Innovation Insights in Aquaculture

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Hatch Innovation Insights

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The Hatch Universe

HATCH Innovation Services

Consulting Unit - Hatch Innovation Services

Senior industry professionals with 65+ years combined experience providing prominent industry stakeholders with innovation scouting, market research, DD support, strategy advice, etc.

Investment Units

Existing portfolio of 43 investments across the aquaculture and alternative seafood space. Recently closed its first round for their 2nd venture fund "Blue Revolution Fund" at a target volume of €100M.

Startup Incubation & Acceleration Programs

Running 3-5 innovation workshops annually for +40 startups and growth-stage companies in several countries. Receiving more than +350 aquaculture-specific applications per year.

Media Platform - The Fish Site

The largest global digital aquaculture-news platform, in-house intelligence, and media agency.

Designed with synergy in mind, our four business units enable us to create value in all different aspects of the aquaculture chain. Our multiple touchpoints with early stage innovators, investors as well as the aquaculture industry creates an unique opportunities for market collaboration and mutual gain, facilitated and designed by Hatch

Key Technology Trends & Drivers

Industry snapshots: Salmon and Shrimp

Atlantic salmon

Whiteleg shrimp

In the future Hatch expects ***to see a higher degree of diversification of farming systems***, where onshore and offshore novel system gaining market traction for future volume growth of the salmon farming industry, ***enabling salmon farming in new geographies and locations close to major seafood markets.***

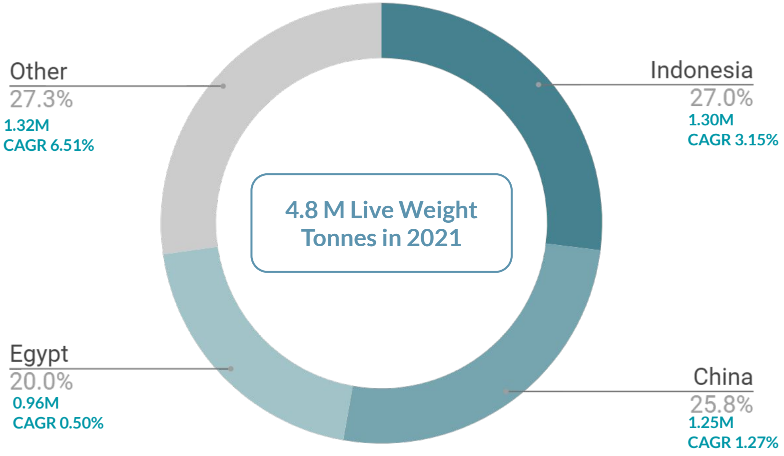
Globally there is a ***trend to intensify shrimp farming*** which will require the use of enabling technologies.

Therefore, in the short term, Hatch expects that ***shrimp farmers will be urged to adopt technologies allowing for more digitization & automation*** of water quality, feeding and general farm management processes.

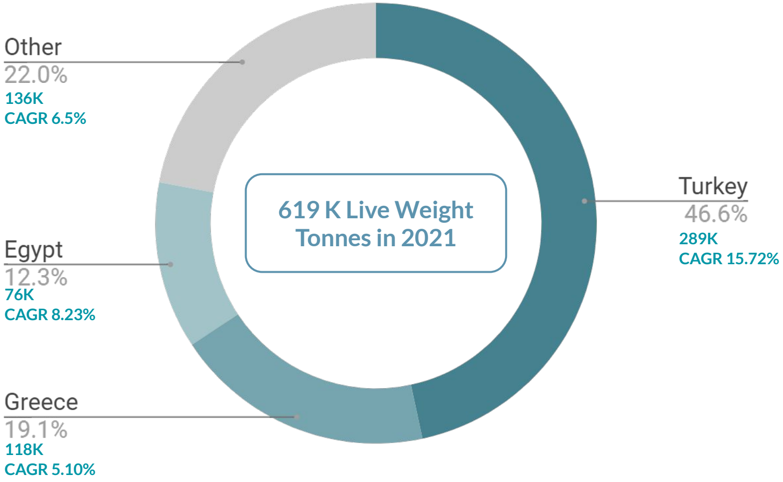
CAGR = 2016-2021

Industry snapshots: Tilapia and Sea Bass & Sea Bream

Nile tilapia



European sea bass & Gilthead sea bream



Tilapia farming will in the future be a mix ***of cage and pond aquaculture.***

lowering their expenditure per kg fish produce. Important innovations will be using better quality feeds, decreasing FCRs and opting for improved fish genetics in the farm cycle.

Health management is key to increase Seabass /bream production. On health topics, viral nervous necrosis (VNN), is one of the most pressing concern in Mediterranean aquaculture alongside with bacterial and parasitic infectious diseases.

Hatchery production still faces high number of skeletal deformities.

CAGR = 2016-2021

What are the Key Driving Forces for Innovation in Aquaculture?

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the fish site

The Aquaculture Innovation Survey was conducted in Oct/Nov 2023 through the Fish Site. Readers connected to the finfish industry were asked to rank key drivers for innovation and new technologies in the aquaculture sector. The numbers represent the ranking of the topics in the survey.

1

COST EFFICIENCY

have been and continue to serve as central motivators for the adaption of new innovations and technologies.

HEALTH & WELFARE

2

Innovations supporting health and welfare of the cultured organisms, are essential to bring the sector forward by preventing damaging outbreaks, limiting losses and reducing pollution

3

ENVIRONMENTAL CHALLENGES

To unlock the entire potential of sustainable aquaculture, reducing the negative environmental impacts of current and future aquaculture operations through innovative technologies and production systems will be imperative.

CLIMATE MITIGATION & ADAPTATION

4

Modifications in aquaculture methods representing a possibility to enhance sustainability, productivity, and profitability of aquaculture operations, leading to positive impacts on both climate change mitigation and adaptation.

Alternative & more resilient feed ingredients
Selective breeding for more robust species
More robust farming systems
Near-market production

REGULATIONS

5

The entire innovation and technology adoption processes are profoundly shaped by the governance system and regulatory landscape. Regulations often present main barrier for the development of aquaculture production in many developed countries, despite a strong desire for growth.

○ = Survey ranking

Technology & Innovation Trends

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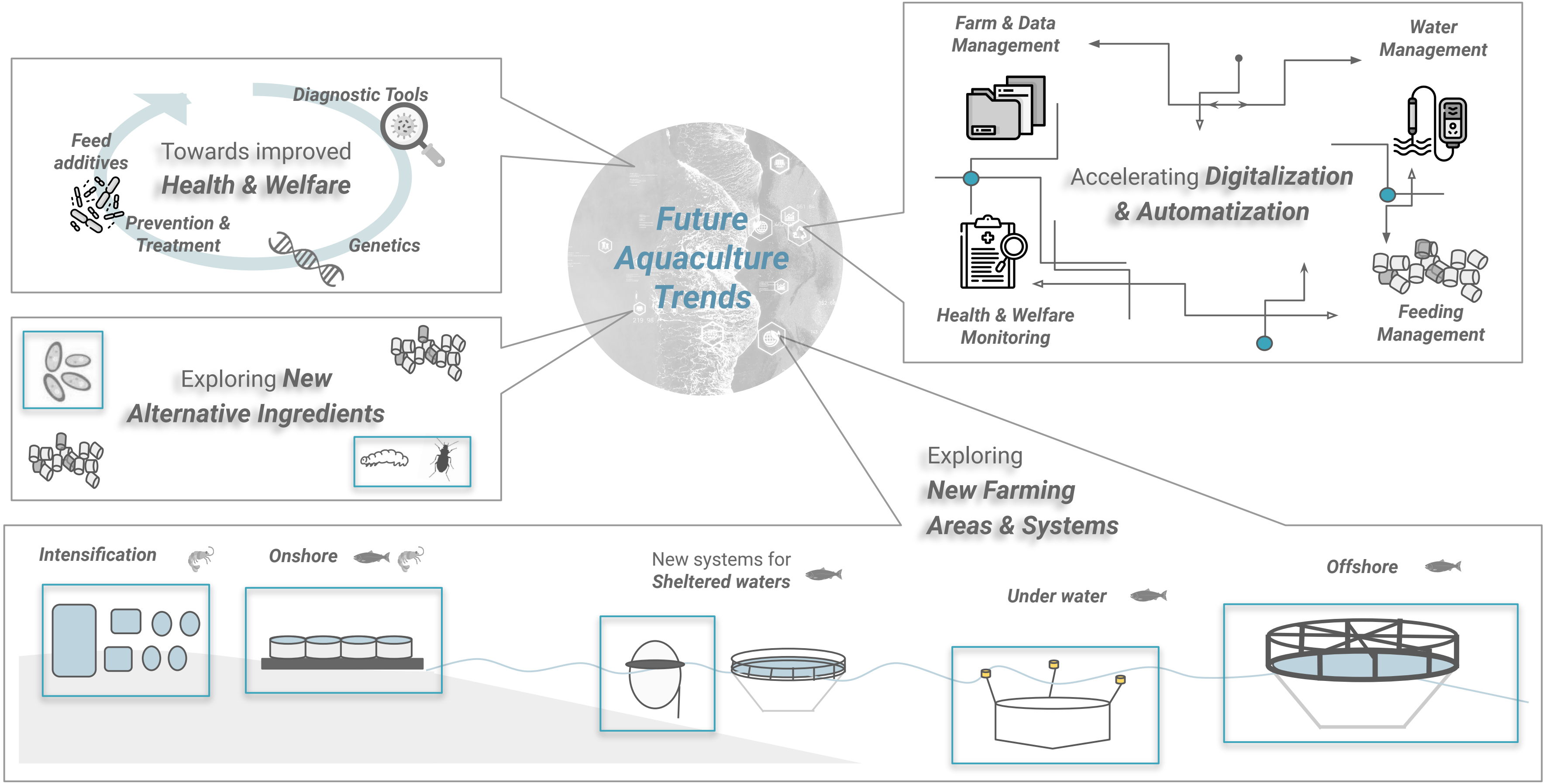
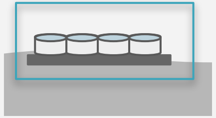


Novel Farming Systems

Strong Development for Onshore Farming Projects



Several land-based aquaculture production projects have been launched, however, most projects are still conceptuale, under construction or at low volumes that have been harvested.

Europe has by far the most significant number of both currently operating and future planned RAS facilities. This is mostly the result of Norway's role as a leader in technology adoption within the sector and its extensive salmon production.

- By situating RAS facilities closer to key consumer markets it can represent a more climate-friendly option.
- Significant electricity demand and consumption, however, renewable energy sources can be used to reduce emissions.

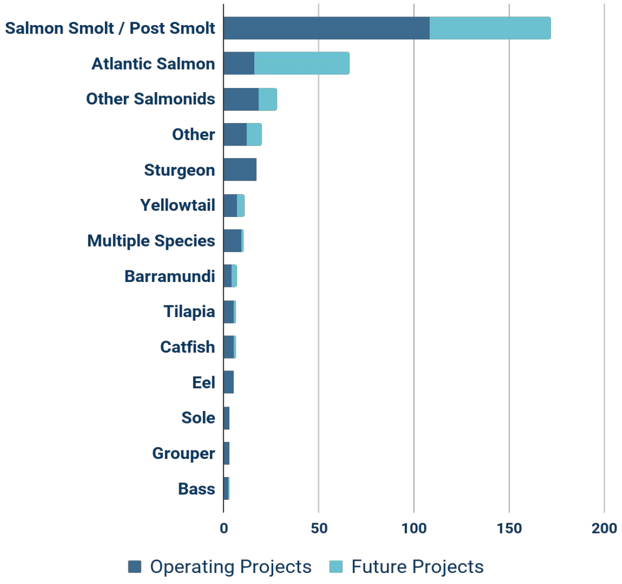
- Complex systems - require high demand on operational skills, technical redundancy, water filtration equipment, biosecurity, etc.
- High CAPEX costs
- RAS facilities rely on cost-effective and reliable energy and water sources

Future Prospects

Investors have shown interest in the onshore sector among others due to advancements in operational expertise and system design. **In Norway, *onshore farming has no entry barriers on licences, which has been a key driver for many of the full life cycle projects.*** Furthermore, the ***onshore post smolt concept is an approach to increased MAB utilization***

Several of the major aquaculture species are facing difficulties in terms of fry supply, grow-out capacity bottlenecks, and environmental challenges, which ***present opportunities for RAS technologies*** whether it is about the full grow-out phase in a land-based facility or the need for larger smolt to reduce time at sea.

RAS Projects by Species



Source: Spheric - Land-based aquaculture report 2023 third edition

New Systems for Sheltered Waters

Emerging ***trend that traditional salmon farmers are partnering up with floating S-CCS technology companies*** with focus on the production of larger smolts.

The ***biggest regulatory challenge remains that closed systems are competing for licenses with commercial open sea cage farming operations***. The Norwegian Government are currently ***investigating a new licencing system*** to enfavour CCS, potentially accelerating the future technology development of CCS farming systems.

- Floating (S-)CCS in sheltered coastal areas can reduce the impact on the surrounding habitat (reduced pollution through sludge collection) as well as reduced impact on wildstock (reduced escape events)

- High CAPEX, however CCS are less CAPEX intensive and require less energy compared to RAS facilities.
- Ambiguous regulatory framework
- Due to positioning in sheltered waters, CCS have a higher potential of social conflicts with local communities compared to offshore farming

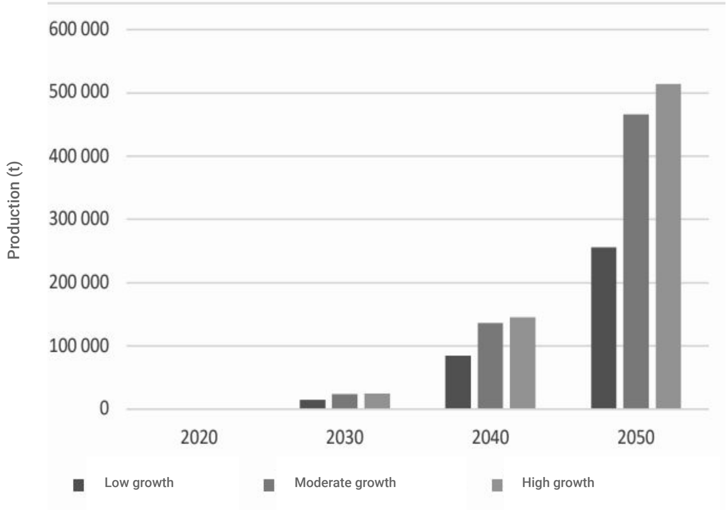
Future Prospects

Technology at pilot stage - lack of proof of concept for full scale production, operational efficiency and cost competitiveness

Focus on Atlantic salmon, but also other species like bass & bream, coho and rainbow trout

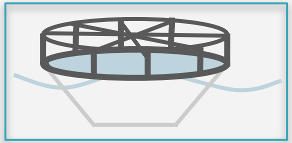
Short term market opportunity: post smolt production; reduced production time yields increased MAB utilization in exploring ways to reduce biomass turnover time

Figure: Future outlook of post-smolt production scenarios in floating closed system. Per Stiim Aqua Cluster report, a significant proportion of post smolts is assumed to be produced in closed marine facilities towards 2050.



Source: Stiim Aqua Cluster Report 2021

Growing support for Offshore farming



Two approaches: ***large-scale projects with players of the salmon industry*** (predominantly in Norway) and ***independent relatively newcomers with focus on more niche high-value species*** and emphasizing the sustainability concept

Various regions are investigating potential locations for open ocean aquaculture. Nevertheless, as of now, ***Norway remains the central hub for active operations in this sector.***

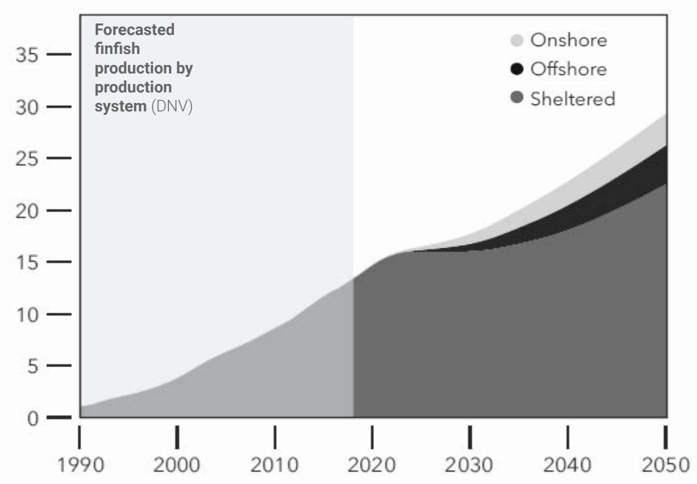
- Offshore farming could present environmental-positive solutions compared to conventional farming, including reduced habitat impact (effluents dilution) and reduced impact on wildstocks (genetic interaction)

- Operational challenges: open rough environment, exposed to extreme ocean conditions, weather, and climate changes. The design and operation of such complex production facilities will heavily rely on existing expertise in ocean engineering.
- High costs due to the use of larger, more complex production facilities.
- Uncertainties connected to the regulatory framework

Future Prospects

- Due to ***substantial CAPEX demands and regulatory uncertainties*** the sector constitutes a considerable risk level
- Focus on high-end value species like salmon, and long term seabass/seabream, coho, barramundi, yellowtail
- ***More mid to long term opportunity since still limited regulatory availability, but new locations are now open in Europe and Americas***.
- Europe and China will be the first regions where these technologies are proved with salmon at big scale operations

Per DNV research, a significant portion of production growth will originate from new farming systems, thereby approximately 13% will be projected for offshore by 2050.



Source: DNV Report - Marine Aquaculture Forecast 2021

Innovations to Tackle Potential Future Biological Problems of Novel Farming Systems

Novel farming system are considered to mitigate or even solve current fish health challenges of conventional net pen farming, e.g. reducing sea lice pressure. Besides that these ***improved health concepts still needs to be proven***, the potential of ***new emerging health challenges need to be assessed***.

Disease Pressure

Explorations of new farming environment, provides an element of risk due to limited knowledge of the pressure of (unknown) viral and / or bacterial diseases

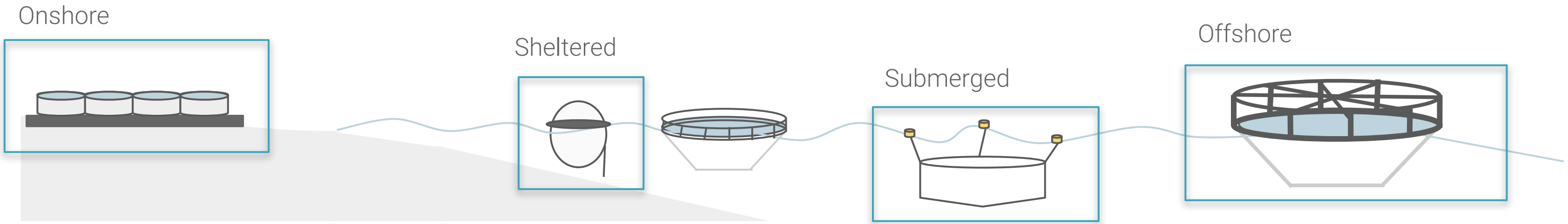
- Knowledge gap of the biofilters role to contain unwanted agents
- Knowledge gap of potential new bacterial/ viral diseases in deeper water layers (direct interaction or through water intake)
- Knowledge gap of potential (new) bacterial/ viral diseases & parasites offshore

Farming Conditions

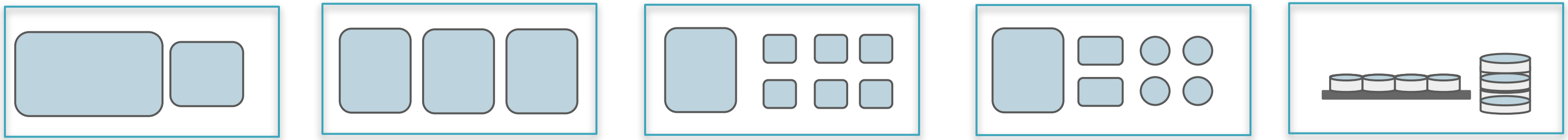
- Within (semi-) closed system maintaining optimal farming conditions is important including lighting, water temperature, and water current otherwise risk of adverse developmental effects.
- Potential health problems due to limited (artificial) surface access
- Knowledge gap of the impact of high currents on the fish

Water Quality

- Maintaining stable and high water quality conditions is critical - Risk of accumulation of toxic agents e.g. H_2S
- Maintaining stable and high water quality conditions is critical - Risk of intake of toxic algal blooms
- Knowledge gap of water quality conditions in these new farming environments, e.g. risk of low O_2 areas



Comparison between Shrimp Farming Systems



	Extensive	Semi-Intensive	Intensive	Super Intensive	RAS
Strengths	Low cost, low risk	-Better control -more sustainable	-high yield - efficient land use	- High yield -advanced technology, -efficient space utilization	- Water recycling reduces waste, -Controlled environment -Suitable for various locations
Weaknesses	-Low yield -susceptible to environmental changes	-higher cost than extensive -more management	High investment Higher risk of disease spread	- High CapEx, requires skilled labor, -Energy-intensive (OpEx)	-very high investment - technical complexity
Opportunities	ecosystem services (maintaining water quality & supporting biodiversity)	-Increased yield with better management	Technological advancements	- Expansion to new markets - New technologies	-Close to markets/customers. -water conservation -technological innovation -premium markets
Threats	-climate change -pollution	-Prone to disease (higher yield)	-disease outbreaks -environmental concerns	- Disease outbreaks, environmental impact concerns- only if poorly managed, potential higher loss	- Risk of system failure, - disease management, - High competition for skilled personnel in technology-driven markets -high OPEX

Emerging Systems in the Shrimp Farming Sector

- With the advancements in RAS technologies, there is a trend for shrimp production in land-based intensive production tank systems.
- ***New farming technologies creating opportunities to tackle the problem of disease outbreaks and elevated mortality rates***.
- Indoor RAS Systems can be categorized as ***clear water or hybrid biofloc system***. There are numerous Indoor RAS System projects implemented or under development.
- RAS systems will require typical equipment used in finfish RAS systems; however, ***shrimp RAS systems are currently in the pilot phase and producing small volumes.***

While still in early stages of development Indoor RAS (Clear water/ Biofloc) have the ***opportunity to reduce losses due to health challenges*** while improving productivity.

Advanced filtration systems, like biofilters and mechanical filters, to remove excess waste and debris from the water, are ***reducing the risk of disease outbreaks*** and maintaining a clean and conducive environment for shrimp.

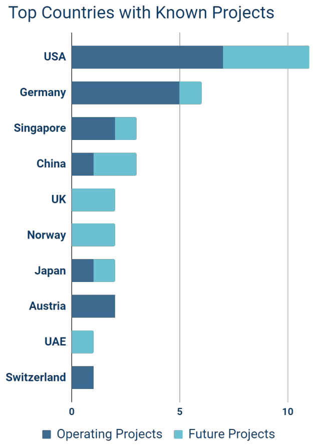
Hatch assessment of Indoor RAS Systems is more ***in favour of Hybrid biofloc systems due to reduced CAPEX***, since biofilters are not needed ***and reduced OPEX***, since pumping requirements are lower, and biofloc is providing feed to shrimp. Such systems also benefit from the possibilities that in indoor systems, biofloc can be managed more effectively

	Indoor RAS Systems	
	Clear water	Hybrid biofloc
CAPEX	$$$	$
Biofilter	✅	
Mechanical filtration	●●●	●
OPEX	$$$	$$
Pumping requirements	●●●	●
Feed	●●●	●

Europe has the most operating projects mainly as a result of Germany's share, but globally the ***USA*** has the highest number of operating / planned shrimp RAS projects on a country level.

Operating:
25
(14 pilot)

Future Projects:
17



Future Prospects

- ***Most of the current projects still with low c***ompetitiveness with imported shrimp from traditional production.
- In the mid term, capacity of indoor production systems projects should achieve 1-2k tons.
- With the perspective that in the ***long-term, technology will mature and multiple projects with increased capacity up to 5k tons may be successful.***
- The development of such systems will require adjustments in the supply chain of PLs, feed and processing capabilities in regions where today such capacities are limited

Digitalization
& Automatization

Accelerating Digitalization & Automatization towards "Precision farming"

Digital and automatization innovations can improve safety, efficiency, the control of production processes and monitor environmental boundaries in an expanding industry

Digital advancements, including Internet of Things (IoT), remotely operated vehicles (ROVs), machine learning, and artificial intelligence (AI), allow farmers to "look" below the water surface. The aim of the so-called ***"precision farming" is to employ control-engineering principles in fish production, enhancing the farmer's capacity to oversee, manage, and record biological processes*** in fish farms. Precision farming will contribute to the transition of commercial aquaculture from a traditional, experience-driven approach to a knowledge-based production system, necessitating greater adoption of emerging technologies and automated systems.

Health & Welfare Monitoring

- Welfare indicators
- Sea lice counting
- Prediction of algal blooms

Water Management

- Water quality sensors
- Real -time monitoring
- Risk management

Feeding Management

- Pellet detection
- Integration of biomass estimation
- Hydroacoustics
- AI-enabled / autonomous feeding

Unmanned Patrol System

- Water sampling
- Animal inspection
- Net inspection
- Net cleaning

Farm & Data Management

- Data analytics
- Modelling & Forecasting
- Machine learning
- Supply chain optimization
- Satellite systems
- IoT-based sensors

Untapped Potential for Digital Innovations & Data Integration

Although some application areas show indication of market saturation, e.g. camera technologies connected to health & welfare monitoring, there is ***still a significant development and extension potential for digital innovations*** in salmon aquaculture sector.

A huge growth opportunity lies within ***the development of farm infrastructure for the development of internal data repositories.***

Innovation Trends Observed

- Integration of high-resolution cameras in fish farm operations to detect and report on fish health and welfare KPIs, such as behaviour, wounds, presence of parasites (lice).
- Using cameras for biomass estimation and integration with feeding protocols.
- Automation of feeding, through detection of feed pellets
- Digital platforms that integrate data around production, fish health etc. for improving farm management and supply chain optimization. In combination with prediction software these data (farm and public data) can be used for forecasting
- Use of unmanned surface & underwater vehicles for autonomous operations, improving safety and efficiency of routine work

Health & Welfare

- Welfare indicators
- Sea lice counting
- Prediction of algal blooms
- Ultrasound technology to reduce lice infestation

Feeding management

- Pellet detection
- Integration of biomass estimation
- Autonomous feeding

ROV's

- Water sampling
- Animal inspection
- Net inspection
- Net cleaning

Farm & Data management

- Data analytics
- Machine learning
- IoT-based sensors
- Supply chain optimization

Main limitations for technology adoption: State-of-the-art capabilities of such tools /technologies vs. the farmers' ability or willingness to effectively operate it.

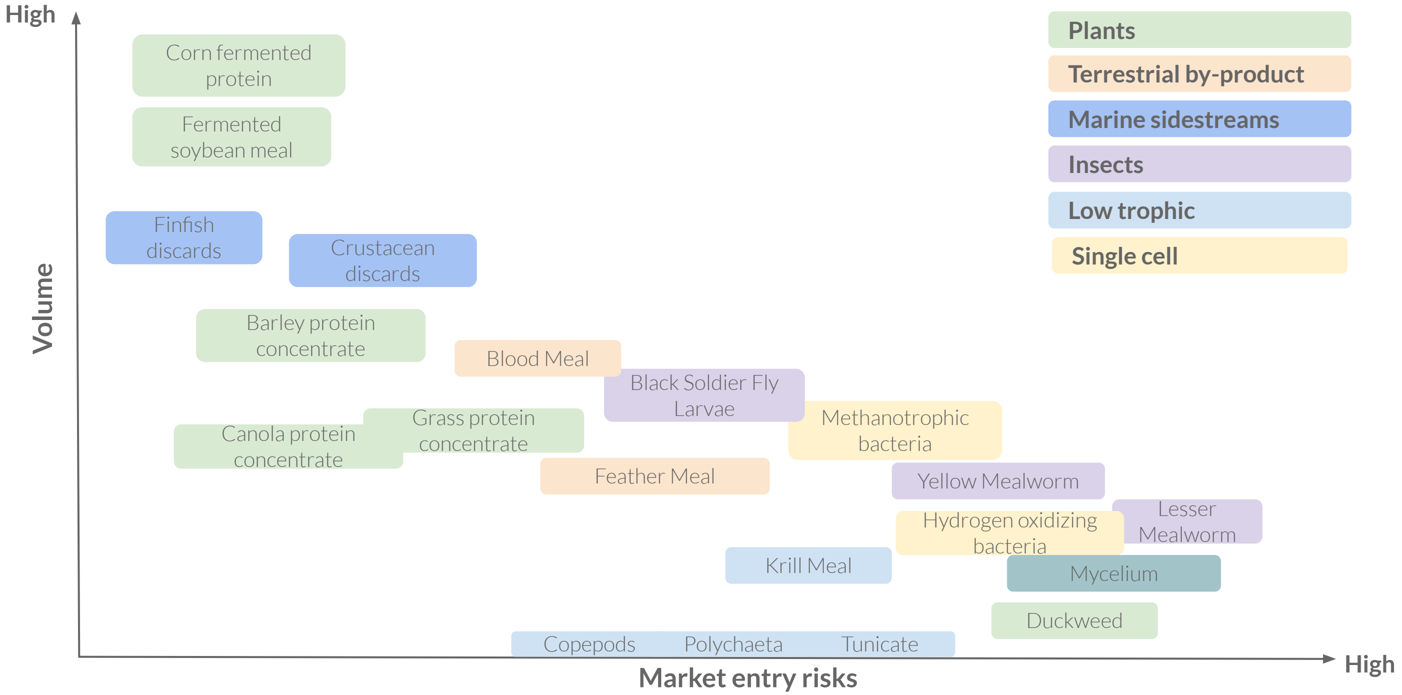
Novel Feeds

Towards Improved Feeds in Aquaculture - Alternative Ingredients

Predictions of emerging protein-rich ingredient to complement Fish meal, Soybean meal and Single Cell Protein. *Agricultural by-products still the most viable option. Other more CAPEX intensive protein production technologies expected to enter the market at significant volumes in the long term.*

Trend Analysis

- By-products from existing agricultural and terrestrial production processes are expected to contribute significant volumes in the next 5 years.
- Other alternatives requiring new production setup are not expected to reach significant volumes (>100,000 MT) in the near term.

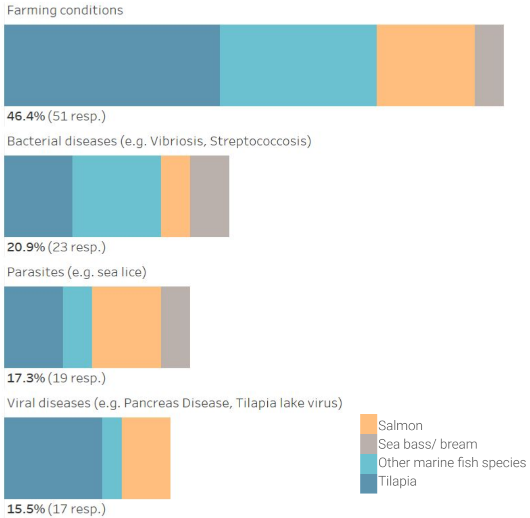


Health & Welfare

Towards Improved Fish Health & Welfare

Fish health management will need to evolve to face future challenges e.g. in the light of new farming solutions and climate change as well as to meet future animal welfare regulations.

The Challenges



the fish site

*Based on the Aquaculture Innovation Survey (respondents connected to finfish aquaculture)

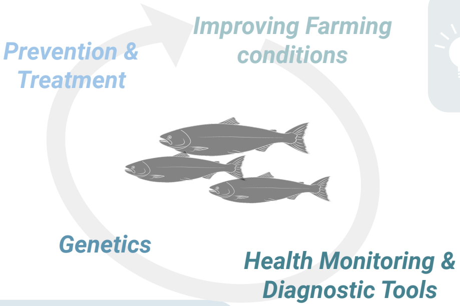
The Way Forward …

New Focus areas for current vaccination (technologies) ***industry*** due to unknown disease pressure for the new farming systems and/or environments

Pre-warning systems to *enable immediate mitigation actions* *through real-time monitoring & analysis of farming conditions* data

Alternative treatment methods

e.g. phage therapy to reduce antibiotic use or autonomous, underwater methods to treat fish and reduce handling



Water quality improving technologies such as nano bubbling for current and new farming environments

Non-lethal, less-handling health monitoring *methods*

Increase disease resistance through feed additives /supplement

Incorporating ***modern genetic selection and editing tools*** with focus on ***robustness & disease resistance***.

New biomarkers for (non-lethal) health monitoring methods

Biosensors - faster identification of pathogens at low-pathogen levels

Towards Improved Shrimp Health & Welfare

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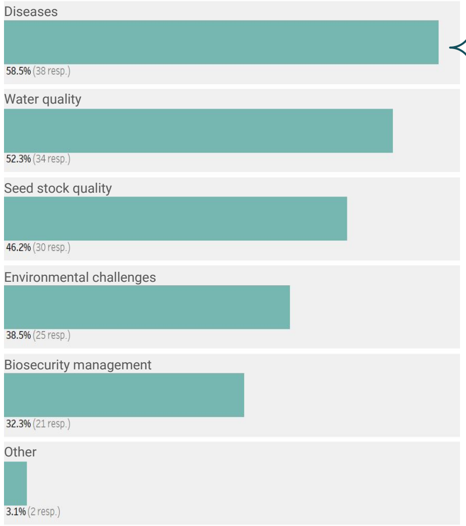
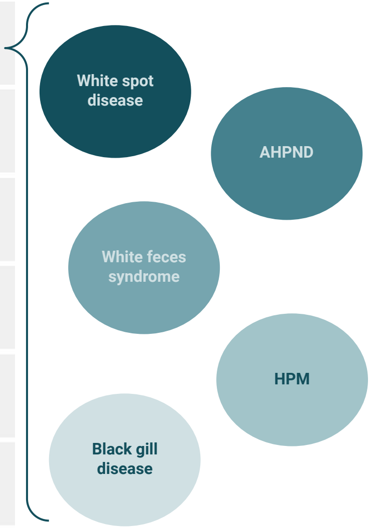
The Challenges

Current largest operational challenge in shrimp farming? *



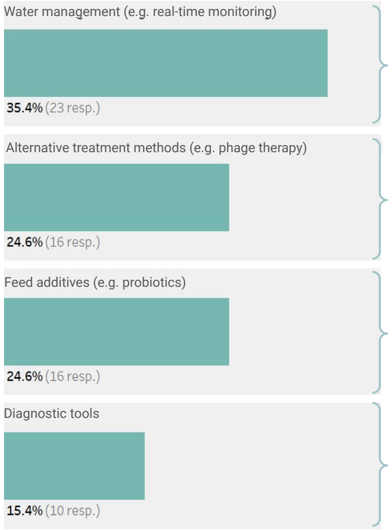
The Troublemakers

Top 5 Diseases causing major challenges *



The Way Forward …

Expected development potential for disease management measures *



More accessible and cost-effective tools designed for capturing, processing, and interpreting water quality data, alongside offering treatment solutions: Smart sensors, nanobubbles, etc.

Phages therapy as an alternative for the use of antibiotics e.g. to tackle *Vibrio* infections

Further development and education of farmers about feed additives which are crucial in shrimp health due to their gut microbiota modulating and anti-microbial properties.

More widely use of robust diagnostic tools (RT-PCR)

Focus on early pathogen detection

Co-detection of multiple pathogens

*Based on Aquaculture Innovation Survey

Gene editing has the potential of becoming a disruptive technology

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GENE EDITING

Targeted gene editing techniques such as CRISPR

CRISPR projects are currently ***targeting production of sterile salmon*** to eliminate genetic interactions with wild stock, as well as to prevent the undesired occurrence of early maturation in production fish.

Other focus areas are disease resistance, production yield and quality (nutritional improvement.

First commercial production of gene-edited red sea bream in Japan (RegionalFish)

Although the CRISPR technology has a tremendous potential, there are ***several technical challenges as well as regulatory and public concerns*** that pertain to its implementation within the aquaculture breeding sector

Depending on the development of the regulatory framework gene editing tools have the ***potential of becoming a disruptive technology*** in the future. There is a likelihood that Europe de-regulate CRISPR technology, recently the EU has announced to take a "different approach" to GE compared to GMO, but adoption will be slow.

GMO

Genetic modification has the potential to ***improve genetically determined traits***, such as growth rate, temperature adaptability and disease resistance.

AquaBounty Technologies Inc's AquAdvantage Salmon, a genetically modified salmon with enhanced growth characteristics, received Food and Drugs Administrations approval in 2015

Regulatory limitations and acceptance. Genetic modification has ***faced resistance*** within the fish farming industry, largely influenced by pressure from NGOs and consumers, especially in Europe.

Increased adoption will ***require higher levels of consumer acceptance*** especially in light of alternative technologies such as Gene Editing.

BREEDING

Solely by improving the growth potential ***through genetic selection future production can be significantly increased***. For salmon production time in seawater is expected to be reduced by 40 - 53%.

New potential focus areas:

Enhancing the digestibility of novel alternative feed ingredients

Resilient fish capable of adapting to new farming areas and a changing climate

Technical limitations remain, however reduced price of genotyping is opening up new opportunities

Implemented practice with a ***large potential for further future development***. Greater development of specialised breeding lines for different farming technologies.

Questions?