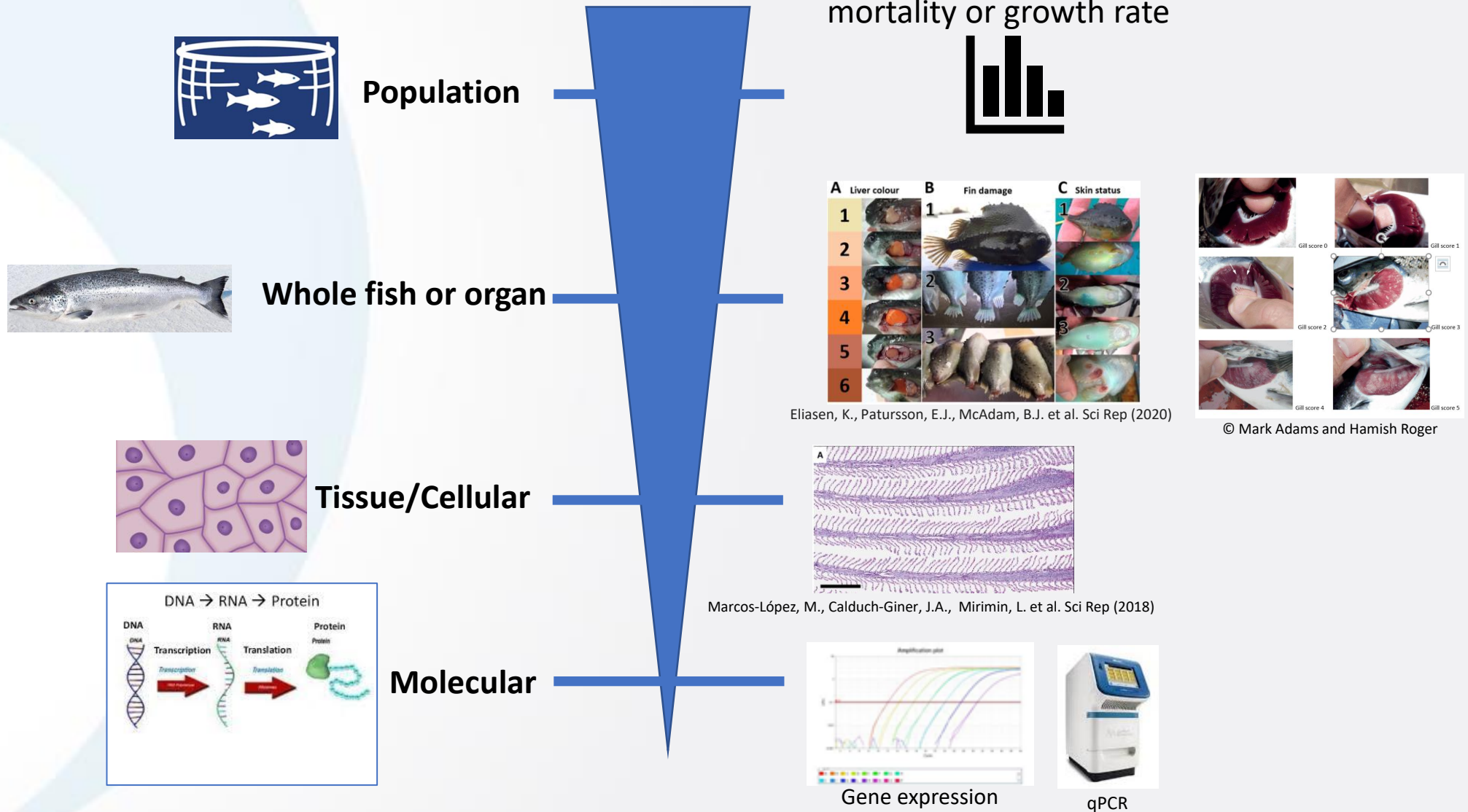


# Biomarkers: What are they? Why are they useful?

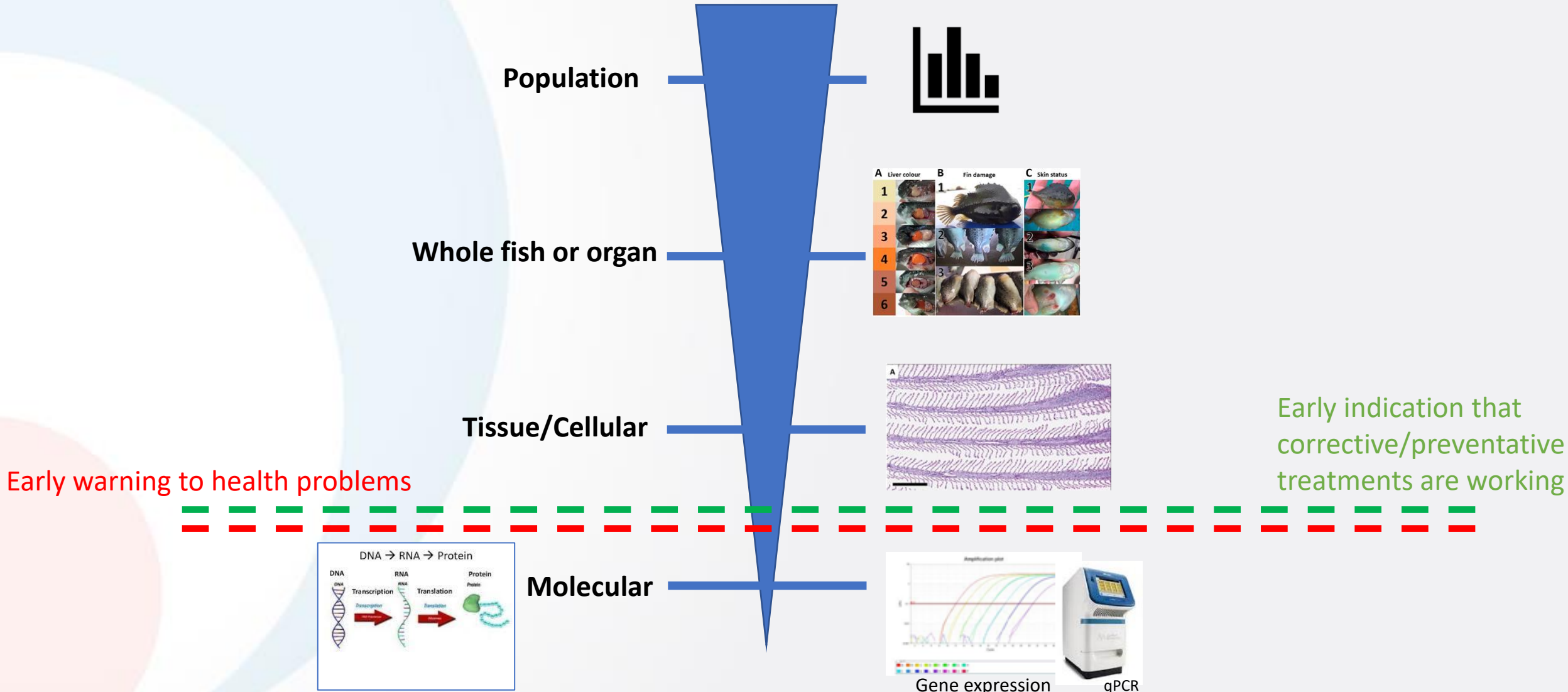
-Amanda Vang-

Vitan til varandi aling 2021


# Measuring changes in health status



# Biomarkers = monitoring molecular level changes



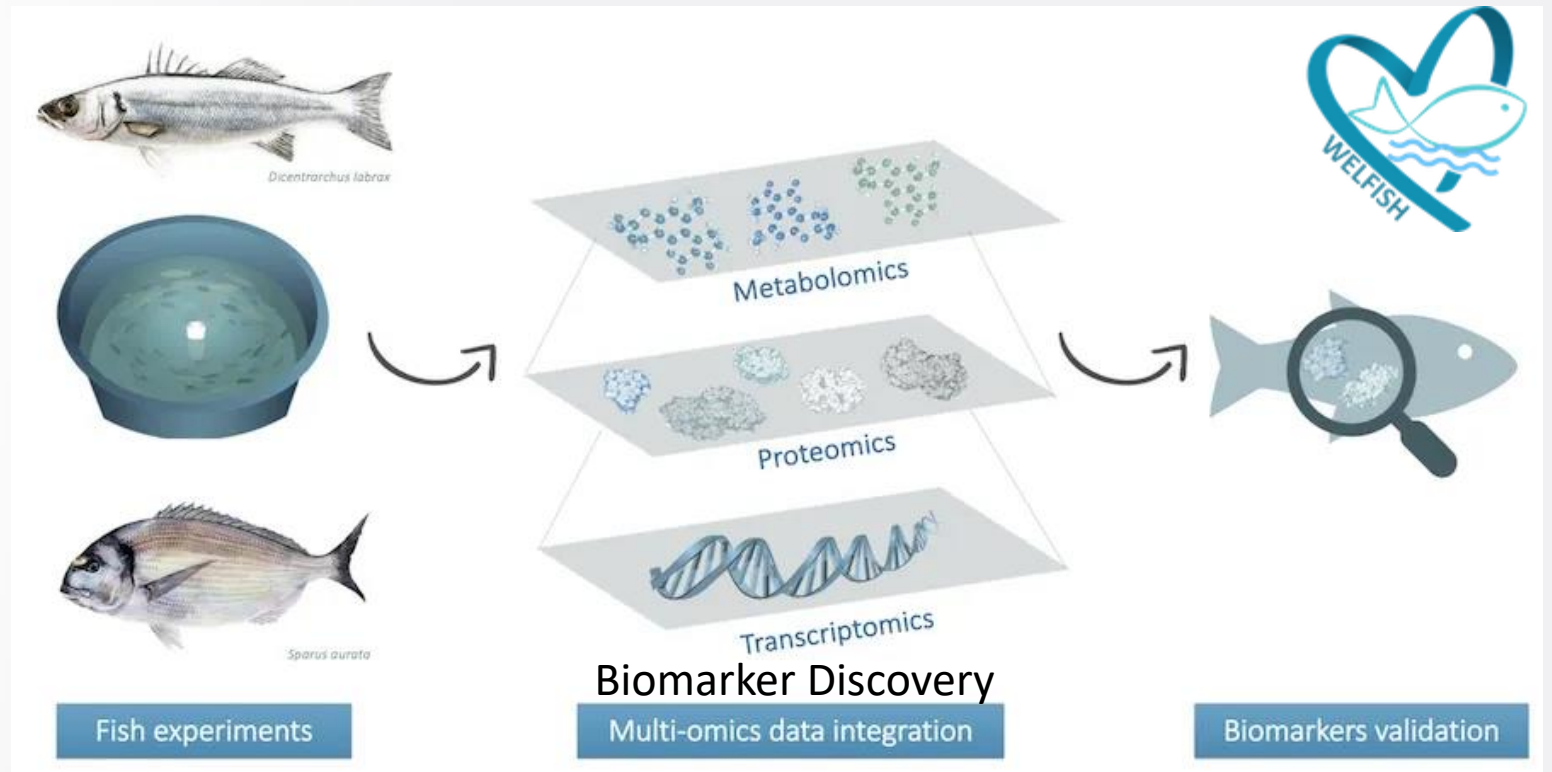
# Biomarkers are an emerging focus in aquaculture due to molecular “omics” that allow researchers to map ALL molecular changes at the same time


 A Free Quick Reference Guide From: **Kap Test Prep** Download for free at: [KapTestPrep.com](http://KapTestPrep.com)

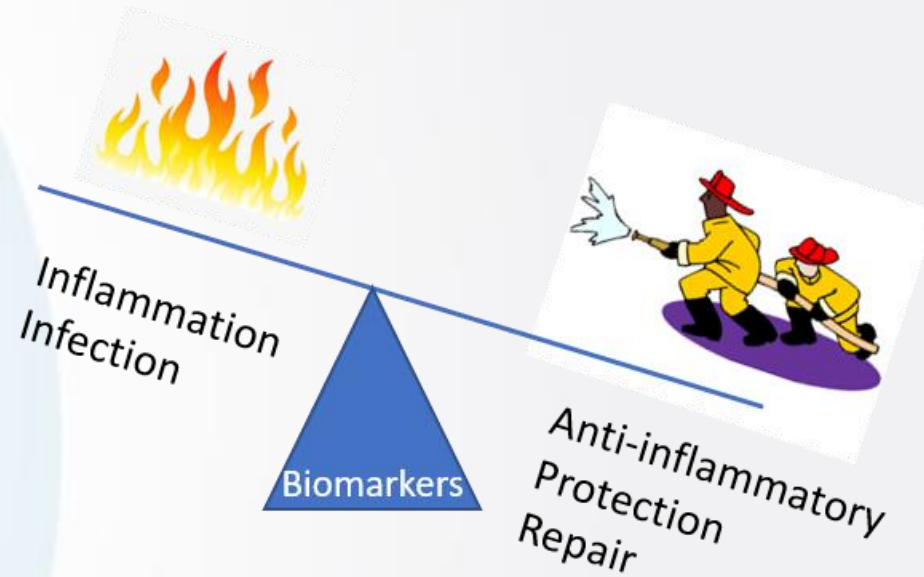
## Normal Lab Values (A to Z)

Blood					
Albumin (Alb)	3.5 - 5.0	Creatinine	0.6 - 1.5	Lymphocytes	20 - 40
Alk Phos	20 - 90	D-dimer	0 - 0.5	Magnesium (Mg)	1.5 - 2.5
ALT	10 - 30	Eosinophils	1 - 4	MCV	80 - 100
Ammonia	9.5 - 49	GFR	Above 90	Monocytes	2 - 8
Amylase	23 - 85	Glucose	70 - 110	Neutrophils	40 - 60
AST	8 - 46	Glucose Tolerance Test (GTT)	Start: 70 - 100 (1hr) Below 200 (2hr) Below 140 (3hr) Below 120	pH	7.35 - 7.45
Bands	3 - 7	HDL	Above 50	Plt Count	100 - 400
Basophils	0 - 2	Hematocrit (Hct)	(M) 41 - 50 (F) 36 - 44	Potassium (K+)	3.5 - 5.0
Bicarb (HCO3)	22 - 26	Hemoglobin (Hgb)	(M) 13 - 18 (F) 12 - 16	Protein	6.0 - 8.3
Bilirubin, Direct	0 - 0.3	HgbA1c	5.6 - 7.5	PT	9 - 12
Bilirubin, Total	0.3 - 1.2	INR	0.8 - 1.2	PTT	24 - 45
BNP	0 - 100	Iron (Fe)	60 - 170	Red Blood Cells (RBCs)	(M) 4.7 - 6.1 (F) 4.2 - 5.4
BUN	7 - 20	Lactic Acid (Lactate)	(Art) 0.5 - 1.6 (Ven) 0.5 - 2.2	RDW	0 - 14.5
Calcium (Ca+)	8.5 - 10.5	LDL	Below 130	SaO2 (Oxygen)	95 - 100
Chloride (Cl-)	95 - 105	Lipase	0 - 160	Sodium (Na+)	135 - 145
Cholesterol, Tot	Below 200			Triglycerides	Below 150
CK or CKMB	3.5 - 5.0			Troponin	0 - 0.015
CO2 (Blood Gas)	35 - 45			WBCs	5 - 10
CO2 (CMP/BMP)	20 - 29				
Urine					
Bacteria	Negative	Color	Yellow - Amber	pH	4.5 - 8.0
Bilirubin	Negative	Glucose	Negative	Protein	0 - 20
Blood (Hgb)	Negative	Ketones	Negative	RBCs	0 - 3
Casts	0 - 5	Leukocytes	Negative	Specific Gravity	1.01 - 1.03
Clarity	Clear	Nitrates	Negative	WBCs	0 - 5
				Yeast	Negative

\*Important. These lab values should be sufficient for the NCLEX, however normal lab values can vary by facility, lab, book, or school. Always use your facility's lab value guidelines for interpretation or testing.



# Endogenous biomarkers are a tool for monitoring how fish manage various stressors and disease



- Multi-factorial inflammation (chronic stress + water quality + nutrition)
- Opportunistic secondary infection related to poor health and welfare
- Presence of pathogens doesn't always equal symptomatic disease

# Focus on validating experimental immune biomarkers

Biomarkers identified by RNA sequencing following experimental infection

## SCIENTIFIC REPORTS

**OPEN** Transcriptome-wide mapping of signaling pathways and early immune responses in lumpfish leukocytes upon *in vitro* bacterial exposure

vol: 19 October 2017  
doi: 10.1038/s41598-017-06318-8  
first online: 27 March 2018

Håvard Ø. Eggestøl<sup>1</sup>, Harald S. Lunde<sup>1</sup>, Anita Rønneseth<sup>1</sup>, David Fredman<sup>2</sup>, Kjell Petersen<sup>3</sup>, Charitra K. Mishra<sup>4</sup>, Tomasz Furmanek<sup>2</sup>, Duncan J. Colquhoun<sup>1,5</sup>, Heidrun I. Wergeland<sup>6</sup> & Gyri T. Haugland<sup>6</sup>



Developmental and Comparative Immunology

journal homepage: [www.elsevier.com/locate/devcompimm](http://www.elsevier.com/locate/devcompimm)

The proinflammatory cytokines TNF- $\alpha$  and IL-6 in lumpfish (*Cyclopterus lumpus* L.) -identification, molecular characterization, phylogeny and gene expression analyses

Håvard Øritsland Eggestøl<sup>1</sup>, Harald S. Lunde, Gyri Teien Haugland<sup>1\*</sup>

<sup>1</sup>Department of Biological Sciences, Bergen High Technology Center, University of Bergen, PO Box 7803, NO-5020, Bergen, Norway



Operational welfare indicators

**OPEN** Liver colour scoring index, carotenoids and lipid content assessment as a proxy for lumpfish (*Cyclopterus lumpus* L.) health and welfare condition

Kirstin Eliassen<sup>1</sup>, Esbern J. Patterson<sup>2</sup>, Bruce J. McAdam<sup>3</sup>, Enrique Pino<sup>4</sup>, Bernat Morro<sup>5</sup>, Monica Betancor<sup>6</sup>, Johanna Bailly<sup>7</sup> & Sonja Rey<sup>8</sup>

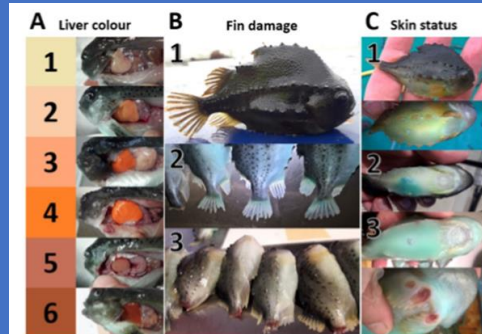
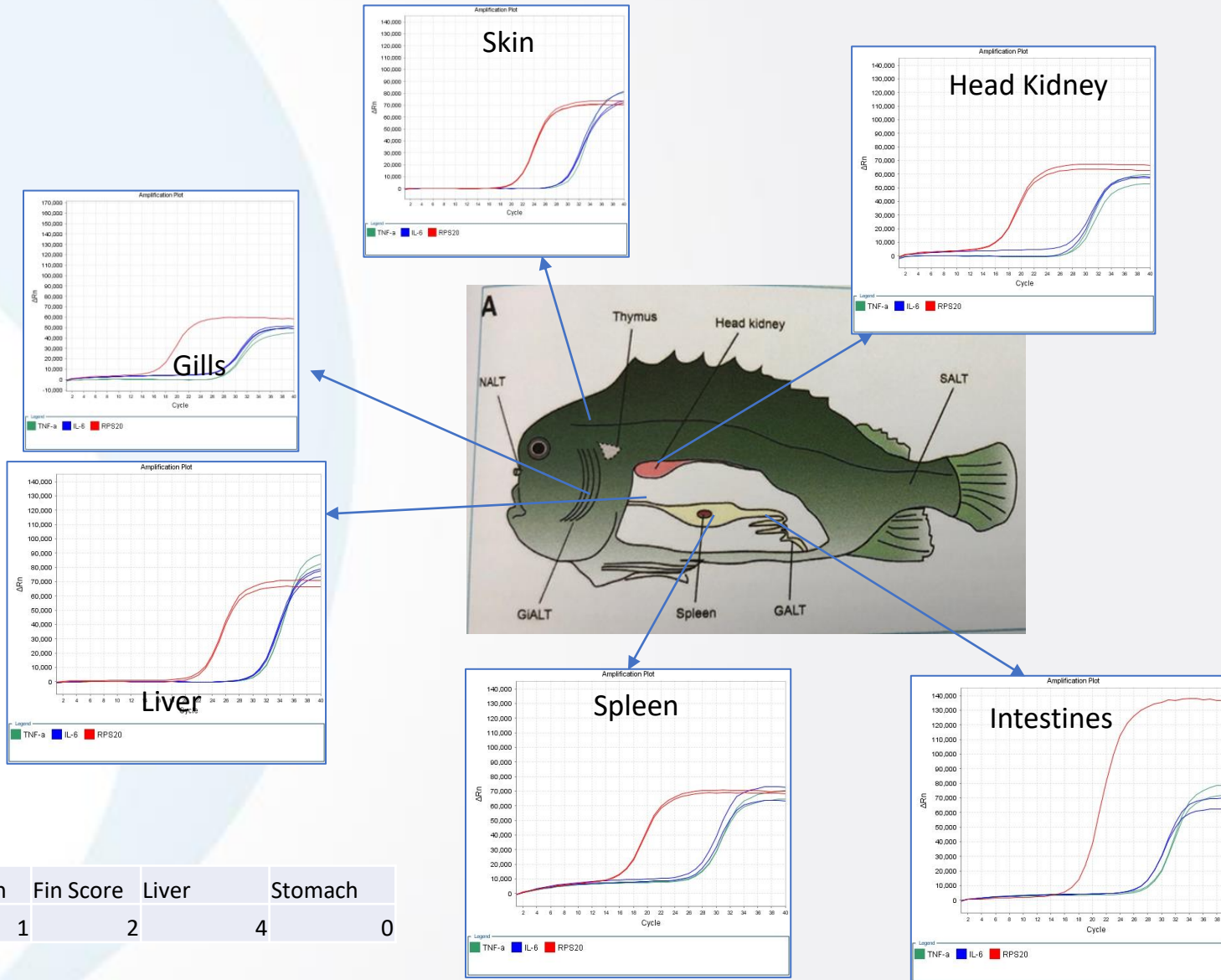


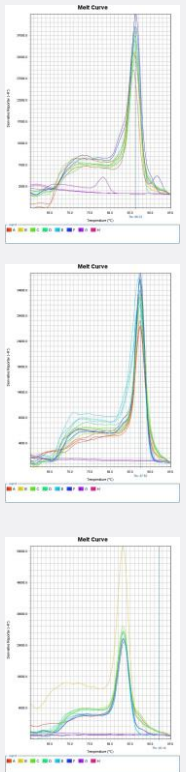
Figure 7. System used to score liver colour (A), fin damage (B) and skin status (C).

Better understand the factors that influence health and welfare

# Gene Expression of proinflammatory cytokines *il6* and *tnfa*



melt curves

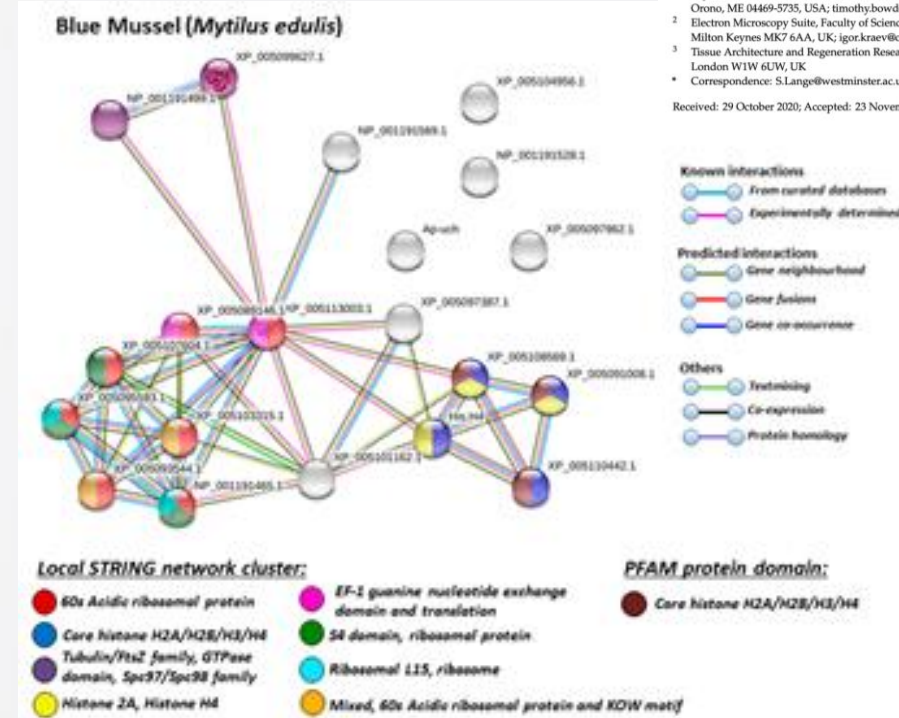


Length (cm)	Weight (g)	Skin	Fin Score	Liver	Stomach
11,2	83,2	1	2	4	0

# Emerging aquaculture: Immune response biomarkers in blue mussel

● Present ⊗ Absent ? Partial evidence ○ No data

			Phagocytic cells			Cytotoxic cells			
			Acanthocytes	Large phagocytes	Myxoid lineage	Morula cells	Lymphoid lineage	Molecular allorecognition mechanism	
Deuterostomes	Chordates	Mammals	⊗	⊗	●	⊗	●	MHC, KIR, TCR	
		Humans	⊗	⊗	●	⊗	●	MHC, KIR(?), TCR	
		Jawless vertebrates	⊗	⊗	●	⊗	●	VLRs	
		Danio	⊗	⊗	●	⊗	●		
		Petromyzon	⊗	⊗	●	⊗	●		
Tunicates	●	●	●	●	?	BHF			
Botryllus	●	●	●	●	?				
Cephalochordates	Branchistoma	●	●	○	○	○			
Echinoderms	Strongylocentrotus	●	●	○	?	○			
Protostomes	Arthropods	Drosophila	●	?	○	?	○		
		Limulus	●	●	○	?	○		
		Molluscs	●	●	○	?	○		
		Tridacna	●	●	○	?	○		
				●	●	○	?	○	



Article  
**Extracellular Vesicles and Post-Translational Protein Deimination Signatures in Mollusca—The Blue Mussel (*Mytilus edulis*), Soft Shell Clam (*Mya arenaria*), Eastern Oyster (*Crassostrea virginica*) and Atlantic Jackknife Clam (*Ensis leei*)**

Timothy J. Bowden <sup>1</sup>, Igor Kraev <sup>2</sup> and Sigrun Lange <sup>3,\*</sup>

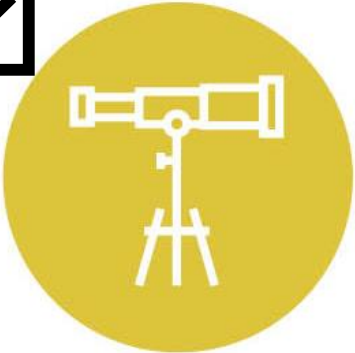
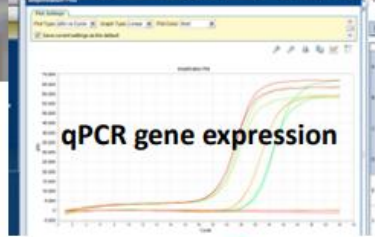
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# Future goals for biomarker research at Fiskaaling



**Predictive**  
What will happen next?



**Prescriptive**  
What should I do?

Looking forward →



Non-lethal CE IVD