



Flexibility in the use of feed ingredients turns the salmon industry sustainable

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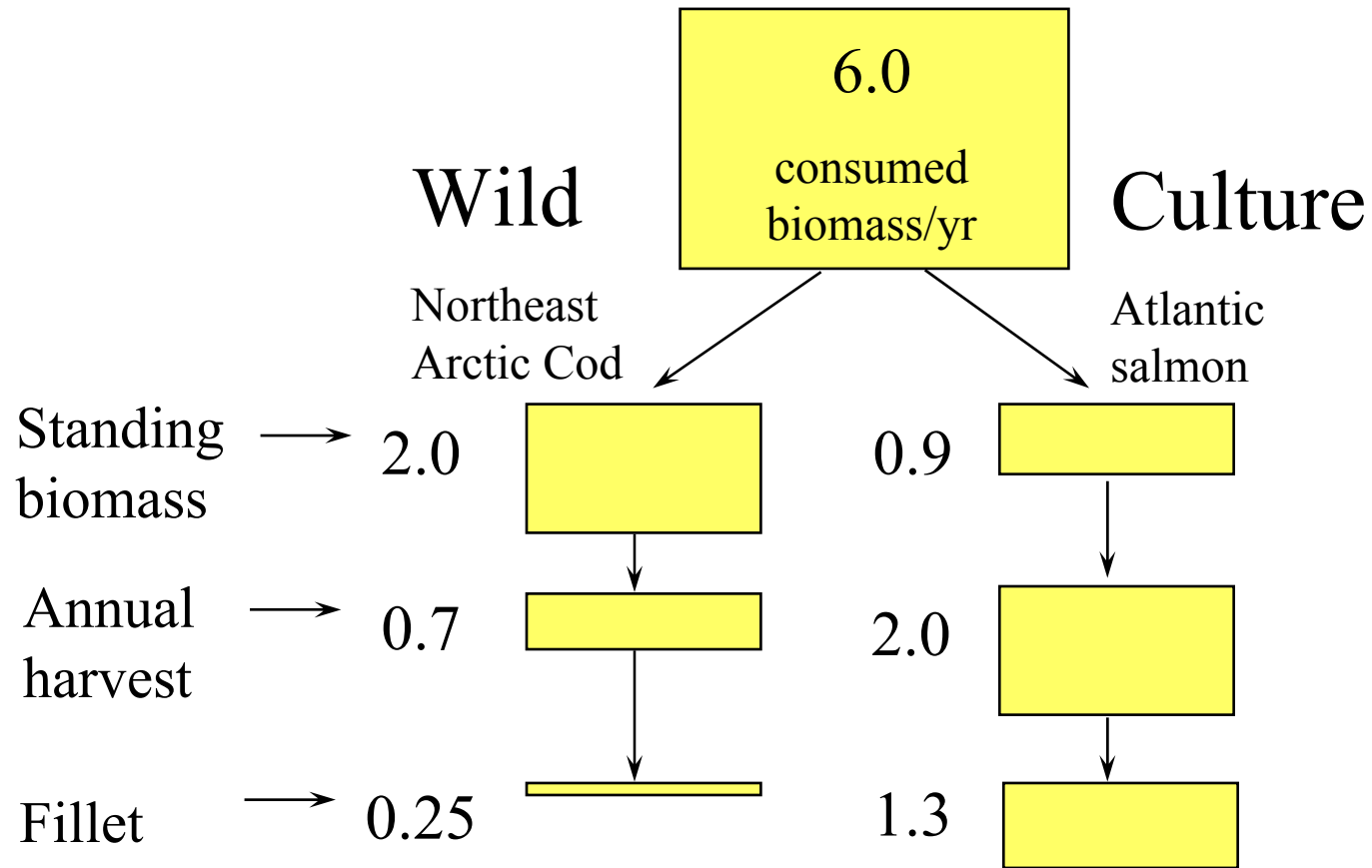
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Conversion efficiency

(numbers in 10^6 tonnes)

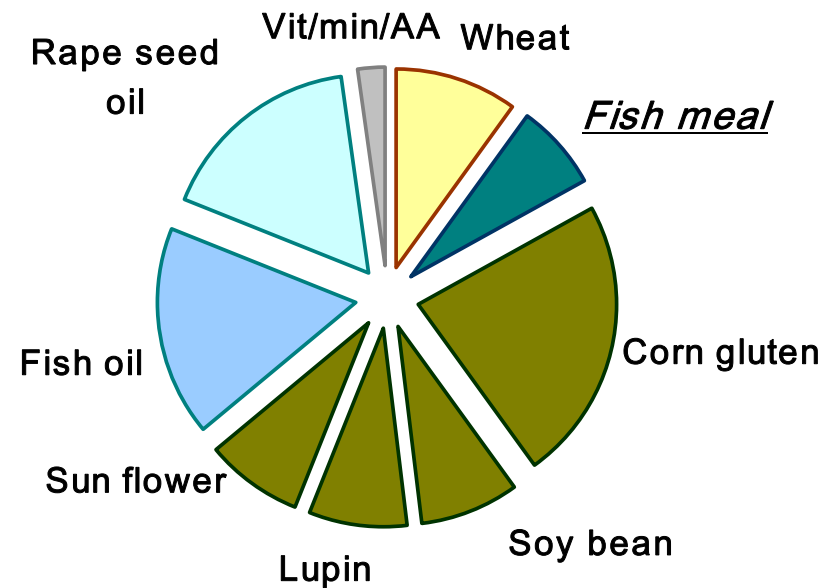
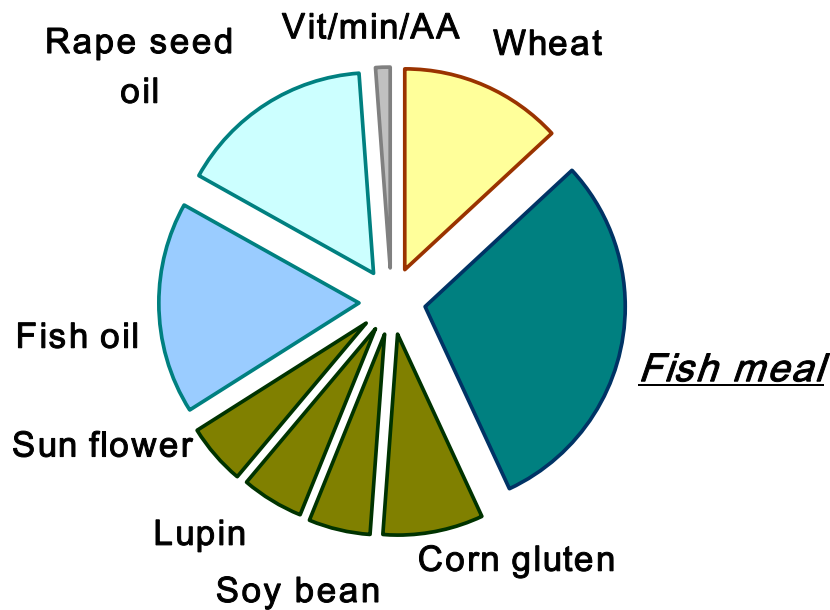


Retention of protein in the edible part of salmon, chicken and swine

Animal	Salmon	Chicken	Swine
Edible part %	65	50	50
Protein (g/kg)	190	200	165
FCR*	1.0	2.5	3.0
Protein retention %	31	21	20

*Recruitment included

Feed today vs. high vegetale feed



Ingredient cost/ kg feed: NOK 5.01
 FCR: 1.05
 Ingredient cost/ kg fish: NOK 5,26

NOK 3,90
 1,15
NOK 4,48

Animal byproduct meal (prohibited in EU 2000)

Blood meal (again accepted from non-ruminants 2003/2007)

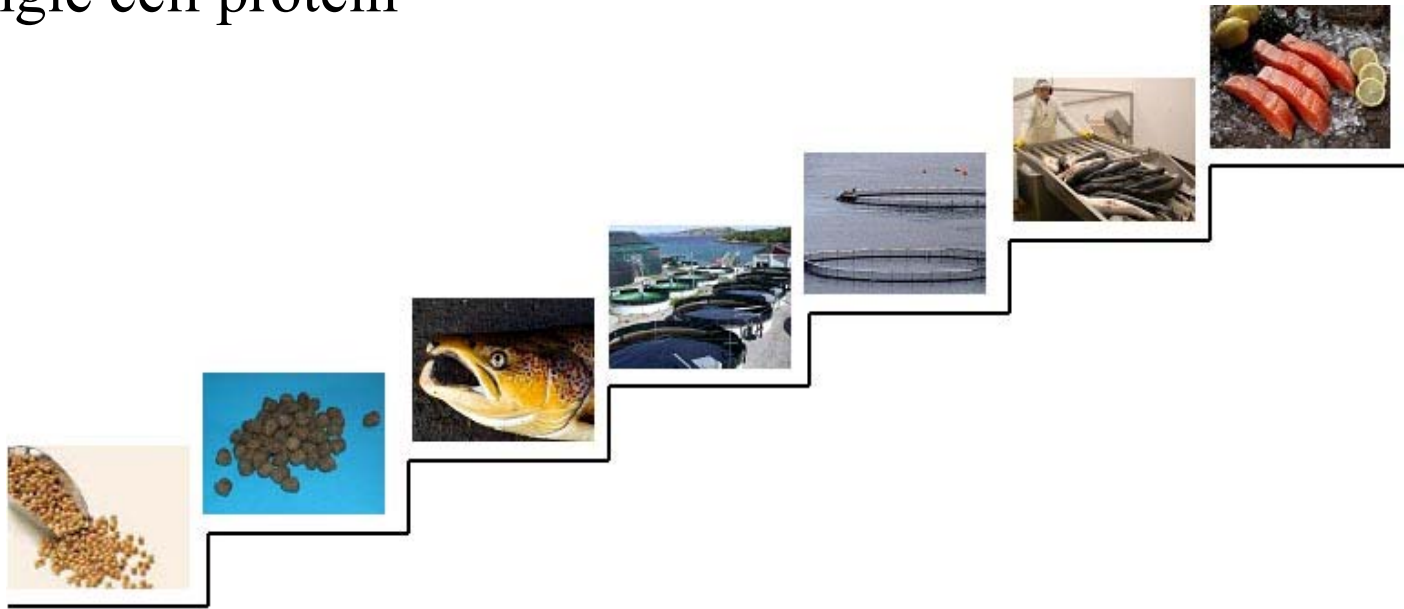
Hydrolysates if molecular size < 10000 Dalton

Poultry by-product meal

Feather meal

Krill meal

Single cell protein



Example:

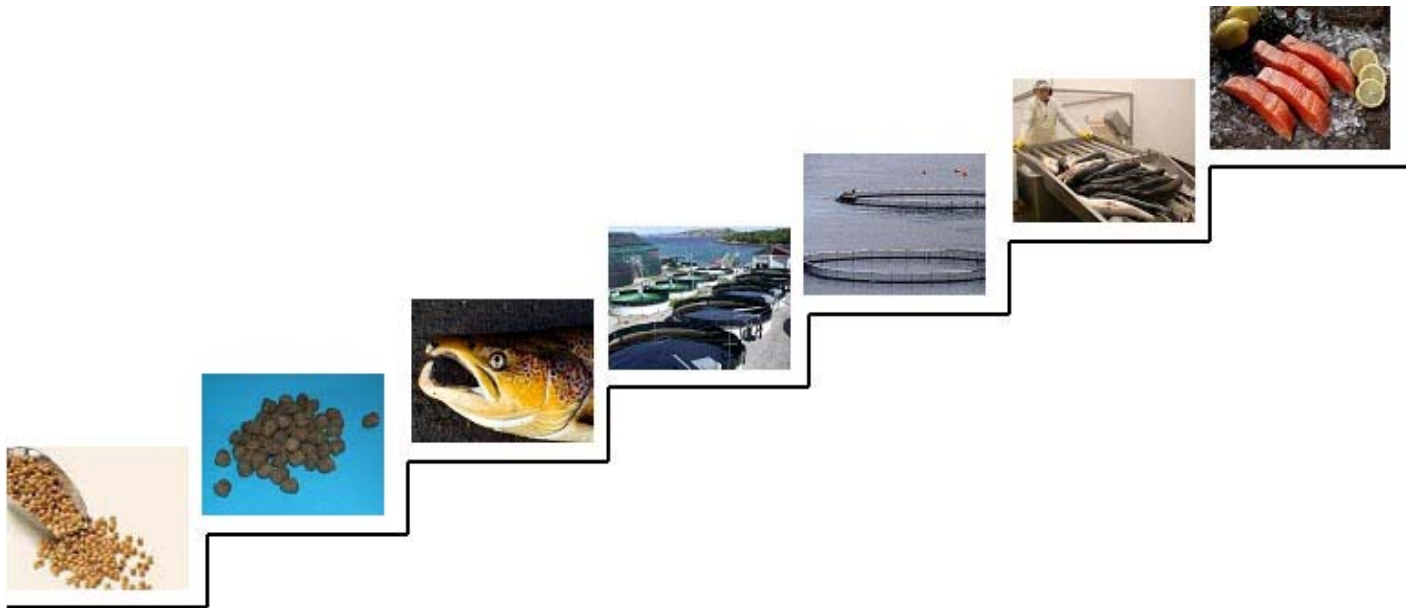
15 % fish meal in the feed (150 g/ kg feed)

Expected FCR 1.2 \Rightarrow $(150\text{g} * 1.2) = 180\text{ g}$ of fish meal containing 67 % protein

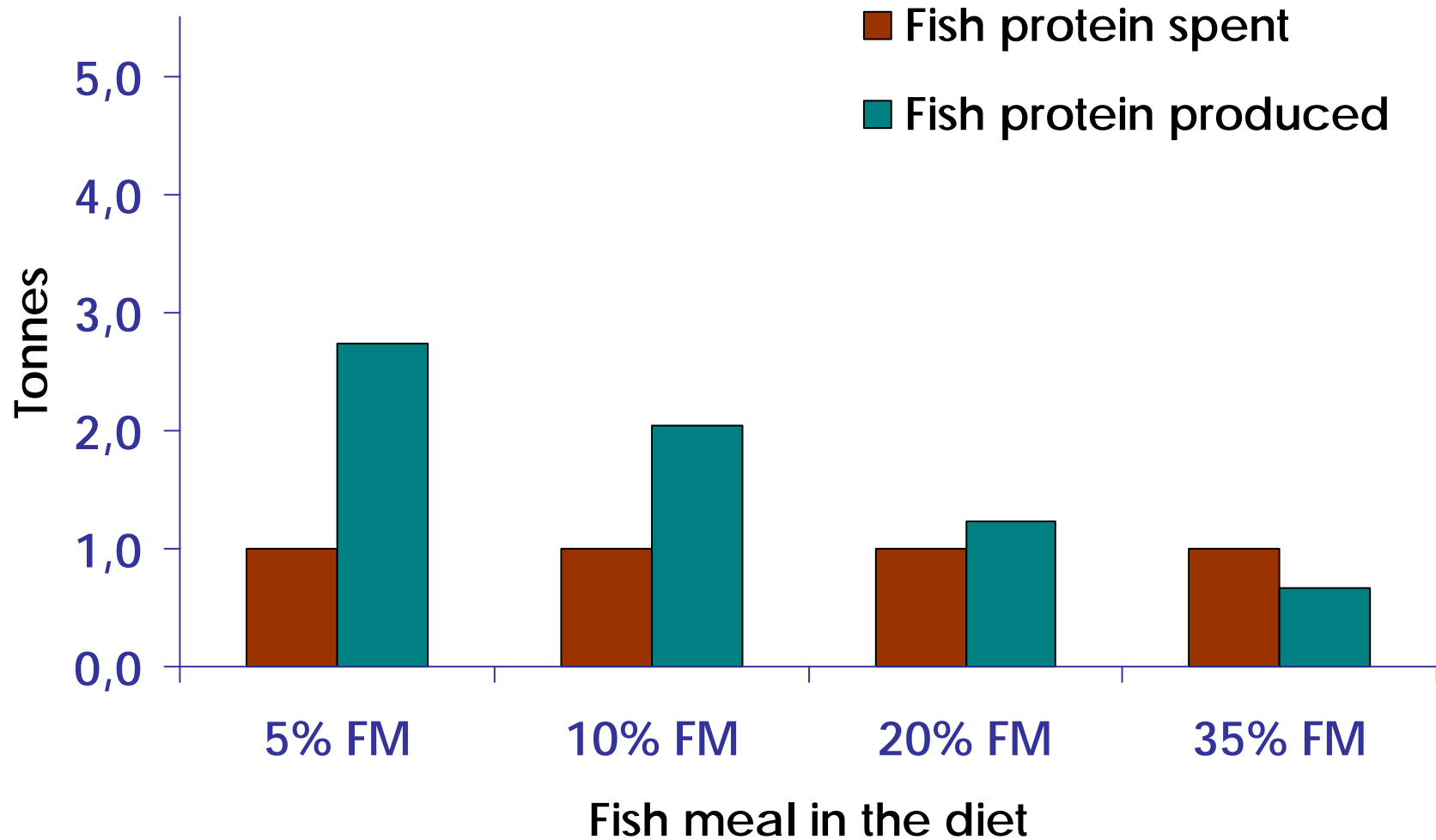
Fish protein spent for production of 1 kg salmon: $(180\text{ g} * 0.67) = 121\text{ g}$
1 kg of salmon contains 180g of fish protein, a gain of $(180\text{g} - 121\text{g}) = 59\text{g}$
which is 49 % more fish protein in the salmon than fish meal protein spent.

FIFO \approx 1 if fish meal inclusion is 20 % and FCR 1.2

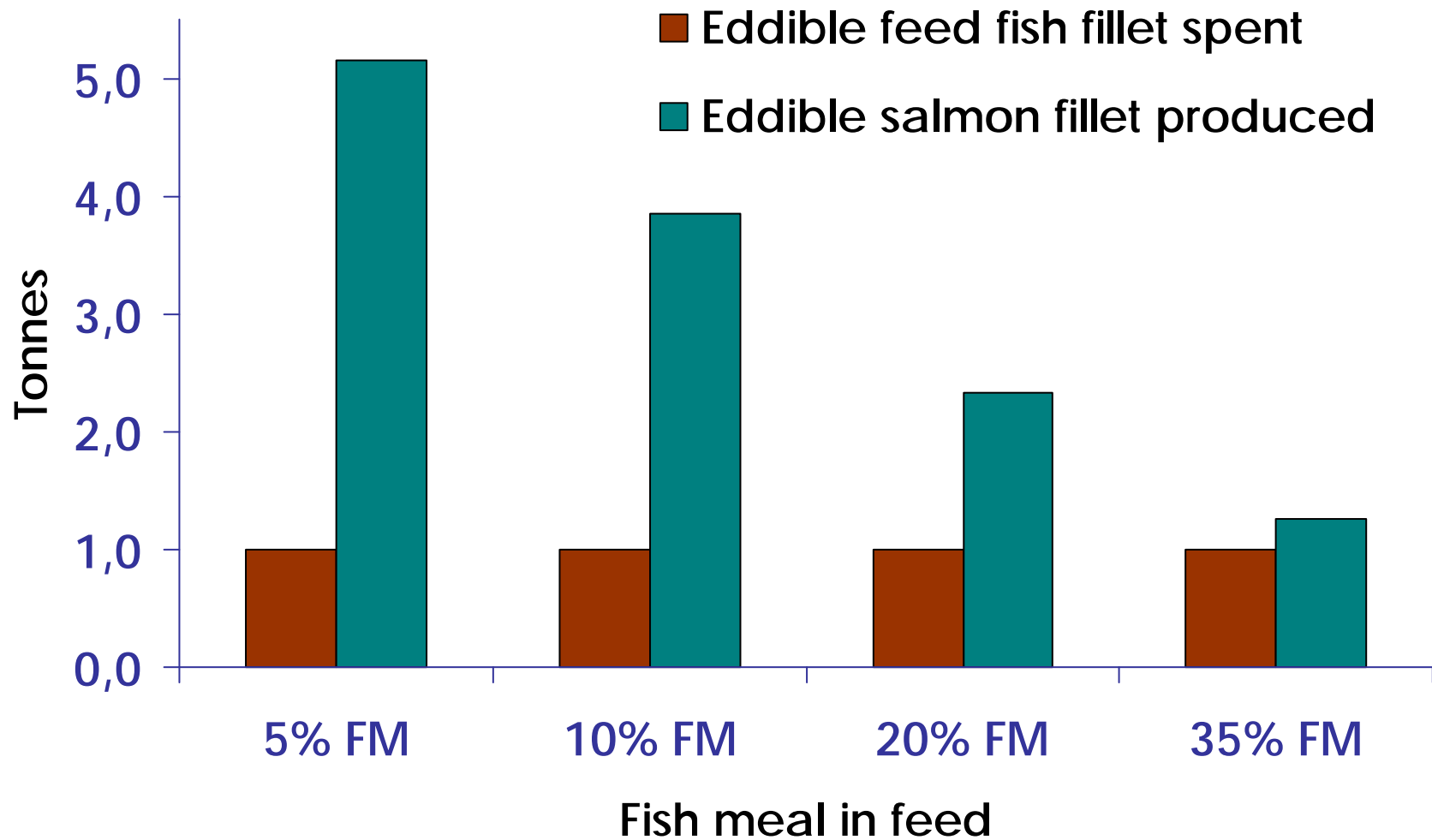
FIFO \approx 1 if fish meal inclusion is 25 % and FCR 1.0



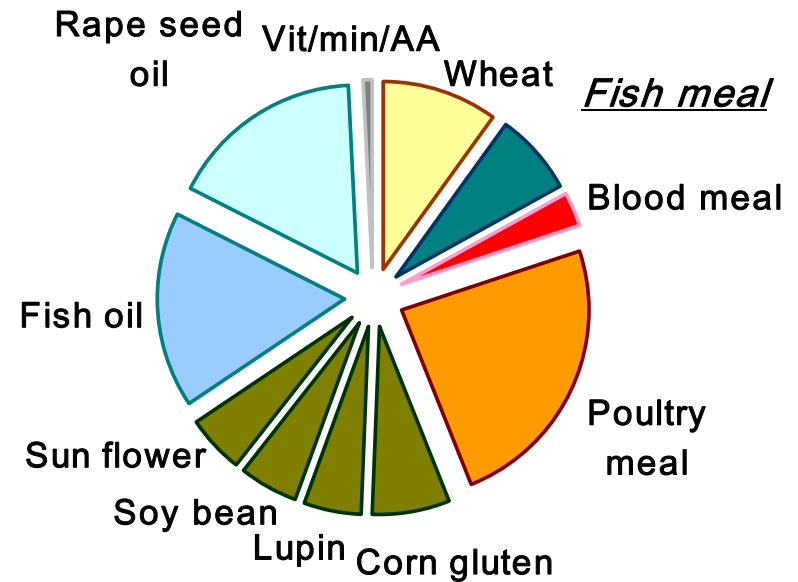
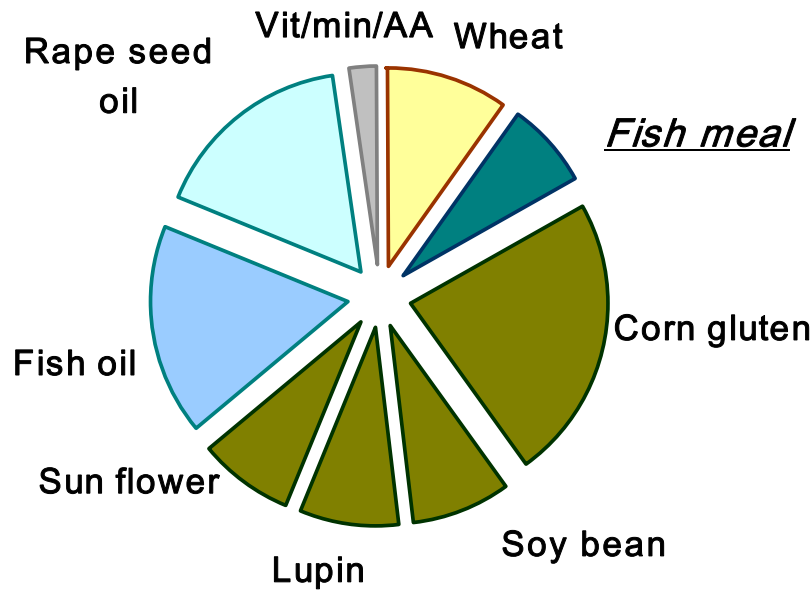
Marine protein spent vs. produced



Fish fillet spent vs. produced



Plant vs. animal protein



Ingredient cost/ kg feed: NOK 3.90
 Fôrfaktor: 1.15
 Ingredient cost/ kg fish: NOK 4.48

NOK 3.71
 1.05
NOK 3.89

Lipid

- Fish used for fish meal contains i. a. 7% lipid
 - 1/3 remains in the fish meal (2,5% of live weight)
 - 2/3 as fish oil (4,5% live weight)
- $\leq 7\%$ fish oil in the feed if $FIFO < 1$
(incl. lipid from fish meal)
- More fish oil can be used if the feed fish contains more lipid

Lipid example:

Industrial fish contains 7 % lipid (=70 g/ kg fish)

What if desired fish lipid level in fish feed is
16 % (= 160 g/ kg)?

Fish meal contains 10 % lipid (100 g oil/ kg)

If feed contains 25 % fish meal it also contains 25 g
fish oil

Lipid example continued:

The first kg of wild caught fish used will contribute 70 g of fish oil.

One additional kg of wild caught fish gives only $(70 \text{ g} - 25 \text{ g}) = 45 \text{ g}$ lipid.

Two additional kg gives 90 g lipid.

In total three kilos gives $(70 \text{ g} + 45 \text{ g} + 45 \text{ g}) = 160 \text{ g}$ lipid.

The rest of the two last kg of fish, 1910 g, will give nearly 0.5 kg of fish meal, which can be used for other purposes than fish production.

Real fish input is then 1000 g whole fish + 90 g fish oil, in total 1090g which at a FCR of 1 gives a FIFO of 1.09.

It is though a fact that 3 kg of wild fish has to be caught.

Lipid

Desired lipid content?

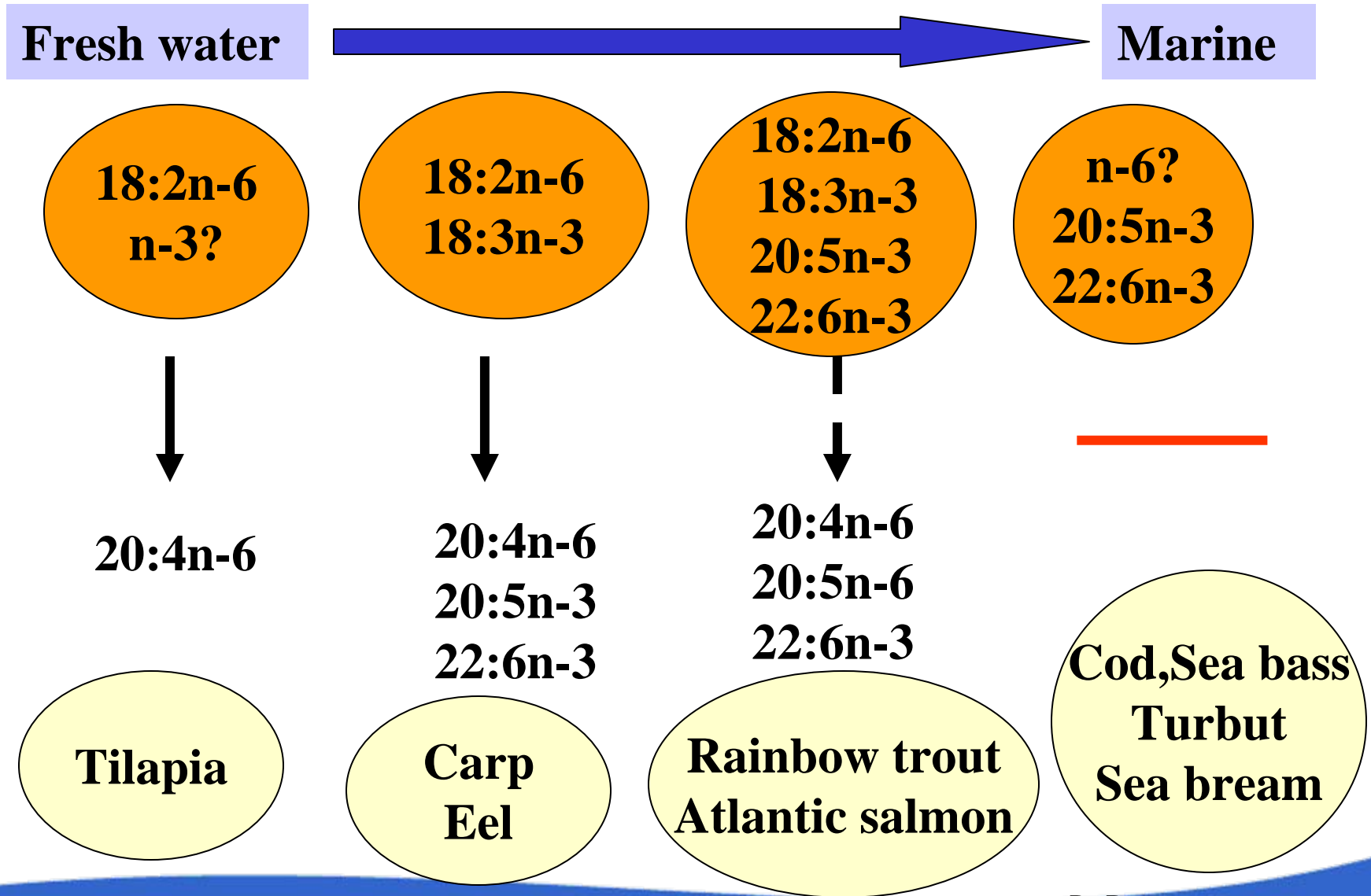
Consumer demand

Health benefits

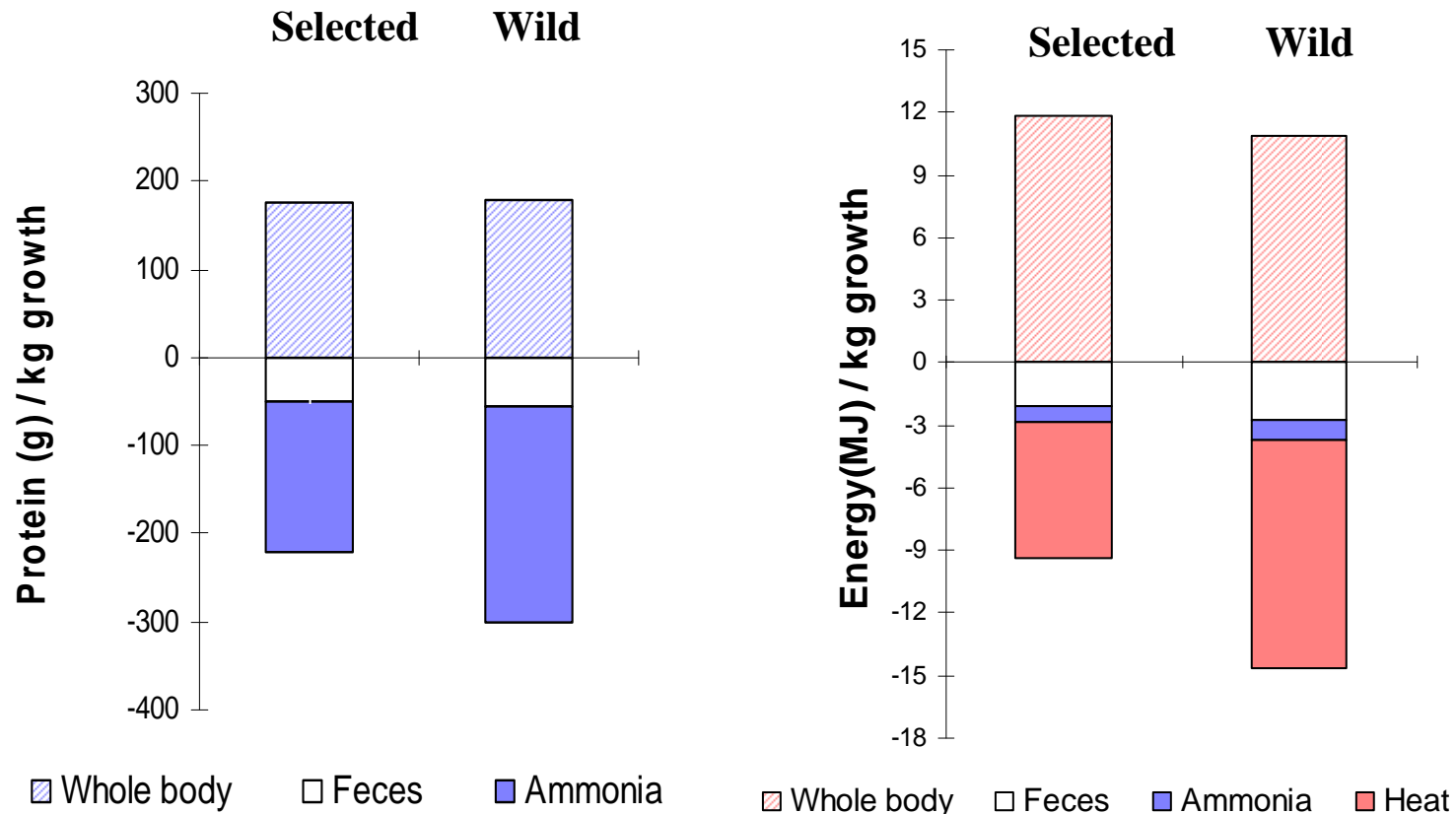
Salmon requires 0.5-1 % n-3 FA in the feed

Herbivorous

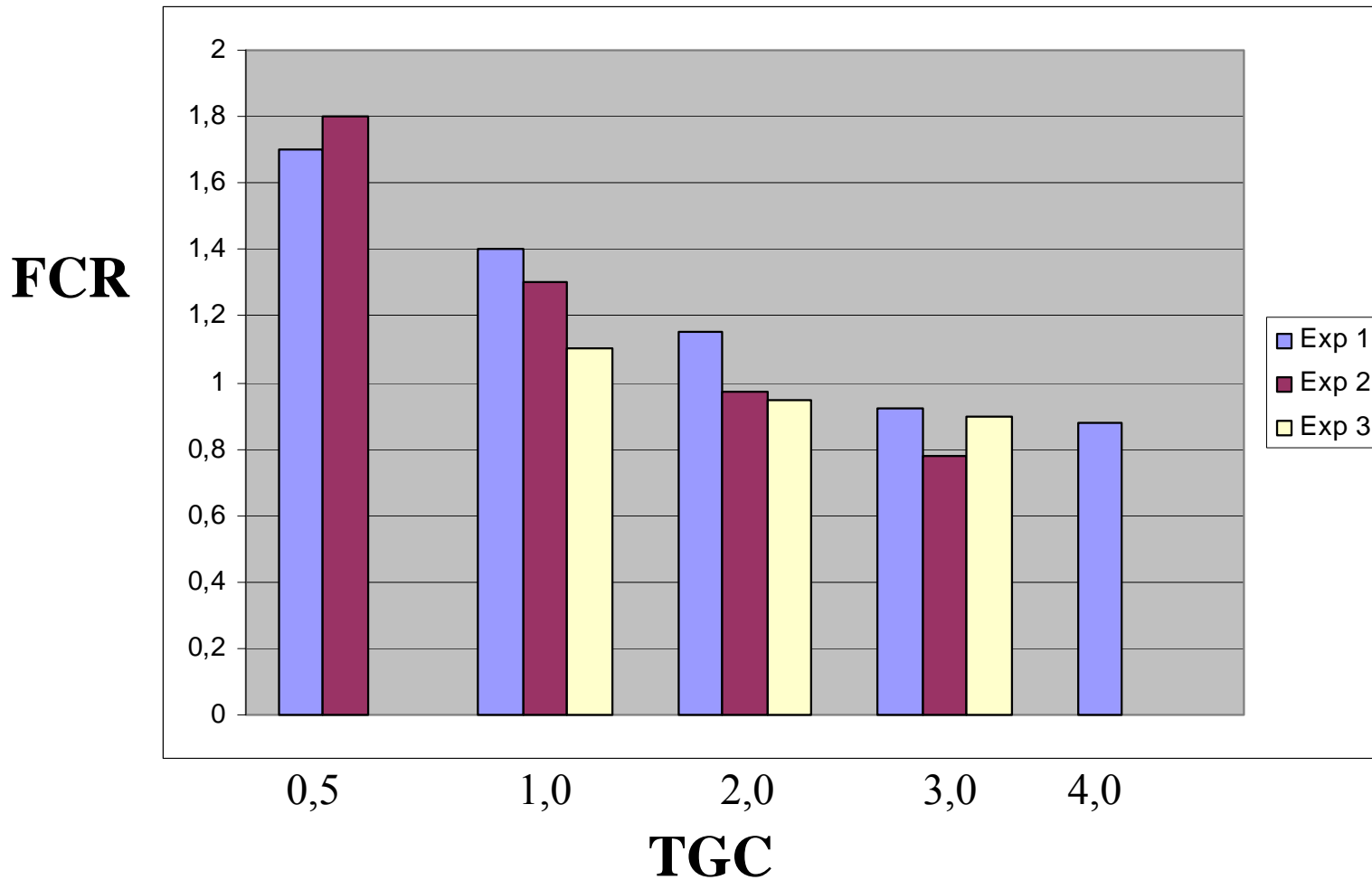
Carnivorous



Budget for protein and energy for 1 kg of growth in culture for Atlantic salmon, wild or selectively bred



Termal Growth Coefficient (TGC) versus Feed Conversion Ratio (FCR)



Conclusions

- **Commercial feed production is gradually becoming more independent of fish meal and oil from fisheries**
- **Increased use of protein from vegetable and animal by-product sources will make Atlantic salmon a net producer of marine protein**
- **Vegetable oil sources can be used at high levels in salmon feeds, as long as the minimum needs for essential fatty acids (1-2% of diet) are covered. The fatty acid profile of the fish will reflect the feed**

conclusions continued

- **In the early 90ies roughly 2.5-3.0 kg of wild fish was spent in the production of 1 kg farmed salmon. This has now been reduced to approximately 1:1 on the protein side. It is possible to improve this further**
- **The slaughter offal from the salmon industry are used as feed for other species**
- **The high degree of flexibility which has been developed in practical salmon nutrition is important for the sustainability of the industry**



Fish need nutrients
not feedstuffs!

Thank you for
your attention!