RAS Design Innovations and Opportunities for New Technologies

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VEOLIA
WATER
Solutions & Technologies

KRÜGER KALDNES

RAS Design Innovations and Opportunities for New Technologies

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4. Design Innovations & New Technologies
5. Future Potential
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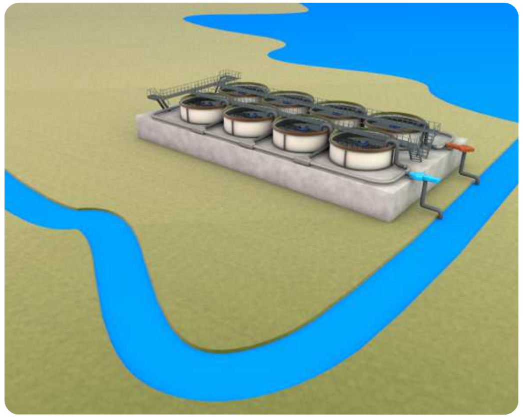
Kaldnes® RAS
Recirculating Aquaculture Systems

1

Recirculating Aquaculture Systems

INTRODUCTION

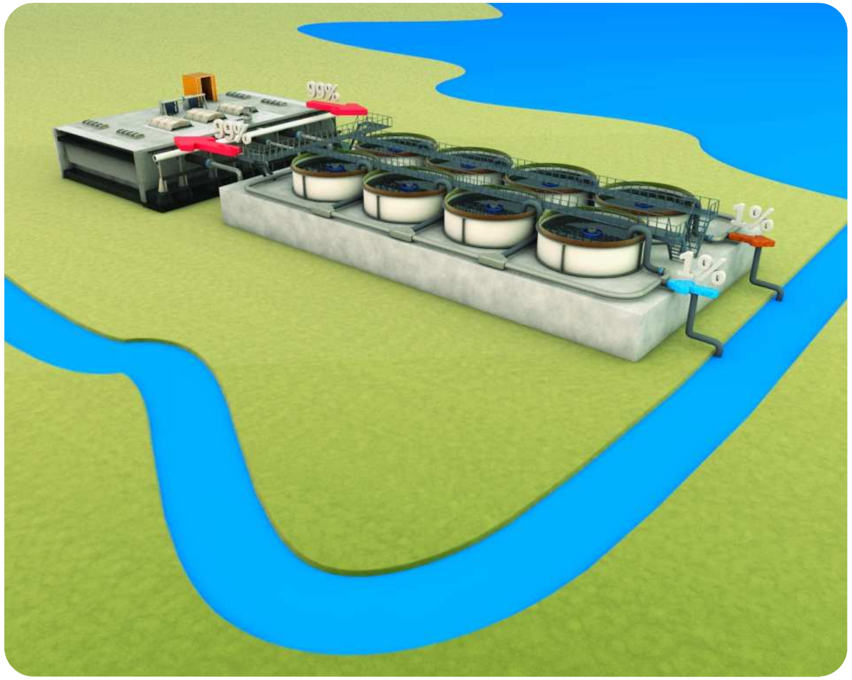
Traditional Fish Farming vs. RAS



Type A: Flow-through system with oxygenation.

- Type B: Semi-closed system with oxygenation, aeration, and particle removal.

- Type C: Recirculation Aquaculture System (RAS) with biological water treatment, including type B.



Objective: Increase production and reduce water consumption.

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Why do we want to use RAS for production of fish?

The industry's perspective.

Today the most common strategy for on land fish production is flow through (single pass)

- large quantities of makeup water
- high energy demand for pumping water
- long production cycle (no control on water temperature and ambient light)
- variable water quality due to inlet water

The farming industry today needs to use RAS to face several challenges:

- Increasing demand for fingerlings (number)
- Necessity for bio secured hatcheries and disease free juveniles
- Demand for larger fish at seawater transfer
- Increasing demand for grow out systems for salmonids
- Lack of available water supplies for production
  - Restricted water supply in existing farms (fully exploited water supplies)
  - High risk for serious seasonal drought
  - Few new licenses are given (restricted public administration)
- Too small licenced areas for existing farms (need for more compact facilities)

Why do we want to use RAS for production of fish?

The environmentalist's perspective.

Increasing focus on environmental sustainability in industrial production of fish has pointed out several main areas for improvement in aquaculture:

- To use less water in production
- To reduce effluent discharges
- To exploit the nutrients evolving from production (sludge and dissolved N/P). This includes integrated production systems
- To minimize the need for chemicals/chemotherapeuticals
- To better manage fish diseases
- To avoid fish escapes

In other words:
To seek for a more environmentally sustainable production.

In short

By using RAS we achieve:

- Increased production capacity
- Better fish quality
- Less environmental "footprint"

RAS may be considered as a substantial improvement concerning higher production efficiency and better environmental sustainability.

RAS can also be regarded as a strategy to make the industry more independent from limiting factors connected to production.

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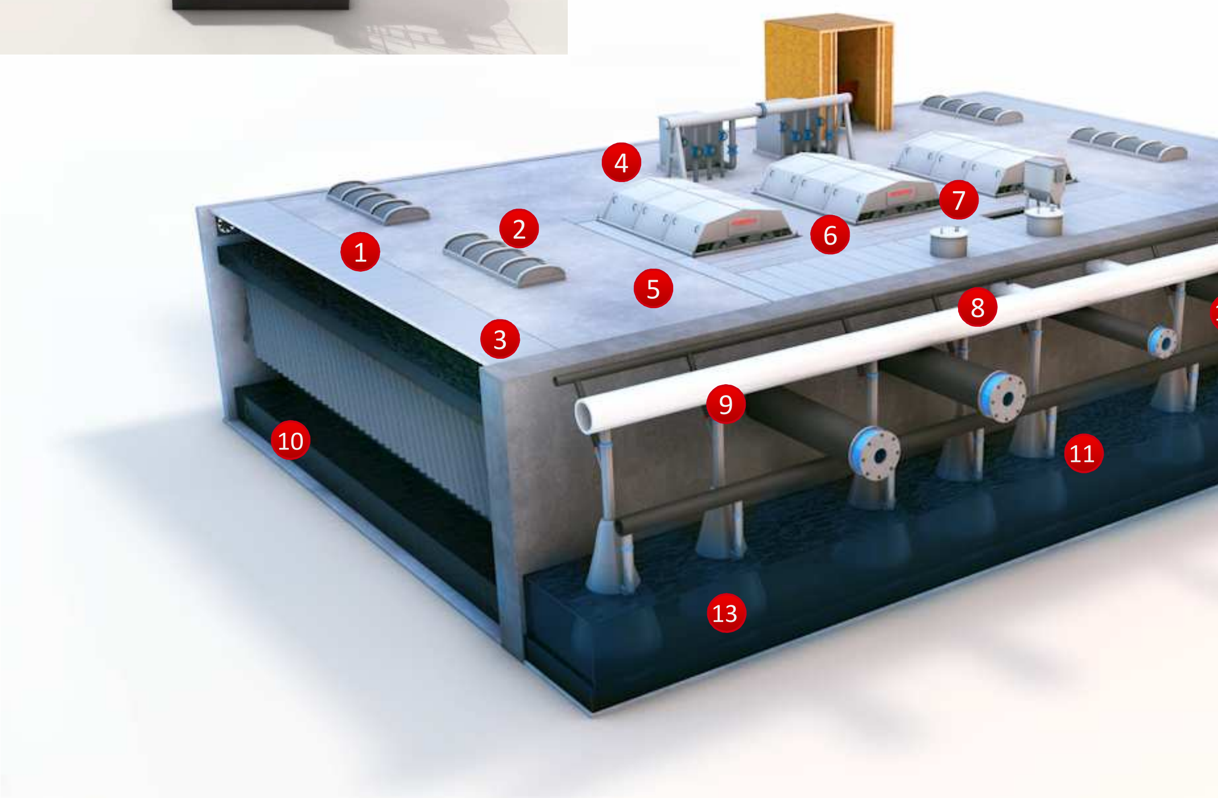
Compact and Energy efficient Design

KALDNES® RAS

Kaldnes ® RAS – *Compact and Energy efficient Design*



1. *Inspechtion and access opening*
2. *Bioreactor 2*
3. *Bioreactor 1*
4. *Air blowers in sound silencer chamber*
5. *Drum filter 60 micron*
6. *Drum filter 20 micron*
7. *Drum filter 60 micron*
8. *Pumps*
9. *Bypass and return water*
10. *CO2 and N2 stripper*
11. *Collection pipe inlet water*
12. *Collection pipe outlet water*
13. *Deepshaft oxygen cone*

Design Innovation

KALDNES® RAS IN PRACTICE

Design Innovation - Kaldnes® RAS in Practice

Nofima Research station – Sunndalsøra (NO)

- Largest aquaculture recycling center in Europe
- Cutting edges technology
- Both fresh- and seawater

Design Innovation - Kaldnes® RAS in Practice

MARINE HARVEST, DALSFJORD – Grow out

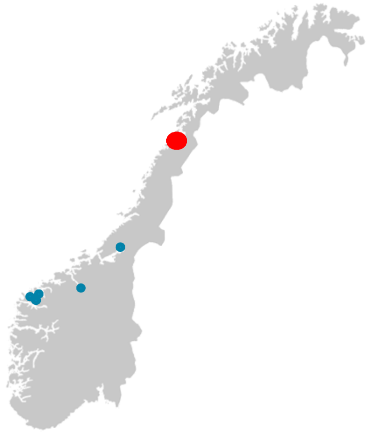
marineharvest
excellence in seafood

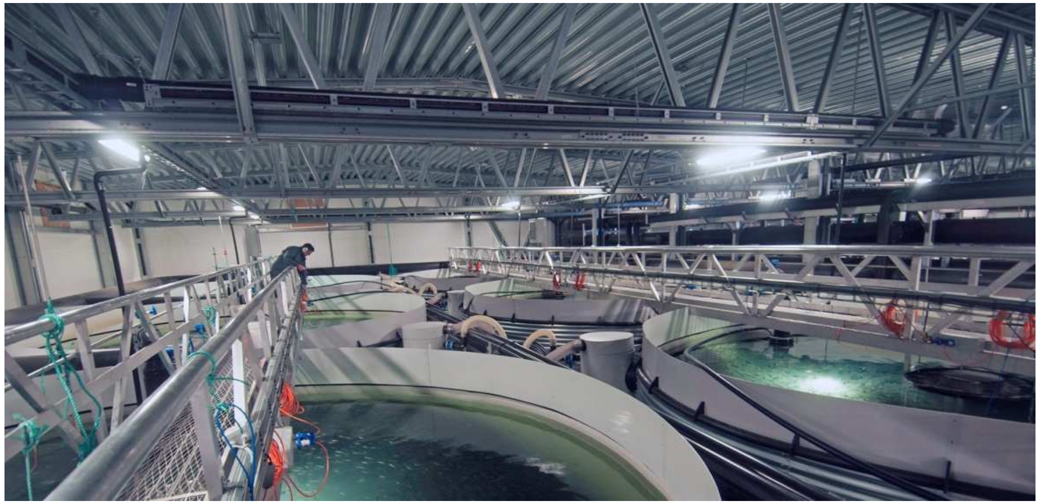
- Capacity over 5 Million smolts/year
- Total rearing volume 4250 m3
- Complete process design and delivery by Krüger Kaldnes

Design Innovation - Kaldnes® RAS in Practice

Sundsfjord Smolt AS

- Capacity 3 Millions smolts/year
- Total rearing volume 3000 m3
- Complete process design and delivery by Krüger Kaldnes

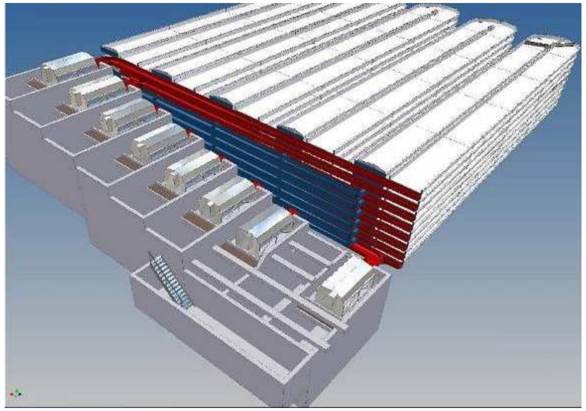




Design Innovation - Kaldnes® RAS in Practice

Seafarm BV (NL) Turbot

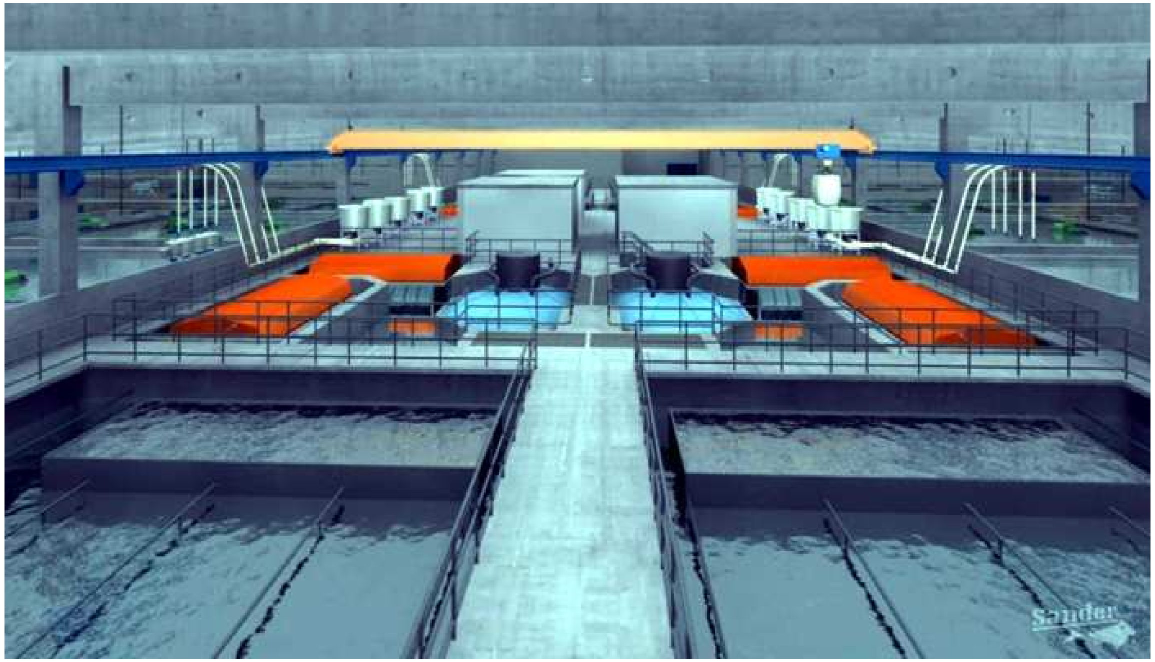
- Capacity 200 MT Turbot/year
- Innovative design as multilevel shallow Raceways (8 layers)



Design Innovation - Kaldnes® RAS in Practice

MFV Völklingen – Germany

- 500 MT Sea bass / Sea bream
- 100 Miles from the Sea!
- Delivery of Hydrotech drumfilters and Kaldnes® MBBR



Design Innovation - Kaldnes® RAS in Practice

Marine Harvest – Steinsvik

- One of the largest land based aquaculture farm in Norway
- Capacity of 5,3 mill smolt/year to size 250 g/pc
- Total rearing volume 9600 m3
- Krüger Kaldnes awarded DB contract for water treatment solutions (under construction)

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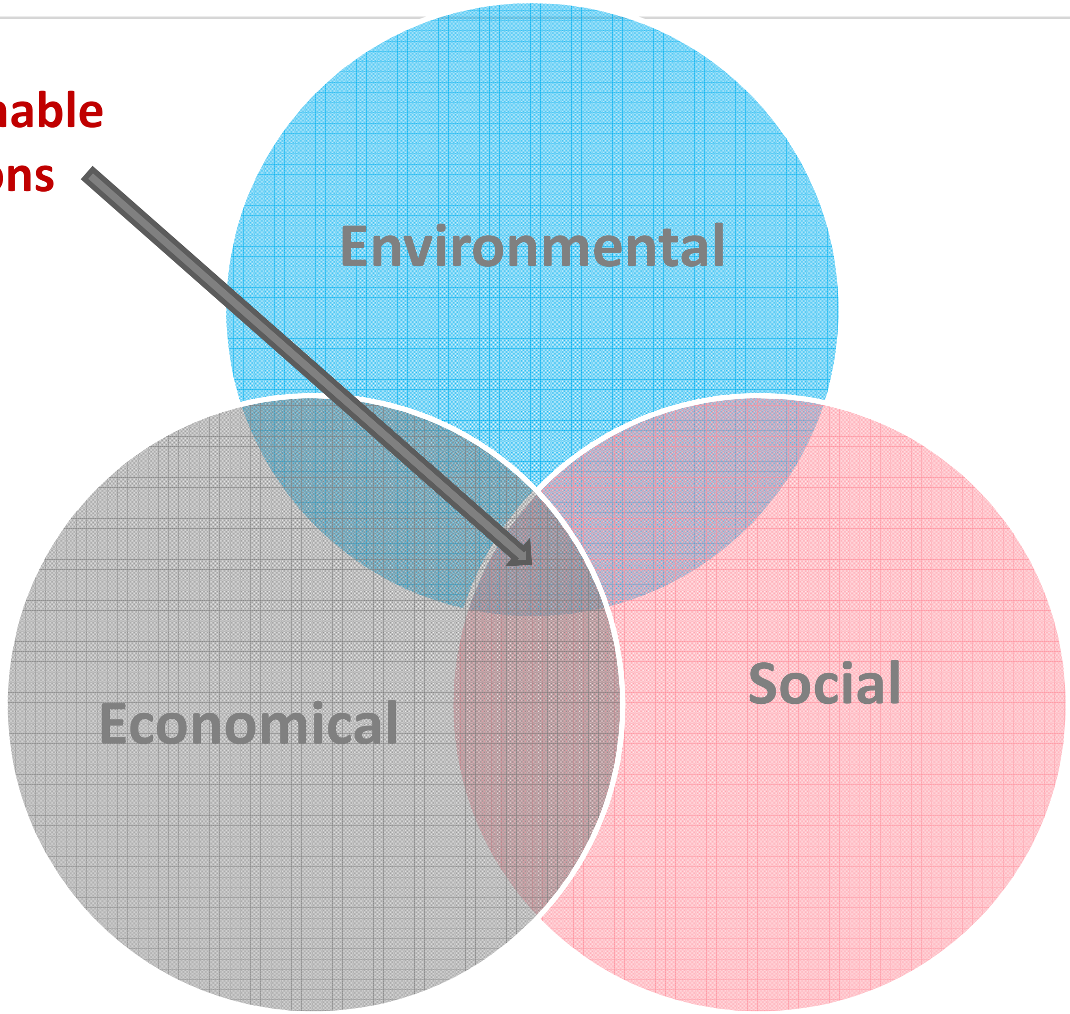
Recirculating Aquaculture System (RAS)

FUTURE CHALLENGES

What are the key challenges for RAS in future ?

Sustainable Solutions



Sustainable Intensification

«Producing more food from the same area of land while reducing the environmental impacts requires what has been called sustainable intensification.» Goldfray et al. (2010)

Sustainable Aquaculture

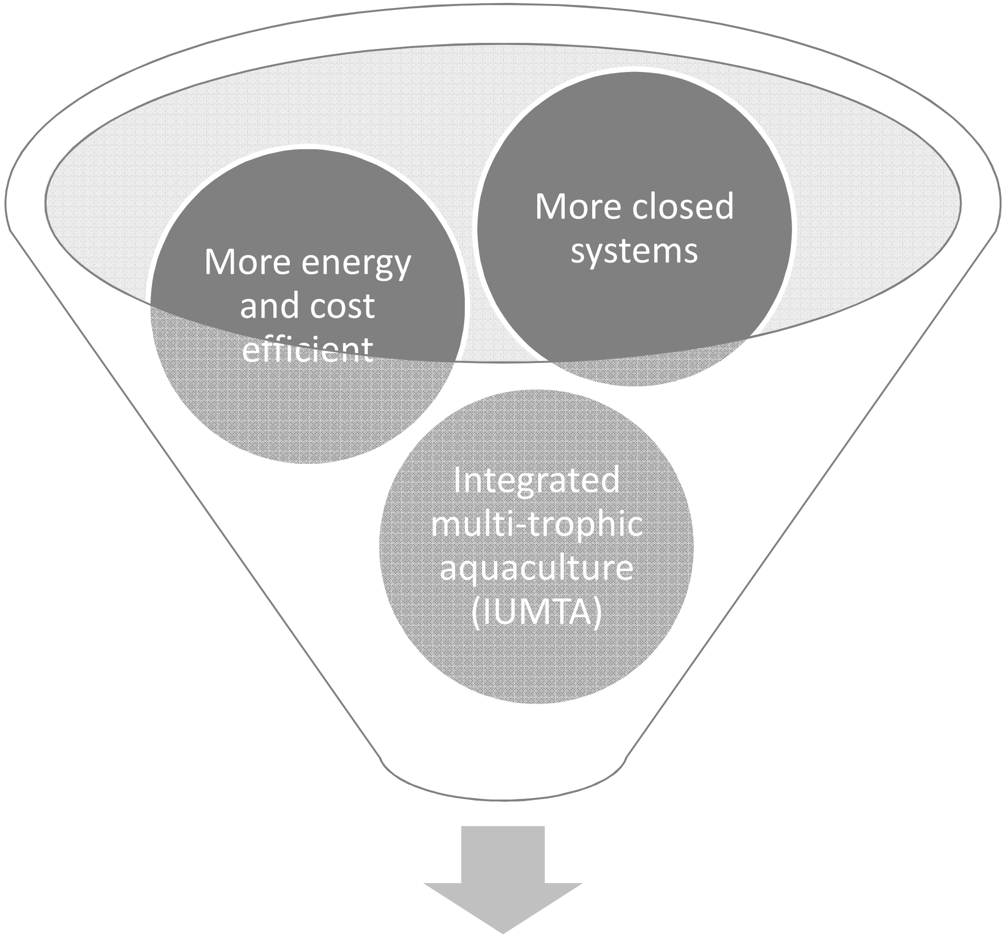
What makes RAS sustainable?

Low impact on environment

- ✓Operated nearly isolated
- ✓Controlable in terms of discharge (waste water)
- ✓No risk of escapes (fish and pathogens)

RAS offers the possibility to achieve a high production, maintaining optimal environmental conditions, securing animal welfare, while creating a minimum ecological impact.

How to improve RAS technology



Engineering Innovations

Water Quality Challenges - Nitrogen

Nitrification

- Organic matter entering the MBBR hampers nitrification.
- As a result, both autrophic and heterotrophic bacteria are growing in the reactor

Challenge:

To enable nitrification to work as chemo-autophic as possible (e.g. by minimizing the organic carbon (OC) in the influent of the nitrification reactor.

Denitrification

- Denitrification reactor in RAS require an influent with a high C:N ratio.
- Often used: External carbon sources (e.g. methanol, ethanol or glucose)
- Anammox solutions to bypass formation of NO3-N (development in RAS still novel)

Challenge:

Use of internal carbon sources or Anammox systems.

Water Quality Challenges - Solids

- Fine solids are often insufficiently removed from the water
- Accumulation of solids in the system decreases:
  - Nitrification
  - Water quality
  - Fish growth

→ **Fine solids control is the bottleneck of many current RAS plants**

Water Quality Challenges - **Phosphate**

- Lack of PO4 removal in system leads to accumulation in the system and relative high concentration in RAS effluent water

→**Needed: Efficient and cost effective phosphate removal**

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Recirculating Aquaculture System (RAS)

DESIGN INNOVATIONS & NEW TECHNOLOGIES

Our **Development Strategy**

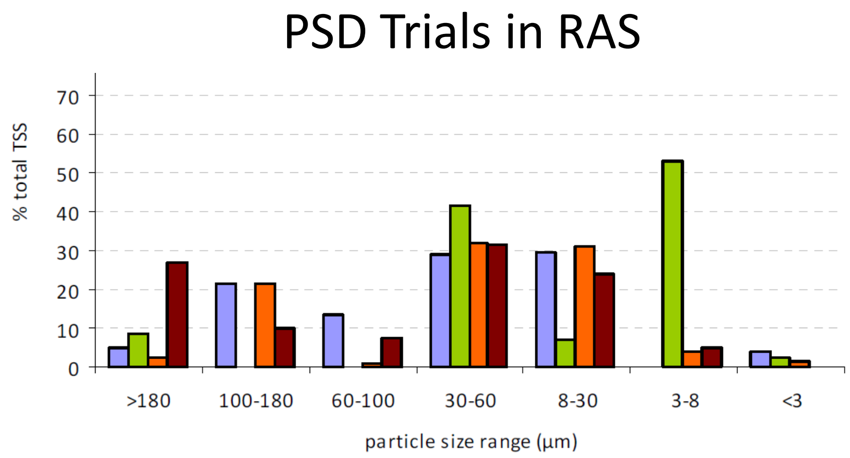
Development of exceptional RAS plants through technological know-how, innovation and validation

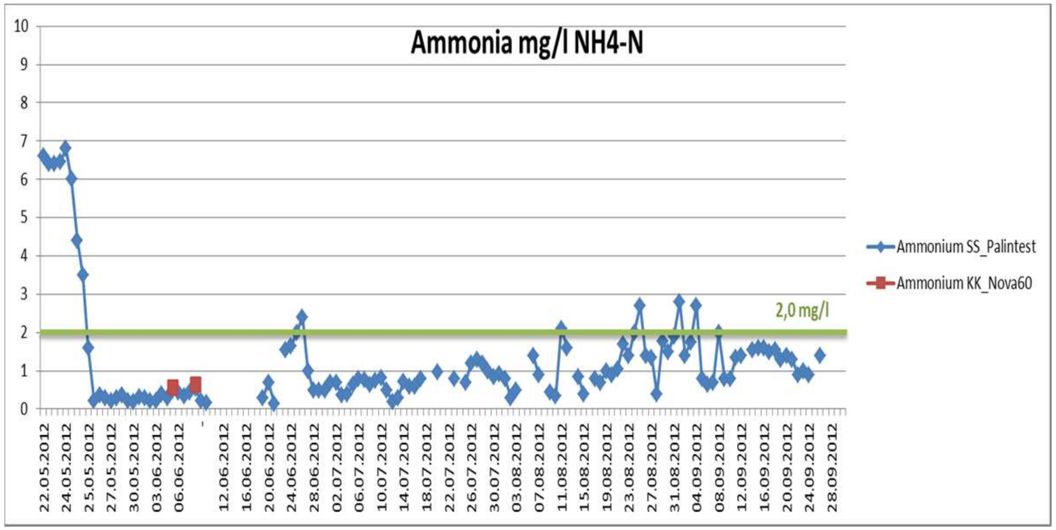
Strong focus on understanding water quality and technological performance enables us to apply the best solutions available

Development Strategy (cont.)

- Development and documentation of:
  - Energy efficient production
  - Biosecurity by application of efficient disinfection and plant management
  - Fine particle control and water quality polishing
  - Optimization of biological water treatment for fresh- and saltwater applications
  - Low energy/low head gas control in RAS treatment loop
  - Efficient and sustainable solutions for sludge treatment and handling

Testing and validation – Kaldnes® RAS

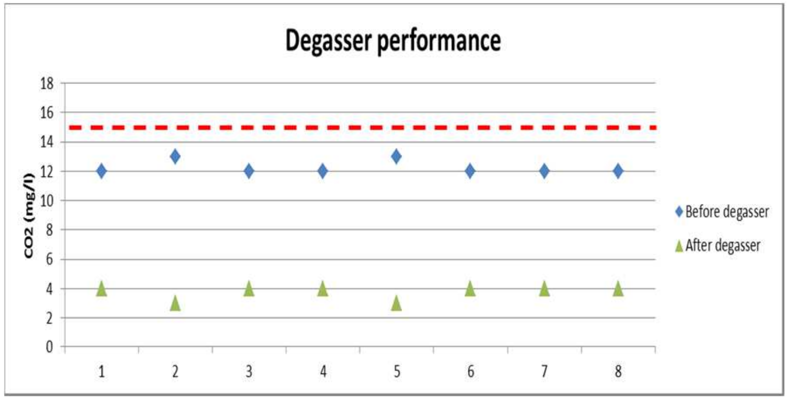


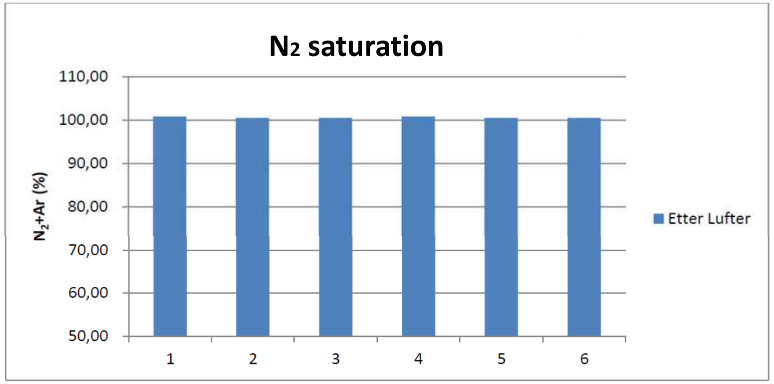


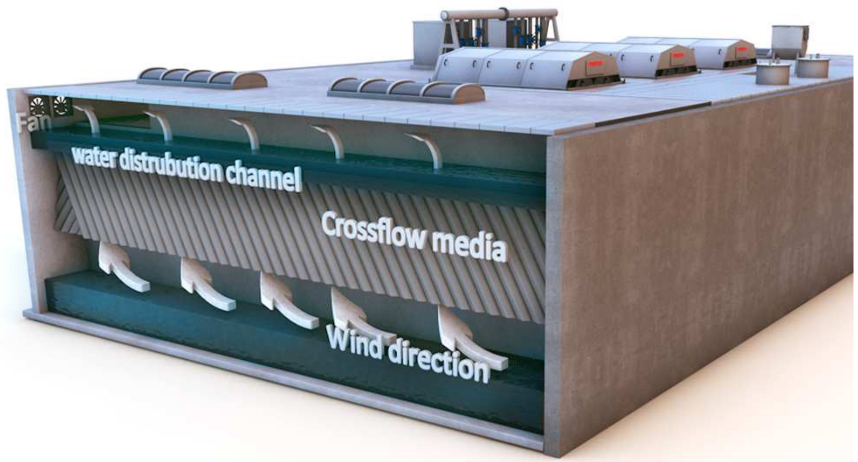
CO_2 og N_2- removal

G:L ratio 5:1

Neg. pressure 0,3 mVs increase capacity



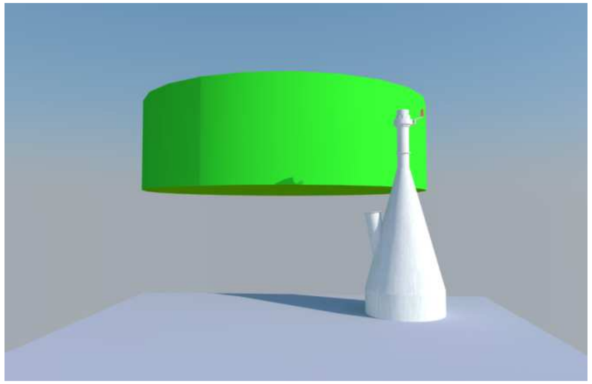




Oxygenation-Deepshaft

- Greatly reduced energy costs
- Pressure 7,5-10m (0,7-1 bar).

- Dissolution efficiency 96-98 % in freshwater



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New Technologies

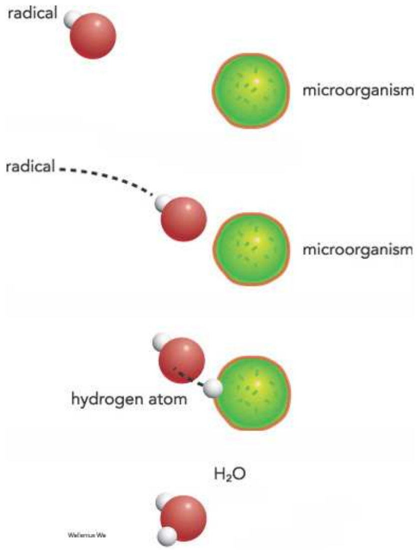
ADVANCED OXYDATION TECHNOLOGY (AOT)

New Technologies – AOT

AOT in RAS systems

- Utilizes the most powerful oxidants in nature – free radicals
- Chemical-free
- Inspired by nature´s own process to degrade organic materials
- Nothing added to the process
- No risk for overdosing
- Low energy consumption
- Decreases turbidity

AOT Function:



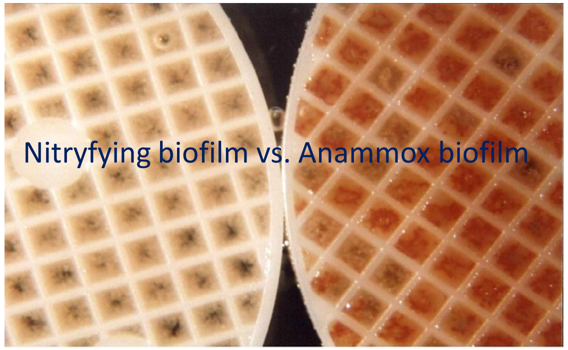
New Technologies

ANITA™ MOX

New Technologies – Anita™ Mox

The key conversion in the ANITA™ Mox is nitrogen removal through anaerobic ammonium oxidation

- Anaerobic ammonium oxidation (Anammox)
- $NH_4^+ + NO_2^- \rightarrow N_2 + 2H_20$



Features:
- Less O2 (≈ 60%)
- No carbon needed
- Less CO2 production
- Less sludge production
- Less alkalinity consumption (≈ 50%)

Disadvantages:
- Slow growth rate, doubling time 11-13 days - long start-up periods
- Necessary to have a long SRT (Biofilm)
- Nitrite accumlation if process is inhibited

New Technologies

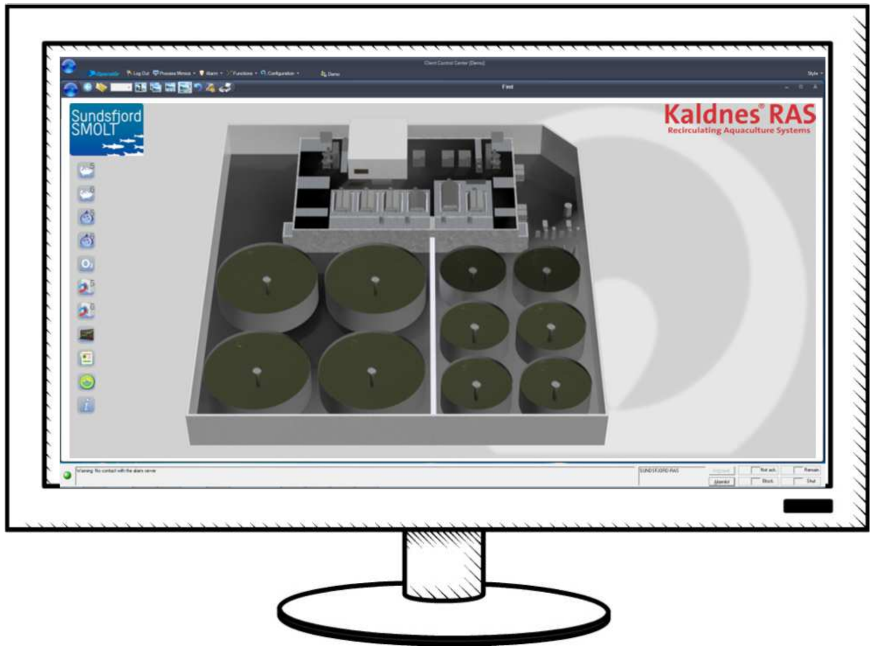
SCADA

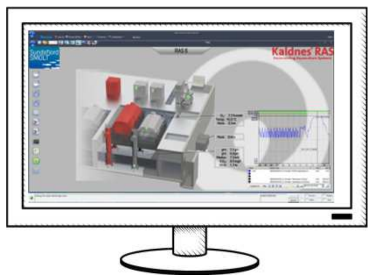
New Technologies – SCADA

VA operator for Kaldnes® RAS

Key features

- Communication features
- Dynamic Pictures & build in support for
  - → Webpages
  - → Cameras
  - → Animated symbols
- Advanced Data collection
- Trend curves
- Designable reports
- Sophisticated alarm setting
- Point and click navigation
- Clean work surface with details on separate dialogs





New Technologies

SOLVOX

New Technologies – SOLVOX®Oxystream

Low pressure oxygenation system

Key features

- Water flow indicator and easy adjuststment of flow direction
- Microbubbles strip N_2 from water
- Reduced total dissolved gas pressure (TDGP)
- High oxygenation efficiency at low pressure (0,5 – 1,5 mWC)
- Low energy consumption
- Creates optimal hydrodynamic conditions in the tank
- Oxygenation efficiency up to 96 %
- Full efficiency at 15 ppt salinity higher

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RAS Technology

FUTURE POTENTIAL

Potential Fish species for RAS

Freshwater

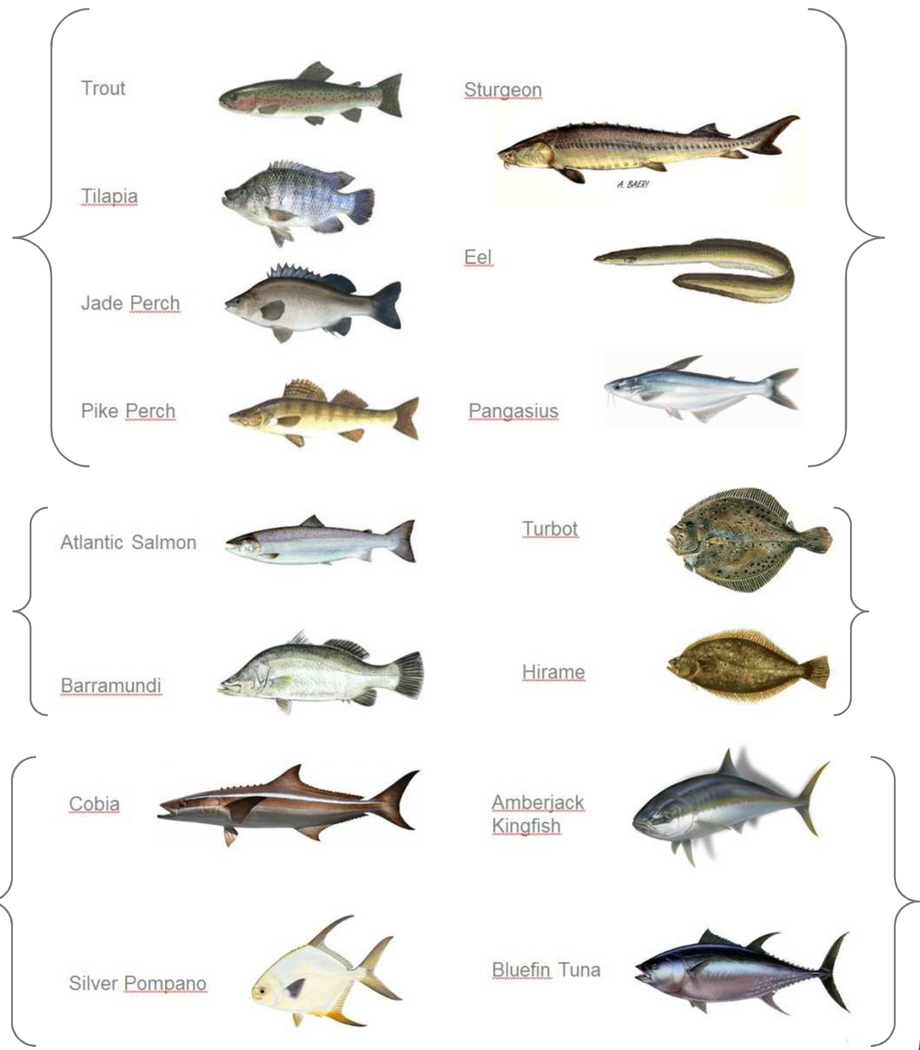
- Hatchery
- Nursery / On Growing
- Grow out intensive systems

Brackish /Seawater

- Hatchery
- Nursery / On Growing
- Grow out intensive systems

Marine Fast growing fishes

- Hatchery
- Nursery / On Growing



...and many more !!!

Future Potential

- The below table show the species that are considered to have the greatest potential for RAS. That is where RAS is expected to offer the greatest value.

Species	production 2010 X 1000 Tons	Projected 2020 X 1000 Tons	Increase	Hot spots
Salmonides	2400	3200	33%	Norway,Chile, Canada,UK
Flatfishes	170	220	23%	China, Europe
Seabass & Seabream	250	290	16%	Asia,Europe
Barramundi	50	80	60%	Asia,USA
Cobia	32	130	305%	Asia,LATAM
Grouper	75	120	60%	Asia

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RAS Technology

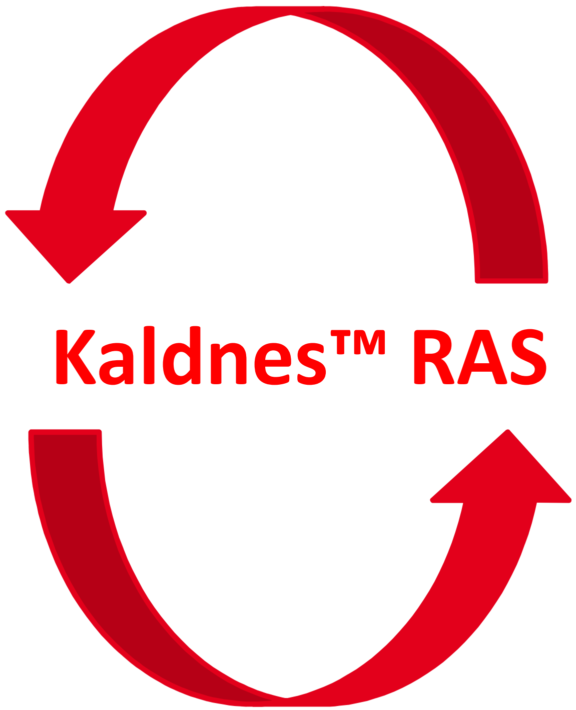
TRENDS & OUTLOOK

Trends Impacting RAS Value Proposition

Species	Trends
Salmonides	A clear drive in the direction of production of larger fish onshore before transfer to sea. Transfer to sea cages at 250 – 1.000 gram compared to 80 – 150 gram today. Disease resistance and increased utilization of maximum total biomass (MTB) limits in sea are the driving forces.
Flatfish	Increased understanding of the importance for water quality control by using RAS in hatcheries and nurseries. Increased interest for using RAS in growout (environmental impact, footprint area, temperature control)
Shrimp	Protect farms against diseases, reduce environmental impact in heavily impacted areas and increase production in existing facilities.
Seabass and Seabream	RAS in hatcheries/nurseries is recognized as the most important reason to achieve high survival and growth of alevins. Higher interest for RAS in growout can be expected (global water quality control, environment)
Other Finfish	In general RAS seems to be most beneficial for hatcheries and nurseries. In some areas RAS for growout will increase (because of environmental issues and reduced footprint area and new cost effective solutions

Outlook

RAS is a key solution for large-scale ecologically sustainable fish production.



Kaldnes® RAS

Contribution to a responsible and sustainable production of food for today and the future!