Táknuheilsa

Fiskaaling
Aquaculture Research Station of the Faroes

Aliráðstevnan

2022

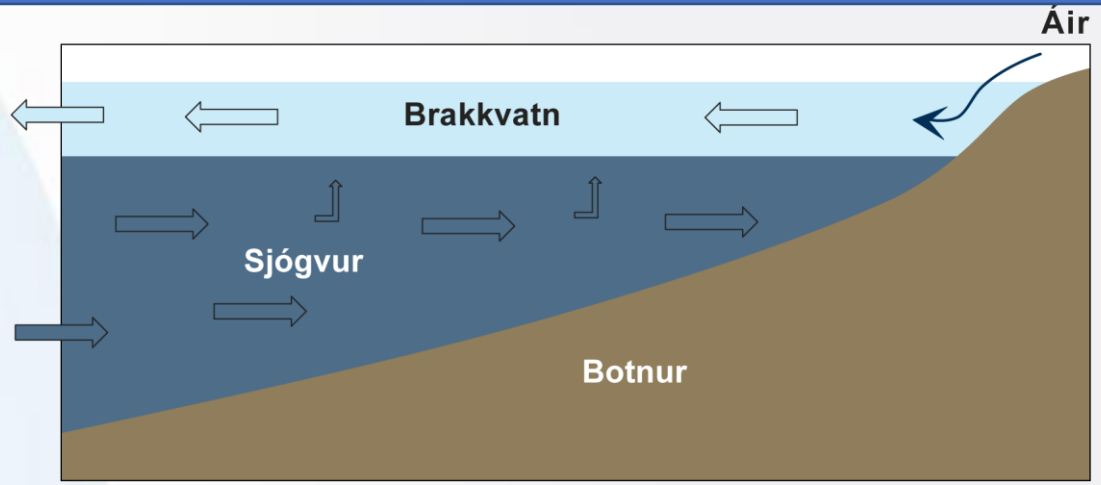
Kim S. G. Bergkvist, PhD

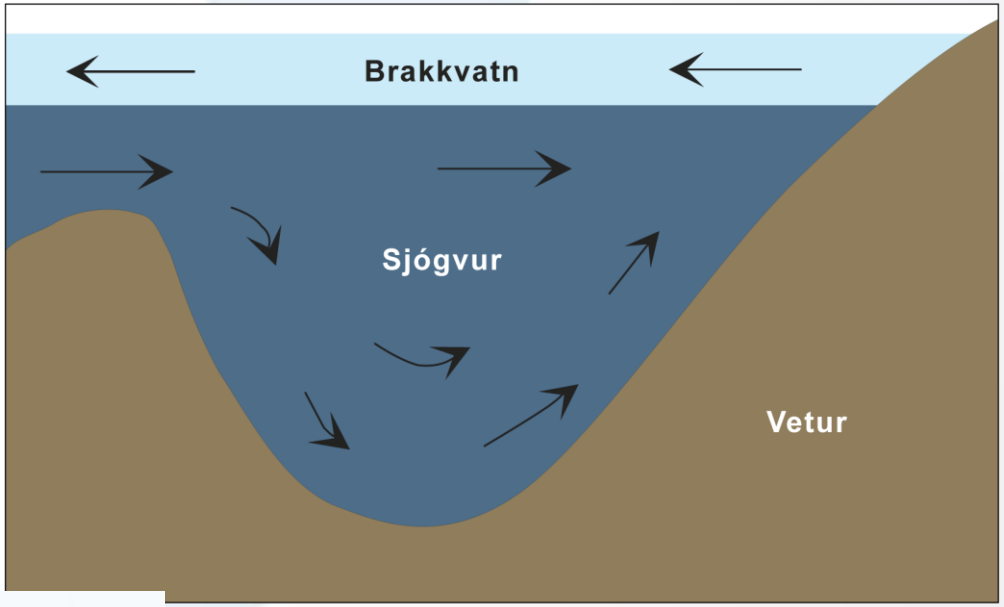
Gællehelse fra en opdrætters perspektiv

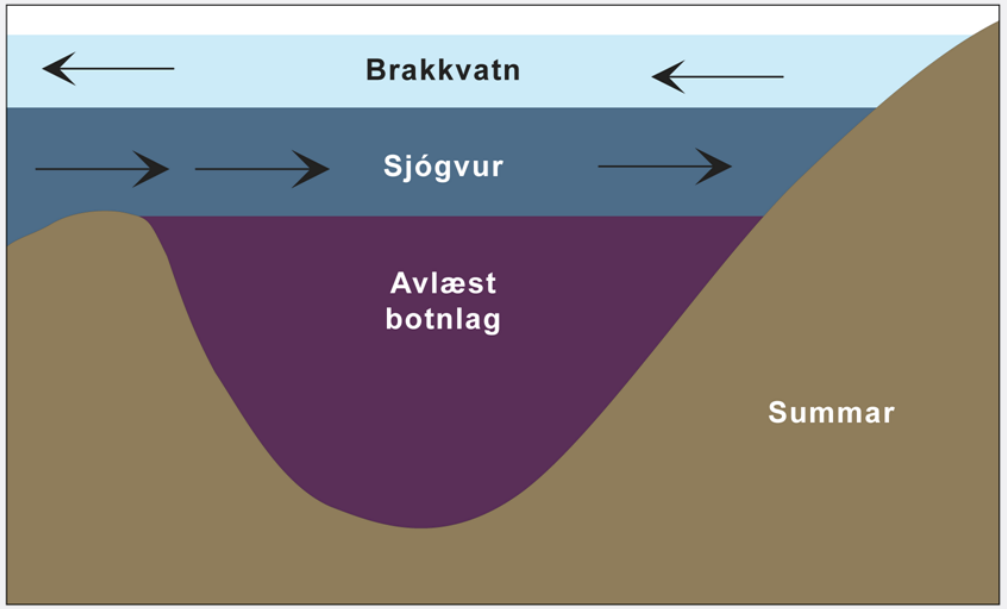
- Desværre er dette billede stadig relevant i dag, efter mange års forskning
- Gællehelse er stadig et kompliceret område med mange ukendte, især for opdrættet laks

Hvorfor har nogle fjorde ofte gælleproblemer I forhold til andre fjorde?

Fiskaaling fokusmoråde:
Hvad er der i vandet?







HAVSTOVAN
FAROE MARINE RESEARCH INSTITUTE

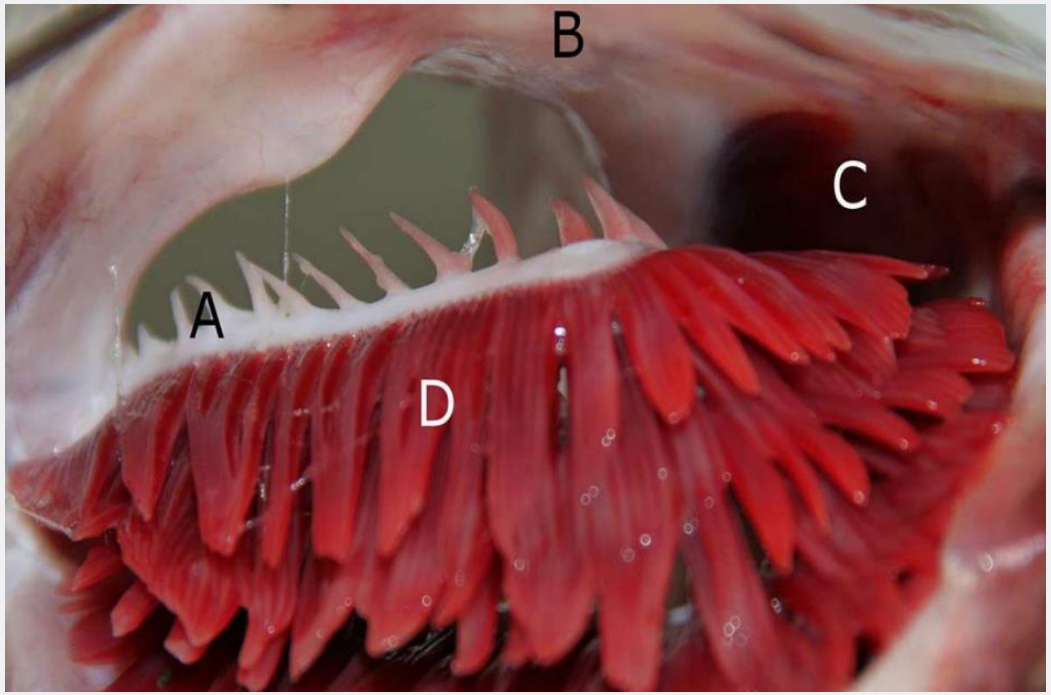
Dagsorden

- Gællernes funktion og opbygning
- Gællesygdomme (CGD)
- “Hvad er der i vandet” (udover virus, bakterier), som irriterer gællerne
  - Mikroalger
  - Små gopler (hydrozoer)
- Gællehelse og stress – immunforsvaret hos fisken er en nøglespiller
- Pilotprojekt – Kan immun-gener sige noget om gællehelse?

Gællernes funktion

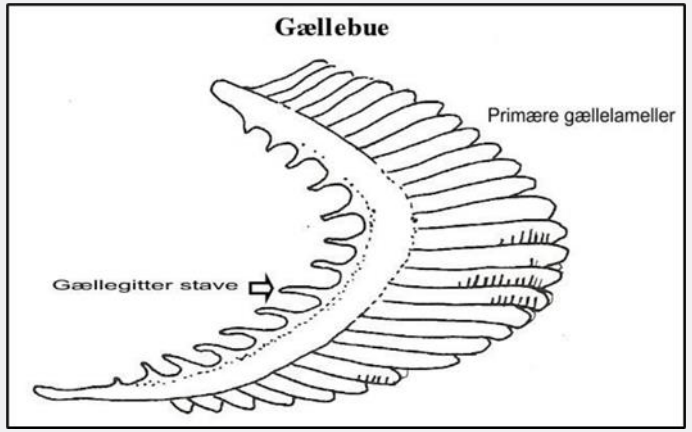
- Åndedræt
  - Optagelse af ilt (O_2) fra vandet
  - Afgivelse af kuldioxid (CO_2) til vandet
- Vand- og saltbalance
  - Optagelse og udskillelse af salte (Cl^-), ferskvand/saltvand
- Syre – base regulering
- Udskillelse af affaldsstoffer
  - Restprodukter fra proteinomsætningen I form af (NH_3), (NH_4^+) via gællerne
- Spiller en vigtig rolle for immunfunktionen

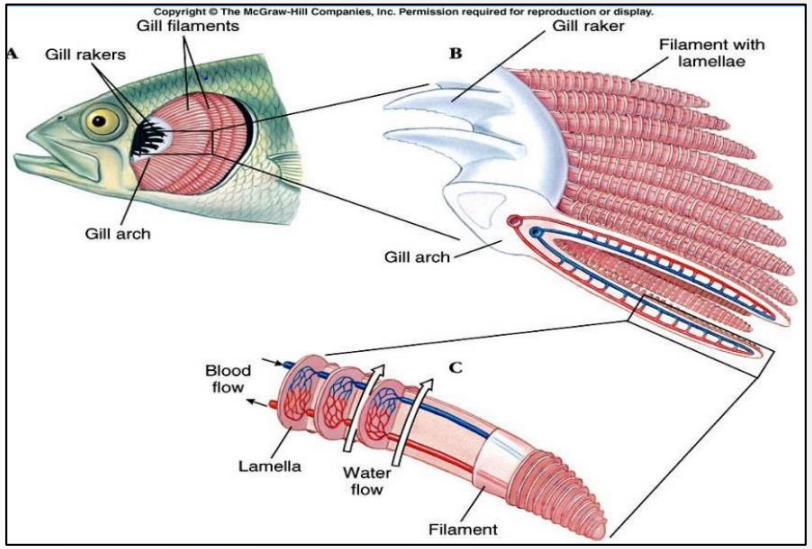
Gællernes opbygning

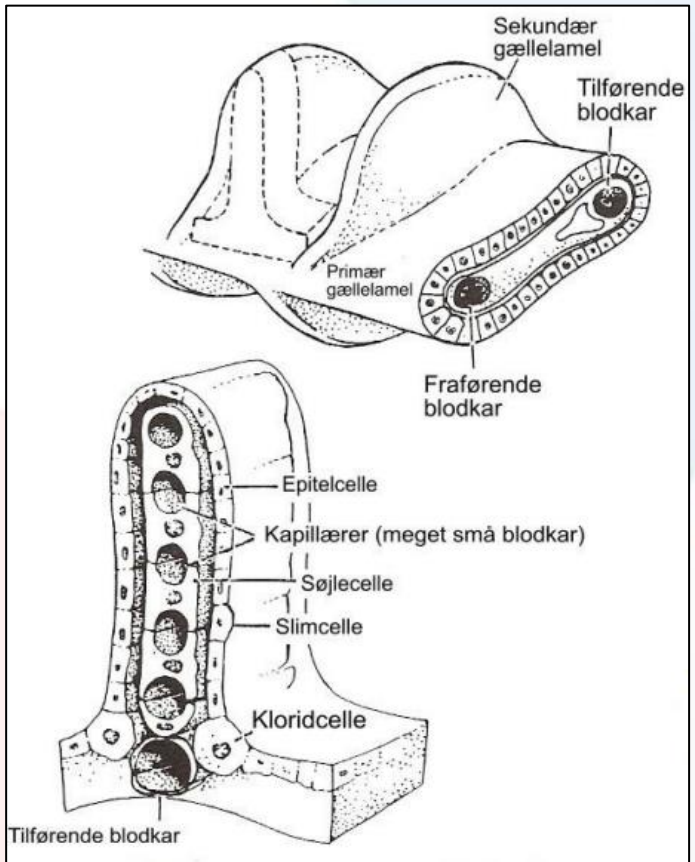


- (A)Fire gællebuer
- (D) Med 2 rækker af gælleblade
- (C) Gællehulen
- (B) Afskærmet af gællelåget
- Der er fire gæller i hver side

Gællernes opbygning





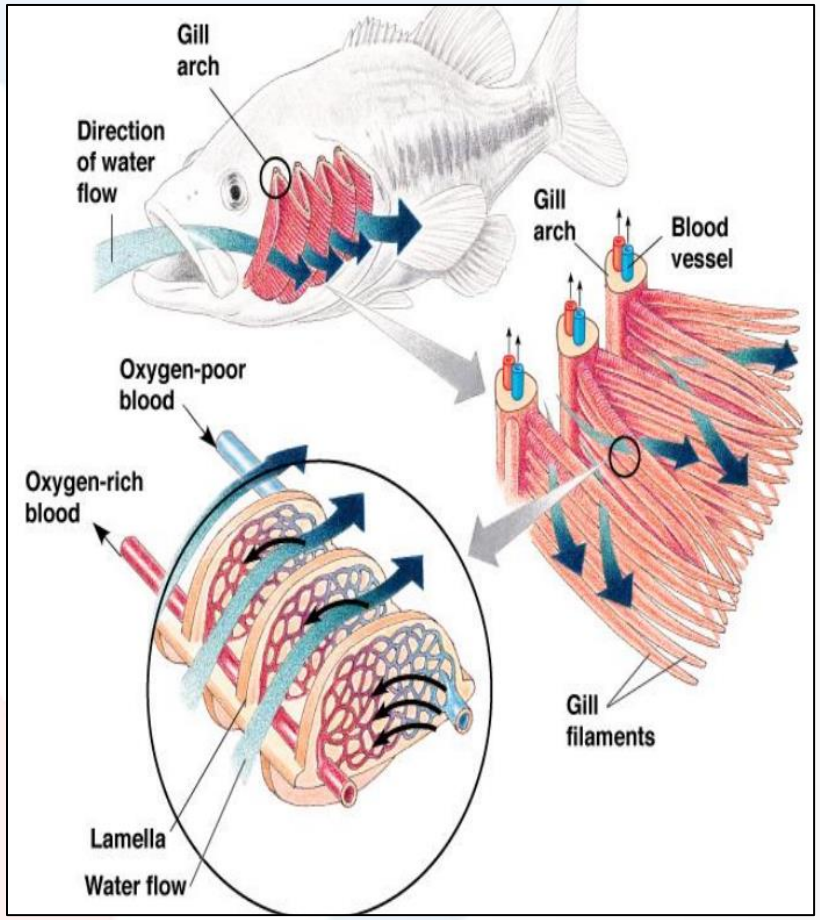


<u>"Gills are everything"</u> Udgør 50% af den samlede overflade på fisken

Strategi ved øget iltbehov

- Øge vandgennemstrømningen gennem gællerne
- Øge mængden af blod gennem gællerne (hjerterytmen)

Ydre påvirking af gællerne



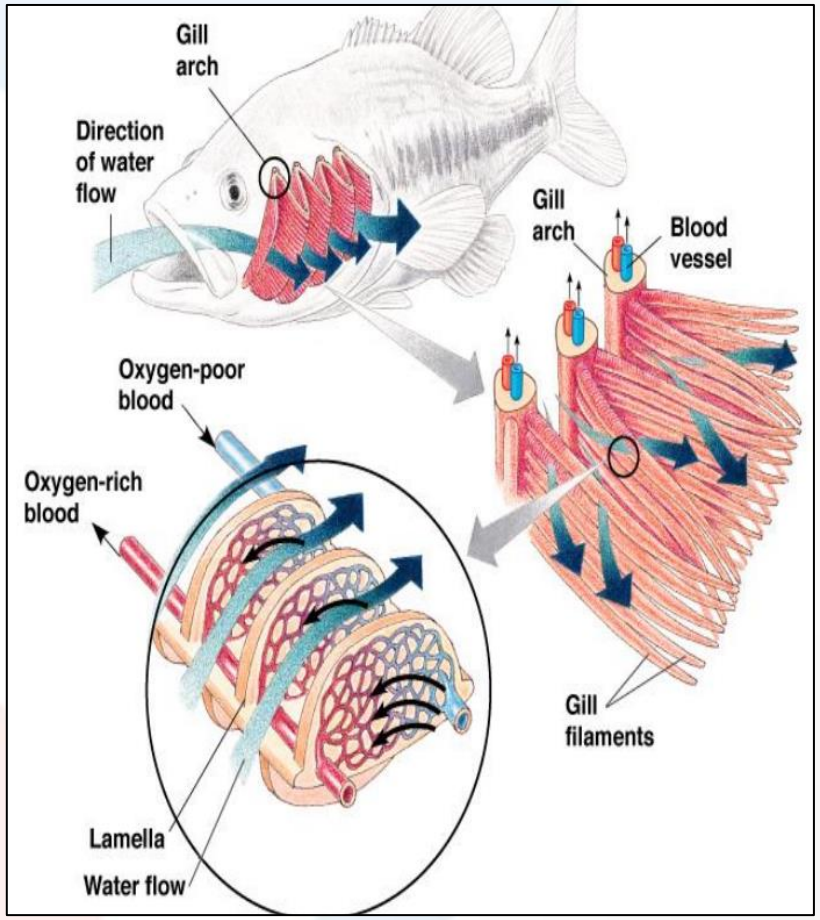
Eksempler:

- Dårlig vandkvalitet
- Lav vandudskiftning
- Parasitter, bakterier og virus
- Mikroalger og gopler

- Gællernes forsvar -

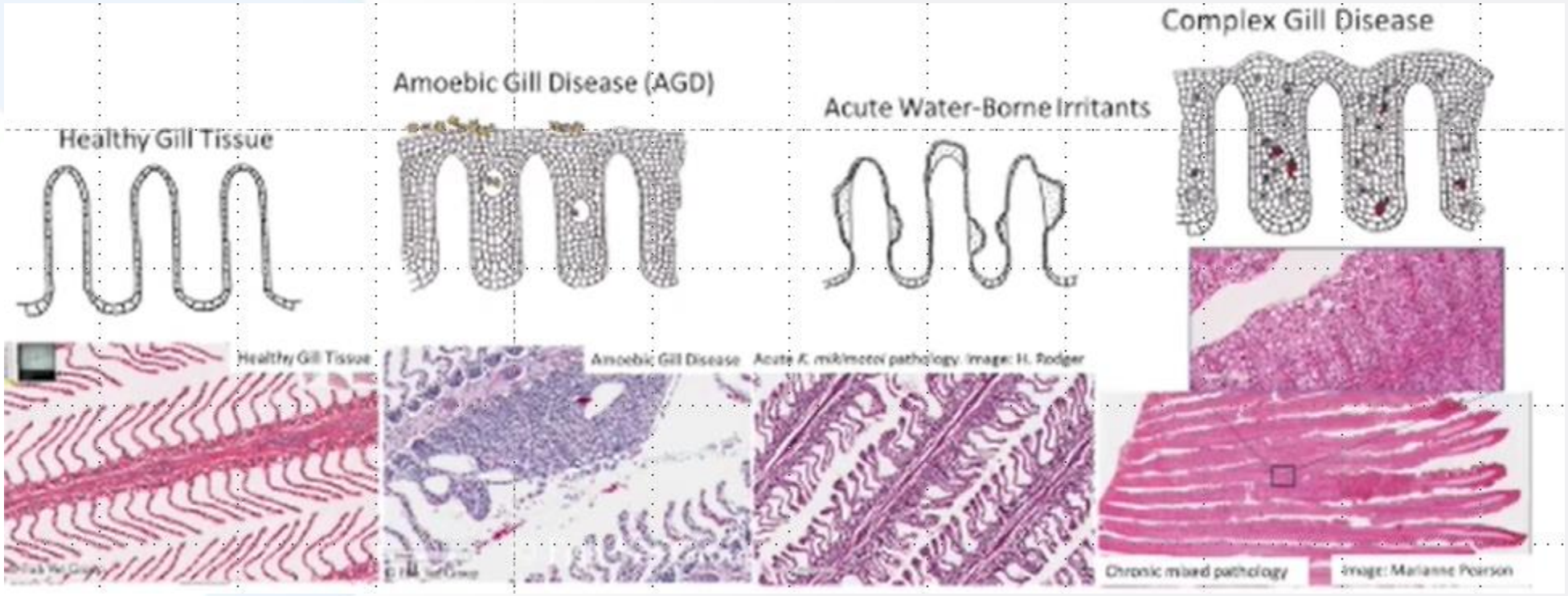
Øget afstand mellem vand og blod

Gællernes reaktion på ydre påvirkning



- Hypertrofi (cellerne bliver tykkere)
- Hyperplasi (der dannes flere celler oven på hinanden)
- Slimudskillelse (ødem/væskeansamling)

Rask vs. beskadiget gæller



Hvad sker der på det mikroskopiske niveau, når fisken udsættes for gællesygdomme

Gællesygdomme

Ofte et kompliceret billede med mange forskellige patogene og mikroorganismer spiller en rolle → *Multifaktoriel årsager*

Agent(er) → Sygdom

Parasitter:

- *Paramoeba perurans*
- *Desmozoon lepeophtherii*

Bakterier:

- *Ca*. Piscichlamydia salmonis
- *Ca*. Branchiomonas cysticola
- *Ca*. Sygnamydia salmonis
- *Tenacibaculum* spp.

Virus:

- *Atlantic salmon paramyxovirus*
- *Salmon gill pox virus (SGPV)*

Mikroorganismer

- Mikroalger, mikro og makro gopler (jellefish)

AGD: Amoebic gill disease

- Rapporteret dødelighed fra Norge op til 80%
- Verdensomspændende
- Høj havtemperatur (>12°C) og salinitet

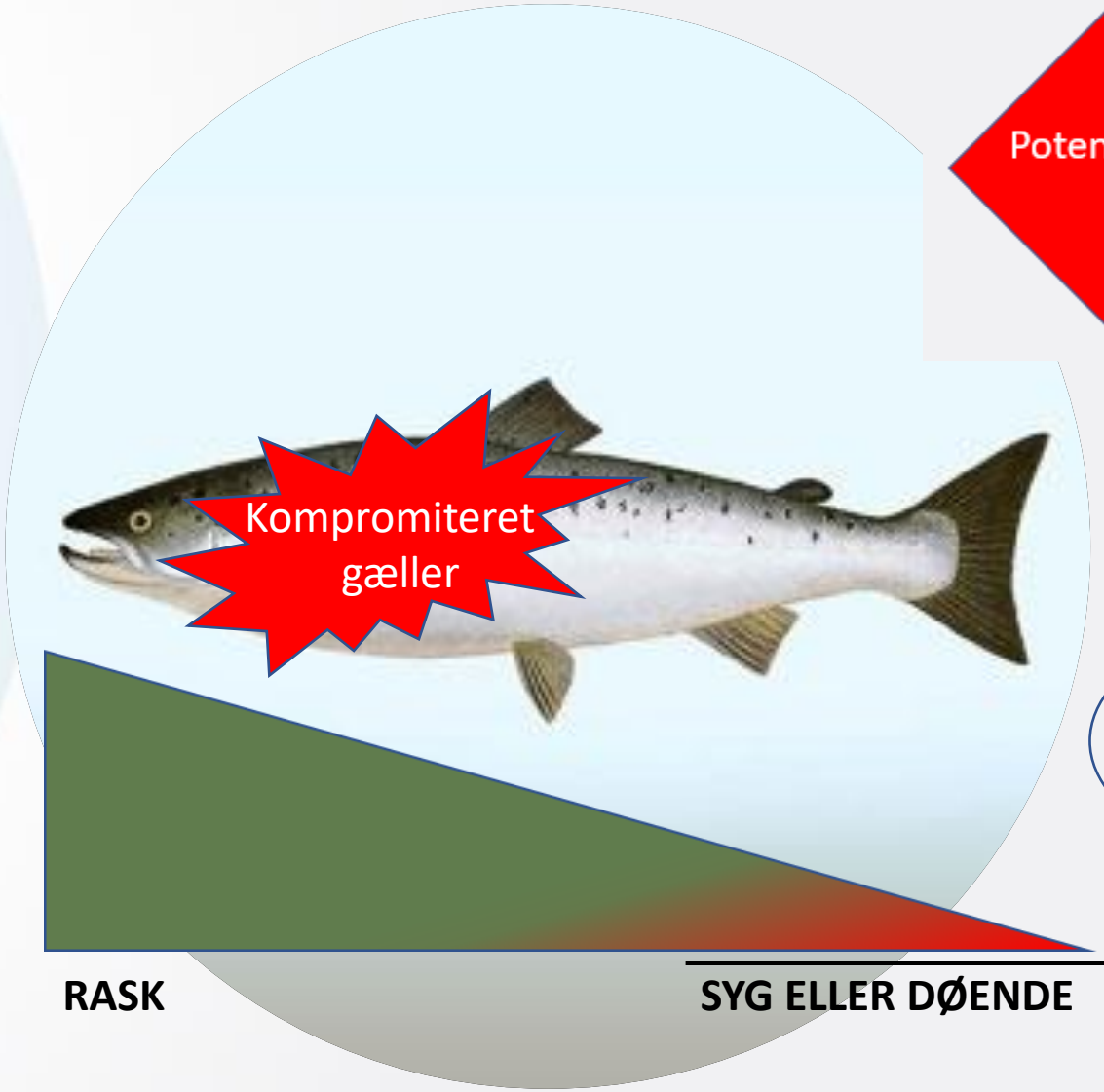
CGD/PGD: Complex gill disease/proliferative gill disease

- En kompleks sygdom med bakterier, virus, parasitter, mikroalger og gopler som resultere i proliferative celler og en reduktion af overfladearealet på gællerne
- Stor fisk (3 kg +)
- Optræder ofte i sensommeren

Gill health og stress – immunforsvaret er en nøglespiller

Den holistiske tilgang/helhedsbillede

- Bagage fra smoltstation
- Sommer / temperatur
- O2/CO2 niveauer
- Vejr/vindforhold
- Håndtering/aflusning
- Net cleaning
- Slagteklar fisk
- Mikroalger/små gopler



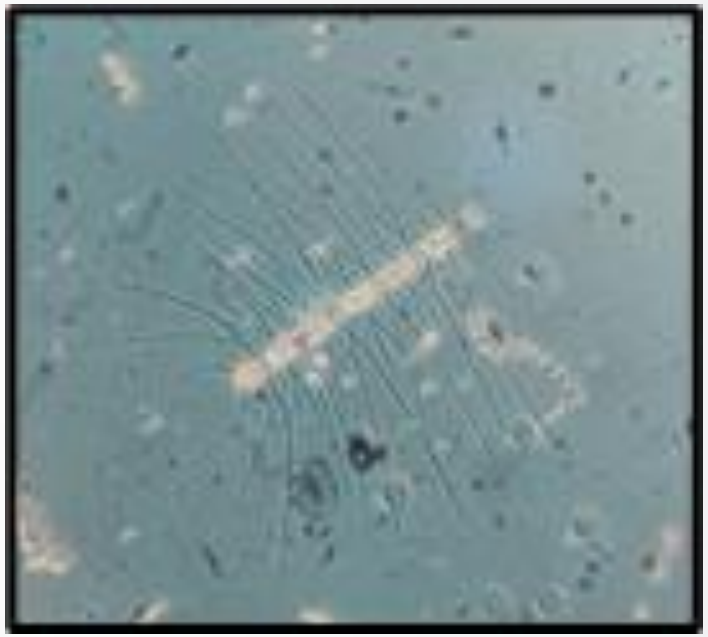
Potentielt sygdomsfremkaldende
Virus/bakterier/AGD

Immunfunktion og healing
Nedsat appetit

Fokus på sygdomme

Vand: Fokus på at identificere hvad der er i vores lokale vandmiljø

Mikroalger

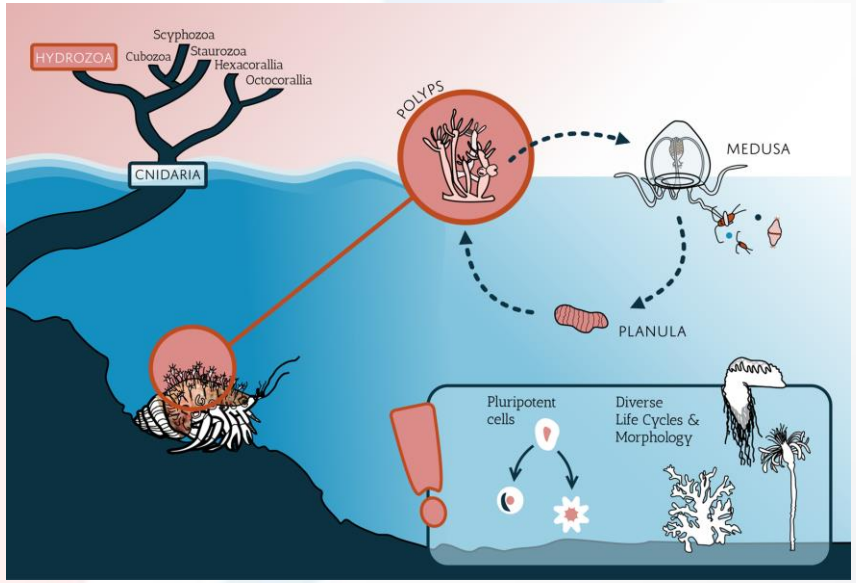


Fiskaaling udfører mikroskopering og qPCR for mikroalger

Vand: Fokus på at identificere hvad der er i vores lokale vandmiljø

Er små gopler (Hydrozoer) et problem på Færøerne – gællehelse?

- Rovdyr som fanger sit bytte vha. Giftige nældeceller
- Dyrene optræder i to livsformer
  - Den fastsiddende polyp
  - Den frit svømmende gople (meduse)
- I alt omfatter goplerne ca. 7700 arter



Små gopler

Billede af en gople i forbindelse med en lusetælling på Færøerne d. 14.04.21.

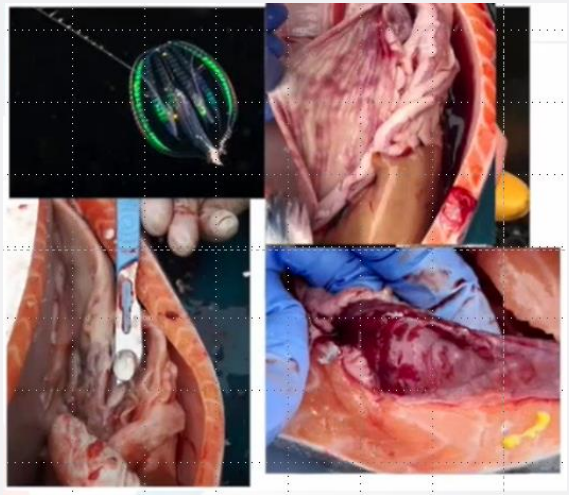
Små gopler

- Gopler er associeret med dødelighed og gælleskader i opdrættet laks fra Skotland og Norge
- Den fritsvømmende (medusa) fase er mest farlig for laksen, fordi de har giftige nældeceller, som kan levere et giftigt stik
- Når de kommer i kontakt med fisken, ødelægge skin, øjne, gællevæv og fordøjelsessystemet
- Goplerne medbringer også skadelige bakterier (bl.a. *Tenacibaculum, også involveret i vintersår*)

<u>Behandling pt.:</u>

- Beluftningssystemer
- "Skirt management"
- Stoppe fodringen

Disse tiltag hjælper på problemet, men løser ikke disse hændelser under ekstreme omstændigheder

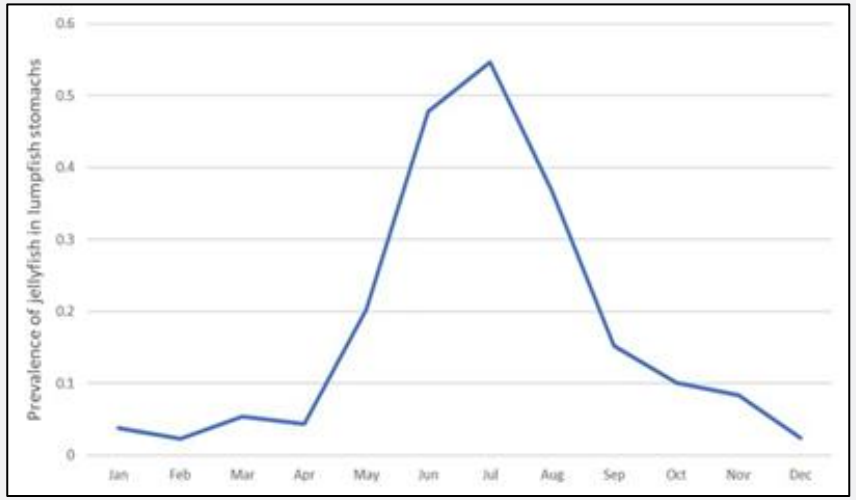


Fordøjelsessystemet: Røde pletter og inflammation i mave-regionen

Er små gopler (Hydrozoer) et problem på Færøerne – gællehelse?

Species	Identifed in Faroese fjords by	
	DNA*	Taxonomy
Auriela aurita	✓	✓
Obelia dichotoma geniculata	✓	✓
Ectopleura larynx Tubularia larynx		✓
Lizzia blondina		
Muggjaea atlantica		
Ectopleura larynx Tubularia larynx		
Pelagia noctiluca		
Phialella quadrata		

*Havstovan har sekvenseret vandprøver fra Skopun-fjorden og identificeret flere forskellige gople-arter
- Hvor repræsentativ er Skopun-fjorden – andre arter er måske også relevante og forskellig fra fjord til fjord



Indsamling af prøver

- Fiskaaling er interesseret i indsamling af gopler på Færøerne
- Indsamling af prøver fra opdrætsstederne
  - Opdrætterne opbevarer gopler i plastikposer eller rør ved 4°C

Monitorering af gopler – implementere viden og erfaringer fra Skotske forskere til Færøerne

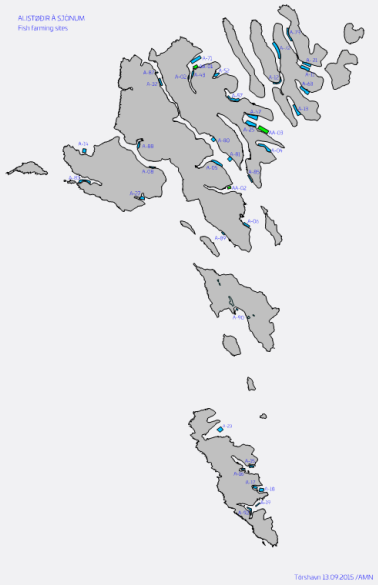
Recommended protocol for sampling - jellyfish

Gear (per sampling trip)

1 x 1.0 m or 0.5 m ring-net 270 µm mesh
1 x 1.0 m or 0.5 m ring-net 500 µm mesh (optional)

1 x non-filtering end-bucket for net
1 x sinking weight (such as old shackles or similar)
1 x deployment rope
1 x General Oceanics flowmeter
1 x 270 µm mesh sieve
1 x 10 l carboy 4% buffered formalin (see below)
1 x log-sheets and labels pack, pencil
1 x safety goggles
1 x disposable gloves
3 x plastic sample jars
1 x spray bottle
1 x plastic washing-up bowl or tray

1.0 m diameter net 0.5 m diameter net



Fokus på immun-gener – indikation for gællehelse

- Akvakulturen har brug for pålidelige velfærdsindikatorer for gællehelse
- Sådanne indikatorer kan være immun-gener

Resultater fra et Pilot projekt om gællehelse

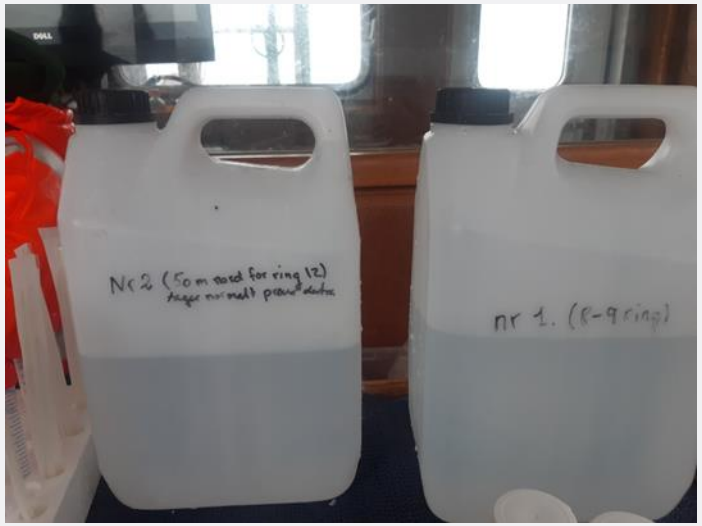
Spørgsmål:

- Kan udvalgte immun-gener detekteres i svaberprøver fra gæller?
- Kan disse gener bruges til at forudsige fiskens gællehelse?
- Erfaringer fra en fjord – samarbejde med Bakkafrost

Prøveindsamling

- Svaberprøver fra gæller i forbindelse med lusetællinger
  - Oprense RNA til genekspression af immun-gener

- Vandprøver blev også indsamlet i fjorden
  - Mikroskopering af kendte mikroalger



Sampling should be Non-lethal

The 3 Rs – science are the guiding principle for more ethical use of animals in testing

Generne blev valgt ud fra publicerede resultater fra gællevæv og modelceller

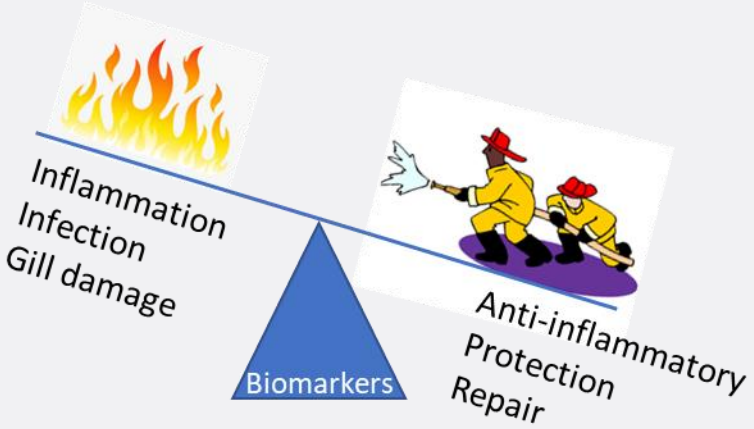
Description	Gene name	Tissue	Citation	Note
Housekeeping	ß-*actin*	Gills	[1]Marcos-López et al, 2018	- Four different genes were tested (*ß-actin, elongation factor 1α, α-tubulin, 18S rRNA*), and found *ß-actin* to be most stable
	etif3	Gills	[2]Sveen et al, 2017	- Evaluated 2 reference genes (*elf1a* and *etif3*) and found etif3 to be most stable
	rps20	TO cells[a]	[3]Nerbøvik et al, 2017	- Evaluated 3 reference genes (*rps20, ef1α* and *ß-actin*) and found *rps20* to be the most stable
Mucins	*muc2.1*	Gills	Sveen et al, 2017	- Secreted mucin, increase after acute handling stress, up-regulated in 3h and 24h
	mucin 2	Gills	Marcos-López et al, 2018	- Mucin genes showed most variability when exposed to AGD[b] and linked to disease severity
	mucin 5	Gills	Marcos-López et al, 2018	
	mucin 18	Gills	Marcos-López et al, 2018	
Immune genes:				
RIG family	*rig-I*	TO cells	Nerbøvik et al, 2017	- Genes were up-regulated upon virus infection in general
	lgp2	TO cells	Nerbøvik et al, 2017	
Interferons	*ifna*	TO cells	Nerbøvik et al, 2017	- Up-regulated upon IPNV[c] and ISAV[d] infection
	tnfa1	TO cells	Nerbøvik et al, 2017	
	ifnb	TO cells	Nerbøvik et al, 2017	- Up-regulated upon SAV[e] infection
Cytokines	*il12*	TO cells	Nerbøvik et al, 2017	
	il4/13a	Gills	Marcos-López et al, 2019	- Genes showed most variability when exposed to AGD and linked to disease severity
	il4/13b2	Gills	Marcos-López et al, 2020	

Table 1. Description of the chosen biomarkers to be included in WP1 and WP2. [a]TO cells are derived from Atlantic salmon head kidney leucocytes, [b]Amoebic Gill Disease (AGD), [c]Infectious Pancreatic Necrosis Virus (IPNV), [d]Infectious Salmon Anaemia Virus (ISAV) and [e]Salmonid Alphavirus (SAV).

1. Marcos-López, M. *et al.* Gene expression analysis of Atlantic salmon gills reveals mucin 5 and interleukin 4/13 as key molecules during amoebic gill disease. *Sci. Rep.* **8**, 1–15 (2018).

2. Sveen, L. R., Grammes, F. T., Ytteborg, E., Takle, H. & Jørgensen, S. M. Genome-wide analysis of atlantic salmon (Salmo salar) mucin genes and their role as biomarkers. *PLoS One* **12**, 1–15 (2017).

3. Nerbøvik, I. K. G. *et al.* Molecular cloning of MDA5, phylogenetic analysis of RIG-I-like receptors (RLRs) and differential gene expression of RLRs, interferons and proinflammatory cytokines after in vitro challenge with IPNV, ISAV and SAV in the salmonid cell line TO. *J. Fish Dis.* **40**, 1529–1544 (2017).

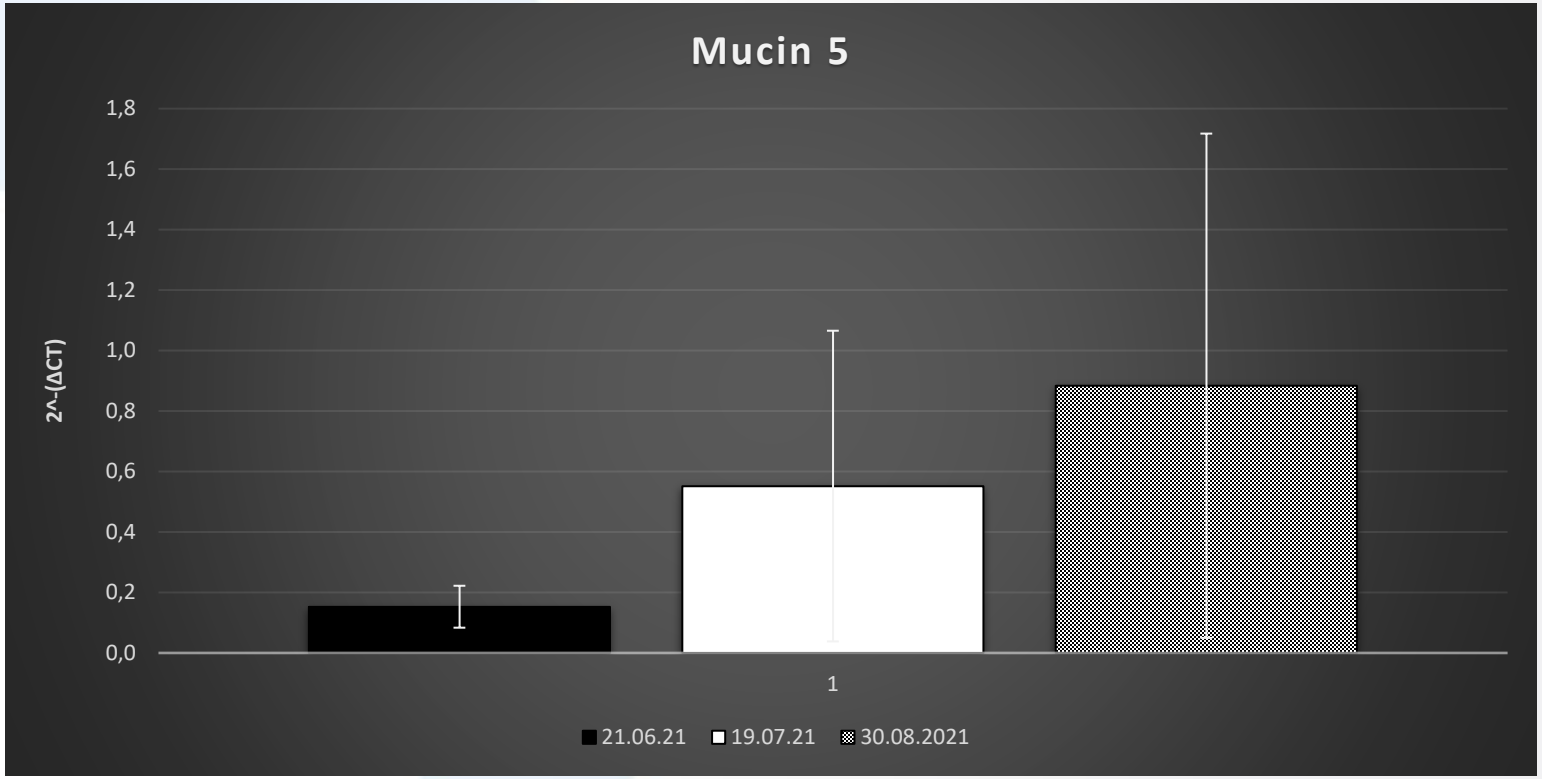


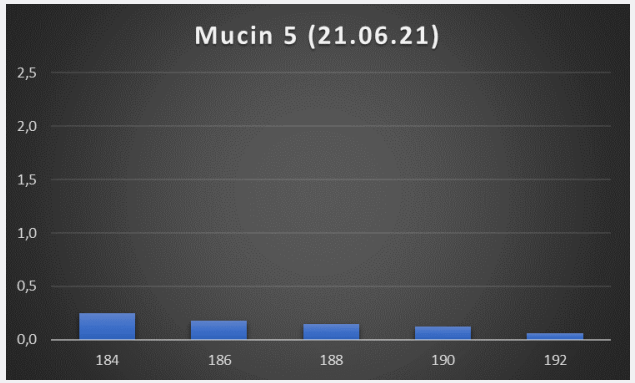
Tidspunkter for prøvetagning

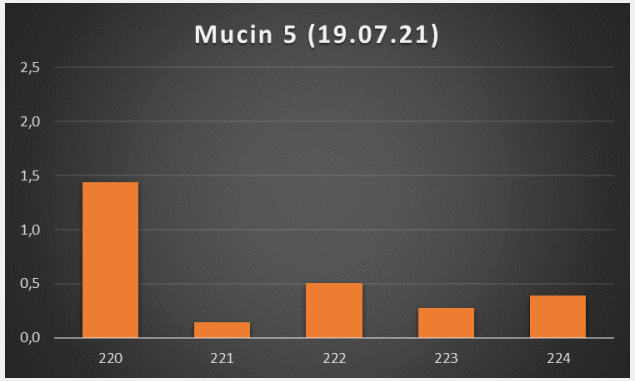
Date	Gill swabs from sea cage*
S1 - 25.05.2021	1, 2, 8, 9, 12
S2 - 07.06.2021	8, 9, 12
S3 - 21.06.2021	8, 9, 12
S4 - 05.07.2021	8, 9, 12
S5 - 19.07.2021	8, 9, 12
S6 - 02.08.2021	8, 9, 12
S7 - 16.08.2021	8, 9, 12
S8 - 30.08.2021	8, 9, 12

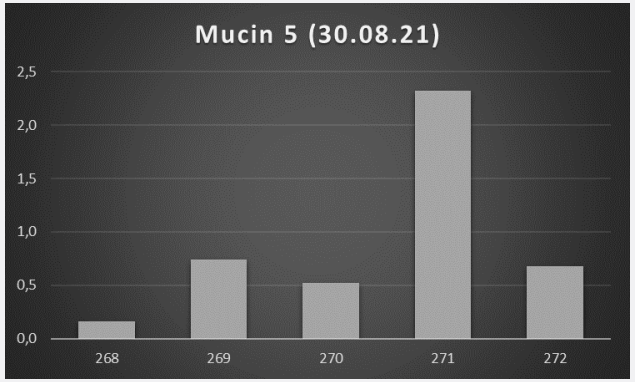
*5 fisk fra hver ring
Vandprøver blev taget ved 4-5m dybde

Resultater – Gener der variere over forsøgsperioden





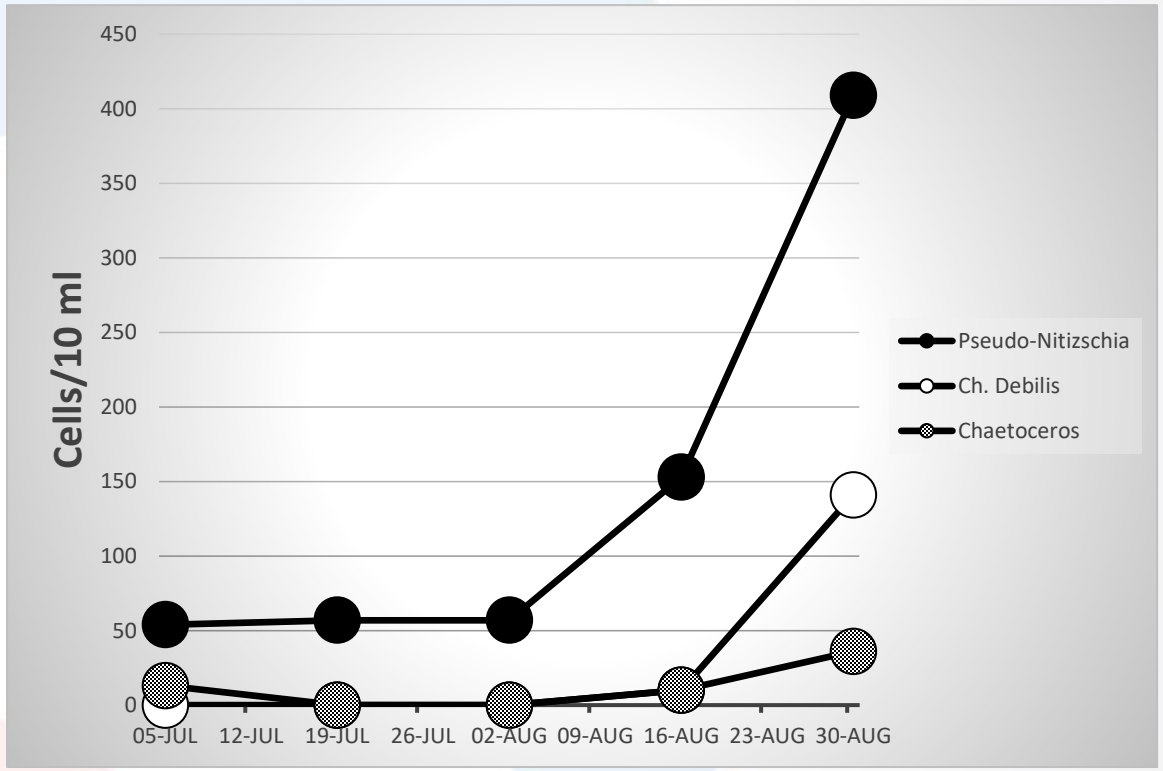


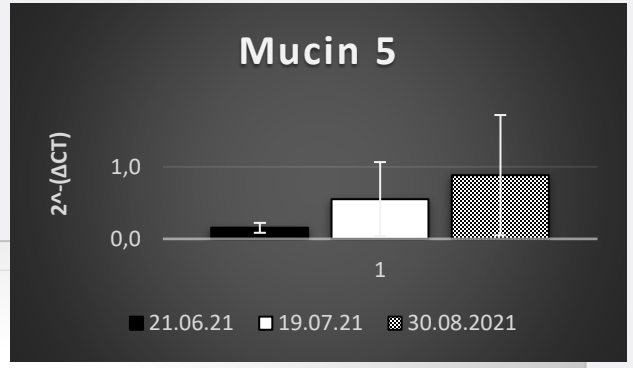


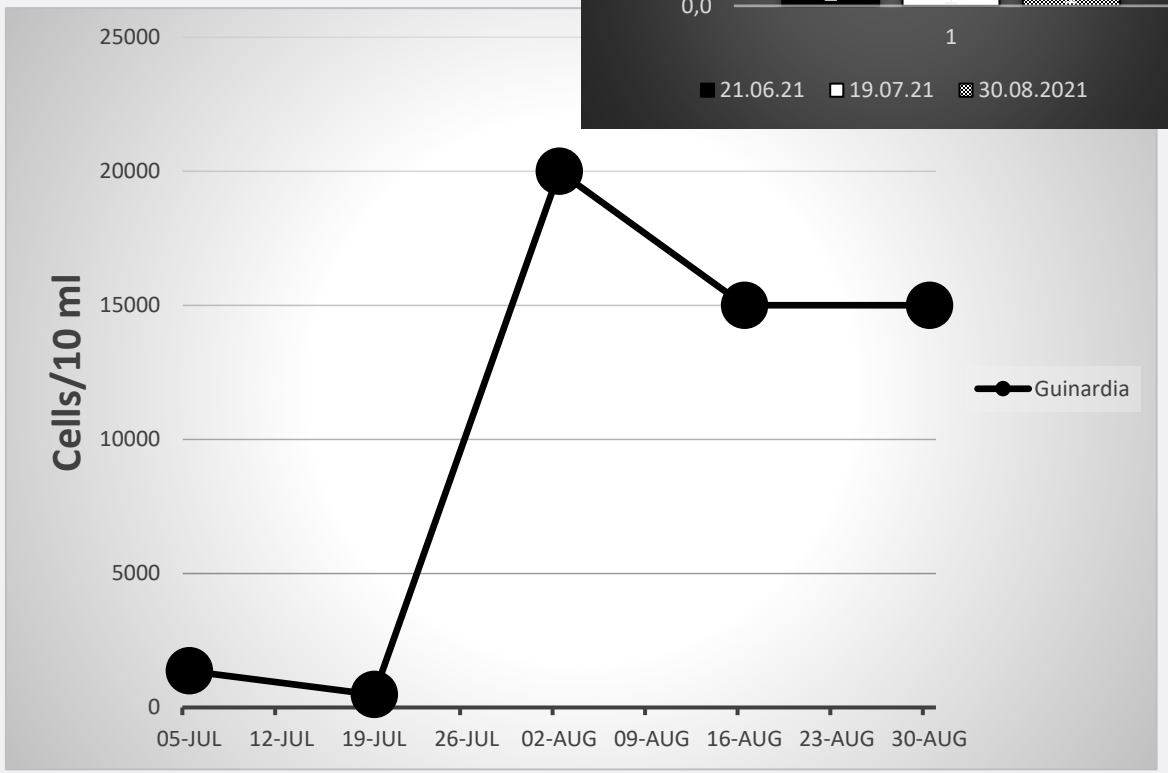
Mucins:

- Glycosylated proteins produced by epithelial cells, part of the protective mucus
- Mucins bind and try to get rid of bacteria
- Mucin 5 linked to AGD and disease severity in salmon
- Humans: biomarkers for several inflammatory diseases including airway diseases and cancer

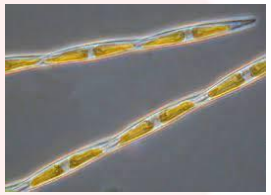
Mikroalger i forsøgsperioden



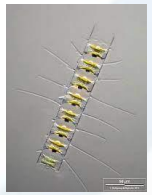




Sample period



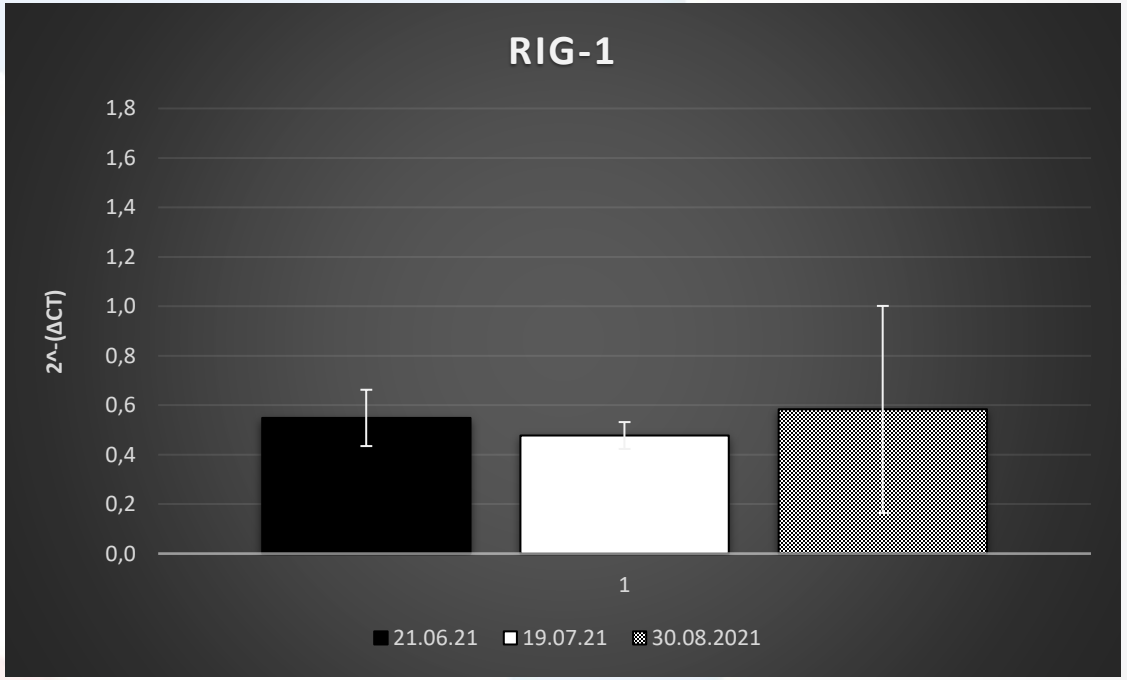
Pseudo-Nitizschia
Toxic

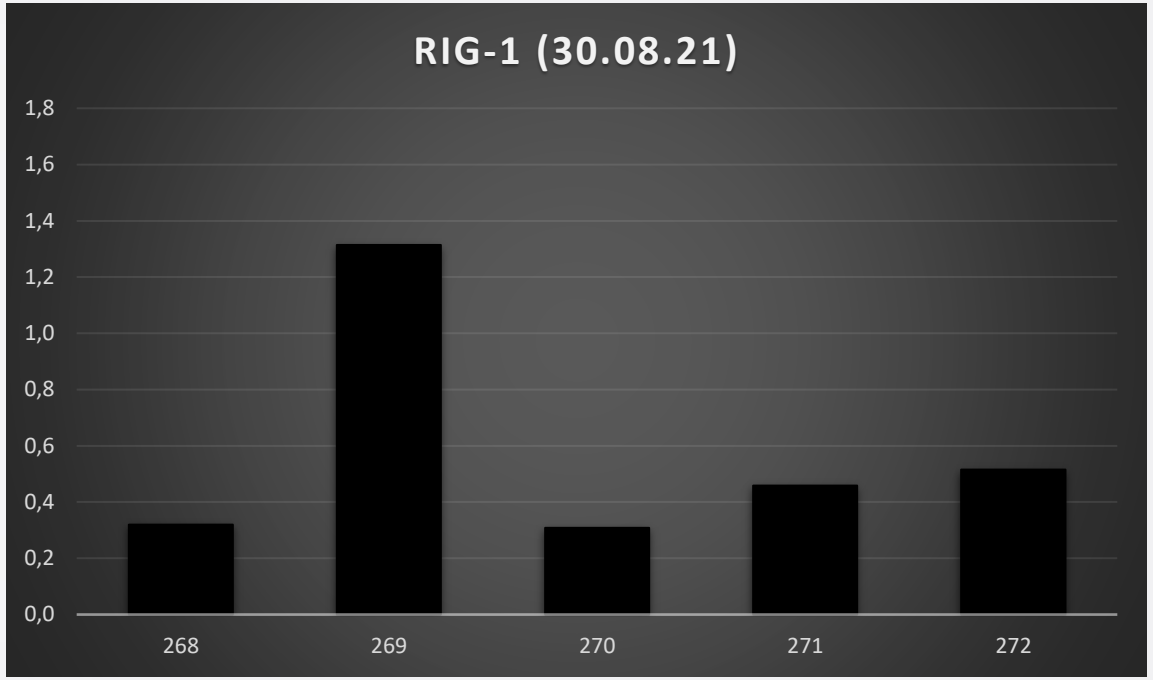


Chaetoceros
Damaged gill

Guinardia

Results – Genes that vary across the 3. time points

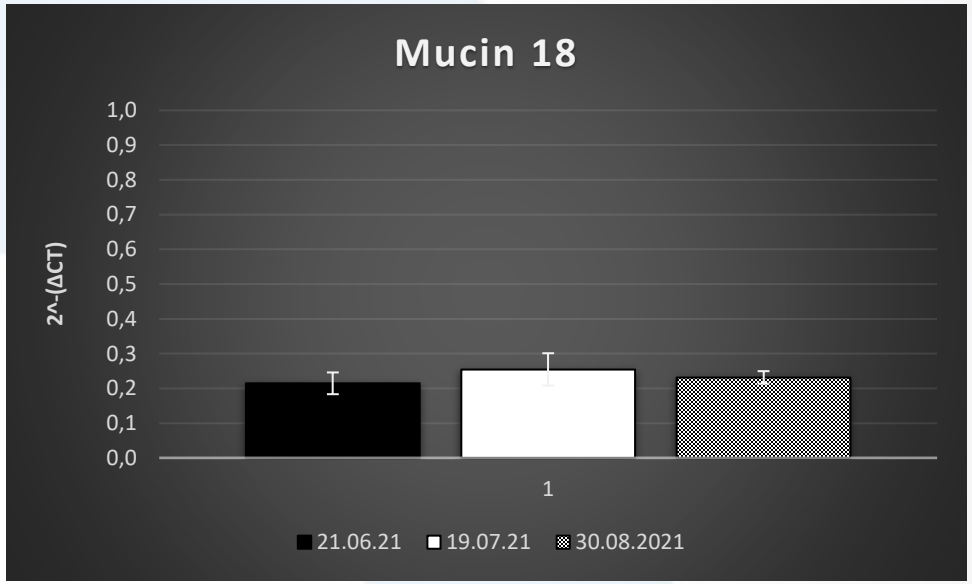


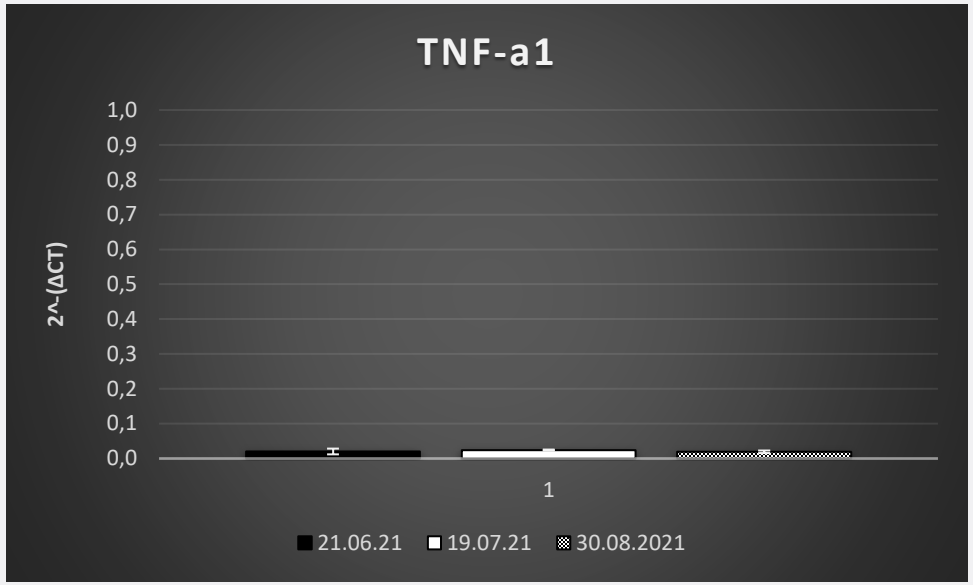


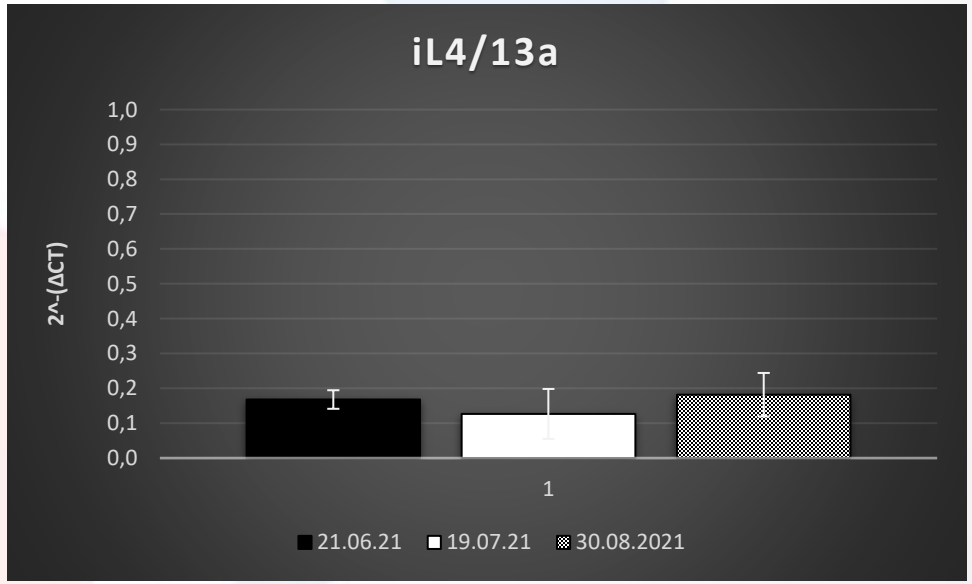
Immune related response:

- RIG family (receptors are key sensors of virus infection, recognize different viruses)

Results – Genes stable expressed across the 3. time points







Immune response to infection:
- TNF-a1 (signal molecules in response to virus infection)
- iL4/13a (broad group of signal proteins (cytokines) – stimulate the immune system)

Del-konklusion: PROOF OF CONCEPT

- Immun-generne kan detekteres i svaberprøverne
- Hvilke immun-gener skal udvælges?

95 immun-gener (ImCom)

Version	Accession	Locus	Symbol	Gene	Annotation	Gene	Forward primer	Sequence	Reverse primer	Sequence
1	NM_001141642	grp78	HSPA5	78 kDa glucose-regulated protein	Stress, chape	78 kDa glucose-regulated protein (g	SS_HSP5_LCF2	AGTTTGAGGAGCTCAACA	SS_HSP5_LCR2	TCCTTCACCAGCTGCTGGACC
1	NM_001245913	b2m	B2M	Beta-2 microglobulin	Antigen prese	beta-2 microglobulin	SS_B2M_LCF1	GACTTAATGGGGGGCGTT	SS_B2M_LCR1	GGCACCTTGGCACAAAGTGTTA
1	NM_001123579	LOC100136446	clra	C type lectin receptor A	Lectin	C type lectin receptor A (LOC10013	SS_clra_LCF1	ATCTCCAGCAGAGGAAAC	SS_clra_LCR1	CCTGCTAAATAAGAGCACGCTCA
1	XM_014173127	LOC106586175	CAT	Catalase	Stress, ROS s	Catalase (Ortho_H)	SS_CAT_LCF1	TTCTACACTGACGAGGGC	SS_CAT_LCR1	TGGATGAAGGATGGGAACAGCA
1	XM_014191808	LOC106600447	CCL4	CC chemokine	Chemokine	CC chemokine	SS_CCL4_LCF1	ACCACCGAACATCTCTCTA	SS_CCL4_LCR1	GTGAACCTTGTTTGCATCAGTGT
1	NM_001173762	LOC106599588	CCR3	C-C chemokine receptor type 3	Chemokine re	C-C chemokine receptor type 3	SS_CCR3_LCF2	TAGAAAAGTCACACTGGT	SS_CCR3_LCR2	TCCACAACATAGATGGGGTCTG
1	XM_014172597	LOC106585878	CCL19	C-C motif chemokine 19-4	Chemokine	C-C motif chemokine 19-4	SS_CCL19_LCF1	AGAGGTCAAGGCTGCTCC	SS_CCL19_LCR1	TTAGCCTTGAAGTTGGTTTCGTG
1	NM_001139913	LOC106572480	CEBPB	CCAAT enhancer binding protein beta	Stress, transc	CCAAT/enhancer-binding protein be	SS_CEBPB_LCF1	ACGACAGGGATTGCTTTG	SS_CEBPB_LCR1	CCTCTCTGCTGAGTTTCGTTATG
1	NM_001141046	cd209d	Cd209d	CD209D	Lymphocytes	CD209 antigen-like protein D	SS_Cd209d_LCF1	ATCTCTCAGATGGAAGAA	SS_Cd209d_LCR1	TTTAGGGAGATGTTGAGAATGACT
1	NM_001141351	pdl1	CD274	CD274	T cells	CD274, Programmed cell death 1 lig	SS_CD274_LCF1	CACTTTGACTGTCAAAGCT	SS_CD274_LCR1	GAGGATAGCCCTCAGACTCACA
1	XM_014151277	LOC106575093	CD28	CD28	T cells	CD28 T-cell-specific surface glycop	SS_CD28_LCF1	TGAAGCTCTCCAGTGCCA	SS_CD28_LCR1	AGGCGATGACAGTGACAGCCA
1	XM_014200898	LOC106605366	CD83	CD83	Lymphocytes	CD83	SS_CD83_LCF1	CCAATCAGAAGAAAGGGA	SS_CD83_LCR1	ATATTCCTTAGGATGACATAGCTG
1	XM_014199487	LOC106604645	ADGRE5	CD97	Adhesion	CD97 antigen precursor alias ADGR	SS_ADGRE5_LCF1	CAGCCTGGACAGACTCTA	SS_ADGRE5_LCR1	ATCTCCAGTTGACAGCGGTCTT
1	XM_014155599	LOC106577510	CHIA	Chitinase	Cytokine	chitinase	SS_CHIA_LCF1	TTACTTGCAGGTCTGTGCT	SS_CHIA_LCR1	AAGCTCATTGGCAGGGTTGATAA
1	NM_001140862	c25ha	CH25H	Cholesterol 25-hydroxylase A	Antiviral	Cholesterol 25-hydroxylase-like pro	SS_CH25H_LCF1	TTCGTGGTGCTGGACCTC	SS_CH25H_LCR1	GTCCCAGATGAGACGCAGCGT
1	XM_014162647	LOC106581002	C4b	Complement component C4	Complement	complement C4	SS_c4b_LCF1	TAGCCTGTACGAAGAGGC	SS_c4b_LCR1	GAAATTGACATTCTCTCCTGGATT
1	NM_001141028	CXCL10	CXCL10	C-X-C motif chemokine 10 precursor	Chemokine	C-X-C motif chemokine 10 precurso	SS_CXCL10_LCF1	ATTCCCTGGTGGAAGATC	SS_CXCL10_LCR1	GAAGACAGAATTTGGGTACACCT
1	XM_014205217	LOC106607825	ATF3	Cyclic AMP-dependent transcription	Differentiatic	Cyclic AMP-dependent transcriptio	SS_ATF3_LCF1	TTCAGCCTGTCCGAGATC	SS_ATF3_LCR1	CTCAGTCCGTTGGACAGCCG
1	XM_014127044	LOC106562274	CYBA	Cytochrome b-245 light chain	Oxidative bur	cytochrome b-245 light chain-like	SS_CYBA_LCF1	TCATTCTCCTTACTGGTGG	SS_CYBA_LCR1	CTTGCCCCTTGGGTACTCTAG
1	XM_014196207	sat1	SAT1	Diamine acetyltransferase 1	NO polyamin	Diamine acetyltransferase 1	SS_SAT1_LCF1	TTGCGACTCATAAAGGAA	SS_SAT1_LCR1	TGACAGTGTATCCGTCTGAGCT
1	223673050	ddit4	DDIT4	DNA-damage-inducible protein 4	Stress DNA	DNA-damage-inducible transcript 4	SS_DDIT4_LCF1	AATGAGCTGGATTTCTGG	SS_DDIT4_LCR1	GTCGCGCGCTATCCTCAGAGT
1	XM_014129062	LOC106563456	FERMT3	Fermitin family	Lymphocytes	Fermitin family	SS_FERMT3_LCF1	TTCCATGACCTGGATCCC	SS_FERMT3_LCR1	GTCAAGATCATCCATGGCAGGA
1	XM_014167081	csf3r	CSF3R	Granulocyte colony-stimulating facto	Cytokine rece	Granulocyte colony-stimulating fac	SS_CSF3R_LCF1	TTAAACTCAAGTGGCCCT	SS_CSF3R_LCR1	CTCTATATGTTCACACAGCCTCA
1	XM_014180523	LOC106590030	HMOX1	Heme oxygenase	Heme metabo	heme oxygenase-like (LOC1065900	SS_HMOX1_LCF1	GGCGACCTATCTGGCGGA	SS_HMOX1_LCR1	GACCTGGATGTTCAACTCGAAG
1	NM_001140849	hepc1	HAMP	Hepcidin	Antibacterial	Hepcidin-1 (hepc1)	SS_HAMP_LCF1	AAGCTTCCTAACAAAACCC	SS_HAMP_LCR1	GTTCGCACCTCGGAGAAAGGAA
1	NM_001145420	il1r2	IL1R2	IL-1 receptor type II	Cytokine rece	interleukin-1 receptor type II	SS_IL1R2_LCF1	CCAAGCAAACTGACATTG	SS_IL1R2_LCR1	TGGAGTCCTTATACCACTCTATTT
1	NM_001141080	i20ra	IL20RA	IL-20 receptor alpha chain	Cytokine rece	Interleukin-20 receptor alpha chair	SS_IL20RA_LCF1	CCCTTGACTGACACATTG	SS_IL20RA_LCR1	TGGATGTGGGGGGAGTTACCT
1	XM_014163747	acod1	ACOD1	Immunoresponsive 1 homolog	Immune	Immunoresponsive 1 homolog	SS_ACOD1_LCF1	TAGCGGTGCACTCTATGG	SS_ACOD1_LCR1	AGTCGCCCCTGCACCTCGAT
1	XM_014179290	LOC106589386	IFIT5	Interferon-induced protein with tetra	Antiviral	Interferon-induced protein with tetr	SS_IFIT5_LCF1	ACAAGATGAGCCCTTCGG	SS_IFIT5_LCR1	GCCTTGTGGAGATACTCAAGAG
1	XM_014152521	il11	IL11	Interleukin 11	Cytokine	interleukin 11 (il11), X1	SS_IL11_LCF1	GAAACCATTGCTTGTCGA	SS_IL11_LCR1	ACGCATGTTCCTTCAATAAATCTG
1	XM_014196344	LOC106603109	IL13RA2	Interleukin 13 receptor alpha-2	Cytokine rece	interleukin-13 receptor subunit alp	SS_IL13RA2_LCF1	AAATTACAGTGGATCCTC	SS_IL13RA2_LCR1	GTACAGTCCTGATCACAGTCCA
1	XM_014162471	il18	IL18	Interleukin-18	Cytokine	Interleukin-18 (il18), X1	SS_IL18_LCF1	CGGAGGTACCACACATGA	SS_IL18_LCR1	GTCACTCGTAAATGTCGCCTTC
1	XM_014162047	CXCL8	CXCL8	Interleukin-8-like	Chemokine	interleukin-8-like (LOC106580715)	SS_CXCL8_LCF1	CGTGGGGTCAGACTTACG	SS_CXCL8_LCR1	GTGGCTATGATCTCAGTGTCTTT
1	NM_001142713	klf4	KLF4	Kruppel-like factor 4b	Immune regu	Kruppel-like factor 4b	SS_KLF4_LCF1	AGTCTGCGATTTTCCATGA	SS_KLF4_LCR1	ACCGCAGGTGATTCAACAATACT
1	XM_014164758	LOC106582060	MARCO	Macrophage receptor MARCO	Macrophfge	Macrophage receptor MARCO	SS_MARCO_LCF1	TACACCTTCCAGAGCAGC	SS_MARCO_LCR1	CGAAAAGACTTTGTAAAGGAGGAA
1	XM_014177344	LOC106588401	MHC1	MHC class Ia heavy chain	Antigen prese	MHC class Ia heavy chain precurso	SS_MHC1_LCF1	AAGGCTTTGTTCCGGCCA	SS_MHC1_LCR1	GACGTTCCTCTTCAGCACCTTC
1	XM_014134365	LOC106566391	nattl	Natterin-like	Acute phase	Natterin-like protein	SS_nattl_LCF1	AGGTATGGCTCGGACATC	SS_nattl_LCR1	TCACCTGGGGTTTGAAGAGGG
1	XM_014193164	LOC106601178	IKBA	NF-kappa-B inhibitor alpha	Immune regu	NF-kappa-B inhibitor alpha-like (LC	SS_IKBA_LCF1	GCTAGTGGACGACAGTGC	SS_IKBA_LCR1	TTCTGACCACTGTAGTTTGGTGT
1	XM_014168158	LOC106583673	ZNFX1	NFX1	Immune	NFX1-type zinc finger containing pr	SS_ZNFX1_LCF1	AGAGAAGGGCTTTTGTCCA	SS_ZNFX1_LCR1	TACCTCTGGAAGGGCAGATCCT
1	XM_014155741	LOC100380740	PLIN2	Perilipin-2	Immune	Perilipin-2	SS_PLIN2_LCF1	ACTGTAGACCTGATTGAA	SS_PLIN2_LCR1	CTGTGTGAGGGAGCGCGCTAT
1	NM_001140738	pkhf1	PLEKHF1	Pleckstrin domain-containing F1	Apoptosis	Pleckstrin homology domain-conta	SS_PLEKHF1_LCF1	AAGTGTTGTAATCCAGCTC	SS_PLEKHF1_LCR1	CAGAGGGGCCAAAGGAGTTCT
1	XM_014210715	LOC106610967	SACS	Sacsin	Antiviral	Sacsin	SS_SACS_LCF1	TACCCTGATGGAGGACAG	SS_SACS_LCR1	ATACAGAGCAGGACCTTGGTAC
1	XM_014199306	LOC106604553	SASH3	SAM and SH3 domain-containing pro	Lymphocytes	SAM and SH3 domain-containing pr	SS_SASH3_LCF1	GTTACGGCGAAAACCTTC	SS_SASH3_LCR1	CCTCTGGCACTGTGTAGTCCAA
1	XM_014190655	LOC106599427	SOCS1	Suppressor of cytokine signaling 1	Immune regu	Suppressor of cytokine signaling 1	SS_SOCS1_LCF1	CACAGTCGACTGAAGGAC	SS_SOCS1_LCR1	TCACTTCCTGCCAGGCTGAAC

Fishgenetik group, Dr. Alexander Rebl

BioMark HD platform

genes

MDPI

Article

Multigene Expression Assay for Assessment of the Immune Status of Atlantic Salmon

Aleksei Krasnov [1,*], Sergey Afanasyev [2], Stian Nylund [3] and Alexander Rebl [4]

1 Nofima AS Osloveien 1, 1433 Ås, Norway
2 Sechenov institute of evolutionary physiology and biochemistry Russian Academy Of Sciences, Torez 44, 194223 Saint-Petersburg, Russia; afanserg@mail.ru
3 Pharmaq Analytiq, Thormoehlens Gate 53D, 5008 Bergen, Norway; stian.nylund@zoetis.com
4 Leibniz Institute for Farm Animal Biology (FBN), Wilhelm-Stahl-Allee 2, 18196 Dummerstorf, Germany; rebl@fbn-dummerstorf.de
* Correspondence: aleksei.krasnov@nofima.no; Tel.: +47-9760-2165

Received: 18 September 2020; Accepted: 19 October 2020; Published: 22 October 2020

check for updates

Konklusion

- Gællehelse er stadig komplekst med mange ukendte faktorer
- Brug for at vide status for gællehelse på en mere regelmæssig praksis for en mere effektiv ledelse
- Immun-gener kan være en god og hurtig indikater for gællehelse i fremtiden

Tak til mine kolleger fra Fiskaaling

Tak til Bakkafrost

BAKKAFROST

@Fiskaaling

Fiskaaling P/F