



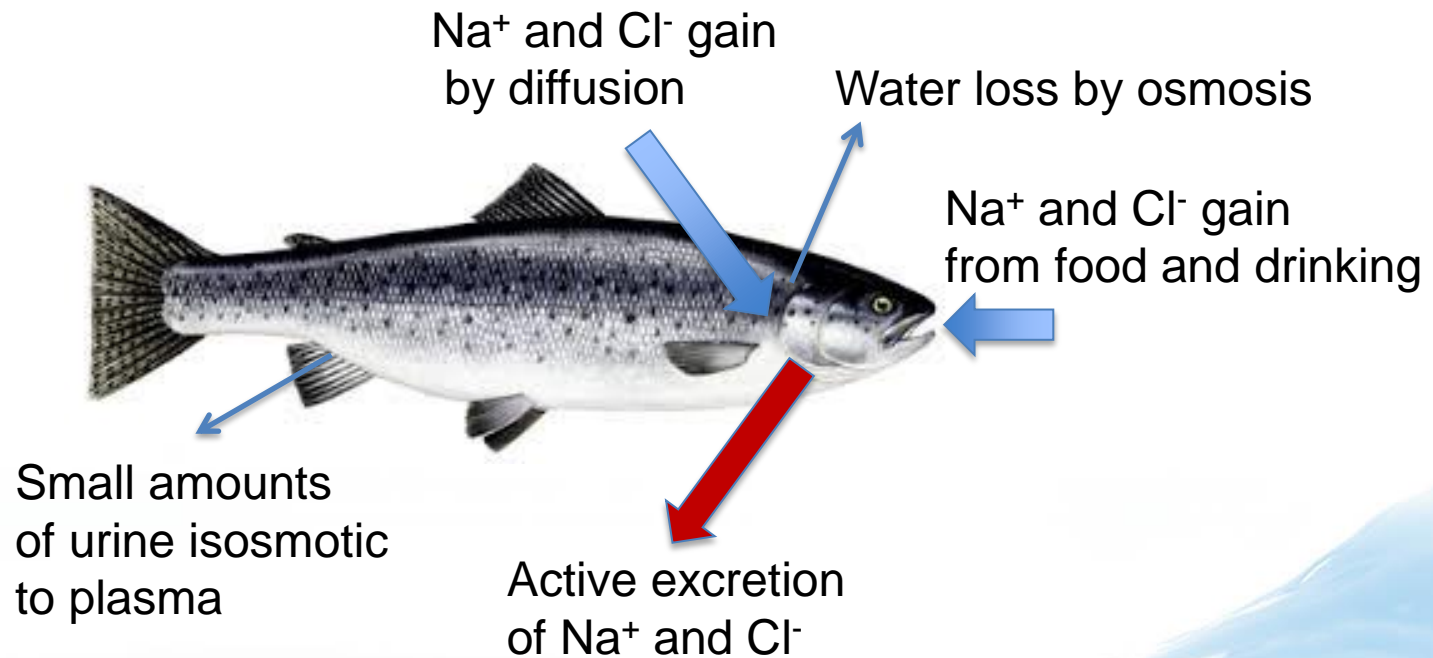
Hvordan opplever laks som har gått i sjøvann behandling med ferskvann? eller What happens when you put a marine salmon into freshwater?

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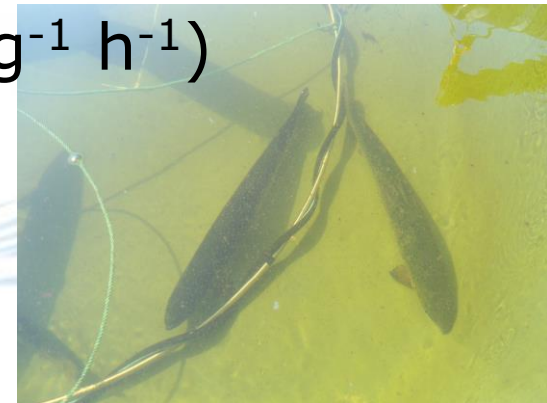
Norwegian Institute for Water Research,
Department of Biology, University of Bergen

Ionic and water movements in a marine salmon

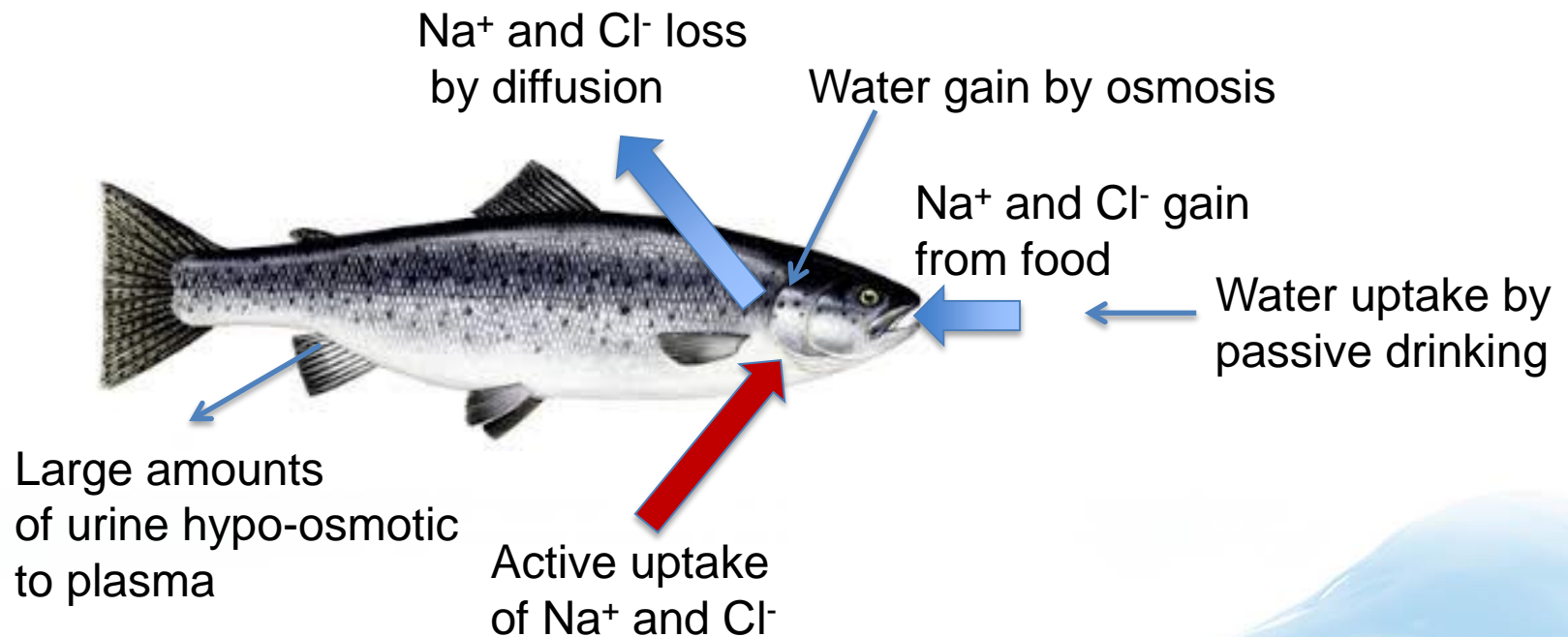


Characteristics of a marine salmon physiology

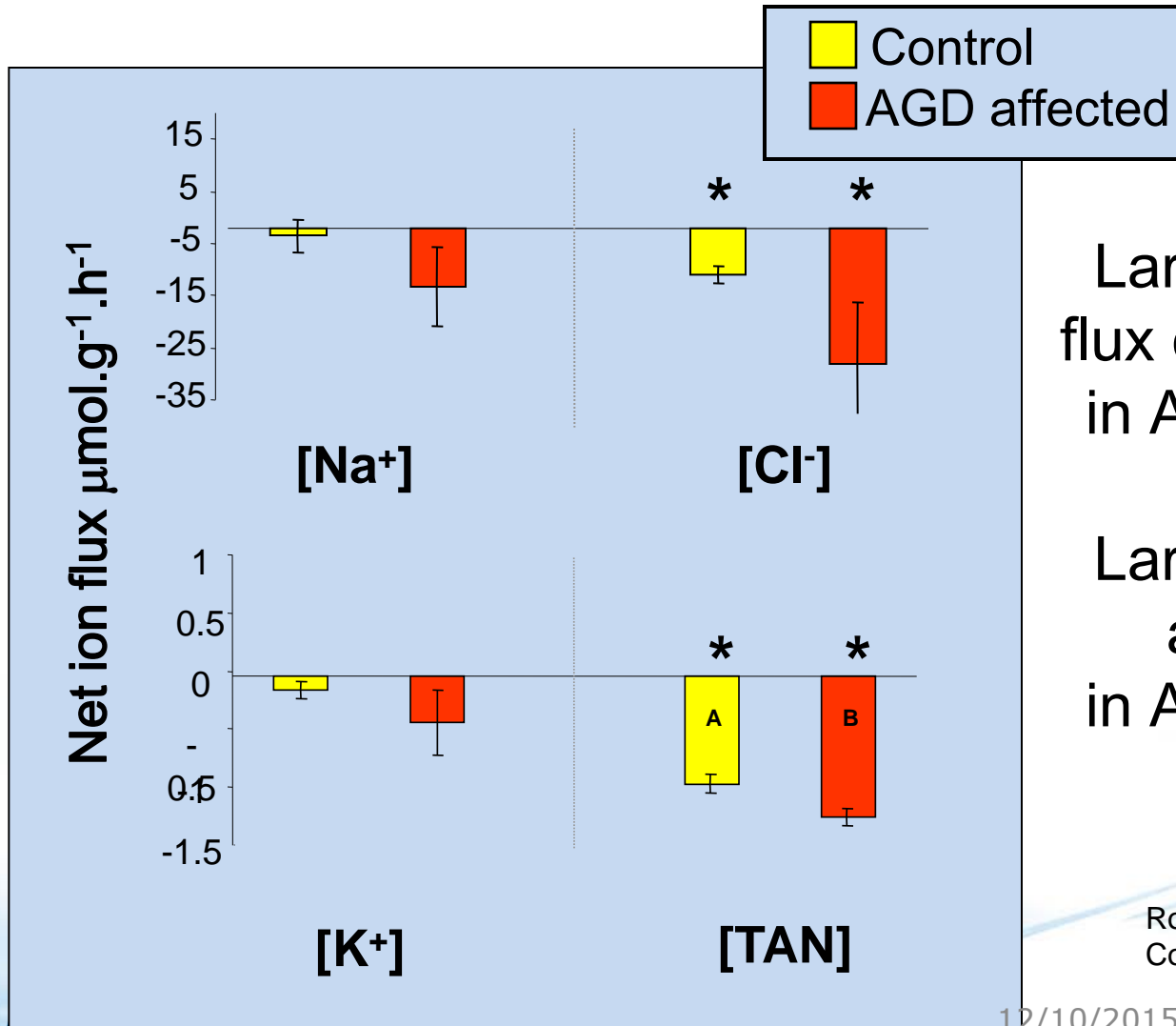
- Gill and skin epithelium is relatively permeable to salts and water
- Active excretion of Na^+ and Cl^- across the gills
 - Chloride cells and accessory cells
- Salt and water uptake across the gut
- Active drinking
- Excretion of Mg^{2+} and SO_4^{2-} across the kidney
- Low volumes ($<5 \text{ ml kg}^{-1} \text{ h}^{-1}$) of isosmotic urine (c.f. freshwater salmonids $>15 \text{ ml kg}^{-1} \text{ h}^{-1}$)



Ionic and water movements in a freshwater salmon



What happens if a saltwater salmon is put into freshwater?



Larger negative net flux of Na⁺, Cl⁻ and K⁺ in AGD affected fish

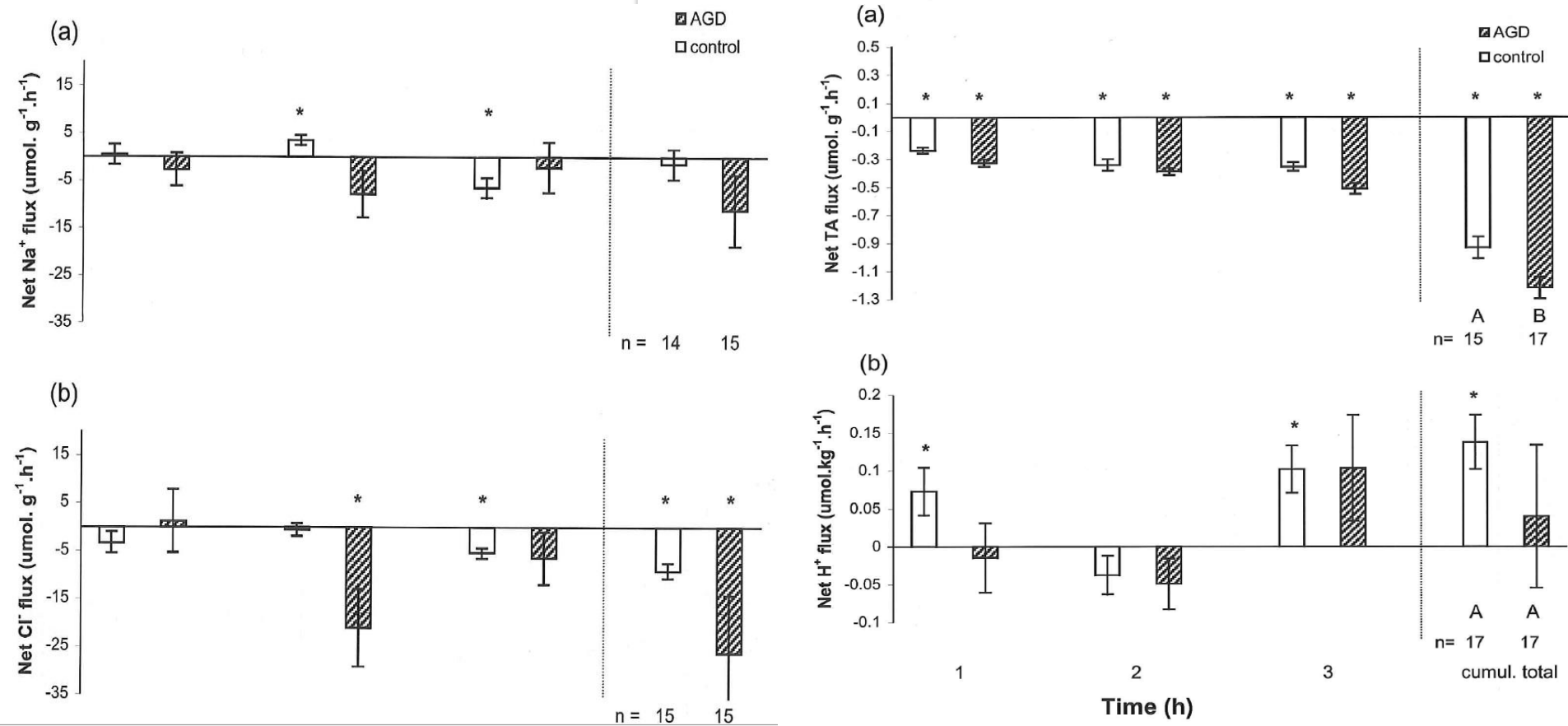
Larger negative net ammonia flux in AGD affected fish

Roberts and Powell (2003)
Comp Biochem Physiol A134: 525-537

Comparative ionic flux and gill mucous cell histochemistry: effects of salinity and disease status in Atlantic salmon (*Salmo salar* L.)

Shane D. Roberts^{a,*}, Mark D. Powell^b

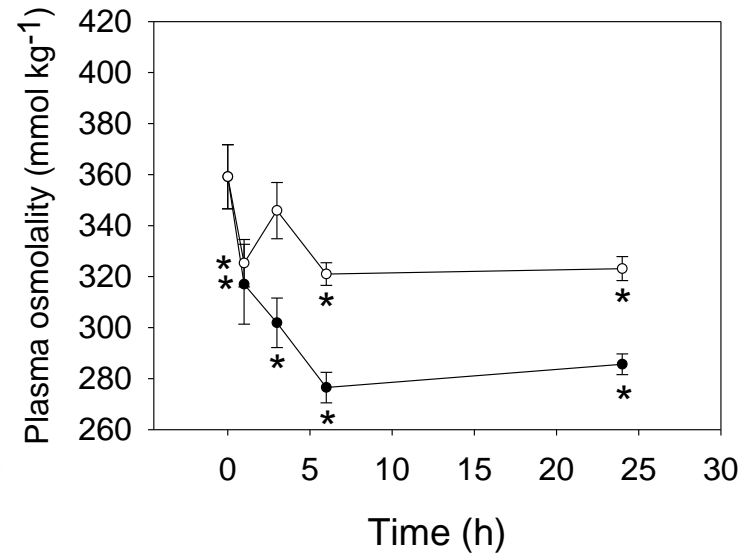
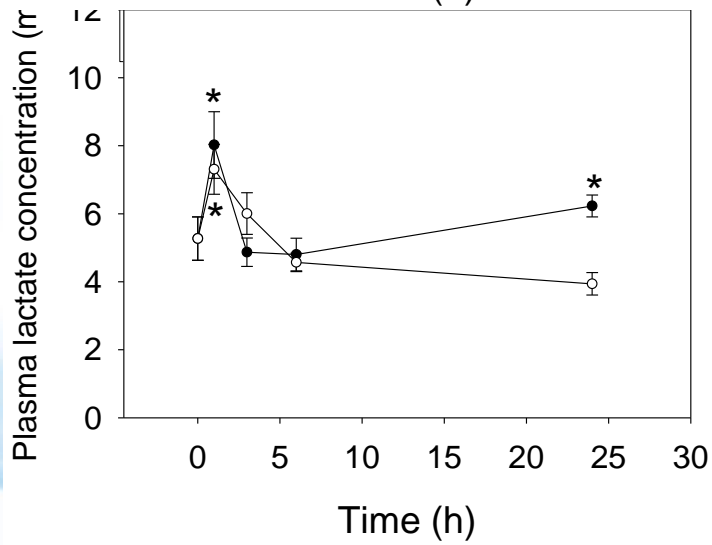
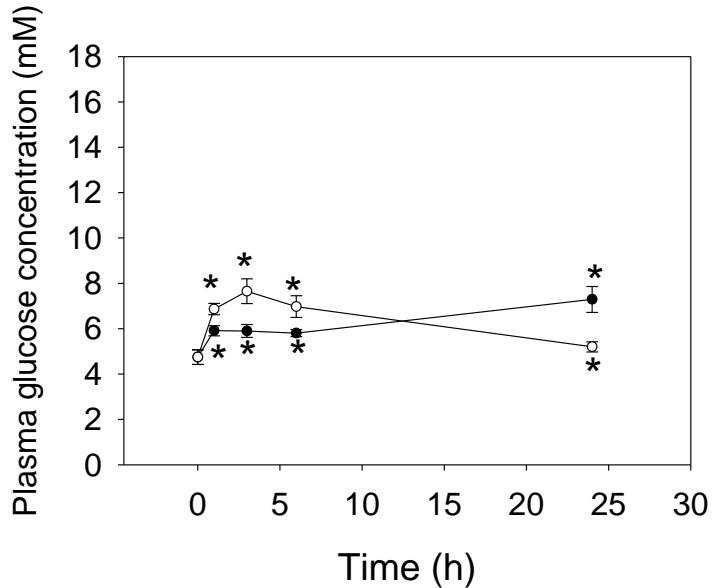
^aSchool of Aquaculture, Tasmanian Aquaculture and Fisheries Institute, University of Tasmania, Locked Bag 1-370, Launceston,



Blood chemistry and stress responses



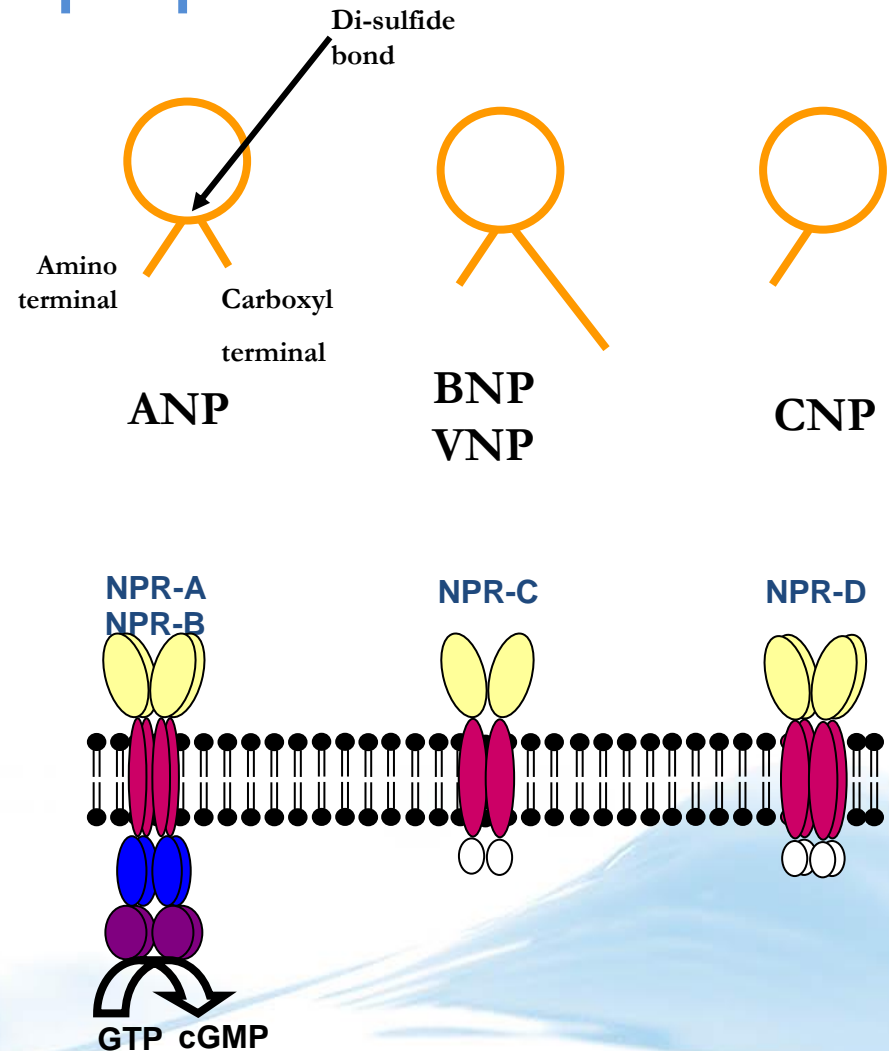
Seawater transfer to freshwater



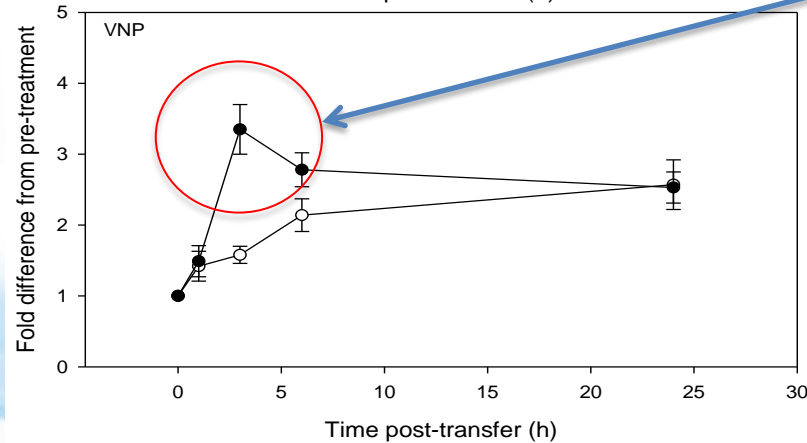
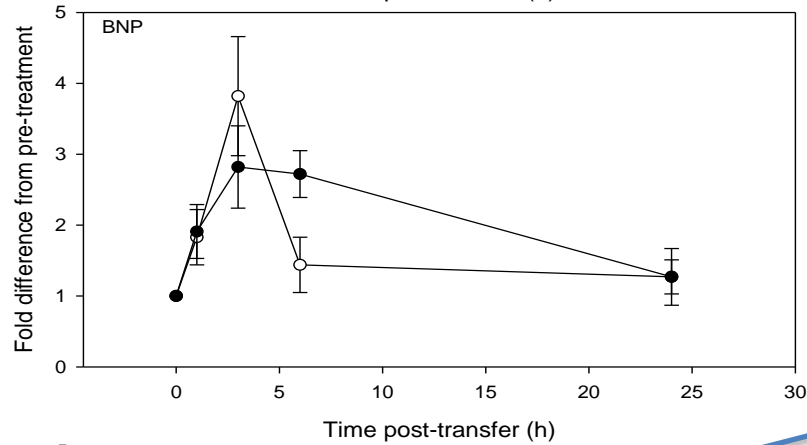
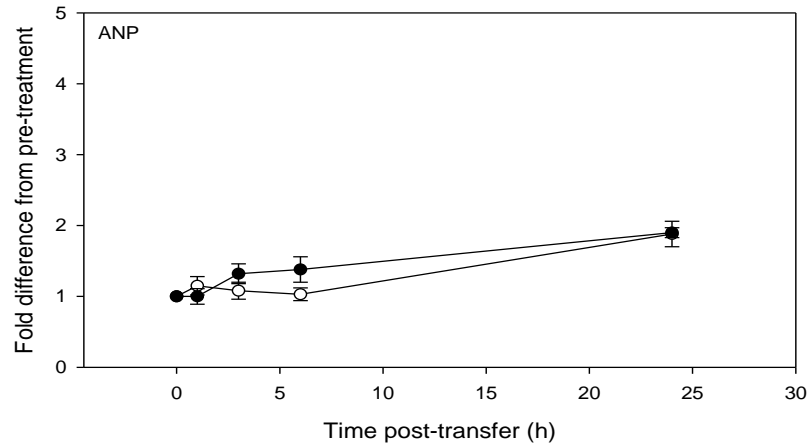
● Seawater-Freshwater
 ○ Seawater-Seawater

Hormonal effects and responses: Natriuretic peptides

- Found in all vertebrates
- Originally discovered in rat atria by deBold (1981)
- Function to maintain salt and water balance (volemia)
 - Lower blood pressure by increasing renal excretion of salt and water and by dilating the blood vessels
- Several different members of natriuretic peptide family, each a separate gene
- Mainly secreted from heart, but brain and other local sites of synthesis also



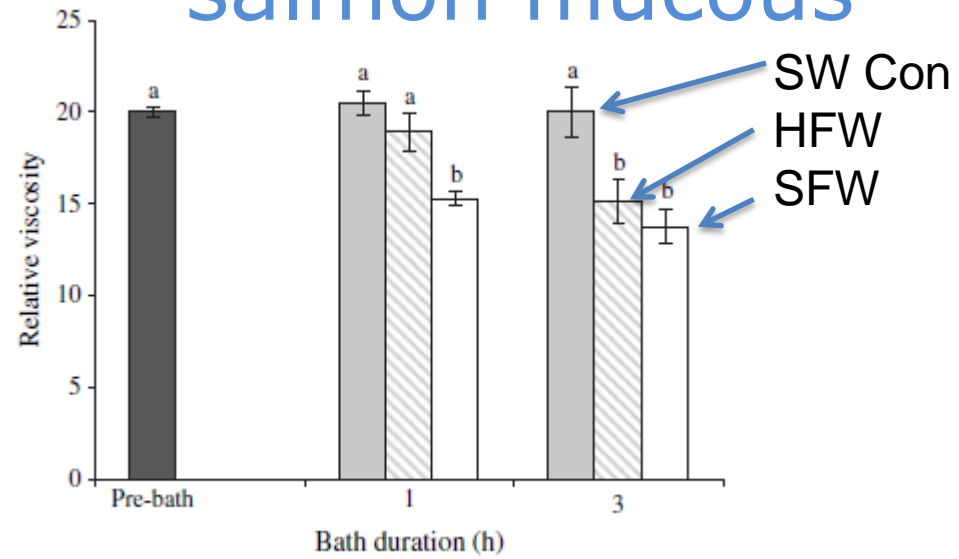
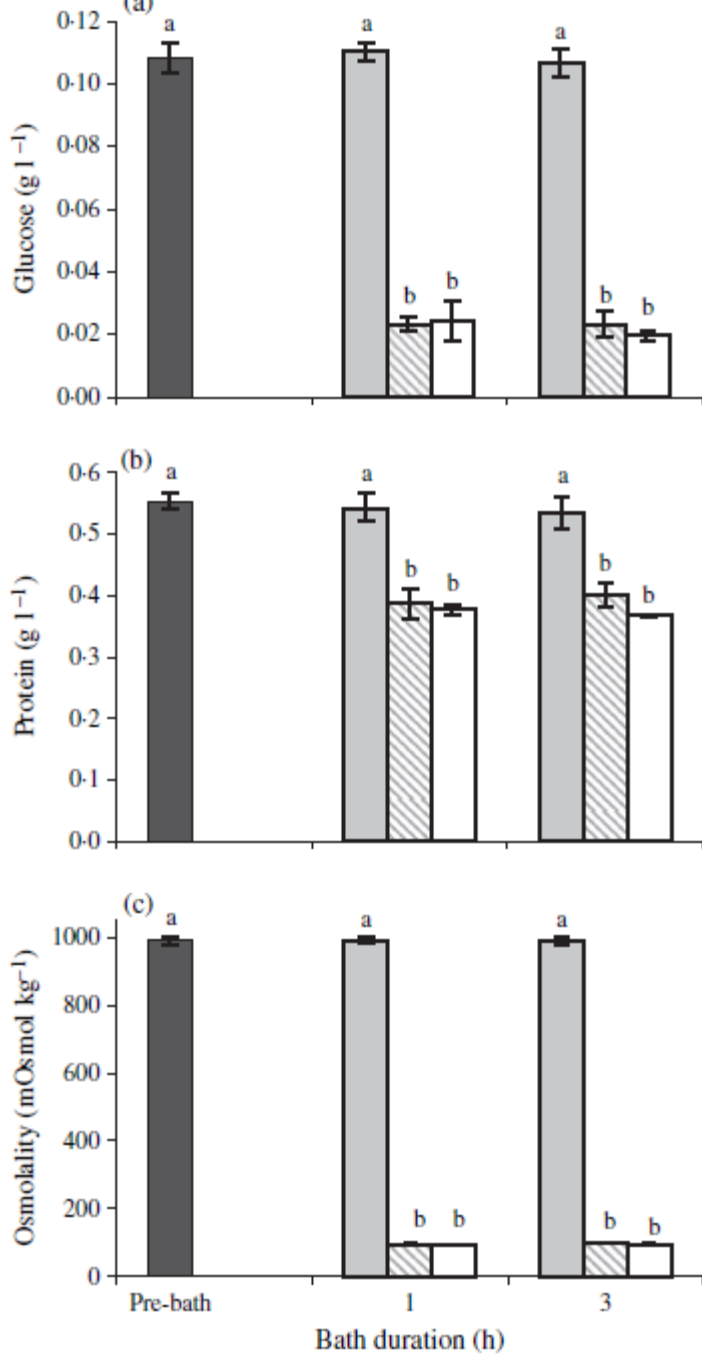
Heart natriuretic peptide response to SW-FW transfer



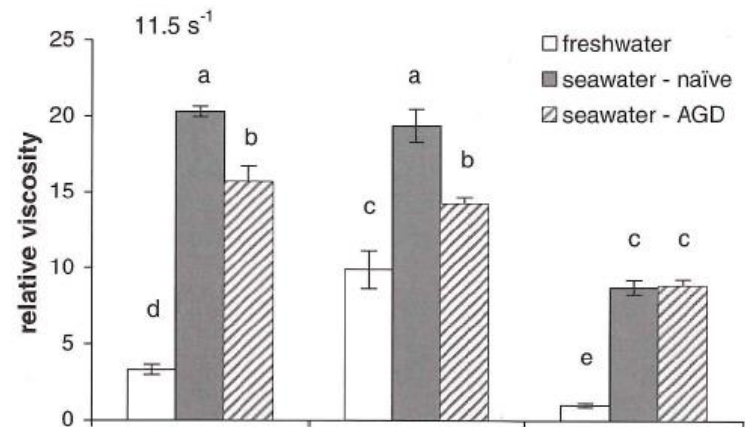
Marked increase in VNP in hypervolemic response

Increased cardiac stretch due to increased blood volume?

Effects of freshwater exposure on marine salmon mucous



The mucous becomes hydrated and less viscous





Effects of FW on sea lice infested salmon



Freshwater treatment of amoebic gill disease and sea-lice in seawater salmon production: Considerations of water chemistry and fish welfare in Norway

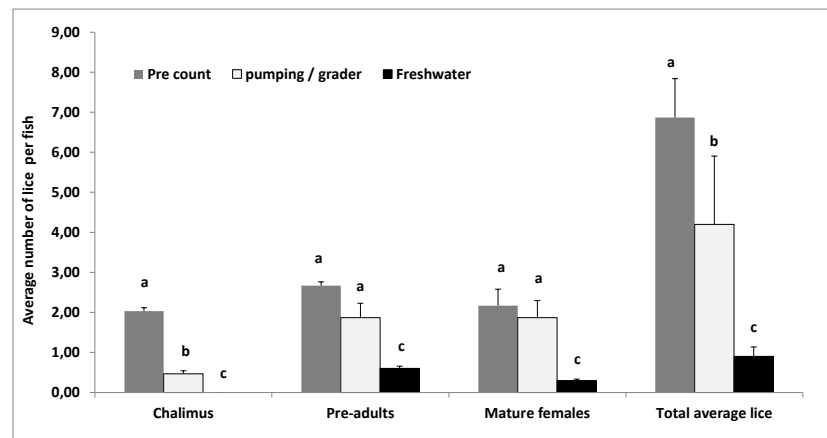
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^a Norwegian Institute for Water Research, Thormøhlens gate 53D, 5006 Bergen Norway

^b Gildeskål Forskningsstasjon AS, 8140 Imndyr, Norway

^c Faculty of Biosciences and Aquaculture, University of Nordland, PO Box 1490, Bodø Norway

Treatment	Na ⁺ mM	K ⁺ mM	TCO ₂ mM	Glucose mg/L	Hct %	pH
Pre	155.1 ^a (± 0.7)	4.06 (± 0.24)	9.6 (± 0.4)	78.9 ^a (± 2.2)	26.9 ^a (± 1.0)	7.353 ^a (± 0.033)
1h 1x handling	152.6 ^a (0.6)	3.56 (0.18)	10.6 (0.9)	97.4 ^b (3.8)	27.4 ^a (0.9)	7.213 ^b (0.045)
1h 2xhandling	162.4 ^b (2.5)	4.16 (0.30)	10.8 (0.8)	96.6 ^b (4.4)	27.6 ^a (1.9)	7.202 ^b (0.018)
15 min 1x handling	158.6 ^a (0.7)	3.02 (0.37)	10.2 (0.5)	91.4 ^b (3.0)	31.6 ^b (0.8)	7.119 ^b (0.019)
15 min 2x handling	166.4 ^b (1.3)	4.24 (0.72)	9.0 (0.7)	89.0 ^a (3.5)	31.0 ^a (0.8)	7.145 ^b (0.038)

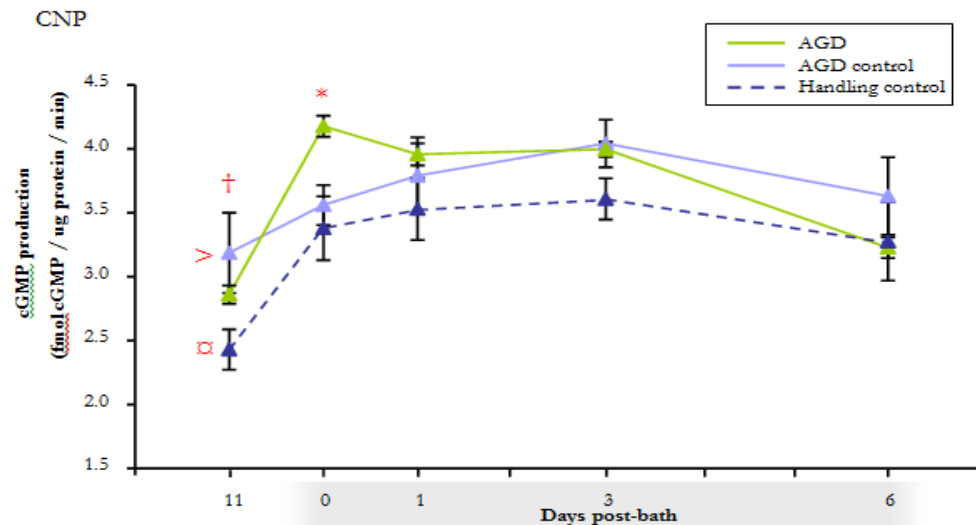
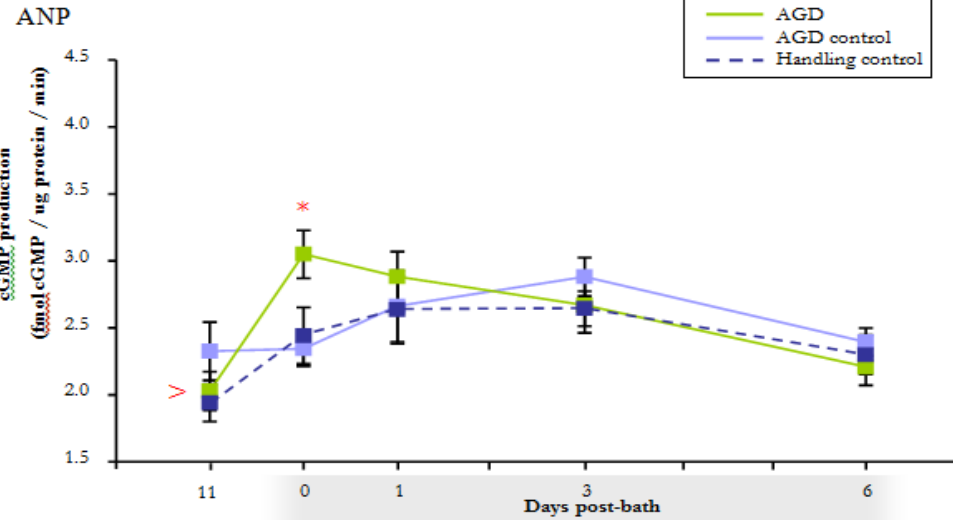
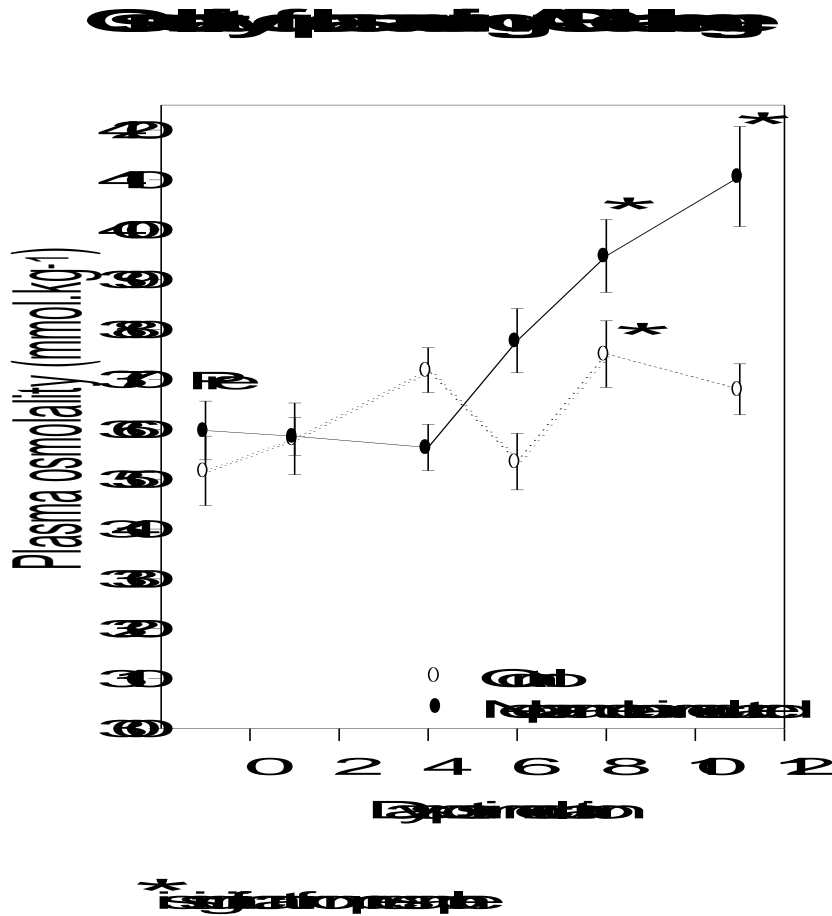


Indicate stress responses to handling

Fish handled back into seawater



Natriuretic peptide responses in AGD affected gills



Effects of acute freshwater exposure on hyperplastic gill lesions

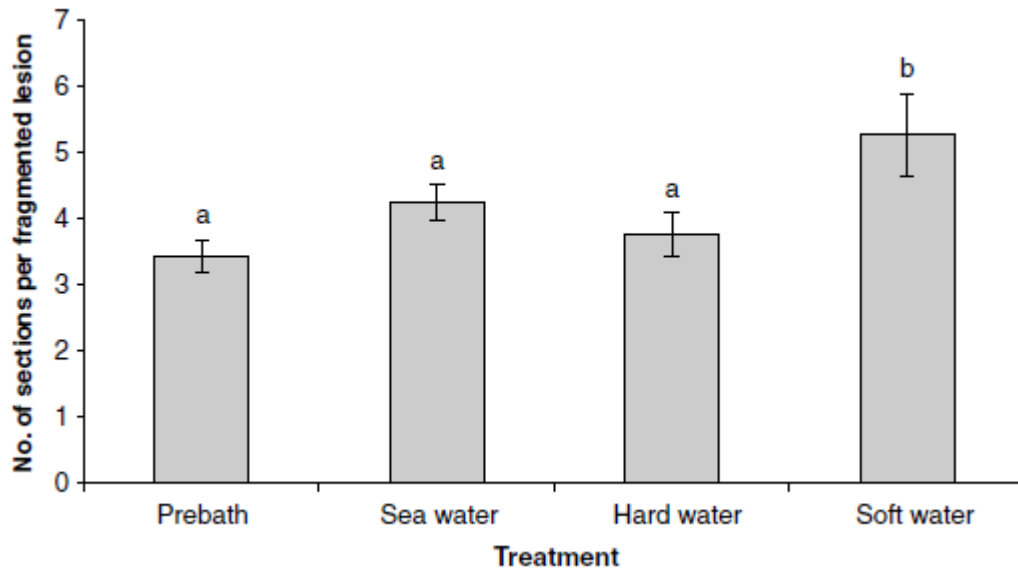


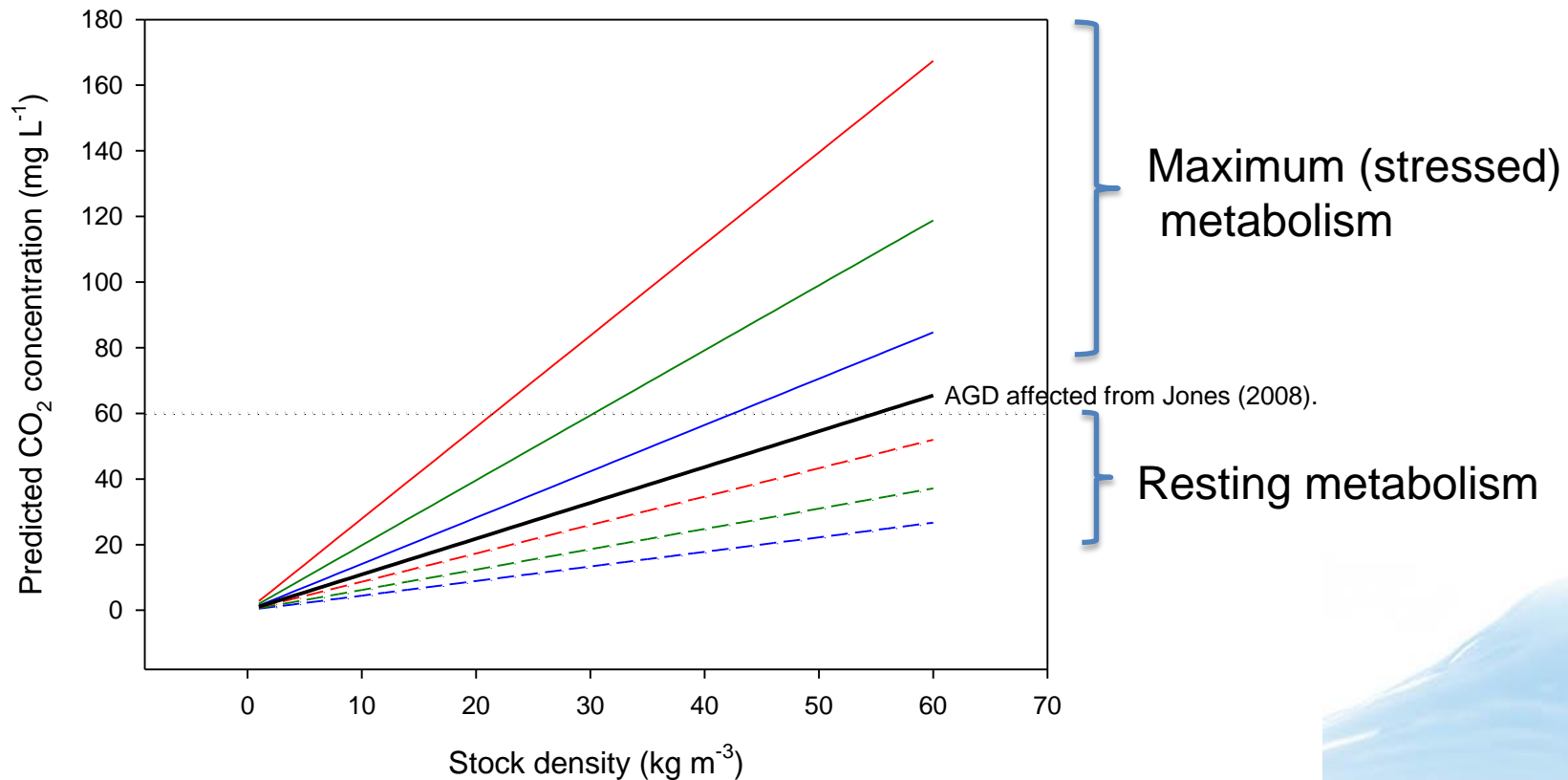
Figure 3 Degree of lesion fragmentation (no. sections per fragmented lesion) (mean \pm SE) on the gills of Atlantic salmon pre- and post-3-h bathing ($n = 9$ per treatment). This data is from the laboratory experiment. Letters indicate significant differences when compared with pre-bath controls ($P < 0.05$).

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

CO₂ predictions for salmon at different stocking densities



— 15°C — 10°C — 5°C



Source: NIVA report 2015
Behandling av amøbegjellesykdom i brønnbåt

Conclusions: Acute freshwater transfer

- Acute ion losses
 - Corrected within 3 h
 - Losses greater in AGD affected fish
- Acute hypervolemia
 - Stimulation of NP release (VNP)
 - Up-regulation of NPRs in the gills: cardioprotective
- Hydration of mucus
 - Changes in protein and carbohydrate composition
 - Reductions in viscosity
- Handling effects more evident than osmotic effects
- Fracturing of hyperplastic tissue (osmotic shock)

Thank you for your attention

- Acknowledgements
 - Australian Research Council
 - Deakin Univeristy – Prof. Tes Toop
 - Aquafin CRC
 - Univeristy of Tasmania
 - University of Nordland - Prof. Torstein Kristensen
 - GIFAS – Dr Pat Reynolds
 - FHF