

Challenging the status quo: innovations in RAS design

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Aquaculture Innovation Worskop – Vancouver_ November 2017



The **only company** in the world able to cover the entire range of environmental solutions

\$24.4 billion
163,226 employees

Activities:

Water



The global benchmark for water services and technologies

Energy



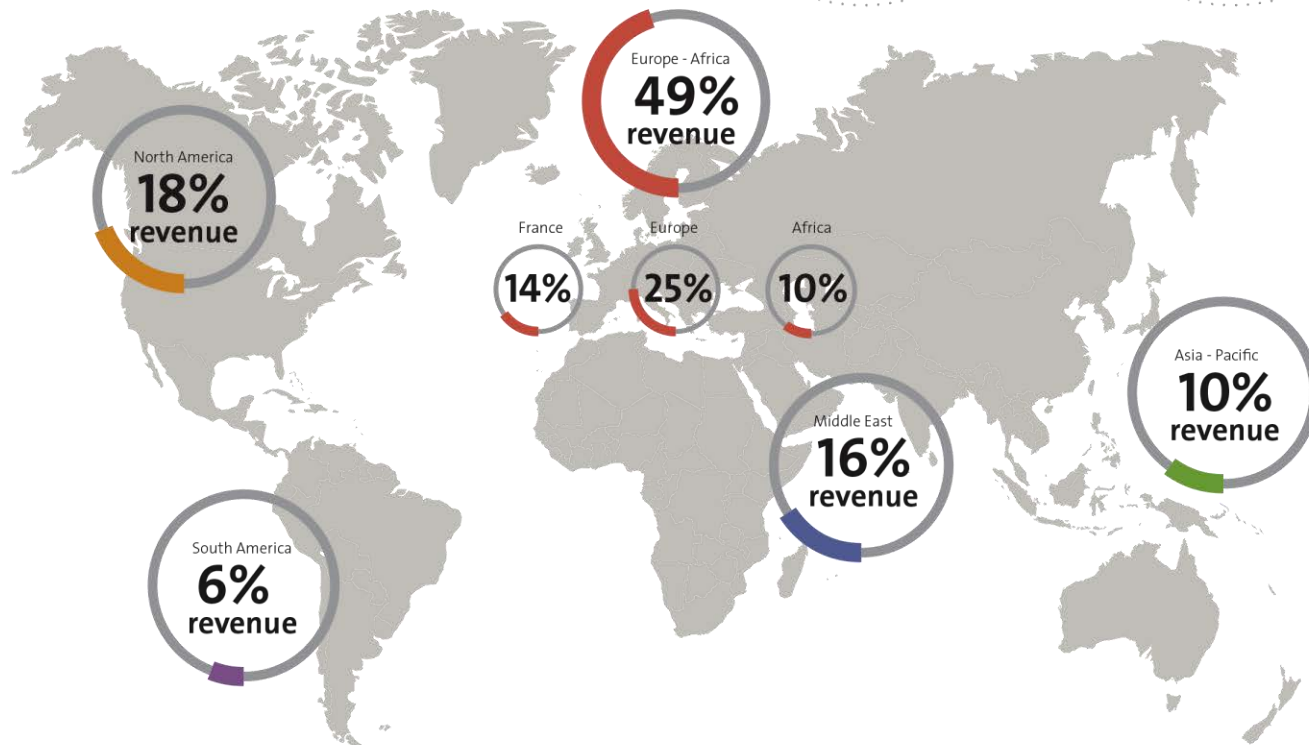
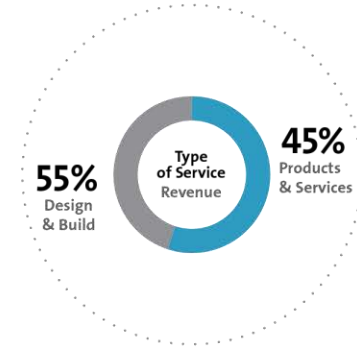
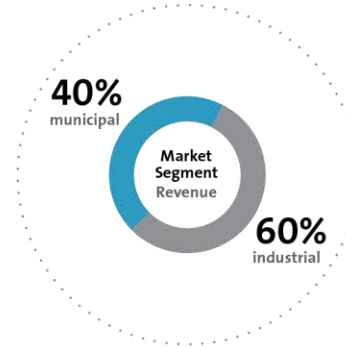
The global benchmark for energy optimization

Waste Management



The global benchmark for waste management and resource recovery

VWT - 2016 Key Figures



VWT - 2016 Key Figures



Our Expertise



Veolia WT Aquaculture Background



Biomedia for aquaculture
Hydrotech filters



2008

MBBR D&B to Nofima -
largest R&D RAS facility in Europe.



2009

Marine Harvest Norway
Dalsfjord: D&B RAS for retrofit



2016

Leading RAS supplier for
large Post-Smolt facilities



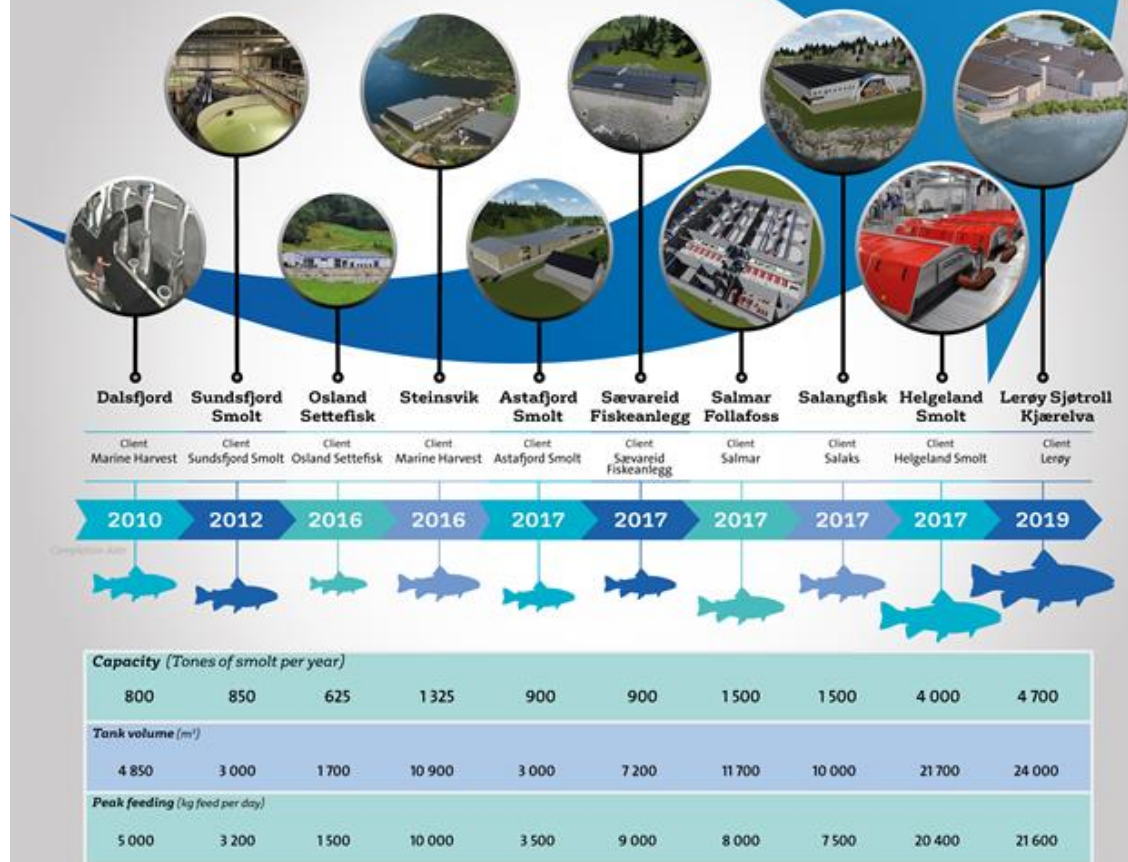
Veolia WT Aquaculture Footprint

RAS Design & Build projects 2009 - YTD2017

Country	Salmonids	Other	Total
Norway	15		15
Denmark		1	1
UK Scotland	1		1
Netherlands		1	1
Germany		1	1
Switzerland	1	2	3
Portugal		1	1
Thailand		1	1
Vietnam		1	1
China	1	3	4
Total	18	11	29

Kaldnes® RAS

Recirculating Aquaculture Systems



Last Reference – Lerøy Sea Food Group - Sjøtroll



Lerøy Sjøtroll Kjærelva

5.5 M 160g smolts

7 M 500g post smolts

- 2 hatcheries + 10 RAS departments
- Fish tank volume 24,200 m³
- Peak feeding 21.6MT/day
- Peak Biomass 4,700 MT
- Footprint **14,000 m²!**



- **Construction 2017-2019**



Challenges

Challenges - Toward Industrial RAS plants

- **Greater demands on design of facilities**

- More biomass - larger volumes and larger footprint
- Limiting factors often differ between sites
- Larger RAS-units and support systems
- More demanding project execution

- **Execution period**

- Compressed schedule – time is money
- Many suppliers on site – many interfaces
- Project planning & Logistics
- High degree of involvement from the customer

- **Commissioning of RAS**

- Partial take-over of RAS departments
- Scheduling defined by production
- Interaction client / supplier is crucial for success



Challenges- Biosecurity & Flexibility

- Fish health and Biosecurity shall be first concern
- Split production in several separate RAS (limiting batches mixing)
- Design efficient systems for cleaning tanks/piping, etc. between production cycles.
- Allow flexibility in tank volume /density
- Logistic of fish, staff, visitors, raw materials and wastes are key criteria in designing

Bioplan and layout shall be elaborated with same level of flexibility, safety and conservativeness as a Good Business plan



Challenges- Upscaling

- Larger Tanks – Hydraulics and Velocities
- Larger flows – piping, particle management, associated risks (Water quality, H₂S, etc..)
- Larger fish – transport, handling, harvesting
- Larger plants – design, functionality, auxiliary systems
- Larger projects – project management, construction schedule, quality control
- Larger investments – Business model, process and performance guarantees

Selection of partners, selection of contractors, selection of contract models (Turn-key, ...)



Preventing risks by design

Biosecured Barrier – Intake treatment

- Adapt the solution to the risks (Threats)!
- Adapt the solution to the water quality!
- Most of the time, minimal disinfection required by law is not enough!

Example:

Lerøy Sjøtroll Kjærelva (*Lerøy Seafood Group*)

Seawater intake treatment (28-32 ppt)

Peak capacity 250 m³/h

- Pre filtration 80 µm
- UF membranes 0,1 µm
- UV disinfection 250mJ/cm²
- **Multi-barrier system with 100% redundancy !**



Learning from references

FROM:

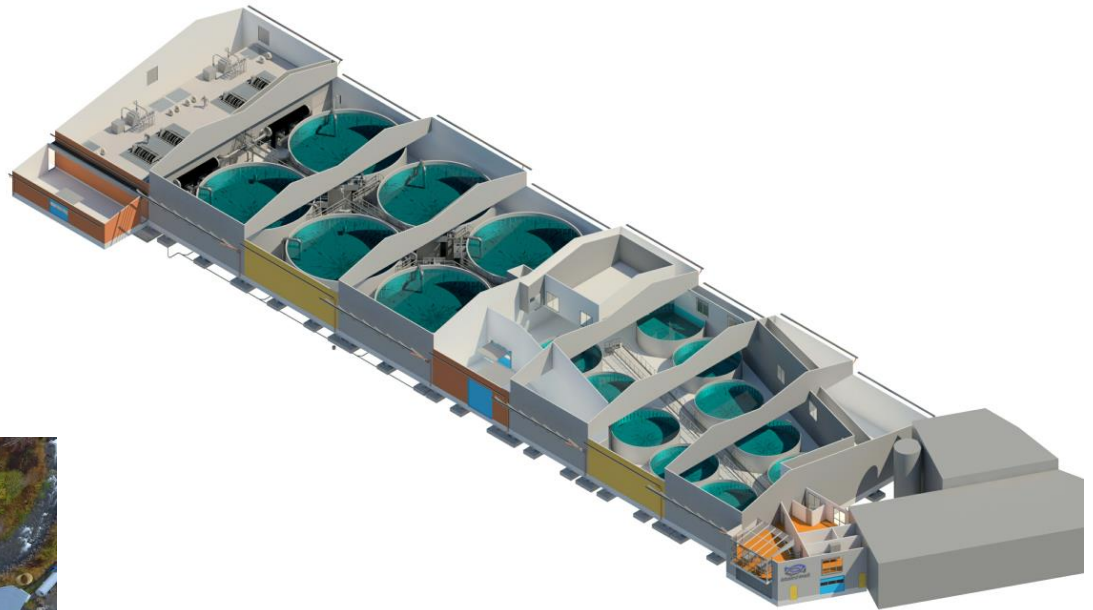
- Detailed survey on ALL plant performances after commissioning
- Close follow up with operators after deliveries
- Return on Experience (troubleshooting, feedbacks from operators)

INTO:

- Piping designed for easy and regular cleaning
- Draining pumps to secure quick and efficient pipe disinfection
- RAS & Piping without any dead zones to prevent accumulation of particles
- Fish tanks internals and fish handling systems reviewed and challenged with FOCUS on fish health and fish welfare.

Interaction with Client – Recipe for success

- Collaboration on future functionality of the plant
- Architecture and ergonomic design of buildings
- Common project schedule and coordination of subcontractors



Astafjord Smolt:

- 2,6 M 250g smolt
- 650MT/year
- 3,5MT feed/day
- Delivery 2017

Large Tanks/RAS – Think outside the box!

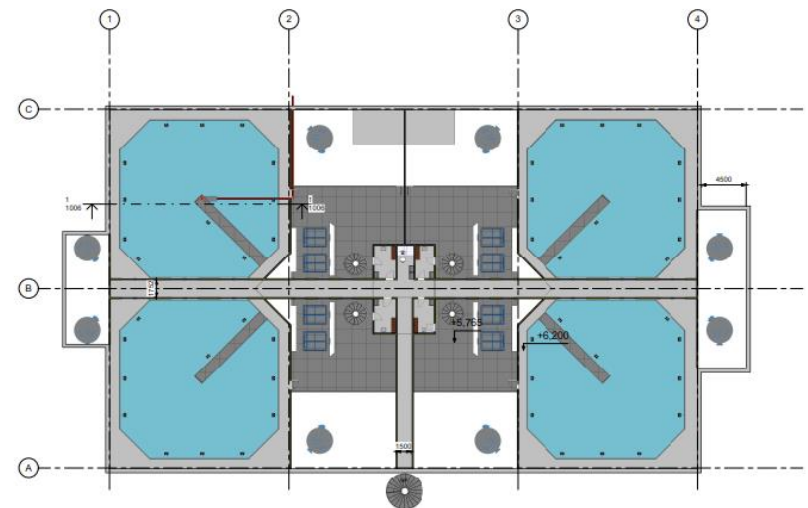
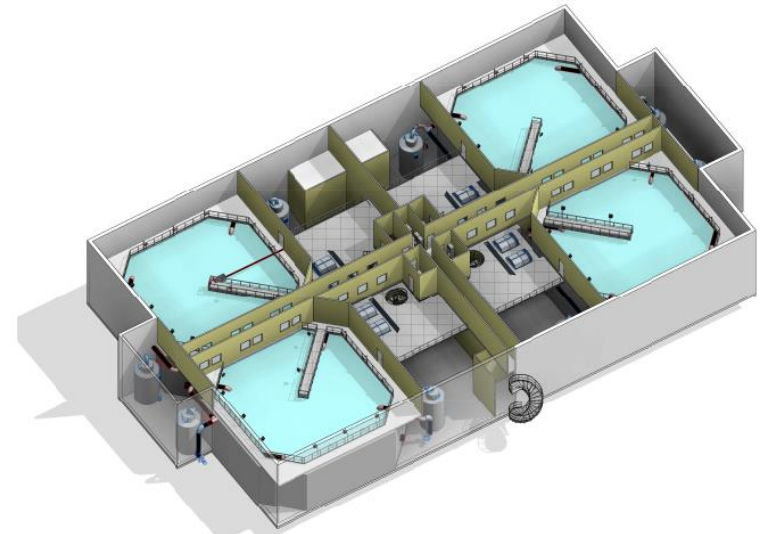
- Optimize hydraulics! (Multiple inlets, dual drain outlet)
- Reduce piping (decentralized CO₂ stripping)
- MBBR with new mixing solution (N₂ control)
- Biosecurity & Flexibility (individual RAS)

Example:

Client ND

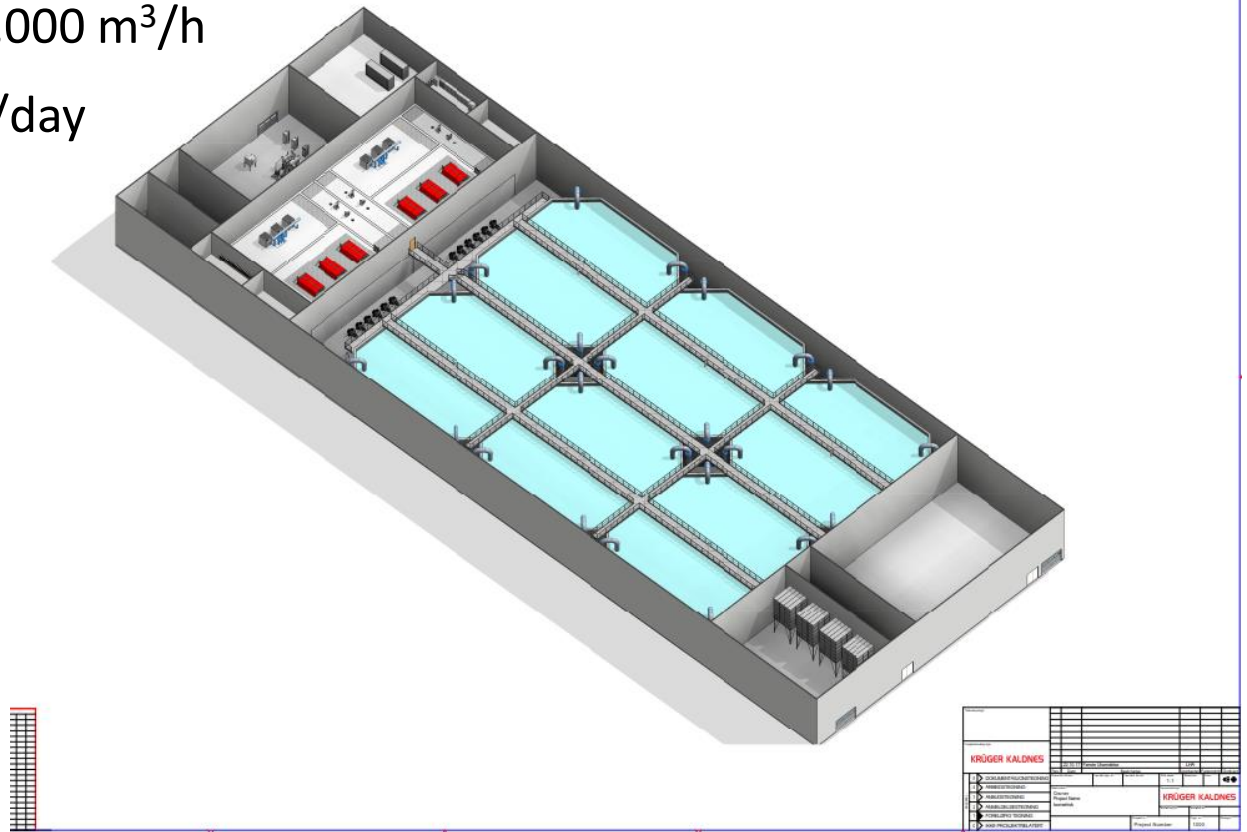
Post Smolt department in Seawater
40g to 400g/1,000g

- 4 individual RAS
- 4*1,800m³ tanks = 7,200 m³
- Peak feeding 6MT/day
- Peak Biomass 100MT/tank
- Footprint **2,000 m²!**
- **Construction 2018-2019**



One single grow out module – Min 1350 MT

- Tank Volume 15,000 m³
- 2 RAS departments
- Each department 3 tanks 2,500 m³
- Peak flow rate/RAS 8,000 m³/h
- Max feeding 6000 kg/day



Production plan scenarios

- All IN all OUT – from 1kg post smolt – 1350 MT
- All IN all OUT – from 400 g post smolt – 1400 MT
- All IN all OUT – from 1kg post smolt with final grading – 1600 MT
- All IN all OUT – from 1kg post smolt with batch mixing – 1687 MT

Growth model based on:

- FWI model- from **1000g** to 4500 g in 37 weeks
- All female scenario
- 6 inputs of 50 000 fish/year
- Standing stocking density 20 kg/m³ to 90 kg/m³

Growth model based on:

- FWI model- from **400g** to 4750 g in 48 weeks
- All female scenario
- 6 inputs of 50 000 fish/year
- Standing stocking density 8 kg/m³ to 94 kg/m³

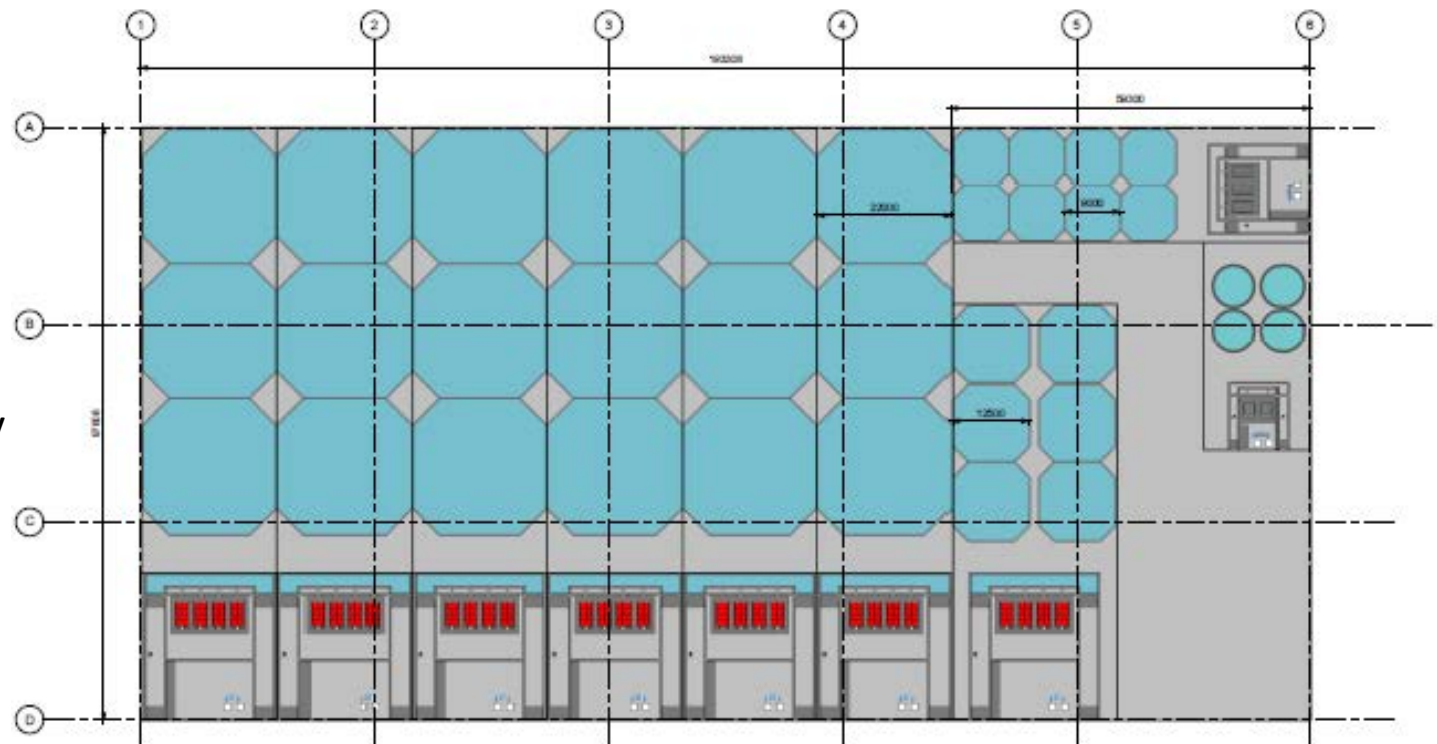
Our preferred solution – 6 500 MT/year

- Production 6 500 tons pr year – 19,000 m²
- Department with all in - all out, adjustment of temperature to optimise production

Large tanks 22 mØ

Volume 52,000 m³

Max feed 32 MT/day



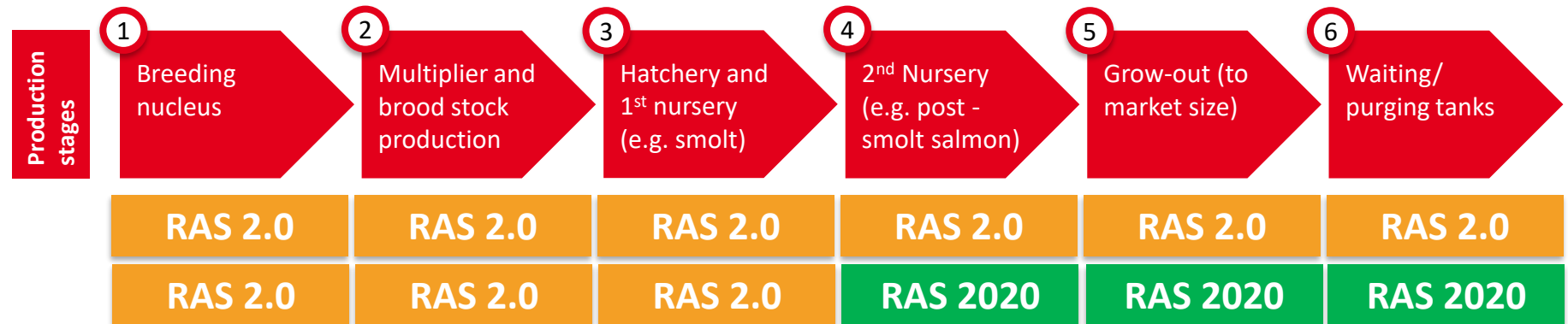
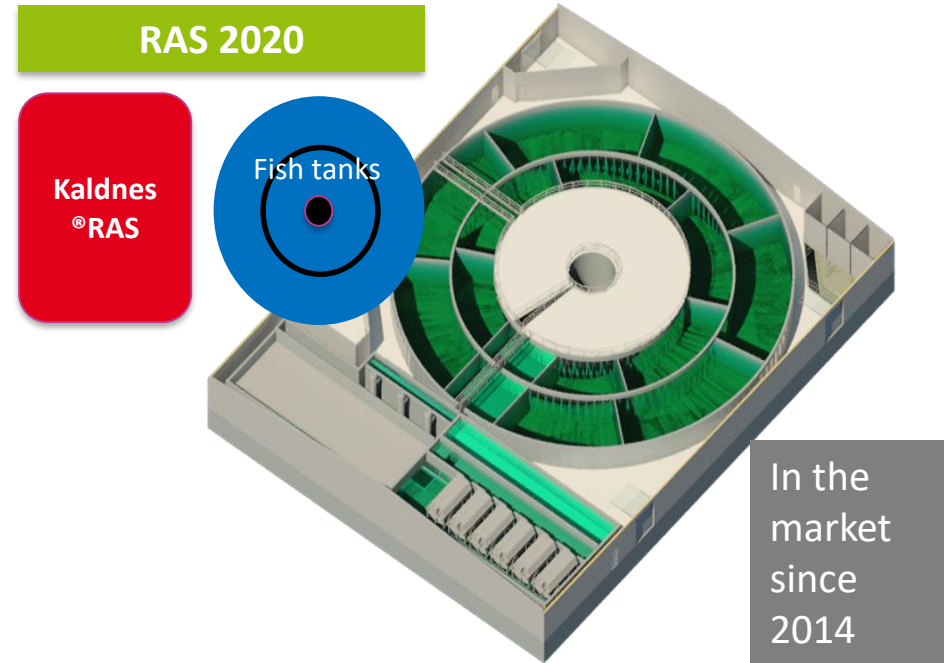
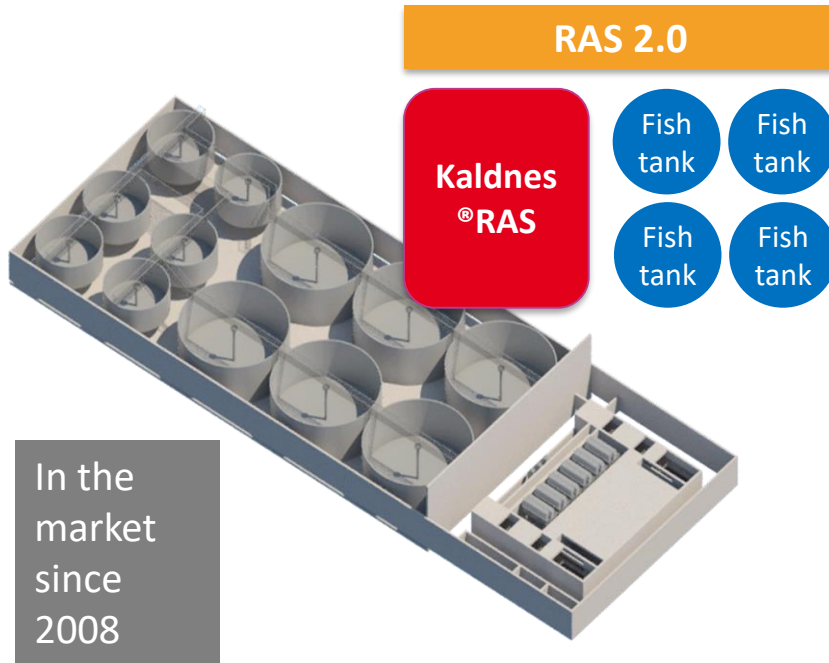
Innovative approach to land-based Fish Farming

RAS2020™

Krüger A/S

Veolia WT Aquaculture Value Proposition

- two concepts of recirculation aquaculture systems (RAS)



RAS2020™ – “in a nutshell”

Foot print (66,8 x 50): 3340 m²

Building height: 9 meter

Tank volume: 6700 m³

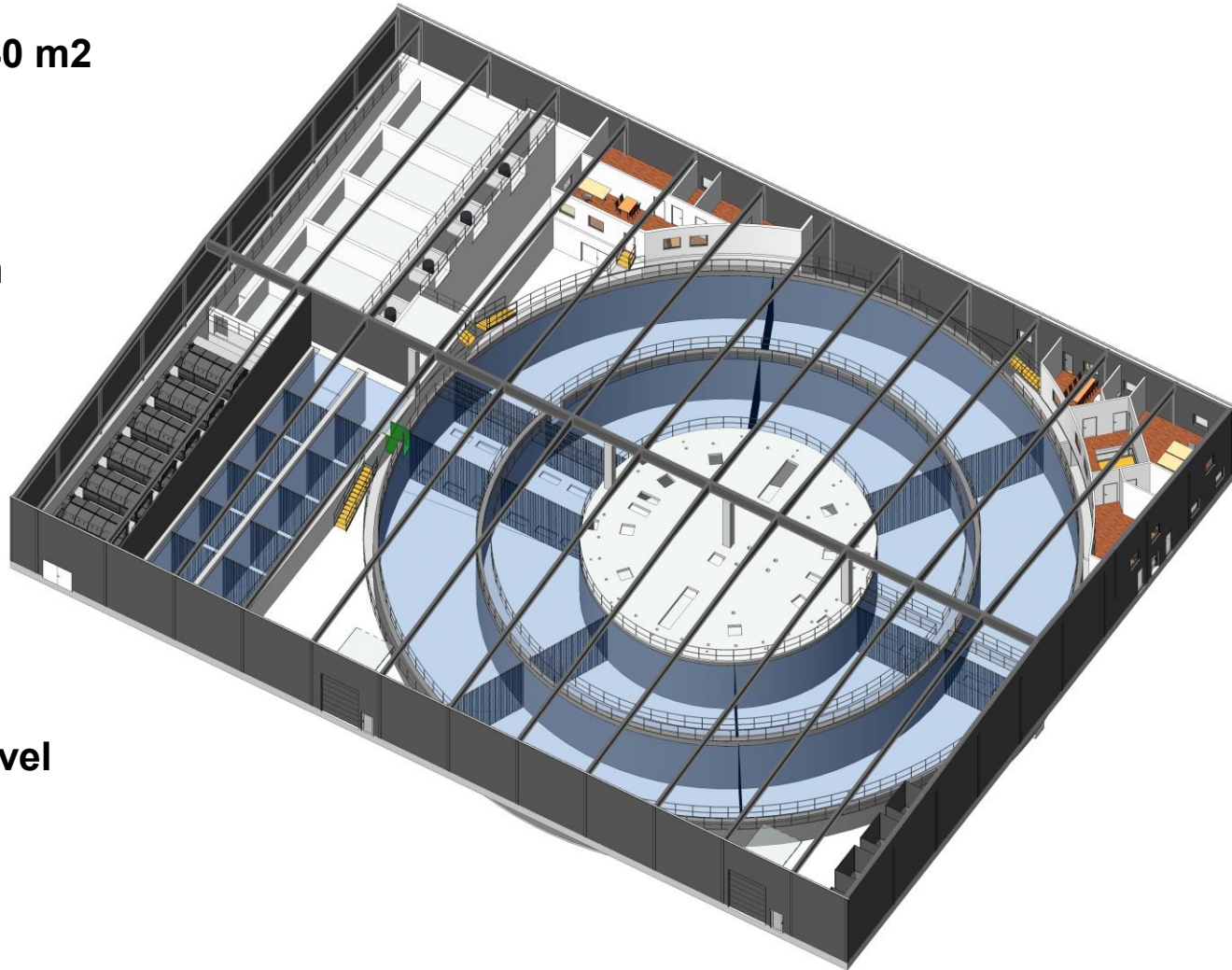
System flow: 10.000 m³/h

Purge tanks: 2 x 385 m³

4000 kg feed /day

**Tailored WWTP for any level
of discharge**

Intake system



References for RAS2020™ Fishfarms

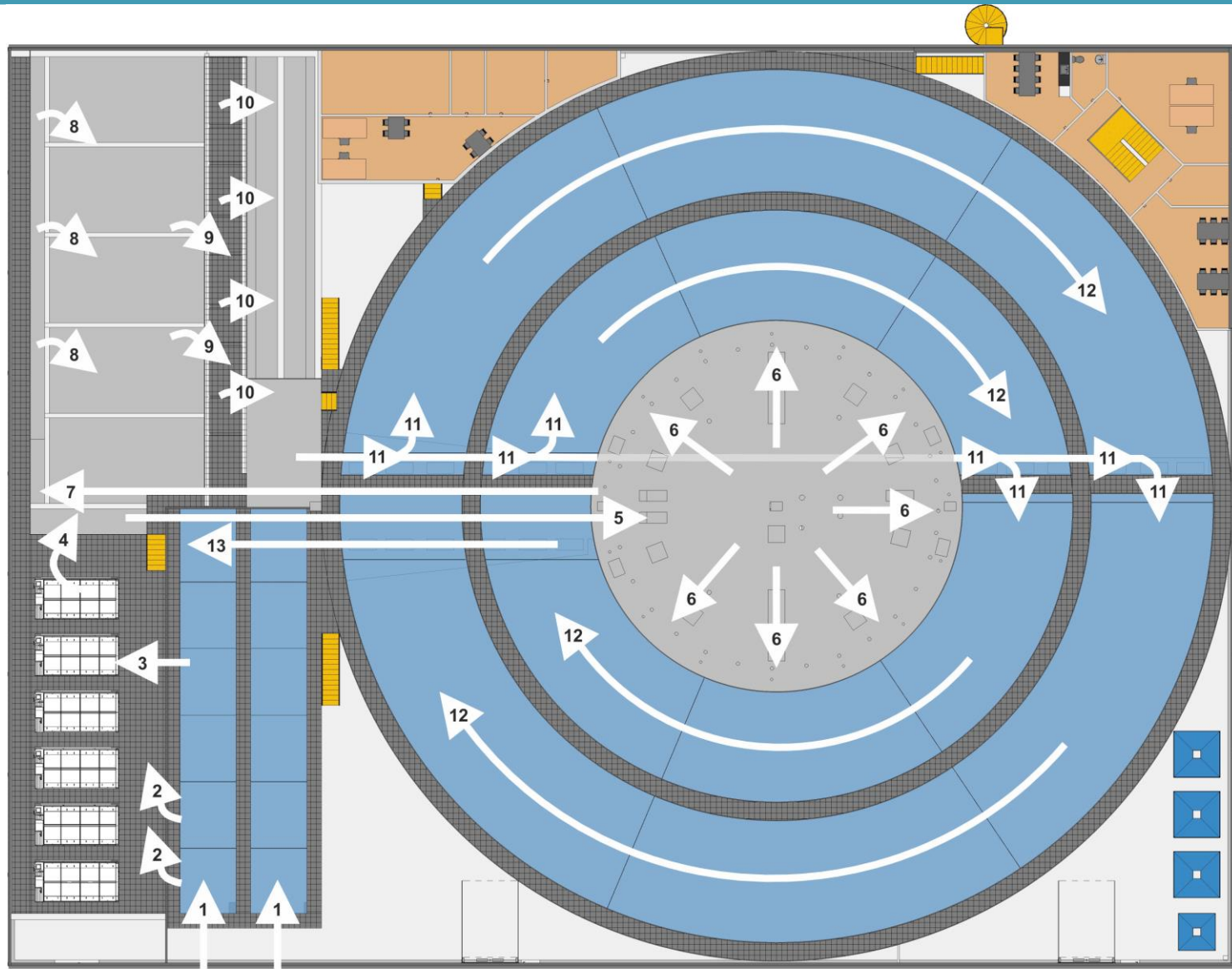
Swiss Alpine Fishn (SAF), Switzerland – Start-up January 2017

Sashimi Royal, Denmark – Start-up July 2017

Fredrikstad Seafoods, Norway – In execution – Start-up 2018

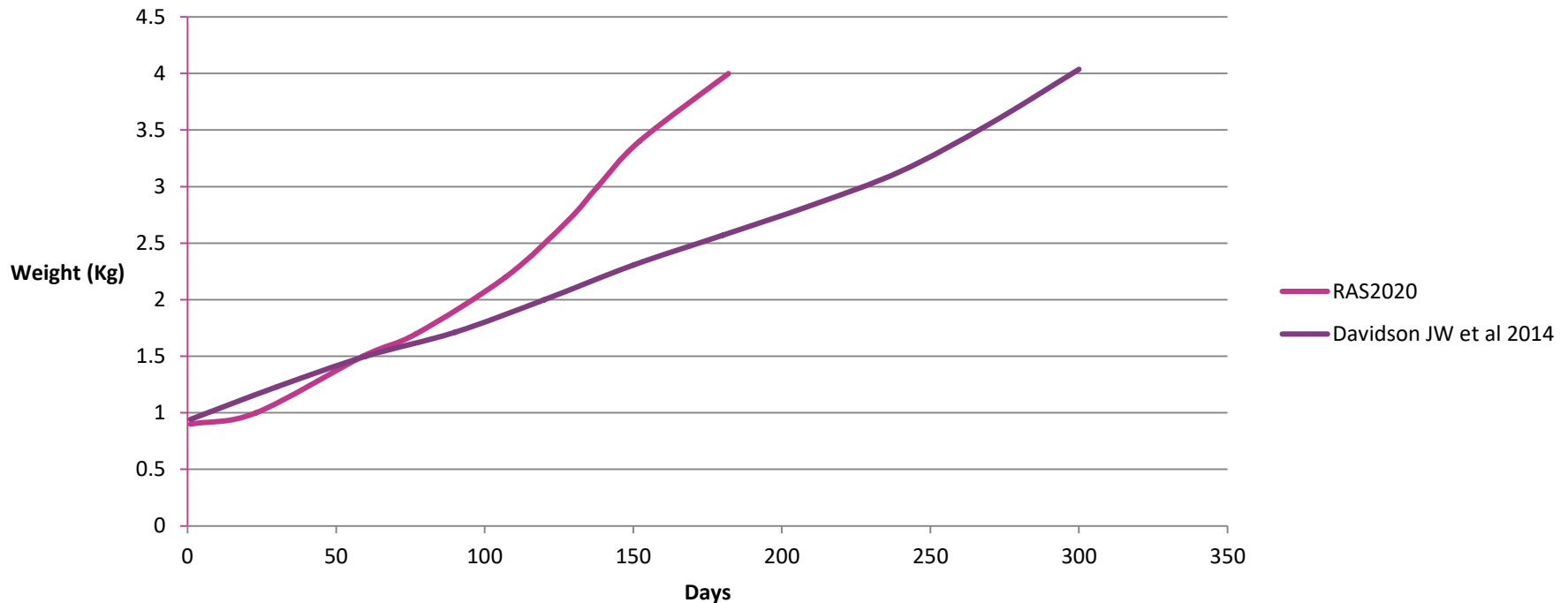


RAS 2020™ – flow pattern



SAF, Switzerland – growth rainbow trout

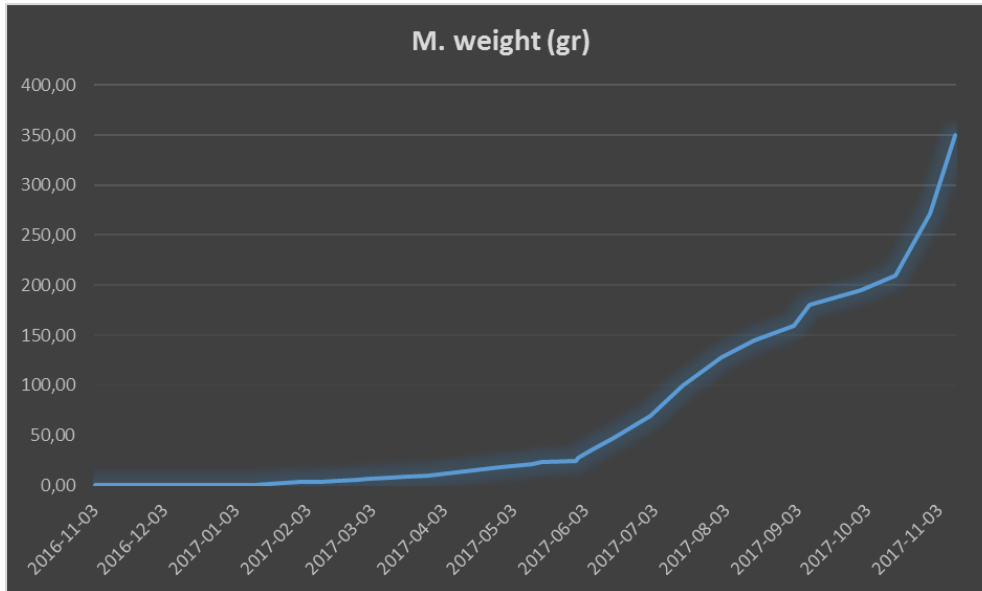
Trout growth from SAF vs growth from Davidson JW et al 2014



SAF – 900 gram to 4000 gram in 182 days

Conventional RAS: 900 gram to 4000 gram in 300 days.

SAF, Switzerland – growth Atlantic salmon



All female eggs from Iceland

Smolt Transferred from quarantine on the 12th of October into the 2020. Average 180 gram.

The 10th of November average weight 350g in 28 days.

	NUMBER OF DAYS	INITIAL WEIGHT	FINAL WEIGHT	FCR	SGR
INCUBATION	41	0,1	0,2	XXX	XXX
FIRST FEEDING	50	0,2	5	0,40	2,91%
FRY	53	5	15	0,53	2,08%
PRE-SMOLT	98	15	25	0,51	1,20%
QUARANTINE	102	25	160	0,59	2,02%
GROWOUT (2020)	28	160	350	0,61	2,61%

SGR of 2,6 % post smolt

Smarter management

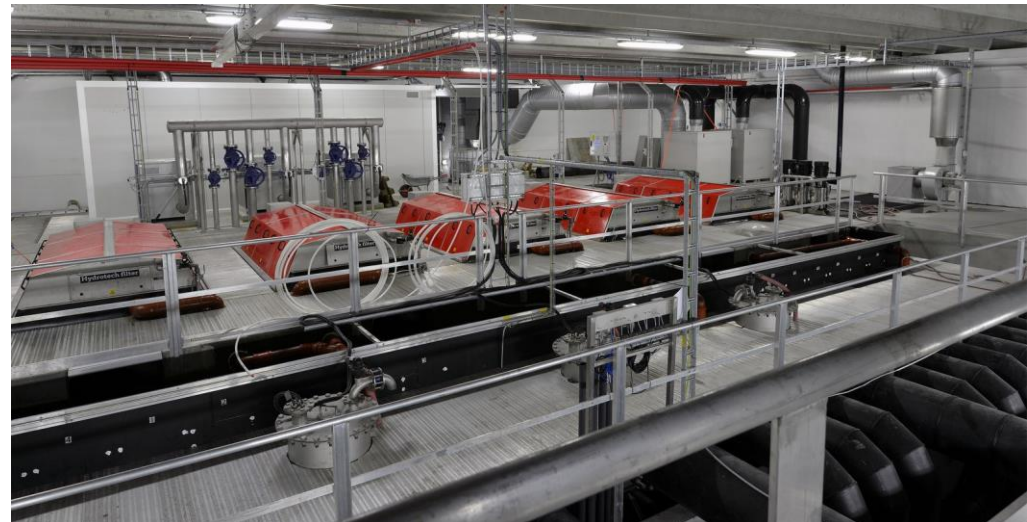
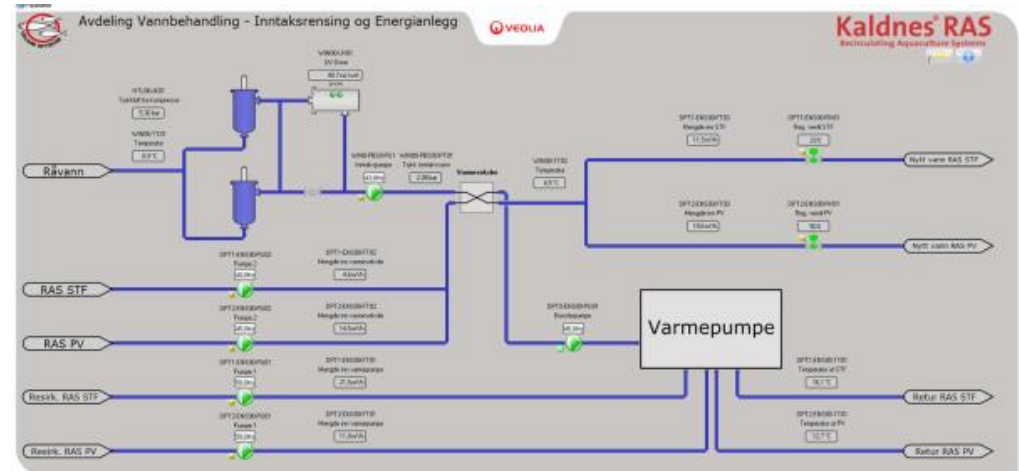
Extended monitoring leading to increased safety and optimized efficiency



Full Control

ALL RAS functions BUT also:

- All chemicals dosing
- Heat pump and energy plant
- Intake treatment and disinfection
- Back up generator & UPS
- Lights (fish tank & building)
- Cameras
- Granted access to staff and visitors
- *And much more.....*



Full Documentation

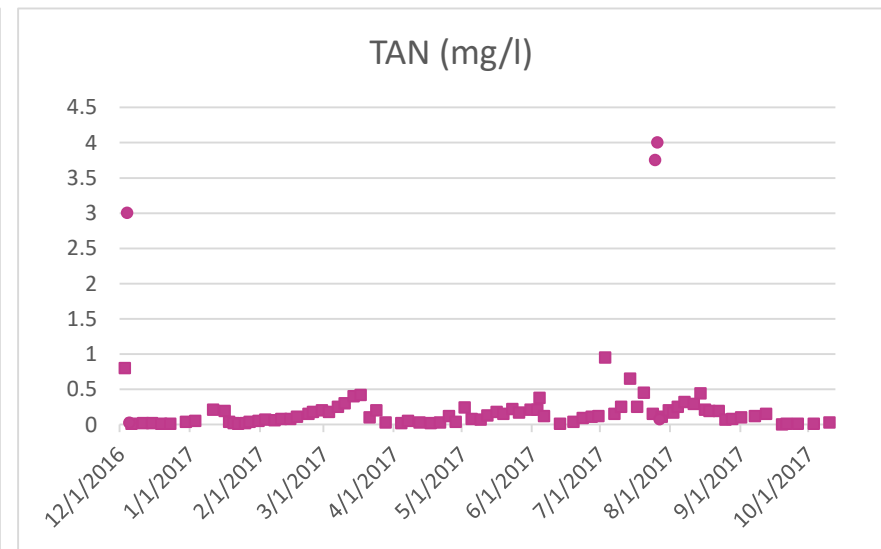
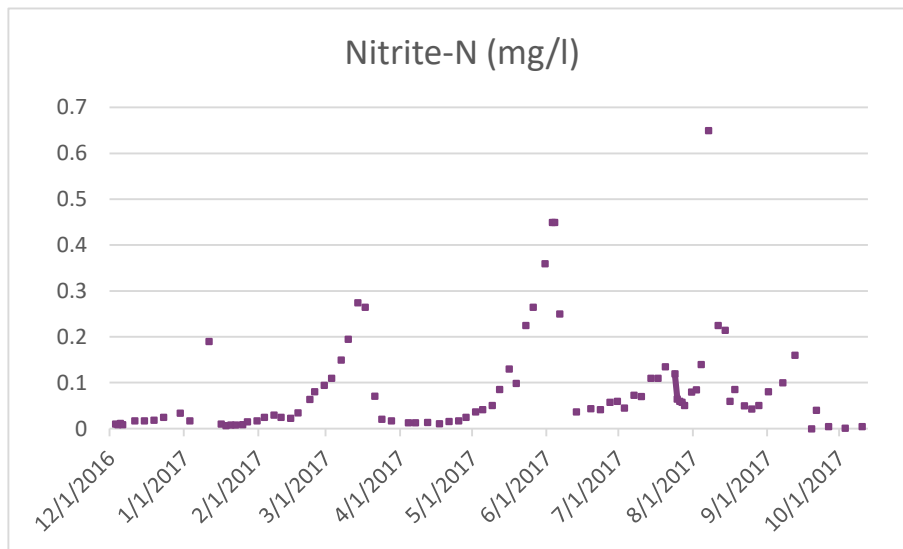
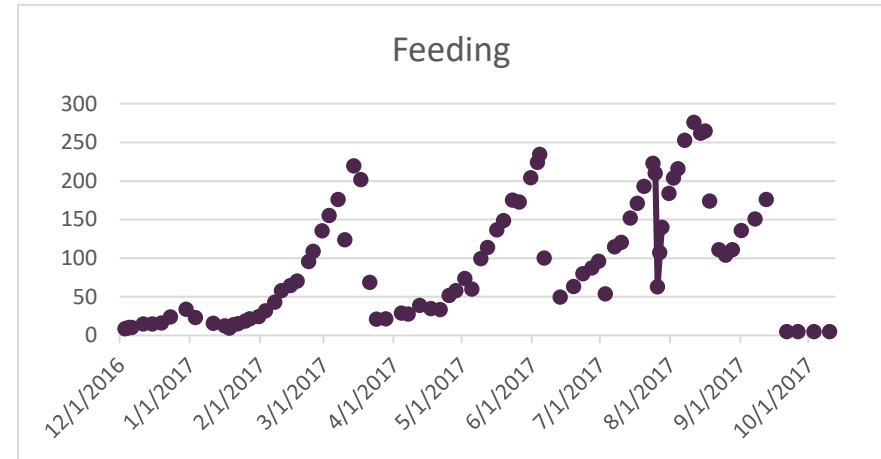
Example: Osland Settefisk

Starfeeding department

Peak biomass 12 MT

Peak feeding 356 kg/day

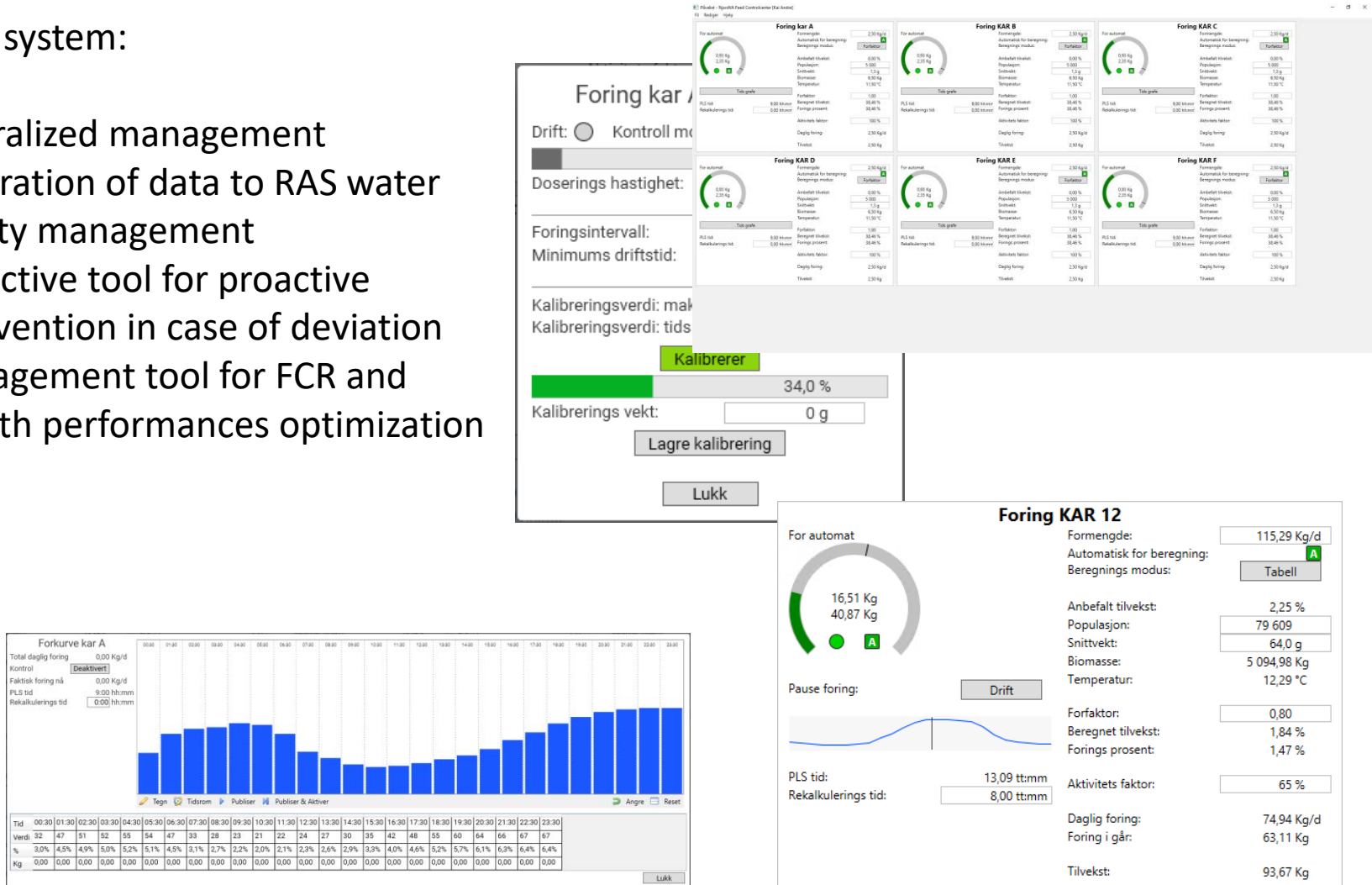
SCADA + daily sampling = Reporting & Analysis



Full Integration

Feeding system:

- Centralized management
- Integration of data to RAS water quality management
- Predictive tool for proactive intervention in case of deviation
- Management tool for FCR and growth performances optimization



Smart Tools



Daily routine & local access to ALL information

Touch screens in the production room, cloning all information from SCADA

Fish handling & Remote control of ALL operation

Tablet in the grading/vaccination room, cloning all information from SCADA

Full control on water level in fish tank (ultra sound sensors)

Full control on speed of quick tank emptying boosting pump (VFD)

Full control of operation (fish pump flows, fish counting, etc..)

Full view on operation (access to fish hall and fish transport room cameras)



On the Go & Remote control of ALL functions

Access to the SCADA & server from the Cloud

Access on smartphone, tablet

Full remote control on all alarms and all functions

Getting into Digitalization

- **Improved asset performance**, higher plant efficiency
 - **Lower operational and capital costs**, reduced maintenance, chemical use and energy consumption
 - Better information with **full overview** of your equipment or plant from a remote location
 - **Optimized efficiency** through faster response and proactive intervention to lower risks
 - **Increases safety** by leveraging predictive analytics to mitigate critical points
 - Minimizes environmental impacts and **promotes sustainability**
-
- Security and reliability through one of the world's most advanced and **secure** cloud-based systems
 - Flexibility through an intuitive dashboard **adapted to your specifications**, needs and existing systems
 - Convenience of monitoring multiple sites **anywhere, anytime** through a single secure portal
 - **Proven results** at hundreds of municipal and industrial plants connected to Aquavista™ today



Concluding remarks!

- RAS has moved from being a **niche** to **State of the art** and **mainstream** production method for salmonids
- Development of smolt farms is towards **larger production** units for **larger smolts/postsmolts**. 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.
- Salmon to full size on land is likely to increase dramatically in the very close future. Experiences from front runners are mixed, though lessons learned and new research and development address key challenges and strategies to make land based salmon farms a viable production method in the future.

QUESTIONS ?