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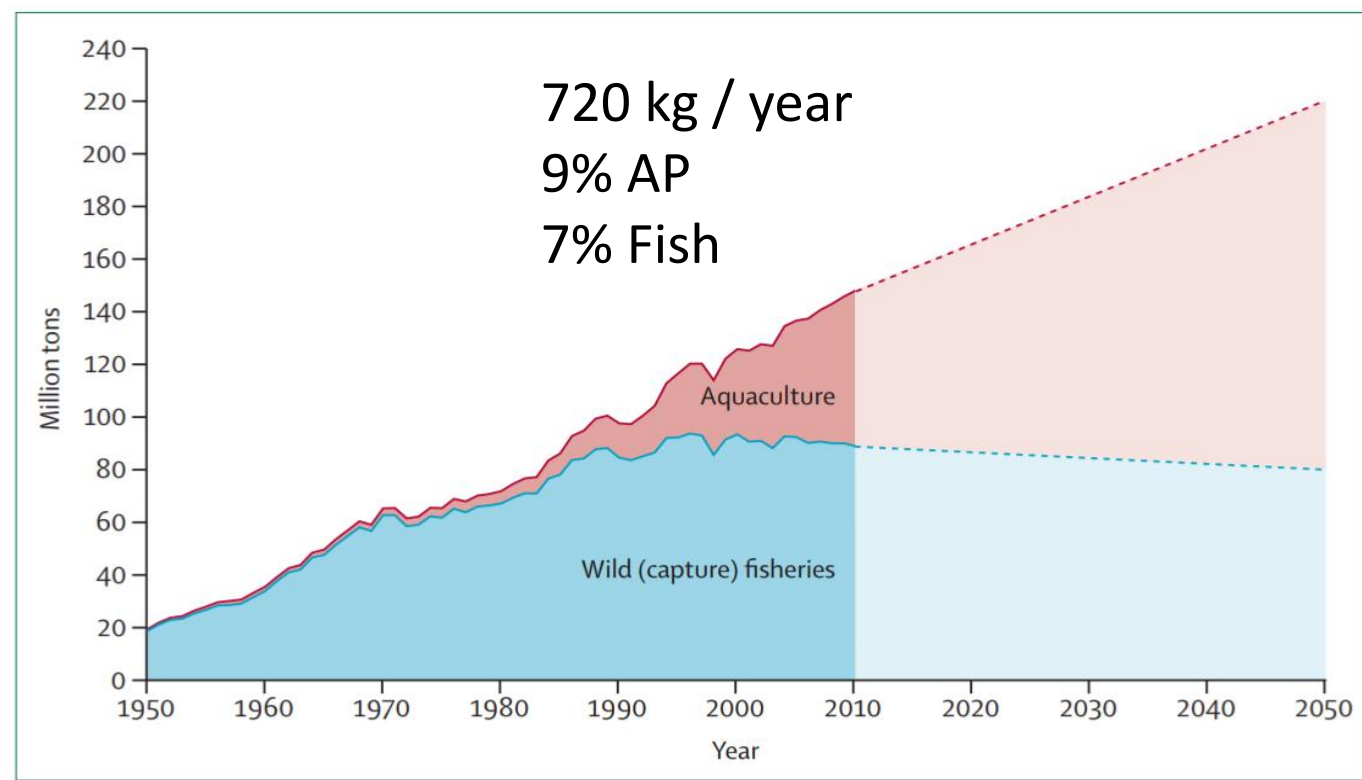
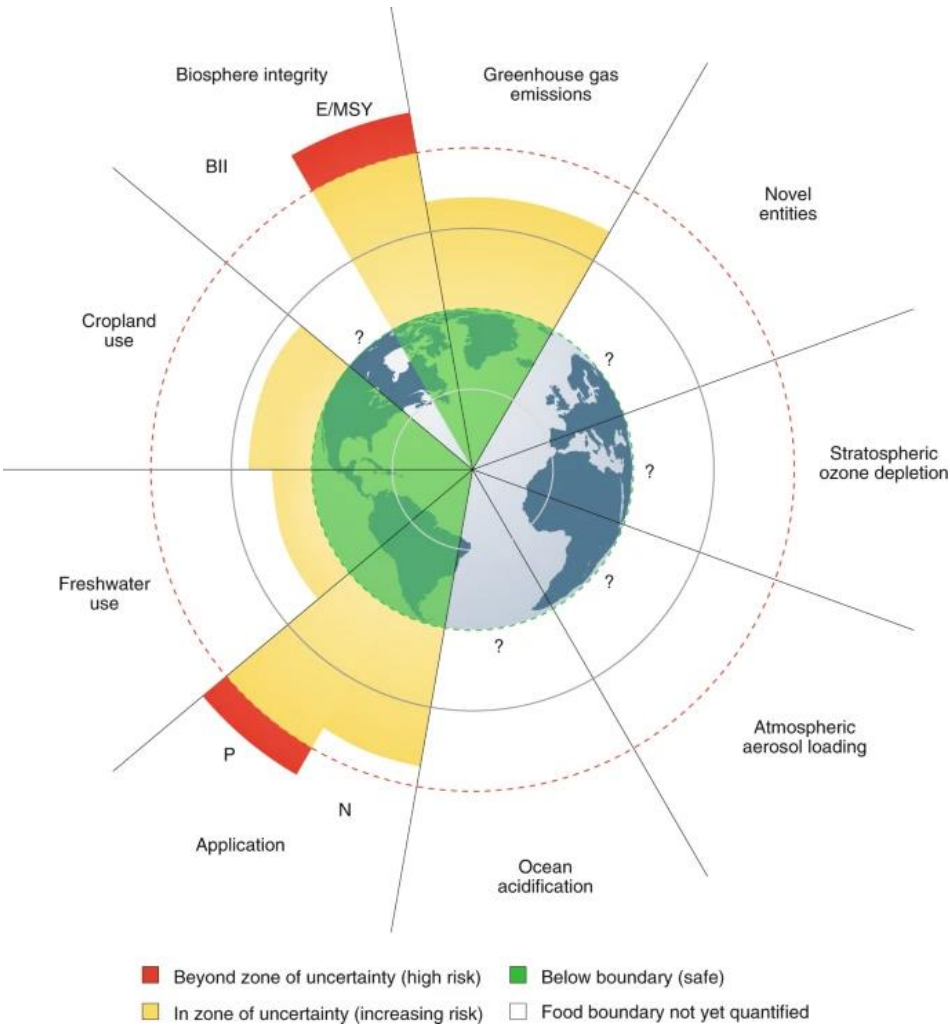
**DEPARTAMENTO DE PRODUCCION
ANIMAL**



FACULTAD DE CIENCIAS
AGRONÓMICAS
UNIVERSIDAD DE CHILE

Fish nutrition: a pillar for health in aquaculture

General context



Does aquaculture add resilience to the global food system?

Max Troell^{a,b,1}, Rosamond L. Naylor^c, Marc Metian^b, Malcolm Beveridge^d, Peter H. Tyedmers^e, Carl Folke^{a,b}, Kenneth J. Arrow^f, Scott Barrett^g, Anne-Sophie Crépin^a, Paul R. Ehrlich^h, Åsa Gren^a, Nils Kautskyⁱ, Simon A. Levin^j, Karine Nyborg^k, Henrik Österblom^b, Stephen Polasky^l, Marten Scheffer^m, Brian H. Walkerⁿ, Tasos Xepapadeas^o, and Aart de Zeeuw^p

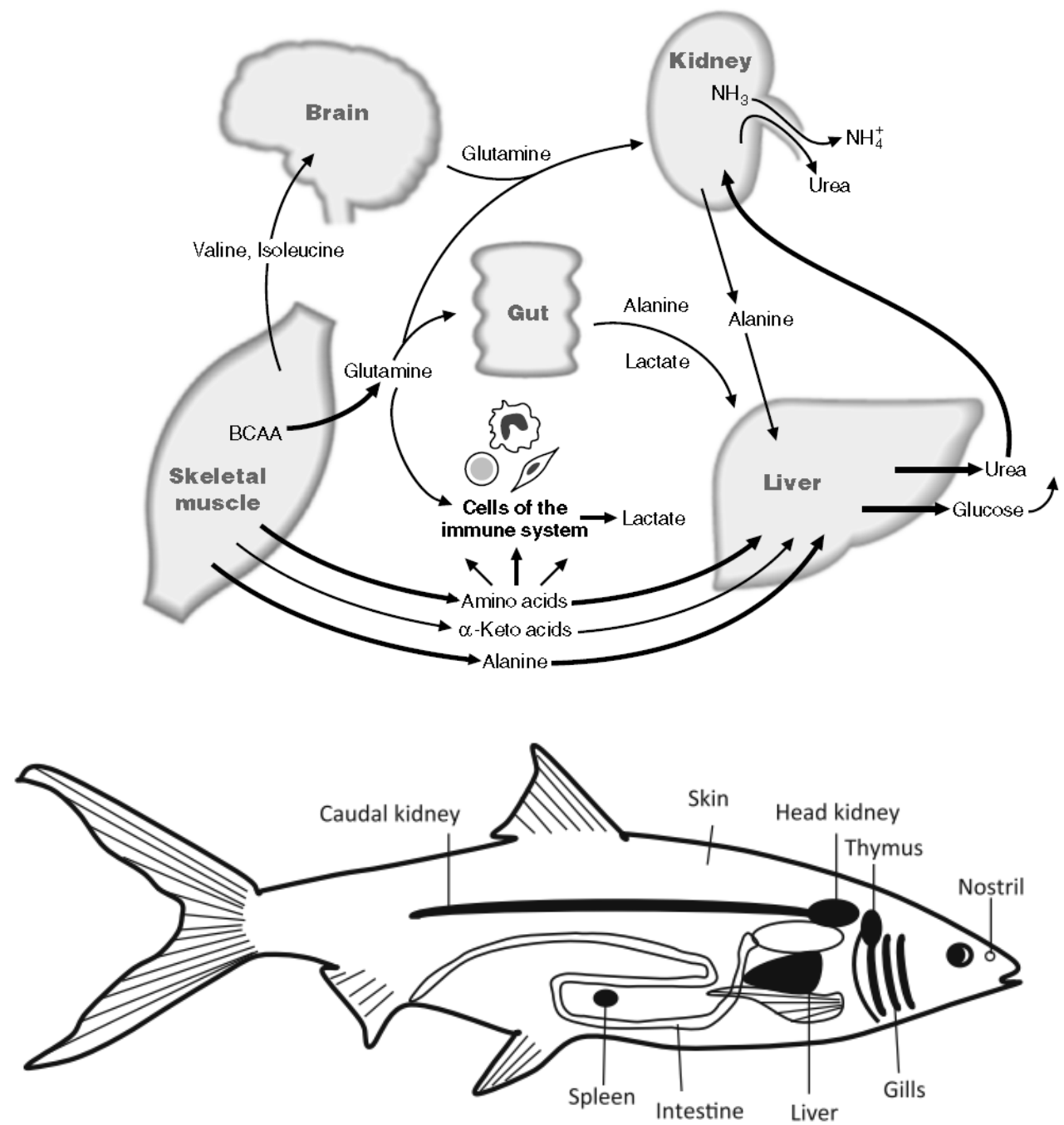
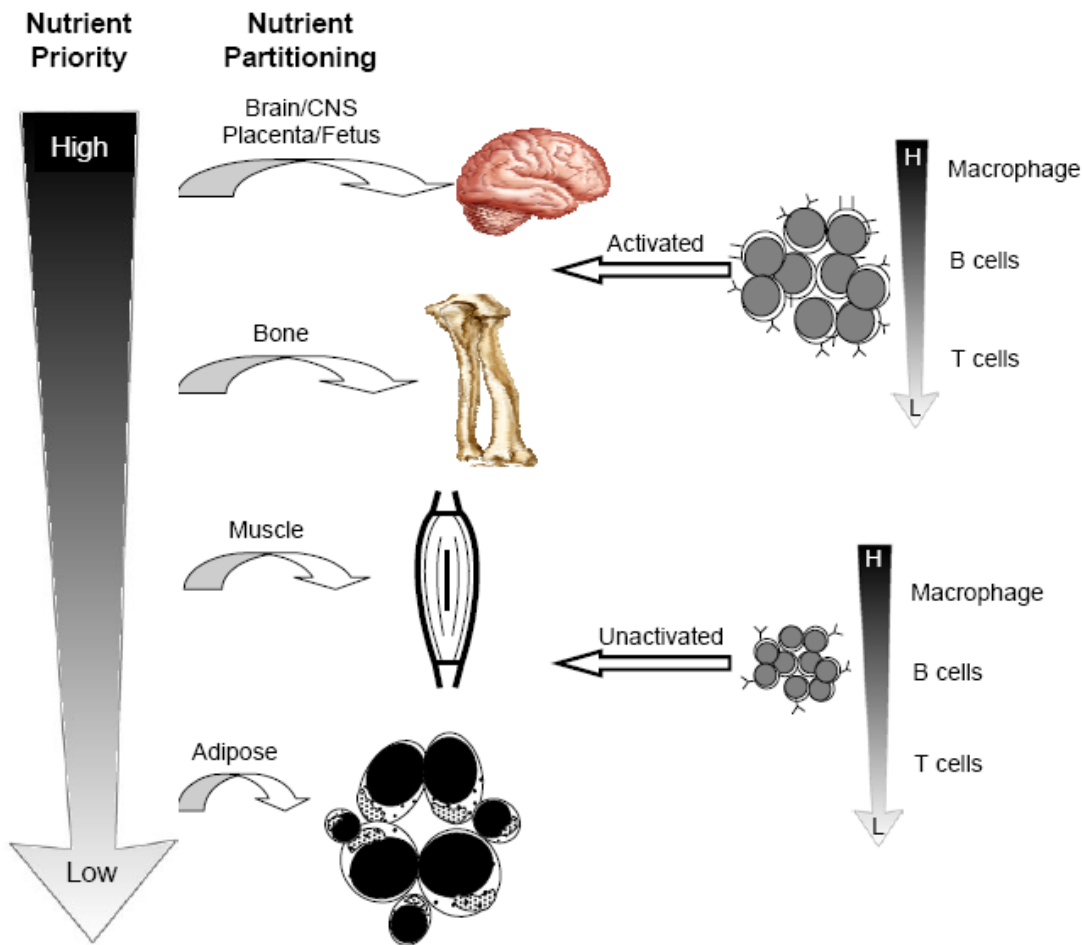
Planet-proofing the global food system

Johan Rockström , Ottmar Edenhofer, Juliana Gaertner & Fabrice DeClerck

Nature Food 1, 3–5(2020) | [Cite this article](#)

...a demanded and constantly changing world

Hammond, 1944 + immune system proposed partitioning



Nutrition and immune system, where is the link?

Effects of dietary protein levels on growth performance, digestibility, anti-oxidative responses and expressions of growth-related genes in triploid rainbow trout *Oncorhynchus mykiss* farmed in seawater

Effects of dietary protein/energy ratio and water temperature on growth performance, digestive enzymes activity and non-specific immune response of spotted seabass (*Lateolabrax maculatus*)

Yeast as a protein source during smoltification of Atlantic salmon (*Salmo salar* L.), enhances performance and modulates health

Dietary tryptophan intervention counteracts stress-induced transcriptional changes in a teleost fish HPI axis during inflammation

Supplementation of arginine, ornithine and citrulline in rainbow trout (*Oncorhynchus mykiss*): Effects on growth, amino acid levels in plasma and gene expression responses in liver tissue

Effects of glutamine on growth performance, nutrient content, fatty acid profile, and blood parameters of rainbow trout (*Oncorhynchus mykiss*)

Antioxidant nutrition in Atlantic salmon (*Salmo salar*) parr and post-smolt, fed diets with high inclusion of plant ingredients and graded levels of micronutrients and selected amino acids

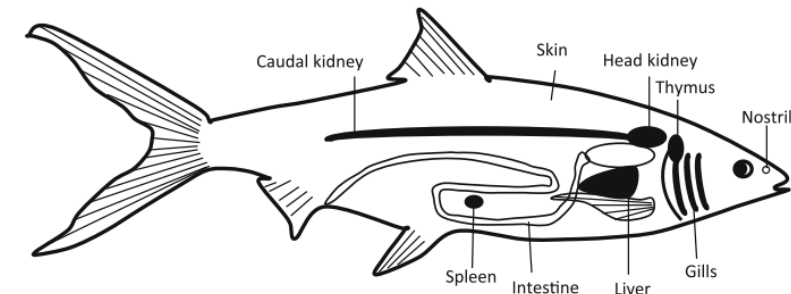
Influence of dietary vitamins E and C and HUFA on rainbow trout (*Oncorhynchus mykiss*) performance under crowding conditions

Effects of dietary vitamin E on growth performance, body composition, antioxidant capacity, and some immune responses in Caspian trout (*Salmo caspius*)

Impact of dietary level and ratio of n-6 and n-3 fatty acids on disease progression and mRNA expression of immune and inflammatory markers in Atlantic salmon (*Salmo salar*) challenged with *Paramoeba perurans*

Effect of the arachidonic acid/vitamin E interaction on the immune response of juvenile Atlantic salmon (*Salmo salar*) challenged against *Piscirickettsia salmonis*

Vegetable omega-3 and omega-6 fatty acids differentially modulate the antiviral and antibacterial immune responses of Atlantic salmon



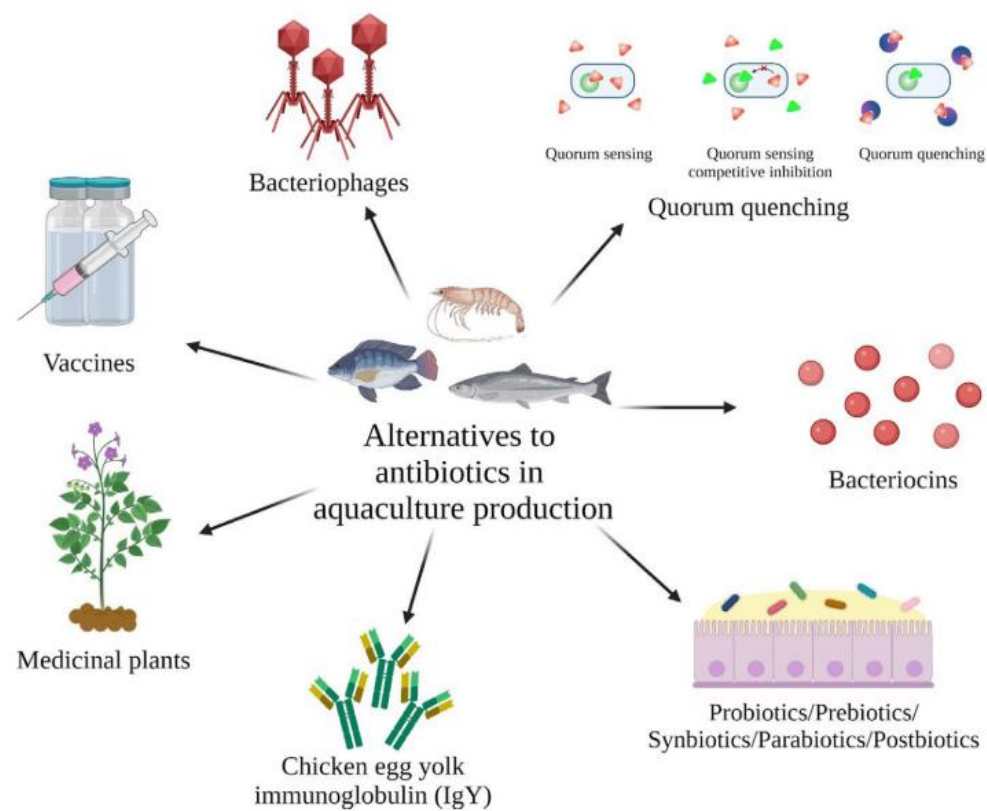
What do we do about this?

Efficient use of ingredients / decrease the impact of diseases

Review of alternatives to antibiotic use in aquaculture



- Lipids – fatty acids
- Protein – amino acids
- Carbohydrates
- Vitamins
- Minerals



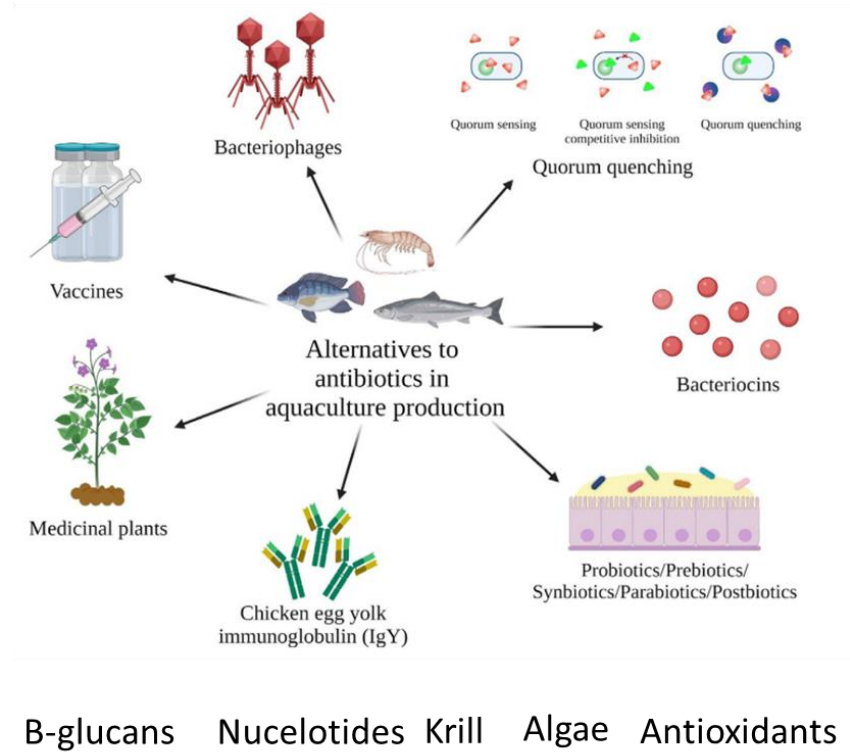
B-glucans Nucelotides Krill Algae Antioxidants



- Nutrition
- Health
- Sustainability

What do we do about this?

In vivo – In vitro – Ex vivo



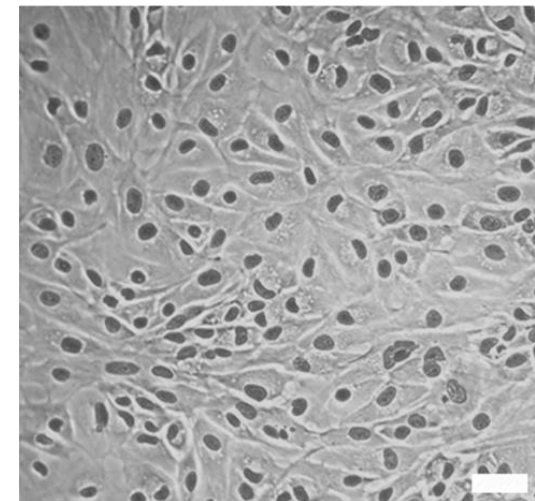
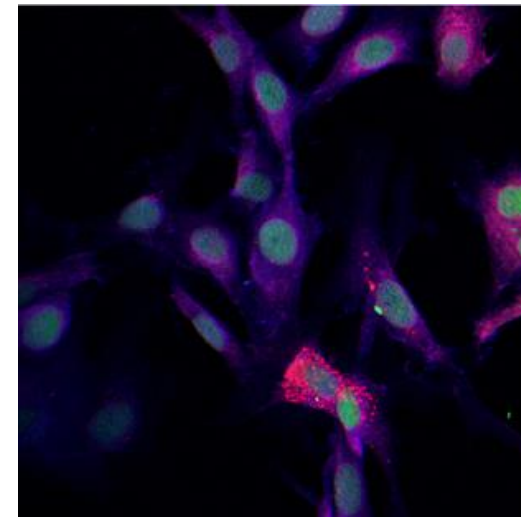
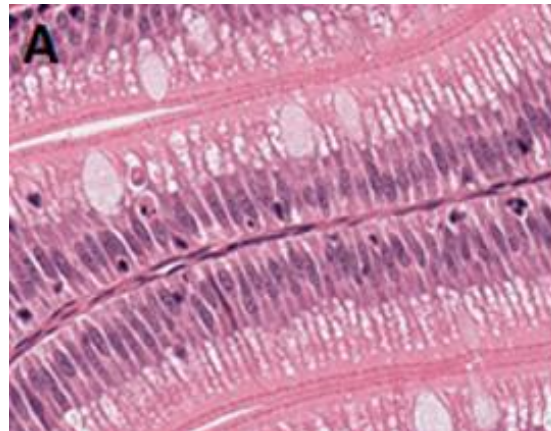
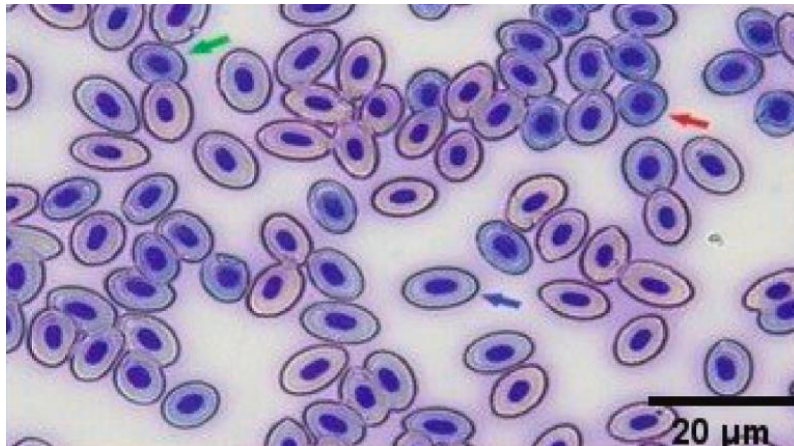
Lipids – fatty acids

Protein – amino acids

Carbohydrates

Vitamins

Minerals



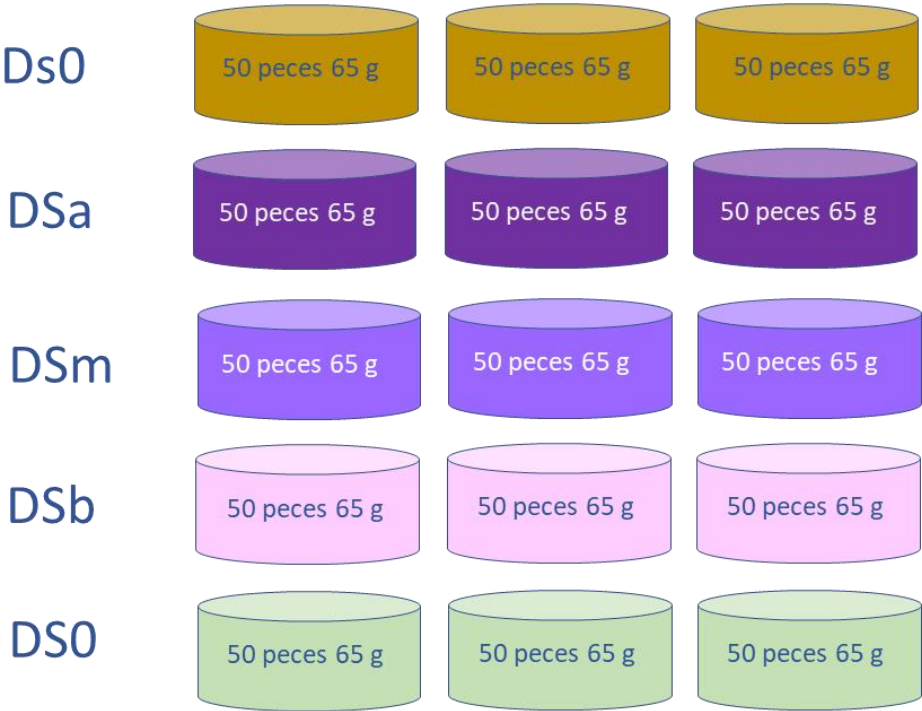
What do we do about this?

In vivo

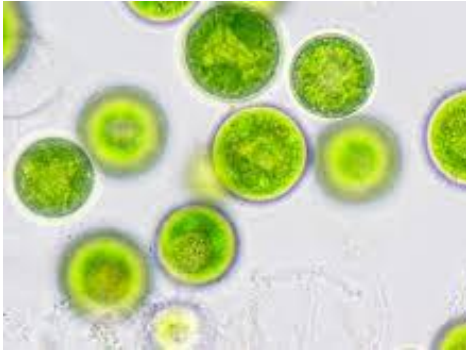
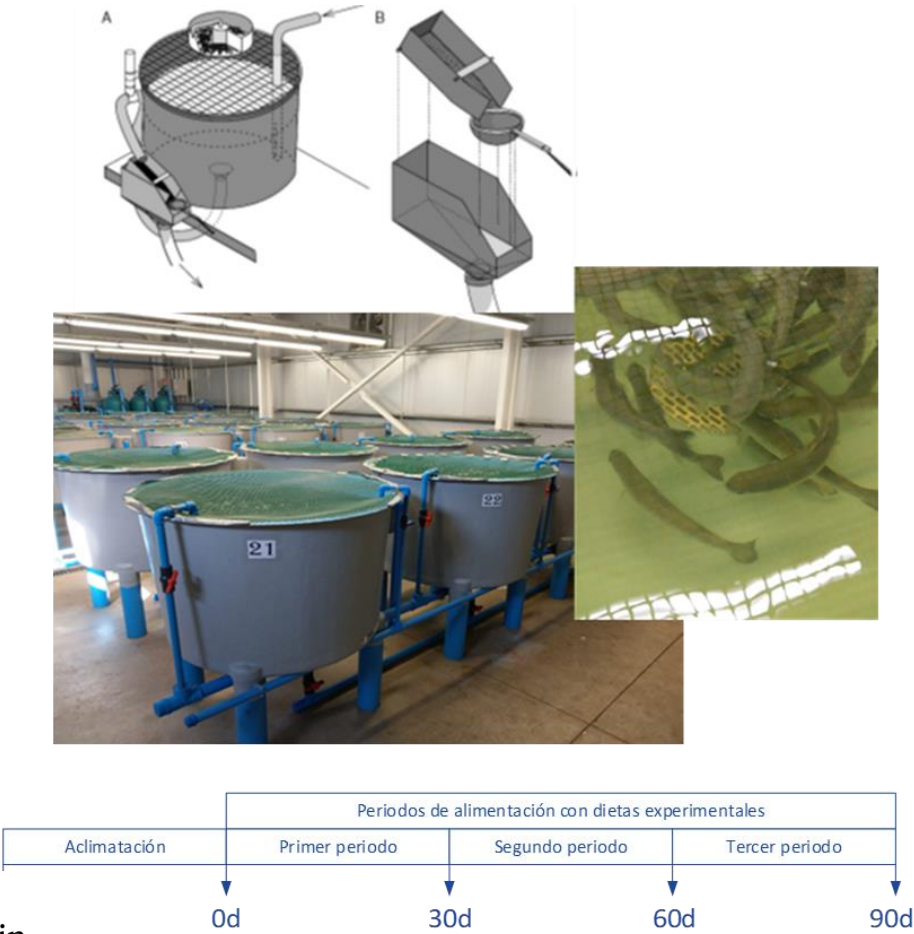
Diets enriched in red seaweed (*Pyropia columbina* and *Gracilaria chilensis*) cryo concentrates modulate the immune-relevant gene encoding the Mx antiviral protein in salmon (*Salmo salar*) white blood cells

Red macroalgae *Pyropia columbina* and *Gracilaria chilensis*: sustainable feed additive in the *Salmo salar* diet and the evaluation of potential antiviral activity against infectious salmon anemia virus

Estanques de 400 L



Effect of dietary inclusion of microalgae (*Nannochloropsis gaditana* and *Schizochytrium spp*) on non-specific immunity and erythrocyte maturity in Atlantic salmon fingerlings



What do we do about this?

Pyropia + Gracilaria

Increase in SGR

Increase in antiviral activity

Modulation of Mx expression



Red macroalgae *Pyropia columbina* and *Gracilaria chilensis*: sustainable feed additive in the *Salmo salar* diet and the evaluation of potential antiviral activity against infectious salmon anemia virus

Diets enriched in red seaweed (*Pyropia columbina* and *Gracilaria chilensis*) cryo concentrates modulate the immune-relevant gene encoding the Mx antiviral protein in salmon (*Salmo salar*) white blood cells



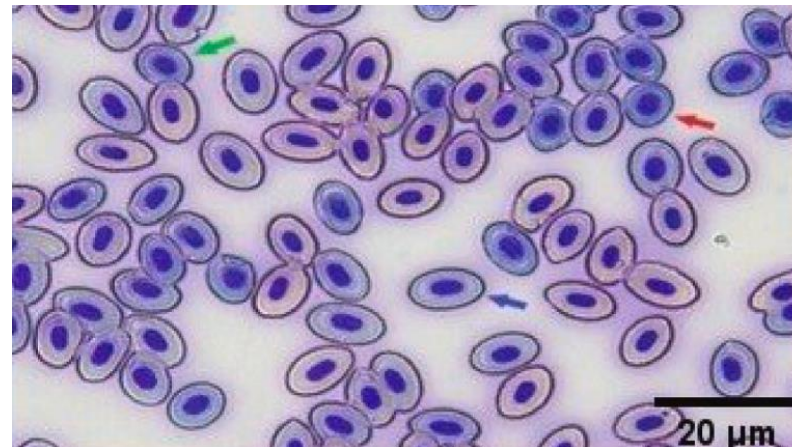
Nannochloropsis + Schizochytrium

Increase in antibacterial humoral components in RBC

Increase in phagocytic cells in peripheral blood

Increase in immature red cells

Effect of dietary inclusion of microalgae (*Nannochloropsis gaditana* and *Schizochytrium spp*) on non-specific immunity and erythrocyte maturity in Atlantic salmon fingerlings

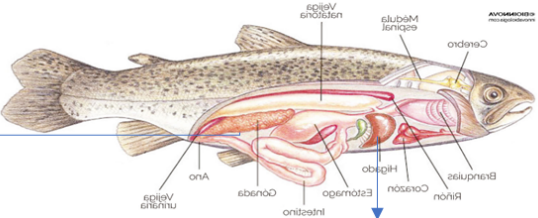


Nuevos ingredientes y reciclaje de nutrientes

Dietas funcionales y vehículos



Dieta harina de soya y con polifenoles



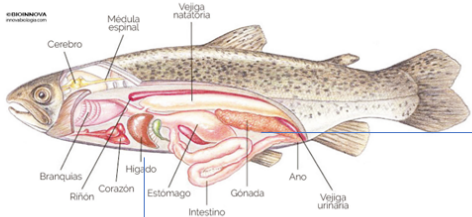
> Capacidad antioxidante plasmática
Hígado con estatus oxidativo favorable

+

< Inflamación intestinal

< Demanda energética

Dieta harina de soya y sin polifenoles

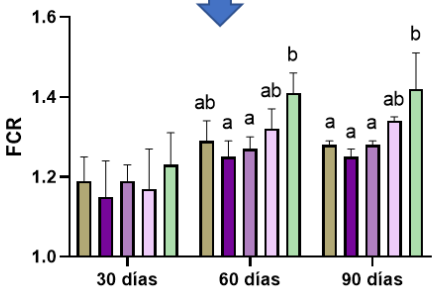
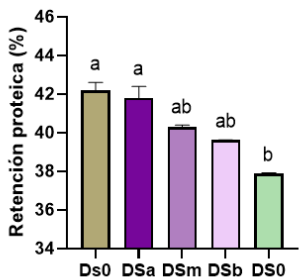


< Capacidad antioxidante plasmática
Hígado con estatus oxidativo desfavorable

+

> Inflamación intestinal

> Demanda energética



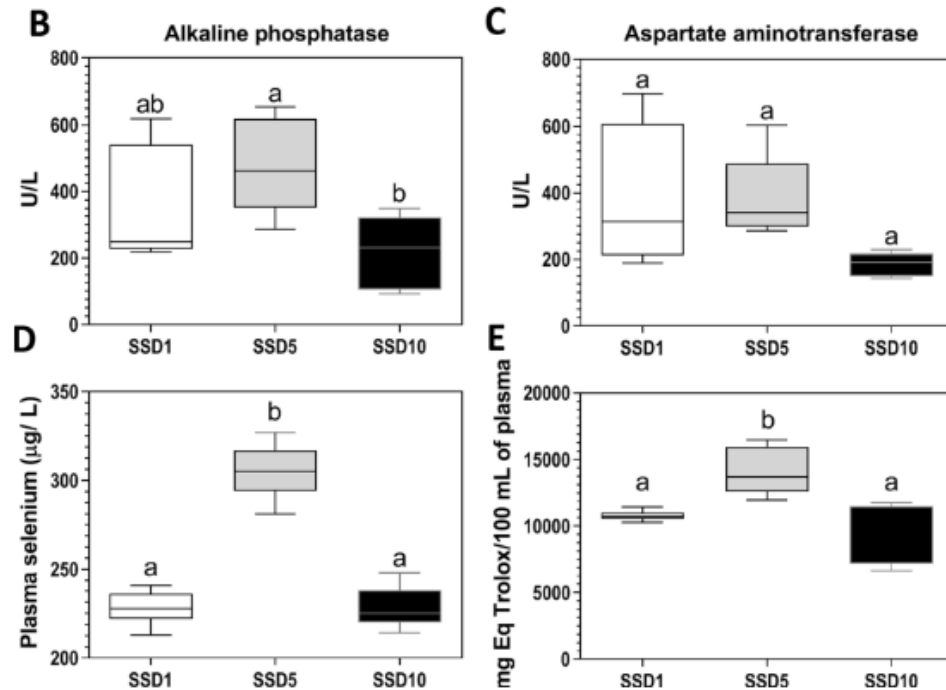
Micro-encapsulated grape pomace extract (MGPE) as a feed additive improves growth performance, antioxidant capacity, and shifts the gut microbiome of rainbow trout

What do we do about this?

Nutrients / **Selenium**

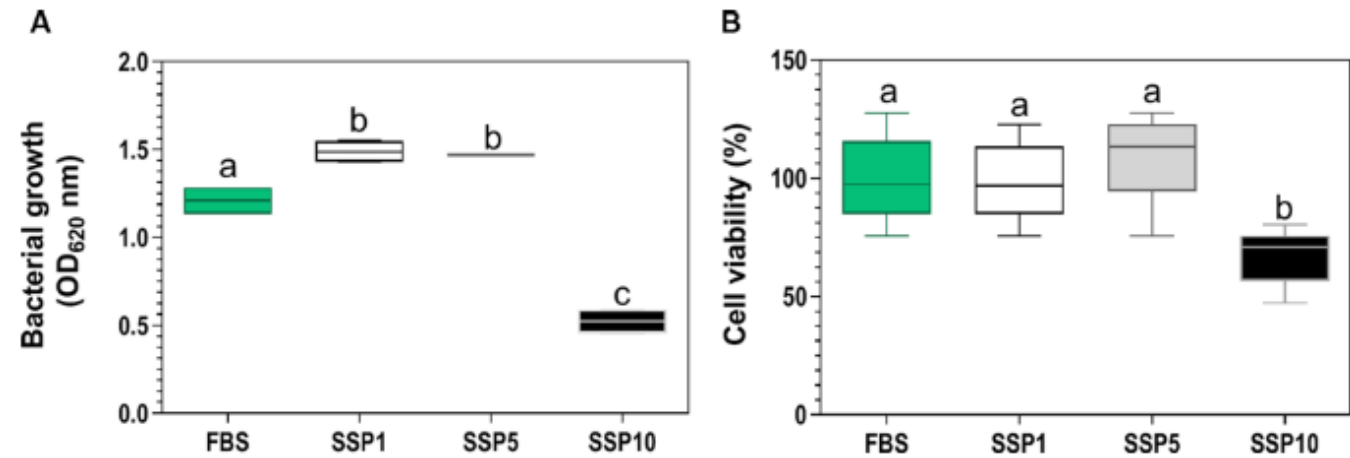
Host directed

Dietary selenium **increases** the plasma concentration of selenium and its **antioxidant capacity** in rainbow trout



Increased dietary availability of selenium in rainbow trout (*Oncorhynchus mykiss*) improves its plasma antioxidant capacity and resistance to infection with *Piscirickettsia salmonis*

High concentrations of trout plasma and selenium supplementation **affects the bacterial growth and viability** in SHK-1

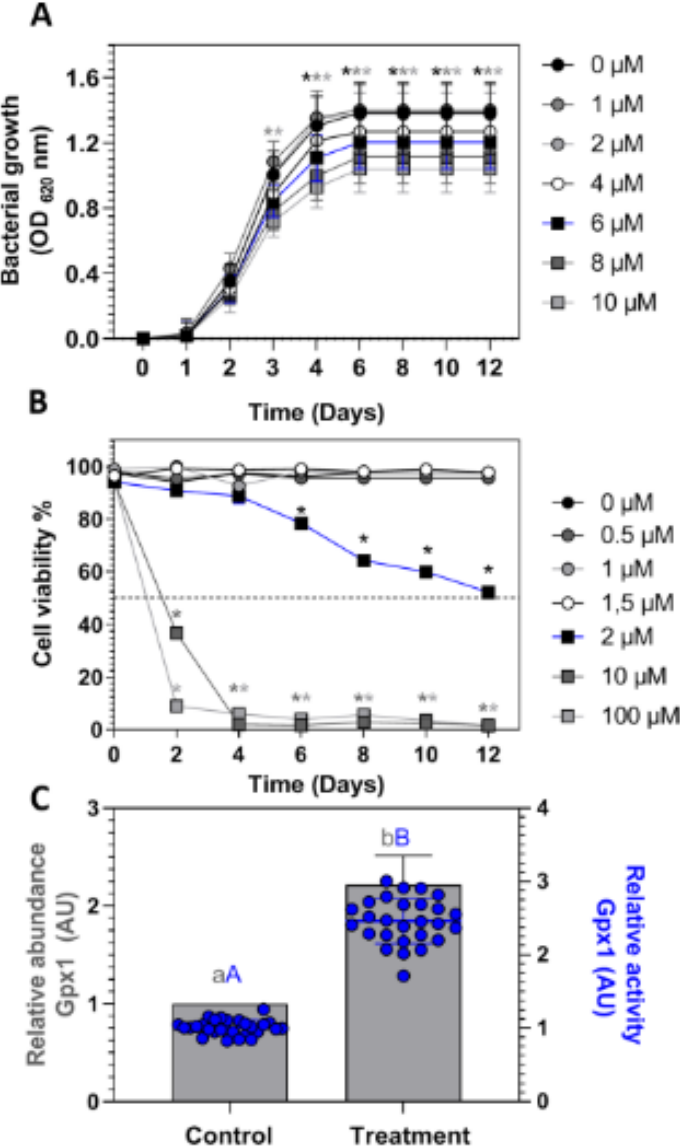


What do we do about this?

Nutrients / **Selenium**

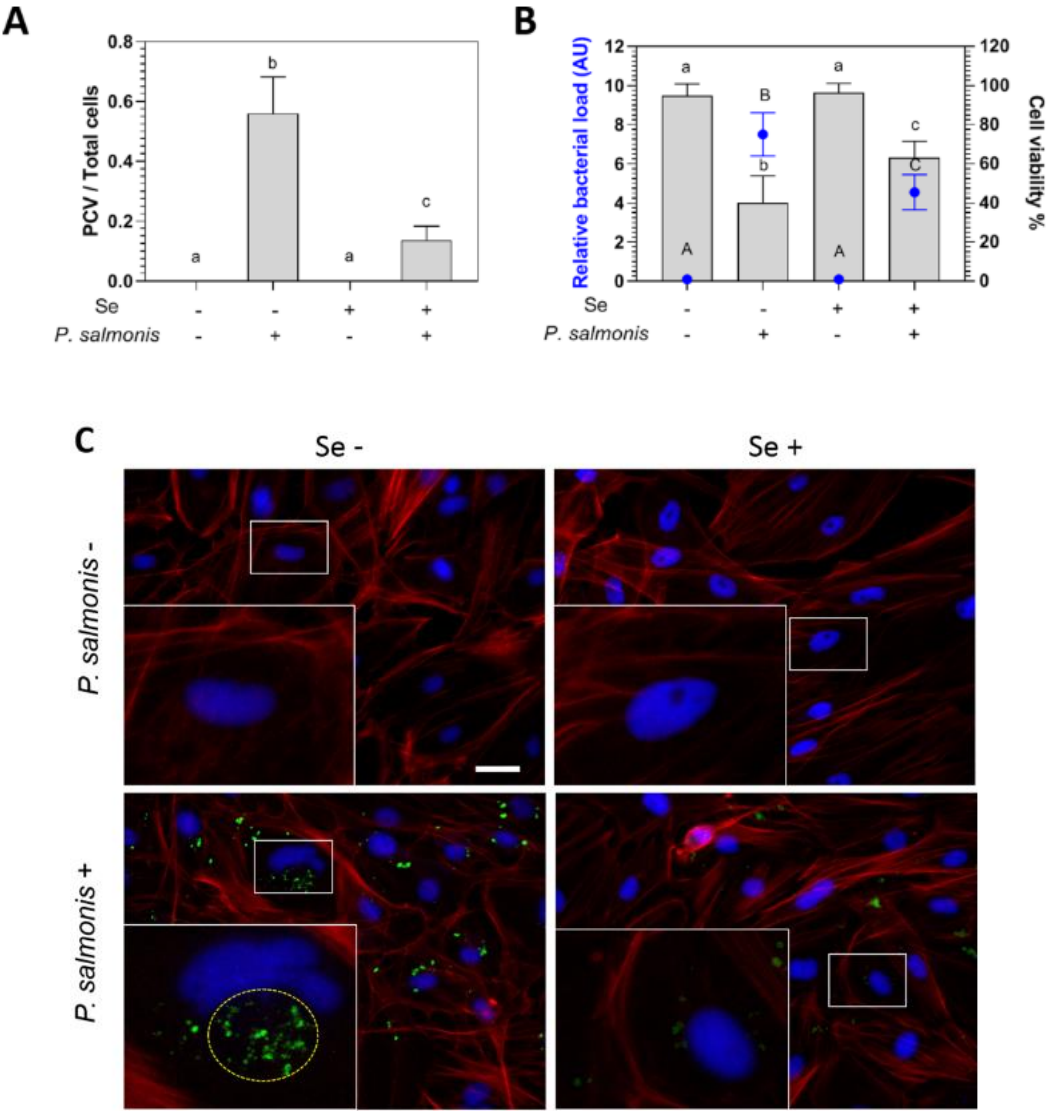
Host directed / In vitro + Ex vivo

Selenium increases the abundance and activity of Gpx1 at non-bactericidal and non-cytotoxic concentrations in SHK-1



Selenium reduces *Piscirickettsia salmonis* infection in SHK-1

Increased dietary availability of selenium in rainbow trout (*Oncorhynchus mykiss*) improves its plasma antioxidant capacity and resistance to infection with *Piscirickettsia salmonis*

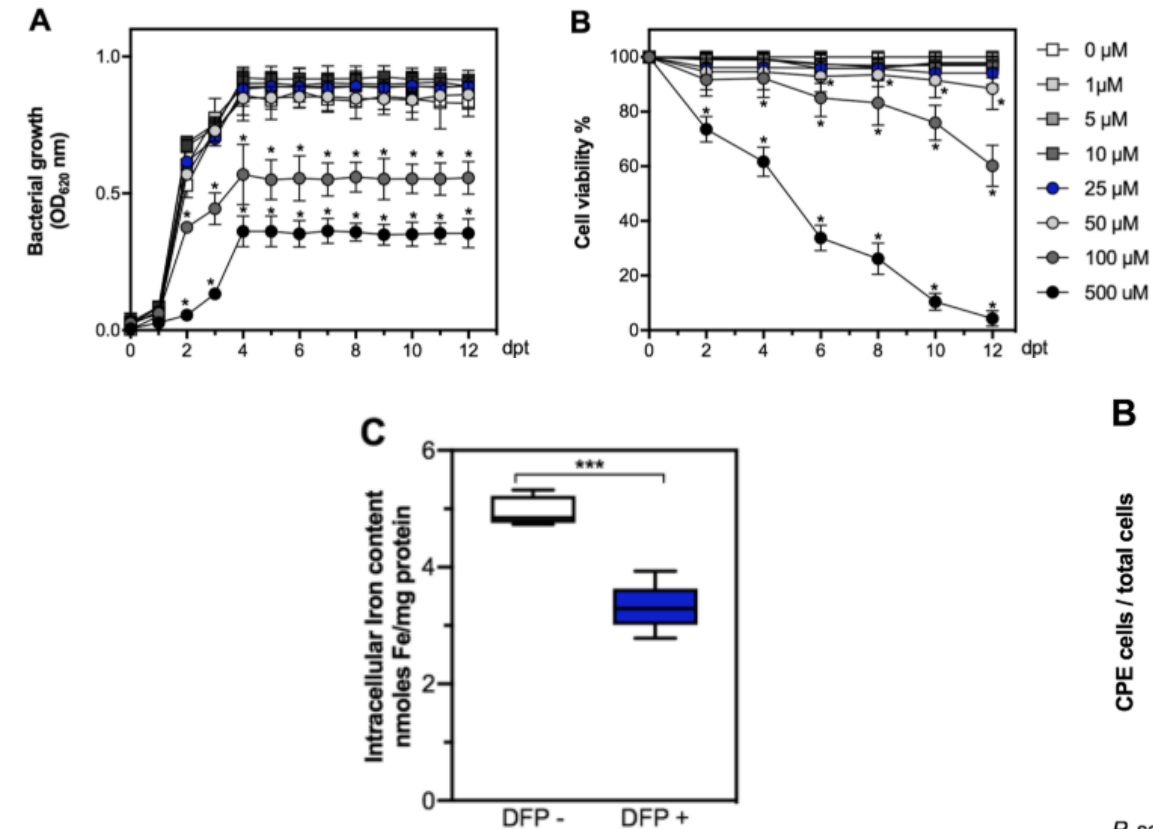


What do we do about this?

Nutrients / **Iron**

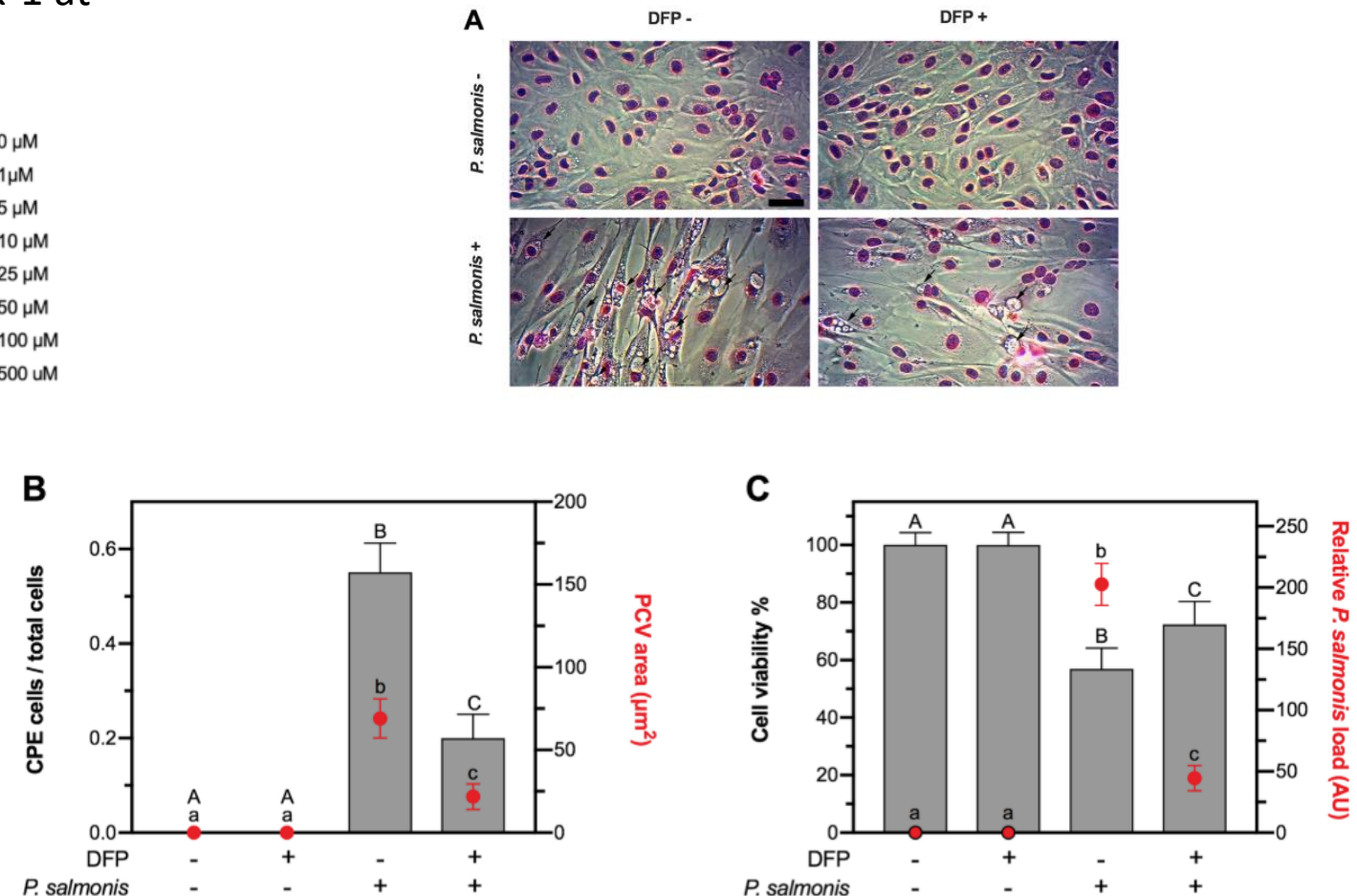
Host directed

Deferiprone **decreases intracellular iron content** in SHK-1 at non-bactericidal nor cytotoxic concentrations



Pharmacological iron-chelation as an assisted nutritional immunity strategy against *Piscirickettsia salmonis* infection

Deferiprone **reduces *Piscirickettsia salmonis* infection** in SHK-1 cells.

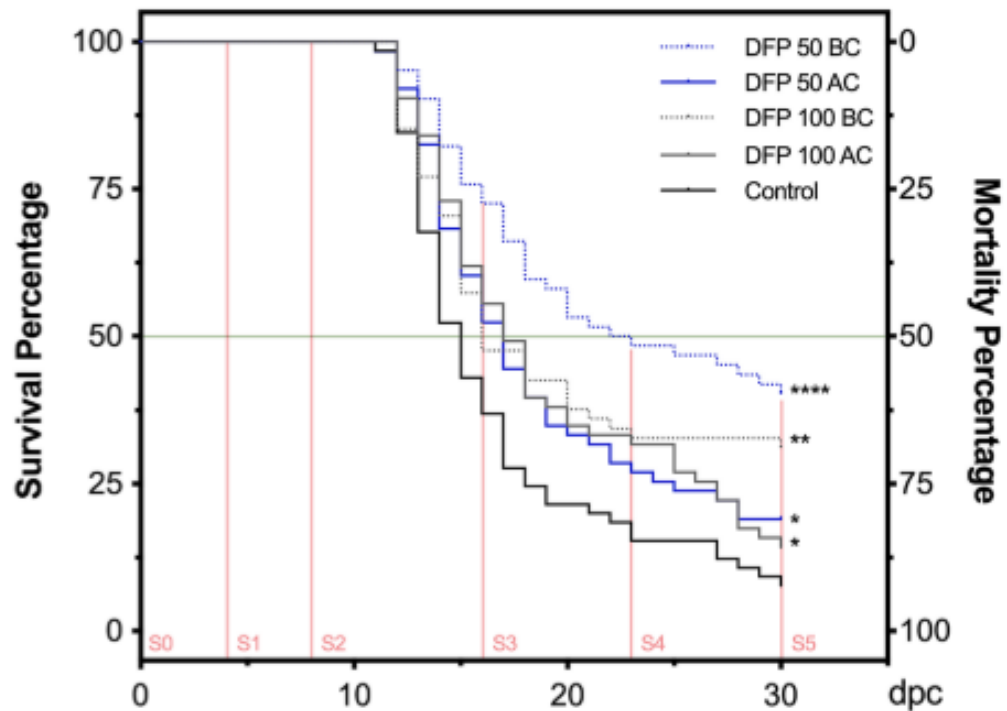


What do we do about this?

Nutrients / **Iron**

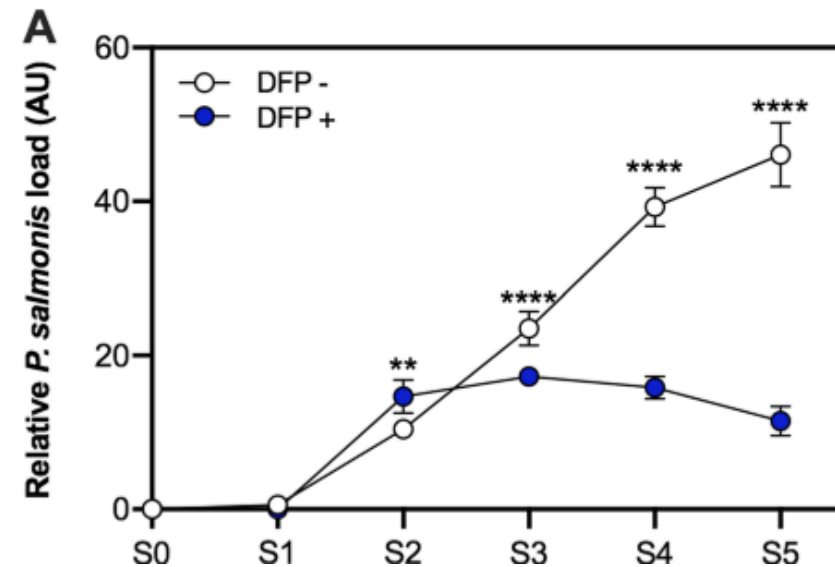
Host directed

Deferiprone **reduces mortality** of *Oncorhynchus mykiss* challenged with *Piscirickettsia salmonis*



Pharmacological iron-chelation
as an assisted nutritional immunity strategy
against *Piscirickettsia salmonis* infection

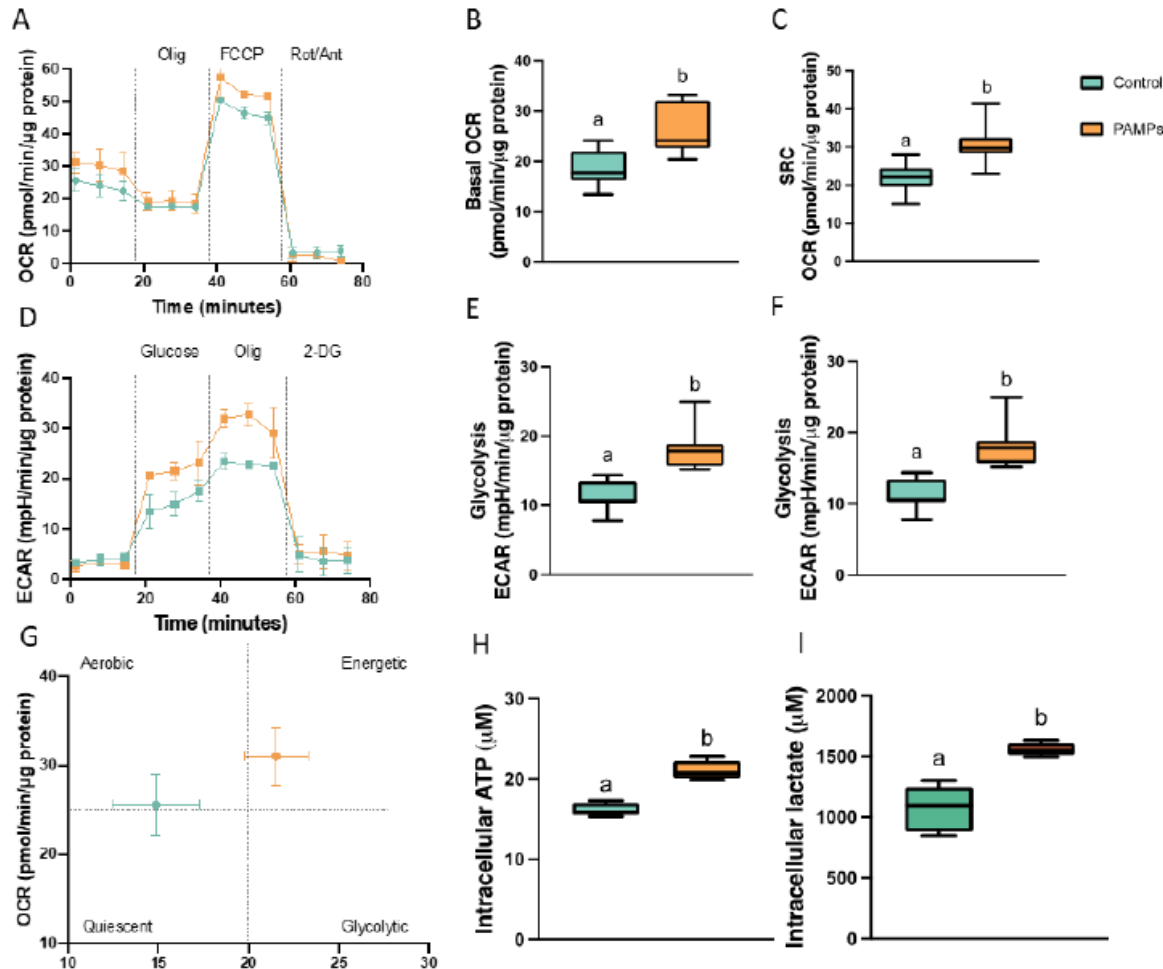
Deferiprone **decreases *Piscirickettsia salmonis* burden** in fish kidney at a non-antibiotic concentration



What do we do about this?

Nutrients / **Glutamine**

Phagocytic cells / nutrient use / metabolic flux

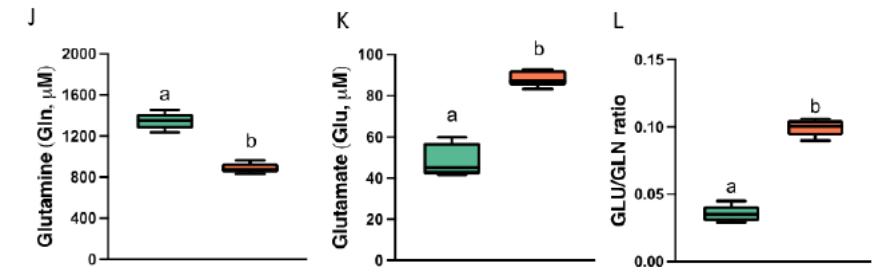


Fish and Shellfish Immunology

Metabolic energetic adaptation of Atlantic salmon phagocytes to changes in carbon sources and exposure to PAMPs

The metabolic phenotype of the SHK-1 cell lines is adjusted to different carbon source

Metabolic energy remodeling of SHK-1 cells exposed to PAMPs of SRS



“...mitochondrial bioenergetics and metabolic plasticity in salmon phagocytes...”

What are we doing?

In vivo – In vitro – Ex vivo

Nutrition – Immune

Pro and antioxidants in fish diets:
**studying the dynamics between oxidative
damage and defenses**

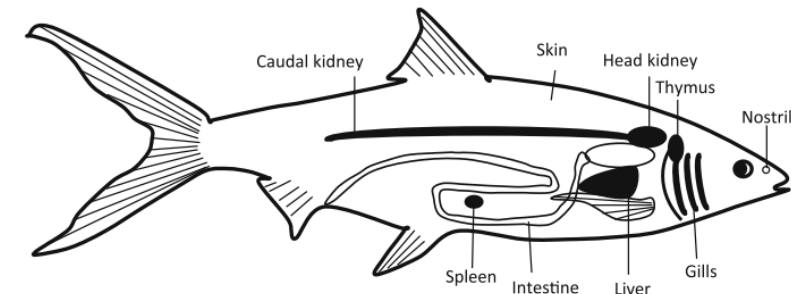


Desarrollo de **formulaciones de liberación controlada** vía oral
para aumentar la biodisponibilidad de oxitetraciclina:
Optimizando una herramienta terapéutica para la producción
animal intensiva

Repurposing of **non-antibiotic host-directed drugs** as
a rational strategy for the control of Salmonid
Rickettsial Septicemia (SRS)

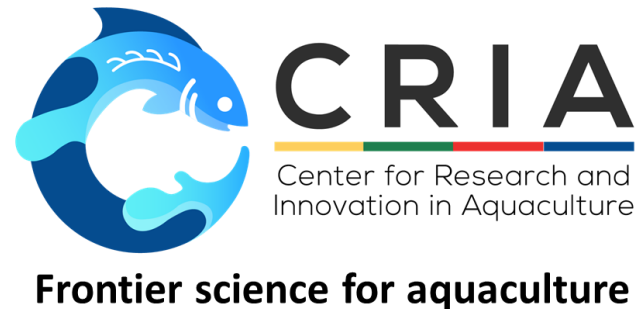
Plataforma habilitante de apoyo para la producción y uso de
insumos vegetales nutricionales provenientes de cultivos de
rotación de la macrozona sur y austral de Chile **como fuente
sostenible de proteínas y aceites** que puedan ser escalables,
costo y ambientalmente efectivas para su uso en la elaboración
de dietas en la industria de salmónidos

IMPLEMENTAR Y VALIDAR UN MÉTODO IN VITRO
PARA EVALUAR INGREDIENTES FUNCIONALES



...The team

What else are we doing? AB encapsulation – Redox balance



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