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Treating gill diseases in freshwater – water chemsitry in tarpaulins and well boats

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Bathing

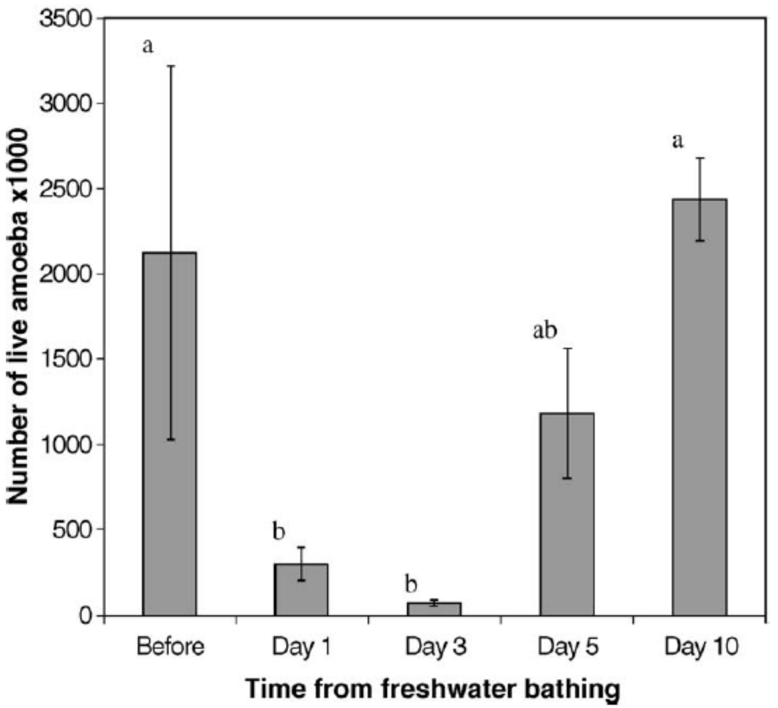
Table 1
Definition of gross AGD gill scores as used by TASSAL

Infection level	Score	Gross signs
Clear	0	gills appear clean, healthy red colour
Very light	1	1 mucoid spot, light mucus
Light	2	2–3 mucous spots, some paling of colour
Medium	3	established thickened mucous patch
Heavy	4	> 3 mucous patches or single large patch

Table 2
Difference in the gross signs, gill smear results, presence of live *Paramoeba* on smears and presence of gill lesions and *Paramoeba* in histological sections before and after freshwater bathing

Variable measured	Before	After
Prevalence of mucoid patches (%)	93.3 (1.9)	55 (7.9)
Gross appearance—clear (%)	6.7 (1.9)	44.9 (7.9)
Gross appearance—very light (%)	18.9 (4.8)	18.0 (5.7)
Gross appearance—light (%)	26.7 (1.9)	24.4 (1.7)
Gross appearance—medium (%)	24.4 (1.7)	9.1 (0.9)
Gross appearance—heavy (%)	23.4 (1.7)	3.5 (1.9)
DiffQuick positive gill smears (%)	77.6 (5.4)	27.1 (2.6)
Paramoeba live on fresh smear (%)	86 ($n = 50$)	27 ($n = 11$)
Number of *Paramoeba* /lesion	0.4 (0.11)	0.07 (0.02)
Number of AGD lesions/filament	0.23 (0.04)	0.21 (0.02)
Paramoeba within cysts (%)	31.9 (5.6)	71.2 (15.8)

Parsons et al. 2001 Aquaculture 195:205-210



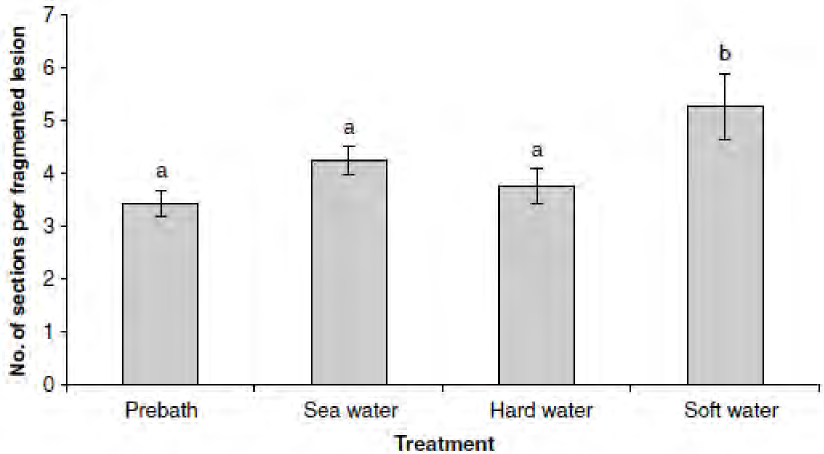
Clark et al. 2003 Aquaculture 219: 135-142

Effects of freshwater bathing of AGD affected Atlantic salmon

Effects of experimental freshwater exposure on mean (±SE) respiratory variables of Atlantic salmon under normoxic (100% saturation) or hyperoxic (200% saturation) conditions. Like symbols are significantly different from each other

	O_2 saturation		O_2 saturation	
	100% Before	100% After	100% Before	200% After
PO_2 (mm Hg)	110.2 (5.9)	118.5 (5.0)*	123.3 (14.1)	154.2 (13.9)*
pH	7.756 (0.017)	7.799 (0.039)	7.706 (0.015)	7.716 (0.043)
CO_2 (ml/100 ml)	11.19 (1.36)	8.22 (0.96)	9.34 (1.38)	9.61 (1.02)
Hct (%)	25.2 (1.9)	26.3 (1.2)	23.3 (0.98)	23.6 (1.7)
Hb (g/100 ml)	7.16 (0.63)	6.72 (0.51)	7.23 (0.47)	5.98 (0.90)
MCHC	0.28 (0.03)	0.25 (0.02)	0.31 (0.02)	0.25 (0.03)
O_2/Hb (ml/g)	1.25 (0.16)	1.01 (0.15)	1.01 (0.18)	1.32 (0.16)

Powell et al. 2001 Aquaculture 199: 259-266



Roberts and Powell 2003 Journal of Fish Diseases 26: 591-599

Comparison of treatment approaches

- Tow infected cage from production to bathing site
- ↓ Pump fish from Production cage into bathing cage lined with tarpaulin
- ↓ Treatment period
- ↓ Pull away tarpaulin fish in «new» cage
- ↓ Tow «clean» cage back to production site

Tarpaulin

- Infected cage in situ
- ↓ Tarpaulin slung under cage or skirt around cage
- ↓ H_2O_2 added to water
- ↓ Treatment period
- ↓ Tarpaulin/skirt pulled away

Wellboat

- Well boat loads with FW
- ↓ WB pull along side infected cage
- ↓ Fish pumped from cage into wellboat well
- H_2O_2 added to water
- ↓ Treatment period
- ↓ Fish pumped back into cage
- ↓ Water «treated/disinfected» and discharged

Factors affecting freshwater abstraction and use

- Legal frameworks
  - SEPA
  - Environmental impact assessment legislation
  - Water framework directive
  - Conservation legislation
- River type
- Season
- Prevailing flow
- Abstraction intake points
- Storage reservoirs
- Pipelines
- Road/boat transport
- **Water chemistry**

Freshwater availability

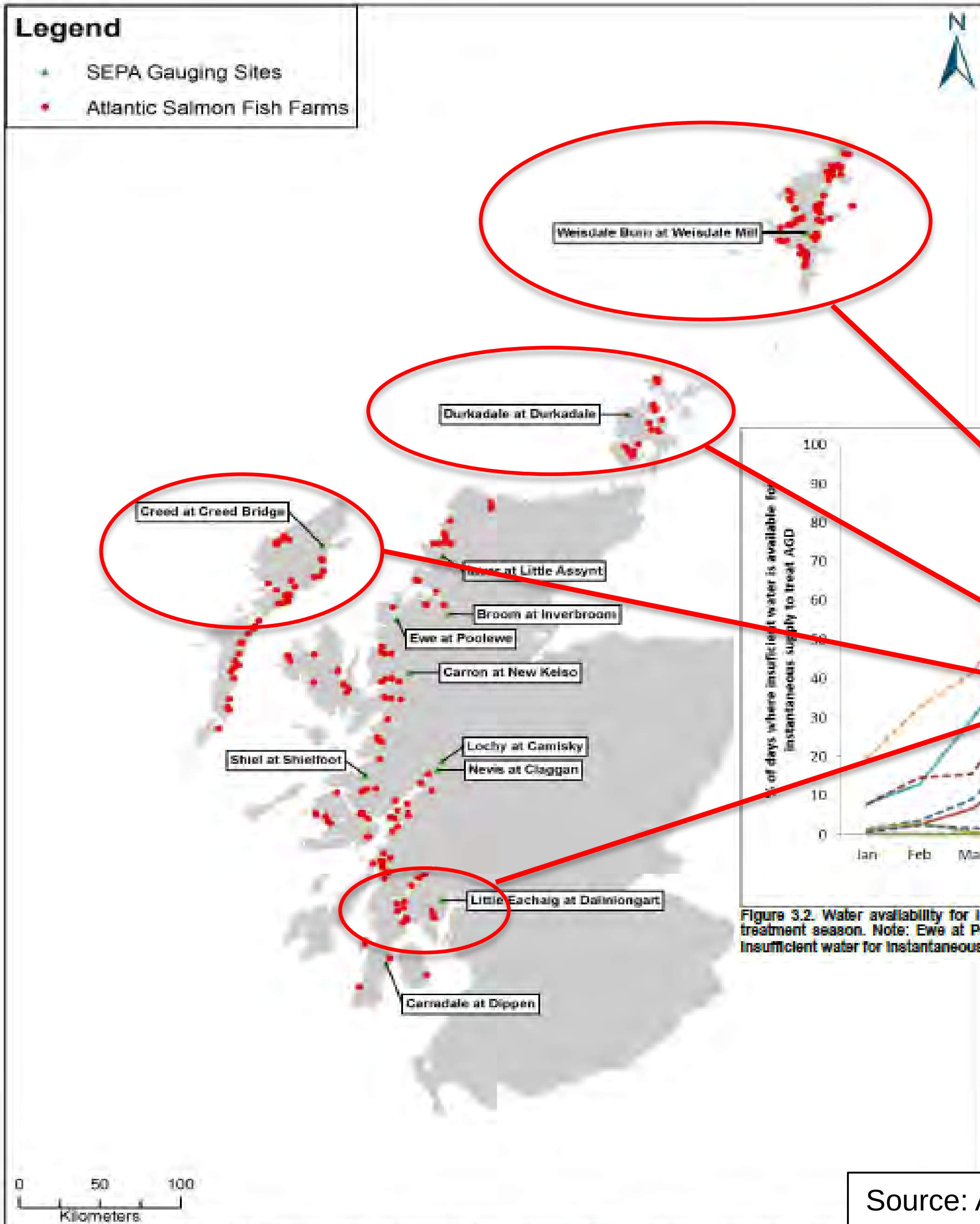


Figure 3.1. Location of SEPA gauging stations within 20 kilometres of fish farms and within 10 kilometres of the coast.

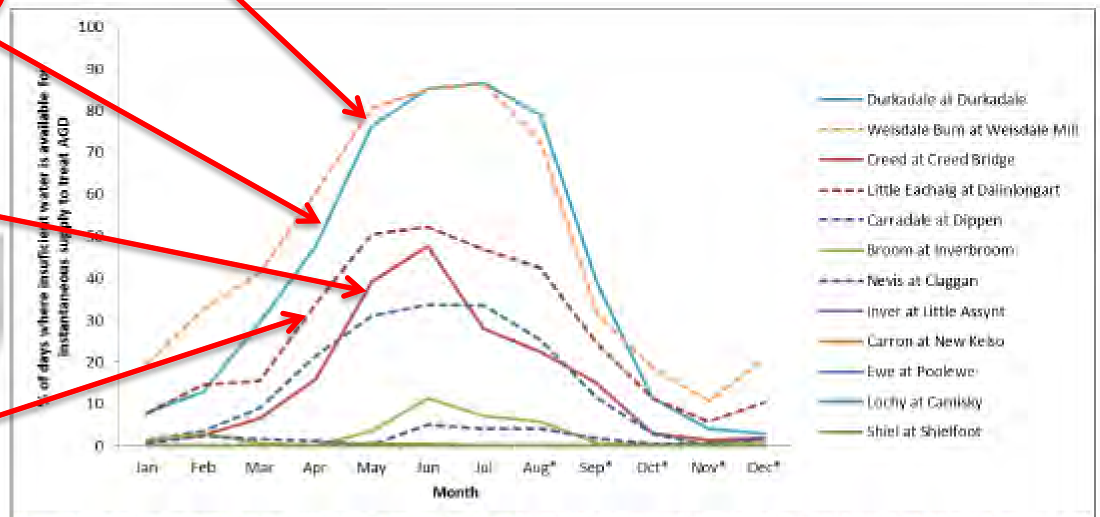
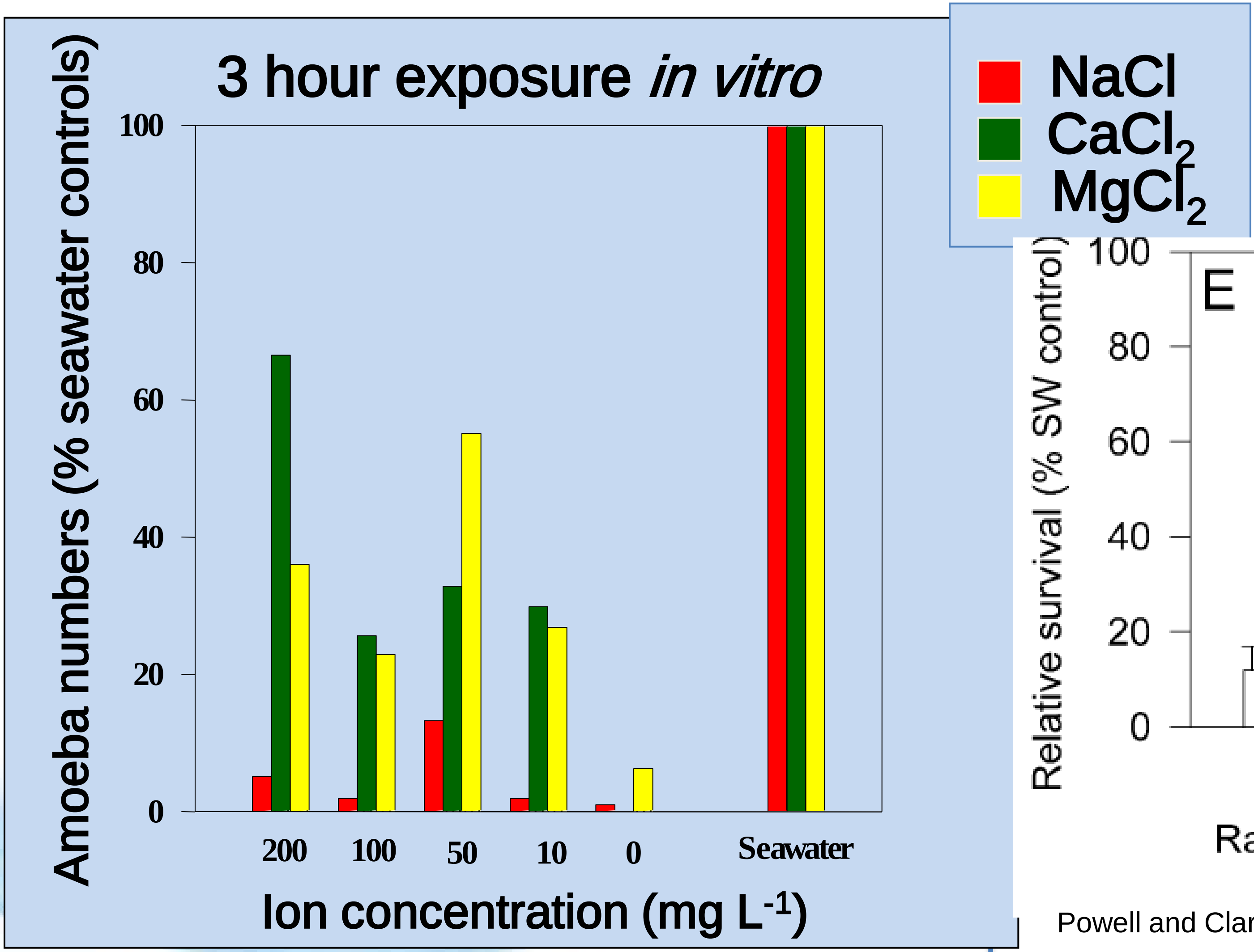
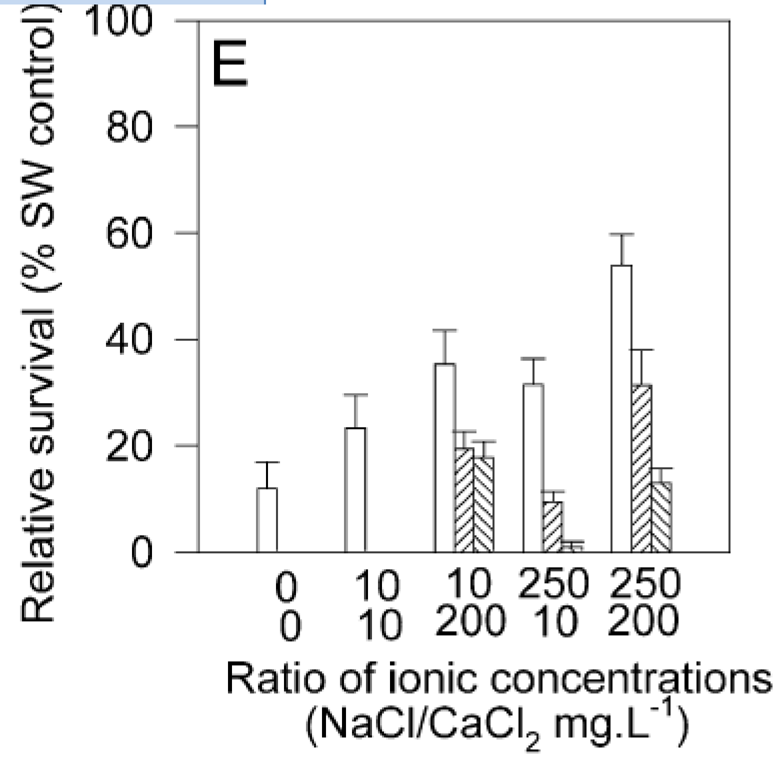


Figure 3.2. Water availability for instantaneous AGD treatment at twelve flow gauging locations on the West coast of Scotland. *= key AGD treatment season. Note: Ewe at Poolewe, Lochy at Camisky, and Shiel at Shielfoot all overlap the X-axis throughout the year (i.e. none have insufficient water for instantaneous abstraction at any time).

Source: APEM (2014) Availability and use of freshwater resources for the treatment of amoebic gill disease at Scottish salmon farms. APEM report 413028 to the Scottish Aquaculture Research Forum.

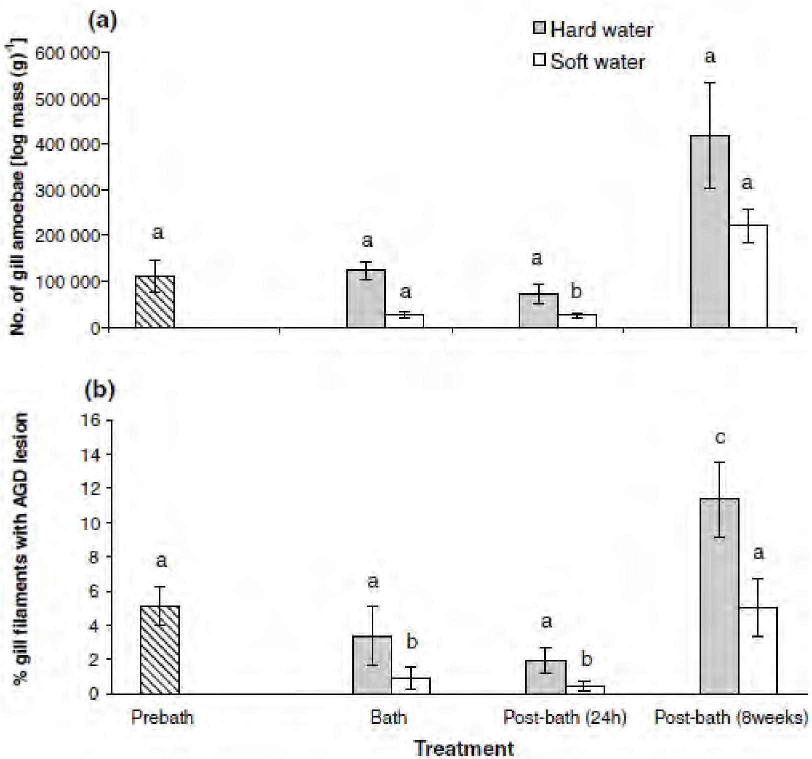
Gill amoeba survival in freshwater: implications for freshwater bathing





Powell and Clark 2003 Aquaculture 220: 135-144

Effects of water hardness on efficacy of freshwater bathing



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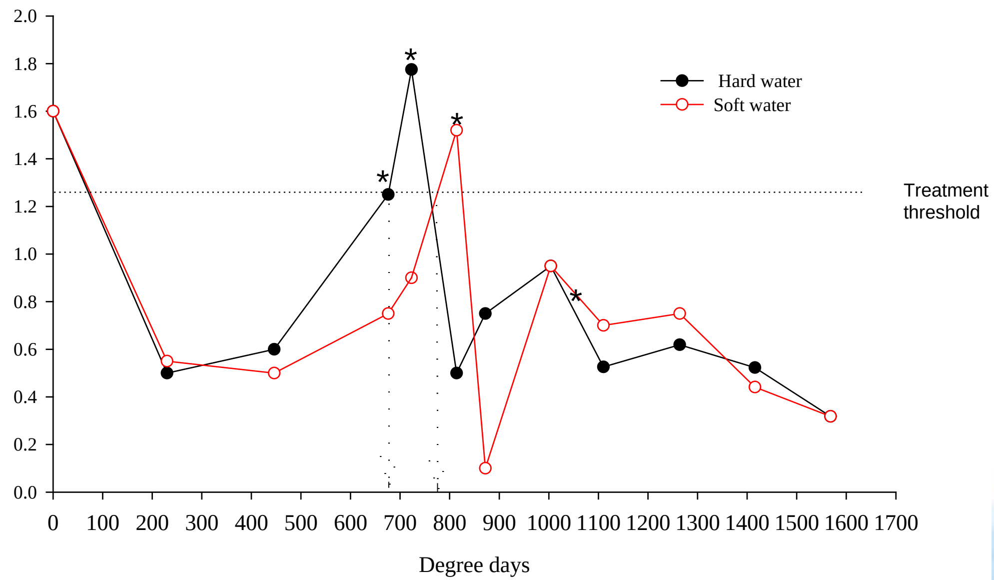
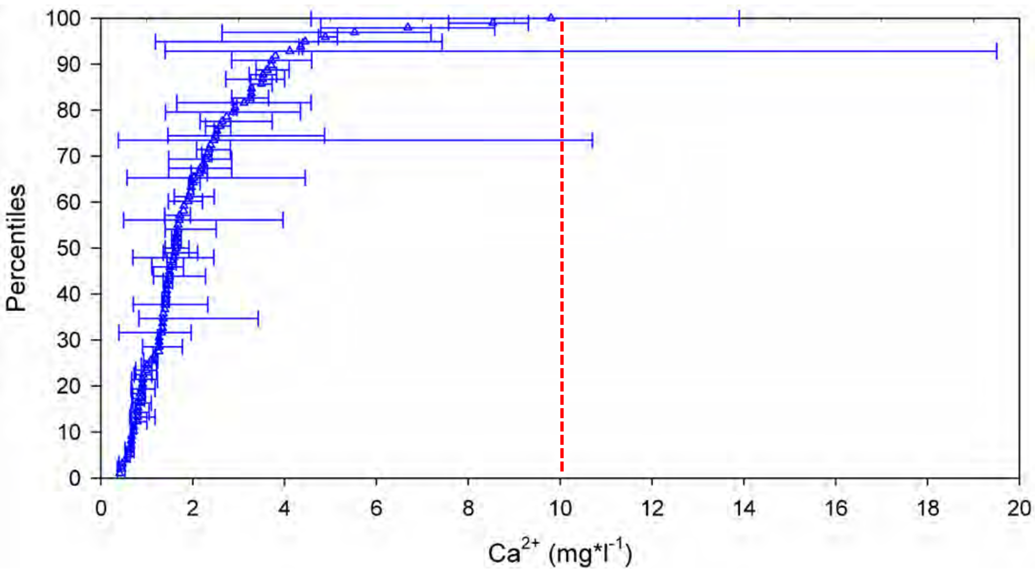
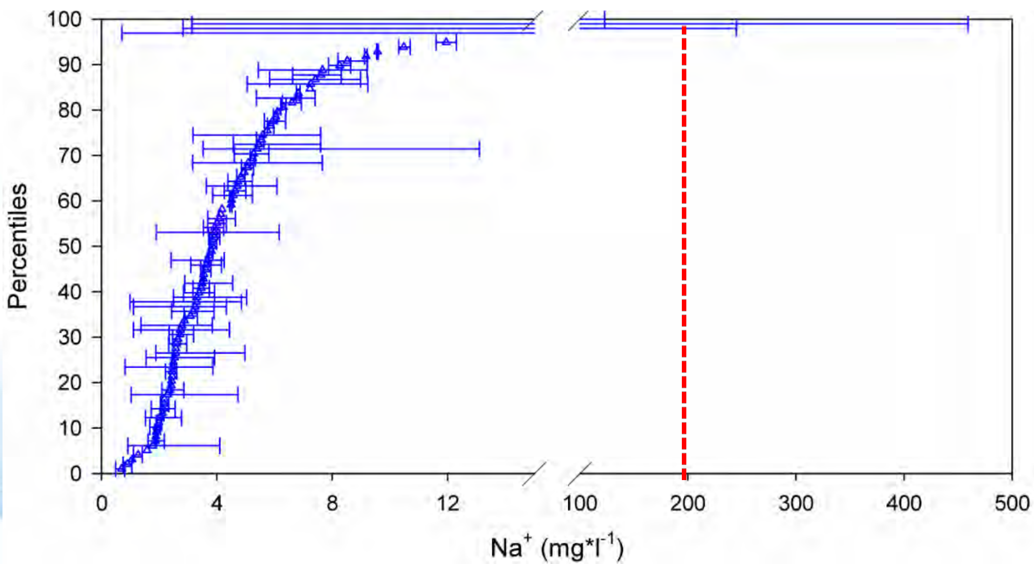


Powell et al. 2005 FRDC project report 2001/205

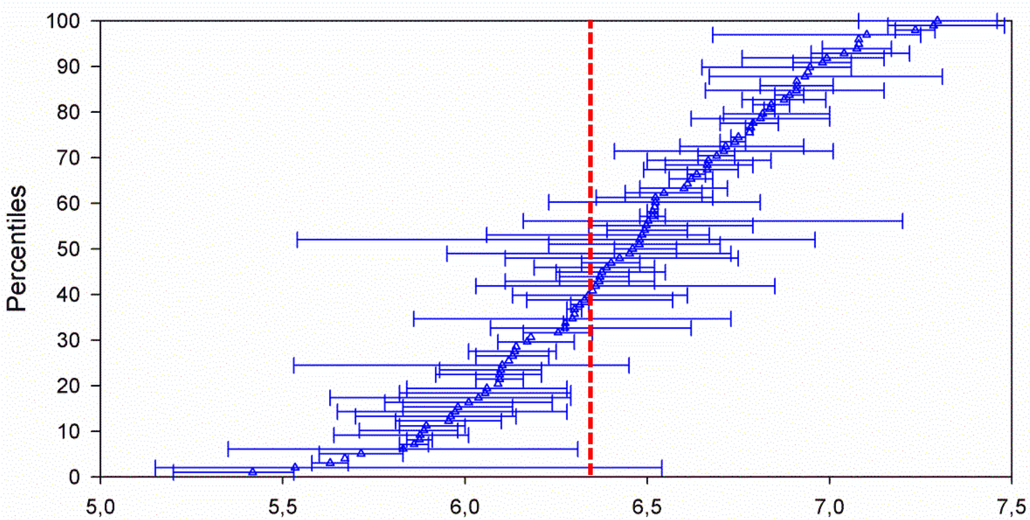
Norwegian freshwater (WQ 99-06)

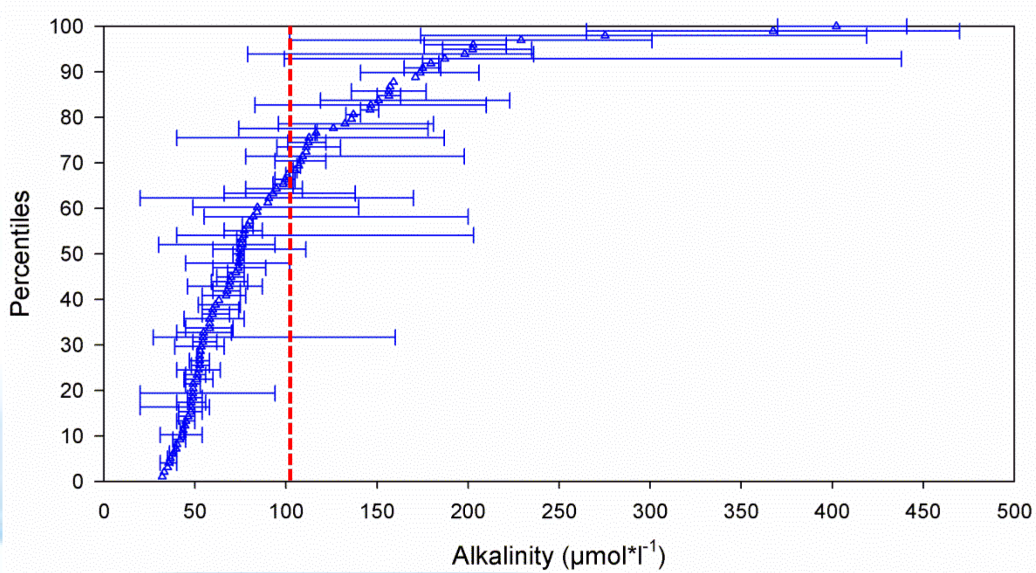




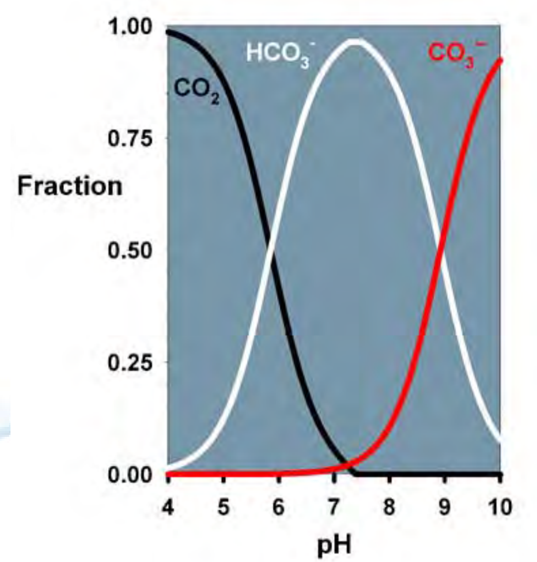
- Low major ion concentrations
- Norwegian WQ is expected to give good treatment efficacy (AGD)

Norwegian freshwater (WQ 99-06)

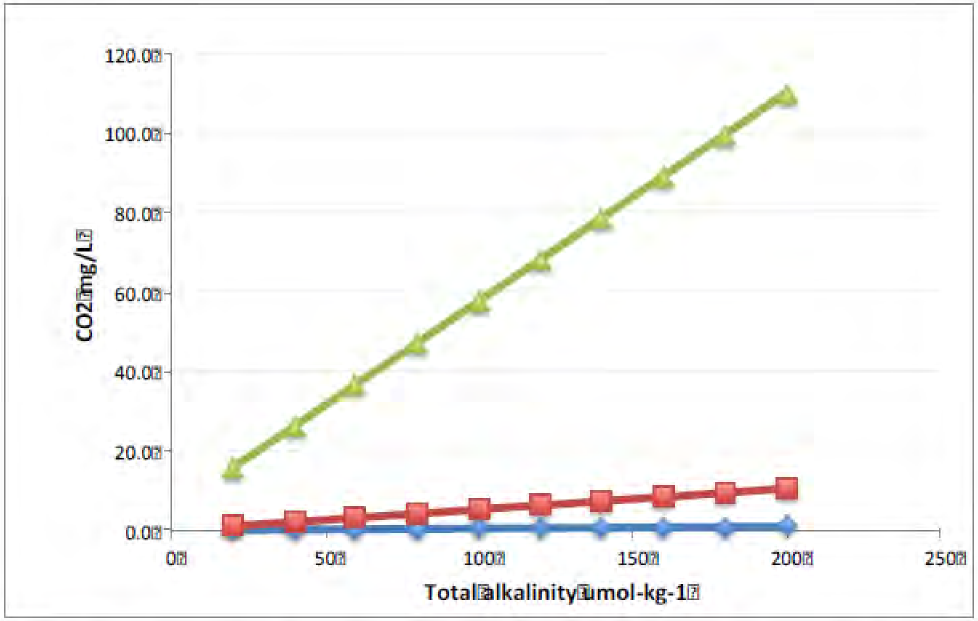




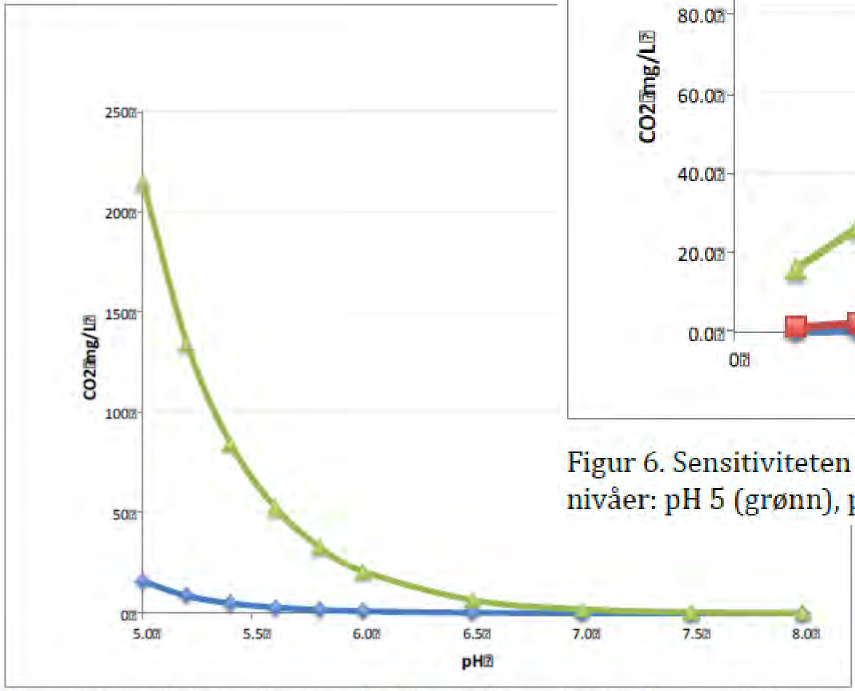
- Generally low pH and buffering capacity
- Closed FW treatment systems with high biomass will generate high degree of CO_2 (g) accumulation and pH drop
- Aeration and oxygenation may result in steady-state conditions



Sensitivity of CO_2 concentration to alkalinity and pH



Figur 6. Sensitiviteten av beregnede CO_2 verdier i forhold til endret total alkalitet ved tre ulike pH-nivåer: pH 5 (grønn), pH 6 (rød) og pH 7 (blå).



Figur 7. Sensitivitet av beregnede CO_2 verdier ved ulik pH og to alkalitetsnivåer (blå – 20 µmol/kg, grønn – 400 µmol/kg). Sensitiviteten øker ved lavere pH og ved høyere alkalitet.

Source: NIVA report 2015
Behandling av amøbegjellesykdom i brønnbåt

…but remember

CO_2 is a weak acid in solution

$$H_2O + CO_2 \Leftrightarrow H_2CO_3 \Leftrightarrow HCO_3^- + H^+ \Leftrightarrow CO_3^{2-} + 2H^+$$

NH_3 is a weak acid in solution

$$NH_3 + H_2O \Leftrightarrow NH_4^+ + OH^-$$

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Modeling the accumulation of CO_2 during high density, re-circulating transport of adult Atlantic salmon, *Salmo salar*, from observations aboard a sea-going commercial live-haul vessel

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[d] *Faculty of Land and Food Systems, University of British Columbia, Canada*

Henderson–Hasselbalch equation:

$$P_{CO2} = \frac{TCO_2}{\alpha 10^{pH-pK^1} + 1} \quad (1)$$

P_{CO2}	partial pressure of CO_2 (mmHg)
TCO_2	total CO_2 in solution (mmol L^{-1})
α	solubility constant of CO_2 (mmol L^{-1} mmHg^{-1})
pH	pH of solution
pK^1	first dissociation constant of CO_2

$$P_{CO2} = \frac{TCO_{2ac} + TCO_{2bg}}{\alpha 10^{pH-pK^1} + 1} \quad (2)$$

TCO_{2ac}	moles of accumulated total CO_2 from respiration (mmol L^{-1})
TCO_{2bg}	moles of background total CO_2 (mmol L^{-1})

The amount of CO_2 created through respiration is calculated from the equation:

$$TCO_{2ac} = \frac{(\dot{M}O_2 \times RER \times mass) \times t}{V_r} \quad (3)$$

$\dot{M}O_2$	O_2 consumption rate (input as mg O_2 min^{-1}kg^{-1}, converted to mmol O_2 min^{-1}kg^{-1})
RER	respiratory exchange ratio (moles CO_2 excreted per moles O_2 consumed). RER can vary between 0.7 and 1.3, increasing with activity level and in relation to the tissue level O_2 consumption and CO_2 production ratio, or respiratory quotient (RQ). An RER of 1.0 was used in the present modeling, but this can be varied.
mass	total fish mass per hold (kg)

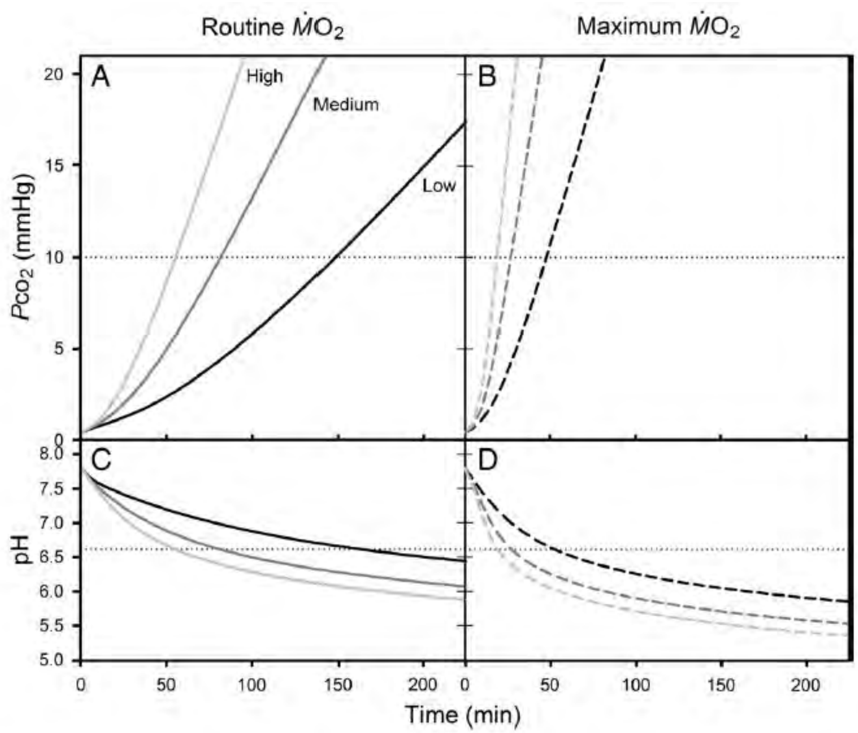
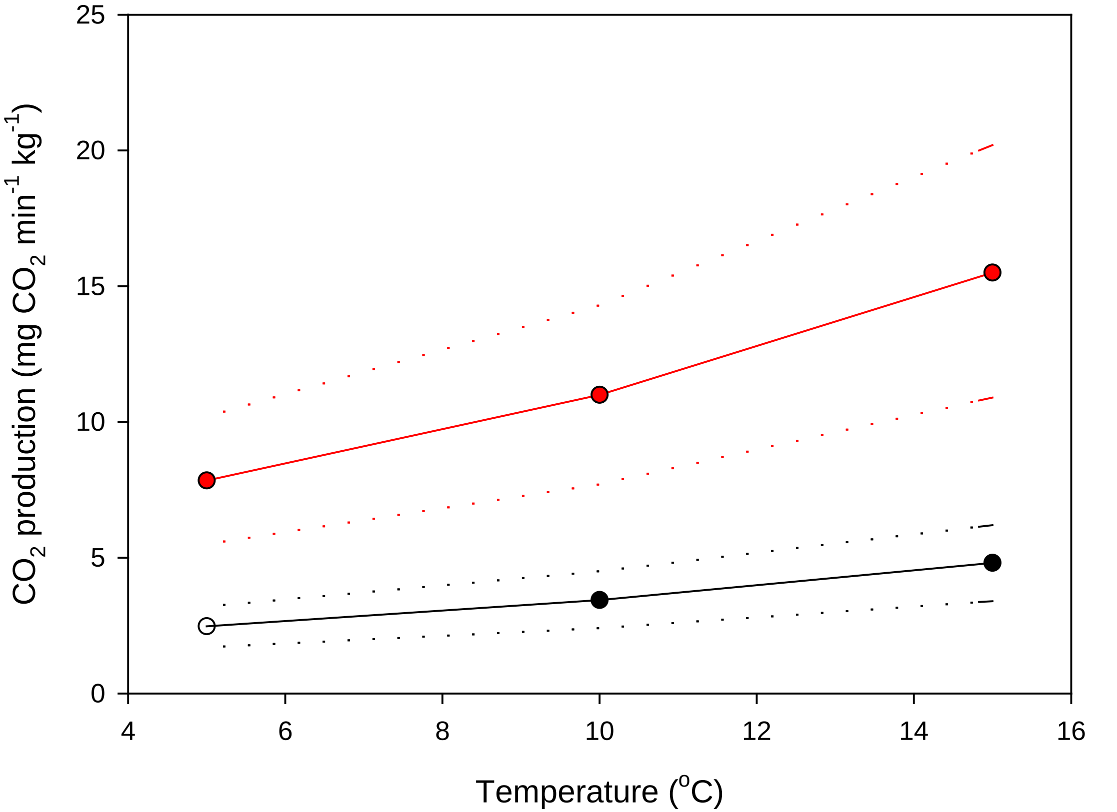
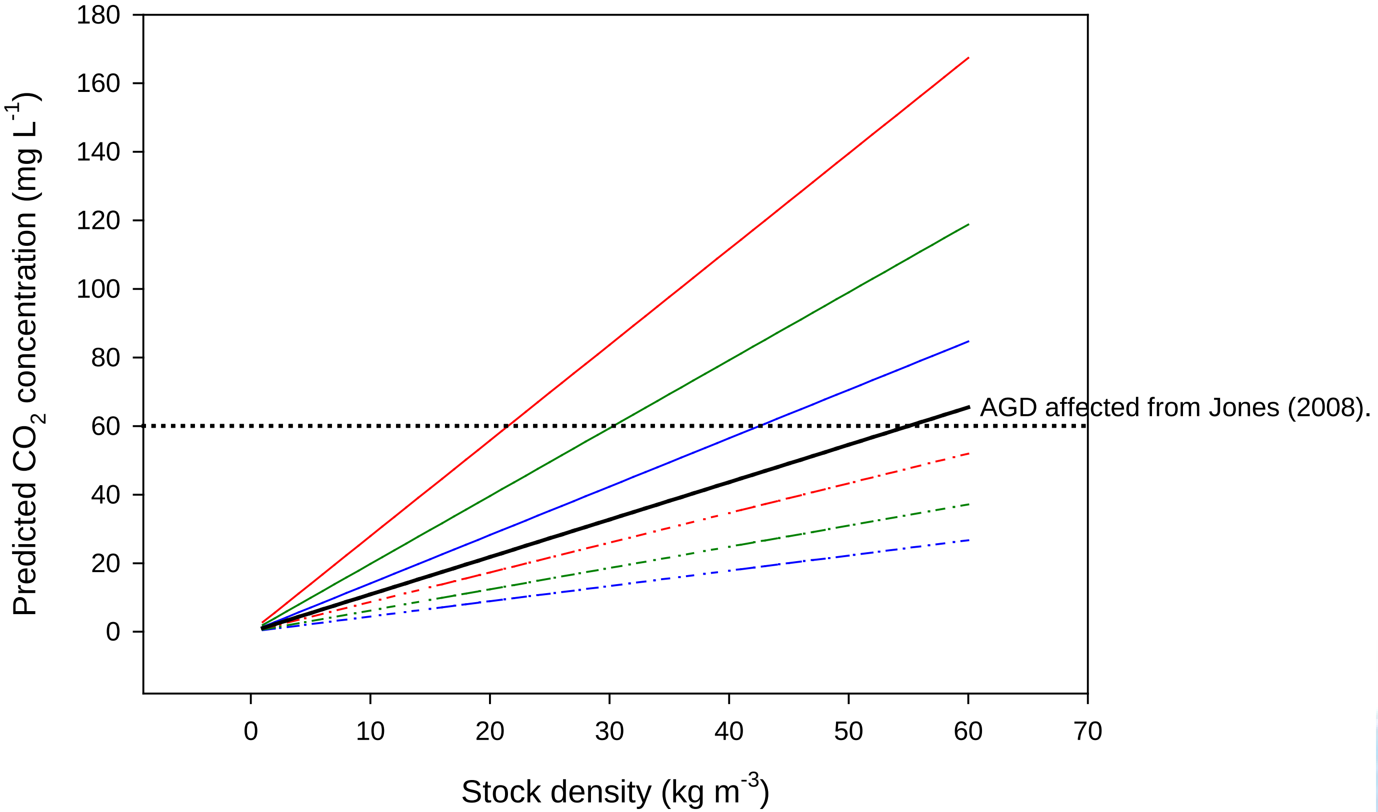


Fig. 3. Modeled changes in water quality during various closed-hold transport scenarios. Simulated P_{CO2} accumulation at routine $\dot{M}O_2$ (2.5 mg O_2 min^{-1}kg^{-1}, solid lines) and maximum $\dot{M}O_2$ (8.0 mg O_2 min^{-1}kg^{-1}, dashed lines) across a range of loading densities; low density (70 kg m^{-3}), medium density (120 kg m^{-3}) and high density (170 kg m^{-3}). (A) Under low stress conditions, low loading density allows a re-circulation time of up to 150 min while at a high density this time is reduced to 56 min. (B) Under high stress conditions, low loading density levels allow re-circulation time of 48 min while high loading densities further reduce the time to reach the 10 mm Hg CO_2 threshold to 19 min. The associated water pH changes at routine $\dot{M}O_2$ (C) and maximum $\dot{M}O_2$ (D) at low, medium and high loading densities show that water pH decreases with increasing water P_{CO2}. The arbitrary threshold P_{CO2} of 10 mm Hg is reached at a water pH of 6.6 (dotted lines) under all scenarios. All trips were modeled using the same water conditions: temperature = 10 °C, salinity = 30 ppt, starting water pH = 7.8.

CO_2 prediction of salmon at different temperatures



CO_2 predictions for salmon at different stocking densities (12C)



Source: NIVA report 2015
Behandling av amøbegjellesykdom i brønnbåt

Effects of DOC and water hardness on AGD bathing efficacy

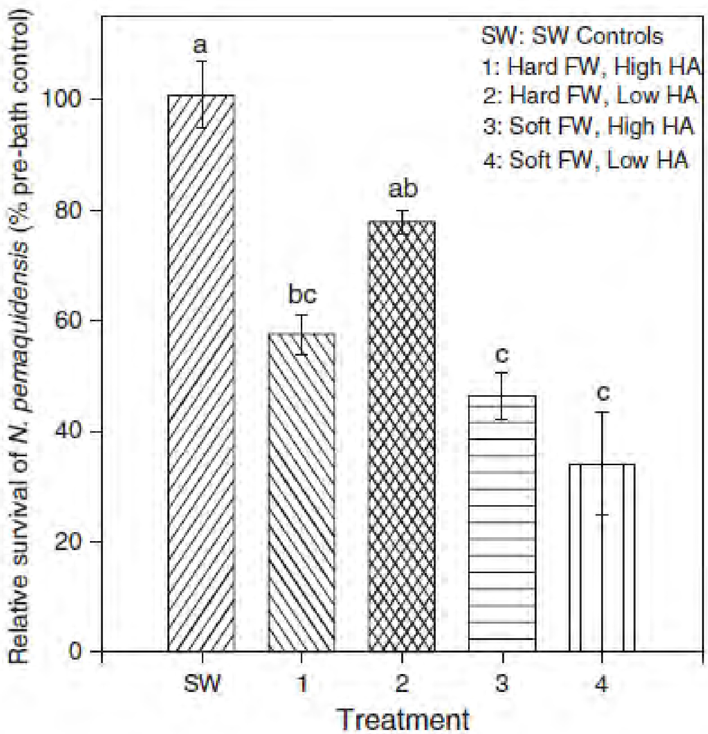


Figure 3 The percentage of viable amoebae present on the gills of Atlantic salmon bathed in freshwater for 2.5 h with varying levels of dissolved organic carbon and total water hardness when compared with pre-bath numbers (mean ± SE). Different letters indicate significant differences between treatments ($P > 0.05$).

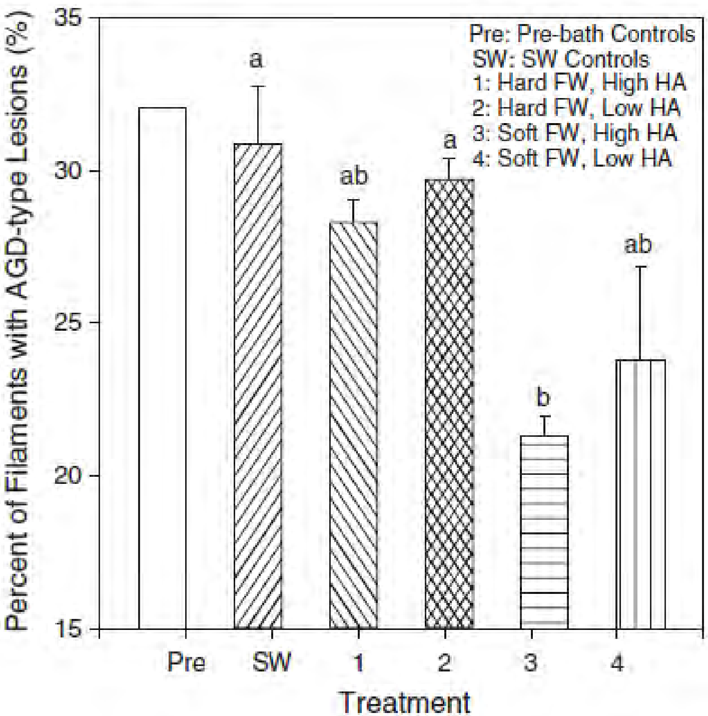
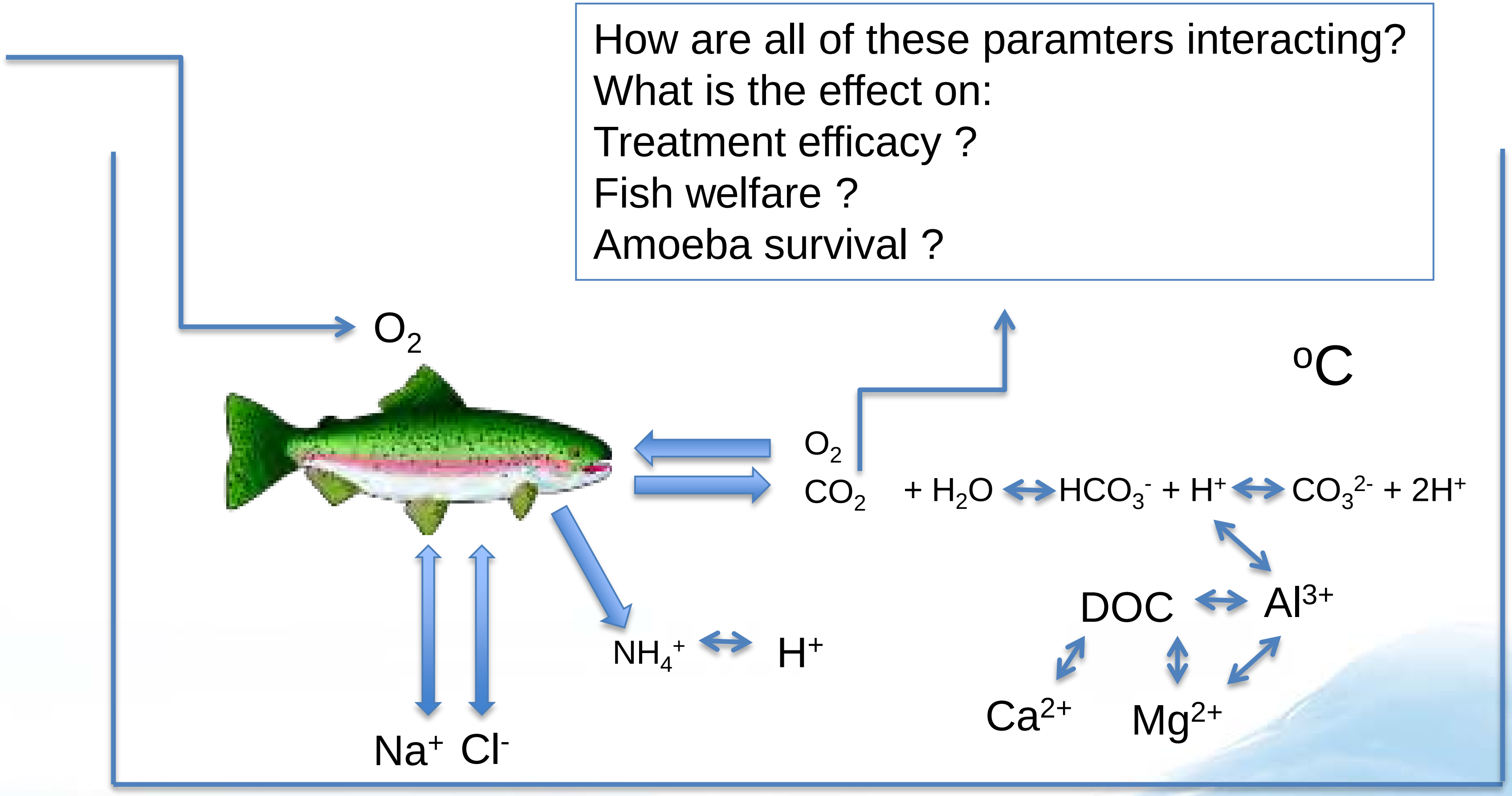


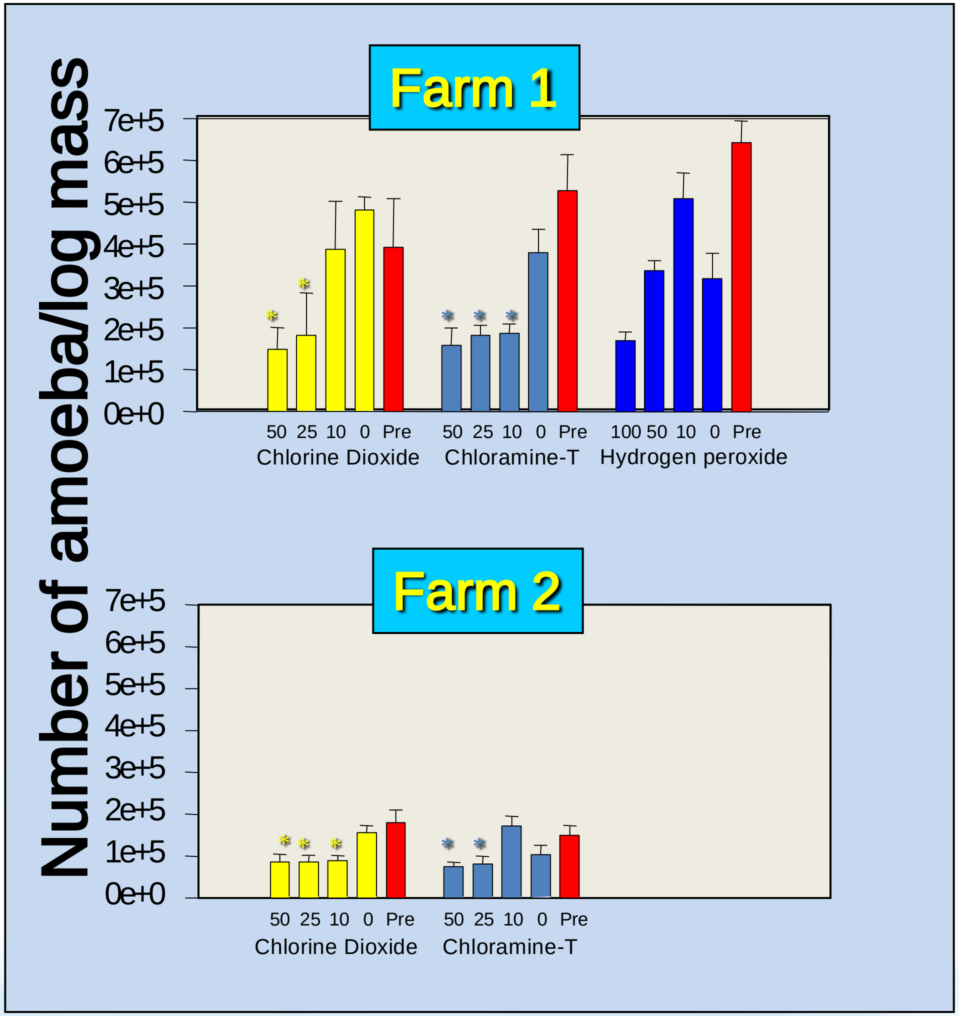
Figure 4 The percent of gill filaments with ameobic gill disease (AGD)-type lesions post bathe (mean ± SE). Different letters indicate significant differences between treatments ($P > 0.05$).

Green et al 2005 Aquaculture Research 36: 398-404

Simplified illustration of water chemistry interactions during freshwater bathing



Efficacy of chemical additives to freshwater baths



Chlorine dioxide and chloramine-T

- Significantly reduce gill amoeba numbers

Hydrogen peroxide < 100 mgl^{-1}

- Results were equivocal

Interactive effects:

- DOC, water chemistry?
- Reactive oxygen based agents are active through the generation of toxic oxy radicals
- The generation of oxy radicals depends in reactive metal concentrations and oganic compounds to enhance breakdown

Powell and Clark (2004) Aquacult Res 35:112-123

Key points for consideration

- Water availability
- Water compostion and chemistry
- Effects of fish metabolism
- Additives to freshwater
- Alternatives to freshwater
- Alternatives to bathing

Thank you for your attention

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