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An IntraFish Industry Report

Land-based salmon farming

Aquaculture's
new reality



IntraFish

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1. Introduction





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The most important elements are:

Biofilter: All RAS rely on biofiltration to convert ammonia and CO₂ excreted by the fish into nitrate as a high concentration of ammonia would be toxic for the fish. Nitrifying bacteria are chemoautotrophs that convert ammonia into nitrates, which are less toxic than ammonia and can be removed by a denitrifying biofilter or by water exchange.

Oxygenation: Re-oxygenating the system water is a crucial step to obtaining high production densities. Fish require oxygen to metabolize food and to grow. Dissolved oxygen levels can be increased through two methods: aeration and oxygenation.

Sludge removal: Solid waste excreted by the fish must be treated in RAS facilities. This is done by concentrating and flushing the solids out of the filters. This reduces bacteria growth, oxygen demand and the spread of potential disease. RAS solids removal involves a sand filter or particle filter where solids become lodged and can be periodically backflushed out of the filter. Another common method is the use of a mechanical drum filter where water is run over a rotating drum screen that is periodically cleaned by pressurized spray nozzles, and the resulting slurry is treated or sent down the drain.

Biosecurity: Disease outbreaks occur more readily when dealing with the high fish stocking densities typically employed in intensive RAS. Outbreaks can be reduced by operating multiple independent systems within the same building and isolating water to water contact between systems by cleaning equipment and personnel that move between them. Ultra violet (UV) or

Early maturation – are all-female eggs the answer?

One of the biggest challenges is still the early maturation of Atlantic salmon when grown in land-based systems. Solving these challenges is currently one of the top priorities of technology suppliers and industry-wide R&D. According to Benchmark Group-owned Icelandic salmon egg supplier Stofnfishkur, the environment -- such as light quality, feeding regime, salinity and water temperature -- is believed to be the factor with the highest effect on maturation. While optimizing environmental factors in land-based systems is one of the advantages for improved growth, this also leads to more fish maturing at an early stage if light and temperature regime is not managed correctly. Male fish tend to go into early maturation more often than females.

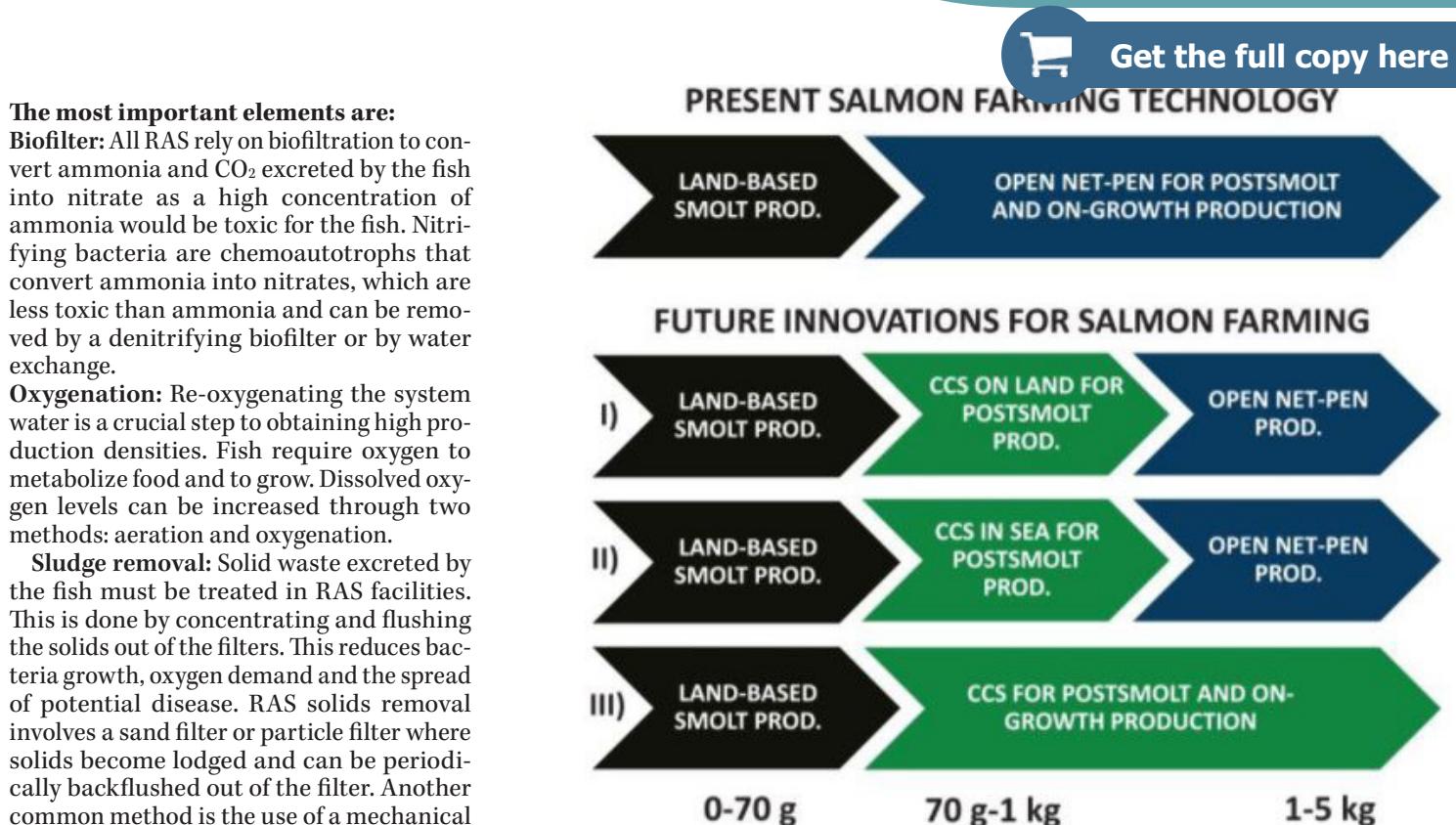
Jonas Jonasson, CEO of Stofnfishkur, described early maturation as “one of the difficulties” for growing Atlantic salmon in land-based systems. As a result, the company started delivering all-female eggs in January 2016. These fish don’t mature as easily as males,

ozone water treatment systems can also be used to reduce the number of free-floating virus and bacteria in the system water. These treatment systems reduce the disease loading that occurs on stressed fish and thus reduce the chance of an outbreak.

pH and temperature control: Both pH and temperature must be carefully monitored and controlled in RAS, which is crucial

to the survival and health of the fish. Atlantic salmon prefers water temperatures of around 14 degrees Celsius.

The most operational metrics, which are “important for return” for successful land-based salmon production, as DNB puts it in its report, are growth, feed conversion, density, early maturation (see panel), off-flavoring or taste of product and mortalities.



*Source: CtrlAqua 2017 Annual Report

eliminating production and quality loss. “The industry has been very positive to this,” Jonasson told IntraFish.

Frédéric Gaumet, business development manager for aquaculture at Krüger Kaldnes/Veolia Water Technologies, which supplies RAS technology, however, said female Atlantic salmon still run the risk of early maturation. “It’s not enough,” he said, adding the “next step are all-female triploids,” which is effectively sterile fish. Gaumet called it the “ultimate solution to avoid early maturation” even though these fish may be more sensitive to the challenging RAS environment.

Jonasson said Stofnfishkur is also able to deliver all-female triploids but that “up to now people aren’t very confident.” This is more of a marketing issue, as customers regularly “confuse it with GMOs. But it has nothing to do with that,” he said. The product is still in development, however. “I wouldn’t recommend it unless you have very difficult conditions” at the RAS farm, Jonasson said.

The feed factor

Land-based aquaculture operations need special feed -- and this feed could be inevitably more expensive due to specific requirements in RAS facilities to make sure the water stays clean. In addition, there are also certain restrictions on some of the raw materials used in feed for RAS fish farms.

The Canadian Department of Fisheries and Oceans (DFO) published a comprehensive study in 2010 on the feasibility of closed-containment farming.

The study found that depending on the location of the land-based facility, "the feed transportation could be lower than for ocean-based farms."

Feed storage, too, was shown to be half the amount for RAS facilities than for net

pens -- \$25,000 (€21,488) vs. \$50,000 (€42,976). The feeding system was also shown to be less than half the cost for RAS facilities -- \$147,000 (€126,348) vs. \$333,000 (€286,217). The feed itself, however, can be costlier.

Dutch fish feed giant BioMar was the first to develop specialized feed for RAS farms. Its Orbit feed for salmon was launched in April 2016 "with the rapid expansion" of RAS facilities, mainly for salmon smolt but "in some cases for on-growing of salmon."

According to the company, the diets focus on delivering high growth and an optimal water quality with a limited load on the biofilter.

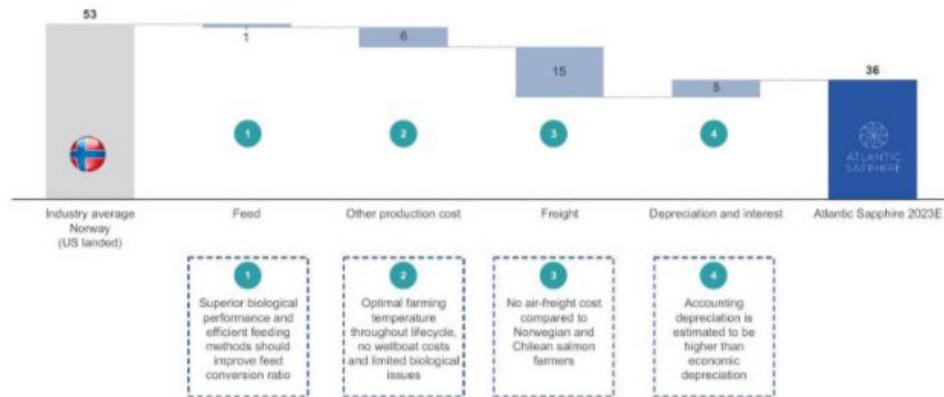
This is achieved mainly through a

combination of changes in the digestible energy to protein ratio, a balanced and precise amino-acid profile, and carefully selected raw materials.

Reacting to increasing demand from land-based producers, the company then announced a DKK 90 million (€69.4 million/\$14.1 million) investment to expand its Danish facility in Brønde, Jutland, in May 2018. Part of the expansion is a new specialized line focused on the production of RAS feed.

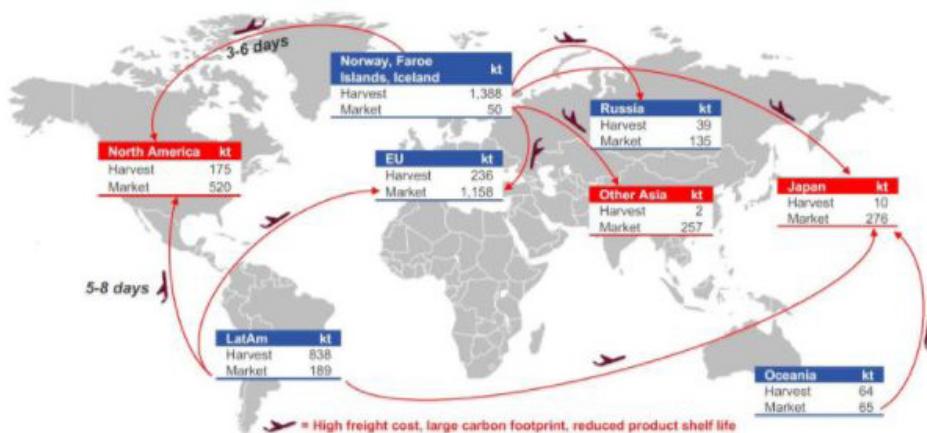
The company says its RAS feed combines optimal feed performance with optimal biofilter performance. The raw materials used combine a balance of highly digestible amino acids, which reduce the amount of waste and ammonia output.

US landed production cost: Norwegian industry average vs. Atlantic Sapphire



Source: Atlantic Sapphire

The salmon map -- why producing close to markets reduces costs



Source: Atlantic Sapphire


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Jurasic Salmon's land-based Atlantic salmon facility in Poland. Credit: Jurasic Salmon



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Founded in 1973, Denmark's Gråkjær is one of the country's leading general and turnkey contractors for agricultural and industrial building. The company offers different types of services, including complete project management with the initial advice followed by planning, calculation, approval, construction management and final servicing of the completed construction project.

In terms of RAS technology for land-based fish farming, the company in 2015 decided to expand its fish farm construction activities as Gråkjær Aqua. Back in September 2017, Gråkjær Aqua Director Morten Malle, announced it possessed "the expertise and competencies it takes to deliver the water treatment system for the land-based fish farm."

Today Gråkjær constructs land-based fish farms in various locations in Europe in association with external contractors who, until now, have provided the water treatment systems. It is expected that this cooperation will continue in more construction projects.

In May 2018, Gråkjær announced the signing of a contract with Cape Nordic Corporation (CNC) in South Africa, for the conceptual design package of a large-scale fish production facility near Cape Town. The package contains the provision of design, processing equipment, supervision, project management, fish farm support, training and start-up. Malle called the contract a "benchmark, since its main focus is on the provision of the water treatment system for a large fish farm for CNC."

The plant, which initially targets trout but will also produce Atlantic salmon further down the line, will contain a hatchery, first feeding, fry, a pre-smolt unit, a smolt and grow-out units and a purge system. The plant will have the capacity to grow sea trout from egg to a final slaughter weight of about 5.2 kilos. In the first delivery, the fish-production plant will produce 1,800 metric tons of sea trout, but the construction will facilitate the production of salmon in the future, the company said.

At the end of May 2018, Gråkjær made a partnering agreement with Norway's Salmo Terra for the construction of a large-scale land-based Atlantic salmon production facility near Bergen. Besides the construction element, Gråkjær will supply the RAS technology. The project comprises a facility about 6,200 square meters with two identical grow-out modules, each of which can produce up to 1,200 metric tons of salmon per year. Each grow-out module consists of a water treatment system with 12 fish tanks, each of which is 625 cubic meters in size. The first grow-out module is expected to be ready for fish in the second half of 2019, and the project as a whole is expected to be completed at the close of 2020.



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A number of the large-scale projects announced this and last year are based in the United States, which comes as no surprise, according to industry watchers. “The US market for Atlantic salmon is the world’s largest and has a strong growth profile and large potential,” Atlantic Sapphire wrote in a recent company presentation to investors. The location in Miami gives a “huge transport cost advantage and increases freshness. Compared to traditional Norwegian salmon

farmers, which have a production cost of NOK 57 (€6/\$6.90) per kilogram, delivered to the United States, Atlantic Sapphire estimates it will be able to supply salmon produced at a cost of NOK 36 (€3.80/\$4.40) per kilogram to the US market by 2022.

DNB wrote in its report that demand from North America, and particularly the United States is increasing, “with large untapped potential in terms of salmon consumed per capita.”

“We are really excited. We want to be able to tell our story and help people understand where their food comes from.”

*Brandon Gottsacker,
COO, Superior Fresh*

AquaBounty’s land-based salmon plans

AquaBounty’s controversial undertakings to grow genetically engineered (GE) Atlantic salmon have dominated seafood news for several years. The company says its AquAdvantage salmon, with its fast growth rate, shortens the production cycle from 32-36 months to 16-18 months, “transforming land-based salmon farming into an economically viable production model.”

The company nabbed US Food and Drug Administration (FDA) approval for the production, sale and consumption in the United States in November 2015 but the following January the FDA banned the import and export of GE fish until guidelines for labeling are published.

In May 2016, AquaBounty’s fish was approved for commercial sale in Canada, with no labeling required. The company reacted with the acquisition of a plant in Canada to help it scale up production capacity.

In 2017, AquaBounty then acquired the land-based assets of the Bell Fish Company farm site in Albany, Indiana, United States. AquaBounty expects to harvest the first salmon from that site in the third quarter of 2019. The site will have a farming capacity of 1,200 metric tons annually once it is fully operational.

“AquaBounty CEO Ron Stotish nevertheless told IntraFish at the beginning of 2018 that the salmon were “well received and demonstrated the potential for future sales as we scale up our production capacity in Canada and the United States”

In the summer of the same year, it sold its first batch of GE salmon to unnamed Canadian customers, drawing much criticism. All these attacks have been largely driven by environmentalists, consumers and fishing organizations, who are concerned about possible negative consequences of growing GE salmon, called “Frankenfish” by some.

AquaBounty CEO Ron Stotish nevertheless told IntraFish at the beginning of 2018 that the salmon were “well received and demonstrated the potential for future sales as we scale up our production capacity in Canada and the United States.”

In 2017, the company also broke ground on a newly acquired site in Canada to construct a modern broodstock facility and a 250-metric ton per year production facility. It has also renovated an existing hatchery facility to increase R&D capacity. All three facilities, which will be operational in 2018, are using RAS technology that recycles 99 percent of the water in the systems.

According to figures by the National Marine Fisheries Service (NMFS), the US salmon market was rocketing in 2017. Total US salmon imports surged 5.2 percent to 371,658 metric tons, with total value jumping 16 percent to \$3.73 billion (€3.2 billion). Imports of Atlantic salmon, which account for the bulk of US salmon imports, rose 6 percent to 300,661 metric tons, worth \$3.14 billion (€2.7 billion), a more than 17 percent jump in value over 2016.

“Made in America” could also become a very strong selling point for domestically produced salmon, said Frédéric Gaumet, business development manager of aquaculture at Krüger Kaldnes. “It’s a very strong incentive, not only for politics, but also a customer incentive,” he said. He called the US salmon market “huge” and “quick-moving.” Investor interest is currently very high. “We have about 25 leads of people right now who want to make salmon, and it’s mainly in the United States.”

The first US-grown, land-based Atlantic salmon hit retail shelves in early July 2018, originating from Hixton, Wisconsin-based Superior Fresh, which runs a 40,000 square foot RAS salmon farm with a 123,000 square foot aquaponics operation that produces leafy greens. The company is producing between 3,000 and 4,000 pounds weekly and retailers within a 400-mile radius, which includes Wisconsin, Minneapolis and parts of Chicago, are first to carry the product.

When IntraFish spoke to Superior Fresh Chief Operating Officer Brandon Gottsacker at the end of May 2018, he said, “We are really excited. We want to be able to tell our story and help people understand where their food comes from.” Gottsacker added the company is already working on phase 2 of the greenhouse and fish house. When complete, the expanded salmon farm will support triple the production it does currently. The company is planning to build similar-type operations beyond Wisconsin.