Scottish Aquaculture Innovation Centre

The Future of Food

scottishaquaculture.com

Zero Waste Scotland, 19 November 2020

The future of food – the Scottish opportunity

ZERO WASTE SCOTLAND

Scottish Aquaculture Innovation Centre

Sam Houston, 19th November 2020

SAIC's innovation programme is delivered through three key workstreams:

DRIVING INNOVATION

Enabling research & development and collaborative projects

NURTURING INNOVATION

Supporting the next generation of innovative leaders

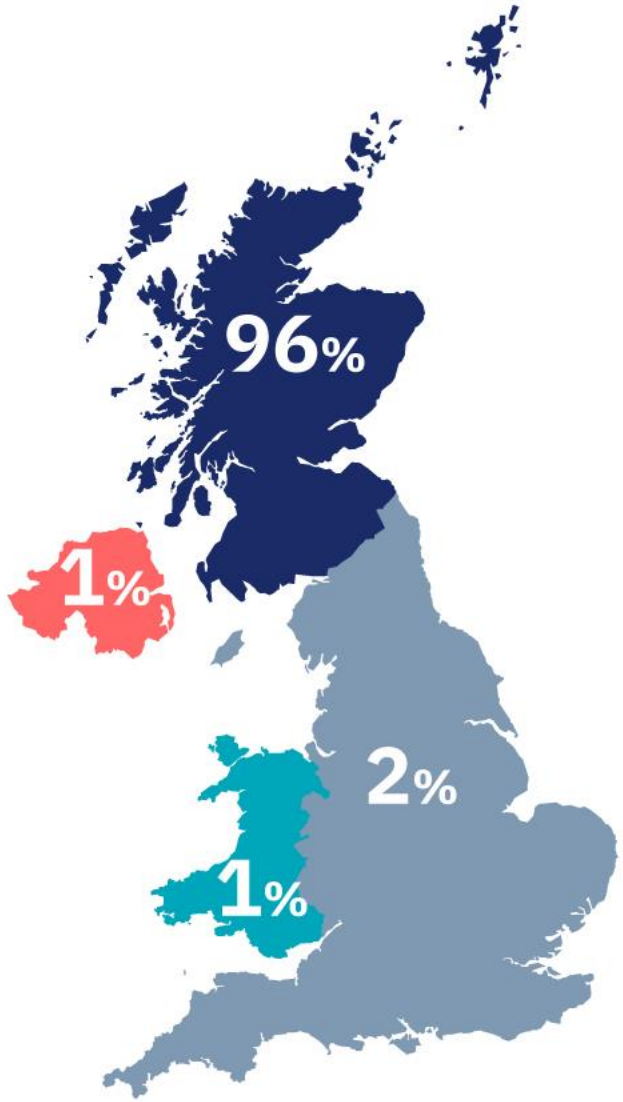
SHARING INNOVATION

Facilitating knowledge exchange, networks and events

Content

Focus on the salmon sector

1. Overview of Scotland's salmon sector
2. Protein and fish nutrition
    1. Fundamental concepts
    2. Current protein sources
    3. Evaluation of ingredients
3. Circular economy and aquaculture

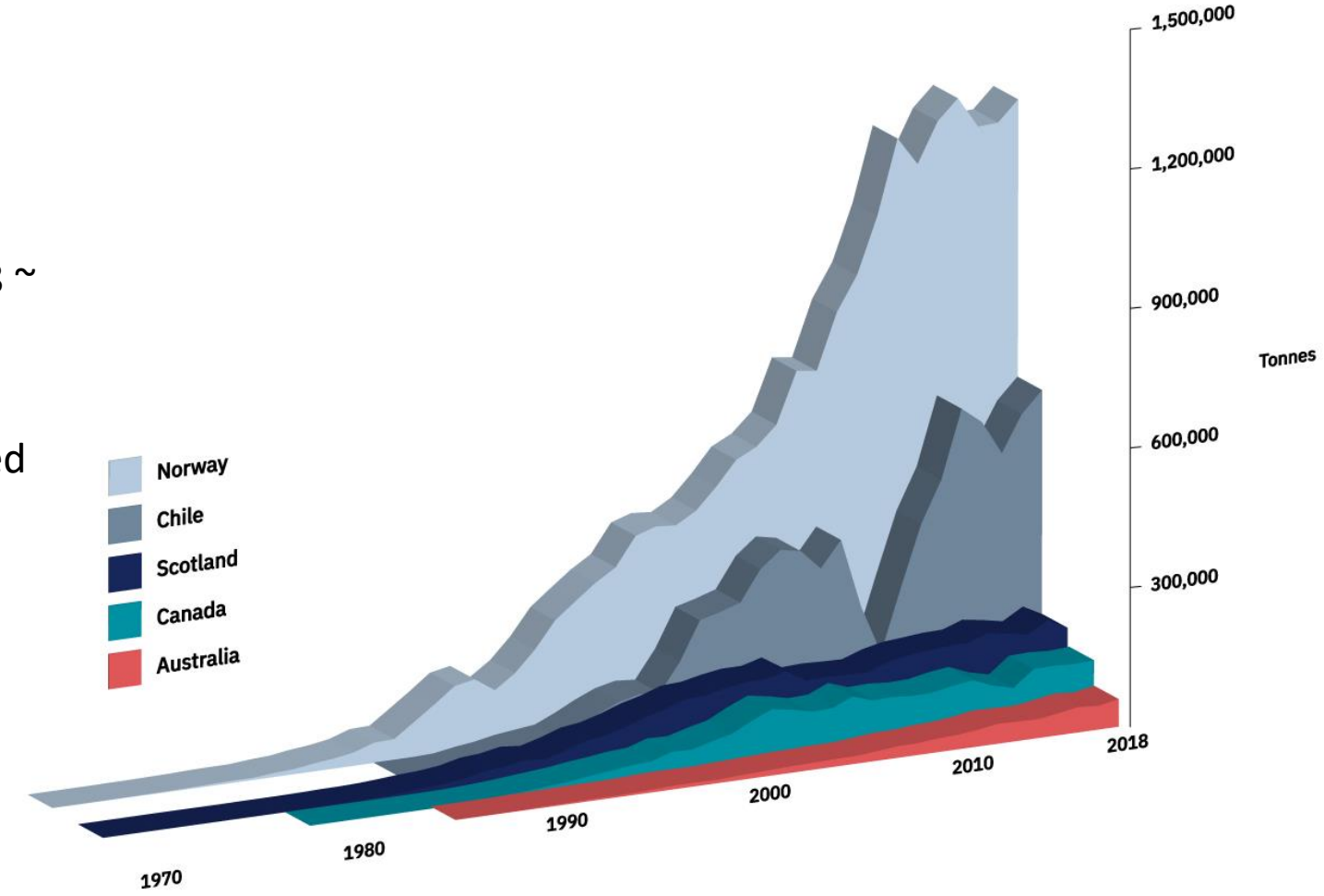


2017 UK aquaculture – value share

Four leading salmon producers

Norway, Chile, Scotland and Canada

- Salmon production of the five leading producers, with peak numbers illustrated
- Global Atlantic salmon production in 2018 ~ **2.44 million** metric tonnes (FAO, 2018)
    - Leading five countries **94%**
- 2019: first time > **200,000** tonnes produced by Scotland



Ambition and values

Scottish Salmon
A Better Future For Us All

Aquaculture Growth to 2030

- Aim to double the value of aquaculture to Scotland's economy by 2030
- Establish as core growth sector in Scotland
- 18,000 jobs in 2030
- rship group for
- on sites to trial ogies

SSPO Sustainability Charter

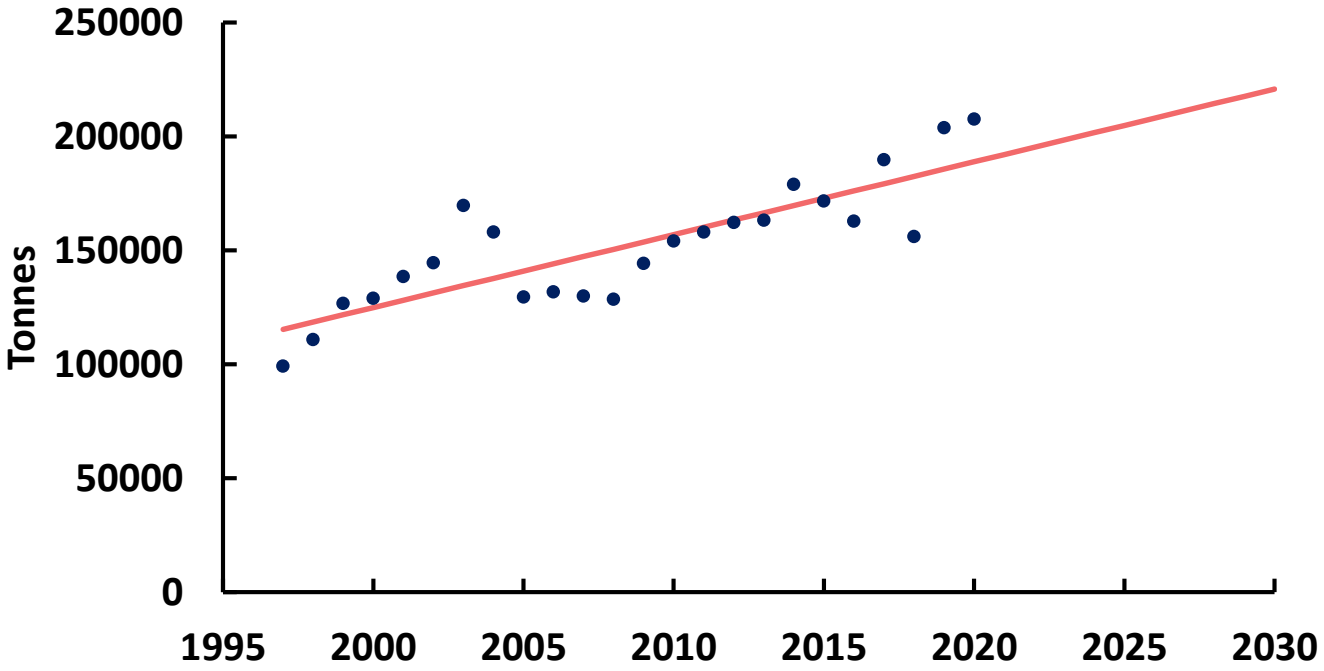
Published 10 November 2020.

Outlines environmental and social commitments:

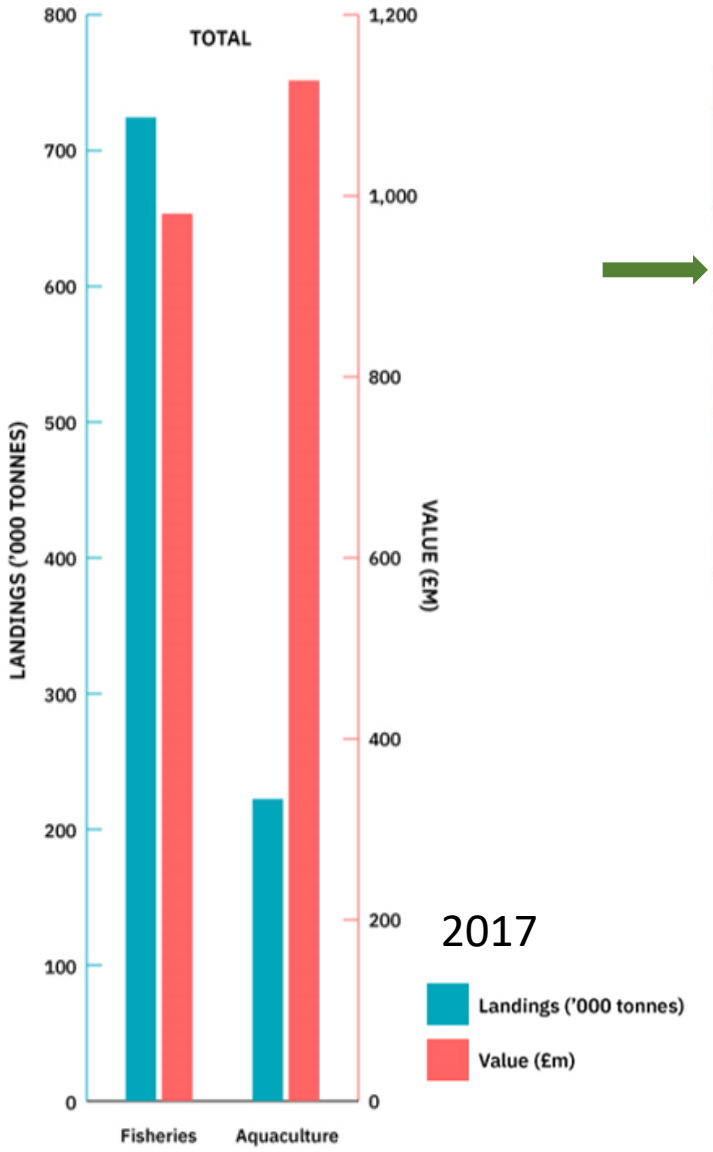
- 100% renewable energy use
- A circular economy for organic waste
- 100% sustainable feed ingredient
- 100% reusable, recyclable or biodegradable packaging
- Explore the potential of new technologies to capture fish waste from marine farming

Scottish salmon production and forecast

- Scottish salmon **production** (Marine Scotland 2020) with a **forecast** until 2030
- Rate of growth = **3,196** tonnes per year
- Model suggests mean annual production in 2030 = **220,762** tonnes
  - Or a CAGR of **2.0** %



UK aquaculture



UK EXPORTS

TOP 10 PRODUCTS				
	2019	Change		
		Value	Value (%)	Volume (%)
Whisky	£5.0bn	£209.6m	4.4%	2.0%
Salmon	£832.6m	£187.7m	29.1%	24.6%
Chocolate	£775.7m	£24.7m	3.3%	6.2%
Cheese	£707.7m	£32.1m	4.8%	9.3%
Gin	£674.9m	£54.6m	8.8%	9.1%
Wine	£661.0m	£29.3m	4.6%	-16.8%
Beef	£584.7m	£45.3m	8.4%	23.1%
Pork	£583.1m	£117.4m	25.2%	7.0%
Beer	£500.1m	£10.7m	2.2%	1.0%
Breakfast cereals	£483.5m	£1.4m	0.3%	2.6%

FY 2019 UK food & drink

TOP 10 PRODUCTS				
	H1 2020	Change		
		Value	% Value	% Volume
Whisky	£1.5bn	-£695.1m	-31.1%	-26.8%
Chocolate	£315.4m	-£38.0m	-10.7%	-11.1%
Salmon	£307.0m	-£93.4m	-23.3%	-27.0%
Cheese	£304.5m	-£44.6m	-12.8%	-13.7%
Pork	£300.6m	£44.8m	17.5%	2.4%
Beef	£257.3m	-£18.7m	-6.8%	1.4%
Gin	£253.0m	-£80.8m	-24.2%	-21.3%
Breakfast cereals	£244.7m	-£1.2m	-0.5%	16.4%
Wine	£239.5m	-£117.6m	-32.9%	-27.0%
Fish	£207.2m	-£5.2m	-2.4%	6.9%

H1 2020 UK food & drink

2017 Scotland values	Value (ex-farm)	Tonnes	Value share
Atlantic salmon	£1,050,976,780.00	189,707	96.96%
Sea mussels	£10,092,432.00	8,232	0.93%
Rainbow trout	£19,446,550.00	7,637	1.79%
Pacific cupped oyster	£2,015,000.00	403	0.19%
Marine fishes - not elsewhere identified	£947,100.00	77	0.09%
Brown trout	£165,300.00	57	0.02%
European flat oyster	£120,000.00	16	0.01%
Queen scallop	£33,000.00	11	0.00%
Great Atlantic scallop	£91,632.00	6	0.01%
Other Salmonids	£12,470.00	4.3	0.00%
Grand total	**£1,083,900,264.00**	**206150.3**	

Salmon producers

Cooke AQUACULTURE

Grieg Seafood®

Loch Duart the Sustainable Salmon Company

MOWI®

ORGANIC SEAHARVEST

Scottish Sea Farms

THE SCOTTISH SALMON COMPANY PLC

Wester Ross Est 1977

Trout producers

dawnfresh

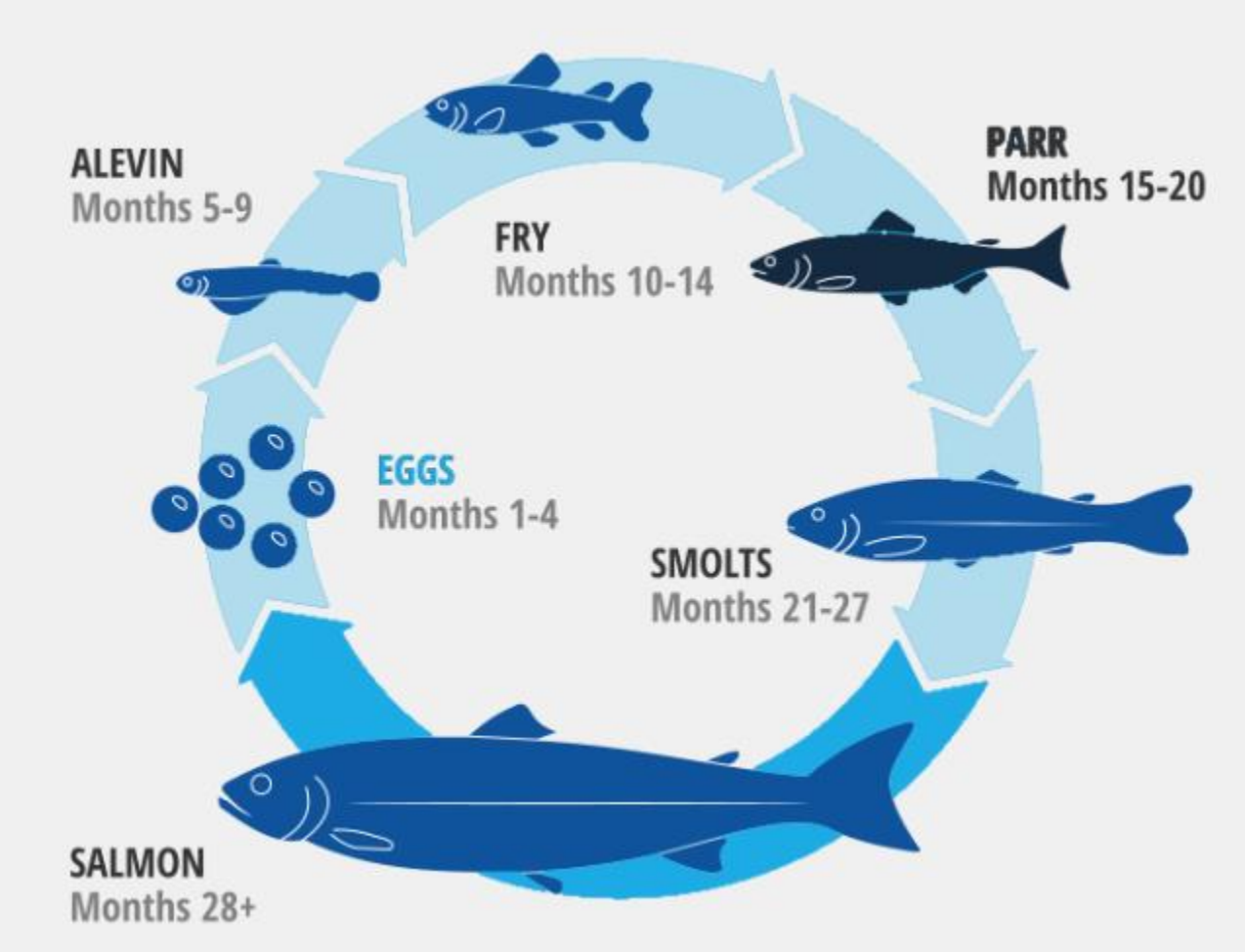
56°15'N 05°31'W KAMES SCOTLAND

Aquafeed manufacturers

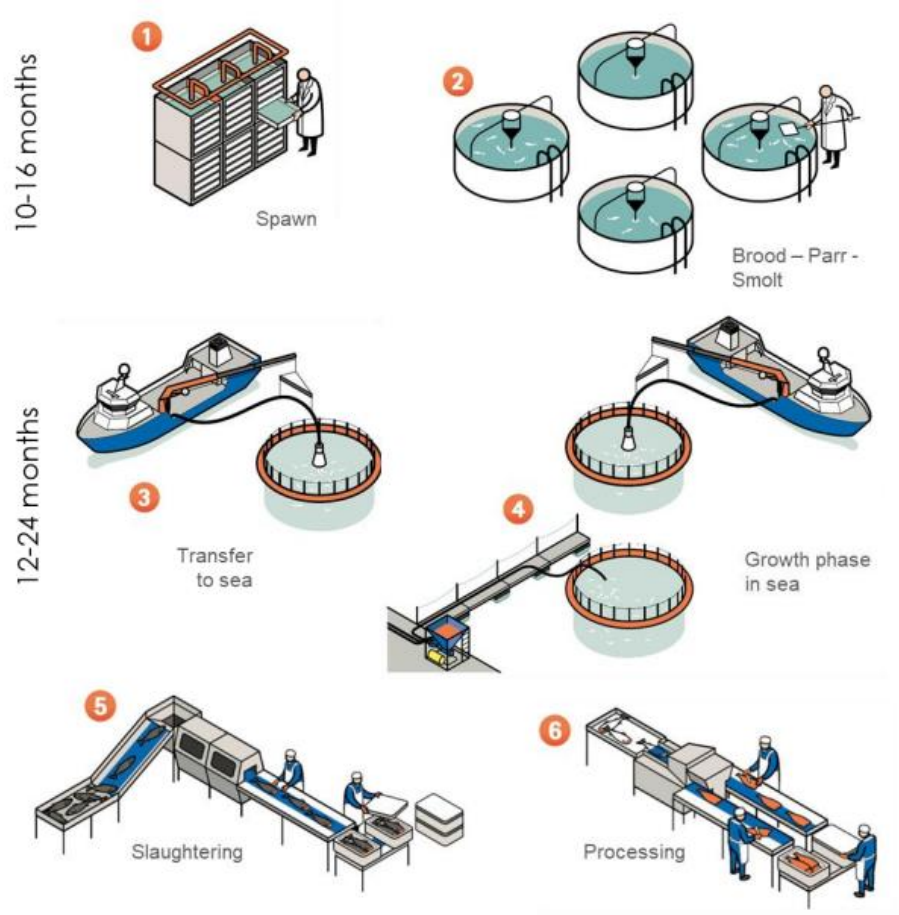
Cargill®

BioMar

Atlantic salmon lifecycle and production



Lifecycle, Fidra 2020



Production, Mowi 2019

Nutrition – the fundamentals

Animals need **nutrients** – **ingredients** contain **nutrients** – mix and match the **ingredients** to supply the right **nutrients**

(Glencross, Tocher)

Aquafeeds

Science into a pellet: density, smell, integrity, digestibility, binding, vacuum filling with oil, extrusion, formulation, grinding, mixing, quality control, animal performance…

- Produced by extrusion
- Must supply all nutrients
- Must taste right
- Must be the right density to sink
- Must bind but not be undigestible

Some definitions

Term	Definition
Ingredient	Material used in a feed
Formulation	A recipe of ingredients
Nutrient	A chemical eaten that is of benefit to the organism
Essential	A nutrient that cannot be synthesised by an animal but is needed
Requirement	Amount of nutrient needed in feed for optimal growth and wellbeing
Specification	Minimal amount of a nutrient in a feed
Amino acid	Building block of proteins
Crude	The nutrient content of an ingredient or feed
Digestible	The biologically accessible portion of the crude nutrient
Absolute	‘Real’ quantities (formulations are ratios, fish eat an absolute quantity)
Relative	Ratios, fractions, percentages

Fundamental principles

Glencross 2017, and those before

1. **Nutrition is biochemistry and physiology**

   There are no magic ingredients

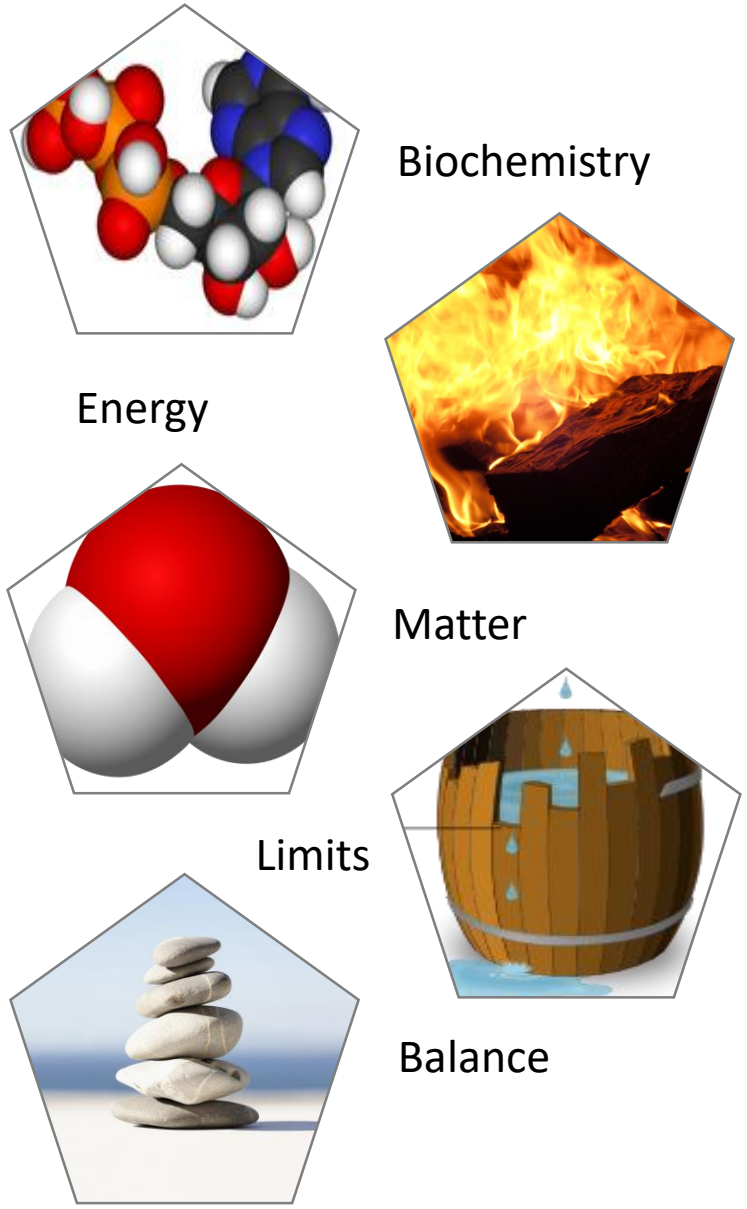
2. **Conservation of energy…**

   First thermodynamic principle

3. **Conservation of mass, only transferred or rearranged**

4. **An organism can only grow as fast as the 1st limiting nutrient allows (Liebig's law)**

5. **Use of nutrients depend on biochemical energy**



Which nutrients are essential to animals?

Macro nutrients

- Energy - DE
- **Protein - DPro**
- Water – H_2O

Amino acids

- **Arg**
- **His**
- **Iso**
- **Leu**
- **Lys**
- **Met**
- **Phe**
- **Thr**
- **Try**
- **Val**
- **Tau**

Fatty acids

- 18:2n-6
- 18:3n-3
- 20:4n-6
- 20:5n-3
- 22:6n-3
- Sterols
- Phospholipids

Minerals

- Ca
- Mg
- P
- K
- Na
- Cu
- I
- Fe
- Mn
- Se
- Zn

Vitamins

- A
- D
- E
- K
- B_1
- B_2
- B_6
- Pa
- Ni
- Bio

Some are not essential some animals – due to biochemistry

- B_{12}
- Fo
- Ch
- In
- C

47 molecules

Fish need energy

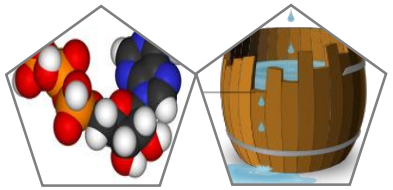
Chemical energy exists in the carbon bonds of proteins, lipids/fats and carbohydrates

- Fish derive energy mainly from protein and fat – **feed intake is according to energy requirement**
- **Relative** energy requirements increase with the fish mass
- Carnivorous fish should not be fed large quantities of carbohydrates
- The first nutrient to specify in a diet is the energy content

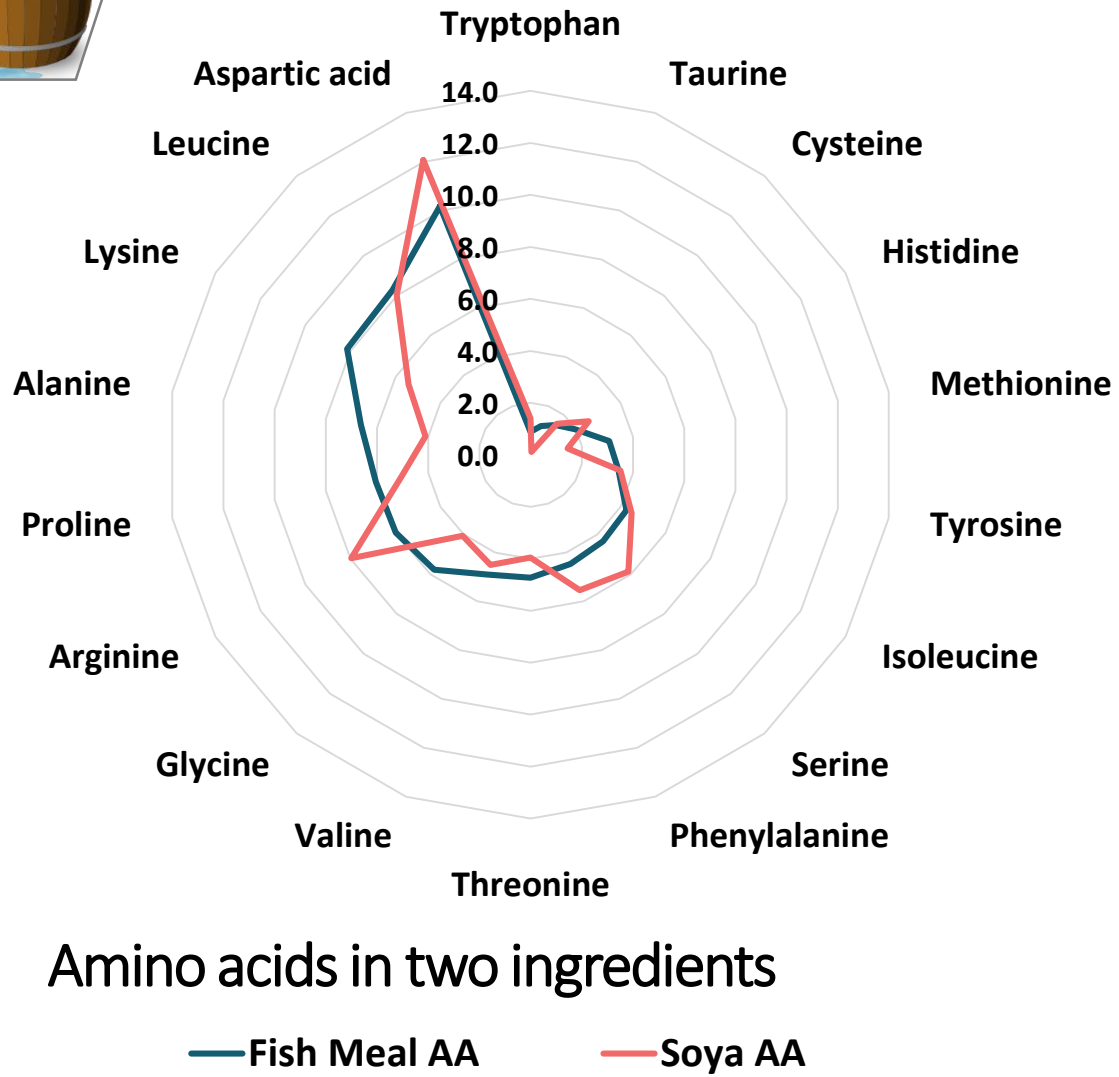
Energy

Fish need protein

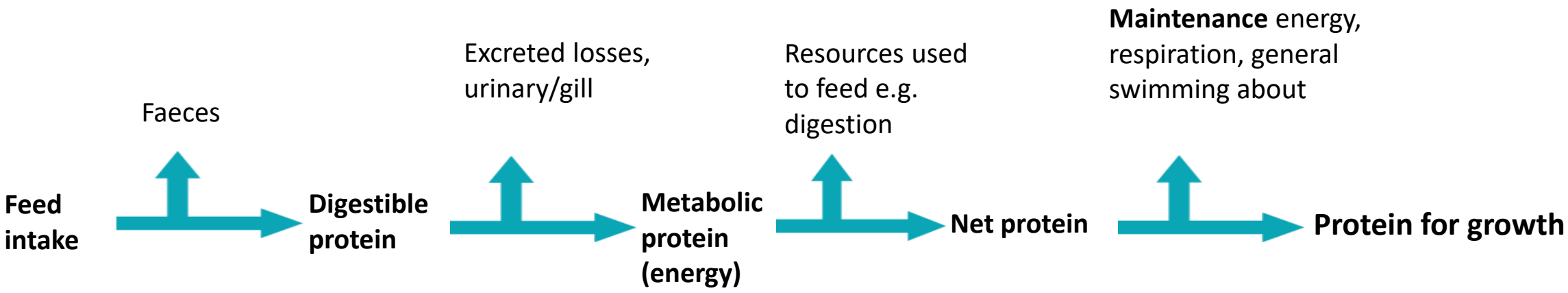
Protein is the term for bulk amino acids



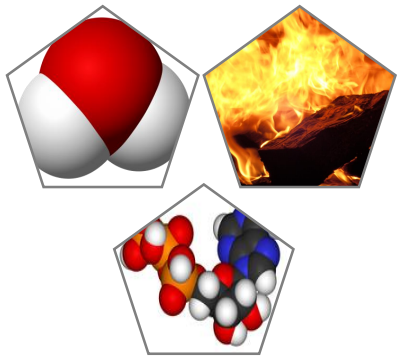
- Fish grow indeterminately
- Fish use protein for both energy and growth
- Protein requirements are dependent on dietary energy level
- Protein requirement is **relatively** higher in smaller fish
- Smaller fish grow **relatively** faster than larger fish
- **Relatively** is emphasised because big fish eat more but nutrients are supplied in different ratios
- Ingredients have varying AA profiles



Protein in animals and fish



(Not to scale)



Conservation of mass and energy

Biochemistry

Excretory and metabolic losses –
It is not good for an organism to engage in circular economy principles

Basics of ingredient selection/evaluation

	Selection process	Description
1	Characterisation	Produce a nutrient specification
2	Palatability	Will fish eat it? Does the ingredient influence feed intake?
3	Digestibility	Do any ingredient properties prevent the fish's digestive system from absorption of nutrients – in our case, protein?
4	Utilisation	2 & 3 tell the nutritionist how to do this. Protein utilisation = growth – a feeding trial is executed and the results define how well the animal uses the ingredient (PER: Protein Efficiency Ratio)
5	Health impacts	Does the ingredient influence fish health? And how?
6	Processing effects/functionality	Physical influence on the pellet characteristics or extrusion process
7	Influence on product quality	Product feel and taste influence

Glencross 2020, and before

Ingredients in aquafeeds

Soybean

Peanuts

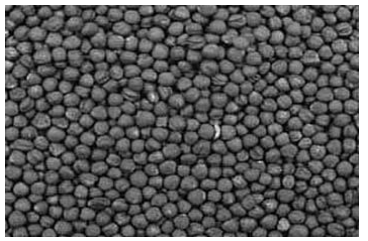
Herring

Cottonseed

Cereal glutens

Field peas

Rapeseed



Krill

Microbial protein

GMO grains

Avian offal

Faba beans

Lupins

Mammalian offal

Insects

Microalgae

Macroalgae

Blood proteins

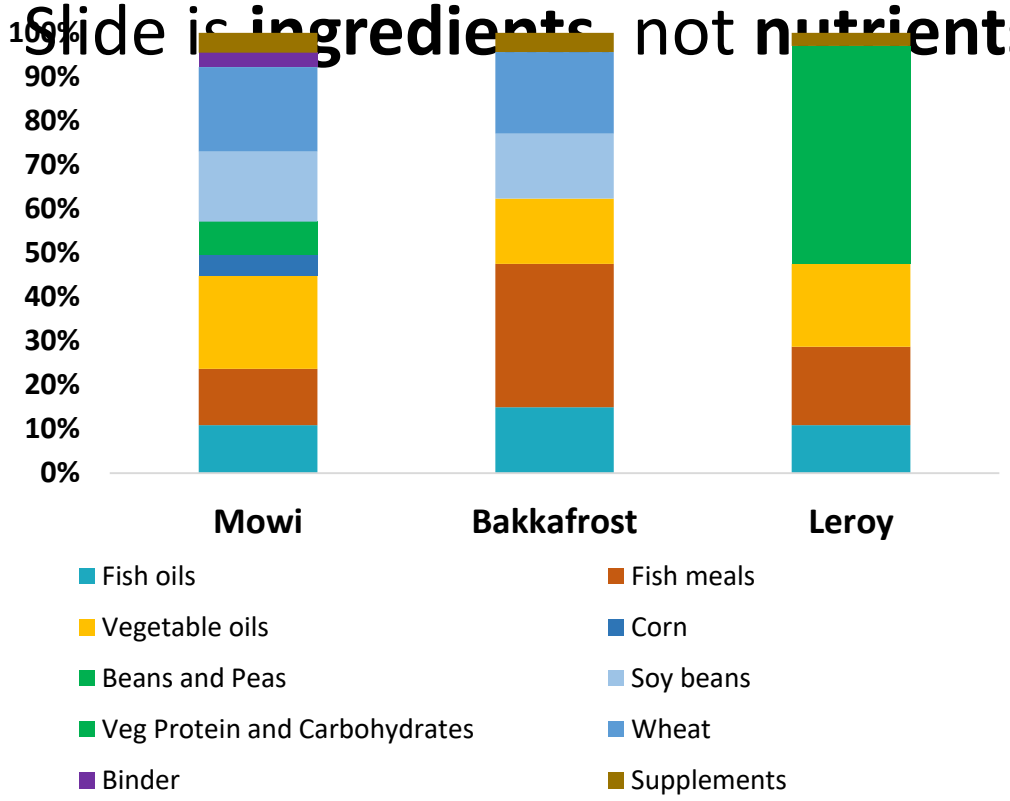
Fish offal

Anchoveta

Current aquafeeds

Data available: Mowi, Lerøy and Bakkafrost

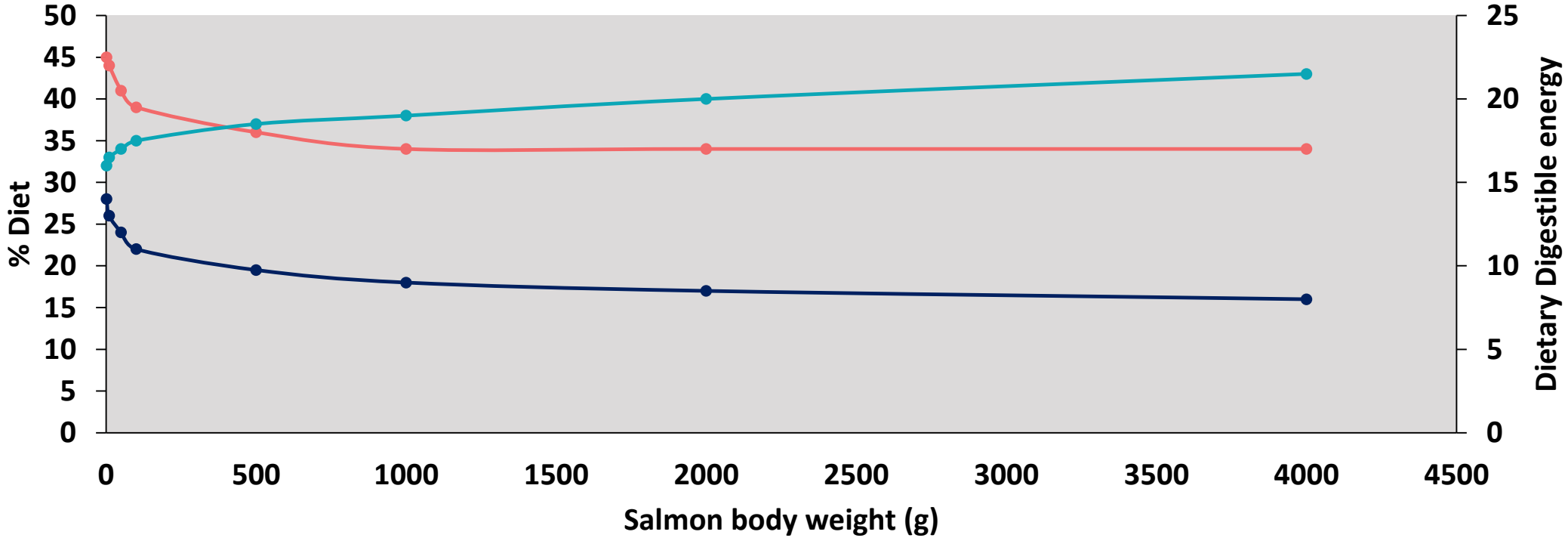
Slide is **ingredients** not **nutrients**

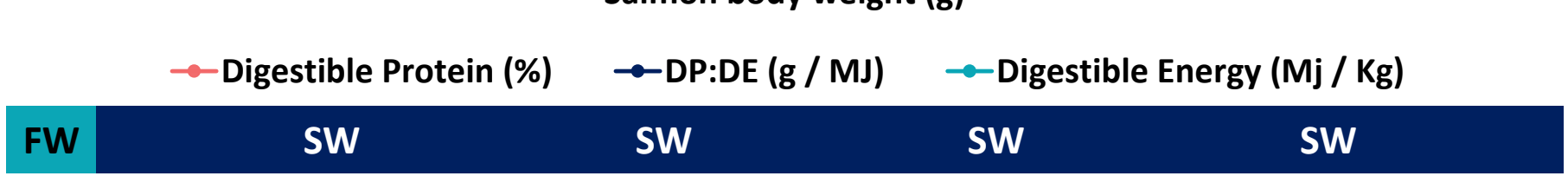


Company	Marine material %	Vegetable material %
Mowi	24	69
Bakkafrost	48	48
Lerøy	29	69

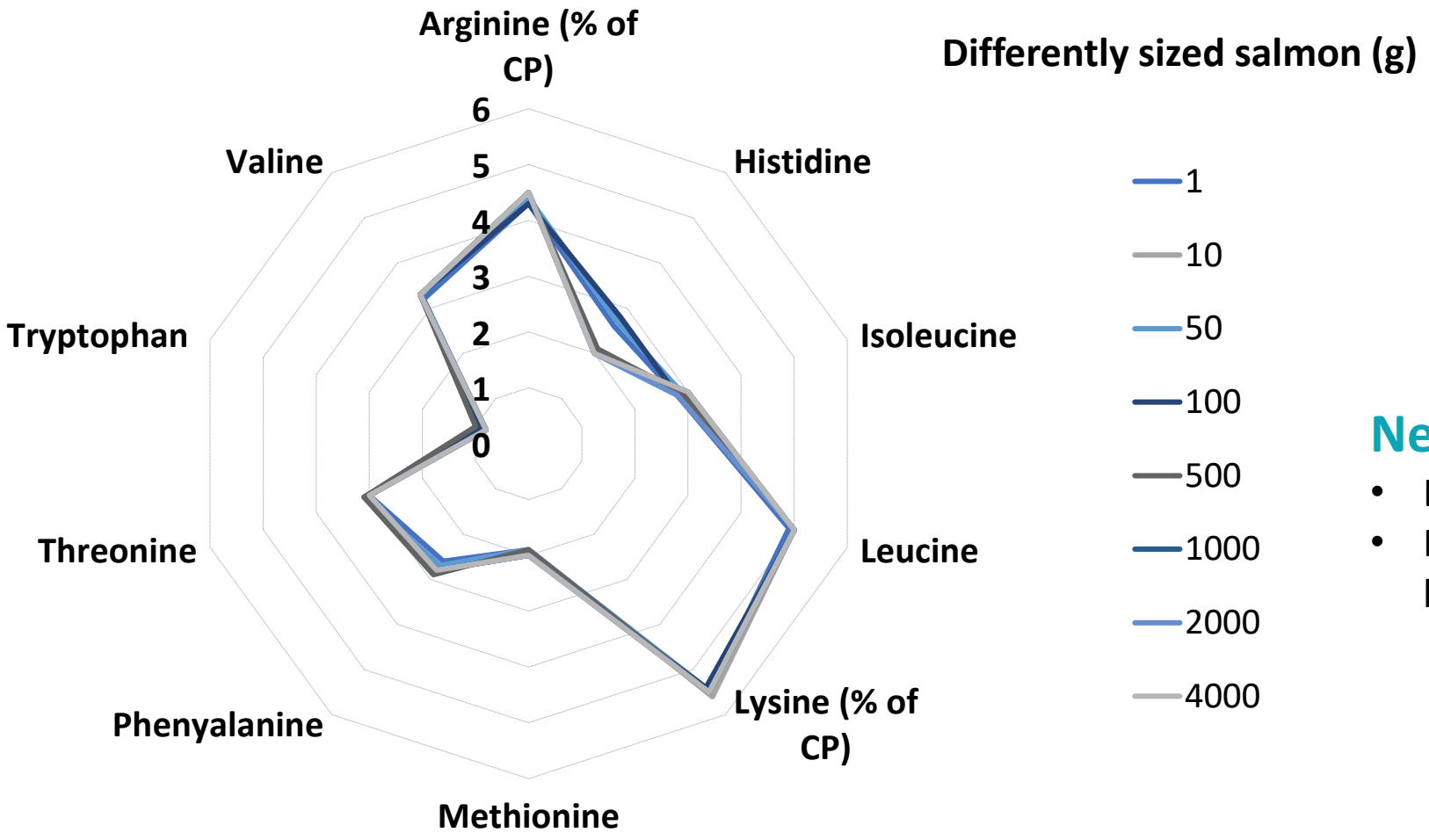
Derived from 2019 corporate sustainability reports

Protein v. energy demands – Atlantic salmon





Amino Acids: salmon requirements



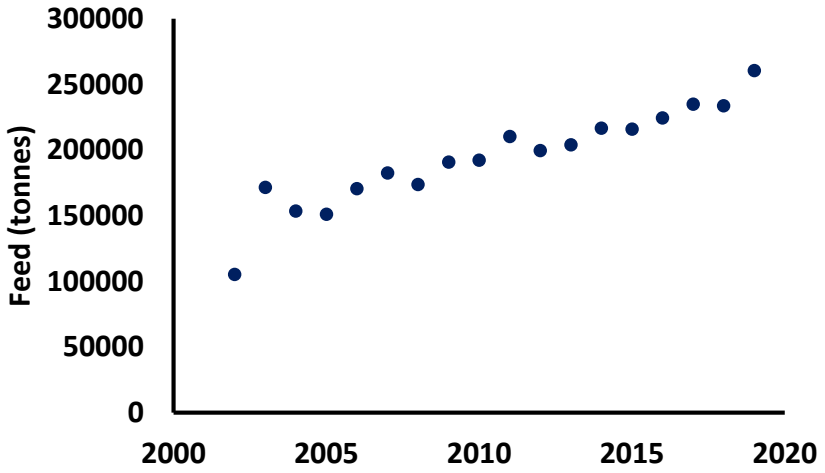
Need to know

- How much do salmon eat?
- How much of what salmon eat needs to be protein?

(Glencross lectures 2017)

Don’t forget taurine!

Protein requirements of the sector in Scotland



- Aquafeed market in Scotland is worth **~ £260m**
- Salmon > 1kg require 39 % **crude protein** (**34% @** digestibility = 0.9)
- Finfish farmed in Scotland (2019) required **~100,000** tonnes of protein

Circular economy and protein

What is the salmon sector’s place in a circular economy?

Salmon farming inputs and outputs

INPUTS

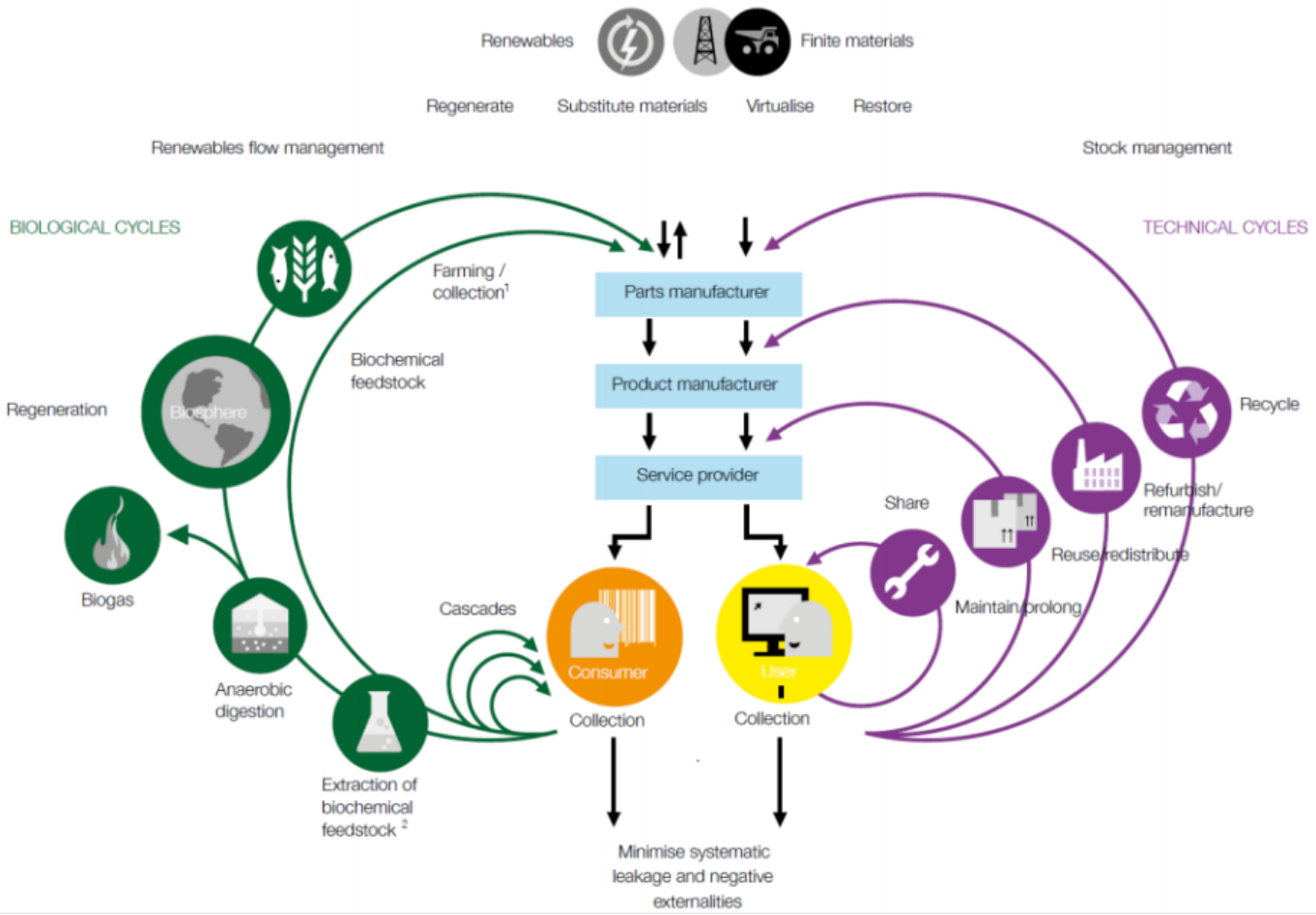
- Raw materials of feed (marine, terrestrial, biotech)
- Energy
- Equipment (sites infrastructure, vessels, land-based facilities, processing and RAS systems)
- Packaging
- Services
- Medicines

OUTPUTS

- Salmon
- Some mortalities
- Processing wastes
- Environmental discharges
- Medicinal discharges
- End-of-life equipment (pens, nets)
- Packaging (in particular poly boxes)

Protein, part of the carbon and nitrogen cycles

Circular economy



Ellen MacArthur Foundation

Principles for an individual actor:

- Minimise waste and do something with unavoidable waste
- Use waste from other sectors

In terms of protein:

- Implied duty to use protein from others' waste streams as the number one choice

This minimises the demand for other sources of protein.

Passing nutrients through animals does not capture everything.

Conclusions

- Animals are not perfect converters of protein
- In open-pen salmon farming excretory nitrogen (ammonia) is lost to the environment
- Aquafeeds need to maintain strong performance
- Seek out by-products for inputs – efforts are underway in fishery by-product utilisation
- Seek out buyers for outputs

Scottish Aquaculture Innovation Centre

TALK TO US

Whether you're looking for a connection, need funding support, want to find out about our training programmes, or would like to make use of our extensive network, we're here to help.

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