

# Generic approach to quantifying nutritional requirements in aquatic species



*Ingrid Lupatsch, Centre for Sustainable Aquaculture Research, Swansea University, UK*

✓ **Requirement studies for key nutrients**

Energy (lipid, carbohydrates, protein)

Protein – (amino acids),

✓ **Feed ingredient evaluation**

Composition

Digestibility

Identification of anti-nutrients

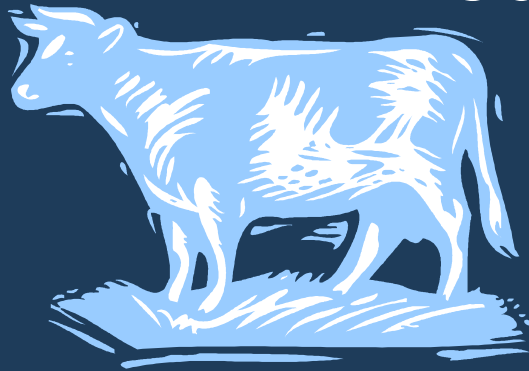
Palatability

**Maintenance**

+

**'Product'  
or Growth**

**Meat**



**Milk**



**Eggs**



# Requirement = Maintenance + Growth

$$\begin{array}{l} \text{Energy} \\ \text{Protein} \end{array} = a \times \text{BW}(\text{kg})^b + c \times \text{growth}$$

## ➤ *Maintenance requirements*

Demand for energy and protein balance, no loss, no gain

Involves demand for movement, body functions dependent on species, fish weight and temperature

## ➤ *Growth requirements*

is dependent on the growth potential of fish – meaning the daily weight gain and energy and protein content of this gain.

**c = cost of production to deposit new growth**

# Absolute requirements per day for

*Maintenance*

+

*Growth*

$$DE \text{ (kJ)} = a \times BW(\text{kg})^{0.80} + c \times \text{energy gain}$$

$$DP(\text{g}) = a \times BW(\text{kg})^{0.70} + c \times \text{protein gain}$$

DE = digestible energy , DP = digestible protein

# Methods – Maintenance requirements

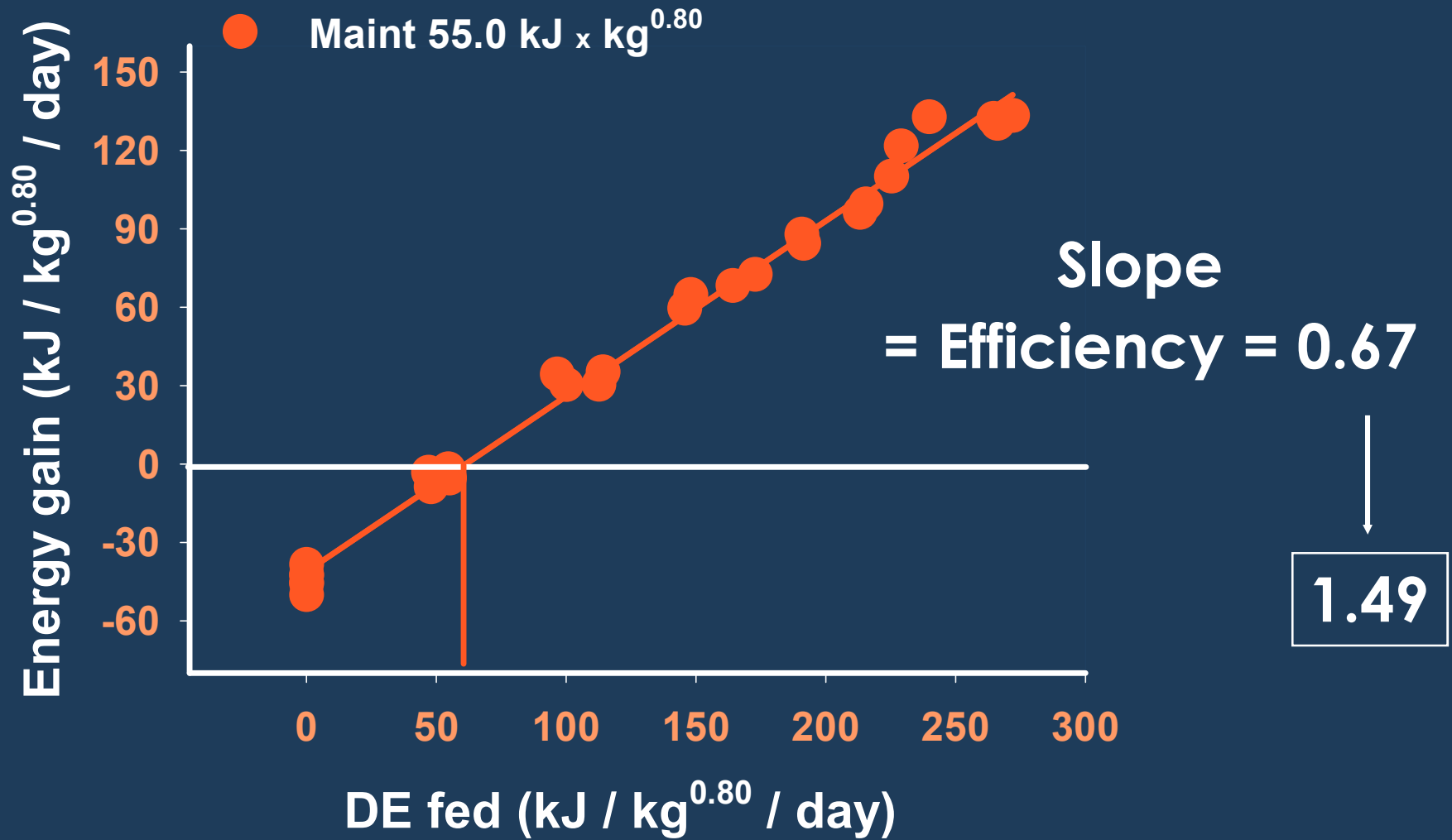
$$DE = a \times (\text{kg})^{0.80} + C \times \text{growth}$$

➤ Fish are fed with feeds of known digestible energy (DE) and digestible protein (DP) content at increasing feeding levels from zero feed to maximum feed intake.

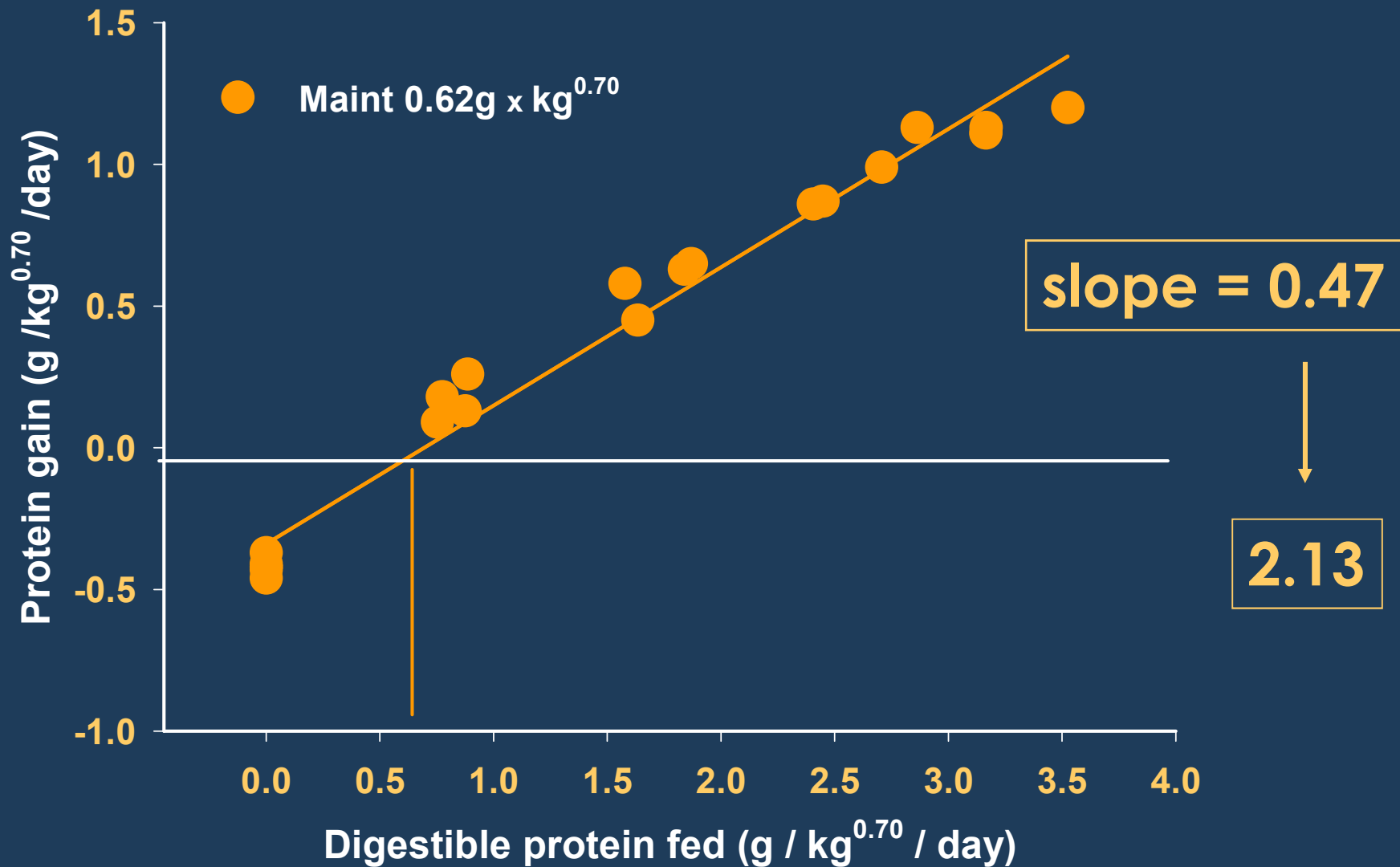
➤ Energy and protein gain or loss measured by comparative carcass analysis



# Maintenance requirements - Energy



# Maintenance requirements - Protein





# Quantification of energy and protein requirements in seabream (at 23°C)

## First Results:

$$DE \text{ (kJ)} = 55.1 \times BW(\text{kg})^{0.80} + 1.49 \times \text{energy gain}$$

$$DP(\text{g}) = 0.62 \times BW(\text{kg})^{0.70} + 2.13 \times \text{protein gain}$$

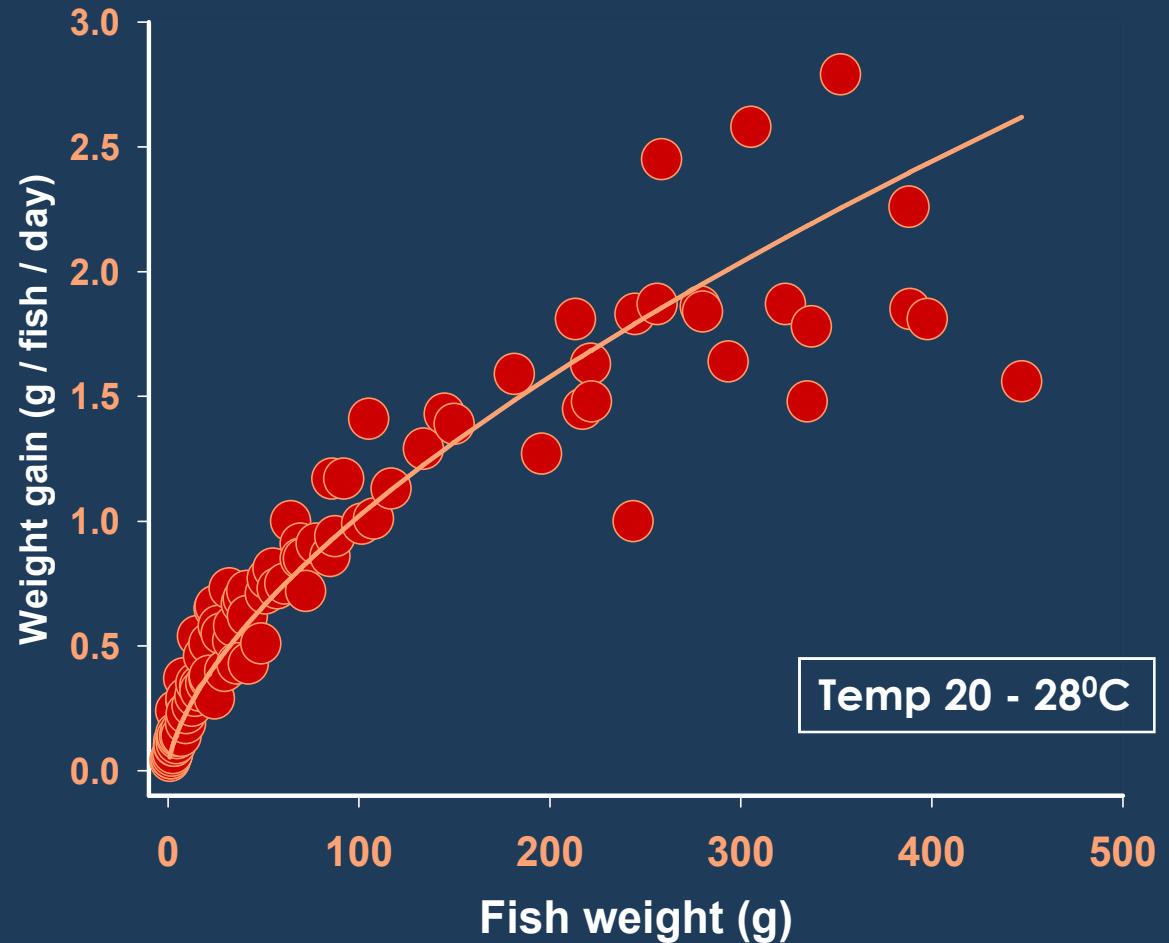
# Methods – Growth

$$DE, DP = a BW(\text{kg})^{0.80} + c \times \text{growth}$$

- Predict daily weight gain using data of past records of growth trials along the growth cycle, where feed intake and growing conditions are optimum.
- Determine composition of fish of different sizes along the growth cycle

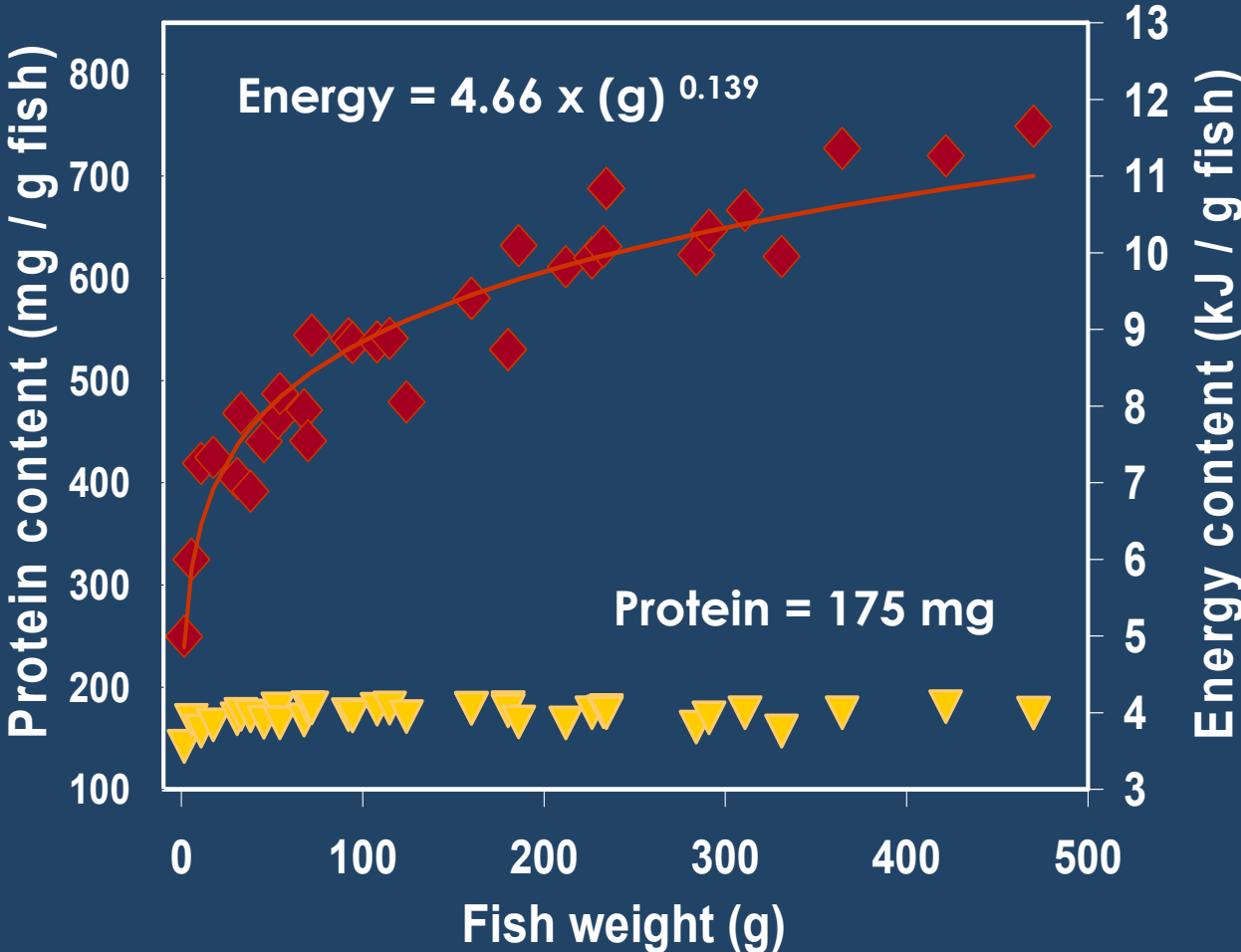


# Predicted Weight gain



$$\text{Gain (g/day)} = 0.024 \times \text{BW (g)}^{0.514} \times \exp^{0.060 \times \text{Temp}}$$

# Composition of weight gain



# Requirements for 100g seabream\_

100g + 1.0 g/d



$$\begin{aligned} \text{DE (kJ)} &= 55.1 \times \text{BW}(0.100)^{0.80} \\ &+ 1.49 \times 1.0\text{g} \times 8.8 \text{ kJ/g} \\ &= \underline{22.1 \text{ kJ / day}} \end{aligned}$$

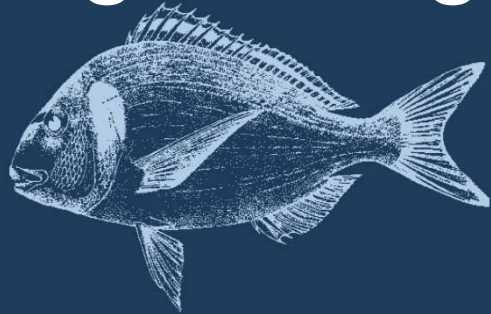
$$\text{DE, DP} = a \times \text{BW}(\text{kg})^{0.80} + c \times \text{growth}$$

$$\begin{aligned} \text{DP (g)} &= 0.62 \times \text{BW}(0.100)^{0.70} \\ &+ 2.13 \times 1.0\text{g} \times 175\text{mg/g} \\ &= \underline{0.50 \text{ g / day}} \end{aligned}$$

T = 23°C

# Requirements for 300g fish

300g + 1.79 g/d



$$\begin{aligned} \text{DE (kJ)} &= 55.1 \times \text{BW}(0.300)^{0.80} \\ &+ 1.49 \times 1.79\text{g} \times 10.3 \text{ kJ/g} \\ &= \underline{48.5 \text{ kJ / day}} \end{aligned}$$

$$\text{DE, DP} = a \times \text{BW}(\text{kg})^{0.80} + c \times \text{growth}$$

$$\begin{aligned} \text{DP (g)} &= 0.62 \times \text{BW}(0.300)^{0.70} \\ &+ 2.13 \times 1.79\text{g} \times 175\text{mg/g} \\ &= \underline{0.93 \text{ g / day}} \end{aligned}$$

T = 23°C

## Feed formulation

100 g + 1.0 g/day at 23°C



### Requirements for a 100g bream

DE = 22.1 kJ/day

GE = 27.6 kJ/day

DP = 0.50 g/day

CP = 0.59 g/day

If feed contains 21 kJ Gross Energy/g

→ Fish need to consume 1.31 g feed / day

→ Crude Protein content 450 mg / g feed

→ DP / DE ratio = 22.6

→ FCR (feed / gain) - 1.31

85% protein digestibility, 80 % energy digestibility

## Feed formulation

100 g + 1.0 g/day at 23°C

Requirements for a 100g bream

GE = 27.6 kJ/day

CP = 0.59 g/day

If feed contains 18 (21) kJ Gross Energy/g

→ Fish need to consume 1.53 (1.31) g / day

→ Crude Protein content 386 (450) mg/g feed

→ DP / DE ratio = 22.6 (22.6)

→ FCR (feed / gain) - 1.53 (1.31)

85% protein digestibility, 80 % energy digestibility



# Quantification of Nutritional Requirements

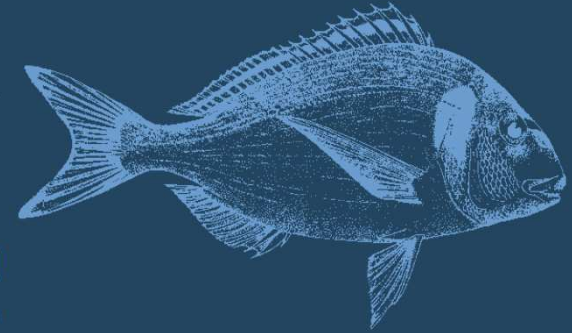
$$\text{Requirement} = a \times (\text{kg})^b + c \times \text{growth}$$

**Growth data** – to describe daily potential weight gain along the growth cycle

**Composition** of weight gain -  
Change in body composition along the growth cycle

**Maintenance** requirements

**Efficiency** of dietary energy and protein retention



**Where to expect similarities?**

**Energy costs for deposition of  
energy and protein similar**

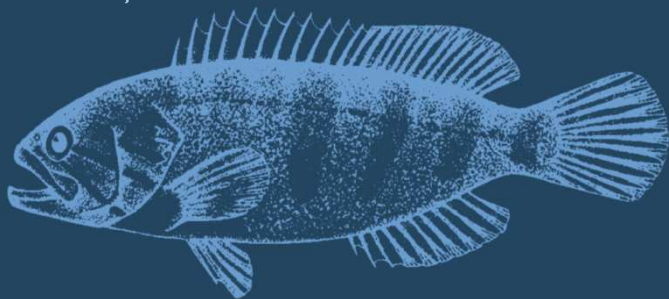
**Where to expect differences?**

**Growth potential**

**Composition of gain**

**Voluntary Feed intake**

**Maintenance requirement**



## Growth of perch pike on three commercial feeds - Inagro

	Diet N	Diet A	Diet B
<b>Initial weight, g</b>	<b>70.7</b>	<b>69.9</b>	<b>69.8</b>
<b>Final weight, g</b>	<b>206</b>	<b>192</b>	<b>214</b>
<b>Gain, g/ fish /day</b>	<b>1.96</b>	<b>1.77</b>	<b>2.09</b>
<b>FCR</b>	<b>1.24</b>	<b>1.33</b>	<b>1.25</b>
<b>Feed intake %/d</b>	<b>2.01</b>	<b>2.02</b>	<b>2.13</b>
<b>Protein content</b>	<b>55.0</b>	<b>52.0</b>	<b>52.0</b>
<b>DP/DE ratio</b>	<b>26.2</b>	<b>25.5</b>	<b>22.3</b>