Norway's leading multidisciplinary environmental research institute in the field of use and protection of water bodies and water quality

Pathology of non-infectious gill diseases

Mark D. Powell, Trine Dale, Bjørn Olav Rosseland

Norwegian Institute for Water Research, NIVA

Mark.Powell@niva.no

*"The science of the **causes and effects of diseases**, especially the branch of medicine that deals with the laboratory **examination** of samples of body **tissue for diagnostic or forensic purposes**"*

source Oxford English dictionary:

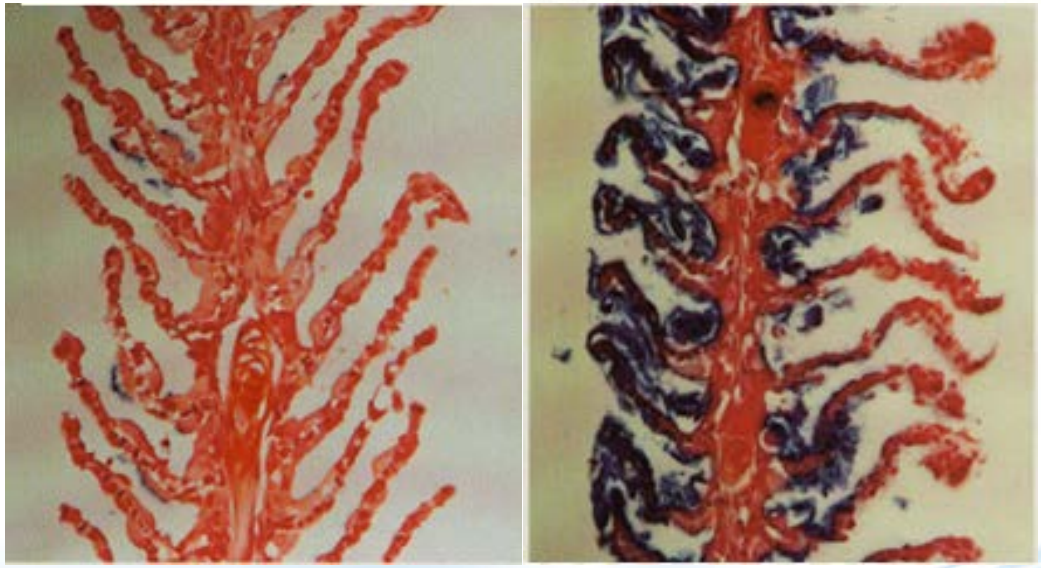
- What can cause adverse effects to gill surface and function other than parasites, bacteria and virus?
- Metals, mainly inorganic low molecular mass (LMM) species
  - Al, Fe, Cu, Ag
  - Morphological effects, physiological effects
- Chemicals and gasses
  - NH_3, Chlorine, N_2, H_2O_2
- Particles with sharp edges
  - Silicates, inorganic particles, organic particles (diatoms)
- Toxins
  - Cyanobacteria, algae, jellyfish
- Others….

The fish gill has become our most important single biomarker for metal toxicity!

Environmental Pollution **78** (1992) 3–8

The mixing zone between limed and acidic river waters: complex aluminium chemistry and extreme toxicity for salmonids

B. O. Rosseland,[a] I. A. Blakar,[b] A. Bulger,[c] F. Kroglund,[a] A. Kvellstad,[d]
E. Lydersen,[e] D. H. Oughton,[f] B. Salbu,[g] M. Staurnes[h] & R. Vogt[i]



"Blue" = Al

Estuarine Mixing Zone with Mobilization of Ali from Alo by increased ionic strength in sea

Both an acid, limed and humic river create Estuarine mixing zones!

Limed River

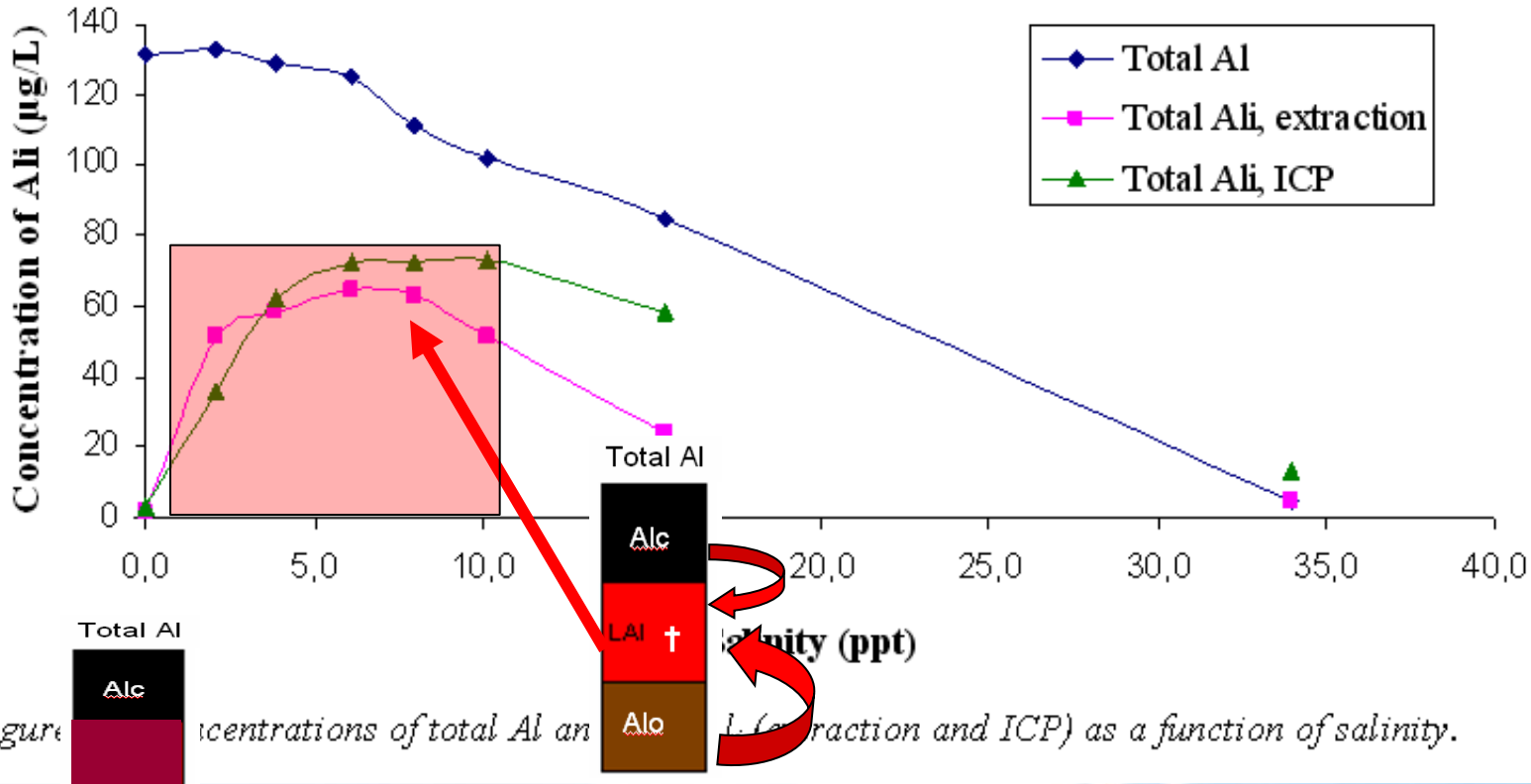
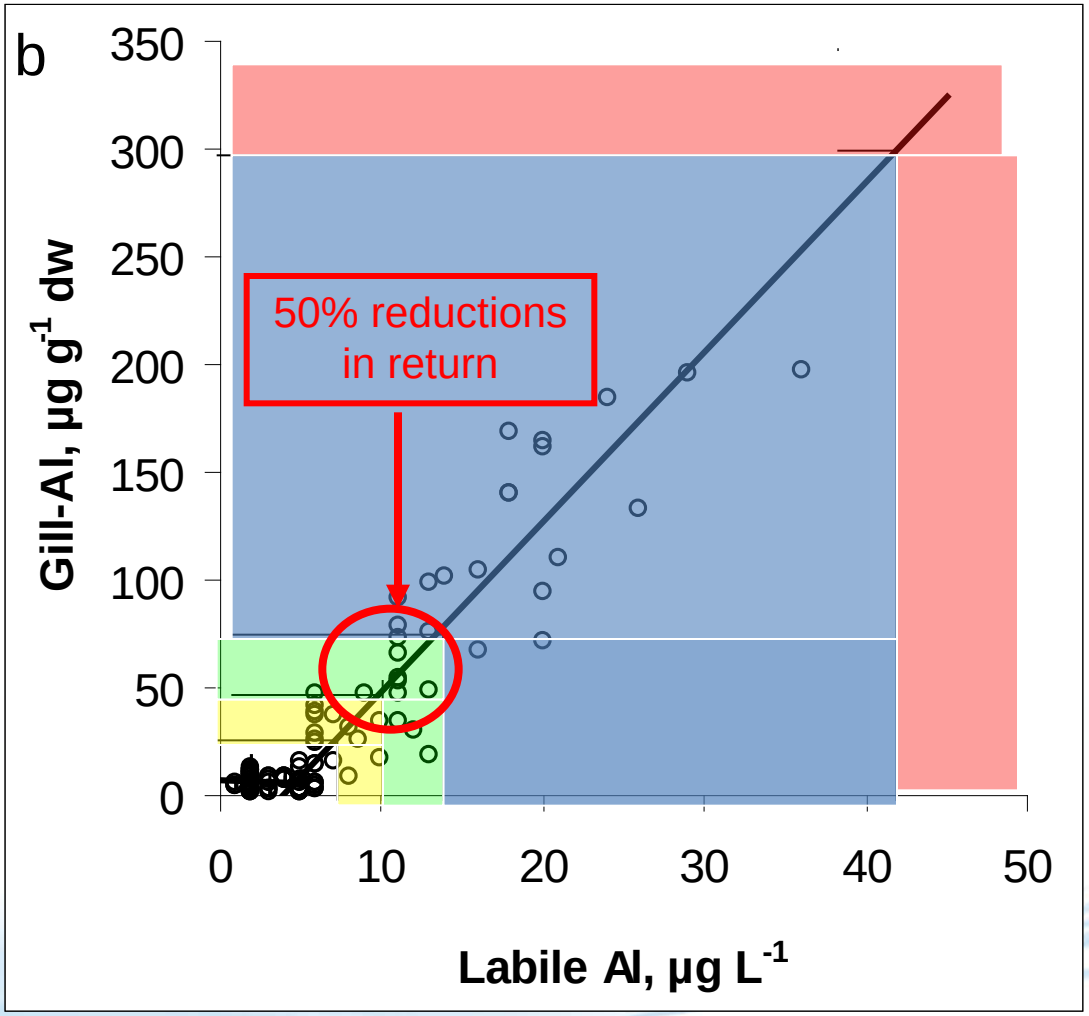


Figure … concentrations of total Al an… l (extraction and ICP) as a function of salinity.

Skalsbakken 2009

Critical levels of Al in water and gill, relative to smolts



Mortality FW

Reduced Plasma Cl

Increased Glucose

Reduced α1b Na-K-ATPase

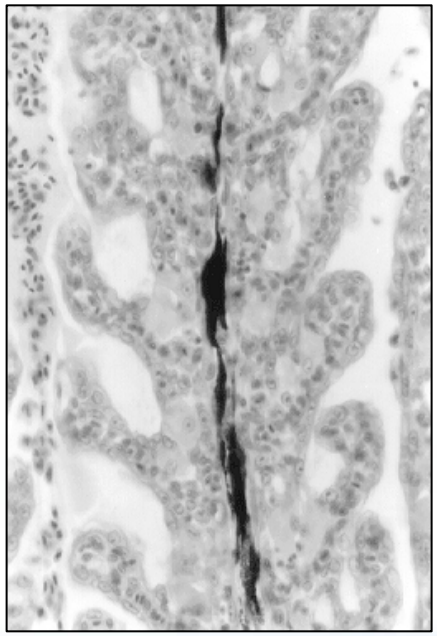
Kroglund et al. 2006

Estuarine Al problems also affects marine fish

Turbot are also affected by Al in estuarine mixing zones (10 ‰)

Gills from turbot (*Psetta maxima*)

Al-exposed



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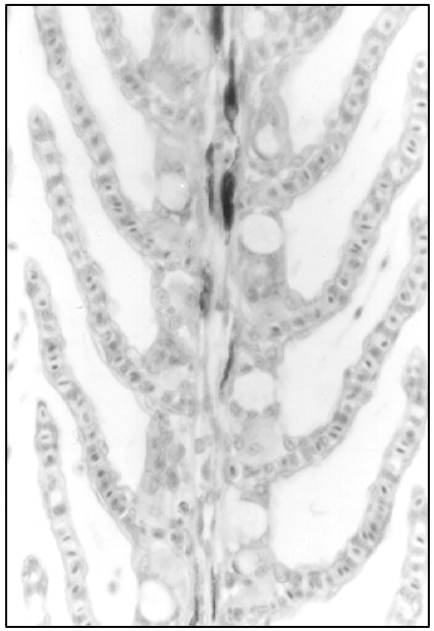


Rosseland et al. 1998

Ag accumulation on fish gills

Aquatic Toxicology 108 (2012) 78–84

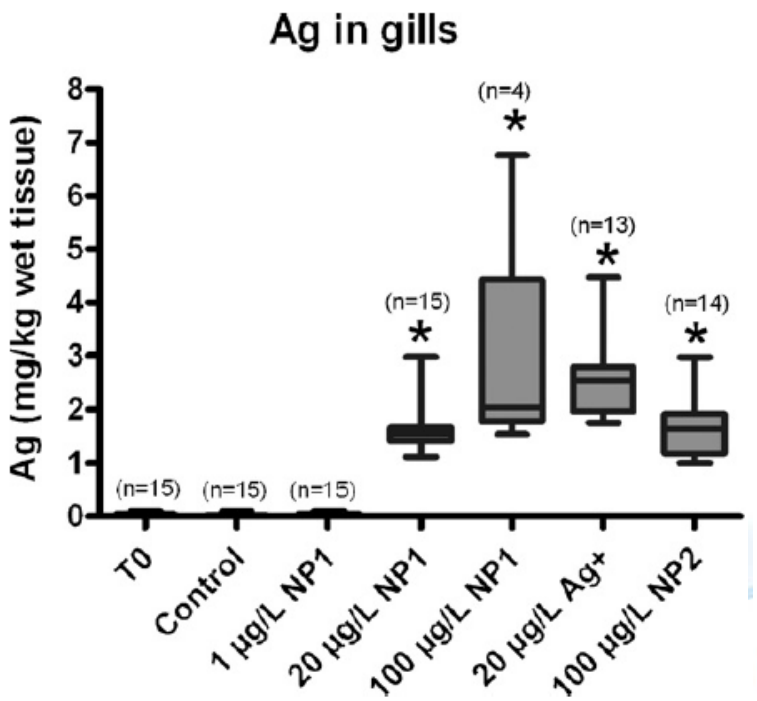
Contents lists available at ScienceDirect

Aquatic Toxicology

journal homepage: www.elsevier.com/locate/aquatox

Acute and sub-lethal effects in juvenile Atlantic salmon exposed to low µg/L concentrations of Ag nanoparticles

E. Farmen[a,b,*], H.N. Mikkelsen[a], Ø. Evensen[c], J. Einset[a], L.S. Heier[a], B.O. Rosseland[a], B. Salbu[a], K.E. Tollefsen[a,b], D.H. Oughton[a]



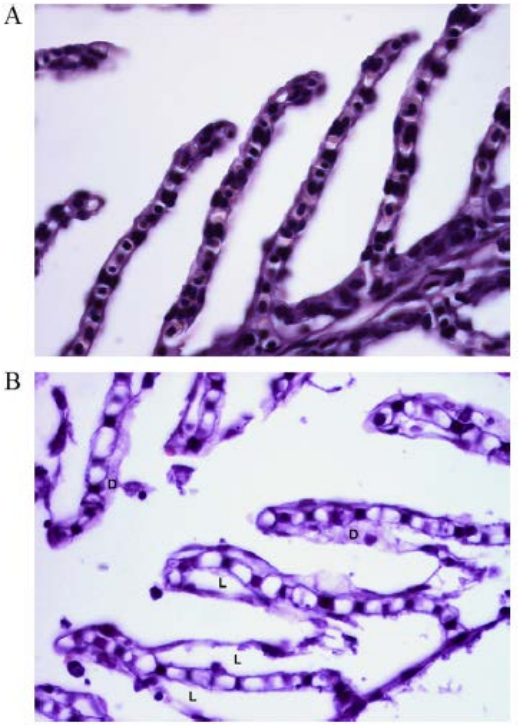
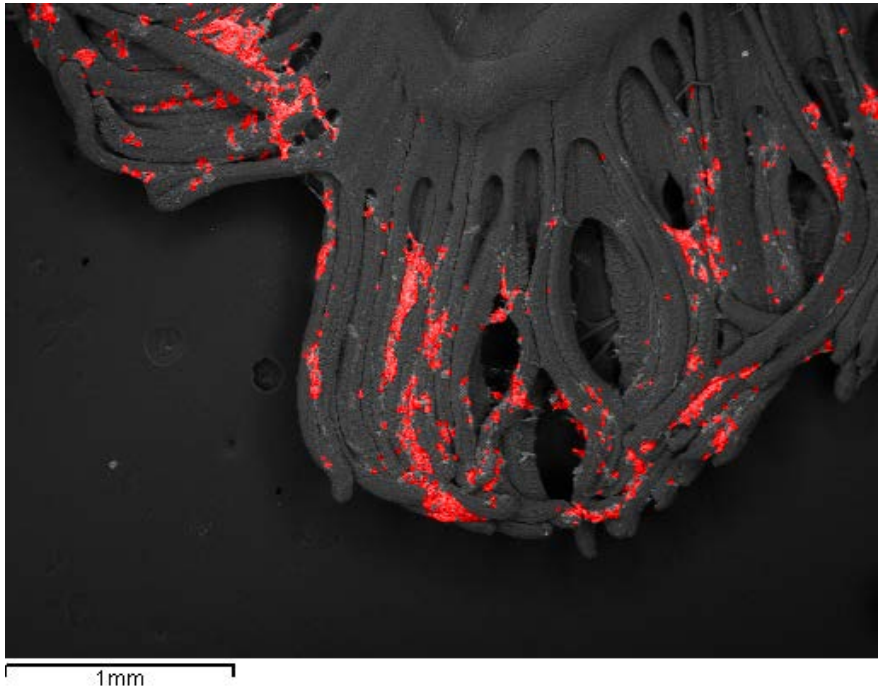
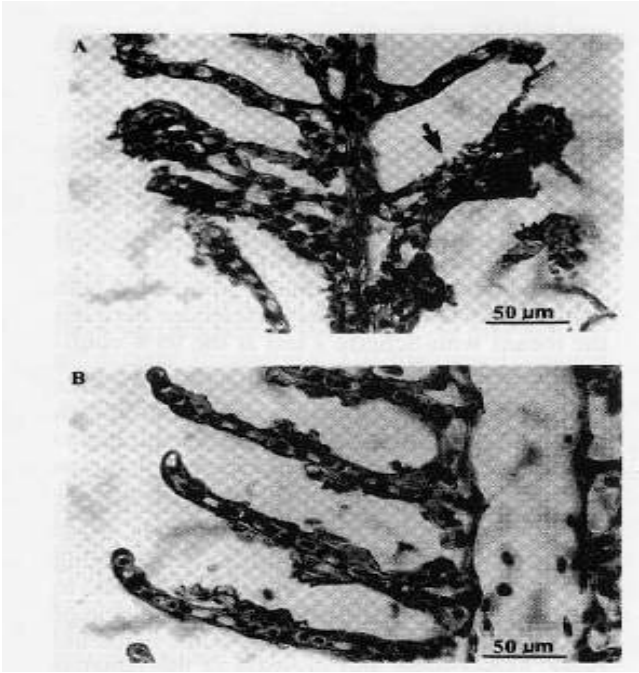


Fig. 3. Gill histology showing (A) normal secondary gill lamellae. In fish exposed to 100 µg/L of the commercial Ag-NP (NP1) (B) the epithelial lining of the secondary

Fe accumulation on gills of fish



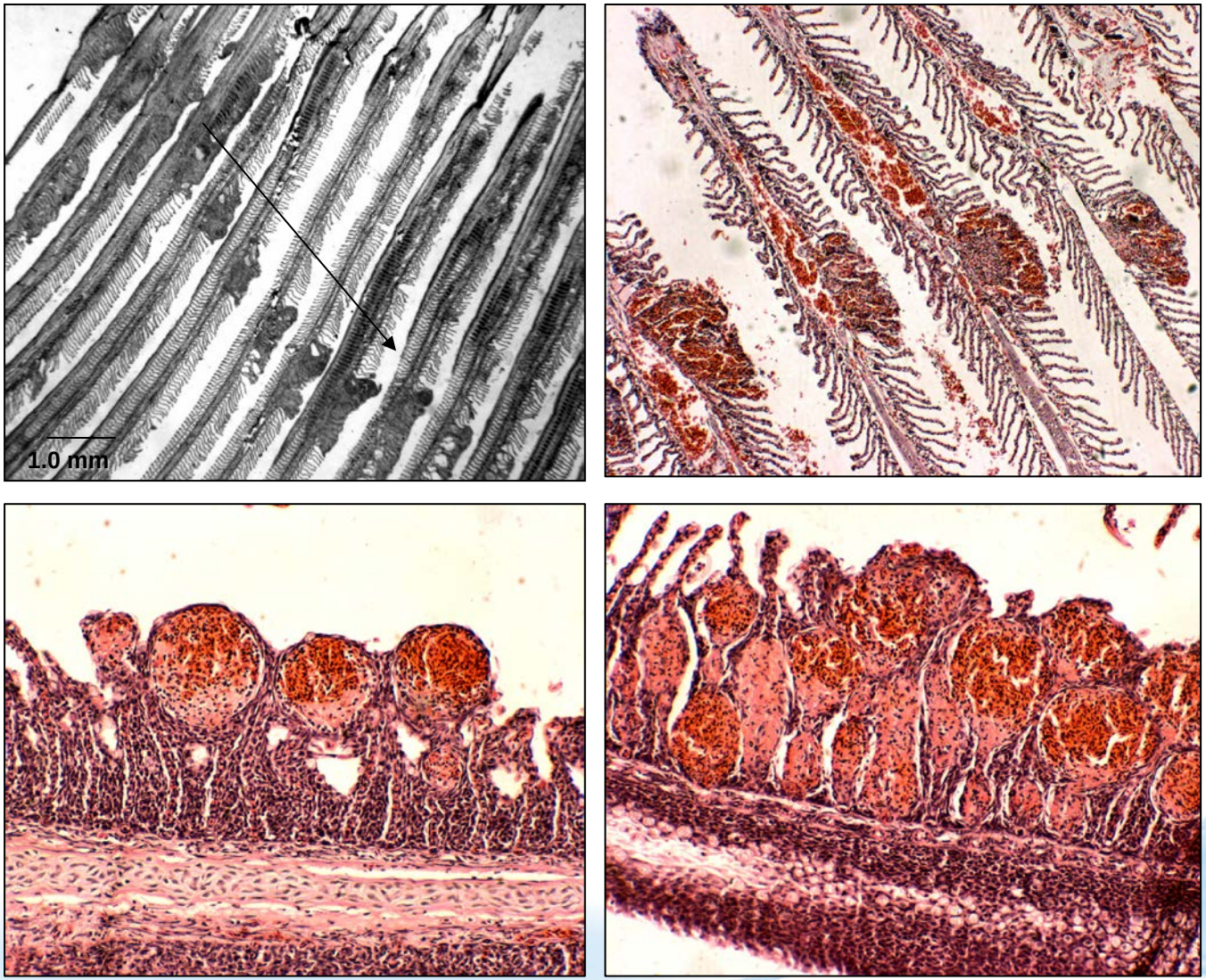
- The mapping of Fe (scanning electron microscopy with x-ray microanalyses) demonstrates deposition of Fe on gills after exposure of Atlantic Salmon to 200 µg Fe^{2+} /L for 120 hrs at pH 7.5. (Skryseth 2007)



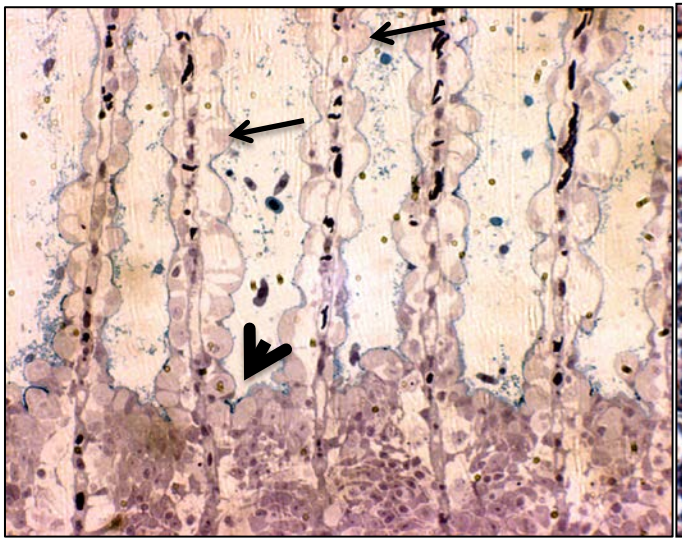
Peuranen et al. 2001

- Gill damage of brown trout due to two days Fe exposure to Fe at pH 5, A) without and B) with humic acids. (Peuranen et al. 2001)

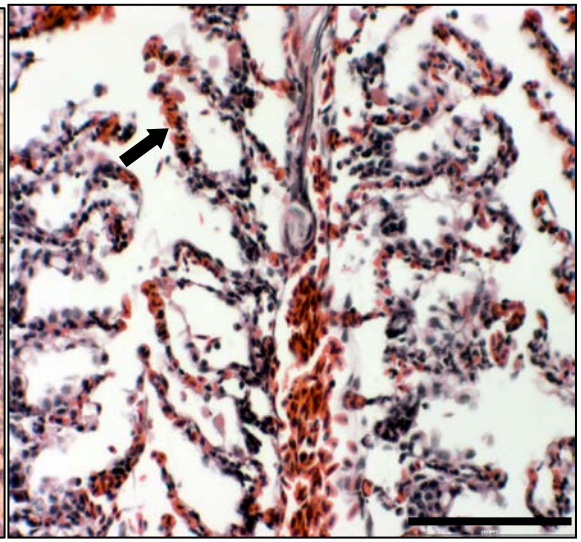
Acute Trauma



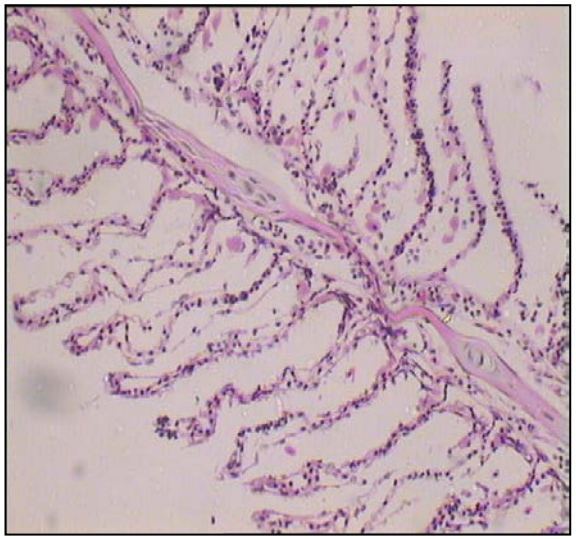
Oxidative and other chemicals



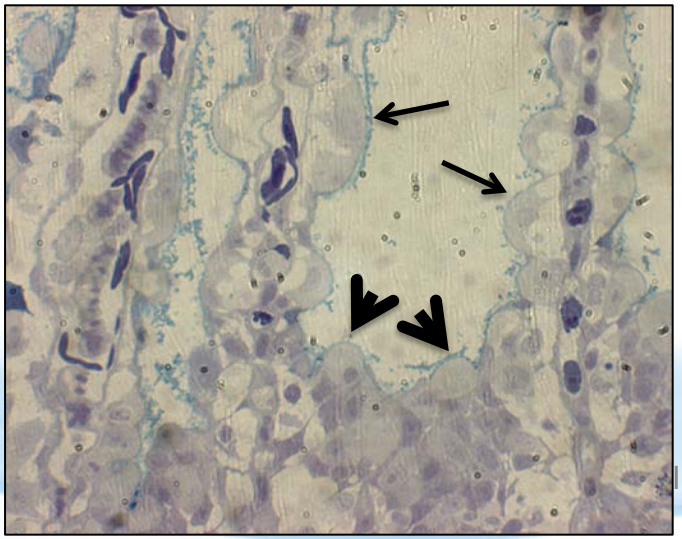
RBT 200% Oxygen

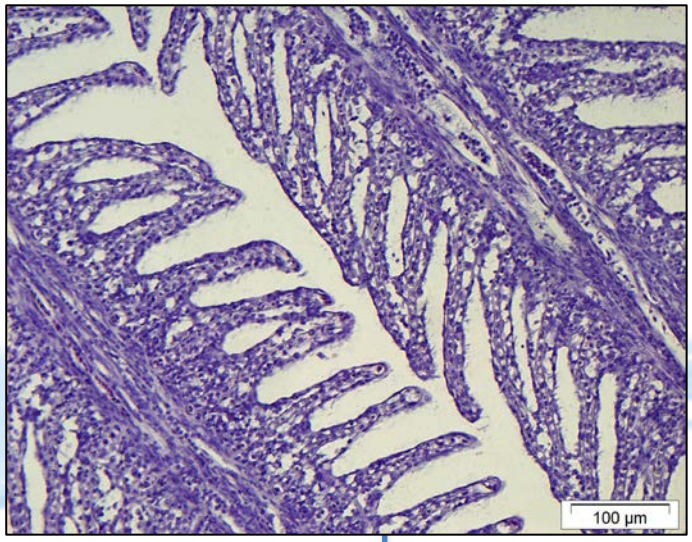


AS 30 mg L^{-1} CLT



AS 100 mg L^{-1} H_2O_2

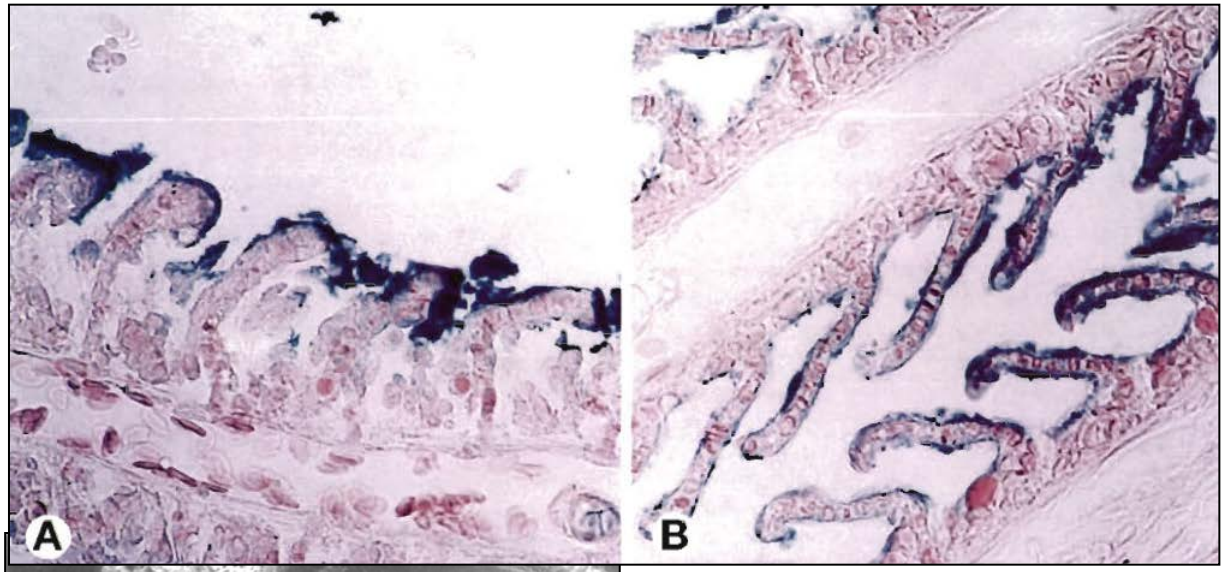


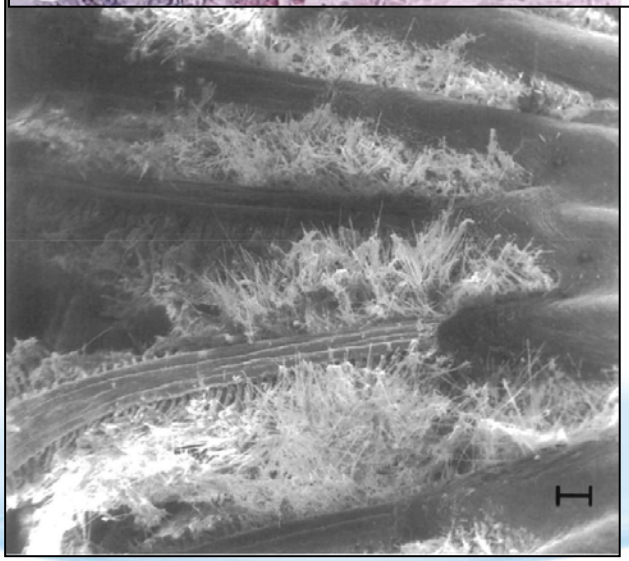


AC
Formalin 2000 ppm

HAB: *Chaetoceros concavicornis*

Photo: www.google.no





Chaetoceros spines cause direct trauma to the brachial epithleium

Eliciting acute mucous response

Yang and Albright 1995 Dis Aquat Org 20: 197-202

HAB: *Skeletonema costatum (NIVA-BAC1)*

Experimental exposure
Atlantic salmon smolt

Control – unexposed
Day 1: 6 h at $3x10^6$ cells L^{-1}
Day 2: 6 h at $6x10^6$ cells L^{-1}

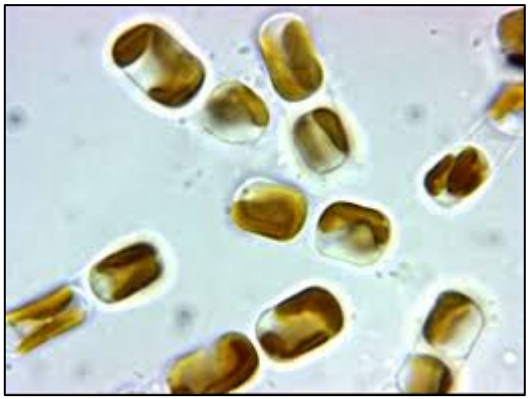
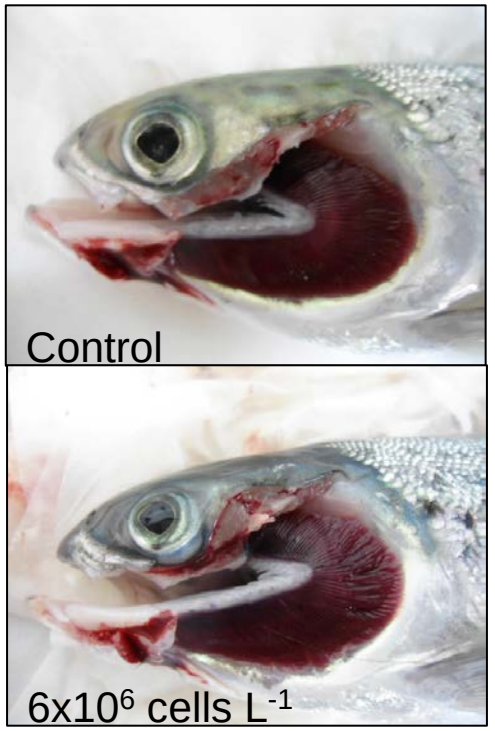
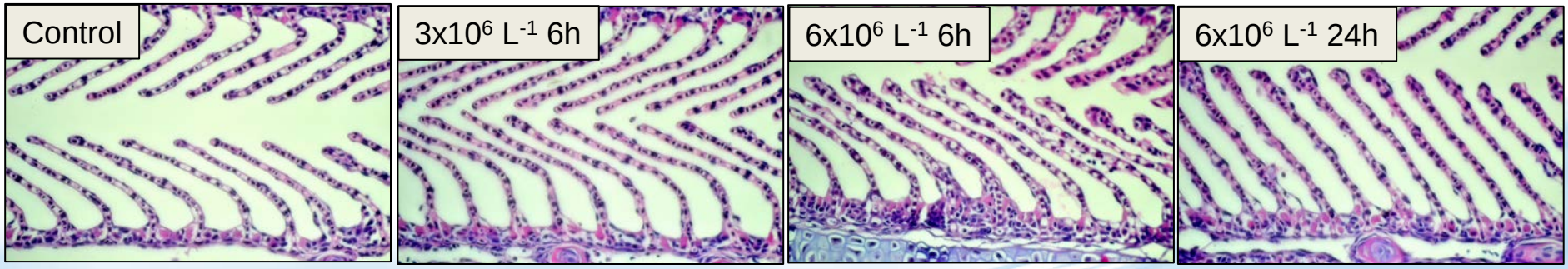


Photo: www.google.no





Sediments – No effect

Journal of Great Lakes Research 40 (2014) 141–148

Contents lists available at ScienceDirect

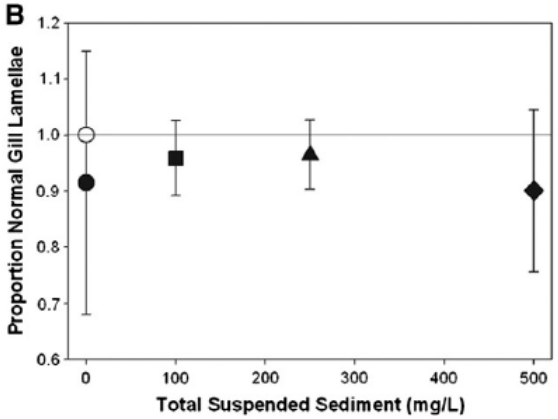
Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

Suspended sediment effects on walleye (*Sander vitreus*)

Burton C. Suedel [a,*], Joan U. Clarke [a,1], Charles H. Lutz [a,2], Douglas G. Clarke [a,3], Céline Godard-Codding [b,4], Jonathan Maul [b,5]

[a] US Army Corps of Engineers, Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS 39180, USA
[b] Department of Environmental Toxicology, The Institute of Environmental and Human Health, Texas Tech University, Box 41163, Lubbock, TX 79409-1163, USA



Suspended sediment pulse effects in rainbow trout (*Oncorhynchus mykiss*) — relating apical and systemic responses

Full Text
PDF (1089 K)
PDF-Plus (640 K)

Christian Michel,[a] Heike Schmidt-Posthaus,[b] Patricia Burkhardt-Holm[c]

[a]Man–Society–Environment (Programm MGU), Department of Environmental Sciences, University of Basel, Basel, Switzerland.

[b]Centre for Fish and Wildlife Health, Institute of Animal Pathology, University of Bern, Bern, Switzerland.

[c]Man–Society–Environment (Programm MGU), Department of Environmental Sciences, University of Basel, Basel, Switzerland; Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada.

Corresponding author: Christian Michel (e-mail: christian.michel@unibas.ch and ch.mi@web.de).

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Aquaculture
Volume 273, Issues 2–3, 18 December 2007, Pages 269–276
Smolt 2005: Proceedings of the 7th International Workshop on Salmonid Smoltification

Effect of daily oscillation in temperature and increased suspended sediment on growth and smolting in juvenile chinook salmon, *Oncorhynchus tshawytscha*

J. Mark Shrimpton[a], Joseph D. Zydlewski[b], John W. Heath[c]

Show more

http://dx.doi.org/10.1016/j.aquaculture.2007.10.009

Table 1
Length, weight, gill Na^+,K^+-ATPase activity, and gill chloride cell size and density for juvenile chinook salmon sampled on June 12

Group	Length[1]	Weight[2]	Na^+,K^+-ATPase	Chloride cell	
			Activity[3]	Size[4]	Density[5]
C	8.1±0.1	5.79±0.27	3.29±0.26	130.9±9.6	1.61±0.05
T	8.2±0.1	6.16±0.34	3.61±0.37	113.1±15	1.63±0.07
S	8.0±0.1	5.29±0.21	2.64±0.33	83.1±4.6	1.43±0.07
T×S	7.8±0.1	5.12±0.18	2.35±0.29	87.6±8.1	1.48±0.06

Sediments – negative effect

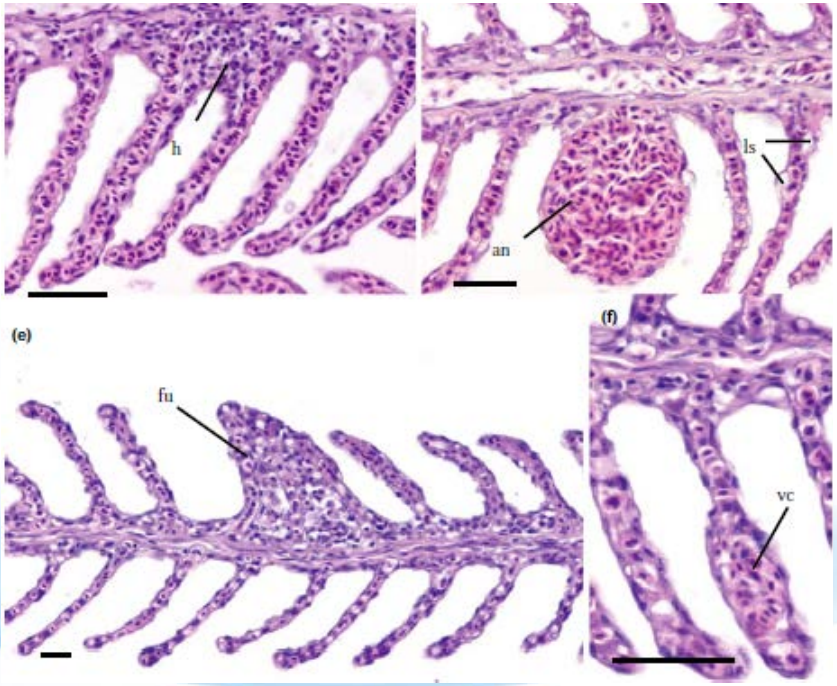
Aquaculture Research

Aquaculture Research, 2013, 44, 1685–1695 doi: 10.1111/j.1365-2109.2012.03173.x

Gill damage to juvenile orange-spotted grouper *Epinephelus coioides* (Hamilton, 1822) following exposure to suspended sediments

Chong Kim Wong, Ivy Ah Pan Pak & Xiang Jiang Liu
School of Life Sciences, The Chinese University of Hong Kong, Hong Kong, China

Correspondence: C K Wong, School of Life Sciences, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong, China. E-mail: chongkimwong@cuhk.edu.hk

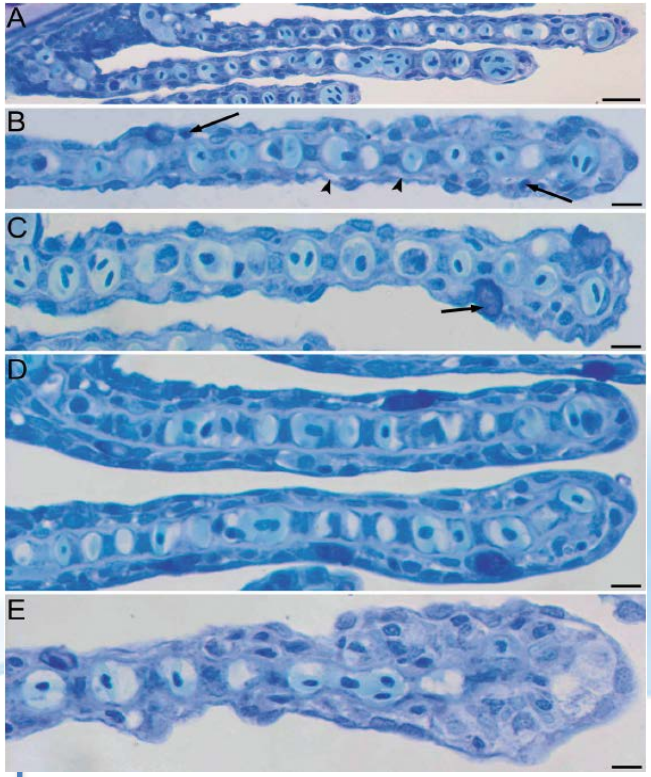


Vol. 309: 247–254, 2006 | MARINE ECOLOGY PROGRESS SERIES Mar Ecol Prog Ser | Published March 15

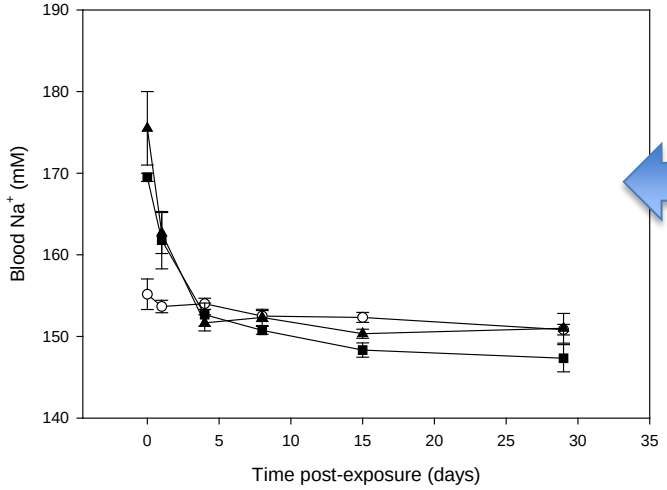
Exposure of cod *Gadus morhua* to resuspended sediment: an experimental study of the impact of bottom trawling

Odd-Børre Humborstad[1], Terje Jørgensen[1,*], Sindre Grotmol[2]

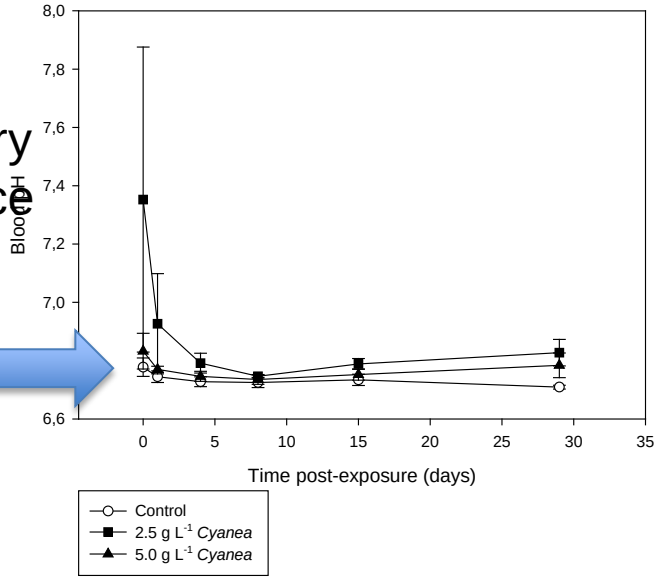
[1]Responsible Fish Capture Research Group, Institute of Marine Research, PO Box 1870 Nordnes, 5817 Bergen, Norway
[2]Department of Biology, University of Bergen, Allégt. 41, 5007 Bergen, Norway



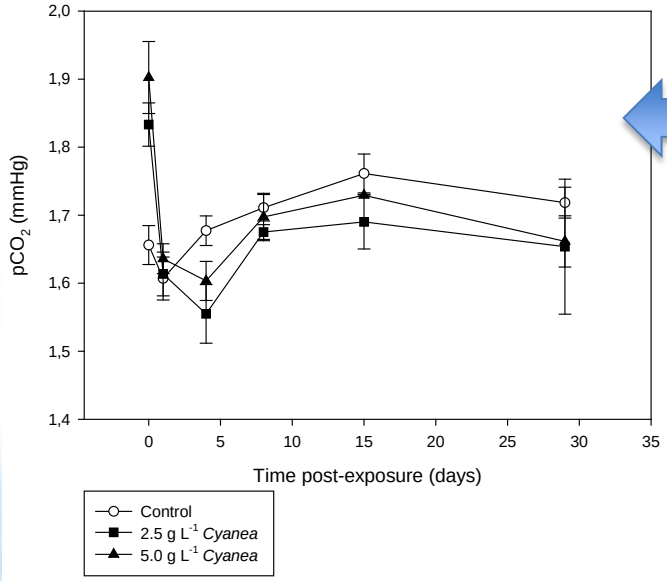
Jellyfish: *Cyanea capillata* – blood chemistry



Acute ionoregulatory disturbance

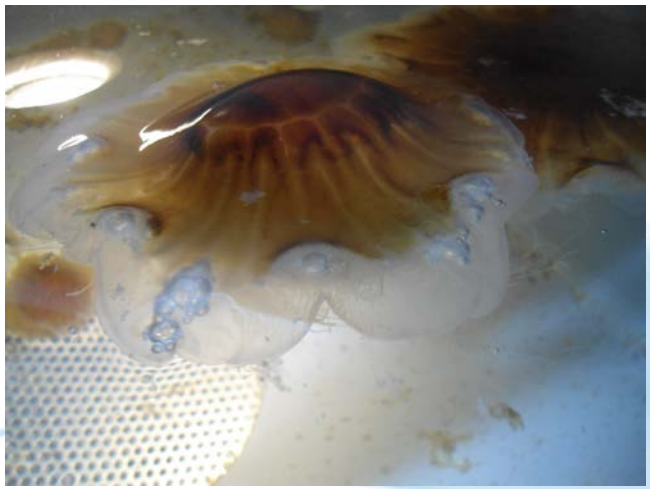


Minor and variable pH disturbance

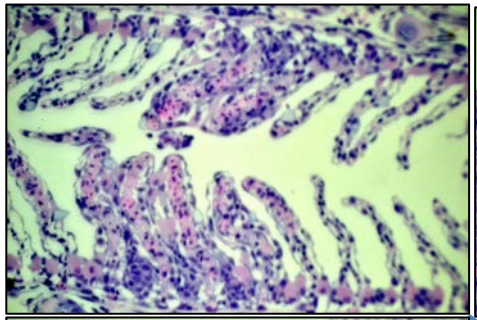


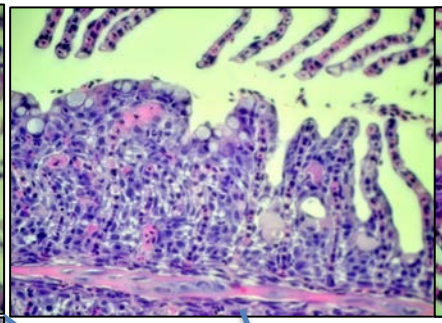
Acute impediment to CO_2 diffusion across the gill

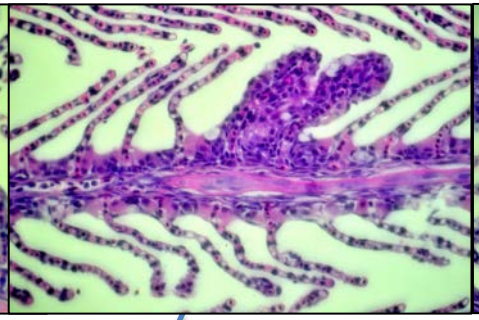
All disturbances occur within the first 5 days

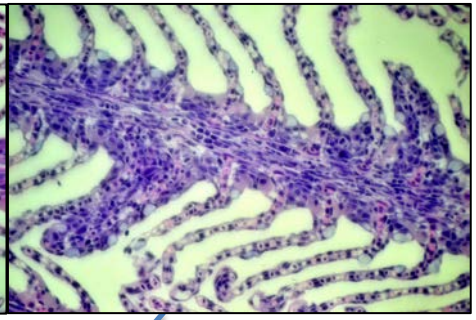


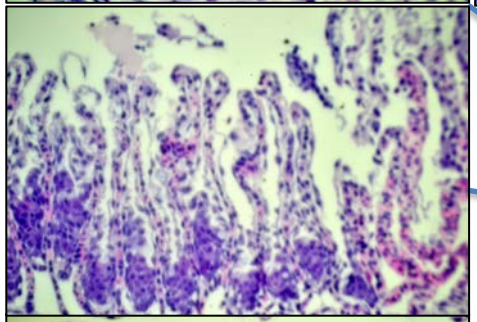
Jellyfish: *Cyanea capillata* – histopathology

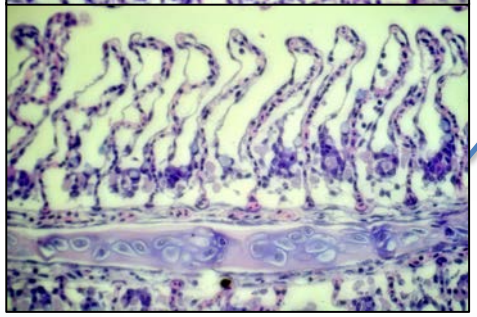


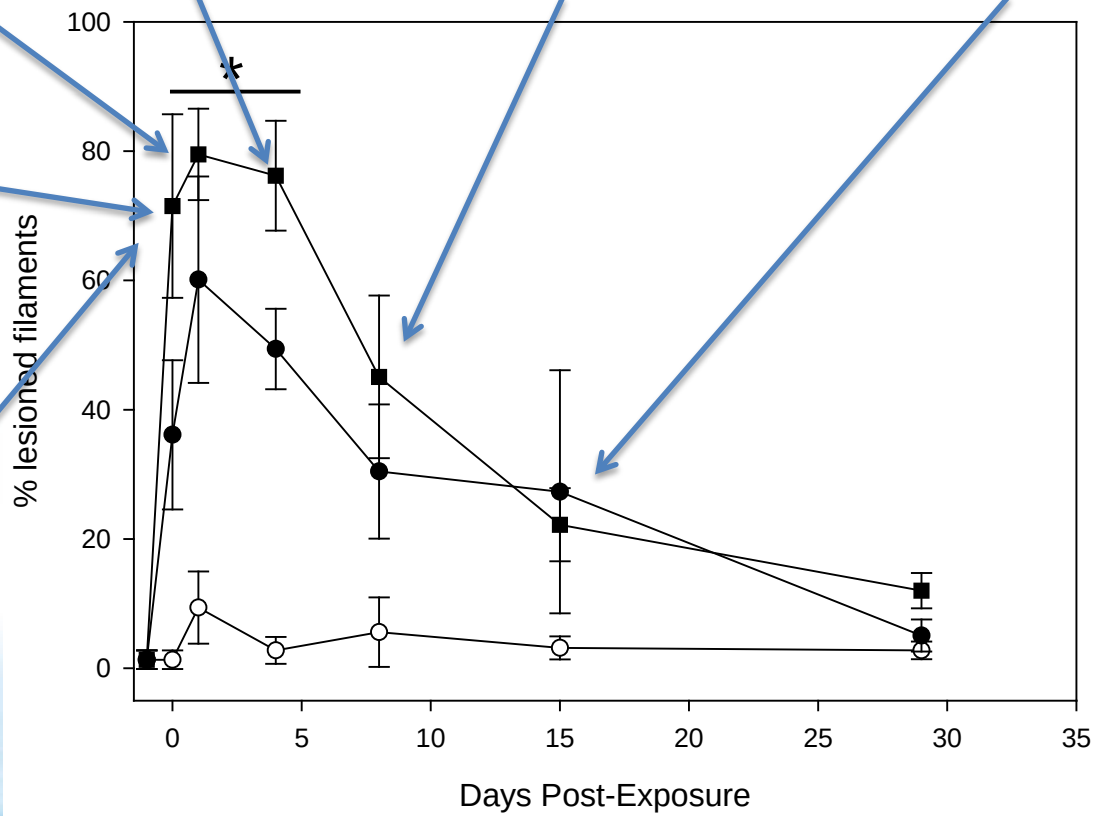












Conclusions

- Gills as a multifuctional organ
  - Highly susceptible different types of insult
- Often insults result in acute osmotic/cardiovascular changes
  - Leads to epithelial separation
  - Telangiectasis and/or haemorrhage
- Abscence of detailed work on the effect of particles
  - Several conflicting studies – most never analysing particles in detail
    - Charge, composition, size and shape etc
  - May not always be a significant issue
- Acute toxic responses may begin by having local tissue changes (gill)
  - systemic effects (e.g.jellyfish toxins and algal toxins)