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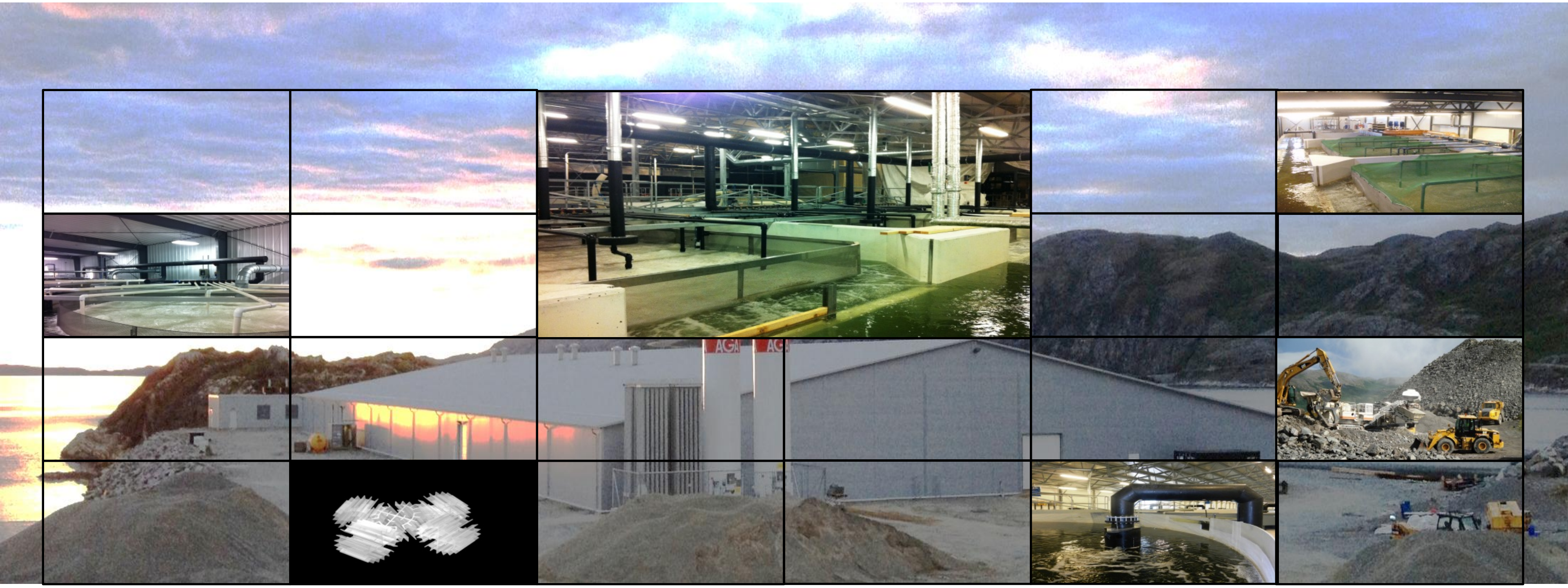

AQUACULTURE INNOVATION WORKSHOP

4-6th September 2013

“Challenges in Construction and Operation at Extremely Remote RAS Locations”

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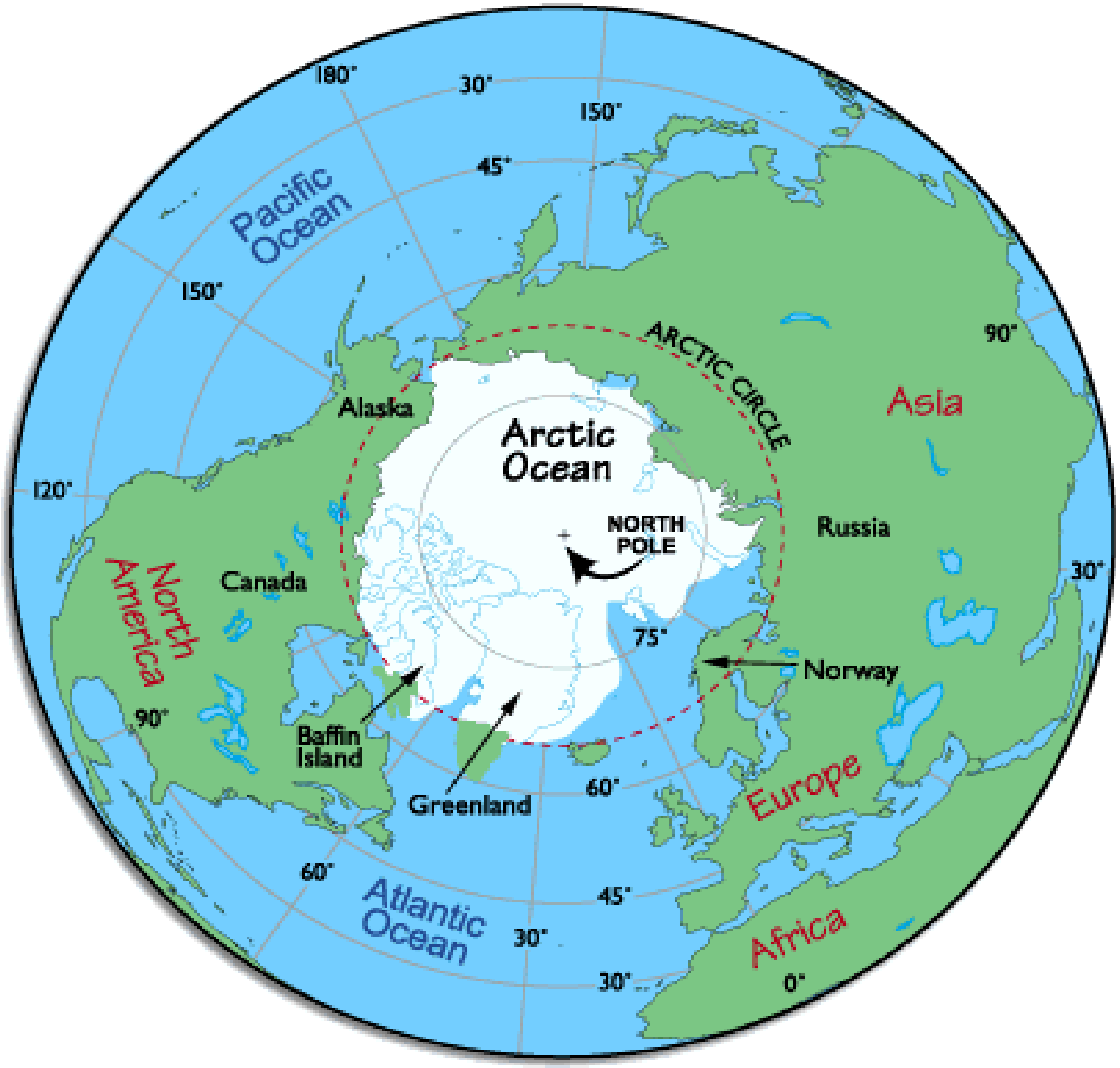
Case Study, Finmark, Norway

Ivar Warrer-Hansen and Jens Ole Olesen

Where is Finmark?



Some facts about the site in Finmark

- Latitude: 70^{o} 30’ 02”
- That is approximately 3,424 km or 2,140 miles North of where we are now
- The site is 700 km or 434 miles North of the Polar Circle
- As a consequence, continuous daylight from mid May till early August. From late November till late January sun is below horizon and only vague light around noon if skies are clear further South.
- Coldest temp. recorded: -51.4^{o}C (- 60.5 F)
- Annual average is -2.4^{o}C (27.7 F)

Start of construction summer 2011


DIECI


It was a struggle to get the building
closed before the winter

Getting closer to completion


Completion Spring 2012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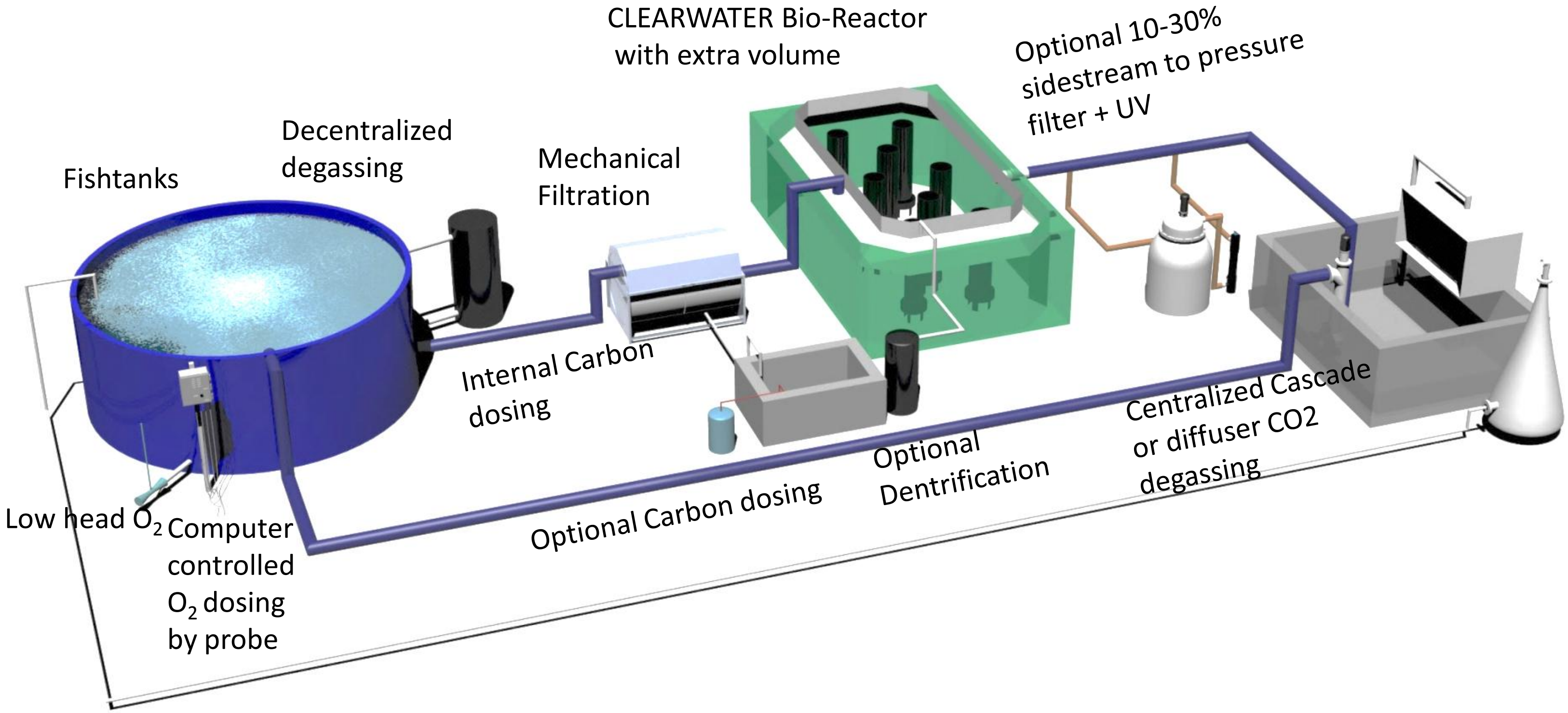
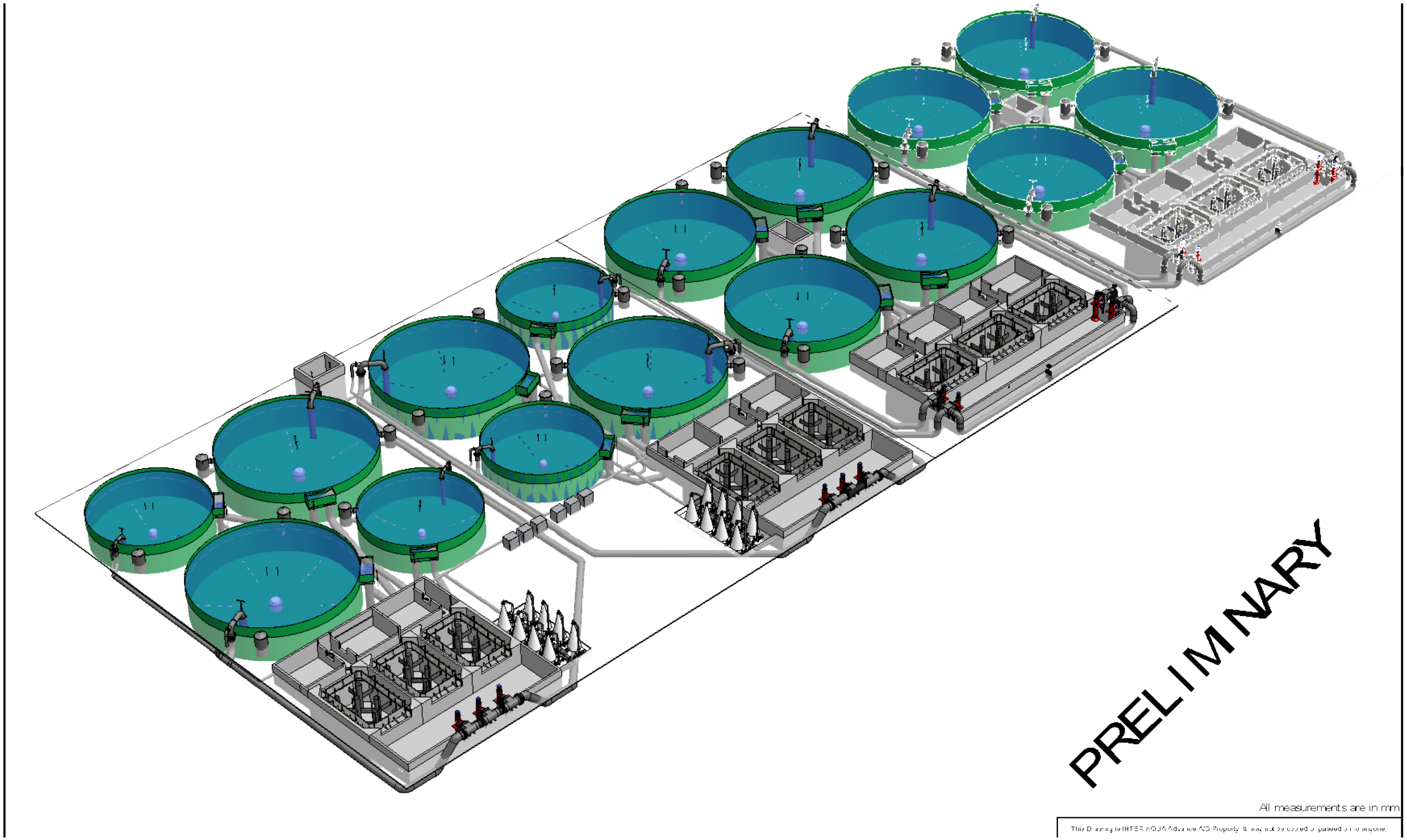
RAS WATER TREATMENT CONCEPT



Our philosophy

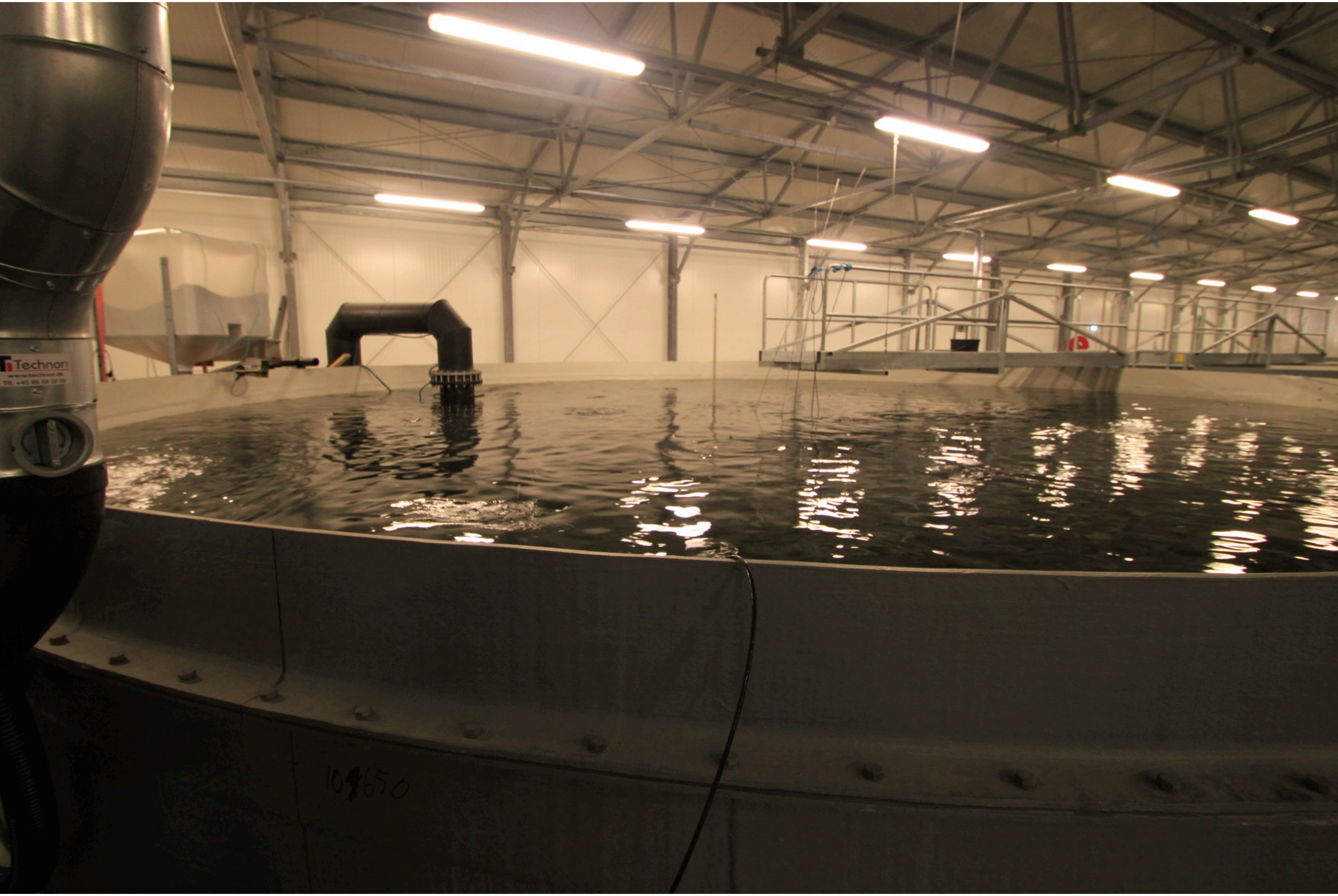
- Interaqua do not want/accept any accumulation of solids/sludge in the system, being it entrapment, settlement or via biological processes.
- We design our systems so solids are led quickly to drum filters and out of system.
- We emphasize on MBBR where no maintenance in needed and no backwashing.
- We want to keep the different processes separate and quantifiable – it is then easier to optimize the different processes

Grieg Seafood, Levesby, Finmark



Key Data

Total Tank Volume:	9,760 m3 (2.58 mio USG)
Flow:	14,600 m3/h (3.86 mio USG)
Total Feeding Capacity:	8,200 kg/day
Maximum Standing Stock:	560 metric tons (sizes up to 1 kg)
Average Power Consumption Including Heating and Misc:	365 kW



MBBR – do they shed particles?

Answer: some do some don't

Interaqua have a very dynamic MBBR aeration configuration with full bio film control, i.e. we do not go beyond stage 4 in Nikolov's scale. So no particles are shed.

There can be some simple MBBR concepts where particles are shed. The relatively calm conditions at the bottom part of the bioreactor will cause poor movement of bio media.

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Stages of bio film system development

Stage 4

Stable growth of bio film system

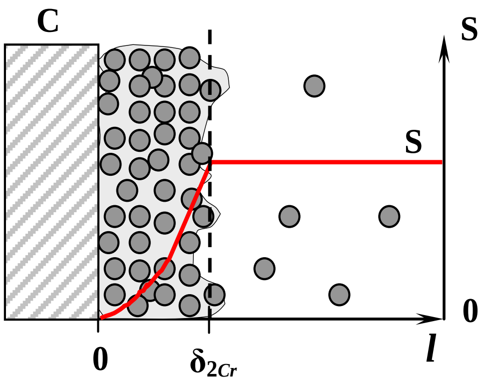

Fig. 4 d. **Stage 4. Stable bio film growth. Second critical bio film thickness - δ_{2Cr}**

- **Start of the stage:** ***first critical bio film thickness -- δ_{1Cr}***
- **End of the stage:** ***second critical bio film thickness -- δ_{2Cr}***

Stages of bio film system development

Stage 5

Uncontrolled and unstable bio film growth

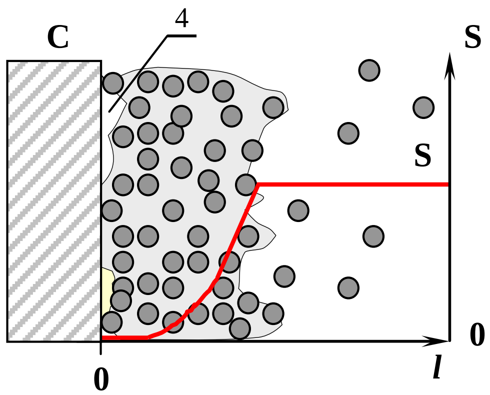

Fig.4 e. **Stage 5. Uncontrolled and unstable bio film growth. Cavities formation**

4 – cavity

- **Start of the stage:** ***second critical bio film thickness -- δ_{2Cr}***
- **End of the stage:** ***cavities formation***

Stages of bio film system development

Stage 6

Bio film destruction

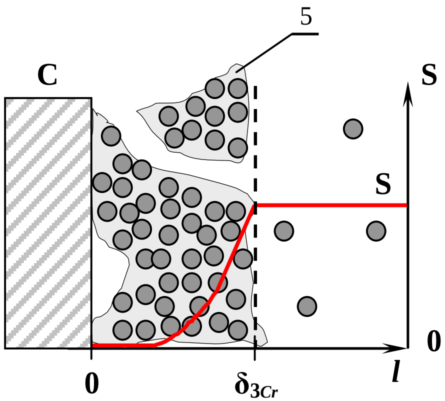

Fig. 4 f. **Stage 6. Bio film destruction. Third critical bio film thickness- δ_{3Cr}**

5 – detached part of the bio film structure

- **Start of the stage:** ***cavities formation***
- **End of the stage:** ***detachment of parts of bio film volume***

……continued

Having said that…..

There can be certain and limited situations where we do get some shedding. When the bio film is being starved (in connection with grading, vaccination for instance) then after a couple of days some bacteria will die off and we get shedding of dead bacteria cell membranes. These will give the water a slightly cloudy appearance. The material is inert with no electrical charge and completely harmless to any fish - regardless of size.

When filter is fed again, shedding stops. So maybe for a total of a week or two during the year we will have slightly cloudy water. We now have some simple fine particle filters on a side loop that clears the water in half a day.


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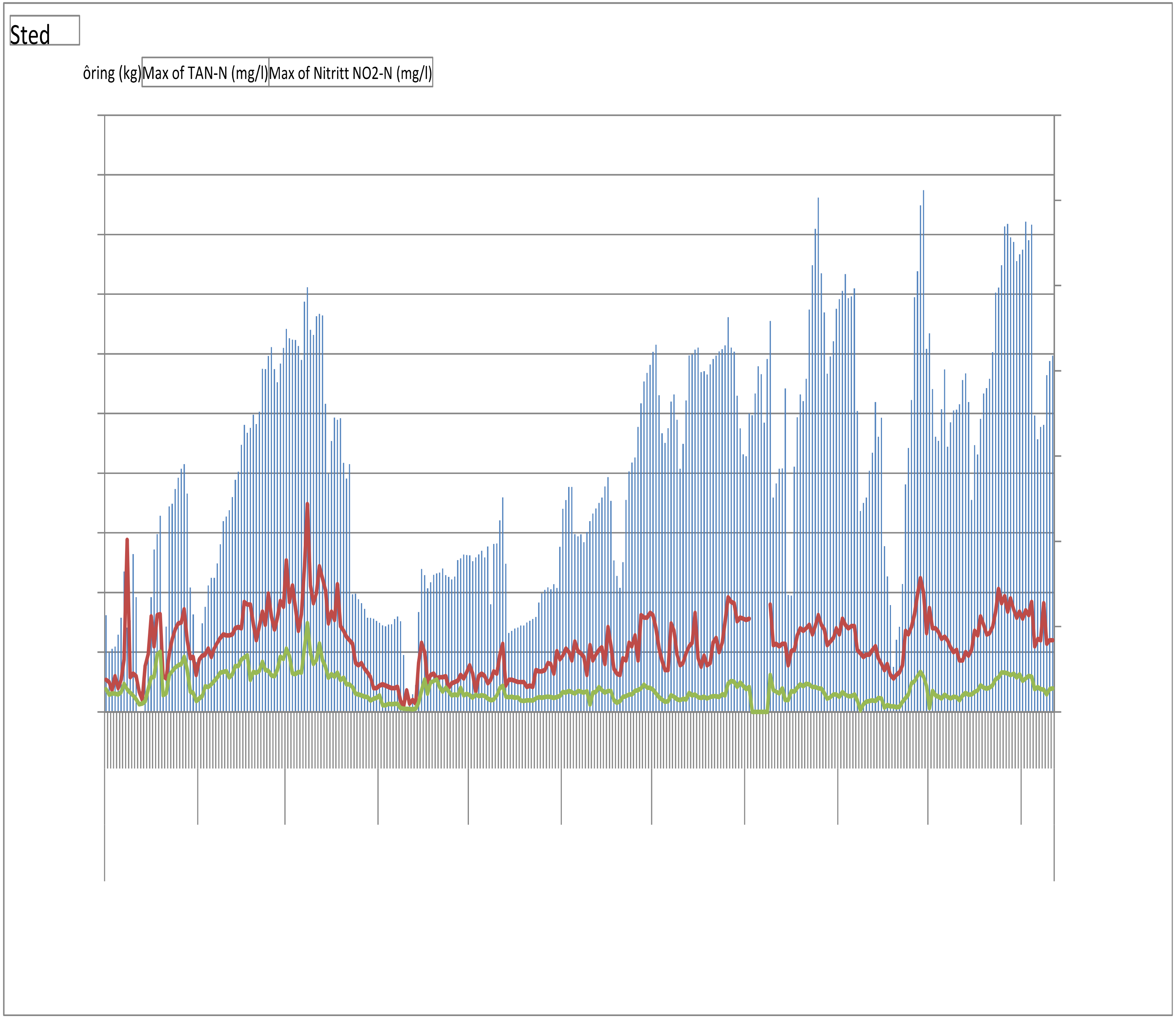
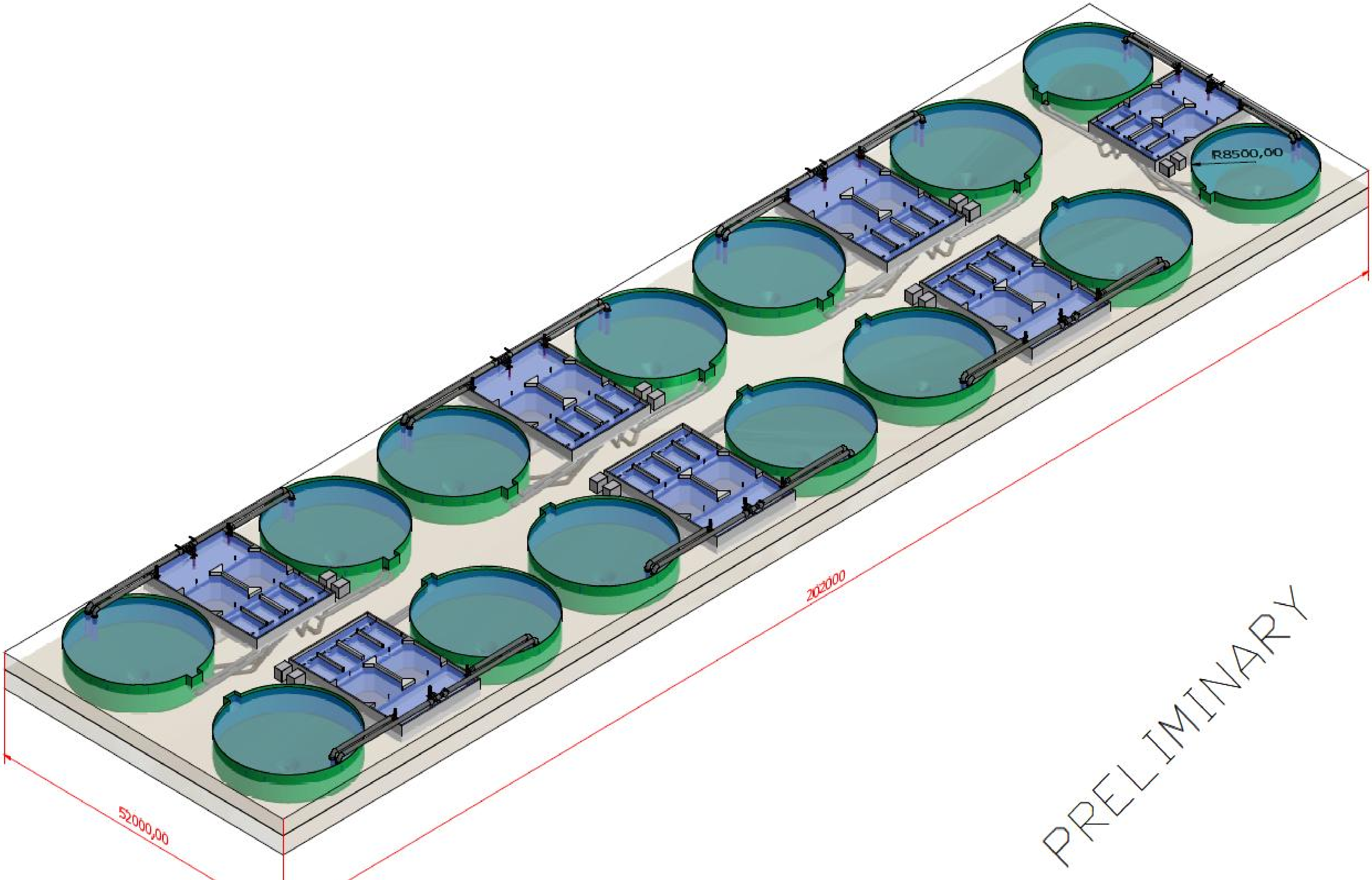

Sted
ôring (kg)
Max of TAN-N (mg/l)
Max of Nitritt NO2-N (mg/l)

Production budget

	Smolt		Grow-out
Production capacity	21,300,000/year	Production capacity	
Production size	75 grams*	Production size	5,500 grams
Capital costs	0.02 €/pcs	Capital costs	0.47 €/kg
Eggs/fry	0.06 €/pcs	Smolt	0.11 €/kg
Feed	0.16 €/pcs	Feed (FCR 1.2)	1.44 €/kg
Energy/O2 @ 0.12 €/kW	0.16 €/pcs	Energy/O2 @ 0.12€/kW	0.42 €/kg
Capacity costs	0.06 €/pcs	Capacity costs	0.16 €/kg
Vaccinations	0.14 €/pcs		
Misc	0.02 €/pcs	Misc	0.08 €/kg
Total costs	**0.62 €/pcs**	**Total costs**	**2.68 €/kg RW**
	(0.82 US$/pcs)		**(3.55 US$/kg)**

IAA Land Based Salmon Grow-out System



Production costs for 3000 tons per annum salmon - Freshwater

Capital costs	3000 tons/annum	€ 10,502,000	USD 13,795,000
Feed costs	3000x1.2 € 1,300	4,680,000	6,177,600
Energy	420 kW (€0.12)	441,504	220,572
Maintenance		100,000	132,000
Labour	6 @ € 40,000	240,000	300,000
Smolt input		720,000	950,000
Oxygen	3000x1.2x0.6	259,200	129,000
Make-up water		100,000	132,000
Misc		500,000	660,000
Total		7,040,704	8,701,172
Per kg ex depreciation		2.34	2.90
Per kg inclusive	15 years	2.57	3.21
Head on gutted		3.02	3.78

Challenges in construction in Finmark

Climate: construction started in the summer and it was a big challenge to get the building completed before the winter. It was lucky that winter came quite late – otherwise nothing could have been done until late Spring.

Winter: psychological strain not seeing the daylight or sun for a couple of months.

Physical distance: a long way from anywhere. The last 3-400 km are “Ice Roads” with need for ice road truckers. Sometimes passes can be closed due to snow for days no end. Concrete came from a distance of 300 km.

Local condition: remote area, very little or no competition from local suppliers (concrete, electrical contractors etc). The harsh climate can lead to huge delays leading to need for keeping crew longer periods and the need for increasing workforce to meet dead lines.

Challenges in construction in Finmark

Economics: It was an expensive project

- with hundreds of 1000's of tons of rock blasting and seashore reclaiming.
- Long distance transport (4000 km for steel girders for building)
- All the mentioned local constraints.

- The project was on schedule and within budget and was the greatest challenge as well as the greatest achievement for Interaqua ever.
- The project cost 75 mio DKK (13 mio US$) – had it been built in less remote area with "normal" climate, it would have cost 20-25% less or in the region of 55-60 mio DKK

Challenges in construction in Finmark

Main lessons learnt:

The extra distance and access problems for supplies of equipment is a matter of planning. It will of course always be at an extra cost.

A very big and costly enterprise in a RAS is concrete constructions and concrete works.
In this case concrete came from a distance of 300 km – i.e. when and if it came.
In this project, it would have been cheaper to have shipped pre-cast concrete elements.
It would have been cheaper to ship these by coastal route.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Operational Challenges

In most salmon farming regions (B.C., Scotland, Ireland) heat retained from the system is adequate for temperature control. However, in Finnmark, due to the extreme temperatures (-20 to -50 deg. C), there is need for additional heat to ensure optimal growth temperatures.

There are no operational challenges otherwise

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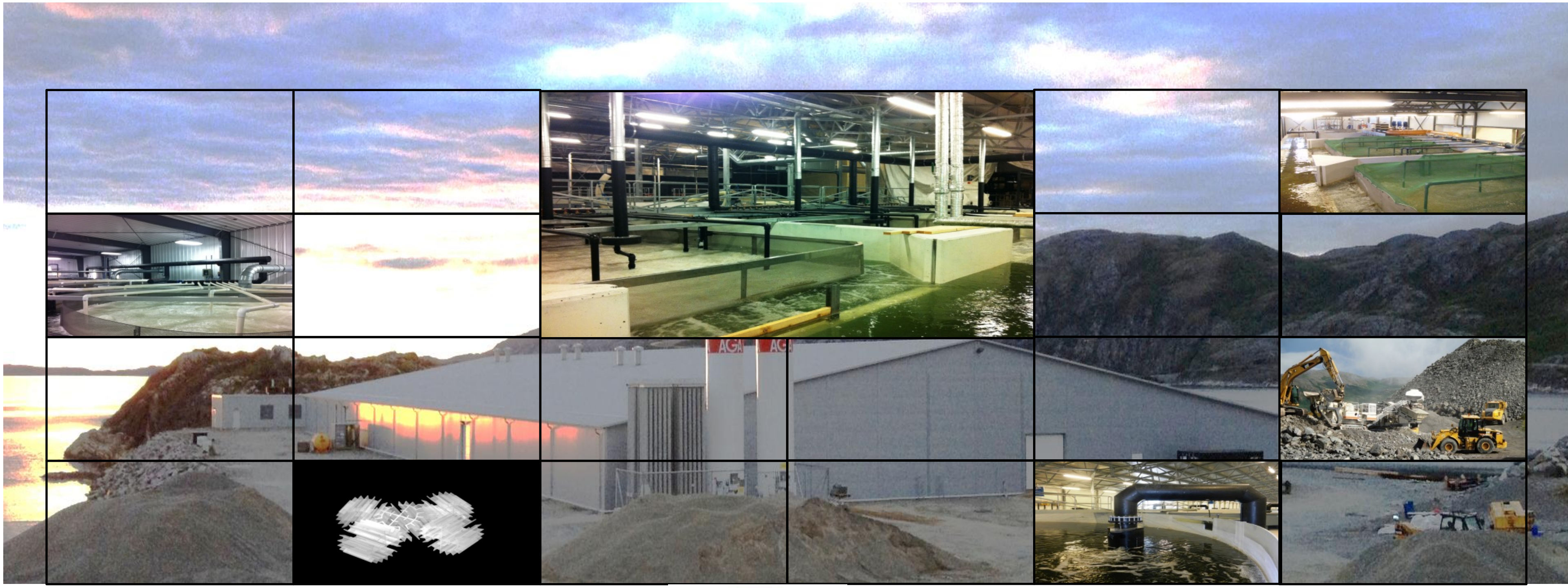

Thank you for your attention

www.interaqua.dk