Expanding salmon smolt and post smolt production in RAS

Aquaculture innovation workshop
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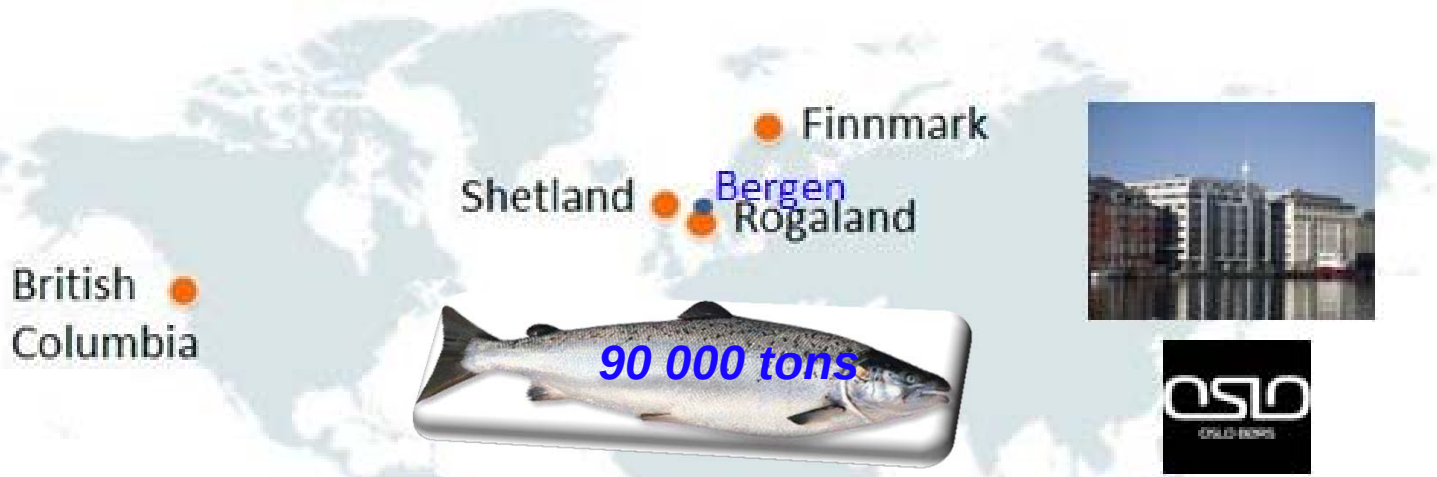
Agenda

- Grieg Seafood ASA
  - Company
  - Smolt strategy
  - Production concept
  - RAS design
- Our RAS experience
  - Water quality
  - Discharge
  - Smolt quality

Grieg Seafood ASA



0 → 0,25 kg

0,25 kg → Harvest

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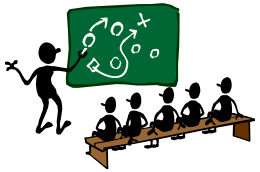
GSF smolt strategy

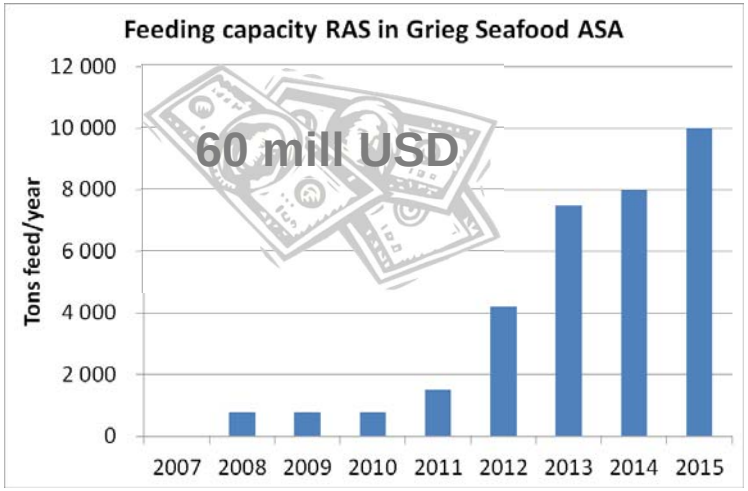
- Become self-sufficient with smolt to ensure:
  - guarantee for deliveries
  - control of quality
  - lowest cost

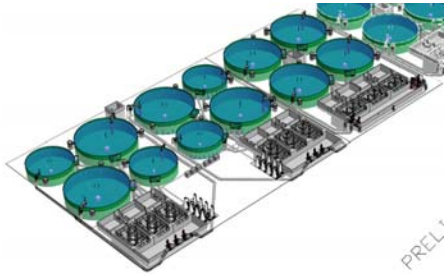
- Produce **post smolt** to ensure:
  - maximal productivity in seawater
  - more flexibility regarding fallow periods and zones
  - RISK management

- Produce the smolt in **RAS** (recirculation aquaculture systems) to ensure:
  - adequate flows
  - optimal water quality

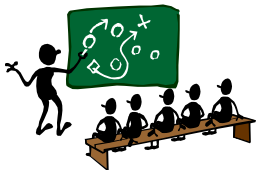
RAS status 2015

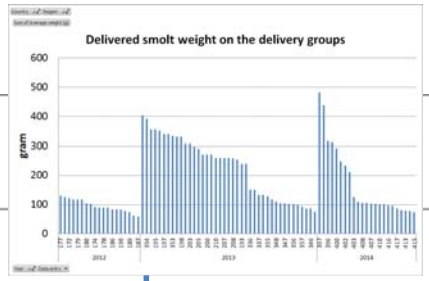


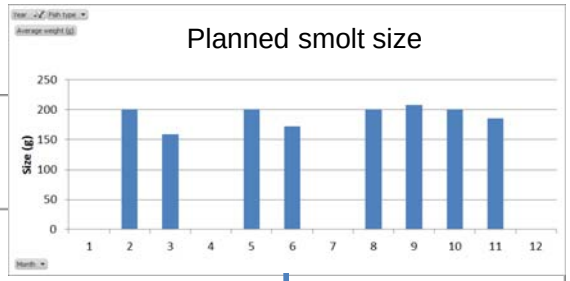


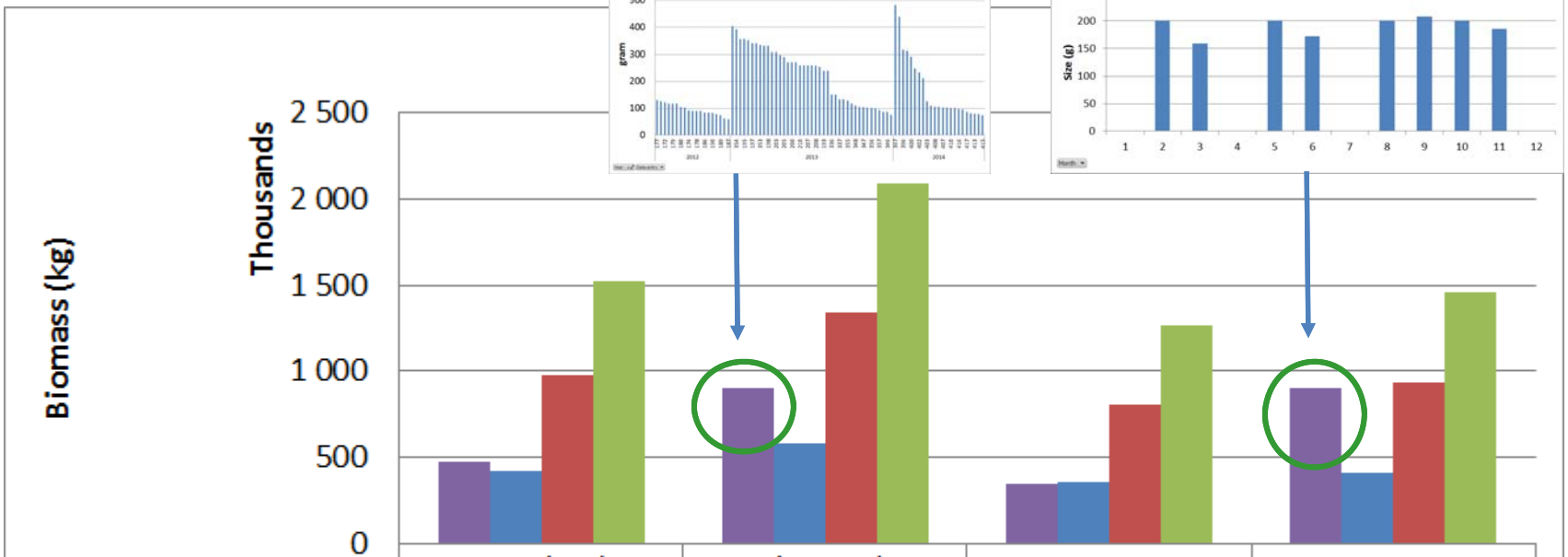


Smolt capacity 2015



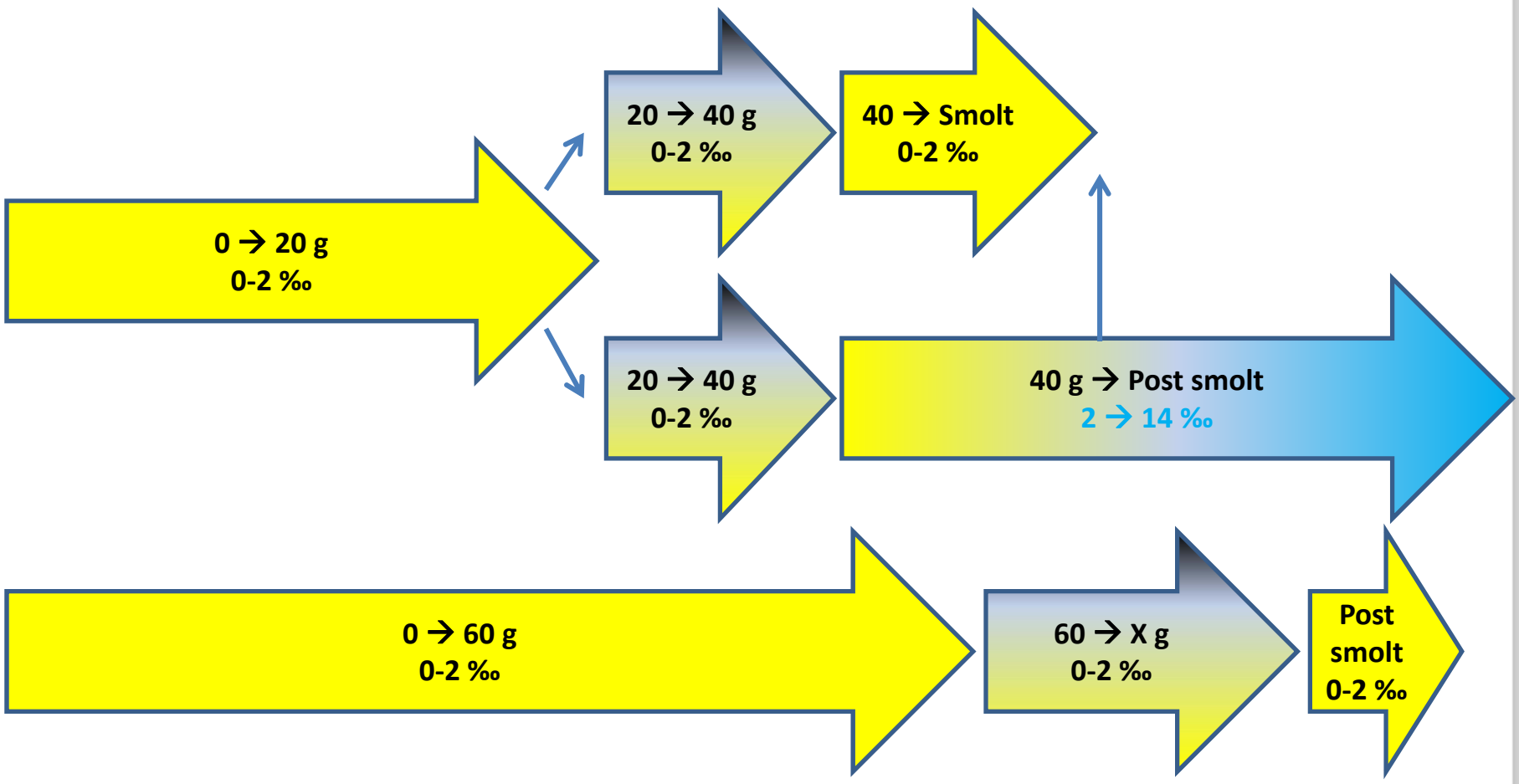




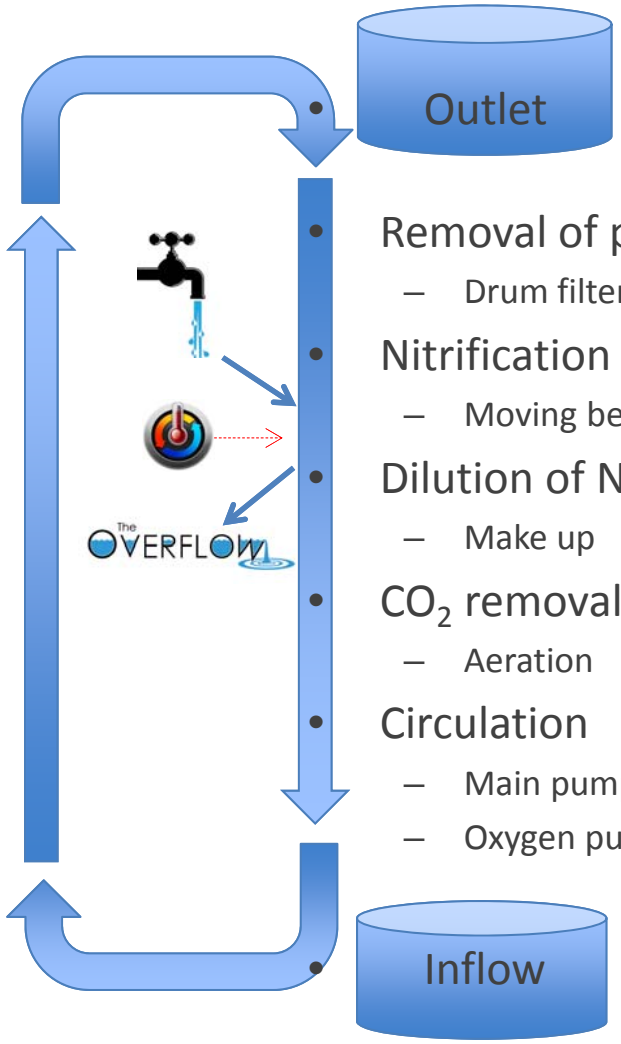


	Rogaland	Finnmark	BC	UK
Existing capacity	470 000	900 000	350 000	900 000
Smolt biomass (70 g)	425 600	585 200	354 667	407 867
Smolt biomass (160 g)	972 800	1 337 600	810 667	932 267
Smolt biomass (250 g)	1 520 000	2 090 000	1 266 667	1 456 667

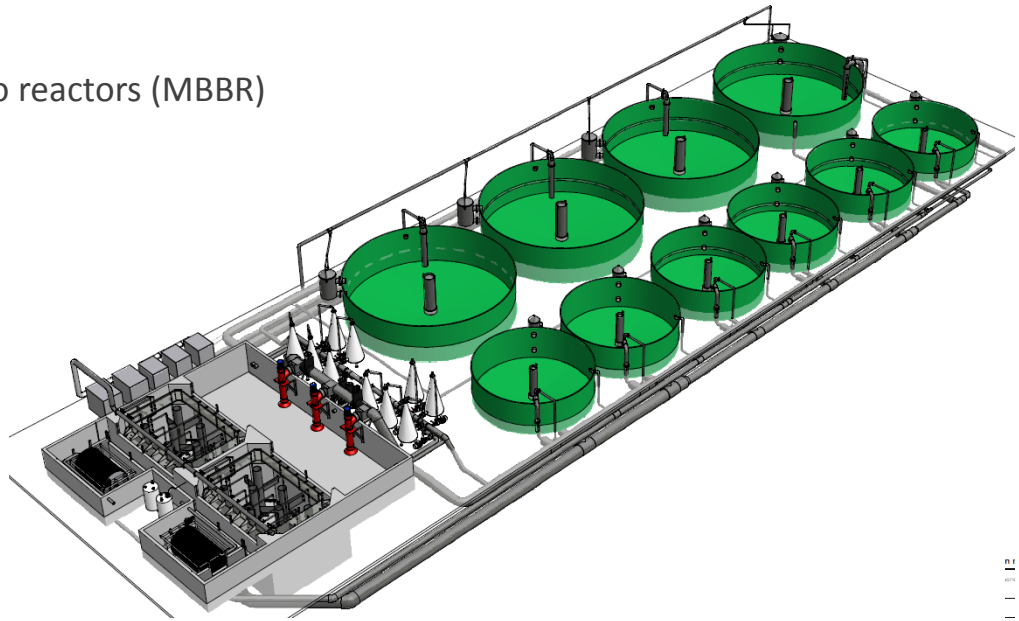
Our smolt production regimes



Our RAS design

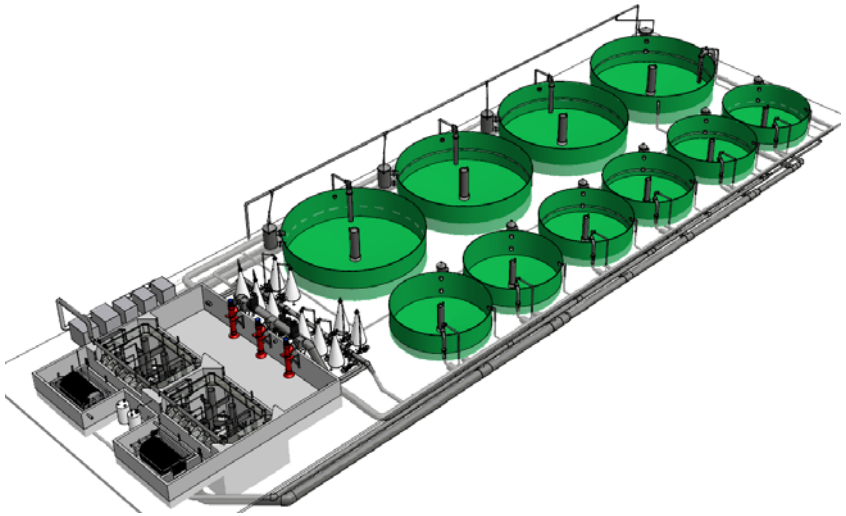


- Removal of particles
  - Drum filters
- Nitrification
  - Moving bed bio reactors (MBBR)
- Dilution of NO_3
  - Make up
- CO_2 removal
  - Aeration
- Circulation
  - Main pumps
  - Oxygen pumps



RAS performance

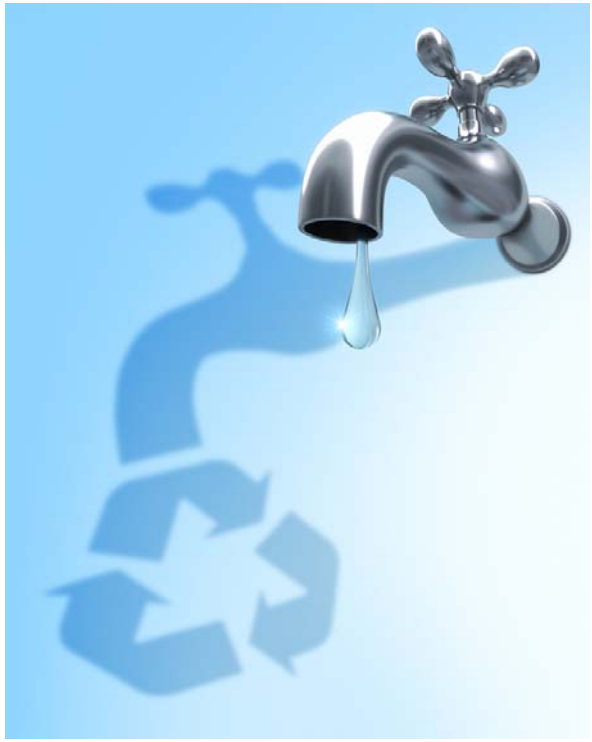
- Trosnavåg, Rogaland, Norway
  - 4 years continuos data
  - 2 000 m^3 tank volume
  - 45 000 l/min circulation volume
  - 0 – 1 500 kg of feed/day
  - No denitrification



Average water use

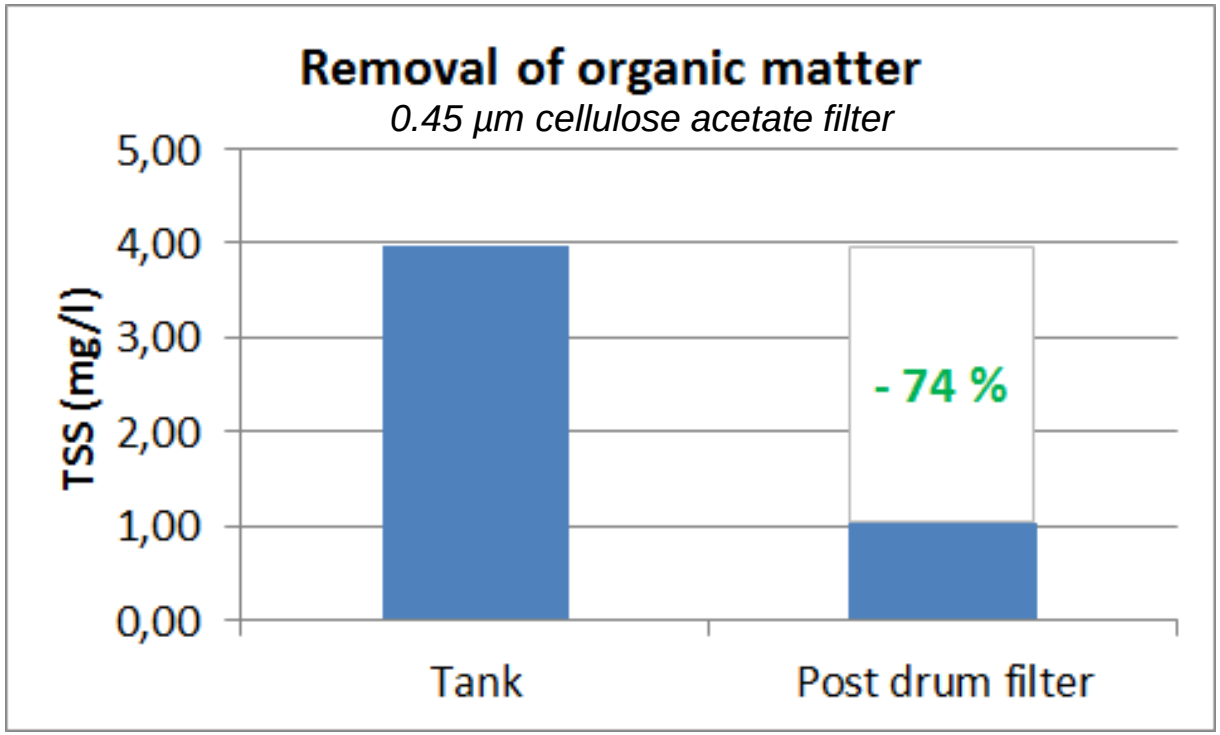
2 000 m^3 tank volume

- 45 000 l/min in circulation
  - ➡ 44 min turnover time in tanks
- 260 l/min makeup
  - ➡ 5,2 days turnover in system
  - ➡ 99,5 % reduction in water use

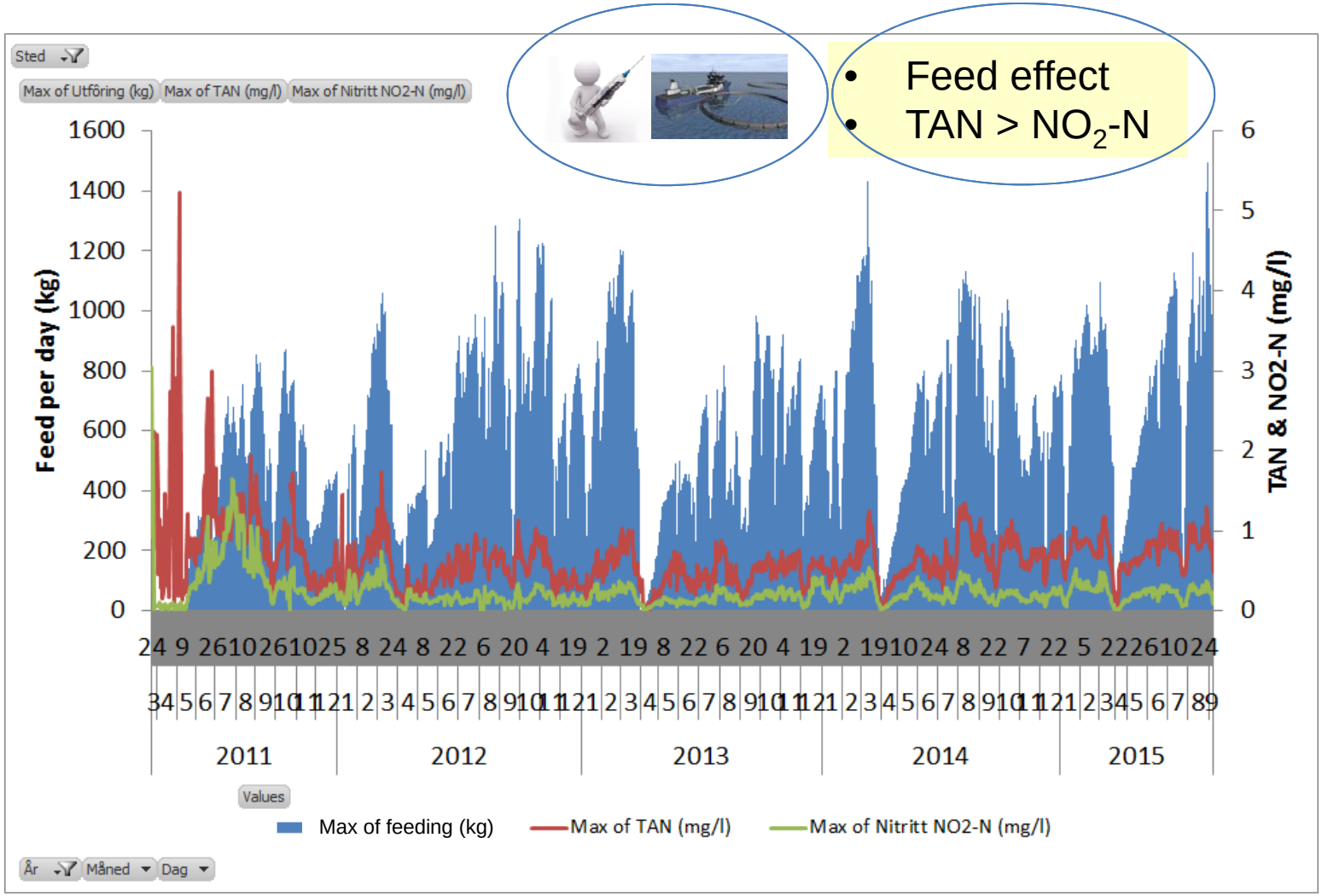


Drum filter efficiency

- 20 µm Hydrotech
- 500 kg feed/day

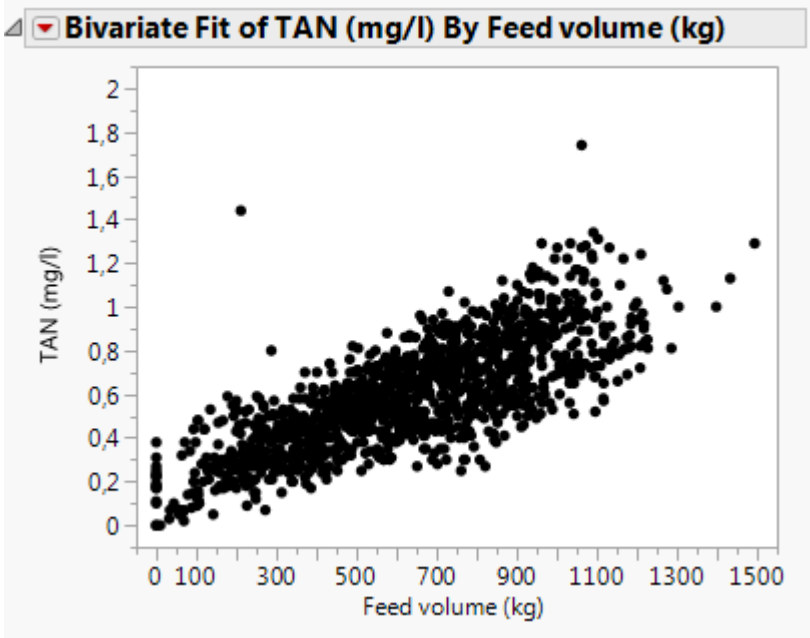


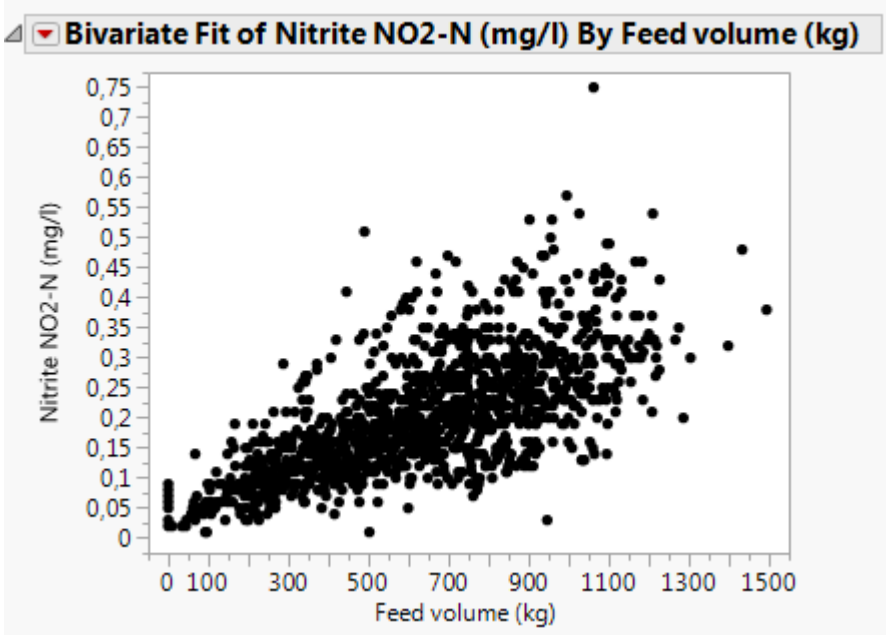
Nitrification



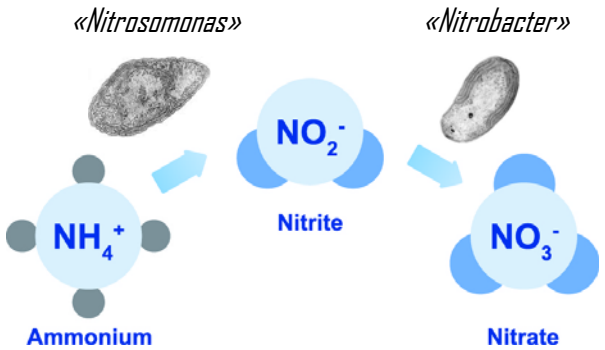
- Feed effect
- TAN > NO_2-N

Nitrification – feed effect

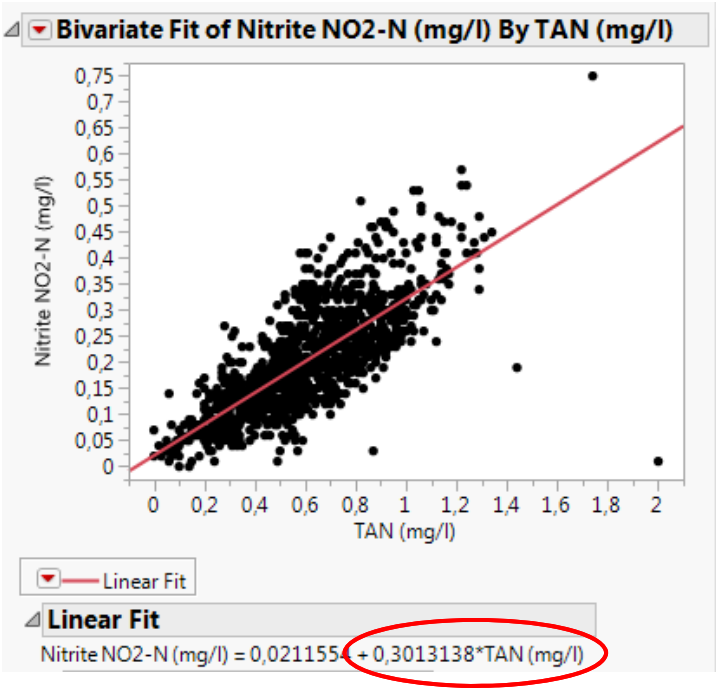


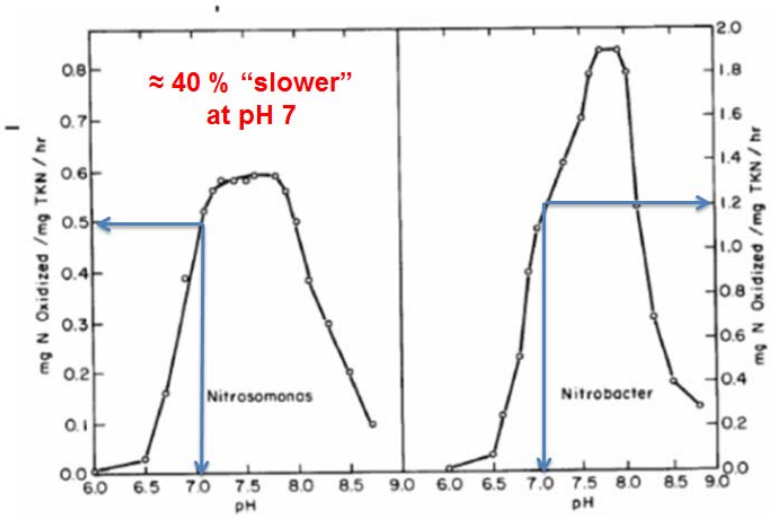


Nitrification – oxidizing capacity



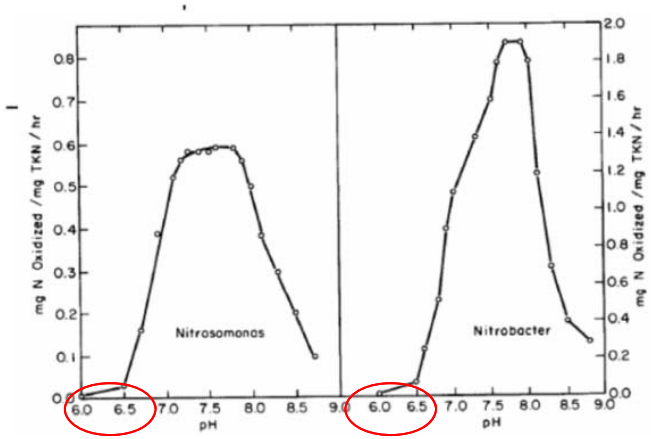
Mineralization of organic matter

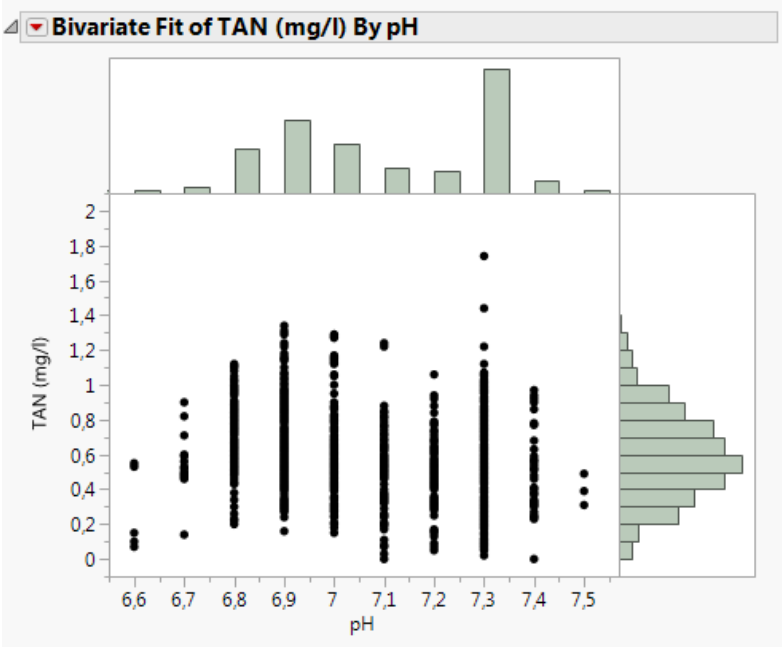


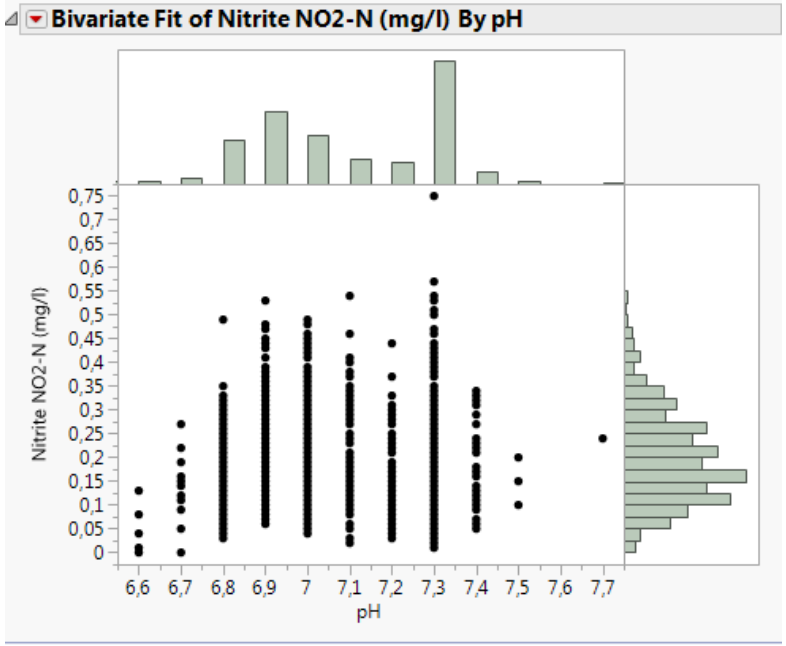


NIVA

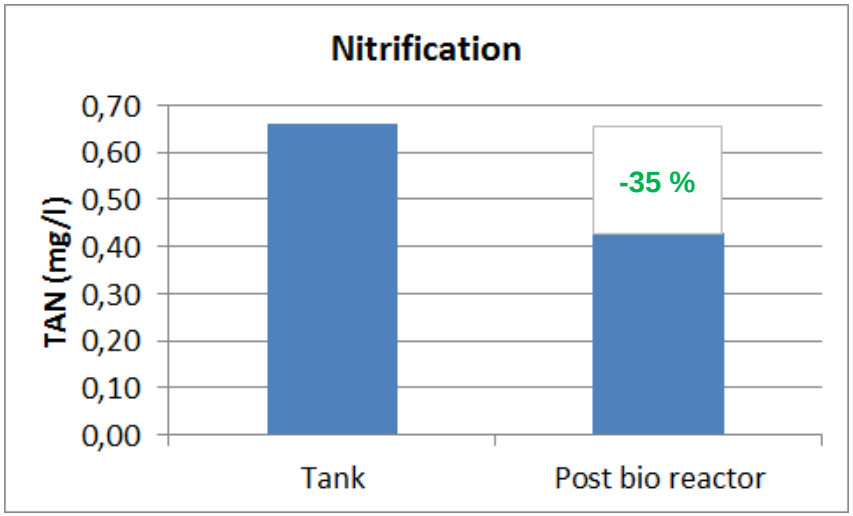
Nitrification – pH sensitivity

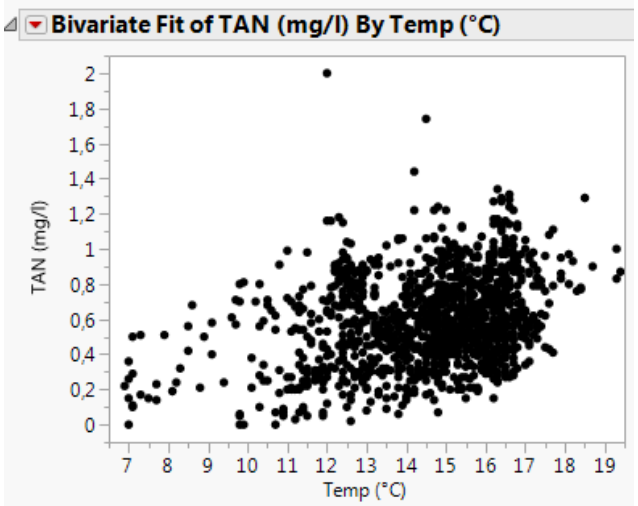






Nitrification – other observations

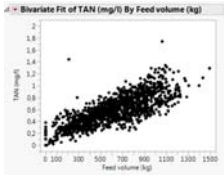




- The water is not cleaned 100 % every time it goes through the water treatment system

➡ Maximizing turnover time in tanks to enhance nitrification capacity

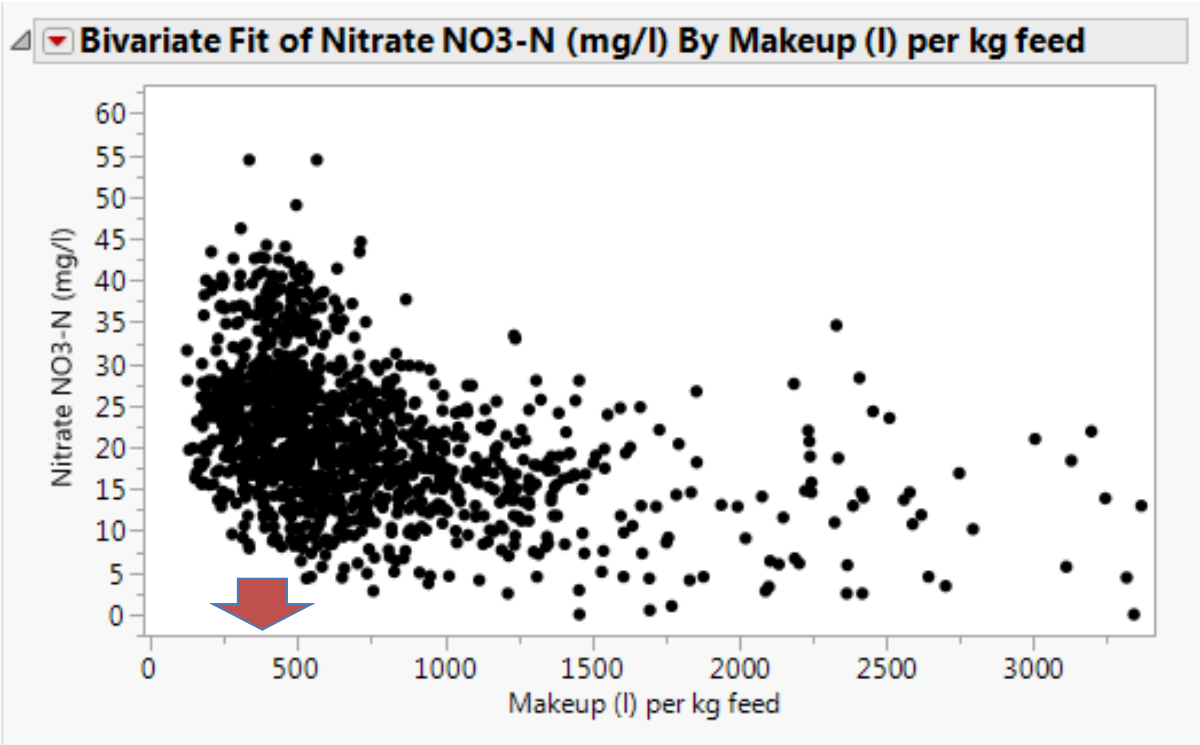
- Not very temperature sensitive
- Feed volume is most important



- And feed volume goes down with lower temperature

NO_3

- Diluted easily with makeup water
- Minimum 300 l/kg feed/day

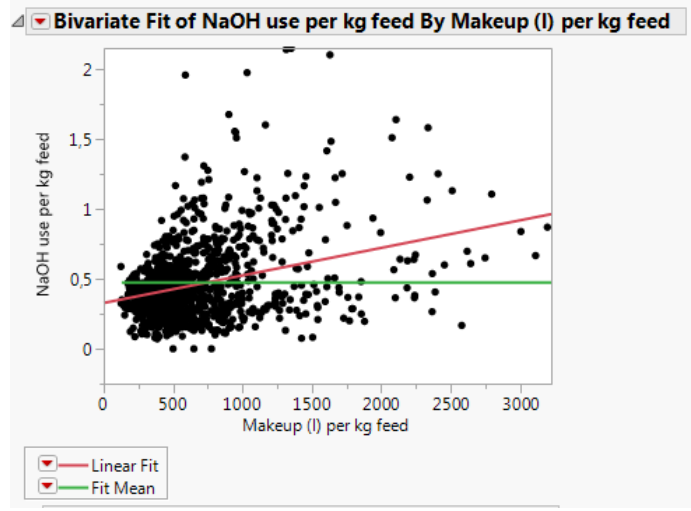


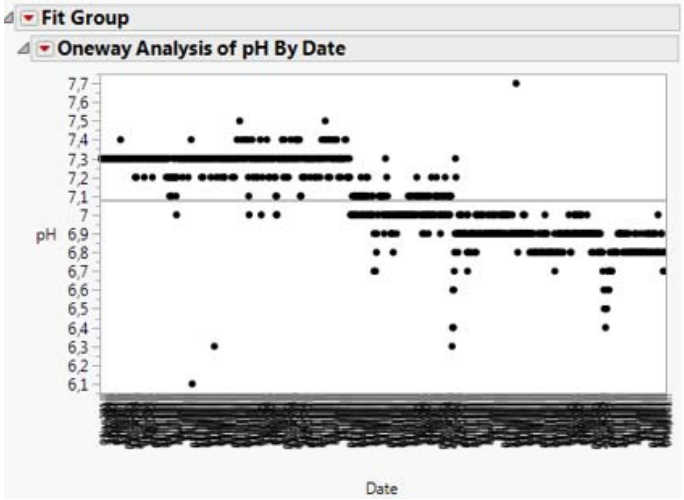
pH and alkalinity

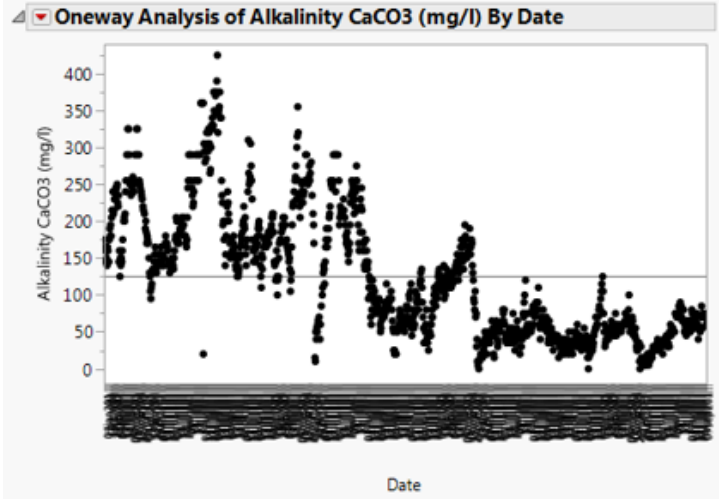
- Water quality in makeup is important
  - 0,5 kg NaOH per kg feed in soft water
- Strip more free CO_2 with lower pH
- Alkalinity in itself is not crucial

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

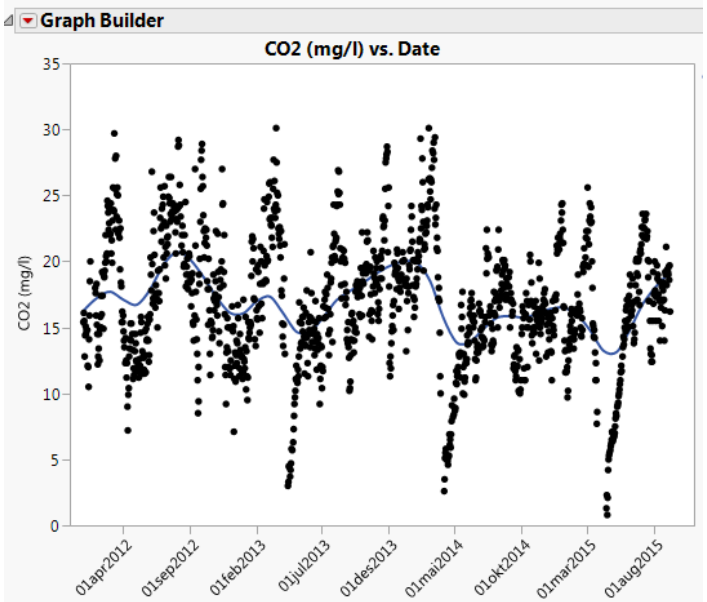
$$CO_2 + H_2O \rightarrow HCO_3^- + H^+$$

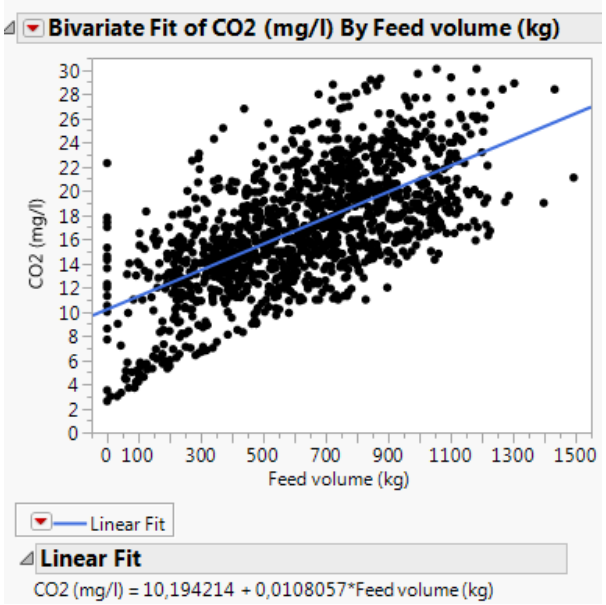






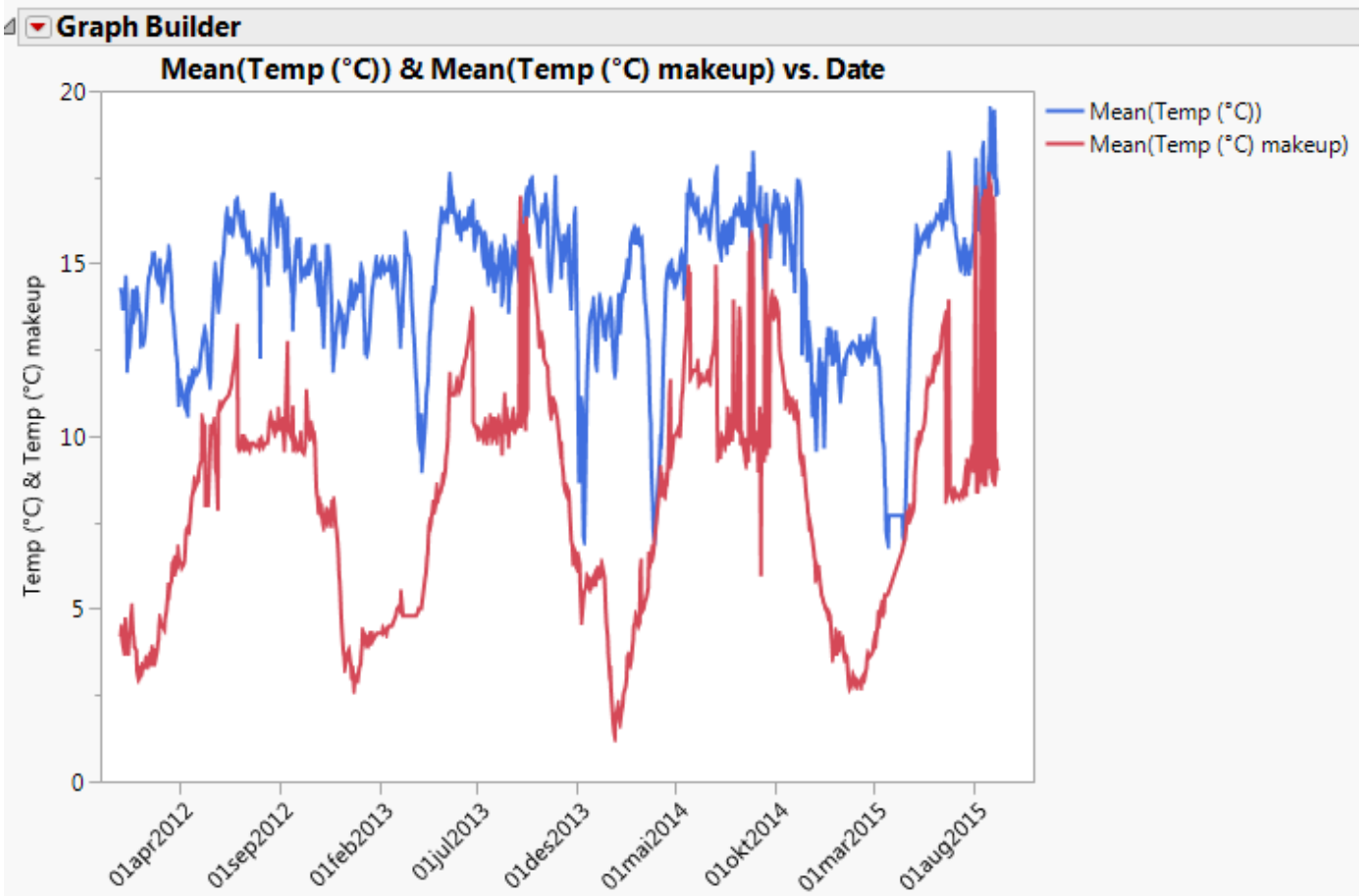
CO_2



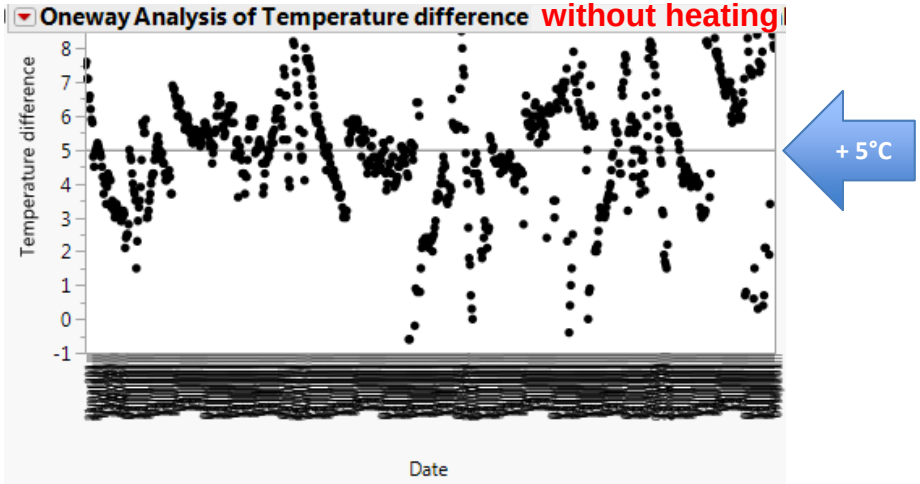


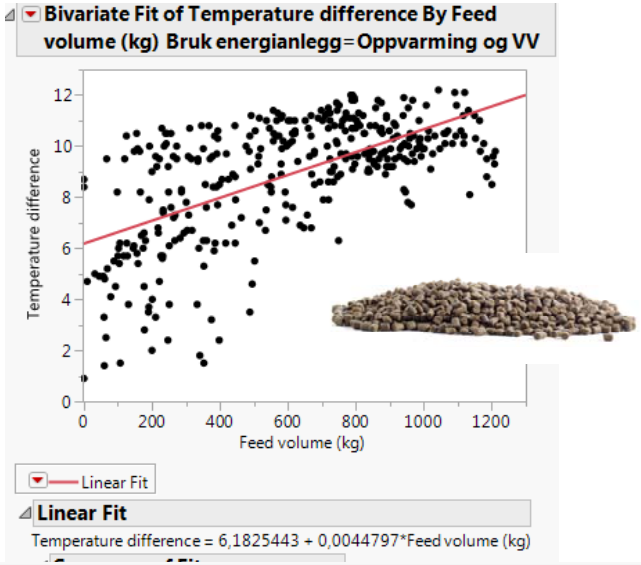
- Main bottle neck for RAS
- Δ CO_2 in – out of tank is probably the most important factor

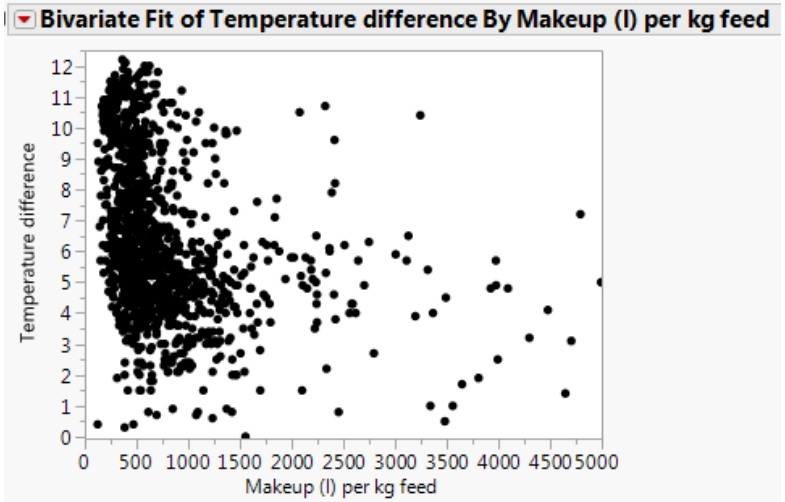
Temperature control



Temperature control



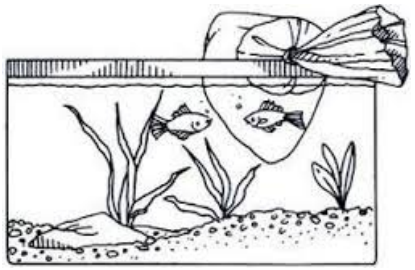


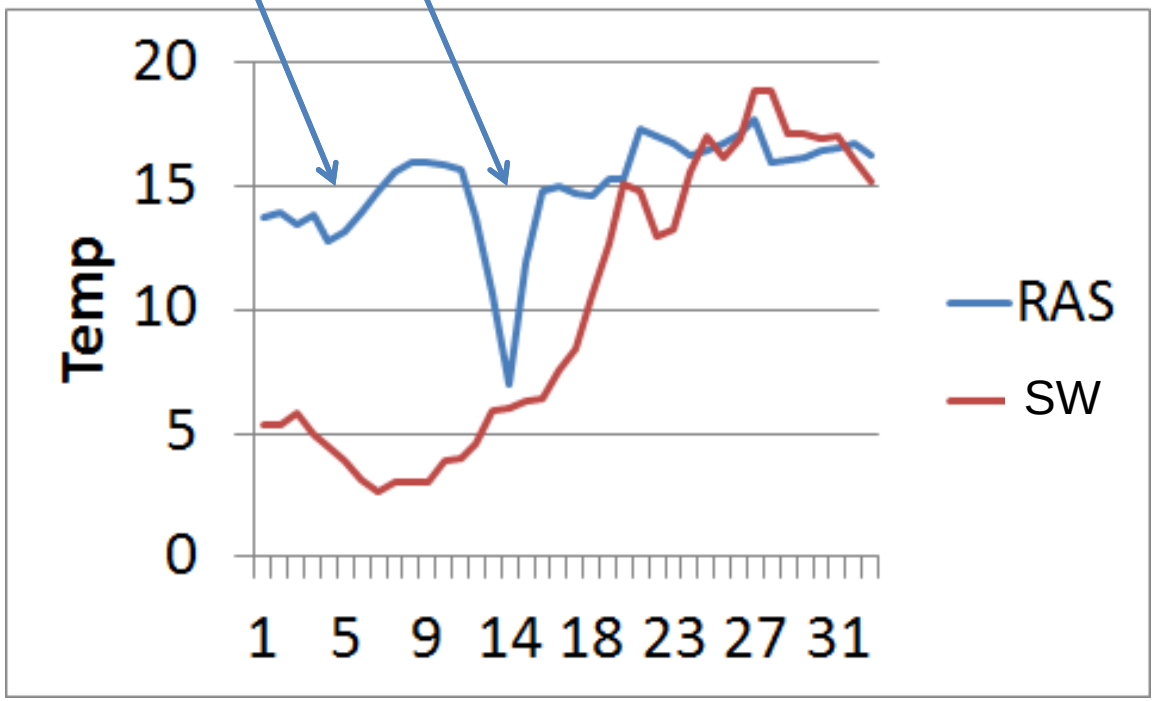


1. Feeding…
2. Makeup control
   - Cold water
   - Flexibility on flow
     - Diluting or conserving
   - Warm water
3. Heat recovery
4. Heating
5. Cooling

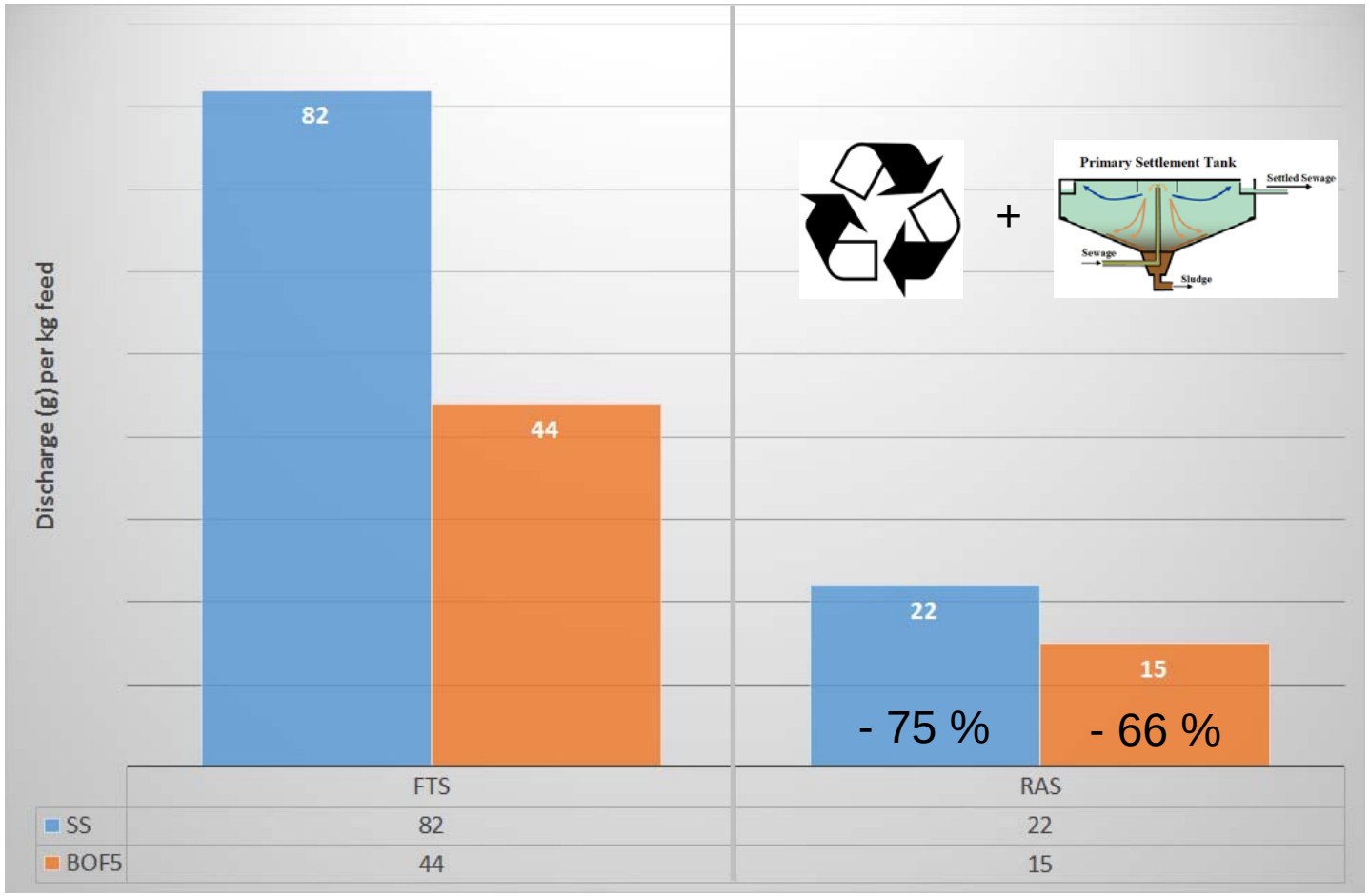
Temperature control

- Acclimatization
- Too productive…



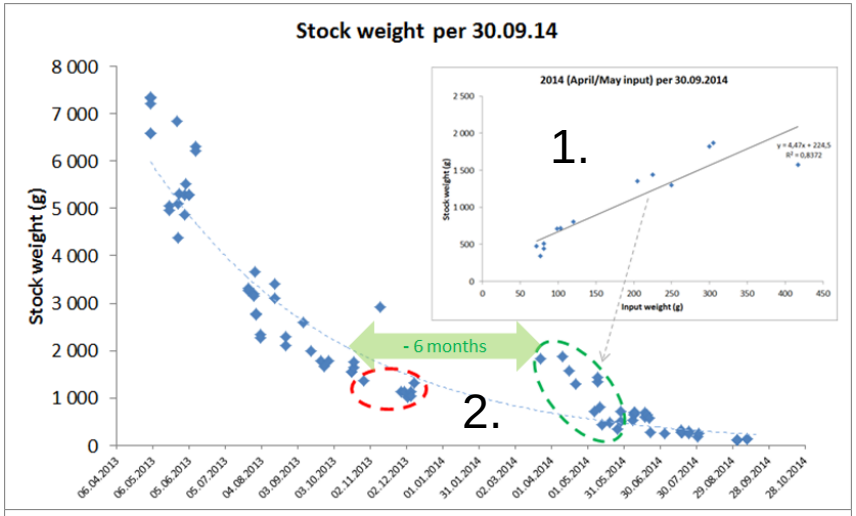


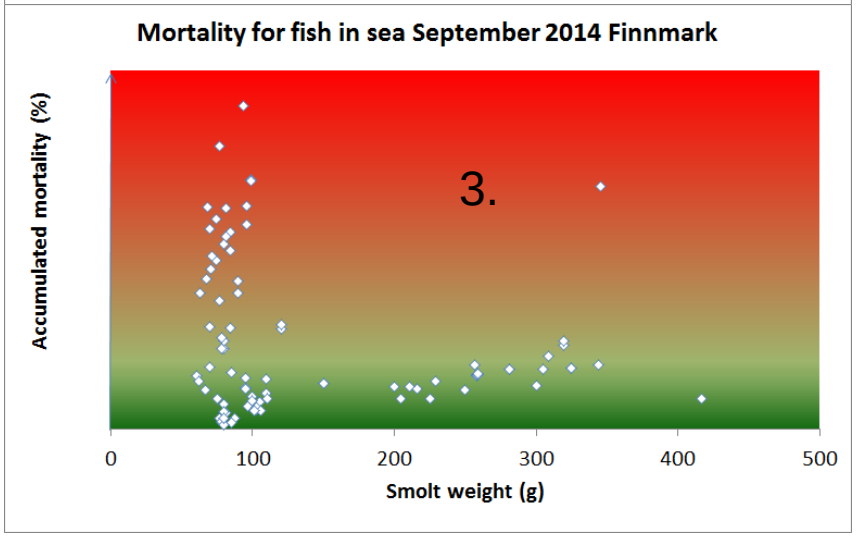
Discharge


Discharge (g) per kg feed
82
44
22
15
- 75 %
- 66 %
+
Primary Settlement Tank
Settled Sewage
Sewage
Sludge
FTS
RAS
SS 82 22
BOF5 44 15

Observed effects of post smolt

1. Continues normal growth pattern in SW
2. >250 g smolt can reduce time in SW with >6 months
   - Versus 80 g in Finnmark
3. Robust fish with low mortality





Thank you for your attention!

All data 2011-2015

	Average	StDev	Min	Maks
Temperature (°C)	14,5	2,0	6,9	19,4
Feeding (kg)	624	288	0	1 494
Makeup (l) per kg feed	822	1 784	124	59 040
pH	7,08	0,21	6,31	7,70
TAN (mg/l)	0,59	0,25	0,00	1,74
Ammonia NH3-N (mg/l)	0,0017	0,0011	0,0000	0,0122
Nitrite NO2-N (mg/l)	0,20	0,10	0,00	0,75
Nitrate NO3-N (mg/l)	20,7	8,7	0,0	54,4
CO2 (mg/l)	16,9	4,9	0,8	30,1
Alkalinity CaCO3 (mg/l)	126	87	0	425
Make up (l/min)	268	151	61	1 620