

# Fish performance and quality of gilthead sea bream fed extremely low fish meal and fish oil diets with or without butyrate supplementation



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# Fish meal and fish oil targets in practical sea bream diets

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Effects of dietary amino acid profile on growth performance, key metabolic enzymes and endocrine axis responsiveness of gilthead sea bream (*Sparus aurata*)

S. Kirchner<sup>a,b</sup>,  
 S. Panfili<sup>b</sup>,  
 J. Sánchez<sup>a,\*</sup>

Protein growth and somatotropic performance replacement by fish meal in gilthead sea bream

P. Gómez-Requeni<sup>a</sup>,  
 F. A. Álvarez<sup>a</sup>

Combined replacement of fish meal and oil in practical diets for growing juveniles of gilthead sea bream (*Sparus aurata* L.): Networking of systemic and local components of GH/IGF axis

Laura Benedito-Palos<sup>a</sup>, Alfonso Saez-Vila<sup>a</sup>, Josep-Arbor Caldach-Giner<sup>a</sup>,  
 Sadayam Kanakiah<sup>b</sup>, Jaume Pérez-Samartín<sup>a</sup>

High levels of vegetable oil in plant protein-rich diets and histological alterations of target tissues in gilthead sea bream (*Sparus aurata* L.): growth performance and histological alterations of target tissues

Laura Benedito-Palos<sup>a</sup>, Juan C. Navarro<sup>a</sup>, Azucena Bermejo-Negrel<sup>a</sup>, Alfonso Saez-Vila<sup>a</sup>,  
 Selamawort Kanakiah<sup>b</sup>, Jaume Pérez-Samartín<sup>a</sup>

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 Aquaculture 260 (2006) 199–212  
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The time course of fish oil wash-out follows a simple dilution model in gilthead sea bream (*Sparus aurata* L.) fed graded levels of vegetable oils

Laura Benedito-Palos<sup>a</sup>, Juan C. Navarro<sup>a</sup>, Azucena Bermejo-Negrel<sup>a</sup>, Alfonso Saez-Vila<sup>a</sup>,  
 Selamawort Kanakiah<sup>b</sup>, Jaume Pérez-Samartín<sup>a</sup>

**ARTICLE INFO**  
**ABSTRACT**  
 The aim of the study was to determine the effect of graded levels of vegetable oil (VO) on the growth performance and histological alterations of target tissues in gilthead sea bream (*Sparus aurata* L.) fed graded levels of vegetable oils. The trial included 3 years of feeding a fish oil washing phase of 100 days, followed by a 100-day wash-out phase. Fish oil wash-out was followed by a 100-day wash-out phase. The trial included 3 years of feeding a fish oil washing phase of 100 days, followed by a 100-day wash-out phase. The trial included 3 years of feeding a fish oil washing phase of 100 days, followed by a 100-day wash-out phase.



**ARRAINA, 2012-2016**

ADVANCED RESEARCH INITIATIVES FOR NUTRITION & AQUACULTURE

**5% FM  
2.5% FO**

**AQUAMAX, 2006-2010**

SUSTAINABLE AQUAFEEDS TO MAXIMISE THE HEALTH BENEFITS OF FARMED FISH FOR CONSUMERS

**15-20% FM  
5% FO**

*Benedito-Palos et al., 2007, 2008, 2009*

**PEPPA, 2001-2004**

PERSPECTIVES OF PLANT PROTEIN USE IN AQUACULTURE

**15-20% FM  
12-15% FO**

*Gómez-Requeni et al., 2003, 2004*

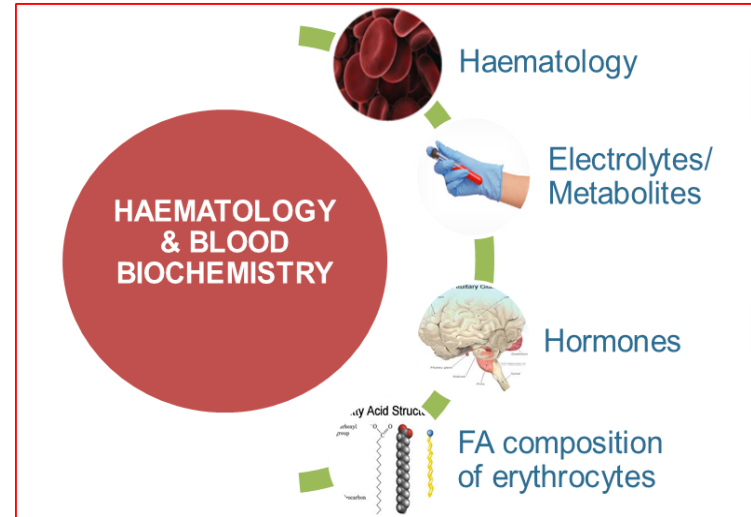
AE 2014, San Sebastian



European Union

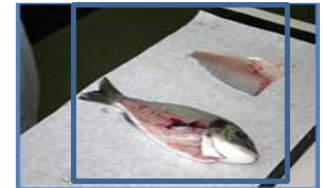


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## OBJECTIVES

- 1- Growth performance
- 2- Basic blood biochemistry
- 3- FA profiling of fillets & RBC



## EXPERIMENTAL SETUP



Four experimental diets with changing FM/FO content formulated by BIOMAR and supplemented by BP70®



Initial BW 15 g  
Replicate tanks (3000-L), 150 fish each  
Natural photoperiod and temperature conditions



Fish are fed to visual satiety 1-2 times per day and 3-6 days per week through the production cycle



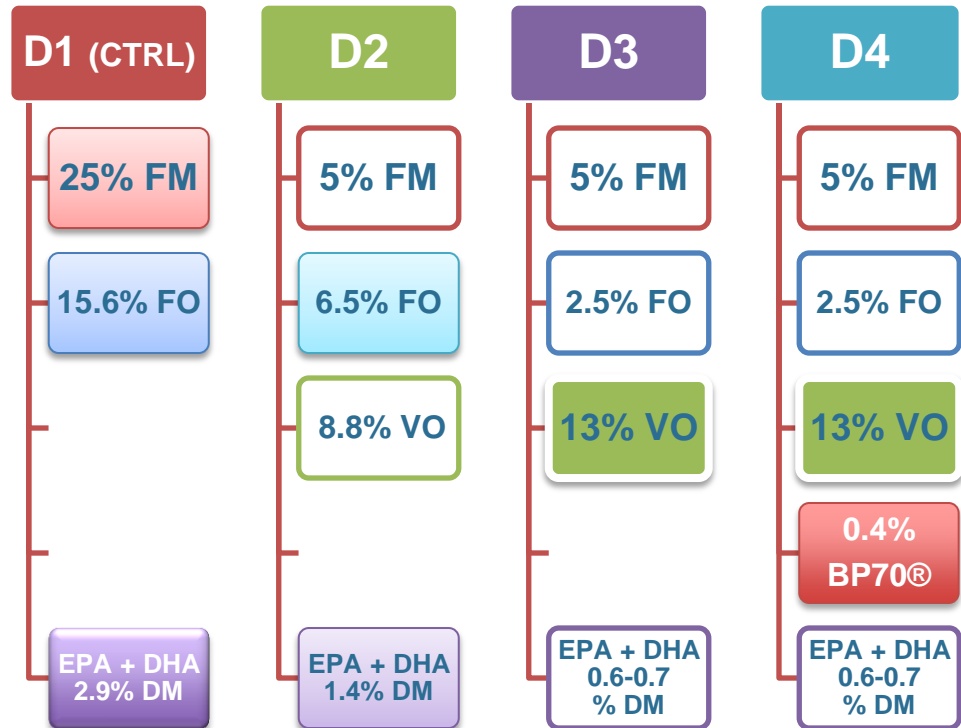
Each 4-6 weeks biomass is determined  
Fish are sampled periodically for blood and tissue samples (biochemical, histological, molecular, proteomic, microbiological, and food safety analyses )



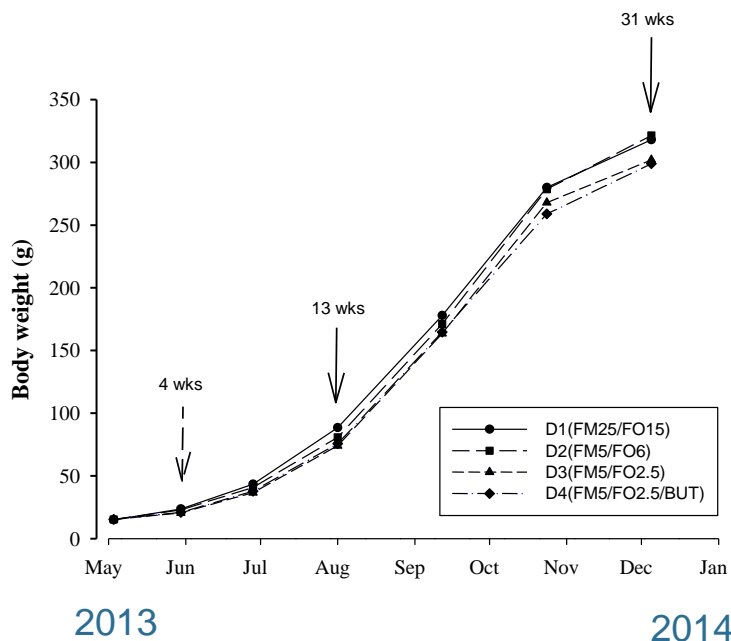
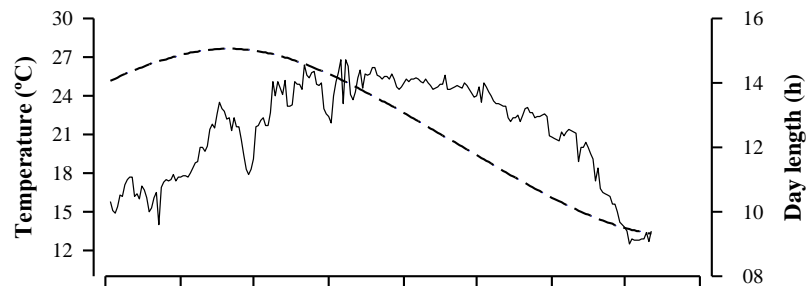
# Diet composition



| Ingredient (%)                   | Diet  |       |       |       |
|----------------------------------|-------|-------|-------|-------|
|                                  | D1    | D2    | D3    | D4    |
| Fish meal                        | 23.00 | 3.00  | 3.00  | 3.00  |
| CPSP 90                          | 2.00  | 2.00  | 2.00  | 2.00  |
| Soya protein                     | 16.00 | 25.00 | 25.00 | 25.00 |
| Corn gluten                      | 15.00 | 25.00 | 25.00 | 25.00 |
| Wheat gluten                     | 4.00  | 7.30  | 7.30  | 7.30  |
| Rapeseed cake                    | 12.00 | 9.70  | 9.90  | 9.90  |
| Wheat                            | 11.08 | 6.80  | 6.64  | 6.24  |
| Fish oil                         | 15.60 | 6.56  | 2.50  | 2.50  |
| Rapeseed oil                     | 0     | 4.40  | 6.50  | 6.50  |
| Palm olein                       | 0     | 4.40  | 6.50  | 6.50  |
| Emulthin G35                     | 0     | 1.625 | 1.456 | 1.456 |
| Choline chloride                 | 0     | 0.199 | 0.196 | 0.196 |
| Monocalcium phosphate            | 0.303 | 2.097 | 2.097 | 2.097 |
| L-Lysine                         | 0.196 | 1.009 | 1.005 | 1.005 |
| L-Histidin                       | 0.136 | 0.136 | 0.136 | 0.136 |
| Methionine                       | 0     | 0.085 | 0.084 | 0.084 |
| Mineral-vitamin mix <sup>1</sup> | 0.500 | 0.500 | 0.500 | 0.500 |
| Cholesterol                      | 0.113 | 0.113 | 0.113 | 0.113 |
| Ethoxiquin                       | 0.020 | 0.020 | 0.020 | 0.020 |
| BAROX BECP                       | 0.025 | 0.025 | 0.025 | 0.025 |
| Yttrium                          | 0.03  | 0.03  | 0.03  | 0.03  |
| BP-70                            | 0     | 0     | 0     | 0.4   |
| <i>Proximate composition</i>     |       |       |       |       |
| Dry matter (DM, %)               | 91.65 | 91.79 | 91.80 | 92.34 |
| Crude protein (% DM)             | 45.48 | 46.73 | 46.12 | 46.03 |
| Crude fat (% DM)                 | 19.80 | 19.56 | 20.13 | 19.40 |
| EPA+DHA (% DM)                   | 2.90  | 1.38  | 0.67  | 0.63  |



# Growth performance I



All groups grew fast,  
final FGR ~ 1



Fish fed CTRL (D1) and D2  
(5FM/6.5 FO) diets are  
undistinguishable



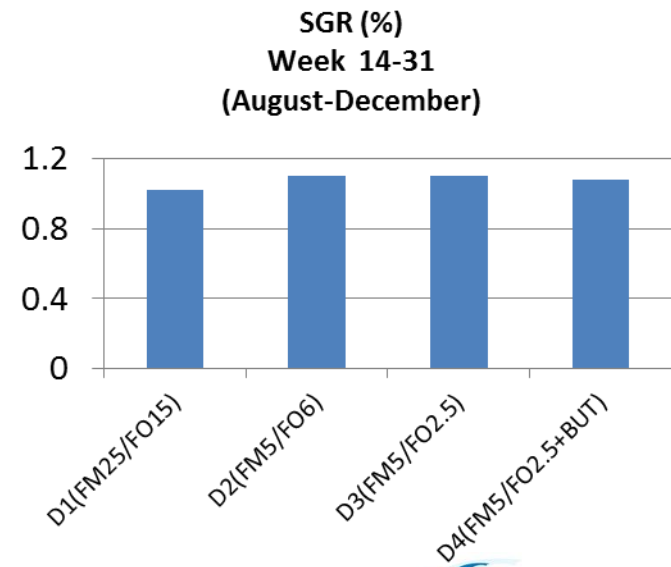
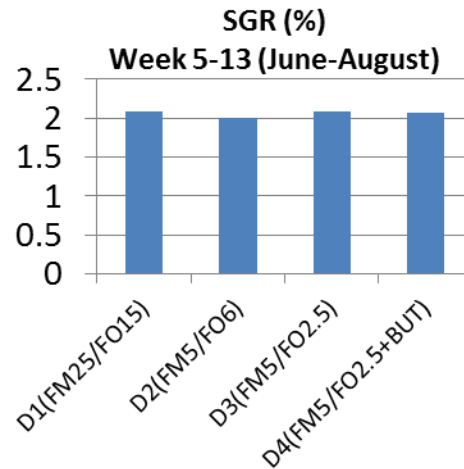
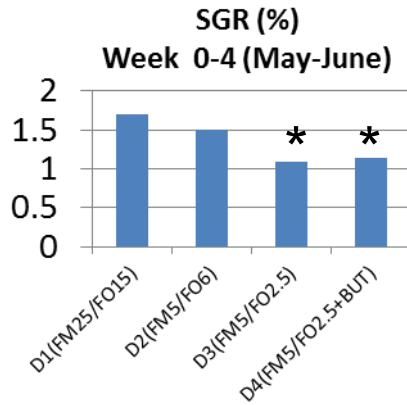
6-7% reduction in BW mass is  
found in fish fed D3 and D4  
diets (5FM/ 2.5FO)



The growth impairment was  
restricted to starting period

# Changes in SGR from May to December

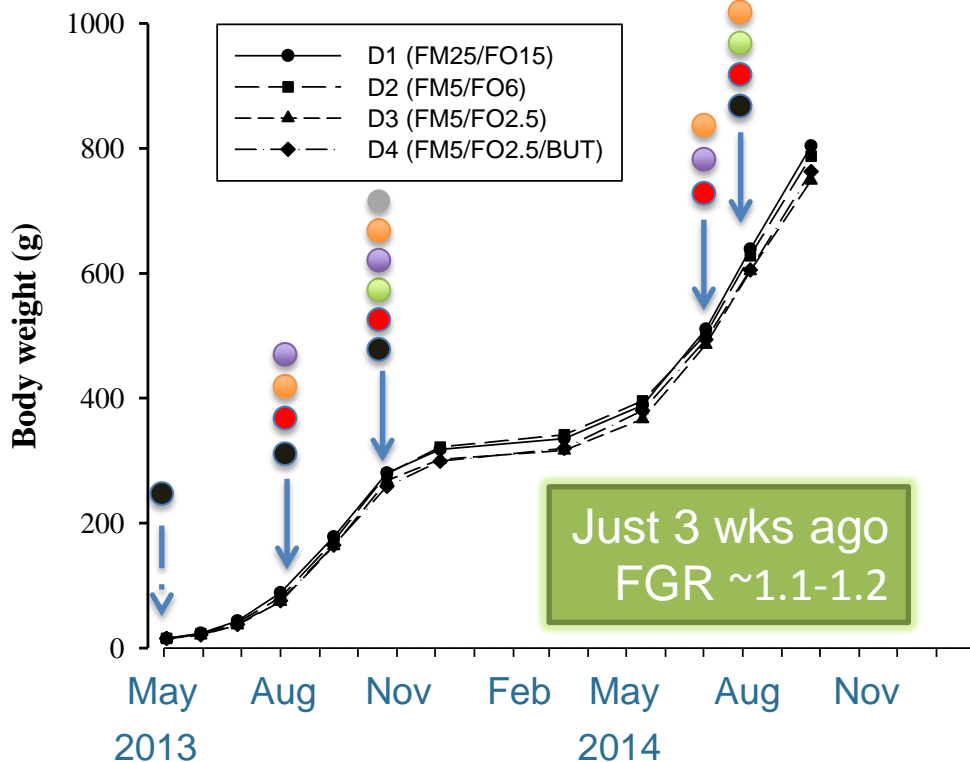
## More than 300 g at the end



Short adaptation periods (2-4 wks) with intermediated diets are required before the use of extremely low FM/FO diets

# Growth performance II

## Sampling schedule



Blood & Tissue  
Sampling

WB composition/  
Nutrient retention ←

Blood biochemistry ←

Tissue FA profiling ←

Histopathological scoring  
of liver & intestine

Transcriptome (liver, SKM,  
intestine)

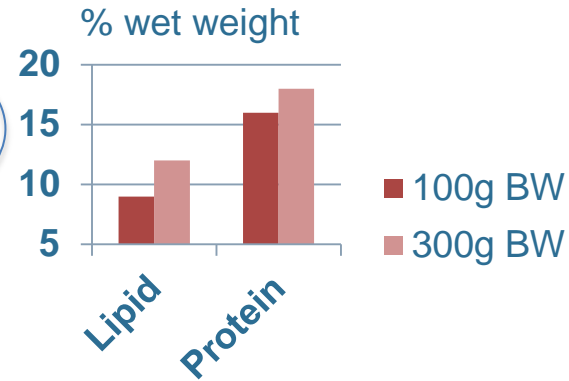
Intestinal mucus proteome

Intestinal microbiota

Screening of contaminants  
(food safety)

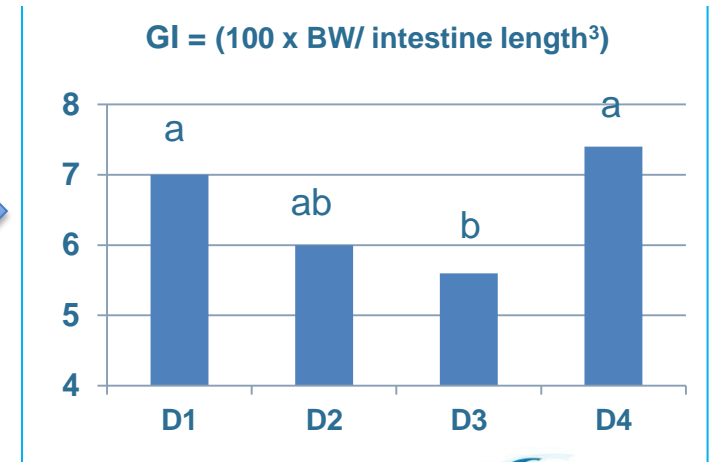
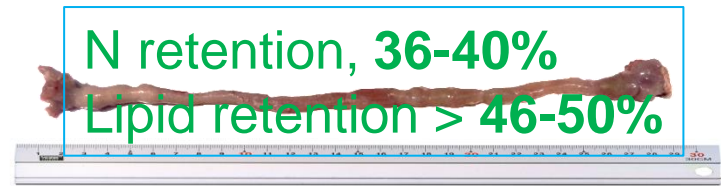


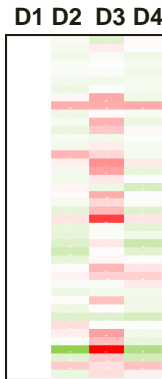
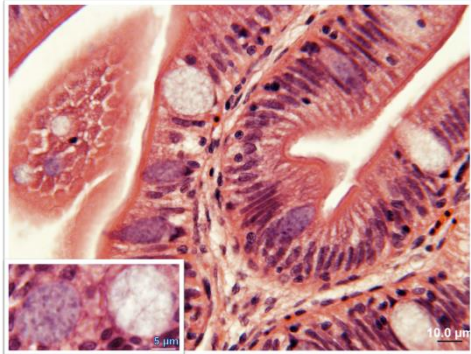
N and Lipid retention are not affected by diet. WB composition just changes with fish size



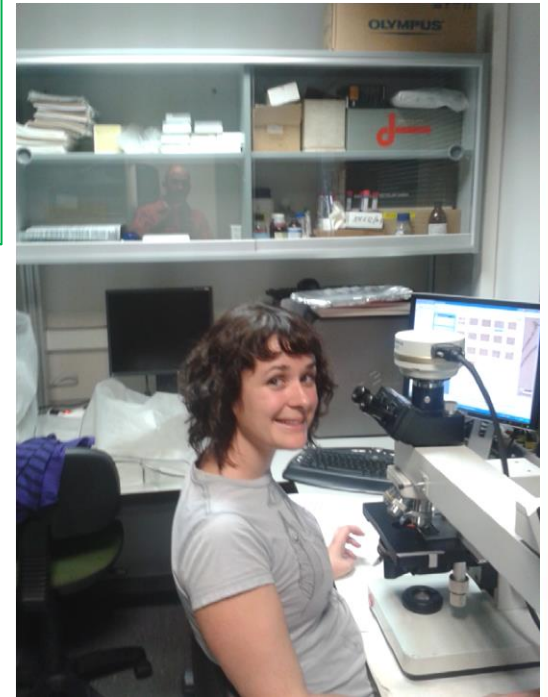
## Gut Index

- At short-term (13 wk), the Gut index (GI) decreases with the highest FM/FO replacement (D3 diet)
- This effect is reversed by BUT supplementation





Gut-chip PCR array:  
86 selected markers of  
intestine function &  
integrity



**Session 14**  
**HISTOPATHOLOGICAL AND**  
**TRANSCRIPTIONAL SCORING OF INTESTINAL**  
**TRAITS IN GILTHEAD SEA BREAM (SPARUS**  
**AURATA) FED LOW FISH MEAL AND FISH OIL**  
**DIETS WITH BUTYRATE SUPPLEMENTATION**

Control values are  
recovered with BUT  
supplementation ....

Itziar Estensoro  
Fish Pathology  
IATS-CSIC



# Blood Biochemistry

## Haematology



- Hc
- Hb
- RBC

## Electrolytes & Metabolites



- Calcium
- Chloride
- Magnesium
- Phosphate
- Glucose
- TG
- Cholesterol
- Proteins
- Creatinine
- Choline

## Enzymes



- ALAT
- ASAT
- GLDH
- ALP
- Lysozyme

## Hormones



- GH
- IGF-I
- Cortisol

## Other



- TAC
- RB



# Basic Blood Biochemistry

## *P-values, ANOVA-II (diet\_season effects)*

|                                  | DIET  | SEASON | INTERACTION |
|----------------------------------|-------|--------|-------------|
| Haemoglobin (g/dl)               | 0.001 | 0.001  | 0.159       |
| Haematocrit (%)                  | 0.602 | 0.061  | 0.259       |
| RBC x 10 <sup>6</sup> /ml        | 0.007 | 0.001  | 0.001       |
| Glucose (mg/dl)                  | 0.294 | 0.08   | 0.621       |
| Triglycerides (mM)               | 0.309 | 0.033  | 0.323       |
| Total cholesterol (mg/dl)        | 0.001 | 0.001  | 0.04        |
| HDL cholesterol (mg/dl)          | 0.001 | 0.001  | 0.001       |
| VLDL/LDL cholesterol (mg/dl)     | 0.001 | 0.001  | 0.001       |
| Total proteins (g/l)             | 0.306 | 0.001  | 0.782       |
| ALAT (U/l)                       | 0.777 | 0.101  | 0.886       |
| ASAT (U/l)                       | 0.661 | 0.025  | 0.217       |
| GLDH (U/l)                       | 0.505 | 0.734  | 0.932       |
| ALP (U/l)                        | 0.316 | 0.008  | 0.213       |
| Creatinine (mg/dl)               | 0.865 | 0.008  | 0.077       |
| Choline (µM)                     | 0.03  | 0.001  | 0.012       |
| Calcium (mg/dl)                  | 0.01  | 0.383  | 0.001       |
| Chloride (mg/dl)                 | 0.065 | 0.05   | 0.915       |
| Magnesium (mg/ml)                | 0.197 | 0.004  | 0.016       |
| Phosphate (mg/dl)                | 0.997 | 0.517  | 0.966       |
| Antioxidant capacity (Trolox mM) | 0.153 | 0.001  | 0.097       |
| Lysozyme (U/l)                   | 0.622 | 0.001  | 0.361       |
| Respiratory burst (IRLU)         | 0.131 | 0.001  | 0.336       |
| GH (ng/ml)                       | 0.091 | 0.001  | 0.483       |
| IGF-I (ng/ml)                    | 0.01  | 0.001  | 0.016       |

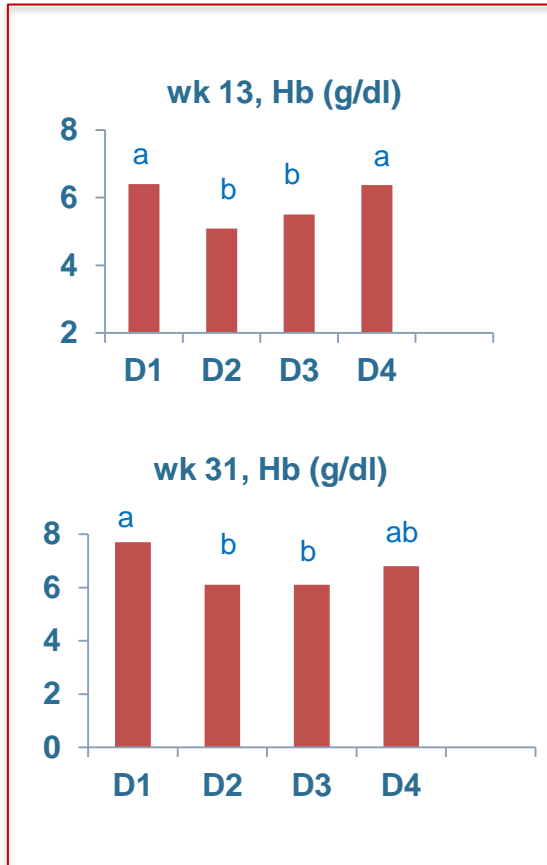
BW 80-100 g  
Aug 2013  
wk 13

BW 290-310 g  
Dec 2013  
wk 31

A sampling-time effect is found for most of the analysed parameters (wks 13-31)

Diet & time-interaction effects are restricted to Hb, cholesterol, choline and IGF-I

# Haemoglobin, g/dl



D2, D3 diets

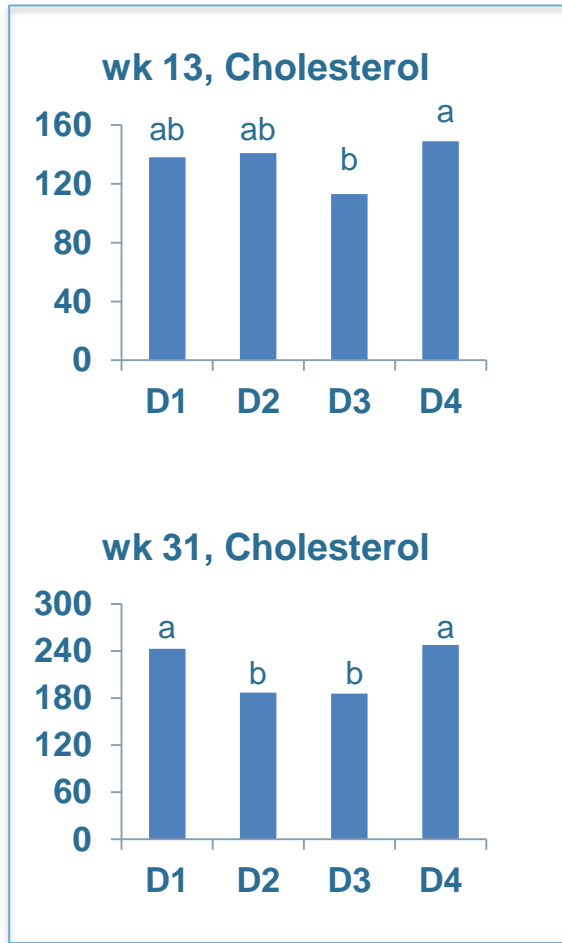
- Low FM inclusion levels (5%) reduce haemoglobin concentration

D4 diet,  
0.4%  
GUSTOR  
BP70®

- Anaemia signs are reversed by BUT supplementation

| Haematology | Electrolytes & Metabolites | Enzymes    | Hormones   | Erythrocyte FAs      |
|-------------|----------------------------|------------|------------|----------------------|
| ■ Hc        | ■ Calcium                  | ■ ALAT     | ■ GH       | ■ EPA+ DHA           |
| ■ Hb        | ■ Chloride                 | ■ ASAT     | ■ IGF-I    | ■ Unsaturation Index |
| ■ RBC       | ■ Magnesium                | ■ GLDH     | ■ Cortisol |                      |
|             | ■ Phosphate                | ■ ALP      |            |                      |
|             | ■ Glucose                  | ■ Lysozyme |            |                      |
|             | ■ TG                       | ■ TAC      |            |                      |
|             | ■ Cholesterol              | ■ IRLU     |            |                      |
|             | ■ Proteins                 |            |            |                      |
|             | ■ Creatinine               |            |            |                      |
|             | ■ Choline                  |            |            |                      |

# Cholesterol, mg/dl

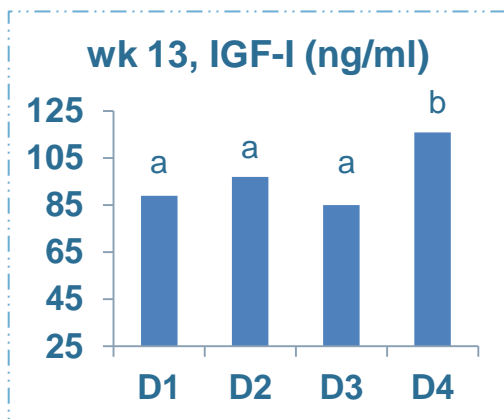
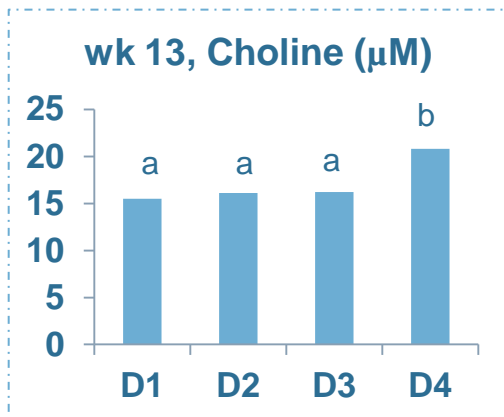


| Haematology | Electrolytes & Metabolites | Enzymes  | Hormones | Erythrocyte FAs    |
|-------------|----------------------------|----------|----------|--------------------|
| Hc          | Calcium                    | ALAT     | GH       | EPA+ DHA           |
| Hb          | Chloride                   | ASAT     | IGF-I    | Unsaturation Index |
| RBC         | Magnesium                  | GLDH     | Cortisol |                    |
|             | Phosphate                  | ALP      |          |                    |
|             | Glucose                    | Lysozyme |          |                    |
|             | TG                         | TAC      |          |                    |
|             | Cholesterol                | IRLU     |          |                    |
|             | Proteins                   |          |          |                    |
|             | Creatinine                 |          |          |                    |
|             | Choline                    |          |          |                    |

**D4 diet**  
0.4% GUSTOR BP70®

Clinical signs of hypocholesterolemia are reversed by BUT supplementation

# Choline & IGF-I



| Haematology | Electrolytes & Metabolites | Enzymes  | Hormones | Erythrocyte FAs    |
|-------------|----------------------------|----------|----------|--------------------|
| Hc          | Calcium                    | ALAT     | GH       | EPA+ DHA           |
| Hb          | Chloride                   | ASAT     | IGF-I    | Unsaturation Index |
| RBC         | Magnesium                  | GLDH     | Cortisol |                    |
|             | Phosphate                  | ALP      |          |                    |
|             | Glucose                    | Lysozyme |          |                    |
|             | TG                         | TAC      |          |                    |
|             | Cholesterol                | IRLU     |          |                    |
|             | Proteins                   |          |          |                    |
|             | Creatinine                 |          |          |                    |
|             | Choline                    |          |          |                    |

D4 diet  
0.4% GUSTOR BP70®

Other potential benefits include transient increases in circulating vitamin and growth-promoting factors

# Fillet FA profile

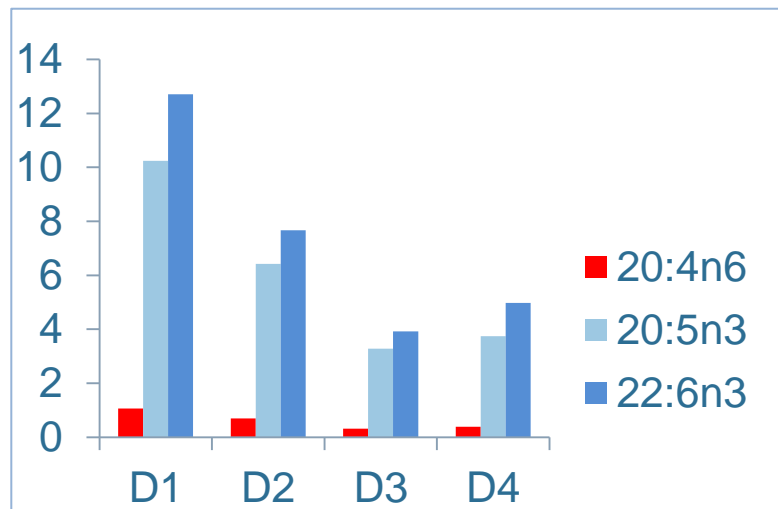
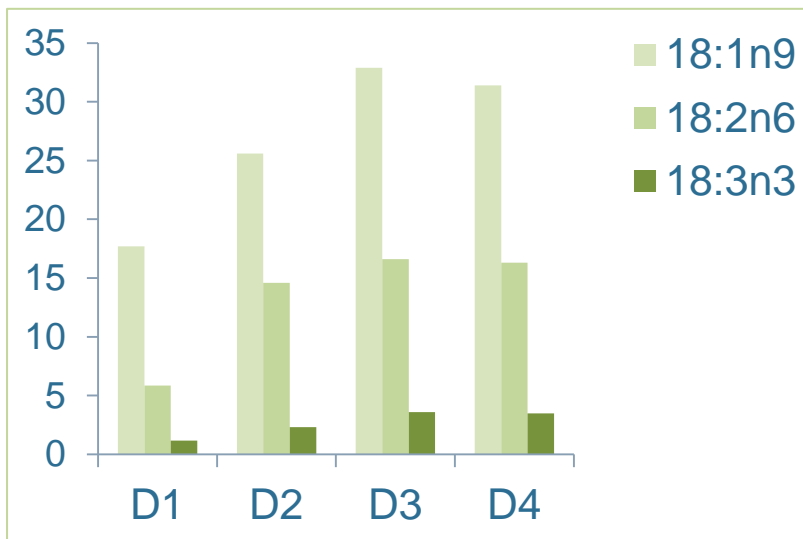
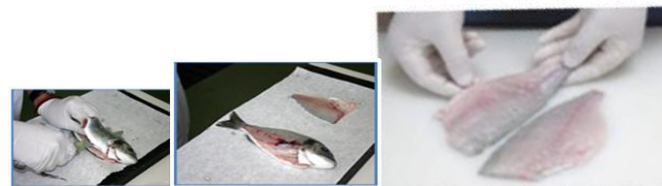
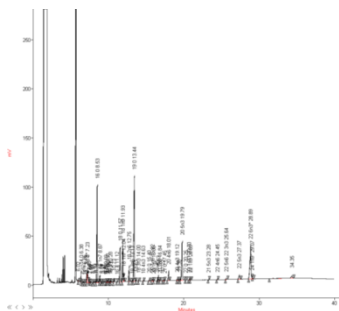


| Fatty acid      | Diet                    |                         |                         |                         |              |
|-----------------|-------------------------|-------------------------|-------------------------|-------------------------|--------------|
|                 | D1                      | D2                      | D3                      | D4                      |              |
| 14:0            | 4.01±0.23 <sup>a</sup>  | 4.69±0.43 <sup>ab</sup> | 5.54±0.27 <sup>b</sup>  | 5.34±0.36 <sup>b</sup>  |              |
| 16:0            | 18.69±0.20 <sup>a</sup> | 18.15±0.54 <sup>a</sup> | 16.99±0.30 <sup>b</sup> | 16.91±0.25 <sup>b</sup> |              |
| 16:1n-7         | 6.75±0.33 <sup>a</sup>  | 4.07±0.23 <sup>b</sup>  | 2.92±0.43 <sup>c</sup>  | 3.35±0.21 <sup>bc</sup> |              |
| 18:0            | 5.01±0.20               | 5.18±0.36               | 4.43±0.30               | 4.57±0.29               | C18-PUFA     |
| 18:1n-9 (Oleic) | 17.7±0.77 <sup>a</sup>  | 25.61±0.88 <sup>b</sup> | 32.96±1.15 <sup>c</sup> | 31.42±1.13 <sup>c</sup> | ← C18-PUFA   |
| 18:1n-7         | 2.79±0.46 <sup>a</sup>  | 0.53±0.21 <sup>b</sup>  | 0.68±0.12 <sup>b</sup>  | 0.91±0.10 <sup>b</sup>  | C18-PUFA     |
| 18:2n-6 (LA)    | 5.85±0.13 <sup>a</sup>  | 14.63±0.25 <sup>b</sup> | 16.64±0.17 <sup>c</sup> | 16.32±0.30 <sup>c</sup> | ← C18-PUFA   |
| 18:3n-6         | 0.27±0.01 <sup>a</sup>  | 0.13±0.01 <sup>b</sup>  | 0.06±0.01 <sup>c</sup>  | 0.07±0.01 <sup>c</sup>  | C18-PUFA     |
| 18:3n-3 (LNA)   | 1.17±0.05 <sup>a</sup>  | 2.32±0.12 <sup>b</sup>  | 3.61±0.13 <sup>c</sup>  | 3.49±0.13 <sup>c</sup>  | ← C18-PUFA   |
| 18:4n-3         | 1.01±0.06 <sup>a</sup>  | 0.46±0.04 <sup>b</sup>  | 0.29±0.03 <sup>c</sup>  | 0.32±0.01 <sup>c</sup>  |              |
| 20:1n-9         | 0.68±0.05 <sup>a</sup>  | 0.85±0.05 <sup>b</sup>  | 1.08±0.04 <sup>c</sup>  | 1.04±0.05 <sup>c</sup>  | n6 LC-PUFA   |
| 20:4n-6 (ARA)   | 1.07±0.07 <sup>a</sup>  | 0.70±0.08 <sup>b</sup>  | 0.32±0.04 <sup>c</sup>  | 0.39±0.05 <sup>c</sup>  | ← n6 LC-PUFA |
| 20:5n-3 (EPA)   | 10.24±0.21 <sup>a</sup> | 6.42±0.51 <sup>b</sup>  | 3.28±0.30 <sup>c</sup>  | 3.74±0.41 <sup>c</sup>  | ← n3 LC-PUFA |
| 22:4n-6         | 0.13±0.01 <sup>a</sup>  | 0.08±0.01 <sup>b</sup>  | 0.04±0.01 <sup>c</sup>  | 0.05±0.01 <sup>c</sup>  |              |
| 22:5n-3         | 0.30±0.02 <sup>a</sup>  | 0.17±0.02 <sup>a</sup>  | 0.08±0.01 <sup>b</sup>  | 0.11±0.02 <sup>b</sup>  | n3 LC-PUFA   |
| 22:6n-3 (DHA)   | 12.72±0.77 <sup>a</sup> | 7.67±0.79 <sup>b</sup>  | 3.92±0.49 <sup>c</sup>  | 4.98±0.70 <sup>c</sup>  | ← n3 LC-PUFA |



# Fillet FA composition

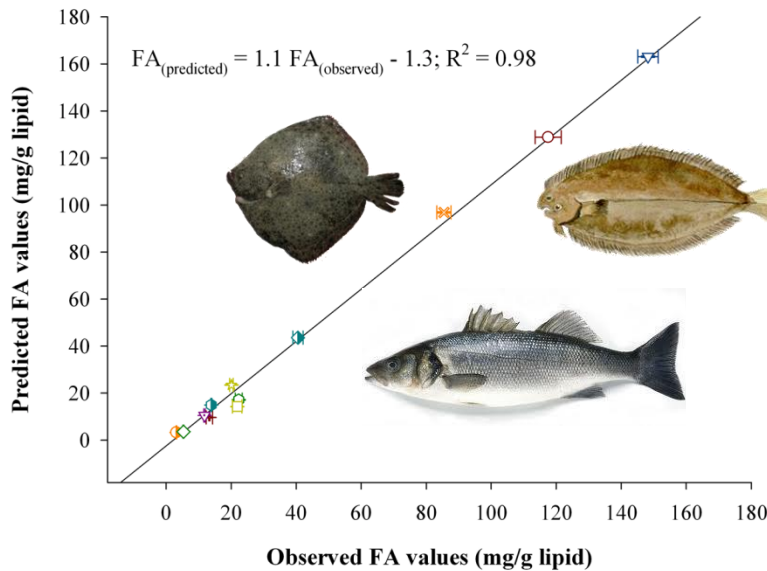
## Total lipids, % FAME



# Dummy regression model: a close association between observed & predicted FA-values



P104  
 Gabriel Ballester-Lozano  
 Nutrigenomics & Fish Growth  
 Endocrinology, IATS-CSIC  
[www.nutrigroup-iats.org](http://www.nutrigroup-iats.org)



- ✦ 14:0
- ✧ 16:0
- ★ 18:0
- 16:1 n-7
- 18:1 n-7
- ▽ 18:1 n-9
- ◇ 20:1 n-9
- 18:2 n-6
- 20:4 n-6
- 20:5 n-3
- ◇ 22:5 n-3
- ◆ 22:6 n-3



**TOWARDS A MULTI-SPECIES PREDICTION MODEL OF FILLET FATTY ACID COMPOSITION IN MARINE FARMED FISH**  
 G.F. BALLESTER-LOZANO<sup>1</sup>, L. BENEDITO-PALOS<sup>1</sup>, M. MINGARRO<sup>2</sup>, J.C. NAVARRO<sup>2</sup>, J. PÉREZ-SÁNCHEZ<sup>1</sup>  
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## INTRODUCTION

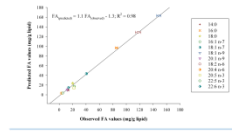
Fish meal and fish oil are finite natural resources, and their use in aquaculture industry has been progressively reduced. Plant ingredients are the most obvious alternative, but vegetable oils are devoid of n-3 long-chain polyunsaturated fatty acids (n-3 LC-PUFA) and the fillet lipid content in EPA + DHA is reduced accordingly. There is therefore a need for predictive FA modelling, and dummy regression approaches have been proved highly informative in flat fish with gilthead sea bream as a reference species subgroup (1). This approach is considered herein for European sea bass in a sequential process with feeding trials at laboratory and fish farm scale.

## HIGHLIGHTS

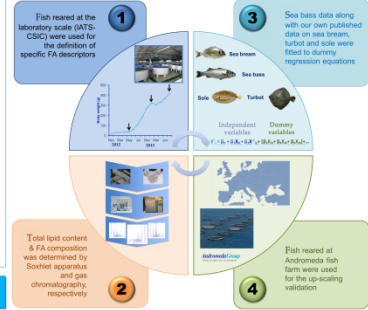
- Up to 13 FA descriptors of saturated, monoenes and LC-PUFAs are reported
- The model allows predicting fillet FA composition in four marine species of a high added value for the European aquaculture
- Predictive values are assessed by the on-line tool hosted at [www.nutrigroup-iats.org/aquafat](http://www.nutrigroup-iats.org/aquafat)

## MAIN RESULTS

- Strong correlation coefficients were found for almost all FAs including LC-PUFAs of n-3 and n-6 series
- The independent variable dietary FA composition contributes significantly to explain the observed variability. The contribution of the independent variable fillet lipid content is generally lower
- Statistically significant interactions between dietary FA composition and fish species subgroups were not found
- The up-scaling of predictive values to farming conditions allowed a close linear association near to equality for the regression plot of the observed vs. predicted values



## MATERIALS & METHODS



## CONCLUDING REMARKS

- Prediction of fillet FA composition is highly feasible in farmed fish with a different nutritional background
- The proposed equations underline the fish species differences in FA desaturation/elongation pathways
- The absence of a statistically significant interaction between fish species and diet composition spans the use of a vast array of diets for all the species in the model

*For more details see the on-line tool and literature references (1,2)\**

REFERENCES  
 1. Ballester-Lozano et al., 2014a, Aquaculture Nutrition 20, 421-430  
 2. Ballester-Lozano et al., 2014b, Aquaculture Research, DOI: 10.1111/anr.12593

What do we eat?  
 Interactive tool for  
 predictive modelling  
 fish fatty acid  
 composition

[nutrigroup-iats.org/aquafat](http://nutrigroup-iats.org/aquafat)

[www.nutrigroup-iats.org/aquafat](http://www.nutrigroup-iats.org/aquafat)



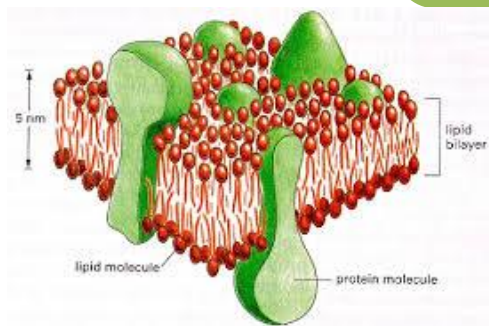
Neutral lipids\_TG

- Reflect feed composition



Polar lipids\_PLs

- Highly regulated



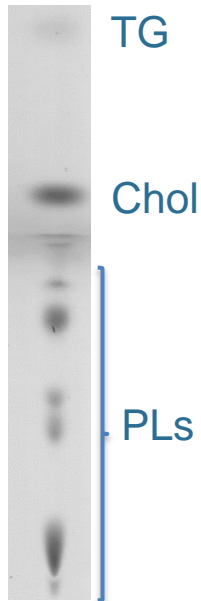
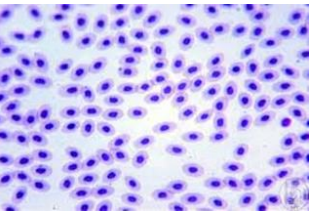
PL allostasis

- Feeding level
- Environment
- EFA deficiencies

*Benedito-Palos et al., 2008, British Journal of Nutrition*  
*Benedito-Palos et al., 2010, Journal of Animal Science*  
*Benedito-Palos et al., 2013, British Journal of Nutrition*

# Unsaturation Index (UI) of RBC

$$UI = \sum_{i=n} (\% \text{ unsaturated FA}_i \times \text{number double bounds})$$



- **Non-invasive method for routine diagnosis of EFA deficiencies in farmed sea bream**

**UI, Cold season**  
• 260-235 (D1-D4)

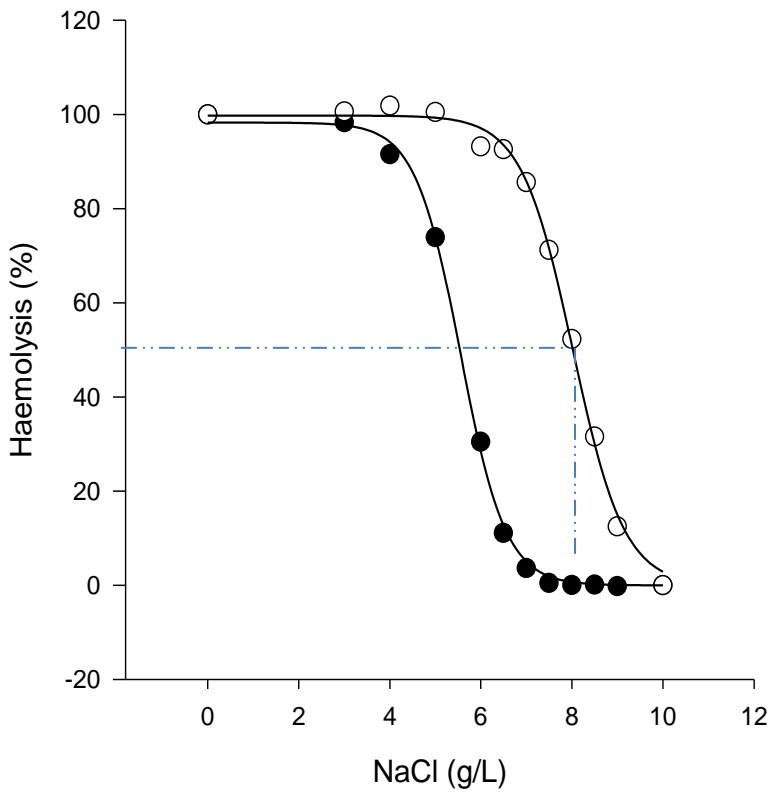


**UI, Warm season**  
• 210-190 (D1-D4)

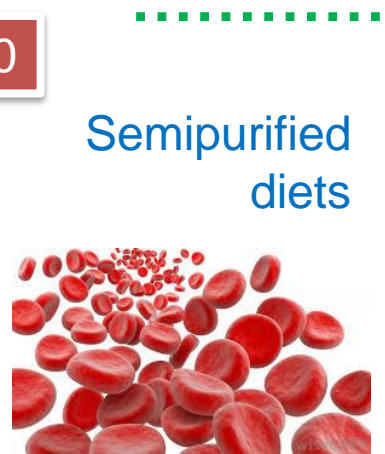
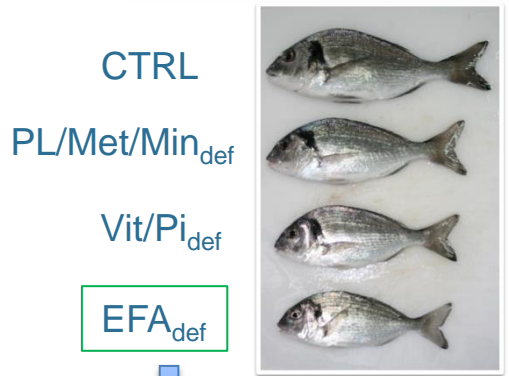
# Clinical signs of EFA deficiencies: growth retardation, dyslipemia,

**UI of RBC < 160**

Ctrl → n-3 LC-PUFA



UI from 260 to 160



**Increases osmotic fragility of RBC  
Mean corpuscular index, MCF > 7.5**



## Concluding Remarks & Perspectives

- The replacement of marine feed ingredients is highly feasible in terms of growth performance when the theoretical requirements in essential nutrients are met by diet
- BUT supplementation prevents the onset of clinical signs of anemia and hypocholesterolemia
- Other potential benefits upon intestine function and integrity are suspected
- Changes in FA composition follow the predictions made by the dummy regression model
- UI of RBC is proposed as a routine marker of EFA deficiencies
- The generated information contributes to identify nutritionally regulated biomarkers and their normal range of variation; it is uploaded to ARRINA-biomarkers database

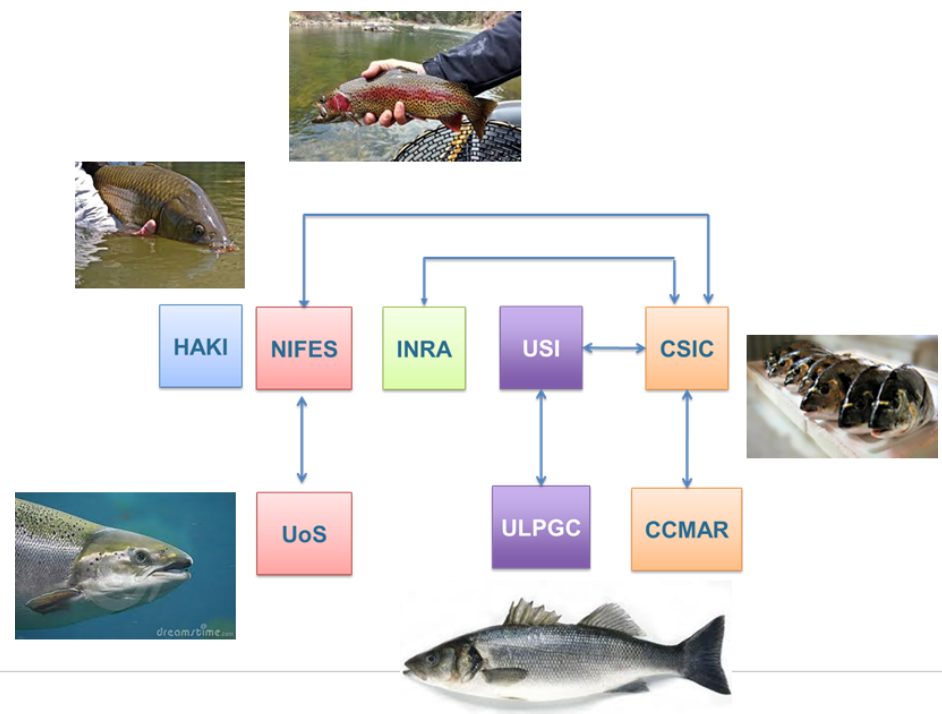
## Filters panel: Choose a nutrient and/or a biological process

**Nutrient**

**Biological process**

- Choose a nutrient
- All
  - None
  - α-Tocopherol
  - Amino acid
  - Ascorbic acid
  - Biotin
  - Boron
  - Calcium
  - Chromium
  - Cobalamin
  - Cobalt
  - Copper
  - DHA
  - Fluoride
  - Folate
  - Glucane (Bio-Mos)
  - Glucose
  - Iodine
  - Iron

General search





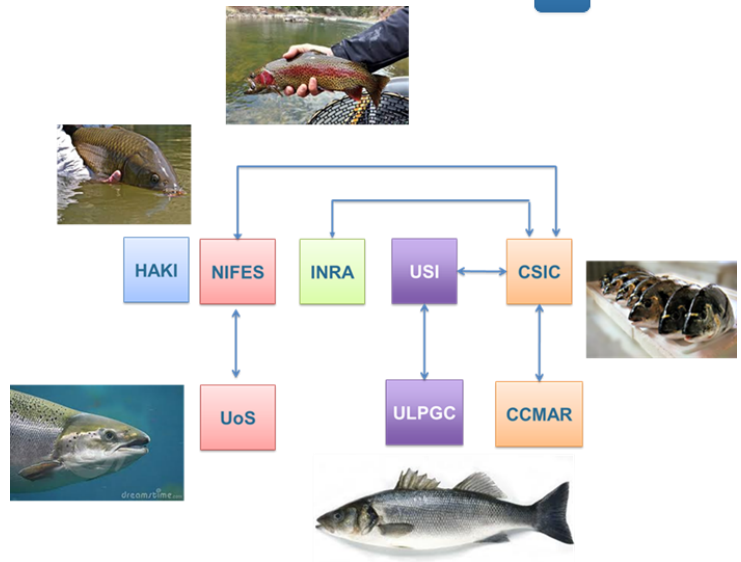
### Filters panel: Choose a nutrient and/or a biological process

**Nutrient**

**Biological process**

- Choose a biological process
- All
  - None
  - Development
  - Growth
  - Health & Welfare
  - Quality at harvest
  - Reproductive performance
  - Safety
  - Stress response

### General search





# Filters panel: Choose a nutrient and/or a biological process

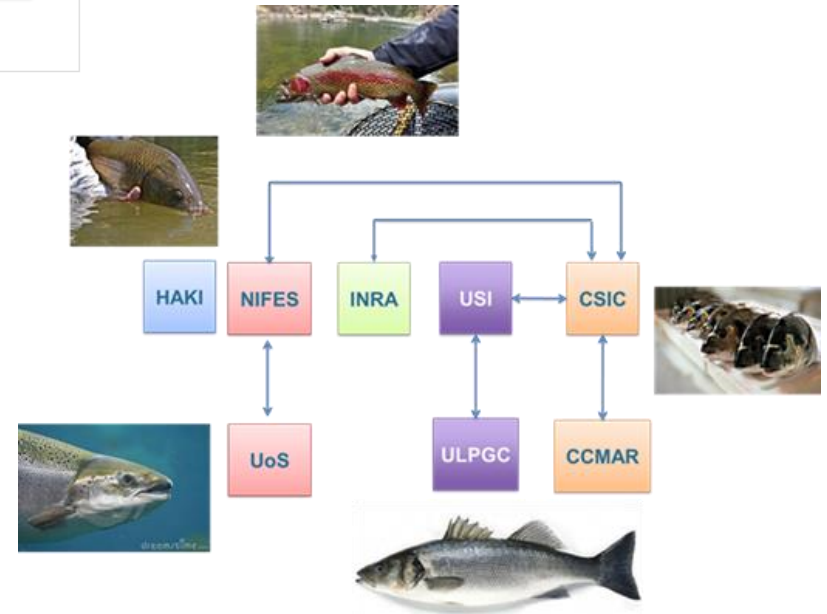
|                                     |   |
|-------------------------------------|---|
| <b>Nutrient</b>                     |   |
| <input type="text"/>                | <input type="button" value="Q"/>          |
| <input type="button" value="X"/>    |   |
| <b>Biological process</b>           | <b>Metabolic process / biocontaminant</b> |
| <input type="text" value="Growth"/> | <input type="text"/>                      |
| <input type="button" value="Q"/>    | <input type="button" value="Q"/>          |
| <input type="button" value="X"/>    |   |

## General search



### Choose a metabolic process / biocontaminant

- All
- None
- Digestion
- Energy wastage
- Feeding behaviour
- Growth dynamics
- Muscle growth
- Muscle structure
- Nutrient sensor
- Performance
- Protein turnover
- Somatotropic axis



Filters panel: Choose a nutrient and/or a biological process

Nutrient

Biological process

General search

Showing 142 rows.

[Export to Excel](#)

[First](#) < 7 8 9 10 11 > [Last](#)

| Nutrient | Biological process | Metabolic process / biocontaminant | Marker                          | Symbol | GenBank number | Description  | Method | Tissue                | Invasive | Species  | Reference  |
|----------|--------------------|------------------------------------|---------------------------------|--------|----------------|--|--------|-----------------------|----------|----------|--|
| None     | Health & Welfare   | Innate immune response             | Interleukin 1β                  | IL1β   | DQ388038       | T cell and cytotoxic activity stimulating cytokine in microbial and viral infections                   | qPCR   | Head kidney,Intestine | Yes      | Sea bass | Nascimento et al., 2007, Mol Immunol             |
| None     | Health & Welfare   | Cell differentiation               | Transforming growth factor beta | TGF-β  | AM421619       | multifunctional cytokine controlling proliferation, differentiation and other functions                | qPCR   | Head kidney,Intestine | Yes      | Sea bass | Piochietti et al., 2009b, Fish Shellfish Immunol |
| None     | Health & Welfare   | Cell differentiation               | Transforming growth factor beta | TGF-β  | AM421619       | multifunctional cytokine controlling proliferation, differentiation and other functions                | qPCR   | Whole body            | Yes      | Sea bass | Abelli et al., 2009, Ann NY Acad Sci             |
| None     | Health & Welfare   | inflammatory response              | Interleukin 1β                  | IL1β   | AJ311925       | cytokine mediating inflammatory response, regulating cell proliferation, differentiation and apoptosis | qPCR   | Head kidney,Intestine | Yes      | Sea bass | Piochietti et al., 2009b, Fish Shellfish Immunol |
| None     | Health & Welfare   | inflammatory response              | Interleukin 1β                  | IL1β   | AJ311925       | cytokine mediating inflammatory response, regulating cell proliferation, differentiation and apoptosis | qPCR   | Whole body            | Yes      | Sea bass | Abelli et al., 2009, Ann NY Acad Sci             |
| None     | Health & Welfare   | inflammatory response              | Interleukin 6                   | IL6    | AM490062       | cytokine potent inducer of the acute phase response  | qPCR   | Intestine,Head kidney | Yes      | Sea bass | Sepulore et al., 2009, J Immunol                 |
| None     | Health & Welfare   | inflammatory response              | Interleukin 8                   | IL8    | AM490063       | cytokine inducing chemotaxis for leukocytes and neutrophil activation                                  | qPCR   | Head kidney,Intestine | Yes      | Sea bass | Sepulore et al., 2009, J Immunol                 |
| None     | Health & Welfare   | inflammatory response              | Interleukin 10                  | IL10   | AM268529       | anti-inflammatory cytokine, inhibitor of multiple cytokines  | qPCR   | Head kidney,Intestine | Yes      | Sea bass | Piochietti et al., 2009b, Fish Shellfish Immunol |
| None     | Health & Welfare   | inflammatory response              | Interleukin 10                  | IL10   | AM268529       | anti-inflammatory cytokine, inhibitor of multiple cytokines  | qPCR   | Whole body            | Yes      | Sea bass | Abelli et al., 2009, Ann NY Acad Sci             |
| None     | Health & Welfare   | inflammatory response              | Tumor necrosis factor-α         | TNF-α  | DQ200910       | proinflammatory cytokine stimulating acute phase reaction  | qPCR   | Spleen                | Yes      | Sea bass | Bado-Nilles et al., 2011, Ecotox Environ Safe    |

**Session 14**  **CSIC**

**O461. Sea bass  
Intestine transcriptome  
Josep A Calduch-Giner**



**P105. Molecular signatures  
of lipid metabolism  
Laura Benedito-Palos**



**Session 14**  **CSIC**

**O595. Histopathological  
and transcriptomic scoring  
of sea bream intestine  
Itziar Estensoro**



**P104. Dummy  
regression of FAs  
G.F Ballester-Lozano**



**P109. Microbiota diversity  
Belén Fouz**

**Session 14**

**O161. Wide-screening  
of contaminants  
Jaime Nácher-Mestre**



**P115 Mycotoxin  
carry-over  
Roque Serrano**

# Thanks you for your attention

## ESKERRIK ASKO



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