



### Presidents Letter

Dear AES members,

It is the time of the year when we begin remembering the last 11 months and thinking on what we want (and need) to improve for the next year to be better. Similar to last year, 2021 has been limited and driven by the COVID pandemic, and unfortunately we are far from saying that it is over. It may be with us forever. Nevertheless, as long as the venues are available, the AES is planning to re-engage the conference and public activity. So check out our agenda to follow up!



Aquaculture 2022 in San Diego will be our first stop where we are planning a special session entitled “Towards Sustainable RAS”. Moreover, in that same conference, the Society will be holding a Board Of Directors and members meeting; all of you attending to San Diego’s conference are more than welcome to join us. It will be a great opportunity to see each other face to face again and share thoughts and gossips from around the industry! The next step will be South Carolina, for the RAStech conference. Still to be confirmed, but another special session is planned entitled “RAS Current Applications and Future Challenges”. As we are seeing within the industry, there are still too many challenges that need to be addressed in RAS. We who are working in the industry should share and discuss these challenges. If we don’t dig in and understand the mistakes and build a path forward then all we have are crusades and fears that limits the industry.

Apart from the conferences, Arve Nilsen DVM, PhD, a veterinarian and researcher at the Norwegian Veterinary Institute with 30 years of experience in fish pathology and aquaculture, has been the latest speaker in our webinar series. For the last 10 years, Arve has studied fish welfare and rearing environment during production of Atlantic salmon in closed containment systems. The webinar Dr. Nilsen will present is titled “Going all the way – from post-smolt to harvest size in floating enclosure systems”. In order to put a context he will present a bit of background around the salmon farming industry (e.g. environmental constraints and fish welfare issues, growth trajectories, and incitements for technological innovation). Nevertheless, the main topic will be closed containment systems; possibilities and challenges (i.e. sea lice, water exchange and water quality, fish health and fish welfare, and post-smolt and harvest size).

2021 has been a year of changes for the Society. We have a nearly complete Board Of Directors and have appointed out new first and second vice presidents, Joseph Tetreault and Marc Sorensen, respectively. We now are 15 people throughout the entire globe, covering between all of us, most of the topics on the industry. Thus, do not hesitate to contact our executive director John Colt for any questions or comments; he will be the one forwarding those to the required officers. With regards to the members, 165 new folks have joined the society, from which 41 are members and 124 students. In terms of countries, the largest totals are Nigeria, India, and the U.S.

Happy Holidays and a happy 2022 to all of you, members and BOD! Hope you enjoy your time together with family and friends and do not forget the virus is still there so be careful and be safe. Enjoy the newsletter and hopefully see you soon somewhere next year! Best regards, Maddi

## Scientific Spotlight

### Effects of fluctuating water quality parameters, their science and management in RAS

Water quality. At first glance perhaps an inconspicuous term, but upon scrutinization, a whole world of variables that often are interconnected. Water quality parameters are traditionally broadly categorized as physical, chemical, and biological. Historically, oxygen content and temperature have probably received the greatest amount of attention. We recognize that individual fish species have a thermal optimum at which they perform at their best in terms of feed intake and utilization. We also know that maintaining oxygen near saturation levels is most ideal, and we can achieve this by means of sensors and feed-back control.

During the past several decades, numerous water quality parameters have been subject to scientific investigation, to determine their significance to the health and growth of fish, or the performance of the production system. These have included classical parameters such as turbidity, odor, conductivity, BOD, pH, etc. As sensors, electrodes, and other determination technologies have become more advanced, other variables, for example carbon dioxide, hydrogen sulfide, microbial water quality and others have become possible to study and monitor experimentally and in production systems. As the degree of recirculation becomes increasingly intensified, accumulation of steroids, stress hormones, and trace metals are being added to the list of water quality parameters of interest.



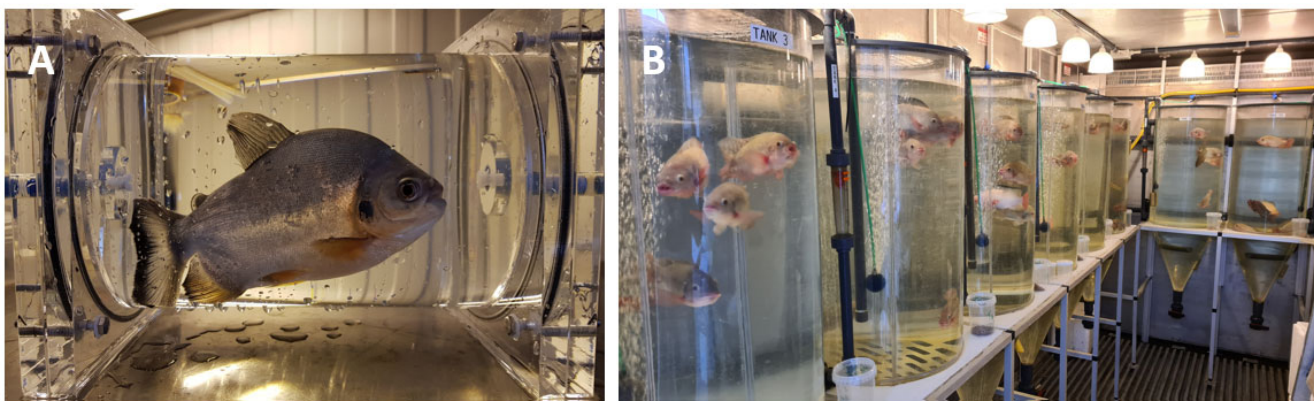
**Figure 1: Water quality parameters are not only of importance in RAS but also during live transport of fish. Here, rainbow trout are transported from land-based production systems to the sea for on-growing. Capture from production units (A) and transfer by fish pump to a transportation truck (B) places physiological demands on the fish, and fish are typically transported at high densities. During transport, fish excrete ammonia nitrogen and carbon dioxide to the water, which may affect their recovery following transfer to sea cages (C).**

Not all water quality parameters are of equal importance. Some are acutely toxic and therefore we cannot talk about tolerance thresholds. Others, such as ammonia and carbon dioxide, are tolerable to fish until critical levels are reached. Tolerable does not mean that they are without effect, but rather implies that fish are able to physiologically compensate or adapt, to avoid adverse effects. As examples, fish can adapt to unfavorable water temperatures by remodeling the fatty acid composition of cell membranes to alter their permeability and regulate activity of ion transporters on the cell surface. This offsets temperature induced changes in membrane fluidity.

Likewise, if fish experience elevated concentrations of dissolved carbon dioxide this leads to an acidification of their internal environment, which is counteracted by an accumulation of bicarbonate to buffer pH changes. Ultimately, the water quality parameters that are tolerable are the ones we attempt to manage in daily operations.

Managing water quality parameters clearly places some demands on RAS design. It also forces us to consider what the effects of a given water quality parameter are on fish, and what the capacity of a treatment unit should be. As an example, we have been investigating the physiological effects of dissolved gases on a variety of aquaculture species over the past years. Oxygen, carbonic dioxide, interactions between oxygen and carbon dioxide, total gas pressure, and hydrogen sulfide. Our approaches have probably not differed much from those of other research groups, in many instances using an approach where groups of fish are acclimated to a change in conditions. For example, chronic exposure to 5, 10 or 20 mg/L of dissolved carbon dioxide over several weeks. The effects of this are then assessed by determining any changes in growth, metabolism, appetite, stress levels, etc. Ultimately, this may lead to a conclusion that 10 mg/L of carbon dioxide can be considered the upper safe level for a given species of fish.

This is a valid assessment under the given experimental conditions, but is that directly transferable to the industry? Asking in a different way, is that what fish experience in a production system? Based on periods of constant monitoring at different facilities, we know that levels of dissolved CO<sub>2</sub> may fluctuate considerably over a 24-hour period. At some facilities these fluctuations may be minor, 3-4 mg/L, while in other places they may be more than 10 mg/L. The magnitude of these fluctuations is determined by hydraulic retention time, biomass, and activity in the rearing units, buffering capacity of the water, and degassing capacity of the system.



**Figure 2: Experimental approaches to determining the effects of water quality parameters on the physiology and performance include examining effects on the individual level. A metabolic chamber (A) can be used to determine changes in baseline or resting metabolism of fish, as well as their maximum oxygen uptake. The difference between the 2 are referred to as the aerobic scope and represents the ability of the fish to do work, feed, or grow. At the group level (B), the effects of water quality is typically assessed by changes in digestibility of nutrients and excretion of dissolved ammonia, which is typically performed in Guelph-type digestibility tanks. Finally, effects of various water quality parameters can also be assessed by conventional growth trials.**



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Theoretically, we can assume that in a system stocked with Atlantic salmon, the carbon dioxide excretion will range from 140 to 350 g CO<sub>2</sub>/ton fish/h, with lower excretion rates at night, and the highest during peak feeding activity. Unless a degassing installation is designed to be able to completely remove all CO<sub>2</sub> during peak activity, dissolved CO<sub>2</sub> levels are likely to fluctuate during the course of a 24-hour period. The same could apply to numerous other water quality parameters.

So, the answer to the question of whether experimental results are directly transferable to the industry is - sometimes, but probably often not. There is limited scientific data on how fluctuations in various water quality parameters might impact fish performance and welfare in aquaculture, but we know for example that fluctuating CO<sub>2</sub> levels limits metabolic performance in European eel. We also know that a nocturnal hypoxic insult leads to reduced feed intake in salmonids, even several hours after oxygen levels have been restored. If fluctuations are sufficiently large this is likely due to a direct stress response, or in the case of smaller fluctuations, due to the cost of adaptation imposed on the fish.

This raises some questions about the science and management of water quality. With respect to management of water quality, perhaps it is better to aim for achieving steady state conditions through design and control, rather than allowing fluctuations, even if they are perceived as minor, and below what might be considered a tolerable threshold. From a scientific perspective, more attention should be devoted to understanding the physiological, welfare, and production related ramifications of water quality fluctuations. This could be an opportunity for increased collaboration between academia and industry in the pursuit of a joint desire for the continued improvement of aquaculture.

To pursue the idea that fluctuating water quality parameters may have a bigger impact on fish production than sub-optimal stable conditions, we are currently investigating the effects of dissolved CO<sub>2</sub> levels in rainbow trout. Here we are testing the effects of chronic elevation at different levels, compared against groups where levels fluctuate on a daily basis. This is achieved by allowing CO<sub>2</sub> levels to gradually decrease during the night. The work is part of a project in collaboration with commercial farmers, fish veterinarians, and equipment suppliers.

Link to KAFREA: <https://orbit.dtu.dk/en/projects/carbon-dioxide-accumulation-in-fully-recirculated-aquaculture-fac>

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## Industrial Spotlight

### Customized automated feeders

In an intensive fish or shrimp farming, with recurrent feeding requirements, it makes sense to **invest in customized automated feeders**. Why? A customized feeder **meets better the needs of a particular farm**, dramatically reducing reliance on manual feeding and **optimizing parameters** such as **FCR and SGR**. In addition, an automated feeder is generally **managed by a software** that controls feeding plans and permits data collection – essential part for providing information within a traceability chain.

We have asked FishFarmFeeder (FFF) who is the leader in manufacturing customized feeders to give us further details. A company based in Spain but providing its products worldwide.

### Components of a feeding system

The **Centralised systems** for aquaculture consist of a central station where the silos and all the (**automatic**) dosing, distribution and control elements are located. The distribution of the feed to the different tanks is done by means of a fluid (typically air in the **pneumatic** systems) that flows through pipes.

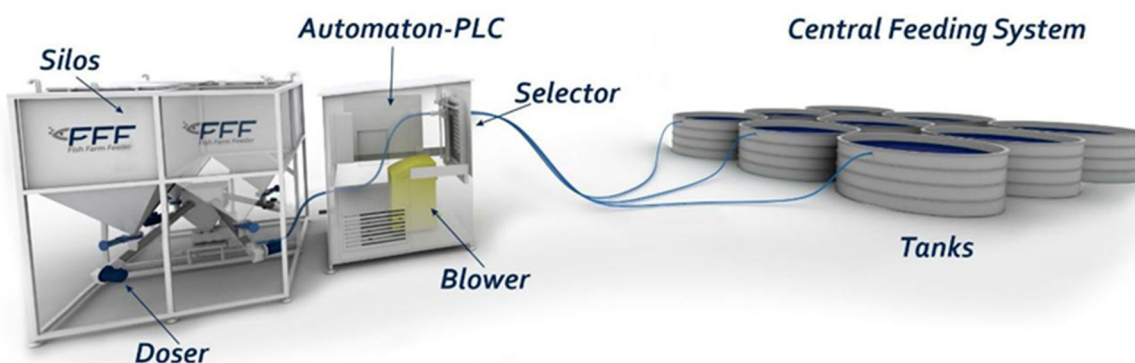


Figure 1: Feeder components

### Silos

Silos, as component of feed storage, vary in number and capacity according to the needs of aquaculture. They can be manufactured in various types of material (stainless steel, galvanized, fiberglass, polyethylene, etc) and must be certified for food purposes. They can be standard or custom-made silos. In case of FFF the size of the silos is designed for 2 or 3 days consumption to avoid the degradation of the feed.

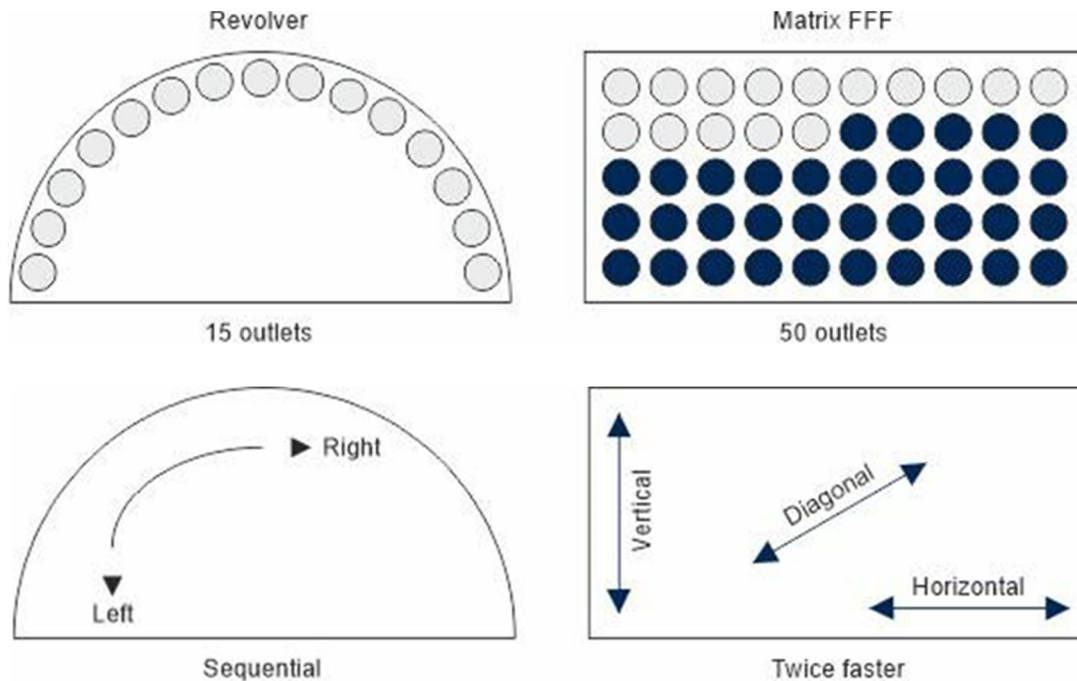
### Doser

Dosing systems are used for feed dosage. The dose can be calculated either based on gravity or volume. It means that in gravimetric systems the doses are weighing by one or more electronic load cells. The only unit of measurement is weight. In volumetric systems the dosage is made according to the volume.

### Selectors

The selector is the device that aims to distribute the feed to the different fish farm tanks. There are mostly two types of selectors: The "REVOLVER" which is a system where the outlets are placed in a circle. The "MATRIX" invented by FFF, where the outputs are placed in a matrixial way and the selection of the port is done by two servo motors, one on the X axis and the other on the Y axis. This second form

permits to submit the **feed to more tanks**, allows a speed of displacement between outputs up to 3 times faster than in revolver system.



**Figure 2: Selector and Matrix**

## Blower for Pneumatic Transport

As FFF used the pneumatic systems, blowers and compressors are the devices that generate the fluid (air) used to transfer the feed from the dosing components to the tanks

Disperser - Spreader

The spreader is used to disperse the food in the tank. This is located at the end of the pipe that brings the food. Its main function, besides throwing the pellet, is to distribute it in a homogeneous way.

## **Software**

The brain of the feeding system is the software that permits the scheduling of the feeding plan and detecting any problems. In case of FFF it contains:

- ◆ Data integration: Real time connection with farm management software, artificial intelligence, big data, etc.
- ◆ Integration of equipment: Can be integrated with any equipment that provides information to the feeding system that can condition the feeding (temperature, oxygen, pH, turbidity, hydrophones, cameras, etc.).
- ◆ Total control of the production: with real time and historical information of feeding data.
- ◆ Feed Traceability: Batch Feed Traceability Management.
- ◆ Fish traceability: Management of fish traceability by batch.

## How to get a customized feeding system?

As explained by Miguel Aróstegui, CEO of FFF, before manufacturing a customized automated feeder the company asked details about the feeding requirements: “Based on them we then design the feeder. We find important to learn feeding data already by first contact with the client as our aim is to make it as specific as possible for each fish or shrimp farm and so **guarantee an optimal feed supply for fish**. Only that way we know what components to include in the feeder, how to adapt them so the system would need a minimum maintenance cost.”

So what are the data that FFF needs to know?

### Number of tanks in feed line

The number of tanks influences **the number of outlets** of the feeder’s selector.

### Minimum and maximum feed consumption per tank and day

Knowing the amount of feed that is required to deliver to tank in a day helps to **size the components of a feeder**.

### Number of hours the fish eats daily

Depending on the type of species and the phase of the fish life cycle, the hours in which a fish eats vary throughout a day. Therefore, this parameter, in combination with other data, helps to **define the number of feeders** that will be necessary to meet the feeding requirements.

### Number of times the fish should eat per day

Data that indicates the **maximum number of doses** to distribute the feed in a day. In the case of FFF feeders, the **doses can be of different sizes**, as they can be customized in the FFF’s software.

### Minimum and maximum pellet size

As a fish grows the size of the pellets increases. Thus, knowing **the variety of pellets** planned for a farm, it helps to **define how many automated feeding systems are necessary** for fulfilling the fish farm needs.

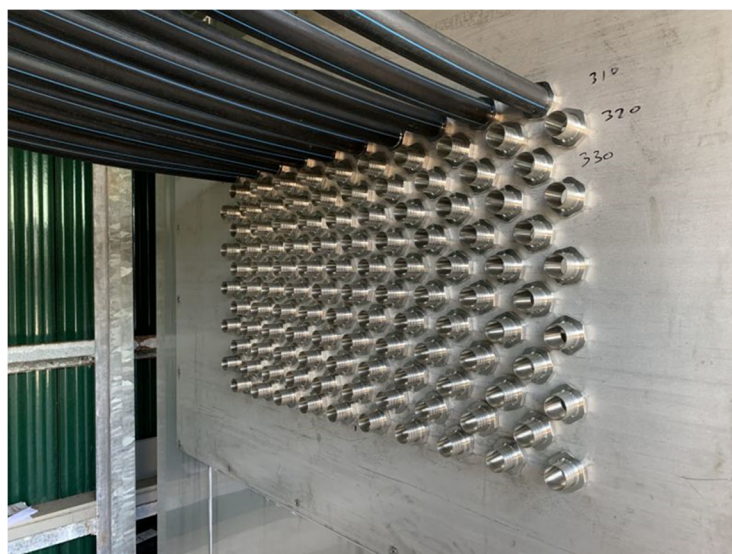


Figure 3: The Matrix feeder



## Number of silos

The **number and size of silos** depend on the number of **pellet size types** to be used, on the farm's **surface limitations** and **for how many days the feed should be deposit**.

## Maximum daily feed consumption

By knowing the maximum amount of daily feed requirements, **the volume of silos** is **proposed**.

## Fish Species

Indicating the type of fish or shrimp species allows to **estimate basic feeding data**.

## Estimated annual production

This information helps to know the maximum volume of fish production and to **reflect the feed demand when designing the automated systems**, taking into account that it is calculated on an **estimated aquaculture production**.

## Distance from feeder to the furthest tank

Knowing this data, it allows to calculate the time that the feed will need to travel from the feeder location to the last tank and so know **the dose limit** that can be supplied per day.

## Fresh or saltwater installation

The type of species of fresh or saltwater provides data to **define the material** from which the automated feeding system is manufactured.



## Upcoming Events 2022

AES is organizing a special session "Towards Sustainable RAS" in Aquaculture 2022 organized in San Diego California 28 Feb - 4 Mar next year.

We welcome you to submit abstracts on circular economy, system efficiency, waste and feeding control, efficiency through genetics and other topics related to on how to build RAS concept more sustainable in future.

Submit the abstract here: <https://lnkd.in/e2EBMEkg>

Please indicate that your submission is for the AES special session

### **Aquaculture 2022**

San Diego, USA (February 28 - March 4)

<https://www.was.org/meeting/code/AQ2022>

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### **RAStech 2022**

South Carolina, USA (March 30-31)

<https://www.ras-tec.com/>



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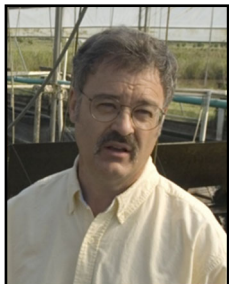
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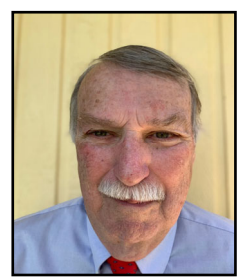
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