produce an antigen similar to a part of the pathogen which triggers an immune reaction. An attenuated live vaccine is made

Figure 3. Quality control of injection point and deposit should be performed regularly during vaccination.

by weakening bacteria or viruses sufficiently enough so that they activate the immune system but are unable to cause disease.

Administration of injectable vaccines

Once an efficacious vaccine has been developed, the next step is to inject it gently, accurately and efficiently into the fish. Vaccination can be done either by manual injection or automatically by machine. Either way, training, equipment, optimization of procedures, fish flow and quality control is key for a good result. Only licensed, well-documented anesthetic substances should be used to ensure a high level of animal welfare and safety, and investment in quality vaccination equipment will pay off. Various brands and types of pistol grip syringes are available, including injectors that enable simultaneous administration of vaccines. In recent years, automatic vaccination has become the "gold standard" for salmonids, and automation is also increasing for species such as European seabass and tilapia. The most advanced machines have integrated units for anesthesia and holding. They scan each fish, optimize the injection point, inject up to three vaccines simultaneously, collect population data, and grade the fish into different tanks.

The future

Healthy fish are profitable fish and caring for the environment is an investment in the future for every fish farmer. The One Health initiative, as well as major organizations such as WHO, OiE and FAO, are warning that antimicrobial resistance caused by the imprudent use of antibiotics in several sectors is becoming a global threat to human and animal health. Furthermore, many water systems are threatened by pollution, and a switch to preventative fish health management is required to ensure healthy and sustainable growth in aquaculture. Innovation is happening fast in the areas of diagnostics and vaccines, but a wide approach is required, and collaboration between all stakeholders will be needed to succeed.

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Micro-dose vaccines: Why less is more

Giulia Faè, Socorex Isba SA

Over the past two decades, aquaculture has grown at an average annual rate of approximately 8%. In 2014, the contribution of aquaculture to supply food for human consumption overtook wild-caught fish for the first time. This unprecedented growth of global aquaculture has not been free of challenges.

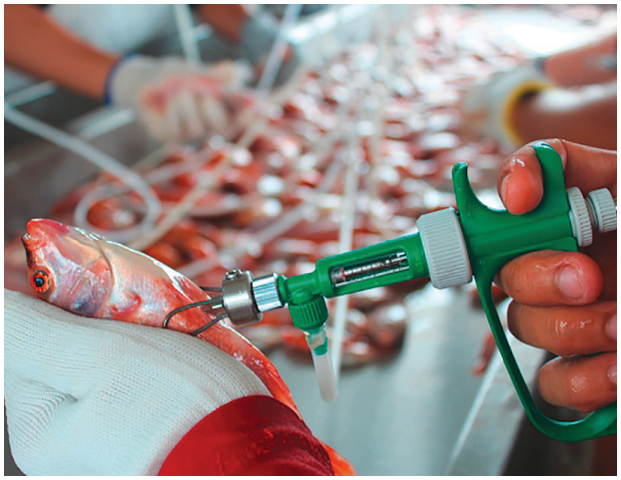
From antibiotics to preventive medicine in aquaculture

The vaccine against enteric redmouth disease (caused by *Yersinia ruckeri*, a gram-negative bacteria) developed in the 1970s was the first to become commercially available. During the past 20 years, fish vaccines have become an established and cost-effective method of controlling several viral and bacterial infectious diseases. The overall positive effect of vaccination in farmed fish is reduced mortality, making production more predictable and profitable.

In Norway, the use of antibiotics has been reduced from 47 tons to approx. 1 ton after vaccination became a common strategy to control bacterial diseases in farmed fish. Viral diseases are more difficult to control (also due to the lack of anti-viral drugs) and have caused catastrophic losses to fish farmers around the globe. Nevertheless, several viral vaccines have been developed in finfish. The Chilean Infectious Salmon Anaemia (ISA) crisis of the first decade of the 21st century was caused by inadequate production management methods, including the failure to vaccinate fish against ISA.

The challenge of reducing side effects when injecting

Vaccination for aquatic species has three major routes of delivery: injection [intraperitoneal (IP) and intramuscular (IM)], immersion, and oral. Among those methods, vaccination by injection has proven



Vaccinating tilapia with Socorex syringe and FishGuide accessory.

preferable where species allow, having several definite advantages. It provides the most direct delivery of antigens throughout the immune system. The vaccine can be concentrated and delivered in the presence of adjuvants and other beneficial compounds (e.g., carriers, bacterial antigens/cells, etc.) that could not be delivered by other methods. However, despite its high efficiency in generating immunity, injection also has some disadvantages. Inflammation and pigmentation in the abdominal cavity, a prolonged period before fish return to normal feeding and, potentially, downgrading of the fish fillets are possible side effects associated with injectable vaccines.

Local reactions may vary from mild, such as very slight adhesions (most frequently around the injection site), or hardly noticeable amounts of melanin on viscera, to severe, including major lesions to the carcass after evisceration. Those affect almost every internal organ in the cranio-dorsal area, often with a considerable amount of melanin, where viscera become unremovable without damaging the integrity of the fillet.

With advancements in immunology, molecular biology and microbiology, vaccine technology has been under continuous development. Minimizing reactions is the main goal. Many factors contribute to the onset of side effects, dose-volume being one of the most important.

Vaccination history over the last 35 years

In the late '80s, fish were injected with relatively high vaccine doses such as 0.2 milliliters, which in some cases is still prevailing, and sometimes resulting in serious adverse reactions in the abdominal cavity.

A vaccine with half that volume was launched on the Norwegian market in the mid-'90s, bringing the advantage of reducing side effects, without downgrading efficacy. In 2003, a 0.1 mL-dose, multivalent vaccine, protecting fish against various pathogens, was introduced. Five years later, the very first 0.05 mL vaccine, containing the same antigens was released. Yet, the reduction in the size of vaccine doses, of utmost importance, went nearly unnoticed by the ichthyology community. Present scientists are not the first to be aware that *dosis sola facit venenum*[1].

Thanks to the increase in vaccine potency, developers have been able to reduce the required doses, starting the successful story of efficacious micro-doses, including multivalent ones.

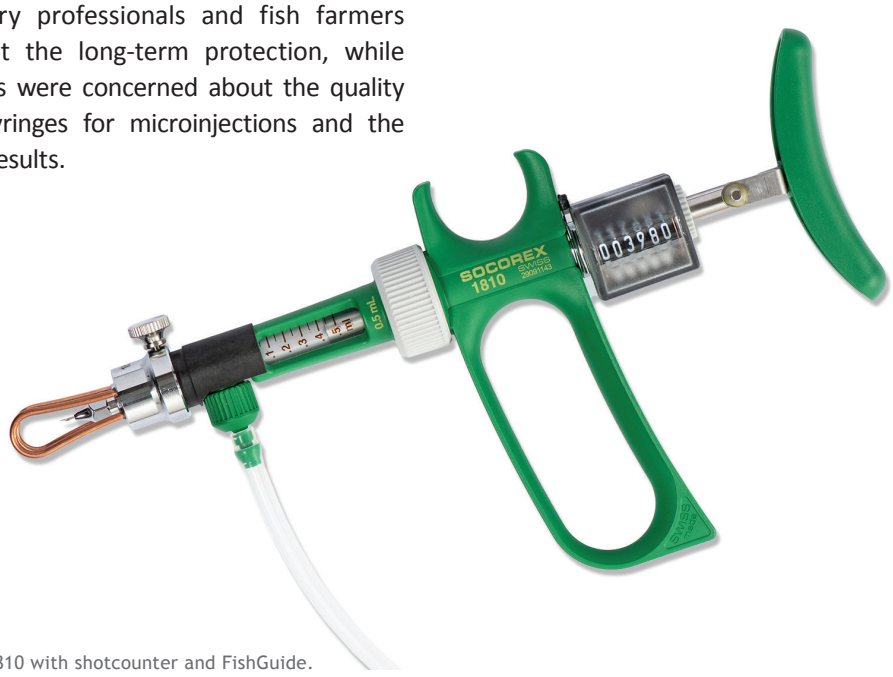
The adoption of the novelty was not fast in the beginning. Skepticism and concern slowed down the process. Veterinary professionals and fish farmers had doubts about the long-term protection, while pharma companies were concerned about the quality of the existing syringes for microinjections and the reproducibility of results.

Bringing medical-grade precision to the aquaculture vaccination sector

One of the key companies that have helped introduce the administration of micro-dose vaccines is the Swiss firm Socorex, a true pioneer in this field. While the company initially focused on glass and metal syringes for human applications, it branched out into developing automatic syringes for the animal health sector in the 1980s. Terrestrial livestock has been their first focus, galvanized by the industry's desire for smaller and more precise doses, Socorex has moved into the fish farming sector later on. Their dedication to accuracy and quality has been an all-time tradition, precision liquid dosing having been their strength for nearly 60 years. Having successfully designed a syringe for delivering vaccines to day-old chicks, which are typically around 40 grams, Socorex realized they could transfer the technology to aquaculture, fish being generally vaccinated between 15 and 80 grams of weight.

Socorex could benefit from their decade-long experience in the lab and biotech fields to develop the new 1810 *ultra* model – a true metrological system – allowing operators to deliver doses as low as 0.02 mL, if needed, without compromising reliability and efficiency.

The medical-grade precision this model brings to the aquaculture sector – the syringes have a 99 to 99.5 percent precision rate, an exceptional performance



Socorex syringe *ultra* 1810 with shotcounter and FishGuide.

and great advantage. Excessive doses could lead to serious adverse reactions and highly increase the cost of vaccination, whereas lesser doses will reduce the vaccine efficacy.

In addition to playing an important role in minimizing side effects, vaccine micro-doses expand application possibilities. In fact, the lesser injected volume, the younger the fish, thus providing more time to build up an immune response before transfer to basins or sea pools. Furthermore, combining several small dosage vaccines in single injections drastically reduces fish stress and costs, while improving productivity.

The new Socorex *ultra* model features a very fast activation pace, making it perfect for injecting a great many fish. Made from high-resistance molded resins, with a thick glass barrel, it is extremely light and requires smoother pressure. Long-lasting, it is extremely resistant to shocks and water, even salt water. The instruments can last indefinitely if properly maintained and if seals and springs are replaced when needed, just like medical instruments.

The 0.1, 0.2, 0.3 and 0.5 mL nominal sizes stretch volume selection from 0.02 mL to 0.5 mL. They are therefore suitable for a wide range of species, including salmonids, tilapia, pangasius, seabass and seabream. They also operate with both oil- and water-based vaccines. A range of accessories to help optimize performance are available. These include the FishGuide, a double copper loop that facilitates the accurate injection, while protecting the operator's hand from accidental self-injection, and the Abacus counter, allowing the exact count of how many doses have been delivered.

Conclusions

Aquaculture will continue to face uphill struggles as its expansion persists, and fish farmers will always appreciate the contribution of leading manufacturers fully committed to supporting its growth, in full respect of the environment.

[1] "Only the dose makes the poison", an aphorism intended to indicate a basic principle of toxicology. It is credited to the Swiss alchemist Paracelsus (16th century).

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Production of high quality and biosecure whiteleg shrimp broodstock using indoor closed aquaculture technology

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[1] NOVATON AG, [2] School of Life Sciences and Technology, Institut Teknologi Bandung, Indonesia

Shrimp are one of the most widely cultivated aquaculture commodities, accounting for up to 55% of the total global shrimp production (FAO, 2020). Within the sector, the demand for whiteleg shrimp (*Litopenaeus vannamei*) has continued to increase – to the point that the market's needs are no longer matched by the current supply.

One of the main obstacles facing shrimp farmers is the availability of high-quality seed from hatchery operations. Alongside considerable differences in seed quality, these producers are encountering a great deal of unpredictability with regards to both biological performance and disease/contamination risks (specific pathogen-free). Furthermore, low-quality seeds can cause failure or losses in shrimp aquaculture systems, including slow growth, non-uniform size and increased sensitivity to changes in water quality and the production environment (Wei *et al.,* 2014). With most seeds produced in hatcheries, the availability of excellent broodstock is a critical factor in establishing high quality.

Conventional aquaculture systems

From a sustainability perspective, the development of the aquaculture industry faces fundamental challenges because the cultivation techniques used for broodstock production are still dominated by conventional systems using semi-batch, flow-through, and outdoor earthen pond systems. These conventional cultivation systems are still widely used because the technologies are relatively simple with low operational costs, and continue to be profitable. Nevertheless, from a long-term standpoint, these conventional aquaculture systems cannot continue to dictate the sector – not least because of their inability to control water quality and prevent disease. In addition, conventional systems tend to produce low quality and quantities of seed. Hence, alternative technologies for broodstock production need to be developed and implemented as a progressive strategy to enhance the overall sustainability of shrimp aquaculture (Eng *et al.*, 1989; Otoshi *et al.*, 2003; Suantika *et al.*, 2018).

NOVATON closed aquaculture system

One alternative for high-quality broodstock production is the application of the NOVATON Closed Aquaculture System. This environmentally-friendly system is designed to reproduce the optimal conditions to grow selected crops. It includes the specific conditioning of water, salinity and temperature while offering high levels of biosecurity and animal welfare, alongside effective waste management.

NOVATON's aquaculture technology stems from the evolution and combination of different methodologies to cultivate shrimp in closed environments together with new cleantech equipments that manage the

Figure 1. NOVATON culture tank at closed aquaculture facilities at Tabuk, KSA.

delivery of energy, aeration, climate and biological parameters in the water. This ensures the quality and stability of the culture water during all cultivation stages of broodstock production.

The water recirculation system technology (RAS) is supported by the principle of equilibrium microbial manipulation in culture tanks and other biological operations. These exclude any chemicals or aggressive technologies.

NOVATON's closed system technology offers proven benefits and efficiencies, including maintaining the optimum physicochemical water parameters that further support the biological parameters of the cultivated animals, reducing stress during cultivation, and maintaining high biosecurity. Collectively, these benefits lead to higher shrimp quality in terms of nutritional value and yield (both production volume and growth rates).

Table 1. Optimum water quality for shrimp cultivation.

Parameter	Tolerance level	Optimum level
Dissolved oxygen (DO)	> 5 mg/L (Bregnballe, 2015)	5-6 mg/L (Yamamoto, 2017)
Temperature	5-30°C (Lekang, 2007) 10-30°C (Yamamoto, 2017) 10-35°C (Bregnballe, 2015)	30°C (Lekang, 2007)
pH	6.5 – 8 (Bregnballe, 2015) 6-9 (Timmons and Ebeling, 2010)	Near 7 (Yamamoto, 2017) 7 – 8.5 (Bregnballe, 2015)
Total ammonia nitrogen ($NH4^+$)	0.05 – 0-5 (FAO, 2018)	0.05 – 0.15 (FAO, 2018)

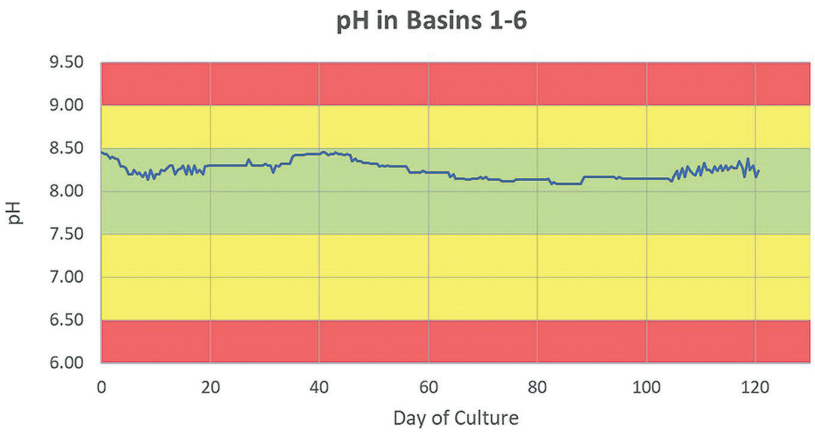


Figure 2. pH level maintained in the optimum range during the rearing period. Green indicates optimal level, yellow indicates tolerance level, and red indicates sub-optimal levels.

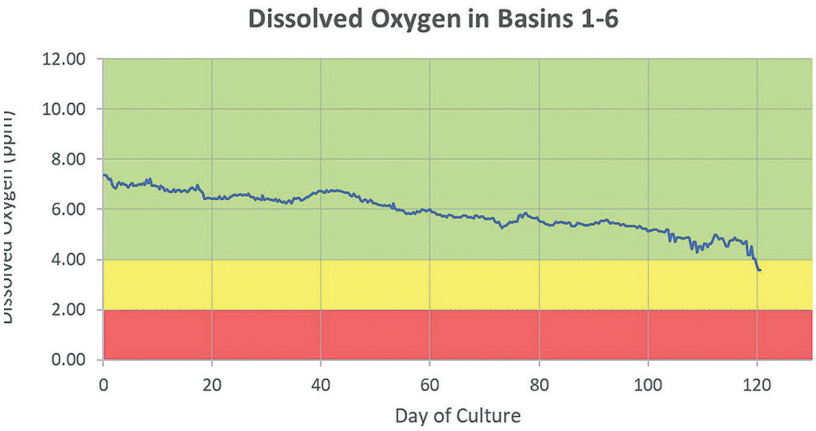


Figure 3. Dissolved oxygen (DO) level was maintained in the optimum range during the rearing period. Green indicates optimal level, yellow indicates tolerance level, and red indicates sub-optimal levels.

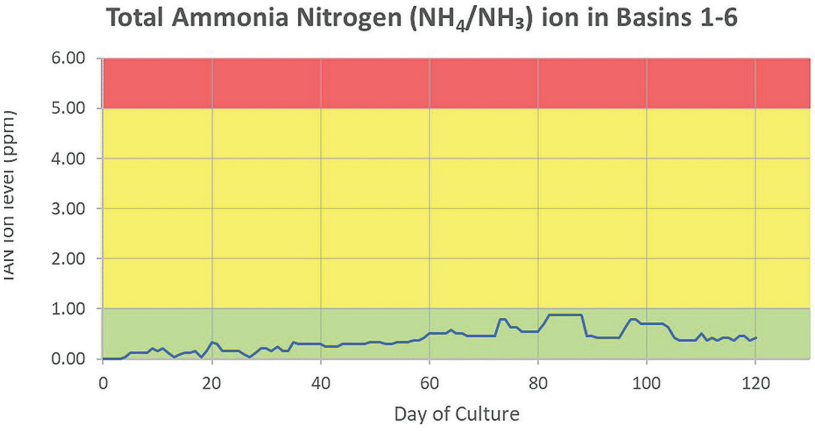


Figure 4. Total ammonia nitrogen (TAN) level was maintained in the optimum range during the rearing period. Green indicates optimal level, yellow indicates tolerance level, and red indicates sub-optimal levels.

Biosecurity

The technology applies biosecurity in three aspects: (1) animal management, (2) pathogen management, and (3) people management.

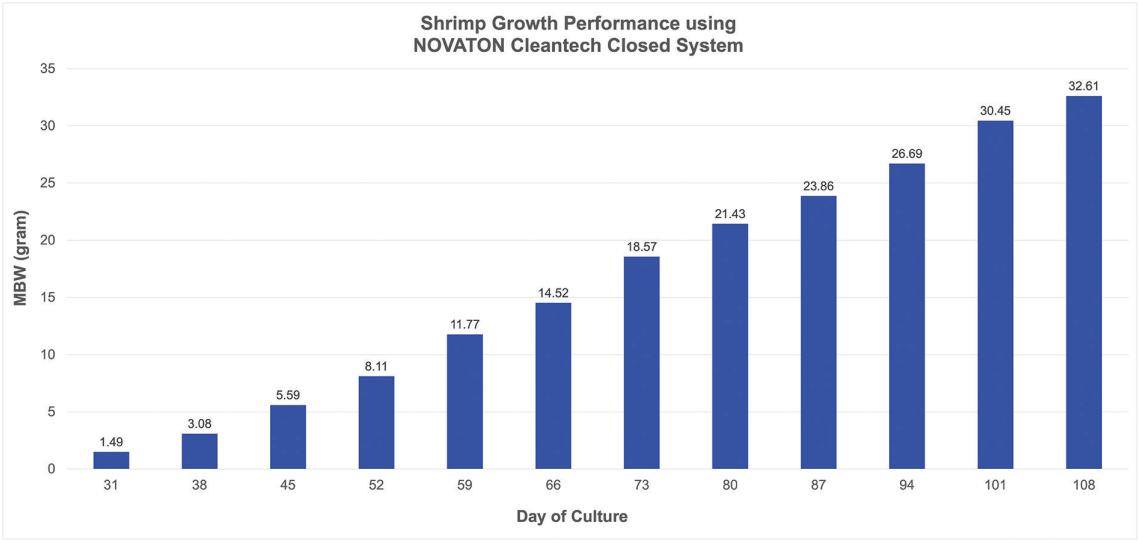
Animal management ensures the cultured animal is in optimum condition, supported by good husbandry procedures. For pathogen management, we prevent and eliminate pathogens from entering the culture area. Other important biosecurity aspects in broodstock production are seed selection, feeding processes, shrimp sampling and monitoring, and equipment cleaning and maintenance (Fig. 1).

Water quality

NOVATON's cleantech closed system technology can also be used for post-larvae (PLs) rearing, starting from PL8 to PL11 for six months until reaching the appropriate size for broodstock candidates. During the cultivation process, shrimp are fed under an optimal feeding management procedure to ensure sufficient feed quantity and quality (nutritional levels) for the shrimp's growth. In addition, water quality management is conducted to maintain the optimum range (Table 1).

Results of daily monitoring have demonstrated that the NOVATON cleantech system can maintain all water quality parameters, including pH levels, dissolved oxygen (DO), and total ammonia nitrogen (TAN) concentration within optimum ranges throughout the 140 days of the broodstock rearing period (Fig. 2, 3, 4).

A



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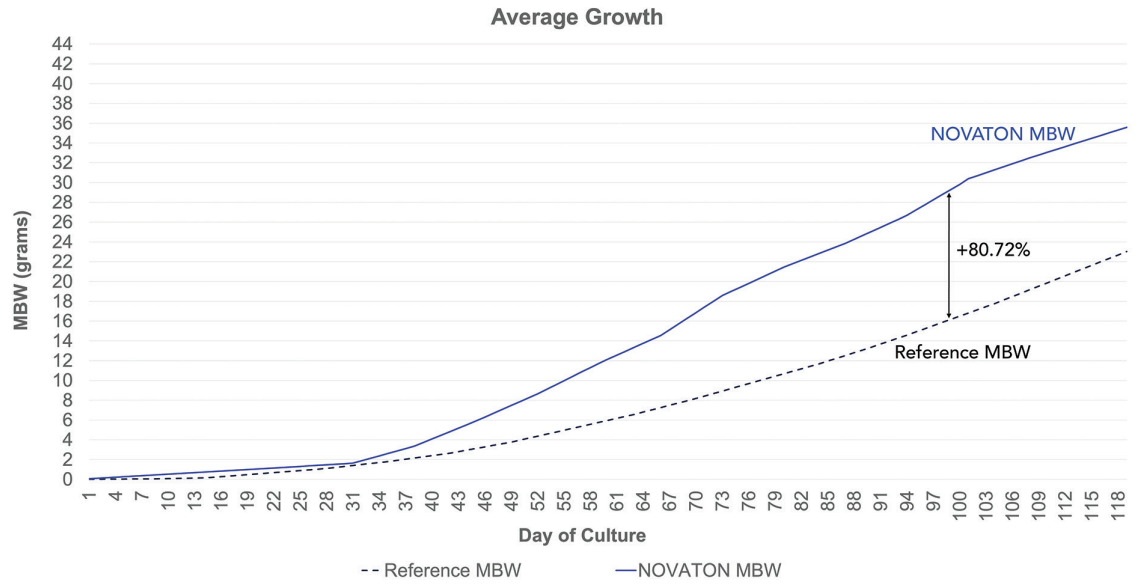

Figure 5. (A) NOVATON shrimp growth performance based on weekly sampling. (B) Comparison of shrimp growth on NOVATON cleantech system (blue line) with average shrimp growth (grey line).

Improved shrimp growth

Moreover, the system's ability to provide optimum water quality conditions significantly affected the shrimp growth performance. The results of weekly monitoring of shrimp growth (mean body weight / MBW) after a one month period under blind feeding procedure until the day of culture 108 are as follows (Fig. 5).

In terms of growth performance, the application of the NOVATON cleantech system results in an extraordinary growth rate with a daily average growth rate of 0.31 g/day. An average body weight/AFBW of 30 g was achieved after 100 days of culture, which was significantly higher compared to the shrimp growth obtained from conventional culture systems (approximately ± 80.7% higher). After 130-140 days, shrimp with the highest growth (AFBW of 40 ± 2 g) and morphological observation (color, rostrum, carapace, etc.) are selected as the candidate broodstock as presented in Figure 6.

Figure 6. Shrimp sampling and monitoring for broodstock candidates.

Conclusion

Based on the overall water quality and shrimp growth performance, it can be concluded that the application of the NOVATON cleantech closed system is a proven alternative aquaculture technology for high-quality shrimp broodstock production and a new strategic approach to sustainable global shrimp production at industrial volumes.

References available on request.

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Closing the cycle in tuna aquaculture: Logistics are essential

Paul-Daniel Sindilariu, Jan Giebichenstein, Next Tuna GmbH

Next Tuna GmbH (Next Tuna) is dedicated to the sustainable production and commercialization of Atlantic Bluefin Tuna (ABT) in the Mediterranean Sea (Med Sea). From our perspective, fish logistics is one of the key success factors for closing the ABT production cycle.

Tuna in general, and especially ABT, are very sensitive to handling. In the early life stages, the small fish are nearly impossible to touch without harm. At later stages, fish are simply too big to be handled in a meaningful way. Large parts of the planning and design work of the Next Tuna production facility concern internal and external fish logistics. The only established means of fish logistics in the existing ABT fattening industry is the fish transport of juvenile (Croatia) and adult (rest of the Med Sea) by transport net pens from the place of catching to the place of further fattening production.

Next Tuna decided to use the established net-pen transport as means of delivery from the juvenile production facility to Next Tuna customers. Thus, no changes to the existing tuna industry standards are needed, and Next Tuna juveniles can feed smoothly into the existing tuna value chain.

We described in the Hatchery Feed & Management Vol 9 Issue 4, the measures planned for the fish logistics inside the hatchery (Giebichenstein & Sindilariu, 2021). This article describes the fish logistics from the hatchery to the transport net-pens departing to Next Tuna customers.

Next Tuna: The production concept

The first Next Tuna project description (Giebichenstein & Sindilariu, 2021) was focused on the land-based operation of Next Tuna (Fig. 1). This contribution focuses on the harbor-based operation, where the 50 g fish received from the hatchery are grown to 2-10 kg juveniles ready to sell (Fig. 1).

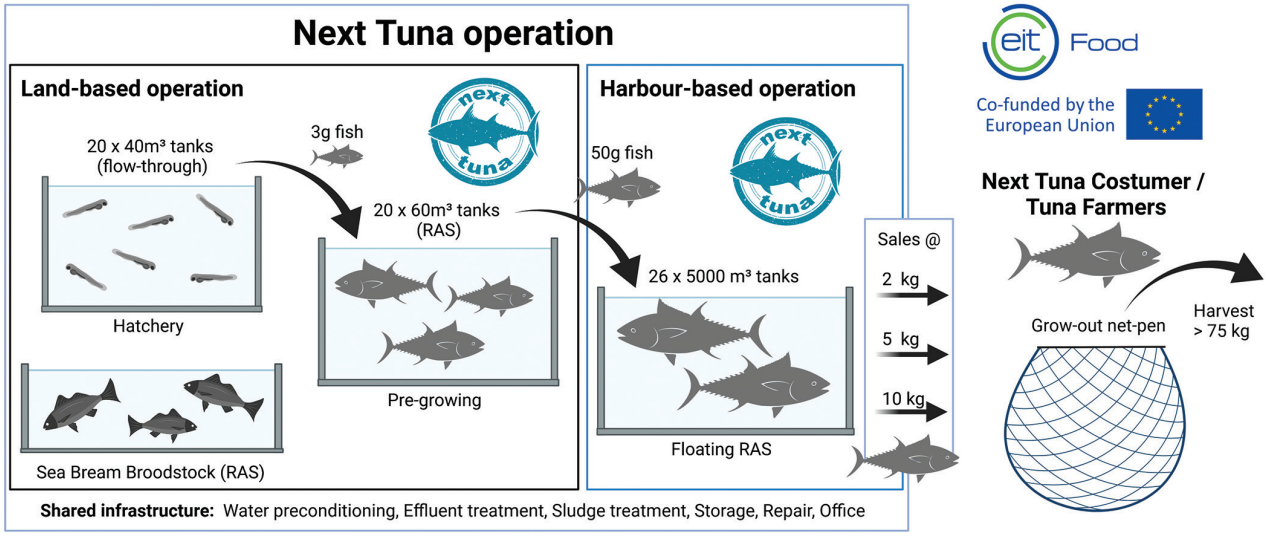

Figure 1. Schematic set-up of Next Tuna production facility. Created with BioRender.com.

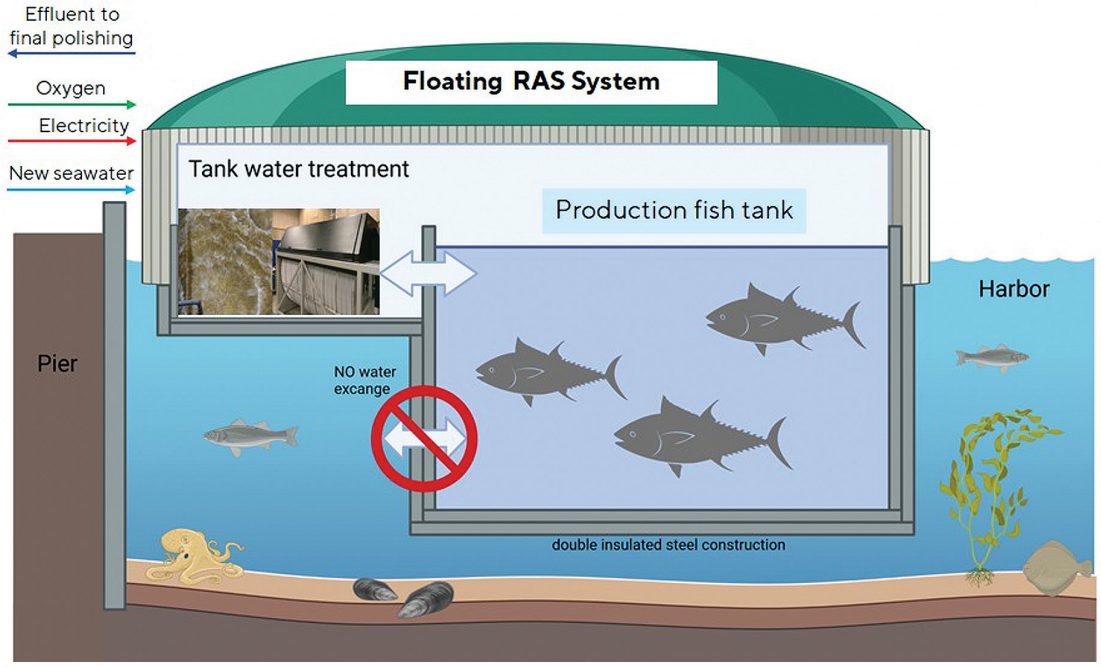

Figure 2. Schematic set-up of floating RAS system. Created with BioRender.com.

Next Tuna harbor-based operation

Next Tuna harbor-based operation consists of up to 26 floating RAS systems. The floating RAS system, designed by Next Tuna and its project partner, Seafarming Systems AS, is comparable to a 25 m diameter, 10 m depth net-pen. However, instead of a net that keeps the fish, the floating RAS has a fish tank made of insulated steel and the RAS treatment infrastructure is allocated on the same floating structure.

The floating RAS systems have two operational modes:

- Production mode: the system is connected to a harbor dock, or moored in a sheltered area and receives all essential supplies from land.
- Delivery mode: the system is disconnected from land supplies, pulled out of the sheltered/harbor area into the open sea and joined with the delivery net-pen, for safe and stress-free fish transfer.

During production mode, the floating RAS receives all supplies from land, including, electricity, oxygen, new (sea) water and delivers all residuals back to land for final effluent water treatment (Fig. 2).

The fish feed is supplied by net-pen feeders, which can be centrally loaded from the feed store in the Next Tuna harbor and connected to each floating RAS. This gives maximum flexibility, with no additional infrastructure for feed supply needed.

The RAS effluent streams are further treated on land. In a sludge thickening station, the particulate matter from the drum-filter backwash is separated from the liquid fraction. The particulate matter is further processed in a biogas facility, while the liquid fraction, is treated together with the system effluent in an IMTA approach (multitrophic integrated aquaculture) with macro/microalgae and mussels.

The floating RAS offers the advantages of a land-based RAS and adds the flexibility of a floating production platform while being in the delivery mode.

In delivery mode, the system is disconnected from all land supplies, but the RAS system is still in full operation. The electricity for the system is supplied from an emergency generator installed on each floating RAS. Oxygen is supplied from a bundle of oxygen bottles used during the transfer mode located on the platform of the floating RAS.

The delivery mode is used on one hand to receive fish from the hatchery with a crane delivery system (Fig. 3) described by Giebichenstein & Sindilariu (2021). The 60m^3 tanks used in the hatchery can also be used for fish transfer. The tanks are lifted out of their place including fish and water, by a crane system and moved on top of the floating RAS. The tank (with fish) is then lowered into the water of the floating

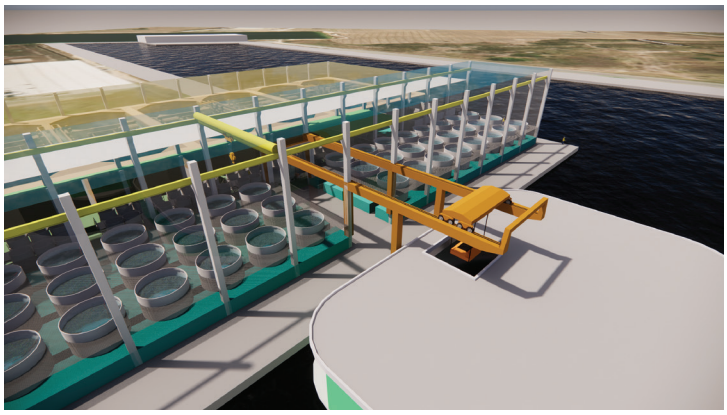

Figure 3. Schematic loading of a hatchery tank into the floating RAS system by crane. Courtesy of AFRY.

Figure 4. Depiction of Next Tuna harbor facility with one floating RAS in delivery mode, leaving the harbor pulled/pushed by two tug boats.

RAS and the fish are gently flushed into their new environment (Fig. 3).

On the other hand, the delivery mode is used to pull the floating RAS out of Next Tuna harbor and join the system with a transport net-pen, to facilitate the delivery of juvenile ABT ready to sell (Fig. 4). The delivery mode, however, can only be operated in calm weather conditions, taking chosen design limits into account.

Next to the flexibility/logistic advantages, the floating RAS offers additional beneficial features for an easy operation:

- Access, service and maintenance: After the delivery of a fish batch, the floating RAS can be easily serviced inside and outside, as the system will rise out of the water as more water is pumped out of the system. Thus, inside and outside maintenance or potential changes are easy to implement, as nearly all parts of the system become accessible;
- Cost of construction: The floating RAS is easier to implement than a land-based system. No costly ground-breaking/digging is necessary. The only requirement is either harbor/dock space or sheltered areas with wave heights within design limits (which can be adapted to local requirements);
- Modular production increase: The number of floating RAS can be increased as production volumes increase. It would actually be the first time in the industry that identical RAS systems are operated across one production facility. This keeps the service and maintenance costs at a minimum.

Conclusion

The floating RAS concept is a key feature of the Next Tuna production facility. It serves fish production and facilitates critical fish logistics. It will allow Next Tuan to achieve its production goals of 1,200T of ABT juveniles in the size range of 2-10 kg.

The system further enables Next Tuna to feed the ABT juveniles into the existing tuna fattening industry and use the well-established means of tuna transportation by net-pens. In addition, the floating RAS offers critical advantages compared to a land-based RAS set-up, like simplified maintenance, real modularity of production and reduced cost of implementing the floating RAS compared to land-based RAS solutions.

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The future of artificial intelligence in hatcheries and post-smolt farms

Caitlyn Parsons, ReelData AI

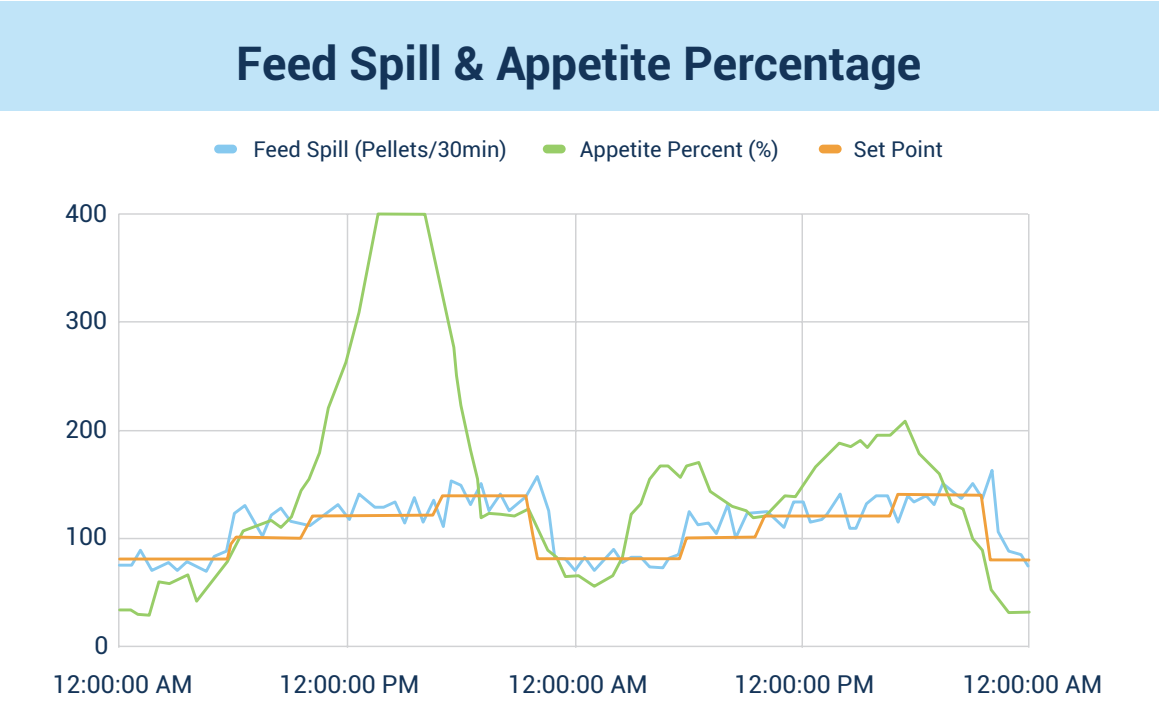
Machine learning experts monitor their artificial intelligence device in a post-smolt facility. Photo © ReelData AI.

With the recent growth of the aquaculture industry, new technology has become more prevalent in common practices, with many larger companies adopting innovative ways to automate their farming operations. The most recent wave of tech has been focused on the practical applications of artificial intelligence in aquaculture, and how it is able to help automate farms and alert farmers of any issues happening with their fish.

Many believe that A.I. and big data will become an important component for industry growth and even influence production yields. They also believe that artificial intelligence will help in creating in-depth analyses by providing operators with a glimpse of the future of fish farms, thereby limiting risks for future fish farmers. In an article in Eurofish Magazine, they discuss how "big data and artificial intelligence have become important drivers of economic development in the fish industry" by making the process "more predictable and reduc[ing] the risks associated with [aquaculture]."

With the recent trend of post-smolt farms keeping their fish in land-based tanks longer, technology is increasingly needed to support Recirculating Aquaculture Systems (RAS) and flow-through systems, which require specific algorithms that are different from those in the ocean-based industry.

ReelData AI is a company from Halifax, Nova Scotia that saw this digital deficit in the land-based industry and decided to do something about it. The company



Graph showing how ReelAppetite can help with feed wastage. Photo © ReelData AI.

was started in 2019 by two Canadian engineers with a passion for entrepreneurship. They saw that there was a growing market for land-based technology and knew that they had the ability and expertise to come up with a solution.

Autonomous feeding software

In the three years since the company's inception, ReelData has succeeded in making a name for themselves by working with several large land-based companies. Most recently they announced a long term agreement with Salmon Evolution to automate the feeding process in their new facility. They are also working with several smolt and post-smolt facilities, making them the first company to successfully create automated AI technology for smolt and post-smolt in Recirculated Aquaculture Systems (RAS).

When asked how their feeding product is applicable to the smolt and post smolt industry, Matthew Zimola, co-founder and CEO, said that "smolt farmers are fearful of water quality issues related to feed waste, and most tend to underfeed their population to avoid this risk. This can impact how quickly the fish grow. We've had a lot of success so far by eliminating the need to pick between growth and feed waste – the farmer can have both by feeding according to the real-time appetite of the population and not a constant rate given by a feed table."

ReelAppetite, an autonomous feeding software, is the inaugural product for the company and promises to stabilize the feeding process by removing issues around underfeeding and overfeeding. It works by calculating the needs of the fish in real-time through monitoring waste in the tank. So far it has seen enormous success since its introduction to the market – immediately saving farms from costly issues surrounding water quality and wasted feed.

In trials, it has shown an astonishing 80% reduction in wasted pellets at the exact same time as producing a more than 20% increase in growth rate. It works autonomously by altering the feed amount the instant it detects a change in the appetite of the fish, which is often the first sign of a stressor in the tank. Farmers are able to monitor these changes through a user interface created by ReelData that details the specific changes and appetites of each tank.

ReelData employees validating their biomass estimation A.I. at a post-smolt facility. Photo © ReelData AI.

ReelAppetite was a breakthrough design created by the ReelData team; there is no other product similar to this in the world. The possibility of applying this technology to the smolt and post-smolt industry has huge potential in ensuring that young fish have all the nutrients they need to grow quickly, increase biomass utilization, and move to market promptly without wasting costly feed.

Monitoring biomass and growth

ReelBiomass is the second product from the company. It consists of non-intrusive high-tech cameras that are placed in tanks to monitor the biomass distribution and growth of the fish. It has the ability to weigh and measure stock with high degrees of accuracy, eliminating the need to remove fish from their tanks. Traditional practices require periodic sampling from tanks which involves sedating the fish and removing them from the water. Oftentimes this creates high-stress situations for the fish, resulting in them losing their appetite and not eating. High stress can also result in scale loss, lesions, and fin damage.

Removing these high-stress events is important for hatcheries and post-smolt facilities where fish require consistent feed and nutrients to grow quickly for the facilitation of sales. Weigh-ins are often a time-intensive process that farms can rarely afford. Reducing the time that fish are required to stay in smolt and post-smolt enclosures can create high returns with a faster turnaround time by producing space for new inhabitants once the older fish have reached the ongrowing stage. These tests often provide incorrect estimations with an "inherent inaccuracy of 15-16%" observed on average.

If you are wondering how this technology differs from others in the industry, you may be surprised to learn that both ReelAppetite and ReelBiomass stand entirely alone in their fields. The few companies focused on monitoring the weight and size of fish are focused entirely on ocean-based farms, building platforms that also monitor health metrics specific to fish at sea, such as sea lice counting.

Aquatech companies have only recently begun to skim the vast pool of possibilities artificial intelligence can offer within the land-based aquaculture industry. There is little doubt that more companies within this growing sector will begin to see potential applications of this new technology in the near future. Early adopters have already begun to see the benefits of A.I.'s applications in hatcheries and post-smolt facilities, with ReelData's products gaining traction exponentially over the past year.

Aquaculture is, and will continue to be, a crucial industry with a global population on the rise. New technology is developing quickly to keep up with the growing demands for protein. Now may be the best time to be a part of this industry, and the prospect of all of this innovative technology being developed to support it makes it that much more exciting.

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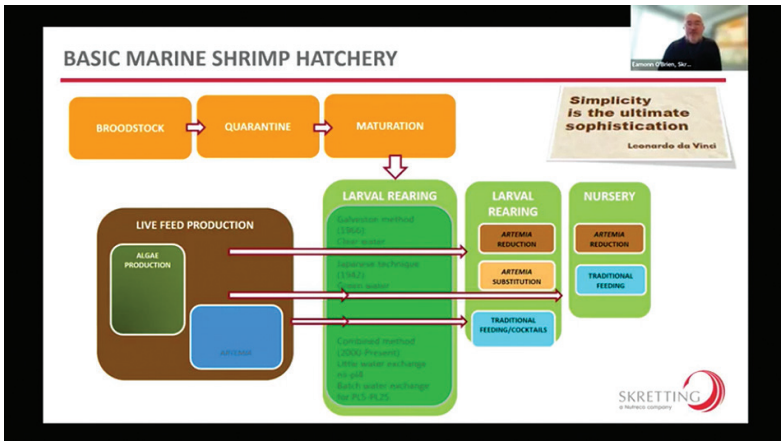
World Hatchery Forum: Feeds, genetics and equipment for hatcheries

Fifteen panelists presented recent developments in hatchery feeds, genetics and equipment for shrimp and fish at the World Hatchery Forum and how they can improve hatchery performance.

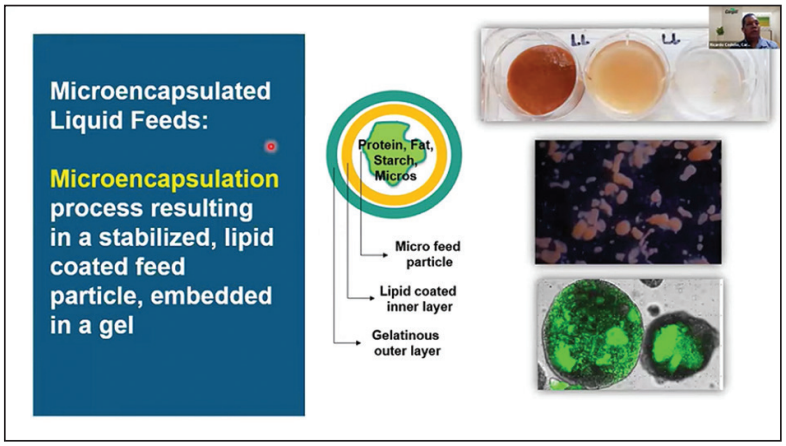
Shrimp feeds: Simplicity, fast growth feeds and precision feeding

"In the past, it was not impossible to condition broodstock without fresh feeds but in a commercial trial in Mexico, Skretting demonstrated that replacing most of the fresh feeds with a specialized broodstock diet led to the same results," said Eamonn O'Brien, product manager at Skretting. Another aspect O'Brien highlighted is the wide variety of feeding protocols, feed sizes and also additives used in shrimp hatcheries leading to a lot of complexities in production and difficulties to standardize the outputs. He suggested the use of advanced, more sustainable and stable formulas that can help improve hatchery success, advocating for simplicity. As a case of success, O'Brien presented a trial Skretting performed in a commercial hatchery in Brazil testing a high-quality diet against an established cocktail mixture in Brazil. Results showed higher survival, less feed in use, and cleaner tanks, among other results.

Ricardo Cedeño, specialist in shrimp farms at Cargill, also highlighted the importance of simplicity. He presented Cargill's liquid feeds for shrimp, which

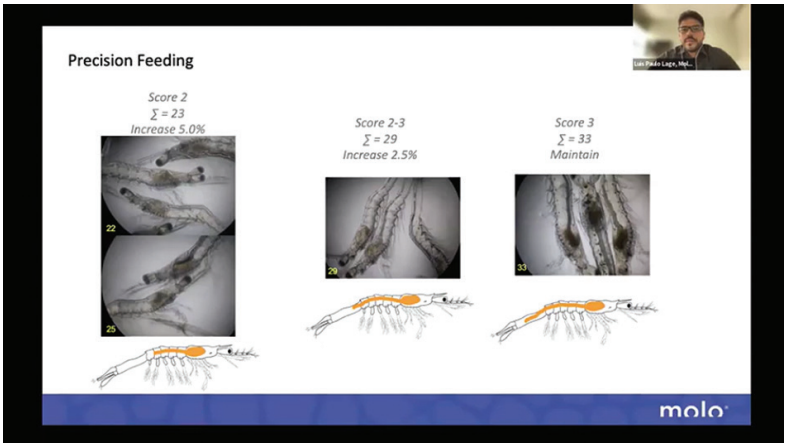


Complex shrimp hatchery production system.
Source: Eamonn O'Brien, Product Manager at Skretting.



Microencapsulated shrimp feed structure.
Source: Ricardo Cedeño, Specialist in Shrimp Farms at Cargill.

use microencapsulation technology resulting in a stabilized, lipid-coated feed particle, embedded in a gel. With liquid feeds, Ricardo said that the production processes are simplified since the number of feeds used is reduced. Cargill's microencapsulated feeds also show improved water quality with decreased total ammonia, higher survival rates and increased weight when compared to traditional feeds.



Molofeed's precision feeding scores and advice.
Source: Luis Paulo Lage, Technical Aquaculture R&D Manager at Molofeed.

Another strategy presented to maximize growth through feeds is BioMar's Fast Growth Feeds. Jef Peeters, global shrimp hatchery and nursery products manager at BioMar, said that apart from the faster growth, fast growth feeds lead to higher health performance, less fouling, higher molt frequencies and cleaner larvae. The robustness of PLs is also higher. These results translate into shorter cycles and more cycles per year, a reduction in size variation, a higher PL price and a predictable production thanks to the higher resistance and survival to stress and diseases.

Luis Paulo Lage, technical and R&D manager at Molofeed, introduced Molofeed Precision Feeding. The tool consists of daily gut feed content evaluations and adjusting the feed as needed. As a case study, Lage presented a trial performed with Molofeed's own range of feeds for shrimp hatcheries tested against a commercial protocol. Results showed higher survival and low feed utilization when feeding with Molofeed's shrimp diets and applying its precision feeding tool.

Fish feeds: Early co-feeding and rotifer substitution diets

The main objective of any hatchery is to produce quality and robust fry for the grow-out stages with high survival, growth and low deformities. "It's clear that whatever we do at the start will definitely have an impact in the following steps of the production process," said Joana Amaral, global product manager for marine fish hatcheries at BioMar.

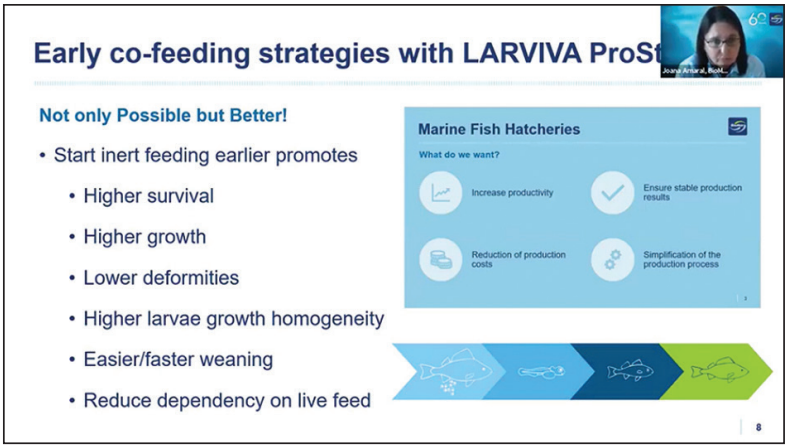
Joana said that currently not only is possible to feed fish from the mouth opening, together with live feed, but it also comes with better results. Through a series of trials in seabream, red bream and seabass in commercial hatcheries, Joana shared how early co-feeding strategies with BioMar's LARVIVA ProStart promotes higher survival, growth, homogeneity, lower deformities, easier weaning and reduced dependency on live feed.

Steven Debono, product manager of fish hatchery products for INVE Aquaculture, presented the latest results in commercial hatcheries of INVE's new rotifer substitution diets, Natura pRo and ExL, presented for the first time in our 2021 series *Trends in aquaculture hatcheries*.

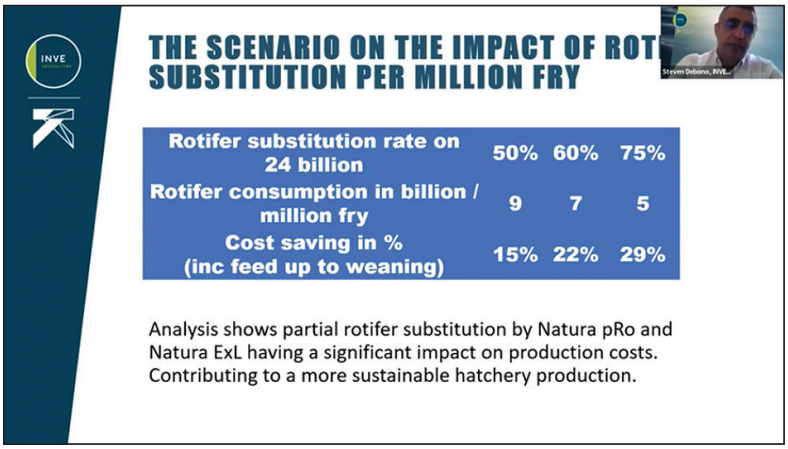
In the past few months, the company has been working with marine hatcheries confirming that this major milestone simplifies the production of quality fry, reduces running costs in rotifer units and improves fry production and performance.

Shrimp genetics: Genomic tools and breeding strategies

"Aquatic breeding programs need to be efficient and learn from terrestrial species to develop technologies in efficient ways," said Alan Tinch, VP of Genetics at the Center for Aquaculture Technologies. To build a breeding program, there are several tools available on the market. For the shrimp industry, the center developed AQUAArray HD vannamei, a comprehensive tool that helps understand the genetics of farmers' shrimp population and can be used in a wide range of applications, from genetic diversity to marker discovery and genomic selection. It has been used in major shrimp-producing countries.



Advantages of early co-feeding strategies in fish.
Source: Joana Amaral, Global Product Manager for Marine Fish Hatcheries at BioMar.



Impact of rotifer substitution diet in production costs.
Source: Steven Debono, Product Manager of Fish Hatchery Product for INVE Aquaculture.

Benchmark Genetics is also applying what has been learned from salmon to the different shrimp lines the company has developed for different traits and conditions. The company developed software called Breed Control, which is now adapting to shrimp, said Oscar Hennig, operations director for Benchmark Genetics. The Maturation Module is now able for shrimp farmers and is able to track performances of the shrimp lines per country, client, batch, line, protocols and ablation. For example, it can evaluate the differences between two countries with the same genetics or assess the differences between ablation and non-ablation – all Benchmark Genetics shrimp lines are selected for non-ablation performance – and advice farmers to improve their hatchery performance.

Mitchell Lucas, lead geneticist for American Penaeid, presented American Penaeid breeding strategy to develop its commercial shrimp lines. The company is one of the few genetics companies that has built its own genetics lab, owns its own germoplasm and is able to supply animals. Mitchel explained the company breeding strategy and how it comes out in specific shrimp lines.

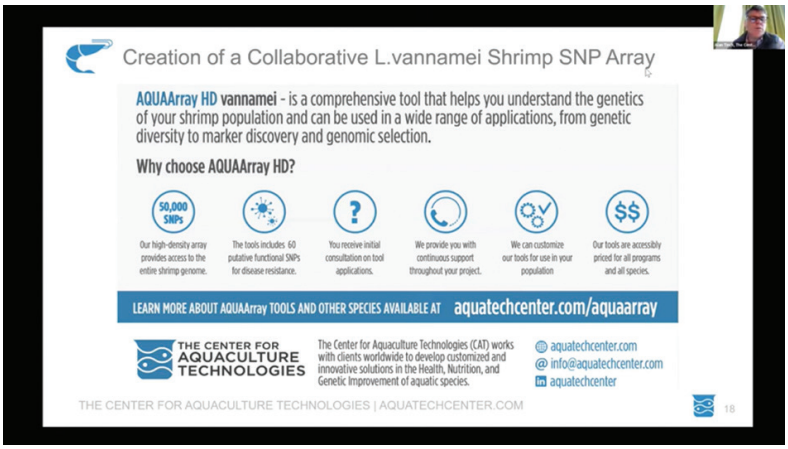
Assaf Schechter, co-founder and CEO of Enzootic, presented Enzootic, a company that started as a genetics company but is now a vertically integrated company that produces freshwater prawns. The company has developed a technology for all-female freshwater prawn farming that can quadruple the density and reach size uniformity of female populations. It operates its own breeding nucleus center and is working currently in Thailand under contract farming with farmers, with expansion plans to other countries.

Fish genetics: Genetic overview

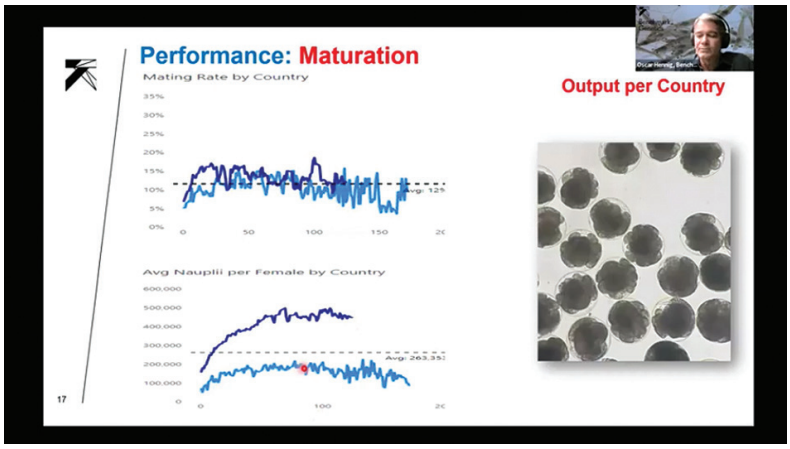
Adriana Artiles, business development manager for the Center for Aquaculture Technologies, presented on how fish hatcheries can take advantage of the genetic overview for better management of their breeding programs. The genetic overview is a compelling service to characterize a population in captivity that is usually managed for commercial purposes. Using a set of tools, the levels of diversity, consanguinity and the genetic structure of the population are provided. If these levels are not tracked, they can eventually neglect gains if they are not properly handled in further generations. The genetic overview can find where the problem is and offer clues about how to solve it and also if the diversity is high, how to keep it.

Equipment and technology

Warren Russell, chief commercial officer at Moleaer, discussed how hatcheries can benefit from



Advantages of AQUAArray HD vannamei.
Source: Alan Tinch, VP of Genetics at the Center for Aquaculture Technologies.



Results from the shrimp Maturation Module from Benchmark Genetics' Breed Control software. Source: Oscar Hennig, Operations Director for Benchmark Genetics.

nanobubbles. Nanobubbles can be used to inject oxygen and are 120 nm in size. "The industry is moving to more efficient utilization of gases to support better oxygen levels, maintain growth ratios and support intensification of aquaculture systems," Warren said. The benefits for smolt hatcheries are an increase in DO levels with high oxygen transfer efficiency and lower energy compared to conventional oxygenation systems. In RAS, it maintains oxygen levels within the system more efficiently and enhances treatment processes within RAS through a better particular protein removal through protein skimming as well as more efficient removal of ammonia.

Bertrand Barrut, CTO of COLDEP, discussed the vacuum airlift, a multifunctional water treatment process that circulates water, exchanges gases and removes particles and dissolved organic matters.

The system increases the stripping efficiency of gases (CO_2, nitrogen) through vacuum and also allows injecting oxygen. The vacuum airlift has higher efficiency and uses less energy than the best foam fractionator, Bertrand said, and also reduces off-flavors.

"Aquaculture is still in its infancy when it comes to technology adoption," said Konstantinos Bovolis, product manager of aquaManager. The company offers management software for hatcheries that aims to get control of the hatchery, optimize efficiency, reduce costs and increase traceability. The software aims to extract knowledge from the hatcheries to make the right decisions and respond to challenges in real-time and produce in a more efficient way.

Microbiome management

Poor microbiome management in aquaculture systems induces dysbiosis that affects the organism's health. Its effects are normally observed by farmers several days after the problem has been caused. Normally, the farmer does not know the cause of the problem. Kytos, a spin-off from the Ghent University, has developed technologies that provide insights that can be linked to performance and make farmers take action on their farms.

Jasmine Heyse, principal scientist at KYTOS, explained that through a sample of water, Kytos analyzes the microbiome on the sample cell by cell, allowing to determine bacteria, fungi and even viruses. The technology provides a series of metrics that provide an overview of the microbial health of the system and tools to help guide day-to-day farm management decisions.

Watch the webinars here.

Industry Events

Send your meeting details to:
editor@hatcheryfm.com

2022

JULY

11 - 13:	38th Meeting of Fish Feed & Nutrition Workshop, USA	www.eventbrite.com
19 - 21:	AQUA EXPO El Oro, Ecuador	aquaexpo.com.ec

AUGUST

15 - 18:	Aquaculture Canada and WAS North America 2022, Canada	www.was.org
25 - 26:	9th International Conference on Fisheries and Aquaculture, Indonesia	aquaconference.com

SEPTEMBER

4 - 6:	Fish International, Germany	fishinternational.de
6 - 8:	Global Shrimp Forum, The Netherlands	www.shrimp-forum.com
27 - 30:	Aquaculture Europe 2022, Italy	www.aquaeas.org

OCTOBER

3 - 8:	2nd International Symposium Mucosal Health in Aquaculture, Spain	www.mha2022.com
3 - 6:	GOAL, USA	www.globalseafood.org
17 - 20:	AQUA EXPO Guayaquil, Ecuador	aquaexpo.com.ec

NOVEMBER

9 - 11:	ILDEX Indonesia & Aquatica Asia	www.ildex-indonesia.com
27 - Dec 2:	International Symposium on Genetics in Aquaculture, Chile	isga.uchile.cl
29 - Dec 2:	World Aquaculture Singapore 2022	www.was.org

DECEMBER

12 - 15:	International Conference of Fish and Shellfish Immunology, Norway	atlanticmice.eventsair.com
13 - 15:	Algaeurope, Italy	algaeurope.org

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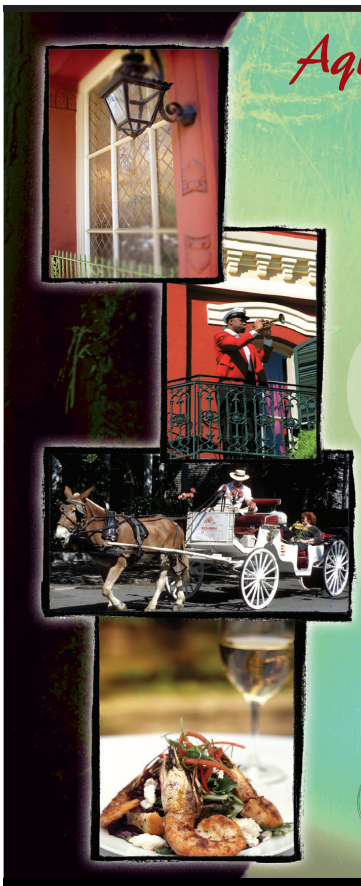

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