

FISK BÆRER SITT IMMUNSYSTEM PÅ UTSIDEN – SO WHAT?

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INNHOLD

1. LAKSEOPPDRETT VED EN VEISKILLE PGA HELSE
2. OM Å ENDRE SYNSVINKELEN
3. SMOLTKVALITET = JOKEREN
4. ET “HELSE”TALL FOR HVER BARRIERE
5. FISKEDETEKTIVEN, FORSIKRING OG INNSATS



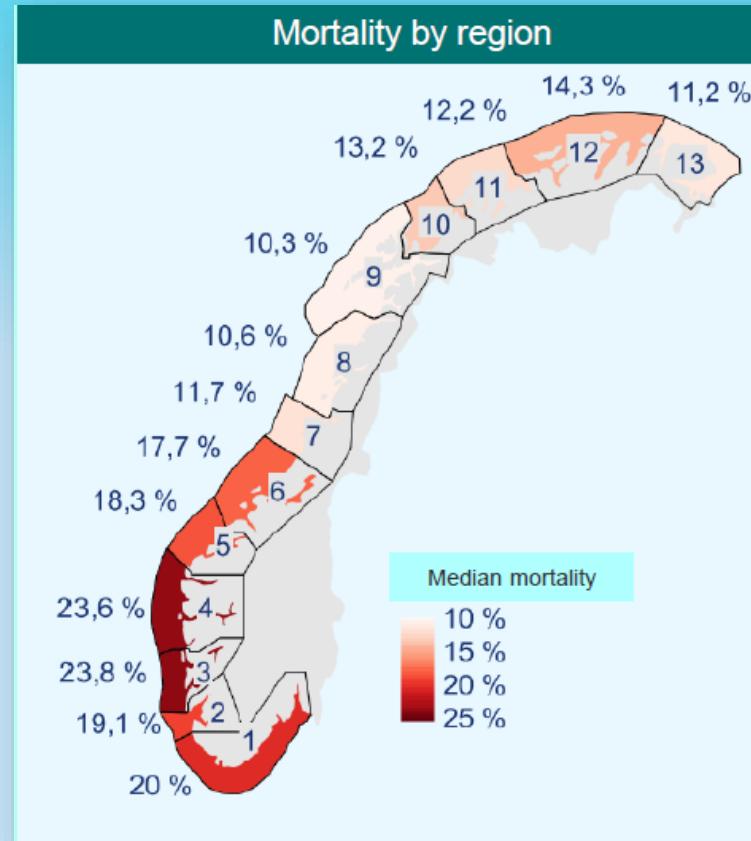
How do you know your stock is healthy?

INDUSTRIAL ANIMAL PRODUCTION VS INDUSTRIAL FISH PRODUCTION

Norsk fiskeoppdrett er ved et veiskille grunnet fiskehelse:

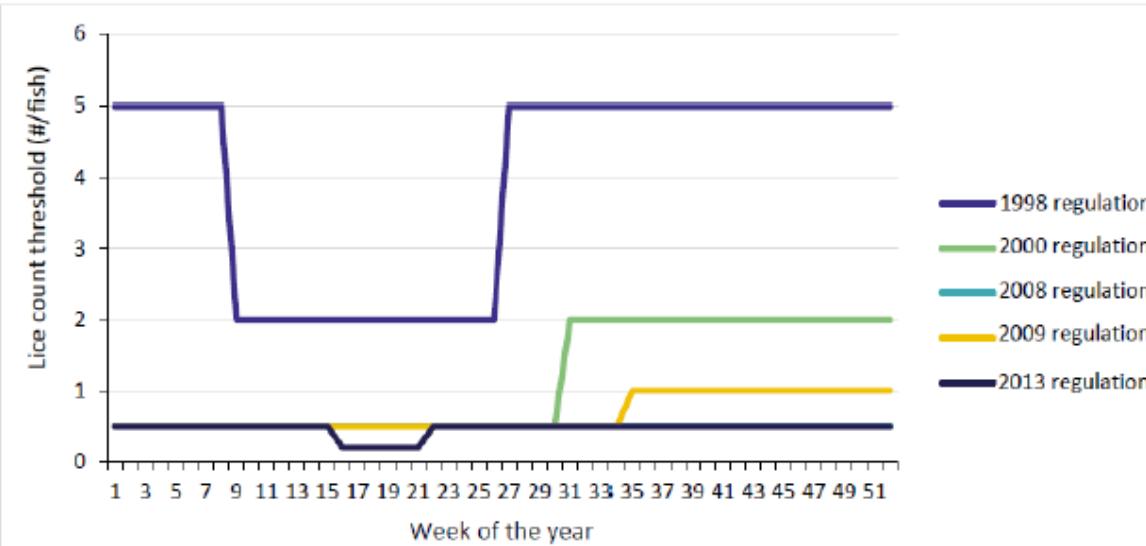
I 2023 døde 63 millioner laks døde i sjøen mens 138 millioner døde før sjøfasen (Riksrevisjon 2023).
«Prodfisk» antall øker.

- Fiskehelse utfordres av lusehåndtering og luseforskriften
- Manglende kunnskap om fiskenes *tålegrenser* kompliserer tiltak
- Manglende standarder for *smoltkvalitet* kompliserer
- Gjellehelse for risikovurdering krever klarhet i hvordan det skal brukes
- Det er et gap mellom tilgjengelig kunnskap og dens anvendelse
- Det er behov for å definere 'normal' fisk og et robust næringssystem
- Generelt ønsker man å forbedre *risiko- og sikkerhetsstyring*



Lusegrensen

Stricter regulations



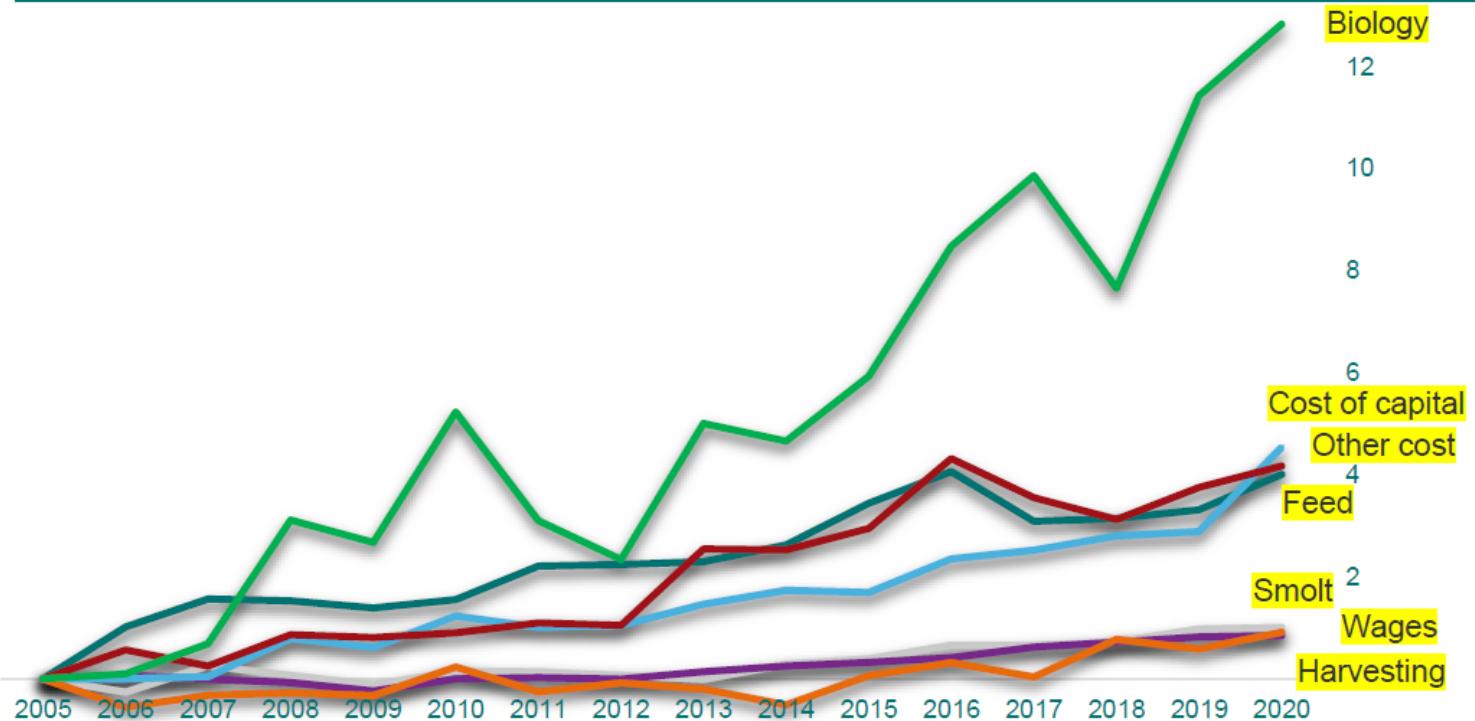
Source: Fiskeridirektoratet, Bård Misund

Økt:
Håndtering
Trengning
Bedøving
Skjelltap
Skader
Transport
Sultdager

ALT BERØRER
HUDENS- OG
GJELLENES
IMMUNFORSVAR

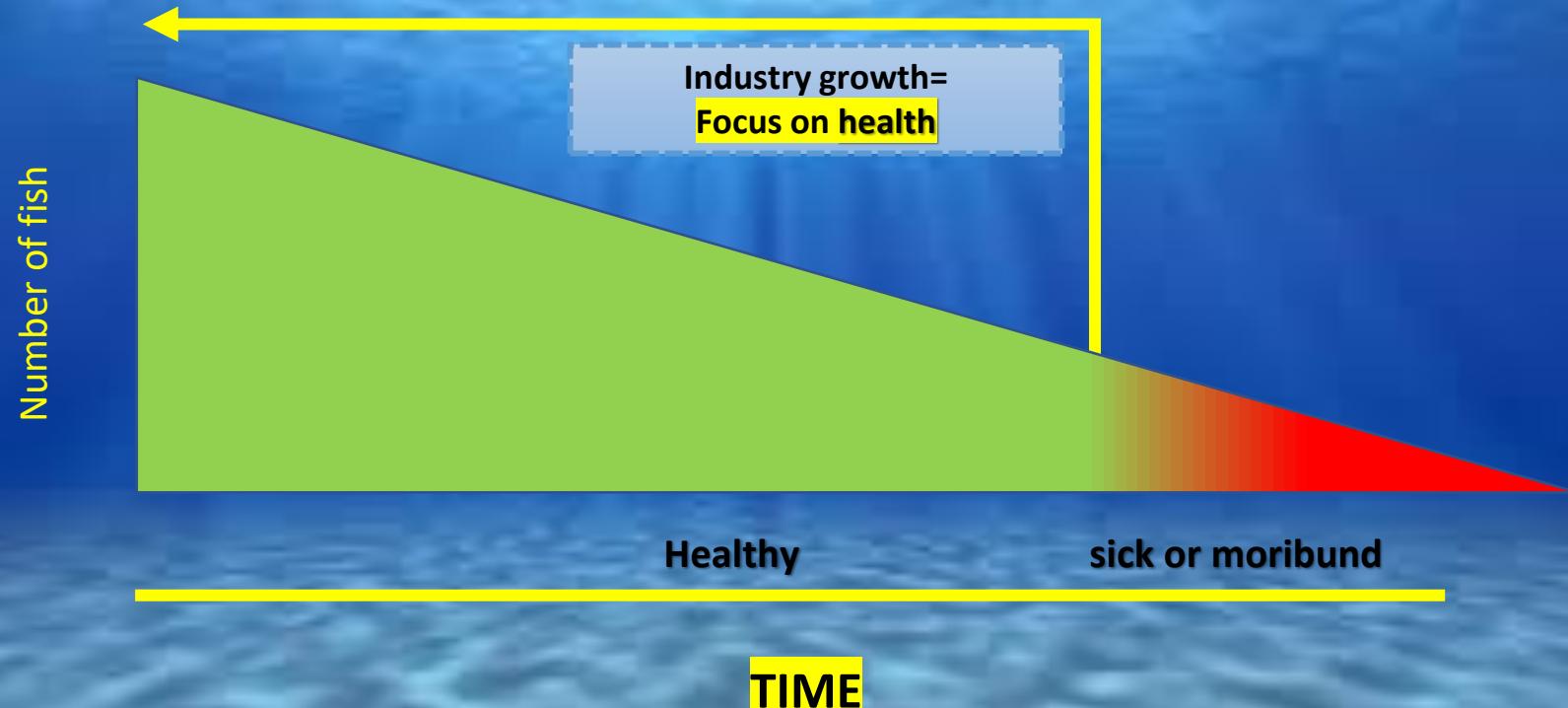
It's lice & disease! Biology a key cost driver

Cost per kg, NOK. Change since 2005



Source: Bård Misund, University of Stavanger

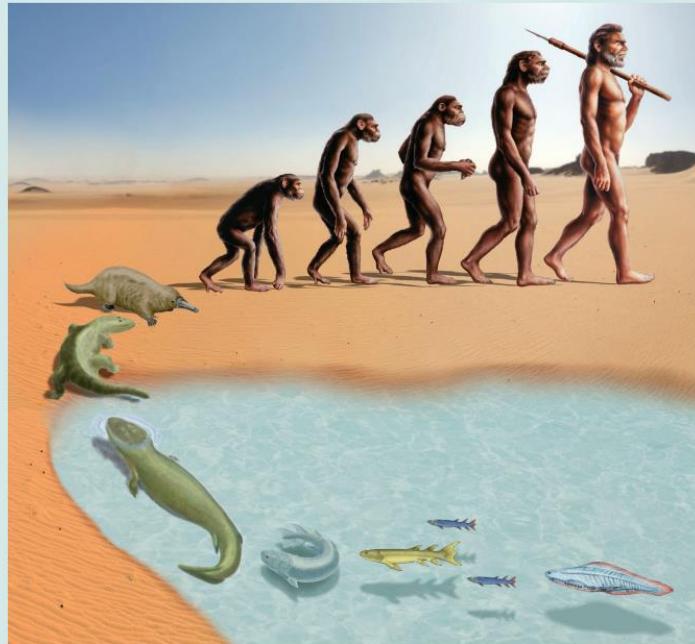
-2



Veribarr™ designed as an industrially scalable metric for fish barrier health

Slimlaget = proactive levende interaktive user-interface mellom dyret og miljø

Evolution in practice: The mucous barriers have protected all animals for over 500 million years. Optimized from nature, absolutely free.

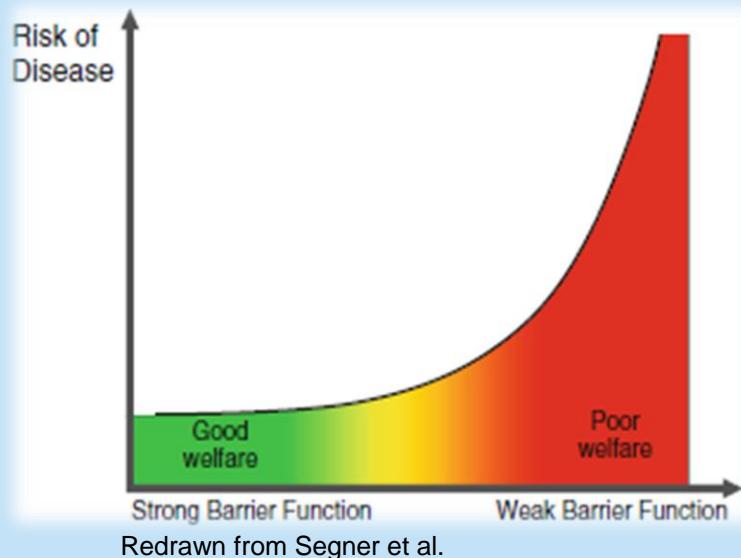


Produktivitetskonferanse Kristiansund 31.10.2023

substance	antibacterial	antifungal	antiviral	antiparasitic
H2A peptider	✓	✓		
H1 oncorhyncin2	✓	✓		
H6 oncorhyncin3	✓			
pleurocidin	✓	✓		
Sal-2	✓	✓		
complement factors	Antigen- antibody	Antigen- antibody	Antigen- antibody	Antigen- antibody
hydrolytic enzymes (proteases etc)	degrade	degrade	degrade	Degrade
IgM, IgT	basic antibodies	basic antibodies	basic antibodies	basic antibodies
lectins	pathogen recognition	pathogen recognition	pathogen recognition	pathogen recognition
mucus extract			✓	✓
interferon			✓	

From: The Robust Fish (2019)

MUCOSAL EPITHELIUM = SKIN, GILLS, GUTS = BARRIER FUNCTIONS



scales

Mucous barrier epithelium wraps over and around the scales, in guts and around gills
- Nice layers, poor statistics

Good barriers = good health

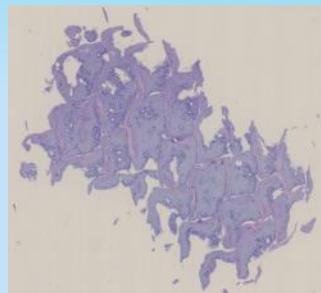
Change your point of view by 90°

Tangential sections for Mucosal Mapping (Veribarr™) analyses = statistically robust results and *millions* of times more surface representation

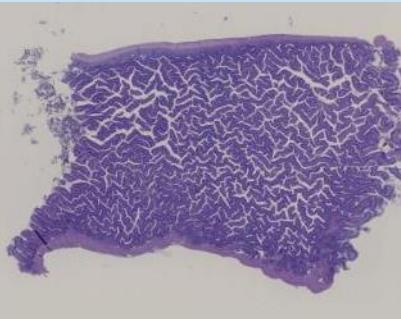
Gill (lamellae, filament)



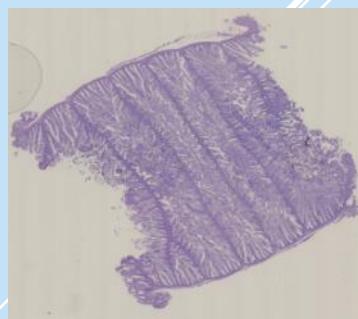
Dorsal hud



Fore gut



Hind gut



Quantitive Analysis

directly comparable across

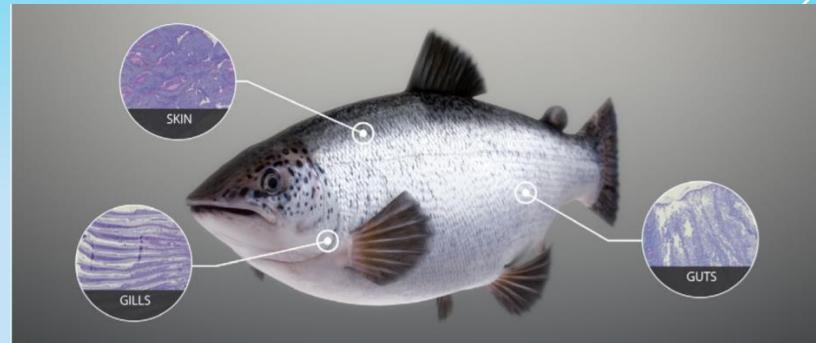
- Species
- Tissue
- Treatment
- Time
- System

Mucosal barrier health – *slime* is more important than intact skin for fish



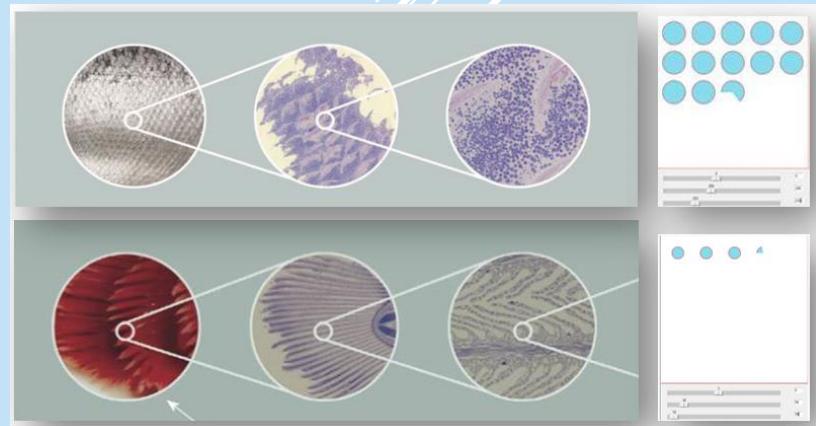
Svendsen & Bøgwald 1997

Aliráðstevnan 1. mars 2024



THE LITTLE BOOK ABOUT THE ROBUST FISH AND THE PROTECTION OF 0.07MM

9



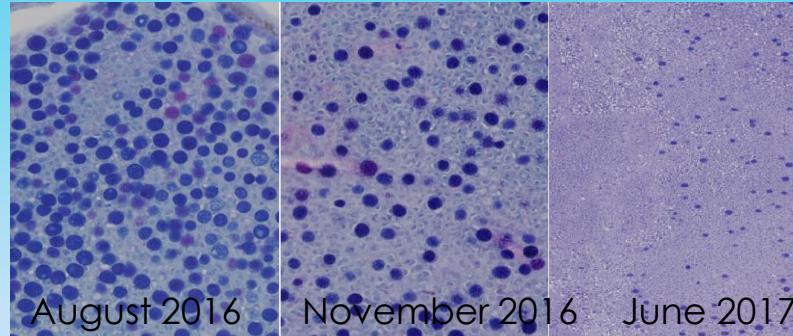
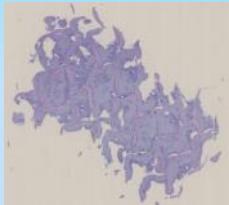
QuantiDoc
Quantifying Robustness

Fisken bærer sitt immunsystem på utsiden

demonstrasjon

GENERATION STUDY

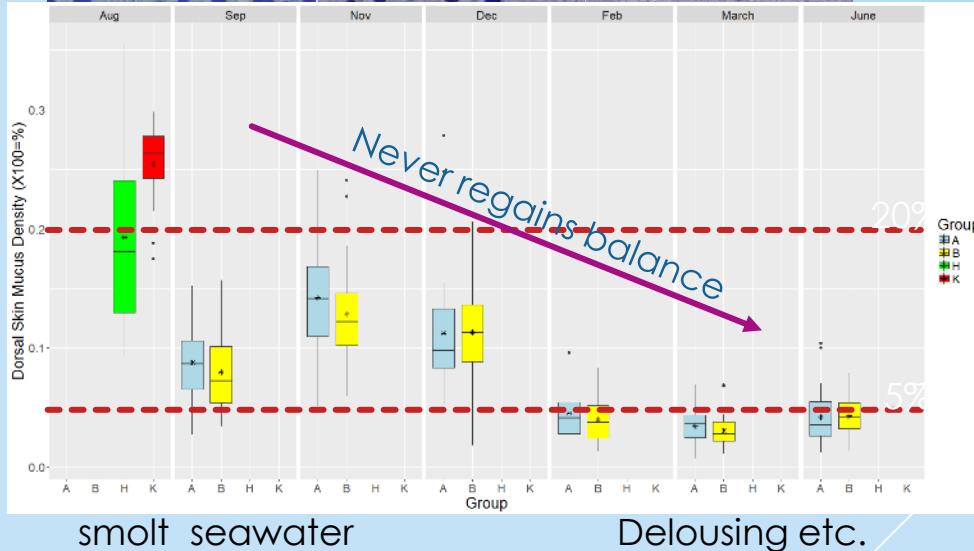
Skin



Smolt origin important

**Stress in transport,
handling,
crowding,
delousings**

**Repeated stress =
repeated
weakening**



GENERATION STUDY

GILLS



Freshwater

Origin differences

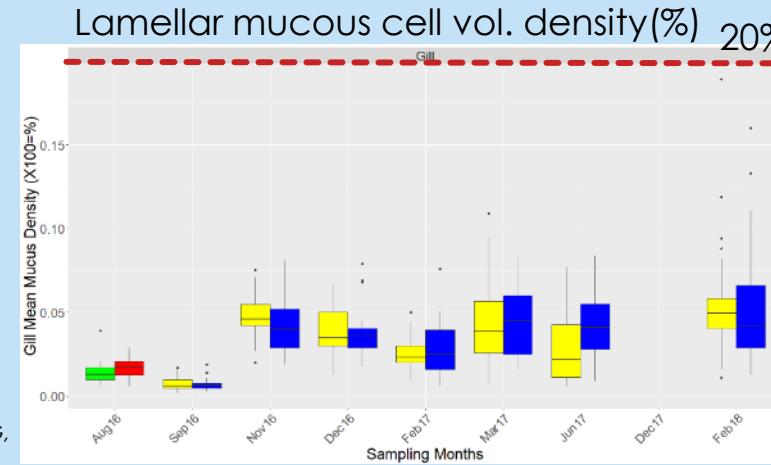
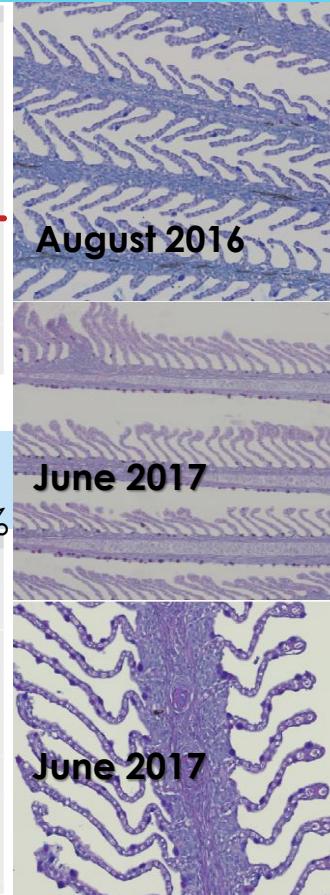
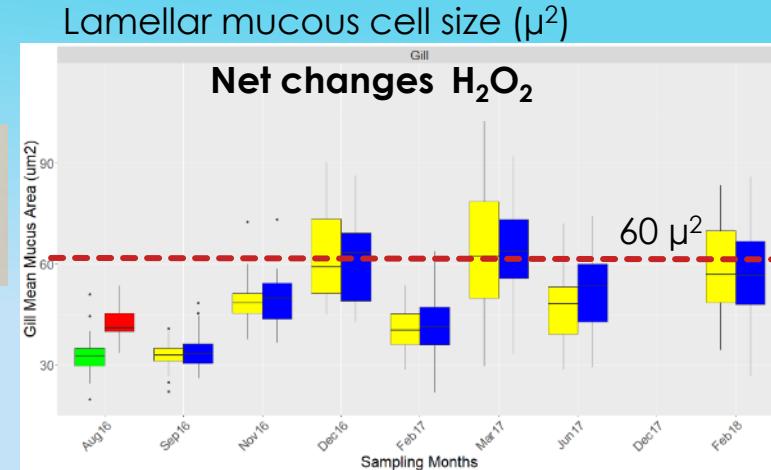
Seawater

Reacts to net changes, particles, delousing

Significant differences within gill score 0-1

n=30-45 under each box
2 treatments in triplicate

WITH MARINE HARVEST, SKRETTING,
FHF, IMR, NIFES OG QUANTIDOC



Smolt er “jokeren”

Før sjøsetting

Vår smolt

Høst smolt

Post smolt

Storsmolt

Mangler standard for

Stammen

Temperatur

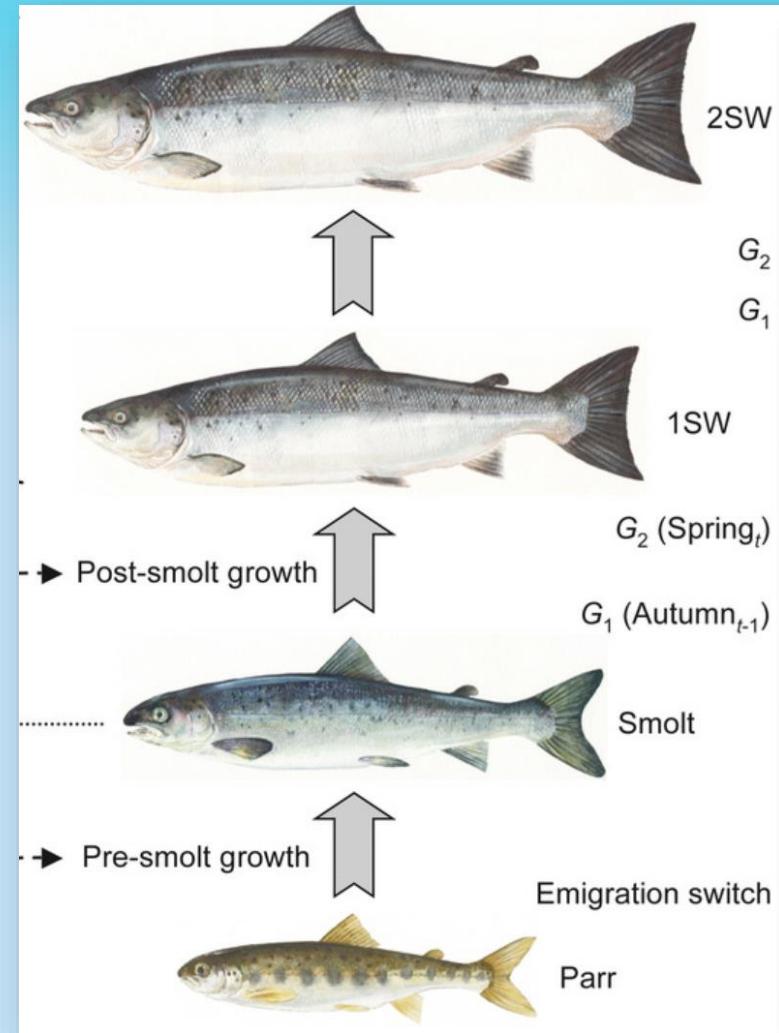
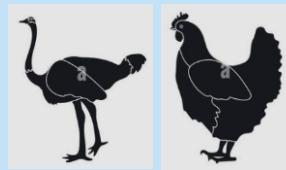
Lysregime

Flytting, sortering

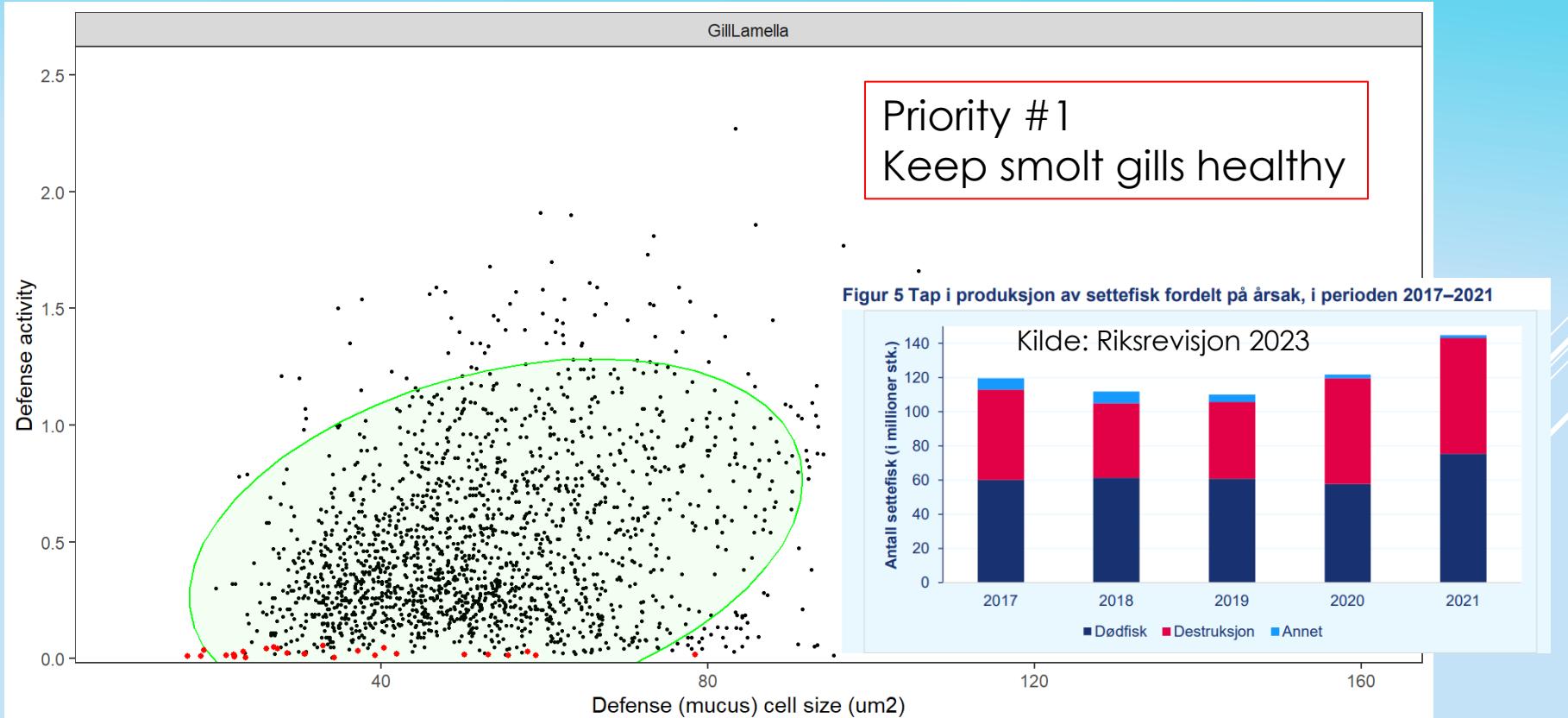
Vaksineringstidspunkt

System (RAS, FT, kar)

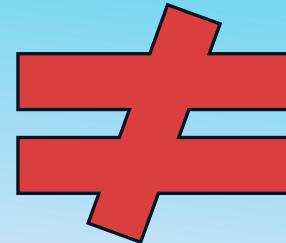
Påvirker:
dødelighet
utseende
lever, hjerte, kjeve
FCR
modning
vekst i sjøfasen



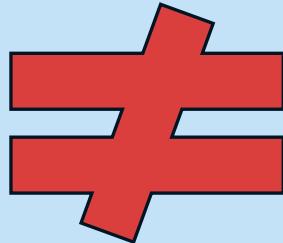
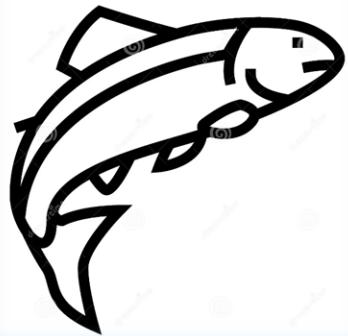
Wild salmon smolt gill lamellae vs farmed salmon gill lamellae



Havbruk



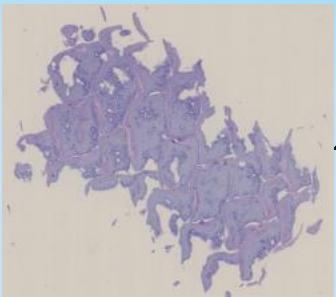
Landbruk
undervann



.....pga yngeldannelse

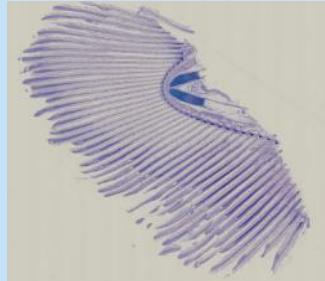
Standarder gir
målbar helse og helsemål:

Dorsal hud

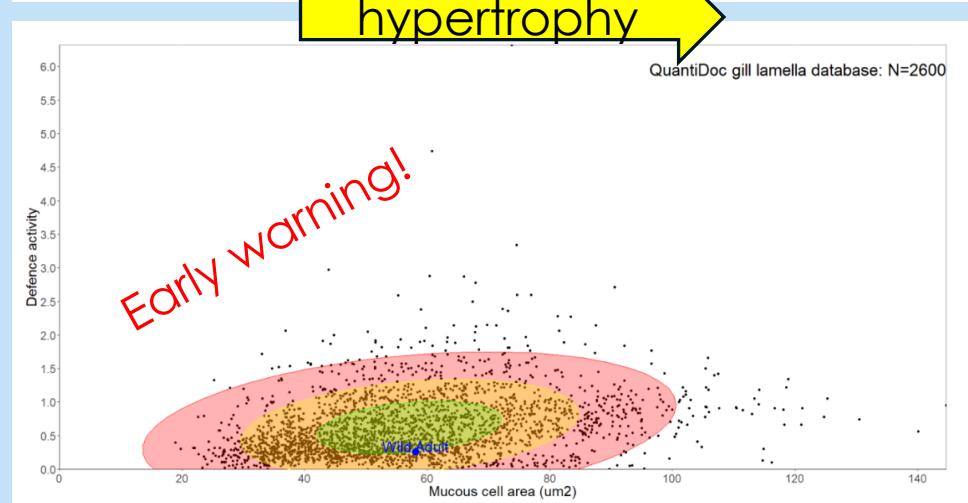
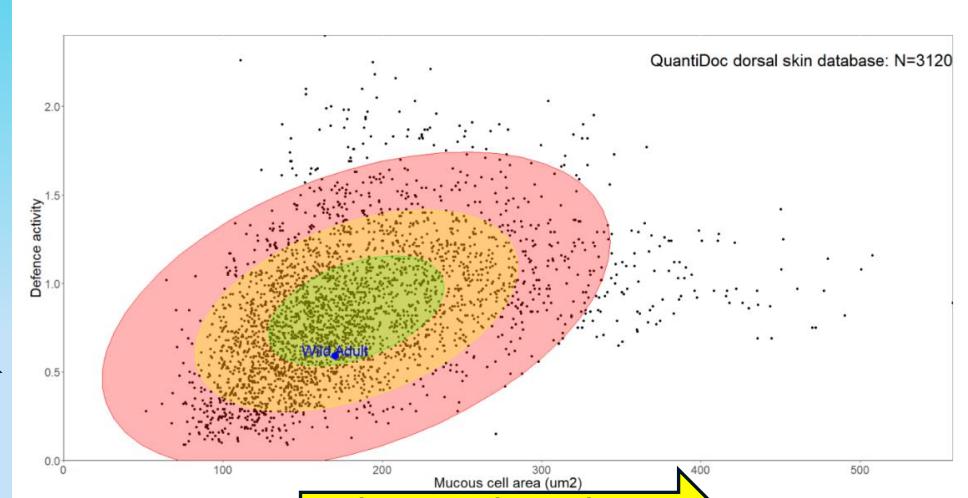


hyperplasia

Gjeller
(lamellae, filament)

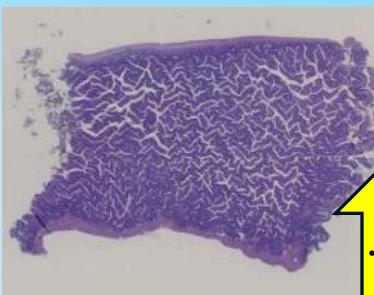


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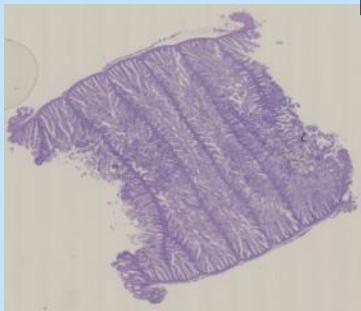


Også for tarmhelse

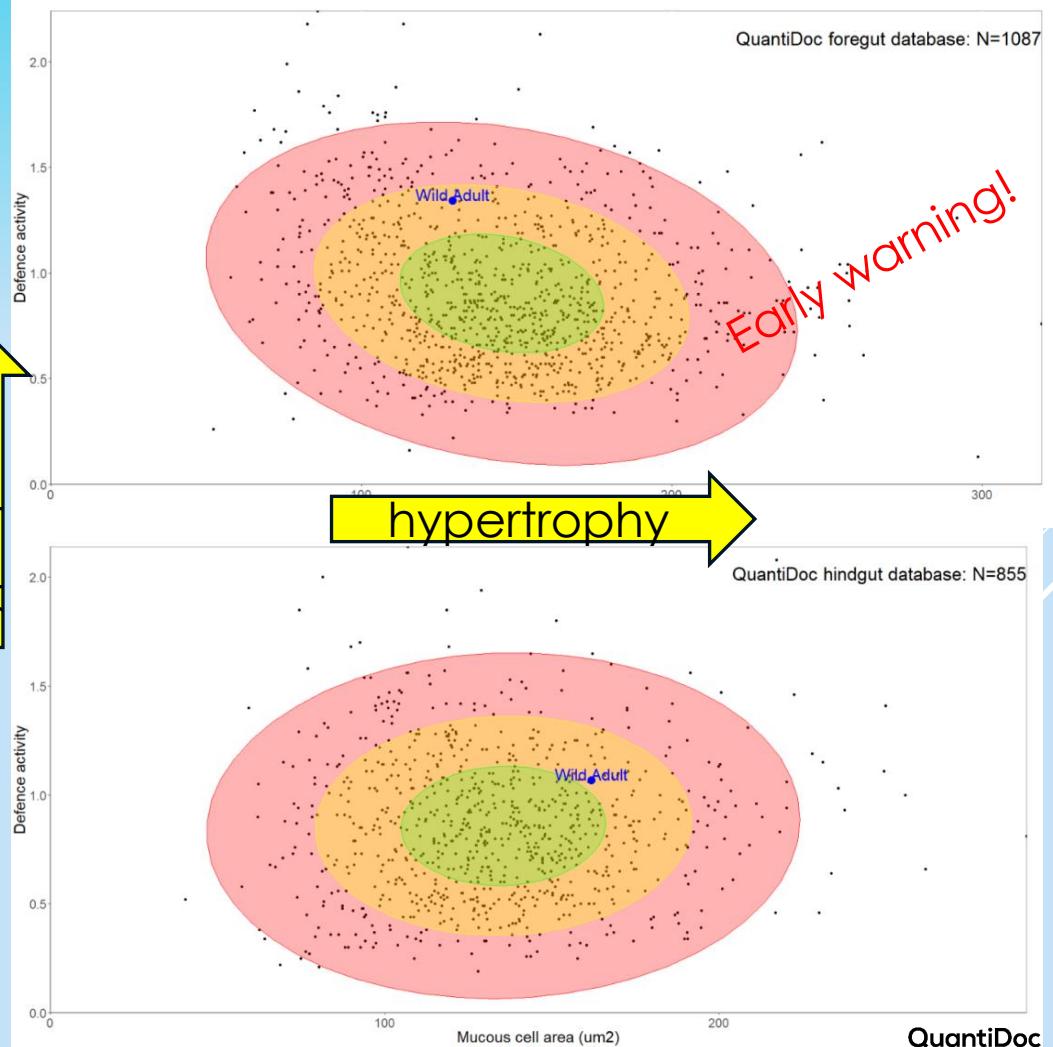
Fore gut



Hind gut

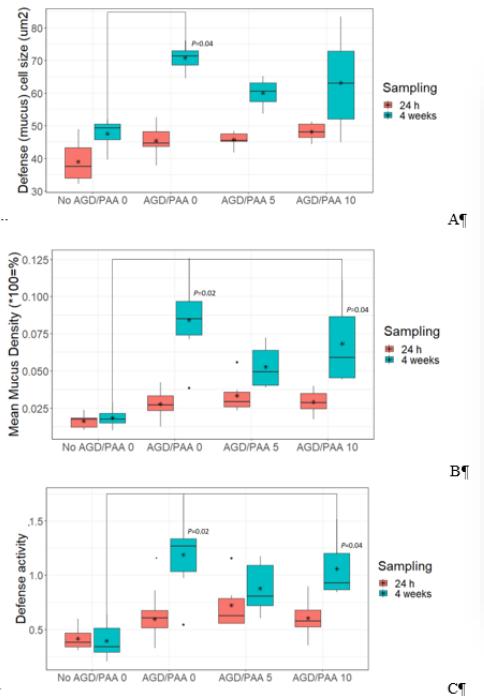


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CASE 1

Boxplots and p-values



24 hrs

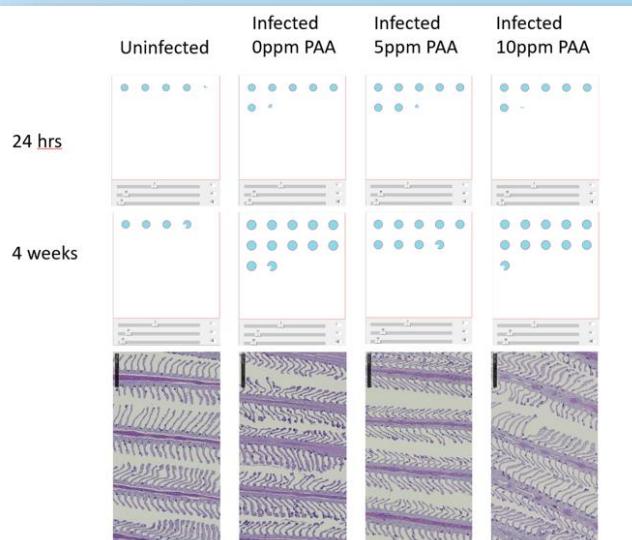
4 weeks

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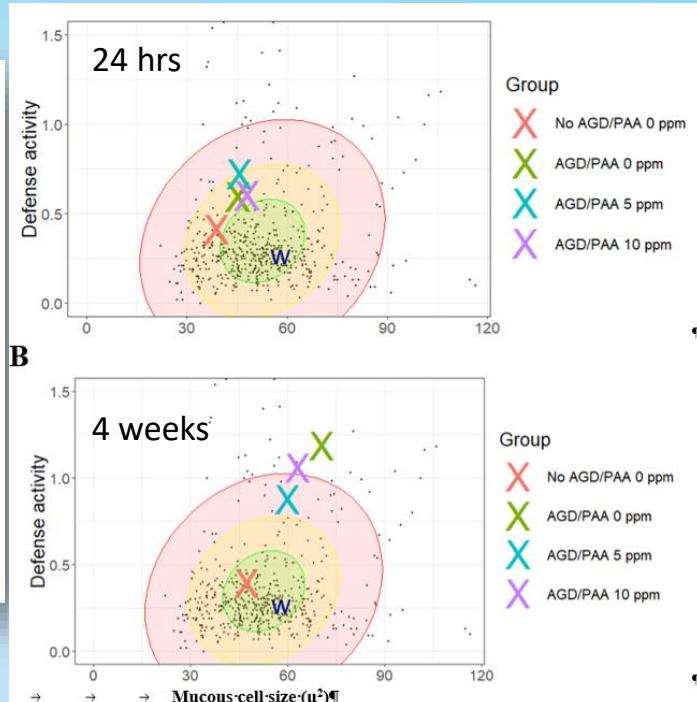
Amoebic Gill Disease increases mucous production within 24 hrs

- Treating with twice the dose Peracetic Acid (PAA) is half as good at 4 weeks

Dicer illustrations of gill lamellar
mucous cells and histological sections



Mean results against Veribarr database



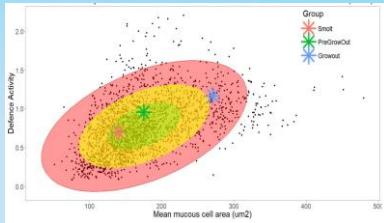
from Lazado et al. 2022. Immunity and stress associated with the infestation of the parasite *Neoparamoeba perurans* are differentially shaped by a potent oxidant in Atlantic salmon (*Salmo salar*)

CASE 2

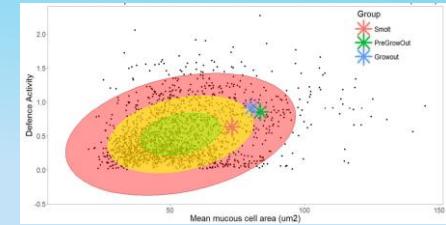
Mucosal responses in multiple tissues for 3 stages in RAS Dicer images and Veribarr database comparison



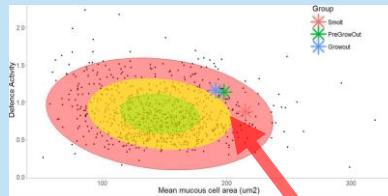
Skin (DB N=2161)



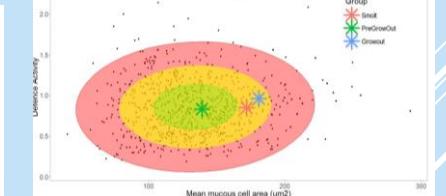
Gills (DB N=1887)



Foregut (DB N=879)



Hindgut (DB N=823)



Diarrhea – revised feed recipe

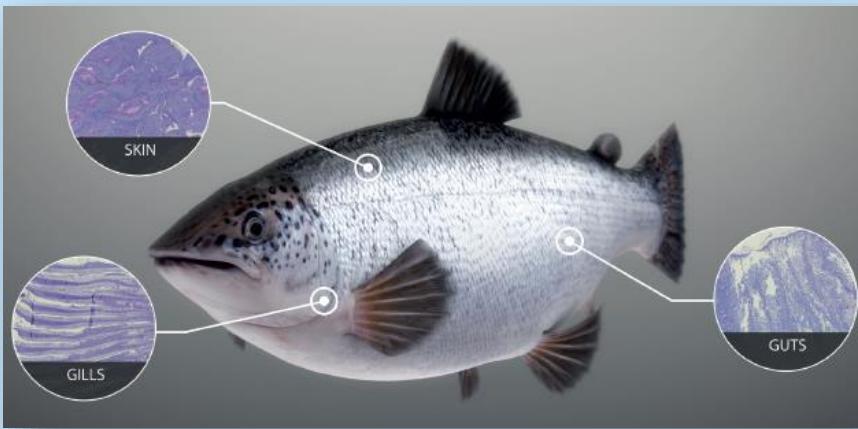
Gills in red zone pregrowout and growout
Foregut in red zone all 3 stages
Red zone = leaving health

The FISH DETECTIVE using Veribarr™

An industrial standard

SKIN = SHIELD

Reflects surface contacts: tank and cage walls, crowding, handling, stocking density



GILLS = SENTINEL GUARD

Reflects stress, water quality, particles, pathogens
50% of fish surface area – earliest warning!

GUT = FOUNDATION

Responds to stress, feeds and water

Database on 13 arter:

Salmon, trout, yellowtail, seabass, seabream, tilapia, lumpfish, wrasse, tuna, barramundi

Works on:

All fish species
All systems

Database on 7 systems

RAS and Flowthrough; open and closed cages; SW and FW, Wild fish in nature

IT'S A NEW DECISION MAKING TOOL IN AQUACULTURE

Score on the Mucosal Index™



Fish is healthy and robust to handle

- None
- Verify status through monitoring

Fish is healthy, but handle with care. Consider actions.

- Continuous monitoring of mucosa
- Evaluate environmental factors
- Consider use of feed additives

Fish is unhealthy. Action is required to avoid disease.

- Monitoring clearly required
- Use feed additives to boost health
- Avoid handling of fish if possible

Fish is weak and at high risk for Mortality & disease

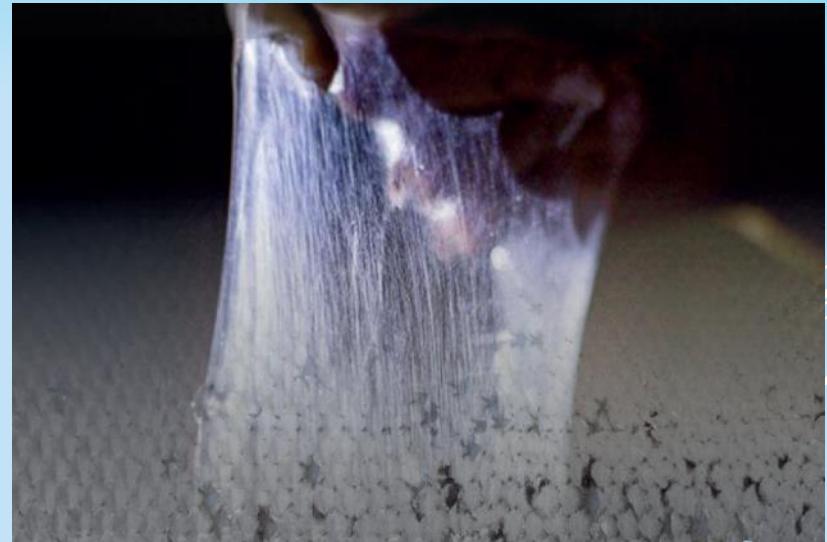
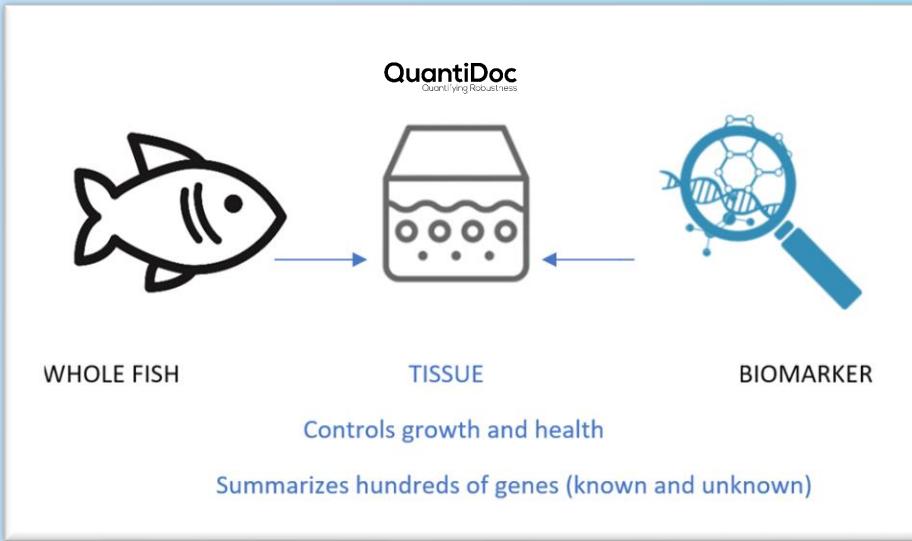
- Do little or no handling of fish
- Consider early harvest

QuantiDoc

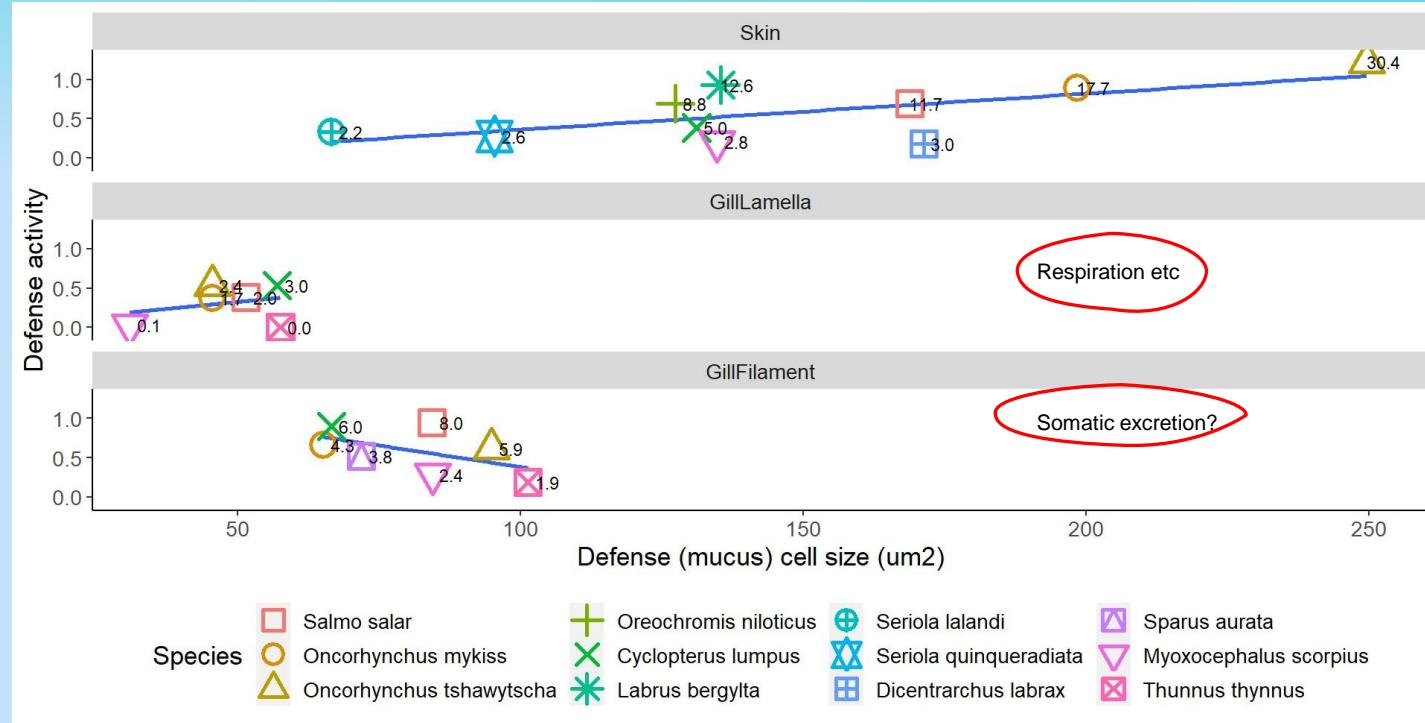
Konklusjoner

- ✓ Fisken bærer sitt immunsystem på utsiden – dette påvirker overlevelse, helse, deformiteter, oppdrettsstrategi, tolerance, produktivitet og bunnlinjen
- ✓ Slimbarrierenes helsestandard muliggjør tidlig oppdagelse av stressorer og sykdom på hud, gjeller og tarm.
- ✓ Normale barrierer kan måles
- ✓ Barrierefelle kan kvantifiseres og settes i “trafikklys” for enkelt tolkning av forebyggende tiltak, forbedringer mm.
- ✓ Standarder og risikobasert vurdering kan anvendes selv med ufullstendig data mao SMOLT
- ✓ Baseline helsemål kan etableres for nye og gamle systemer / arter / batch (KPI)
- ✓ VeriBarr™ barrierestandarden er skalerbar for industri og sammenlignbar over hele havbruksverdikjeden
- ✓ Et objektivt mål for barrierefelle kan anvendes på **oppdrett, forsikring, og logistikk**

An external membrane 0.07 mm thick protects fish health: the mucous membranes of skin, guts and gills



Results across 12 species

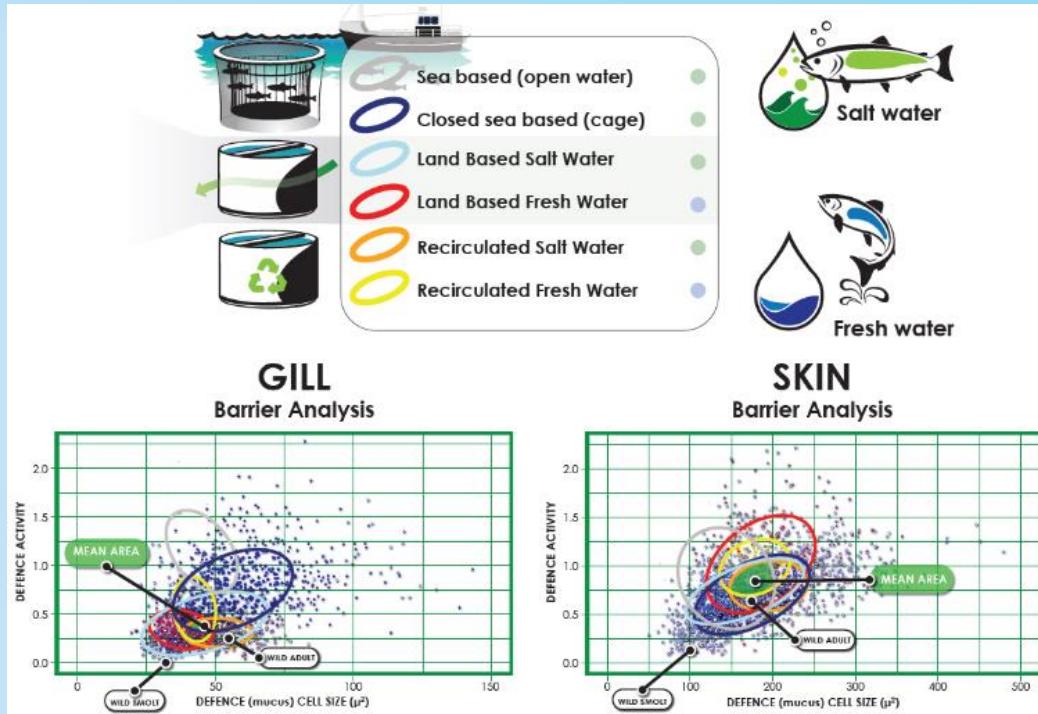


The variation in MC size (μm^2) in epithelia and calculated MC defense activity of the tissue ($1000 / (\text{MC size} / \text{MC volumetric density})$) for 12 fish species. MC volumetric densities in the epithelia (%) are presented as labels.

From: Merkin et al (in prep) Revising current understanding of the mucosal interface in fish based on the quantitative pattern of mucous cell production in the skin and gills of Atlantic salmon and 11 other fish species

Standardization increases understanding and control of barrier health

Veribarr™ salmon database from 2018 (Skin N=~2000 Gills N=~1000)



Veribarr vs traditional histology

Comparison	Histological quantification of mucous cells	Veribarr™ on mucous cells (design-based stereology, 3D from 2D)
Length or area	1-2 mm running length	1-2 cm ² surface area
Unit of measure	Relative to existing structures	Universally applicable
Orientation of section	Very important	Not important
Standardization	- No standardized units - Not directly comparable across treatment and organs	- Standardized reporting - Comparable across treatment and organs
Qualitative or quantitative	Qualitative and quantitative	Quantitative
Method	Manual	Semi-automated
Bias	Biased unless random rules applied	Unbiased

(Table modified from Dang *et al.* 2020, Table 4).