EQUITY RESEARCH
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11 February 2019

DNB MARKETS

SEAFOOD – SPECIAL REPORT

A deeper-dive into land-based farms

Following up on our report published in 2017, we continue to see solid rationale for land-based fish farming given rising costs in – and ongoing challenges to – traditional methods. We estimate ~500kt of new planned production capacity in the land-based sector, more than double the figure of just two years ago. While some of that is delayed projects, generally developments have grown in number and scale.

The number of new projects has more than doubled from the ~150kt planned production volume we identified in 2016, fuelled by ongoing challenges in traditional fish farming and expectations of high salmon prices.

Developments totalling ~500kt in annual production by 2026. Comparing current developments we identified with the numbers two years ago, we note volumes have been pushed out in time, and projects have increased in number and scale. We believe several of the new and revised projects are also likely to fail due to a lack of financing or other challenges; of more interest to us is the backlog growth trajectory. If the backlog has more than doubled in two years, where could it be in another two years? Another doubling in another two years would imply ~800kt of planned land-based capacity by 2021, equating to 35% of 2017 global production of 2,300kt.

Solid rationale for land-based. In our previous deep dive report into land-based salmon farming looking at 2016 (published in February 2017), we highlighted five factors supporting land-based salmon farming and other new production technologies: 1) better visibility on prices; 2) improving 'new' land-based technology; 3) rising in-sea production costs; 4) increasing 'upfront investment' for traditional growth; and 5) demand in remote markets picking up. We still consider all five points valid.

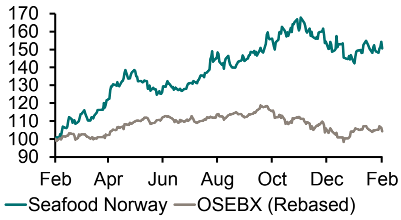
The importance of ESG. Land-based salmon may appeal to many customers and investors for reasons such as the absence of pathogens or use of antibiotics, a smaller carbon footprint (air freight versus locally produced), and reduced impact on wildlife (depending on discharge method, water source, etc).

Underestimating change in the long term. In our view, Bill Gates' quote from 'The Road Ahead' accurately describes our view of growth in land-based salmon farming: "We overestimate the change that will occur in the next two years and underestimate what will change in the next ten"

Company	Cur	Rec	Target Price	Share Price	P/E 18e	P/E 19e	P/E 20e
Atlantic Sapphire	NOK	BUY	118.00	93.00	nm	nm	59.9
Austevoll Seafood	NOK	HOLD	119.0	108.4	11.8	9.9	10.2
Bakkafrost	NOK	HOLD	450.0	447.8	17.4	15.3	14.4
Grieg Seafood	NOK	BUY	135.0	108.7	15.2	10.0	7.9
Lerøy Seafood	NOK	HOLD	75.00	67.98	14.6	11.8	11.7
Mowi	NOK	HOLD	180.0	188.1	17.3	13.3	12.5
Norway Royal Salmon	NOK	HOLD	200.0	209.0	12.6	12.6	11.1
SalMar	NOK	SELL	390.0	430.0	17.3	15.2	14.8
Salmones Camanchaca	NOK	BUY	85.00	84.00	11.6	9.5	7.6
The Scottish Salmon Compa	NOK	HOLD	17.00	15.40	6.9	8.8	7.6

Source: DNB Markets

Seafood Norway vs OSEBX (12m)



Source: Factset

Note: Unless otherwise stated, the share prices in this section are the last closing price

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Why land-based salmon farming is still interesting

'Investment summary' of land-based salmon farming in general

We find quality and consistency of feed combined with access to skilled labour the biggest short-term challenges to land-based farming. We expect all eyes to be on Atlantic Sapphire's US facility and how the ramp-up progresses: while investors are hoping for the best, a seamless transition without any hiccups is a tall order for any company, even one with Danish operations running smoothly in the background.

We took an in-depth look at land-based salmon farming in 2016 (see our report published in February 2017. We listed five reasons to look at land-based salmon farming and other new production technologies. We believe all these factors are still relevant, and that having a finger on the pulse of new production solutions is important.

Reasons for looking at land-based salmon farming, defined two years ago, are still valid

1 Improved visibility on pricing – stronger for longer means less probability of a collapse in prices before land-based volumes hit the market. We estimate a salmon price of NOK60/kg in 2019 and NOK59/kg in 2020.

2 Improved 'new' land-based technology – enables increased scale and quality issues are addressed. The large equipment providers and salmon farmers report sizeable investments in recirculating aquaculture systems (RAS).

3 In-sea production costs rising – NOK5/kg increase just in sea-lice-related costs. Average production costs have not come down, but look fairly 'stable and high'.

4 Increasing 'upfront investment' for traditional growth – licence prices increasing. In the latest auctions in Norway, but appetite for licences was high, with the traffic-light auction implying a figure of ~NOK120/kg.

5 Demand in remote markets picking up – land-based farming has an advantage in transport and freshness if production is close to the end-consumer. US consumption of salmon is continuing to rise, while prices in Miami were fairly stable throughout 2018.

Land-based salmon farming is perhaps the most interesting alternative production method, and we believe will contribute to volumes. Salmon farmers have already invested heavily in land-based production (smolt), and we see many full-scale salmon projects being developed, some of which are already harvesting salmon at 3–5kg.

We believe land-based will replace traditional salmon farming techniques, and bring additional volume

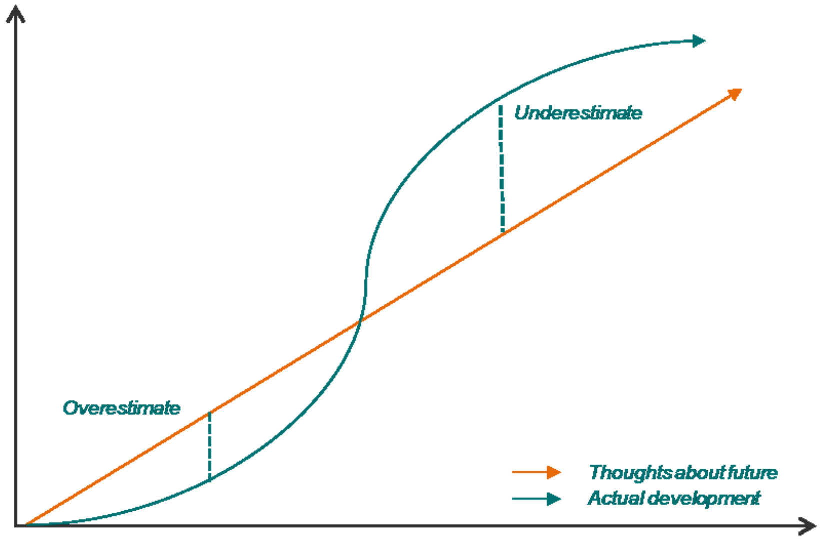
We do not believe land-based salmon farming will replace traditional production, but do believe land-based could add volumes. We are confident that development of RAS technology and competence will continue, also being important for the traditional farmers looking to reduce biological risk by increasing time on land before salmon is released into the sea.

Development of new technology is rarely linear

In our view, Bill Gates' quote from 'The Road Ahead' sums up our view on both land-based and traditional salmon farming very well: "We overestimate the change that will occur in the next two years and underestimate what will change in the next ten"[1].

[1] https://abcnews.go.com/Technology/PCWorld/story?id=5214635

Figure 1: Expectations vs. change



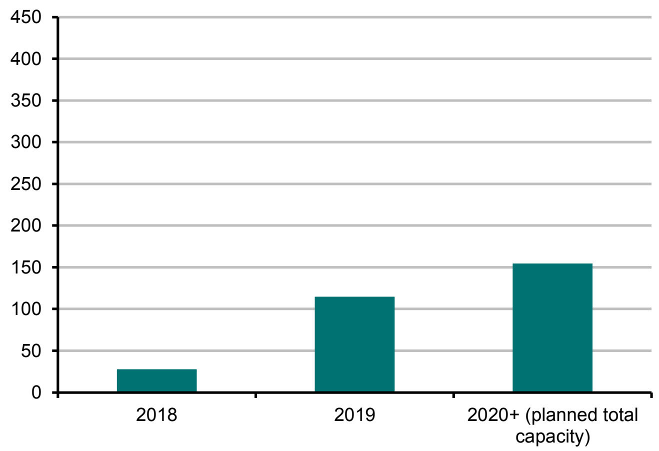
Source: www.rocrastination.com (underlying data), DNB Markets (further analysis)

Status of land-based salmon farming projects

Comparing current plans versus where we were two years ago, we see that: 1) volumes have been pushed out in time (this is as we had expected, since many of the projects were lacking permits, financing or biological experience); and 2) the number and size of projects has more than doubled (some projects that were in development or expanding two years ago are now selling fish).

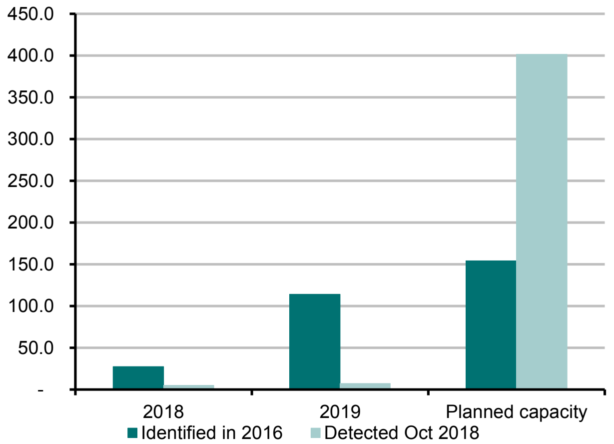
Volumes have been pushed out in time, and some projects will probably never materialise

Figure 2: Volume plans identified in 2016



Source: Company information (on volumes in total and distribution if available), DNB Markets(estimate on distribution if not available)

Figure 3: Volume plans identified in 2016 vs 2018

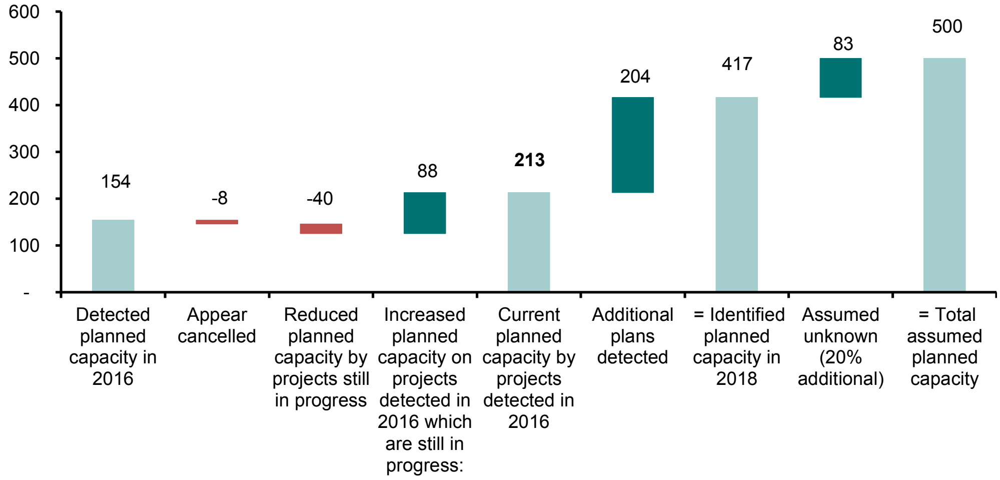


Source: Company information (on volumes in total and distribution if available), DNB Markets(estimate on distribution if not available)

In 2017 we identified 154kt of planned capacity, implying a total of ~114kt of production in 2019. As we said at the time, most of the projects were 'pending financing', which we considered the main bottleneck. Looking at the revised numbers, the land-based industry is nowhere near producing 114kt in 2019, and about half the projects have not made it off the drawing board. The total number of new projects and planned volumes has though increased dramatically, driven by continued challenges with traditional farming, development of RAS and high salmon prices. We have now identified 500kt+ of planned capacity additions by 2026. It would be a fair assumption to say our list is incomplete and that actual total planned capacity is probably higher than we have identified.

Land-based farming nowhere near the ~144kt additional production we identified two years ago

Figure 4: Identified plan of production in 2016 vs. identified in 2018 (HOG kt)



Source: Company information (on volumes in total and distribution if available), DNB Markets (estimate on distribution if not available). Please note that there are probably a large amount of projects that we are not aware of

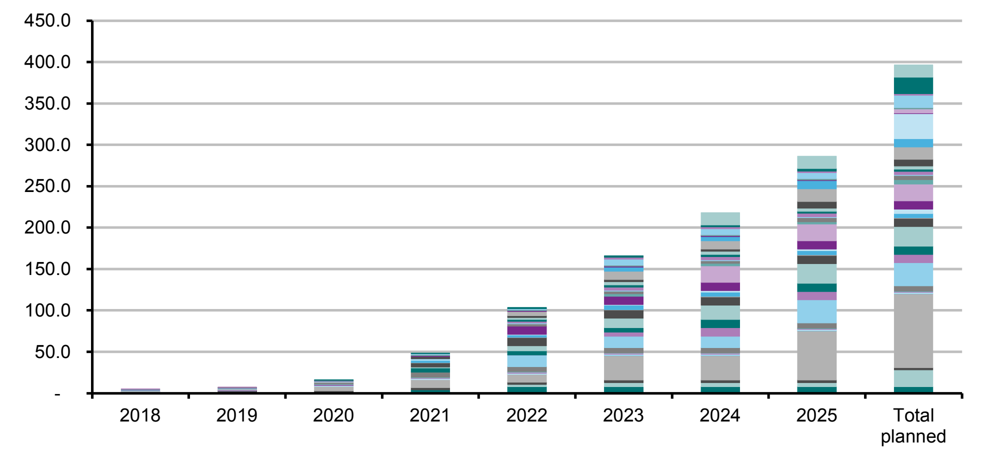
Also, we expect volumes to be pushed out in time, and do not expect all to reach their volume ambitions. Restricting factors vary between projects, and include permits (e.g. water intake and discharge), RAS or salmon farming experience, and capacity to invest in cost/capex and scale.

We believe that some projects are much more likely to succeed in reaching timeline and volumes planned

Several of these new and revised projects are also likely to fail in our opinion due to a lack of financing or other challenges; however, we are more interested in the backlog growth trajectory. If the backlog of planned projects has more than doubled in two years, what will the pipeline look like another two years? If it doubles again, we could see ~800kt of planned land-based capacity by 2020, corresponding to 35% of 2017 global production of 2,300kt.

Many projects underestimate the time and money needed

Figure 5: Identified planned production volumes in 2018 (HOG kt)



Source: Company information (on volumes in total and distribution if available), DNB Markets (estimate on distribution if not available). Please note that there are probably a large amount of projects that we are not aware of

What does the future hold for land-based volumes?

Experience has taught us that planned volumes can vary significantly from actual volumes, just looking at estimates for new production in 2016 versus the current figures. And we see a real likelihood that many of the projects currently in development will follow suit, with delays due to challenges with financing and regulations, and lower volumes than planned in the wake of operational and biological challenges. As highlighted – we have tended to overestimate the change 1–2 years out.

We believe in downside to the projects' own volume estimates as the underestimate the time and money needed, or the biological challenges

Since producing large salmon onshore has yet to be perfected and there are as many versions of best practice as there are land-based farms, getting skilled labour can prove a challenge. A senior RAS operator from a traditional farmer may have a different opinion on best practice based on his or her past experience. Fortunately, the RAS facilities seem to converge

We believe that labour with the needed experience and understanding may prove a challenge technology-wise, which we believe should enable best practice to be developed over time. Atlantic Sapphire has said it is well on the way to securing skilled operators for its Danish and US facilities. We have a separate piece on Atlantic Sapphire in the next section, but in the context of growth in land-based overall, we believe it worth mentioning that much competence and operational experience will have to build for each project. We notice, that the Atlantic Sapphire's US facility is guided to produce ~10kt which more than the combined global output of all land-based production today, implying a doubling of the 'global workforce' for land-based farming to meet the manpower requirements. As the demand for RAS competence and operational experience with farming increases scarce resource, some of the projects may find it difficult to hire all the talent that they need.

Land-based projects in development have increased in number and scale versus two years ago, and several commercial concepts are selling high-quality products at a premium price. We believe some may be able to ramp-up production earlier than their estimates. Success of larger production facilities such as Atlantic Sapphire in Miami is also likely to send positive signals to earlier-stage projects, and perhaps also enable easier access to financing, in our view.

More and larger projects means lower share of successful projects needed to reach material volumes

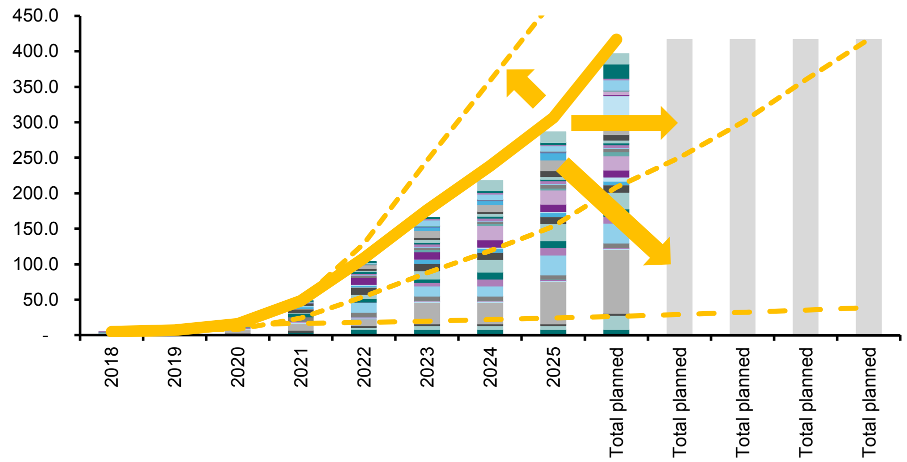
While Atlantic Sapphire has not communicated any plans to ramp-up production earlier than communicated in its business plan, we believe it likely it would be tempted to build far larger capacity earlier to enhance its competitive advantage, speed up the learning curve, generate economies of scale and volumes to build brand awareness, etc. This would of course depend on available external financing, as the company does not have excessive cash as its current communicated plan is to finance capex with operational cash flow.

If proven successful in US we believe that the Atlantic Sapphire is incentivised to use the positive investor environment to speed up their ramp-up to increase entry barriers and learning curve

Below are illustrations of alternative routes for the land-based salmon farming volumes in the future.

There are several alternative routes for building land-based volumes

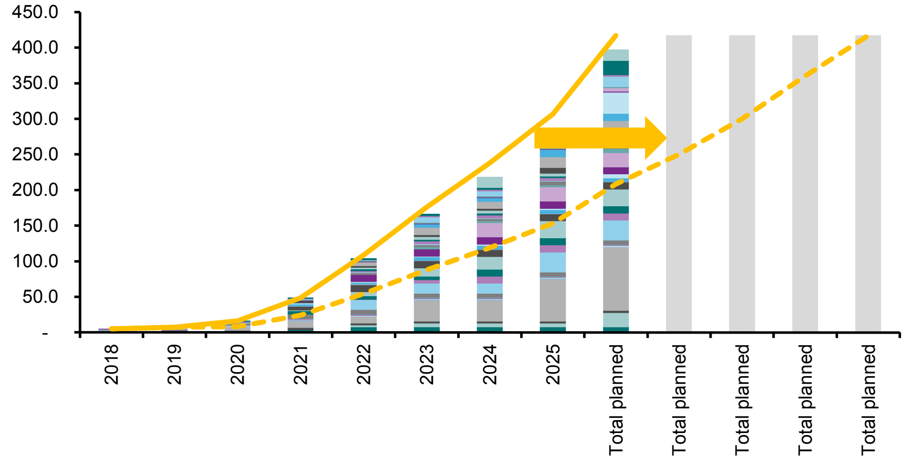
Figure 6: Different scenarios include ramp up, delays and fail



Source: DNB Markets illustration

Volumes may be pushed out in time due to biological challenges, lack of financing or approvals, and other delays

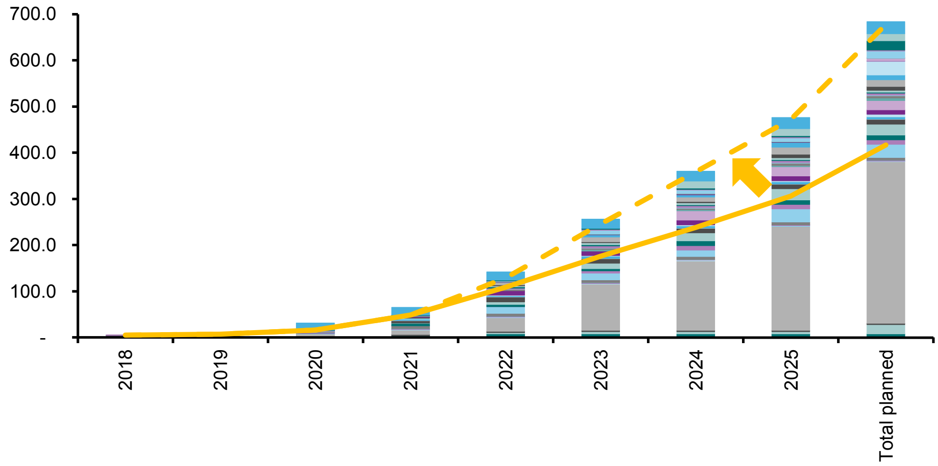
Figure 7: Many of the smaller project lack the needed funding or approvals



Source: DNB Markets illustration

Successful projects may want to ramp-up faster than previously planned

Figure 8: Large scale successful project may decide to ramp-up



Source: DNB Markets illustration

Which companies are producing Atlantic salmon now?

Atlantic Sapphire is selling fish from their Danish site and has inserted eggs in their first phase in US

Atlantic Sapphire started harvesting salmon again in Denmark (Langsand) in September 2018. The company had a major setback in terms of production due to mass mortality caused by hydrogen sulphide (H_2S), in July 2016. Since then the fish have been harvested at an average weight of 3.5kg, below the 4.5kg in the past. The company said it can increase the harvest weight, but that this is the ideal weight based on an evaluation of optimisation of production turnover, feed conversion and prices. The company guided a total harvest of 82k fish at this average weight from this facility in 2018, equating to roughly 250 tons.

There are still few datapoints based on low volumes, but the company said it is seeing a price of NOK100/kg ±NOK5 back to farm (assuming ex-farmgate Miami; USD9/lb fillet).

Figure 9: Atlantic Sapphire salmon

Source: Atlantic Sapphire on Instagram

Figure 10: Atlantic Sapphire salmon

Source: Atlantic Sapphire on Instagram

Platina Seafood's sells both its Langsand-produced Atlantic salmon and Danish salmon under the Atlantic Sapphire brand.

Figure 11: Atlantic Sapphire at Wegmans

Source: Received from Atlantic Sapphire

Figure 12: Atlantic Sapphire at Wegmans

Source: Received from Atlantic Sapphire

Danish Salmon in Denmark

Danish Salmon has produced salmon since 2013 and was one of the first to produce Atlantic salmon, although being a pioneer brought some challenges. The technology was partly provided by AKVA Group in 2012–2014, but the facility has gone through many changes since it was built. Site capacity is ~2kt, but we understand it is producing less than half this.

Danish Salmon has produced salmon on land for quite some time and is selling through Platina Seafoods

The company's salmon is ASC-certified and sold both in co-operation with Nissui-owned Nordic Seafood's subsidiary Pesca Nordica and Platina Seafoods (owned by Atlantic Sapphire).

Kuterra in Canada

The company describes itself as a 'proof of concept project'. Kuterra is currently restocking its R&D facility in Canada (on Vancouver Island, British Columbia). Kuterra is owned by the 'Namgis First Nations, and stocked its first salmon smolt in 2013. In 2014 it harvested ~100 tons HOG, ~235 tons HOG annually in 2015–2017, but just ~110 tons HOG in 2018 due

Maintenance shutdown leaves 2018 harvest significantly down on previous years, and the target for 2019 is just a quarter of the facility's capacity to a major maintenance shutdown, but the plan is to start ramping up production again, with a target of 65 tons in 2019 – albeit just a fraction of site capacity of ~260 tons per annum. When asked, the company said "focus will continue to be using the facility to determine the optimal conditions for rearing, feeding, and harvesting the fish in a commercial environment, which will inform the design of new or expanded facilities". Improvements to date have reduced early maturation from >30% per cohort to <3%, and increased average size harvested from a low of 1.7 kg live weight to 4.0 kg live weight.

The company has said it is not yet profitable but is confident the facility will be profitable once all the optimisation projects have been completed. It also said total capex to date is USD7.5m, and require additional start-up opex of ~USD4.5m in capital. Capital sources coming from Sustainable Development Technology Canada (USD4.1m), the Canadian government (USD1.3m), Tides Canada and the Gordon and Betty Moore foundation (USD2.5m), as well as other funders providing ~USD0.6m and Namgis contributing ~USD3.5m.

Management has said it expects to move into the black once the site is fully optimised

Sustainable Blue in the US/Canada

Established in 2007, it sold its first Atlantic salmon in 2015. In line with other early movers, the company produces low volumes (~100kt) sold at a premium price, but is expanding production capacity to ~600kt annually. Sustainable Blue sells its salmon online through Afishionado: as at December 2018 it was selling frozen fillets for USD11.5/8oz (8oz is roughly 220g); converting this to kg yields ~USD50–51/kg, or ~NOK440/kg fillet.

Sustainable blue sell their salmon online to a significant premium

According to Afishionado: "Due to its delicate flavour, Atlantic salmon is a popular fish that can be prepared in a variety of ways – from raw, to herb crusted, to maple and soy-sauce glazed. It has a firmer flesh that will naturally vary in colour from a light pink to deep orange. Because of the pristine conditions in which Sustainable Blue salmon are raised, and natural feed, they pack a flavour that will parallel a wild Atlantic salmon".

Swiss Alpine in Lostallo Alps

Swiss Lachs is now harvesting salmon at 3.4kg in the Alps (Lostallo) and selling pre-packed smoked salmon at CHF12 per 100 grammes, i.e. ~NOK100/100g (packaged and sold as a luxury product, versus standard fresh/frozen salmon). The company produces salmon in RAS2020 facilities (Veolia technology – the same technology Nordic Aquafarms uses to produce yellowtail kingfish in Denmark and will be using for some of its production in Fredrikstad); annual production capacity at the Swiss Lachs site is currently roughly 600 tons.

Swiss Alpine is perhaps the highest end version of them all, produced in the Alps

Figure 13: Swiss Lachs (also known as Swiss Alpine) salmon

Source: Swiss Lachs' homepage https://swisslachs.ch/?lang=en

Global salmon, AquaMaof's test facility is producing harvest-size salmon in Poland

The facility is in Plonsk (an hour's drive from Warsaw, four hours from Berlin). The entire production cycle is on site (from egg to maturity); the current harvest weight is roughly 4–5kg. The facility was originally established in 2012 by Polish investors to produce tilapia, but was converted to an R&D facility for salmon farming when AquaMaof took it over in 2016, due to

The technology provider has their own test facility producing salmon in Warsaw growing interest in land-based salmon production. Following conversion, AquaMaof estimates annual production capacity of 600 tons, but says its main focus will be on R&D, testing fish responses with different water quality, feed, lighting, stocking density, tank colour, etc.

AquaMaof technology uses trickling types of biofilters, which are more energy efficient than other types of biofilters (the company estimates it uses ~2.5kWh of electricity per kg of harvested salmon – roughly half that used in moving bed biofilm technology, according to our industry sources), and limited water exchange. We visited the facility and tasted the salmon prepared as sashimi

We visited the facility and tasted the salmon prepared as sushi

Figure 14: AquaMaof salmon prepared at sushi restaurant in Warsaw

Source: DNB Markets (photo taken during site visit)

Select projects in the US with plans for large-scale production

Land-based salmon farming makes the most sense in regions with significant consumption potential and transportation cost advantages over traditional net pen farming. Broadly speaking, we view these as the US and Asia.

Atlantic Sapphire's US site is on track

Construction of the first phase of **Atlantic Sapphire's** 9.5kt production facility is under way; the development is on schedule, and it plans to start harvesting fish in 2020. The facility received 800k eggs (roe) at end-November 2018; the company plans to insert 540k eggs every seven weeks, of which it estimates 350k will eventually reach maturity and harvest, taking into consideration mortality and culling.

As of 5 February, Atlantic Sapphire USA had successfully transferred the first salmon from the Bluehouse hatchery to the brand new start feeding tanks. These will eventually be the first-ever commercial batches of salmon harvested in Florida (assuming it is successful), in mid-2020 (see pictures below).

The company is aiming for production totalling 90kt in 2026. We visited the site in April and December 2018: key takeaways from the latest visit can be found in our sector note 'Final stages of an eight-year bull-run' published on 4 December 2018.

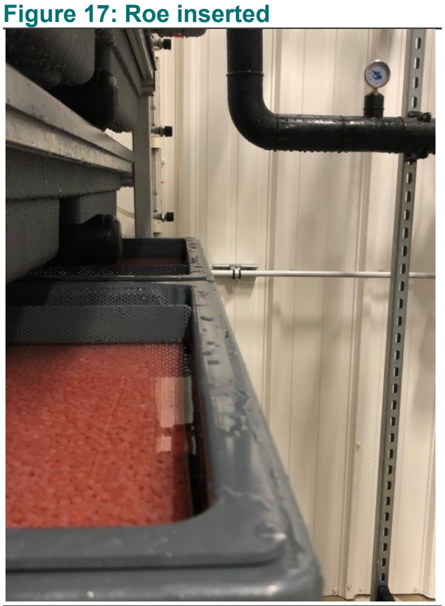
Figure 15: Atlantic Sapphire US 'pre walls and roof'

Source: Company, Newsweb: Presentation published 15 November 2018

Figure 16: Atlantic Sapphire – November 2018

Source: Company, Newsweb: Presentation published 15 November 2018

Figure 17: Roe inserted



Source: Atlantic Sapphire

Figure 18: Test batch

Source: Taken by DNB Markets on site visit

Figure 19: Water source

Source: Taken by DNB Markets on site visit

The colour of the water in the test batch is less transparent than it will be in the live environment as the test-system does not include reverse osmosis. The tank includes roughly 3k swimming fish; in addition, the hatchery is being tested with 10k eggs.

Figure 20: Start-feeding tanks with and without fish

Source: Atlantic Sapphire

Figure 21: Fish moved to start-feeding (February 2019)

Source: Atlantic Sapphire

Please contact your DNB representative to get our latest report on Atlantic Sapphire.

Whole Oceans LLC

Whole Ocean is one of two large land-based projects in Maine, US

A land-based aquaculture company headquartered in Portland, Maine, US, Whole Oceans is finalising various state, federal and local permits prior to commencing construction in Bucksport, Maine, at the former site of the Verso paper mill. According to the company, the first phase of construction will begin in 2019 and will produce 5k mt of Atlantic salmon (HOG) annually once completed. It is planning additional phases over the next 10–15 years to increase capacity, the timing of which will depend on production successes. Whole Oceans said it has committed to producing a non-GMO product and to vertically integrating operations at both ends of the value chain over time. It will source eggs from StofnFiskur in Iceland. Whole Oceans has a multi-year offtake agreement with an American seafood distributor for up to 100% of its product[2].

Nordic Aquafarms

Nordic Aquafarms Ltd is the other

The group is planning to build a ~28kt HOG facility in Maine, US, for which management has said it is finalising the permits and financing. Construction is due to start in Q3 2019.

The company is also building a facility for production of salmon in Norway

In addition, it is nearing completion of its facility in Fredrikstad, Norway. The two systems in Norway are planned to produce ~1.7kt HOG annually, and are based on Veolia's RAS2020 design, while design of the US facility is being developed by the company itself.

Nordic Aquafarms produces yellowtail kingfish in Denmark

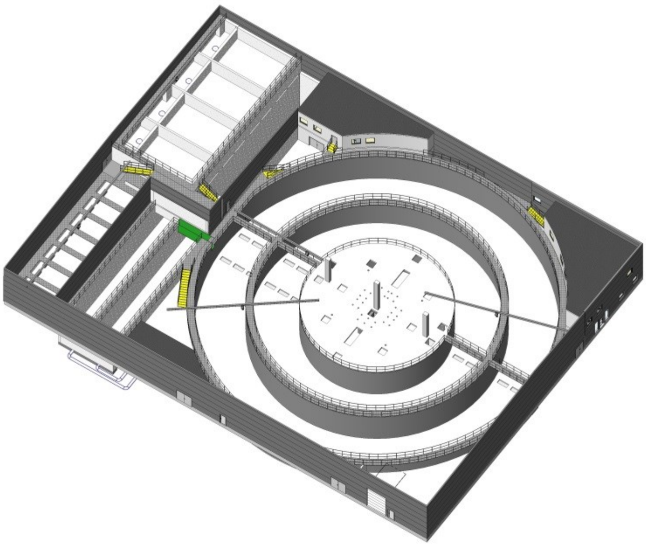
The company is majority owner of Sashimi Royal, which is producing yellowtail kingfish in a RAS2020 facility in Hanstholm, Denmark. Additionally they own 50% of the marine RAS hatchery Maximus that produces yellowtail kingfish fingerlings for Sashimi Royal. The company hired many of the resources from former technology provider Inter Aqua in 2018.

[2] Source: Hennifer Fortier, Whole Oceans

Figure 22: Planned design of Nordic Aquafarm's US site

Source: Nordic Aquafarms

Figure 23: RAS2020 design used in Fredrikstad, Norway



Source: Kruger Veolia

Projects in Asia

We would like to have more information on projects in Asia than we do

We have little insight into development of land-based salmon farming in Asia; the following is an overview of the projects we are currently aware of.

According to Intrafish, Nordic Aqua Partners (previously known as Salmon Dragon) is planning to build an 8k-ton Atlantic salmon production facility in China, outside Ningbo. The same source says that, led by Ove Nodland, Johannes Netland in management and Ragnar Joensen with 17 years' experience from Marine Harvest (MOWI) as chairman, the company is working on financing, with a capex need estimated at NOK800m, and is looking to raise NOK370m. It also says Nordic Aqua Partners plans to achieve NOK45/kg in production costs and transportation cost savings of NOK15/kg and tax at NOK5/kg, and that the company plans to start construction in 2019, given that they financed construction in 2018. With plans to insert roe in the end of 2019, we see potential volumes from this site by the end of 2021[3].

Three producing facilities in China – that we know of

Three projects identified in China

These are two smaller sites with production below 1k tons, and the Nordic Aqua Partners project. While researching as extensively as possible, we believe there are other sites that we were not able to locate, nor were we able to gather much information on the projects we are aware of. What we have identified is a total of three projects probably producing salmon in China; each of the facilities is producing 250–500 tons of salmon annually.

In addition, we know there are many offshore salmon projects being developed in China, all of which will need smolt, implying that more RAS systems are already being built.

[3] http://www.intrafish.no/nyheter/1594060/tidligere-marine-harvest-direktor-paa-pengejakt

Enablers – 8F Asset Management Limited's Pure Salmon

8F look to produce almost 300,000 in land-based facilities

In addition to individual projects and companies, a 'new' player is moving into the land-based salmon farming industry. 8F Asset Management, a financial player is looking to facilitate growth of the industry.

To quote Martin Fothergill (co-founder and Partner of 8F Investment Partners): "Pure Salmon (www.pure-salmon.com) describe themselves as a new land-based Atlantic salmon farming company with a mission to revolutionise the industry. With global operations and a target to produce 260k tons per annum, Pure Salmon say they look to become the world leader in high-quality, clean, sustainable and fresh salmon.

"Pure Salmon has been developed by 8F Asset Management Pte. Ltd., a global asset management firm focused on impact investing. Pure Salmon will use Recirculating Aquaculture System (RAS) technology in its land-based farms and has selected AquaMaof Aquaculture Technologies proprietary technology for its facilities. AquaMaof is a leading provider of RAS technology and has a successful track record in building RAS facilities around the world.

The financial player is part-owner of a land-based facility in Poland

"Pure Salmon's first Atlantic salmon RAS facility is already fully operational in Poland and producing adult-size fish of 5–6kg. It is 50% owned by 8F's private equity fund and 50% by AquaMaof. In addition to acting as a commercial proof-of-concept, the facility is also the research and development centre for AquaMaof and centre of excellence and staff training location for Pure Salmon globally. The Poland facility will produce 580 tons of Atlantic salmon per annum.

"A second facility has been recently announced in Japan. A USD162m (EUR141.9m) investment is being made to create 'Soul of Japan', a state-of-the-art RAS salmon farm that will be the largest-ever built in Asia, and one of the largest globally. The 137,000sqm farm will produce up to 10k metric tons of Atlantic salmon annually and is due to be fully operational from 2021.

"With further planned roll outs of large scale facilities of 10k tons or 20k tons production per annum in the US, Europe, China and around the world to comprise a total of 260k tons of production, Pure Salmon's launch is the most ambitious of its kind for land-based salmon farming, generating hundreds of local jobs and helping solve the global fish shortage.

"In addition to the facilities in Poland and Japan, Pure Salmon's first phase will also include a 20k-ton facility in Virginia, USA, and 10k tons in either France or Italy.

"All Pure Salmon land-based sites will be fully integrated with on-site hatcheries, grow-out systems and processing facilities, delivering a clean, healthy and fresher salmon for local consumption, reducing wastage and limiting its carbon footprint.

"8F Asset Management Pte. Ltd. is headquartered and regulated in Singapore. It has group offices in London and New York. Being a founding signatory to the Blue Economy Finance Principles (developed by the WWF, the EU Commission, the EIB and the World Resources Institute), 8F believes that expanding land-based RAS facilities is the way to relieve our oceans from the enormous pressures they are under and reduce the impact on marine ecosystems."

Figure 24: David Cahill, Pure Salmon's global head of production with a 6kg salmon from the Polish facility

Source: 8F/Pure Salmon

Figure 25: The facility in Japan (computer-generated)

Source: 8F/Pure Salmon

8F look to enable financing of large land-based facilities and cooperate with the technology provider AquaMaof who is already producing salmon on land

When asked about the financing of the projects, Martin Fothergill explained: "We are raising the capital through private equity vehicles. The first one, 8F Aquaculture Fund I, will finance and own the first-phase facilities (Poland, Japan, US, France/Italy) plus a share of the operating company (Pure Salmon). For Fund I we are raising USD300m equity and investing USD500m, the balance coming from grants and financing. Fund II will invest in the China facilities, and so on.

"The funds are managed by 8F Asset Management. We decide on where the portfolios will be invested (i.e. where the facilities will be located) find the land, negotiate grants, financing, off-take agreements, etc. 8F has set-up Pure Salmon and hired the team who will operate the facilities (grow the fish!). There is a formal investment process that outlines the DD etc, and an Investment Committee. The selection process considers, for example, the local consumption level of Atlantic salmon, growth potential, import levels, distance from incumbents, land availability and price, environment, government grants, regulations, and so on."

What the future holds

Key developments within (land-based) salmon farming

We believe feed and genetics will be important areas of development for both traditional and land-based salmon farming. ESG is also very important, with opportunities and challenges for salmon farmers, both on land and in the sea.

Feed – one of just three external inputs (with eggs and water)

Feed is obviously one of the factors that affect growth; the higher the fat content, the higher the energy content and the higher growth per kg of feed. However, there are many other considerations to take into account in feed composition (formula), key of which is that the biofilters and RAS system must be able to 'clean' the water of surplus fat (ensure water stability). Several suppliers have developed feed specifically to ensure water stability, with slower feed sinking time.

The farmers needs to balance growth vs water stability when deciding on feed

When asked for more insight into the development, Alex Obach, managing director of Skretting ARC, said: "Recirculating aquaculture systems need high performance feeds in terms of physical and nutritional quality, to make the fish growth faster and healthier and to keep the water quality in the system.

Feed is key to health and growth hence production yield

"They should be designed to optimise land-based production based on 3 key principles: maximise performance while reducing nutrient load for biofilters, provide excellent physical quality of the pellets and improve faeces quality to make mechanical filtration more efficient.

"In terms of nutritional composition, RAS feeds should have precise level of nutrients. Both the digestible and the indigestible fraction of nutrients have to be considered when formulating the diets. Flexibility in the use of raw materials is of course key to be able to optimise costs. The use of ingredients with high digestibility will maximise nutrient utilisation for fish growth and minimise nutrient loss, since excess of nutrients in the water will represent an additional load to the biofilter.

The feed need to optimise the salmon's growth and health together with what the RAS facility is able to handle

"In terms of physical quality, four main parameters to measure to assess the physical quality of RAS feeds: high durability (pellet strength), very low fat leakage, high water stability and adequate sinking speed. Durable feed pellets reduced the amount of dust creation and broken pellets and contribute to better water quality. Low fat leakage and high water stability of feed reduce nutrient leaching and turbidity, thereby ensuring good water quality for fish growth.

4 main parameters for physical quality:
1. high durability (pellet strength)
2. limited fat leakage
3. high water stability
4. adequate sinking speed.

"Use of ingredients that bind faecal matter (faecal binders) facilitates the filtration and removal of solid waste particles and also reduces faecal leaching and lowers the load on the bio-filter. As water quality is improved, fish health is optimised and the production capacity of the system may be increased.

"Feed consistency is also important for recirculating systems in order to successfully maintain fish performance and the conditions of the fish rearing environment. For this reason, it is important to put in place meticulous quality procedures to ensure that the quality and formulation of pellets is of consistent quality from batch to batch.

Consistency in quality is key when it comes to feed used in RAS systems

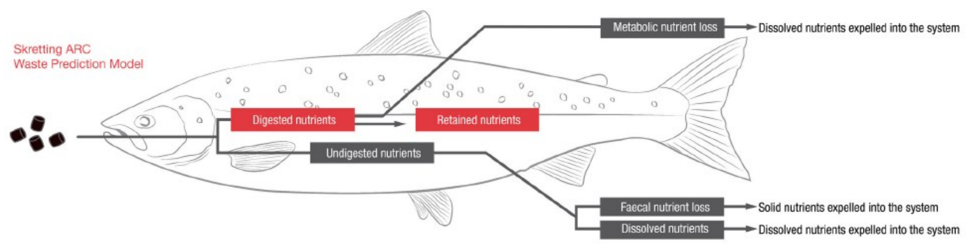
"Over the past decade, we have collected a significant amount of data from fish feeding trials from our own research facilities but also from external ones. With this dataset, we have developed a number of models to predict several performance and quality parameters but also to predict nutrient utilisation and nutrient excretion.

Skretting on their model built for anticipating feed performance in RAS systems

"If we know the amount of feed consumed, the nutrient content in the feed and the digestibility of nutrients, the growth of the fish and the fish body composition we can calculate the amount of nutrients excreted as solids or dissolved in water. With this information we could developed a waste prediction model for Atlantic salmon.

"By using this model in RAS systems, we are able to calculate the level of dissolved key nutrients in the water, namely nitrogen, phosphorus and carbon and measure the impact of changing dietary formulations, taking into account the use of different raw material qualities and specific nutrient levels. We are also able to quantify the additional effect of adding binders to the feed on the reduction of important nutrients such as nitrogen, phosphorus and carbon."[4]

Figure 26: Skretting – growth and waste prediction models



Source: Skretting (AIW, November 2018)

Atlantic Sapphire – how it works with feed optimisation

Atlantic Sapphire say that many considerations has to be taken into account when selecting feed composition

When we asked Atlantic Sapphire about how it works with feed, Ole Christian Norvik, managing director of the Denmark facility, said: "Atlantic Sapphire is working together with the feed companies to define and develop the optimal feed formula for achieving the best possible performance in land-based farming with attention to growth, fillet colour, physical properties of feed (oil leakage, pellet strength and dust) and to minimise the negative impact on the biofilter performance (faecal stability, raw material variation and absorption nutrients in the fish versus excretion through faeces). This is a continuous process where we are testing different feed, and it's still too early for us to quantify what the growth implications could be of a change in feed. The different approved formulas will be tested and benchmarked against other feed alternatives and formulas both at the feed companies own R&D facilities and in a controlled way at our site in Denmark to verify the quality and performance of the feed.

"The oil (fat) content versus protein is an area we are working to optimise. As a starting point, growth feed for land-based facilities have ~37% protein and ~32% oil/fat. This is significantly lower than in feed for traditional farming, but we are nonetheless achieving good growth. The MJ (digestible energy) is also lower, with levels at 21–21.5 MJ versus more than 22 MJ on traditional salmon feed. Our FCR is on level with the best performing traditional sea-based salmon farms even though we have a lower fat content in our feed.

Everything you put into the RAS facility that isn't eaten or digested by the fish, has to be handled by the recirculation system.

"In RAS, a simple, key takeaway is that everything you put into the facility that isn't eaten or digested by the fish, has to be handled by the recirculation system. This is contrary to net pen farming, where all redundant input is spilled out into the ocean."

Johan Andreassen added: "Feed is obviously a major topic for any fish farmer as it by far the largest trade in the business representing up to 50% of the cost of production. It is a topic that is very complex and there are a lot of considerations that need to be done when choosing what feed to use. Cost, technical quality, Omega3 contents, sustainability, PCB/dioxine levels, seasonal and geographic availability of raw materials etc. In Atlantic Sapphire we are innovating Bluehouse farming and for us technical feed quality, digestibility and water quality are driving forces in our decision making process on feed. We have for the last 8 years been using diets that also comply with Whole Foods Quality standards. In general I would say that there is a lot of innovation needed in order to develop efficient and tailor made feeds for salmon in RAS environments and the feed suppliers and farmers have to be prepared to spend large amounts of money to develop their diets".

Genetics

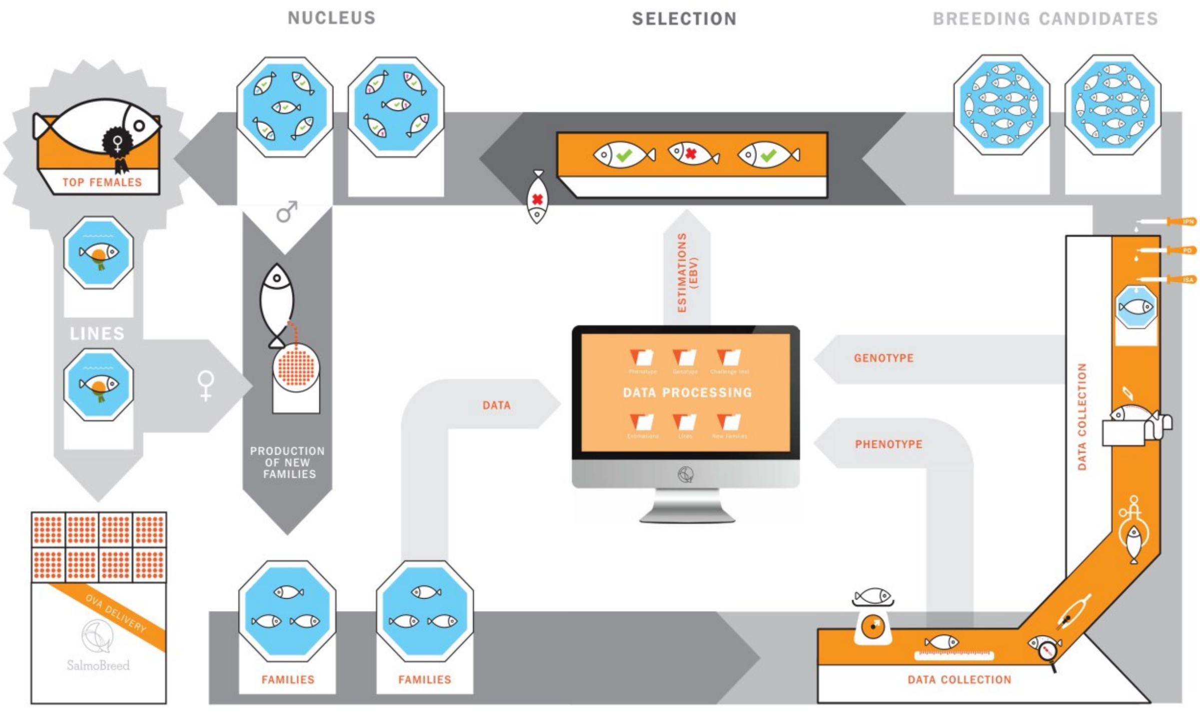
Salmon farming is a young industry versus other proteins; we see significant potential in genetic developments

Salmon farming is a young industry and far less industrialised than other proteins such as pork and poultry. Note that EW Group (at the forefront of genetic development within poultry and owns AkvaGen) subscribed to 10% of the NOK600m equity offering in Atlantic Sapphire.

[4] Source: Alex Obach and Sophie Noonan from Skretting, received 10 January 2018

Jan-Emil Johannesen, head of the Genetics division at Benchmark Holding, said: “In my point of view, selection on individual level (genomic selection/QTL) has given entirely new opportunities within breeding programs and production of commercial salmon roe; both in terms of speeding up the development, increased precision within breeding and provides opportunities related to even more custom-made roe production for customers. Today 100% of the roe we are selling have at least one trait that is selected individually”

Figure 27: ‘Family breeding wheel’ illustrated by Benchmark Genetics



Source: Benchmark Genetics

The following text on selective breeding, genomic methods and domestication has been validated and edited at the request of Benchmark Genetics’ Genetics department.

Selective breeding

Is the method used to improve the performance of an entire breeding population for a set of heritable traits. The breeding candidates are scored and ranked based on their own as well at their relatives’ performance for a set of traits, and then the best breeding candidates are chosen to produce the next generation.

Genomic methods

Quantitative Trait Loci (QTL) is a gene or ‘a part of the genome’ highly linked to a gene which highly affects how an individual performs for a certain trait. The expression of certain traits can therefore be predicted with help from a QTL, such as IPN resistance, and the breeding company can select breeding candidates with predicted high resistance to this disease.

Genomic Selection (GS) utilises the information from thousands of Single Nucleotide Polymorphisms (SNPs) evenly distributed over the entire genome to predict the performance of a breeding candidate for a certain trait. This is different from the QTL, as the QTL only utilises the information from a few SNPs. GS is the preferred methods to use when the expression of a trait is controlled by many genes.

Domestication

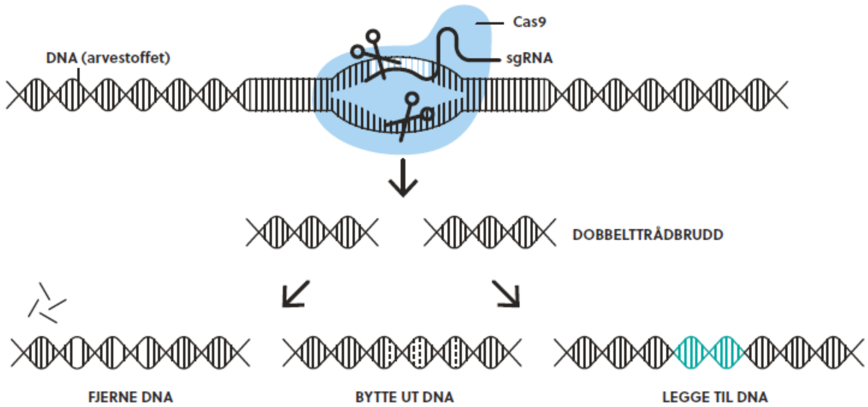
Encyclopaedia Britannica defines domestication as “the process of hereditary reorganisation of wild animals and plants into domestic and cultivated forms”. Selection based on behavioural traits, such as temperament and stress levels, show heritability. StofnFiskur describes how selection of fast-growing brood fish will enhance domestication, since less stressed fish grow faster.

CRISPR

CRISPR is genome editing, and not defined as GMO. Tekna has made a booklet on opportunities related to CRISPR and how different stakeholders look at CRISPR technology and the related opportunities for aquaculture industry. The full booklet called 'Salmo Unique' can be found here: https://www.tekna.no/havaker

CRISPR is gene-editing is not defined as GMO as the process does not include gene material from other species

Figure 28: Cas9 protein cuts the DNA based on a specified sequence



Source: tekna.no/havaker

Transgenic salmon developed by AquaBounty Technologies

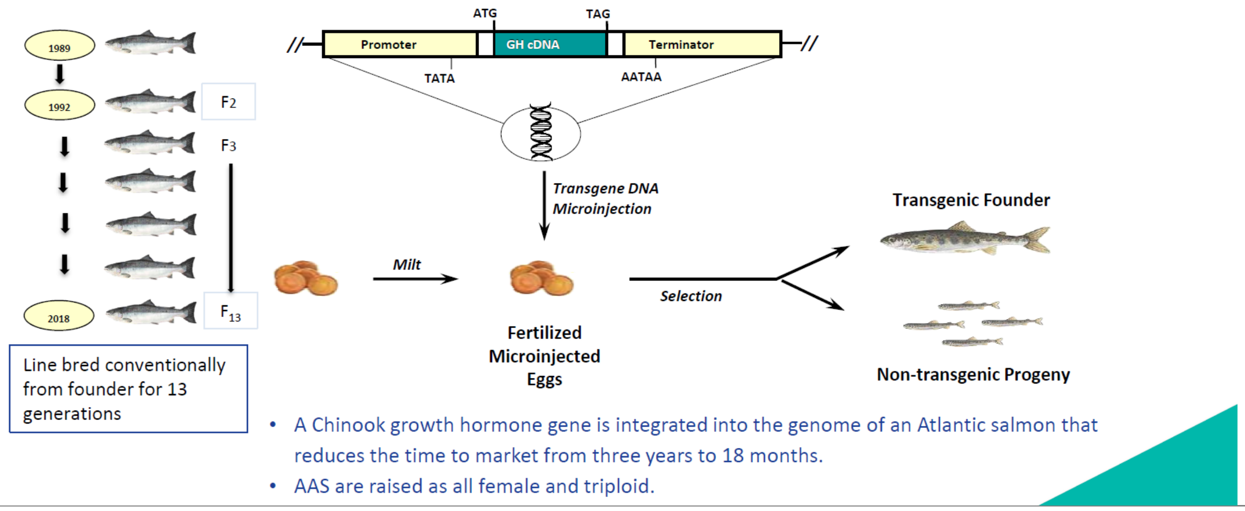
AquaBounty introduces gene material from Chinook salmon in order to speed up the growth

AquaBounty Technologies is a biotechnology company. AquaBounty is currently producing their AquAdvantage® Salmon in a small R&D facility in Panama, and has sold two batches of 10-ton harvests (processed as five tons of fillets) in Canada (June 2017 and June 2018). The volumes were sold at market prices according to the company.

A growth hormone gene from the Chinook salmon, operating under the control of a promoter sequence from ocean pout, is integrated into the Atlantic salmon genome, which reduces the time to harvest from 30–36 months in sea pens to 16–18 months in land-based tanks, according to the company. The salmon does not grow larger than standard salmon, but reaches market weight faster. AquaBounty estimates that the feed used to reach market weight is reduced by 25%. Its all-female and triploid salmon is raised in land-based RAS facilities. Currently the company is producing the AquAdvantage® Salmon in Panama, and while waiting for the FDA Import Alert issued in January 2016 to be removed, the company is producing standard Atlantic salmon (non-transgenic) in its 1.2k metric ton facility in Indiana, US. The company is also building a 250-metric ton facility in Rollo Bay, PEI, Canada. It expects its first harvest of AquAdvantage® Salmon from Indiana in H2 2020.

The company says "Our first product, AquAdvantage® Salmon (AAS) – a faster-growing Atlantic salmon – has been approved by the US FDA and Canadian regulatory authorities for production, sale and consumption in the US and Canada" (AquaBounty company presentation).

Figure 29: The technology, AquAdvantage® Salmon (AquaBounty)



Source: AquaBounty

ESG

Identifying ESG-related risks and opportunities in land-based salmon farming

We have identified several ESG factors we believe could become financially material challenges or opportunities for the salmon farmers. Inspired by the Task Force on climate-related financial disclosures (TCFD) report (June 2017), we identify the main challenges as either transition or physical risks. Within transition risks we include those related to political and legal change, technological developments, market change and reputational risks related to being perceived as or acting unsustainably. Physical risks can be divided into acute (such as acute outbreaks) and prevailing (such as an ongoing challenge with sea lice). ESG opportunities encompass increased resource efficiency (both related to end-products and input factors such as feed), new products and services, opening new markets (regions or types of products) and more resilient supply chains.

We have identified ESG-related risks and opportunities important for the companies' ability to grow and their profitability

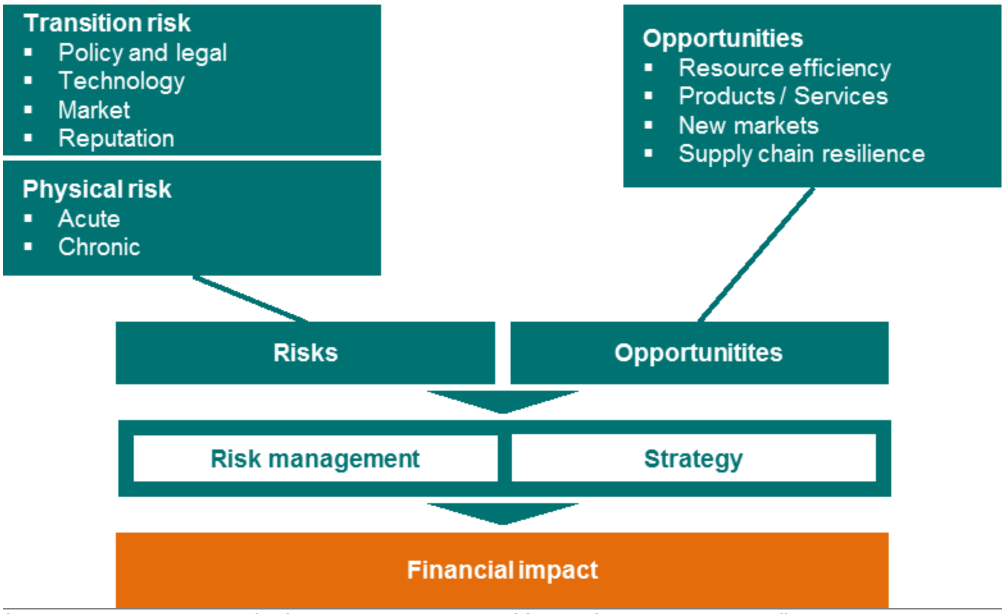
Among the companies on which we have coverage, SalMar and Atlantic Sapphire are at the forefront of development of new technology (albeit in very different ways). Given Atlantic Sapphire is able to produce according to plan with control of biology, production has many ESG-related advantages and related opportunities. Our high-level ESG assessment of Atlantic Sapphire is included in the appendix.

ESG related risks and opportunities are mitigated and exploited by the companies through new technology, including land-based

Control of biology and water is the key to fish welfare and sustainable production; hence we have included a section on sustainability and challenges that land-based salmon face. Without full control, there is obviously significant risk related to ESG.

Challenges and opportunities related to ESG for land-based farmers are dependent on full control of fish welfare, and will differ between projects

Figure 30: Sustainable investment methodology



Source: DNB Markets (illustration of TFCD report applied at a general ESG level; TCFD is based on climate effects – June2017)

ESG as opportunity and risk for land-based salmon farmers

Improved sustainability and environmental impact are often highlighted by land-based farmers, as traditional farming affects the surrounding water. The carbon footprint of salmon products transported across the sea is also an important contributor to sustainability versus select land-based salmon produced in the same country. Below is an illustration of the impact sea-based cages have on their surrounding environment. Important factors are escapes, pesticides, disease, and sludge from both the fish and feed spill.

Feed spill (and sludge), chemicals used for lice treatment and escapes affect surrounding water, wildlife and the sea floor below the sites. Havforskningsinstituttet (Ocean Research Institute in Norway) regularly performs risk analysis looking at both the potential impact – in its view, the key environmental risks relate to sea lice and escapes.

Fishermen along the coast in all the main salmon farming regions have faced resistance on many fronts. Farmers in British Columbia, Canada, in particular have faced opposition from local groups: in December 2018, news broke that 10 out of 17 salmon farms close to Broughton Island would have to shut after the indigenous First Nations raised concerns that the farms were disrupting wild salmon migration. Both MOWI and Cermaq have facilities in the area and are looking at how to navigate. Anti-fish farm groups also claim that pesticides have resulted in sea lice becoming resistant to SLICE, a common 'drug' used to control outbreaks[5].

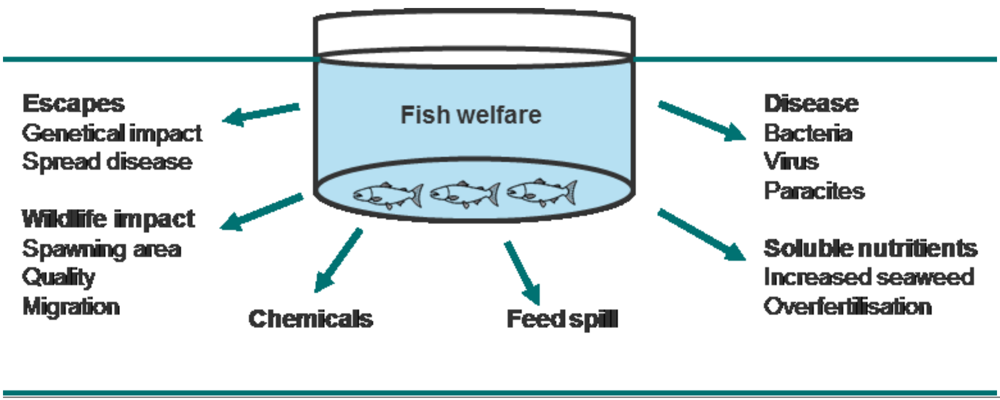
Local resistance due to fears of impact on wildlife is a challenge for salmon farmers in British Columbia, Canada

Norwegian fishermen have also shown resistance to salmon farming, citing wild salmon affected by high concentrations of sea lice at farms, excess feed being eaten by wild species, and broader fears of genetic mutations as a result of escapes. The most radical action in 2018 saw the municipal council of Tromsø not allow more in-sea licences, as well as stipulating that current concessions would not be extended without production being moved to closed-containment facilities. The consequences (including evaluating whether the local council has the authority to take such decisions) are yet to be borne out.

With closed production on land, many of these challenges and impact factors are eased or resolved entirely. Among others, removal of the impact on wildlife and the environment is dependent on methods and processes for sludge removal, facility robustness and proximity to the coast (some are very close to the shore, while others are some way off, such as Swiss alpine and Atlantic Sapphire).

With closed production on land, many of these challenges and impact factors are reduced or entirely removed

Figure 31: Environmental impact of fish aquaculture in open net pens



Source: DNB Markets (based on an illustration in Havforskningsinstituttet's 'Risk report: Norwegian salmon farming 2018'
Note that the illustration is both translated and simplified.

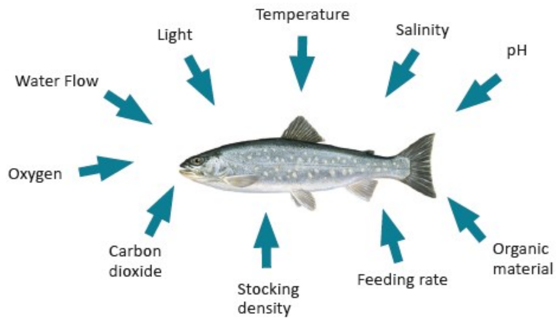
Welfare concerns for land-based salmon farming

There are also welfare concerns related to land-based salmon farming. Measuring and controlling water quality is of course important, while fish density is far higher in land-based facilities (it has to be to make the systems profitable). Hence disease outbreaks or poor water quality can have a rapid and severe impact. We believe hydrogen sulphide (H_2S) is one of the main risks to land-based salmon farming; incidents can be fatal and have increased exponentially since RAS using saltwater (to produce larger smolt and to full harvest size) was introduced (see below for more detail).

Numerous water quality indicators have to be monitored. Below we include the same illustration that we presented in our last report on land-based farming ('Deep-dive into land-based farming' published on 1 February 2017). Control of each of these parameters is important for fish welfare and production yield; lack of control can affect growth and mortality.

[5] https://www.intrafish.no/nyheter/1657610/cermaq-og-marine-harvest-maa-stenge-canadiske-anlegg; http://www.digitaljournal.com/news/world/drug-resistant-sea-lice-out-of-control-on-b-c-coast/article/536122

Figure 32: Parameters affecting growth



Source: FAO, Eurofish International

Hydrogen sulphide

Hydrogen sulphide – the sniper in RAS

H_2S has been called "the sniper within RAS", and for good reason; the bursting of an H_2S bubble can instantly kill all the salmon in the containment area (be it a tank, system or entire facility depending on the number of bubbles, facility size and location).

According to the US Department of Labor: "Hydrogen sulphide (H_2S) is a colourless, flammable, extremely hazardous gas with a 'rotten egg' smell. It occurs naturally in crude petroleum and natural gas, and can be produced by the breakdown of organic matter and human/ animal wastes (e.g., sewage). It is heavier than air and can collect in low-lying and enclosed, poorly ventilated areas".[6]

Hydrogen sulphide is a key risk; we would go so far as to say that no one should invest in land-based projects without a good understanding of the H_2S risk mitigation plan

H_2S is formed through an anaerobic process (bacteria digestion) in which sulphate is present. Since sulphide is present in salt water (e.g. above 2% salt), functions such as sludge gathering will create an environment in which the bacteria in the facility can create the toxic gas.

The table below is a simplified illustration of how H_2S is formed.

1. If oxygen is available organic material will be reduced to water (H_2O) and carbon dioxide ($CO_{2)}$ through bacterial breakdown.
2. If oxygen (O_2) is not present but nitrate is, bacterial breakdown will result in nitrogen gas (N_2) and carbon dioxide (CO_2).
3. If sulphate (SO_3) is present, but not oxygen or nitrate (NO_3), sulphate-reducing bacteria will break down the organic material and create H_2S in addition to CO_2.

Figure 33: H_2S
H_2S and sulphate-reducing bacteria (SRB) in preferred order

1.	O_2 +	Organic material	=	$H_2O + CO_2$	
2.	NO_3 +	Organic material	=	$N_2 + CO_2$	Ex O_2
3.	**SO_4 +**	**Organic material**	**=**	**$H_2S + CO_2$**	**Ex O_2 and NO_3**
				Sulphate-reducing bacteria	

Source: Kari Attramadal associate professor at Department of Biotechnology and Food science at NTNU, provided by NIVA

Both design and operations has to take hydrogen sulphide risk into consideration.

Åse Aatland from NIVA (Norwegian Institute for Water research) held a presentation on the topic at TEKSET two years ago, which is even more relevant today, with the increasing number and size of RAS facilities using brackish or salt-water. In just the past year there have been a number of H_2S incidents, including at MOWI (smolt) and Langsand (fully land-based). We know some of these incidents have killed more than 1m smolt, estimated by the company to be worth ~NOK20m.

Åse Aatland recently said more research needs to be done (NIVA is working with an NTNU student to get a better overview of incidents), but that she believes risk mitigation comes down to system design: reducing the likelihood of sludge gathering through system transparency (making it quick to detect); enabling efficient cleaning; and sensors that detect H_2S at low levels. She says there has been suspicion of biofilters with fixed bed possibly

[6] source: www.osha.gov

being more challenged by H2S (due to “more sediment being trapped” in the system), but that there are many different views on this and that H_2S has also been observed in moving bed filter systems.

Safety and redundancy

Each facility has its own in-built risk-reducing strategy to improve biosecurity, such as firewalls with several separate systems within one facility (reducing the risk of one disease outbreak, H_2S or other challenges affecting the entire production simultaneously). Veolia recommends minimising handling of fish and fish stress, as well as avoiding too much piping and slopes, avoid bending, and allow drainage, cleaning and drying of all pipes.

Sensors – Blue Unit as example

Sensors help control important water quality parameters and aid understanding using data on the salmon and water in different conditions

With many parameters to be monitored, most farmers use sensors, and innovation within the field is ongoing, with significant potential for data gathering and learning from production data. This was also highlighted by Grieg Seafood at its CMD in 2018, when it illustrated how it can apply experience gained from algal control and incidents in Canada to sites in UK. We have included a description of a ‘new sensor system’ from Blue Unit, a small Danish company supplying systems to several large salmon farmers in Norway and to Atlantic Sapphire in Denmark and the US.

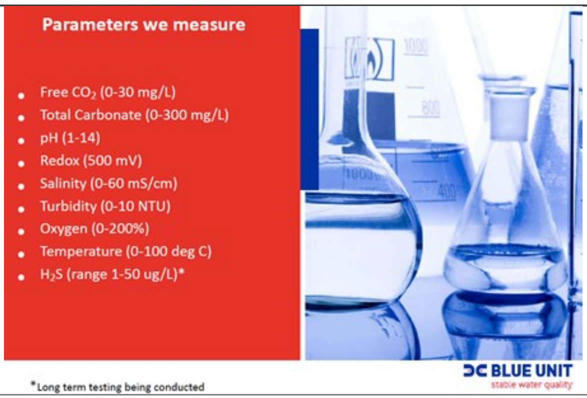
There are several producers of different types of sensor measuring water quality indicators such as pH, carbon dioxide, oxygen and temperature.

Blue Unit – an example of provider of technology and systems for measuring water quality

The Blue unit measures up to 12 different locations with one set of individual sensors that measure up to nine parameters automatically (i.e. nine different sensors at up to 12 locations). This is being used or tested by several salmon farmers at their smolt facilities, including SalMar (Follafoss) and Lerøy Midt at Lensvik (the latter has annual production of ~2.2m smolt according to the Ewos Forum 2017). Blue Unit’s system also measures H_2S at low levels, and long-terms testing is ongoing. Detection of H_2S is important for farmers using salt/brackish water, given the mortality risk (more detail is provided later in this report); Atlantic Sapphire (which has installed a Blue Unit system at its facilities in Denmark and the US) describes this toxic gas as its main risk.

Sales manager Pedro Fossat said “We offer the technology to produce data. The data for itself it is a very big step forward in understanding water quality. However, only that info as we see it is not enough to day-by-day to follow up and have a stable water quality. This is why we offer a service in which we look at the water quality remotely and help the farmers to keep track on what is going on and help to stabilise if needed”.

Figure 34: Blue Unit sensors



Source: Blue Unit, company presentation.

Comment on 'running the numbers'

With reference to our first report on the subject, land-based projects still make more sense, at least in the spreadsheet. However, each project is different, and the risk/reward needs to be evaluated on that basis. We find risk profiles can vary significantly, based on the technology used, system design, contingency plans, management experience, funds available, etc.

The high investment costs combined with operational risk has been a major barrier for land-based production

High production costs and investment needs combined with elevated risk and the long period from investment to first cash flow have been major barriers to land-based salmon facilities. Historically, relatively low capex for traditional salmon production has meant investment in new sea sites and licences has been any easy call, particularly of late with the current super-profits.

Investment per kg of land-based produced salmon produced has fallen with technological development and increased scale, while the risk has reduced with experience from operations and examples of successful production. In addition, opportunities to invest in establishing new traditional farms are rare, since biological challenges have left governments reluctant to award more licences.

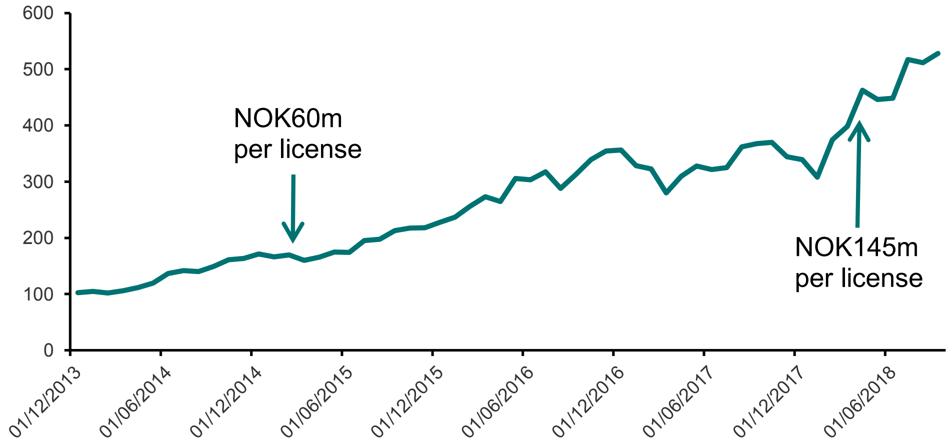
Required investment per kg has fallen for land-based while increased for traditional salmon farming

The typical cost of a standard licence is likely NOK180m+

Group B in Norway's Green licence round of 2014 marked the first time the true value of a just the licence was revealed: the average price for each of the 15 licences auctioned was NOK60m; SalMar placed the highest bid at NOK66m. Since then, the Oslo Seafood index risen approximately 270%; hence, the latest auction price of NOK145m in June 2018 had tracked stock market values. It would be natural to assume that the further 30% stock price appreciation since the June 2018 auction means the licence price has risen further. The increase of the Oslo Seafood index suggests a current market price for a licence is NOK188m or NOK157/kg (compared to NOK121/kg which was the June traffic light auction price).

It would be natural to assume that the stock price appreciation auction has also been reflected by the licence price

Figure 35: Oslo Seafood Index (figures indicate the Green licence round B in March 2014 and the June 2018 traffic-light auction price)



Source: Bloomberg (historical data) DNB Markets (further calculations)

We have adjusted the numbers in Grieg Seafood's tables to reflect the assumption the price of a licence has risen further since its Capital Markets DAY presentation (CMD on 5 September 2018).

Figure 36: Our estimates of the investment need based on a licence price of NOK188m, NOK

Capital employed per kilo	Expanding current MAB	Onshore expansion	Traffic light auction June 2018	Traffic light increase
Licence	0	0	121	158
Smolt phase	3	3	3	3
Post smolt and farming	15	38	15	15
Biomass (working capital)	25	25	25	25
Primary processing	5	5	5	5
Total Capital Employed	**48**	**71**	**169**	**206**
ROCE target 12%	6	9	20	25
Cost	38	38	38	38
Implied break-even price	44	47	58	63

Investment per kilo	Expanding current MAB	Onshore expansion	Traffic light auction June 2018	Traffic light increase
Licence			121	158
Smolt phase	6	6	6	6
Post smolt and farming	30	75	30	30
Primary processing	9	9	9	9
Total Investment	**45**	**90**	**166**	**203**
Biomass (working capital)	25	25	25	25
Total funding needed	**70**	**115**	**191**	**228**

Source: DNB Markets

Appendix

Figure 37: Veolia on the responsibilities clients need to understand

Land (water, ground, access, logistics)
Licences & permits (intake, effluent, production, construction start-up)
Infrastructure
Business case and marked plan
Finances
Client project organisation

Source: Veolia (AIW, Miami – December 2018)

The fish-health toolbox

According to the Norwegian School of Veterinary Science there are five ways to prevent and treat fish diseases:

1 **Pharmaceuticals (antibiotics and anti-parasite pharmaceuticals).** The term ‘infectious diseases’ includes bacterial and virus infections; however, only bacteria can be treated with antibiotics. Antibiotics are a chemical substance that in high dilution inhibit growth or eradicate other microorganisms such as bacteria and fungi. Anti-parasites are substances that eliminate or incapacitate parasites (in salmon farming, mainly sea lice). The main challenges with anti-parasites are increasing resistance and that they are non-specific and therefore can possibly affect non-targeted organisms such as crustaceans.

Only bacteria can be effectively treated with antibiotics

2 **Vaccination.** Prepares and to an extent prevents disease from the relevant pathogen. Effective vaccines are an important factor for sustainable growth in intensive salmon farming systems. The efficacy of vaccines was demonstrated when they virtually eradicated bacterial diseases in fish, reducing fish mortality and dramatically cutting the use of antibiotics in Norwegian aquaculture during the late-1980s/early-1990s.

Vaccination prepares fish for infections and by that prevent disease outbreak

3 **Selective breeding (search for genes that code for resistance against diseases).** Selective breeding is selecting for a desired characteristic; in this case, resistance to selected pathogens. Supported by genetic tools (QTL, MAS), this increased resistance can be inherited. However, disease resistance is often complicated and monitored by several genes, which make heritability low and thereby the selective breeding time-consuming.

Selective breeding is selecting fish that naturally have better resistance to certain pathogens and use them as parents for the next generation

4 **Zoo-sanitary measures (bio-safety).** Constant focus on zoo-sanitary measures like keeping the environment clean and healthy helps the fish to remain healthy and thereby avoid diseases. In general, the key is keeping stress levels low, and therefore operational measures as few and gentle as possible. Stress not only stunts growth but also makes the fish vulnerable to pathogens. Fallowing of farms between generations is important, and used to break disease cycles. Year class separations minimise inter-generational transfer of pathogens and parasites between fish.

A clean and healthy environment will reduce the probability of increased stress levels

Improve the fish environment and resilience. In the event of an outbreak it is important to improve the environment to help the fish either fight the disease or keep it under control. The measures are supposed to limit developing the symptoms (and thereby mortality) and also to reduce the transmission of pathogens. The main focus will be to lower operational measures to a minimum and try to boost the fish’s immune system with health feeds. For listed diseases as ISA and PD extra measures like zones and prolonged fallowing can be imposed by the FSA.

If outbreaks do occur, it is beneficial to limit transmission and mortality by keeping potential stress factors low and boosting the immune system with health feeds

Figure 38: ESG risks and opportunities – Atlantic Sapphire

Transition risks	
Policy and legal	Leader: Well positioned for growth, as regulation in sea is hampered by regulatory framework. Leader: Discharge permits and access to pure water from subterranean sources in Florida. Challenge: Uncharted territory.
Technology	Leader: 'Ground-breaking' production on land. Positioned to be the first large commercial land-based producer.
Market	Leader: No usage of antibiotics and no lice treatment reduces risk. Leader: Very low CO_2 footprint compared to airfreighted salmon to the US.
Reputation	Challenge: Incident with mass mortality at its Danish pilot (test site).
Physical risk	
Acute & Chronic	Challenge may be acute: Lost control on water parameters will have major impact on production e.g. using wrong feed, problems with intake water, sensor errors etc. Leader on Chronic: Control of temperature and what enters the totally land-based systems, should not be any parasites or diseases in systems when control of intake water and entire value chain in system. Leader on land-based: Low mortality and FCR in Danish facilities. Separate water systems reduce risk (the size of consequence) from acute outbreaks in one system.
Opportunities	
Resource efficiency	Leader/Challenge: Better control of water and temperature should improve FCR, though 'fragile' in terms of water quality parameters and hiccups. Leader: Sludge to be used as energy source or fertiliser
Products/Services	Leader: Salmon farming generally is a resource-efficient protein compared with other livestock. Leader: Unique competence and knowledge within RAS.
New markets	Leader: Recommended choice for sustainability concerned consumers. Leader: Differentiated as 'US-made' and low CO_2 footprint.
Supply chain resilience	Leader: Vertically integrated from smolt to end-market (buy feed and eggs externally). Leader: Discharge into the ground rather than out into the sea avoids impact on environment and sea Challenge: Does not own its own strain and is to an extent dependent on feed suppliers having control of its sub-suppliers. Partnership with genetic supplier (EW Group, also part owner)
Information/transparency	
Sustainability report	n.a.
GSI membership	n.a.

Source: Company (underlying information), DNB Markets (review)

How recirculating aquaculture systems (RAS) work

Billund Aquaculture defines recirculation as: "a production unit where the same water is re-used in a closed circuit after passing through a treatment system". Many parameters affect water quality, and therefore growth and welfare of the salmon. The water is continuously treated to keep conditions optimal for fish growth.

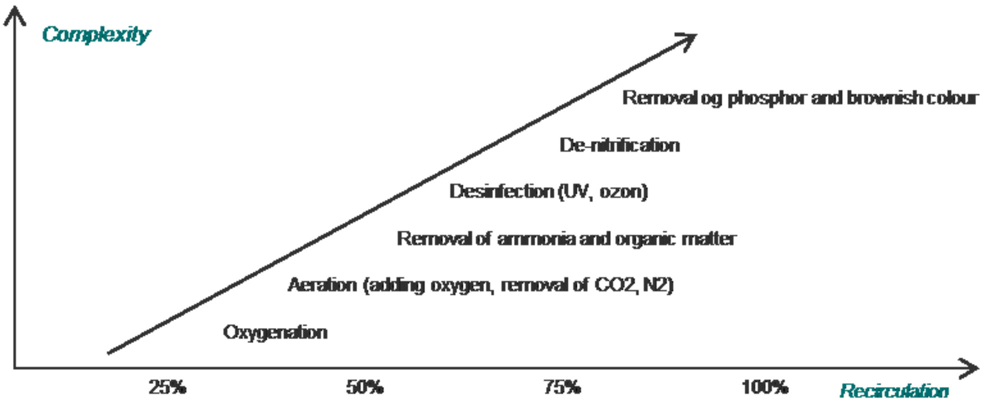
The less water consumed, the more complex a RAS system needs to be. Very complex systems have up to 99.9% recirculation and consist of many different technologies e.g. UV filters, ozone-adding, protein skimmers. These components remove even more particles, bacteria in the water column or other unwanted components in the water.

Below ~99% recirculation there are three main components that need to be removed: organic material (faeces and feed spill), nitrogen waste in the form of ammonium (NH_4^+) and carbon dioxide (CO_2).

3 main components to be removed;
1. organic material
2. nitrogen waste
3. carbon dioxide (CO_2)

The illustration below shows how the higher the degree of recirculation, the more is required from the RAS system, and the more complex the system, due to more components required to reduce water consumption.

Figure 39: RAS system complexity is a function of water consumption to % exchange of system volume = increased complexity with reduced use



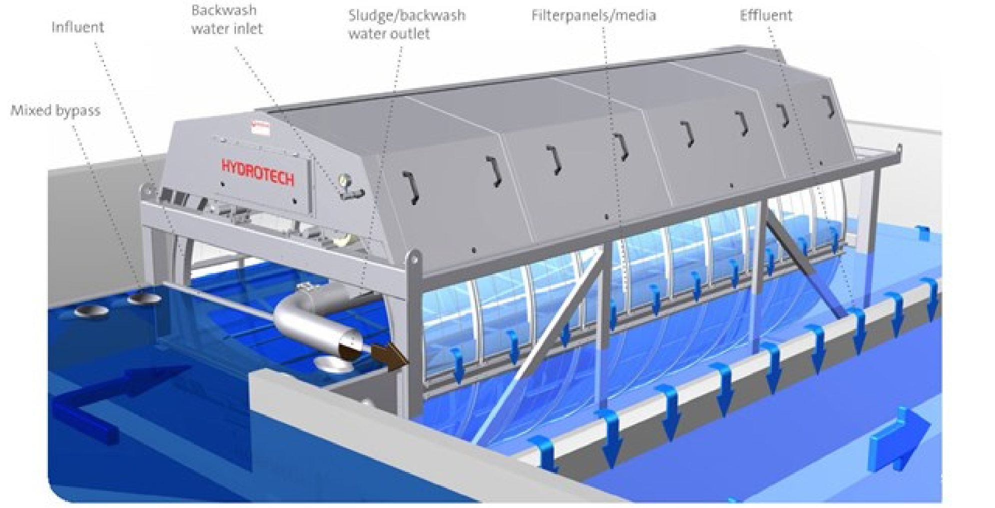
Source: DNB Markets version of Billund Aquaculture illustration from AIW

Oxygenation is performed by a separate system/component in the RAS (degassing can to some extent be included in biofilters). Oxygen is added to the water, and is also used in traditional salmon farming in net pens and in-flow through systems on land.

Aeration degasses gasses like CO_2 and N_2 and gets oxygen concentration to saturation.

Removal of particles – separate, dedicated filters (although submerged fixed biofilters will also do this). Often performed by a drum-filter, as illustrated below.

Figure 40: Organic waste removal, mechanical filter



Source: Hydrotech illustration received from Frode Mathiesen Grieg Seafood

Nitrification

Removal of ammonia, a microbiological process in which ammonium is converted to nitrite and nitrate: one of the main functions of the biofilters.

Disinfection UV and ozone in separate components

Can be performed in many places such as side loops or in the main loop. The two technologies are very different. UV light destroys the DNA in bacteria and viruses.

Denitrification

Nitrate is reduced to nitrite. Then "nitrite is reduced to nitrogen gas, assuming that a substrate in the form of organic matter is present in the water.

Removal of colour

Normally done with ozone.

The different components

Mechanical filter

Particles and solid waste e.g. faecal and other organic material like excess feed are most often removed by a mechanical filter.

Biofilter

See below.

Reoxygenation

The water is reoxygenated with a trickling filter or vacuum degassing. CO_2 and nitrogen gas are removed with aeration using almost 100% O_2; and the pH is normally controlled by adding a base to the water.

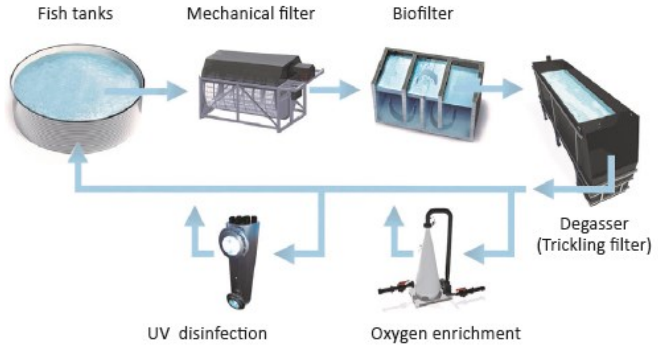
UV disinfection

A RAS also consists of UV disinfection functions and an ozone system that disinfects the water and removes the brownish colour.

Ozone

It is important to control temperature and biosecurity, as is controlling smolt quality, as it is in traditional farming. Several separate tanks in addition to filtering, UV and ozone reduce the chances of an outbreak. Some facilities introduce the salmon as eggs (roe) to reduce the risk.

Figure 41: Simplified illustration of RAS components



Source: FAO, Eurofish International

RAS components ensure water quality, removing particles and chemicals, and maintaining oxygen levels

Different types of biofilters

A RAS needs to treat all the residuals in the system water from fish production. These can generally be split into excretion of ammonia and CO_2 over the gills, and faecal output from the fish gut. The typical RAS design has three main functions:

The typical RAS has three main functions

1. Particle removal
2. Conversion of ammonia (toxic) to nitrate (far less toxic), also called nitrification
3. The degassing of CO_2

Depending on their design, the biofilters will tackle with at least one of the three. The system design addresses the required water quality depending on the fish species and availability of new water. The less water consumed the more complex the RAS system needs to be; highly complex systems have up to 99.9% recirculation.

"The different biofilter technologies – need different management, and management methods are linked to the other equipment in the system. This is a very complex field, and we see a lot of different ways to design systems. But knowledge in the industry is increasing fast, and generally it is my impression systems are becoming more alike", Thue Holm, CTO Atlantic Sapphire.

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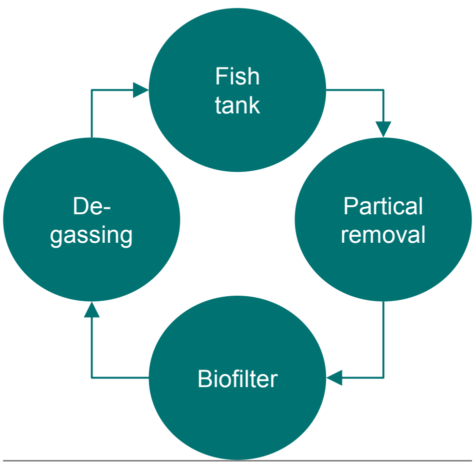
Figure 42: Basic flow in RAS



Source: DNB Markets illustration

Figure 43: Plastic beads, biofilter media

Source: http://www.ecotao.co.za/html/filtermedia.html

The biofilters are one of the most important components in RAS

By far the most important components of a RAS are the biofilter surfaces on which bacteria grow. The biofilter media can be anything from very fine sand, plastic media to glass pearls (the most common currently are plastic – see photo above).

Biofilters used in modern aquaculture can generally be split into three categories: moving bed; fixed filter; and submerged fixed bed.

Fixed filters comprise a mesh structure through which water (and also often air) passes; these systems have a large surface area, and one of their advantages is a low H_2S risk.

Moving bed filters are generally a plastic media kept in suspension by air or stirrers. The advantage is they require no cleaning and generally have large surface areas that hold more bacteria.

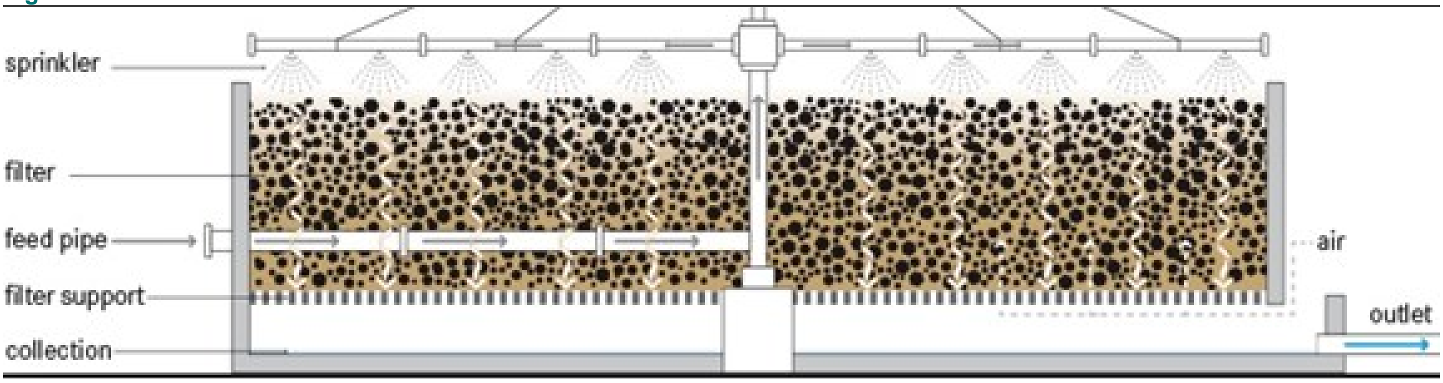
The submerged fixed bed filter is generally designed as a 'sandwich' where the filter plastic media is held between perforated plates through which water flows. The media is static. Over time bacteria and particles will accumulate, and the filter will require cleaning. One advantage is that the filter also catches particles.

Figure 44: Different types of filters

	1. Moving bed	2. Fixed	3. Submerged fixed
Particle removal*	No	Yes	No
Nitrification	Yes	Yes	Yes
Degassing	Some	No	Some
Creates particles	Yes	Rarely	Some
Cleaning needed	No	Yes	Rarely
Biofilter management	Low	High	Medium
Space efficiency	High to medium	High to medium	Low
Capex-intensive**	Medium	High	Low
H_2S risks	Medium to low	High to Low	Very Low

Source: DNB Markets, Thue Holm (CTO Atlantic Sapphire)
*: Some moving beds have drum-filters and some particle removal
**Depending on combination and implementation of solution – this is valid for the biofilter solution itself in modern smolt facilities but not the whole system solution

Figure 45: Fixed with trickle filter



Source: Frode Mathiesen, Grieg Seafood

Figure 46: Moving bed

Source: Thue Holm

Figure 47: Fixed

Source: Thue Holm

Figure 48: Submerged fixed

Source: Thue Holm

Different suppliers use different types of biofilters and often have their own versions of these.

Figure 49: Technology supplier – standard set-up for salmon smolt

Company	Particle removal	Biofilter	Degassing	Others
Akva – Aquatec	Drum filters	Submerged fixed	Diffusers	Ozone
AquaMaof	Sedimentation filter	Submerged fixed	Fixed filter	Ozone
AquaOptima	Drum filters	Moving bed	Fixed filter	Ozone skimmer
Billund Aqua	Drum filters	Submerged fixed	Diffusers and fixed filter	UV
Pentair	Drum filters	Moving bed	Diffusers	Ozone
Others – we do not have information on all suppliers and are aware that many change, or mix and match				

Source: Thue Holm, Atlantic Sapphire

Sludge

Sludge is a waste consisting of resources that can be used for energy creation and fertiliser

The different filters collect particles from the water and are regularly flushed; the particles in flushed water are in concentrated form, referred to as sludge. The sludge from a RAS can be a resource; it has a high energy content in carbohydrates (organic matter) and nutrients such as phosphorus and nitrogen. The sludge is concentrated through two secondary filtration treatments, up to 90% dry matter. For reference, normal garden soil is 50–80% dry matter, 90% is very close to dust. The dryness of the sludge produced from the farm is often decided by the off-take stream. At 30–90% dry matter it can be used in fertiliser pellets, while for biogas the sludge is kept in liquid form so it can be pumped – 8% dry matter. It all depends on the location of the facility, transport costs, off-take usage, and energy costs in the given area.

Land-based facilities must have a discharge plan and permits.

In Norway, local regulators issue a permit, 'discharge certificate', for each facility, setting out restrictions on waste water. Requirements can vary between facilities in a given region and between different regions, depending on 'biological pressure'. For example, according to Sterner, requirements are sometimes stricter in Rogaland and Hordaland than elsewhere in Norway due to high levels of marine activity in the area.

Atlantic Sapphire uses technology provider Scanship in the US and AL2 in Denmark. In Denmark, the sludge is 8% dry matter and used for biogass. Volumes totalling roughly 60m^3 are collected each week, and the company estimates it pays DKK0.08 for the removal of the sludge per kg of fish produced. In the US it expects to have much less volume per kg fish produced since the plan is to have 30% dry matter, but it also estimates 60m^3 weekly collections by volume.

Operating metrics important for returns

Operating metrics to have in mind when looking at land-based salmon farming project

Production cost estimates for land-based facilities are still largely ‘spreadsheet estimates’ rather than ‘empirical data’ based on large-scale and multiple generations; hence, sceptics may be reluctant to accept the validity of ‘equal’ production costs for the two farming methods. Thus previous obstacles created by the large amount of water needed, and energy used for pumping, are no longer an issue.

Key metrics for land-based salmon production include:

- Growth, feed conversion and density
- Feed (see separate section)
- Early maturation
- Taste of product
- Mortality
- Genetics (see separate section)

Growth, feed conversion and density

Control of temperature and feeding need should increase growth and feed conversion as the salmon have more appetite at certain water temperatures, in addition to more control of feeding. The slow fish growth reported by many RAS farms related to bad water quality, specifically CO_2, particles, etc. Furthermore, the poor water quality limits fish density in tanks. Ideal water conditions for salmon are crucial to maximising production (yield per m^3).

Early maturation

Many facilities have struggled with early maturation. This means lower quality and therefore lower prices. Land-based salmon farming systems are closed environments where all parameters can be controlled, responsibility for which falls to site management. It is important to send the right environmental signals to the salmon to avoid maturation. The industry currently has fewer and fewer problems with early maturation. Atlantic Sapphire says that the industry’s issues in the past were linked to poor smoltification, low salinity, poor temperature control, and other biological factors.

Taste

Off-flavours can be produced in the systems, leading to the salmon tasting ‘earthy’. Some land-based farms resolve this with flow through (purging/depurating) for some time before harvesting. Others have developed methods to totally exclude these compounds from their systems. E.g. Atlantic Sapphire does not have purging systems, while Nordic Aquafarms has these in Fredrikstad. The disadvantage with depuration/purging before harvesting is fish weight-loss during purging.

Mortality

It is no secret that some farms have experienced mass mortalities as a result of different issues (see separate section on H_2S). Overall, mortality is fairly low on an ongoing/daily basis in the different facilities around the world; hence, the key is to avoid these major mortality incidents. Construction of systems takes this into consideration to reduce risk; more sensors, alarms, increased biosecurity, and several separate systems (not putting all their eggs in one basket).

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DNB Markets recommendations are based on absolute performance:

Buy	- indicates an expected return greater than 10% within 12 months
Hold	- indicates an expected return between 0 and 10% within 12 months
Sell	- indicates an expected negative return within 12 months

The return-requirement bands above may be applied with some degree of flexibility depending on the liquidity and volatility characteristics of the individual share.

High risk	- Volatility over 40 percent.
Medium risk	- Volatility from 25 percent to 40 percent.
Low risk	- Volatility under 25 percent.

Investing in any security is subject to substantial risk. Return on investment may vary greatly.
Careful consideration for possible financial distress should be accounted for before investing in any security.

Price targets are based on a combination of several valuation methods such as discounted cash flow, pricing based on earnings multiples, multiple on book value, net asset value and peer comparison. Substantial material sources for coverage of this company include historical financial figures and communication with the company, and relevant third party information. If you would like further information on the valuation, methodology or underlying assumptions used in this note, please contact the analyst (contact details on front page).

Recommendation distribution and corporate clients for the last 12 months

	Buy	Hold	Sell	No_rec	Total
Number	142	65	21	12	240
% of total	59%	27%	9%	5%	
DNB Markets client	25%	8%	1%	2%	84

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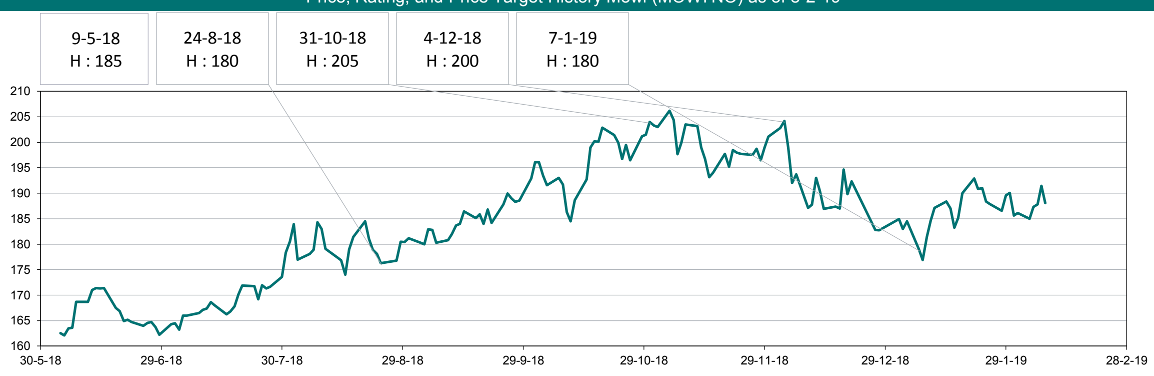
Price, Rating, and Price Target History Mowi (MOWI NO) as of 8-2-19



Source: Factset Estimates (Prices) / DNB (ratings and target price)

Current 6 months volatility rates this security as MEDIUM risk.

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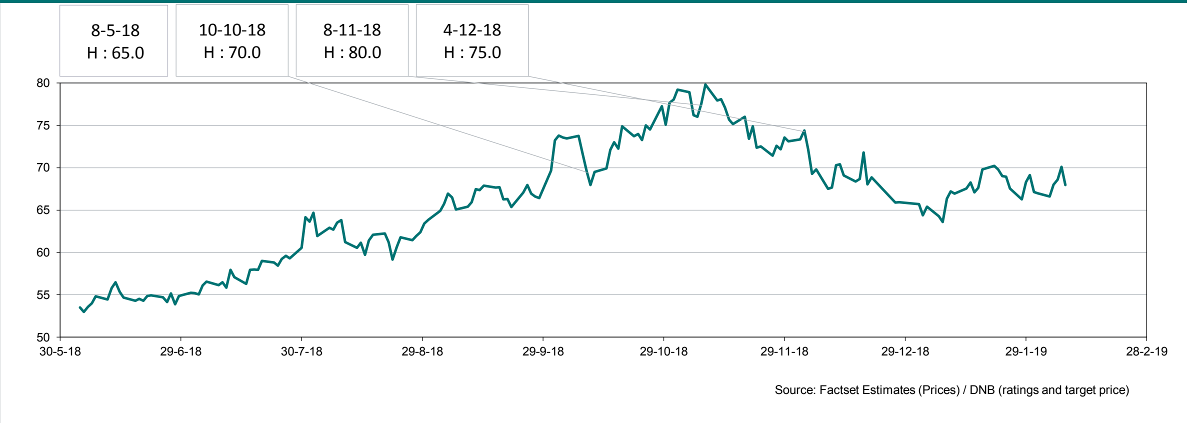
Price, Rating, and Price Target History Lerøy Seafood (LSG NO) as of 8-2-19



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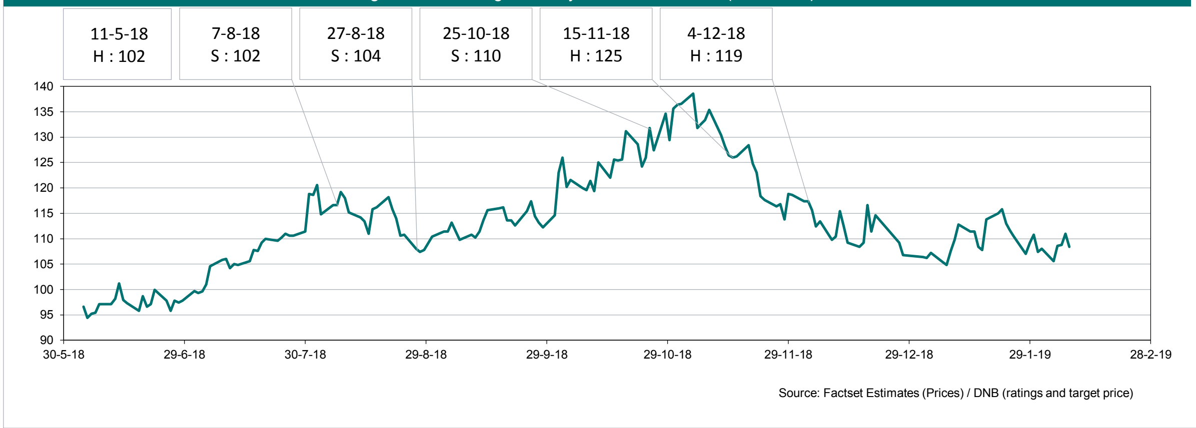
Price, Rating, and Price Target History Austevoll Seafood (AUSS NO) as of 8-2-19



Current 6 months volatility rates this security as MEDIUM risk.

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Number of shares	0	0	0	11/02/2019

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Price, Rating, and Price Target History SalMar (SALM NO) as of 8-2-19

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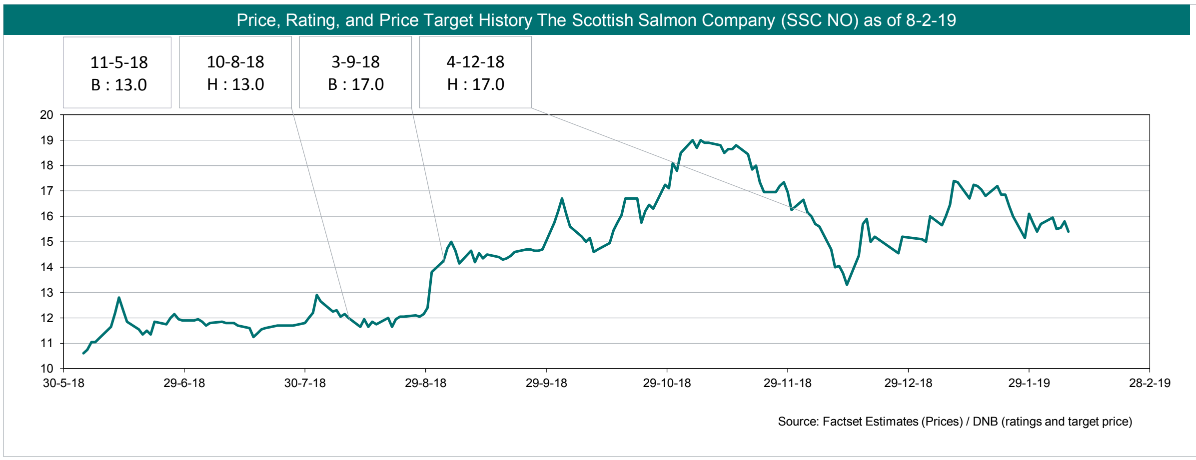

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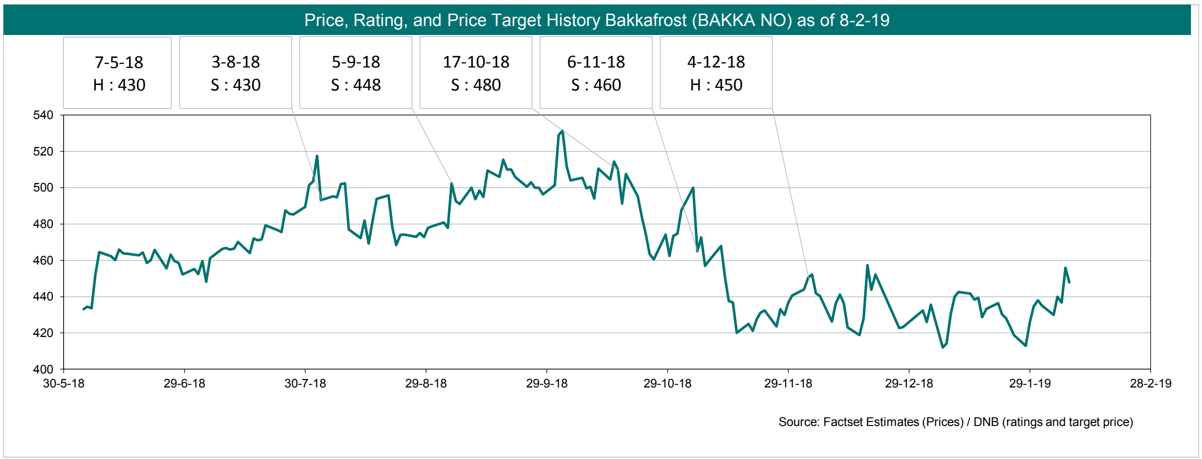

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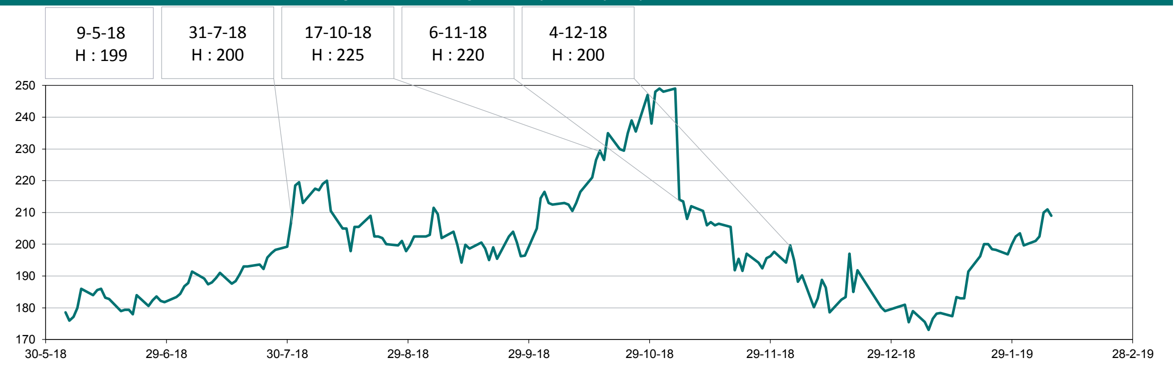
Price, Rating, and Price Target History Norway Royal Salmon (NRS NO) as of 8-2-19



Source: Factset Estimates (Prices) / DNB (ratings and target price)

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Share positions in the company:	Analyst*	Employees**	DNB***	Update
Number of shares	0	0	0	11/02/2019

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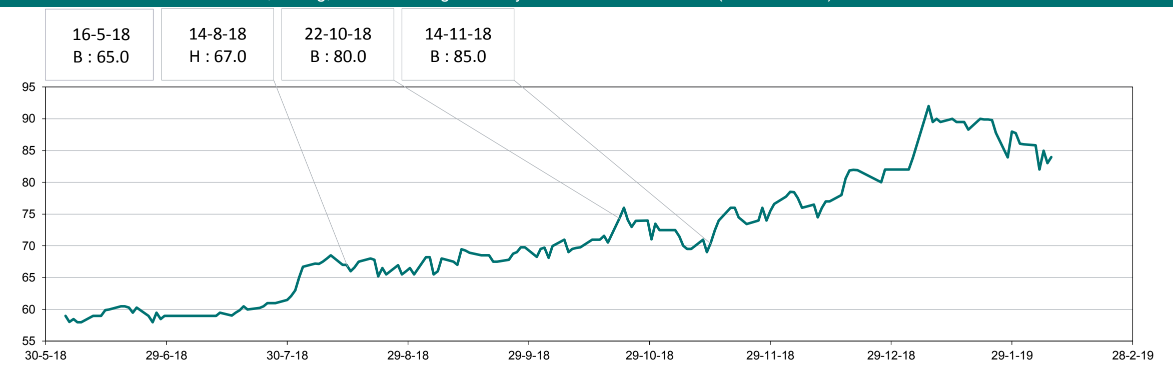
Price, Rating, and Price Target History Salmones Camanchaca (SALMON NO) as of 8-2-19



Source: Factset Estimates (Prices) / DNB (ratings and target price)

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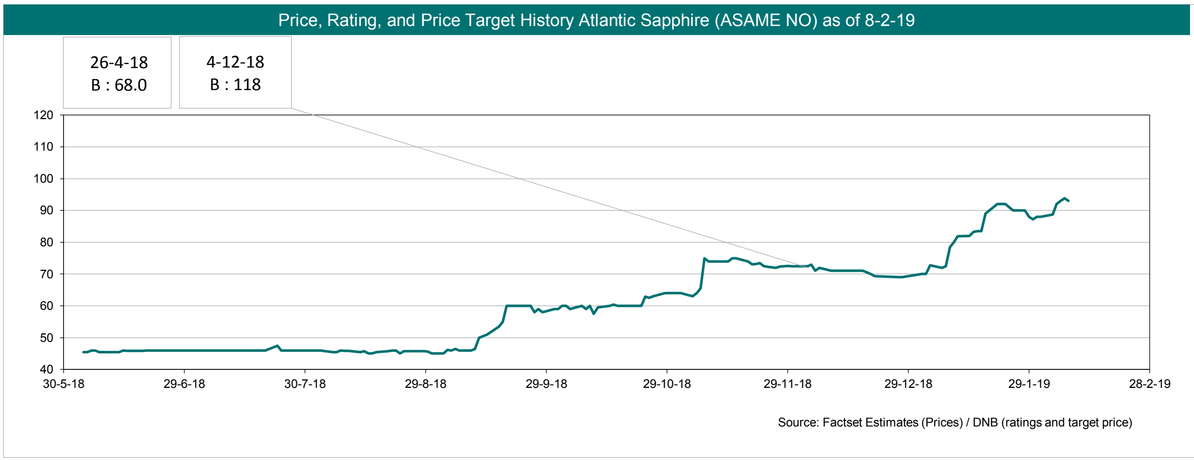

Current 6 months volatility rates this security as MEDIUM risk.

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