Marine Salmonid Gill Disease

7th November 2012

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Vet Aqua INTERNATIONAL

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- Clients in Ireland, UK, rest of world
- Disease diagnostics
- Health management
- Consultancy
- Training
- Research

- www.vetaquainter.com

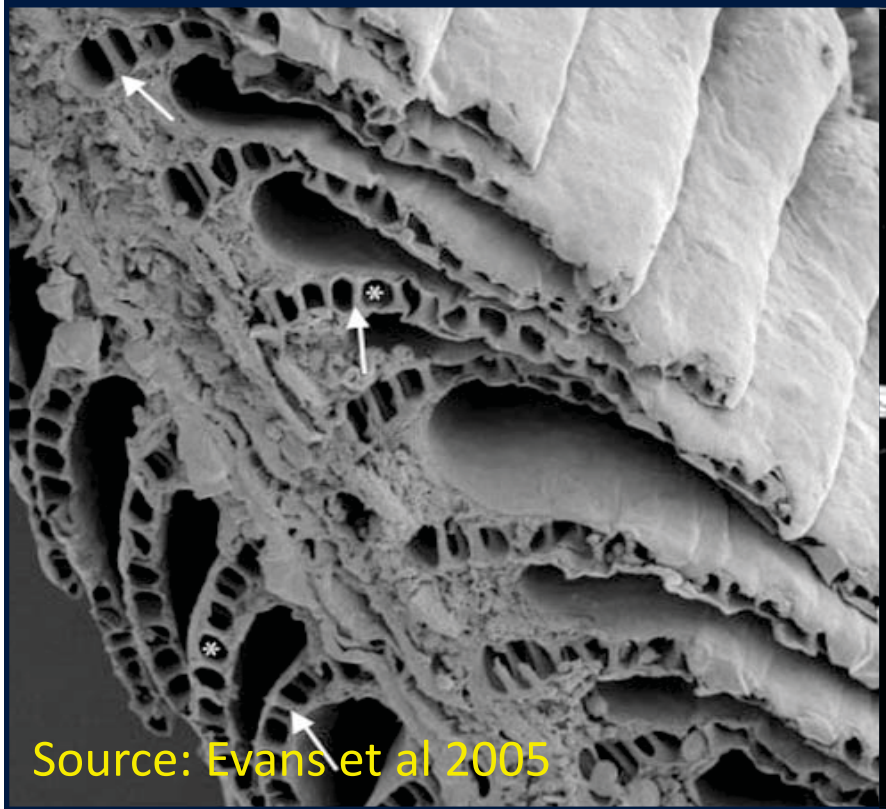
Outline

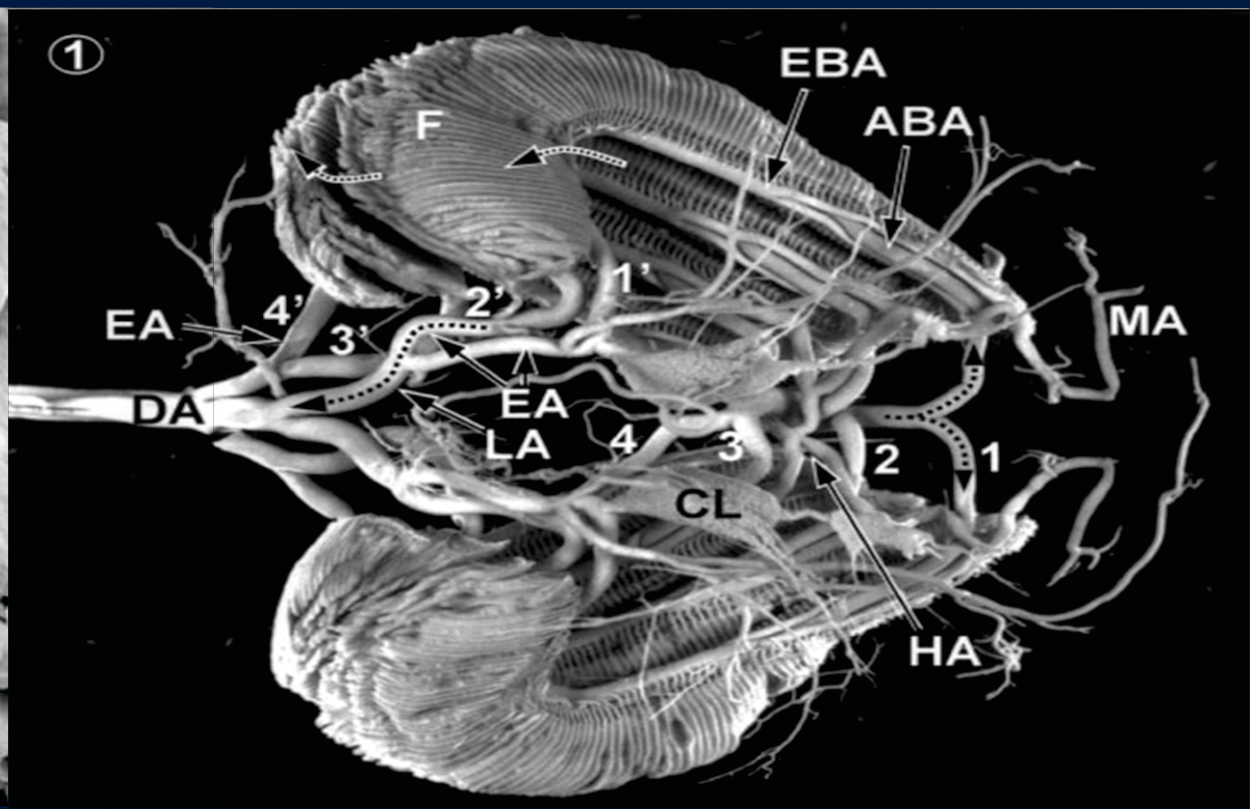
- Gill anatomy & physiology
- Gill disease background
- Observational epidemiology
- Aetiologies of marine gill disease
- Pathologies


"The fish gill is the most physiologically diversified vertebrate organ and its vasculature the most intricate"
Olson (2002)

Principle components of gill

- Connective tissue scaffold
- Vascular network
  - Arterioarterial vasculature (respiration)
  - Arteriovenous vasculature (nonrespiratory, nutritive)





Source: Evans et al 2005


Blood flow countercurrent to water flow
Histological section through salmon gill

Gill rakers

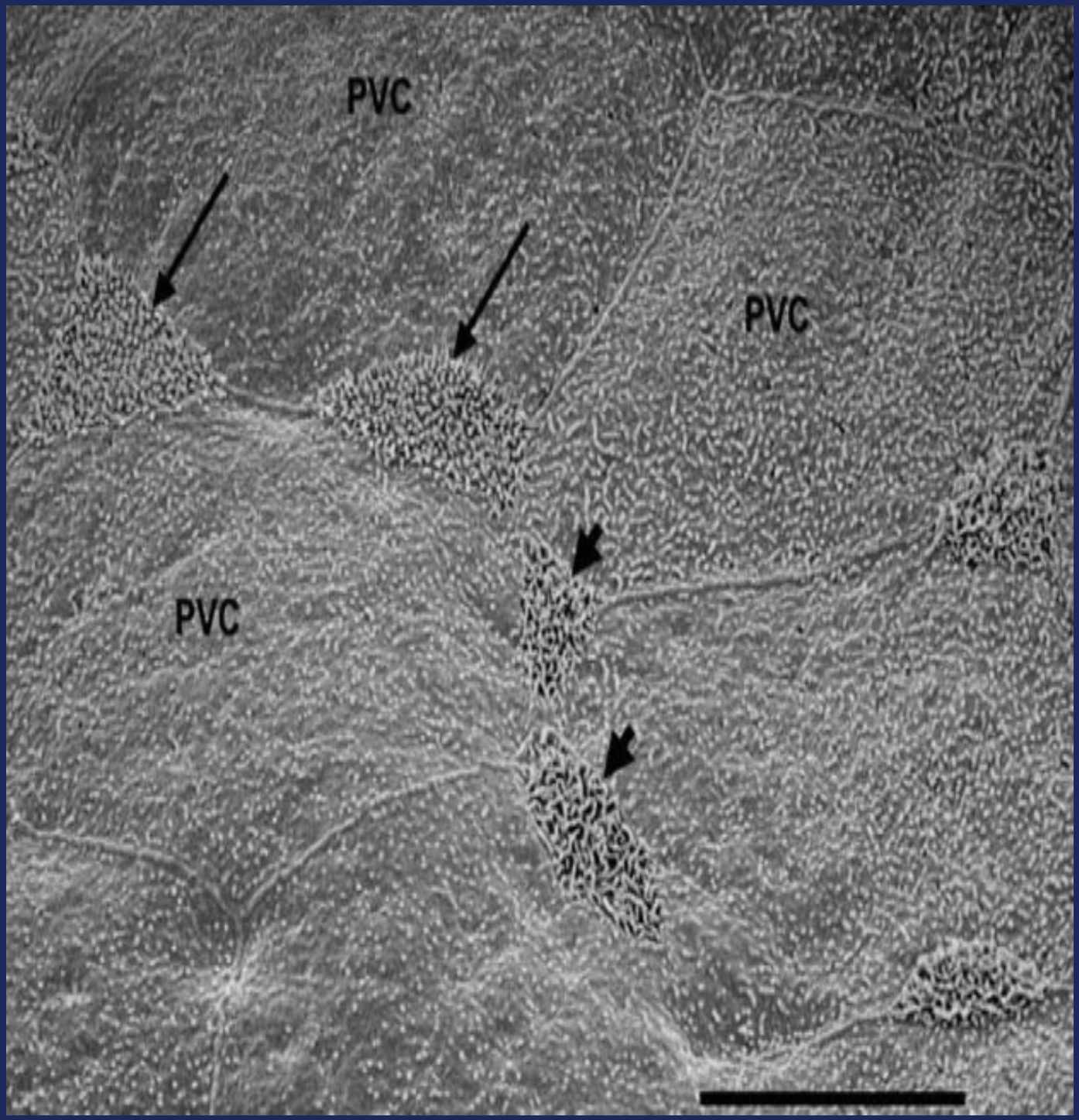
SEM gill epithelium

Source: Evans et al 2005

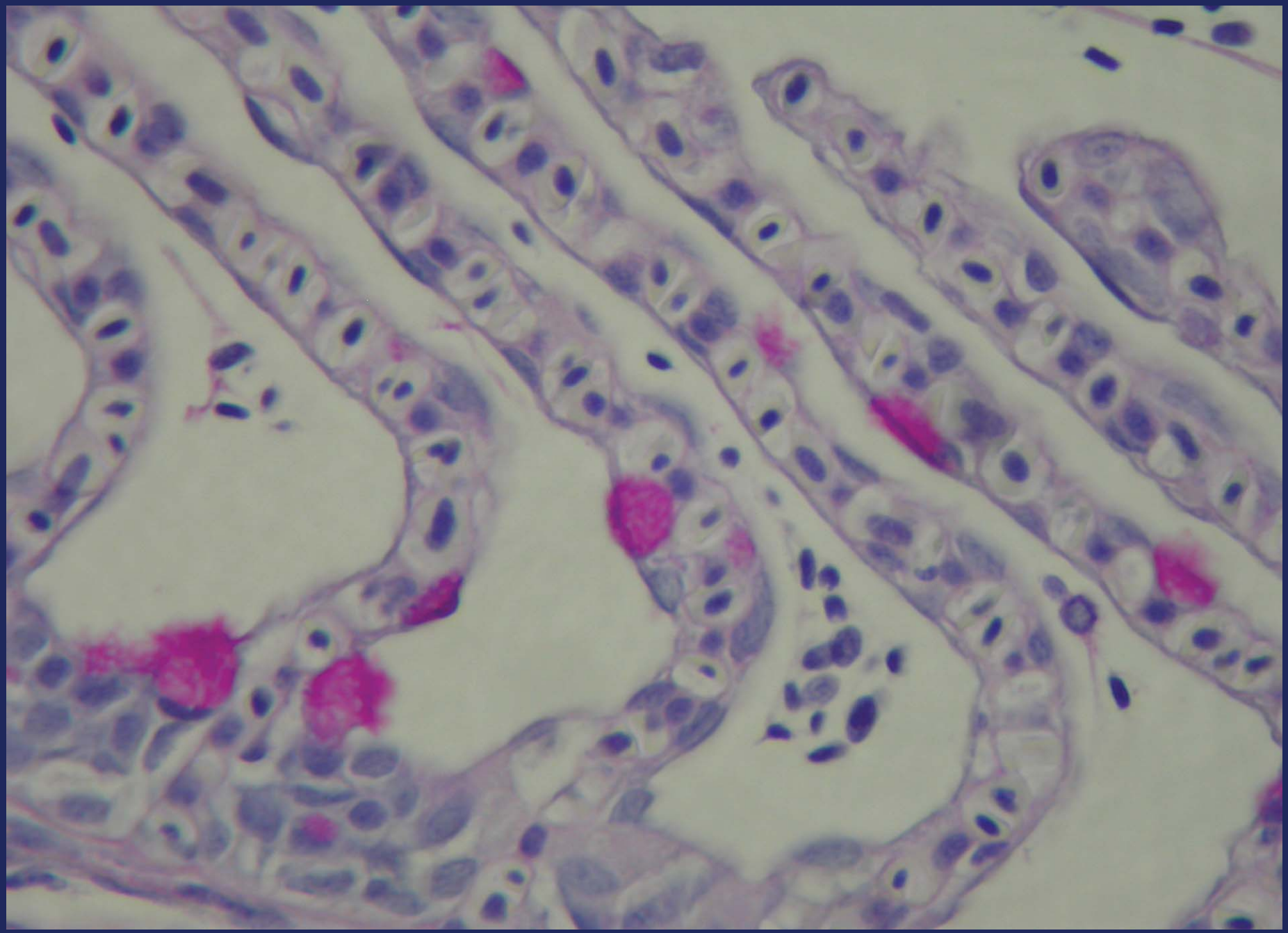
PVC – pavement cells

Note microvilli & ridges (increase surface & glycocalyx)

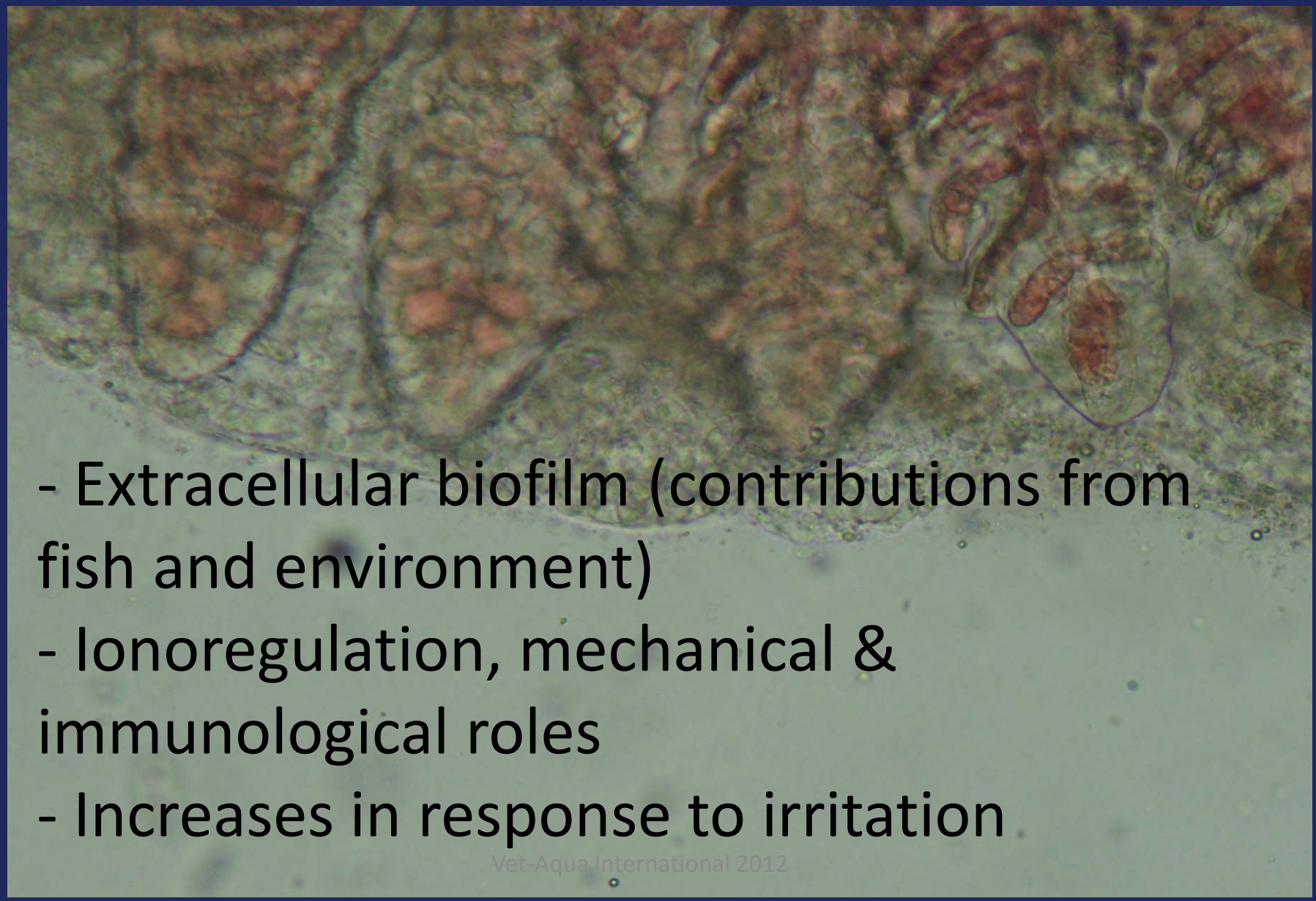
Sensitive to stress…



Histological section of salmon gill showing mucous cells (PAS)



Fresh gill smear (salmon) with high levels of gill mucus

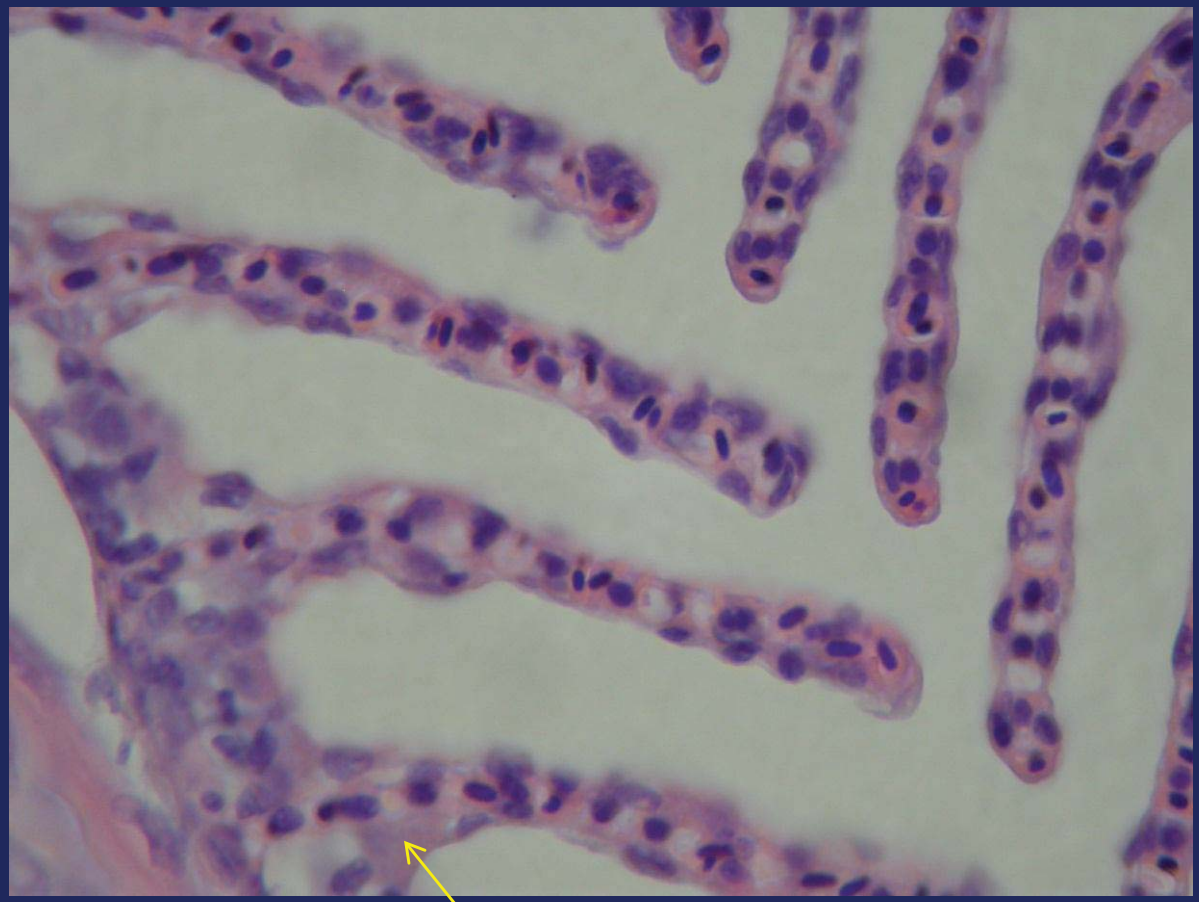


- Extracellular biofilm (contributions from fish and environment)
- Ionoregulation, mechanical & immunological roles
- Increases in response to irritation

Chloride cells

Secrete NaCl in seawater

Mitochondria rich



Main gill functions

- Gas exchange (O_2, CO_2)
- Acid – base balance
- Osmoregulation
- Excretion of nitrogenous waste products (mainly NH_3)

- O_2, CO_2 sensors (neurons)

Gas exchange

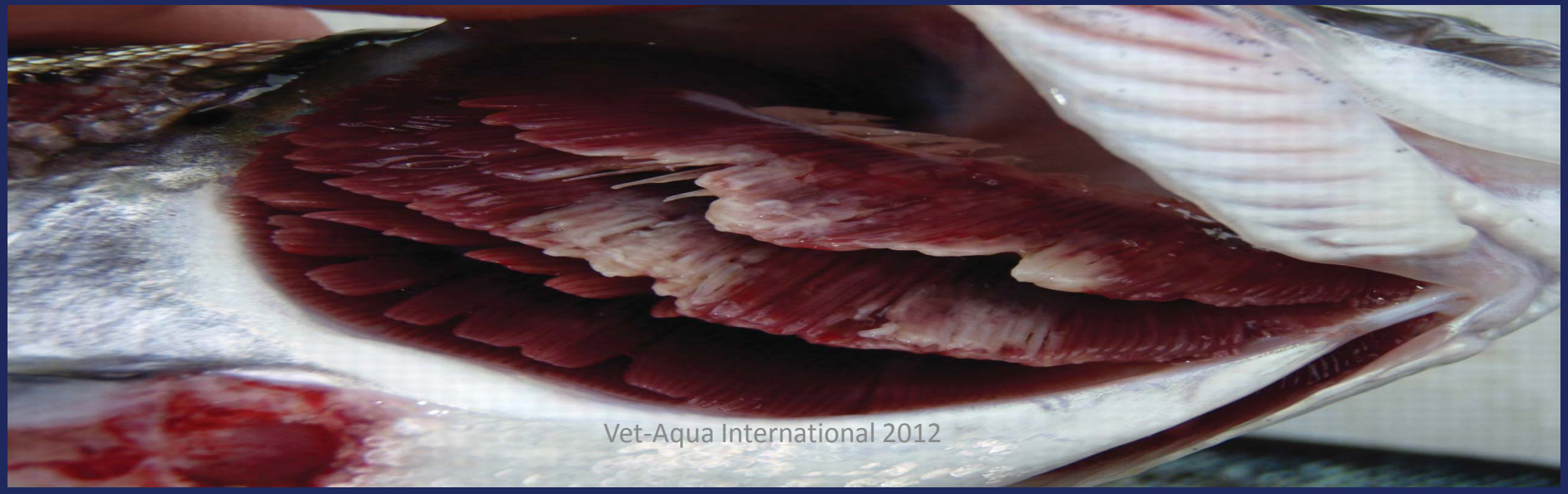
- Efficiency affected by:
  - balance between ventilation & perfusion
  - diffusion distance
  - environment
- Reduction in surface area leads to significant increase in blood carbon dioxide

Gill disorders – marine salmonid farms

- Scotland – proliferative/hyperplastic gill disease & amoebic gill disease (AGD), algae, jellyfish
- Norway – gill disease/proliferative gill inflammation (PGI) present in 15 to 20% marine farms (morts up to 40%)
- Tasmania – AGD, plus
- Chile & USA – AGD, harmful algae, others?
- Canada – harmful algae, PGD-type?

Background

- 2003 to 2006 most serious cause of mortality in marine farms in Ireland
- Affected all stages of fish from post smolts to near harvest sized fish
- Significant welfare problem



Economic impact

- Ireland – mean 8% loss equates to 1920 tonnes production lost in biomass alone
- Additional costs of mortality removal, disposal, loss in growth, susceptibility to other diseases, treatments

Causes of gill disorders

- Harmful algal blooms (physical, toxins or deoxygenation)
- Harmful zooplankton swarms (nematocysts)
- Amoebic gill disease & other parasites
- Bacterial gill disease (*Tenacibaculum* sp., others)
- Viruses?
- Chemical (hydrogen sulphide)
- Unsubs & mix of above

Gill Health Research in Ireland

- Epidemiology
  - Sequential study of 4 marine farms 2008
  - A national survey of gill health and disease in finfish farms (2010)
- Zooplankton studies (Dr. E. Baxter)
- Epitheliocystis & bacteria studies (Dr. S. Mitchell)
- Molecular studies on 4 gill pathogens (Dr. E. Fringuelli)
- Phytoplankton monitoring
- Hydroid studies

Epidemiology

- 4 site sequential study findings
  - Primary insult to gills in some cases due to small harmful zooplankton
  - Coincided with tenacibaculosis & eventual parasitism
  - Associated with summer months
  - Spread from pen to pen in 2/4 sites
  - Strong genetic susceptibility
  - Significant economic loss for each site

Reference: Rodger *et al.* (2011) Veterinary Record, 168, 668

Epidemiology

- National survey (2008 data)
- 17 marine populations (13 salmon sites, 5.3 million)
- 10/13 salmon sites had gill disorders, 1/3 trout sites
- Average mortality 13%

National survey of variables

- Location
- Smolt type
- Strain
- Vaccine
- Size at input
- Length of fallow
- Stock movement
- Input number
- Epitheliocystis
- PD
- Net washing method
- Distance to nearest farm
- Stocking density
- Feed type

Highlights

- Epitheliocystis positive sites higher mortalities [28.3% (±18.9) cp. negative (7.0% (±8.8)] *P*= 0.026

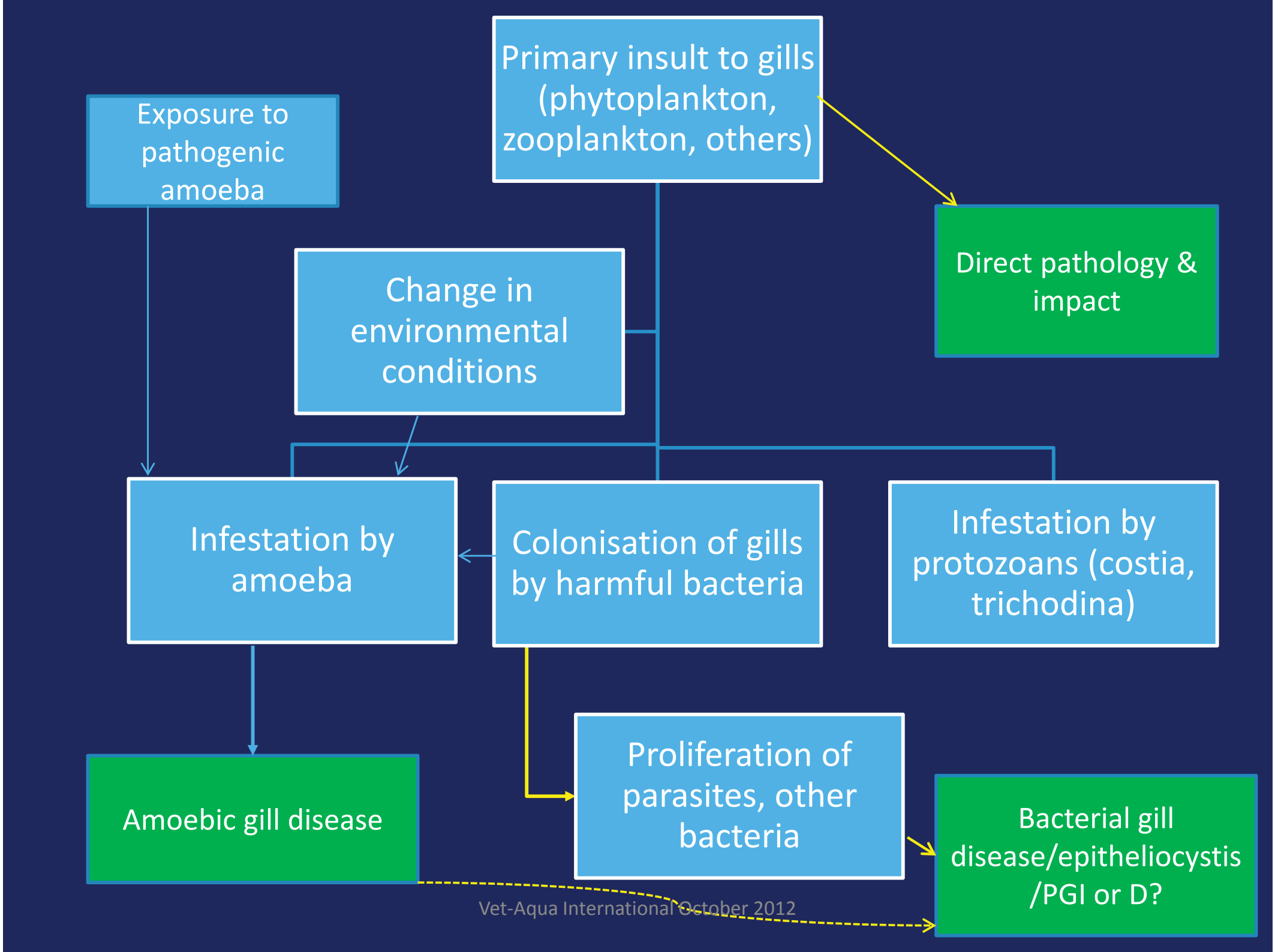
Highlights

- No *significant* difference in gill disorder losses comparing washer (21.7 ± 18.2) to changing (15.3 ± 19.0)

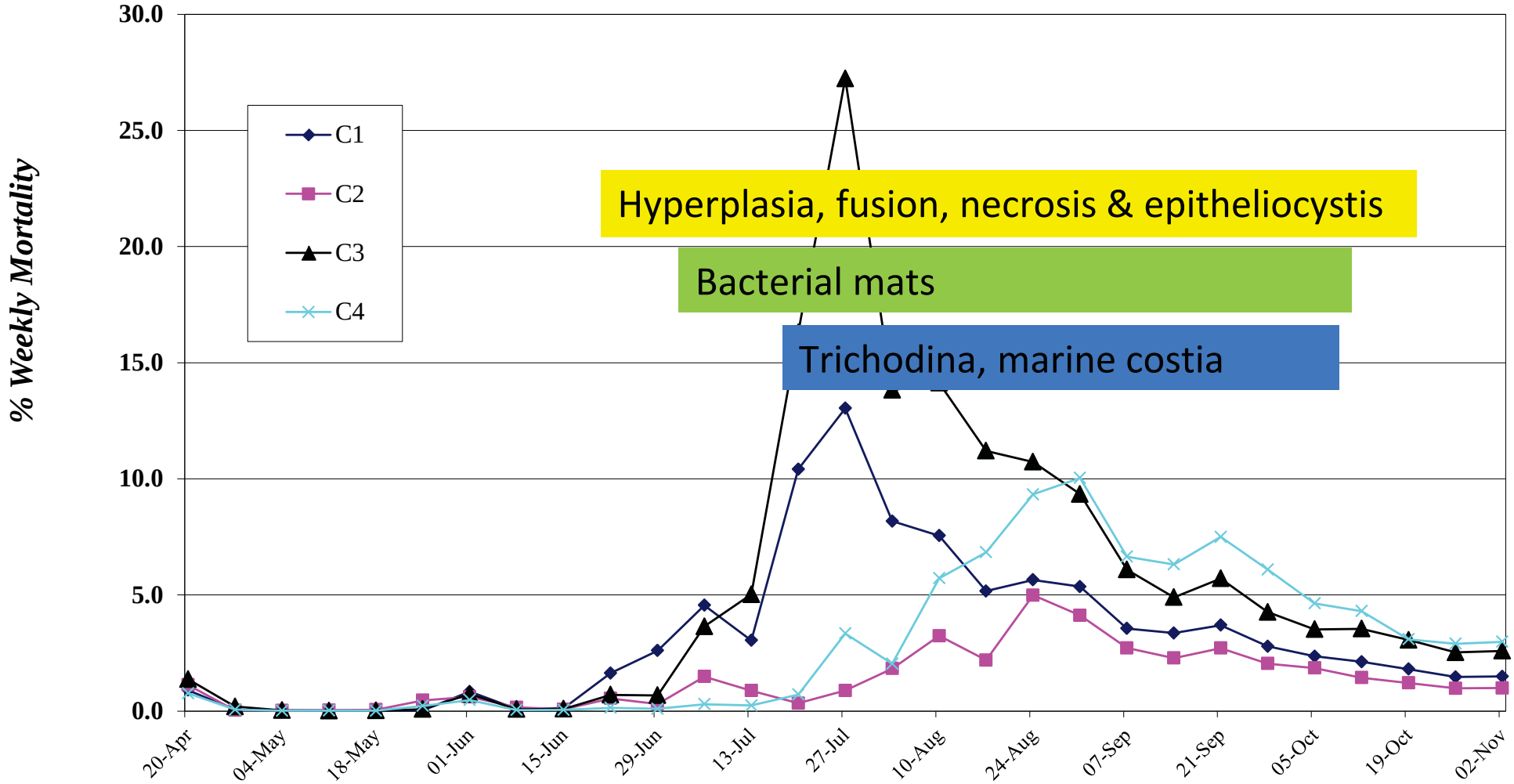
Highlights

- Strain of salmon – significant difference

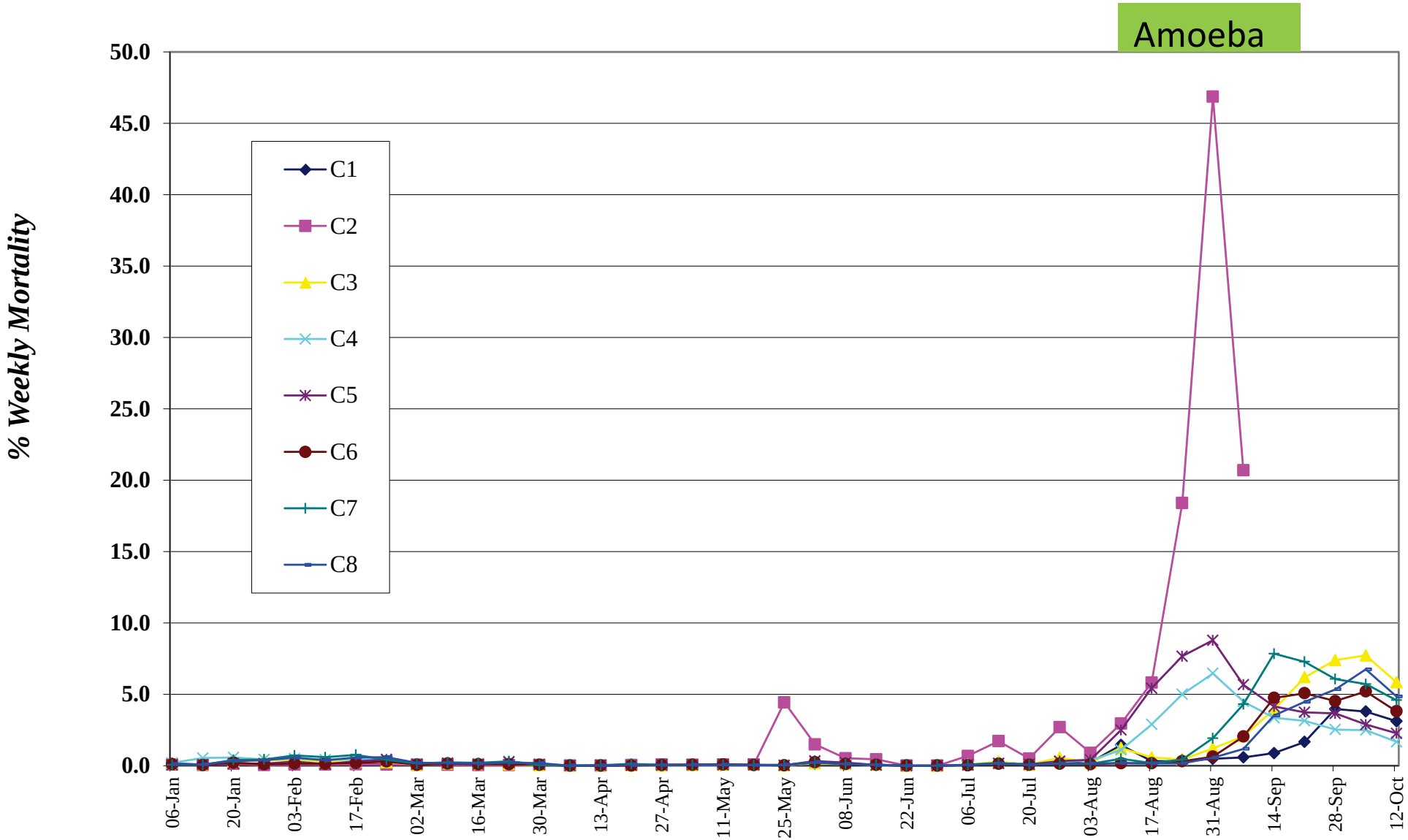
	Gill disorder mortality (%)	SD
Strain X	7.7	10.9
Strain Y	16.2	14.3
Strain Z	47.2	16.1


Primary insult to gills (phytoplankton, zooplankton, others)
Exposure to pathogenic amoeba
Direct pathology & impact
Change in environmental conditions
Infestation by amoeba
Colonisation of gills by harmful bacteria
Infestation by protozoans (costia, trichodina)
Amoebic gill disease
Proliferation of parasites, other bacteria
Bacterial gill disease/epitheliocystis /PGI or D?

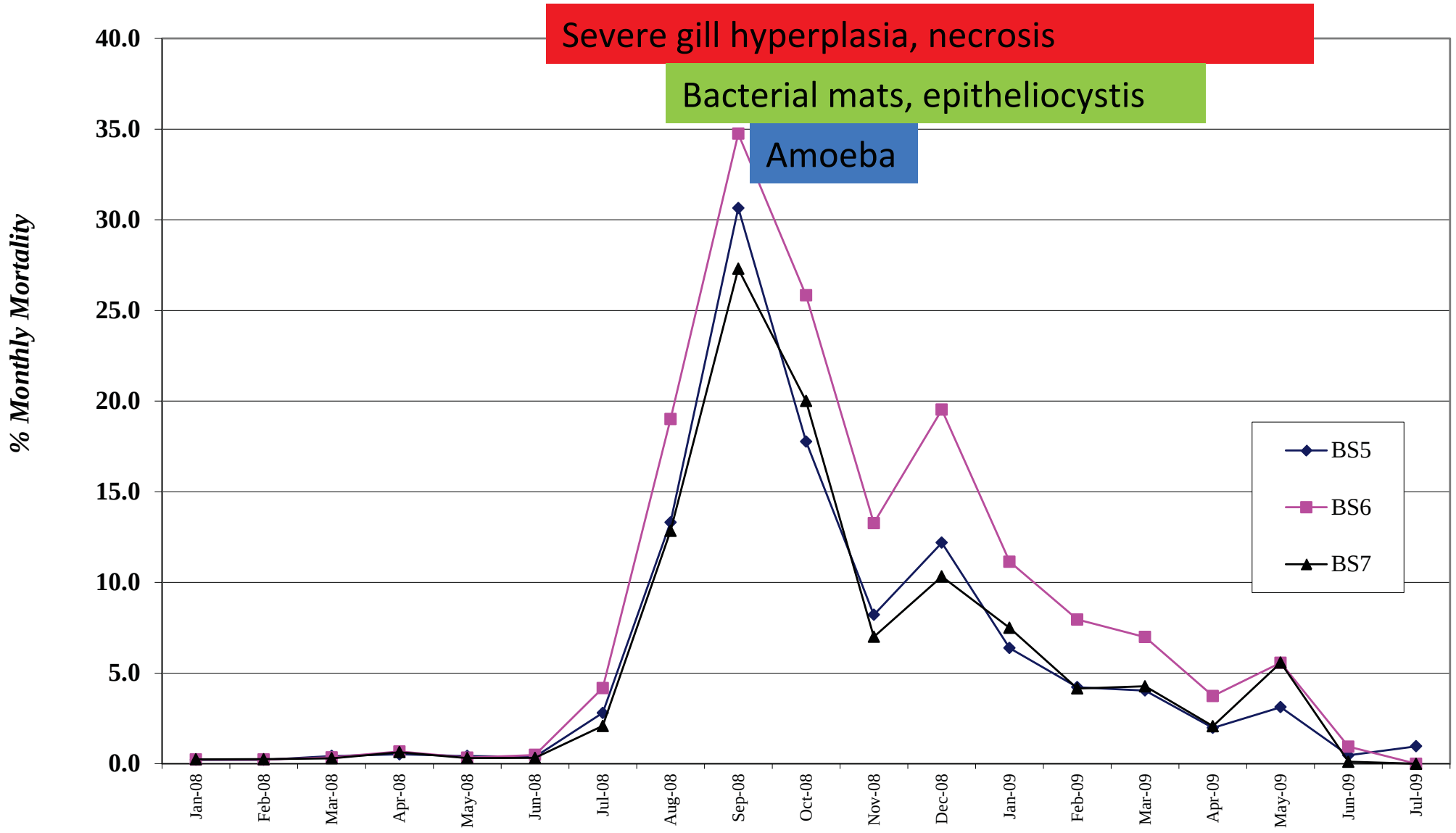
Site A 08GS1 Weekly Mortality Per Pen



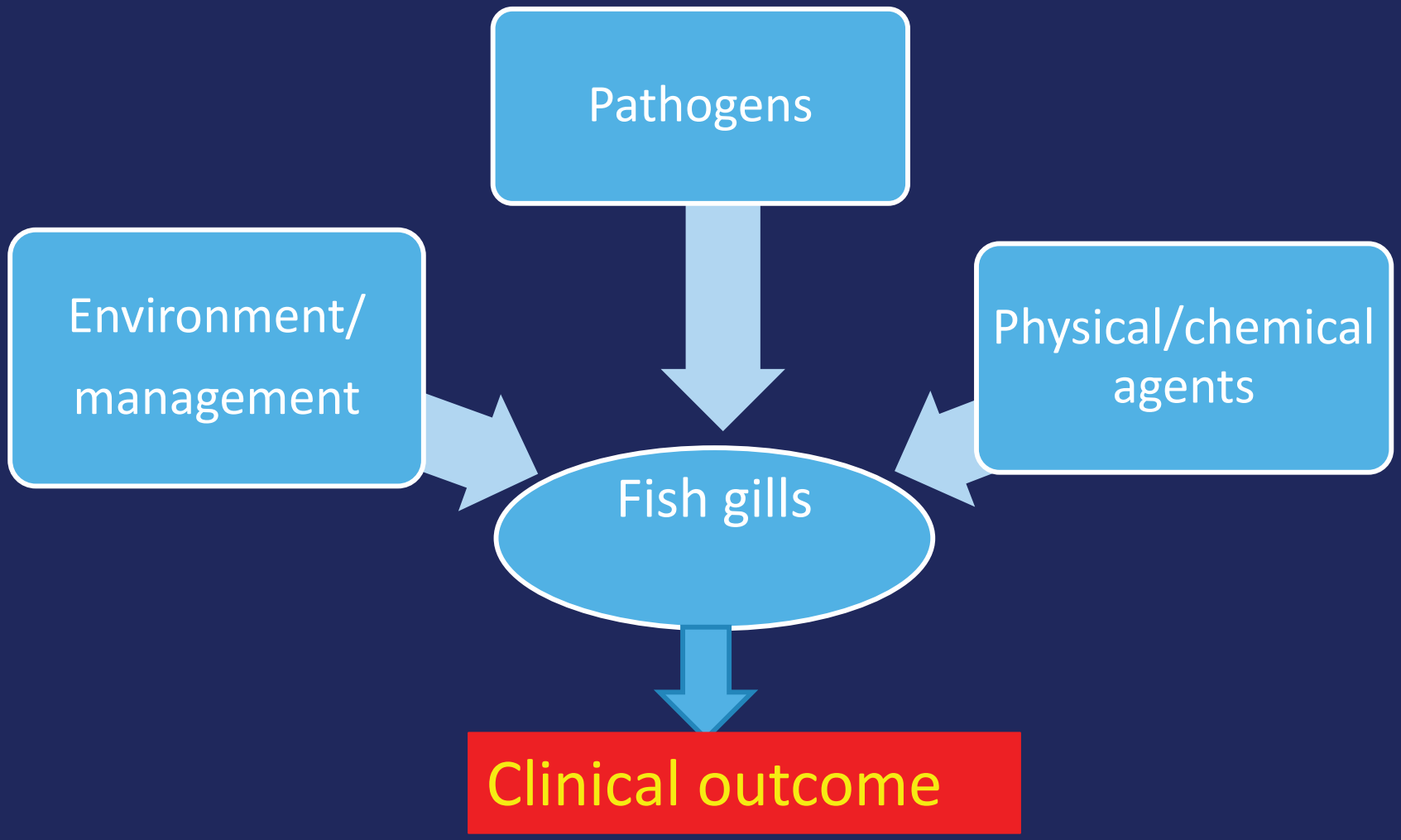
Site B 07GS0 Mortality Per Pen



Site C 07GS0 Mortality Per Pen



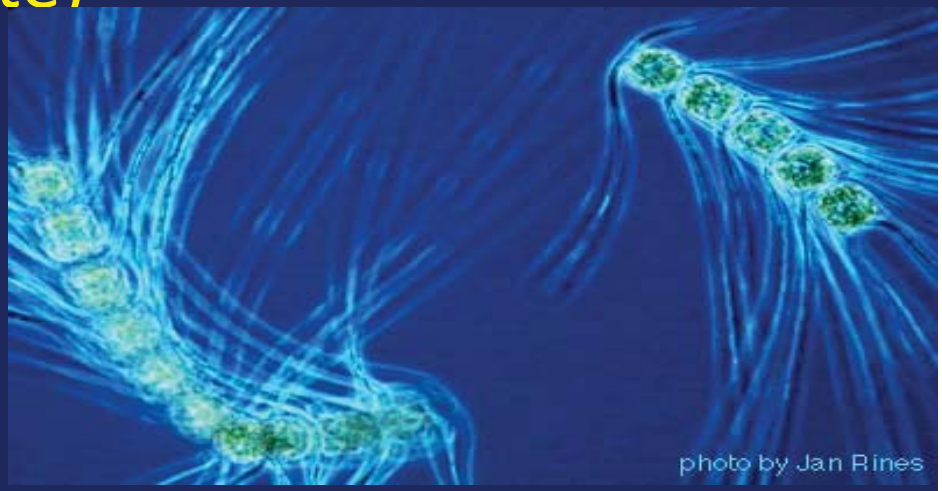
Gill disease can be simple or complex



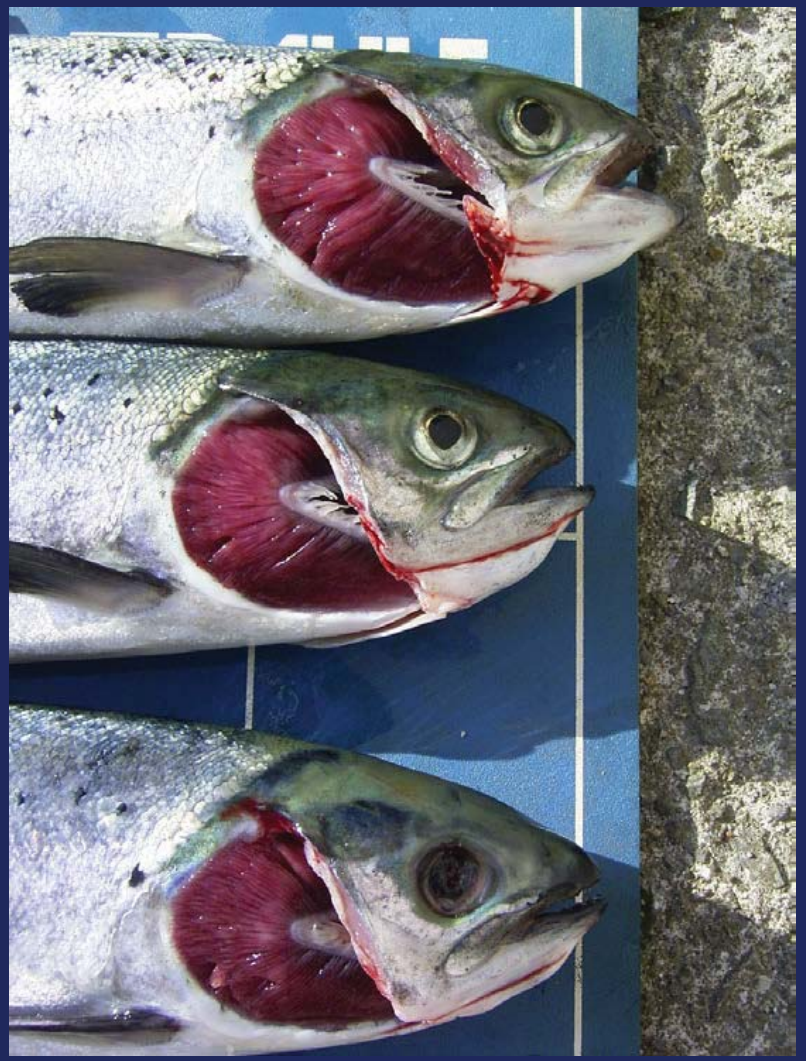
Harmful algae pathology

Harmful algal blooms (marine)

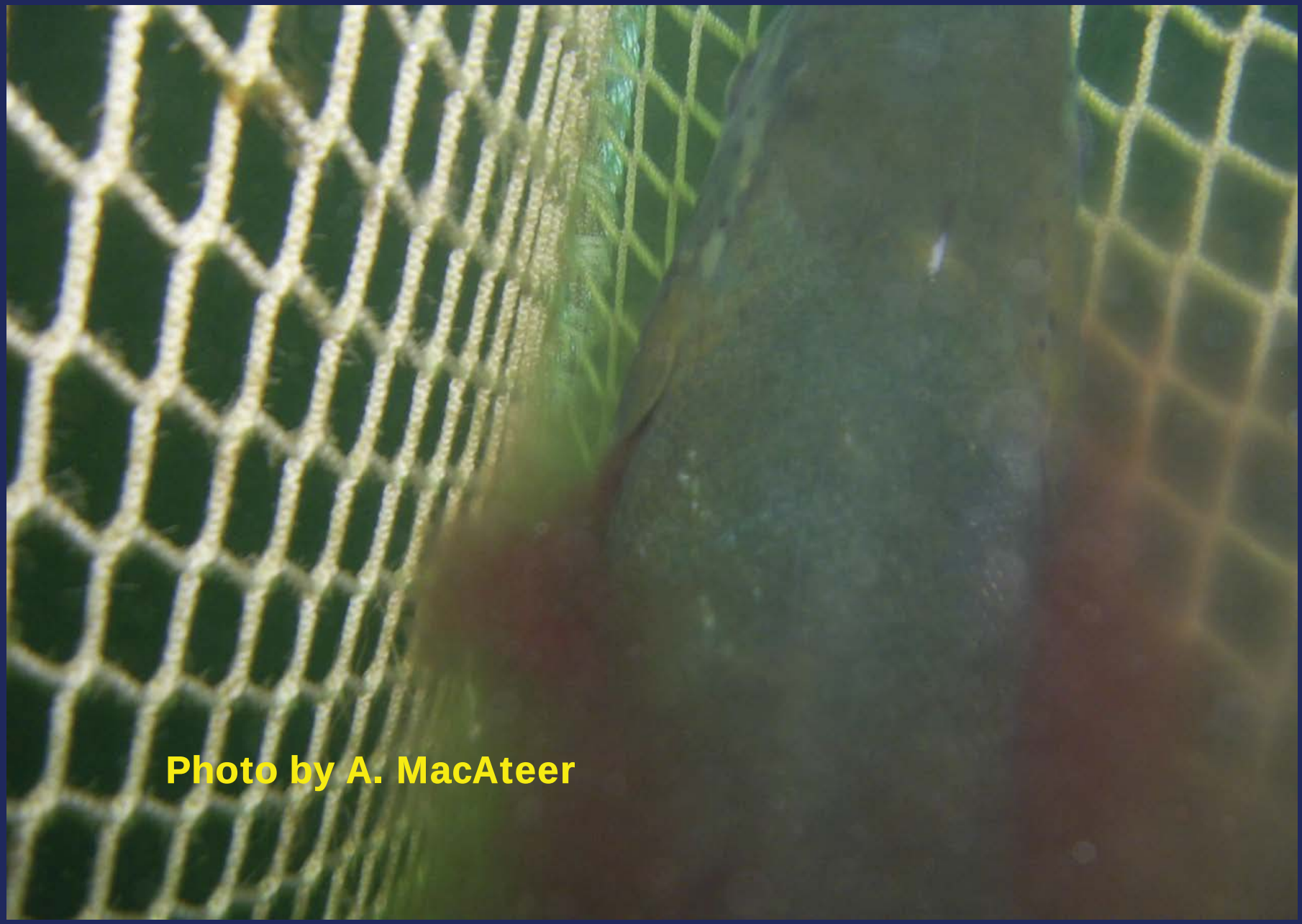
- *Karenia mikimoti* (dinoflagellate)
- *Noctiluca scintillans* (dinoflagellate)
- *Pseudo-nitzschia* sp. (diatom)
- *Chaetoceros* sp. (diatom)
- *Akashiwo sanguinea* (dinoflagellate)
- Others (*Cosinodiscus wailesii*)



Harmful algal blooms (HAB) – clinical signs



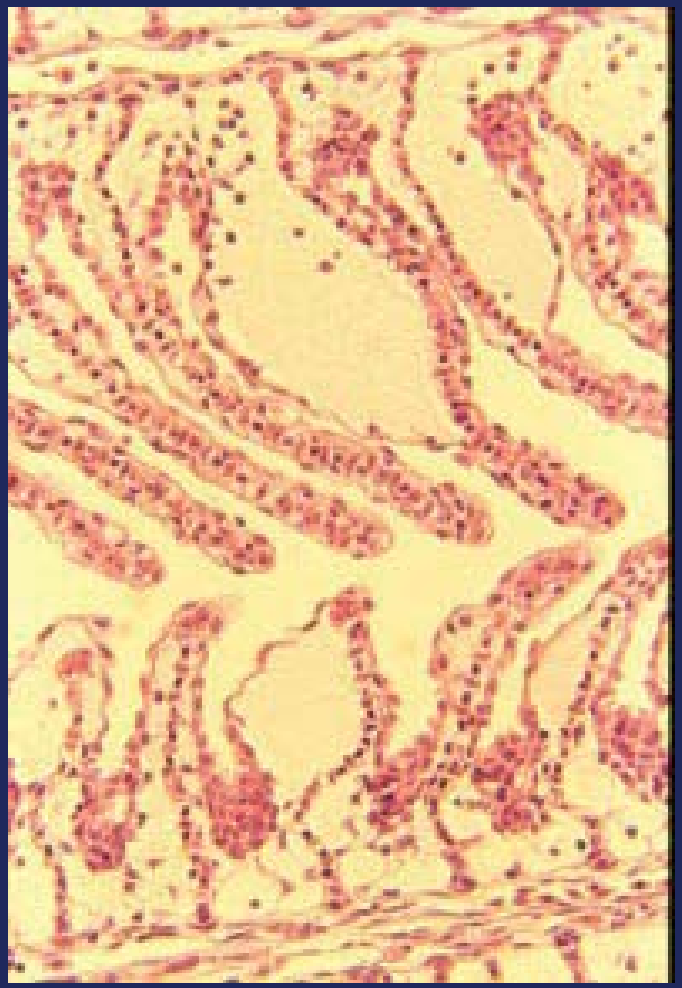
Fragile, bleeding gills



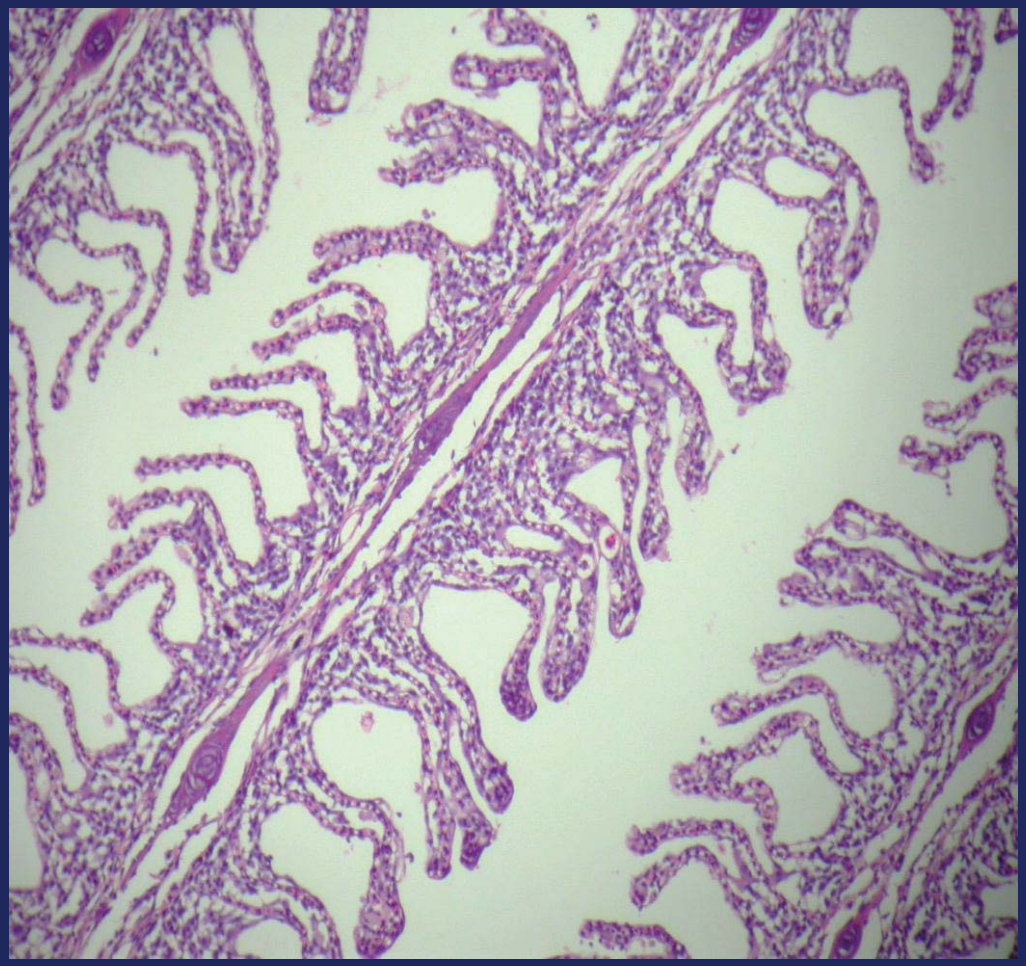
Harmful algal blooms – gross pathology

Harmful algae histopathology

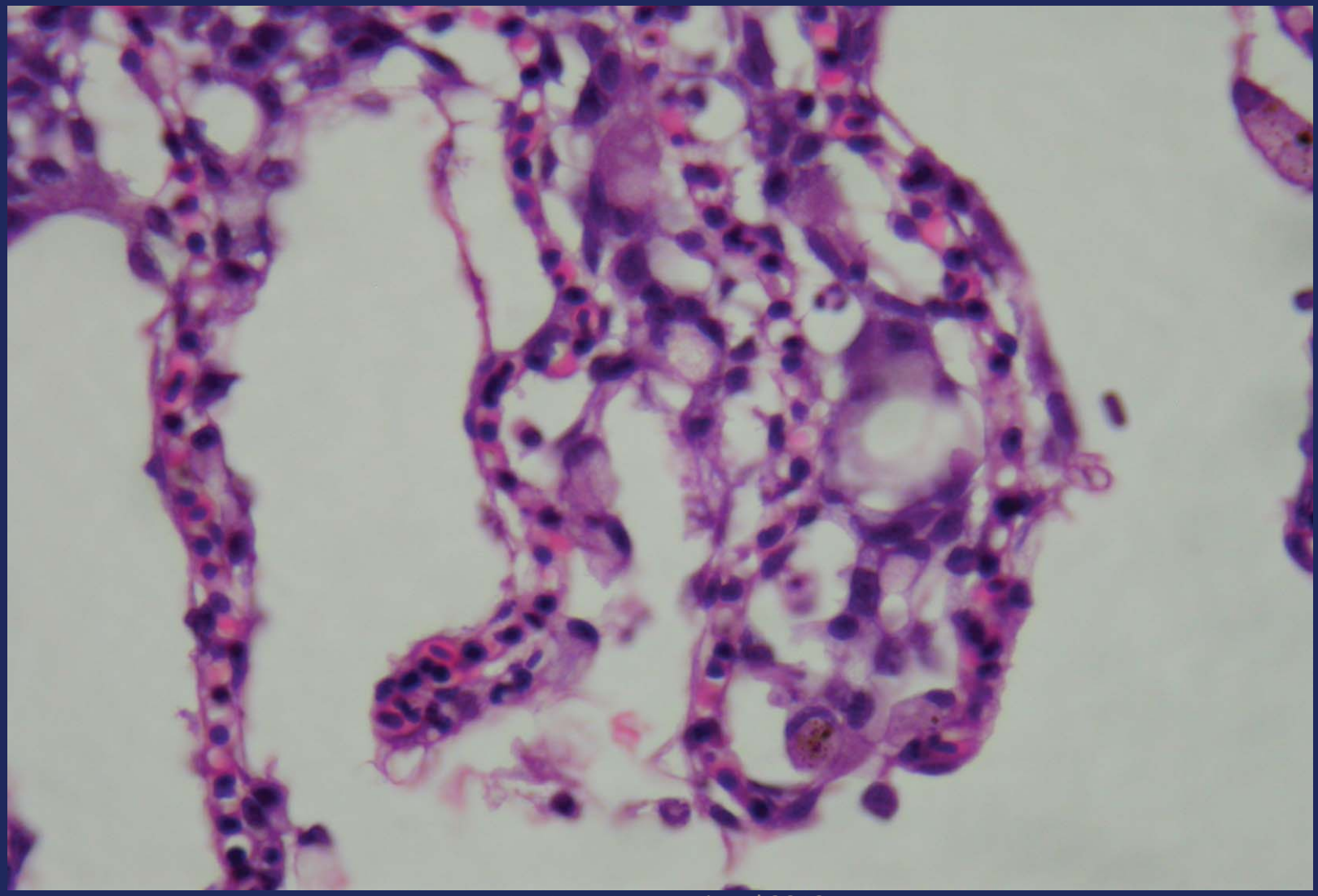
Loch Leven bloom (*Anabaena flos-aquae*)



Wild pipefish – affected by *K. mikimotoi*



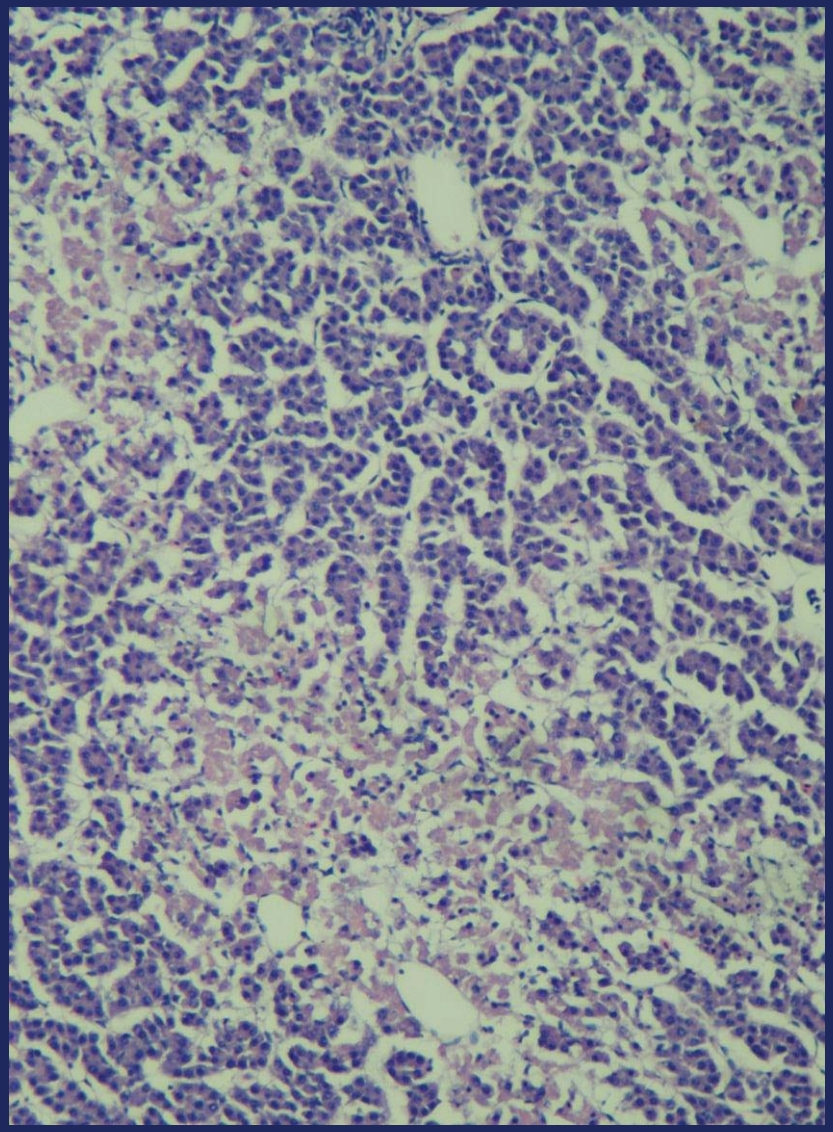
Epithelial apposition, sloughing & necrosis (*Karenia mikimotoi*)



HAB histopathology

- Also extensive, diffuse epithelial necrosis in gills
- Does this progress?

- May also have focal to multifocal liver pathology

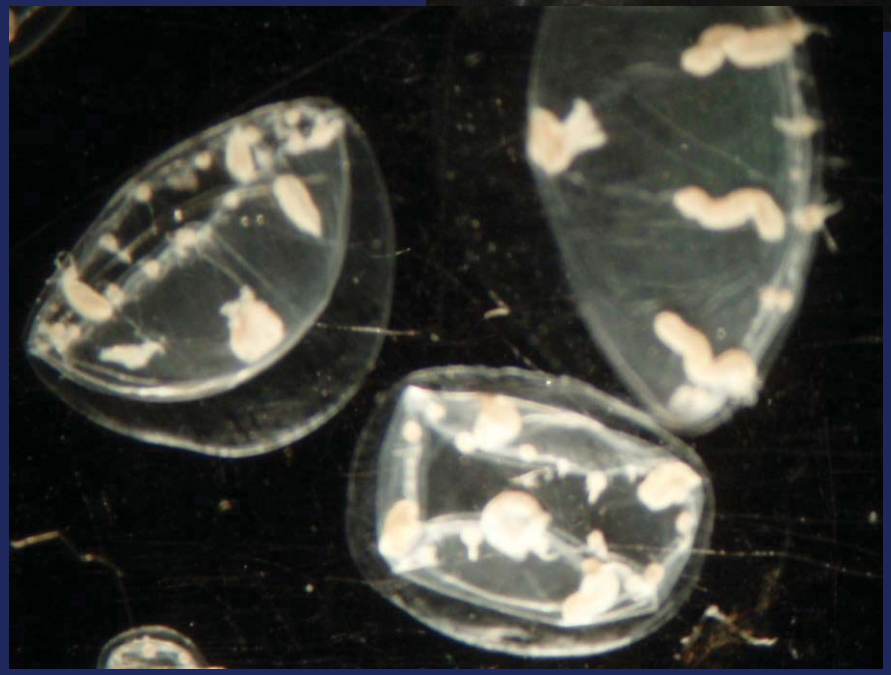


Harmful jellyfish or zooplankton pathology

Jellyfish pathology

Mixed population (Ireland 2010)

***Muggiaea atlantica* & *Phialella* sp.**



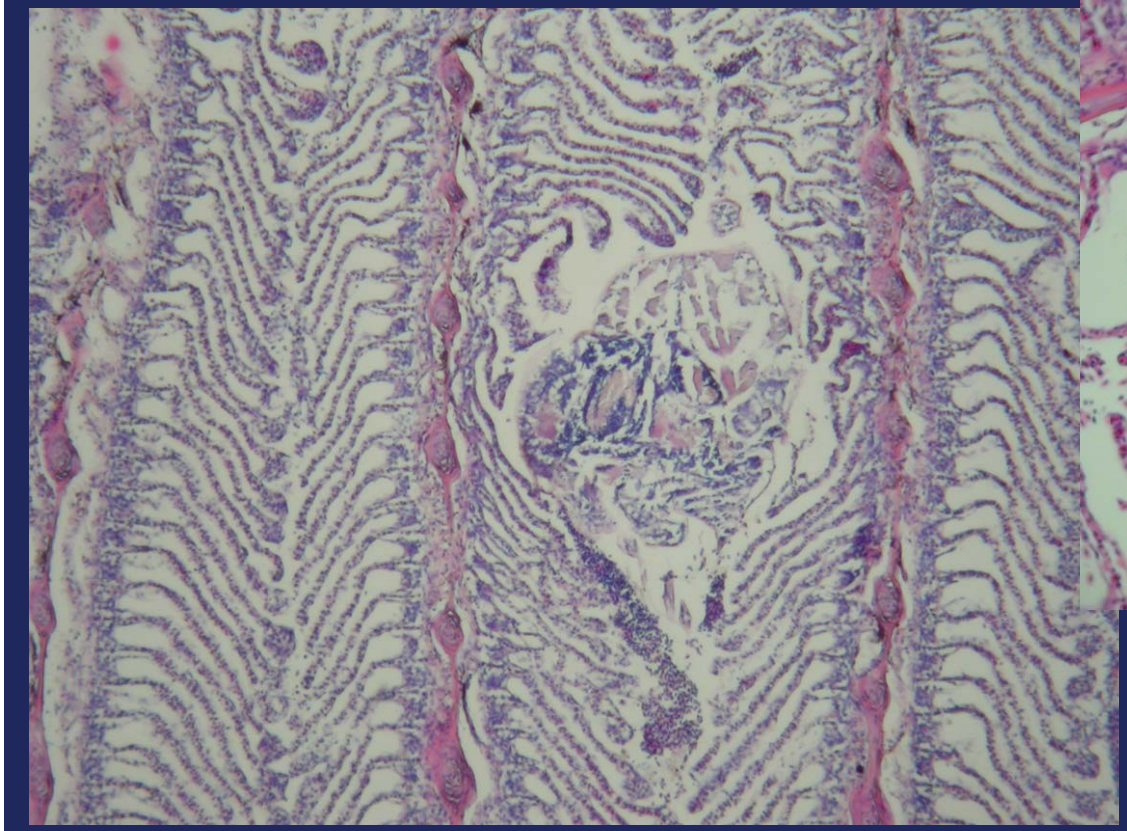
Jellyfish pathology

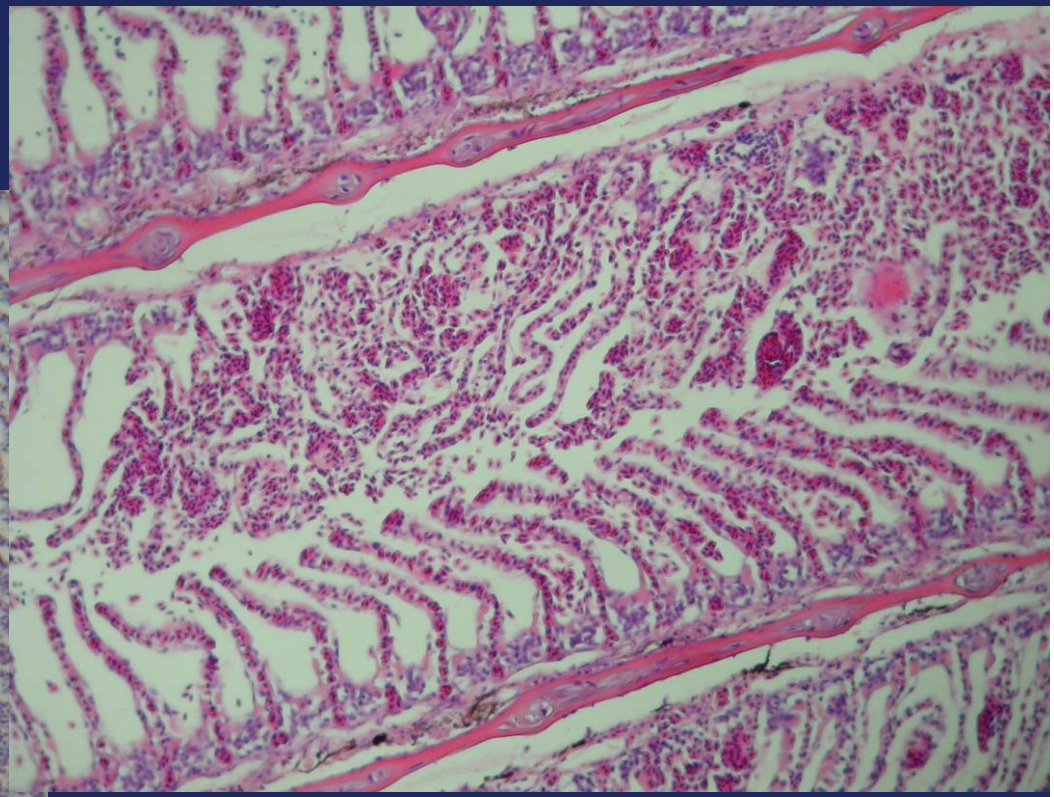
Common moon jelly

Photo: Dr. Emily Baxter

***Aurelia aurita* (Donegal 2010)**

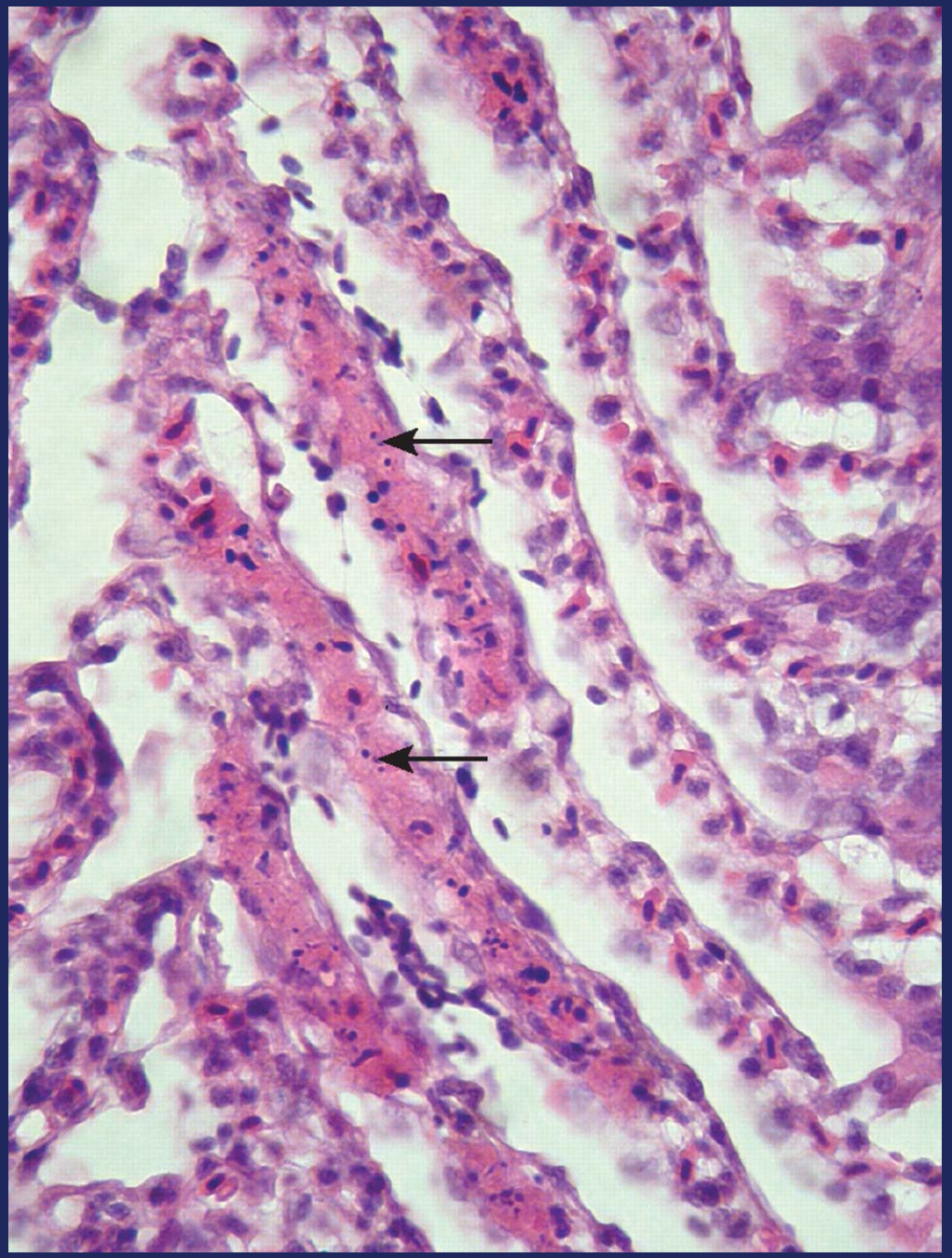
Harmful zooplankton histopathology





Harmful zooplankton gill histopathology

- Focal epithelial necrosis, sloughing and haemorrhage or haemolysis (*Aurelia aurita*)
- Concurrent or secondary bacterial infections
- Progression or healing?



Marine gill parasites

Amoebic gill disease pathology

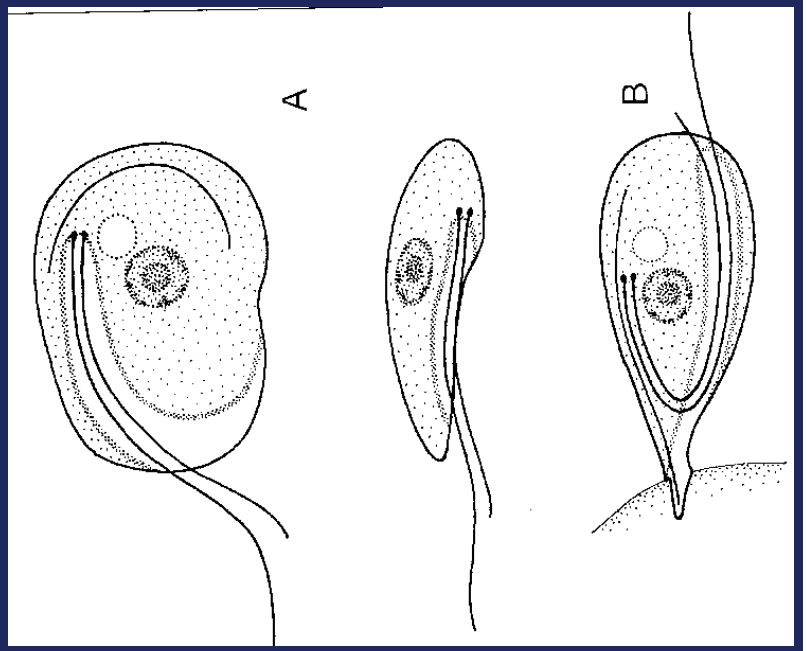
Amoeba (*Neoparamoeba perurans*)

Other gill protozoans

- Marine costia
- Trichodina
- *Desmozoon lepeophtherii* (syn *Paranucleospora theridion*)
- *Loma salmonae*

Marine costia

- First summer at sea
- Scotland, Ireland, Norway
- *Ichthyobodo* sp. (9)
- Failed smolts



Marine costia

Gill hyperplasia

Lamellar fusion

Mucous cells

Formalin baths

Freshwater

Halibut gills (*Hippoglossus hippoglossus*)

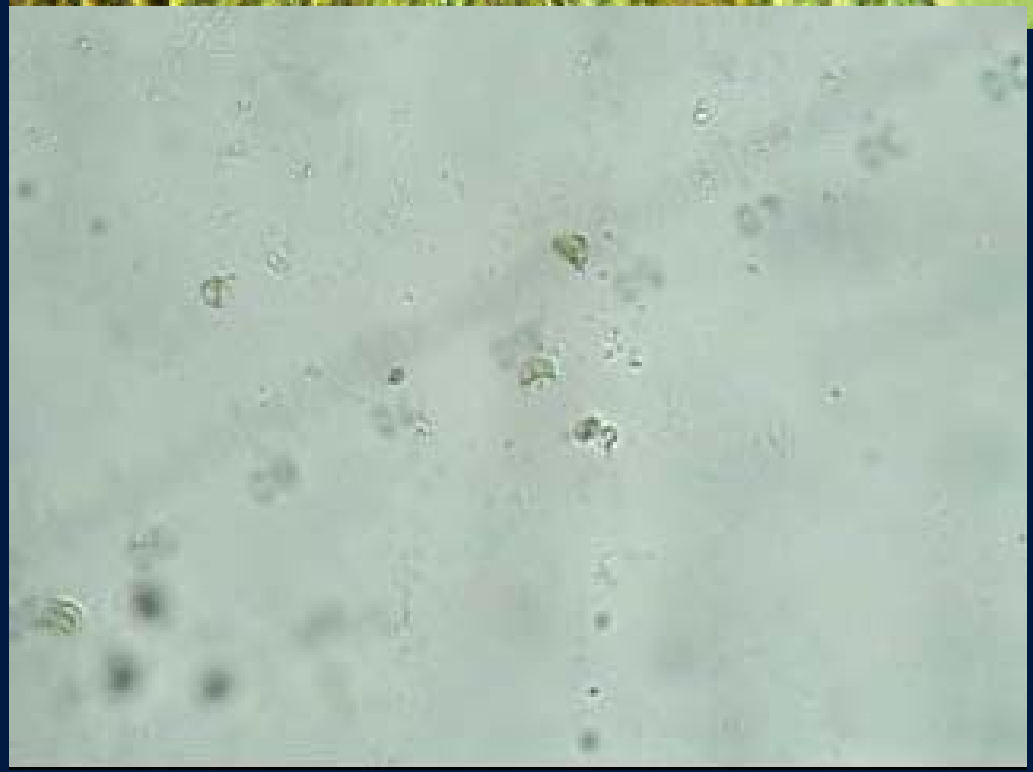
Trichodina

Mainly gills in marine

Severe hyperplasia, Oedema & erosion

Formalin & FW baths

PGI – Norway?



Loma salmonae

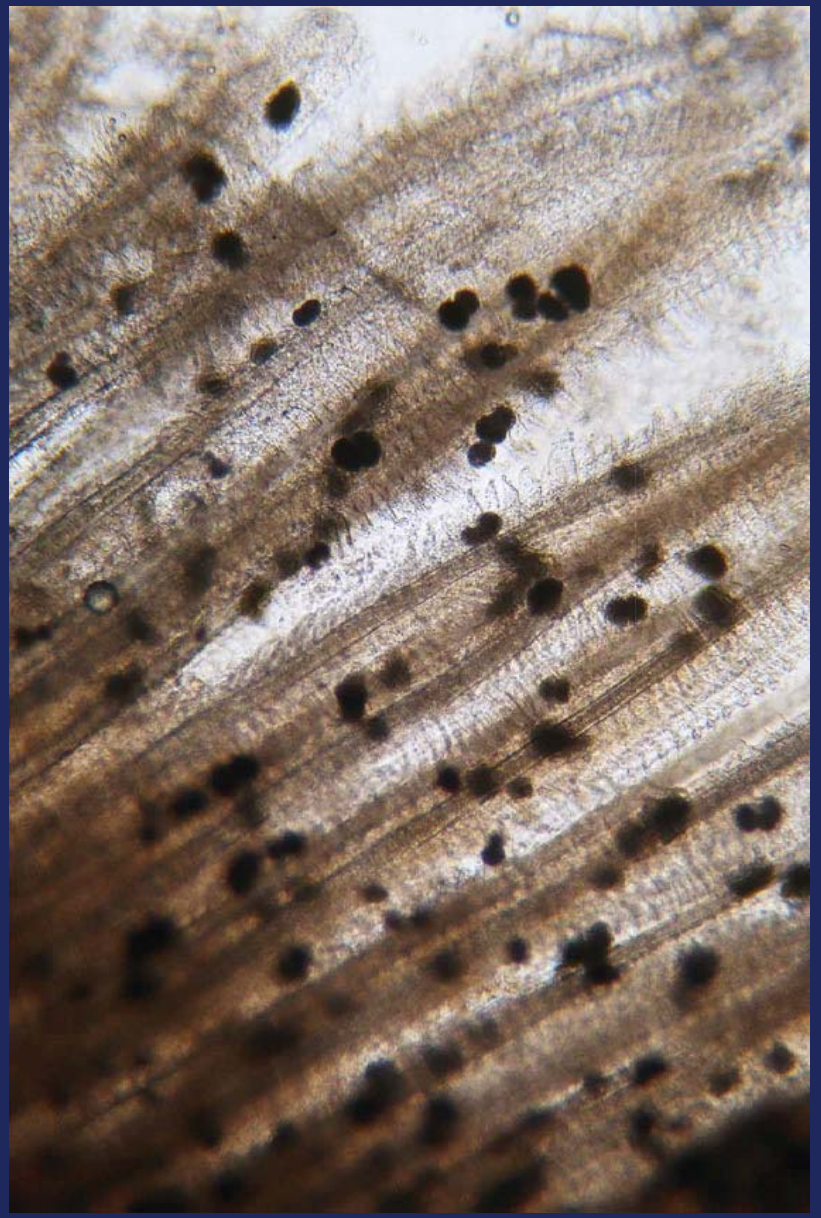
- Washington & Western Canada
- Japan
- Scotland (1994)
  - freshwater rainbow trout, low level mortalities

Atlantic salmon appear resistant

Pacific salmon (& trout) – respiratory distress, secondary disease & mortality

Vaccine?

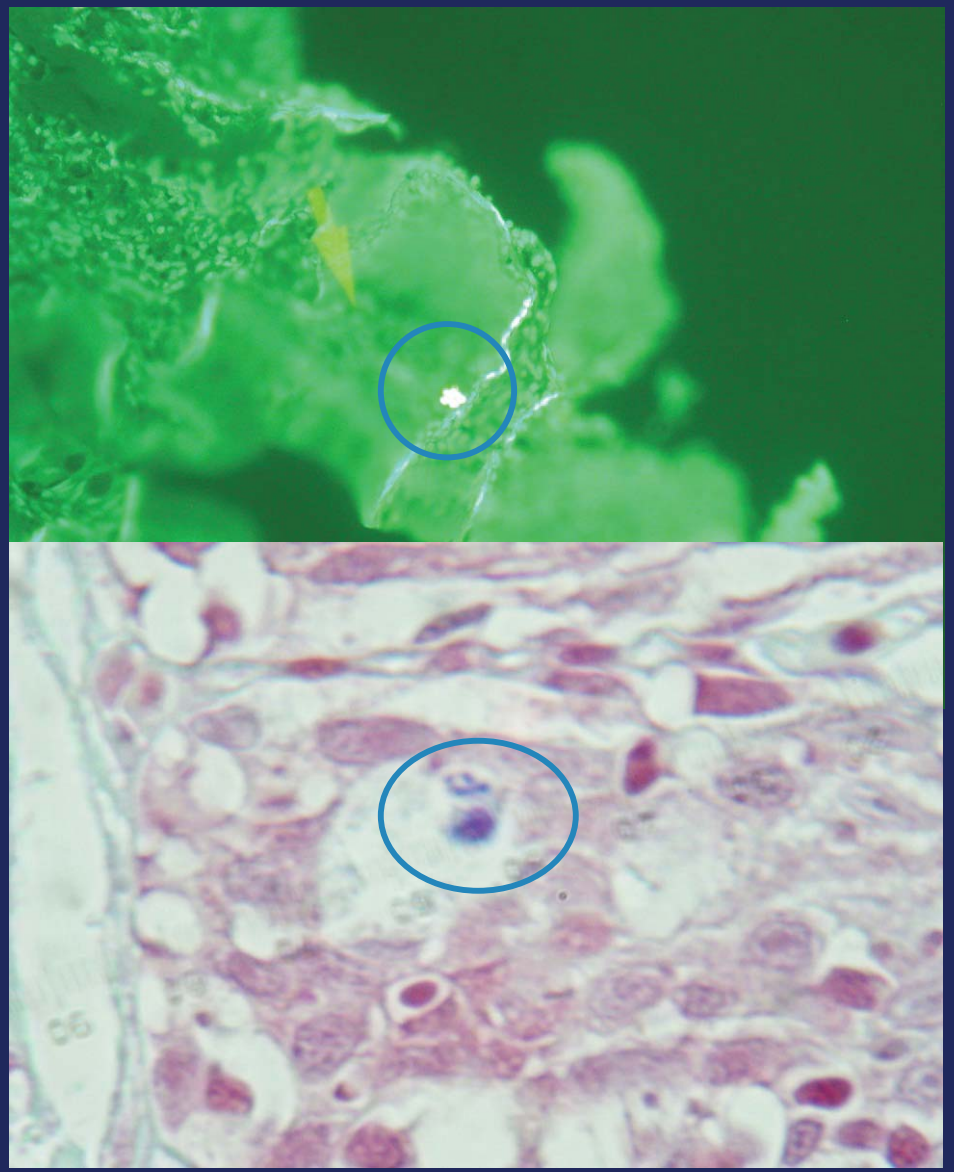
Loma salmonae
- microsporidian



Rainbow trout (*O. mykiss*), Scotland

Desmozoon lepeophtherii (syn *Paranucleospora theridion*)

- Microsporidian parasite
- Marine Atlantic salmon
- Lice (*L. salmonis*)
- Role to be established
- Norway, Scotland, Ireland (& Canada)



Desmozoon lepeophtherii (syn *Paranucleospora theridion*)

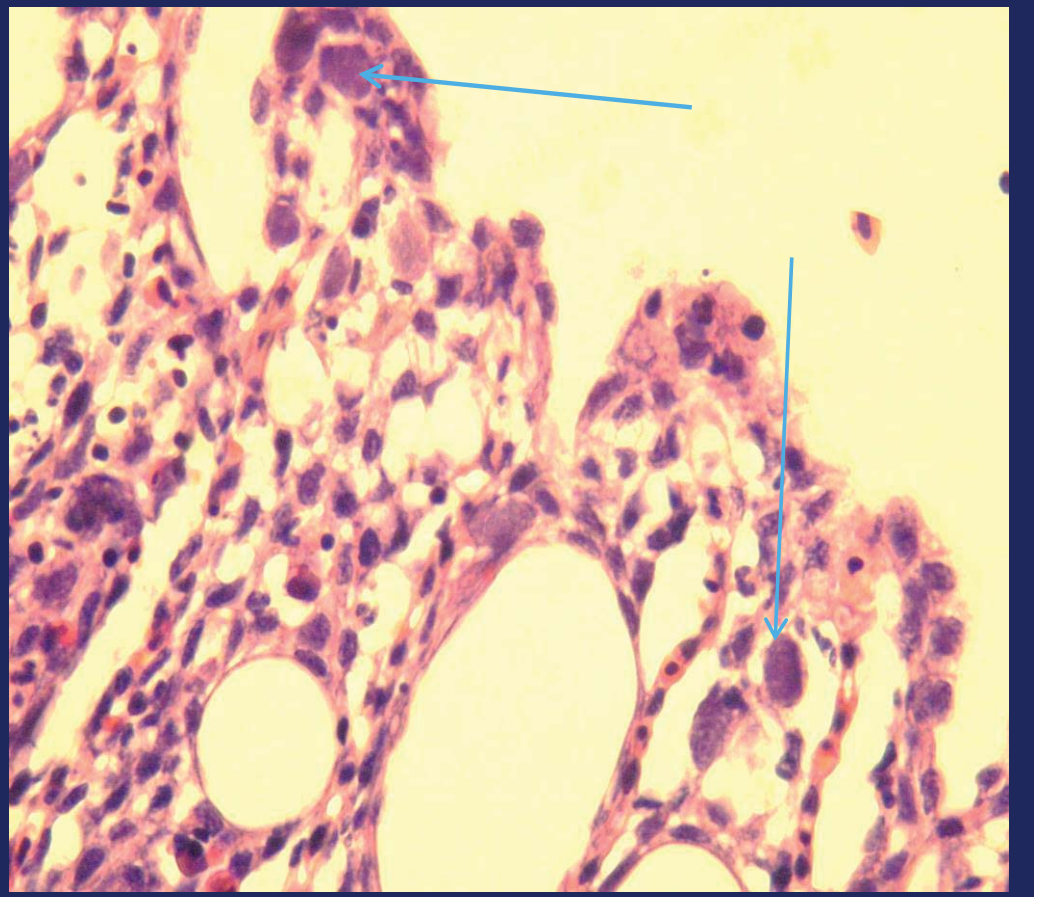
- Histopathology (Gram Twort, Calcofluor White)
- qPCR
- Low Ct values in cases in autumn in Scotland
- Hyperplastic/proliferative gill disease association?
- Histopathological gill score* & Ct value trend

* Mitchell *et al*. (2012) Aquaculture International, 20, 813 - 825

Bacteria

Epitheliocystis

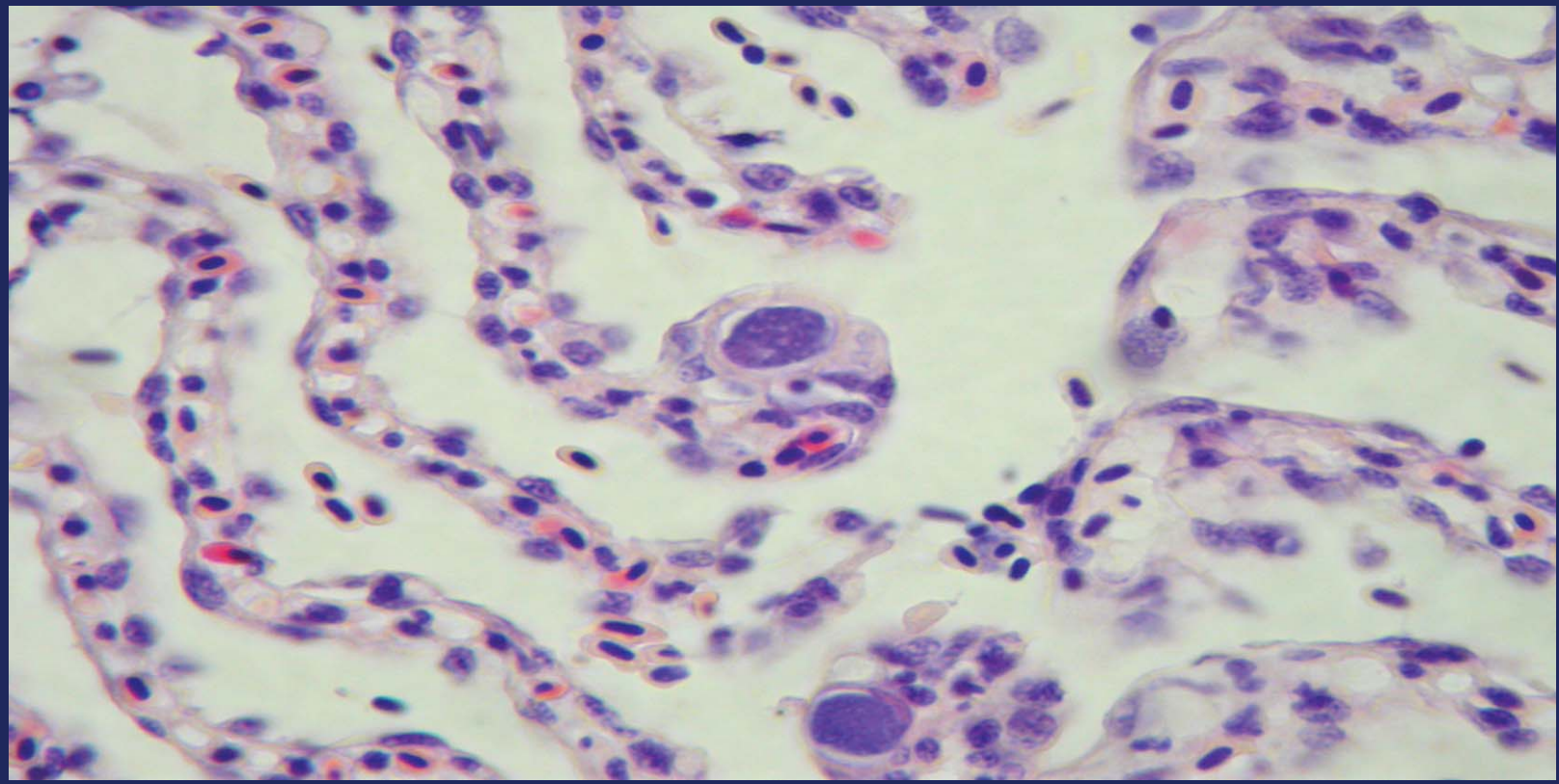
***Candidatus* Branchiomonas cysticola**



Toenshoff *et al*. (2012) PLoS ONE 7(3): e32696. doi:10.1371/journal.pone.0032696

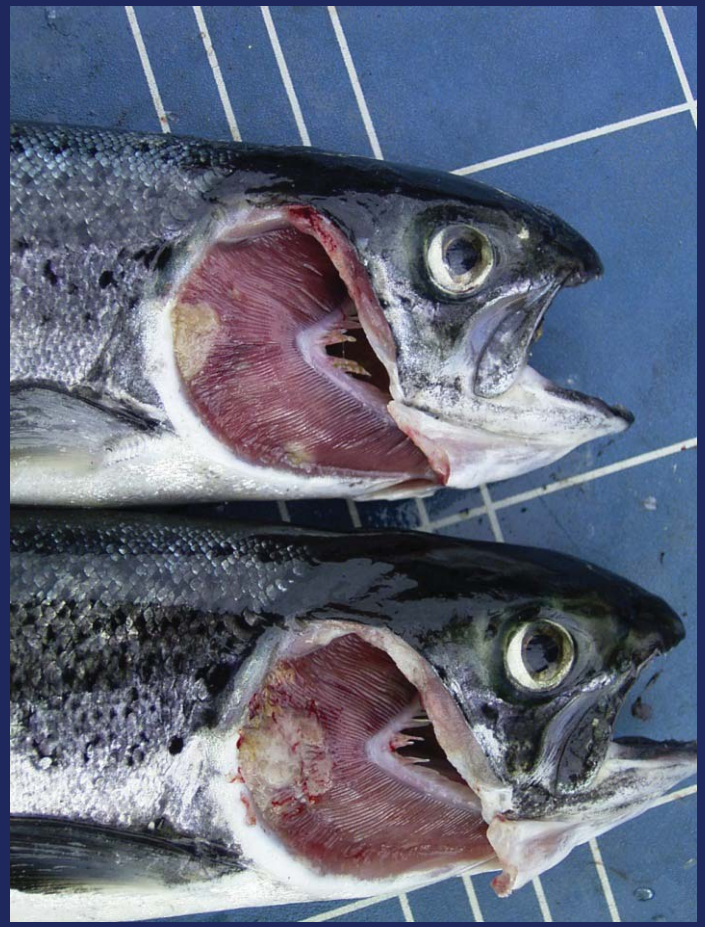
Candidatus Branchiomonas cysticola (Ireland)

- Fish with higher number of gill cysts have higher levels of pathology (Mitchell 2011)
- Cause or effect???



Bacteria

***Tenacibaculum* sp.**

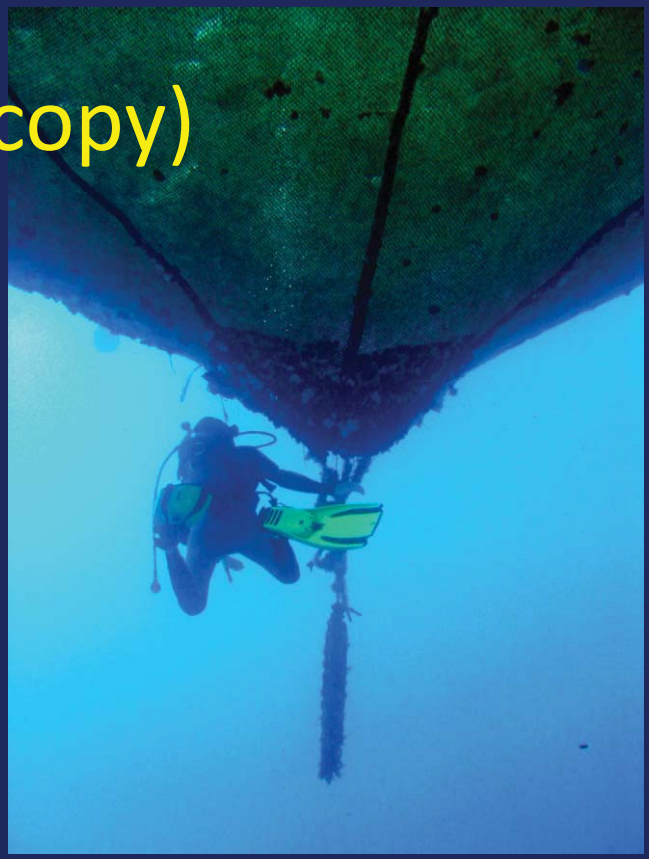


Research - Ireland

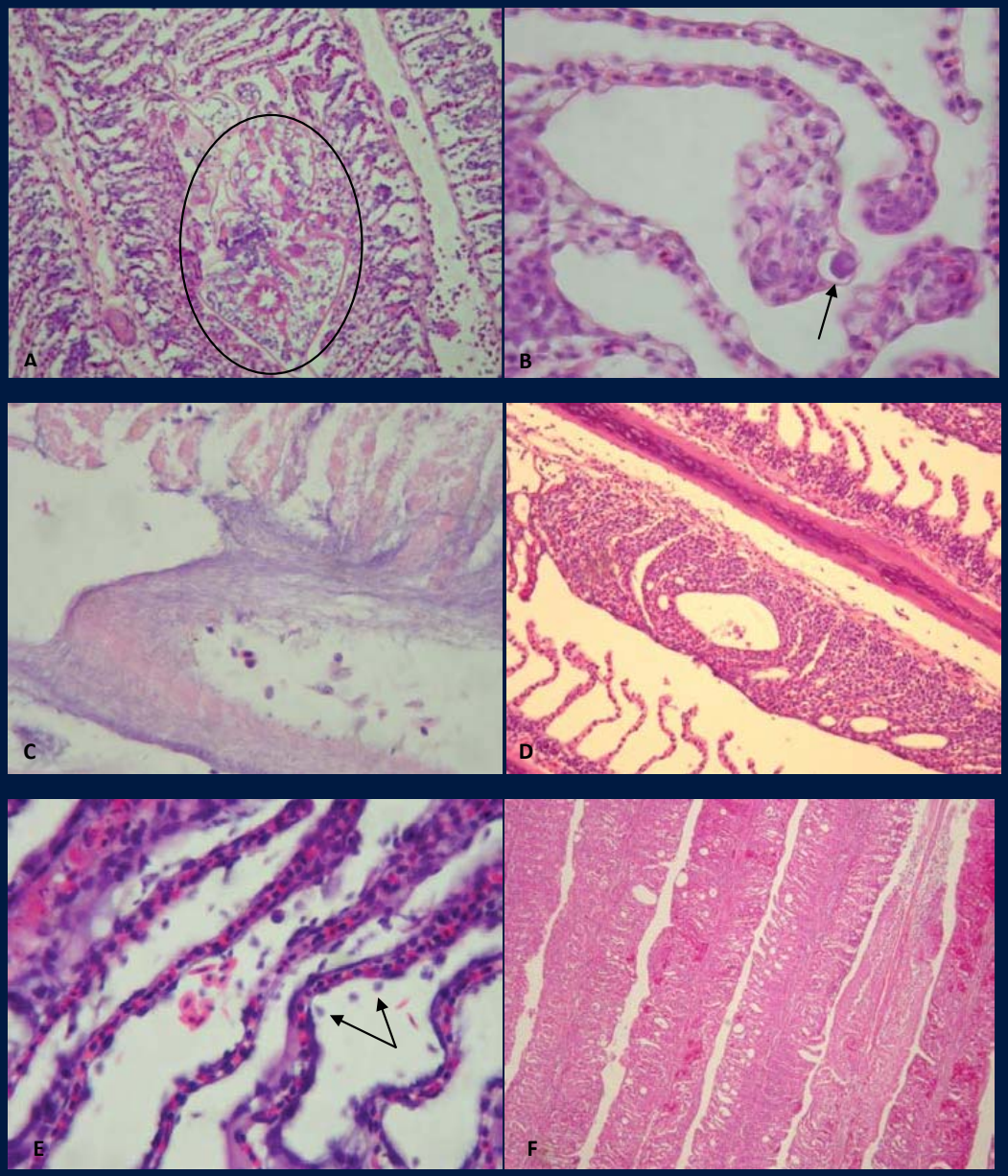
- GILPAT project - duplex quantitative RT-PCR (Dr. E. Fringuelli, AFBI) for *N. perurans, T. maritimum* & *Piscichlamydia salmonis*
- Longitudinal studies (2 marine farms), March to December (every 2 weeks)

Differential diagnosis

- Clinical history & signs
- Water quality, plankton sampling & observations
- Fresh gill smears (on site microscopy)
- Histopathology
- PCR, bacteriology



Differential diagnosis - histopathology



Treatment & control

- HAB & zooplankton: stop feeding, aerate/oxygenate?, move pens?, enclose pens ? but early warning required
- AGD: freshwater baths, hydrogen peroxide, improve environment
- Bacterial gill disease: oral antibiotic if feeding, improve environment

Other conditions

Jaw deformities

Opercular shortening

Summary

- Gill disease highly significant health challenge
- May be uni- or multifactorial
- Accurate, early diagnosis crucial
- Treatments available for some conditions
- Much research required

Acknowledgements

- Dr. Susie Mitchell, Vet-Aqua Int.
- Dr. Emily Baxter, Vet-Aqua Int.
- Dr. Elena Fringueilli, AFBI
- Ms. Sara Pflaum, Uni. of Stirling
- Salmon farmers & vets (Ireland & Scotland)