RAS grow-out production of cold water species

Market study

08 February 2022

Prepared for

Matfiskodlarna

EY Parthenon

Disclaimer

Any person intending to read this report should first read this letter

EY / EY-Parthenon has been mandated by Matfiskodlarna Sverige AB (“Client”, “Company”), to prepare a market study addressing key aspects regarding the current maturity for RAS grow-out farming of cold-water species Atlantic Salmon, Rainbow Trout and Arctic Char. We understand that the Client will share the report with its member firms and the Client’s/member firms’ advisors and be used for the purpose of supporting the member firm’s operating permit application processes.

This report is prepared on the understanding that it is solely for this purpose and subject to the terms of the Engagement Agreement, and its contents may not be quoted or referred to for any other purpose. By reading this report you agree to that, to the fullest extent permitted by law, we and any EY Firm neither owe nor accept any duty or responsibility or liability to you or any other party, whether in contract, tort (including negligence) or otherwise in respect of any use you may make of the Report, which is entirely at your own risk, and shall not be liable in respect of any loss, damage or expense which is caused by your or any other party's reliance upon the Report or the Information herein.

The work behind this report is primarily based on (i) obtaining relevant data and information from third party sources (comprising primary and/or secondary research) and (ii) applying analytical procedures to that data and information and (iii) analysis of the data, information and explanations provided to us by the Client. We have not independently verified any of such information and we assume no responsibility for, nor give any representations with respect to, the accuracy or completeness of any such information.

Our work was completed on or around 08 February 2022. Therefore, our report does not take account of events or circumstances arising, or information made available, after this date, and we have no responsibility to update the report for such events or circumstances or information.

Agenda

- **Report context and executive summary**
- Aquaculture market context
- Recirculating Aquaculture Systems (RAS) technology
- Production technology outlook

This report has been prepared to address the current and expected future market maturity for RAS grow-out farming of select cold water species

Report scope and limitations

Report scope

- Provide an overview of current status of RAS development in relation to grow-out farming of cold water species Atlantic Salmon, Rainbow Trout and Artic Char, including:
  - Overview of current facilities incl. status of e.g. production volumes, capacity and species
  - Primary drivers of RAS development and increased interest in RAS facilities
  - Current economic performance for RAS grow-out farming
- Provide perspectives on the current market expectations in terms of future aquaculture production and production technology, e.g. is RAS expected to replace open net cages or are they expected to co-exist
- Provide a view on whether RAS grow-out can be considered to be a currently available technology for grow-out production of cold water species to market size, from both an economic and technological perspective
  - To what extent does the current status of development support the economic and technological viability at scale

Key limitations

- Atlantic Salmon accounts for the large majority of announced / operational projects for RAS grow-out of species in scope. Consequently, this specie is the basis for most of the report analyses. Nevertheless, RAS grow-out production has similar key characteristics for all three cold water species in scope and conclusions should therefore (to a varying degree) be generalizable across the species
- The comparison of the production methods in the report is limited to a comparison of RAS grow-out to conventional Open Net Pen (“ONP”) farming
  - I.e. it does not assess in detail any of the other emerging production methods: offshore production, semi-closed pens, closed pens and flow through systems
- EY collects and tracks a comprehensive list of RAS grow-out projects for cold water species which is basis for many of the report analyses. Although this is one of the most comprehensive and detailed lists available, it is not complete and specific projects could be missing
- The report does not include any assessment of the environmental footprint of RAS versus conventional ONP farming

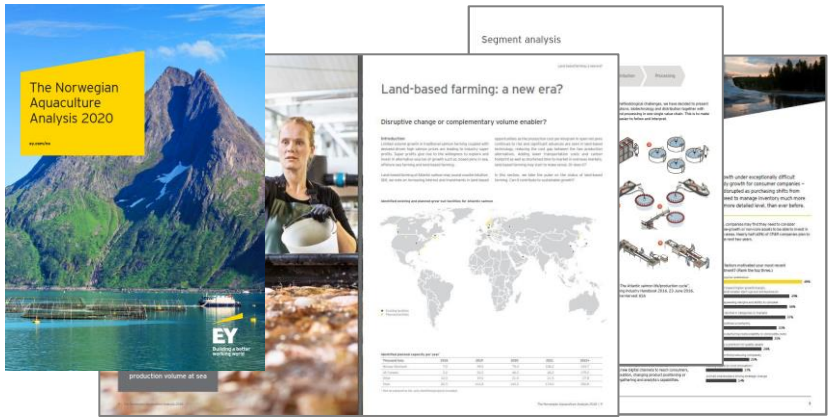
Our perspectives are based on deep industry insights and a range of primary and secondary sources, and several interviews with RAS grow-out market participants

Sources and approach

EY has an international network of fisheries and aquaculture capabilities, with a center of excellence in Norway…

- EY possesses deep insight into each segment of the fisheries and aquaculture value chain with teams located in numerous seafood clusters and regions
- Our global center of excellence is located in Bergen, Norway, where many of the leading seafood companies have headquarters and research centers
- Our team of aquaculture professionals are located in more than 50 offices worldwide, comprising a wide network of industrial skills

…and publish leading research on the aquaculture industry…



…EY is also partner with the world's leading seafood cluster, the NCE Seafood Innovation Cluster

Norwegian Centres of Expertise
NCE Seafood
Innovation Cluster

Information in this report is based on a combination of interviews and primary / secondary research

Interviews

- EY has over recent years performed a large number of interviews with RAS farming companies and relevant industry stakeholders as part of industry research projects
- In preparing this report, EY has also interviewed relevant industry associations in Sweden, Denmark and Iceland, as well as in-house subject matter experts

Secondary sources

- Food and Agriculture Organization of the United Nations (FAO), OECD, Eurostat, Kontali, Norwegian Directorate of Fisheries, Norwegian Veterinary Institute, SINTEF, EUMOFA, Seafish, SeafoodSource, Nofima, GRV Inc., The Conservation Fund
- SalmonBusiness, Intrafish, Seafood Watch, and misc. press releases and newspaper articles
- Pareto Securities, DNB, Kepler Cheuvreux
- Euronext, Yahoo Finance, Fish Pool Index, Proff Forvalt, Retriever
- Company reports and websites
- EY - The Norwegian Aquaculture Analysis

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Abbreviations

Terminology used throughout the report

Avg.	Average	**kg**	Kilogram
CAGR	Compound annual growth rate	**NA**	Not applicable
Capex	Capital expenditures	**OECD**	Organization for Economic Co-operation and Development
E	Estimate	**ONP**	Open Net Pen
EBITDA	Earnings Before Interest, Tax, Depreciation and Amortization	**Opex**	Operating expenditure
F	Forecast	**p.a.**	Per annum
FAO	Food and Agriculture Organization of the United Nations	**R&D**	Research and Development
FCR	Feed Conversion Ratio	**RAS**	Recirculating Aquaculture System
FTS	Flow Through System	**WFE**	Whole Fish Equivalent
HOG	Head-On-Gutted	**USD**	United States Dollar

Executive summary (1/2)

Executive summary

Aquaculture market context

- The growth in global seafood production volumes has been primarily driven by aquaculture as wild catch resources are largely exhausted. This trend is expected to continue going forward and by 2028F c. 2/3 of the total seafood market value is expected to come from aquaculture
- Atlantic Salmon is by far the most farmed diadromous specie, accounting for ~71% of diadromous aquaculture volumes, followed by Rainbow Trout (~19%) and relatively low production volumes for Arctic Char (<1%). While Atlantic Salmon and Arctic Char have seen growing production volumes (5% p.a. and 11% p.a. from 2007-2019 for Atlantic Salmon and Arctic Char, respectively) the growth in Rainbow Trout production has been relatively flat
- Norway is the leading aquaculture producer in the Nordics, accounting for ~93% of Nordic aquaculture production of which the large majority is Atlantic Salmon. Denmark is the second largest producer (~3%) due to its position as a EU leader in Rainbow Trout production, followed by Iceland (~2%), Finland (~1%) and Sweden (<1%)

Current RAS grow-out maturity

- Grow-out production has conventionally taken place in sea pens. Land-based production is emerging as a complementary technology, and there are also other technologies being developed and tested. Recirculating Aquaculture Systems ("RAS") is an aquaculture production method where water is re-circulated in a closed system. It can therefore be placed on land and is not bounded by the geographical proximity of the species natural habitat. However, delicate and strict processes are required to re-create necessary growing conditions
- The RAS technology has a ~70 year history and entered its first maturing phase in the 90s. It has since 2005 been industry standard for early stage Salmon production (smolt), but there are still only a limited number of operational facilities for full-cycle grow-out Salmon production
- Atlantic Salmon, Rainbow Trout and Arctic Char have all been cultivated to grow-out size with RAS facilities, however, production at scale has only been partially achieved. There is however high development activity for scaling RAS grow-out capacity with many projects being in planning or build-out stages
- Globally, there is announced projects totaling 1,892 kilotons RAS grow-out capacity, of which only 31 kilotons is operational today. This highlights the strong interest in RAS grow-out, however, the low operational volumes confirms the limited evidence of viable commercial operations at scale (+1,000 tons). Furthermore, operational capacity should not be perceived as harvest volumes and the harvest volumes in operational RAS facilities are still significantly lower than the operational capacity. That is, they have not yet been able to reach harvest volumes in line with expected production capacity
  - The majority of announced capacity identified (+95% of total) is for Atlantic Salmon (1,810 kilotons), followed by Rainbow Trout (42 kilotons) and Arctic Char (9 kilotons). Note that only a limited number of these projects have received farming licenses, and even fewer have secured funding. Therefore, it is uncertain how much of this capacity will actually be realized and how many years it will take. The operational capacity is also largely for Atlantic Salmon (25 kilotons), with smaller operational volumes for Rainbow Trout (6 kilotons) and one small scale Arctic Char RAS grow-out facility identified (0.45 kilotons)
- 2021 was a challenging year for listed RAS companies such as Nordic Aqua Partners, Proximar Seafood, Atlantic Sapphire, and AquaBounty Technologies
- While RAS farms have managed to successfully grow Atlantic Salmon, Rainbow Trout and Arctic Char to harvesting size, among the cases for which financial data has been available to us, no RAS grow-out farm has reached profitability

Executive summary (2/2)

Executive summary

RAS grow-out economics

- RAS has significantly higher operational costs per kg produced Atlantic Salmon (+~35%) compared to farming in open net pens
  - Based on a benchmark of RAS projects (based on budgeted and not actual numbers) we estimate an Opex of ~5.2 USD per kg WFE Atlantic Salmon for RAS grow-out, compared to 3.9 USD per kg WFE for ONP (based on Norwegian ONP farming operational costs)
  - RAS grow-out Opex in the benchmark varies from 4.2 USD kg WFE to 6.0 kg WFE Atlantic Salmon and the uncertainty towards actual realized Opex is high, given the relatively small sample of projects and the lack of evidence from large-scale production
- Certain benchmarking studies also indicate that RAS grow-out systems require substantially higher upfront Capex than conventional ONP farming, estimated at ~18.1 USD per kg WFE Atlantic Salmon, compared to 4.7 USD per kg WFE for ONPs (excluding licenses and based on Norwegian ONP Capex)
  - The RAS estimate is based on a benchmark of RAS grow-out Atlantic Salmon projects (based on budgeted and not actual numbers), ranging from 14 USD per kg to 25 USD per kg
  - High investment costs are driven by expensive upfront investments in RAS equipment, land & buildings, and construction & concrete works
- Receiving external financing for RAS projects from credit institutions could be challenging, and many players have turned to private investors for funding

Production technology outlook

- We expect investments into RAS facilities to continue, due to several promising supply-side drivers. However, different production technologies (i.e. sea pens, land-based and offshore production methods) offers distinct advantages and are therefore likely to co-exist as complementary production methods in the future
  - RAS key advantages include the geographical flexibility to be able to produce close to end markets, and better control of outputs and effluents, however, is not a fully commercially proven technology for RAS grow-out and requires significantly higher upfront investment costs
  - Key disadvantages include the higher initial capital costs, high operational costs and the more sophisticated technology with several issues to be solved to realize stable production at scale
- Looking at Atlantic Salmon, we expect land-based farming to emerge, however, conventional sea based farming to still be the leading production method by 2040e

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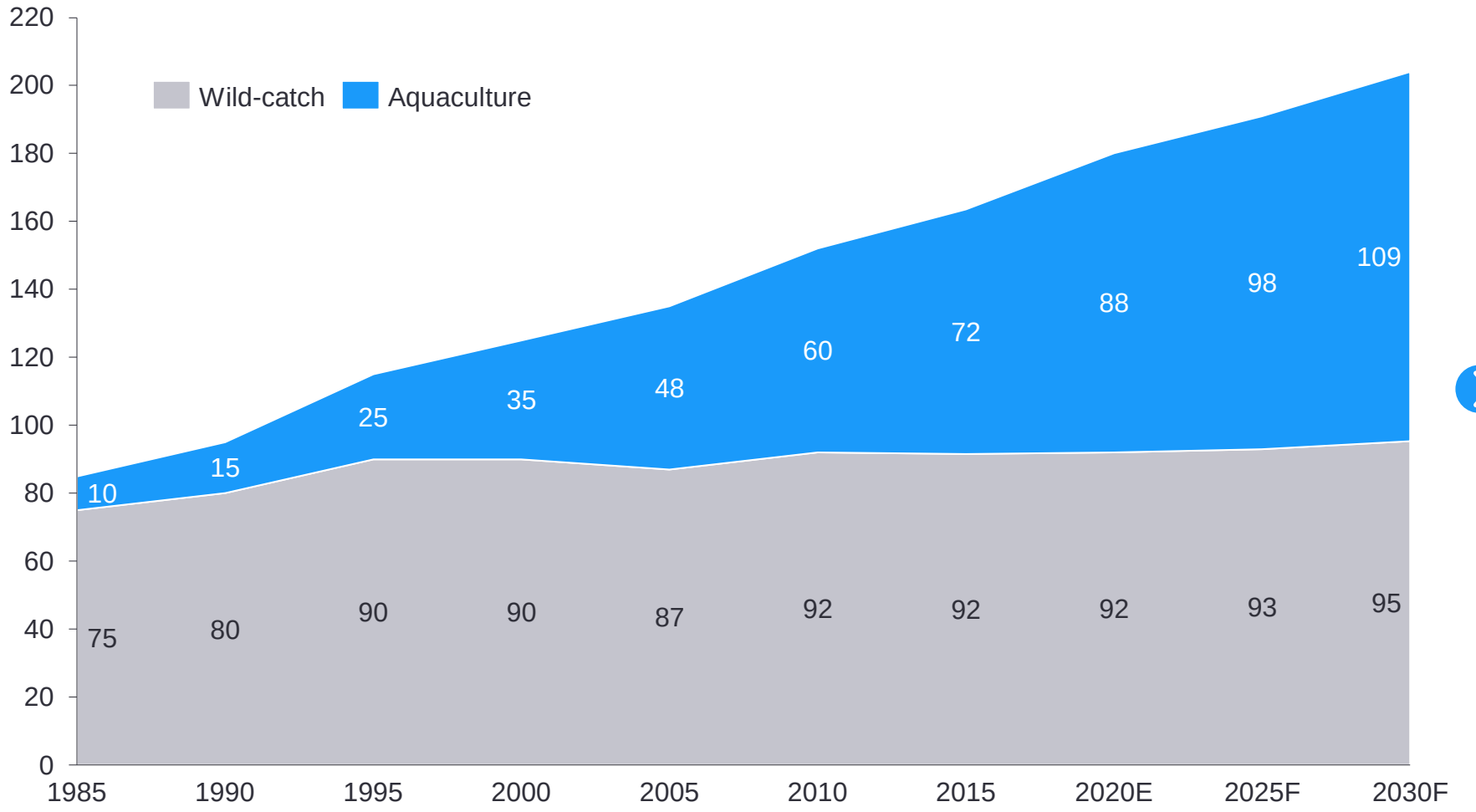
The growth in global seafood production volumes is primarily driven by aquaculture, as wild catch resources are largely exhausted

Global capture fisheries and aquaculture production volume[1], 1985 – 2030F (Million tons)



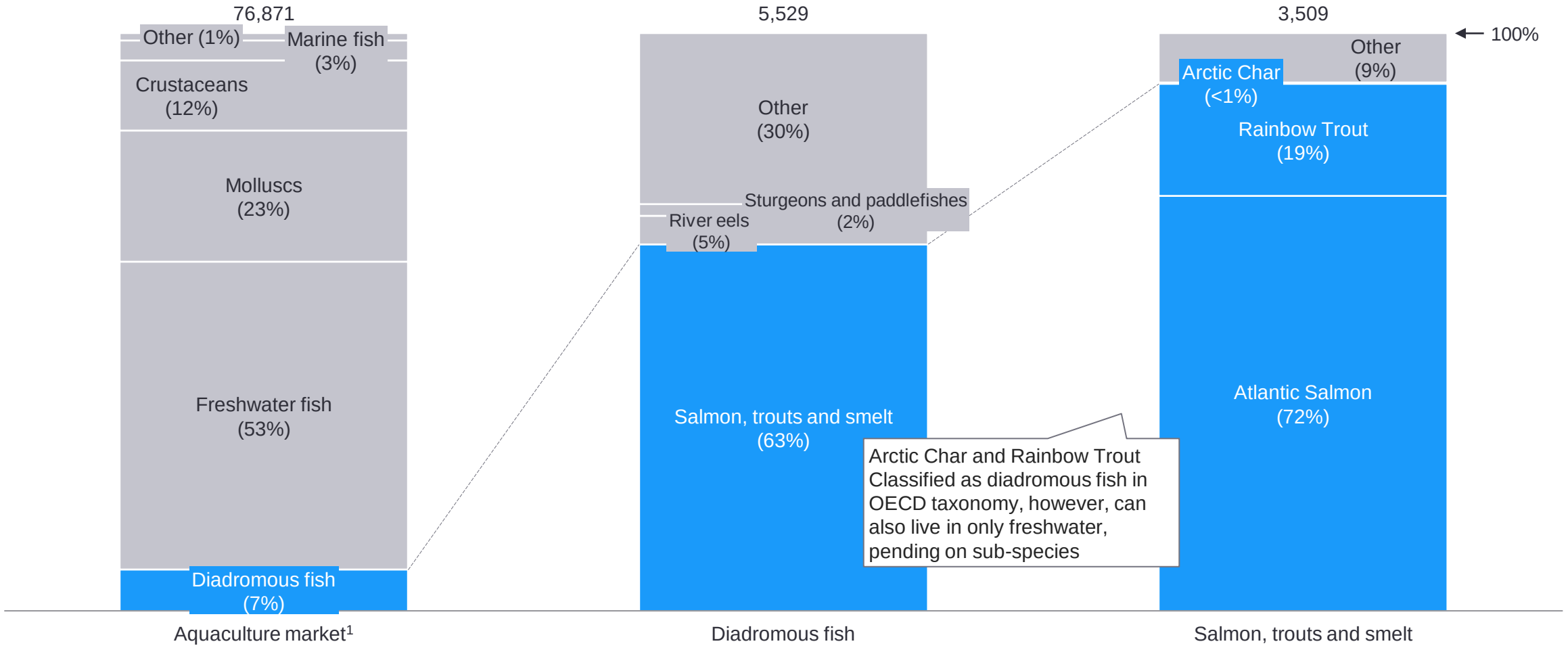
- Total fish production is expected to expand to 204 million tons by 2030
- Aquaculture will continue to be the driving force behind the growth in global fish production
- Aquaculture production expected to grow at a CAGR of 2.1% between 2020-2030, whereas capture production is expected to grow at a CAGR of 0.4% during the same period

1. Excluding aquatic plants
Source: FAO; EY-Parthenon analysis

EY Parthenon

Atlantic Salmon, Rainbow Trout and Arctic Char account for 4% of global aquaculture production volumes, of which Atlantic Salmon is the most farmed specie

Global aquaculture production breakdown[1], 2019 (Kilotons)

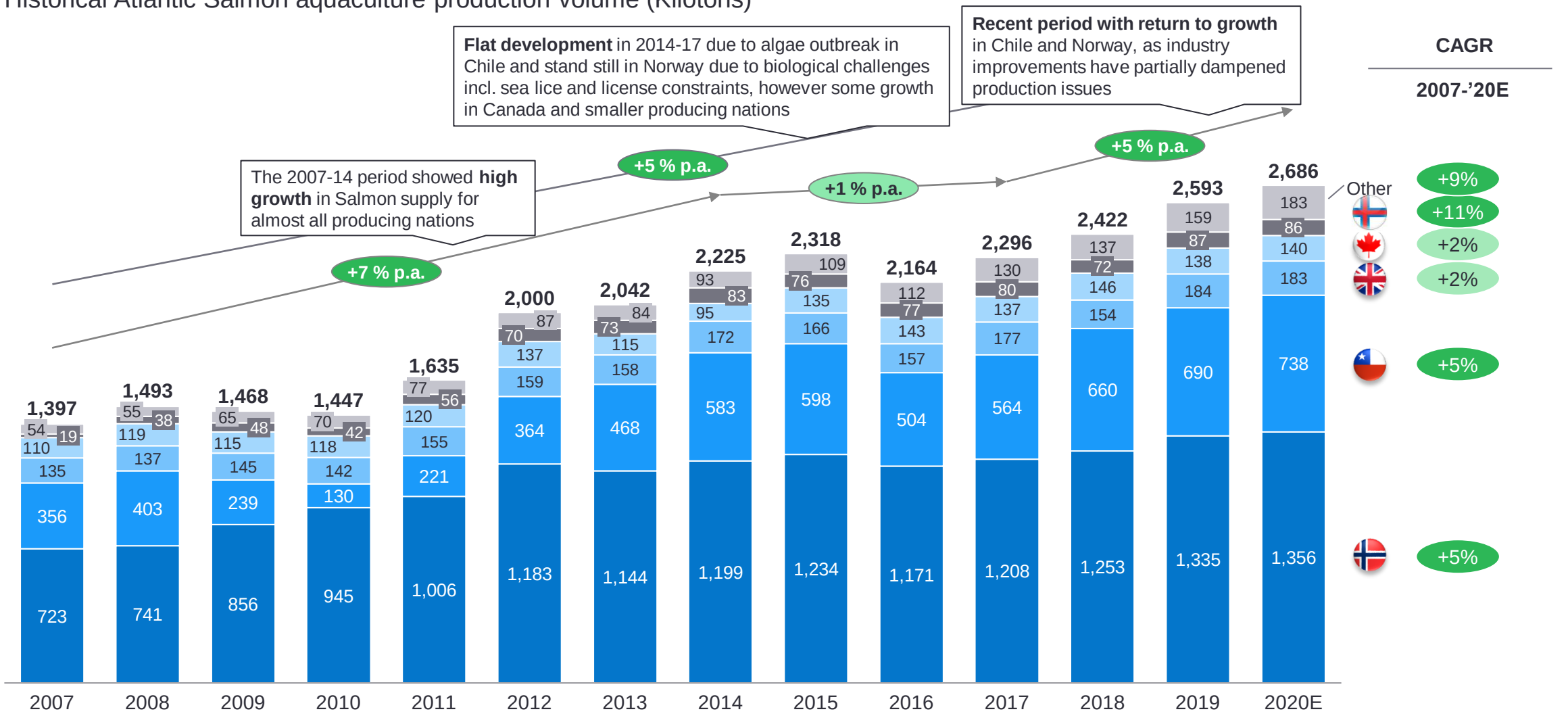


1. Excludes aquatic plants
Source: OECD; EY-Parthenon analysis

EY Parthenon

Global **Atlantic Salmon** growth has averaged 5% since 2007, however, with periods of lower growth due to production challenges

Historical Atlantic Salmon aquaculture production volume (Kilotons)



Source: Pareto Securities; Kontali; EY-Parthenon analysis

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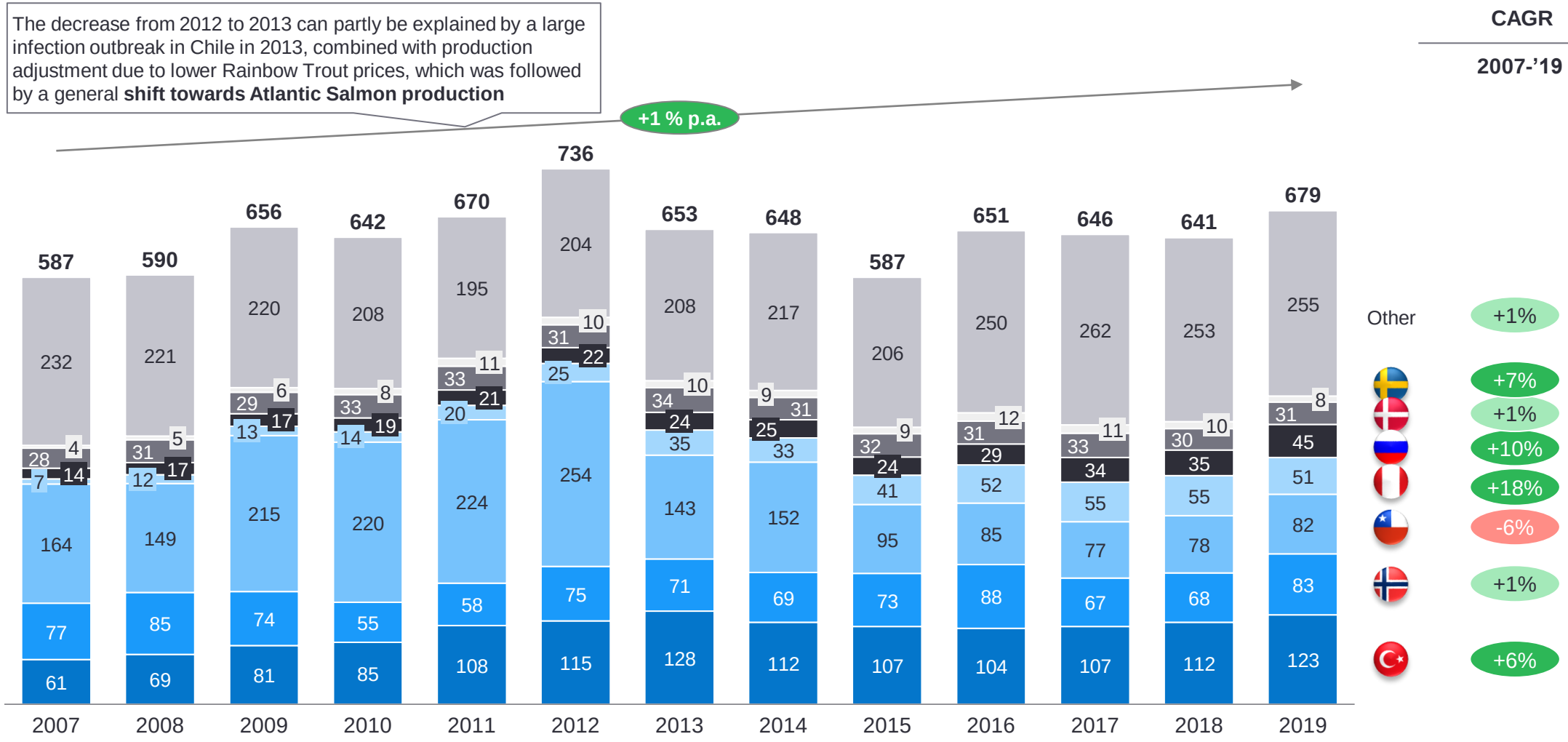
Rainbow Trout is a popular alternative to Atlantic Salmon, however total production volume growth has been relatively flat since 2007

Historical Rainbow Trout aquaculture production volume (Kilotons)

The decrease from 2012 to 2013 can partly be explained by a large infection outbreak in Chile in 2013, combined with production adjustment due to lower Rainbow Trout prices, which was followed by a general **shift towards Atlantic Salmon production**

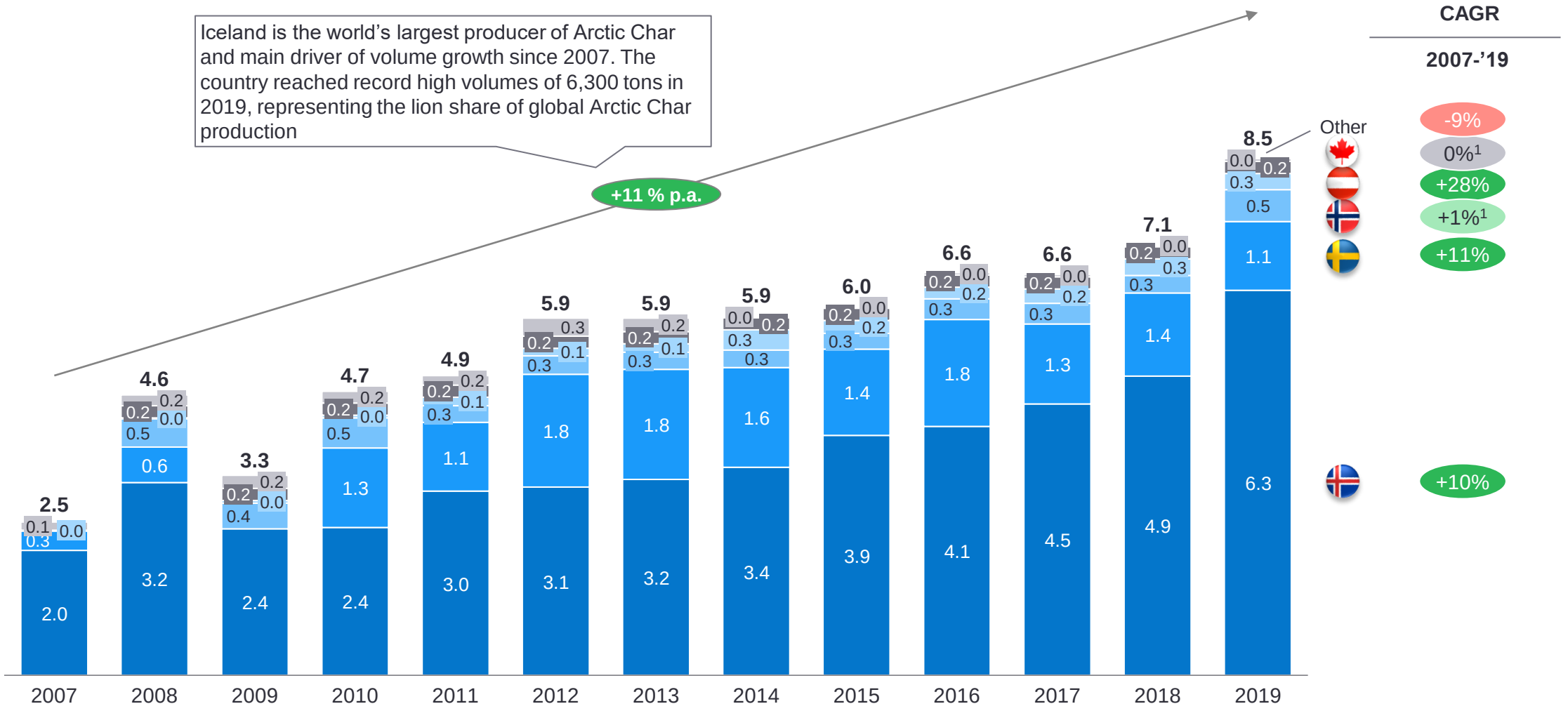


Source: OECD; Seafood Watch; EY-Parthenon analysis

EY Parthenon

Arctic Char production has grown with 11% p.a. since 2007, from low volumes, driven by Icelandic production; Sweden is the second largest Arctic Char producer

Historical Arctic Char aquaculture production volume (Kilotons)



1. CAGR 2008-2019

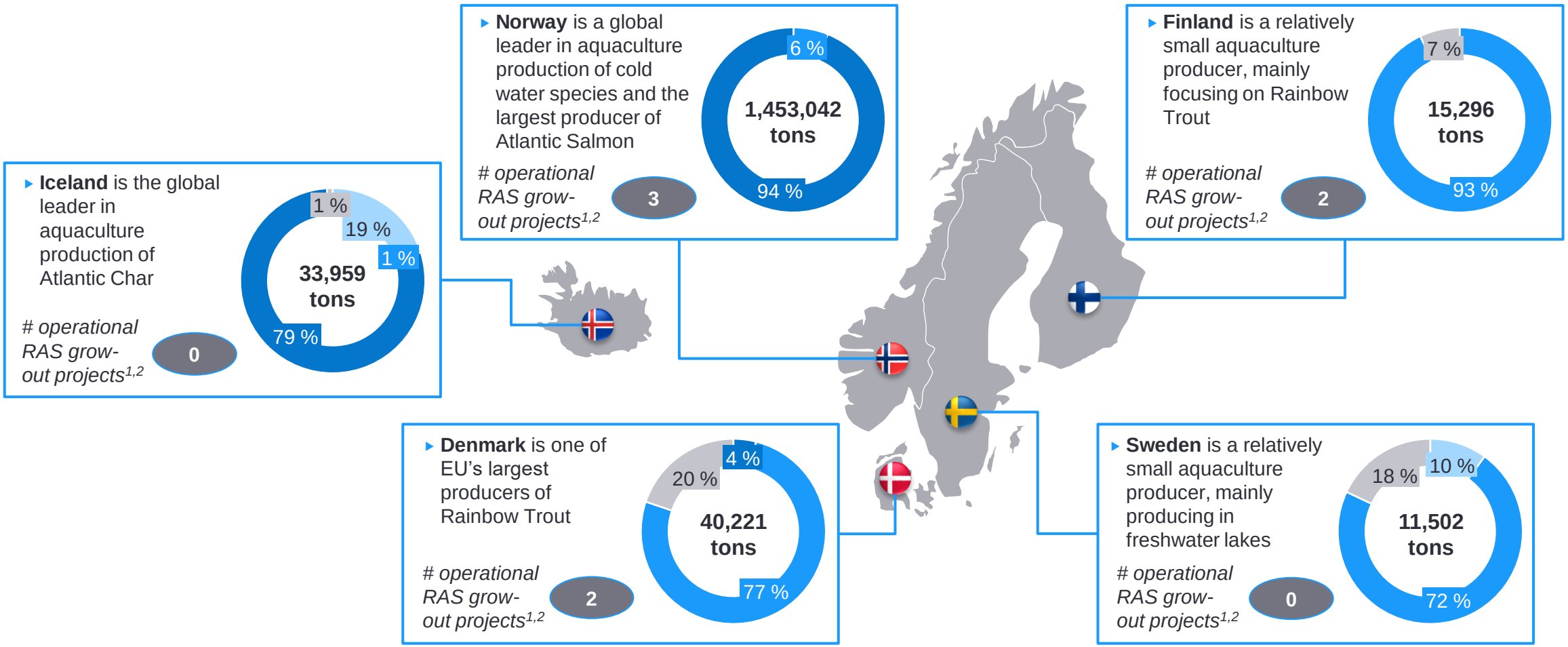
Source: OECD; EY-Parthenon analysis

EY Parthenon

Norway is by far the largest aquaculture producer in the Nordics, with a total production of nearly 1,5 million tons; Denmark and Iceland are the 2nd and 3rd largest producers

Nordic aquaculture market overview, production volume, 2019 (Tons)

Species legend: Atlantic Salmon | Rainbow Trout | Arctic Char | Other



1. Of the relevant species; Atlantic Salmon, Arctic Char and Rainbow Trout
2. Based on our overview of operational RAS facilities. Smaller facilities, e.g. pilot or research projects could be excluded

Source: OECD; EY-Parthenon analysis

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- **Recirculating Aquaculture Systems (RAS) technology**
  - Introduction to RAS
  - Current RAS grow-out maturity
  - RAS grow-out economics
- Production technology outlook

Globally, grow-out production has conventionally taken place in sea pens, but land-based production is emerging, and there are also other technologies being tested

Production structure type characteristics – description

Focus of this report

Conventional production methods

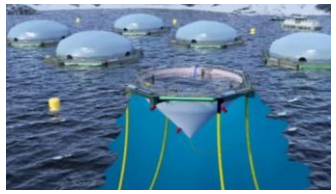
Sea pens

Open pens

- Traditional open net pens contain the fish
- Fish is moved around from pen-to-pen throughout their life growth cycle
- Vessels are typically needed for fish logistics, monitoring and health treatment

Semi-closed and closed containment[1]

- Physical barrier separating the rearing environment from the external



Emerging production methods

Land facilities

RAS facility

- Land based tanks contain the fish and tubes are used for logistics and to connect to water systems
- Various water systems used to monitor and treat water salinity, oxygen, CO2, nitrates, solids, bacteria etc.
- Water can be recirculated using a recirculating aquaculture system (RAS)

FTS facility

- Flow Through System (FTS) utilize fresh sea water, which is pumped through the facility
- Must be placed close to sea level and is only possible in selected areas satisfying strict water temperature and quality criterion

Ponds

- Semi or fully-enclosed bodies of water
- Discharges untreated wastewater polluting the environment
- Usually, closer to sea or water bodies

Other technologies

Offshore

- Fish farm designed for harsh areas positioned at open sea, farther away from the coast
- Less environmental footprint

1. Potential future technologies to solve e.g. sea lice issues in selected geographies with open sea pens, however still in early stages and the large majority is farmed in open sea pens

Source: EY-Parthenon analysis

EY Parthenon

RAS technology offers many advantages, however, is still an emerging technology subject to more complexity and higher facility investments costs

Overview of RAS method advantages and challenges

The RAS method can bring several advantages to the production…

- **Allows for better control of growing conditions** including water temperature and chemical conditions, turbidity and disease
- **High location flexibility** - RAS production is not constrained by the geographical and biological conditions associated with traditional aquaculture methods, including water temperature and proximity to sea. RAS seafood can therefore be produced close to end-market (e.g. Salmon production in Asia and America in RAS facilities close to end markets)
- **Better control of outputs and effluents** (contrary to many conventional production methods), which can reduce local environmental impact and allow the reuse of effluents e.g. as fertilizer or for energy
- **Potentially reduced biological risks and costs arising from e.g. climate, infections, predation**
- **Significant degree of species flexibility,** as RAS facilities can be adjusted to accommodate most species, thus giving an ability to pivot to species with growing demand
- **Avoids significant costs related to transportation** of livestock, such as well-boats used or Atlantic Salmon

… but also comes with some challenges

- **Higher initial capital costs** for R&D, water pumping and treatment systems; system start-up costs is most often higher than for conventional aquaculture farming, however, this can be partly offset by higher cost of licensing for conventional (in locations with high license costs)
- **High operational costs** to maintain **oxygen, chemical balances, energy requirements and water levels**
- **Sophisticated technology** requiring higher degree of expertise
- **Physical and permanent footprint on land** due to construction needs
- **Ongoing risks related to water conditions** (e.g. H_2S incidents, fast spreading of diseases)
- **Low margins of error** with several **incidents of mass mortality**
- **Product quality challenges**, e.g. **off-flavor** and **less intense (red) fish meat color**

Source: Market participant reviews; Literature search; Norwegian Directorate of Fisheries; Nofima; EY-Parthenon analysis

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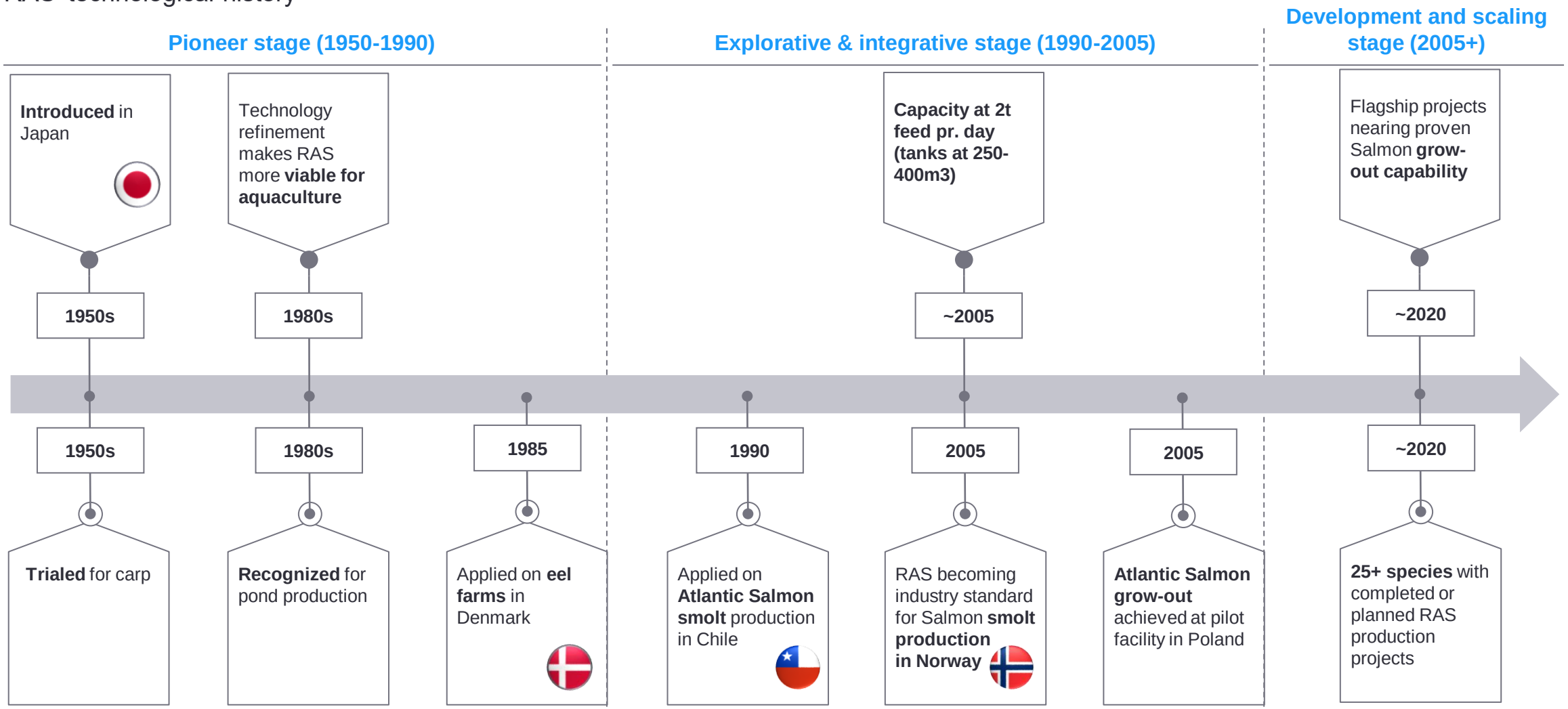
RAS technology has a ~70 year history and entered its first maturing phase in the 90s. It has since 2005 been industry standard for early stage Salmon production (smolt)

RAS' technological history



Source: DNB; Intrafish; Expert interviews; EY-Parthenon analysis

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RAS is still less mature for full-cycle grow-out Salmon production, however, with many projects in planning and long established as industry standard for smolt farming

Aquaculture development stages for Atlantic Salmon

High ··· Low

	Smolt (60 – 100g) on land	**Post-smolt** (100g-1kg) on land	**Grow-out** (1-8kg) on land
Development stages of land-based aquaculture	**Industry standard for smolt production** 1990- ▸ Smolt was originally produced in freshwater lakes ▸ In the 1990s production was transferred to land-based facilities with flow-through water ▸ Today, recirculation systems (RAS) is the leading technology for smolt production	**Increases farming productivity** 2010- ▸ Originally produced in open sea pens ▸ RAS technology has made it possible to produce post-smolt on land in seawater; considerable R&D confirms viability	**Full-cycle farming on land** 2020- ▸ Grow-out phase has previously always been produced in open sea, in large size cages ▸ RAS technology has made it possible to produce grow-out on land, however, is still in an early phase and full (or at least a high degree of) utilization of production capacity is still uncertain, as is commercial viability
Current adaption of land-based / RAS production	**Industry standard** ▸ In leading countries (e.g. Norway) 50%+ of smolt grown with RAS	**Medium adaptation** ▸ Most larger Norwegian conventional farmers have transition projects	**Very low adaption to date** ▸ Some operational facilities, but at smaller scale

Source: Expert interviews; EY-Parthenon analysis

EY Parthenon

Atlantic Salmon, Rainbow Trout and Arctic Char all have operational RAS grow-out facilities, however, production at scale has only been partially achieved

RAS grow-out status per specie

Yes · Partially · No

Specie	Ideal growth temperature	Key characteristics and RAS grow-out status	Operational RAS grow-out facilities	RAS grow-out at scale achieved	Sample RAS facilities
Atlantic Salmon 	**6-16 °C**	▸ Anadromous fish, raised in freshwater and grown in seawater ▸ Smolt has long been reared in RAS, and is now a mature market ▸ Grow-out has proven possible in recent years. Large majority of cold-water RAS projects announced are for Atlantic Salmon	✓	~	▸ Atlantic Sapphire, USA ▸ Nordic Aquafarms, Norway ▸ AquaBounty, USA
Rainbow Trout 	**9-14 °C**	▸ A hardy fish, easy to spawn, easy to feed, fast growing and tolerant to a wide range of environments and handling ▸ Several operational RAS grow-out projects currently exists ▸ Can be grown in both seawater and freshwater dependent on sub-species	✓	~	▸ Finnforel, Finland ▸ Fifax, Finland ▸ F-Trout, Russia
Arctic Char 	**7-15 °C**	▸ Arctic Char is a robust specie that tolerates relatively high stocking densities ▸ Smaller than Atlantic Salmon and Rainbow Trout ▸ Low aquaculture volumes and few to none operational RAS grow-out projects to date ▸ Can be grown in both seawater and freshwater	~	✗	▸ Blåfjell ▸ UAB Noras Ltd, Lithuania (pilot facility)

Source: FAO; Seafish; Desktop research; EY-Parthenon analysis

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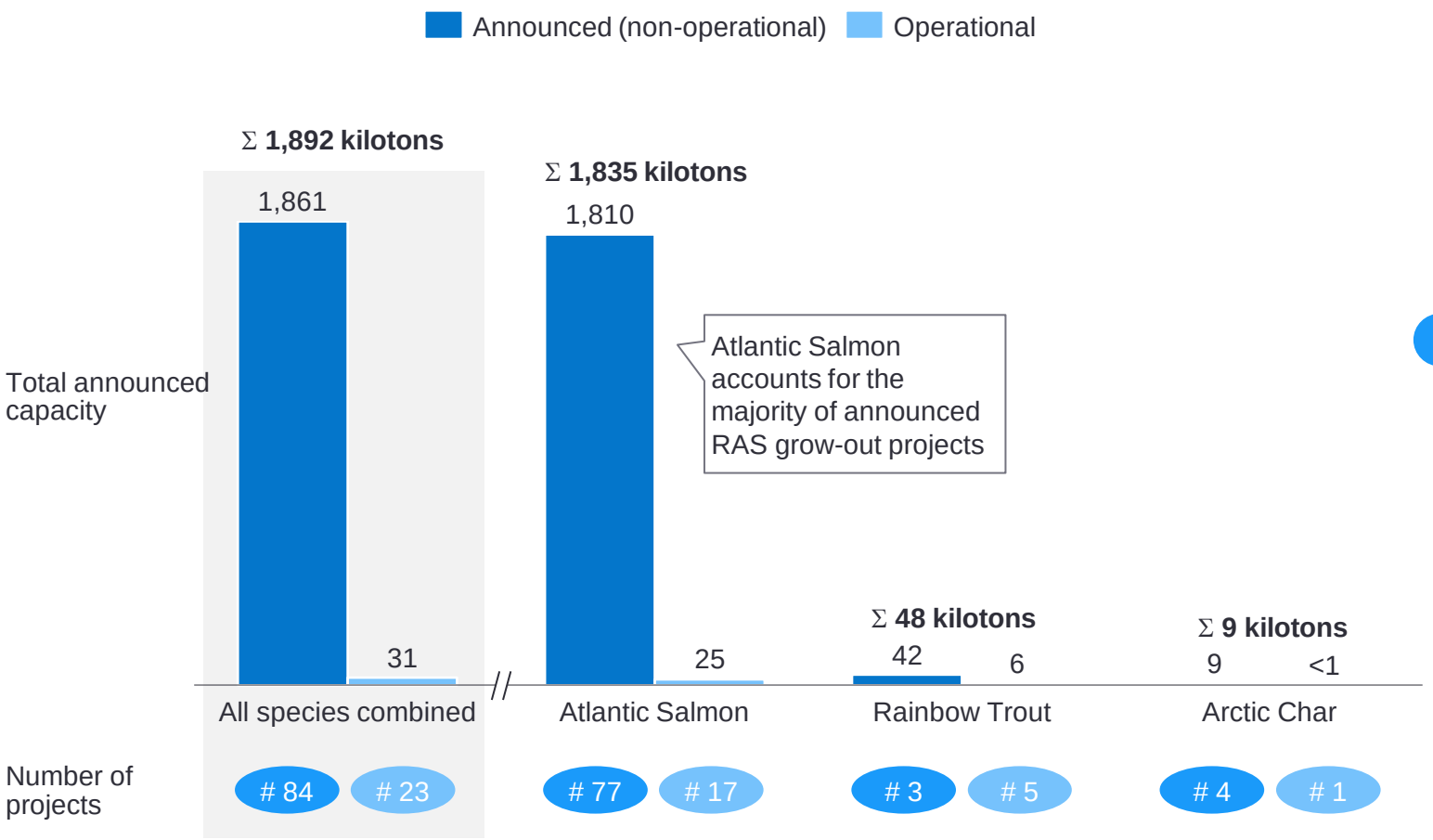
Globally, there is a total of 1,892 kilotons RAS grow-out capacity announced for Atlantic Salmon, Rainbow Trout and Arctic Char, of which only 31 kilotons is operational today

Capacity and number of projects announced and operational for RAS grow-out[1] (Kilotons, WFE)

BASED ON EY PROJECT LIST

Announced capacity highlights the strong interest in RAS grow-out, however, the low operational volumes confirms the current lack of viability for large-scale farming



- The operational production capacity for RAS grow-out is still very limited, of which only ~2% of the total announced capacity being currently operational
- Salmon accounts for the large majority of announced capacity (>95%), followed by Rainbow Trout and Arctic Char
- The analysis is based on an extensive list of announced and operational RAS grow-out projects
  - The list focuses on cold water species and includes a large majority of all announced RAS projects publicly available, however, with highest focus on Atlantic Salmon
- Announced capacity is defined as the full operational capacity of a facility when/if finalized
  - Note that most projects are still in an early phase and it is likely that a large share of announced projects will never be realized
  - Furthermore, new projects could be announced in the future increasing the total
  - Note also that there is a distinction between operational capacity and actual realized harvest volumes, due to lead time from smolt to harvest and facilities not being able to operate at full capacity. Consequently, current volumes are significantly below the stated capacity for operational RAS grow-out facilities[2]

1. The list is non exhaustive, but believed to give a representative picture of global RAS projects
2. For projects with multiple stages only the finalized facilities are included as operational capacity

Source: EY-Parthenon analysis

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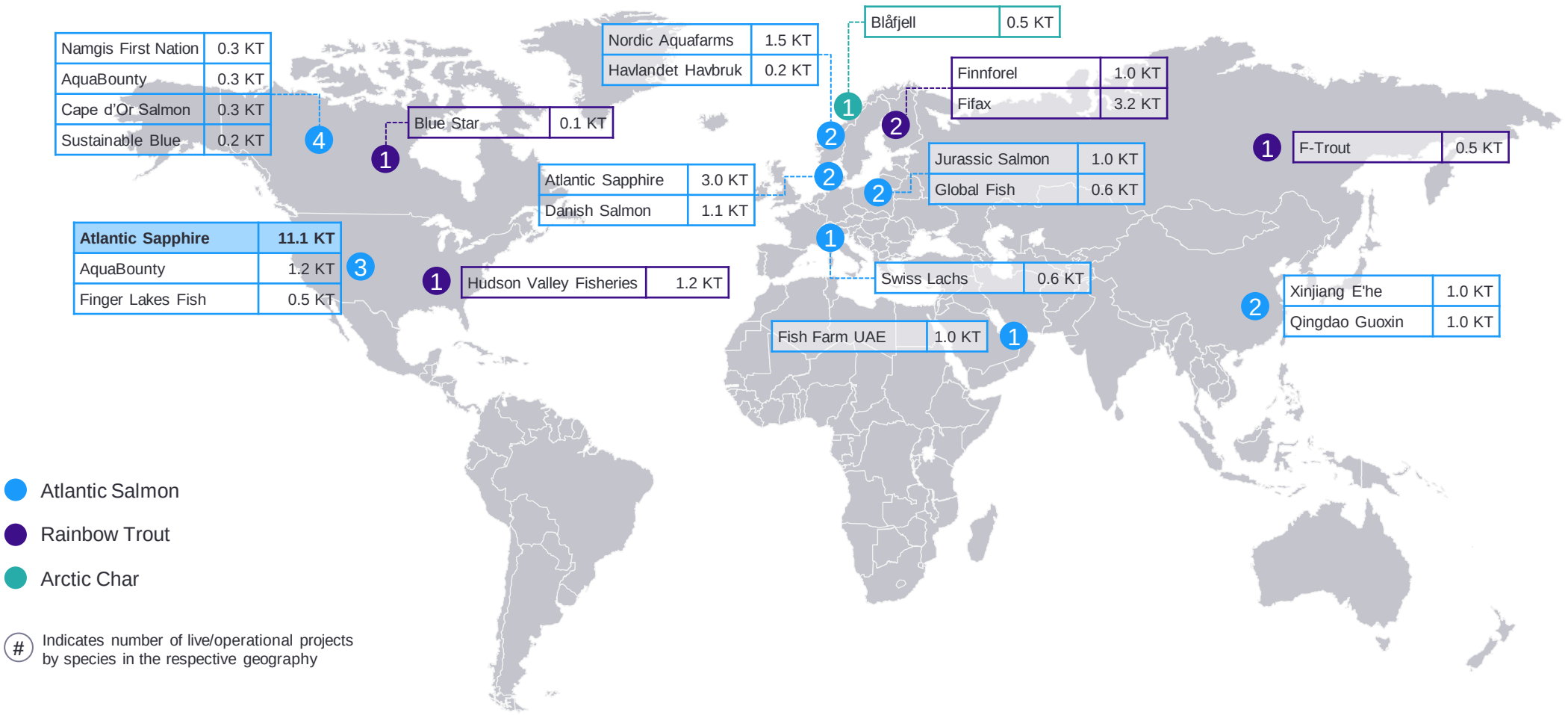
In total we have identified 23 operational facilities of which Atlantic Sapphire's Miami farm with a 2021 capacity of ~11 kilotons Atlantic Salmon is the largest

Global RAS operational grow-out farms[1]



1. The list is non exhaustive, but believed to give a representative picture of global RAS projects for cold water species Atlantic Salmon, Rainbow Trout and Arctic Char

Source: Company websites; Newspaper articles; EY-Parthenon analysis

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Overview of top ten largest operational **Atlantic Salmon** RAS grow-out facilities

Operational RAS grow-out facilities (1/2)

SELECTION OF OPERATIONAL PROJECTS

Projects	Project status	# kilotons capacity (WFE)	Location	Species	Operational Year
Atlantic Sapphire US	▸ First commercial harvest completed mid 2020 ▸ Not yet producing at full phase 1 capacity and later stages will see significantly higher volumes	11.1		Atlantic Salmon	2020
Atlantic Sapphire DK	▸ Long track-record, with first harvest at the Danish facility back in 2011	3.0			2011
Nordic Aquafarms	▸ The Nordic Aquafarms subsidiary Fredrikstad Seafoods began harvesting mid 2020	1.5			2019
AquaBounty	▸ Harvesting genetically modified Salmon at the facility in Albany, Indiana	1.2			2019
Danish Salmon	▸ Recently acquired by Japanese giant The Marubeni Corporation with plans to double output	1.1			2011
Xinjiang E'he Construction	▸ Have been producing for more than five years at the facility in the Gobi desert in China	1.0			2014
Jurassic Salmon	▸ First phase operational since 2015 at facility in Janowo, Poland	1.0			2015
Fish Farm	▸ Produced first harvest in 2018 and targeting the highly import-dependent domestic market in UAE	1.0			2018
Qingdao Guoxin Dev. Group	▸ First Chinese RAS farm with harvest of first batch more than 10 years ago	1.0			2010
Global Fish	▸ Operational since 2017 and includes a production facility and R&D center	0.6			2017

Source: EY-Parthenon analysis

EY Parthenon

Overview of operational **Rainbow Trout** and **Arctic Char** RAS grow-out facilities

Operational RAS grow-out facilities (2/2)

SELECTION OF OPERATIONAL PROJECTS

Projects	Project status	# kilotons capacity (WFE)	Location	Species	Operational Year
Fifax	▸ First delivery to the market was in 2016. Expects to reach a fish stock level of 900 tons by first half of '22	3.2		Rainbow Trout	2015
Hudson Valley Fisheries	▸ Made first "true market ready" harvest in the second quarter of 2018 (5000 lbs of Rainbow Trout)	1.2			2017
Finnforel	▸ Operational in 2018 and reached maximum capacity of 1,000 tons of Rainbow Trout in 2020	1.0			2018
F-Trout	▸ Operational since 2014, with annual production capacity of 520 tons of Rainbow Trout	0.5			2014
Blue Star	▸ One of the oldest continuously operating RAS projects, with capacity of c. 100 tons of Rainbow Trout a year	0.1			2012
Blåfjell	▸ First commercial RAS farm for production of Arctic Char in Norway[1]	0.5		Arctic Char	2019

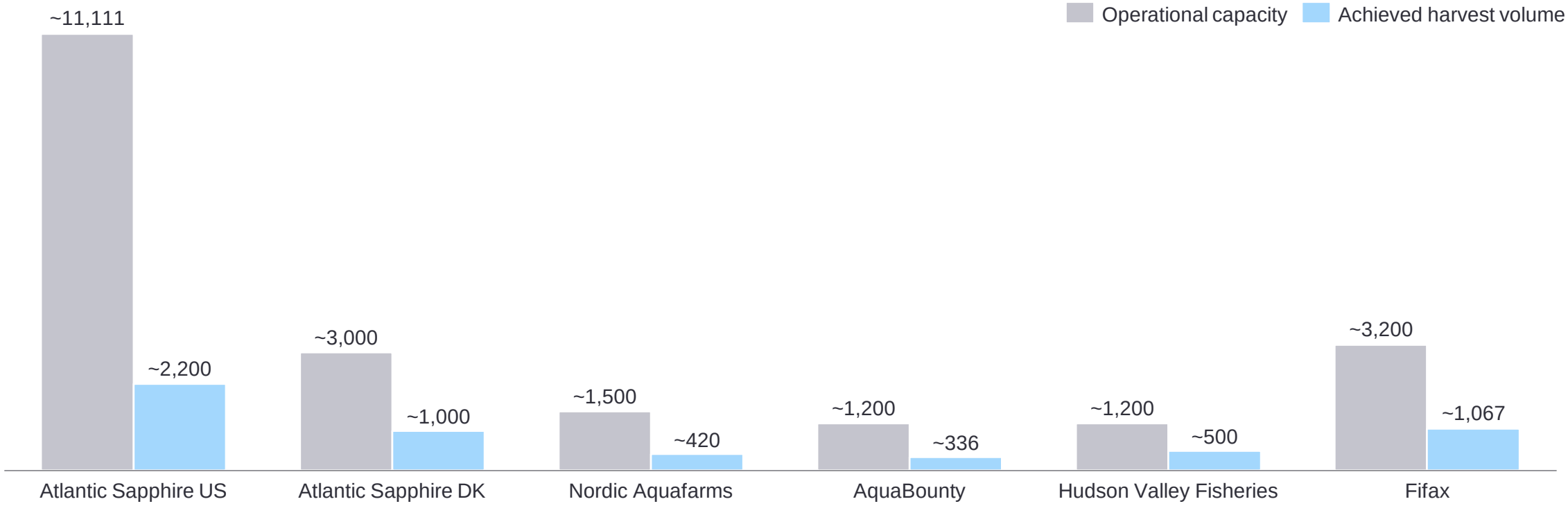
1. Blåfjell AS went into bankruptcy during 2020 and was replaced by Blåfjell Drift AS

Source: Company websites; Newspaper articles; EY-Parthenon analysis

RAS grow-out farmers generally achieve significantly lower realized harvest volumes compared to the operational capacity of the facility

Harvest volumes compared to operational capacity (Tons)[1]

HIGH LEVEL ESTIMATES



- Reported 1,100 tons HOG harvest in US facility for first half 2021
- Estimated to 2,200 tons HOG annual production[2]

- Achieved 250 tons HOG Q2 2020 in Denmark facility
- Estimated to 1,000 tons HOG annual production[2]

- According to 'thefishsite' the facility was set to produce 420 tons in 2020, compared to a capacity of 1,500 tons

- Harvested 84 tons in Q3 2021 in according to the company
- Estimated to 336 tons annual production[2]

- According to an article from 2019 the company stated the capacity to 1,200 tons, but actual volumes likely to be around 500 tons

- Estimate that approximately on third of capacity has been reached

1. The sample includes operational projects with available information on realized harvest volumes. The information on harvest volumes is generally limited and sporadic and the accuracy of the analysis is therefore likewise inaccurate. It is, however, undoubtfully so that RAS grow-out farmers currently realize harvest volumes significantly below the capacity of the facility
2. High level estimate assuming equal harvest volumes in all quarters of the year. The accuracy of this estimate will likely vary significantly and has not been assessed in detail

Source: Company websites; Newspaper articles; EY-Parthenon analysis

None of the identified operational Nordic RAS grow-out farmers have been able to achieve profitable operations to date

Financial performance, Nordic RAS companies (USDm)

Company	Loc.	Specie	Capacity (Tons)	Operational Year	Revenue	EBITDA	Net income
Atlantic Sapphire Denmark A/S[1]		Atlantic Salmon	3,000	2011	n.a.	-2.84 -1.64 -3.25 -5.46 -10.70	-1.84 -2.98 -3.30 -6.53 -15.89
Nordic Aquafarms Group AS[2]		Atlantic Salmon	1,500	2019	0.04 0.14 0.64 1.06 7.16	-0.34 -0.66 -1.08 -0.55 -10.77	-0.35 -0.57 -0.88 -0.85 -14.16
Danish Salmon A/S		Atlantic Salmon	1,100	2011	n.a n.a n.a n.a 5.62[4]	-2.13 -0.13 0.64 0.19 n.a[5]	-1.80 -0.50 0.02 -0.40 -0.69[4]
Fifax OYJ		Rainbow Trout	3,200	2015	0.10 0.86 0.38 0.82 1.42	-2.90 -4.21 -5.16 -6.04 -7.01	-3.52 -5.05 -6.95 -8.04 -9.59
Finnforel OY		Rainbow Trout	1,000	2018	0.00 1.19 2.71 2.88 3.34	-0.07 -0.27 -2.61 -4.05 -4.34	-0.07 -0.45 -3.41 -5.18 -5.54
Blåfjell AS		Arctic Char	450	2019	0.00 0.00 0.01 1.14 0.00[3]	-0.16 -0.67 -0.68 0.31 0.00[3]	-0.16 -1.17 -1.24 -0.59 0.00[3]
Havlandet RAS Pilot AS		Atlantic Salmon	200	2021	0.00 0.00 0.00 0.00 0.00	0.00 -0.01 -0.03 -0.16 -0.15	0.00 0.00 -0.02 -0.13 -0.14
					2016 '17 '18 '19 2020	2016 '17 '18 '19 2020	2016 '17 '18 '19 2020

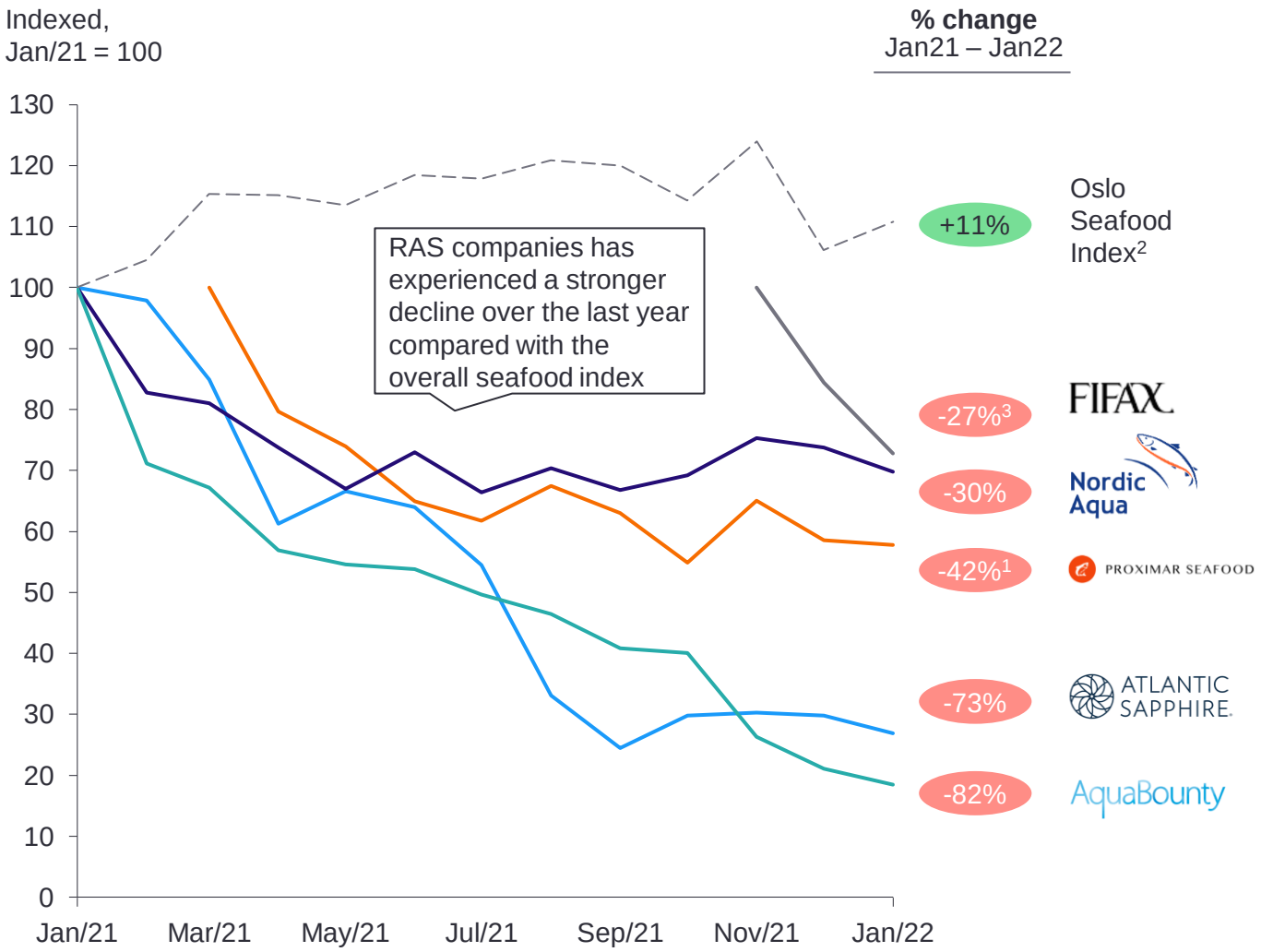
1. Subsidiary of Atlantic Sapphire ASA
2. Also produces Yellow Kingfish
3. Blåfjell AS went into bankruptcy during 2020 and was replaced by Blåfjell Drift AS
4. Only reported figures for 15 months (2020 + Q1 21). Pro-forma adjusted to 12 months 2020
5. EBITDA not available. Operating loss for 2020 was -0.77 USDm. Pro forma adjusted as per footnote #4

Source: Proff Forvalt; Retriever; Company annual reports; EY-Parthenon analysis

EY Parthenon

2021 was also a challenging year for the listed RAS companies Nordic Aqua Partners, Proximar Seafood, Atlantic Sapphire, and AquaBounty Technologies

Share price development of RAS projects, 2021



- **Fifax** was founded in 2012 and is located in Åland. The share price has declined with 27% since the IPO and public listing late October 2021
- Danish **Nordic Aqua Partners,** listed in December 2020, is building a RAS facility in China, with an initial annual capacity of 8000 tons. Larger cornerstone investors sold their shares a few months after the IPO
- **Proximar Seafood** is a Norway-based company planning to build the first large-scale RAS facility in Japan. The company was listed in February 2021, and since then the share price has been dropping
- **Atlantic Sapphire** took several hits to it's share price during 2021, due to various production issues and high fish mortality rates at their facilities in Denmark and US. Analysts covering the share, lowered their estimates during the year
- **AquaBounty Technologies** (USA)'s share price also dropped during 2021, partly explained by secondary offerings. The company is planning to build its first large-scale commercial facility, based on RAS technology, in Ohio

1. Percentage change March/21-Jan/22
2. Oslo Seafood Index (SSSFX) is made up of a selection of the most liquid Norwegian Fisheries and Aquaculture companies listed on Oslo Børs and Oslo Axess
3. Percentage change from listing 26 Oct 21 to Jan/22

Source: Company websites; Newspaper articles; Yahoo Finance; Euronext; EY-Parthenon analysis

EY Parthenon

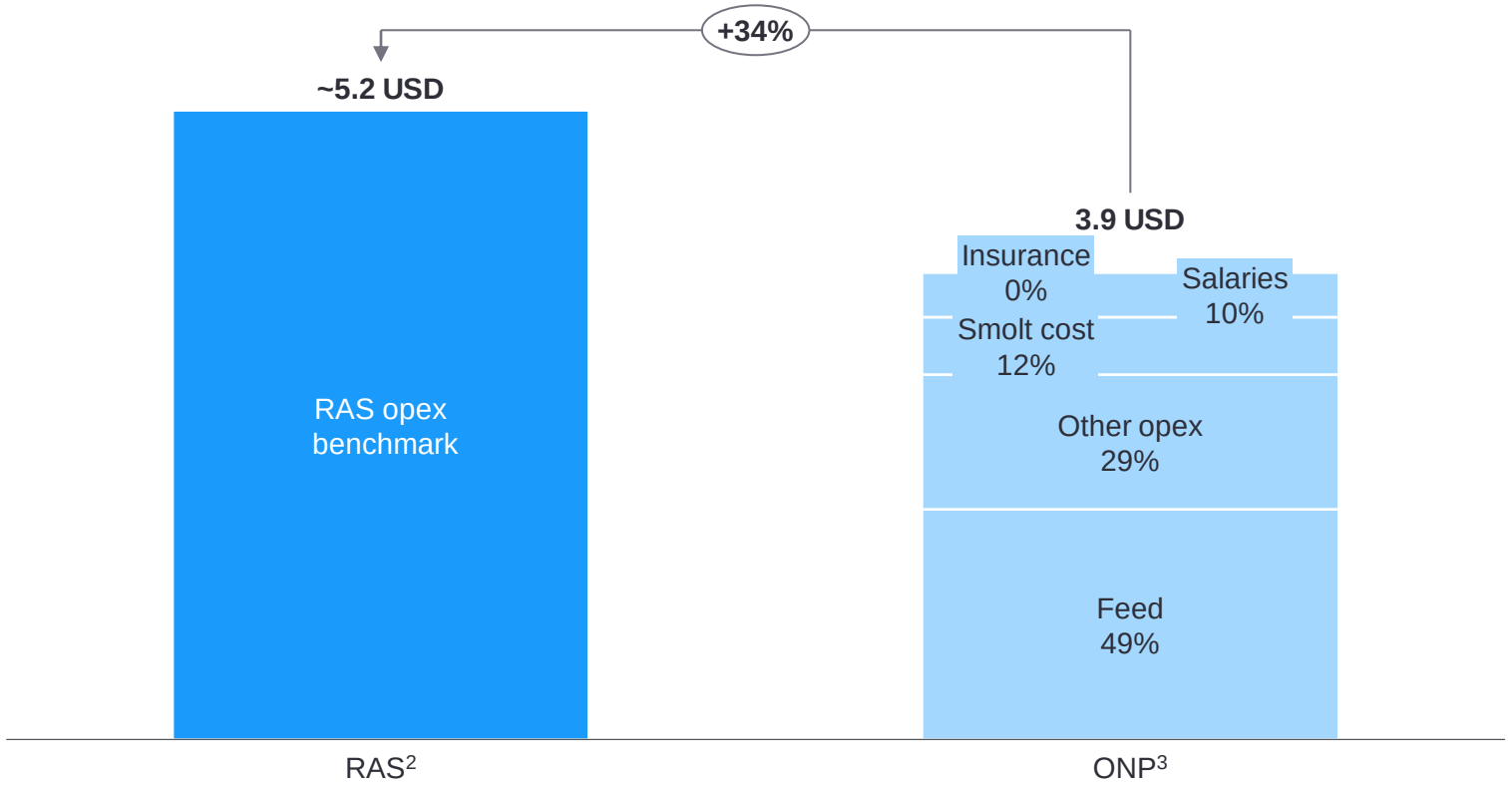
Agenda

- Report context and executive summary
- Aquaculture market context
- **Recirculating Aquaculture Systems (RAS) technology**
  - Introduction to RAS
  - Current RAS grow-out maturity
  - RAS grow-out economics
- Production technology outlook

A benchmark analysis suggest higher operational costs per kg produced Atlantic Salmon (+34%) for RAS grow-out, compared to farming in open net pens

Comparison of operational costs per production method

Operational costs comparison for RAS and ONP Atlantic Salmon farming[1] (USD per kg WFE)



- A benchmark analysis suggest that RAS grow-out projects have significantly higher operational costs (34%), than Open Net Pen farming
- The comparison is per kg produced fish and excludes cost of slaughtering and transportation
- The higher cost is driven by the more complex production method, with RAS farms having operational costs related to oxygen, electricity and water treatment
- A study conducted by the Norwegian University of Science and Technology (NTNU), in cooperation with research institutes SINTEF Ocean, found production costs for land-based grow-out to be 42% higher than those in the sea[4]
- The RAS benchmark is based on cost estimations for steady state operations (i.e. is budgeted costs, not actual realized costs) and it remains to see what cost levels RAS grow-out projects can realize in the future

1. Operational costs excludes depreciations and financial costs
2. RAS operational cost based on benchmark of available RAS grow-out projects for Atlantic Salmon (see next page). Sample is based on expected opex in a steady state production scenario. The estimate is uncertain due to 1) the small sample size and 2) the lack of evidence from full scale (steady state) operational RAS facilities
3. Calculation for ONP based on reported 2020 figures of production costs per kg from the Norwegian Directory of Fisheries. The sample is based on reported company data from Norwegian Salmon and Trout companies. Due to the Norwegian production mix it largely reflects Atlantic Salmon production (94% of reported revenues)
4. https://www.intrafish.com/aquaculture/new-analysis-finds-greater-costs-for-land-based-aquaculture/2-1-444543

Source: Norwegian Directorate of Fisheries; Desktop research; RAS grow-out benchmark; Market participant interviews; EY-Parthenon analysis

The estimation of RAS operational costs is based on a sample of RAS grow-out facilities' calculations for steady state Opex, in the range of 4.2 USD to 6.0 USD per kg WFE

RAS Opex benchmark[5]

Opex benchmark of select Salmon RAS farms (budgeted, not realized costs)

Key indicators	Benchmark 1	Benchmark 2	Benchmark 3	Benchmark 4	Benchmark 5	Benchmark 6	Benchmark 7
Country	USA[1]	USA[1]	USA[2]	China[4]	USA[4]	USA[3]	Norway[4]
Production capacity (tons WFE per annum)	3,947	3,667	8,857	11,071	13,000	3,333	4,000
Species	Atlantic Salmon						
Opex per kg produced Salmon	**4.2**	**6.0**	**5.9**	**4.9**	**5.2**	**5.1**	**5.2**

1. Investment calculation for two separate RAS facilities. Report by The Conservation fund and SINTEF
2. Kepler Cheuvreux cost estimate for Atlantic Sapphire production in 2021
3. Investment calculation, GRV inc.
4. Confidential project
5. Operational costs excludes depreciations and financial cots

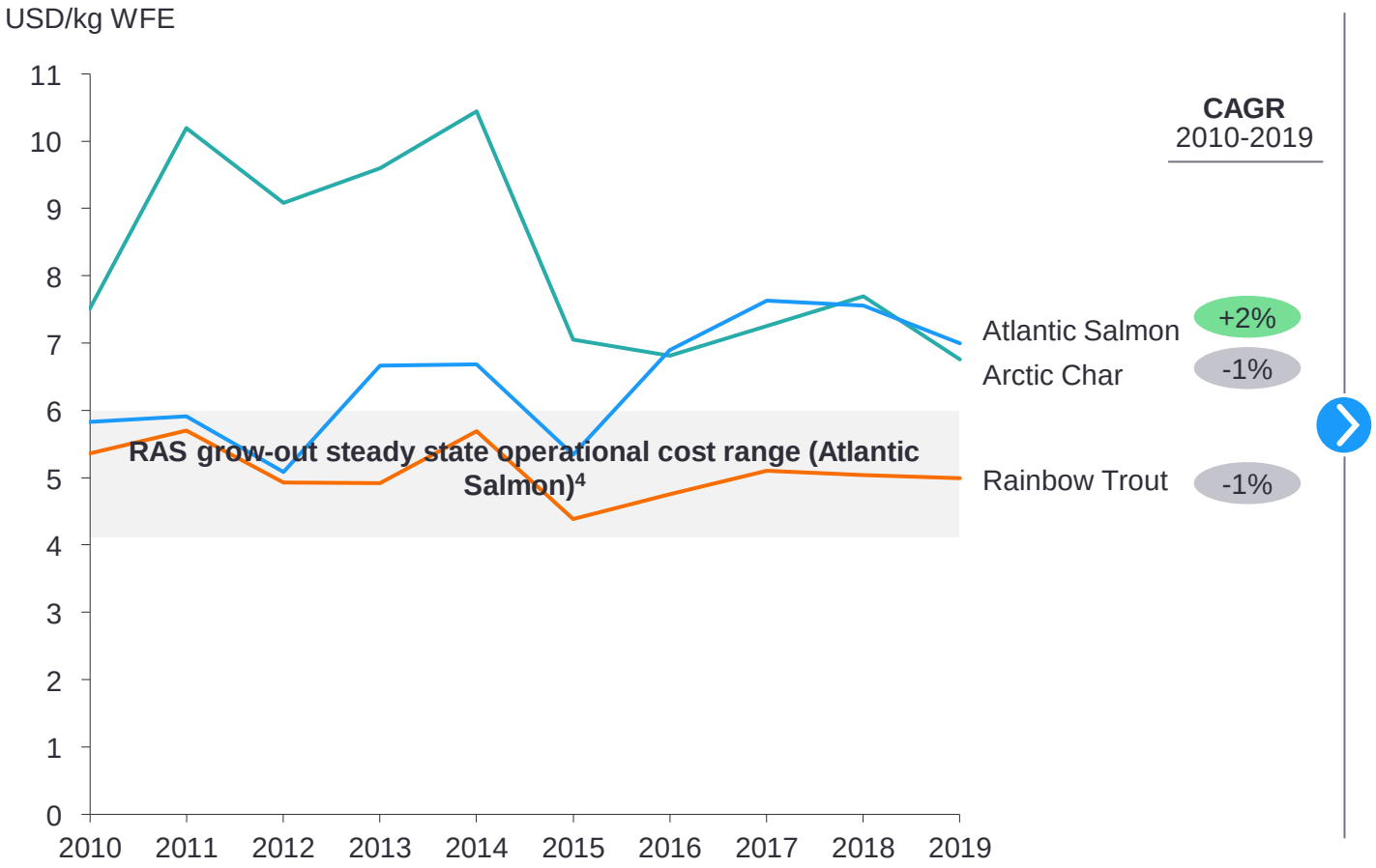
Source: Confidential RAS project information; Desktop research; SINTEF; The Conservation fund; Kepler Cheuvreux; GRV inc.; EY-Parthenon analysis

EY Parthenon

Production from RAS facilities is likely to require a price premium above average sales price in order to ensure profitability

Comparison of price points[3]

Atlantic Salmon has seen high and relatively stable prices and above estimated RAS grow-out opex per kilo, compared to more volatile prices for Arctic Char and lower per kilo prices for Rainbow Trout



- Atlantic Salmon prices has in the last years been above the estimated opex per kilo range for RAS grow-out
  - This is, however, before considering financial costs, depreciations, slaughtering and transportation costs
  - Furthermore, RAS farmers to date are not able to realize harvest volumes in line with the capacity, thus significantly increasing the realized cost per kilo compared to the steady state capacity cost range
  - It is thus uncertain if profitability could be achieved with current price and cost levels, and no operational grow-out facilities in sample has yet reached profitability
- Arctic Char and Rainbow Trout has historically had different prices than Atlantic Salmon, implying a different production cost per kilo would be required to achieve profitability
  - Lower (higher) price per kilo would naturally require a lower (higher) production cost to be profitable
- Furthermore, many RAS players aim to sell their fish at premium price points, arguing that higher prices can be achieved e.g. due to sustainability credentials, localness, and associated freshness. Some suggest that "the RAS premium" could be in the range of +5% to +20% per kilo[1]. Nevertheless, it remains to see whether the market will be willing to pay such premiums and if RAS players will achieve desired product quality, e.g. no off-flavors

1. According to stakeholder interviews conducted by EUMOFA in relation to the "Recirculating Aquaculture Systems Report December 2020"
2. Please see EY's "Norwegian Aquaculture Analysis 2019" for further information
3. The prices are based on OECD data and does not address different price points per sub-species, fish size etc. Consequently achieved prices could deviate significantly
4. Based on benchmark on previous page. Range from 4.2 to 6.0 USD per kilo WFE

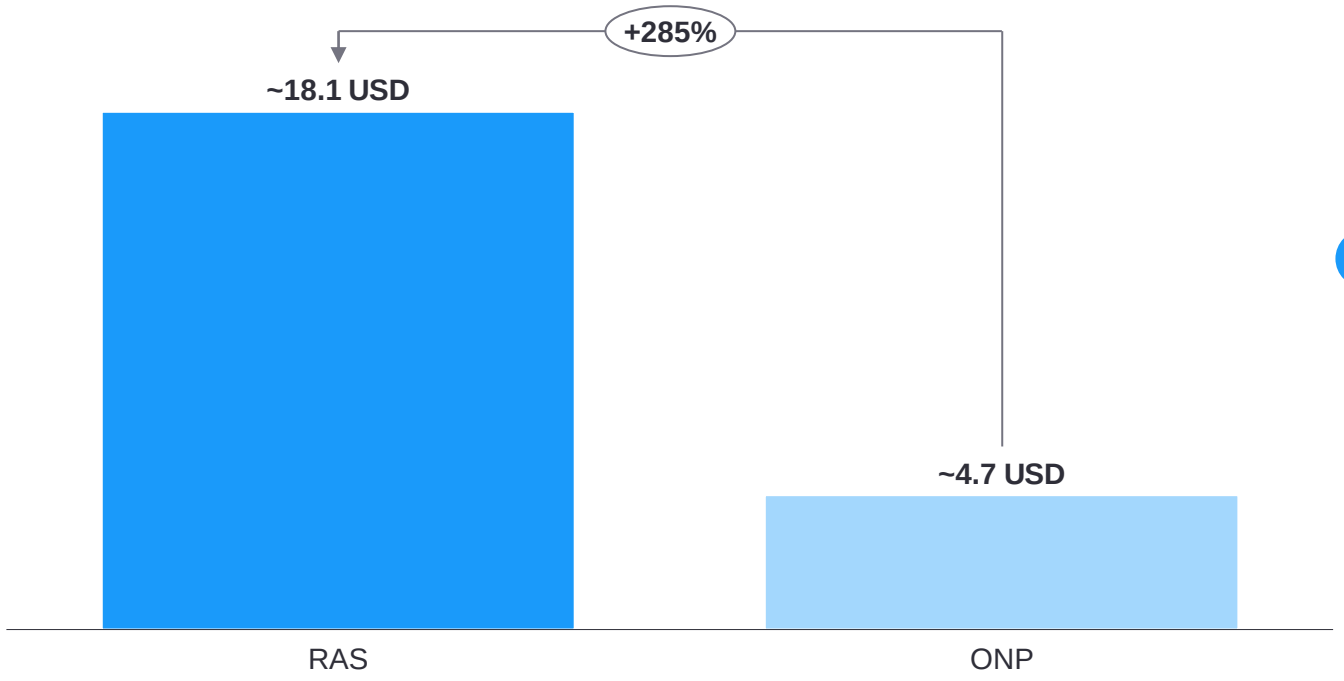
Source: OECD; Fish Pool; IntraFish; EY – The Norwegian Aquaculture Analysis 2020; EUMOFA – Recirculating Aquaculture Systems December 2020; EY-Parthenon analysis

EY Parthenon

RAS grow-out systems require substantially higher upfront Capex than conventional farming in open net pens

Comparison of investment costs per production method

Capex comparison for RAS (budgeted, not realized) and ONP Atlantic Salmon farming[4] (USD per kg WFE)



RAS

- High Capex driven by expensive buildings and RAS equipment
  - A study estimates that the RAS equipment accounts for 46% of investment cost, land & buildings 24%, construction incl. concrete works 24% and other 6%[1]
- The estimate is based on a benchmark of RAS projects (see next page)

Open Net Pens

- The investment cost for ONP is based on sample data from a selection of leading Norwegian aquaculture farmers
  - The calculation is based on total value of accumulated acquisition costs for the tangible assets divided by the annual production volume (2020 figures)[2,3]
- the typical asset categories for sea farming (as reported in the annual reports) are ‘land and real estate’, ‘machinery and equipment’, ‘ships and floating installations’ and ‘other inventory’
- Licenses are not included in the calculation

1. SINTEF / NTNU / SNF study with production facility of 3,600 tons
2. Figures from annual reports. Sample include: Salmar farming AS, Cermaq Norway AS, Lerøy Midt AS, Lerøy Vest AS, Nova Sea AS, Nordlaks Oppdrett AS, Lerøy Aurora AS, Grieg Seafood Finmark AS, Sjøtroll Havbruk AS, Alsaker AS, NRS Farming AS
3. Book value of leased assets also included in the calculation
4. Does not include maintenance capex. The calculation is a best effort comparison of investment cost per kilo capacity and does not consider the expected lifetime of the assets

Source: Desktop research; Market participant interviews; The Conservation fund; SINTEF / NTNU / SNF EY-Parthenon analysis

EY Parthenon

The Capex per kg production capacity of RAS grow-out farms benchmarked is in the range of USD 14 to USD 25 per kg

Capex benchmark – Investment budget estimates[3]

Included in Capex: ✓ Yes ✗ No ⊗ Not confirmed

	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7	Project 8	Project 9	Project 10
Project location	US	To be announced	Europe	Europe	US	Asia	Asia	Europe	US	Asia
Capex USD/kg[1]	18.1	15.8	21.0	13.7	20.9	20.6	15.3	25.2	18.1	16.4
Capex (USDm)[1]	250	158	645	205	220	206	136[2]	117	180	182
Volume (WFE)	13,850	10,000	30,700	15,000	10,500	10,000	8,850	4,650	9,550	11,050
Hatchery	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Smolt /	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Grow-out	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Slaughtering	✓	✓	✗	✓	✓	✓	✓	✗	✓	✓
Processing	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓
Admin. building	✓	⊗	✓	⊗	✓	✓	⊗	⊗	✓	✓
Land cost	✓	⊗	⊗	⊗	⊗	✓	⊗	⊗	✓	⊗

1. Provided Capex figures are estimates based on available information and accuracy may vary. The average is used for projects where capex is reported as a range.
2. Excluding (Capex reducing) effect from government grants
3. Based on budgets for actual investment cases, however not actual realized investment costs

Source: Desktop research; Market participant interviews; EY-Parthenon analysis

EY Parthenon

Receiving external financing for RAS projects from credit institutions could be challenging, and many players have turned to private investors for financing

Fundraising of RAS project

Debt

- Banks have historically been somewhat reluctant to provide financing for RAS grow-out projects
- In 2015, DNB, the largest aquaculture loan issuer, expressed that they were unwilling to provide any sort of financing to land-based Salmon production. However DNB's viewpoint has become slightly more nuanced in recent years and the banks now states that they are open to finance projects which fulfill certain criteria, e.g. grow-out facilities for companies which can combine with existing operations within the aquaculture value chain[1]
- Still, Atlantic Sapphire is to date the only known large-scale RAS project to have achieved sizeable bank financing[2]

Proximar chasing expensive green bonds instead of cheap bank loans

Banks skeptical about financing land-based fish farms: "Must have a better overview of the overall risks"

Land-based salmon farmers in line for funding. Banks separate the wheat from the chaff

Equity

- While receiving bank financing could be challenging, there has been a relatively strong interest in certain RAS projects from investors who are willing to supply risk capital in hope of successful commercialization of the technology
- Several significant financial events has taken place over the last couple of years, incl. both listings of larger RAS projects and successful private placements
- However, considering no current large-scale land-based Salmon farming up and running with multiple successful (large) harvests, some investors are probably waiting for more large-scale proof of concepts before investing their money into RAS

Atlantic Sapphire succesfully raises $121 million, no discount to price, in private placement

Pure Salmon begins $700m fundraising for five China RAS units

Nordic Aqua Partners raises €55.1m with Oslo listing

While RAS projects must tick off many boxes to reduce credit risk to an acceptable level for the banks, the investors' interest in investing in certain RAS projects indicates a belief in RAS becoming a profitable production method in the future. However, a large number of RAS projects have been announced in recent years, and it is unlikely that all currently announced RAS projects will be able to raise enough capital to see the day of light, in the end

1. DNB Bank executive on land-based Salmon farms: "Our viewpoint is slightly nuanced now", SalmonBusiness, 30 Oct 2018
2. Atlantic Sapphire secured a 210 USDm loan deal with DNB in April 2020

Source: EY – The Norwegian Aquaculture Analysis 2019 and 2020; SalmonBusiness; EY-Parthenon analysis

Agenda

- Report context and executive summary
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- Recirculating Aquaculture Systems (RAS) technology
- **Production technology outlook**

We expect investments into RAS facilities to continue, due to several promising supply-side drivers

Key controllable supply-side drivers of Atlantic Salmon aquaculture – RAS and ONP comparison

High positive impact … High negative impact

Drivers	Description	Production type characteristics: Conventional ONP	Production type characteristics: Land-based RAS
Proven ability to produce at scale	▸ To attain profitability, the fish has to grow at a sufficient speed and output volume needs to be above a certain level	▸ Proven profitability, with high volumes reached and good growth speed	▸ Technology still not fully proven at commercial scale with large scale profitable farming still to be achieved
Regulatory requirements	▸ Generally stricter regulatory requirements in open and exposed environments, i.e. ONP farming	▸ Requirements getting stricter such as the traffic light system in Norway for controlling production	▸ Fewer observed regulatory restrictions for land-based facilities
Transportation costs and market proximity	▸ Can be ~25% of total costs, however, depend on production proximity to end market	▸ Confined to selected geographies, resulting in long delivery distances and high transportation costs	▸ Can be located anywhere, minimizing market distance and delivering fresher products
Equipment investments	▸ Depending on facility type, investment costs of construction and commission can be high	▸ Efficient in terms of construction material and equipment	▸ Equipment intensive – Estimated Capex for RAS grow-out Atlantic Salmon: 18.1 USD/kg[1]
License costs[3]	▸ License costs can be anything from free to very costly, e.g. Norwegian license cost in 2019 was 16.7 USD/kg WFE for conventional farming	▸ Sea license capacity exhausted in many geographies, e.g. in Norway where license costs was 16.7 USD/kg WFE in 2020[2]	▸ Licenses free / low cost

1. Estimated based on selected projects. Capex for several of these projects includes elements of admin. buildings/slaughtering/processing facilities and land costs.
2. License cost is based on auction of new Salmon farming licenses fall 2020 (Norway)
3. Note that this will vary per geography. On a global scale it is nevertheless little evidence of license costs for RAS, whereas leading sea based farming countries are experiencing expensive licenses

Source: Expert interviews; Norwegian Veterinary Institute; EY-Parthenon analysis

EY Parthenon

However, different production technologies offers distinct advantages and are therefore likely to co-exist as complementary production methods in the future

Production structure type characteristics – comparison

	Sea pens (Conventional)		Land facilities		Alternative technologies
	Open pens	Semi-closed and closed containment	RAS facility	FTS facility	Offshore
Technology maturity	▸ Industry standard	▸ Full-scale pilot facilities under development ▸ Some in testing phase	▸ Advanced, less mature technology, but in rapid development ▸ Several pilot projects with successful harvest	▸ Less mature, but in rapid development ▸ Some pilot projects with successful harvest	▸ Full-scale pilot facility installed by Salmar
Geographical flexibility	▸ Natural restrictions related to climate and environment including water temperature	▸ Same restrictions as for open pens, but can be easier to get licenses due to less externalities	▸ High geographical flexibility ▸ Still need access to land and water, which in some areas is a limited resource	▸ Must be placed close to sea level and is only possible in selected areas with desired water temperature and quality	▸ Natural restrictions due to climate and environment, incl. currents and weather
Capital efficiency	▸ Low equipment costs (licenses excluded)	▸ Higher R&D/equipment costs than open pens	▸ Expected higher Capex than conventional farming	▸ Somewhat lower Capex expected for FTS, compared to RAS	▸ High R&D and construction costs

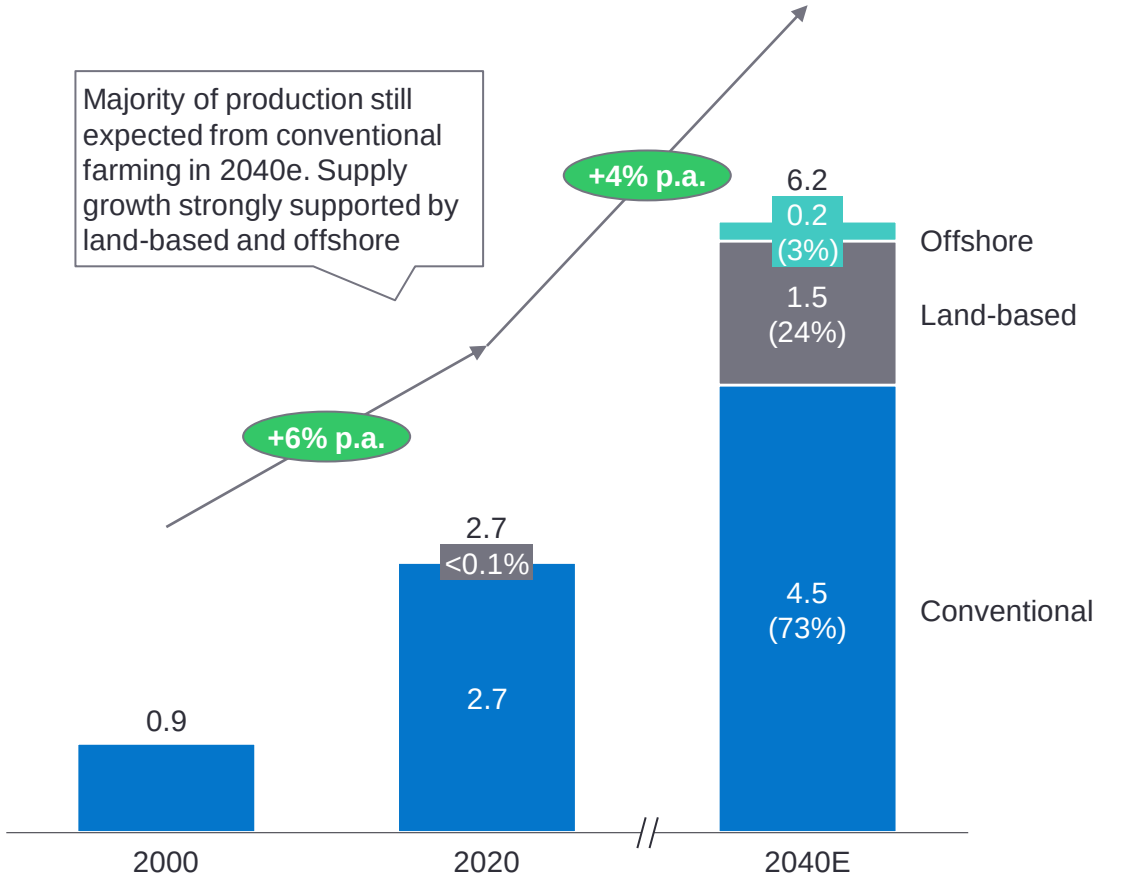
Source: EY-Parthenon analysis

Looking at Atlantic Salmon, we expect land-based farming to emerge, however, conventional sea based farming to still be the leading production method by 2040e

Estimated 2040 Atlantic Salmon aquaculture supply (Million tons)

Estimated 2040 Atlantic Salmon aquaculture production by method[1]

ILLUSTRATIVE 2040 SCENARIO



Key growth enablers per production method

Conventional (sea-based)

- Post smolt
- Knowledge based farming
- New technology (semi-closed and closed)
- Biological improvements
- Regulations

Land-based

- Time to market
- Established technology
- Access to capital

Offshore

- Additional sea areas being opened up to use
- Biological improvements
- New market entrants

1. Approximated ranges for 2040e. The scenario is based on multiple discussions with a range of industry professionals across the relevant segments. More details in the EY 2020 Aquaculture analysis

Source: EY – The Norwegian Aquaculture Analysis 2020; EY-Parthenon analysis

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