EQUITY RESEARCH
Research report prepared by DNB Markets, a division of DNB Bank ASA

1 February 2017

SEAFOOD – SPECIAL REPORT

Deep dive into land-based farming

Prospects for non-conventional farming have never looked better, in our view, and in this report we take a look at land-based farming. Our findings suggest the technology has come further than generally expected and setting up full-scale land-based operations can, under certain conditions, yield acceptable returns. Land-based success or failure will likely depend on traditional farming's ability to resume growth, but we expect meaningful volumes from land-based farming by 2020.

Prospects have never looked better. With supply growth from traditional salmon farming dwindling due to biological concerns and tighter regulatory controls and the cost of acquiring new licences skyrocketing, the prospects for non-traditional farming, such as land-based, look better than ever in our view. With low supply growth, salmon prices are likely to stay high for the next two years, reducing the risk of a price collapse before volumes from a land-based project reach the market. At the same time, production costs for traditional and land-based farming are starting to converge as biological costs for sea-based farming increase and technological advances reduce land-based costs.

Substantial advances in recirculation technology. Recirculating aquaculture systems (RAS) have seen significant technological improvements over the past 5–10 years. Paradoxically, these advances have been driven by the large investments in smolt production made by traditional salmon farmers. The switch from 'flow through' systems to 'recirculation' has reduced water need by 99% and in recirculation the effectiveness has increased 3–4x since 2008. Research suggests an estimated production costs for a mid-sized (3-5kt) land-based facility at NOK37/kg, close to traditional sea-based farming.

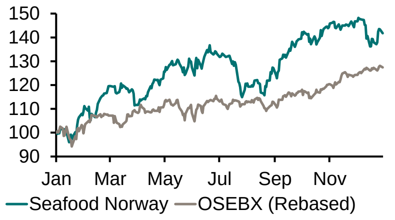
We identify 150kt of land-based projects in the pipeline by 2020. We have carried out a deep dive into land-based projects and identified planned production of 150kt by 2020 from 20+ projects around the world. About 10 projects produced a combined ~7kt in 2016. If all planned land-based expansion materialises, land-based production in 2020 would rival the output from Canada and make land-based the fourth largest 'region'.

Running the numbers reveals decent risk/reward. We have made internal rate of return (IRR) calculations on land-based versus traditional farming, which suggests attractive returns for land-based projects where transport advantages exist. Spreadsheet models are only as good as their input variables, for which there are still few, hence this is our best guess based on available input. Nonetheless, we believe certain land-based projects show good enough prospects to be considered viable investments and believe meaningful volumes from land-based farming will materialise post 2020. Land-based success or failure will depend on traditional farming's ability to resume growth.

Company	Cur	Rec	Target	Price	P/E 16e	P/E 17e	P/E 18e
Austevoll Seafood	NOK	HOLD	82.00	78.25	13.5	9.0	9.4
Bakkafrost	NOK	HOLD	370.0	330.7	16.2	11.5	13.2
Grieg Seafood	NOK	HOLD	80.00	73.25	12.4	7.8	8.0
Lerøy	NOK	HOLD	495.0	459.5	13.6	9.0	9.4
Marine Harvest	NOK	HOLD	165.0	154.1	15.8	10.5	10.5
Norway Royal Salmon	NOK	HOLD	190.0	197.0	16.0	13.0	13.2
SalMar	NOK	BUY	275.0	240.0	14.2	10.0	10.7
The Scottish Salmon Compa	NOK	BUY	10.00	9.69	63.9	10.0	7.2

Source: DNB Markets

Seafood Norway vs OSEBX (12m)



Source: Factset

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Summary

Prospects have never looked better for non-traditional growth

With a muted outlook for traditional growth and expectations for record-high salmon prices, prospects for alternative farming methods look better than ever. We have seen greenfield investments being made in new regions like Iceland (Norway Royal Salmon and SalMar) and Eastern Canada (Grieg Seafood and Marine Harvest) in addition to several new R&D concepts being applied for in Norway. In this report we have decided to focus on the prospects for full-scale land-based farming of salmon.

Sustained high prices with low growth expectations incentivise new technology

Land-based has the largest potential impact on the industry

Out of the non-traditional growth initiatives, we see land-based farming, if successfully developed, as having the largest potential to impact the future of the salmon farming industry. A critical entry barrier to the industry is access to a region/area with suitable natural conditions, an entry barrier which would be lowered significantly if land-based farming can be successfully scaled up.

Land-based could significantly lower the entry barriers to the industry; hence we view it as one of the most critical technologies to watch

Why is it interesting now?

We see land-based farming as more interesting now due to: 1) low growth prospects from traditional farming; 2) the potential for sustained high salmon prices; 3) converging cost levels between land-based and traditional farming as technology improves and biological costs in the sea keep escalating. We have estimated production cost for a mid –sized (3-5kt) land-based farming operation at NOK37/kg, close to sea-based production's NOK36/kg, while some land-based projects suggest even lower production costs; 4) rising licence costs for traditional farming push its up-front investments closer to those of setting up a land-based facility, which would not have to purchase a farming licence.

Estimated land-based production cost of around NOK37/kg (HOG)

We have identified 20+ projects with a planned output of 150kt by 2020

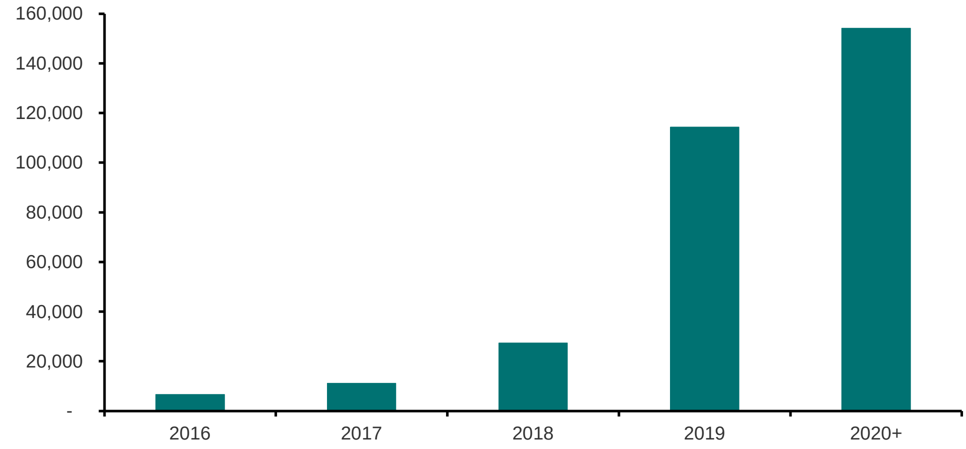
Land-based aquaculture of species other than Atlantic salmon has been around for some time, with production all over the world. The development of recirculating aquaculture systems (RAS), which reuse water, has been a game changer for salmon production, increasing control of water quality and reducing energy costs. It is our impression that RAS is now an 'off the shelf' technology that can be delivered on a turnkey basis with 24-hour support.

Production plans of 150kt would see land-based farming surpassing Canadian output.

Looking more thoroughly at current production and future plans, we find that land-based salmon production has come further and is bigger than we expected. In total, we have identified 20+ projects for full-cycle salmon production on land, with planned capacity of ~150,000 tons i.e. 7% of 2016e volumes (DNB Markets).

Relatively large expansion plans, though less than 10% of current global volumes

Figure 1: Capacity plans full on-growing of salmon (harvest volume, HOG, tons)



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

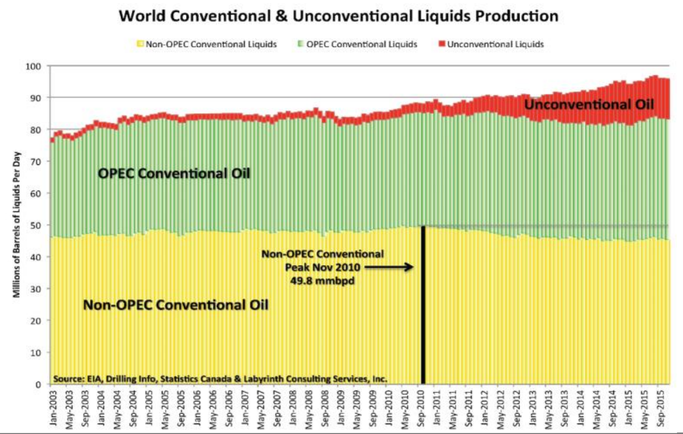
Should we be concerned about higher global supply from land-based farming?

From the oil industry we learned that a high oil price over time incentivised investments in unconventional new technology in order to grow. The share of new “unconventional supply” is actually less than 10% of total supply, but still enough to tip the supply/demand balance out of favour, hence the price. Although the seafood industry differs from oil in several ways, the similarities are plain enough to show how fast an industry can change.

The increased production of unconventional oil was not that large...

Shale production is less than 10% of total oil production

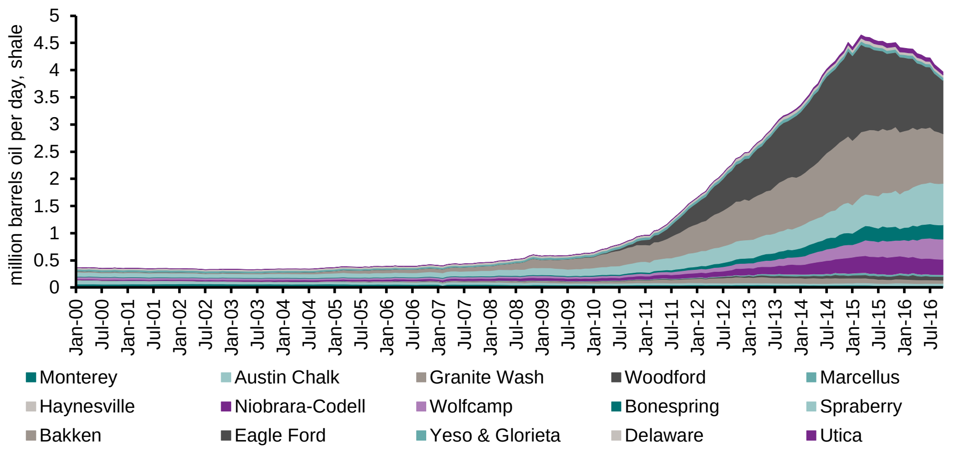
Figure 2: Unconventional volumes of oil



Source: EIA, drilling Info, Statistics Canada & Labyrinth Consulting Services

Another observation from the oil industry is the rapid ramp-up of new technology once it has been accepted. In the graph below, we can see a five-fold increase in shale oil production within four years.

Figure 3: Shale oil production increased fivefold in few years

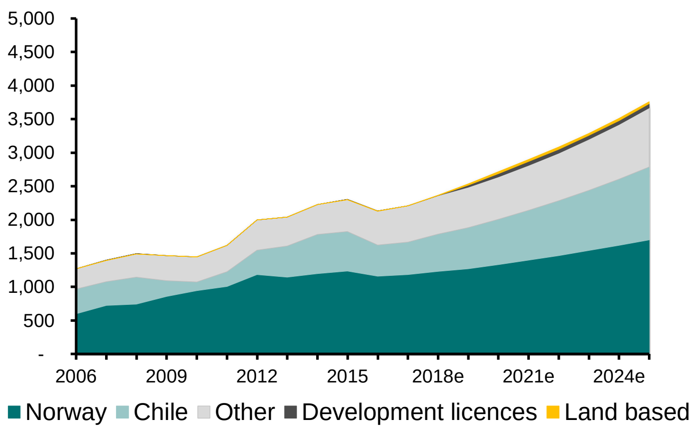


Source: US Energy Information Administration (EIA)

Land-based farming success hinges on pace of supply recovery from traditional farming

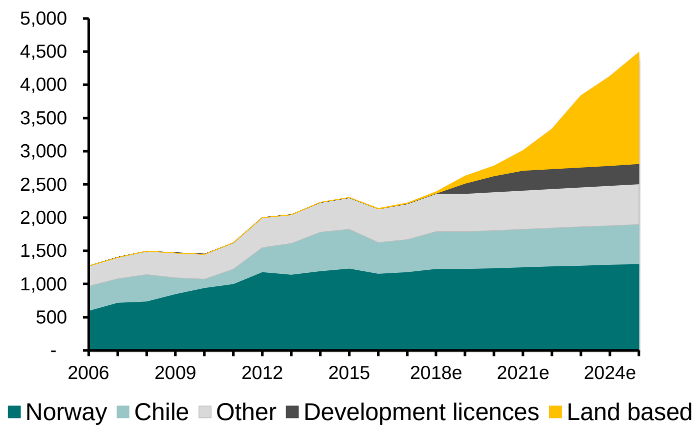
We expect land-based full-cycle production on land to either a) blossom to contribute a substantial share of total production volumes as traditional growth fails to recover, or b) wither, with a few projects causing only a marginal volume contribution as traditional growth manages to recover, reducing the attractiveness of the new technology.

Figure 4: Growth from traditional farming recovers



Source: Kontali(actuals), DNB Markets (estimates)

Figure 5: Land-based take-off as traditional growth fails

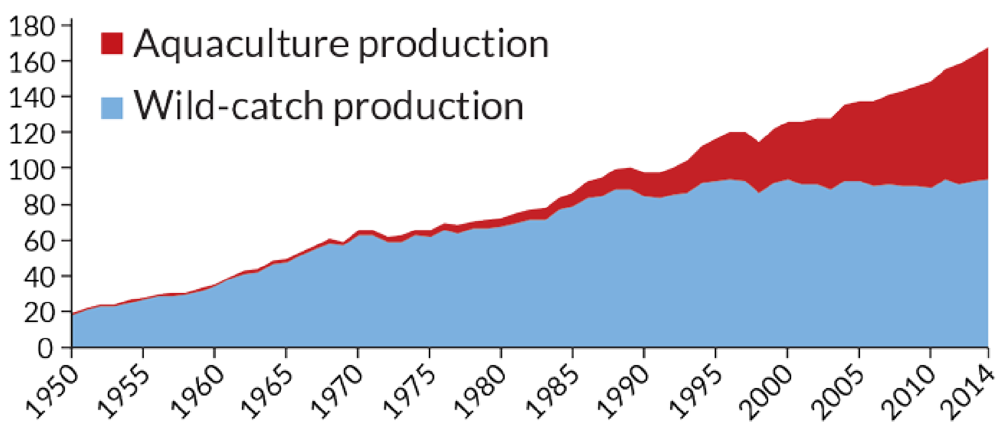


Source: Kontali(actuals), DNB Markets (estimates)

For volumes to blossom, we believe that we would need to see a market situation similar to the current (i.e. high price and low growth expectations relative to demand) for some years as it gives strong incentives to invest in development of technology. If traditional salmon farming or other new technology (e.g. offshore projects) finds a solution to increase growth before the concept is proved in scale, we expect the investments to diminish. As with all new technology, success should result in rapid growth. Past land-based projects have not managed to create more than a tiny niche in the market rather than revolutionising it.

The illustration of land-based take-off looks quite similar to the developments in fish supply for human consumption. The absence of growth from wild-catch triggered aquaculture growth.

Figure 6: Fish supply from wild-catch and aquaculture, million metric tons



Source: FAO 2016

Aquaculture filled the gap when wild-catch failed to grow…

…could land based do the same if traditional farming fails to revive growth?

Challenges remain for land-based farming

Land-based farming still has issues to address

Land-based production still faces several challenges, which could culminate in production output not living up to spreadsheet expectations. Most notably, land-based farming will likely have to deal with: 1) higher fish density (kg/m^3) than traditional farms; 2) early maturity; 3) off-flavouring; and 4) sludge or waste removal and filtration. It is our impression that significant progress has been made on all of these fronts over the past few years.

Scale and location important for land-based salmon production to blossom

We believe the facilities' scale and location in markets where transportation costs are high, will be critical for the industry to take off.

The economies of scale are substantial due to high investments per facility and large fixed costs in production. We note the increasing size of projects compared to already-producing and planned projects. Current production volumes of existing facilities are low, with most of the producing facilities in the range 500–1,000 tons. Facilities planned to come on-stream within a couple of years are bigger, typically at 2,000–10,000 tons, and some with the aim of ~40,000–50,000 tons.

For the industry to blossom, we need large-scale land-based facilities located in the end markets, e.g. US and Asia, where the transport advantage comes into full effect

Though there are facilities in the US and Canada, a large proportion of the advanced facilities for full-cycle production of salmon is located in the Nordics. This may not seem logical with transportation costs to US/Asia at NOK13–18/kg. Based on conversations with founders and investors, the main reasons are the closeness to the competence cluster of knowledgeable farmers and technology providers in the current "proof of concept" stage. In addition, processing and infrastructure is already in place.

Many of the ongoing projects are located close to competence and infrastructure

We expect that the concepts will be rolled out in other regions, in end markets, on a larger scale if proved successful. An example of a player already implementing this strategy is Atlantic Sapphire. Atlantic Sapphire owns Langsand Laks in Denmark, which is currently producing ~700 tons and plans expansion to 2,000 tons, while in Florida Atlantic Sapphire is building a facility with planned capacity of 10x the Danish one.

We expect successful Nordic projects will be used as prototypes for large-scale facilities in US or Asia

Figure 7: Timeline of Atlantic Sapphire

2011-2013 Grow the first generations of harvest in Denmark	PHASE I: 2013-2015	PHASE II: 2015-2016	PHASE III: Start of 2017	PHASE IV: 2019	PHASE V: 2020+
Achieve empirical data on performance	Site selection	Get permits in the US	Construction phase Build the farm	First fish to market	Further growth
Start sales of Danish fish in the US under Atlantic Sapphire brand	Build mgt team	Access incentives and approve financing	Start of production in the US	Optimization if the concept	Raise capital for expansion
	Define production methods	Achieve empirical data performance from Denmark	Start of production in the US	Start branding as an American product	IPO List shares on Oslo Stock Exchange or NYSE
	Financing of pre-project		Expansion in Demark to 2,000 tons/year		
	Achieve empirical data on performance from Denmark				

Source: Atlantic Sapphire, presentation from Freshwater Institute

Atlantic Sapphire is set to be built on technology and lessons learned by Langsand, which produces land-based salmon in Denmark

Internal rate of return (IRR)

Our IRR calculations reveal that a land-based facility with transport advantages should yield the highest return (23% IRR), while the other projects should be in the range 8–15%. The capital structure obviously plays a role for an equity investor and we calculate a 40–16% return on equity based on a 50% equity ratio for land-based and 30% equity ratio for traditional farming projects. These returns are highly sensitive to changes in input variables, and we stress they have deliberately been simplified in order to illustrate the impact of changes in upfront capex and transport advantages under the assumption that production costs are the same for land-based and traditional farming.

Spreadsheets show attractive IRRs for land-based, with transport advantages

Conclusion

Paradoxically, land-based farming's success or failure lies in the hands of traditional farmers as their success or failure in reviving supply growth will determine the attractiveness of land-based projects. In 2011, Marine Harvest was seeking investors for USD10m to finance a "Land Based Pilot Project" where they were to grow salmon to market size (5.5kg) in Canada; however, the plans were cancelled due to supply growth and falling salmon prices (MHG Canada). The same year, Marine Harvest was according to trade press close to giving the green light to plans for a land-based facility in Norway at Askøy, close to Bergen, with a production capacity of 50,000 tons; the plans were later scrapped (IntraFish). Marine Harvest Canada said it was "the first in BC to produce market size Atlantic Salmon in Land Based Tanks"; 2014 marked 10 years of these operations". That year, total production was 100 tons, with an average live weight of 13kg; the fish normally reach 5.5kg in 15 months. The company has said it has conducted analysis and decided against growing more fish on land, as it does

Success of land-based will depend on the success or failure of reviving supply growth from traditional farming

Poor supply-growth outlook in traditional farming means land-based farming gaining foothold looks more likely not consider the risk/reward to be adequate. Since we see limited traditional growth prospects over the coming years, the likelihood of land-based gaining a foothold now looks greater. If growth in traditional farming can be revived, land-based projects would likely be stopped in their tracks as financing would dry up before the commercial viability of the concept can be proven.

Overall, we believe the land-based farming industry is bigger and has come further than expected. Success will depend on a multitude of factors, but we believe the prospects for certain projects, located close to end markets which are far from traditional farming hubs, show good risk/reward characteristics. Although a 100% hit rate on the current 150kt of land-based projects identified is unlikely, we still expect meaningful volumes from land-based farming post 2020 if our current view of marginal supply growth and continued high prices materialises.

We believe meaningful land-based volumes will come post 2020

About land-based farming

Why is land-based farming interesting – what has changed?

There are a number of reasons for the increased interest in land-based production:

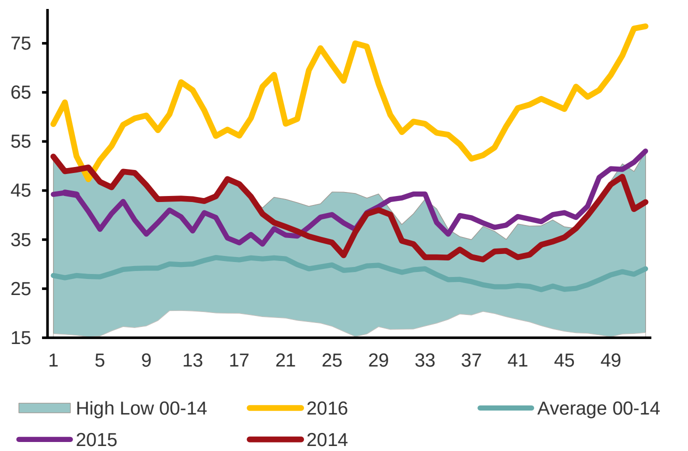
- High salmon price due to:
  - Low growth expectations from traditional farming.
  - High demand
- Converging cost levels between traditional and land-based due to:
  - Biological challenges within traditional farming.
  - Advances in land-based technology.
  - Increased upfront capex for traditional farming due to rising license cost
- Increasing demand and focus on sustainability.

High salmon price

In 2016 salmon achieved record-high prices, both in the spot and forward markets. This has led to discussions on whether the salmon price has found a ‘new normal’. If so, the returns from land-based farming would likely be attractive despite higher capex and production costs.

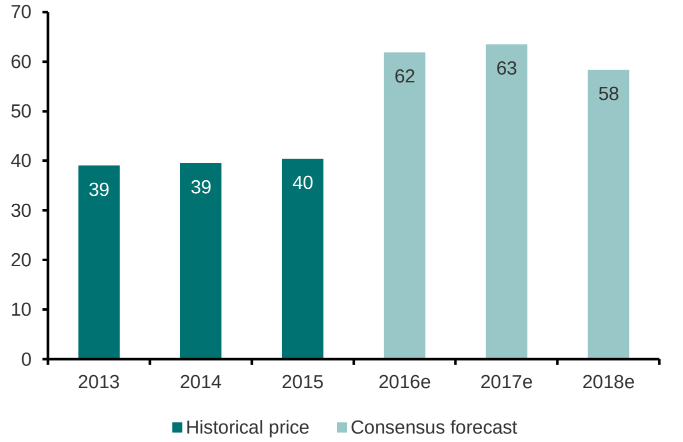
High prices and visibility on continued high prices

Figure 8: Salmon price (NOK/kg)



Source: Fishpool, DNB Markets

Figure 9: Salmon price consensus forecast (NOK/kg)



Source: Fishpool, SME Direkt (consensus forecast)

Low growth expectations

Biological challenges for traditional farming together with strict new regulations in both Norway and Chile are limiting further supply growth. The low supply outlook for traditional farming supports a ‘stronger for longer’ view on salmon prices as well as lower price volatility, as supply is partially out of the farmers’ hands. In order to satisfy demand, more volume will have to come from non-conventional farming and with an outlook for a high and stable salmon price, the risk/reward of investing in new technology has improved.

Biological challenges within traditional farming

Sea-lice and diseases are key challenges for traditional farming. Land-based production gives the potential for lice- and disease-free production with low mortality. No vaccination, antibiotics or pesticides used reduces costs, improves fish welfare and is valued by the customer. The probability of escapees interacting with wild populations is also removed with closed containment on land.

Lice and disease challenges should be reduced when the salmon is produced on land

However, we acknowledge the biological challenges faced by land-based production. It is critical to have control over the water quality in the system (to avoid diseases and ensure growth) and over discharge from the facility. Advanced facilities have had problems that have required them to shut facilities down temporarily; for example, a Danish facility had bacteria entering the facility

Land-based production is not free from biological challenges with intake water. Another Danish facility has struggled with emissions, creating odours and having other environmental impacts, causing discontent in the municipality (sources: Undercurrent News and "FødevareWatch).

Traditional salmon farming costs have increased towards land-based

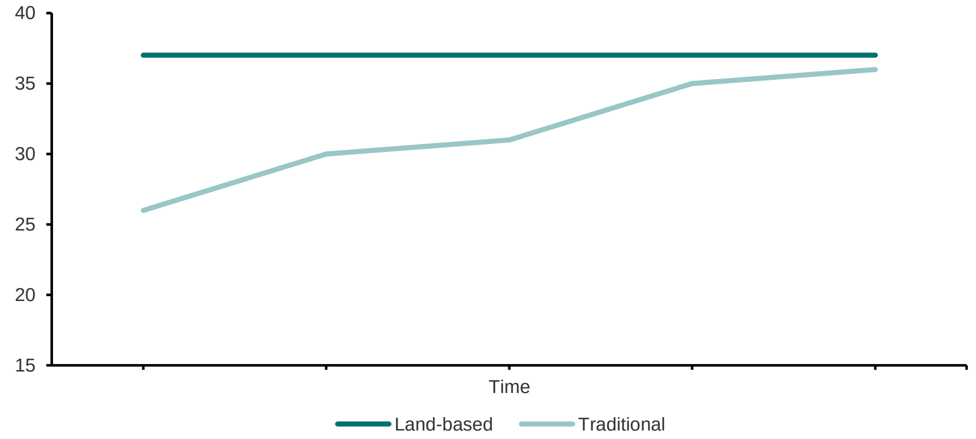
Increased costs for traditional farming

The biological situation, in addition to feed, is one of the main reasons for the increased cost per kg of salmon produced in open net pens. Production costs for traditional farming have increased substantially over recent years; the average cost per kg HOG in Norway increased from NOK26 in 2012 to NOK35 in 2015 and on to an estimated NOK36/kg in 2016.

Removal of hiccups in land-based production is the key to competitive production costs

Overall, we have the impression that cost estimates for land-based production have not changed significantly in recent years, and are not far from those in traditional farming today. We believe that the major factors affecting land-based farming are the experience gained from operating land-based facilities and the development of technology to address initial challenges, which should reduce the amount of costly hiccups in production. Another real kicker for land-based farming is the transport advantage of producing near consumers, saving air freight and increasing shelf life with a fresher product. We estimate that sending salmon from Norway to e.g. the US or Asia costs NOK13–18/kg (we do however acknowledge that the transport advantage was also present in the past, and is per se not 'different' this time around).

Figure 10: Cost per kg HOG, illustrative (NOK)



Source: Directorate of fisheries (traditional), DNB Markets (illustrative for traditional cost)

Technology development

Improved land-based technology

The movement from flow-through technology to recycling technology was a game changer for land-based production (both for smolt and full on-growing) due to the reduced need for water and energy and increased control of water quality. Providers of recirculating aquaculture systems (RAS) now sell full turnkey projects. According to them, the technology is there and is now just waiting to be proved.

Capex required for land-based might not be far from traditional farming

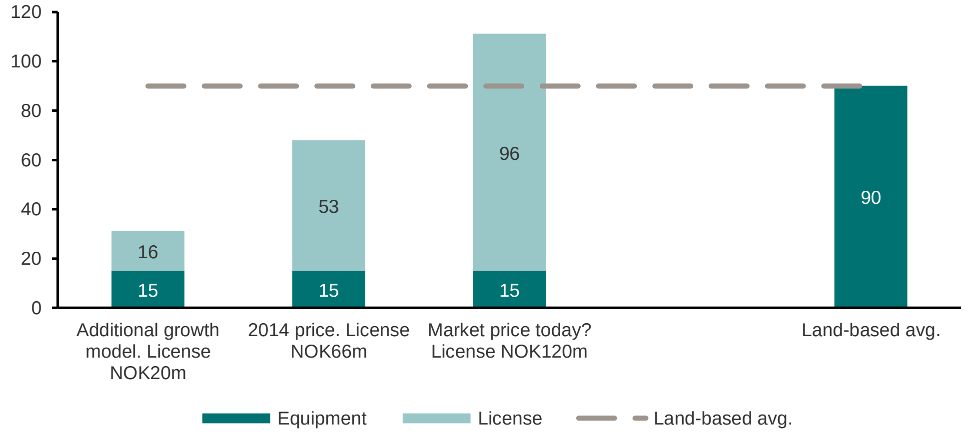
Scale of land-based facilities has reduced capex needed per kg

The difference in capex per kg depends on the assumed price for a licence

Capex per kg of salmon produced in land-based facilities has been reduced due to technological developments enabling facilities to increase in size. The average investment in equipment for large land-based facilities we have identified with production above 1,000 tons is NOK90/kg. Licence for land-based aquaculture is allocated on an ongoing basis without a licence fee. We estimate the investment required in equipment at NOK15/kg for traditional growth. The current price of a licence for traditional farming is uncertain due to the fact that none have been awarded since 2014, when SalMar bid NOK66m for a licence. Since then, the Seafood Index (OSLSFX) has doubled, suggesting the market value of a licence is also higher. To illustrate, we have included three alternative scenarios for the price of a licence below.

- The Norwegian government's scheme to allow producers to apply for 5% maximum allowed biomass (MAB) growth for a fee of NOK1m (which expired in January 2017) suggested a licence cost of NOK20m.
- The price paid by SalMar in 2014 was NOK66m per licence.
- The market price of a licence has increased to NOK120m based on the Oslo Seafood Index having almost doubled since SalMar purchased its NOK66m licence.

Figure 11: Capex (NOK/kg)



Source: DNB Markets

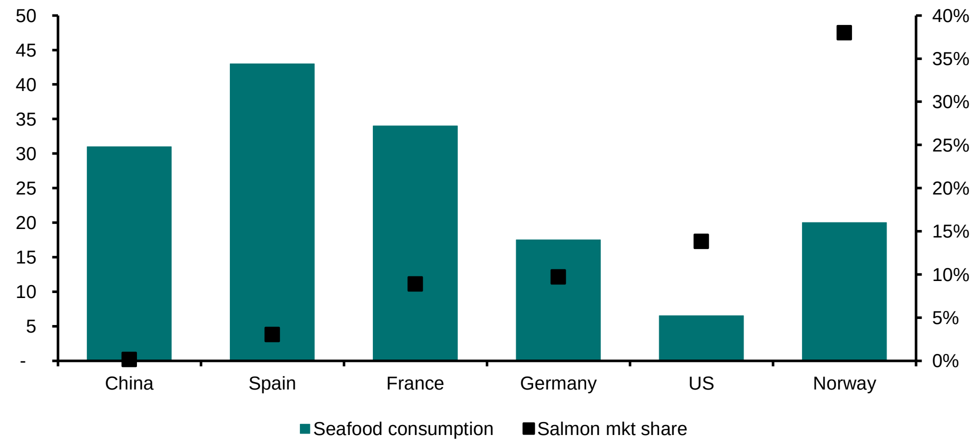
Conscious consumers and more demand from US consumers

US demand for healthy sustainable protein

Sustainability produced salmon achieves premium prices, as observed for the (current low) volumes of land-based salmon sold in US and Canada, through online outlets for USD38/kg. Demand from these regions is increasing, with large untapped potential in terms of salmon consumed per capita.

Despite low seafood consumption in the US and salmon consumption lagging behind European levels, salmon has a strong US market position at 14% of all seafood, compared to 3–10% in Europe. Salmon is the third-most consumed seafood type in the US, after scampi and tuna. This suggests salmon would have a strong position if general seafood growth were to pick up in the US. Even if the US doubled its seafood consumption from 6.5kg to 13kg per capita per annum, it would still consume only about half the amount that Europe does (25kg per capita per annum).

Figure 12: Seafood consumption and salmon's market share

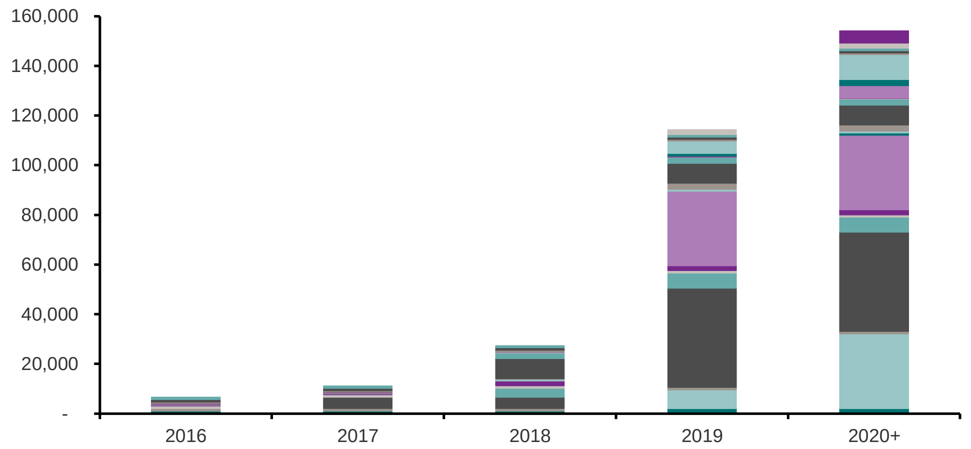


Source: Norwegian Seafood Council, DNB Markets

20+ projects with 150kt output potential identified

We have identified 20+ full cycle land-based projects with a planned output of 150kt by 2020. About half of the projects are producing salmon, but total 2016 output is estimated at only 7kt.

Figure 13: Capacity plans full on-growing of salmon (harvest volume, HOG, kt)



Source: Company information (on volumes in total and distribution if available), DNB Markets (estimate of distribution if not available)
Note: Nekst with 20,000 tons planned capacity not included as this is planned to be only partially land-based (not full on-growing)

There are numerous projects on land-based farming of Atlantic salmon, the majority located in regions familiar with salmon production; the Nordics, Canada and the US. The majority of the facilities are based on RAS technology, i.e. recycling of close to 100% of water.

Figure 14: Land-based full-scale production of salmon

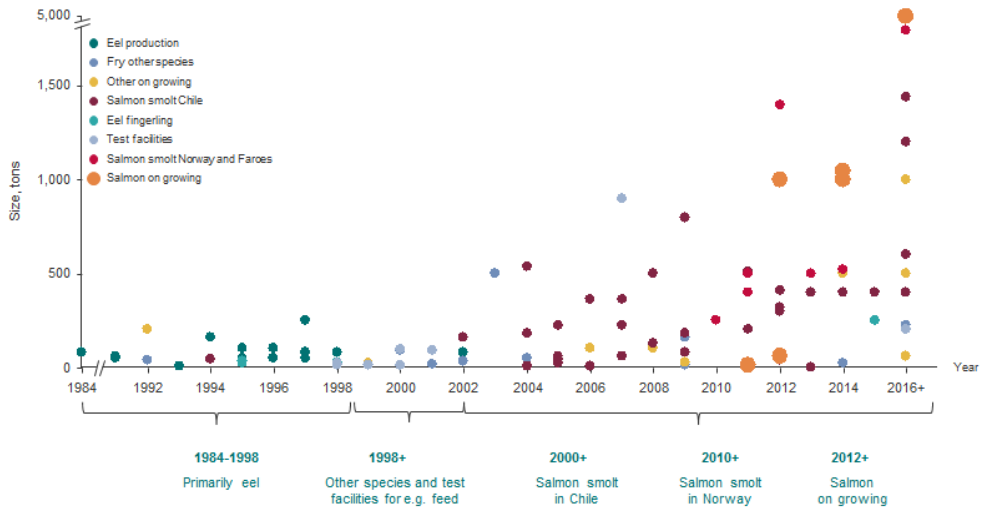
Most land-based facilities are located in the Nordics, US and Canada

Source: Company
Note: Nekst which is only partially land-based is included

The development in the industry of recirculation aquaculture systems (RAS) is illustrated by a leading supplier's reference list. Billund Aquaculture started producing RAS for warm-water species, then for salmon smolt for Chilean companies, before demand for RAS also increased for salmon smolt in Norway and, most recently, for full on-growing of salmon.

Providers of RAS equipment with long-term experience of both salmon smolt and full on-growing of other species

Figure 15: Illustration of Billund Aquaculture reference list



Source: Billund Aquaculture, DNB Markets illustration Note: Some of the facilities are assumed in size by DNB Markets

Land-based company/project overview

Below we have listed the companies and projects we are aware of, but this is not an exhaustive list as information about Asian projects in particular is scarce. There are three major projects of 30–40kt planned for 2019–2020, which make up 100kt out of the total 150kt by 2020. If these projects fail to materialise, the impact from land-based volumes would naturally be lower, but on the flip side, we could easily see an addition of 2–4 such large projects announced over the next 12 months.

Figure 16: Project and ramp-up plan for land-based volumes (kt)

	Project name	2016	2017	2018	2019	2020+
1	Project A	1,000	1,000	1,000	2,000	2,000
2	Project B	1,000	1,000	1,000	1,000	1,000
3	Project C	1,000	1,000	1,000	1,000	1,000
4	Project D	400	400	2,000	2,000	2,000
5	Project E	200	200	700	700	700
6	Project F	250	250	250	2,500	2,500
7	Project G	200	200	200	200	200
8	Project H	600	600	600	600	600
9	Project H	1,000	1,000	1,000	1,000	1,000
10	Project I	1,000	1,000	1,000	1,000	1,000
11	Project J	-	4,500	4,500	40,000	40,000
12	Project K	-	-	8,000	8,000	8,000
13	Project L	-	-	3,600	6,000	6,000
14	Project M	-	-	2,400	2,400	2,400
15	Project N	-	-	200	200	200
16	Project O	-	-	-	7,500	30,000
17	Project P	-	-	-	30,000	30,000
18	Project Q	-	-	-	200	5,000
19	Project R	-	-	-	1,000	2,500
20	Project S	-	-	-	5,000	10,000
21	Project T	-	-	-	2,000	2,000
22	Project U	-	-	-	-	5,000
23	Project V	-	-	-	-	1,000
24	Project W (partly in sea)					
	Total	**6,650**	**11,150**	**27,450**	**114,300**	**154,100**

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

For a full description of projects, please contact your DNB representative.

Dividing the numerous land-based projects into categories

Groups of land-based projects

Going through the list of projects identified, we have categorised projects on full-cycle land-based salmon production with certain similarities.

- Producing ~1,000–2000 tons
- Planned production >3,000 tons
- Large projects ~10,000+ tons
- R&D based >1,000 tons

Producing ~1,000–2,000 tons

Ongoing production of 1,000–2,000 tons, located in Denmark and Poland

There are a handful of projects, mostly European, with a capacity of 1,000–2,000 tons, which have been around for some years and are currently selling salmon produced to harvest size in land-based facilities. As one would expect, these early-mover companies have had some production challenges along the way, which have necessitated additional investment and higher production costs from what was initially planned.

Online outlets sell land-based salmon at a premium price

A Canadian land-based farmer is currently selling Atlantic salmon at a significant premium. The production involves the entire production cycle – from roe until harvest. First eggs were stocked in January 2014 and first salmon was sold in September 2015. The salmon is branded as "sustainably-farmed fresh Atlantic Salmon", and is possible to buy online, with a price tag on the fillet (32oz i.e. 900 grams) of USD37.99/kg (December 2016). The salmon is recommended by Ocean Wise (trademark), which is a conservation program ensuring that correct information is passed to restaurant and markets, helping them to make ocean-friendly buying decisions. Its production volumes are lower than the European ones in this group, currently at 200 tons, with plans to increase volumes by 500 tons. This company is grouped together with these as the farmer has a more commercial profile than the other smaller US/Canadian companies with an R&D profile.

Planned production >3,000 tons

Planned projects at >3,000 tons

Currently there are several projects with somewhat more ambitious production volumes. These are currently being built or are close to construction start. One of the facilities closest to production is a Norwegian company which has started to build its facilities and plans for 6,000 tons of production volume. The company is part of a Group, also producing other species (land-based production of premium sushi fish) in Denmark using the exact same technology.

Other projects in this category are located in the US and Norway. We believe that most of the projects in this group will work as prototypes, with facilities built based on the same technology and increased scale, if proved successful.

Large projects >10,000 tons

Large projects >10,000 tons currently in financing phase

There are also some projects that already have quite ambitious production volumes. Several of these projects have founders with experience in land-based production: One in Florida, the US and one in Scotland. In Norway there are other examples of ambitious projects in terms of volumes. None of the large-scale facilities is yet constructed, and as far as we know are in the financing phase.

R&D based >1,000 tons

R&D based >1,000 tons

There are 2–3 facilities with land-based production of salmon at a smaller scale (~500 tons). These have been around for quite some time in Canada and the US, e.g. Kuterra (Canada), Canaqua (Canada), and Freshwater Institute (US). The projects appear to be moving from a R&D phase towards more commercial production. Expansion plans include Kuterra (from 200 to 2,000 tons) and Canaqua (from 250 to 2,500 tons). This sustainable land-based production is supported by local authorities and organisations in Canada and US, with the objective of protecting the coastline from traditional farming. Kuterra and Freshwater Institute bring research and knowledge to benefit the entire industry (see section on Research centres). Nofima's facilities in Sunndalsøra are included in the table below to show that R&D is not only performed in US/Canada. Note that production is dependent on current research projects.

A description of all projects found on land-based salmon farming identified during our research is included in the Appendix. Note that the list is continuously increasing, and there are a number of rumoured projects with less information available e.g. in China.

Figure 17: Categories of land-based farmers

	i. Producing	ii. Mid-sized	iii. Large	iv. Small (R&D)	v. Other / less info
Europe	Company A Company B Company C Company H	Company L Company M Company R Company V Company W	Company K Company Q Company X*	*Nofima Sunndalsøra (R&D only)	Company I Company J Company O Company U Other 1 Other 2 Other 3
US /Can	Company E	Company N Company O Company S Company T	Company P	Kuterra Canaqua Freshwater Institute	

Source: Companies Note: Company X is partly in sea

Technological developments

Reduced water needs

The land-based salmon production trials in the late 1980s and early 1990s can be described as ‘garage scale systems’. The flow-through systems (not recirculating water) required huge amounts of water (e.g. 25,000 m^3/day for facility feeding 500kg per day) , and the control on water quality was not satisfactory. This resulted in significant challenges for fish health, including bacterial gill disease. Developments have focused on larger facilities that are more efficient with lower investment per production capacity. In 2008 a large RAS facility for smolt had a capacity of 2 tons of feed per day and tanks at 250–400m^3, while in 2016 this was increased 3–4x, with systems capable of 20 tons of feed per day with tanks at 1,000m^3. Requests are also received for larger projects at 100+ tons of feed per day (source: Kruger Kaldnes).

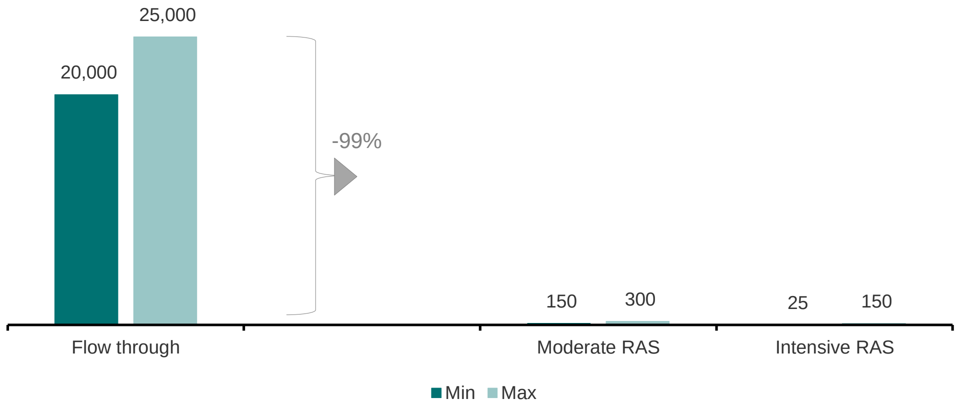
Previously most land-based production was based on flow-through systems, requiring a tremendous amount of water

The development of technology from flow-through systems to RAS with ~99% recycling of water has been a game changer. Thus previous obstacles created by enormous water requirements and energy used for pumping is reduced. Recycling of the water also increases control of the water quality and other operating measures.

The technological development of land-based facilities has moved towards low-water use and increased scale

The table below, with numbers from Billund Aquaculture, shows the reduced need for water with RAS. If the water exchange is 300 litres of new water per day per kg feed and the facility use 500kg of fish feed per day in the RAS, the total daily water exchange will be 150m^3/day (i.e. 6.25 m^3/hour) versus 20,000–25,000m^3/day(i.e. 1,000m^3/hour) with flow-through systems.

Figure 18: Reduction in water need with RAS from FT, new water per day (m3)



Source: Billund Aquaculture, Note: Example with 500kg feed/day

Figure 19: Water need with different systems

	New water per kg feed		Estimated new water per day	
M^3	Min	Max	Min	Max
Intensive RAS	50	300	25	150
Moderate RAS	300	600	150	300
Flow Through	40,000	50,000	20,000	25,000
Assumed feeding per day	500	500	500	500

Source: Billund Aquaculture

Quality issues

Key focus areas include solutions to early maturity and off-flavouring (taste) including own tanks for purging, lightening, temperature and the use of female stocks only (a large proportion of the male population matures early) (Warrer Hansen, 2016). According to equipment providers, methods to successfully overcome off-flavouring issues are being implemented. Early maturation in land-based salmon production has been cut from around 35% to 5% through improved farming methods (Billund Aquaculture, 2014). Increased output from land-based facilities is achieved through increased growth and density. A more thorough description of important operation parameters is included later in this report.

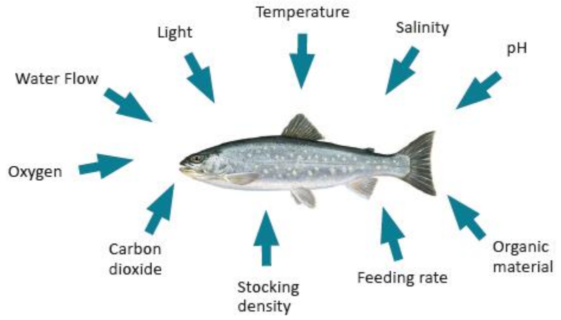
How recirculating aquaculture systems (RAS) work

The definition of recirculation given by Billund Aquaculture is:

“Recirculation is a production unit where the same water is re-used in a closed circuit after passing through a treatment system”

Many parameters affect the water quality, and hence growth and welfare of the salmon. The water is treated on a continuous basis to keep conditions optimal for the salmon’s growth.

Figure 20: Parameters affecting growth



Source: FAO, Eurofish International

A series of filtration processes are performed on the frequently renewed water. The most important elements in the RAS are:

- Mechanical filter
- Biofilter
- Reoxygenation
- UV disinfection
- OzoneMechanical filter

A series of processes is required to ensure good growth conditions for the salmon

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

Biofilter

Ammonia and CO2 are waste products from the salmon, and a high concentration would be toxic for the fish. The biofilter captures small particles and consists of bacteria, which convert ammonia to nitrate. The bacteria produce CO2, and acid is released during the nitrification process.

Reoxygenation

The water is reoxygenated with a trickling filter or vacuum degassing. CO2 and Nitrogen gas is removed with aeration using almost 100% O2, and the pH is normally controlled through adding a base to the water.

UV disinfection

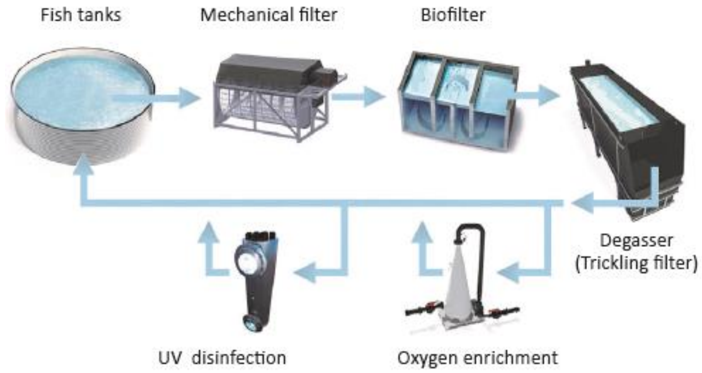
In addition a RAS consists of UV disinfection and an ozone system that disinfects the water and removes the brownish colour.

Ozone

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

RAS components ensuring water quality removing particles, chemicals and ensuring oxygen level

Figure 21: Simplified illustration of RAS components



Source: FAO, Eurofish International

Sludge

The RAS filters have to be cleaned frequently to ensure stable water quality. The process of rinsing and flushing the filters creates waste water that contains small amounts of sludge/dry material, often measured in terms of the percentage of dry solids (DS). Initially the water consists of ~0.01% DS, and a drying process takes the percentage to 30–90%. A higher DS percentage means a lower volume and hence more effective waste disposal. Higher DS has also been found to reduce biological activity significantly when the content of water is less than 10% (i.e. 90% DS). This entails reduced smell, meaning that the waste may be stored for longer (source: Sterner).

The water used for cleaning filters is included in the water needed (and accounted for in the recirculation degree). The volume of sludge created by a facility may vary substantially, but as a rule of thumb one creates 2.5 litres of liquid with 5% DS sludge from 1kg of fish feed (source: Sterner). Excess feeding may increase this ratio. Hence, the sludge created from production can be reduced with improved feed quality and feeding-system technology. Fish-feed providers sell specialised feed for RAS, with less discharge; this improves water quality and biofilter capacity (e.g. BioMar’s ORBIT and EWOS’ Clear).

Sludge can be used as fertiliser

There is ongoing R&D in the field of using waste as fertiliser or an energy source. The sludge from salmon smolt consists of 20–40% inorganic material, including phosphor and nitrogen, which can be used as fertiliser. The ability to use the waste as fertiliser depends on the components in the waste; this in turn depends largely on the feed (e.g. if the feed contains cadmium and zinc, the waste will also include these heavy metals. The sludge consists of 60–80% organic material that may be used to create energy; biogas is created by breaking down the easily degradable components of sludge such as protein, fat and carbohydrates into methane and carbon dioxide (source: Sterner).

In Norway, Local regulators issue a permit, “discharge certificate”, for each facility, specifying restrictions on waste water. The requirements may vary between facilities in one region and between different regions depending on the “biological pressure” in the area. For example, requirements are sometimes stricter in Rogaland and Hordaland due to high levels of marine activity in the area (source: Sterner).

Operational metrics important for return

Production cost estimates for land-based facilities are still largely ‘spreadsheet estimates’ rather than real-life based on large scale and multiple generations, hence sceptics will be reluctant to accept the validity of ‘equal’ production cost for the two farming methods. However, the movement from flow-through systems to RAS with ~99% recycling water is set to be a game changer. Thus previous obstacles created by the large amount of water needed, and energy used for pumping, are no longer there.

Key metrics for land-based salmon production include:

- Growth
- Feed conversion
- Density
- Early maturation
- Taste on product
- Mortality

Growth and feed conversion

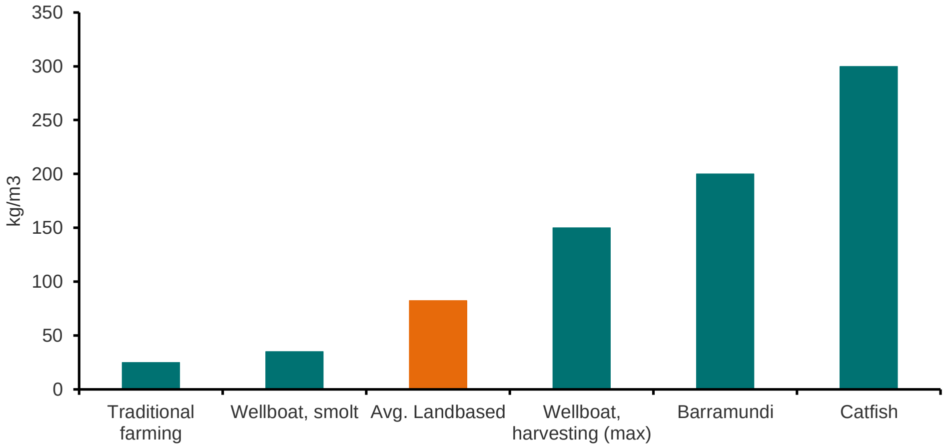
Control of temperature and feeding need should increase growth and feed conversion as the salmon have more appetite at certain temperature levels, in addition to more control of feeding. The temperature level needs to be optimised as in addition to increasing appetite, high temperatures have also been shown to affect maturation. Feed raw materials and quality also affect growth (and water quality), hence feed companies have created specialised feed for RAS production (e.g. BioMar’s ORBIT and EWOS CLEAR.

Control of temperature increase growth and feed conversion

Density (kg/m^3)

Naturally, the more fish produced per cbm, the better the return. The economy of a land-based project is dependent on the density of fish in tanks, which is much higher in than in sea-based pens. Studies show that salmon may be stocked at 75–80kg/m^3 without causing stress i.e. increasing levels of cortisol(Nofima). This density is well above the maximum allowed 25kg/m^3 in sea-based pens, ~40–50 in well boats during smolt transfer (higher when transported for harvesting), while much lower than some of the species that have been farmed on land for a longer time. E.g. Catfish at 400–600kg/m^3 (source: fao.org).

Figure 22: Density benchmarking

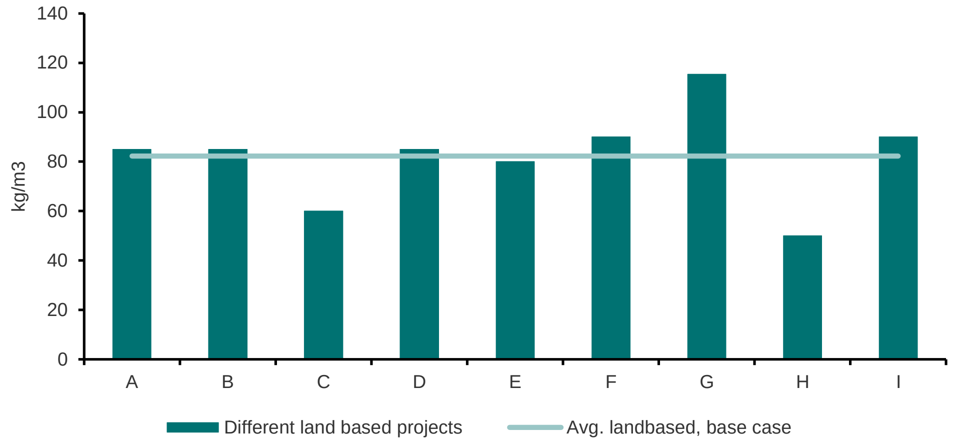


Source: Publicly available information

Land-based production of salmon has a much higher density than traditional farming in open net pens

The base case density in projects giving information on current or planned density is ~80kg/m^3 on average. This often varies throughout the cycle, and the projects we have looked at have the highest density in the last phase of on-growing before purging.

Figure 23: Density of land-based projects



Source: Companies

Land-based production has a density in production well above the maximum level of 25kg/m^3 in open net pens. The density of land-based production of salmon is not that remarkable when benchmarked towards salmon transported for harvesting and other land-based aquaculture.

Other species are farmed at a much higher density than Atlantic salmon

Early maturation

Solving challenges with early maturation is a top priority for the technology suppliers and a key area for R&D. Early maturation deteriorates flesh quality. Elements shown to have an effect on maturation are salinity, temperature and gender. Hence many of the facilities use brackish or marine water with a certain level of salinity (R&D is ongoing to determine the optimal level), in addition to only female eggs. The temperature is a trade-off as cooler temperatures may reduce maturity, but also growth (and hence feed conversion). Other strategies include lighting regime and stocking density. Salmon produced in land-based facilities has reduced early maturation from around 35% to 5% through improved farming methods (Billund Aquaculture, 2014).

Early maturation reduced from 35% to 5%

Off-flavouring

Off-flavouring, which means deterioration of taste, is described by some as an earthy flavour. The taste is created as the salmon absorb and accumulate flavour-changing elements in their fatty flesh. Off-flavouring is mainly solved through purging: kept off feed for ~1–2 weeks before harvesting. According to one of the equipment suppliers, the purging is often performed in tanks with flow-through systems. Examples of ongoing R&D in improved purging are work-out regimes.

To avoid off-flavouring, the last phase of production includes purging i.e. starvation of the fish for the 1–2 weeks before harvesting

Mortality

Mortality is assumed to be lower for land-based production due to reduced challenges with lice and predators (e.g. birds). Low mortality is naturally dependent on good control of water conditions and the quality of the fish/roe introduced to tanks.

Other areas of R&D include waste water and sludge capture and treatment. Sludge could be a resource, either as energy or fertiliser. In addition, substantial efforts are being made to reduce costs and in defining optimal water quality conditions.

Figure 24: Langsand challenges and solutions

Bacteria and diseases	Filtration of intake water PCR screening
High CO2 in tanks	Increase degassing and flow
Production cost	Increase production volume and improve purchasing
Early maturation	New pipeline, Ozone, LED lights, grading
High harvest costs	Stun, bleed, gutting and packaging on site
Water quality and clarity	Ozone and skimmer system
Off flavor	Managing water quality – harvesting directly out of tanks

Source: Atlantic Sapphire

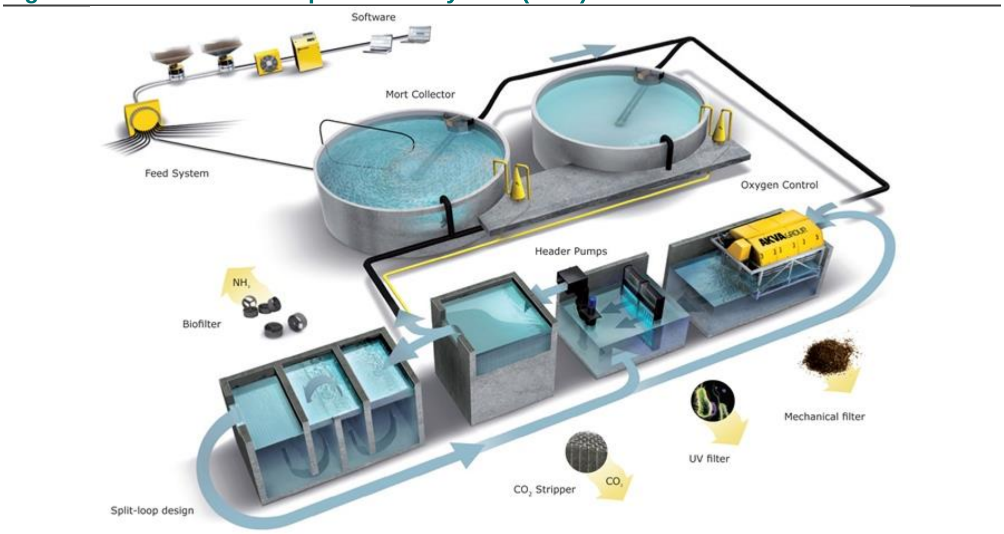
Different types of land-based systems

The newer systems simulate the nature using seawater for the on-growing phase

The facilities differ in terms of water: there are examples of freshwater only, brackish water, seawater and a combination of fresh- and seawater. Seawater for on-growing appears to be more common for newer facilities. The equipment providers say that there are fewer difficulties with early maturation when using seawater for on-growing. According to several equipment-providers, RAS for seawater is not more complicated to design and build, but the biofilter needs to be bigger and naturally the equipment used needs to be 'saltwater-proof'. Hence, the investment cost is somewhat higher, though not substantially, estimated at roughly 10% by Billund Aquaculture.

The size of the smolt when released into the tanks may vary both between cohorts, tanks and facilities. The salmon may be raised from a very small size (even roe), with separate tanks for different sizes, using freshwater for smolt and seawater for on-growing. The smolt phase in freshwater and on-growing in seawater is in line with the 'nature'.

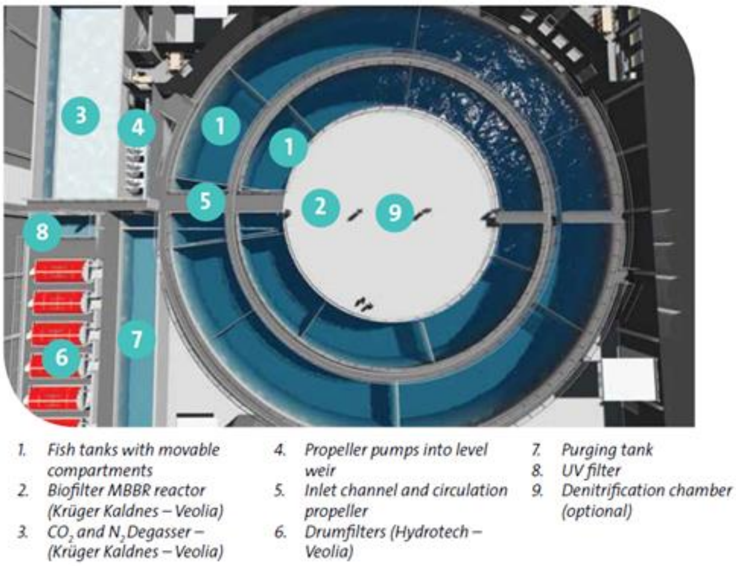
Figure 25: Recirculation Aquaculture System (RAS)



Source: AKVA Group

One of the more recent 'concentric tank' concepts has shared tank walls both inter-tank and (possibly) for the treatment system. Both Inter Aqua and Veolia (Kruger Kaldnes /Gråkjær) have this type of concept, e.g. the RAS2020 system of Veolia (Gråkjær/Kruger Kaldnes).

Figure 26: RAS2020



Source: Kruger Kaldnes

There are substantial R&D efforts going into improving land-based technology with the goal to increase control and understanding of biological parameters/water quality affecting fish health and welfare.

Suppliers of equipment and technology

While the founders of projects have a varying track record and experience from aquaculture, the suppliers of the technology are highly experienced within aquaculture and recycling technology. Several of the technology suppliers deliver large RAS for post-smolt to the world's leading salmon farmers, and/or facilities for full on-growing of other species.

The suppliers of technology are highly experienced within aquaculture

The headquarters of known technology providers are mostly located in the Nordics. The majority of the suppliers specialise in recycling technology (RAS) and are heading towards turnkey projects. They call themselves total suppliers as they are involved from the sketching and design of the facility, to construction, training of personnel and maintenance, with some providing a 24-hour hotline.

Suppliers deliver turnkey plants with 24 hours support service. In our opinion the technology appear to be 'off the shelf'

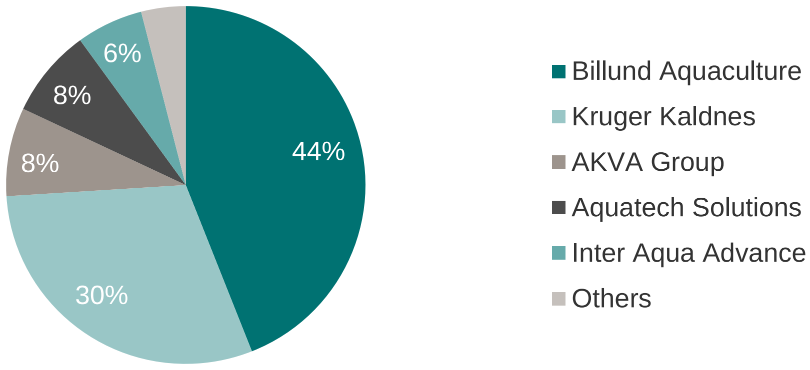
Figure 27: Identified suppliers of land-based facilities

Most of the specialised suppliers are located in Northern Europe

Source: Companies, DNB Markets illustration

According to Billund Aquaculture, approximately 30% of smolt production in Norway is based on RAS. The suppliers of these systems include the leading providers of systems for full-scale land-based salmon production.

Figure 28: RAS suppliers part of salmon smolt production in Norway



Source: Billund Aquaculture. Distibution based on # smolt produced in 2015 Note: Aquatec solutions is owned by AKVA group. Note that Kruger Kaldnes has built more facilities than Billund since then and hence increased its share

The technology providers of systems for full life-cycle on land are the ones building smolt-RAS for salmon farmers

The three largest providers of RAS for smolt also appear to be the largest suppliers to full-cycle land-based production: Veolia (Kruger Kaldnes and Gråkjær), AKVA group and Billund Aquaculture. These three have built 90% of RAS for smolt production in Norway when including Aquatec Solutions' figures in AKVA group's (source: Billund Aquaculture). All of them have experience of full on-growing, of which we know Veolia and Billund have current projects while AKVA Group focuses on RAS for salmon smolt at the time.

90% of RAS systems built by top 3 players, Billund Aquaculture, Veolia and AKVA group

We have been speaking to several of the largest specialised RAS suppliers, which are all very optimistic on the outlook for land-based production, including full on-growing. They report a high level of activity, with many requests from all over the world, including Russia and Asia. For example, one of the equipment suppliers says that it currently has a backlog for 2017 of 7–8 on-growing facilities, each with more than 1,000 tons of production capacity.

High activity reported by suppliers

As to why it is not building bigger, the director of one of the equipment providers said:

"My opinion is that these facilities will increase tremendously in size due to the economies of scale. However, we are currently recommending our customers to start with ~1,000 tons to prove the concept first, and then scale up".

Figure 29: Overview of selected technology suppliers

		AKVA GROUP	BA	AQUAOPTIMA		AQUA MAOF		PENTAIR	aquatec solutions
HQ									
Business segments	Diversified, water treatment	Diversified, aquaculture equipment and services	Specialized on land based production	Specialized on RAS	Specialized on RAS	Group diversified within aquaculture, fish equipment and processing	Specialized on recirculation aquaculture systems	Diversified within flow management and heat solutions	Specialized on land based aquaculture
Species	80% of aquaculture income from salmon	LBT focus on salmon smolt	Currently 90% of income is salmon. Worked with 25 different species	Atlantic salmon, cod, barramundi, eel ++	Atlantic salmon, Sturgeon, Tilapia	Salmon, trout, king fish, tilapia ++	Salmon, trout, sturgeon, turbot ++	Tilapia, Trout, Char, King Salmon, Silver Salmon	Salmon
Full ongrowing (salmon)	✓	✓	✓	✓	✗	✓	✓	✗	✗
Salmon references	✓	✓	✓	✓	✓	✓	✓	✓	✓
Share of RAS for smolt in Norway (2015)	30%	16%	44%	n.a.	6%	n.a.	n.a.	n.a.	8% (incl. in AKVAGroup)

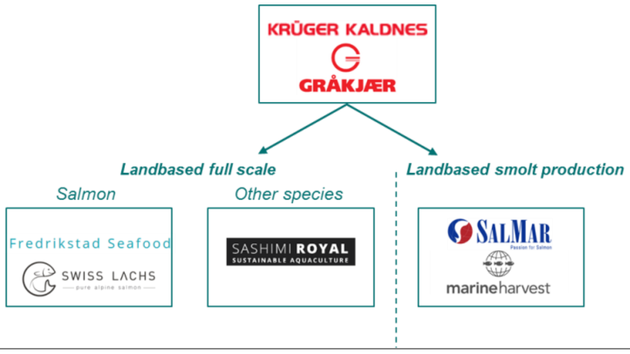
Source: Companies, Billund aquaculture(market share) Note that Kruger Kaldnes has built more facilities than Billund since then and increased its share
Note: Yellow tick means full on-growing, but only other species than salmon known

Veolia, i.e. Gråkjær and Kruger Kaldnes is an equipment and solution provider for land-based production of smolt and full on-growing. Veolia is a Group including Kruger Kaldnes (Norway) and Gråkjær (Denmark). Together with Billund and AKVA Group, these companies are frontrunners within RAS, building some of the first facilities for land-based salmon production.

Veolia Group includes Gråkjær and Kruger Kaldnes

The company provides solutions for both full-cycle production of salmon and turnkey RAS projects for smolt production to the largest salmon farmers e.g. SalMar and Marine Harvest.

Figure 30: Illustration of Veolia's Gråkjær and Kruger Kaldnes



Source: Companies

The RAS2020 concept consists of four ring tanks of various sizes with the same centre and one combined water treatment plant. Please see the illustration in the technology section.

Several new land-based projects use its newest concept, RAS2020

The company is experiencing high activity within smolt, especially larger smolt. In addition to full cycle in Switzerland and Fredrikstad, Kruger Kaldnes/ Gråkjær is currently building several smolt facilities in Norway; SalMar Follafoss (Kruger, 2017), Salangfisk (Gråkjær, 2017), Sævareid Fiskeanlegg (Gråkjær, 2016). Kruger Kaldnes has built numerous smolt facilities for Marine Harvest. Osland Settefisk, completed in 2016, was the first RAS turnkey concept, which means full delivery of equipment and services including water treatment and sludge treatment.

AKVA group (Norway) is one of the leading consolidators in terms of aquaculture equipment; the most recent acquisitions are Technodive, 66% of Sperre, AD offshore and Aquatec Solutions (land-based technology with Bakkafrost contract on DKK150m). AKVA group expects significant growth within its business segment Land-Based Technology (LBT), with half of its backlog in this segment. Its land-based projects are mostly salmon smolt, not full-scale, in the Nordics. The group has communicated that it is not going to be driving development within land-based full-cycle because it is focusing on the large salmon farmers, and is currently requesting land-based facilities for smolt.

Ongoing consolidation with AKVA group as one of the main consolidators

Billund Aquaculture (Denmark) is perhaps the leading specialised RAS provider, with more than 30 years of experience with RAS. Billund has built more than 500 RAS facilities on 120 projects in 28 different countries. The company started off producing RAS for eel production in the 1980s. After a while, the equipment provider began producing RAS for other species, including salmon smolt. Billund has built a large number of salmon-smolt facilities in Chile since 2000 and numerous RAS for salmon smolt in Norway since 2010. Currently 90% of its revenues are related to the salmon industry (70% large smolt and 30% full-scale salmon production), while the company has delivered solutions for 25 different species. At the time of writing (December 2016), the company has projects in Armenia, Chile, Holland, Moldova, Norway, Scotland, South Africa and Tasmania.

Billund Aquaculture is a leading supplier with a track record of 120 RAS projects

Figure 31: Illustration of Billund Aquaculture reference list

Source: Billund Aquaculture, DNB Markets illustration, Note that assumptions are made on size of facility when confidential

Running the numbers

Land-based projects starting to make more sense

High production costs and investment needs combined with elevated risk and the long period from investment to first cash flow have been major barriers for land-based salmon facilities. Historically, the relatively low capex for traditional salmon production has meant that investment in new sea sites and licences has been a no-brainer, especially of late with the current super-profits.

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

Now, required investment per kg of land-based produced salmon produced has fallen with the technological development and increased scale. The risk involved is reduced with experience from operations and examples of successful production. In addition, the opportunity to invest in establishing new traditional farms is rare as biological challenges have made the government reluctant to award more licences.

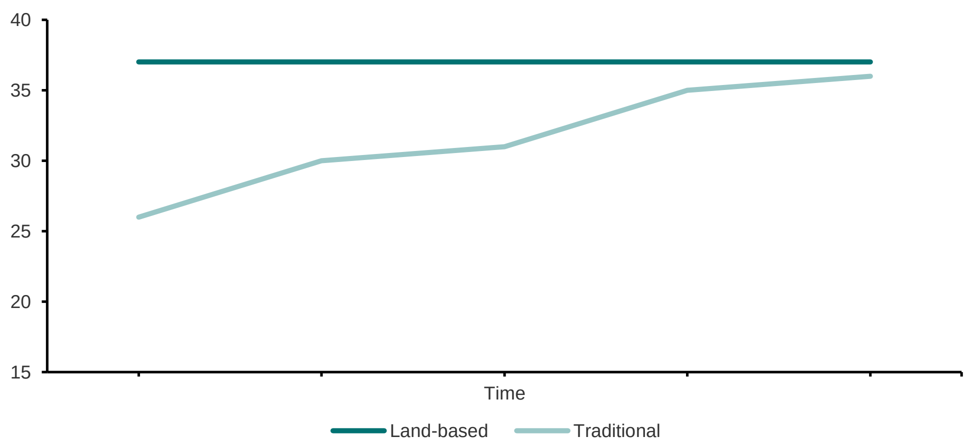
Opportunities to invest in traditional growth is limited due to biological challenges and strict regulations

Traditional salmon farming costs have increased towards land-based

The biological situation, in addition to feed, is one of the main reasons for the increased cost per kg of salmon produced in open net pens. Production costs for traditional farming have increased substantially over recent years, with the average cost per kg HOG in Norway having risen from NOK26 in 2012 to NOK35 in 2015 and on to an estimated NOK36/kg in 2016.

Increased costs for traditional farming

Figure 32: Cost per kg HOG, illustrative (NOK)



Source: Directorate of Fisheries (traditional cost); DNB Markets (illustration of land-based)

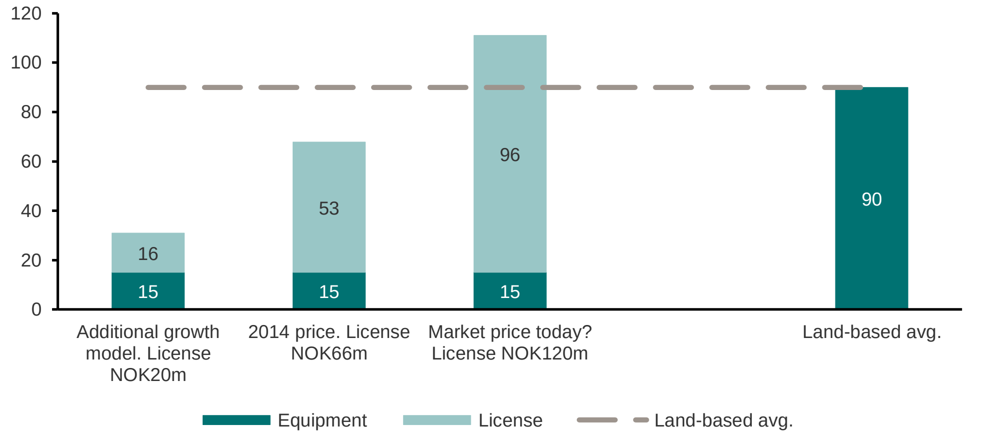
Rising cost of traditional farming due to health issues and rising feed cost

Capex required for land-based might not be far from traditional farming

Capex per kg of salmon produced in land-based facilities has been reduced due to technological developments enabling facilities to increase in size. The average investment in equipment for large land-based facilities we have identified with production above 1,000 tons is NOK90/kg. For traditional farming, we estimate the investment required in equipment at NOK15/kg, while the current price of a licence is uncertain. No new licences have been awarded since 2014, when SalMar bid NOK66m for a licence. Since then, the Seafood Index (OSLSFX) has doubled, suggesting the market value of a licence is also higher.

The difference in capex per kg depends on the assumed price for a licence

Figure 33: Capex (NOK/kg)



Source: DNB Markets

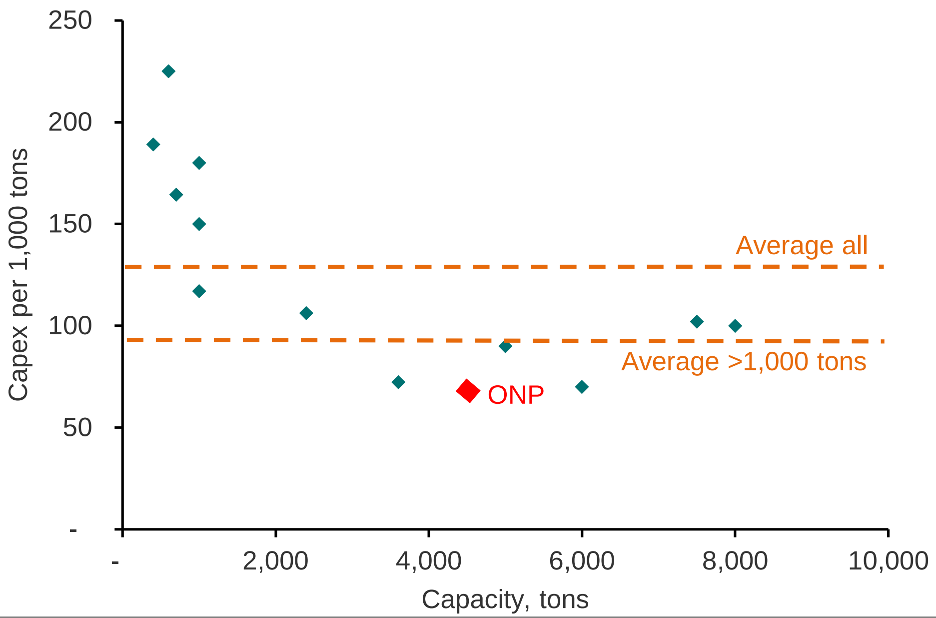
Increased scale and improved technology reduces investment per kg output

Technological developments have enabled increased size of a standard RAS and improved control of water parameters. Hence there has been a reduction in both initial capex per kg and the need for unplanned add-on investments.

Capex per capacity (volume) is reduced due to learning effects and increased size on facilities

- The level of estimated capex in the projects identified is approximately NOK90m per 1,000 tons of capacity, i.e. NOK90/kg, for facilities with capacity above 1,000 tons, corresponding to capex/kg of NOK90. A traditional open net pen site (ONP) would cost roughly NOK63–71/kg with NOK48-56/kg related to license cost (NOK60–70m) – if a licence can be obtained (see section above regarding correct licence costs).
- Including the smaller (and older) land-based facilities, the average capex per production volume is higher at ~NOK130m per thousand tons of capacity.

Figure 34: Capex per thousand tons of capacity, NOKm



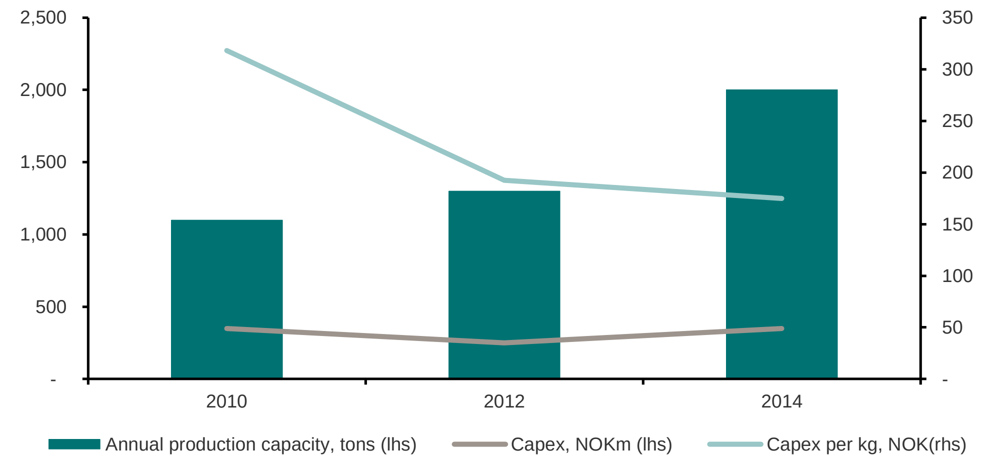
Source: Companies, iLaks.no, IntraFish.no, Kyst.no, DNB Markets (ONP estimate)

RAS systems getting larger

The standard size of RAS facilities has grown over time. What seemed a large RAS only a few years ago is now relatively small. The salmon farmers appear to be competing in having the biggest RAS for their smolt. Examples of RAS for smolt built in 2010, 2012 and 2014 provided by Kruger Kaldnes are shown in the graph below. This illustrates the development towards increased capacity and less capex per production volume. Note that the numbers are approximate based on total deliveries with somewhat different specifications.

2014 RAS smolt facility 3x capacity for the same capex as in 2010

Figure 35: Development of RAS for smolt production



Source: Kruger Kaldnes

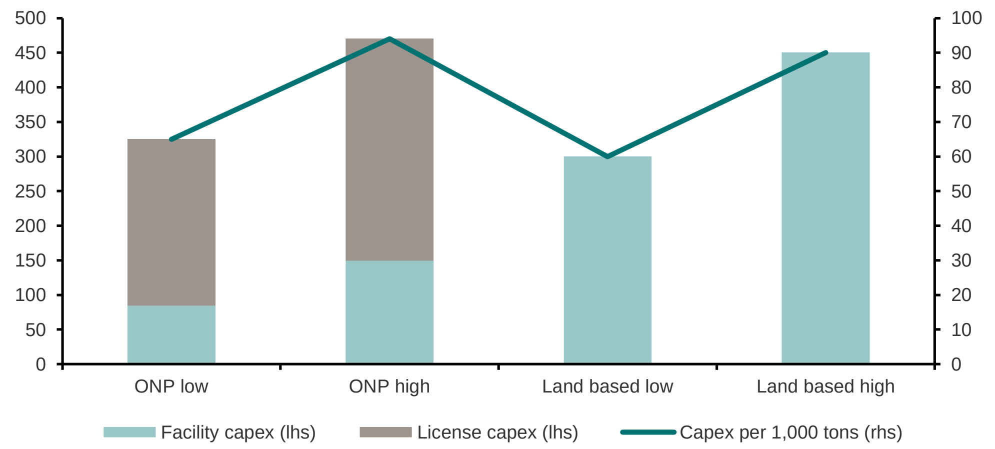
Experience from frontrunners' systems reduce capex per kg and uncertainty in investment size

The newer facilities are being built based on the knowledge created through trial and error by the frontrunners. We do not have investment costs on all of the smaller and older facilities, but assume that the capex per volume produced is relatively high. This is due to additional investments made to overcome the initial challenges. Land-based farmers claim that the investment required to rebuild their facilities would be much less if they were to do so today.

Capex needed to build land-based facilities is not that far from open net pens when including cost for licences

The estimated capex is higher than in traditional farming, but not hugely so. Land-based farming receives licences for free, while a licence for open net pens have a price tag of ~NOK60–70m or NOK48-56/kg assuming annual output of 1,250 tons (the true market price is debatable, see page 25-26 for more detail). In addition to licences, there are the costs of building net pens in the sea, estimated at around NOK15/kg. An analysis performed by the aquaculture team at Deloitte estimated investment for 5,000 tons capacity in the range of NOK325–470m for open net pens, while it is NOK300–450m for a land-based facility. Deloitte's estimates are based on a licence cost of NOK60-80m.

Figure 36: Capex estimated by Deloitte



Source: Deloitte

Much room for error in capex estimates

As many of the facilities are yet to be built, the availability of information on investment costs differ and is not easily available. There are many uncertainties which could increase capex and/or reduce the production volume, e.g. density estimates may be too optimistic and the facilities may not achieve the planned production volume.

Financing

Most of the founders need external capital due to the high upfront investment, including both capex in facilities and 16–24 months of lead time before the fish are fully grown. The risk involved in investment in a concept waiting to be proved means a high required return and gearing being less available. Currently most of the projects are financed partly by the founders themselves, in addition to local investors, family offices and high-net-worth individuals. Rasmussen-gruppen and Wilhelmsen have both invested in land based facilities. Rasmussen and Wilhelmsen have invested NOK50m and NOK20m, respectively according to the industry paper www.iLaks.no. We would expect this type of investor to take part in financing expansion if the concept is proven.

Deep pockets are already involved, which should help expansion financing

Equipment providers have said that private equity companies, both Nordic and UK-based, are interested in financing promising land-based projects, hence they help the founders to connect with these financial players.

Most of the older and smaller projects have received financial support from local authorities and/or organisations. Examples of this type of institution are Kuterra in Canada and Freshwater Institute in the US. Both are financially supported by environmental and/or native inhabitants' organisations with the goal of protecting the coast e.g. First Nations and The Conservation Fund.

Environmental organizations have contributed with funding of US/Canadian projects

Licences for land-based aquaculture allocated without fee

In June 2016, the Norwegian Directorate of Fisheries issued new allocation rules for land-based aquaculture of salmon, trout and rainbow trout. The regulations now allow for continuous allocation of licences without fees. Applications are to be sent to Fylkeskommunen (a local municipality) and will be processed on a continuous basis. Previously, i.e. until June, land-based aquaculture was subject to the same licencing requirements and procedures as traditional salmon farming.

Land-based licences are awarded on an ongoing basis without fee

Converging production costs

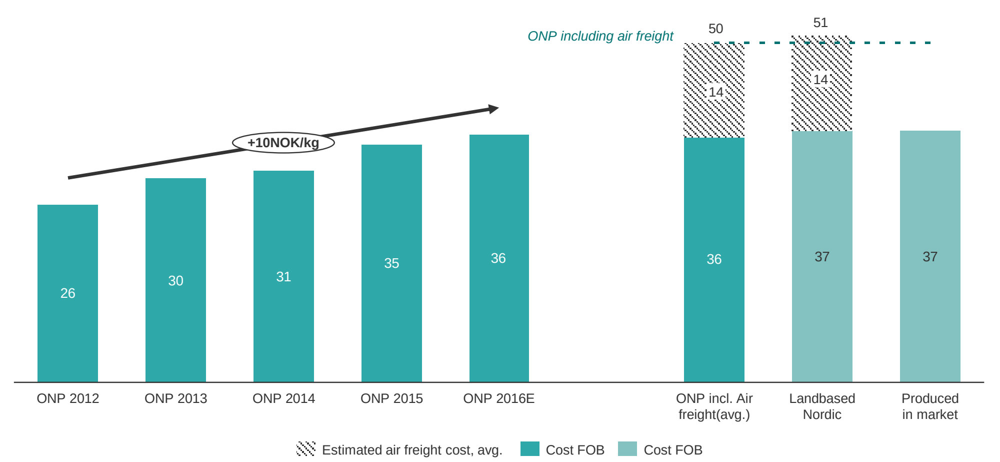
Overall, production costs communicated by industry sources and researchers indicate land-based production costs and traditional sea-based costs are converging at NOK35–37/kg HOG. The major driver of this is the rapid increase in health-related costs for open net pen farming.

Analysis of production cost per kg land-based and traditional farming cost are converging

The figure below shows the trend for average cost FOB in traditional open net pen (ONP) farming in Norway, with a NOK10/kg increase in the last five years. On the right hand side we have estimated the production cost for a mid –sized (3-5kt) land-based farming operation, with and without a transport advantage. Current production cost for a land based operation is likely much higher than our projected NOK37/kg as most are pilot projects with low volume output and hence a high fixed cost component. We base our cost estimate on the assumption that the technology will be scaled up, which will give a more realistic 'normalized' production cost. We find this cost assumption to be the most relevant way of approaching the cost conundrum of land based farming and conversations with various industry sources support this assumption. If the land-based facility is located in the US or Asia, the transport advantage of land-based salmon delivered to the customer would be NOK14/kg versus airfreighting the product from e.g. Norway.

We estimate NOK37/kg production cost for a mid-sized (3-5kt) land based facility

Figure 37: Cost trend (NOK/kg) and benchmarking versus land-based farming



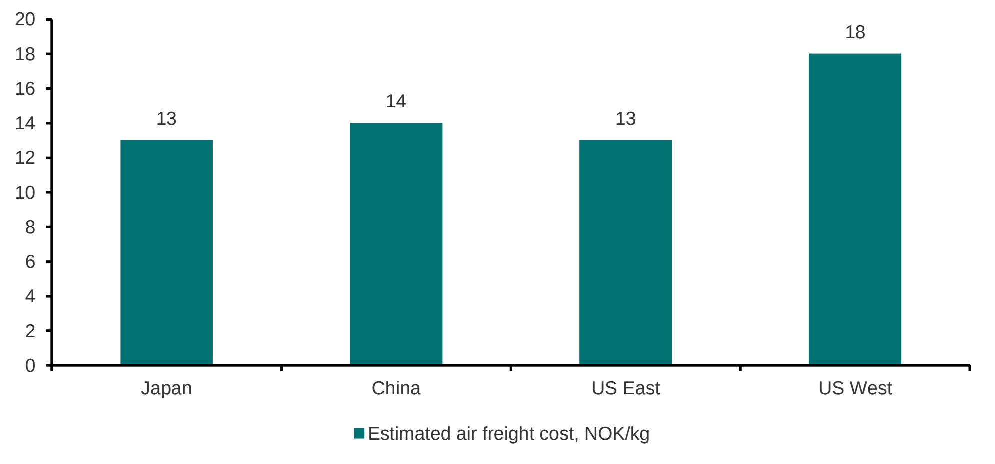
Source: Directorate of Fisheries(actuals), Kontali(air freight), DNB Markets estimates

Up to one third of total production cost 'delivered to consumer' removed when the salmon is produced in the end markets "backyard"

The impact of removing air freight from the calculation, achieved through locating the land-based production facility in the market, is illustrated by adding average transportation cost to US/Asia of ~NOK14/kg. Kontali estimates transportation costs to US and Asian markets in the range NOK13–18/kg. NOK18/kg saved on salmon sold on the US West coast would represent about one-third of the total cost for the customer. These transport figures are also validated by salmon farmers.

US/Asia transport cost of NOK13-18/kg

Figure 38: Air freight costs, NOK/kg



Source: Kontali

Nofima report suggest land-based in low cost country could be competitive

In 2013 Nofima found production costs, incl. harvesting, for land-based RAS production of NOK35/kg, while the production cost for traditional open net pen was estimated at NOK27/kg. Under the assumption the land-based RAS facility was located in a low-cost country, Nofima estimated production cost of NOK27/kg, in line with traditional open pen farming.

A Nofima report (2013) suggested land-based production cost in a low-cost country would be comparable to open net pen production

Figure 39: Nofima production cost est. for different technologies (2013, NOK/kg)

	ONP base	Land-based	Land-based in low cost country	Offshore	Closed exposed	Closed protected
Feed	11	10	10	11	11	10
Smolt	2	2	1	2	2	2
Salaries	2	2	1	3	3	2
Other operating costs	3	6	5	3	4	4
Depreciation	1	3	2	2	6	3
Production cost total	**19**	**23**	**18**	**22**	**25**	**22**
Net finance	2	6	4	6	6	4
Insurance	0	0	0	0	0	0
Harvesting cost	3	3	1	3	3	3
Production cost, (WFE)	**24**	**31**	**24**	**31**	**34**	**29**
Production cost (HOG)	**27**	**35**	**27**	**35**	**39**	**32**

Source: Nofima

We highlight that Nofima's report includes a sizable finance cost for land-based production as its calculations were based on 7.5% interest on the total land-based investment.

Figure 40: Breakdown of Nofima's 'other operating cost' (NOK/kg)

	ONP base	Land-based	Land-based in low cost country	Offshore	Closed exposed	Closed protected
De-licing	0.7			0.7		
Fish health	0.5	0.3	0.2	0.5	0.5	0.5
Administration	0.2	0.4	0.2	0.2	0.2	0.2
Electricity		1.7	1.7		0.8	0.8
Oxygen		0.8	0.8			
Sludge/waste		0.1	0.1		0.1	0.1
Alkalinity		0.1	0.1			
Other	2.0	3.0	1.5	2.0	2.5	2.5
Total Other operating costs	**3.4**	**6.3**	**4.6**	**3.4**	**4.1**	**4.1**

Source: Nofima

In the table above we have listed the breakdown of 'other operating cost' from Nofima's report, but as the report is from 2013, we highlight some obsolete data for open net pen base case. Fish health and de-licing cost of NOK0.7/kg and NOK0.5/kg respectively are too low, given current challenges with fish health and should add up to at least NOK5/kg. This would take open net pen production cost up to NOK31/kg, and an additional NOK4/kg increase due to higher feed cost would correspond to 2016 cost of NOK35/kg, which corresponds with our view of current production cost.

DNB estimates and project data suggest converging cost

In the table below, we have included our cost estimates for land-based production and traditional farming (open net pen) in 2016. Our estimate for land-based production is based on the report published by Nofima in 2013, adjusted to reflect the development of higher feed, smolt and salary cost. We have also adjusted net finance costs from NOK6/kg to NOK3/kg, which we believe is more accurate assuming a 'normal' debt level once operational, rather than 7–8% interest cost on total investment. E.g. 50% debt would suggest NOK3/kg for a 5kt land-based facility. Open net pen costs are based on Directorate of Fisheries in 2015 and DNB Markets estimates for 2016.

DNB Markets estimates land-based production cost of NOK37/kg (HOG), close to our NOK36/kg cost estimate for open net pen in 2016

In addition to our own estimate (land-based DNB estimates), we have included the cost breakdown from an advanced land-based project (land-based Project X, based on a scenario with 3kt harvest output). The land-based production cost estimates of NOK35–37/kg HOG compares to our estimate of industry average open net pen production cost of NOK36/kg for 2016.

An advanced land-based project indicate NOK35/kg (HOG) production cost

Health-related cost of NOK+5/kg for open net pen production

A major driver of open net pen production cost has been health-related, with direct cost for sea lice treatment as well as indirect cost from loss of feeding days, increased mortality,

Solving health-related cost would see open net pen production regain a sizable cost advantage over land-based smaller fish size and downgraded quality. If these cost drivers could be reversed, open net pen production would regain a sizable cost advantage over land-based production.

Figure 41: Cost estimate for land-based and open net pen (NOK/kg)

Cost per kg round weight	Land-based (DNB est.)	Land-based (Project X)	ONP 2012	ONP 2015	ONP 2016e
Feed	13	13	11	13	15
Smolt	2		2	3	3
Salaries	3	3	2	2	2
Other operating costs	6	7	3	6	7
Depreciation	3	3	1	1	2
Production cost total	**27**	**26**	**19**	**26**	**28**
Net finance	3	1	0	0	0
Insurance	0		0	0	0
Harvesting cost	3	3	3	3	3
Production cost, (WFE)	**32**	**31**	**22**	**29**	**31**
Production cost (HOG)	**36**	**34**	**25**	**32**	**35**
Air freight packing	0	0	1	1	1
Inland freight	1	1	1	1	1
Export levy	0	0	0	0	0
FOB Norwegian boarder	**37**	**35**	**26**	**34**	**37**
Estimated freight cost (Asia/US)	0	0	14	14	14
Import duties	–	–	–	–	–
Estimated total cost to Asia/US	**37**	**35**	**40**	**48**	**51**

Source: Directorate of Fisheries (actual), Kontali (estimate), DNB Markets (estimates)

Biological challenges, especially lice, are the main driver for the increased cost level in traditional farming

Cost per kilo produced salmon in sea-based pens has increased substantially in the last few years. Other costs and feed are the cost items that have increased the most. Some of the costs related to lice and diseases e.g. treatment and medicals, are included in the item 'other costs'. The current biological challenges related to sea lice impact both costs and harvesting volumes within traditional farming (open net pens). The closed systems remove biological challenges such as lice and escapes. Currently Marine Harvest communicate NOK4/kg in lice costs, and the actual cost is probably higher, taking effects like increased mortality and reduced growth into account.

The quite similar production costs for land-based and traditional farming consist of different elements

There are differences between cost elements between the two farming methods. Improved feed conversion reduces feed cost on land-based compared to open net pens. Control of temperature and advanced feeding systems improve growth, which reduces costs of feed and smolt through higher feed conversion and smolt yield.

Land-based facilities have costs related to energy and water treatment that are not relevant for traditional farming. Previously, flow-through systems required pumping of tremendous volumes of water from sea level in and out of facilities, resulting in high energy costs. This is reduced with RAS, which enables reuse of 95–100% of the water and conserves more of the temperature.

Other costs: same, same, but different

Electricity costs estimated to ~NOK2/kg

Other costs are estimated at NOK6–7/kg for both types of production, but include different elements. The main share of other costs for salmon raised in open net pens are health costs including delousing and vaccines. Land-based other costs include costs for oxygen, sludge and electricity. The electricity cost is estimated in the range NOK0.8–1.7/kg dependent on the location of the facility (Nofima). Liu, Summerfelt and Rosten (2016) estimates the electricity cost at NOK2.3/kg for a land-based facility in the US.

Supporting analysis on production costs converging

Deloitte estimates nearly the same production cost per kg salmon (WFE) produced in land-based facilities: NOK26.75/kg, at the same level as for salmon transferred to open net pens at 100 grams of NOK26.5/kg. Deloitte's estimates are based on 5,000 tons of production, both located in Norway. Figure 29 illustrates these cost estimates converted into HOG.

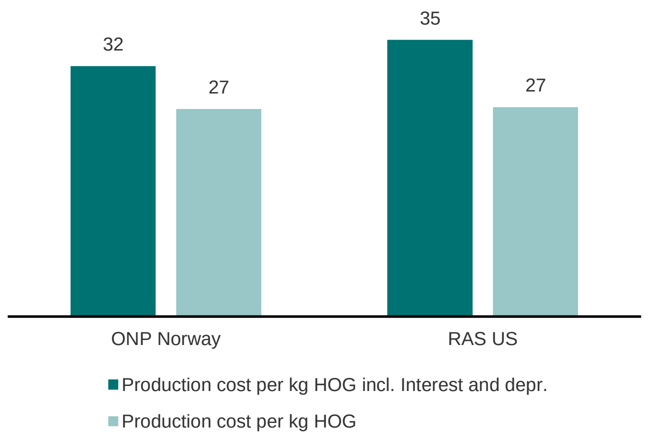
Another example is Liu et al. (2016), who found that operating expenses excluding insurance, maintenance, depreciation and interest would be lower for land-based salmon production (NOK26/kg versus NOK29/kg) when excluding interest, maintenance and depreciation. All inclusive, the tables turn and open net pen production is shown to be lower at NOK35/kg versus NOK39/kg.

Note that the estimated production cost by Liu et al is based on a 3,300-ton farm which is smaller than most open net pen sites in Norway. However, there are also parameters underestimating costs, e.g. health is estimated at NOK0.2/kg, which is much lower than the current level in Norway. We refer to their report for a thorough description of assumptions made.

Land-based give up is gains when including interest cost, maintenance and depreciation. We believe these cost levels will come down as the technology matures.

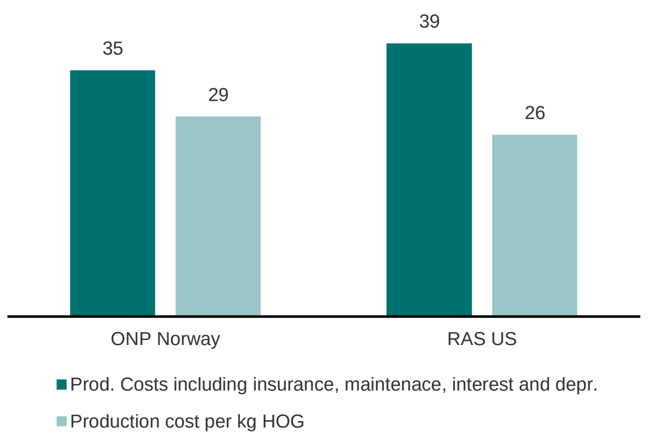
We note that production costs excluding maintenance and finance costs are estimated to be very similar for open net pens and RAS. Hence we would expect total production costs of land-based farming to come down over time when the concept is proven and the facilities achieve ongoing/stable production, which should reduce maintenance, interest and possibly depreciation costs.

Figure 42: Deloitte estimates



Source: Deloitte Note: Liu et al. depreciation and maintenance estimates added (Liu et al.)

Figure 43: Liu et al. estimates



Source: Liu et al. (2016) SINTEF and Freshwater Institute

Spreadsheets versus real life cost estimates

Due to few producing land-based salmon farmers, little empirical data exists and the large variances between concepts mean there are significant uncertainties in estimating land-based production cost. This section of the report illustrates that the difference in production costs between the two production methods may not be as large as could be expected.

Exact level of operational cost will vary between concepts and is yet to be proven due to R&D phase

Internal rate of return

Having concluded that the investment and operational costs of traditional farming are rising while land-based technology has moved the other way, the obvious question is at what point do the returns for land-based become attractive enough to gain real investor attention.

The concept of 'spreadsheet projects' has been mentioned earlier in this report but in the absence of hard data from projects up and running, spreadsheet guestimates based on assumptions from multiple projected concepts are the best input data we have. Of course a spreadsheet project can be highly unreliable, but we have tried to be as realistic as possible for the major assumptions. We have avoided digging into the P&L lines, which are likely to be incorrect in the real world anyway, and instead focused on 'big picture' assumptions.

'Garbage in, garbage out' in spreadsheet models, but big picture assumptions should be in the ballpark

We have looked at four different projects, all based on 10kt output. Two land-based projects, one without a transport advantage (i.e. located in Norway), while the other is assumed to be located in the US or Asia, far from traditional farming hubs. The last two projects are based on traditional farming in Norway, one with NOK60m per licence cost (assuming new licences will be offered by the government) and a second scenario with an assumed M&A price per licence of NOK120m. The other major assumptions for the projects are summarised below.

Four projects evaluated: 1) land-based with transport advantage; 2) land-based without transport advantage; 3) traditional farming with NOK60m licence; 4) traditional farming with NOK120m licence

Production cost is assumed to be the same for traditional and land-based as both have pros and cons (higher energy cost for land-based versus biological cost for traditional sea-based farming).

Our assumptions for land-based projects

- Investment capex of NOK86/kg (average of all researched projects)
- Same realised price and production cost as for traditional farming (NOK15/kg EBITDA margin)
- Margin stays flat for the duration of the project
- 20-year life span with negative terminal value due to decommissioning cost of NOK30m
- For the ROE calculation, we estimate 50% debt at 5% interest
- For US/Asia-based projects, NOK14kg higher margin due to transport advantage

Our assumptions for traditional sea-based projects

- NOK60m cost per licence (assuming you can get your hands on one) and NOK120m per licence in our M&A scenario
- Equipment cost of NOK15/kg to set up a sea site
- 20-year life span for project with a terminal value of NOK30m per licence (low terminal licence value as we assume alternative production methods will have reduced market value of a farming licence)
- 10-year lifespan for equipment, hence investment in equipment happens twice during the life of the project
- Project financed by 70% debt at 5% interest.

There are several shortcomings when doing such exercises, e.g. if the land-based technology works, the supply will increase and reduce the margin towards the end of the valuation model. Hence, every project will look attractive on a stand-alone basis, but put together they will likely impact price and corrupt the model.

Land-based set to be competitive in the US and Asia

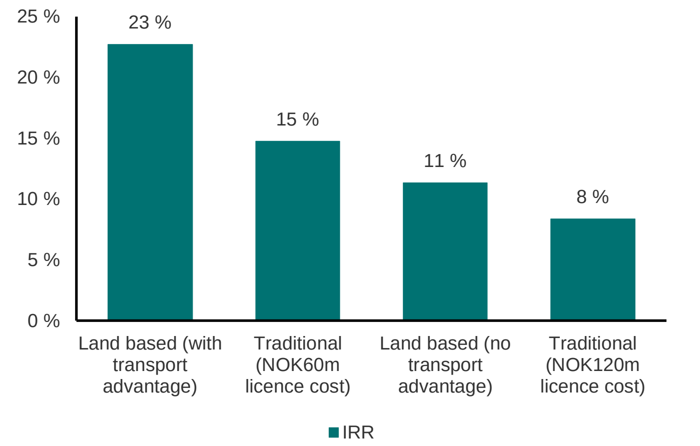
The internal rate of return in these land-based projects reveal setting up production in, or close to, regions with current production are unlikely to return an adequate risk return profile. The benefit of setting up in regions far from traditional farming regions, where the transport cost and freshness of product comes into play does however appear to have an attractive risk /reward. We have looked at project internal rate of return (IRR) and return on equity (ROE). Given the risk in land-based projects versus traditional farming, the amount of equity required is likely to be much higher. The first projects are likely to be financed almost entirely with

The transport cost likely to be the 'kicker' in the land-based case

Capital structure favours traditional farming equity, but we assume 50% equity in our estimates, while traditional farming will only require 30% equity. For all the projects the cost of debt is assumed to be 5%.

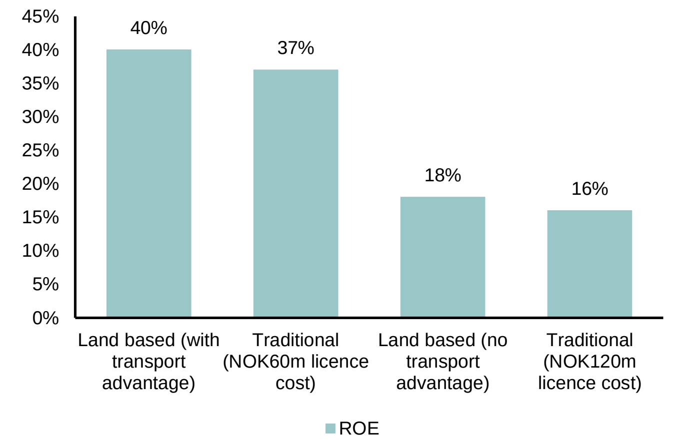
From our estimates, a land-based facility with transport advantage will generate the highest IRR (23%) closely followed by a traditional site with NOK60m licence cost. Land-based with no transport advantage is expected to yield an 11% IRR, while traditional with M&A pricing on licence would only yield 8%. With the assumed 50% debt and 5% cost of debt for land-based projects and 30% equity for traditional projects, the ROE show a traditional site with NOK60m licence cost yield a ROE of 37% while the land-based with transport advantage yield 40%. Land-based without transport and a traditional site with NOK120m licence cost would yield 18% and 16% ROE, respectively.

Figure 44: Estimated internal rate of return (IRR) on project



Source: DNB Markets

Figure 45: Estimated return on equity (ROE) of project



Source: DNB Markets

Adequate risk/reward

In the absence of new ‘cheap’ new licences, land-based in regions with transport advantage shows good enough prospects to be taken seriously

Considering the risk profile, one could argue that a land-based facility in Norway or close to traditional farming hubs makes less sense, while setting up a land-based facility in or close to an end market where the transport cost is high makes sense. Since new licences are few and far between, the most realistic option for traditional growth is through M&A, but the cost is so high that returns do not appear attractive enough. That leaves land-based faming in a remote end market one of the few options for growth. The interest in such projects has picked up in tandem with the weak outlook for supply growth and high salmon prices, although it is still not accepted as a mainstream investment option. Most of the projects are still financed by entrepreneurial capital, but family offices and other more permanent types of capital have started to take an interest. Traditional banks are still considering the prospect of lending to land-based a risky venture, but with a growing pile of evidence the projects have de-risked, and we could soon see a higher share of bank financing for solid land-based projects.

Success of land based depends on failure to revive traditional supply growth

In summary we conclude that land-based facilities in a market with a transport advantage are likely to yield an adequate risk/return in order to attract investments. The speed of which new projects come on stream and availability of financing are still uncertain. As mentioned before, the success of land-based projects will to a certain extent be dependent on traditional farmers’ ability to resurrect supply growth. If traditional growth recovers before land-based concepts can be proven viable, the technology will likely be shelved until the next supply shortage.

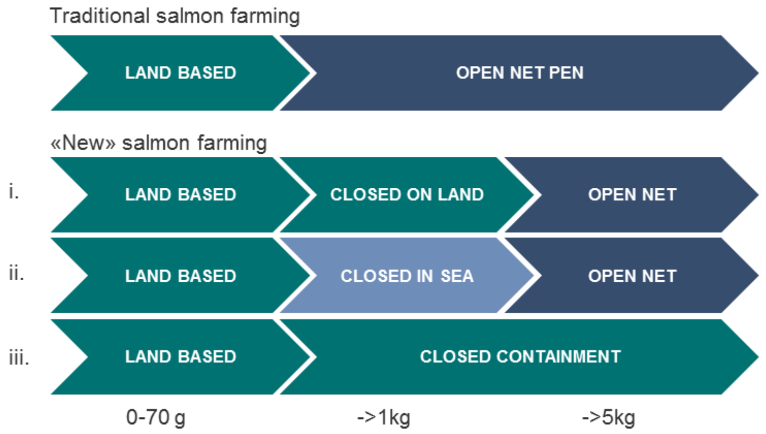
These return figures are highly sensitive to changes in input variables, and we stress they have deliberately been simplified in order to illustrate the impact of changes in upfront capex and transport advantages under the assumption that production costs are the same for land-based and traditional farming.

RAS for smolt – the silent partner in crime

The farmers' challenges with lice and diseases with the result of biological challenges is a setback resulting in reduced production and restricted growth; we estimate Norway will not reach the 2012 level of harvesting volumes until 2018.

The improved recirculation technology and the understanding of advantages of reducing the time fish spend in the sea has resulted in Norwegian salmon farmers investing heavily in RAS technology. As illustrated below, 'new' salmon farming grows the smolt to a larger size in land-based facilities before being released to open net pens (please see the RAS section on investments made by salmon farmers).

Figure 46: Technology development within salmon farming



Source: CtrlAqua (Nofima)

No. of RAS facilities has increased ~4x in the last three years

Large investments within RAS have been made by salmon farmers and independent smolt producers, and flow of news on expansion and new facilities to be built. Equipment providers claim that the farmers are basically competing to have the largest facility.

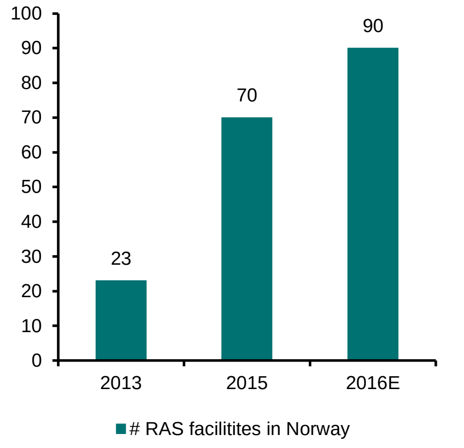
The capacity of large smolt and post-smolt is increased with the goal of reducing time in sea and decreasing the risk of exposure to sea lice and disease. Facilities being built are to a large extent based on RAS technology with increasing size of smolt.

The traditional salmon farming industry contributes to the development of water recycling technology

Hence, the traditional salmon farming industry contributes to the development of recycling technology. As put by technology supplier Veolia, "The development of smolt farms goes towards larger production units for larger smolt/post-smolt. This causes changed conditions for how RAS plants are built and operated. Many challenges are addressed for efficient, predictable and cost-efficient means of production".

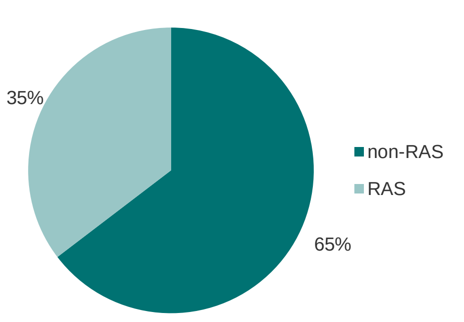
Equipment providers claim that the activity is at all-time high with large backlogs on new projects. Looking at the development so far, the number of RAS facilities in 2016 grew to a total of 90 facilities, from around 20 three years ago(Nofima).

Figure 47: RAS facilities in Norway



Source: Nofima

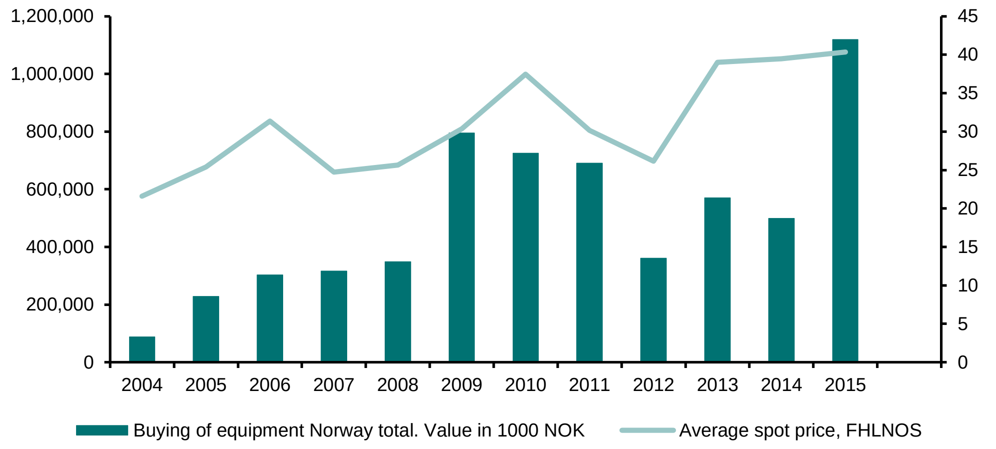
Figure 48: Smolts in Norway



Source: Nofima

Increased equipment investments by smolt producers have been substantial. The average 2015 level was almost doubled from 2014. Note that the graph shows investments made by independent smolt producers and excludes integrated salmon farmers' investments.

Figure 49: Investments in equipment by Norwegian independent smolt producers



Source: Directorate of Fisheries (investments), FHLNOS (price)

We have spoken with industry specialist Bendik Fyhn Terjesen (Nofima and CtrlAqua) to understand the observed salmon price trend, which he divides into the following phases:

Steady increase from 2004–2008

The salmon price saw quite a steep increase from 2004 to 2006. Smolt producers built smolt facilities to meet the increased production capacity in sea-based production (open net pens). The concept was mainly built on traditional smolt production based on flowthrough systems.

Steep rise in investments in 2009

The salmon price increased in 2007–2010 after a drop in 2007. The focus within smolt production was on the shortcomings in freshwater capacity to meet the expected increase in production of salmon with normal smolt. This resulted in movement towards investments in production with recycling of water (i.e. RAS) for "normal sized" smolt at 80–100 grams. A report published in 2006 by Nofima (the findings took some years to be accepted) helped to establish that: a) freshwater availability is a scarce resource in terms of smolt production, and b) establishing RAS as a possible "strong contributor" in increasing smolt quantity and quality.

Trend downwards 2009–2014

Salmon price reduction in the period 2010–2012, which is in line with investments bottoming out in 2012. The demand for increased capacity in smolt production was saturated.

Heavy investments in 2015

Increased demand for RAS facilities for larger smolt (post smolt). These facilities are larger and require heavier investments than those for smolt of 80–100 grams. The farmers have realised their challenges in increasing production volumes and challenges with lice. Larger smolt in RAS is a solution to reducing exposure to lice for a larger share of the production cycle. Demand for larger smolt is increased and smolt producers have adapted accordingly.

The large integrated salmon farmers recognise the advantages of larger smolt, and invest in their own RAS facilities. Bakkafrost alone estimates capex on freshwater facilities at ~DKK1,100m within the next five years. Marine Harvest has communicated that it plans to build a new RAS facility every 2nd year. The world's largest salmon farmer said:

"A key focus area for Marine Harvest is to further expand within the Farming segment and particularly on the freshwater side where the ambition is to produce larger smolts"

Marine Harvest has invested NOK900m in freshwater facilities (RAS only) in the last three years, with planned freshwater expansion of EUR50m in 2016. At its 2016 CMD, the company identified smolt as the main bottleneck to growth in several Norwegian regions as well as Canada and Scotland. Investments have been made in Norway (West and South), Canada and the Faroe Islands, and are to continue in Scotland and Norway (North and Centre).

Figure 50: Investments in RAS for smolt

Company	Known investments in RAS for smolt
Grieg Seafood	Strategy for recycling fresh water on smolt sites since 2007. Increase capacity from 500 tons to 1,300 tons in Rogaland with total capex of NOK120m; to be completed in 2017. Considering new smolt plant in BC.
SalMar	Increasing capacity of smolt by ~30m (20 in 2016 + 8.5 in 2017). Total capex for the two is NOK800m.
Norway Royal Salmon	Considering to build RAS facility in Northern Norway with capacity on 10m smolt with a size of 120-180grams, Capex of NOK350m (source: Intrafish). Arctic Fish in Iceland building facility with capacity up to 7m smolt.
Lerøy Seafood Group	RAS facility in Laksefjord Finnmark 2015 (NOK150m), Belsvik in 2013 (NOK350m). Invested considerable resources in the development of closed containment floating facilities for post-smolt.
Marine Harvest	Almost NOK700m in freshwater facilities in Norway in 2015 (NOK900m in the last three years). Planned EUR50m in freshwater expansion in 2016. Expansion in Faroe Islands, Norway, Scotland (GBP20m) and Canada (USD40m investment, 2016–2017).
Bakkafrost	Total investments in freshwater over the next five years totalling DKK1,100m. Increasing size from 114g (2015) to 500g (2020e) Smolt capacity to increase with 600%. Finalising Vidareidi in 2016, new facility in Strond (2018), new site 2019 and upgrade existing facilities 2019–2020
Scottish Sea Farms	GBP35m investment RAS increasing capacity from 5 to 11 million smolt. First fish entering the water in 2019
Grieg Newfoundland	Investment of USD60m to expand smolt facilities (Canada), weight up to 1.5kg, 7m smolt
Fister smolt /Tytlandsvik Aqua	Investment of NOK750m in 5,000 tons RAS facility to increase the size of smolt from Fister by an additional 4–6 months on land. First delivery of smolt in 2019. To be completed in 2021.
Nordlaks	Smolten Innhavet: more than doubling smolt capacity with investment of NOK500m. Set to be completed in 2019.
Bremnes Seashore	Investment of >NOK500m in RAS facility, several building steps, completed in 2018–2019. Final capacity of 6m smolt at ~500 grams
Sævareid fiskeanlegg	Doubling annual capacity from 10m to 20m smolt
Sørsmolt	Investment of NOK55m, capacity of 1,000 tons
Total	**More than NOK6bn and ~40,000 tons of identified investments in RAS for smolt, increasing capacity from 2016 and onwards**

Source: Company, Publicly available sources, DNB Markets
Note: Total tons estimate based on assumption on average weight for some of the companies where only a number of smolts found. Total does not include NRS potential investment or investments made in capacity before 2016, e.g. Lerøy.

Lessons from the oil industry

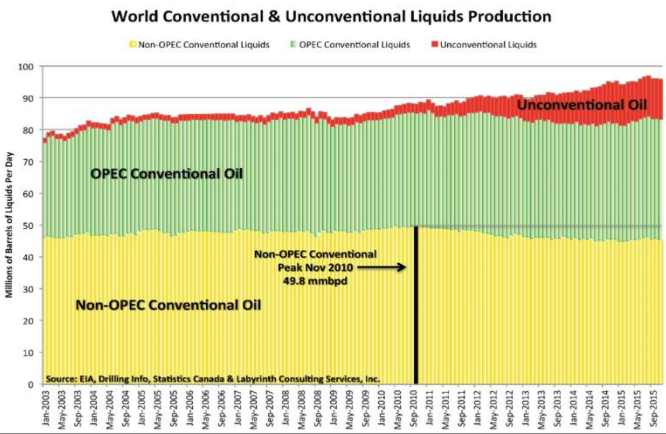
Although the two sectors are not directly comparable, there are still enough similarities to warrant a deeper look at what lessons can be learnt from the offshore and oil industry.

With a rapidly increasing oil price following increased global demand and dwindling supply growth, large investments have been made in new technology and production cost soared as returns were still adequate to justify the higher-cost projects.

Note that the amount of non-conventional oil added to global supply was about 10%, while the oil price plummeted from more than USD100 per barrel in 2014 to less than USD30 early in 2016.

The increased production of unconventional oil was not that large...

Figure 51: Development of unconventional oil production



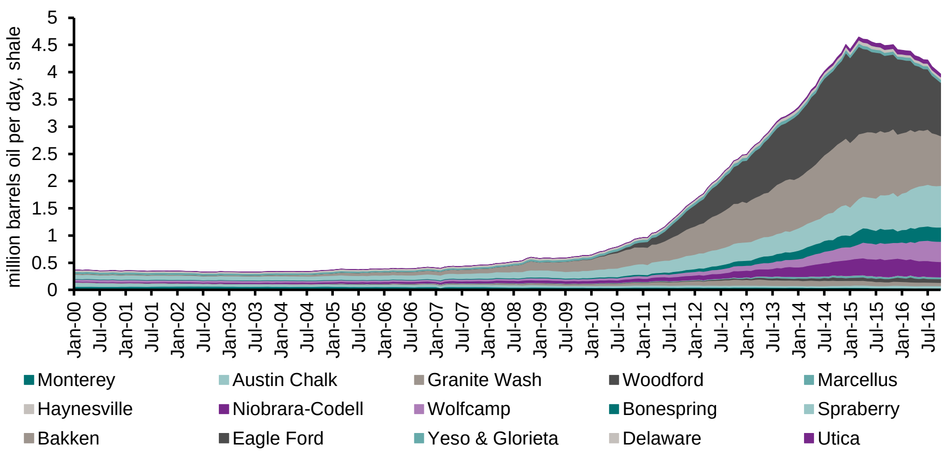
Source: EIA, drilling Info, Statistics Canada & Labyrinth Consulting Services

Obviously we cannot attribute the entire drop in oil price to the increase in supply as demand also fell, but we can surely envision a scenario with demand destruction for salmon at the same time as supply growth starts to recover.

It is also interesting to see how fast supply growth of new shale oil came on-stream once the technology was accepted. Our point is that if or when new technology is accepted, whether oil or fish production, the ramp-up is often faster and larger than expected.

Fivefold increase in production in only a few years

Figure 52: Shale production increased fivefold in few years

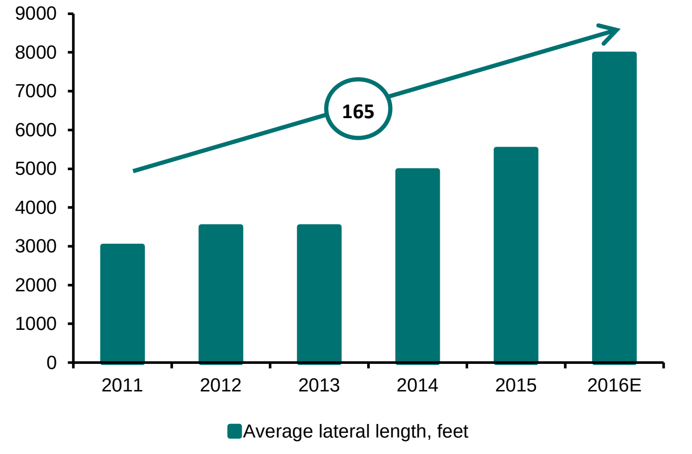


Source: US Energy Information Administration (EIA)

Production cost likely to drop as technology enters a commercial stage

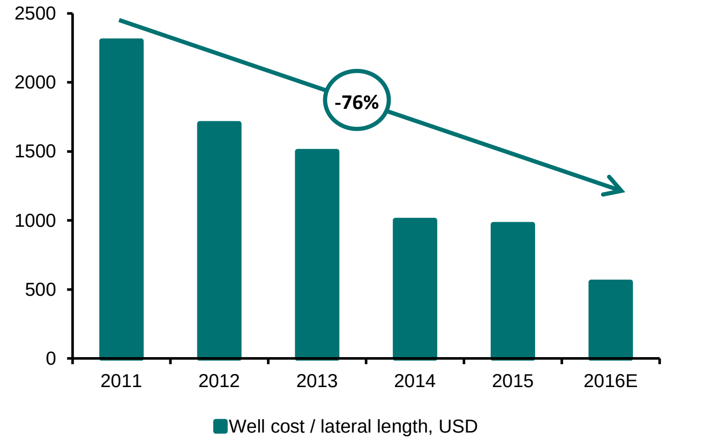
Once new technology is accepted, the production and investment cost is also likely to drop dramatically as volume positively impacts production cost and standardisation reduce upfront investments. Figure 43 below (from Range Resources (RRC US), an independent oil and gas company), shows more than an 80% reduction capex per incremental output for onshore gas production cost between 2011 and 2016.

Figure 53: Average lateral length, feet



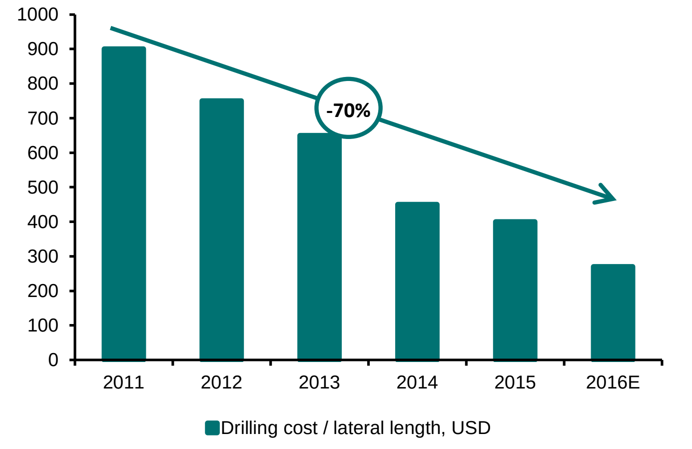
Source: Range Resources

Figure 54: Well costs/lateral length, USD



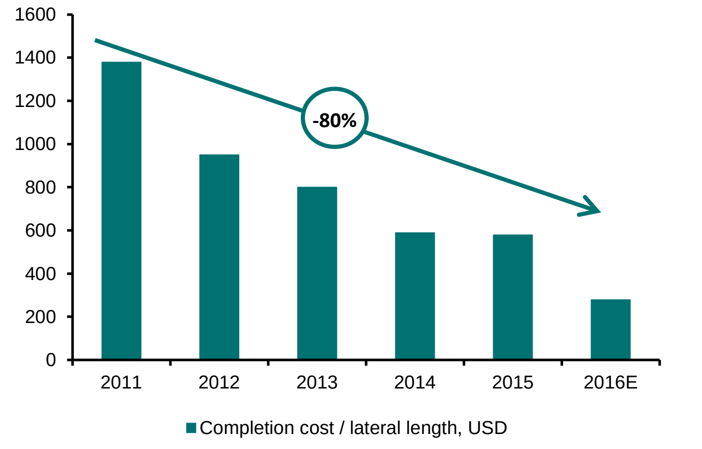
Source: Range Resources

Figure 55: Drilling costs/lateral length, USD



Source: Range Resources

Figure 56: Completion costs/lateral length, USD



Source: Range Resources

Appendices

Projects that may affect transportation costs

New seafood terminal at OSL Airport

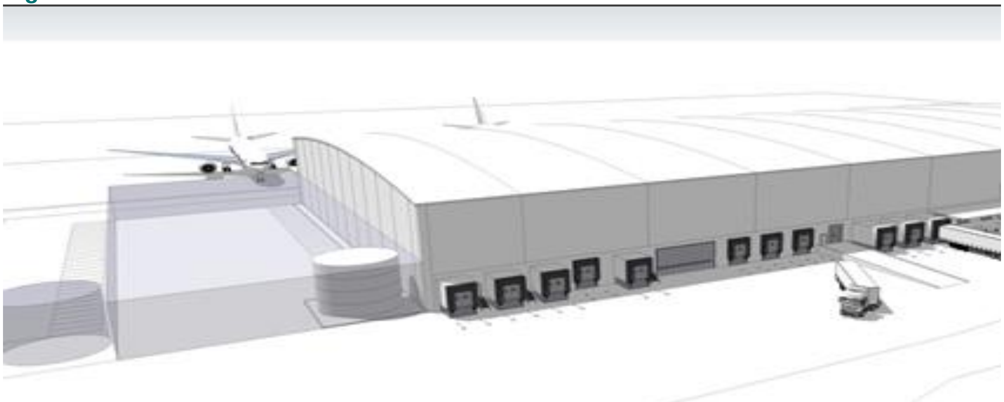
Avinor is building a new terminal with cooling capacity to meet increasing demand for seafood in the US and Asia. The new terminal, with construction planned to start in 2017 and to be completed by 2020, is to be approximately 15,000 m^2 with estimated capex of NOK800m (NRK). Currently ~30% of seafood transported as air cargo goes from Oslo airport, while the remaining 70% goes to other airports in Europe by truck (Hangar.no). The goal is to increase traffic with a higher share of seafood exports. In addition, freight income should increase the competitiveness of more routes, according to Minister of Transport and Communications Ketil Solvik Olsen (NRK).

New seafood terminal at Oslo airport to increase freight capacity to 10,000 tons of seafood

The new terminal can increase the capacity of two new intercontinental routes. According to Intrafish, this would mean increasing freight capacity to 10,000 tons of seafood, and reducing the transportation time for the fish by 1–2 days (Fiskeribladet Fiskaren). According to Infrafish, Marine Harvest, Lerøy Seafood Group and SalMar are giving input regarding the layout of the terminal.

The reduced time to market could cut freight costs somewhat, but also open up new markets for Norwegian seafood. The increased volume of 10,000 tons is not substantial, and the effect should not be significant.

Figure 57: Seafood terminal at OSL



Source: Avinor

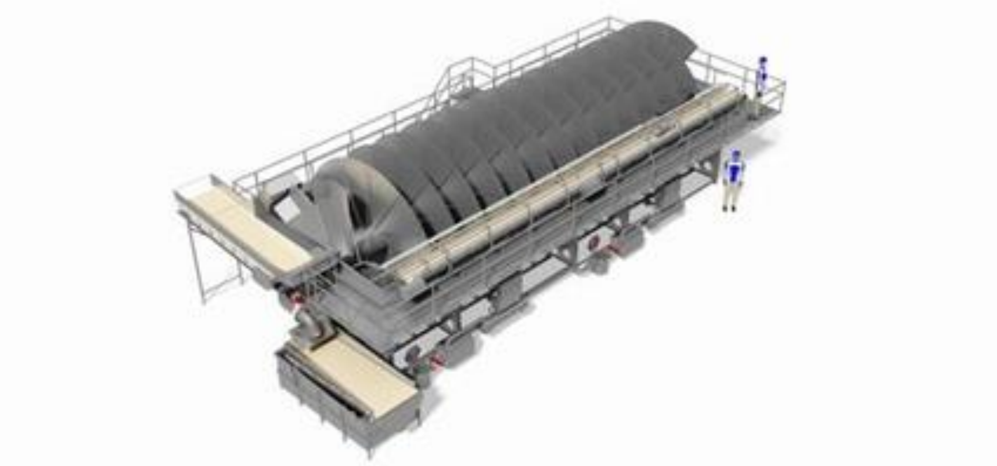
Sub-chilling from Skagin

Awarded innovative packaging without ice (claimed to reduce costs by NOK2–3/kg)

Sub-chilling increases durability

The concept is called sub-chilling and takes the fish through a ‘screw’ which quickly chills the fish and sterilises it. According to product developer Hognason, the effect is several days of increased durability, meaning an increased shelf-life and that the salmon can be sent without ice. SubChilling won the Innovation prize at the Icelandic fishery and aquaculture conference, Sjávarútvegsráðstefnan, in November 2016. The technology is currently used by Arnarlax, the largest salmon farmer in Iceland. In December 2016, Grieg Seafood also signed a deal to acquire the sub-chilling system. The capex of a machine with capacity of 60–100 fish per minute is approximately NOK15m (IntraFish).

Figure 58: Subchilling, Skaginn



Source: Intrafish

R&D centres

There are several important research centres in the Nordics, the US and Canada. The organisations and centres cooperate on several projects in addition to exchanging knowledge and building on each other's research. Our impression is that the US and Canadian research is environmentally focused with full-scale production on land, while the Norwegian is more focused on optimising and increasing the smolt phase on land. This is in line with the post-smolt strategy currently being implemented by the large salmon farmers.

R&D centres important to the development of land-based technology

Some of the most cited and well-known research centres and projects are listed below

Kuterra (Canada)

Kuterra was one of the frontrunners within land-based RAS operations, and the first one in North America. Its mission is to "assess technical, biological, economic feasibility of raising Atlantic Salmon to harvest-size using land-based RAS".

Kuterra in Canada was one of the first land-based production facilities for Atlantic salmon

Kuterra says it has two roles:

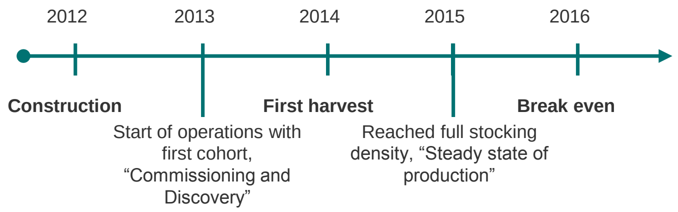
- Kuterra LP is a standalone business that grows and sells KUTERRA Land Raised™ Atlantic salmon.
- Kuturra LP is also a platform that aims to help catalyse a new industry, land-based Atlantic salmon, in recirculating aquaculture systems (RAS). Kuterra is also listed under land-based salmon farmers later in the Appendix

Figure 59: Kuterra – own summary of achievements

1. We've proven and assessed the technological and biological feasability of growing Atlantic Salmon in RAS
2. We've identified the key opportunitites for improvement and optimization
3. We've provided concrete technical, biological and economic data in order to reduce the risks for others and to speed innovation and the development of the indsutry
4. We've identified the elements needed for economic succes

Source: Company

Figure 60: Kuterra – stages and milestones



Source: Company presentation, DNB Markets illustration

Kuterra describes themselves as being under transition from funder-driven industry development to what it calls "profit-driven business development". Currently it works to improve growth, the timing of smolt, solve early maturation and reduce the high R&D and reporting costs to improve profitability, which includes addressing the scale issue.

Figure 61: Kuterra – illustrations of transition

Source: Company

Tides Canada and its Salmon Aquaculture Innovation Fund

To describe Tides Canada and the Salmon Aquaculture Fund, we have compiled its own descriptions of the fund and its activities: "In 2010, Tides Canada established the Salmon Aquaculture Innovation Fund"…"The CAD6 million fund supported research in British Columbia in the following aspects of closed containment aquaculture"… "The Fund worked with several land-based, closed containment demonstration projects in development, including the Namgis First Nation's Kuterra Project. The Northern Vancouver Island-based project is producing Atlantic salmon to assess the technical, biological and economic feasibility of land-based closed containment aquaculture as an alternative production method, which better protects wild salmon and the marine environment. Regular reports on the status of this project were provided through Aquaculture Innovation Workshops co-sponsored by Tides Canada and The Freshwater Institute and the publication of reports." (source: Tides Canada). More information, including a blog and a description of other initiatives, can be found at tidescanada.org.

The Conservation Fund (TCF) – Freshwater Institute (US)

The Freshwater institute is also listed under land-based salmon farmers later in the Appendix:

The Conservation Fund focuses on achieving environmental protection with economic vitality, of which the Freshwater Institute is one of its projects.

The Freshwater Institute, with director Steve Summerfelt, is highly recognised for its R&D efforts

One of the Freshwater Institute's many projects is the "Development of Sustainable Land-Based Aquaculture Production Systems". The project is funded by the US Department of Agriculture, Agricultural Research Service.

The outcome of the project is described as follows:

"This research will advance the capacity to produce a nutritious seafood product in an aquaculture system that is secure, reliable, and both economically and environmentally sustainable. Improvements in resource and capital efficiencies for controlled intensive aquaculture systems will result in better production systems, management practices, and **expanded market and investment opportunities for domestic aquaculture production**. The research will result in more sustainable and globally competitive aquaculture systems for US farmers. **This work is relevant to consumers demanding cost competitive, high quality fish raised in environmentally friendly production systems**, fish farmers producing a variety of freshwater and marine species in tank-based systems, and scientists and consultants who design and evaluate sustainable land-based finfish production systems" (source: the conservationfund.org's project profile on "Development of land-based aquacultutre production systems", note that the highlighting is made by DNB Markets).

The project "Land-based Closed-Containment Aquaculture" is in cooperation with the Atlantic Salmon Federation. The two organisations started their cooperation and stocked its first salmon in 2011. Since then, large volumes of salmon have been produced in land-based (RAS) facilities.

Findings (presented by Steve Summerfelt, August 2016):

- Producing salmon in RAS is biologically and technically viable
- Rapid growth
- High survival
- Good FCR
- No sea-lice
- Good health and welfare

The programme leads of The Freshwater Institute include Joe Hankins (Vice President) and Steve Summerfelt (Director).

The Freshwater Institute is also listed under land-based salmon farmers later in the Appendix. Note that the findings are assumed to be based on collaborative projects.

SINTEF Fisheries and Aquaculture Ltd (NO)

SINTEF is Scandinavia's largest independent research organisation. SINTEF Fisheries and Aquaculture Ltd. represent technological expertise and industry knowledge in the utilisation of renewable marine resources. Under the vision "Technology for a better society", they work for a knowledge-based bio marine industry.

One of their main areas is Aquaculture Technology. This includes aquaculture structures, land-based facilities, management and operation as well as traceability of marine products. In 2016, along with Summerfelt and Vinci from Freshwater Institute, SINTEF's Liu, Rosten and Henriksen published "Comparative economic performance and carbon footprint of two farming models for producing Atlantic salmon (Salmo salar): Land-based closed containment system in freshwater and open net pen in seawater".

Nofima

Nofima carries out research and development for the fisheries, aquaculture and food industries. One of its departments, called "Production biology", works with major challenges in the aquaculture industry, including salmon lice, escapes, animal welfare, sustainability and production optimisation.

Nofima's R&D is focused on large smolt and full on-growing on land, in addition to closed systems in the sea

Most research is performed at the land-based research station in Sunndalsøra built in 1971, with fresh water, seawater and recirculated water. The Nofima Centre for Recirculation in Aquaculture (NCRA) built in 2010 is also located at the research station.

Experiments carried out by Nofima scientists have shown that closed-containment systems give better control of the fish environment, and good management gives higher water quality, growth and welfare than can be achieved in traditional facilities.

Quotation: "Full control is a vital concept for the sustainable intensive production of farmed salmon, with good fish welfare and a minimum of risk. We are working at Nofima to achieve full control of the environment in which fish live. This enables the full growth potential of the salmon to be realised, and reduces production costs".

According to Nofima, "their research into technological solutions and the welfare of fish in closed facilities has contributed to the aquaculture industry now primarily building fish hatcheries with recirculation systems".

Findings include:

- Growth rate improved in RAS with lower salinity and more exercise
- Improved feed utilisation at lower RAS salinities (FCR, feed:gain)
- Improved survival at low salinities, when kept in similar conditions throughout
- Little early maturation observed when using RAS post smolt strategies at ~12.5°C
- RAS fish handle sea water earlier than fish from flow-through systems, despite similar body size

The senior scientist in the area is Bendik Fyhn Terjesen. Synnøve Helland is the Manager of the research station. Mr Terjesen has confirmed the information above, and the description the research institute and CtrlAqua below.

CtrlAqua (NO)

The CtrlAqua projects focus solely on closed containment

CtrlAqua is a project started in 2015, led by Nofima with numerous partners from both R&D and industry. The total budget for CtrlAqua will be NOK199m, spread over eight years. The main goal is to develop technological and biological innovations that will make closed systems a reliable and economically viable technology. CtrlAqua perform research on both closed systems that are land-based (recycled water) and sea-based (tanks receive clean water from depth).

CtrlAqua consist of 18 current projects including research on sensor protection and maintenance, hydrodynamic challenges in huge tanks (<1,000m3), optimal CO2 levels for use in dimensioning of RAS for post-smolts, particle tolerance, barrier-functions against pathogens and machine vision for biomass in closed systems.

Figure 62: CtrlAqua on postsmolts, closed systems

Source: CtrlAqua, Nofima

R&D Partners: Uni Research AS, Universitetet i Bergen (have principal responsibility for research education at the centre), NTNU, Freshwater Institute (US), Gøteborg Universitet (Sweden) and University of South-East Norway.

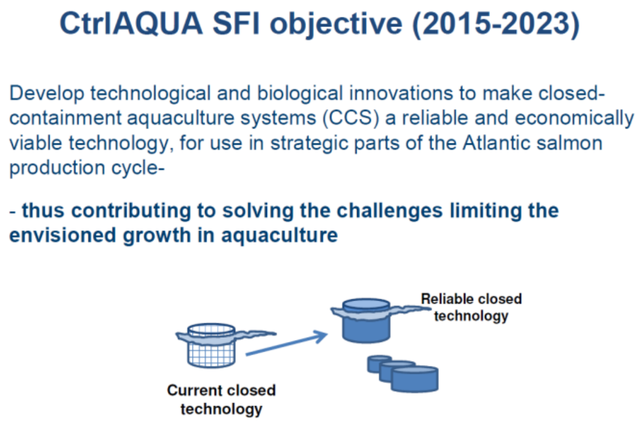
Partners, Technology suppliers: Krüger Kaldnes AS, Oslofjord Ressurspark AS, FISHGlobe AS, Botngaard AS, Storvik Aqua AS and Aquafarm Equipment AS.

Partners, Salmon farmers: Marine Harvest, Grieg Seafood, Lerøy Seafood Group, Cermaq, Bremnes Seashore and Smøla klekkeri og settefiskanlegg.

Partners, Biotechnology companies: Pharmaq and Pharmaq Analytiq

Senior Scientist Bendik Fyhn Terjesen from Nofima at Sunndalsøra is the director of CtrlAqua.

Figure 63: CtrlAqua, centre of Research-based Innovation In Closed-Containment Aquaculture



Source: CtrlAqua

Genetic engineering

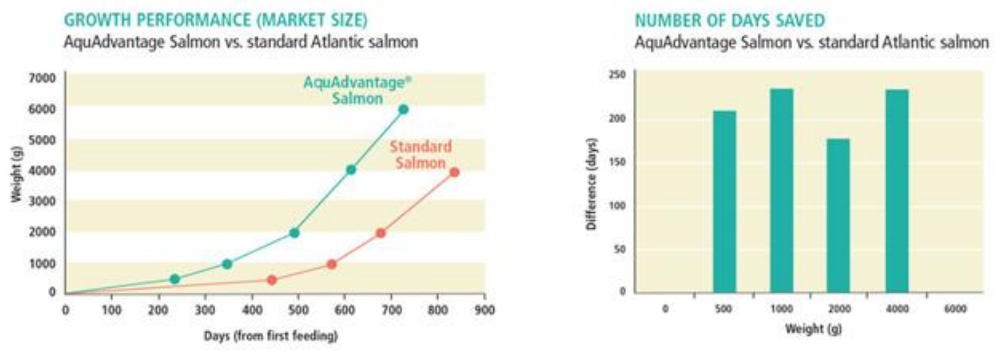
AquaBounty (Massachusetts, US) – AquAdvantage salmon used as example

Genetic engineering of salmon to increase growth rates

"AquaBounty's innovative 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"(Source: AquaBounty).

"AquAdvantage Salmon has been genetically engineered to grow more rapidly than its non-GE farm-raised Atlantic salmon counterpart. It does so because it contains an rDNA construct that is composed of the growth hormone gene from Chinook salmon under the control of a promoter (a sequence of DNA that turns on the expression of a gene) from another type of fish called an ocean pout. This allows the salmon to reach a growth marker important to the aquaculture industry faster than non-GE farm-raised Atlantic salmon" (Source: FDA)

Figure 64: AquAdvantage



Source: Company

News regarding sale and production of AquAdvantage in US and Canada, 2015–2016:

- November 2015: US Food and Drug Administration (FDA) approved for production, sale and consumption In the US
- January 2016: FDA banning of import/export of genetically engineered fish until guidelines for labelling are published
- May 2016: AquAdvantage approved for commercial sale in Canada. No labelling required.
- July 2016: AquaBounty acquires plant in Canada to help scale in production capacity.

Figure 65: AquaBounty Salmon and conventional Atlantic Salmon at same age

Source: AquaBounty

Criticism and ethical issues with genetically engineered salmon (non-exhaustive)

Genetically engineered salmon has received much criticism and the salmon is by some called Frankenfish. A number of environmentalists, consumers, and fishing organisations are concerned about possible negative consequences of growing genetically engineered salmon.

The "Frankenfish" has received much criticism for its potential impact on wild fish

A lawsuit was filed against FDA for approving the AquaBounty salmon as food. According to CBC news, the lawsuit alleges the possible risks include that (SCS quoted below):

- The salmon will escape from the facilities where they're being grown and breed with wild endangered salmon, compete with those salmon for food or pass on infectious diseases.
- The impacts on salmon fisheries, and the economic well-being of those who depend on them.
- The risks to eco-systems from the introduction of what the lawsuit calls invasive species.

What may be seen as the worst-case scenario with genetically engineered salmon is that it is released into the wild and out-competes wild fish for food and mates. This could result in extinction or a significant reduction in the wild population (source: Eurocbc).

New regions

Iceland

We have previously estimated that Iceland could eventually become a 70–100kt region, but currently this is a greenfield operation and would likely take 5–10years to reach this level of output. Both SalMar and Norway Royal Salmon have invested in Icelandic salmon farming companies, offering their farming knowledge and capital to the Icelandic start-ups. Icelandic salmon farming has seen several false starts due to a rough climate and we consider the region to carry high operational risk.

Iceland may produce meaningful volumes of salmon in 5–10 years

East Canada

According to government of Canada, approximately 70% of Canadian salmon production was on the West Coast (British Columbia) in 2014 (Nofima).

According to Nofima, the East Coast has quite a few advantages including the political environment being friendlier to aquaculture:

The temperature is quite similar to Finnmark in Norway, though it has less daylight. This means almost no growth during winter due to low temperature. On the other side, lower summer temperatures (below 15 degrees) create fewer biological challenges. The deeper waters, lower temperatures and streams create better oxygen levels than on the West Coast (Nofima).

The east coast of Canada has biological and political advantages over the west coast

Marine Harvest produces its Canadian salmon on the West Coast. In December 2016 it announced that it has been nominated to purchase farming assets on the East Coast owned by Gray Aqua Group. The assets consist of two farming licences in New Brunswick and 7 in

Newfoundland. In addition, the company has applied for 17 farming licences in Newfoundland yet to be approved. The reason communicated is that the broadening of footprint and the market for North-East America continues to develop favourably: "Marine Harvest will shortly start to detail a production plan and investment framework for the East Coast of Canada, including building an organisation capable to produce 15,000–20,000 tons gutted weight equivalent of salmon per annum" (Source: Marine Harvest).

Japan – Nissui as case example

Nissui (Nippon Suisan Kaiha) is a large Japanese conglomerate with five business segments; Marine Products, Food, Logistics, Fine Chemicals and Others (including construction of ships). Within the Marine Products segment, in addition to the Chilean farmer Salmones Antartica, it owns Nordic Seafood, which process and distributes fish. The conglomerate comprises six companies just within salmon and trout, whose operations include aquaculture, processing and distribution.

Figure 66: Nissui, Japanese conglomerate with seafood presence

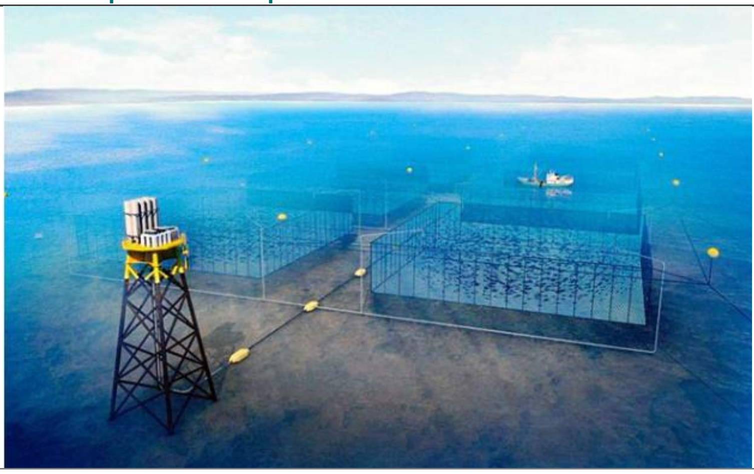
Company name (country)	Major products/functions/sales areas
F.W. BRYCE, INC. F.W.Bryce,Inc. (U.S.A.)	• Crab, salmon, trout, white fish, shrimp • Commercial and retail • U.S. and Canada
NORDIC SEAFOOD Nordic Seafood A/S (Denmark)	• White fish, salmon, shrimp, squid,shellfish, and processed foods • Industrial, commercial, and retail • European countries with the exception of Spain and Portugal
YTC Yokohama Trading Corporation (Japan)	• Salmon, crab, Alaska, pollack, roe, etc. • Industrial and commercial • Trade with Russia, Asia, and other group companies
NISSUI NISSUI(THAILAND)Co.,Ltd. Nissui (Thailand) Co.,Ltd.	• Salmon and trout processing • Industrial, commercial, and retail • Asia, and other group companies
NISSUI Nippon Suisan Kaisha,Ltd. Fisheries Business Department 1 (Japan)	• Crab, fish roe, and salmon • Industrial, commercial, and retail • Trade with overseas companies and domestic group companies
J.P. KLAUSEN & CO. A/S J.P. Klausen & Co. A/S (Denmark)	• Fillets and other general white fish products as well as fish paste (surimi) • Industrial • All of Europe
FIVE STAR Salmones Antartica, S.A. (Chile)	• Aquaculture and processing of salmon and trout • Industrial, commercial, and retail • Japan, North America,South America, and Europe

Source: Company

Offshore production of coho salmon

Nippon has communicated that it is planning to build offshore facilities for coho salmon farming. It began testing prototypes in December 2016 (source: Fishsite.com). The pens are to be 3km off the coast (see illustration) and built to withstand waves up to 7m. Feeding may be controlled through devices (e.g. iPhones) on land, and a tower feeds the pens through pipes (source: undercurrent news). Sensors give information on feeding requirements. According to news source The Asahi Shimbun, the engineering company Nippon Steel & Sumikin Engineering plans to spend six months testing the system, then to market it in 2017 or later.

Figure 67: Offshore production Japan



Source: Intrafish

Other land-based species

Sashimi Royal

Sashimi Royal, located in Hanstholm, Denmark, expects to produce 1,200 tons of Yellowtail Kingfish per year from 2017. The construction (building) of facilities started in September 2016 (source: company homepage).

Sashimi Royal describes itself as having “solid investors and grant support from the Danish government”. According to the company, it will have the world’s largest onshore grow-out facility for this specie and will be vertically integrated with their fingerling farm Maximus.

According to Ilaks.no, the production of Yellowtail Kingfish will increase the value of Danish aquaculture production by 30% (and volumes by 10%).

Figure 68: Yellowtail Kingfish

Source: Company

Figure 69: Yellowtail kingfish

Source: Company

Pentair – aquaponics farming reimagined

Several of these sustainable farming concepts with combined agriculture and aquaculture use sludge from the fish as fertiliser for plants. Pentair, a provider of aquaponic solutions, describes the concept thus: “this hybrid farming method marries aquaculture (raising fish) and hydroponics (growing plants in water) to create a symbiotic relationship that provides clean water for the fish and organic nutrients for the plants”.

One of its systems is the Urban Organic, located in a former brewery in Minnesota, a challenging state for farming due to its climate. The facility including RAS produces about ~6,000 tons of tilapia and ~1 acre of crops.

Green Sky Grower is another system, positioned on a rooftop in Florida. The restaurant El Fresco uses many of its ingredients, in addition to the ‘harvest’ being sold at the local market. Products include tilapia and greens such as oregano, basil and lettuce (Greenskygrowers.com).

Figure 70: Green Sky Grower, Florida US

Source: Company

'Fjellørret' (Norway) – Land-based production of 3,200 tons

The two founders Stein Kjartan Vik and Olav Skjøtskift plan to produce 3,200 tons of trout. The location is planned to be Driva in the municipality of Oppdal (Norway) and they aim to have fish in facilities from 2020. The investment size is estimated in the range of NOK300–500m. The founders are currently in the phase of mapping geodata and searching for investors. Innovasjon Norge and SIVA are possible contributors according to the local newspaper OPP (source: iLaks.no)

Development licences

Currently growth within aquaculture in Norway is very low/non-existent due to a lack of growth within existing licences and few new ones being given. The possibility to apply for development licences and the fact that the industry is highly profitable has brought many innovative solutions to the table. There are a wide range of different technologies; closed, open and semi-closed pens with a varying share of production on land. Common for the concepts is the ambition to reduce biological risk – especially lice, which is putting a lot of pressure on farmers as it threatens fish welfare, growth prospects and the reputation of the industry as a whole.

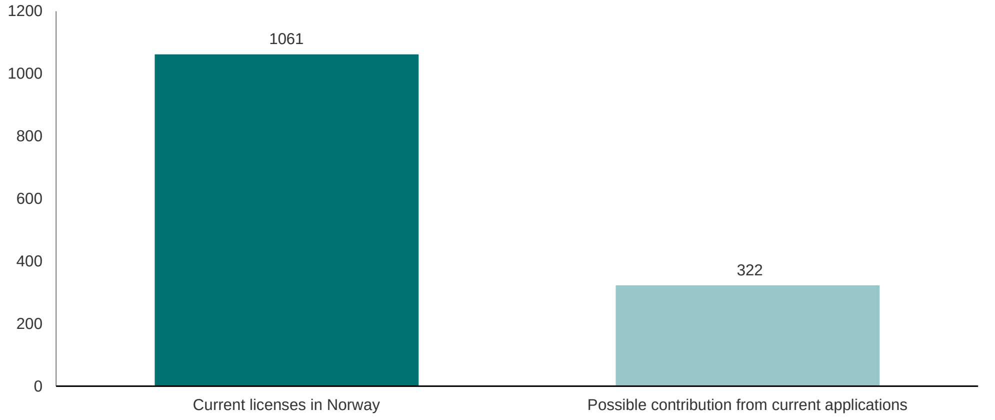
The 322 licences granted or awaiting approval could increase volumes by 30% in Norway

Will development licences increase Norwegian production volumes by 30%+?

The opportunity to apply for development licences in Norway is a government initiative to foster innovation. The current number of development licences awaiting an outcome has reached 304 (18+ awarded already). 30%+ of additional volume would be added if all these applications were accepted. So far, we have observed the approval process to be quite lengthy. Six applications totalling 41 licences have been rejected so far (source: Directorate of Fisheries). The process along with a tightly defined scope including the criteria of a unique and innovative concept means it will take some time before volumes hit the market and we expect the number of awarded licences to be restricted.

The lengthy process and strict criteria for approval limit our expectations to add volumes from development licences

Figure 71: Outstanding licences versus development applications



Source: Directorate of Fisheries

SalMar's Ocean Farming and Nordlaks Seafarm are the only two applications approved for development licences (8 licences + 10 licences) so far. Three applications (Marine Harvest, MNH and AKVA group with partners) have received positive feedback (25 November 2016), which means that they are reviewed by Fiskeridirektoratet and found to qualify for development licences as they meet the innovation and (substantial) investment criteria. However, they have been informed that they are under review for a much lower number of licences than they applied for.

Figure 72: Development licences applications approved or pending

#	Applicant	Status	Licenses	MAB	Output (kt) HOG
1	**Ocean Farming AS (SalMar)**	**Accepted**	**8**	**6240**	**7**
2	**Nordlaks Oppdrett AS**	**Accepted, 10 out of 39 applied for**	**10**	**7800**	**9**
3	**Akva group, Sinkaberg-Hansen, Egersund Net**	**Positive feedback**	**6**	**4680**	**6**
4	**Marine Harvest Norway AS**	**Positive feedback**	**14**	**10920**	**13**
5	**MNH Produksjon AS**	**Positive feedback**	**8**	**6240**	**7**
6	Marine Harvest Norway AS	Pending	6	4680	6
7	Marine Harvest Norway AS	Pending	8	6240	7
8	Marine Harvest Norway AS	Pending	6	4680	6
9	Norway Royal Salmon ASA og Aker ASA	Pending	15	11700	14
10	Norsk Marin Fisk AS og Stjernefarm SUS	Pending	3	2340	3
11	Kobbevik og Furuholmen Oppdrett AS	Pending	4	3120	4
12	Eide Fjordbruk AS	Pending	6	4680	6
13	Eide Fjordbruk	Pending	3	2340	3
14	Lerøy Seafood Group AS	Pending	9	7020	8
15	Stadion Laks	Pending	15	11700	14
16	Folla Alger AS	Pending	3	2340	3
17	Steinvik Fiskefarm AS	Pending	8	6240	7
18	Norsk Sjømat Oppdrett AS	Pending	4	3120	4
19	Engesund Fiskeoppdrett AS	Pending	3	2340	3
20	Bremnes Seashore	Pending	6	4680	6
21	Pure Farming AS	Pending	6	4680	6
22	Øyfisk AS / Blue Salmon	Pending	4	3120	4
23	Aqualine	Pending	10	7800	9
24	Aquafarm Utvikling	Pending	6	4680	6
25	Ballangen Sjøfarm	Pending	4	3120	4
26	SalmoTech	Pending	6	4680	6
27	Cermaq Norway	Pending	10	7800	9
28	SFD Innovation	Pending	6	4680	6
29	Kvarøy Fiskeoppdrett	Pending	4	3120	4
30	Lovundlaks	Pending	3	2340	3
31	Oxyvision/Aakvik Holding	Pending	5	3900	5
32	Nekst	Pending	16	12480	15
33	Aqua Viva	Pending	6	4680	6
34	Bolaks Utvikling	Pending	6	4680	6
35	Pure Atlantic	Pending	46	35100	42
36	Grieg Seafood Rogaland	Pending	10	7800	9
37	Aqua Star Invest AS	Pending	6	4680	6
38	Ocean Aquafarms	Pending	13	10140	12
39	Osland Havbruk	Pending	6	4680	6
40	Hydra Salmon Company	Pending	4	3120	4
	Total / Average		**322**	**250380**	**300**

Source: Directorate of Fisheries

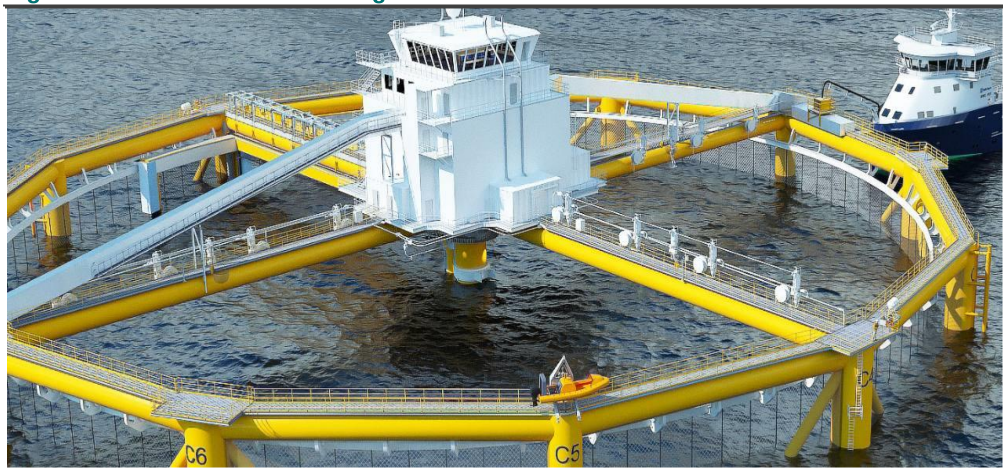
Concepts approved

SalMar Ocean Farming

SalMar was the first to receive approval of eight development licences (February 2016) for the 'Ocean Farming' concept based on offshore technology. It is intended for offshore installation in water depths of 100 to 300 metres. Completion/transfer of fish is planned for summer 2017 and the first fish are due to be harvested in 2018. SalMar estimates the total investment in Ocean Farming at NOK690m. SalMar Ocean Farming is established as a subsidiary of the SalMar Group.

SalMar Ocean Farming could add 7,000 tons by 2018–2019

Figure 73: SalMar Ocean Farming



Source: Company

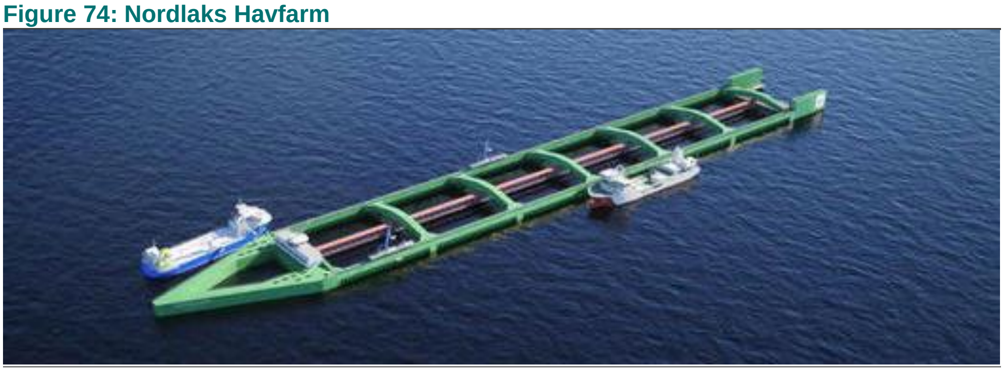
Nordlaks Seafarm

One Nordlaks Seafarm has production capacity of 10,000 tons

The Seafarm is built by NSK Ship Design, which describes it thus: "On the drawing board is a ship, the Ocean Farm, 430 metres in length and 54 metres wide, it will be at anchor, fixed to the seafloor using the offshore industry's technology. One Seafarm will be able to contain 10,000 tons of salmon – over 2 million fish. The facilities will be able to withstand a wave height of ten metres, and can be raised by four metres during inclement weather. The ocean farm itself will extend ten metres below sea level. The farm will be constructed as a steel frame for six 'cages' measuring 50 by 50 metres on the surface, with aquaculture nets going to a depth of 60 metres."

Nordlaks initially applied for 39 licences and received feedback from Fiskeridirektoratet. 10 licences were approved, and the company is now looking into how to move forward. According to iLaks (January 2017), Nordlaks plans to appeal the decision to grant only 10 licences.

Figure 74: Nordlaks Havfarm



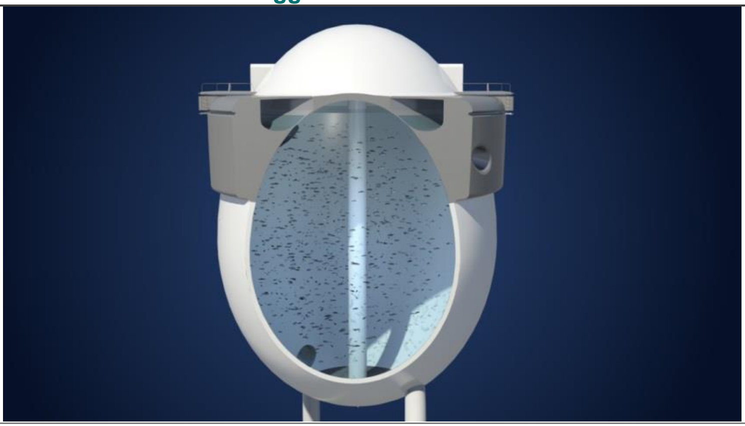
Source: Company

Concepts with preliminary positive response

The Egg/'Egget' – Closed system in the sea (Marine Harvest)

The Egg is a closed containment construction in composite to be placed in the sea (90% of the tank is submerged at all times). Inside the tank, a central tube is placed which strengthen the structure vertically. Water is pumped into the egg from below 20 metres with entry secured so lice larvae do not enter the pen. Both the inlet and outlet are secured to avoid escapes, and collection of particular waste is collected in the tanks.

Figure 75: Marine Harvest's "The Egg"



Source: Company

Marine Harvest has applied for 14 licences, i.e. a total MAB of 10,920 tons. The entire project has a total estimated cost of NOK600m. According to the Directorate of Fisheries, Marine Harvest has estimated the cost of a prototype egg at NOK88m, which is included in the total cost of NOK600m. One egg is planned to have a capacity of ~1,000 tons of salmon. Based on information from the company, the Directorate of Fisheries estimates an investment of NOK50m per egg when moving the project to full scale. This is based on NOK450m for an additional nine eggs, and the directorate expects it to be somewhat higher with fewer eggs.

Low up-front capex, with prototype estimated at NOK88m

Figure 76: The Egg

Phase	#egg	#licences	tons	capex, NOKm	capex/ktons
Total full scale	10	14	10,920	600	~55

Source: Fiskeridirektoratet

The response received from Directorate of Fisheries in November 2016 is that the project meets the criteria for receiving licences. However, it rejected 10 licence applications, and is continuing with the approval process for four others. Approval is yet to be finalised, but is expected. Each licence has a maximum allowed biomass (MAB) on 780 tons, hence 4 licences mean 3,120 in additional capacity. If Marine Harvest receives approval and decides to go through with the project and the Egg is proven to be effective, Marine Harvest is expected to build more.

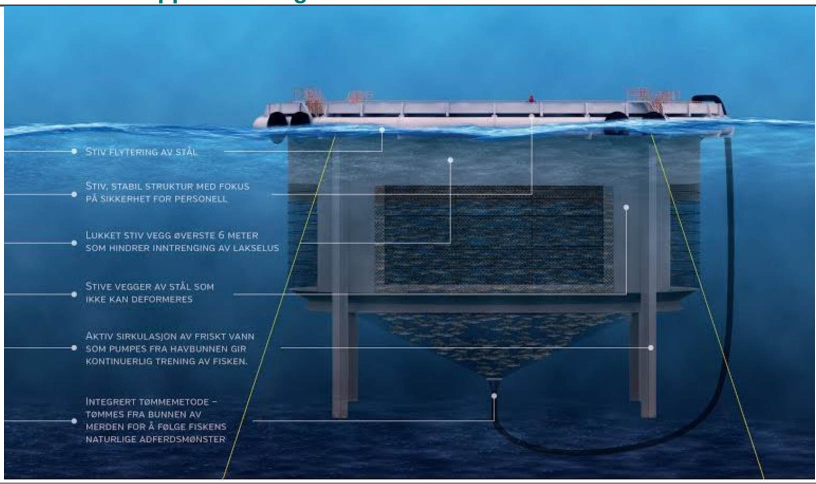
MNH Produksjon – semi-closed pens

The concept is a stiff semi-closed cage of steel. 'Semi-closed' means that the upper walls of the cages are closed, while the bottom is open. The entire cage can be lifted out of the water (iLaks). This allows disinfection, inspection and maintenance. The pen has a mechanical water supply (in addition to the natural inflow at the bottom) where seawater is pumped from the depths up into the upper part of the cage (IntraFish).

The application requested for eight licences. The response from Fiskeridirektoratet in November 2016 is that the project meets the criteria for receiving licences, but is not expected to be approved for more than four licences.

MNH Produksjon is 100% owned by MNH (iLaks).

Figure 77: MNH has applied for eight licences



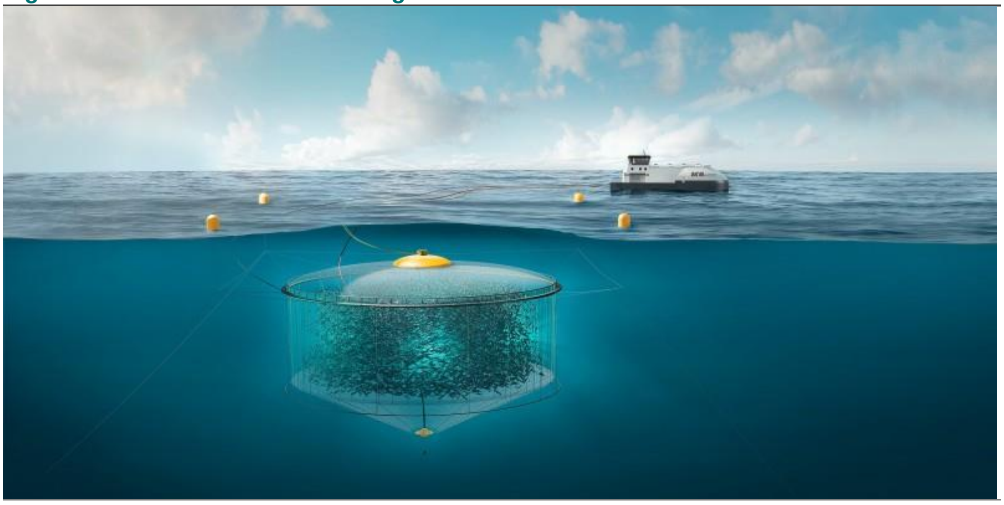
Source: iLaks

Atlantis Subsea – submerged pens (AKVA group, Sinkaberg-Hansen, Egersund Net)

"In partnership with the companies Sinkaberg-Hansen AS and Egersund Net AS, AKVA group ASA has established the company Atlantis Subsea Farming with the purpose of developing submersible fish-farming facilities).

Atlantis has applied for six licences and received feedback from Fiskerdirektoratet that the concept meets the criteria of development licenced and will be further evaluated based on more information to be provided by the applicant." (source: quote AKVA Group homepage

Figure 78: Atlantis Subsea Farming



Source: iLaks

Nekst – Almost the entire production on land

Kjell Audun Aasen and Martin Ramsdal are the founders and owners of Nekst. The concept is production of fish up to 2.7kg in land-based facilities, then brought to sea for on-growing in submerged pens for only 6 months (source: IntraFish). Nekst has applied for 16 development licences (12,480 tons). The estimated total investment size is NOK3,100m comprising a land-based facility investment of NOK2,300m and a facility for on-growing in sea of NOK800m(source: iLaks.no). According to Intrafish, the founders are currently seeking financing hoping to have the facility in operation by 2019. The RAS technology is to be delivered from Aquatec Solutions. The fingerling/smolt is kept in fresh water until 60 grams, then in brackish water. The maximum density is estimated to 70kg/m^3, which is during the phase when the smolt is between 63 and 250 grams (source: attachment to Nekst's application for large smolt production, prepared by Rådgivende Biologer As).

Figure 79: Illustration of Nekst

Source: Kyst.no

Carbon footprint

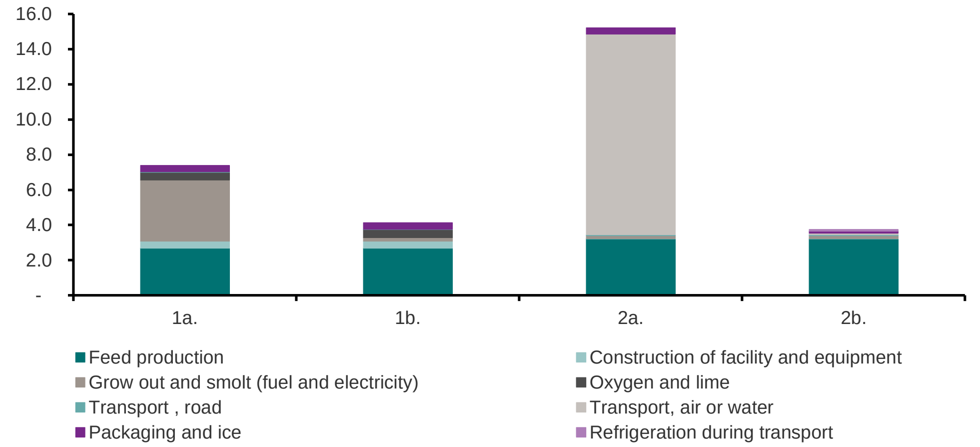
Researchers from SINTEF and the Freshwater Institute have published a report, “Comparative economic performance and carbon footprint of two farming models for producing Atlantic Salmon (Salmo salar): Land-based closed containment system in freshwater and open net pen in seawater”. In a carbon footprint comparison, they estimate the volume of C02 emission per kg salmon produced (HOG) with four alternative production methods to provide a retailer in Seattle with salmon described as follows:

- 1a. Salmon from a LBCC-RAS system in the US running on electricity generated from a source that uses a typical mix of coal, gas, nuclear, wind and hydropower. Salmon is assumed to be transported fresh to the retailer 250km by truck.
- 1b. Salmon from a LBCC-RAS System in the US running on electricity generated from a source that uses 90% hydropower and 10% coal. Salmon is assumed to be transported fresh to the retailer 250km by truck.
- 2a. Salmon from a Norwegian Open Net Pen (ONP) system. Salmon is assumed to be transported fresh, first by truck in Norway to Oslo, 520km, and then with airfreight to Seattle, 7,328km.
- 2b. Salmon from a Norwegian ONP system. Salmon is assumed to be transported frozen, first by truck in Norway to Oslo, 520km, and then by ship from Ålesund, Norway, to Seattle through the Panama Canal, 16,473km.

Please see description of further assumptions in the report published by Liu et al (2016).

The difference in environmental impact is substantial, and the kicker is the transportation by air, adding more than 11kg C02 emission per kg salmon HOG.

Figure 80: CO2e/kg HOG salmon at retailer gate



Source: Liu et al. (2016), SINTEF and Freshwater Institute

Description of projects

For a full description of projects, please contact your DNB representative

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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.

Recommendation distribution and corporate clients for the last 12 months

	Buy	Hold	Sell	No rec	Total
Number	89	82	42	8	221
% of total	40 %	37 %	19 %	4 %	
DNB Markets client	11 %	7 %	3 %	3 %	54

Conflict of interest, risk classification and price target history for Marine Harvest

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Share positions in the company:	Analyst*	Employees**	DNB***	Update
Number of shares	0	200	0	01/02/2017

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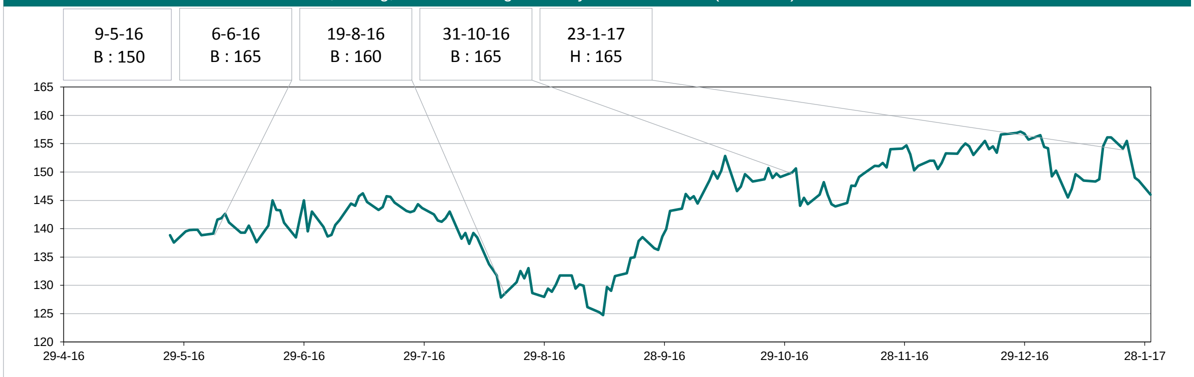
Price, Rating, and Price Target History Marine Harvest (MHG NO) as of 31-1-17



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

Current 6 months volatility rates this security as MEDIUM risk.

Conflict of interest, risk classification and price target history for Lerøy

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Price, Rating, and Price Target History Lerøy (LSG NO) as of 31-1-17

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Conflict of interest, risk classification and price target history for Austevoll Seafood

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Price, Rating, and Price Target History Austevoll Seafood (AUSS NO) as of 31-1-17

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Conflict of interest, risk classification and price target history for SalMar

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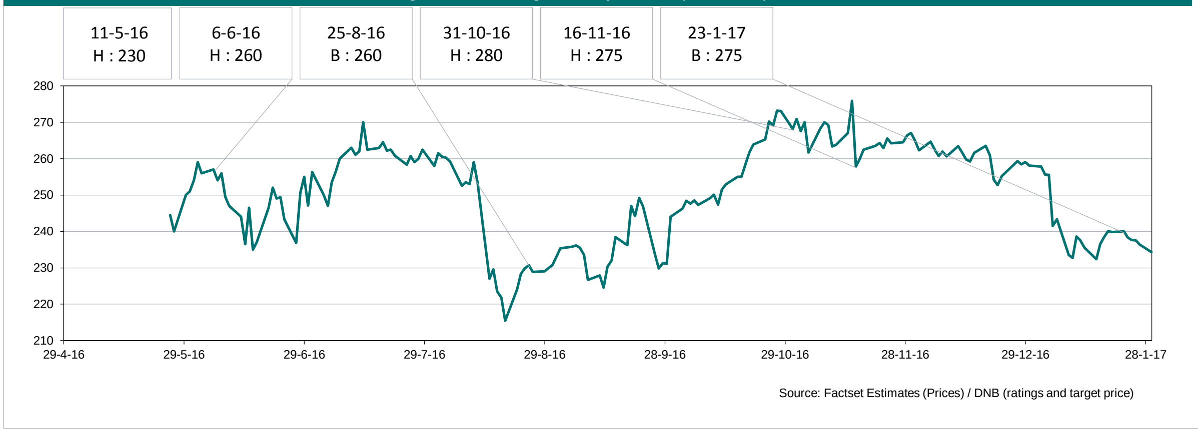
Price, Rating, and Price Target History SalMar (SALM NO) as of 31-1-17



Current 6 months volatility rates this security as MEDIUM risk.

Conflict of interest, risk classification and price target history for Grieg Seafood

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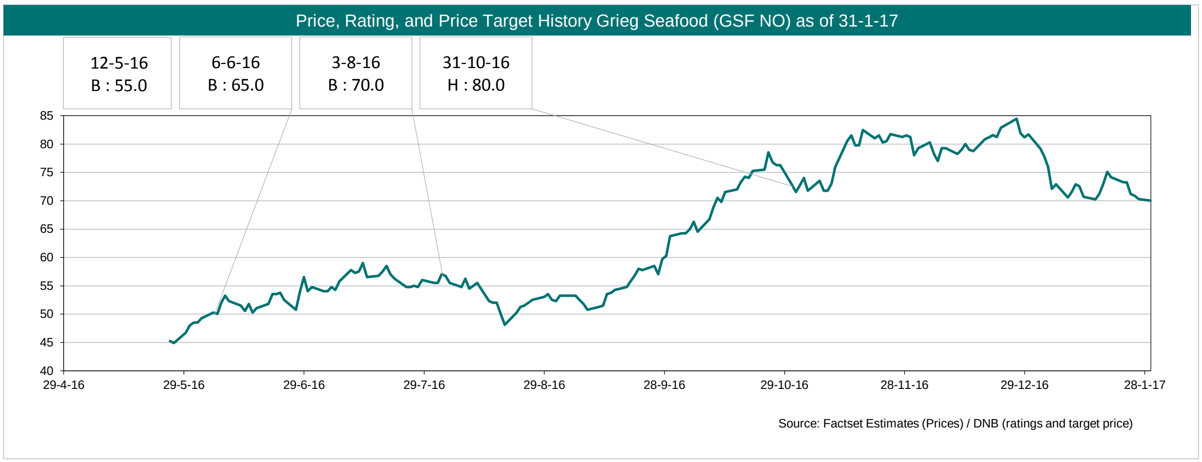

Current 6 months volatility rates this security as MEDIUM risk.

Conflict of interest, risk classification and price target history for The Scottish Salmon Company

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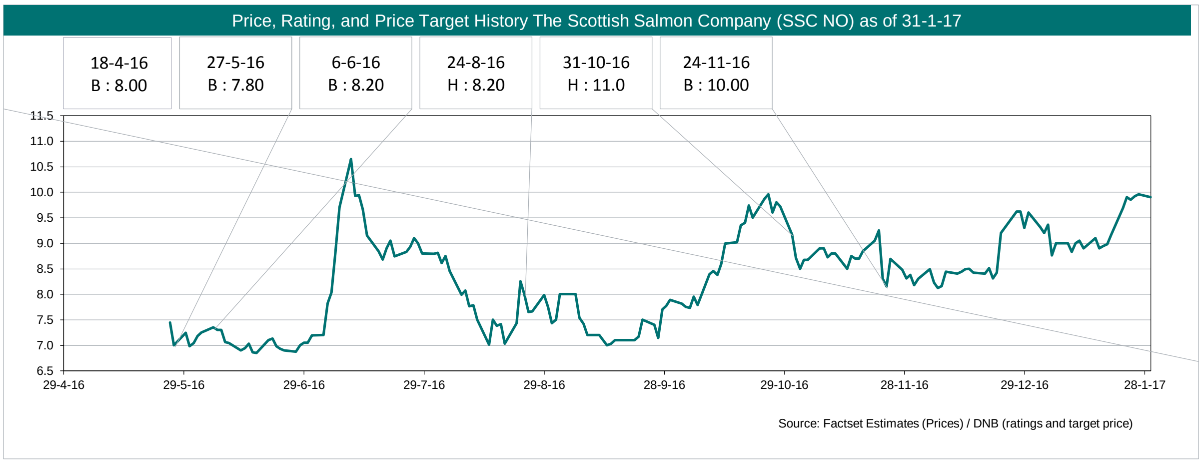

Current 6 months volatility rates this security as HIGH risk.

Conflict of interest, risk classification and price target history for Bakkafrost

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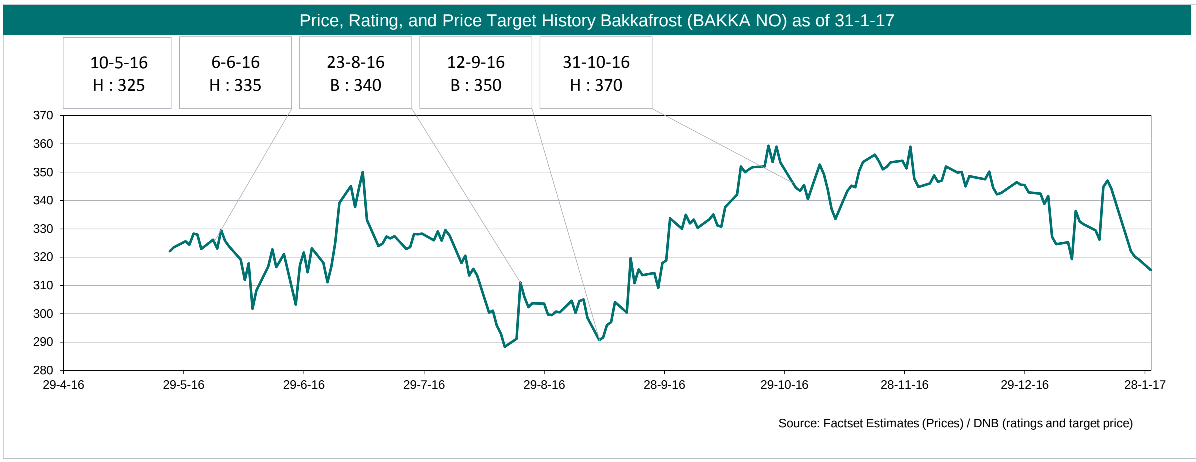

Current 6 months volatility rates this security as MEDIUM risk.

Conflict of interest, risk classification and price target history for Norway Royal Salmon

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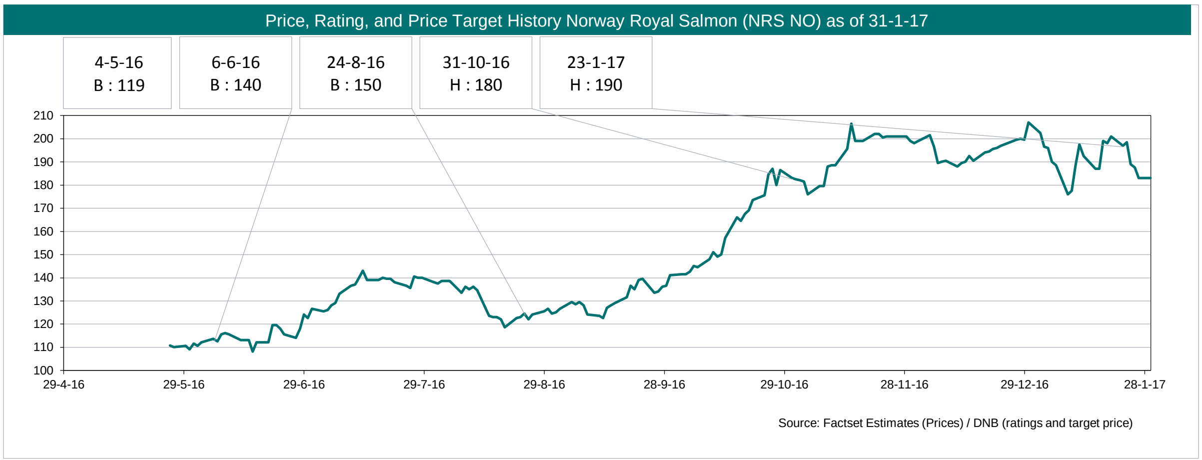

Current 6 months volatility rates this security as MEDIUM risk.

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