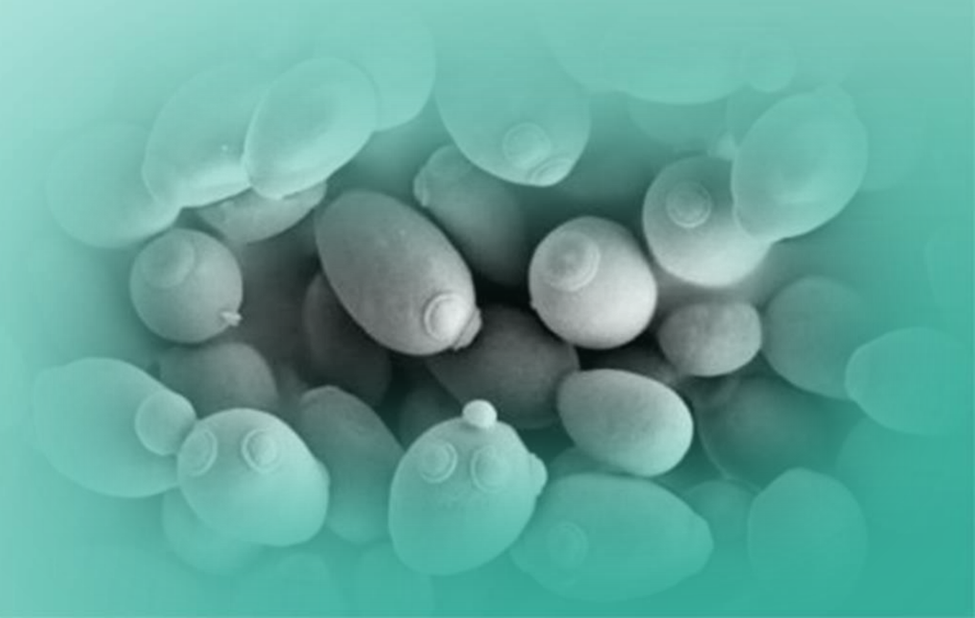
→ *Professor Margareth Øverland*
→ *Foods of Norway, Fakultetet for Biovitenskap, NMBU*
→ *June 18, 2025*

How do we feed our salmon to meet the protein requirement?

Lecture in the immunonutrition NOVA/SDG pilot call cource



SDG pilot call – INTFELLES Global Research Council

Sharing knowledge and smart technologies for sustainable agro-aquatic production systems

NOVA course - a joint PhD level course financed by the Nordic Forestry, Veterinary and Agricultural University Network (NOVA).

→ **Supporting the development of international scientific networks.**

The Research Council of Norway

NordForsk

BIOECONOMY IN THE NORTH

FOODS of NORWAY

Agencia Nacional de Investigación y Desarrollo

Ministerio de Ciencia, Tecnología, Conocimiento e Innovación

Gobierno de Chile

Universidad Católica del Norte Chile

Bursa Uludağ Üniversitesi

SDG Pilot Call Partners:

University of the North, Chile, Project lead, Prof. German Merino

Norwegian University of Life Sciences, NMBU, Norway, Prof. Margareth Øverland

Bursa Uludağ Üniversity, Turkey, Prof. Nezih Kamil Salihoglu

Aligning UN SDGs 2, 12, 13 & 17

SDG pilot call

FOODS of NORWAY

NMBU

Sharing knowledge and smart technologies across disciplines to develop sustainable agro-aqua systems—like hydroponics and recirculating aquaculture systems—that use water efficiently, support new businesses, and help ensure clean water and food safety and security.

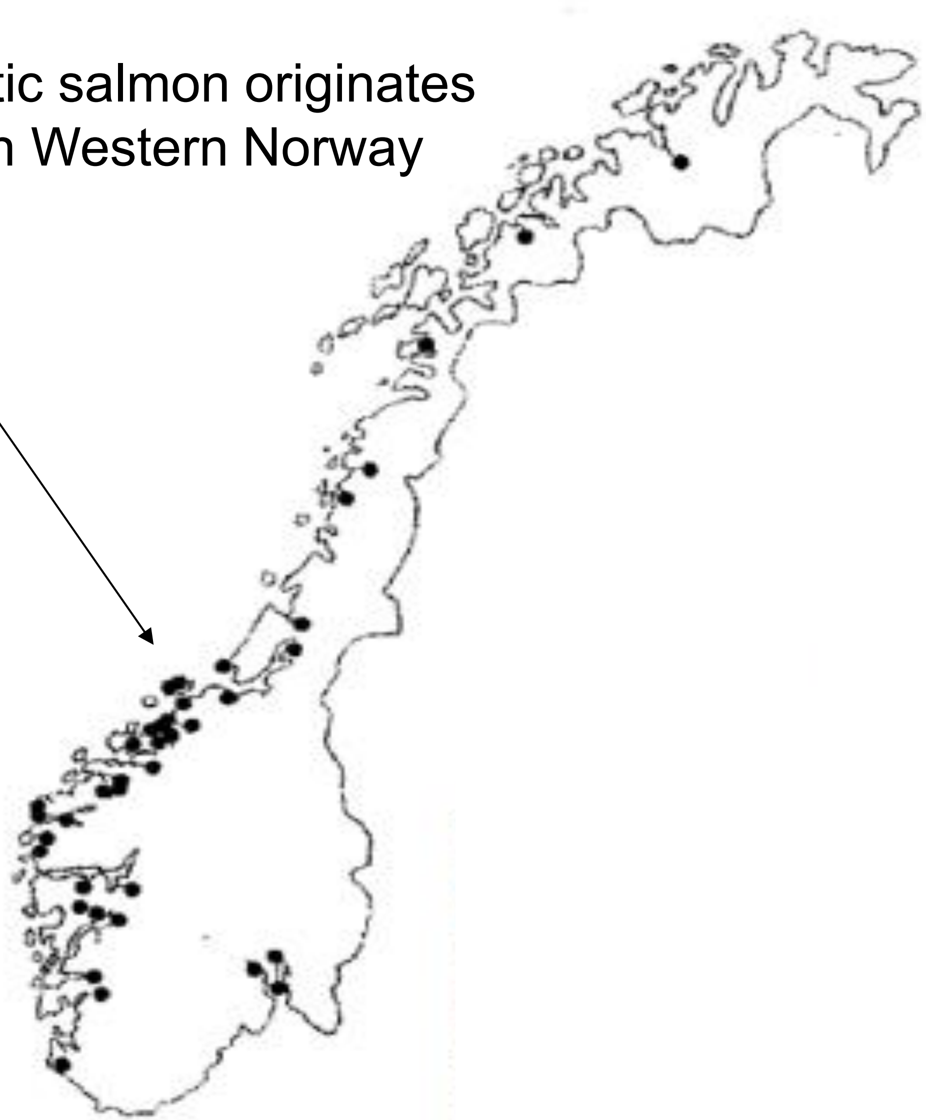
- **Zero huger**
- **Responsible Consumption & Production**
- **Climate action**
- **Partnership to achieve the goals**

Outline

- Introduction
- History of Atlantic salmon farming
- Why is protein important for fish
- Amino acids needed for growth and health
- How do we measure the protein and amino acid requirements
- How do we measure the protein quaility of feedstuffs
- Amino acid composition and digestibility in common feedstuffs
- How do we feed the fish to meet the requirement to day and in the future
- Concluding remarks

History of aquaculture at our university

Domestic Atlantic salmon originates from 41 rivers in Western Norway



We have been teaching aquaculture since 1887

Aquaculture lab from 1900

Prof. Harald Skjervold, the farther of farmed salmon

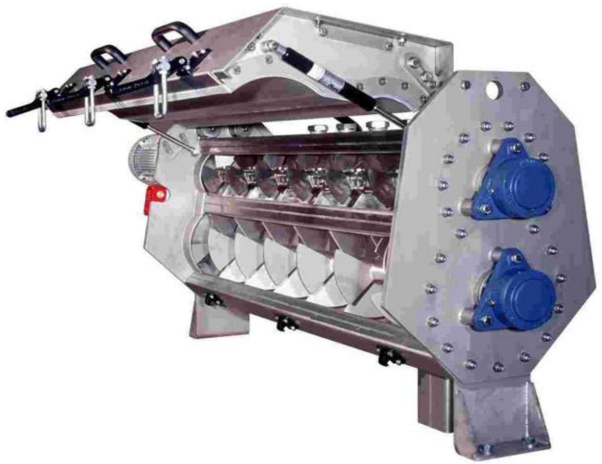
Development of modern fish feeds

- Methods to determine:
    - nutritional value feed
    - nutritional requirement of salmon

Major breaktrough

- Change from wet to dry feed
- Increased fat content in the feed
- New feed processing technology
    - Extrusion
    - Vacuum coating

Extrusion technology revolutionized the modern fish feed



Conditioner: ~90ºC

1983: First commercial extruded salmon feed

1983-1990: Extruded dry feed dominated Norwegian aquaculture

1990: New methods in feed technology, e.g. vacuum coating

Extruder: ~110-140ºC

Dryer: ~90-110ºC

APC
Aquaculture Protein Centre
Centre of Excellence

All its research aims at finding sustainable alternatives to fishmeal in diets for carnivorous fish

Established in 2003

APC has given:
- Important new expertise
- New methods to measure amino acid requirements
- Knowledge of use and limitations of new ingredients
- New methods for processing of fish feed
- New knowledge on health effects of bioactive components in novel feed ingredients
- Integrated expertise important in a global context

Ended in 2013

2015: Foods of Norway was established


FOODS OF NORWAY


Novel feeds for fish and farmed animals

FOODS OF NORWAY

Norwegian Centre for Research-based Innovation

Industrial partners

Borregaard

Felleskjøpet

AquaGen

enifer

geno

Norsvin

BioMar

Nortura

VIKEN SKOG

denofa

ANIMALIA

LALLEMAND

TINE

norilia

Seaweed Solutions

Supporting partners

NORGES BONDELAG

NORSK LANDBRUKSSAMVIRKE

NHO Mat og Drikke

Innovation Norway

Academic partners and collaborators

Norwegian University of Life Sciences

AARHUS UNIVERSITY

SLU

UNIVERSIDAD DE CHILE

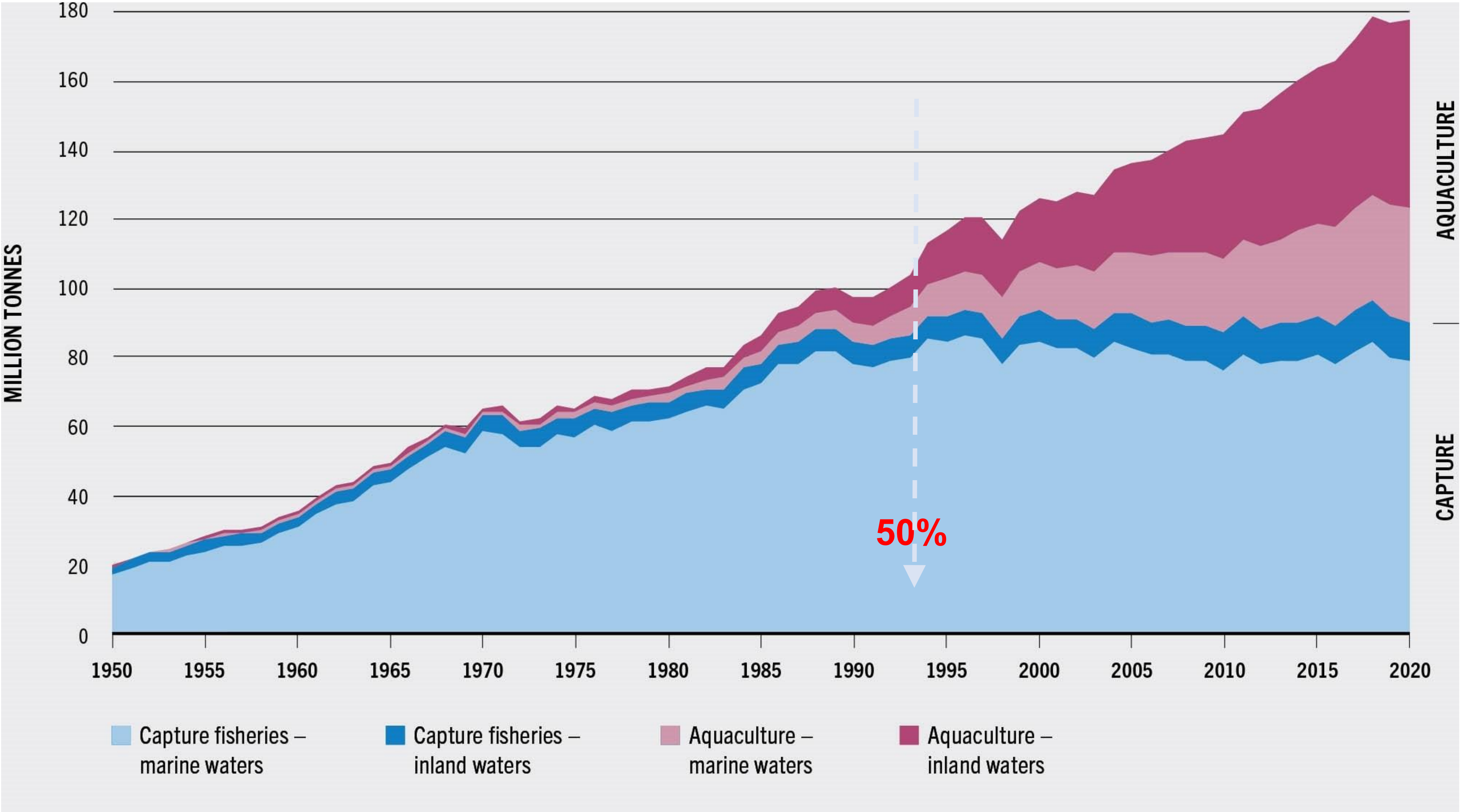
THE UNIVERSITY OF WESTERN AUSTRALIA

UNIVERSITY OF COPENHAGEN

UNIVERSITY OF MINNESOTA

USDA

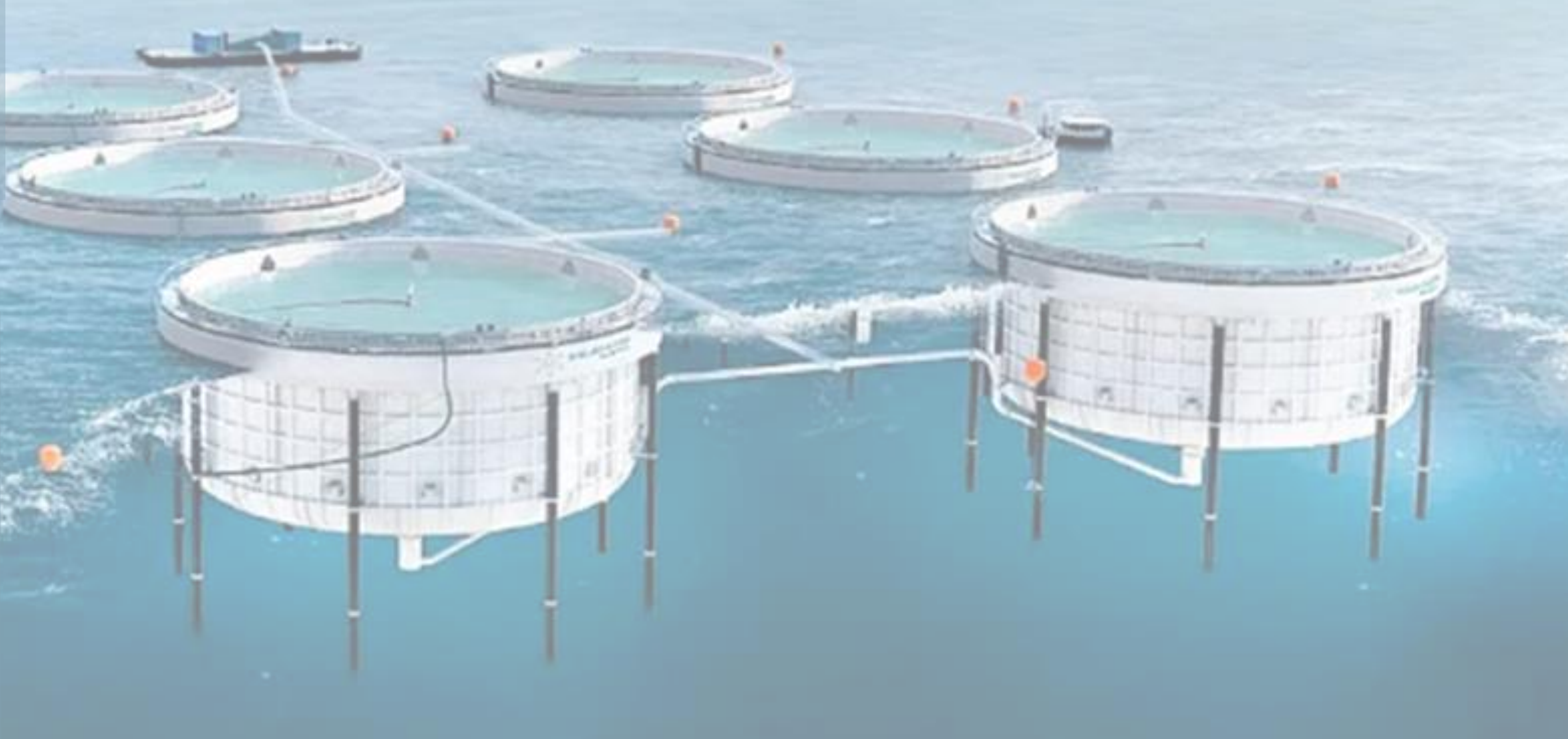
Aquaculture production keeps growing



Constraints on growth of the aquaculture industry

- Limited access to high quality feed raw materials

- Increased demand for sustainable raw materials

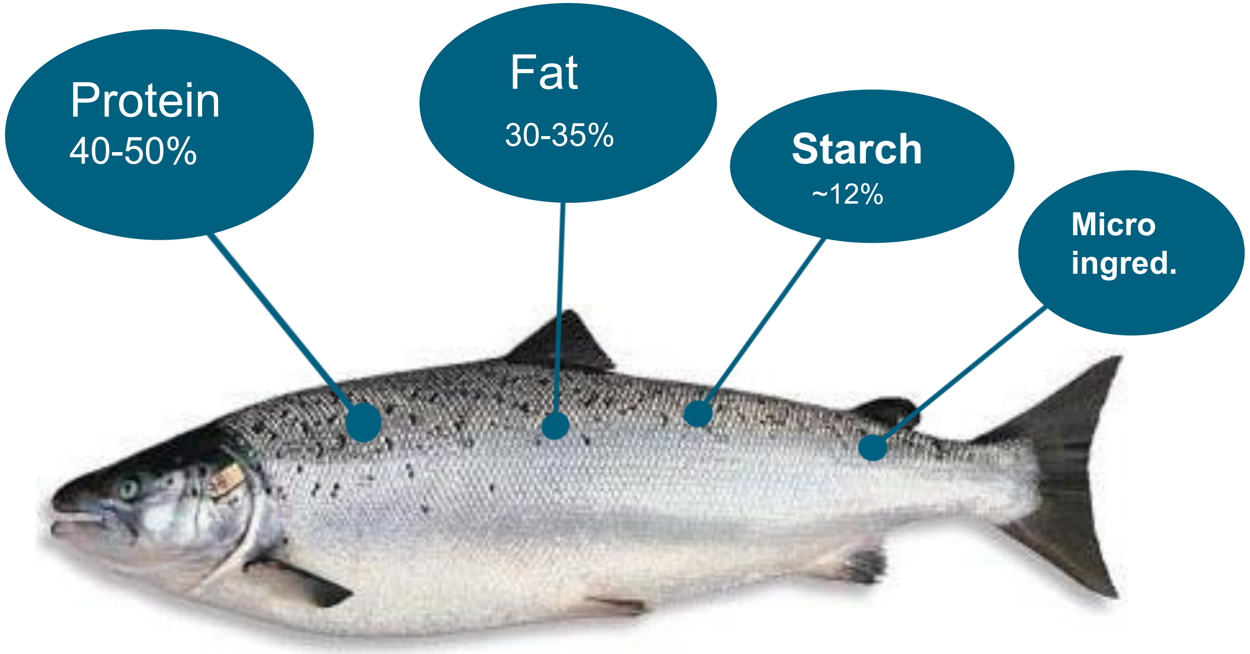


Equipment. *Foto: Aquafarm Equipment*

Meeting the nutritional requirements of the fish

Fish don’t need to eat fish to grow, but they require essential nutrients

Feeding is about finding the right balance



Feed is the largest cost component in salmon production: 46% of the total production costs. Protein is the most expensive part of the diet and accounts for 50-60% of the total value.

You need to know the nutrient content and digestibility of the raw materials and how well they are utilized to formulate diets to match the requirements of the fish.

* with current conversion ratio measured in dry weight

Protein requirement of fish

Fish have high protein requirement

Fish are by far more efficient than traditional farm animals

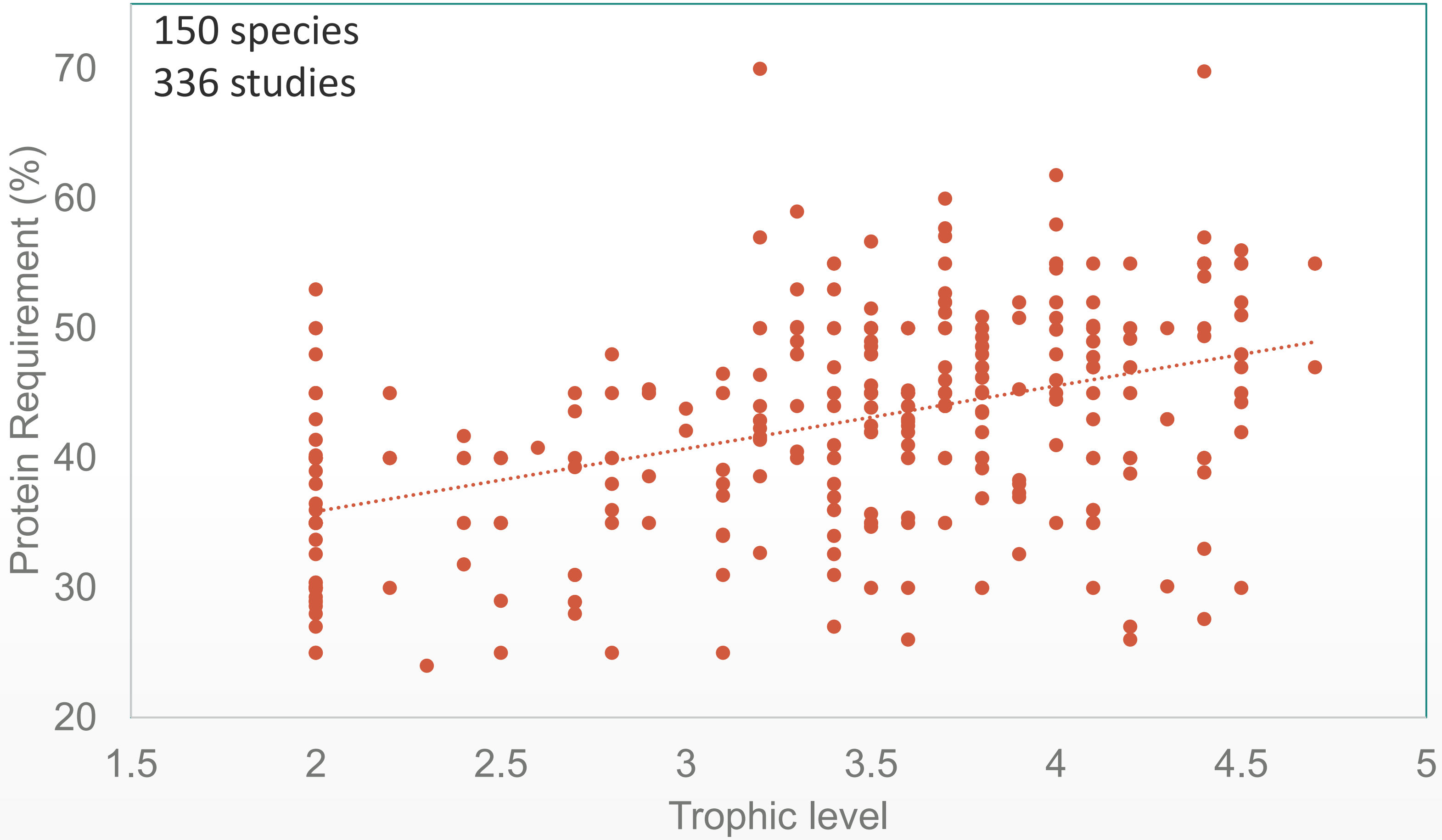
Large differences exist in protein requirements among species

Species	Dietary protein (%)
European sea bass	50
Gilthead sea bream	45
Atlantic salmon	44
Rainbow trout	40
Common carp	38
Nile tilapia	34
Broiler chickens	14-23

NRC 2011

Protein requirements (% diet) of selected fish species

Understanding Protein Requirements Based on Trophic Level



Protein requirements (% diet) & trophic level

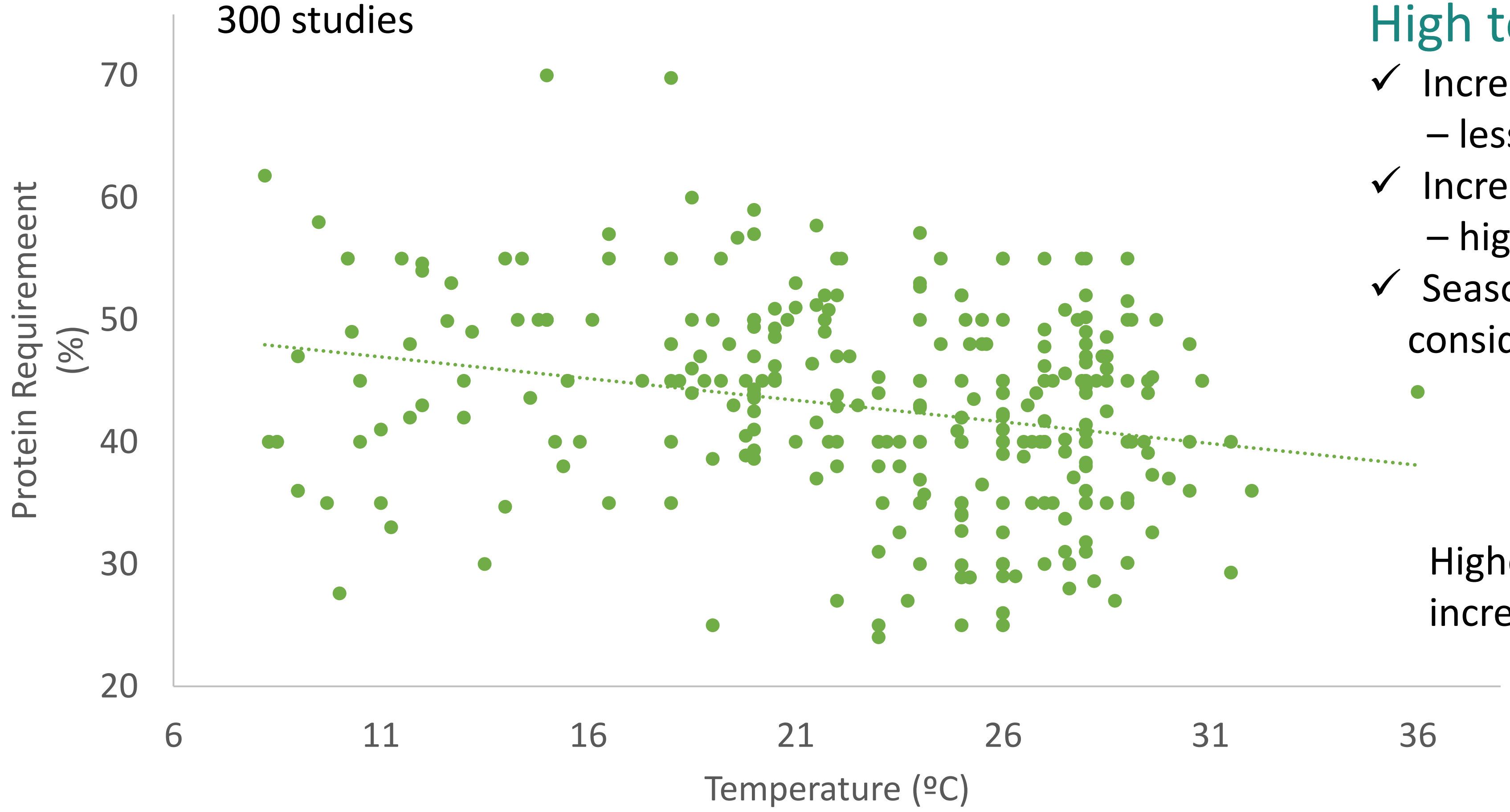
Fish at different tropic level have different protein requirements, this is influenced by:

1) Metabolic rates,
2) Growth rates,
3) Feeding behaviors,
4) Adaptation to habitat and ecological conditions

Fish adapt to their habitat and environmental conditions

Source: Oliva-Teles et al 2020

Effect of Temperature on Protein Requirements in Fish



High temperature:

- ✓ Increases feed intake and growth rates – less protein is needed for maintenance
- ✓ Increases digestive capacity – higher protein utililation
- ✓ Seasonal variation should be considered when formulating diets

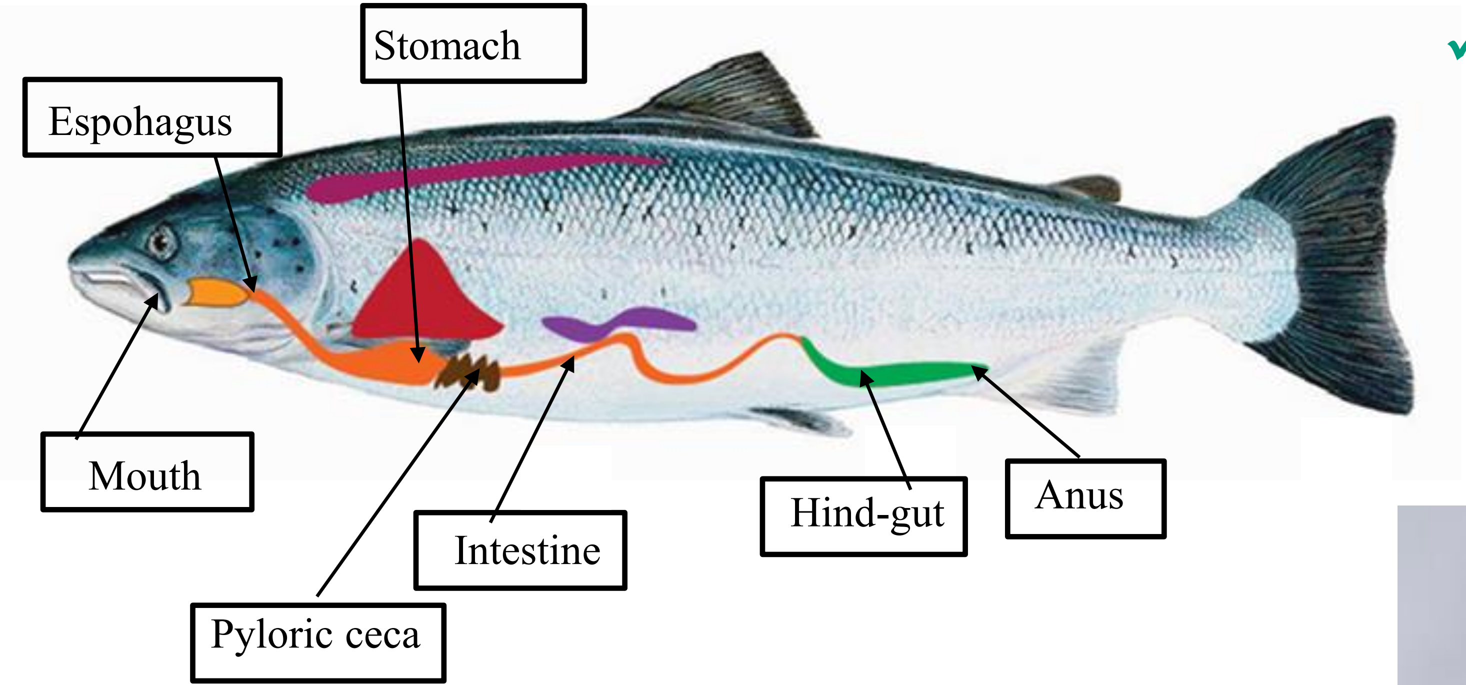
Higher temperature does not increase the protein requirement

Source: Oliva-Teles et al 2020

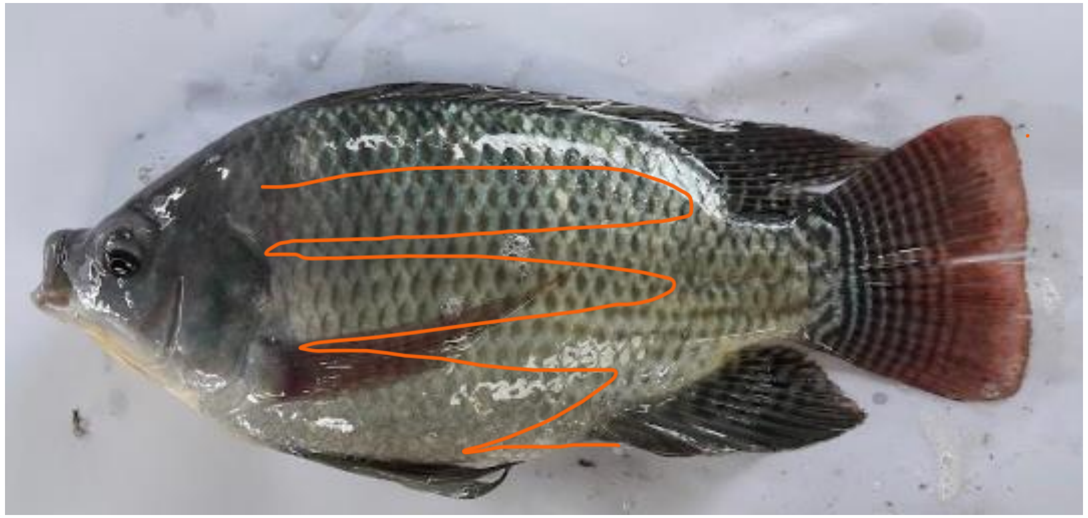
Protein requirements (% diet) & temperature

Protein requirement of the fish

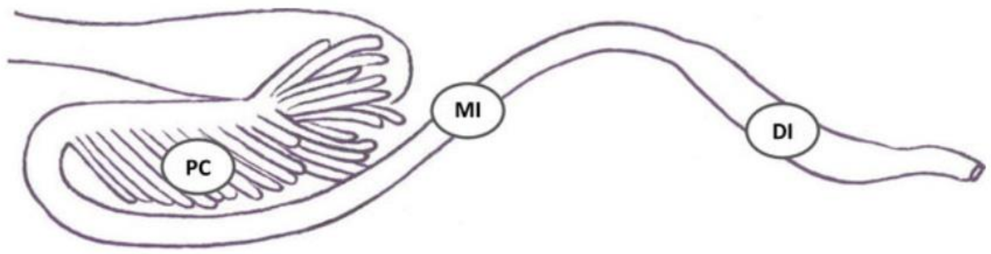
Gastro-intestinal tract (GIT) of the fish

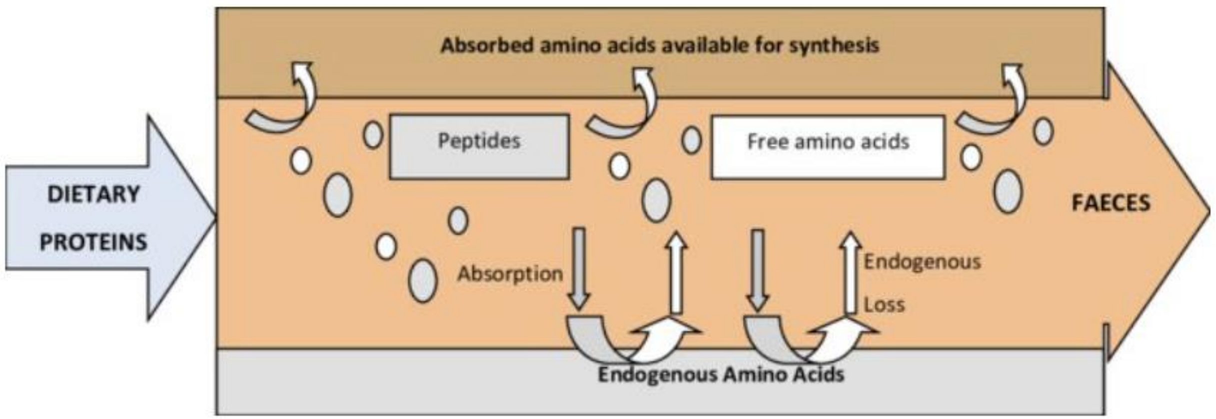


- ✓ Gut:body length :
  Salmon: 0.8 times its body length
  Nile Tilapia: 5-8 times its body length



Protein Digestion Process in Fish





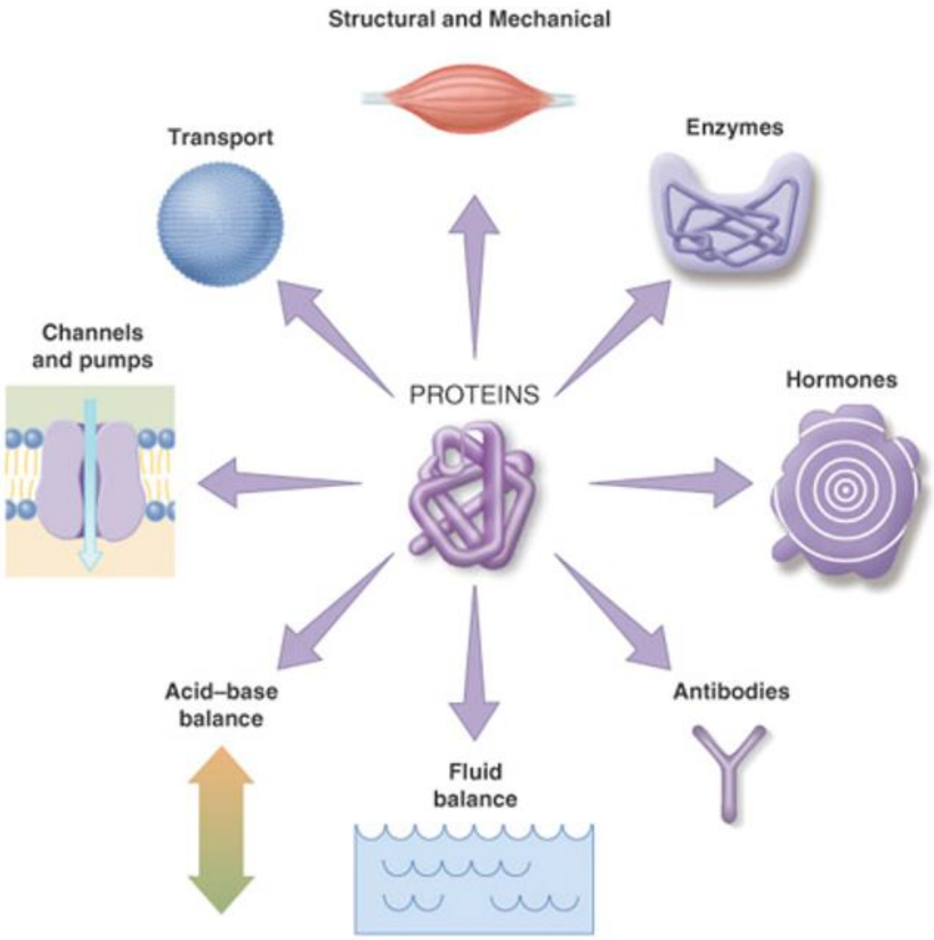
1. **Stomach (low pH):** Pepsin breaks proteins → smaller peptides
2. **Pyloric region:** Mixing with bicarbonate, bile acids, digestive enzymes
3. **Pancreatic enzymes:** Trypsin, chymotrypsin, peptidases break peptides → smaller peptides & amino acids
4. **Brush border enzymes:** Leucine aminopeptidase and others break peptides → amino acids
5. **Absorption:** Amino acids and small peptides absorbed via transporters (Na-dependent & Na-independent) into bloodstream

3. Amino Acid Absorption at the Brush Border

Source: M A Kabir Chowdhury/ Guro Løkka

Why do fish require protein?

Vital protein functions in the body



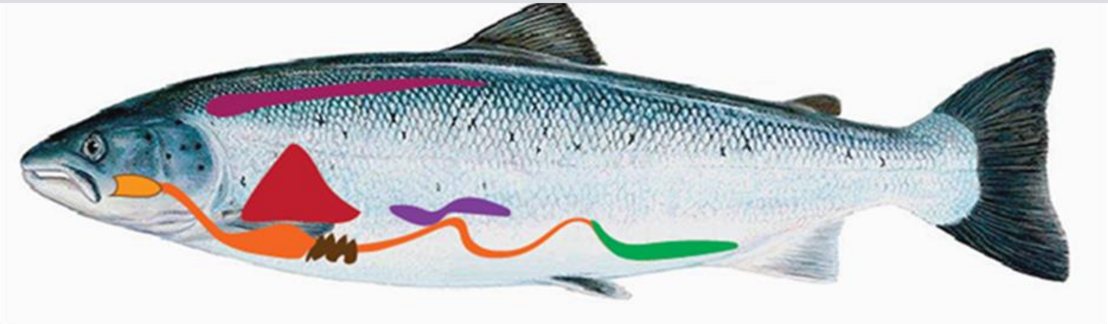
Proteins is required for:

- ✓ Growth & development
- ✓ Tissue repair
- ✓ Maintaining body tissue
- ✓ Source of dietary glucose and energy
- ✓ Optimal health status
- ✓ Many other vital body functions

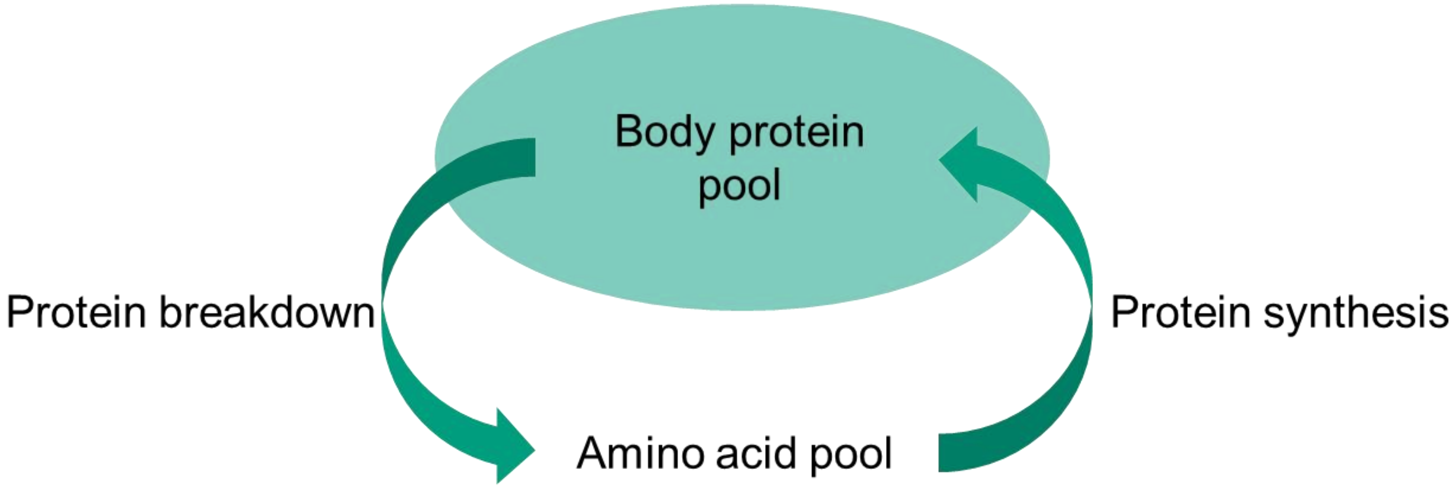
Adapted from Millward, 2012

Protein turnover

After absorbed from the gut, AAs are transported via the portal vein to the liver and enters the AA pool and where they are used for protein synthesis and broken down and reused for other proteins or molecules or deaminated and used as a source of glucose or energy



- Continuous breakdown and
- resynthesis of body protein



Protein requirement of the fish

Fish **do not require protein to grow**, but they need a mixture of well balanced amino acids, such as essental, semi-essential and non-essential amino acids from the feed.

Essential amino acids

1. Arginine*
2. Histidine*
3. Isoleucine
4. Leucine
5. Lysine
6. Methionine
7. Phenylalanine
8. Threonine
9. Tryptophan
10. Valine

Semi essential amino acids

Cystein → Methionine

Tyrosine → Phenylalanine

Non-essential amino acids

1. Alanine
2. Asparagine
3. Aspartic acid (Aspartate)
4. Cysteine
5. Glutamic acid (Glutamate)
6. Glutamine
7. Glycine
8. Proline
9. Serine
10. Tyrosine

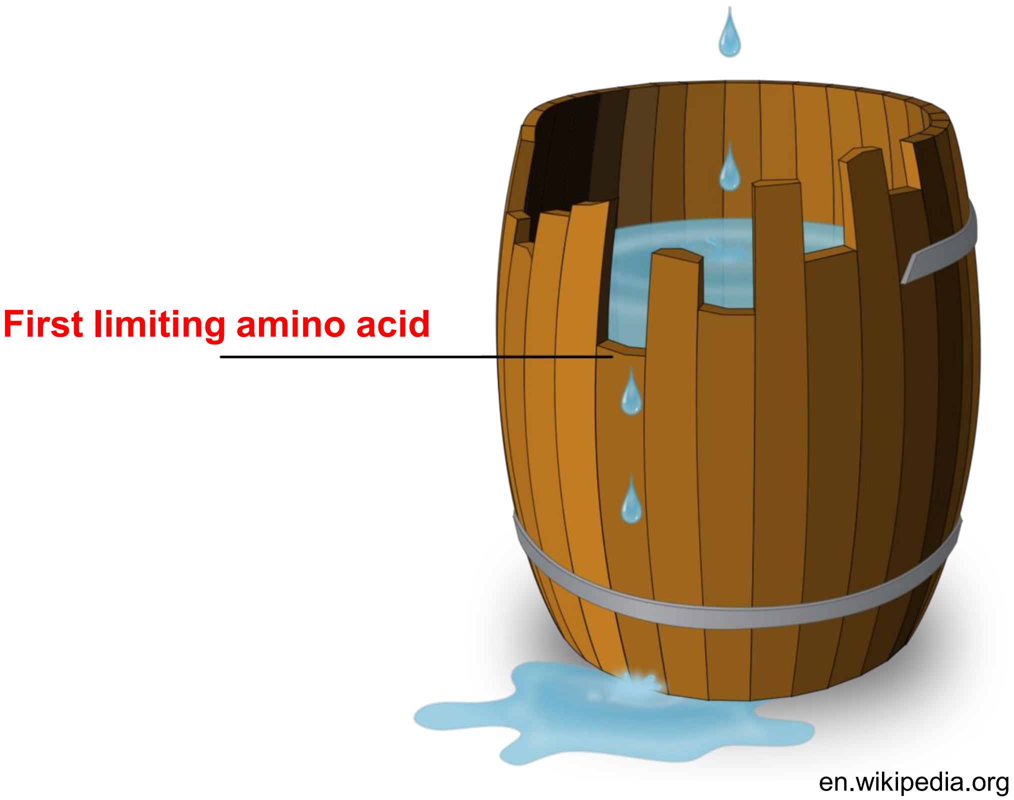
Important physiological function: Ex Arg, Tau, His

Large biological role: immunity, osmoregulation, antioxidation, cell membrane stability, neurotransmission, vision & many other functions.

Rain Barrel Concept

To grow, fish need a constant supply of AA from the diet, because protein synthesis will only proceed as long as all the AA are present

Protein growth requires that the right amino acids are present in the right amount and in the right balance compared to the requirement.



- The barrel represent the protein growth
- Each stave represent the individual AAs requirement.
- You can only fill the barrel (growth rate) to the level of the shortest stave, then the water will start to leak
- If one amino acid is limited, the protein synthesis can only proceed to that level and then stop

Evaluation of protein requirement of the fish

Dietary amino acid requirement for fish

To formuate the feed we need to know the fish's overall requirement for maintenance and production

Maintenance amino acid (AAs) requirement + **Production** e.g. growth

The amount required to replace protein & AAs losses:
- ✓ from the gut after a meal
- ✓ from body turnover and oxidation of AAs
- ✓ from skin & scales
- ✓ Used for synthesis of non-protein products

The amount required to:
- ✓ Support optimal growth
- ✓ (reproduction)

Methods to determine maintenance requirement for nitrogen (protein)

Maintenance requirement is determined by 2 methods:

1) Direct method – measuring N balance during fasting:
   - ✓ by measuring all N-losses in feces, urine, skin and gills (measuring NH_3 and CO_2 in water).

   – the requirement is the amount of N (protein) needed to replace the total losses

2) Indirect method – by measuring N-retention of fish at end of a dose-response trial when feeding increasing levels of protein.

   – the maintenance requirement is the protein intake at zero weight gain (when the curve flattens out).

Protein or AA requirement – by emperical method - Dose response studies

- Principle:
  - Measure growth when feeding graded level of protein or AAs.
  - The requirement is the minimum level of AA required for maximum growth, where the curve reaches a plateau

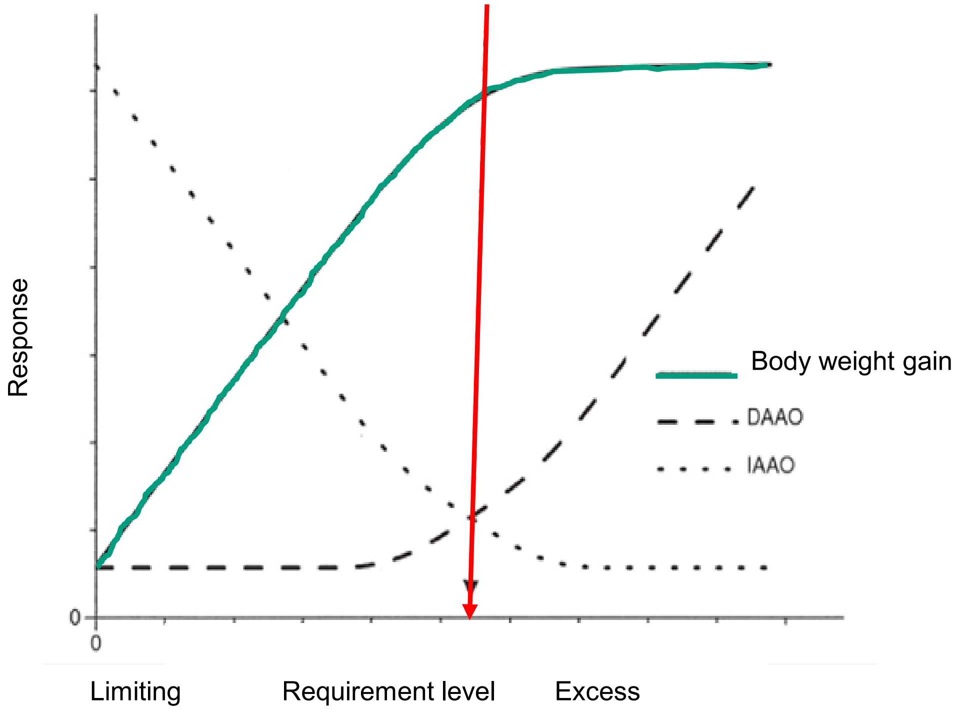


Figure: Levesque and Ball, 2013. Annual Review of Nutrition, 23: 101-116.

Dose response method

Basal diet:

- Feeding a balanced diet, deficient in protein or the test amino acid, which is fed below and above requirement
- Requirement is the break-point
- Fine tuned by the broken line model

Nitrogen balance studies at optimal growth:

- Indirect method: Slaughter technique – total N intake from feed, total weigh gain and changes in N composition of the fish during the experiment
- Direct method: N intake from feed minus N losses in feces, gills and urine at optimal growth

Principles of the factorial method

This is an **experimental approach** to estimating protein / AA requirements.
The focus is on the **step-by-step determination** of how much of the protein / AAs is required for: **Maintenance, Growth**, & **Other physiological functions**

Key Points:

•Determine **maintenance needs** in non-growing fish.
•Determine needs for **growth in** feeding trials.
•Evaluate the **efficiency** of protein / amino acid utilization.

The total requirement:

1. sum of AAs needed for all physiological processes
2. Include efficiency of AA utilization – how well the AAs are converted into body proteins – some are lost in the process
3. Include additional amounts needed for other functions such as stress.

Total requirement: = sum of AA deposited in the body, AA used for maintenance, catabolic losses and losses in feces.

Limitation to the factorial method

✓Often results in estimation of one amino acid at the time
✓Costly and time consuming
✓Assume no interaction among amino acids and other nutrients

Limited by both biological and dietary factors:

.

Dietary factors

1) Composition of the experimental diets
   - Energy density – DP:DE ratio
   - Protein source used in reference diet
2) Feeding level
3) Taste of the diet

Biological factors

1) Weight of fish
2) Growth rate of the fish
3) Environmental conditions
4) Genetic make up
5) Stocking density, health status

- Improved model: Takes into account dietary and biological factors that influence EAA utilization

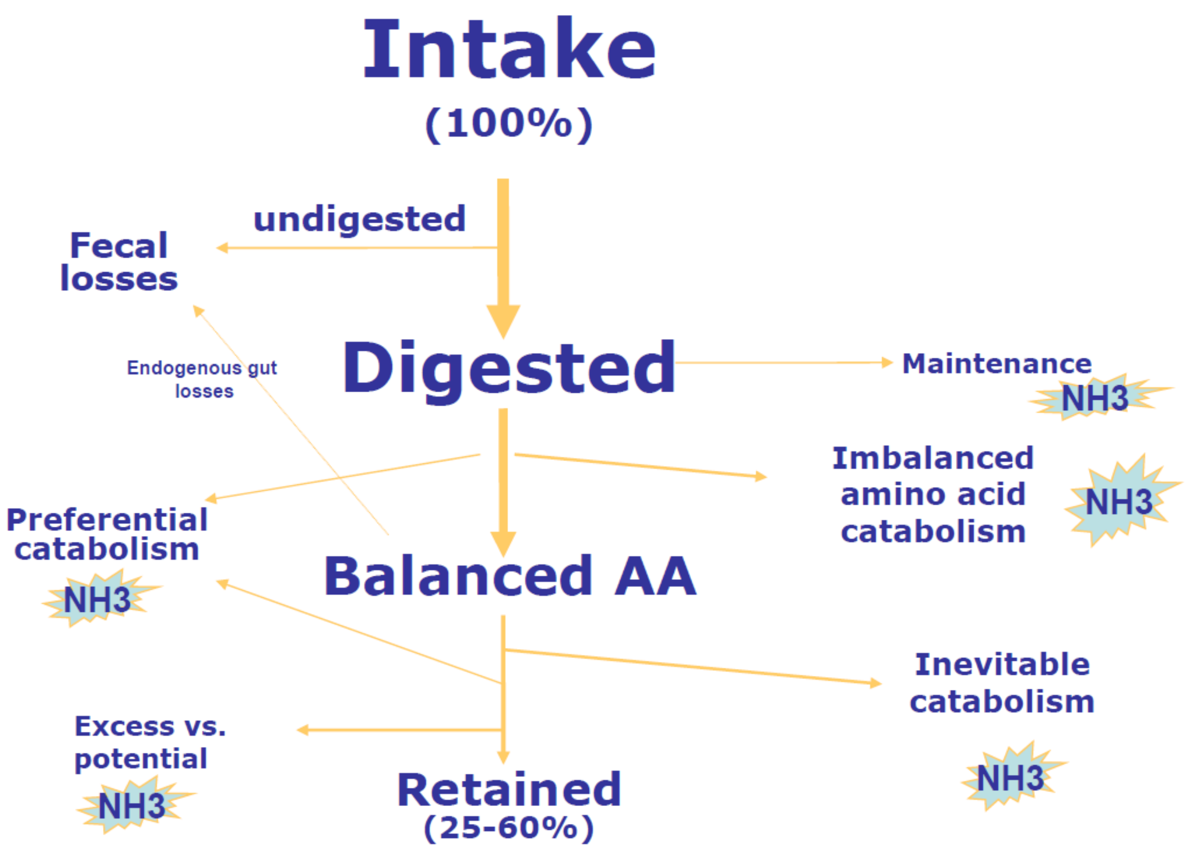
  More precice diet formulations

Source: Hua & Bureau, 2019, Aquaculture 513, 734440

How do we formulate the diets to meet the requirement?

Factorial model - Predict how much AAs needs to be **supplied in the diet** to meet net requirements after accounting for losses.

Figure: How amino acid are utilized after ingestion



Requirement for growth is what is left after accounting for losses

- ✓ The ingested AA are digested,
- ✓ Some are lost in the feces
- ✓ The rest are absorbed
- ✓ Part of the absorbed AA digested is used for maintenance
- ✓ Part will be catabolized
- ✓ The rest will be used for growth

Ideal protein

Amino acid requirement is a mirror immage of the amino acid pattern in the fish muscle

The requirement of each amino acid is expressed in relation to each other, where lysin is used as the basis

Once the lysine requirment is known, the amino acid requirment is calculated by expressing these in relation to lysine, which is set to 100

Ideal protein concept is also used to evaluate the nutritional value of a protein ingredients

Advantages

- Useful when the AA requirement are only partially known.
- Allows feeding a balanced diet that prevents over- or under-feeding of AA
- Maximizes utilization of protein & minimizes N-excretion
- Minimizes the amount of AA/CP needed in the diets, which reduces production costs & increases profitability.

Ideal protein composition of salmonids.

The ideal AA composition in Atlantic salmon and rainbow trout based on whole body composition, g/100 g.

Amino acid	Atlantic salmon[1]	Rainbow trout[4]
Ala	6.52	6.57
Arg	6.61	6.41
Asp	9.92	9.94
Cys	0.95	0.80
Glu	14.31	14.22
Gly	7.41	7.76
His	3.02	2.96
Ile	4.41	4.34
Leu	7.72	7.59
Lys	9.28	8.49
Met	1.83	2.88
Phe	4.36	4.38
Pro	4.64	4.89
Ser	4.61	4.66
Thr	4.95	4.76
Try	0.93	0.93
Tyr	3.50	3.38
Val	5.09	5.09

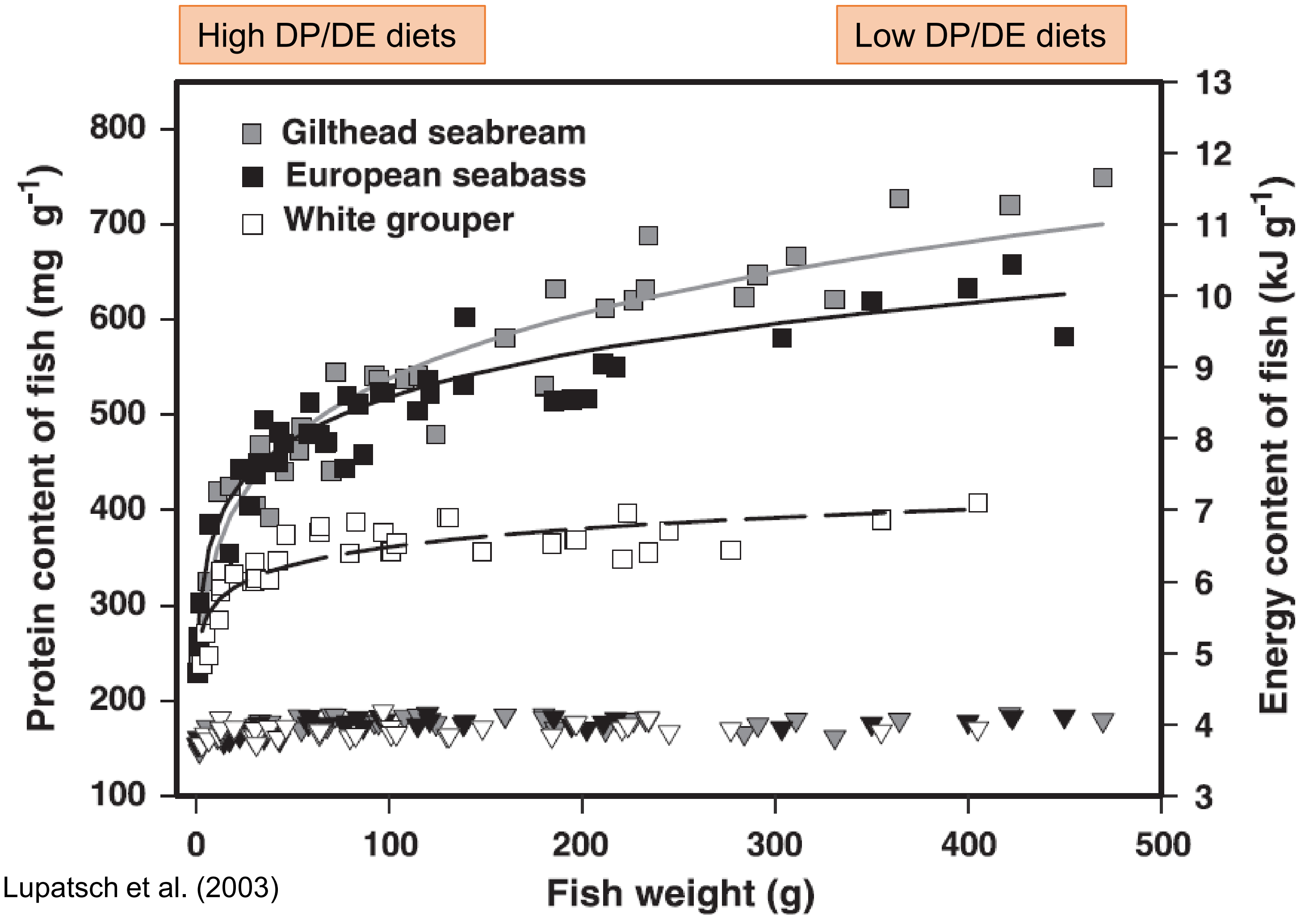
= 100%

Source: Lall and Andresen 2005

The amino acid requirement of fish is given relative to lysine (100%)

Relationship between protein and energy content and fish size v.s. dietary DP:DE ratio

NMBU



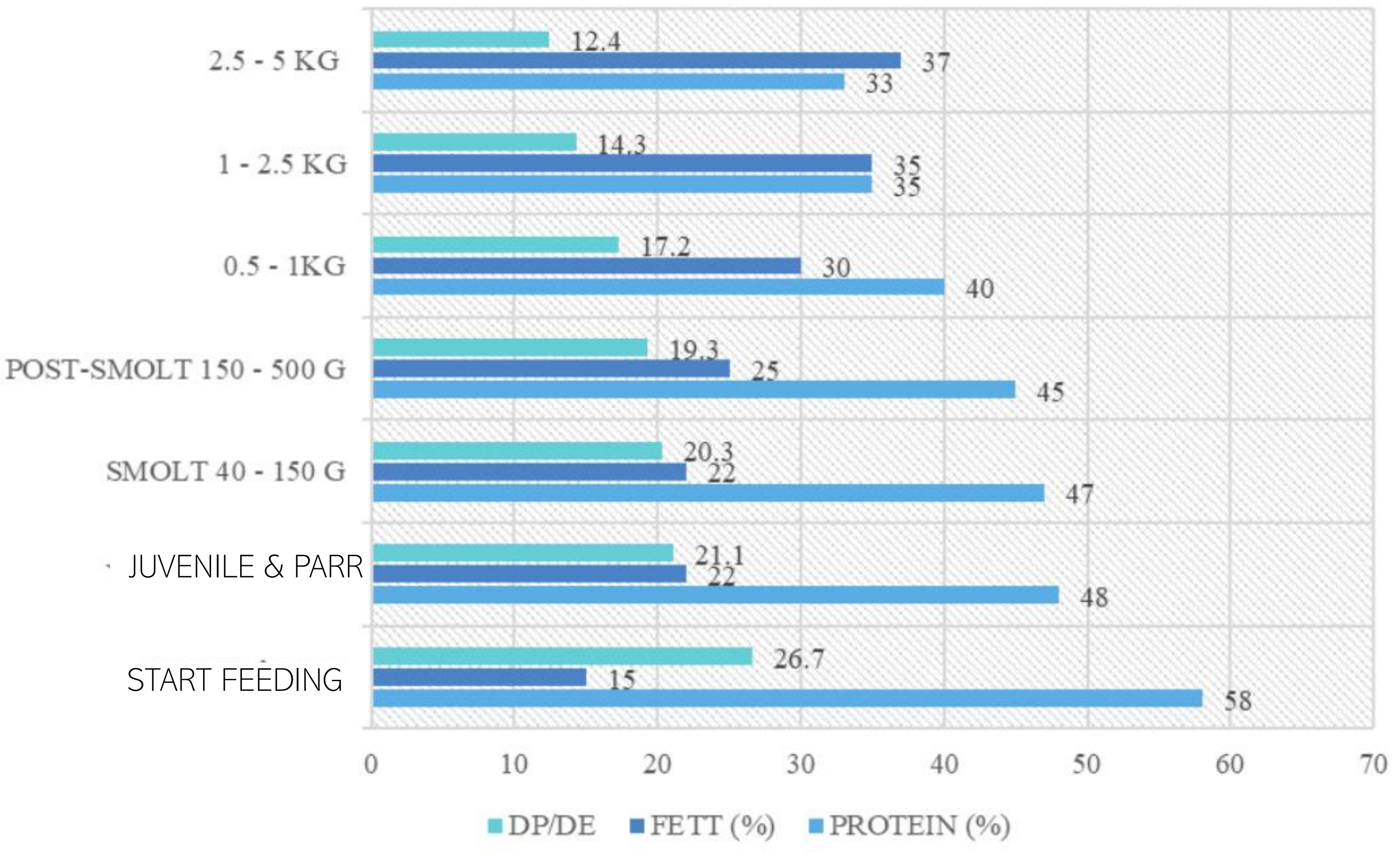
Lupatsch et al. (2003)

Whole-body protein & energy content & fish size

Dietary DP/DE decreases with fish weight due to:

- ✓ Smaller fish have higher growth rates and require more protein for tissue development and growth.
- ✓ The metabolic rate decreases as fish grow.
- ✓ Larger fish have higher capacity to utilize non-protein energy sources from fat and carbohydrates, leading to a lower DP/DE ratio in their diet.
- ✓ The basis to determine the DP:DE ratio of the feed is to know the protein & energy content & digestibility of the raw materials

Dietary DP:DE-ratio in salmon at different life stages



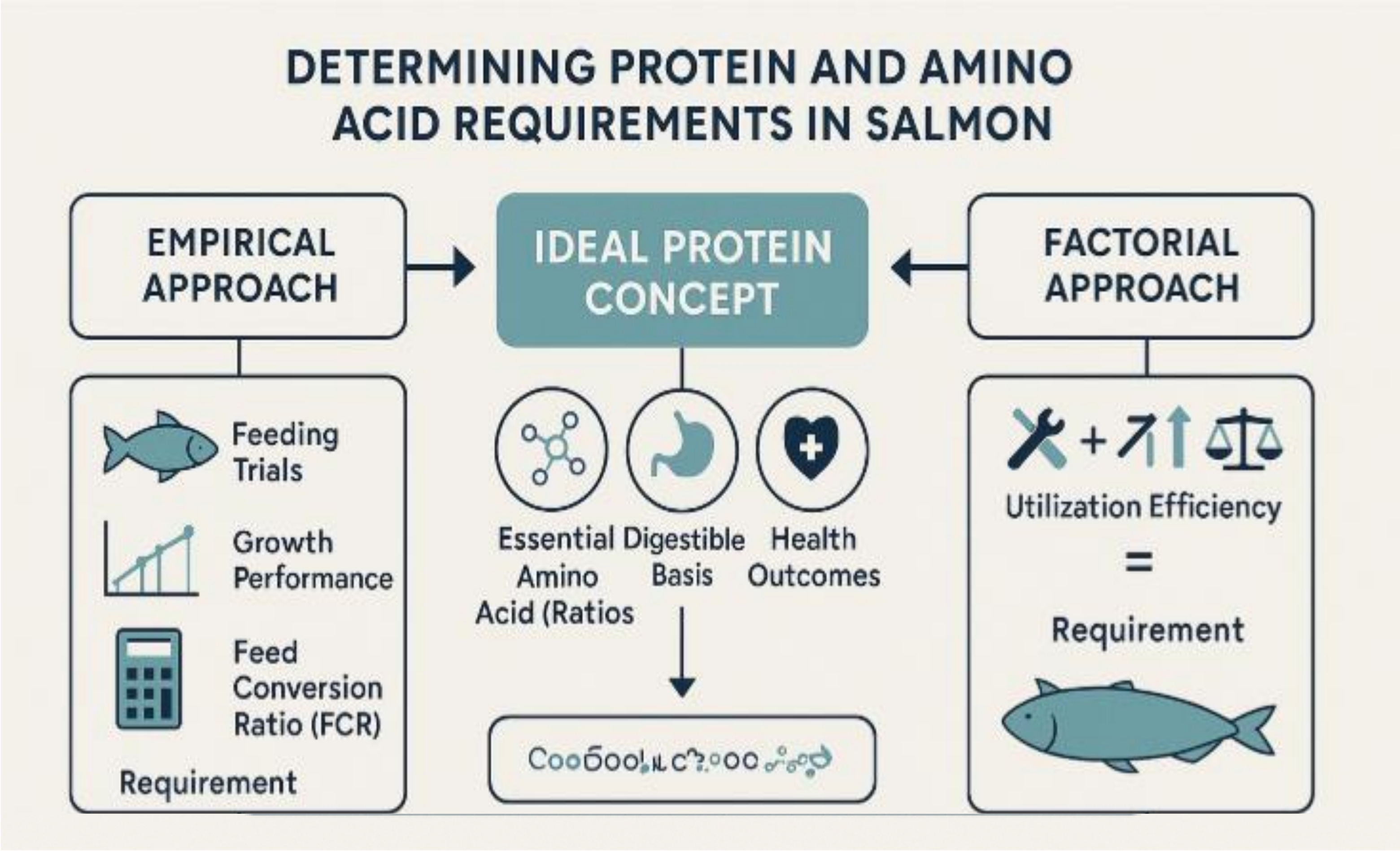
The DP:DE ratio for salmonids:

Juvenile salmon: 26,7 g DP/MJ DE
Larger salmon: 12.4 g DP/MJ DE

Dessen

How to formulate the diets to meet the requirements

Principles for Determining Protein and Amino Acid Requirements



1. **Know the amino acid requirement**
   Expressed as mg of digestible AA / kg of body weigh / day

2. **Formulate diets taking into account:**
   - content of digestible protein and AAs,
   - an optimal DP:DE ratio &
   - the ideal protein concept

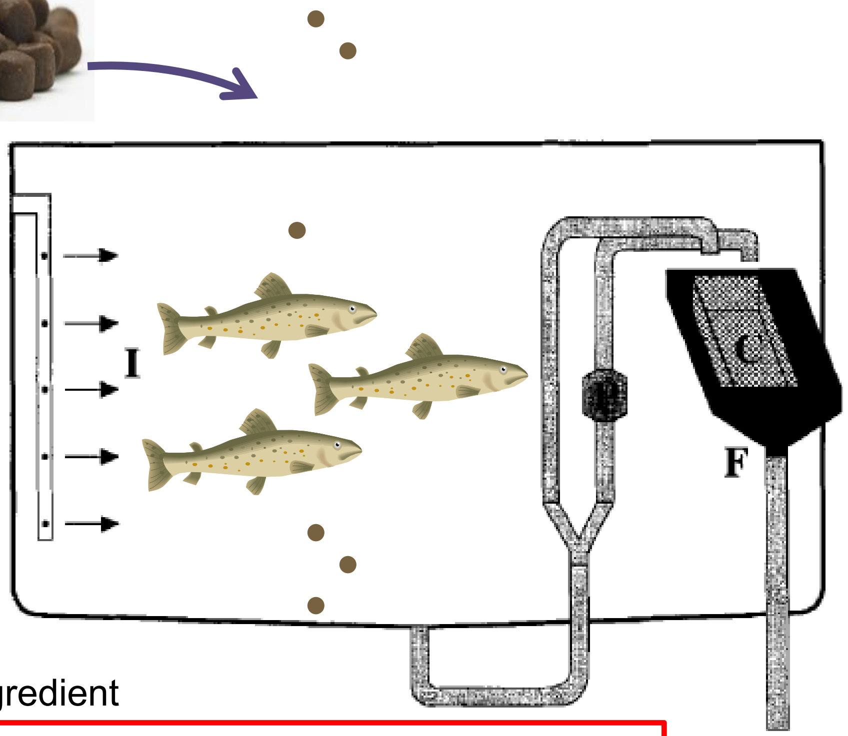
3. **To calculate the concentration of the AA to meet the requirement in the diet, requires knowledge on the feed intake of the fish, expressed as %/day**

4. **The diet is then formulated based on the expected amount of feed eaten per day**

Evaluation of protein quality in the feed ingredients / diets

Methods used to determine protein digestibility

- Feeding a reference diet and a test diet where 30% of the test ingredient is mixed with the reference diet & use of an intert marker (e.g Y_2O_3)



Fecal collection methods

✓ Fecal stripping
✓ Setteling column
✓ Atomatic collection by screen rotation
✓ Dissection

Sources: Shomorin et al., 2019, Aquaculture , 504; 81-87

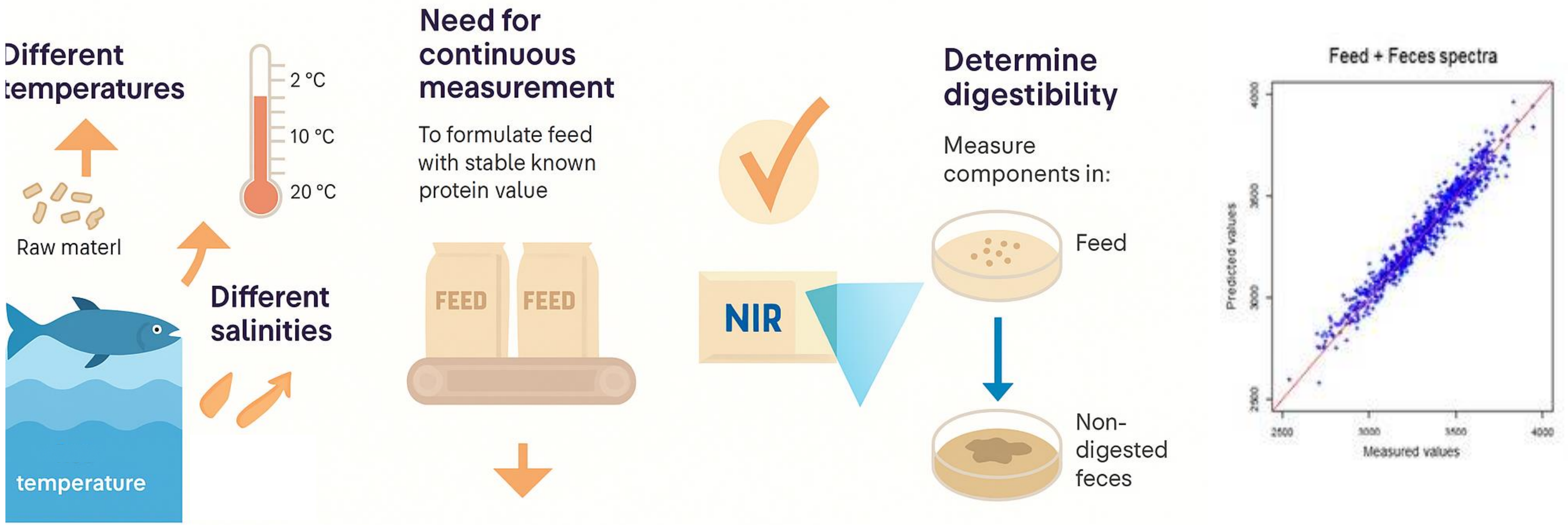
Digestibility of the ingredient

$$ADC_{ingredients}\ (\%) = ADC_{testdiet} + \left(ADC_{testdiet} - ADC_{refdiet}\right) \times \left(\frac{0.7 \times Nutrient_{refdiet}}{0.3 \times Nutrient_{testingr}}\right)$$

$$\frac{\text{Nutrient in feces}}{\text{Nutrient in feed}}$$

Digestibility varies

Between raw material, from batch to batch and with water temperatures and salinity



Nutritional value of common protein ingredients in fish nutrition

Amino acid composition of common protein feedstuffs, g/100 g protein

	Fish meal[1]	Soy protein concentrate[2]	Pea protein concentrate[3]	Canola protein concentrate[2]	Wheat gluten[1]
Crude protein	74,9	70,2	49,6	59,5	89,3
Arginine	5,27	6,41	8,74	5,11	3,26
Histidine	1,87	2,5	2,65	2,42	1,74
Isoleucine	3,69	4,14	4,32	3,62	3,37
Leucine	6,26	6,64	7,21	6,18	6,49
Lysine	6,92	5,53	7,07	4,38	1,57
Methionine	2,42	1,18	0,9	1,7	1,92
Phenylalanine	3,37	4,45	4,73	3,57	5,69
Threonine	3,65	3,52	3,73	3,67	2,54
Tryprophan	0,73	1,14	0,99	1,16	0,76
Valine	4,03	4,06	4,66	4,29	3,71
Total EAA	38,2	39,6	45,0	36,1	31,0

Source: [1]Storebakken et al., 2015, Aquaculture, 448, 2014-2018; [2]Zhang et al., 2012, Aquaculture, 360-361, 25-36;
[3]Øverland et al., 2009, Aquaculture 288, 305-311

Digestibility of common protein sources for salmoninds

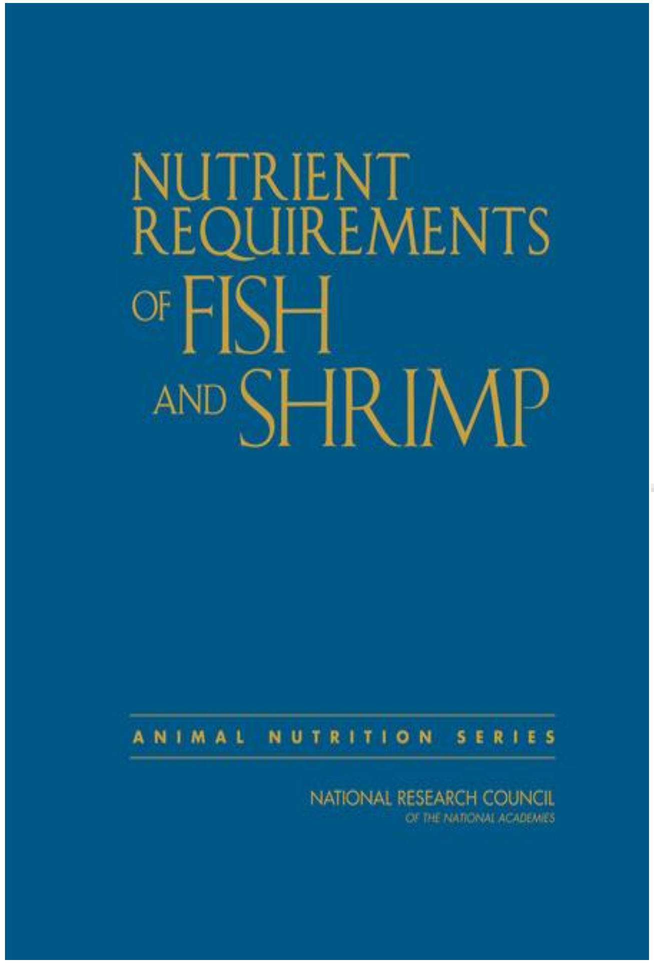
Digestibility of protein and amino acid for salmoninds in selected common protein sources, %							
	Fish meal	Soy protein concentrate	Wheat gluten	Corn gluten	Rapeseed meal	Pea protein	Mycelium[2]
Crude protein	89	96	100	92	75	99	86.5
Lysine	95	97	95	91	88	100	93.8
Methionine	97	97	97	92	87	100	91.5
Threonine	94	93	94	93	90	99	88.4
Isoleucine	97	96	92	91	85	98	90.5
Leucine	99	97	97	97	92	97	91.1
Valine	95	95	94	94	87	98	89.7
Histidine	94	96	95	96	96	93	92.0
Phenylalanine	93	95	97	95	90	93	-
Tyrosine	98	99	96	95	90	98	-

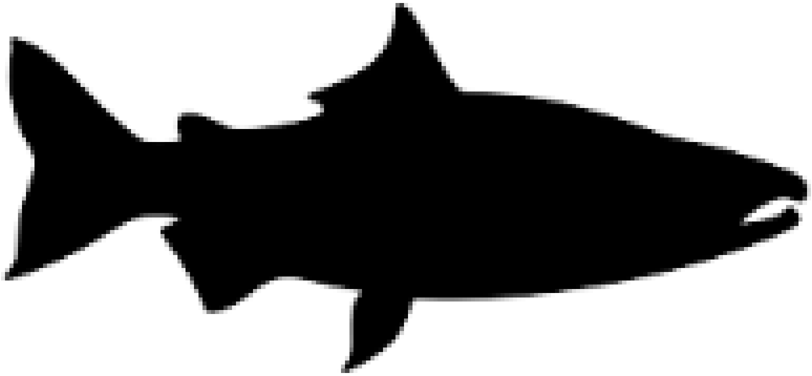
Source:
[1]After **Barrows et al., 2011**. Database of Nutrient Digestibility's of Traditional and Novel Feed Ingredients for Trout
[2]**Gaudhaman et al., 2025.** Fungal Protein from Non-Food Bioresources in Diets for Rainbow Trout (Oncorhynchus mykiss). Fishes

Protein requirements of fish

Atlantic salmon

National Research Council - NRC, 2011:



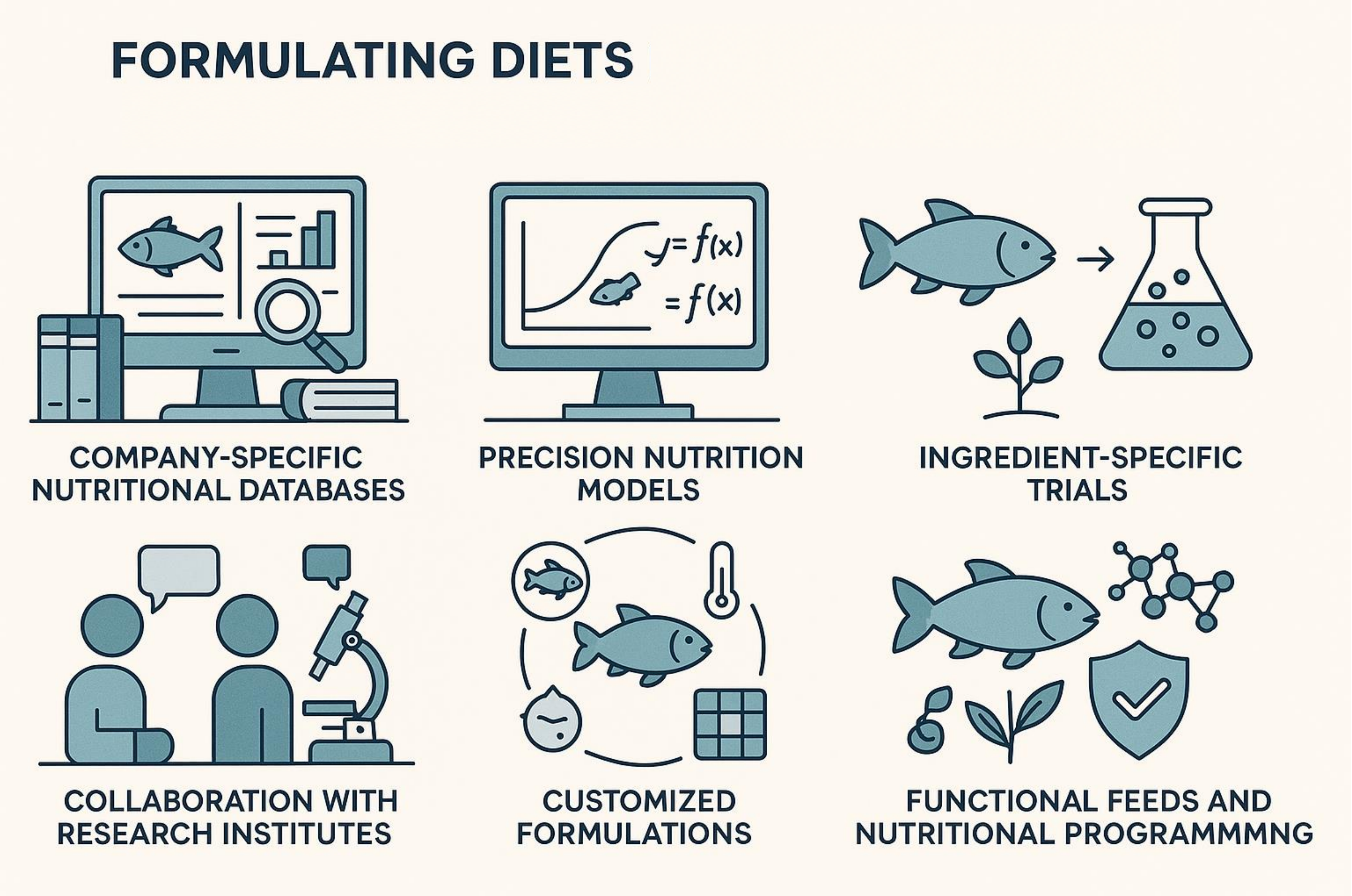


Limitations

- AA requirement for Salmon is not well known.
- Old and not relevant for modern genotypes
- Mainly performed on juveniles
- Established based on LT-fish meal diets, less relevant for plant-based diets
- AA requirement is often based on growth performance, don't take into account other metabolic needs.

www.nap.edu

Major feed companies have developed their own company-specific database



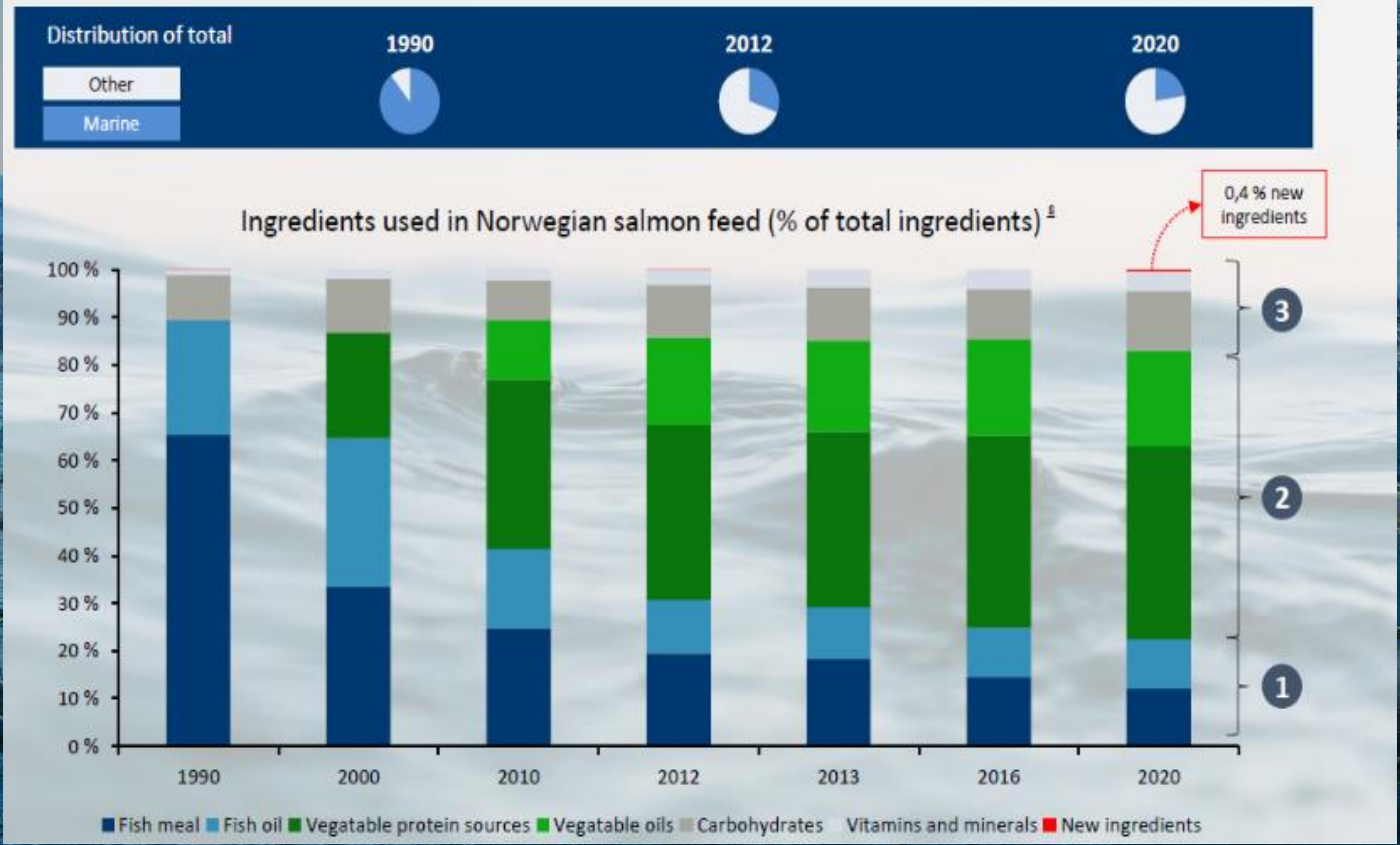
1. Nutrient requirement
Extensive in-house trials.
Field trials
Published scientific literature,
Precision Nutrition Models

2. Regulatory and Market Requirements

Choice of feed raw materials to meet the protein requirement & future perspectives

Fish meal and fish oil

Changes in the salmon feed composition



Source: Aas et al., 2022

From marine to land – the new salmon feed
Common plant-ingredients in fish feed





Soy
- 45% crude protein
- 4-6% fiber
- Oligosaccharides
- Protease inhibitors
- Saponins,
- Phytic acid
- Phytoestrogens

Rapeseed
- 35% crude protein
- High in fiber
- Glucosinolates
- Sinapine, tannins
- Phytic acid

Sunflower
- 38-40% crude protein in dehulled meal
- 15-20% fiber
- Low ANFs & no trypsin inhibitors

Peas
- 25% crude protein
- High in starch
- Low level of ANF

Field beans
- 30% crude protein
- Fiber-rich hull fraction
- Low level of ANF

Other sources: Wheat and maize gluten (60% crude protein),
Plant by-products: brewer and distiller grains

Source. Pictures from google.com/images

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Plant ingredients

Plant ingredients are abundant and cheap and relieve pressure on wild catch for fish meal production

Strengths

- Available in large quantitie at a low cost
- Large potential to improve nutritional value through targeted processing
- New advances in fermentation technology provide new opportunities

Barriers

- Low nutrient density / high fiber content
- Unbalanced amino acids composition
- Low palatability
- Contain a wide range of anti-nutritional factors
- Competition for food, feeds and non-food products such as biofuels
- Increased pressure on land and water resources
- Increased use of pesticides & herbicides
- Social and environmental sustainability

Norwegian governments' sustainable feed mission

We need to produce enough feed, sustainably, to meet the demands of aquaculture

Sustainable and cost-effective feeds are essential for advancing aquaculture in the future

92% of the salmon feed raw materials is imported.

Feed accounts for 75-83% of greenhouse gas emissions in salmon production (before transport to market).

Political goals: By 2034, all feed should come from sustainable sources , and preferably produced locally.

Need to adapt a more circular feed system.

Several promising sources of future feed raw material

Future ingredients can be categorized into harvested novel marine and plant-based ingredients, farmed organisms and underutilized resources

Harvested resources

Farmed organisms

Underutilized resources

Novel marine ingredients
- Mesopelagic fish
- *Calanus finmarchius*
- Krill

Plant by-products**
- Fermented soybean meal/rape seed meal

Insects
- Black soldier fly
- Mealworms

Marine low-trophic species
- Blue mussels***
- Polychaeta
- Gammaridae
- Tunicate
- Seaweed

Microbial ingredients
- Bacteria
- Yeast
- Fungus
- Heterotrophic microalgae

Photoautotrophic microalgae****

Land animal by-products*****
- Poultry
- Pork

Marine by-products
- Whitefish
- Pelagic fish
- Aquaculture*

Rethinking on how we feed the fish

Norwegian University of Life Sciences

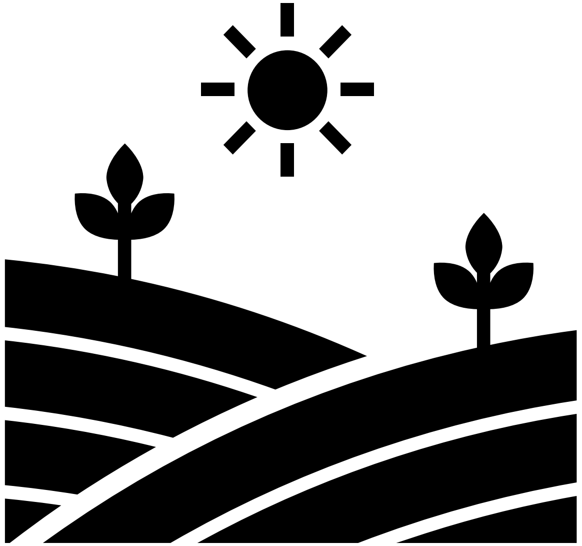
Sustainable feed is the key to future growth

Shift from linear to circular systems

"Circular feeds" a holistic approach to produce feed that prioritizes sustainability, resource efficiency, and environmental responsibility.

Shift from Linear to Circular Systems

Optimizing resource use, minimizing waste, and promoting sustainability along the feed value chain

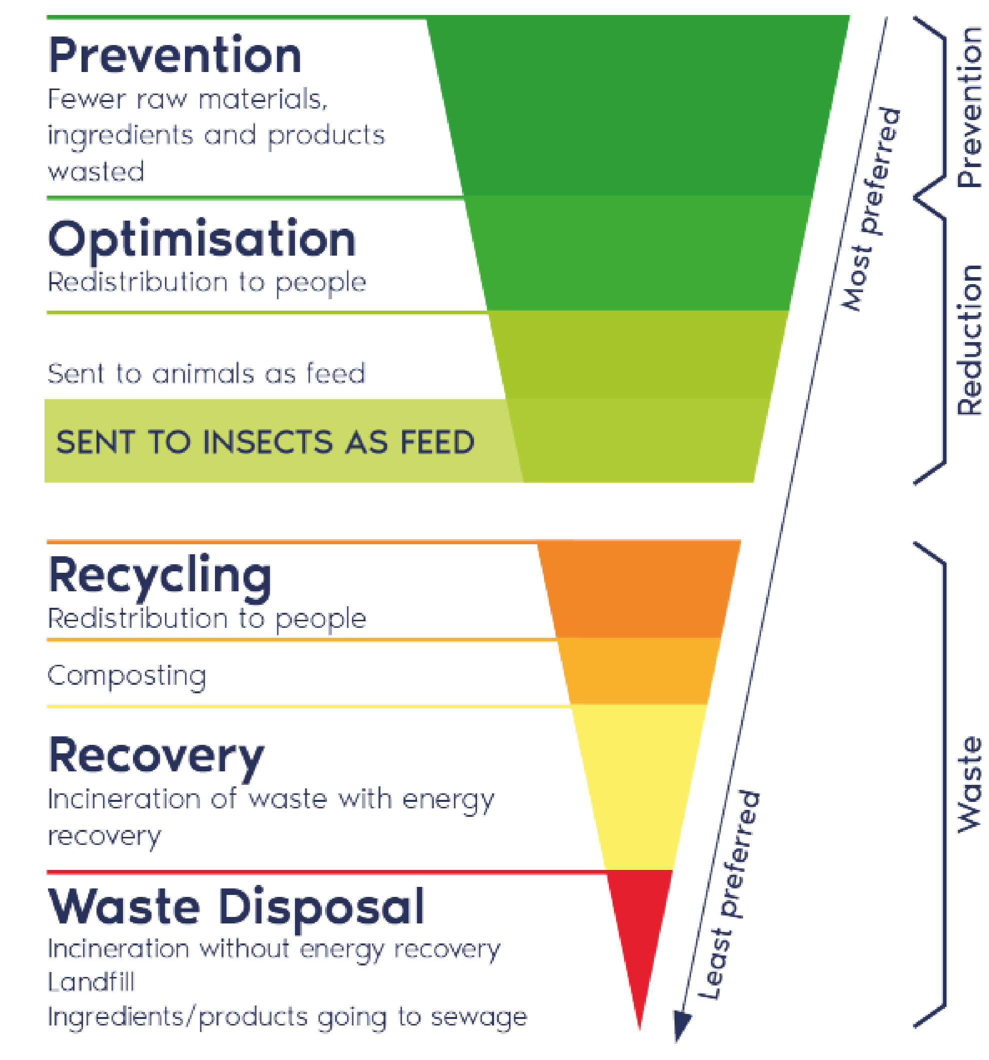


- ✓Facilitate **circular economy** by adopting **nutrient recycling**
- ✓Use side-streams and low value biomass to maximize circularity

Norwegian University of Life Sciences

Moving towards a circular food system

Insects & microbes can add a new layer to the waste hierarchy



✓ Use of **insects** to convert pre- and post-consumer food waste streams into high-value protein and energy sources for aquafeed

✓ Upcycling biomass to high-value aquafeeds by **microbial** biocoversion

✓ Use of innovative **fermentation processing** to increase nutritional value of crop by-products

From Forest to Fjord: Rethinking Fish Feed in a Changing World

Norwegian University of Life Sciences

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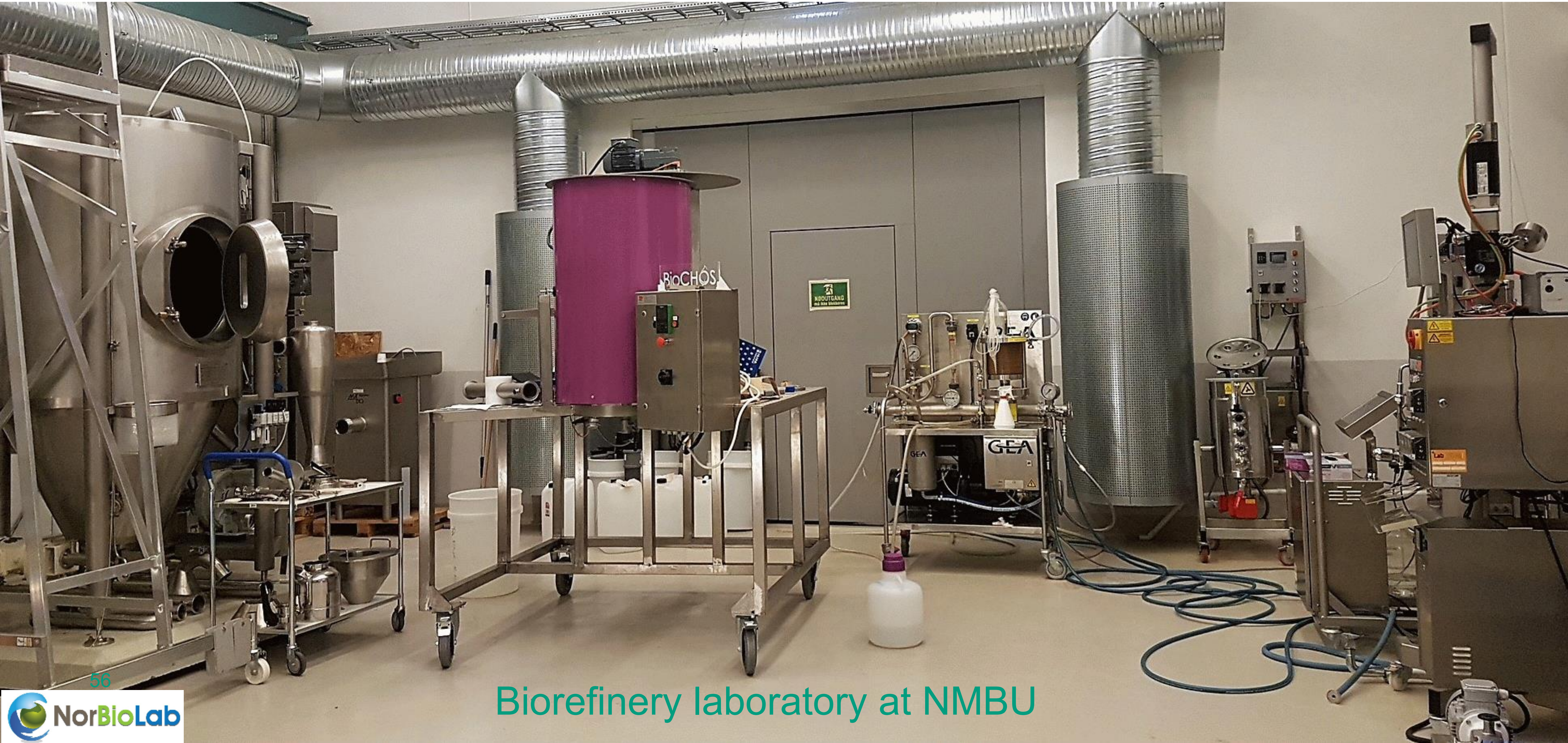
Yeast fermentation on small scale at NMBU



Biorefinery laboratory at NMBU

NorBioLab

Microbial ingredients in diets for salmon

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Foods of Norway achieves large-scale production of yeast from trees

NMBU

Borregaard

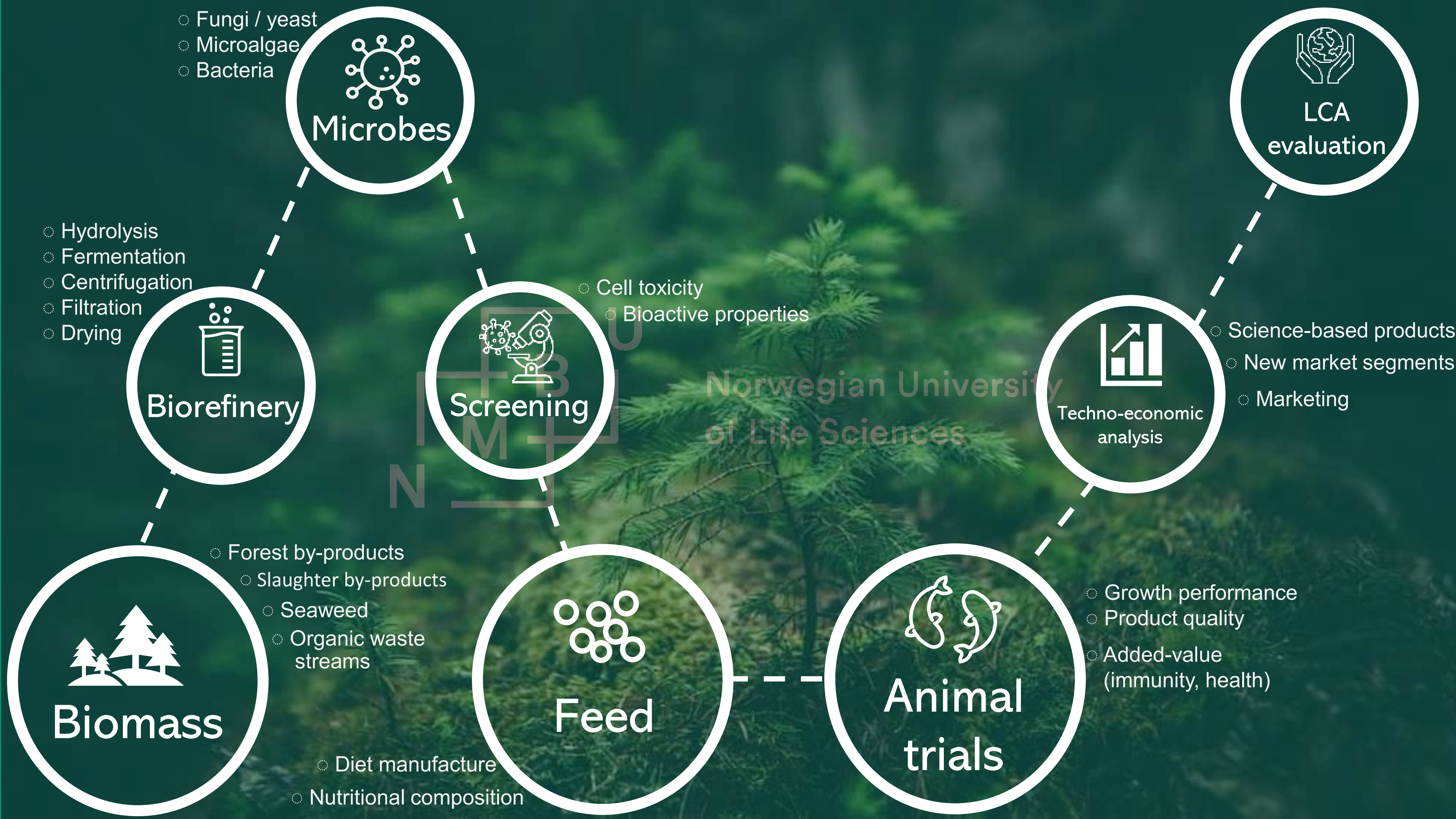
LALLEMAND

BioMar

NMBU Norwegian University of Life Sciences

VIKEN SKOG

FOODS of NORWAY



Microbes
Fungi / yeast
Microalgae
Bacteria
Biorefinery
Hydrolysis
Fermentation
Centrifugation
Filtration
Drying
Screening
Cell toxicity
Bioactive properties
LCA evaluation
Techno-economic analysis
Science-based products
New market segments
Marketing
Biomass
Forest by-products
Slaughter by-products
Seaweed
Organic waste streams
Feed
Diet manufacture
Nutritional composition
Animal trials
Growth performance
Product quality
Added-value (immunity, health)

NORDIC FEED

Lead: M. Øverland, NMBU
Partners. SLU, Natural Resources Institute Finland, Biomar, enifer
Vattenbrukscentrum Norr AB, Sweden
Duration: 2019-2025
Finance: 12 Mill NOK, Nordforsk

ForestFeed

Lead: M. Øverland, NMBU.
Partners. SLU, enifer, Finland, Inst. for Food and Env. Research, Germany
Duration: 2024-2027
Finance: 14 Mill NOK, Bioeconomy in the North

FOODS OF NORWAY

Research

Innovation

Education

Foods of Norway 2.0 feeds a knowledge platform for sustainable feed solutions

Norges miljø- og
biovitenskapelige
universitet