Atlantic Salmon in RAS in Norway

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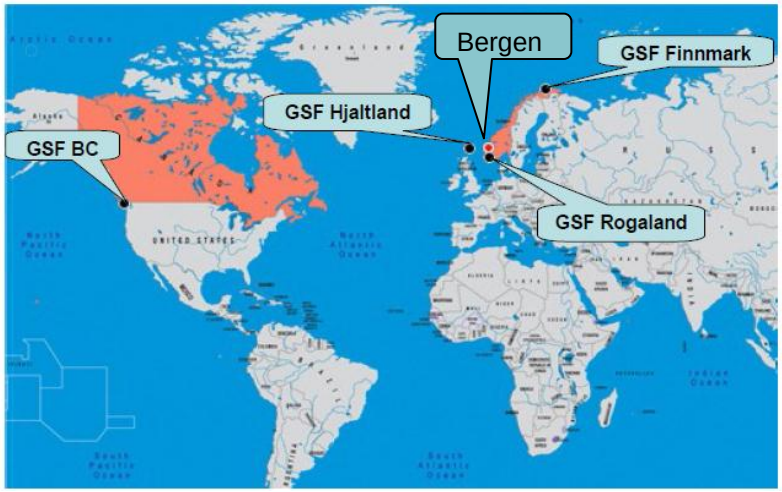
Grieg Seafood ASA



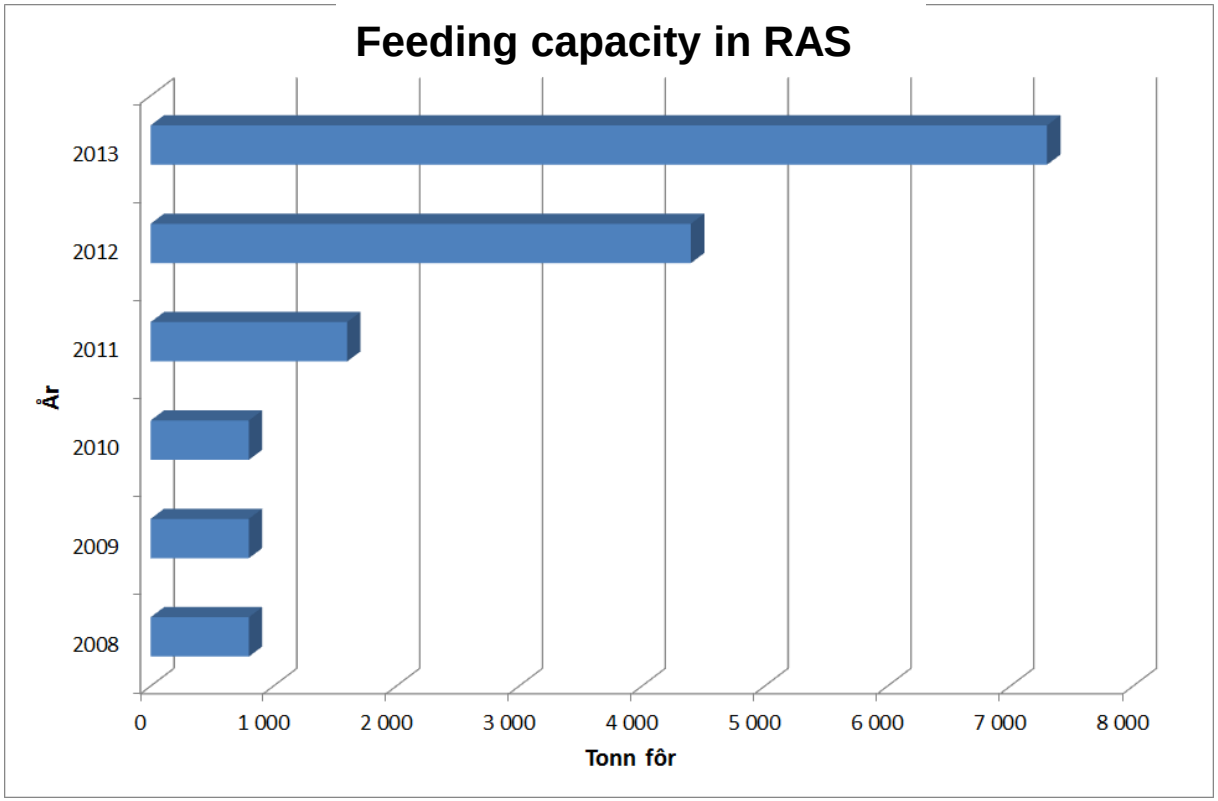
Consolidated Income Statement

Amounts in NOK 1 000	Note	2011	2010
Sales revenue	7	2 046 991	2 446 490
Other income	7	16 568	10 161
Other gains and losses	7	201	-763
Share of profit from associated companies and jointly controlled activities	13	13 704	4 747
Changes in inventories	19,20	197 753	-10 412
Raw materials and consumables used	19,20	-1 087 430	-932 118
Salaries and personnel expenses	9,10	-238 382	-238 409
Other operating expenses	9	-603 585	-592 752
Operating profit before depreciation and fair value adjustments of biological assets		**345 820**	**686 944**
Depreciation	17	-136 984	-115 912
Amortisation of licenses and other intangible assets	16	-3 222	-3 662
Reversal of previous amortisation of licences	6, 16	0	72 385
Operating profit before fair value adjustment of biological assets		**205 613**	**639 754**

	Rogaland (NOR)	Finnmark (NOR)	Hjaltland (UK)	BC (CAN)
Atlantic Salmon	**X**	**X**	**X**	**X**
Pacific Salmon				**X**
Trout		**X**		
Organic			**X**	
VAP			**X**	**(Skuna Bay)**
Volume (tons)	25 000	28 000	25 000	20 000

2007 – GSF Smolt strategy

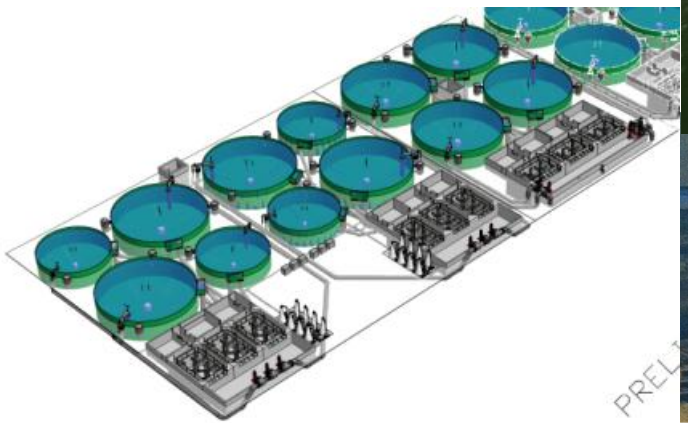
- Become self sufficient
- Produce a significant volume of post smolt (0,1 – 0,25 [1,0 kg])
- **Use RAS**



2013
7 500 tonn

Rogaland 2011

Finnmark 2012



RAS development in production of Atlantic Salmon in Norway

		Land		Sea	
	Size (kg)	FTS	RAS	Nets	"Closed"
	0,00				
	0,10				
2007	0,25				
	1,00				
	5,50				
	0,00				
	0,10				
2008	0,25				
	1,00				
	5,50				
	0,00				
	0,10				
2012	0,25				
	1,00				
	5,50				
	0,00				
	0,10				
2013	0,25				
	1,00				
	5,50				

More post smolt, but…

- ✓ Semi closed FTS

or

- ✓ RAS

		Land		Sea	
	Size (kg)	FTS	RAS	Nets	"Closed"
	0,00				
	0,10				
2020	0,25				
	1,00				
	5,50				

Advantages with RAS

- Fish welfare
  - Controlled water quality
  - Optimal flow factor
  - Improved biosecurity

- Resources (environment)
  - Water use
  - Discharge

- Productivity
  - Optimal growth temperature all year

Our approach to RAS

- As few system elements as possible
- "No maintenance"
- Optimized self cleaning
  - High flow
  - "No screens" in the tanks
- Low head
- Automation
- Disinfection of make up
- Continuous production to maximize productivity…

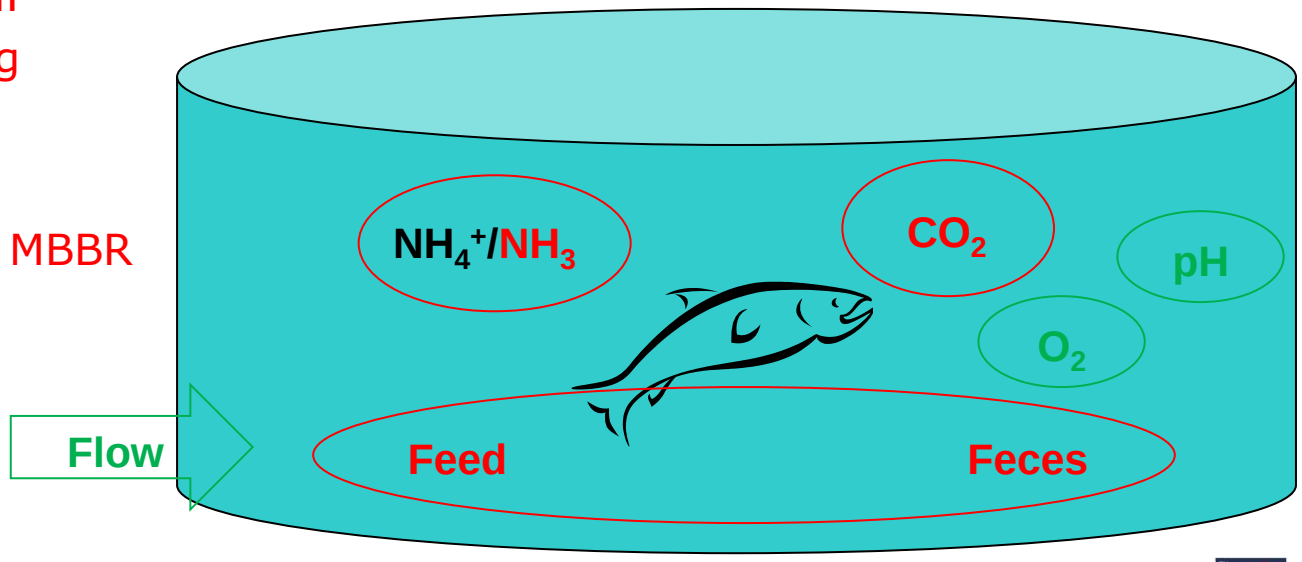
- Under evaluation…
  - Degree of disinfection on system water
    - Not 100 %...
  - "Cleaning of system water"

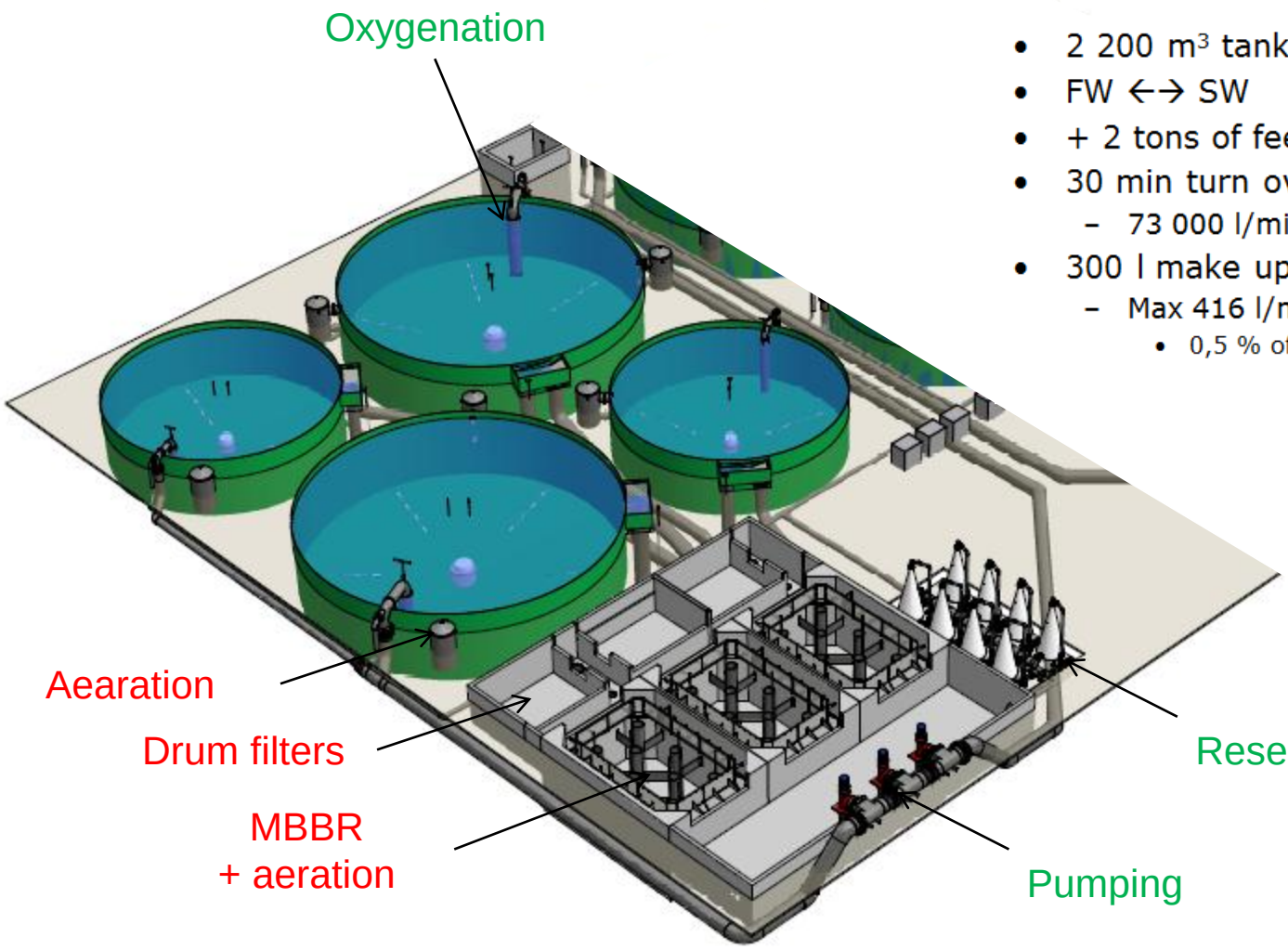
Our approach to RAS

- As few system elements as possible
- "No maintenance"
- Max self cleaning in tanks
  - High flow
  - "No screens" in the tanks
- Low head
- Automation
- Disinfection of make up
- Continuous production to maximize productivity…

- Low head pumping
  - Surplus capacity
  - PLC controlled speed drives
- Oxygenation
  - Solvox on main flow
  - PLC controlled dosing
- pH support
  - Continuous addition of base
  - PLC controlled dosing

- Solids removal
  - Self cleaning
  - Drum filter
- TAN removal
  - Nitrification MBBR
- Aeration
  - MBBR
  - In tank

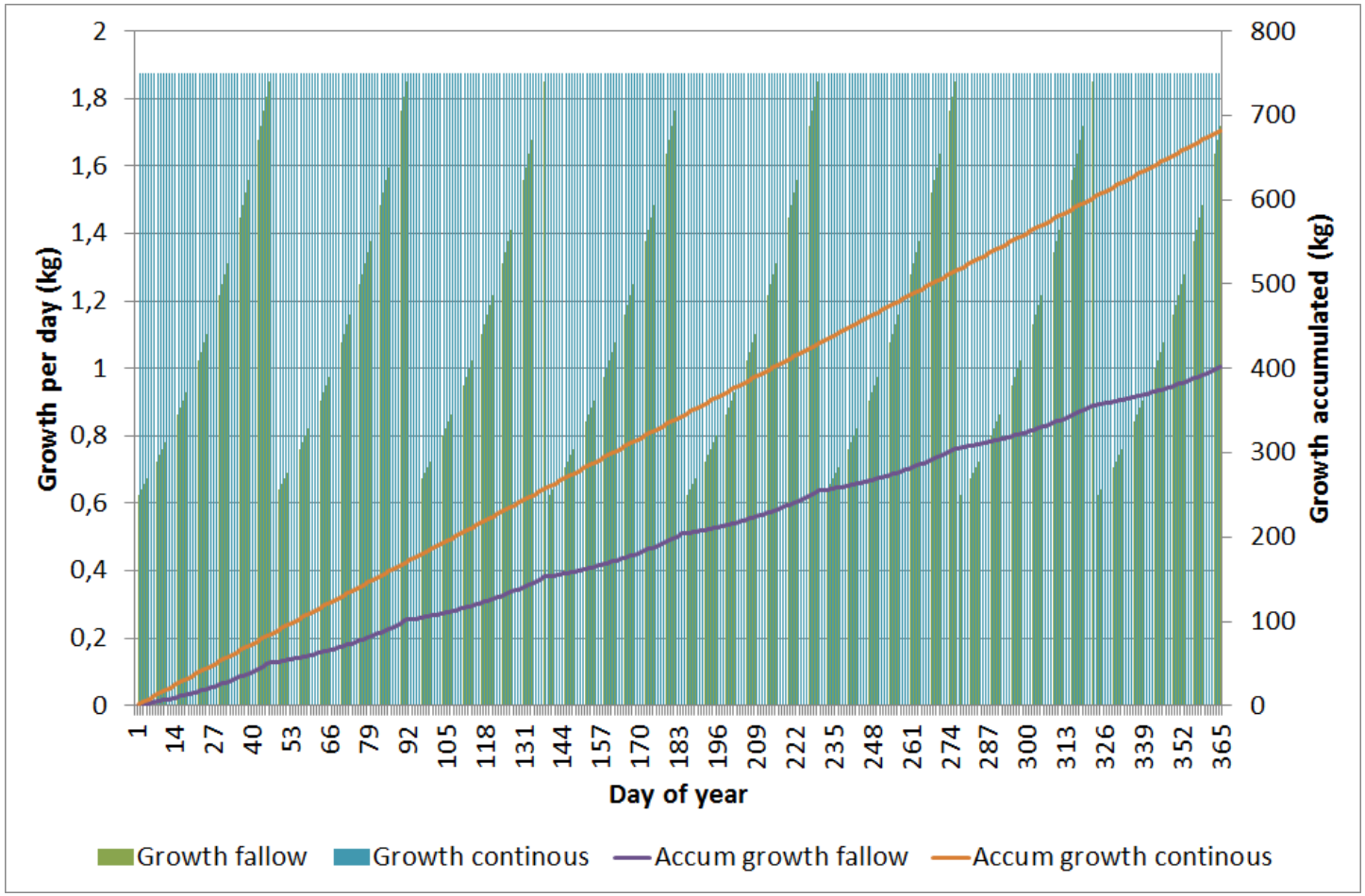




- 2 200 m^3 tank volume
- FW ←→ SW
- + 2 tons of feed per day
- 30 min turn over time
  - 73 000 l/min
- 300 l make up/kg feed
  - Max 416 l/min
    - 0,5 % of circulation flow

Productivity

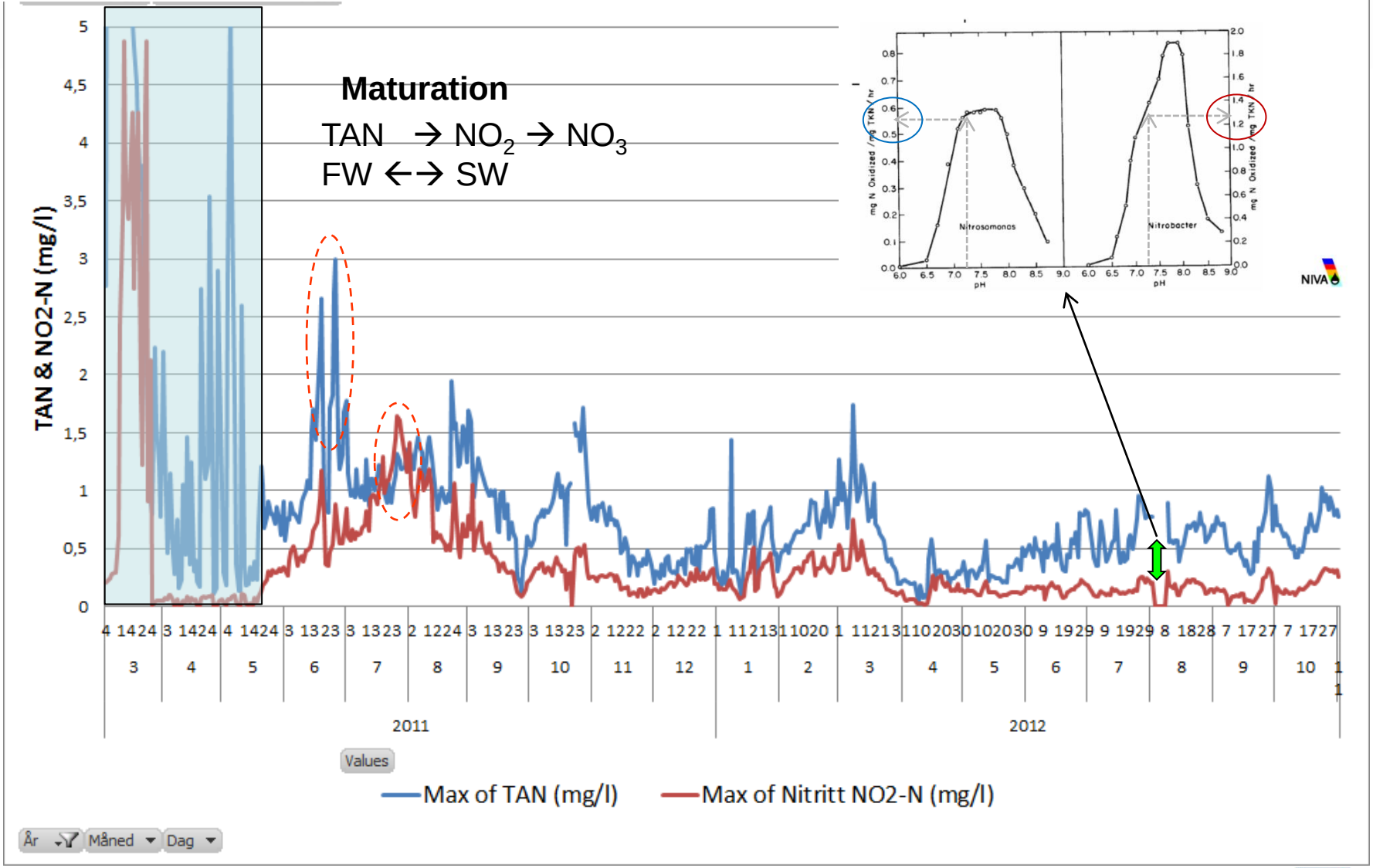
25 → 75 kg/m^3 versus 75 kg/m^3 **2,5 % SGR**



Achieved water quality

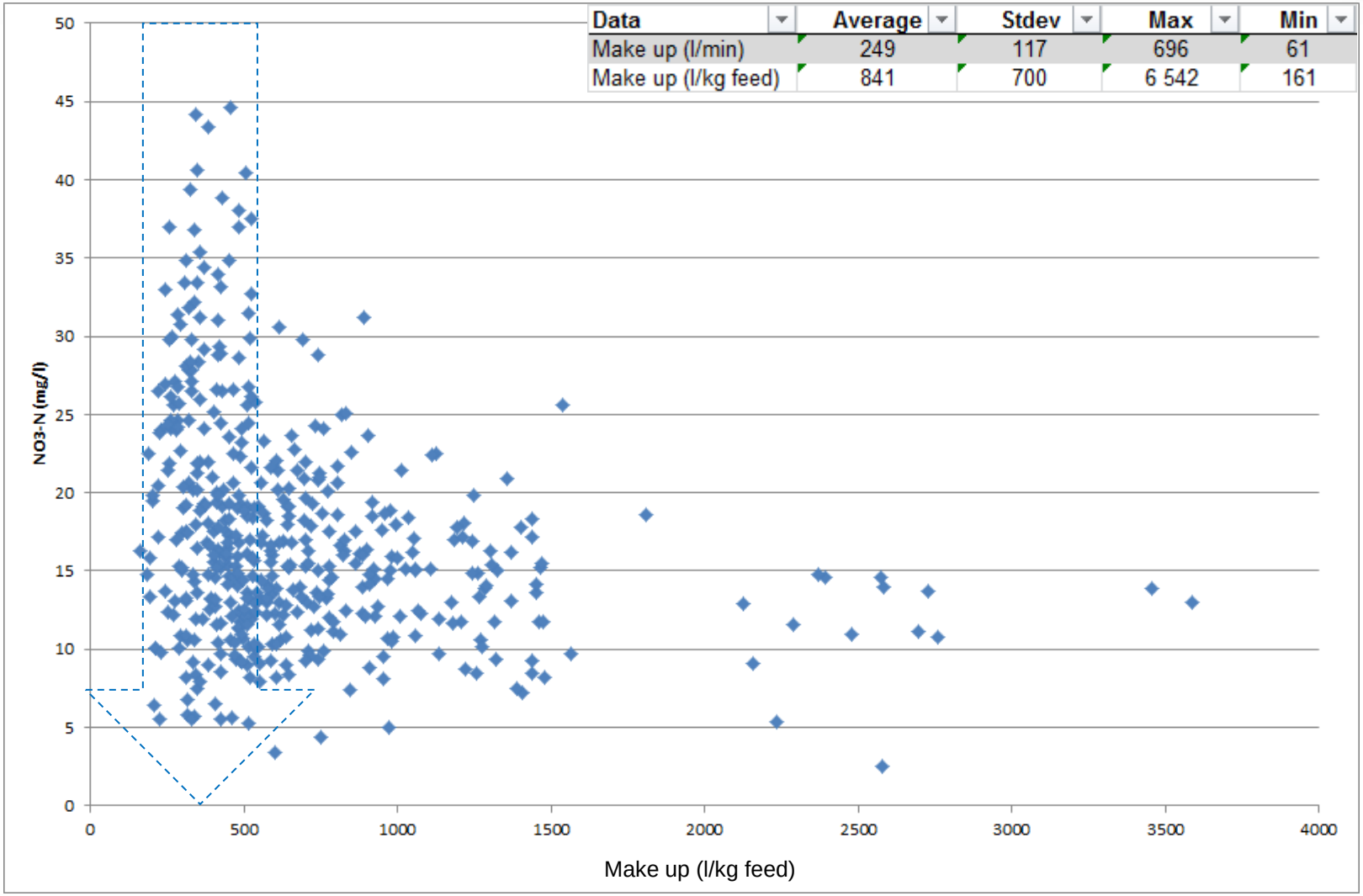
Rogaland system since May 2011 (FW**)**

$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$

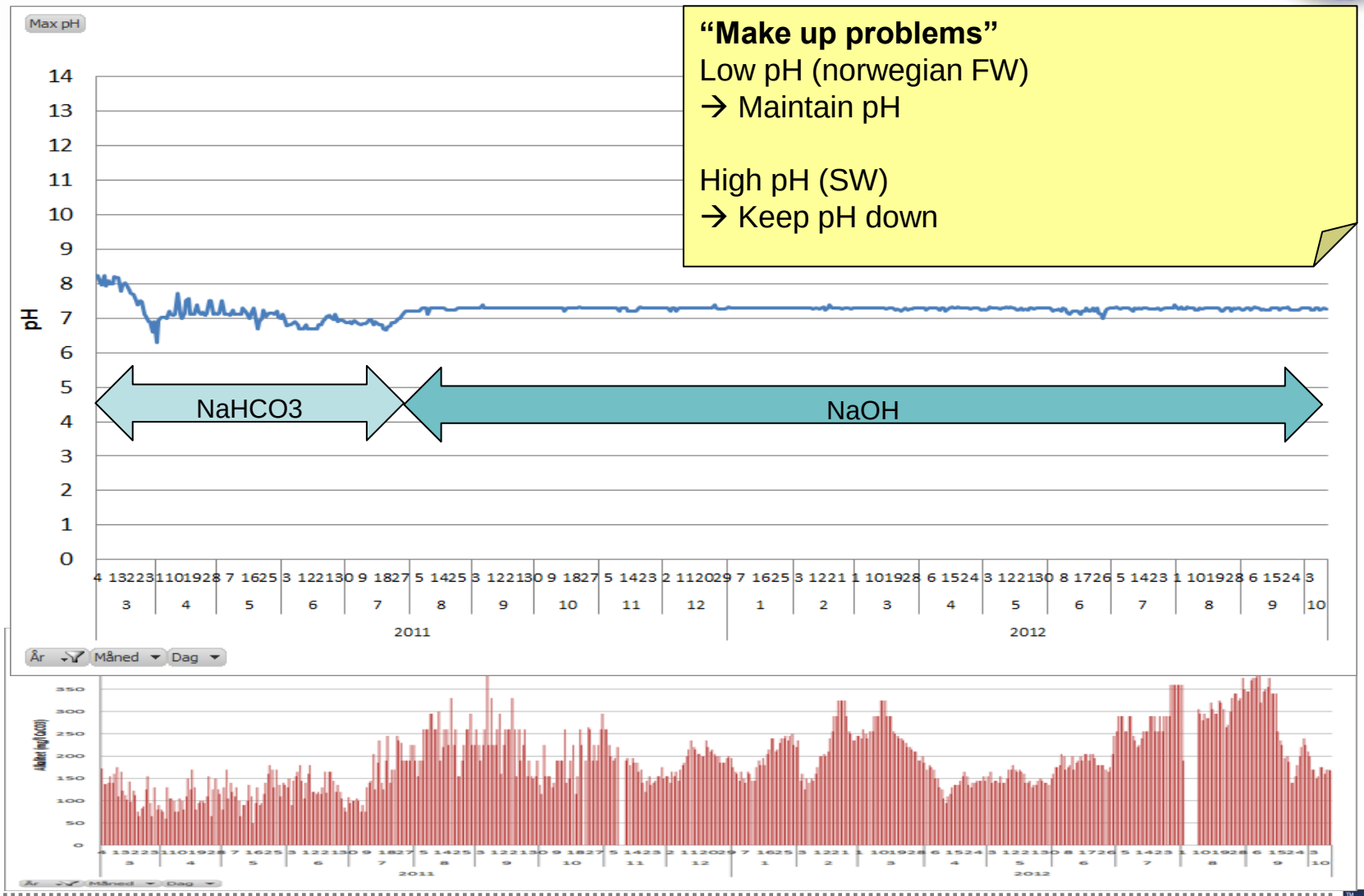


NO_3^- controlled by make up volum

Data	Average	Stdev	Max	Min
Make up (l/min)	249	117	696	61
Make up (l/kg feed)	841	700	6 542	161



pH - alkalinity

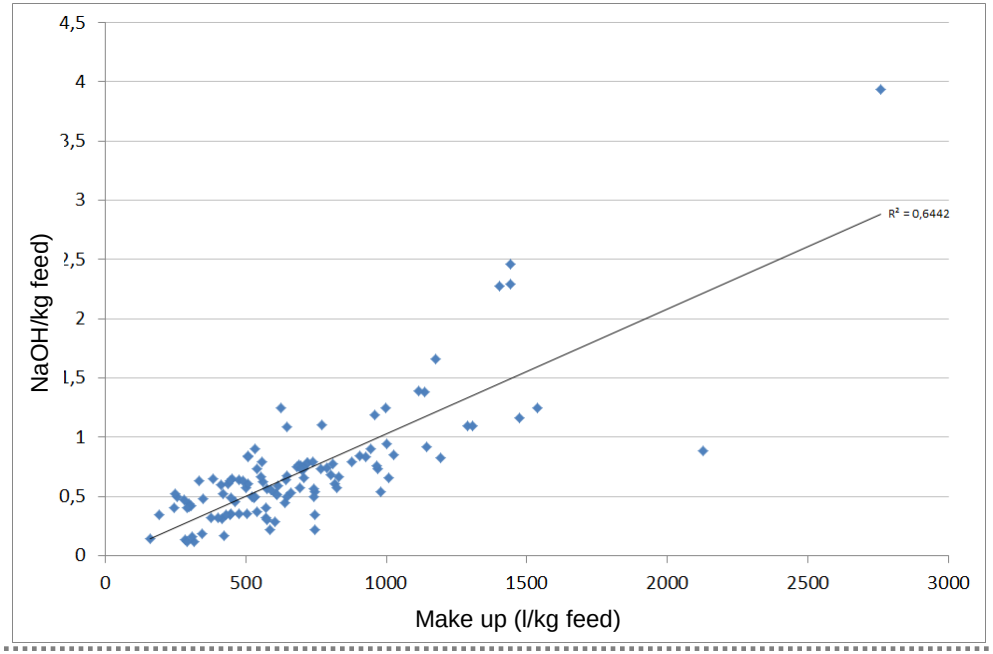


“Make up problems”
Low pH (norwegian FW)
→ Maintain pH

High pH (SW)
→ Keep pH down

Maintaining pH

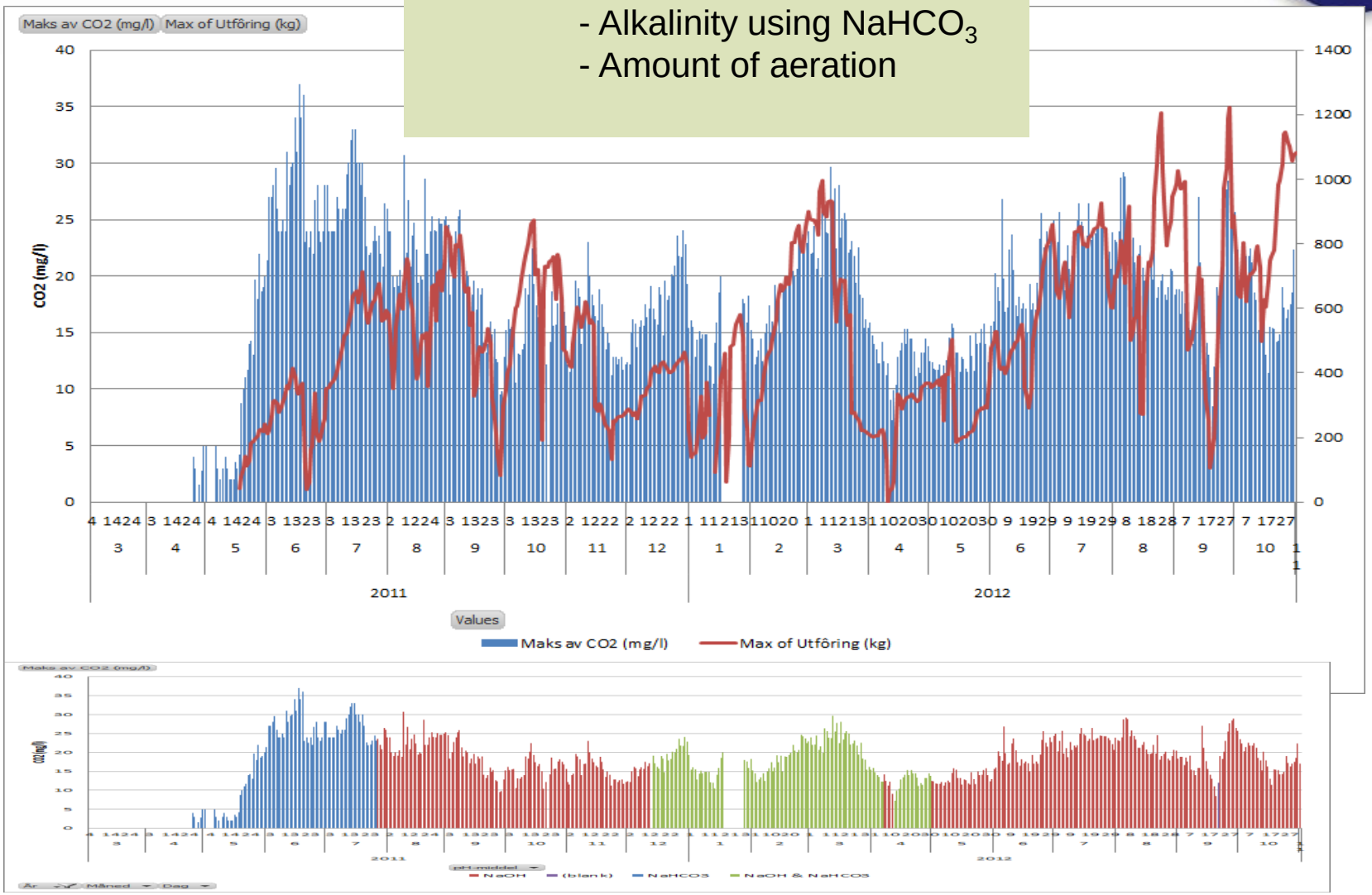
- Make up with low pH and alcalinity
  - ✓ 0,6 kg NaOH (50%) per kg feed
    - 0,5 CAD/kg feed
- Improved by:
  - ✓ Increased recirculation
  - ✓ Make up with higher pH and buffer capacity



CO_2

Corresponds with:

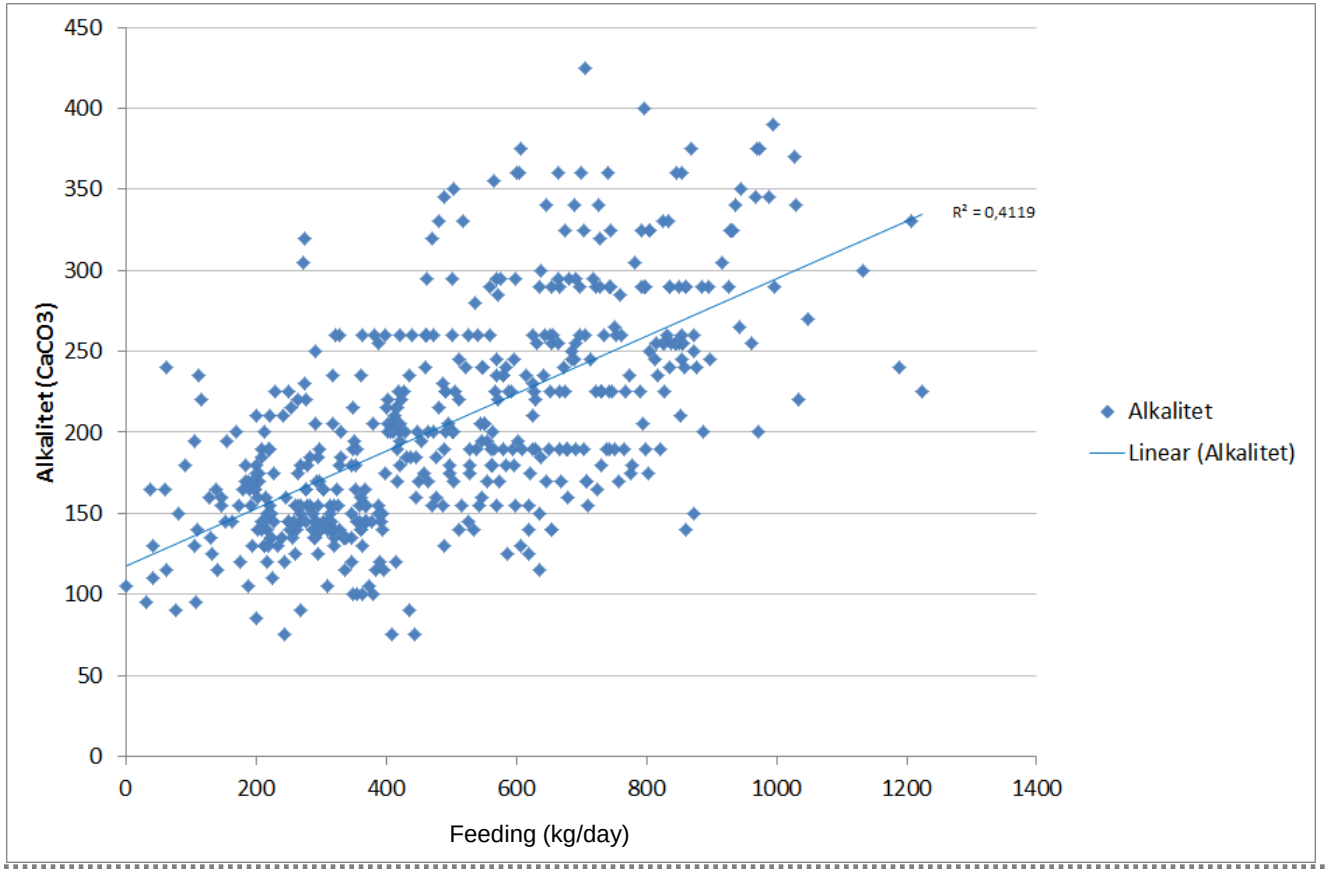
- Feeding
- Alkalinity using $NaHCO_3$
- Amount of aeration



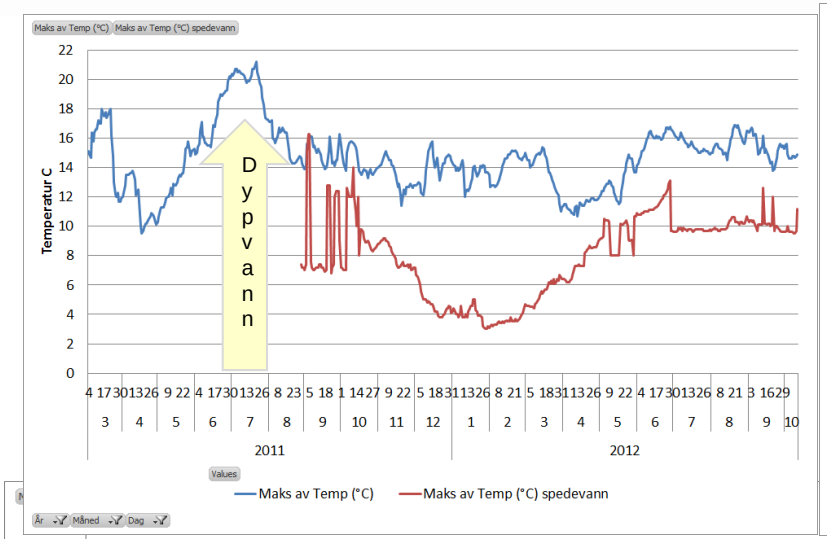
Alkalinity increases with feeding

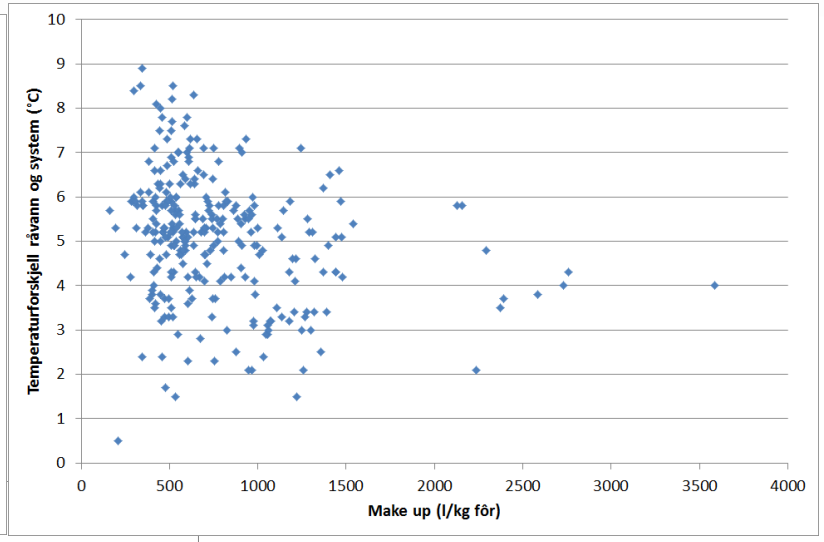
$$A_T = [HCO_3^-]_T + 2[CO_3^{-2}]_T + [B(OH)_4^-]_T + [OH^-]_T + 2[PO_4^{-3}]_T + [HPO_4^{-2}]_T + [SiO(OH)_3^-]_T - [H^+]_{sws} - [HSO_4^-]$$

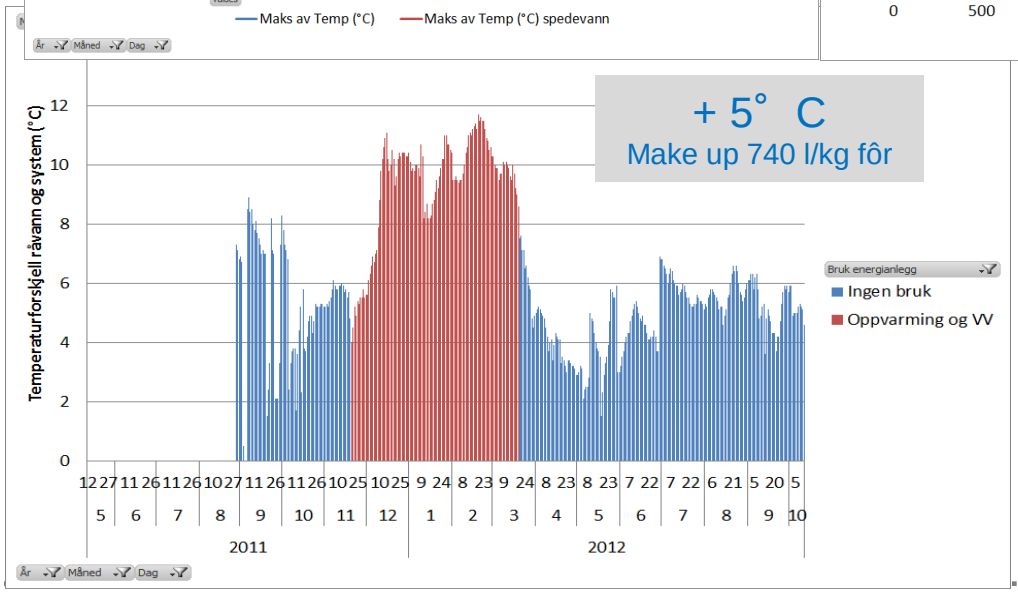
$$CO_2 + H_2O \rightarrow HCO_3^- + H^+$$



Temperature

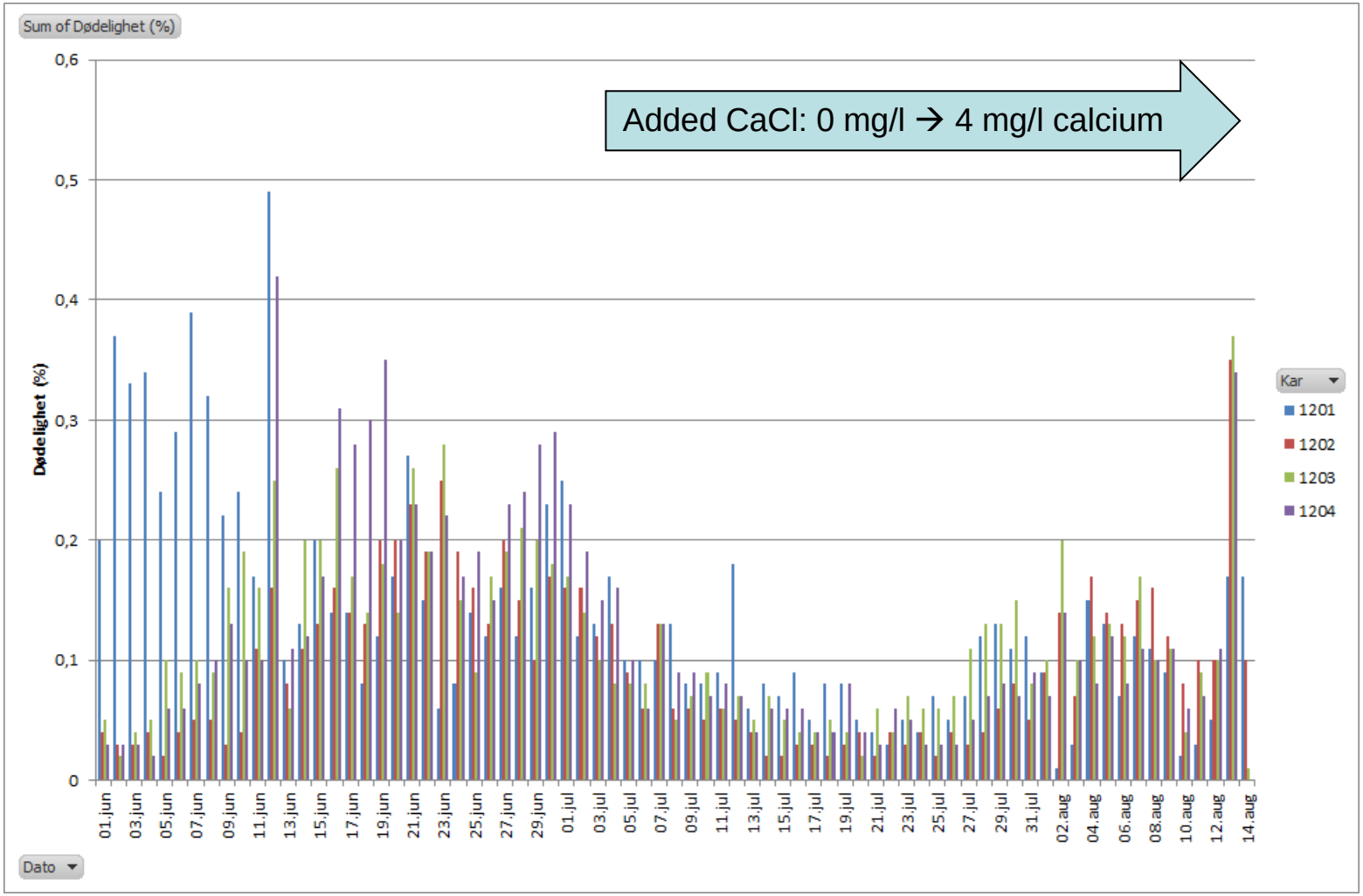




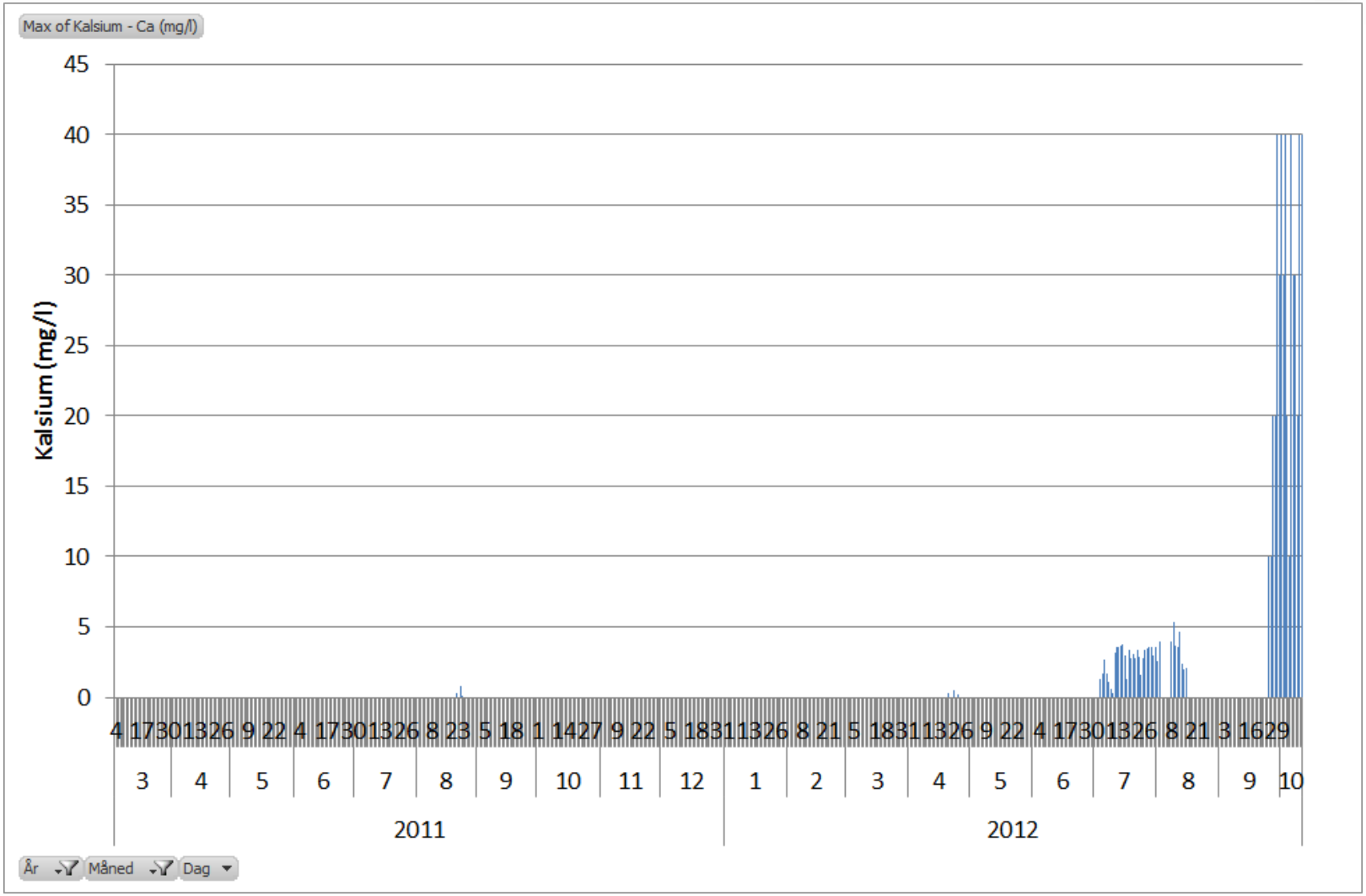


- Temperature control:
  1. In take depth
  2. Make up volume
  3. Heat exchanging
  4. Heating
  5. ~~Cooling~~

Water quality and post smolt



Calcium


Max of Kalsium - Ca (mg/l)
Kalsium (mg/l)
45
40
35
30
25
20
15
10
5
0
4 17 30 13 26 9 22 4 17 30 13 26 8 23 5 18 1 14 27 9 22 5 18 31 13 26 8 21 5 18 31 13 26 9 22 4 17 30 13 26 8 21 3 16 29
3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10
2011
2012
År
Måned
Dag

Unexpected mortality in well boat transport on post smolt from RAS (FW)