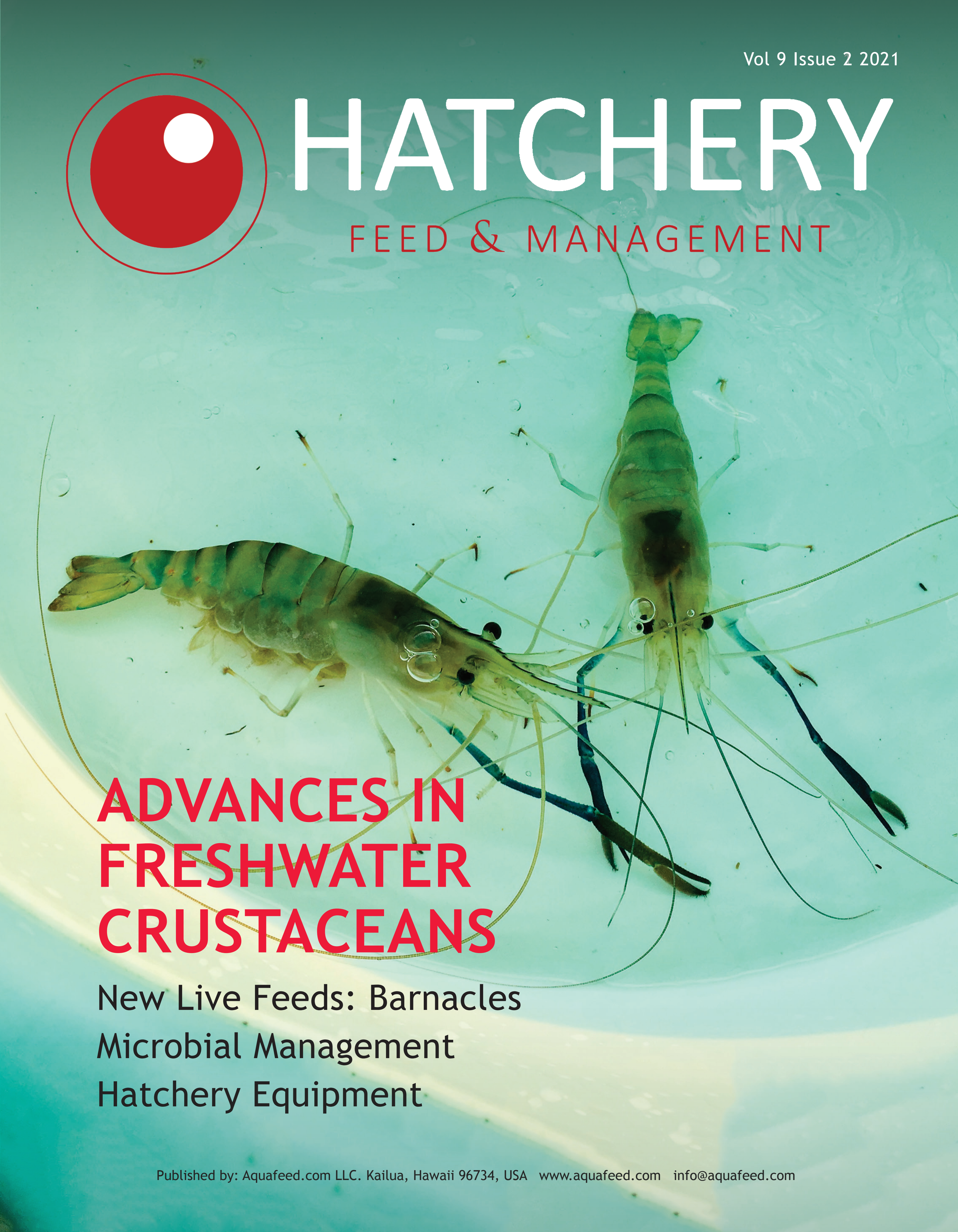
Vol 9 Issue 2 2021

HATCHERY

FEED & MANAGEMENT



ADVANCES IN FRESHWATER CRUSTACEANS

New Live Feeds: Barnacles

Microbial Management

Hatchery Equipment

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Hatchery Feed & Management magazine is published by Aquafeed.com LLC.
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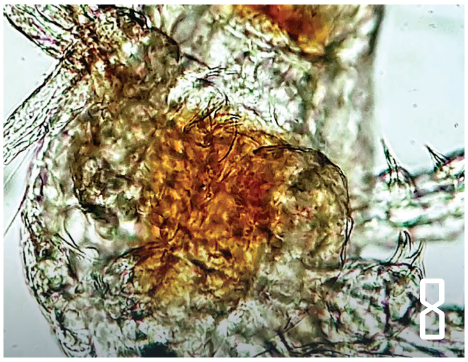
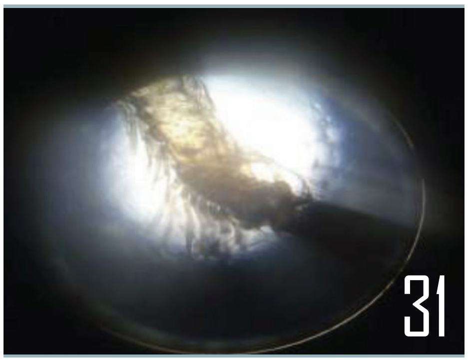




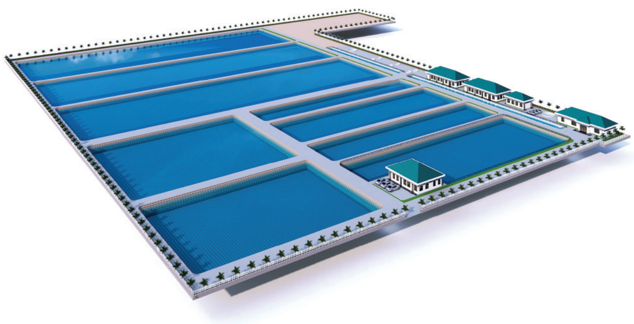
NEWS REVIEW

HATCHERY FEED & MANAGEMENT

Highlights of recent news from Hatcheryfm.com

News as it happens in the Newsroom at Hatcheryfm.com - sign up for our free weekly newsletter for updates

GenoMar Genetics opens subsidiary in Vietnam



GenoMar Genetics opened a wholly-owned subsidiary in Vietnam. The company will serve the Vietnamese tilapia farmers with high-quality genetic material as well as explore opportunities in the wider aquaculture genetics field.

The first hatchery center located in the Tay Ninh province is under construction and will deliver the first products to market in Q3 2021. The company plans a second hatchery in Northern Vietnam to be in operation by Q1 2022.

BioMar's new RAS feed targets the bottleneck in marine nurseries

BioMar unveiled a new RAS feed concept, LARVIVA ORBIT, that aims to improve the efficiency of marine nurseries. It will support an industry move of a prolonged time at the hatchery for fry before they are transferred to sea. This will aid in the expected acceleration in the use of RAS technology in marine nurseries, and thereby support the development of hatchery businesses for marine fish species.

Benchmark Genetics signs its largest salmon ova contract

Pure Salmon signed a multi-year agreement with Benchmark Genetics to supply Atlantic salmon ova to their projects worldwide. The contract's potential volume represents more than 80 million eggs per year at full capacity with the first delivery of ova expected in 2022. The agreement also formalizes a strategic collaborative partnership focusing on continuous product development and R&D.

BioMar acquires majority shares of Viet-Uc to develop the aquafeed business in Vietnam

After comprehensive due diligence, BioMar and Viet-Uc have signed an agreement for BioMar to acquire the majority of Viet-Uc feed business. Through this acquisition, BioMar establishes a partnership together with one of the leading seafood groups active in shrimp hatcheries, fish hatcheries and shrimp farming in Vietnam. The ambition is to grow the market for high-end feed products focusing on sustainability, traceability, quality and performance. The acquisition is subject to customary approvals by the authorities.

Brazilian researchers develop new shrimp genetic tool

Brazilian researchers of Embrapa Recursos Genéticos e Biotecnologia and Embrapa Informatica Agropecuária developed VannaPlus, a genomic tool that will help whiteleg shrimp producers improve their genetic programs and identify shrimp families raised in grow-out ponds. VannaPlus allows hatchery producers to manage broodstock reducing the risk of undesirable crossings and improving and increasing production.

Virbac opens its first R&D warm water aquaculture center in Vietnam

The center aims to support the global warm water aquaculture market by becoming the company's reference center for studies in Asia. The company also wants to support Africa and the various global markets where the diagnostic offer is currently limited. The Virbac aquaculture technology center will enable the development of vaccines, probiotics and products to fight infections and ensure a more harmonious and sustainable growth of species.

ICAR-CIBA develops vaccine for viral nervous necrosis in fish

ICAR-CIBA, Chennai developed an indigenous vaccine for viral nervous necrosis (VNN) that affects several species of fish. This is the first vaccine to be released for aquaculture in India and will help prevent VNN in fish hatcheries and bring down the incidence of VNN in grow-out farms.

Blue Aqua launches exclusive Doctor Shrimp Academy

Doctor Shrimp Academy is an exclusive educational platform for the aquaculture and shrimp farming industry that provides both hands-on and theory education in the five main cultured species of shrimp. Doctor Shrimp Academy will accept applications of students for both in-person and online courses, specializing in both intensive and super-intensive shrimp farming.

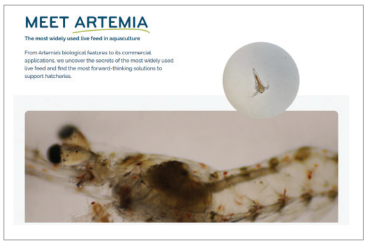
New bivalve hatchery R&D center opens in Portugal

The Portuguese company Oceano Fresco opened its new world-class Biomarine Center in Nazaré, Portugal. The new center integrates a bivalve hatchery, R&D laboratories and offices and is committed to innovation, breeding and production of European native clams species *Ruditapes decussatus* and *Venerupis corrugata*. The center will apply advanced selection and breeding methods to native European clam species.

Xelect introduces new consultancy service for trout producers

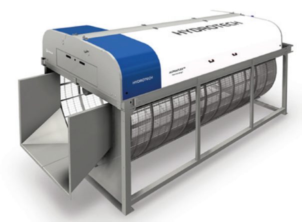
GeneXpertise service is a one-stop genetic broodstock health check for trout producers. For a modest, fixed price, GeneXpertise customers will get advice on genetic best practices, a detailed report on the genetic health of their population along with guidance on which crosses to avoid and which to make.

INVE Aquaculture unveils new Artemia knowledge hub



INVE Aquaculture unveiled a new web-based service dedicated to the sharing of information and expertise about the most widely used live feed in the aquaculture sector, Artemia. This hub is ideal for hatchery managers, researchers and newcomers wanting to understand everything from the fundamentals of Artemia culture to advances in Artemia technology and how to effectively benefit from its use in aquaculture.

Hydrotech introduces cost-effective drum filters



Hydrotech introduced a new drum filter value series, a new generation of cost-effective drum filters that focuses on reduced maintenance, increased component quality and simplified operation. The series aims to give maximum filtration performance at a minimum operational cost.

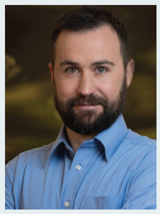
New nitrate checker for marine applications

Hanna Instruments USA, Inc. unveiled the Marine Nitrate High Range Checker® HC (HI782), specifically designed to quickly and accurately determine high levels of nitrate for saltwater and marine applications. Its small, portable size makes testing on-the-go simple. Unlike with manual chemical test kits where users have to decipher color results visually, Hanna's new nitrate checker provides an exact digital read-out.

PEOPLE IN THE NEWS

Donald Lightner

Shrimp industry veteran, Donald V. Lightner, passed away. Lightner put together a team of researchers at the University of Arizona that provided much of the basic knowledge on shrimp disease and health which enabled shrimp aquaculture to grow into a global industry.



Andrew C. Preston

Benchmark Genetics appointed Andrew Cree Preston in the role of RAS technical manager, Global. Preston will dedicate his time to customer service and sharing his operational, academic and technical skills and experiences to help customers succeed and reach their production targets.

Neil Manchester

After nearly seven years as managing director, building the aquaculture business unit in Hendrix Genetics to a global leading position in three major species, salmon, trout and shrimp, Neil Manchester decided to step down and focus on different priorities.

Guy Alon

AquaMaof reinforced its Customer Service & Support Division with the appointment of Guy Alon, as division manager. Alon will manage cross-organizational customer service processes, create new methodologies in the world of customer success and lead the division's growing team.

Do we have a viable solution for replacing rotifers and Artemia?

Nils Tokle, Planktonic

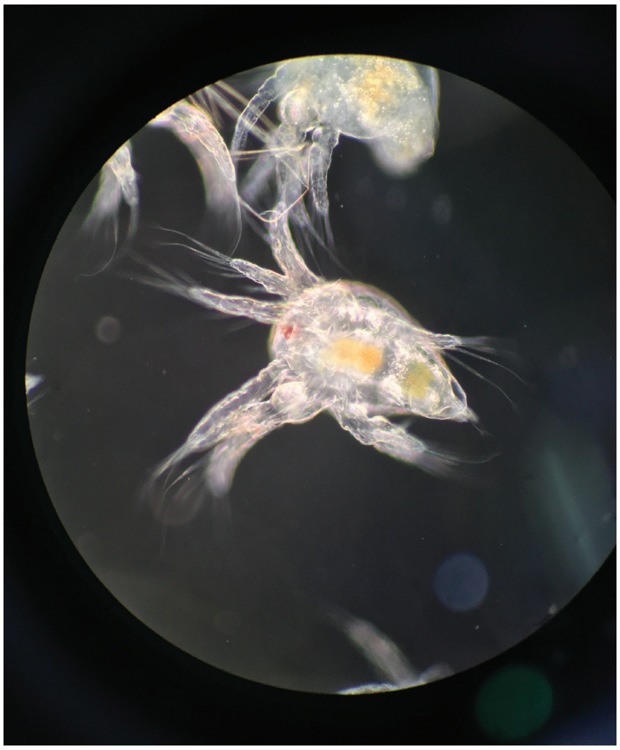


Figure 1. Nauplius of *Semibalanus balanoides*.

Live preys are a necessity for the larviculture of most marine fish species and have until recently been restricted to rotifers and Artemia. None of these live preys perfectly meet the nutritional requirements of marine larvae. However, it is well-known that these requirements are met by natural zooplankton.

CryoPlankton

Crustacean barnacle nauplii, in their planktonic state, form a part of the diet for marine larvae in their natural habitat. The Norwegian company Planktonic has developed CryoPlankton, a live feed whereby eggs are extracted from adult barnacles and subsequently cryopreserved. The live feed is stored in dewars with liquid nitrogen and easily transported to end-users. Hatchery staff can prepare live feed at any time with just minutes of preparation and are therefore not dependent on time-consuming and costly cultures of rotifers/Artemia.

There are two types of CryoPlankton: Small - replacing rotifers and Large - replacing Artemia. Importantly, there is no need for any kind of enrichment before being fed to the larvae. CryoPlankton is naturally rich in the phospholipid forms of essential marine fatty acids DHA/EPA and their nutritional profile is equal to that of other marine copepods.

Proven in commercial aquaculture

Finfish

All major producers of ballan wrasse in Norway and UK are using CryoPlankton and this is the most important reason that it is now possible to cultivate this species

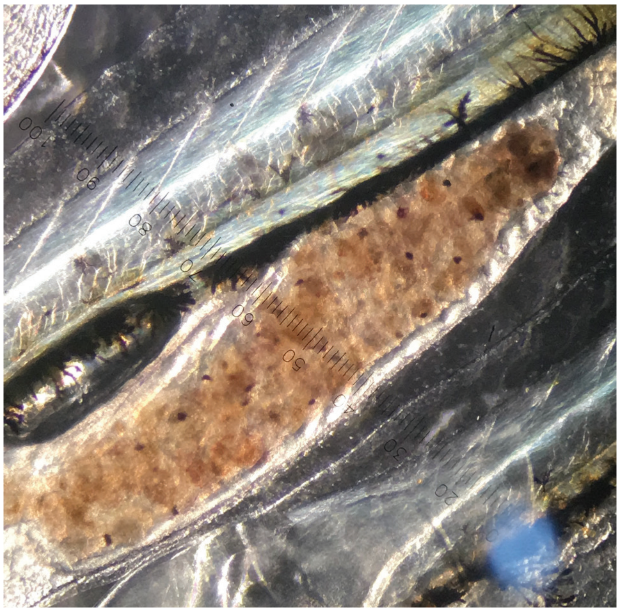


Figure 2. Larval seabass gut with CryoPlankton.

at a commercial scale. Ballan wrasse has demonstrated a higher nutritional requirement than many other cultivated marine species in aquaculture and using enriched rotifers and Artemia do not work well for this type of fish. However, when using CryoPlankton, the survival and overall quality of ballan wrasse juveniles are considerably enhanced.

Ballan wrasse producers also report that they have succeeded in much earlier weaning to dry feed when using CryoPlankton, from 58 dph to 38 dph. Producers see faster development of the larvae, and higher stress tolerance, making it possible to introduce dry feed at an earlier stage.

Yellowtail amberjack (*Seriola lalandi*) is a species that is gaining a lot of interest and where large investments are being made to increase production capacity, both in Europe, Australia and the U.S. One of the largest producers report that after introducing CryoPlankton as first feed, their production is more stable, and the quality of fry has increased considerably.

At commercial hatcheries in Greece, it is documented that seabass and seabream perform better on a diet of CryoPlankton compared to rotifers and Artemia (Fig. 2,3). A growth difference of 75% and 50% have been observed for seabass and seabream, respectively, 45-55 days post-hatching. Evidence points in the direction of increased FCR in sea cages when larvae have been offered natural plankton as live feed, and this could potentially have a huge impact on profitability in Mediterranean aquaculture.
This has been clearly demonstrated to be the case for Atlantic cod, when offered natural plankton as live prey there was a 10% higher slaughter weight after two years in sea pens (*Institute of Marine Research, Norway*).

Atlantic cod has received renewed attention in Norway, and production targets for the coming years are considerable. At a Norwegian hatchery producing Atlantic cod, CryoPlankton has replaced all use of rotifers and Artemia. It is reported that survival after weaning is considerably higher as opposed to using conventional live feeds.

Shrimp production

Barnacle nauplii was recently tested at a whiteleg shrimp hatchery and Artemia was partially replaced from Zoea3 to PL5. With only 2 kg of barnacle nauplii per million produced PL13, the response was exceptional. In the trial, eggs sourced from the same broodstock were divided into two treatments: 1) Control and 2) Experimental protocol where 50% of the Artemia was replaced with barnacle nauplii. The trial was completed at PL13. Whiteleg shrimp eggs in the trial were assessed as being of low quality, which according to the manager of the hatchery is not uncommon.
As a result, the survival rate for the Control group was only 19% when juveniles reached PL13.
In comparison, the experimental protocol which included barnacle nauplii achieved a 83%

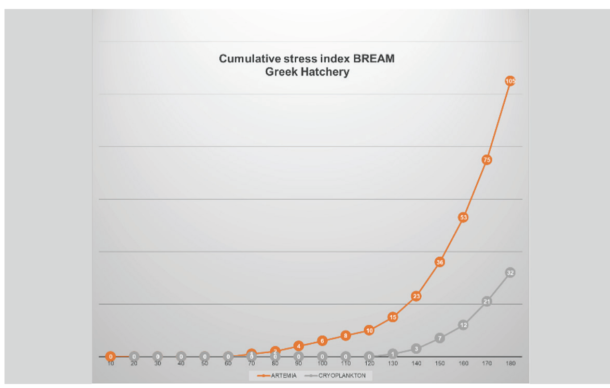


Figure 3. Cumulative mortality of seabream larvae after stress induction.

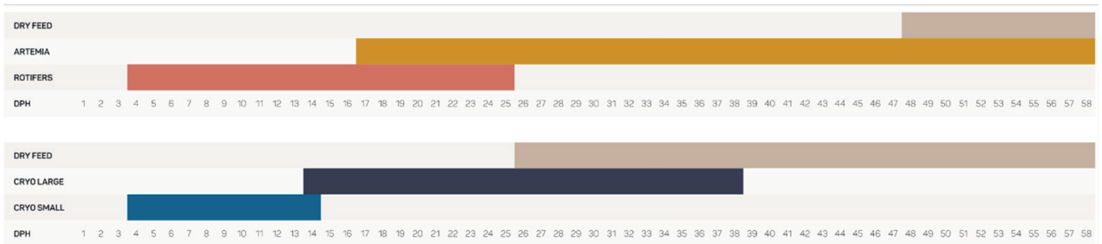


Figure 4. Replacing conventional live feed with CryoPlankton makes for earlier weaning to dry feed in ballan wrasse.

survival at the end. This strongly indicates that shrimp juveniles got the extra needed biochemical substances from the barnacle nauplii to overcome their poor start in life. Another extraordinary response from the experimental protocol with barnacle nauplii was the growth rate, displaying postlarvae 23% longer than the control shrimps.

Consistency and biosecurity are key

It is a well-known fact that live feed is a source of many problems with unwanted microorganisms in larviculture. Microorganism population instability is one of the main reasons it is difficult to replicate the same good result consistently between tank runs. Biosafety in CryoPlankton is superior to all other types of feed. The CryoPlankton are at developmental stage 1 and have not yet opened their mouths when they are fed to the fish. They will thus not bring unwanted pathogens into the fish tank. Breeders also report that they have far fewer problems with Vibrio after using CryoPlankton. Planktonic's harvesting techniques and production process also ensure that product quality and nutritional values are unchanged over time, further ensuring reproducibility between production cycles for the hatchery manager.

Summary

It has been proven in industrial larviculture that it is possible to replace live feed cultures with CryoPlankton, a live off-the-shelf product of better nutritional quality. The production process in hatcheries can be simplified, reducing risk, cost and lowering bacterial levels in feed. The ultimate aim is always to significantly improve fry quality compared to current practices and achieve highly improved FCR and SGR in growth cages, thus increasing profitability for the producers.

More information available at www.planktonic.no

Acknowledgments

Much of the above-mentioned progress of the CryoPlankton is made possible due to Horizon2020 and the funded MAXIPLAN project.

References available on request

More information:

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Artemia harvest made easy

Geert Rombaut, INVE Aquaculture - Benchmark Advanced Nutrition

To guarantee a consistently high-quality, hatcheries need to respect procedures and provide tools to harvest the Artemia in the most optimal way.

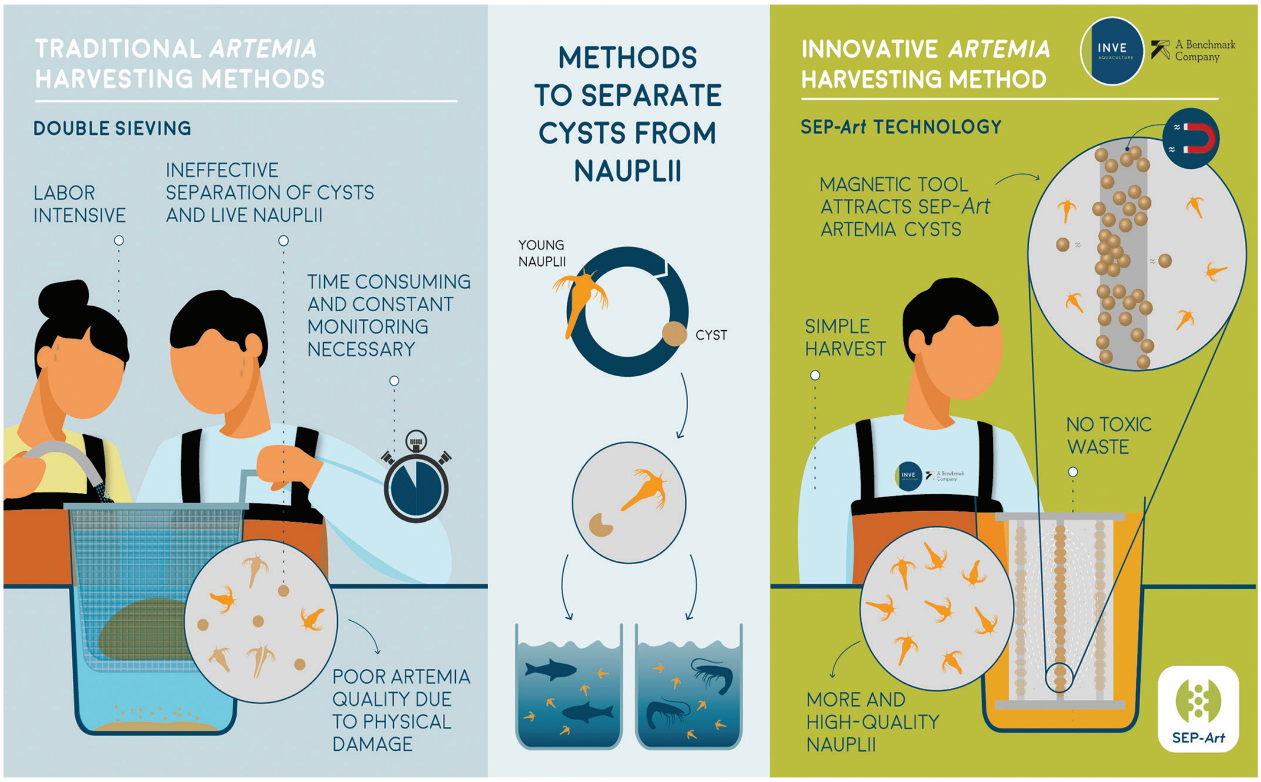

Figure 1. Methods to separate cysts from Nauplii.

Fish and shrimp hatcheries around the globe rely on Artemia nauplii as the preferred live larval feed to obtain a consistent and predictable production. Artemia triggers the feeding behavior of fish and shrimp larvae, has the appropriate size and is highly nutritious.

Convention but not convenient

During the hatching process, Artemia embryos inside the cysts develop into free-swimming live nauplii that can be found in the hatching tank together with the rigid shells and unhatched cysts. These unhatched cysts and remaining shells are inedible and must be separated from the nauplii before they can be used as feed. The cyst removal is a challenge even to modern aquaculture since the current methods are not always efficient and sustainable.

Artemia nauplii are separated from the cysts and shells by using the double-sieving method (Fig. 1). Double sieving is conceptually easy requiring only two superimposed, fine-meshed nets that function as a two-layered filter to separate the cysts from the Artemia nauplii, forcing the nauplii to pass through the mesh. This filtration process is time-consuming and laborious, and it determines the final quality of the live feed.

Additionally, the efficiency of the double-sieving method is influenced by several factors.

Cysts with a smaller size than the mesh will pass through the sieve, polluting the live nauplii suspension with indigestible material.

Double sieving can only be done when the live nauplii are still small (first larval stage, instar I), which restricts the method to an optimal harvesting time and the nauplii to be at high risk of being damaged during the separation process. Damaged and dead nauplii are a less attractive feed and leak nutrients to the medium. Together with the presence of unhatched cysts and shells, these nutrients can induce suboptimal conditions in the larval tanks favoring unwanted bacterial development in the larval tanks, increasing biosecurity risks in the hatchery.

Because of the clogging of the sieve, double sieving is not able to recover all nauplii and only a fraction of the obtainable Artemia biomass can be recovered, resulting in direct economic losses in the hatchery and increased production costs.

All of these factors contribute to the fact that the double sieve is an inefficient and labor-intensive method, less suited for economic upscaling.

A more efficient method

SEP-*Art* addresses the shortcomings of double-sieving, particularly the suboptimal recovery of biomass and the quality loss of the live feed. SEP-*Art* uses magnetism to separate Artemia nauplii from their cysts (Fig. 1).

Opposed to double sieving, SEP-*Art* does not employ meshed nets, entirely removing the chance of physical damage to the nauplii. All the nauplii present in the hatching tank can be efficiently recovered. The result is a suspension of very attractive, undamaged and highly active nauplii ready to be fed to the larvae.

More and better quality Artemia nauplii are harvested in less time and with fewer efforts. It increases the efficiency of the process and the quality of Artemia, allowing the upscale of nauplii production to support the sustainable growth of the aquaculture sector.

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OMICS research can help answer shrimp farmers practical questions

Ana Rodiles, Stepháne Ralite, Lallemand Animal Nutrition

Studying and managing shrimp gut and water microbiota.

The main microbial components of shrimp farming systems are the water, the soil and the shrimp gut microbiota. Lallemand Animal Nutrition has developed in-feed probiotics and bioremediation solutions that can help target the modulation of gut and water microbiota, respectively. In turn, it helps secure shrimp farming outcomes. What is their real impact on these microbial ecosystems? Thanks to metagenomics, recent studies conducted help us to answer some practical questions often asked by shrimp farmers.

Trial setup

We carried out a controlled experiment in Vietnam covering both the hatchery and nursery phases of whiteleg shrimp (*Litopenaeus vannamei*). The trial evaluated the use of a water bioremediation product (LALSEA PL Pack, Lallemand Animal Nutrition) alongside an in-feed probiotic (BACTOCELL or LALPACK PROBIO, Lallemand Animal Nutrition) in comparison to, at the hatchery phase, water antibiotic prophylaxis and, at the nursery phase, competitor's microbial solutions or a negative control (Fig. 1).

Using amplicon sequencing[1] technique as a metagenomic approach, it was possible to assess the changes in gut and water microbiota induced by the different microbial solutions and the consequences on performance. Here, the application of state-of-the-art genomic techniques enabled researchers to answer practical questions related to positive microbiota management in shrimp farming.

	Bioremediation products	In-feed probiotic
	Hatchery (22 days, n = 6/treatment)	
Lallemand (LAL)	**LALSEA PL PACK**	**BACTOCELL**
Antibiotic (ABX)	OTC (5ppm/day)	-
	Nursery (28 days, n = 4/treatment)	
Lallemand (LAL)	**LALSEA PL PACK**	**LALPACK PROBIO**
Competitor (COMP)	Competitor product	Competitor product
Control (CON)	No product	No product

BACTOCELL: *Pediococcus acidilactici* CNCM I-4622 (MA 18/5M); LALSEA PL PACK: *Bacillus* spp. and BACTOCELL; LALPACK PROBIO: BACTOCELL and *Saccharomyces cerevisiae* var. *boulardii* (CNCM I-1079); OTC: oxytetracycline

Figure 1. Treatments of water bioremediation and in-feed probiotics in a commercial hatchery and nursery under routine husbandry practices.

Does the water microbiome impact all life-stages of shrimp similarly?

No. In the hatchery phase, the gut and water microbial populations were very similar, unlike in the nursery phase. In the later stages, shrimp and water microbiota progressively differentiate as the gut microbiota becomes much more influenced by the feed and by its host, the shrimp. This suggests that, at later stages, the use of both specific in-feed probiotic and in-water (bioremediation) bacteria will be necessary to target these well differentiated microbial compartments.

Can we track the added beneficial bacteria in the water and in the shrimp?

Yes. The bacteria from the water bioremediation solution (*Bacillus and Pediococcus*) were tracked back to the genus level. Both could be found in the water.

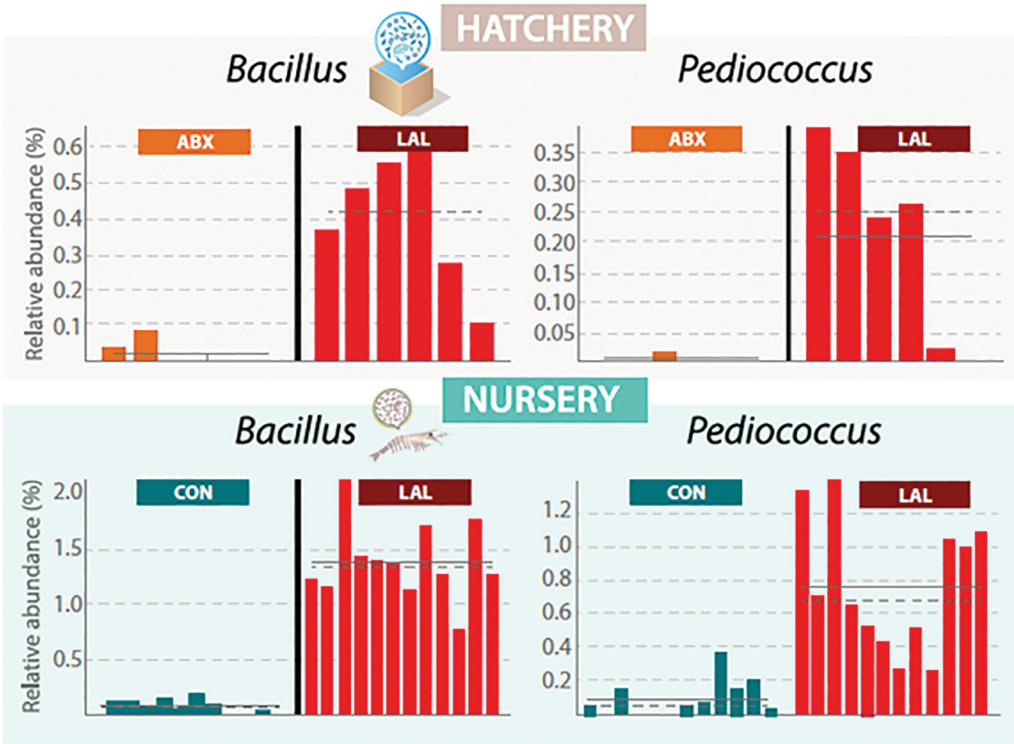

Figure 2. Relative abundance of *Bacillus* and *Pediococcus* in ABX and LAL treatments in hatchery water and nursery shrimp gut microbiota ($P<0.05$); the individual data, average (straight line) and median (dotted line) for each treatment are shown.

Similarly, at the nursery phase, the bacteria from the probiotic solution could be found in the shrimp gut (Fig. 2).

Do probiotic and bioremediation products reduce the prevalence of undesirable bacteria?

Yes. In the hatchery, a number of undesirable bacterial groups detected in the water of the antibiotic group were not identified when using our products, including a family of *Vibrio* species and a genus linked to early mortality syndrome transfer in shrimp.

Similarly, in the nursery phase, the application of our solutions significantly reduced the prevalence of potential pathogens in the shrimp gut from 7.5% to 0.28%, including *Vibrio, Acinetobacter, Thalassomonas, Owenweeksia* and *Sedimenicola*. The prevalence of the *Enterobacteriaceae* family was reduced. There was no *Cellvibrio*, which hydrolyses chitin, and no *Coccinistipes* were detected. This last genus is typically favored by some microalgal bloom and generally found in locations relatively rich in organic carbon.

Can we see effects on the presence of beneficial bacteria?

Yes. In both stages, researchers could see enrichment of shrimp gut microbiota with beneficial bacteria.

These include *Thalassobious* from the *Rhodobacteraceae* family at nursery phase. This family has been recently suggested as a source of probiotics as it is able to synthesize vitamin B12 and tropodithietic acid (antagonistic to *Vibrio* species) while having a large potential contribution to feed digestibility. A higher proportion of *Psychroserpens* was also found, in line with previous findings after probiotic feeding.

In the nursery phase, researchers noticed an increase in *Phaeobacter*, a genus affiliated with the *Rhodobacteraceae* family and proposed as probiotic for its involvement in the biosynthesis of natural antimicrobial compounds and nitrate reduction.

In the water, *Bacillus* were detected only in the group with Lallemand products, together with a significantly higher proportion of *Sphingomonas*, which are involved in denitrification; *Rubrivivax*, which carry nitrogen and help with carbon fixation; and *Kaistobacter*, which have the capacity to degrade toxic aromatic compounds.

Maintaining a positive microbiota both in the shrimp gut and the water has several benefits such as: support for the immune system and animal robustness; improved nutritional performance and water quality. This helps contribute to lower pathogen pressure, which, in turn, reduces the likelihood of disease outbreaks.

Finally, does this translate into performance?

Yes. End-point body weight, feed conversion ratio (FCR) and survival were improved in the LAL group compared to the COMP group in the nursery phase as a result of good water quality and balanced intestinal microbiota. The LAL group yielded better and more consistent performance.

Conclusion

The latest molecular tools are effective to shed some light in the understanding of microbiota associated with shrimp farming and their positive manipulation by microbial solutions (probiotics and bioremediation products). The microbial inputs can be tracked in the water and in the shrimp gut. They can help reduce undesirable bacteria pressure and increase the presence of symbionts.

The choice of a product containing carefully selected and well-documented bacterial strains is crucial to deliver the expected effects of microbial solutions at the farm level – promoting a positive microbial environment in and around the shrimp that secures healthy stock and robust growth.

[1]The term "metagenomics" applies to a suite of sequencing technologies and bioinformatics tools to directly access the genetic content of entire communities of microorganisms: the metagenome. However, in order to describe the microbial composition of a sample using a sequencing strategy, it is not always necessary to sequence the full metagenome. A common practice is to target a fragment of the bacterial genome, which is used as a marker, or a sort of ID card, fora bacteria. This approach is called amplicon sequencing or barcoding.

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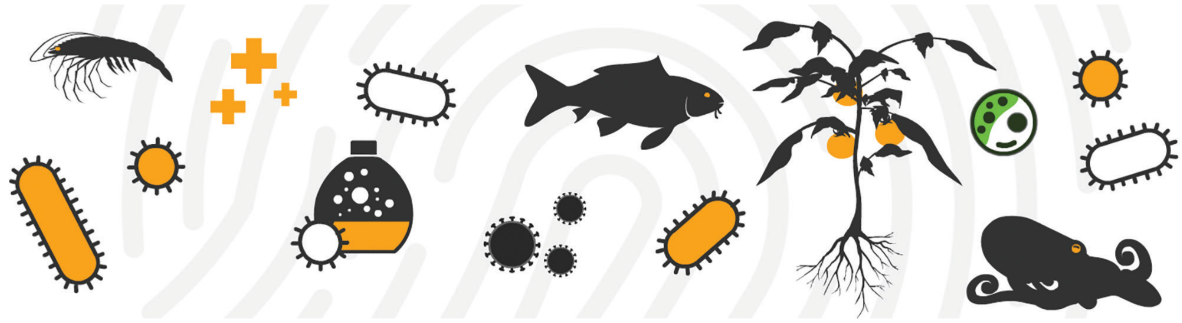
Managing microbiomes, one cell at a time

Ruben Props, Frederiek-Maarten Kerckhof, Marc Indigne, Nico Boon, KYTOS



It's no secret that microscopic life in aquaculture facilities is incredibly diverse, ranging from viruses to algae, to protozoa. Yet, current microbiome management practices in aquaculture typically center around a narrow set of opportunistic pathogens that may become virulent and cause diseases. In shrimp specifically, new microbial diseases have stagnated and even collapsed the growth of the industry on several occasions over the past few decades. As diseases prove difficult to fully eradicate once they are established, farmers try to safeguard crops via targeted diagnostics, and via strengthening resident microbiomes by the addition of prophylactic health products (e.g., pre-, pro-, and synbiotics). Such a management approach, however, poses several problems. First, it completely disregards the thousands of microbial organisms which are not pathogenic and occupy important niches in the aquaculture ecosystem. Secondly, most opportunistic pathogens are residents of both healthy and diseased aquaculture systems and only become virulent under specific environmental conditions. Lastly, prophylactic health agents are used according to rigid protocols. All of this results in a suboptimal management plan guided by sparse and infrequent microbiome information.

Breaking the status quo

At KYTOS, a spin-off company of the Center for Microbial Ecology and Technology (CMET) and Ghent University, we develop novel technologies to make routine microbiome health assessments an intrinsic part of day-to-day farming operations. Our core technology platform makes use of cytometry in which cells are propelled through a high-powered laser beam at rates of up to 5,000 microbes per second, while simultaneously recording their physiological properties. For each water sample, up to 1,000,000 data points that characterize the microbiome are collected. We then use machine-learning methods to translate these big data into so-called microbiome fingerprints. From these fingerprints, important microbiome health insights are extracted, that when compared to our curated reference database, can be used as a basis for formulating (pro-) active actionable management insights. Our holistic approach to microbiome health differs strongly from the current state-of-the-art diagnostic approaches as we make an assessment based on all microbial cells, and not a handful of opportunistic pathogens. Disease epidemics are caused by nearly all forms of microbial life (e.g., viruses, bacteria, algae, protozoa) and therefore we believe a holistic approach is key to getting a grip on the aquaculture microbiome.

Improving sampling efforts

One of the major challenges facing microbiome analysis in the industry is gathering representative data. Ideally, samples are measured instantaneously, but in practice,

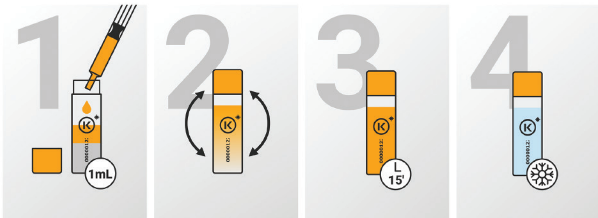


Figure 1. A simple sampling protocol for preserving aquaculture microbiome samples. One milliliter of sample is transferred into the vial, after which it is closed, shaken, incubated at room temperature and then stored at 4-10°C until analysis.

this is almost never possible. Prolonged storage, combined with tropical environmental conditions, strongly affect the microbial composition of water samples. Our sampling protocol using the KYTOvial preservation system requires only a single milliliter of water and protects the microbiome for up to 1 month at nominal refrigeration (4-10°C, Fig. 1). The small footprint of the sample vials facilitates easy and intensive sampling across the entire farm. The performance of this system has been extensively validated in field trials in Thailand and Indonesia.

A holistic approach to microbiome analysis

The preserved microbiome samples can then be analyzed and processed by our software platform, which derives important health insights from each sample's microbial fingerprint. For example, at the moment, we can identify up to seven algae populations, from filamentous cyanobacteria to probiotic Chaetoceros, as well as changes in the diversity, cell size, and cell numbers of bacteria. We are also working on characterizing large viruses in the same workflow. A recent addition has been the development of a microbiome performance index, which has correlated strongly with farming success (i.e. crop survival rates). This microbiome performance index is now being further validated in ongoing commercial trials and would pose a major stepping stone in linking microbiome and animal health. All of these advances open up the perspective for farmers to use microbiome intel in the management of their farming operations.

Treating every aquaculture system as unique

As most farmers, we are aware from first-hand experience, that each aquaculture microbiome is unique and therefore requires a tailored definition of its microbiome health. We have found shrimp ponds that primarily require tight control on the (micro-)algae, while other ponds on the same farm demand control over bacterial health aspects. While our algorithms continue to improve with increasing access to data from more ecosystems (e.g., species, farming technologies, feeding regime), we will be able to create truly bespoke and predictive health assessments for each ecosystem.

From the perspective of the farmer, this means that the microbiome health insights that we can extract from (historical) data will only improve in the future. It is our goal to increase our microbiome database from tens of thousands of samples today, to hundreds of thousands of samples in the near future. Current practices such as agar plating, microscopic, and molecular analysis do not share this advantage. By direct contact with farmers and product developers, we will collect and integrate their operational and product insights (i.e. so-called domain knowledge) with our expanding dataset to create machine learning-based proactive management advice.

Not only will this help the farmer make better day-to-day decisions, it will also ensure the correct and timely use of the wide array of agrobiological and biocontrol products on the markets. As more countries will become driven by sustainability goals (e.g. the EU objective is set to reduce antimicrobial sales by 50% by 2030), the reduced use of antimicrobials will have to be matched by more effective microbiome management. KYTOS aims to help the aquaculture industry get ready for this transition.

Acknowledgements

KYTOS was realized through funding by Ghent University's Industrial Research Fund (IRF) and coaching by the IRF consortia BLUEGent (Dr. ir. Margriet Drouillon, MBA), ChemTech (Dr. Bart Hommez) and CropFit (Dr. ir. Maaike Perneel). Furthermore, KYTOS was supported by Ghent University's Center for Microbial Ecology and Technology (Prof. Dr. ir. Nico Boon and Prof. Dr. ir. Bart De Gusseme) and Flanders Innovation and Entrepreneurship (VLAIO).

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Active microbiome management

Tom Scrope, Nova Q Ltd.

How Recirculating Aquaculture System (RAS) managers can get the most out of their biofilter microbiome.

Active Microbiome Management (regularly adding functional bacteria) should be a part of every RAS farmer's toolkit.

Why RAS?

Recirculating Aquaculture Systems (RAS) can help make aquaculture more sustainable – whether in the much-hyped full-grow out systems or for hatchery, smolt, and now post-smolt production of Atlantic Salmon.

Not only do RAS have a low direct environmental impact (especially if renewable power sources are available), but they provide optimal growing conditions. They can reduce mortality and improve feed conversion ratios, reducing the overall emissions per kilo produced.

Improvements that can make RAS more efficient and reliable will play a key role in making the aquaculture industry more environmentally sustainable.

The challenge

RAS aquaculture, though, is not just about farming fish, but the bacteria of the biofilter too. RAS managers recognize that bacteria are crucial to operating a RAS. But as long as adequate nitrification kicks in following "seeding", most producers are inclined to leave the biofilter "well alone" for fear of disturbing the delicate balance.

While other aspects of RAS are being continuously improved – from genetics to system engineering – the functionality of the bacteria in RAS has not been optimized in the same way. To do things better, by definition, we need to do them differently.

This lack of innovation has led to problems currently facing RAS sites:

- Inefficient nitrification, including nitrite spikes.
- Slow and unpredictable restarts – particularly problematic for sites with short timescales before the introduction of fish to the system (e.g. research sites).
- Hydrogen sulphide (H_2S) spikes caused by sulphate-reducing bacteria being able to establish themselves in the system.
- Off-flavor compounds (OFCs) in grow-out RAS reducing the value of stock and requiring expensive and inefficient "purging" to remove.

Advances in the last few years in sequencing technology (especially 16S rRNA sequencing) need to be combined with innovative tools to positively influence the microbiome and solve the problems identified above. Some of these tools will involve a more considered use of inputs (e.g. feed) that impact the microbiome.

Table 1. Fast-growing, potentially pathogenic r-strategists ("A") outgrow many slow growing, beneficial K-strategist species ("B").

Elapsed time in hours	Number of Bacteria "A" Takezs 30 minutes to duplicate	Number of Bacteria "B" Takes 60 minutes to duplicate
0	1	1
0.5	2	1
1.0	4	2
1.5	8	2
2.0	16	4
2.5	32	4
3.0	64	8
3.5	128	8
4.0	256	16
4.5	512	32
After 5.0 hrs	**1024 count of type A**	**32 count of type B**

Regularly adding large quantities of functional bacteria removes their slow reproduction rates as a limiting factor. (It's worth noting that developing the composition and stabilization of an appropriate consortium of functional bacteria is an area that has been at the core of the R&D work Nova Q and our partners have undertaken over the last 40 years. Simply introducing single-species products or poorly balanced consortia can lead to an unstable microbiome in the medium term). This approach allows the efficient nitrification of high quantities of ammonia – much higher than would ever be ordinarily produced in a RAS.

But a vital part of the toolkit for any RAS farmer should be *Active Microbiome Management*.

What is Active Microbiome Management?

Active Microbiome Management, an advanced form of bio-augmentation, involves directly influencing the biofilter microbiome through constant additions of beneficial bacteria. This approach is already common in wastewater treatment (WWT) to avoid the system becoming dominated by "undesirable" bacteria.

The critical insight here is that many beneficial species are slow to reproduce K-strategists (we refer to them as functional species). By contrast, potentially pathogenic r-strategists (opportunists) can multiply much faster (Table 1).

Simplified Kinetic Model

$$E_{eff} = \frac{E_{inf}}{1 + \chi_c \, \kappa_s \, \Phi_h}$$

Where

E_{eff} – Effluent water parameters

E_{inf} – Influent water parameters

X_c – Cell Mass in mg/l (bacteria available)

K_s – Specific rate coefficient mgs/l*day (consumption)

Φ_h – Hydraulic residence time (retention time)

Figure 2. The quality of water coming out of the biofilter (E_{eff}) is dependent on the incoming water quality (E_{inf}), the volume of bacteria (X_c), the efficiency of the bacteria (K_s), and the length of time the bacteria have to perform their functions (ϕ_h). In RAS ϕ_h is relatively low, so X_c and K_s need to be increased to make up for this.

How does Active Microbiome Management work in RAS?

There are key challenges to harnessing the power of bacteria in RAS:

- While the overall nutrient load in RAS is lower than in WWT, so is the hydraulic retention time – RAS bacteria don't have much time to perform their functions (Fig. 2).
- Disinfection systems in RAS loops, including ozone and UV, can damage the populations of beneficial bacteria in the biofilter.
- RAS often require rapid restarts to meet stocking deadlines.

The way around these is to deploy large quantities of the bacteria and optimize the bacteria to system conditions so that they are functional (e.g. nitrifying) straight away.

Although good results can be achieved by experienced operators simply applying stabilized bacteria from a bottle, much more powerful impacts are possible using a bio-reactor grow tank to multiply and activate the bacteria before applying them to the system.

Latest bio-reactor grow tank technology

The two critical necessities for a successful bio-reactor are heat and aeration. It is possible to create a "grow-

Figure 3. BrewTus bio-reactors. With an advanced control panel, and in-built heating and aeration, these units offer the ability to regularly produce large quantities of functional bacteria for easy Active Microbiome Management.

tank" from a spare container, a heater, and an air pump (and some of our customers follow this approach). However, for complete control and ease of application, an automated and purpose-built bio-reactor is a much better solution.

Our Canadian partners have developed the BrewTus range of bio-reactors for this very purpose, following a long process of R&D over the last five years (Fig. 3). BrewTus units are currently used in a wide range of sectors, from agriculture to lake remediation. The technology is being adapted by Nova Q for RAS, with the installation of the first units expected in autumn 2021.

Results

Active Microbiome Management is a proven approach:

Enhanced nitrification

The SALMSON project at Ireland's Marine Institute utilizes Active Microbiome Management, with impressive nitrification results (Fig. 4).

Rapid restart

A parr hatchery owned by one of the global salmon producers was under pressure to restart the system in a matter of days (rather than the usual weeks) before the stocking of the system.
Bacteria were added directly from a prepared bio-reactor to the MBBR on day 1, with fish introduced from day 3 and feed on day 5 (Fig. 5).

- Nitrification started immediately - nitrate production occurred from the moment feed was added
- Stable nitrification maintained even as feed levels increased
- Nitrite peak at a similar level and quicker recovery than historically normal.

Off-flavor compound (OFC) control

Regularly "swamping" the systems with large numbers of beneficial bacteria denies opportunistic species - including sulphate-reducing bacteria (H_2S) and cyanobacteria (OFCs) - the chance to gain a "foothold". (It's worth noting that Active Microbiome Management does not supersede other forms of good RAS husbandry - e.g. regular cleaning avoids the creation of anoxic zones often responsible for H_2S spikes). There is even evidence that introducing Active Microbiome Management can break down high pre-existing OFC levels.

One study produced by a Nova Q partner showed that only two weeks of dosing with beneficial bacteria at the end of a production cycle reduced high levels of geosmin and MIB (Table 2). Geosmin reduction was comparable to a two-week depuration purge

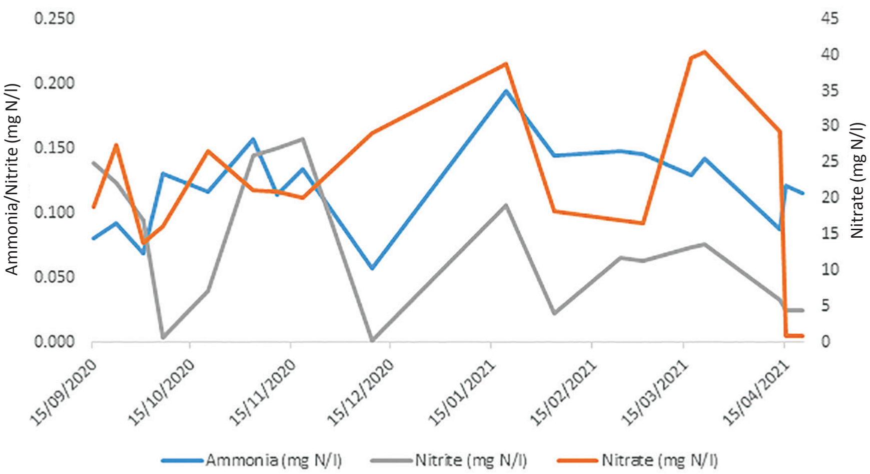

Figure 4. ENHANCED NITRIFICATION: Optimized nitrification throughout the study. Ammonia and nitrite never move above 0.2 ppm. Data courtesy of the Marine Institute. The SALMSON project is funded by BIM Knowledge Gateway – 17/KGS/009.

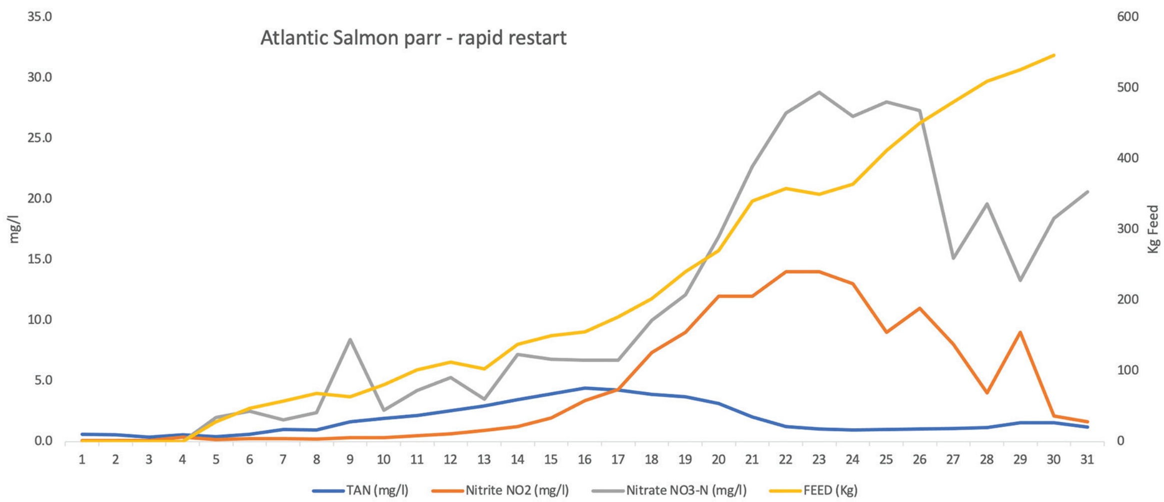

Figure 5. RAPID START: The site was under pressure to restart the system in a matter of days following a deep clean of all the fish tanks and the moving bed bioreactor (MBBR).

Table 2. OFF-FLAVOUR COMPOUND (OFC) CONTROL: Geosmin reductions comparable to a purge achieved while still feeding the fish, by using Active Microbiome Management.

	Depuration – removed from growth			Non-depuration – maintenance dosing		
	T = 0	T = 1 Week	T = 2 Weeks	T = 0	T = 1 Week	T = 2 Weeks
2-methyl isoborneal (MIB)	870.46	297.97	66.19 (-92.4%)	1012.20	703.62	448.80 (-55.7%)
Geosmin	294.71a	136.79b	76.34c (-74.1%)	332.01a	318.95a	103.33bc (-68.9%)

(4.8% weight loss). By contrast, fish with the Active Microbiome Management regime continued to be fed (2.3% weight gain).

Nova Q is currently conducting trials with producer partners to assess the results of longer-term Active Microbiome Management on levels of off-flavor compounds in Atlantic salmon RAS - results expected in Autumn 2021.

Conclusions

Active Microbiome Management (regularly adding functional bacteria) will improve RAS water quality:

- Enhanced nitrification, reducing the chances of ammonia or nitrite spikes (and accompanying mortalities).
- Fast restarts, with rapid nitrification.
- “Crowding out” undesirable species, reducing the risk of potentially lethal H_2S spikes or high OFC levels requiring expensive and inefficient “purging”.
- Improve the ability to control the system, increasing predictability and allowing more efficient planning of production cycles.

Improving RAS efficiency and profitability will facilitate the expansion of this low-impact technology, driving sustainable aquaculture growth.

References available on request.

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Regional developments

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Freshwater prawn hatcheries in Asia – racing with the shrimp

Freshwater prawn farming is widespread in Asia. The top producing countries are China, Bangladesh, Thailand, Indonesia, Vietnam, and India. Globally more than 600,000 tons of freshwater prawns valued at over $5 billion are produced. The oriental river prawn, *Macrobrachium nipponense* in China, and giant river prawn, *M. rosenbergii* in China and the rest of the world, are the two major species contributing to this growth. While the global expansion of freshwater prawn aquaculture is remarkable, there is still a long way to go for them to attain an organized level of development at par with the marine shrimp industry.

Advanced hatchery technologies emerge in Asia, but their impact is more evident in marine shrimp or fish hatcheries. Compared to the marine shrimp, the freshwater prawn hatcheries return lower profit margins, mainly because of the longer larval rearing time required (18 to 25 or more days per cycle in prawn hatcheries compared to 9 – 12 days for shrimp) and the greater consumption of the live feed, Artemia. Some species, such as *M.malcolmsonii* in India and Pakistan, and *M. lar,* a native of Fiji and Pacific Island territories, have a longer larval cycle and more difficult for their hatcheries to be commercially viable. The Cleanwater system for prawn hatchery is more prevalent than the Greenwater system. Most countries rely on hatchery-produced seed, but the wild collection of prawn juveniles continues in some countries. For example, Bangladesh produces approximately 350 million prawn postlarvae (PL) in hatcheries, while up to 2 billion PL are sourced from the wild. In Myanmar, there is a demand of 400 million prawn PL, but there are only about 15 hatcheries with limited production. Therefore, most of the seed demand is to be met by imports from neighboring Thailand. In Sri Lanka, the industry is developing, and two hatcheries are operational, producing about 100 million PL annually. Most of the prawn PL is used for culture-based fisheries in reservoirs, growing them up to 450 g for females and 850 g for males.

Gravid female prawn with eggs ready to hatch.

China leads the prawn aquaculture contributing to more than half of the global production. The main drivers of the Chinese industry are the emergence of ecological production models and the more intensive production systems mainly in the Zhejiang Province, the use of recirculating aquaculture systems, and the application of probiotics in response to stricter regulations on releasing aquaculture effluents to the

Small scale prawn hatchery in Thailand.

environment. Genetic improvement of *M. rosenbergii* has been a key feature of the prawn industry in China. New selectively-bred strains having superior pond survival and harvest body weight have been introduced. A similar selective breeding program for *M. rosenbergii* has also been undertaken in Vietnam.

The larval stocking densities followed in most Asian hatcheries range from 100 – 150 PL/liter. Coastal hatcheries use seawater diluted to the optimum salinity of 12±2 ppt, while inland hatcheries use brine transported from distant sources. Many hatcheries follow high larval stocking densities such as 300/liter initially and then reducing to lower densities of about 100/liter. Larval survival is often variable and ranges from 30 to 80% depending on the rearing conditions. Much of the survival is linked to broodstock quality, rearing water conditions and larval feeds used. Artemia is still an essential larval feed for prawn hatcheries. Besides, egg custard prepared by blending shrimp/ fish meat, eggs, squid oil and vitamin premix, which is then boiled and passed through appropriate mesh size for the specific particle size required for larval feeding is used. Of late, several formulated inert feeds are commonplace that have improved hatchery success.

Synchronization of PL settlement is an issue facing hatcheries that affect PL quality. The earliest settling PL (within 3 to 4 days) in a batch is found better. High larval densities coupled with lower seasonal temperatures often lead to diseases in hatcheries and nurseries. The Macrobrachium industry had been hit by rampant viral infections such as the white muscle disease caused by MrNV and XSV since 2000 in many parts of the world. Some recent diseases include the growth retardation syndrome (GRS), popularly called “iron prawn” with prawns showing unsynchronized growth pattern, and Decapod iridescent virus-1 (DIV-1), both reported from China. This also represents a risk of cross-species pathogen transmission from crayfish or crabs, given the expansion of their polyculture with prawn. Many emerging diseases are still under investigation for more precise determination of their aetiology and mitigation measures.

More complex prawn production issues, specifically in the hatchery phase, have been reported in Asia. The hatcheries in Bangladesh have been facing severe larval mortalities and poor PL health for a long time, the reasons for which have not yet been clearly understood. Only a handful out of about 50 prawn hatcheries in Bangladesh is currently operating. The reasons cited are the lack of good quality broodstock and inadequate water quality. New production methods involving matured greenwater, bioflocs and recirculating systems are being tested.


Prawn farmer & hatchery operator in Thailand with nursed juveniles.

Broodstock quality is considered one of the significant factors affecting larval production in prawn hatcheries. Hatcheries in Bangladesh, Malaysia, Myanmar and Thailand have reported issues related to broodstock. Large hatcheries maintain their broodstock ponds using the same PL produced or procure berried (gravid) females from commercial farm ponds. Wild broodstock is still considered more robust and disease resistant. However, indiscriminate exploitation of wild PL also impacts the sourcing of good broodstock from the wild.

Recent biotechnological innovations have focused on broodstock quality. This has prompted the development of specific pathogen-free (SPF) prawn broodstock, pioneered by the CP Group of Thailand. The broodstock for producing SPF all-female and all-male prawns have been commercialized by researchers in Israel (Enzootic Genetics and Tiran Shipping Company supported by the Ben-Gurion University of the Negev) and are currently tested in Thailand and Vietnam. Enzootics has also recently engaged with the Israel-based NRGene Ltd. to apply novel quantitative genomics-based tools for advanced breeding and explore the full potential of the new whole-genome sequencing data available for *M.rosenbergii*. Broodstock that produces fast-growing PL comparable to the superior growth achieved for marine shrimp will be a significant milestone for inviting largescale investments in the freshwater prawn industry. These innovations, coupled with a growing domestic market in many producer-nations, are poised to steer the future expansion of the global freshwater prawn industry.

A peek into a Singapore firm's revolutionary modular crawfish hatchery

Desmond Chow, Singapore Crawfish

A Singapore firm is planning to build the world's first specific pathogen-free (SPF) hatchery producing 300,000 crayfish fries per day to satisfy growing regional demand for the popular crustacean.

Despite the global growth in the popularity of crawfish farming in recent years, two major challenges are faced. Most traditional farmers face the problems of limited knowledge of crawfish breeding and the hefty labor cost of manually separating fry from adults to prevent filial cannibalism.

Since 2018, Singapore Crawfish Pte Ltd. vowed to search for a solution to help traditional crawfish farmers solve their problems. After years of research and rigorous testing and multiple project failures, finally, in 2020 they managed to produce a modular Auto Birthing System (ABS™), one that is not only cost-efficient, space conducive but also can be easily maintained and is highly modular.

The patented system can provide a quantifiable and sustainable way to produce a constant number of crawfish fry daily. Fry mortality decreases significantly and this technology could change the face of global aquaculture since it aims to solve five main problems:

1. The high cost of traditional crawfish hatcheries.

2. The immense labor required to extract or separate crawfish fry.
3. The high mortality of crawfish fry face when mishandled.
4. The unstable production and supply of crawfish fry in traditional farms.
5. The difficulties in scaling up or down for traditional crawfish hatcheries.

Improving the breeding process

The main objective is to improve the survival and stable reproduction rates of crawfish that increase the profitability and sustainability for farmers, even those with limited knowledge, infrastructure and resources.

The traditional method of stripping eggs from the adults and putting the eggs on trays stresses both adults and eggs. The new system is way more reliable and efficient compared to the traditional methods of extracting crawfish fry where mortality can spike up to 80%, especially when mishandled and exposed to bacteria.

To date, most crawfish farmers have to manually harvest the eggs and the process is labor-intensive. A crayfish female spawns up to three times a year, producing up to 1,200 eggs each time – thus removing eggs from thousands of crawfishes can be a momentous task.

The ABS™ system looks like a few simple rows of tanks joint together but the magic happens within where genetically selected male and female crawfishes are carefully stocked within at the exact ratio in an environment made suited for reproduction and breeding.

Specific feed formula

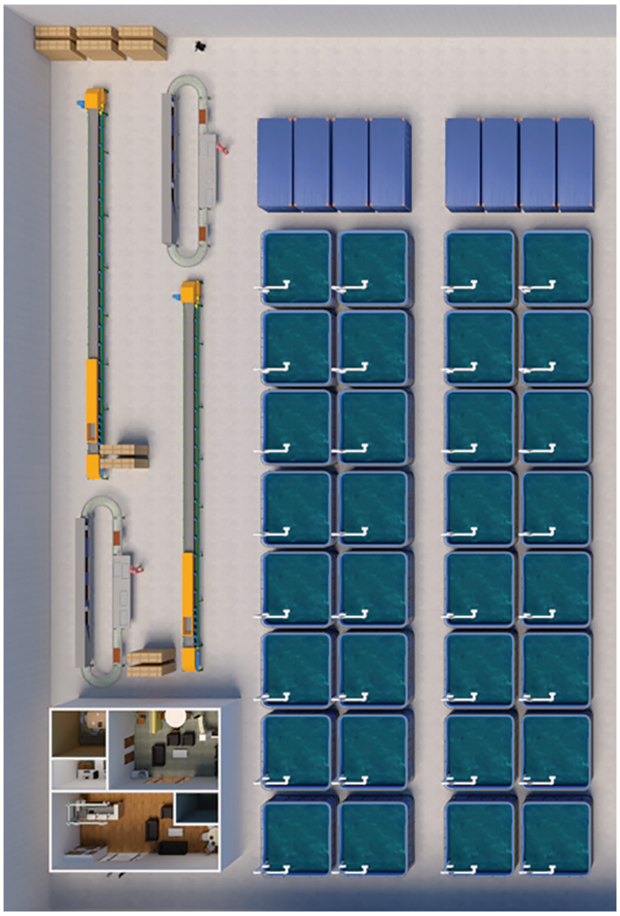
Broodstock are fed a highly nutritious, specialized feed which increases their fecundity rates, a special formula made in-house by Singapore Crawfish. Their specialized feed is unique in a few ways since it increases the growth rate of crawfish by up to 100%, stimulates mating and reproduction, increases the number of eggs produced by up to 200% and does not pollute the water environment.

Modular system

The new system is modular and can be stacked or upgraded at any time to maximize value through economies of scale. It requires minimal technical expertise, enabling any users to upgrade their existing system without having to disrupt their operations. It is paired with a fully self-contained land-based recirculating aquaculture system (RAS) that removes the sludge and keeps the water clean. It is most suited for commercial farmers who want to have a stable and quantifiable source of fry to provide and distribute to the local market or farmers.

Market perspectives

The company is looking for franchises in different countries. With an entry cost of $1,000,000, farmers will be able to produce a minimum of 20,000 fry per day and 7.3 million fry per year. Investors can look at breaking even within 18 months and start having revenues of $1,000,000 starting the second year. The company will have a limited number of hatcheries



in each market to prevent price wars and competition. Currently, Singapore Crawfish only offers their ABS™ hatchery through pre-orders and ships the product to any international buyer within 30 days. The company has an especially large potential impact in emerging markets like Malaysia where their crawfish industry is booming and eventually plans to have their hatchery franchises all over the world.

The company is also working with two major genetic companies to develop stronger- and faster-growing strains. They are testing the concept of having genetically-mapped crawfish that is tolerant to various environmental conditions such as temperature and pH fluctuations and expect to have its genetically-enhanced crawfish by 2022.

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Study on the impact of an antiviral and immune modulator for sustainable health management and seed production of *Macrobrachium rosenbergii*

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No suitable immune modulator and/or antiviral therapeutic has been found to use in *Macrobrachium rosenbergii* hatcheries to help achieve the sustainable production of PLs in Bangladesh. There is a remarkable crisis regarding the production of PL due to the inability to prevent and/or control the observed and suspected protozoan, bacterial, and possible but yet unidentified viral diseases occurring in the hatchery phase due to the unavailability of any suitable immune-enhancing and/or antiviral remedial product. Presently, available approved aquaculture medicinal products, protozoacides, probiotics, etc. have not been found

Table 1. Larval health through weekly random sampling of animals.

	With VIUSID® Aqua (number of weak larvae)	Without VIUSID® Aqua (number of weak larvae)	Remarks
Week 1	0 larvae/liter	5-6 larvae/liter	Weak larvae, ash-colored and settled at the bottom of the tank. They were unfed and slender (thin).
Week 2	1-3 larvae/liter	8-11 larvae/liter	Few mortalities in weak and ash-colored larvae were seen. Ash-colored larvae were found to have increased.
Week 3	1-2 larvae/liter	5-7 larvae/liter	Little mortality found to continue, but reduced from the previous week.
Week 4	0-1 larvae/liter	4-5 larvae/liter	Mortality found to be reduced, but a few in the control tanks were only found to be surviving with a kind of disability in their periopods, or walking legs, as seen under the microscope, assumed to be due to nutritional or immune deficiencies.
Week 5	0 larvae/liter	1-2 larvae/liter	Mortality stopped in trial tanks and further reduced in control tanks

to efficiently contribute to sustainable PL production in Bangladeshi hatcheries. In such a situation, the introduction of VIUSID® Aqua as an immune modulator and antiviral therapeutic product is also assumed to play a significantly positive role in PL production by defending against disease crises.

The company, Catalysis, has also found that VIUSID® Aqua is effective as a preventive and a supportive treatment against (i) viral events that are complicated by bacteria, (ii) Early Mortality Syndrome (EMS) caused by *Vibrio parahaemolyticus* and *Vibrio* spp., (iii) Acute Hepatopancreatic Necrosis Syndrome (AHPNS), and (iv) other pathogens that affect shrimp from larval to grow-out stages. It stimulates appetite, increases feeding efficiency, promotes rapid recovery, improves feed conversion, and its application procedure is flexible, making it advantageous for managing its application in hatcheries.

VIUSID® Aqua was tested by FishTech BD Ltd. in semi-intensive freshwater prawn culture farm-ponds of Gazi Fish Ltd, Bangladesh in 9 trial tanks (operated with VIUSID® Aqua) and 3 control tanks (not treated). Results are briefly laid out in this article.

Water parameters

VIUSID® Aqua was tested during larval stages to assess the effect on water parameters. pH, DO, ammonia, nitrate and nitrite showed differences in their average contents, which are closer to the favorable limit in the nine trial tanks. Meanwhile, control tanks showed a negative influence on the above parameters.

Larval health

The percentage of weak larvae in control tanks and their mortality were determined during the first and second week. Some mortality was found in all tanks in the third week, which was found to be negligible in trial tanks and reduced during the 4th and 5th and final week (Table 1).

Growth, survival and PL yield

Performances in terms of larval survival, growth and PL harvest were better in all the trial tanks compared to the control tanks (Table 2). Parameters such as body pigmentation, feeding efficiency, diseases, larval movement, etc. were also taken into consideration, as shown in Table 2.

Table 2. Effect of VIUSID® Aqua on growth, survival and PL yield.

	With VIUSID® Aqua	Without VIUSID® Aqua
Pigmentation	Good and glowing pigmentation	Some grayish, not glowing pigmentation
Hepatopancreaus	Bright and brownish	Brownish gray to grayish
Protozoan parasitic Infestation	Did not occur	Occurred
Bacterial necrosis	Did not occur	Occurred during 9-10 days
Viral disease symptoms seen	No	No
Larval movement	Strong, speedy, good movement	Sluggish or poorer movement than trial tanks with VIUSID
Feeding performance	Excellent all throughout the cycle	Sometimes poorer throughout the cycle
Metamorphosis by molting	Usual, as expected	More delayed than the trial tanks
Larval stages at 23-35 days	Stage PL2-PL13	--
Larval stages at 29-35 days	--	Stage PL2 -PL8
Survival (%)	85	68
Average harvested PL/tank (million)	0.255	0.204
Total harvested PL (million)	2.295	0.612
PL production/liter (Pcs./L)	102.0	81.6
PL3 average body length (mm)	10.0	08.5
PL3 average body weight (mg)	13.0	11.3
Growth rate	Satisfactory and as desired	Slower than the trial tanks
Size variation of larvae	Minor	Major
Cannibalism	Absent	Observed throughout
1st day of appearance of PL (days)	22	28
Completion of metamorphosis to PL (days)	26	35

Metamorphosis

Metamorphosis of one stage to the next stage was found to be quicker and more regular in the tanks treated with VIUSID® Aqua than in the control tanks. PL Stage I appeared on the 22nd day of culture in trial tanks, whereas the control tanks appeared after 28 days of culture, indicating the positive influence of VIUSID® Aqua on larval growth (Table 3).

Discussion

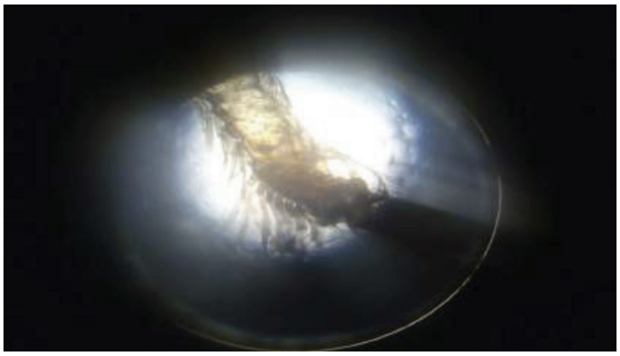
In the present study, VIUSID® Aqua was found to have a superior effect on larval survival within a 5-week span. Larval metamorphosis between the stages was found to be more favorable in the trial tanks than in the control tanks. The time between metamorphosis through the molting stages was shorter in this study than the observed at Chowdhury *et al*., 1993. In this study, post-larvae were found at 26 days, while with VIUSID® Aqua, PLs were found at 22 days, indicating a significant effect in larval growth.

A few symptoms of the early stages of bacterial necrosis in pleopods of larvae in stages V-VI were observed in control tanks, which recovered through an application of a probiotic treatment (Mojumder, 2007; Austin & Brunt, 2008) and oxytetracycline. No similar symptoms were observed in trial tanks. No other distinct symptoms of bacterial and/or viral infection were found, similar results as in another field trial on Perch fish (*Perca schrenkii*) by Catalysis in China.

Some of the critical physicochemical parameters of the

Table 3. Comparative metamorphosis of larval stages in trial and control tanks.

Larval stages	With VIUSID® Aqua (days of culture)	Control (days of culture)
Stage I	1	1
Stage II	2-3	2-3
Stage II-III	3-4	3-6
Stage III-IV	4-6	6-9
Stage IV-V	6-9	9-11
Stage V-VI	9-11	11-14
Stage VI-VII	11-13	14-16
Stage VII-VIII	13-15	16-19
Stage VIII-IX	15-17	19-22
Stage IX-X	17-18	22-25
Stage X-XI	18-20	26-30
Stage XI-PL1	20-22	26-28
Stage PL2-PL13	23-35	--
Stage PL2-PL8	--	29-35



water in the trial tanks were positively influenced by the treatment. More water exchanges were required in the control tanks than in the trial tanks, which was assumed to be possibly related to the use of VIUSID® Aqua in addition to probiotics.

Control tanks showed some considerable negative performance in growth, survival, feeding appetite, feeding performances, etc. (Table 2). Some ash-colored weak larvae were found, which ultimately died, thereby reducing the survival rate of larvae in those tanks. Size variation was also observed there, which is assumed to be related to a poorer feeding appetite in the larvae in the control tank. Cannibalism was also observed in the control tanks. Development of pigmentation on the larval body was also found to be poorer in control tanks. It was presumed that VIUSID® Aqua's positive influence on increased appetite led to better feeding efficiency of the larvae, helping to increase the effectiveness of the probiotic used in the experiment (Bairagi *et al.*, 2002), resulting in better output from the hatchery.

Moreover, improved overall movement, better survival, bright pigmentation on the larval body, enhanced feeding appetite and feeding performance of larvae, earlier and/or regular metamorphosis for stage-changes, absence of symptoms of any kind of viral (and/or bacterial) infection, etc. in trial tanks indicated that VIUSID® Aqua's effect on immune stimulation had a positive contribution on the larval growth and survival in the hatchery phase of freshwater prawns. Final survival was found to be 17% greater in the trial tanks than in the control tanks. In addition, with better growth performances, the average body length (1.5 cm) and weight (1.5 mg) of PL4 in trial tanks were higher than in control tanks.

Some indirect positive influences on aquatic parameters were the improved larval health by increasing appetite, thereby helping reduce the accumulation of the animals' waste in the bottom of the tanks. Better feeding performances reduced the feed waste and made the feed administration easier for the operators.

Broodstock were also treated with VIUSID® Aqua exhibiting better spawning, hatching and survival of newly-hatched larvae without any symptoms of disease in prawns and hatchlings. It is noteworthy that, while local officials found some broodstock positive in *Macrobrachium rosenbergii* Nodavirus (MrNV), broodstock used in this study, with the same origin as the above mentioned, did not exhibit any viral problems during egg incubation, spawning, and hatching of larvae. In view of the above, it is assumed that there might have been some positive effect on treated broodstock. PL transportation water was also treated showing better effects in relation to the PL's transport mortality at farmer's end. Detailed findings on broodstock and PLs' transport mortality are not included in this article.

Conclusions

VIUSID® Aqua offers immune stimulation and anti-viral influences on freshwater prawn larval phase in hatchery captivity. It was found to contribute to the increased survival, growth and overall production of seeds by enhancing their appetite, improving feeding efficiency and making larvae and PL resistant to disease, thereby helping to develop a sustainable shrimp hatchery management protocol to combat the possible occurrence of critical disease problems in the freshwater prawn hatchery sector. Full report accessible via www.catalysis.es/hatcheryfm.

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Developments in aquaculture from BLUEGent

Simon Hernandez Lucas,
PhD Candidate at BLUEGent, Ghent University

Sustainability optimization in hatcheries

Aquaculture is one of the fastest-growing food-producing industries worldwide. The industry production has topped wild-catch fisheries production for several years already and is still growing. However, while yield per unit feed used is superior in aquaculture compared to most terrestrial livestock production systems, there definitely are aspects where the sustainability of the sector can be further improved.

Sustainability is indeed a subject of much international research and development. Solutions and techniques exist, and more are being developed, that will decrease the environmental impact the sector currently has. One phase in the chain of aquaculture production, which is key and a necessity for most species that are produced, is the hatchery phase. As the biomass and resource inputs that are involved in the hatchery phase are logically smaller than those in the grow-out phase, the need to assess their sustainability has long been overlooked. However, they are a key link in most aquaculture production, and their potential impact on the environment is not negligible.

Types of aquaculture systems used in hatchery and nursery facilities include batch, flow-through, and increasingly also recirculating aquaculture systems (RAS). Depending on various factors such as seawater availability, staff costs and expertise, and infrastructure, some systems may be preferred over others.

An important measure by which sustainability can be assessed is the resource use efficiency of a system. The efficiency of a system that is able to consistently produce juvenile organisms, but requires enormous volumes of water or energy to do so, is clearly questionable.

Generally speaking, although RAS is not as widely applied yet in hatchery systems, it is considered most sustainable in terms of water use and discharge of untreated wastewater. Indeed, as the name suggests, a RAS design reuses the water, with various treatment steps, to ensure constant water quality is maintained. As the early life stages are the most sensitive and fickle, maintaining good water quality is key. However, if we consider the nutrients that are removed from the water in the biofilter as a resource, perhaps there are ways to go about it more efficiently. Various research groups are testing the use of seaweed biofilters to create more valuable or useful biomass than the bacterial colonies that generally thrive in biofilters. Another resource, that is potentially lost and could be recuperated through extra steps, is microalgae that the larvae of many species feed on. Protein skimmers do indeed have a tendency to capture large quantities of microalgae. The sequential rearing of multiple species with varying needs and sensitivities within the same RAS could potentially minimize this so-called microalgal waste stream.

Another factor to consider when looking at the sustainability of hatchery designs is energy consumption. As mentioned above, many larval life stages of species that are reared through aquaculture require live feed in the form of microalgae. Microalgal production systems, however, require specialized infrastructure, management by experienced staff and are energy-intensive, especially in-door systems. As such, they are a nuisance for hatchery managers to maintain. The centralized production of microalgae by specialized and dedicated companies, which should have more efficient systems, could alleviate this pressure on hatchery managers. To overcome the unavoidable "spoilage" or "expiration" of a live microalgal product, the use of freeze-dried algae could provide a solution. Even though the process of producing freeze-dried algae from live algae is energy-intensive, the energy consumption of a dedicated and specialized freeze-dried algae producing company may still be less than that of scattered and inefficient micro-facilities.

With regard to the potential outflow of waste to the environment and the applicability in various parts of the world, RAS systems score well. However, RAS does fall off when considering equipment and energy consumption, both of which can be translated to a certain carbon footprint. With the gradual transition to a carbon-neutral energy supply over the coming decades, the carbon footprint associated with RAS energy requirements should gradually diminish.

Different groups at Ghent University (BLUEGent, the Laboratory of Aquaculture & Artemia Reference Center, the Laboratory of Phycology and the Laboratory for Environmental Toxicology), together with five companies (Aquacultuur Oostende, Colruyt Group, DEME, IMAQUA and SIOEN), are currently involved in BlueMarine^3.Com. This project focuses on researching and developing RAS design hatchery systems for three species groups, namely shrimp, bivalves and seaweeds. Monitoring of resource streams throughout these hatchery systems will improve our understanding of the efficiency and sustainability of the systems and can help us identify potential synergies between certain species groups. In the following phase, multi-species concepts will be developed and tested, to see whether theoretical synergies can be translated into practice.

Although industrial-scale aquaculture is a relatively young sector, its dominance in the seafood market is key and will become increasingly important. It provides solutions to problems associated with unpredictable wild fish populations and can alleviate the impact the fisheries sector has without interrupting the stream of seafood to consumer's plates. Multiple challenges still exist in terms of sustainability, technical and economic feasibility. However, the challenges are being faced head-on and various projects are tackling the present-day issues.

To what extent can ozone remove geosmin in RAS?

Aikaterini Spiliotopoulou, Water ApS

Ozone in RAS

In land-based recirculating aquaculture systems (RAS), fish are farmed in reused water. Good water quality is vital in such systems to support growth, minimize disease outbreaks and ensure the welfare of the aquatic organisms. Ozone is an excellent candidate to improve water quality by oxidizing natural organic matter, removing color and suspended solids, accelerating protein degradation, improving coagulation and filtration processes, enriching the water with oxygen, removing off-flavor compounds (geosmin and 2-methylisoborneol (MIB)), and therefore improving the taste of fish.
It is also able to control the microbial load resulting in improved growth.
If ozone is not properly used, it can adversely affect both human and aquatic organisms. Ozone is toxic at residual concentrations (0.01 - 0.1 mg/L) as it oxidizes the gills and the surface mucus layer of the fish eventually leading to death or making the fish susceptible to microbial infections. Depending on the water matrix, detrimental byproducts might be formed, such as bromine (LC_{50} of 0.068 mg/l BrO^- in rainbow trout), bromite and bromamines, which are toxic to fish, bivalves and crustaceans while bromoform (bioaccumulates in aquatic animals) and bromate are potential human carcinogens.

When the right equipment meets the expertise

Over the years, OxyGuard Group has gained deep knowledge in dissolving ozone gas optimally into the water, ensuring maximum treatment efficiency and minimum cost and operational risks. Ozone is an unstable molecule and expensive to produce.

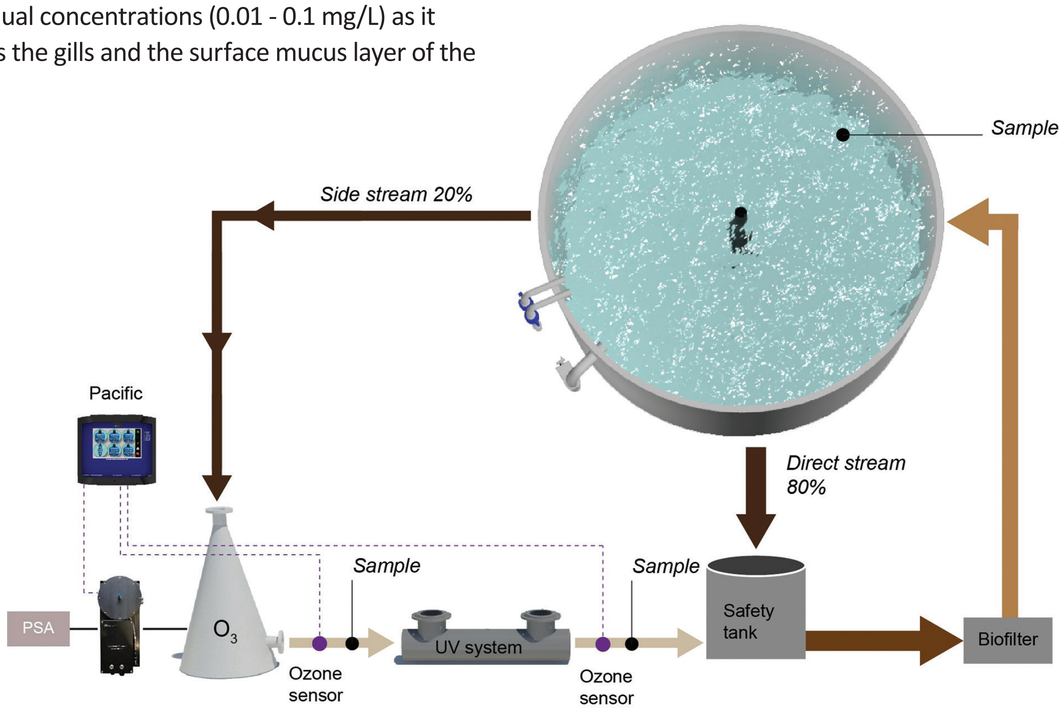

Figure 1. System overview - VIDA project.

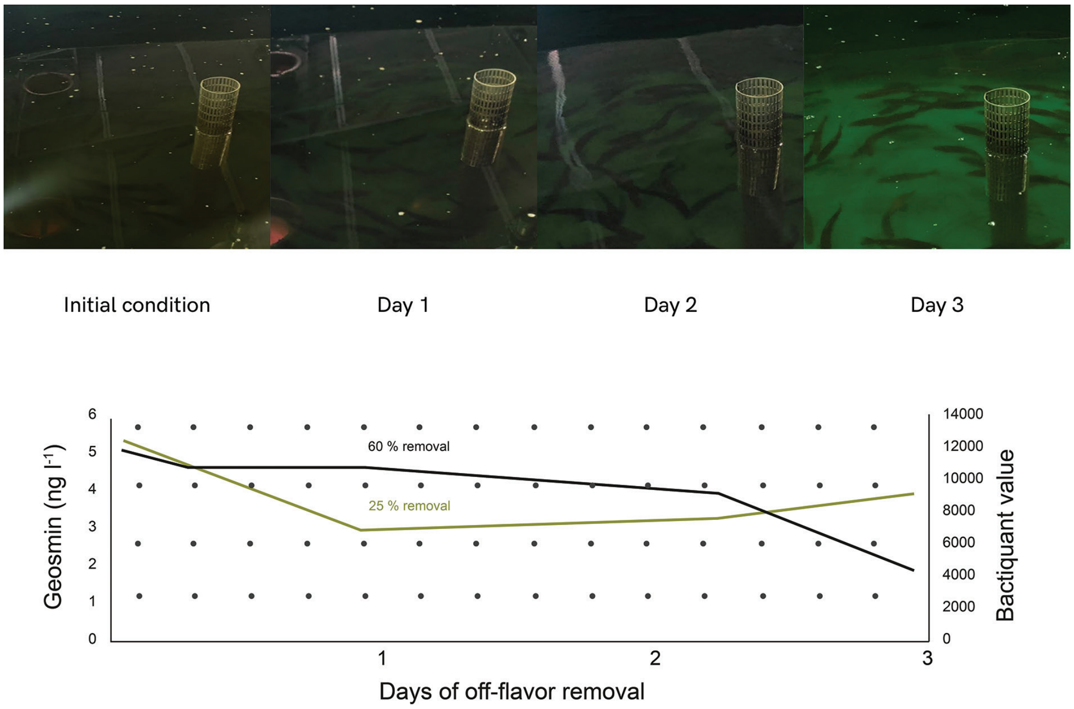

Figure 2. Water quality improvement and geosmin removal due to ozonation - VIDA project, funded by the program "Value-added innovation in food chains" and supported by the EU program INNOSUP.

Ozone's lifetime is very short and highly affected by temperature. The length of the tubing used to transfer ozone should be kept as short as possible to minimize ozone destruction within the residence time in the inlet tubing. Thus, it must be produced on-site, next to the dissolution point. Several advantages are stemming from this decentralized use:

- Maximum dissolution efficiency
- Minimum losses
- Increased safety
- Minimum risks of leaks
- Low installation cost (fewer parts, shorter tubes)
- Maximum water treatment efficiency - even if one of the ozone generators stops working, most water will be treated

Water ApS has developed a reliable and safe ozone generator with stable output, which is easy to work with. The Gaia Ozone Generator produces steadily high ozone concentrations (8-15% wt/wt) with the lowest possible energy consumption.

Another significant issue is to measure and continually monitor the ozone to avoid under or overdosing. OxyGuard International A/S has developed an ozone sensor specially designed for aquaculture, which measures the partial pressure of the ozone directly in the water. The sensor is exceptionally stable and has an extremely fast response time. The detection limit of the probe is down to a few ppb.

To increase security and control, it is a good idea to couple both ozone sensor and ozone generator to a monitoring and control system like the OxyGuard Pacific system. Such a system can receive data from the ozone sensor and control the production of new ozone. In case of high ozone concentrations in the water, the monitoring and control system will shut down the ozone production and secure that no residual ozone will reach the fish tanks. The amount of ozone required is system-specific and highly dependent on the ozone demand (ozone reacts rapidly with the easily degradable compounds, resulting in an immediate ozone consumption), which depends on the amount of feed added, feed utilization, water treatment, the degree of dilution, etc. The ozone dosage will be adjusted according to the water quality requirements of the specific system. This automatic adjustment of the ozonation will save energy, keep running costs for the entire ozonation system low, and will ensure a safe work environment.

Another beneficial add-on for an ozonation system is a digital platform, like Cobália, that can draw conclusions across logged data. As modern algorithms such as machine learning and AI play an increasingly large part in aquaculture, the possibilities are endless for forecasting needed ozonation related to changes in the water matrix, and with the precision possible through digitalization, the water matrix can be completely controlled, which increases both safety and animal welfare.

Removal of off-flavor compounds by ozone

Although purging is a common practice to remove off-flavor compounds from fish flesh, it has a significant environmental impact resulting in reduced revenue. To address the issue of off-flavor compounds in RAS, which are responsible for the muddy taste and odor of fish, OxyGuard Group participated in the VIDA project (funded by the program "Value-added innovation in food chains" and supported by the EU program INNOSUP), where ozone was integrated into a commercial RAS. The ozonation was followed by a small UV system (Water ApS) to enhance hydroxyl radical formation (Advanced Oxidation Process; AOP) and destruct the residual ozone converting it to oxygen. Ozone sensors were used to continually measure potential residual ozone and control the ozone treatment (Fig. 1).

A remarkable improvement in the color due to the oxidation of humic substances was observed just a few hours after treatment initiation. After three days, the whole water volume in the freshwater RAS department was transparent. Although the initial geosmin content was low (~5ng/L), ozonation achieved a 60% geosmin removal in 3 days while the bacterial activity (determined by BactiQuant™, Mycometer) was reduced by 25% during the same period (Fig. 2). Bacteria are important for optimal operation (e.g. biofilters) and the intention was not to disinfect the system, therefore, just a reduction was expected.

Fish behaved as expected and welfare was improved (subjective evaluation based on watching the swimming activity and comparing to fish in untreated muddy water). Fish remained in the treated water for a couple of days and showed no sign of failure to thrive - they also started feed intake after the first night "in the new environment." The ozone sensors regulated the amount

of ozone that was injected into the system to avoid overdosing. This demonstrates the value of the newly developed highly sensitive ozone sensors and the ability of the system set up to manage the whole process.

This short-term study provided some encouraging results regarding ozonation in RAS and its effect on the water quality as both the organic matter as geosmin were removed from the water without compromising fish welfare. However, additional research is needed to test the concept for a longer period in systems with higher geosmin contents. The expertise and novel equipment developed by OxyGuard Group seems to significantly improve water quality and aquatic animal welfare in RAS.

References available on request.

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On-site generation of oxygen using vacuum pressure swing adsorption (VPSA)

Libardo Estupinan, Joshua Tolley, Oxygen Solutions

The on-site production of oxygen (O_2) for industrial and medical applications is carried out using adsorption-based technologies. Since 1960, when Skarstrom patented the first Pressure Swing Adsorption (PSA) cycle for air separation, on-site production of O_2, where the purity required is no higher than 95%, became technically and economically feasible (Skarstrom, C.W. patents, 1960, 1966). For industries whose O_2 requirements are less than 300 TPD (tons per day) at 90-95% purity, adsorption technologies became preferred from an economic standpoint. Adsorption technologies are less expensive than the cryogenic distillation of air to produce liquid O_2 (LOX) (Ackley, 2019). Additionally, on-site O_2 production allows industries located in remote areas, where access to LOX is cost-prohibitive or simply not available, to have a reliable and inexpensive source of O_2.

Development of pressure swing adsorption

The evolution of adsorption technologies to produce high purity O_2 can be traced to the discovery of new adsorbent materials and the development of more complex adsorption cycles. The discovery of Lithium-exchanged zeolites has been one of the most significant and impactful events in this field.

Prior to this discovery, O_2 was produced using Pressure Swing Adsorption. In this process, an adsorption column is pressurized with air up to a pressure of 4-8 barg using a compressor. The zeolite,

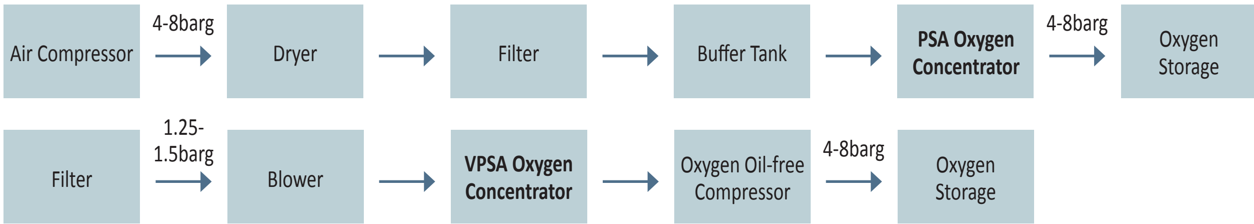

Figure 1. Process schematic for PSA and VPSA O_2 concentrators.
PSA: All air requires compression to 4-8 barg **VPSA:** Only Product Oxygen requires compression to 4-8 barg

which is Nitrogen (N_2) selective, adsorbs N_2 while most of the O_2 and argon pass through the column. High purity O_2 (<95%) will be produced until the zeolite capacity to uptake N_2 is reached. To remove the N_2 from the zeolite, it is required to decrease the pressure (P_{des}) inside the adsorption column to atmospheric levels. PSA processes require a high-pressure ratio (P_{ads}/P_{des}).

The discovery of Lithium-exchanged zeolites is considered a technological breakthrough for the separation of air using adsorption because it made it possible to run the PSA process at pressures close to atmospheric levels. This replaces the use of the air compressor with a blower, which requires less energy to run, and eliminates the use of all the pre-treatment equipment such as dryers, filters, and buffer tanks as shown in Figure 1. This type of process is called Vacuum Pressure Swing Adsorption (VPSA) or Vacuum Swing Adsorption (VSA). During the O_2 production stage, the column is pressurized, using air, to slightly higher than atmospheric pressure and during the regeneration stage, the pressure decreases to vacuum levels. This reduces the pressure ratio (P_{ads}/P_{des}) and the overall energy consumption of the process since it is not required to compress the air to the typical 4-8 barg necessary to run a PSA unit.

Aquaculture applications

As mentioned earlier, the VPSA process eliminates the use of all the air pre-treatment equipment used in the PSA process that increases the capital and maintenance costs of the separation system. The VPSA system was made viable using Li-exchanged zeolites in addition to a "guard bed" inside the adsorption column to remove moisture and contaminants such as CO_2.

Even though the cost of the adsorbent is higher in a VPSA system, it is important to note that it does not need to be replaced as frequently as in the PSA process where the zeolite needs to be changed due to the high pressures of the process, which results in the formation of powder and disintegration of the zeolite.

The VPSA process enabled the creation of a more simple, compact, and energy-efficient air separation unit to produce on-site, high purity O_2. These benefits led to massive adoption of this technology in all the different industries that require O_2. The aquaculture industry was one of the early adopters of the VPSA technology because it significantly reduced the cost of O_2 and enabled the possibility of building fish farms in remote areas where access to LOX was not possible. On-site O_2 production has given aquaculture companies the possibility of managing the O_2 supply while maintaining a low-energy, low-maintenance process.

Energy-efficient and cost-effective technology

Adsorption technologies such as PSA and VPSA become more energy efficient as the scale of the process becomes bigger. As mentioned above, adsorption technologies are economically better than cryogenic distillation (LOX production) when the required production is below 300 TPD. VPSA O_2 generators have shown energy consumptions as low as 0.25 kWh/(kg O_2 produced) for units producing between 200-300 sm^3/h. On the other hand, PSA O_2 concentrators show energy consumptions of around 0.41 kWh/(kg O_2 produced) for the same range of production. This significant difference in energy consumption has made the VPSA technology the industry standard for on-site O_2 generation.

Recent advances in process simulation and optimization, and the availability of high-performance computer processors have dramatically improved the understanding of the adsorption-based separation processes and have resulted in the development of more energy-efficient process configurations (Estupinan, 2019). Additionally, the discovery of new adsorbent materials with higher N_2 selectivity would make the VPSA technology even more energy-efficient and cost-effective in the near future.

Conclusions

As a result of the advances in adsorption technology and the discovery of the Lithium-exchanged zeolites, vacuum pressure swing adsorption (VPSA) has become the most energy-efficient method of producing 90-95% O_2 in amounts less than 300 TPD. VPSA units are mobile and allow for companies to produce O_2 in remote areas where it would otherwise be impossible to viably acquire. In addition to this, VPSA units use up to 40% less energy than PSA units producing the same quantity of O_2 resulting in lowered operating costs. These benefits are what make VPSA units superior to LOX and PSA for 90-95% purity O_2 production under 300 TPD.

References

Skarstrom, C.W.: Method and apparatus for fractionating gaseous mixtures by adsorption. US Patent 2,944,627 (1960).

Skarstrom, C.W.: Oxygen concentration process. US Patent 3,237,377 (1966).

Ackley, M.W. (2019) Medical oxygen concentrators: a review of progress in air separation technology. *Adsorption. 25. 1437–1474*.

Estupinan L. (2019) Experimental validation of multi-objective optimization techniques for design of vacuum swing adsorption processes. *Sep. Purif. Technol. 168. 19–31*.

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UV system performance evaluation: Control and monitoring approach

Aran Lavi, Atlantium Technologies Ltd.

Ultraviolet (UV) light disinfection can play an important role in water biosecurity and the prevention of fish diseases in aquaculture facilities. UV is highly effective in ensuring the microbiological safety of the intake water. In the recirculation loops, UV is also instrumental in maintaining a controlled growth environment and for preventing outbreaks of diseases even under high-stress conditions. Alongside its many advantages, UV technology, at its core, is highly sensitive to operating conditions and extremely difficult to monitor.

With the market currently saturated with a variety of UV system providers with offerings at a wide range of price points and performance levels, sites often fail to achieve the desired water biosecurity due to underperformance and inaccurate evaluation of their UV systems. That raises the question: What tools are at the disposal of UV laypersons in order to evaluate the expected performance of a UV system already in the project engineering stage? In other words, how can we ensure that the required UV dose is delivered in the disinfection chamber at all times?

Measuring UV performance

At the core of UV system's performance evaluation is the understanding that the UV dose cannot be directly measured within the UV system's disinfection chamber. The most effective method to evaluate a UV system's performance is by water sampling and microbiological tests. For this reason, third-party validation institutes determine the performance of UV systems (often referred to as Envelope of Operation) by performing biodosimetry tests to determine the Reduction Equivalent UV dose (RED). This UV dose is deduced from testing the microbiological log reduction of the UV system under various operating conditions and not according to a direct measurement of the UV dose by a "UV sensor". Unfortunately, this option is not available

Figure 1. Monitoring lamp UV output and water UVT in a two-lamp UV system. Together with flow rate indications, these three variables are essential for reliable UV-dose delivery.

for production sites prior to the installation of the UV system and when fish are already cultivated in the facility, by which time a wrong choice of a UV system might prove very costly.

Since the UV dose itself cannot be measured, we must focus on the components which constitute the UV dose function and are at the core of the UV-dose algorithm of each UV system. The general - and unavoidable - UV-dose function contains the following four variables:

UV Dose = Lamp output x Flow Rate x Water UV Transmission (UVT) x System Design

To keep things simple, and since we as users cannot evaluate the 'System Design' variable, we will consider the latter as a constant (even though not all UV systems are created equal and the geometry and design of the systems play a considerable role in determining power efficiency and dose delivery). That means that we are left with Flow Rate, Power, and UVT, three straightforward variables which - given the adequate instrumentation - can be accurately monitored in real-time to assure the user that the UV system is performing as expected. Evaluation of a UV system's performance is, therefore, an evaluation of the sensors in the UV system dedicated to monitoring the abovementioned three variables.

Lamp output

Perhaps the most difficult variable to monitor is lamp output, a direct measurement of the UV photons emitted by the UV lamps and to be delivered into the disinfection chamber. As each lamp in the UV system contributes its fractional share to the aggregated UV dose, monitoring the UV output of each individual lamp in the UV system is crucial. With stated lamp operating hours reaching 14,000 and more for some UV providers, it is amazing how the overwhelming majority of UV systems are not equipped with 'per-lamp' dedicated output monitoring and are unable to account for the real efficiency of the UV lamp. In this respect, UV systems with a minimal amount of lamps have a clear advantage in this field compared to UV systems with dozens of lamps that are unable to provide dedicated lamp monitoring and, therefore, must resort to kilowatts monitoring, average evaluation, and calculation factors.

Water UV transmission

The second variable, water UVT, is relatively easy to monitor, and yet, hardly any UV system employs an integrated UVT sensor. Also, very few UV providers offer a UVT meter as an add-on, which in itself is not as accurate as an integrated UVT sensor that takes quartz sleeve deposit into account. UVT has a decisive weight on the outcome of the UV-dose equation and might periodically change during the production cycle. Failure to account for the real UVT in the disinfection chamber, and respond accordingly, often leads to undercalculation of the UV dose and consequently results in loss of water biosecurity.

Flow rate

Flow rate is the simplest variable to measure using any standard flow meter or other flow measurement device. Still, as in the case of water UVT, most UV systems operate according to a predetermined fixed maximum flow configuration which may or may not represent the real flow conditions. The result is, again, an inaccurate representation of the delivered UV dose in the disinfection chamber. A flow measurement device is required for proper operation for safety reasons (so that the UV will not operate without water flow) as well as accurate UV dose measurement.

Other factors

Additional factors for evaluating expected performance exist. As mentioned earlier, a large number of lamps will inevitably lead to performance deterioration as this is harder to monitor and maintain. The UV-dose type used for the design is also crucial for the purpose of performance evaluation since most systems are based on average UV dose or theoretical computerized flow dynamics, which leave ample room for manipulation and error as opposed to third-party validated UV systems and RED designs. Service and proven experience with industry-related pathogens are equally important factors as sustainable operation is expected from the UV system.

In this article, we focus on the monitoring aspect of UV operation as it relates to tangible elements in the UV system which can be assessed with relative certainty and since it touches the underlining objective of UV systems in aquaculture production, namely delivering the minimum required UV dose at all times, under changing operation conditions in order to enable a disease-free production environment.

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18 - 19:	Aqua Nor, Trondheim, Norway	www.aquanor.no

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14 - 16:	SPACE, France	space.fr
21 - 22:	International Webinar on Aquaculture and Marine Biology	www.conferencemind.com
20 - 23:	20th International Conference on Disease of Fish and Shellfish	www.delegate-reg.co.uk

OCTOBER

4 - 7:	Aquaculture Europe 2021, Portugal	aquaeas.org
13 - 15:	Simposio Acuicultura Guatemala	export.com.gt
25 - 28:	AquaExpo Guayaquil, Ecuador	www.aquaexpo.com.ec

NOVEMBER

8 - 12:	World Aquaculture 2021, Mexico	www.was.org
28 - Dec 3:	International Symposium on Genetics in Aquaculture, Chile	www.isga.uchile.cl

DECEMBER

5 - 8:	World Aquaculture 2020, Singapore	www.was.org
11 - 14:	Aquaculture Africa, Egypt	www.was.org

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12 - 14:	VIV Asia 2022, Bangkok, Thailand	vivasia.nl

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