Webinar

Sustainable and resilient feed and feed strategy

FUTURE EUAQUA

Elena Mente

Aristotle University of Thessaloniki, Greece

Email: emente@vet.auth.gr

FutureEUAqua project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 817737

Webinar description

- **This webinar will demonstrate sustainable and resilient nutritional solutions aimed at the highest possible fish performance in the framework of a safe and sustainable aquaculture.**
- **It will cover innovative, species-specific nutritionally adequate, tailor-made, low ecological footprint fish diets and their nutritional impact on farmed fish growth performance, health and quality for a better performing sustainable and organic aquaculture.**
- **The webinar builds on the basic knowledge of fish biology, physiology and biochemistry.**

The webinar is organized in two sessions:

- **Part I - Fish nutrition in aquaculture**
- **Part II - Innovative fish feeds for healthy fish for a healthy human consumption**

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Learning objectives

At the completion of this webinar participants will be able to:

1.

- understand the role of nutritional research in sustainable and organic aquaculture

2.

-understand the relationship between innovative fish feeds and nutrition for the production of a healthy fish

Outlines

1	**Introduction**	Key concept; Knowledge gaps
2	**Part I**	**Fish nutrition in aquaculture:** Basic issues in fish nutrition; Essential nutrients; Fish species-life stages-specific nutritional requirements; Fish growth and physiological functions.
3	**Part II**	**Innovative fish feeds for healthy fish for a healthy human consumption:** Feed ingredients, raw material quality, diet formulation, feed efficiency, feeding management, novel sustainable fish feeds.

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Knowledge gaps

- Feeding the future farmed fish by formulating sustainable/ecological feeds and providing the dietary essential nutrients to meet the species-life stage-specific nutritional requirements to promote optimal growth and health.
- Understanding the dietary supply line of essential nutrients in relation to their bioavailability to obtain the best feeding strategy for farmed fish.

Key concepts

- Critical thinking in nutrition and the knowledge of fish nutrition
- The evaluation of the formulation of ecological, tailored-made species-life stage-specific fish diets

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Glossary

- **Conventional aquaculture**: Aquaculture is the farming of fish, crustaceans, molluscs, aquatic plants, algae, and other organisms. Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions in flow-through systems, ponds, net cages and longlines, and can be contrasted with commercial fishing, which is the harvesting of wild fish.
- **Recirculating Aquaculture Systems** (RAS): Aquaculture production system on land, that allows for full control of production, that re-uses water and therefore needs water treatment units to remove accumulated waste.
- **Organic Aquaculture**: Organic production essentially means maintaining control of production, no use of synthetic drugs or pesticides, and strict regulation of production conditions and water quality. An organic fish is also considered a domesticated animal and is not the same as a wild fish

*"**Organic production** is an **overall system** of farm management and food production that combines **best environmental practices**, a high level of **biodiversity**, the **preservation of natural resources**, the application of high **animal welfare** standards and a production method in line with the preference of certain consumers for **products produced using natural substances and processes**. EU, 2007"*

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As a general principle in nutrition of farmed aquatic animals

Feeds should meet all **nutritional requirements** of the organisms, **promote** animal's **well-being, health and growth**, ensure **high quality** of the **final product** and have **low environmental impact**.

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NUTRITION

Nutrition:

- the provision of all indispensable nutrients in adequate amounts to insure proper growth and maintenance of body functions
- involves various chemical reactions and physiological transformations which convert feed into body tissues and activities
- involves ingestion, digestion and absorption of various nutrients
- transport into cells
- removal of unusable elements and waste products of metabolism

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Nutrient: nutrients are chemical compounds in feed that are used by the animal organism to meet its physiological function, grow and maintain health.

Essential nutrient: provided in the diet in order to insure adequate growth and maintenance.

Nutrient categories: macro and micro

-macronutrients: protein, lipid, carbohydrate, etc.

-micronutrients: trace metals, vitamins, amino acids, fatty acids

Nutrient requirement: The amount of each specific nutrient that fish needs to sustain all its **physiological** functions for growth, reproduction while maintain a healthy life.

proteins: g/kg vitamins: μg/kg

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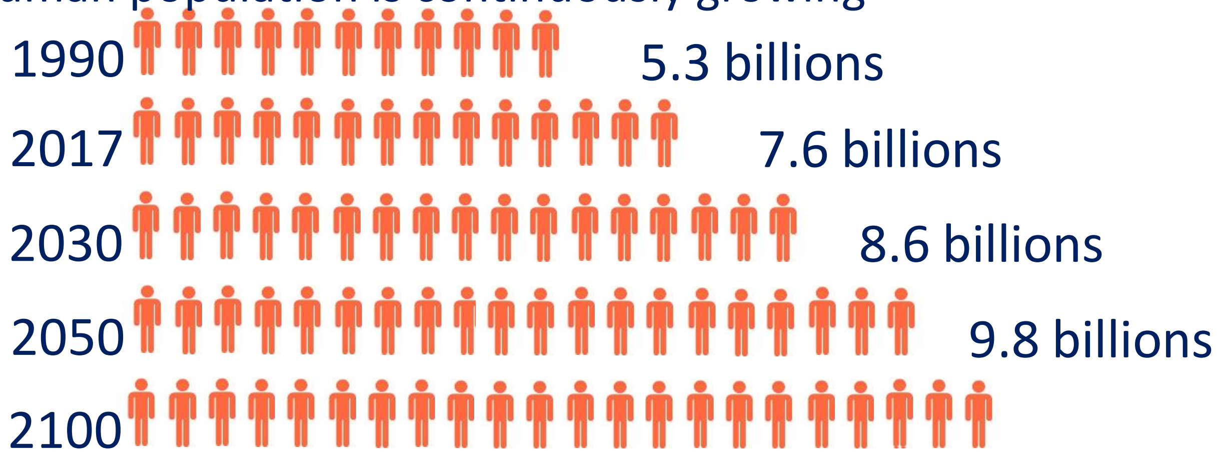
Food

Sourcing essential nutrients

Human population is continuously growing



Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2007)

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Why aquaculture?

STAGNATION CAPTURE FISHERIES

INCREASED MARKET DEMAND

Europe imports about 65 % of its aquatic foodstuffs

INCREASED AQUACULTURE PRODUCTION

from empiricial farming
towards a knowledge-based bio-industry

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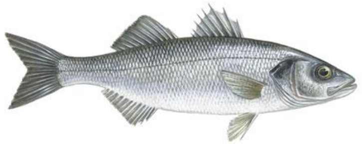


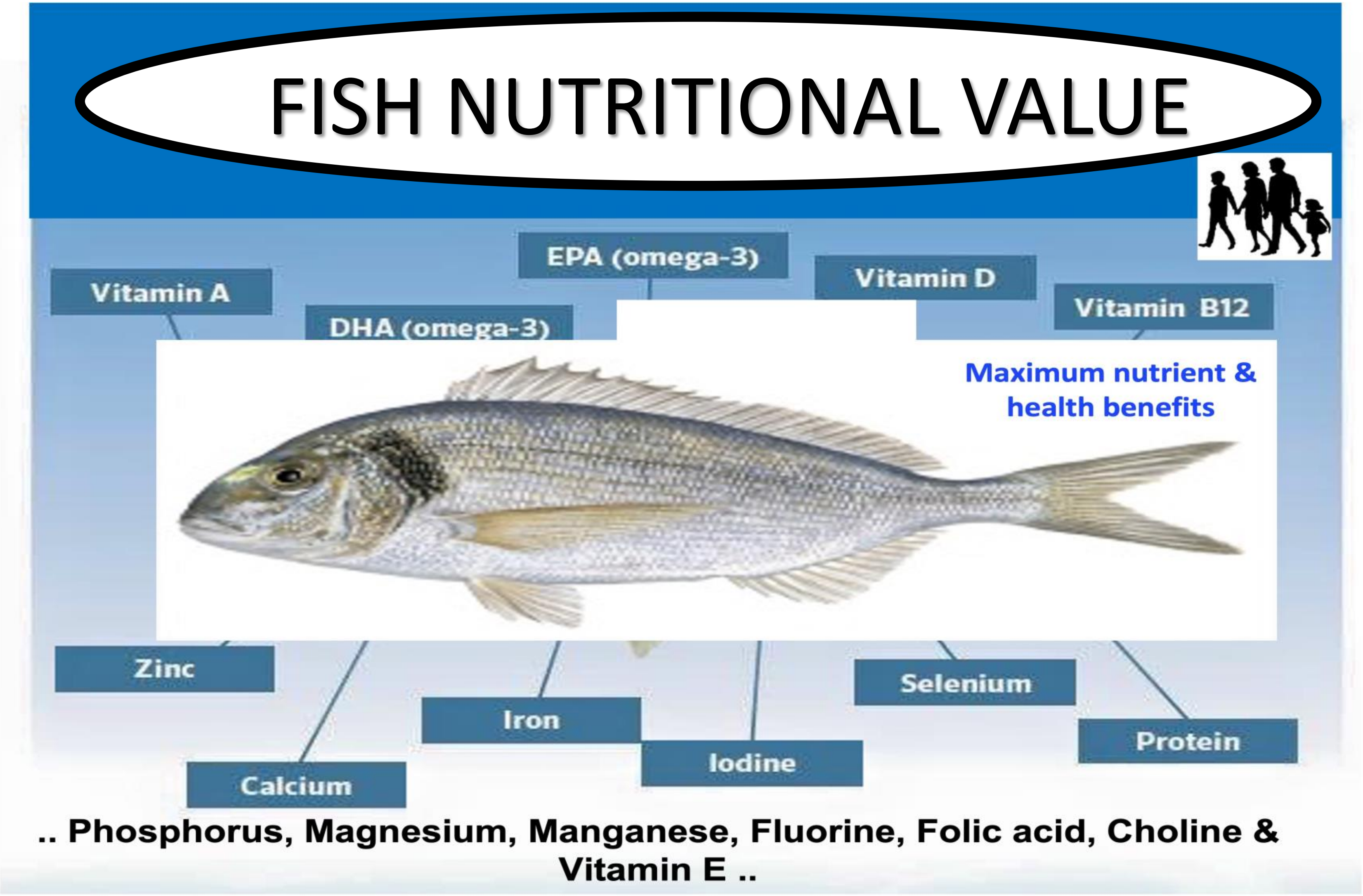
Farmed fish

Highly digestible protein & amino acids*

Omega-3 polyunsaturated fatty acids DHA* & EPA*

Minerals & trace elements Ca, Mg, Fe, Cu Zn, I*, Se*, Cr

Vitamins & other nutrients A* D* E* B_{12} B_9 Choline, CoQ_{10}



Farmed fish: it is possible to **improve the nutritional quality of the flesh/fillet**, thus enhance its potential health value

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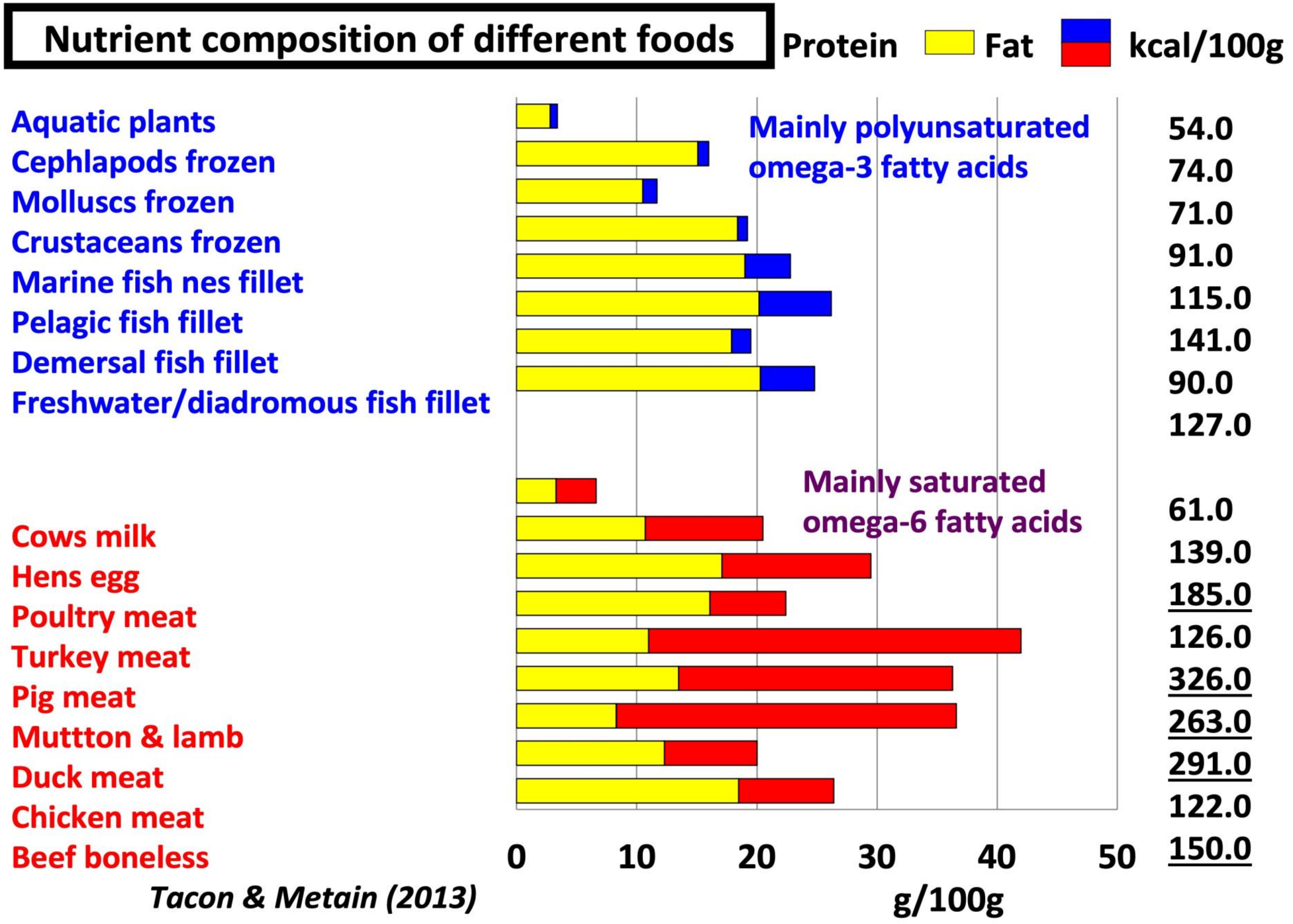
We are what fish eat



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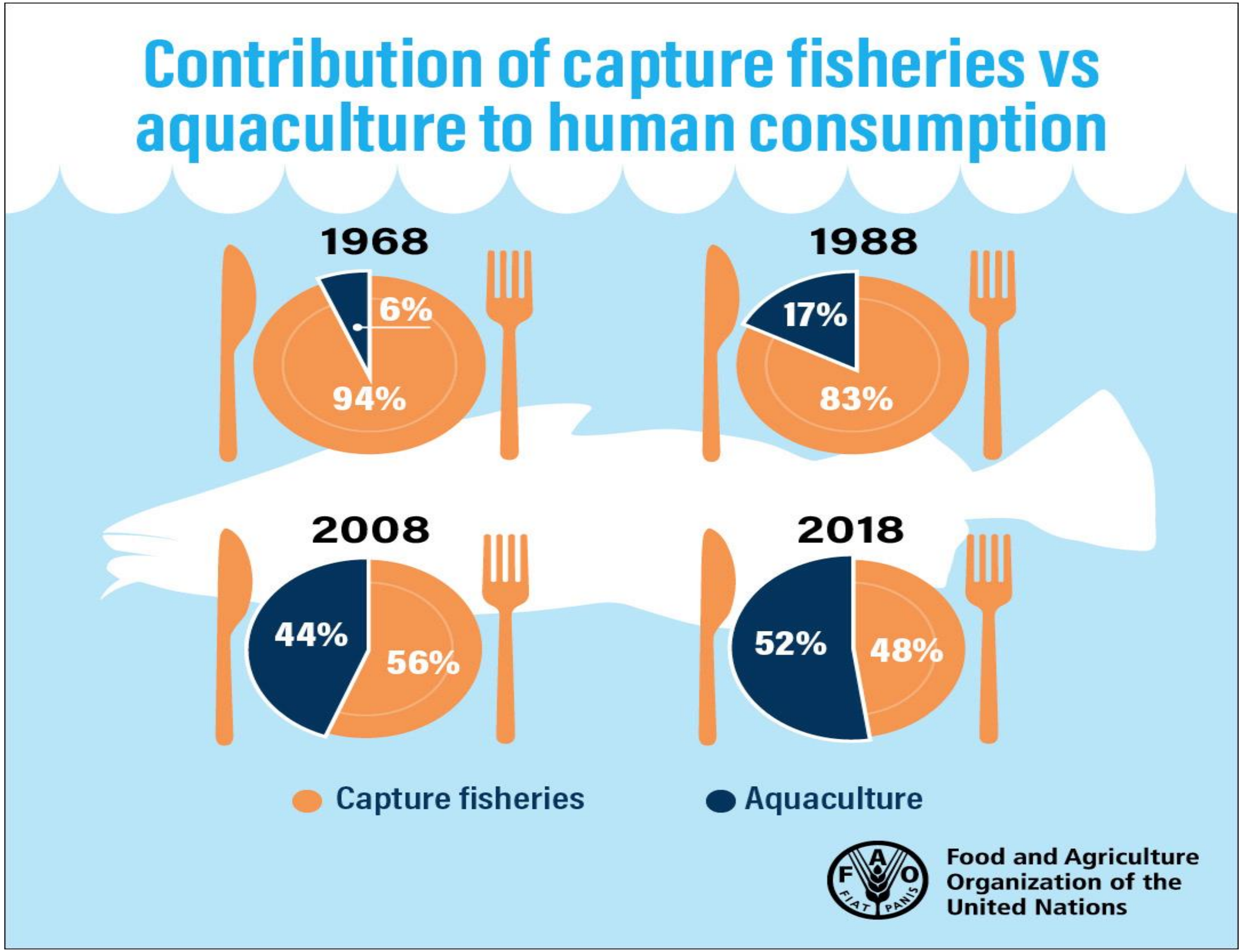

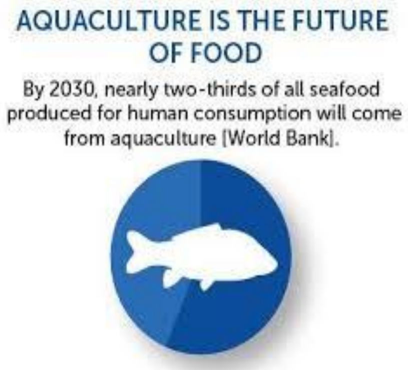

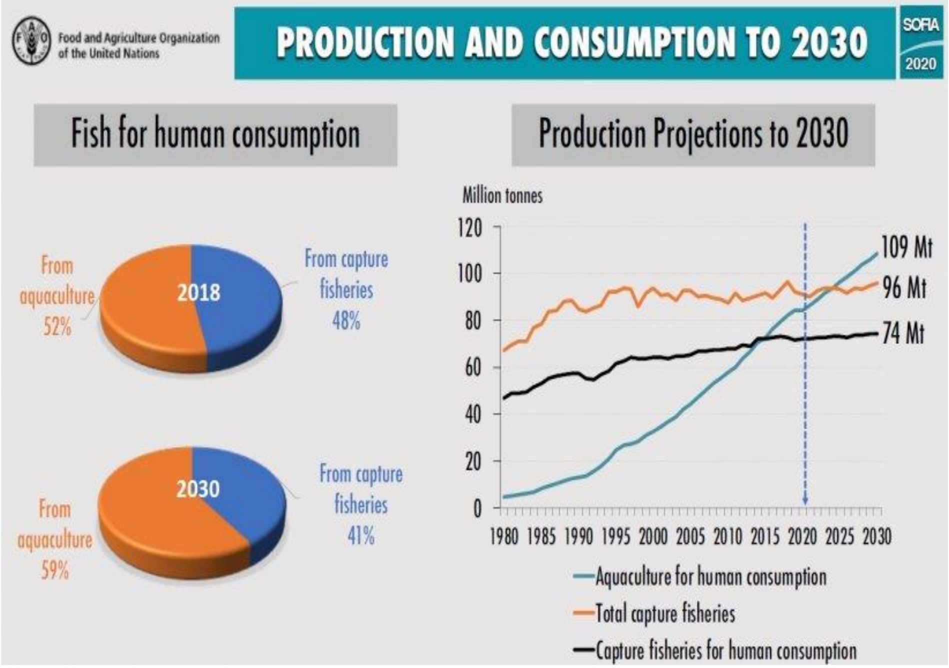

40Mt aquafeeds

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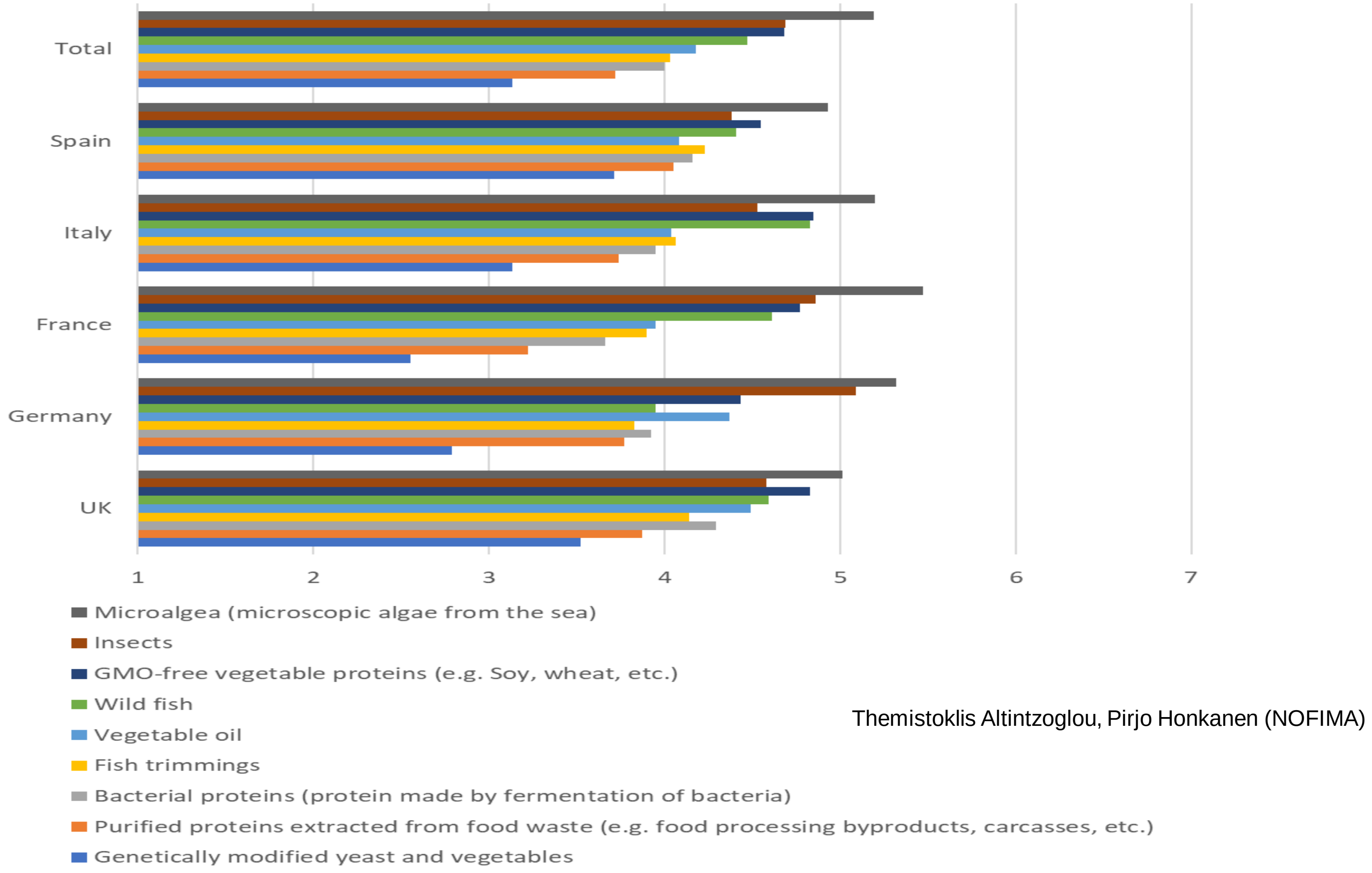
Aquafeeds
Sourcing essential nutrients



Themistoklis Altintzoglou, Pirjo Honkanen (NOFIMA)

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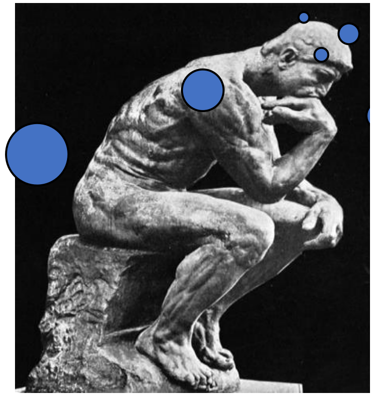
Sourcing aquafeeds ingredients

FISH FEEDS
Novel ingredients and technology

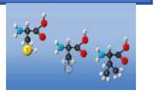
ECOLOGICAL
environmentally sound Aquaculture

Understanding the ways of utilisation of sustainable innovative tailor-made diets and nutrition in farmed fish

NUTRITION
Nutritional physiology research



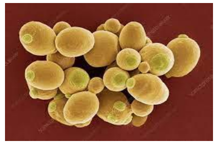
40 essential nutrients



Biotechnology

microalgae

Bacterial protein



yeast

FISH NUTRITION

FOR FEED PRODUCERS?

THE FORMULATION OF TAILORED MADE SPECIES-SPECIFIC, AVAILABILITY OF RAW INGREDIETNS, LOW COST, ENVIROMENTALLY FRIENDLY DIETS

FOR FARMERS?

THE OPTIMIZATION OF FEEDING TO PROMOTE THE BEST FISH GROWTH

FOR THE RESEARCHES/STUDENTS?

THE EVALUATION OF THE LONG-TERM EFFECTS OF NOVEL DIETS TO MEET FISH NUTRITIONAL REQUIREMENTS AND PHYSIOLOGICAL FUNCTIONS AND OBTAIN THE BEST FISH GROWTH/HEALTH PERFORMANCE

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FISH NUTRIENT REQUIREMENTS

The amount of each specific nutrient that fish needs to sustain all its physiological functions for growth, reproduction while maintain a healthy life.

- The requirement of one nutrient often depends on the quantity and interaction of another nutrient (i.e. optimal histidine/lysine ratio)
- The nutrient requirements depend on:

fish age/body mass, temperature, rearing system, fish species-freshwater/marine, coldwater/warmwater

- The nutrient requirements estimates are independent on the amount of the other nutrient if the levels of that nutrient is not limiting (i.e. minimise the impact of nutrient interactions and ensure that they are not limiting, nutrient-based models)
- Values in nutrient requirement tables don’t allow for processing or storage losses

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FISH DIGESTIVE PHYSIOLOGY

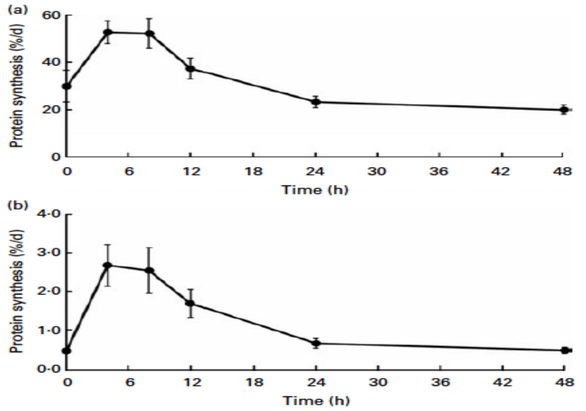
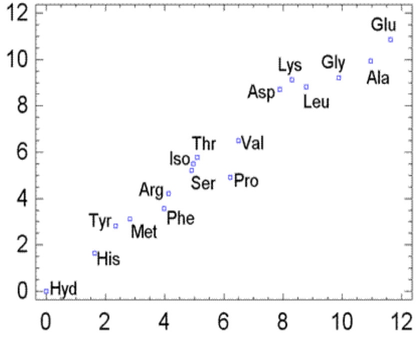
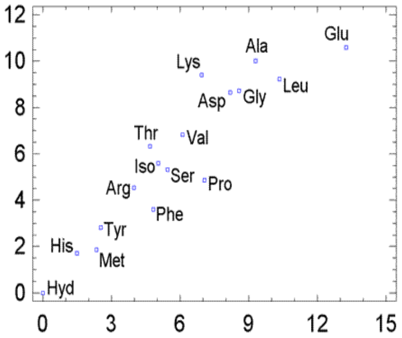


Fig. 2. Protein synthesis (%/d) in (a) liver and (b) white muscle of sea bream before feeding and at different times after feeding. Values are means, with their standard errors represented by vertical bars (*n* 8).

The fish liver has a high capacity to compensate for some nutritional imbalances in order to optimize white muscle protein turnover and prioritise protein growth.



FM



Challenge: Differences in amino acid up-take pattern between fishmeal (FM) and plant meal (PM) based diets

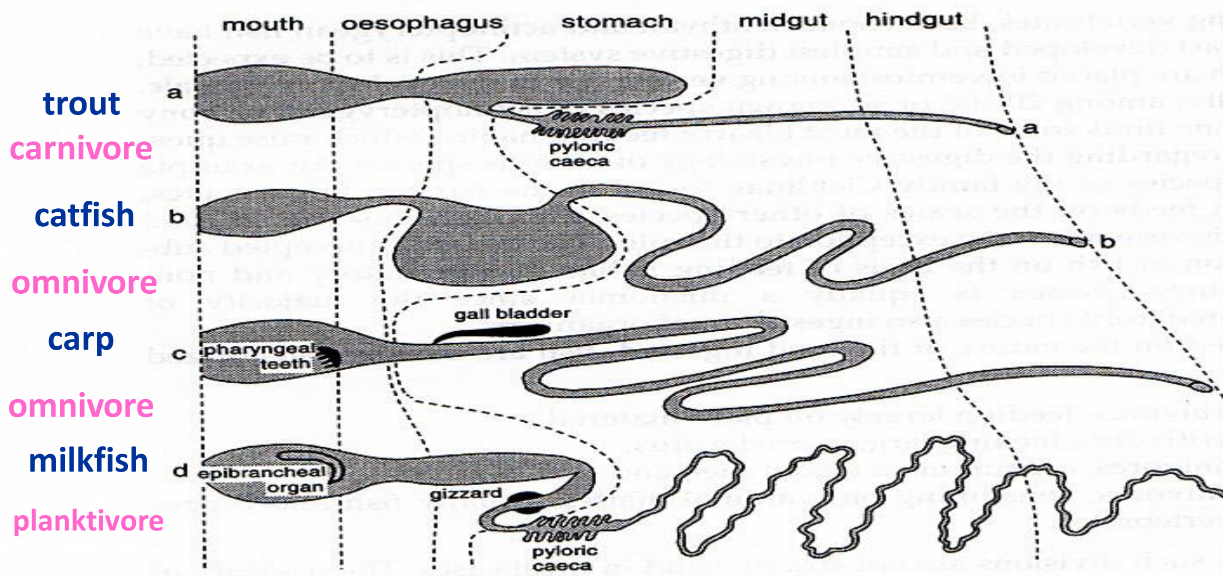


Figure 4.1 The digestive systems of four fish described in the text, arranged in order of increasing gut length. (a) Rainbow trout (carnivore). (b) Catfish (omnivore emphasizing animal sources of food). (c) Carp (omnivore, emphasizing plant sources of food). (d) Milkfish (microphagous planktivore). (From Smith, 1980.)

De Silva and Anderson, 1995)

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FISH ENERGY BUDGET

I = M + G + E

where: I = ingested energy

M = energy expended for metabolism

G = energy stored as growth

E = energy lost to environment

-Feed quantity-quality

-Feed conversion and economic conversion

-Feeding costs

-Temperature

-Waste solids N, P

-Oxygen consumption

-NH_3 and CO_2 production

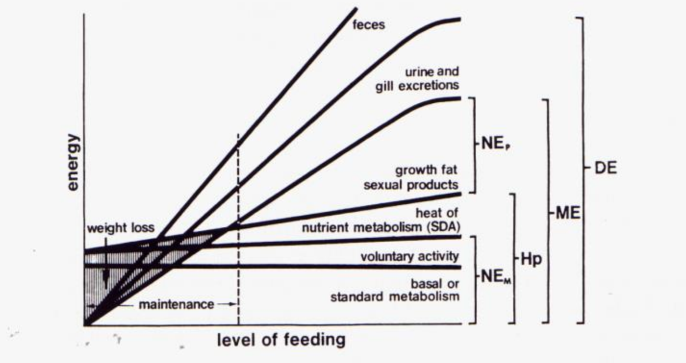
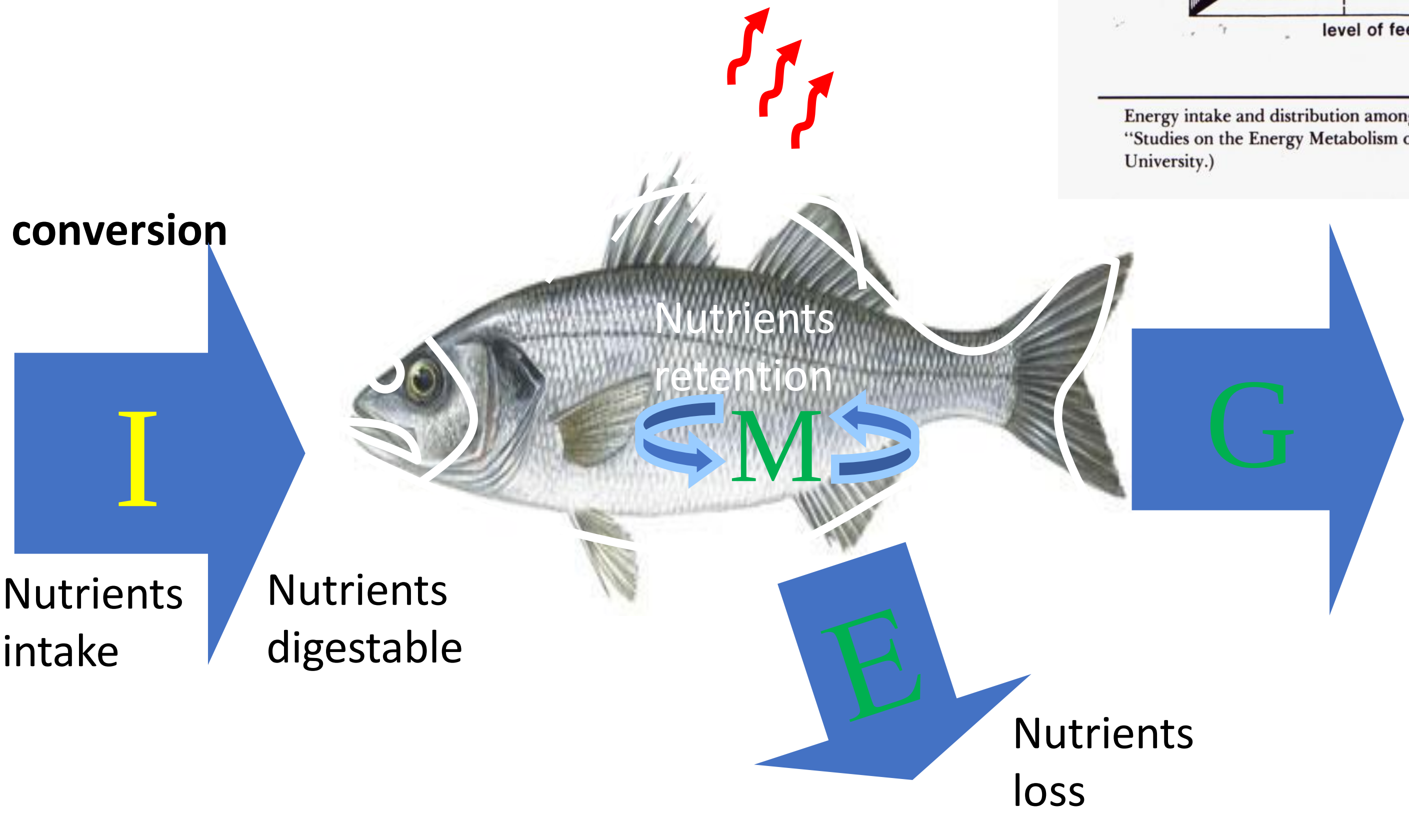


FIG. 1.2

Energy intake and distribution among energy-requiring processes. (From Smith, *In* "Studies on the Energy Metabolism of Cultured Fishes", 1976 Thesis, Cornell University.)



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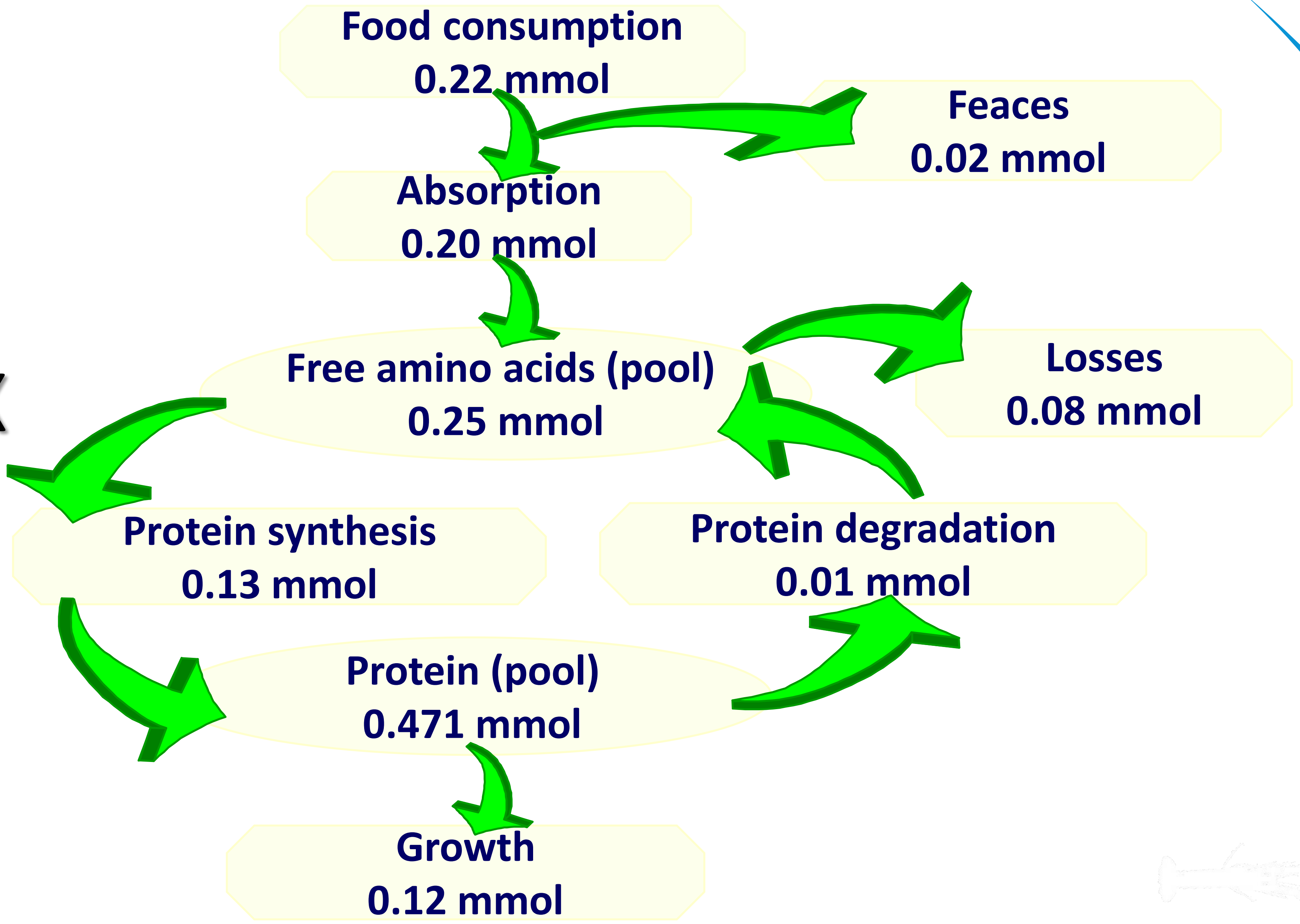
AMINO ACID FLUX MODEL



Mente, E., Houlihan, D.F. Coutteau, P. and Sorgeloos, P. (2002). Protein turnover, amino acid profile and amino acid flux in juvenile shrimp *Litopenaeus vannamei*: effects of dietary protein source. *Journal of Experimental Biology*, **205:** 3107-3122.

Part II: Innovative fish feeds for healthy fish for a healthy human consumption

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NUTRIENT SOURCES FROM FISHING ACTIVITIES

Fishmeal

Fish oil

Select raw materials

FM and FO, krill meal, squid meal

Mineral and Vitamin premix

Novel ingredients

- *Pea protein*
- *Yeast*
- *Fermented soya*
- *Bacterial protein*
- *Yeast*
- *Microalgae*
- *Insects*
- *Tunicate meal*

Micro-macro

40 essential nutrients

Biotechnology

microalgae

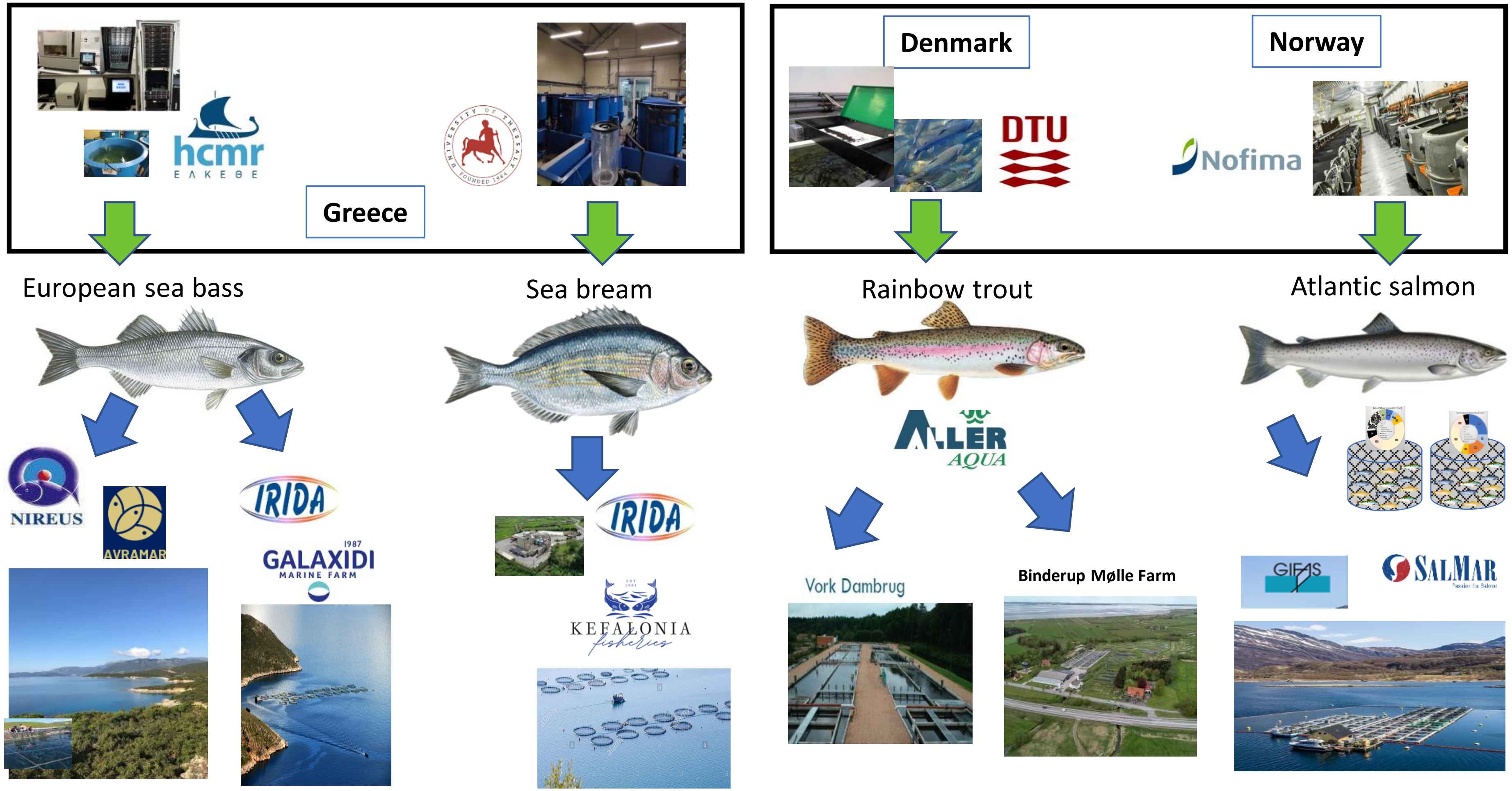
Bacterial protein

yeast

NUTRIENT SOURCES FROM AGRICULTURAL ACTIVITES

Plant meals, land animal meals, PAPs, by products meals and oils, microbial feed ingredients

Feeding fish trials with FutureEUAqua novel aquafeeds



Sea bass novel diets

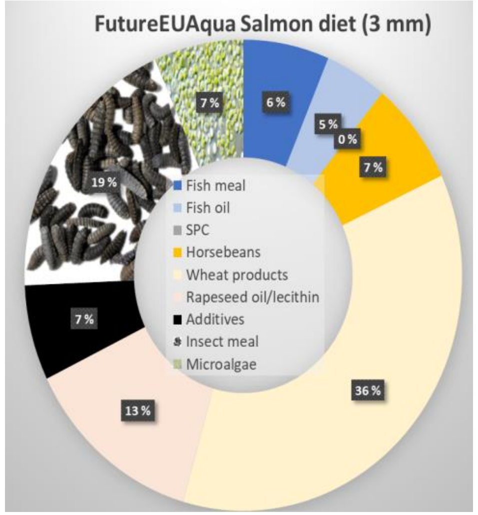
Lower values Novel ingredients

Higher values Novel ingredients

Low FIFO

- *Bacterial protein*
- *Yeast meal*
- *Microalgae*

Salmon novel diets



1) Salmon & sea bream trials: Fish meal, tunicate meal, black solder fry meal, algal meals, biomasses and fish oil
2) Sea bass and sea bream trials: Conventional fish meal, fish meal made from trimmings, krill meal, bacterial protein, yeast protein, algal meal, squid meal, pea protein, rapeseed oil and fish oil, corn gluten, wheat gluten, soy bean meal.

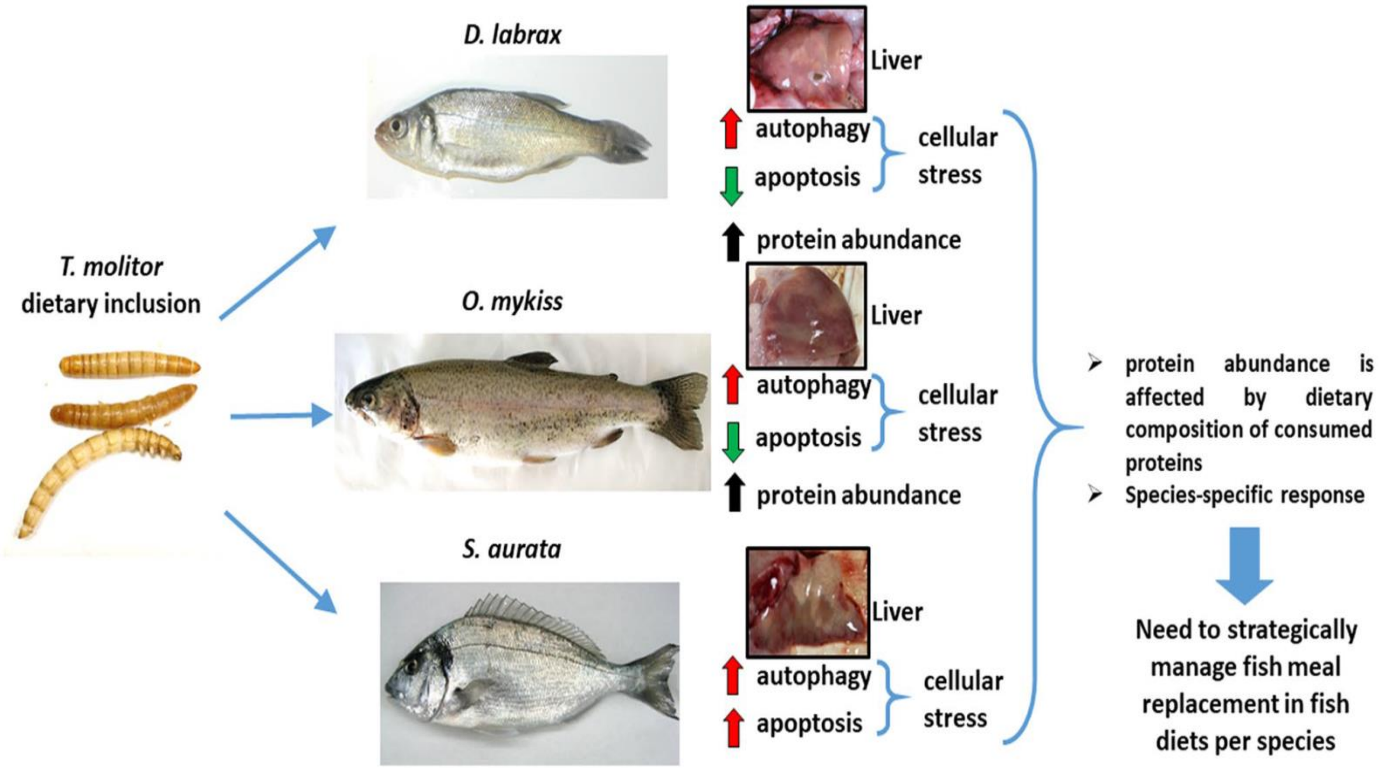
scientific reports

Check for updates

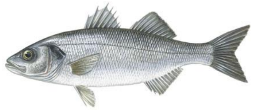
OPEN

Tenebrio molitor larvae meal inclusion affects hepatic proteome and apoptosis and/or autophagy of three farmed fish species

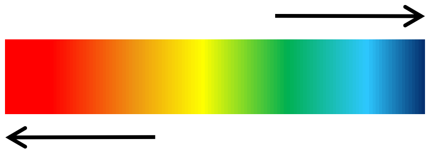
Eleni Mente[1,2✉], Thomas Bousdras[3], Konstantinos Feidantsis[3], Nikolas Panteli[3], Maria Mastoraki[3], Konstantinos Ar. Kormas[2], Stavros Chatzifotis[4], Giovanni Piccolo[5], Laura Gasco[6], Francesco Gai[7], Samuel A. M. Martin[8] & Efthimia Antonopoulou[3]



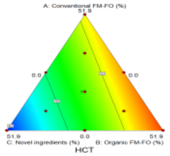
- ➢ differences in liver proteome in each of the three fish species
- ➢ *T. molitor* meal inclusion in fish diets has a more observable effect on liver proteome of European seabass and gilthead sea bream
- ➢ gilthead sea bream ⇒ fewer proteins spots were altered in comparison to European seabass and rainbow trout ⇒ possible relationship to the animal's natural chitin-enriched diet



Lower values Novel ingredients



Higher values Novel ingredients

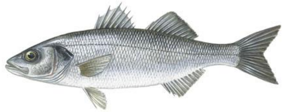


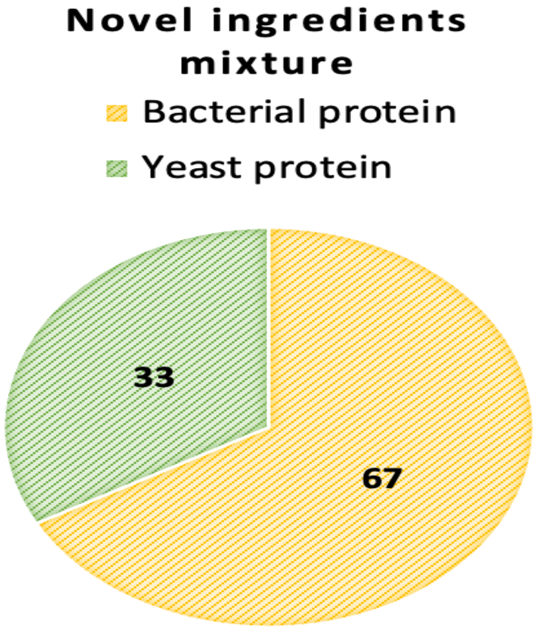
Best growth and FCR for **Conventional** and **Trimmings** mixture with **moderate** inclusion **of Novel ingredients**

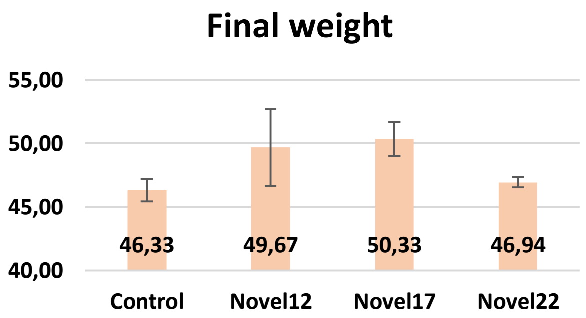
Negative effects of exclusive inclusion of **Novel** ingredients possibly due to:

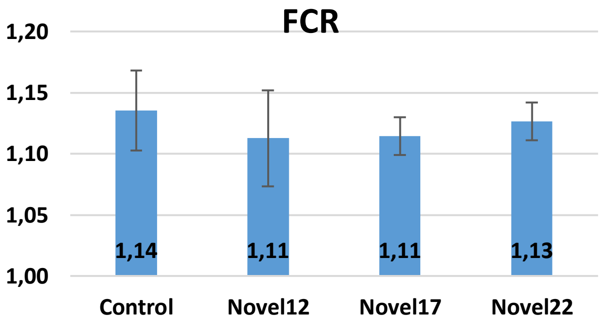
- More fat was accumulated in both intestinal and liver tissues of **Conventional** and **Trimmings** fed groups. Possibly related to increased feed intake and final weight

The histopathological examination of the liver showed minimal (steatosis) lipid accumulation for Trimming mixture with moderate inclusion of Novel ingredients









- ✓ Trent observed for higher final weight of moderate inclusion of Novel ingredients
- ✓ Improved FCR at moderate inclusion of Novel ingredients

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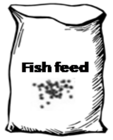
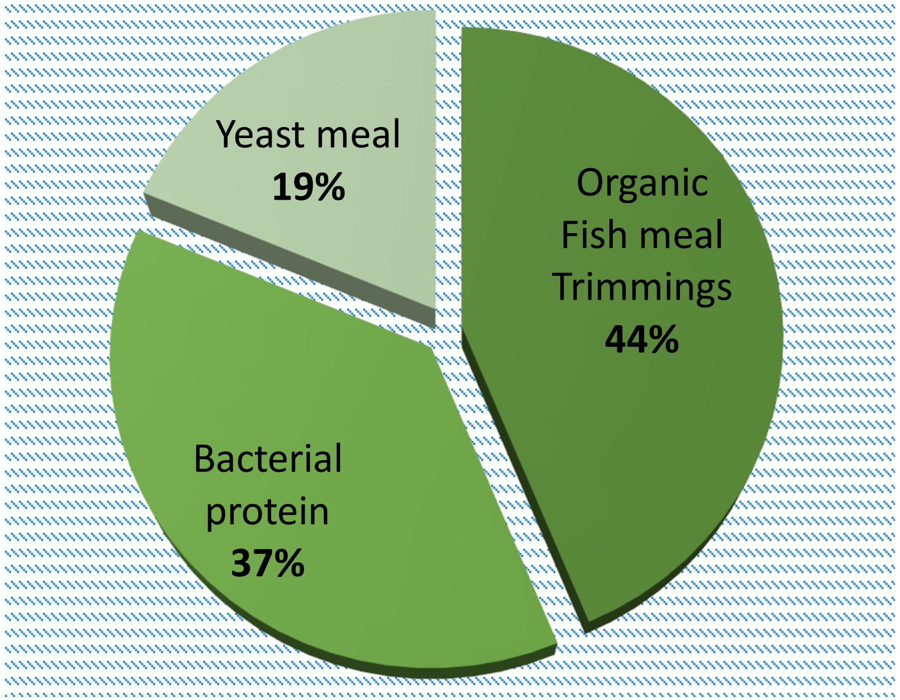
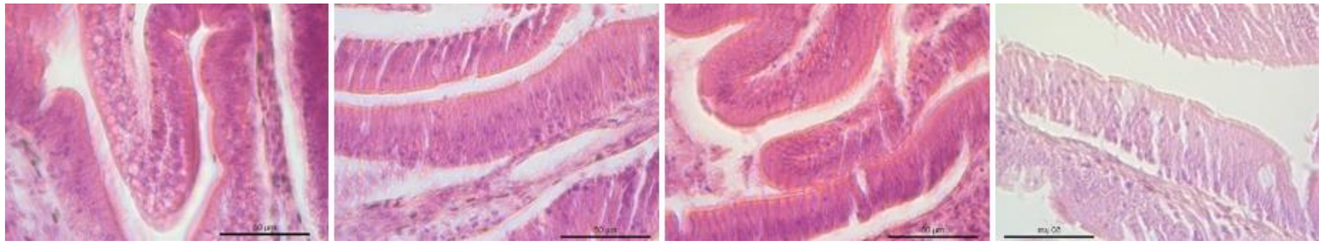


Diet 1 0% Low FiFo
Diet 2 20% Low FiFo
Diet 3 25% Low FiFo
Diet 4 30% Low FiFo

Low FiFo for organic diets



Higher growth performance for LFiFo25 diet compared to control diet



Anterior gut, liver appears to have normal structure in all dietary groups with normal distribution of goblet cells.

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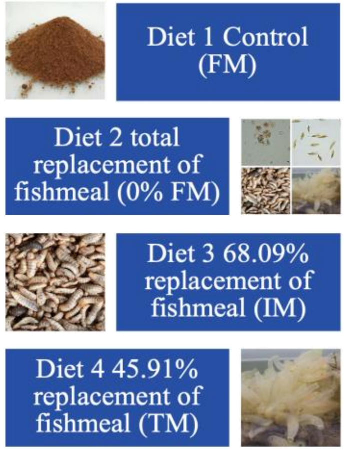

Sea bream

The total replacement of fishmeal with algae meal, (*Phaeodactylum tricornutum* and *Schizochytrium limacinum*),insect meal (black soldier fry) and tunicate meal (*Chiona intestinalis*) and no fish oil did not affect sea bream growth performance.

However, sea breams showed better growth performance when they fed **organic fish meal, krill, and algae** (*Schizochytrium limacinum*, HA) and *Phaeodactylum tricornutum*, PA) and slow growth rates when they fed on tunicate meal.

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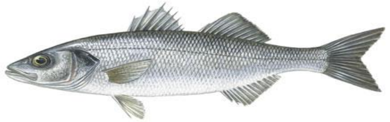
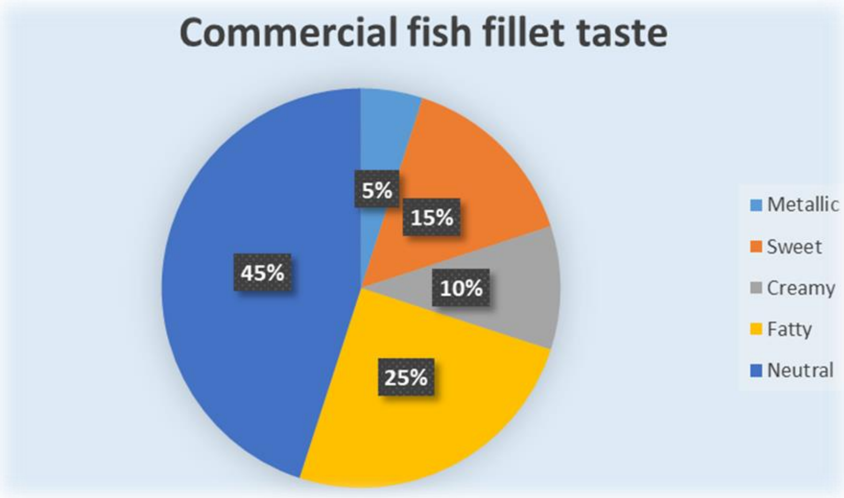
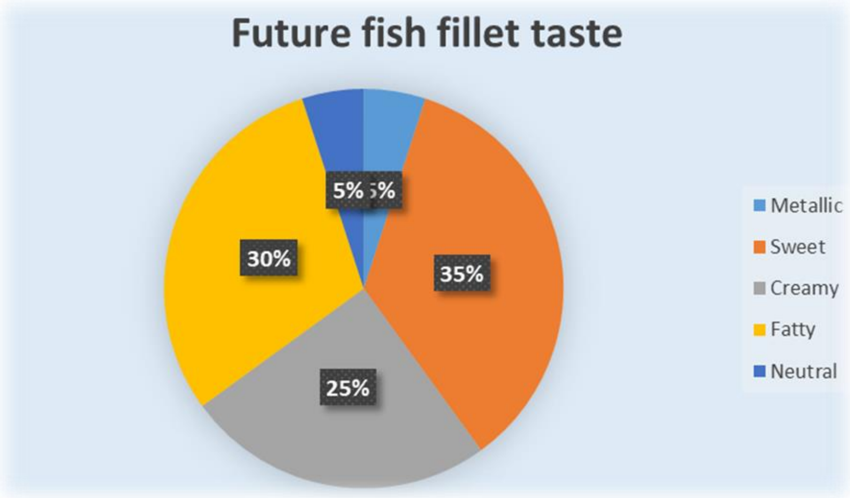
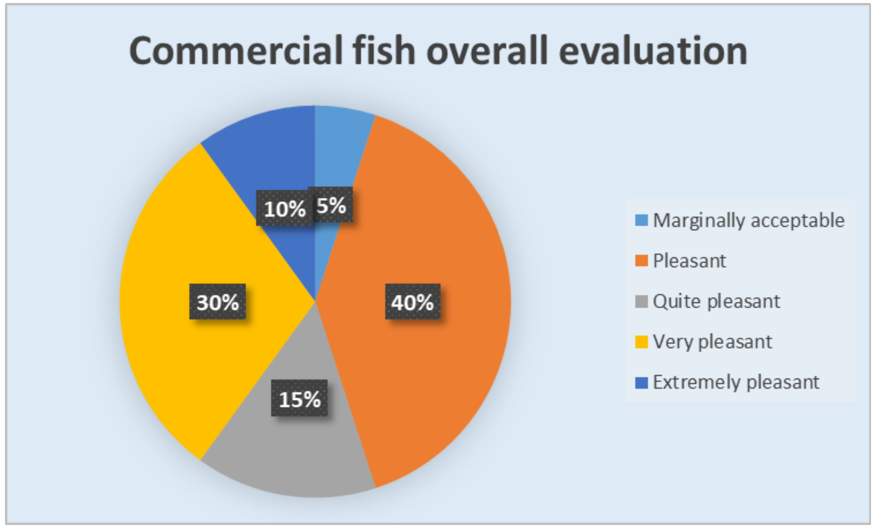


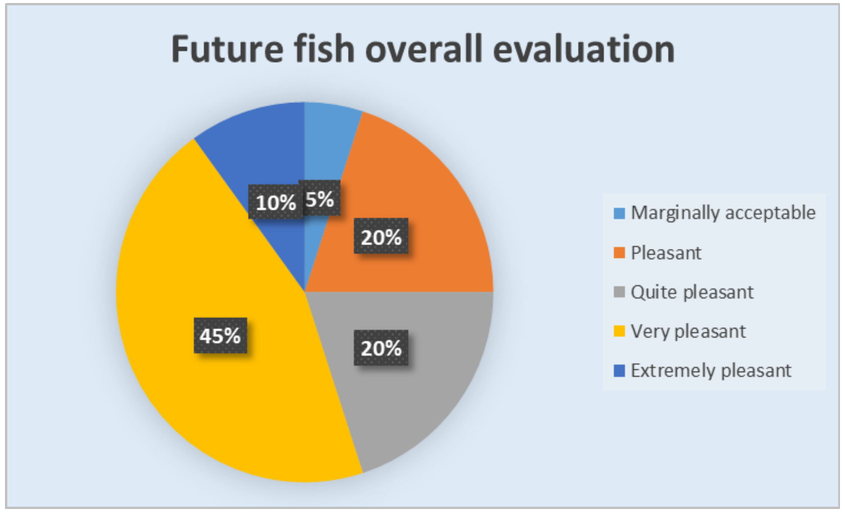
Commercial diet

FutureEUAqua diet

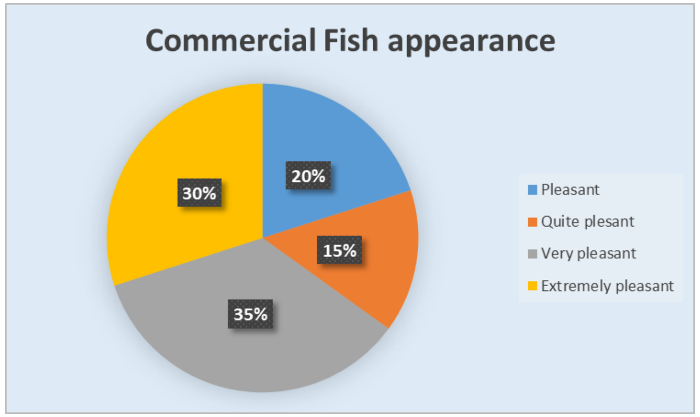


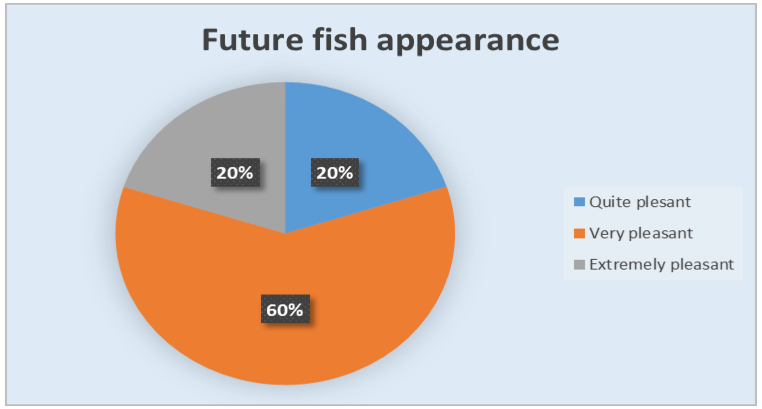


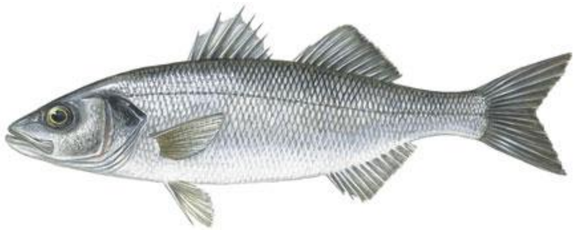


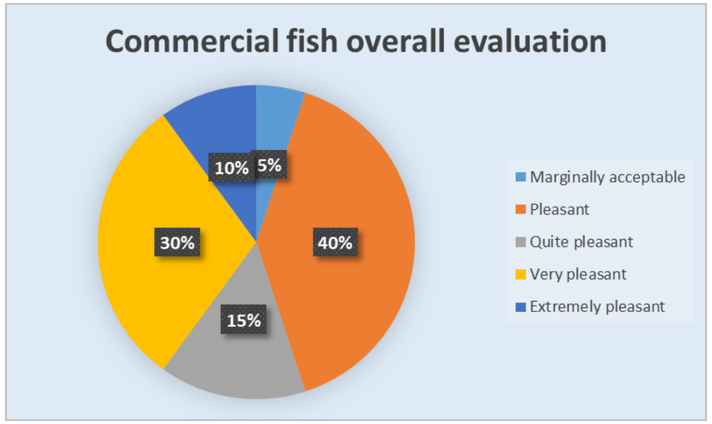


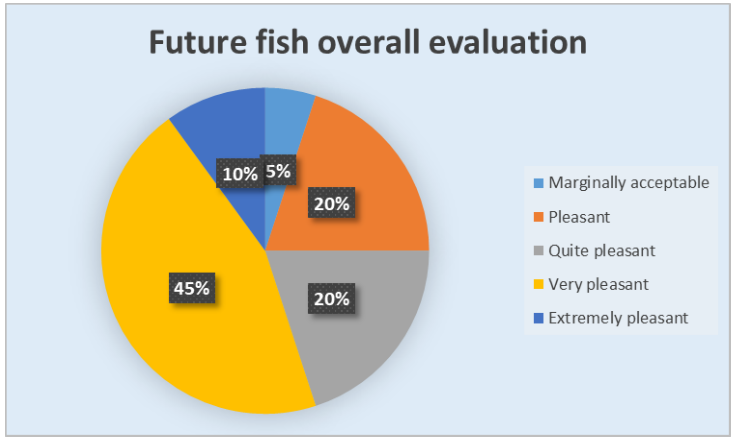
Sea bass appearance and overall evaluation







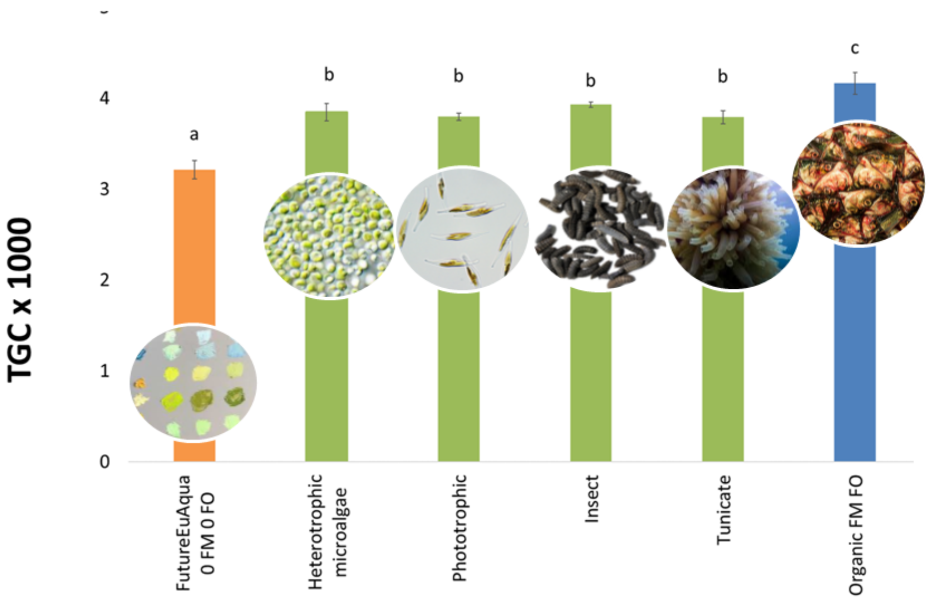


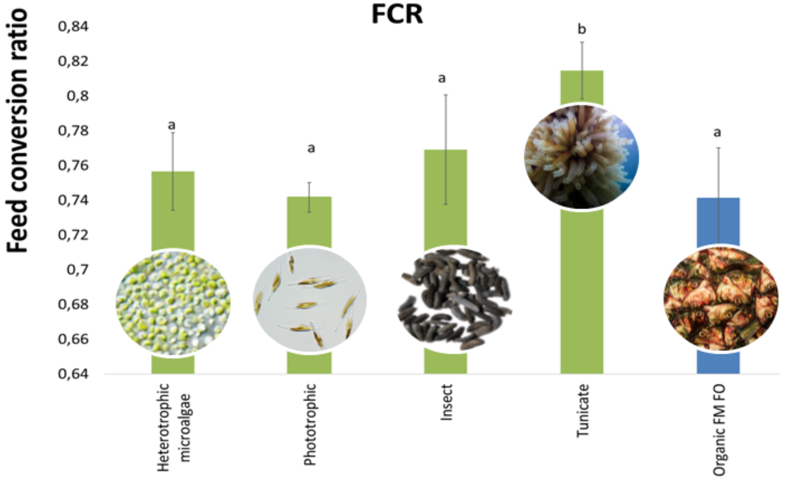


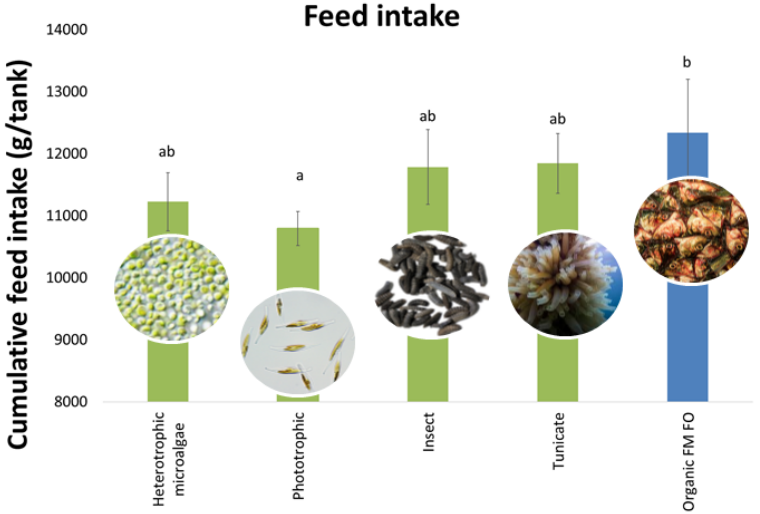
FutureEUAqua project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 817737

7. FISH PERFORMANCE

Kousoulaki, Sveen, Krasnov, Johansson, Norén, Richardson & Espmark







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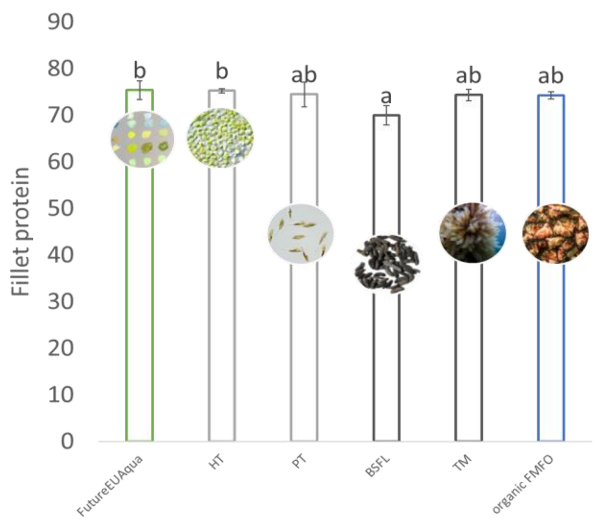
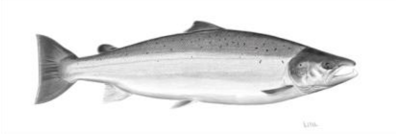
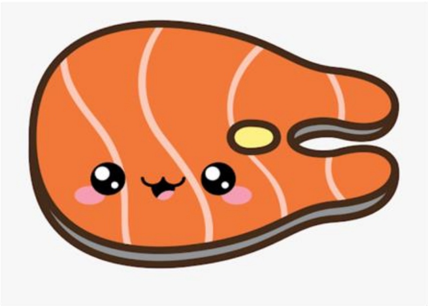
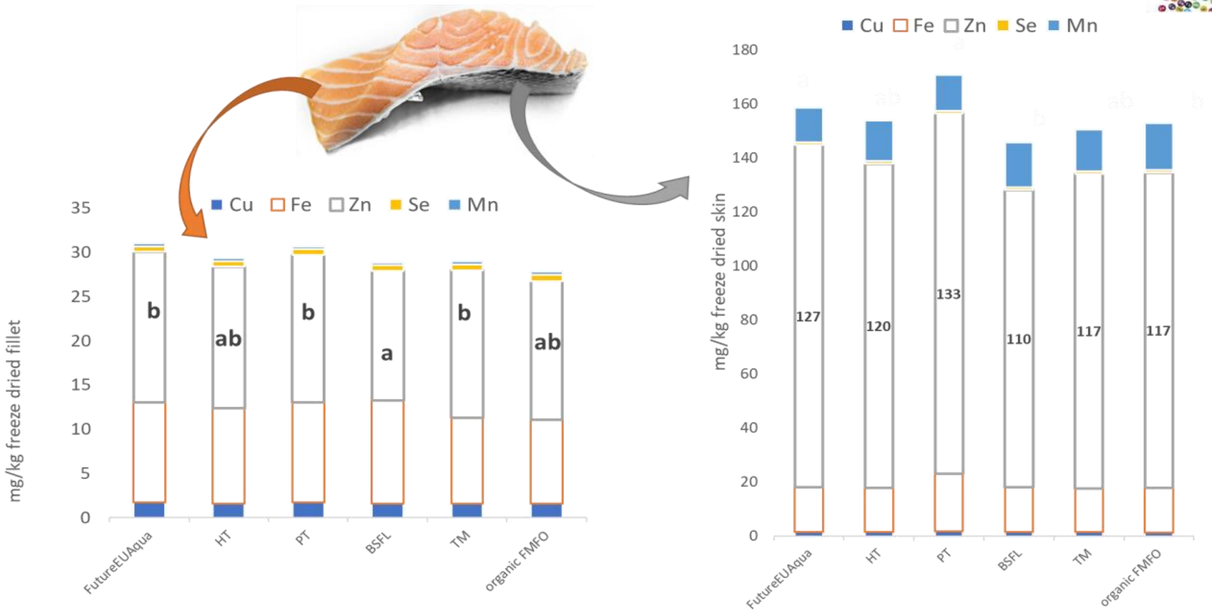
7. PRODUCT QUALITY, FILLET PROTEIN







7. HEALTH (SKIN AND FILLET MINERALISATION) AND QUALITY



INCREASED **FILLET** AND **SKIN ZN** LEVELS IN THE **PT MICROALGAE** GROUPS

Ingredients to be tested for conventional trout farming

Fermented rapeseed meal and fermented soybean meal

Why ?

Soy bean are no. 1 protein source in aquaculture feeds and exists in various qualities and may contain antinutritional factors

- Fermentation may deactivate antinutritional factors and reduce undesirable substances

Ingredients to be tested for organic trout farming

- Rules for antinutrient removal have to follow organic rules. Organic regulation does not allow synthetic amino acids to balance diets – hence one of few high protein alternatives is fish meal.

Fish meal protein concentrate processed from trimmings

Why ?

Traditional fish meal or fish trimmings has an environmental draw back with a high phosphorus (P) content. New technology has developed this type with low P content and high protein content **(>80 % protein)** -thus allowing high protein and high energy – not common in organic diets.

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Role of fish gut microbiota ?

Microorganisms, mostly bacteria, live in close association with practically every animal on Earth. Their major roles lay in the nutrition of the animal host through various metabolic processes and the protection of the host against other pathogenic microorganisms.

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RESEARCH ARTICLE

Core versus diet-associated and postprandial bacterial communities of the rainbow trout (*Oncorhynchus mykiss*) midgut and faeces

Eleni Mente[1,2], Eleni Nikouli[1], Efthimia Antonopoulou[3], Samuel A. M. Martin[2] and Konstantinos A. Kormas[1,*]

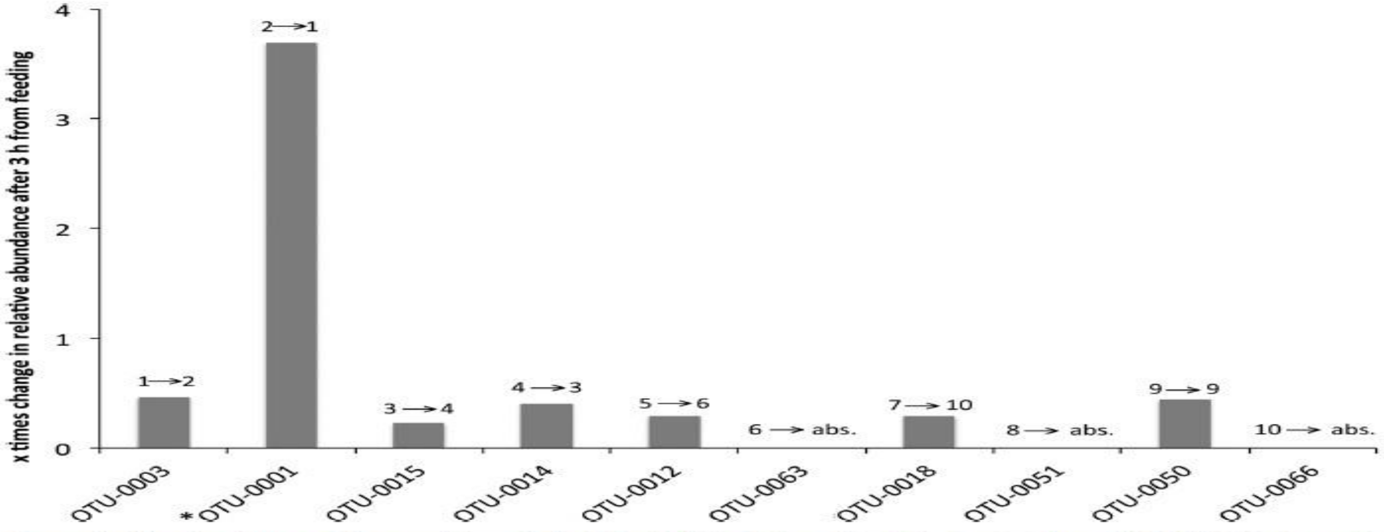
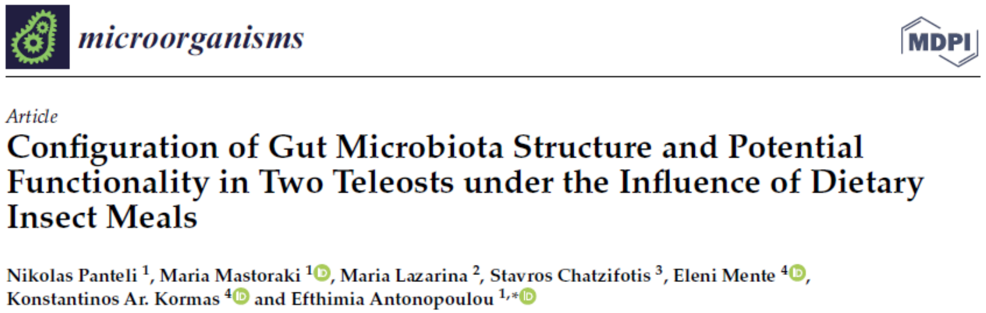


Fig. 6. Relative change in the abundance of the most abundant midgut OTUs of *O. mykiss* 3 h after feeding with Diet D. Numbers above each bar indicate the change in OTU ranking from 0 h → 3 h. * indicates a core OTU; 'abs.' indicates absent.



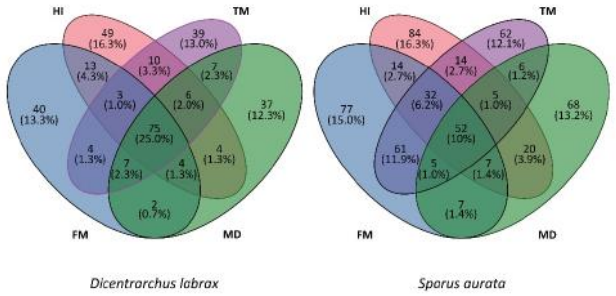
microorganisms

MDPI

Article

Configuration of Gut Microbiota Structure and Potential Functionality in Two Teleosts under the Influence of Dietary Insect Meals

Nikolas Panteli [1], Maria Mastoraki [1], Maria Lazarina [2], Stavros Chatzifotis [3], Eleni Mente [4], Konstantinos Ar. Kormas [4] and Efthimia Antonopoulou [1,*]



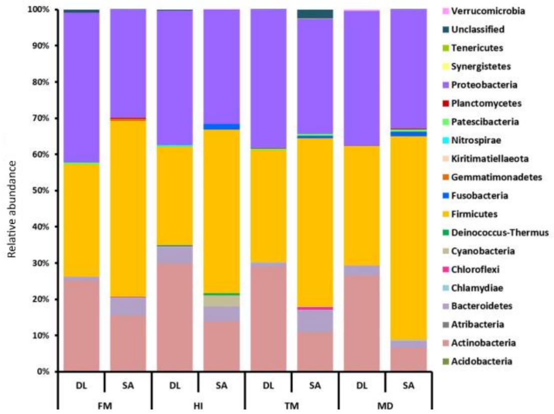
✓ dominance of Actinobacteria, Firmicutes, and Proteobacteria in both teleost species

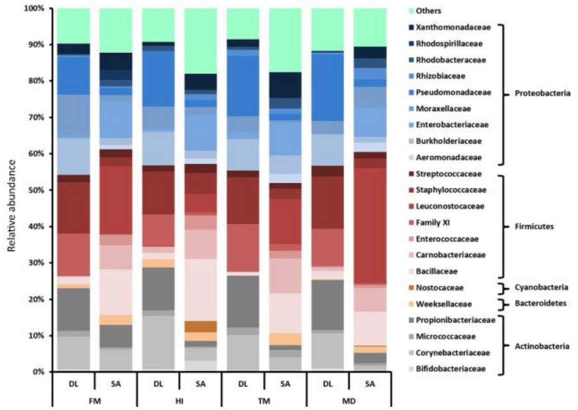
✓ insect meal inclusion ⇒ enrichment of beneficial bacterial species e.g. *Aeromonas*, *Pseudomonas*, *Carnobacterium* ⇒ secretion of several digestive enzymes

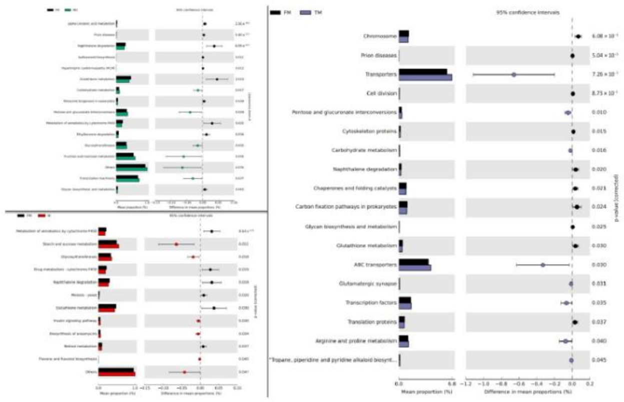
✓ changes in microbial communities functionality including pathways related to metabolism

⇓

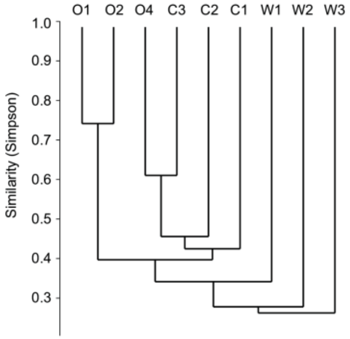
different insects as fish feed ingredients elicit species-specific differential responses of structural and functional dynamics in gut microbial communities

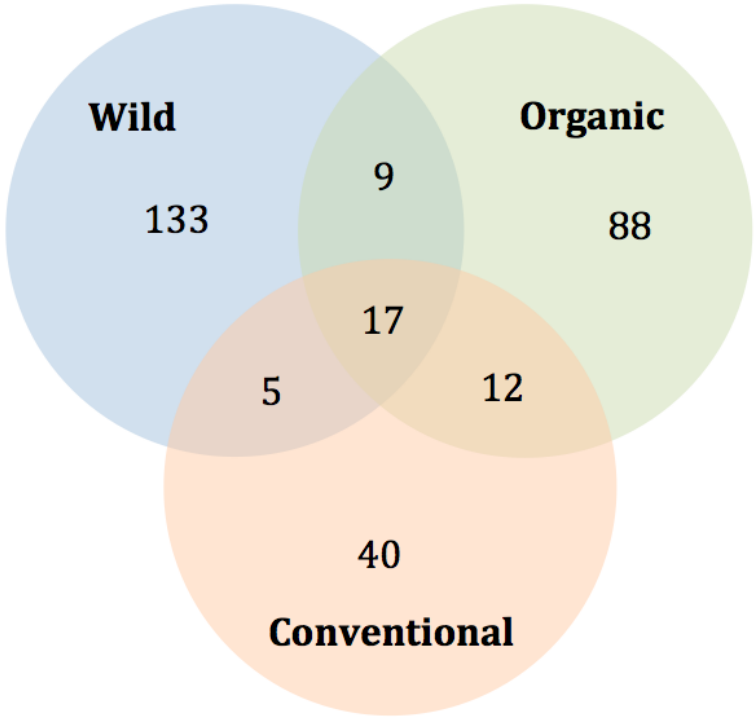


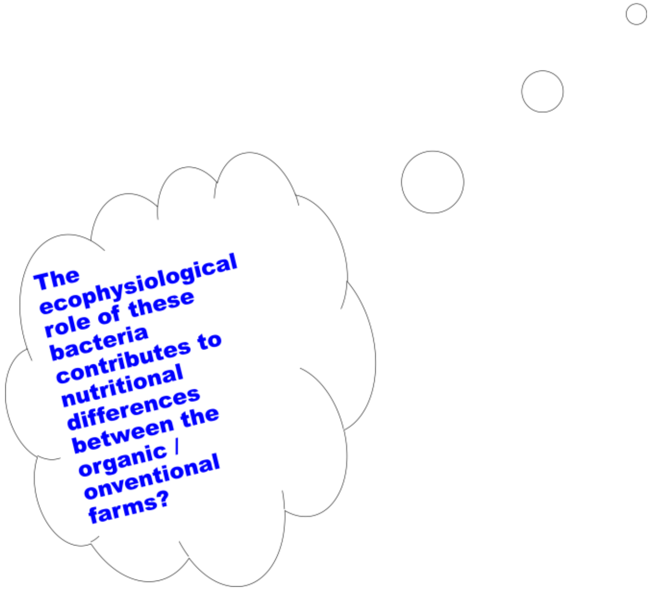




Results



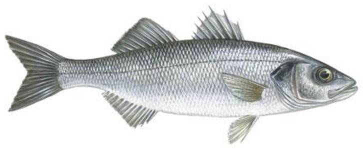




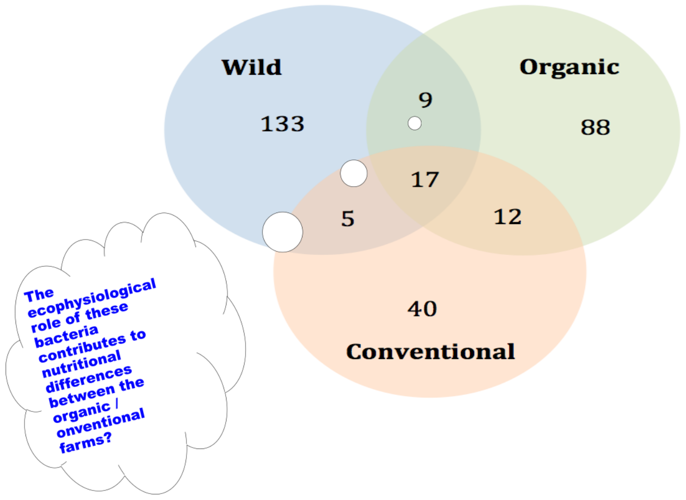
Decreasing number of intestinal tract bacterial species from wild to conventional

Although the expected results show the structure of the bacterial communities, the relative abundance of dominant tags provide information on possible gut bacterial residents that could serve as true symbionts of the animals in the two rearing conditions.

Kormas, A.K., Meziti, A., Mente, E., Frentzos, A. (2014). Dietary differences are reflected on the gut prokaryotic community structure of wild and commercially reared sea bream (*Sparus aurata*). Microbiology Open.



Fish gut microbiota and nutrition



Gut microbial diversity could be influenced by nutrition or environmental factors *but* few studies on fish and crustaceans are available that experimentally confirm this.

FutureEUAqua

- Do gut bacterial communities exhibit temporal shifts/diversity mostly relating to temporal variations in food supply of nutrients?

- Which are the gut bacterial communities that could serve as providers of essential nutrients to fish?

Diet is a major factor driving the composition and metabolism of the gut microbiota while gut microbiota is actively involved in nutrient assimilation and immunity of the host organism.

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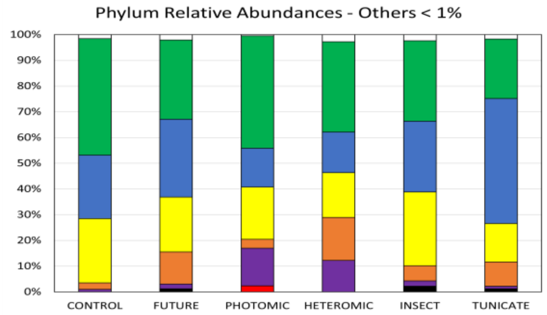
FutureEUAquaSalmon (My)Bioma

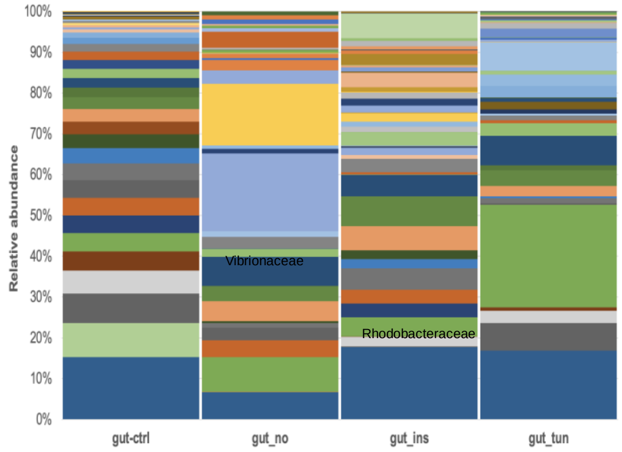


FutureEUAquaSeabream (My)Bioma

Compared to the control feed, tunicate and insect did not alter the dominant midgut bacterial group

Low shared OTUs and it shows the distinct microbiota of each treatment,

Tunicate was the most distinct micriobita



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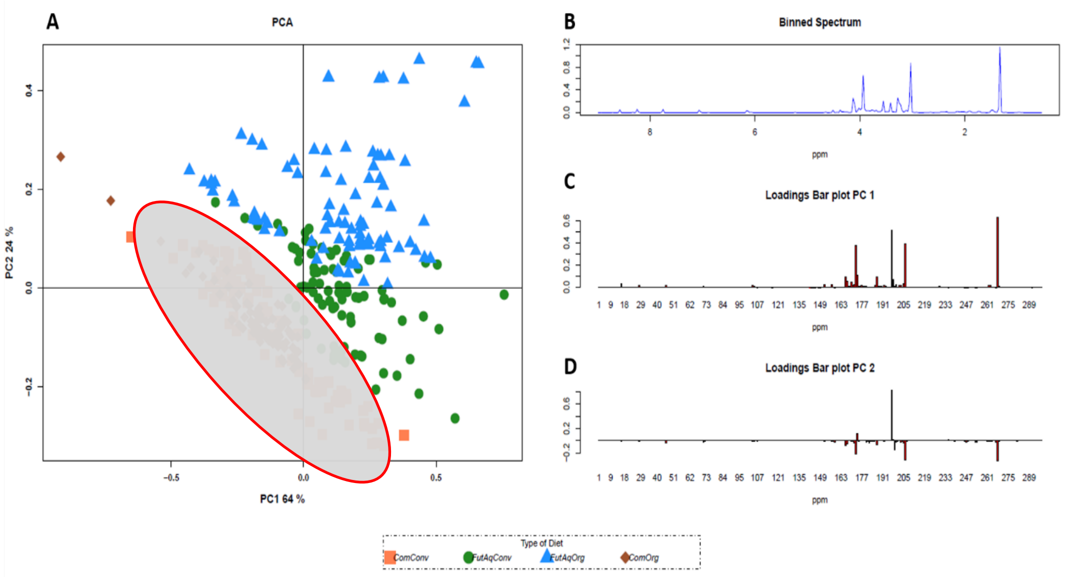
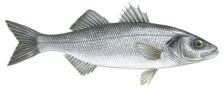


Fish metabolome



Francesco Capozzi, University of Bologna

-There is no difference between the two commercial diets.

-FutureEUAqua organic diet modify fish metabolome in a different way.

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FutureEUAqua nutrition team Thank you!!!

FUTURE EUAQUA

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