

Shift from marine to plant ingredients in salmon farming

– consequences for resource efficiency



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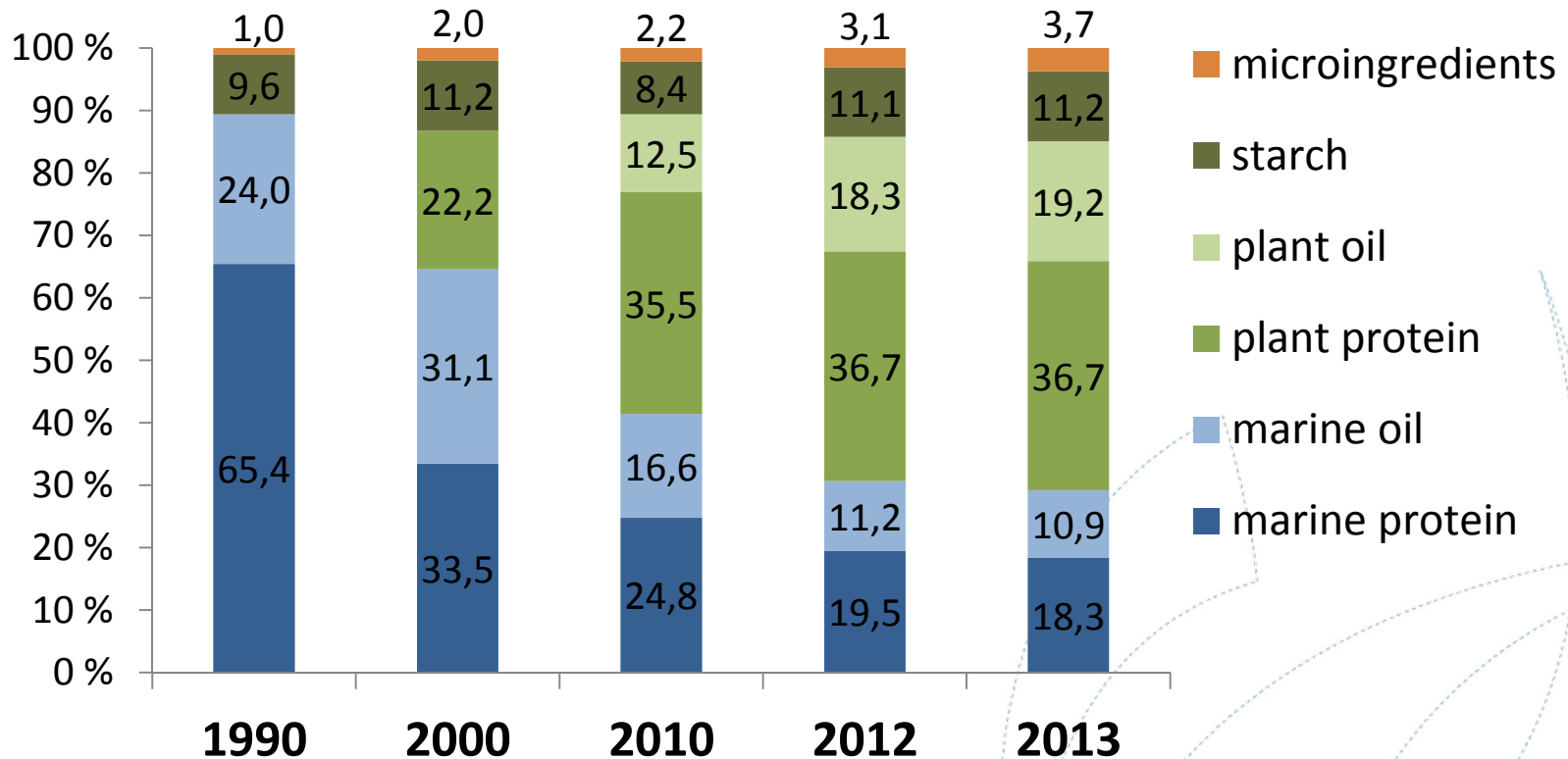
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Bente Ruyter, Erik Skontorp Hognes, Friederike
Ziegler, Veronica Sund, Torbjørn Åsgård

1990: 90 % marine ingredients

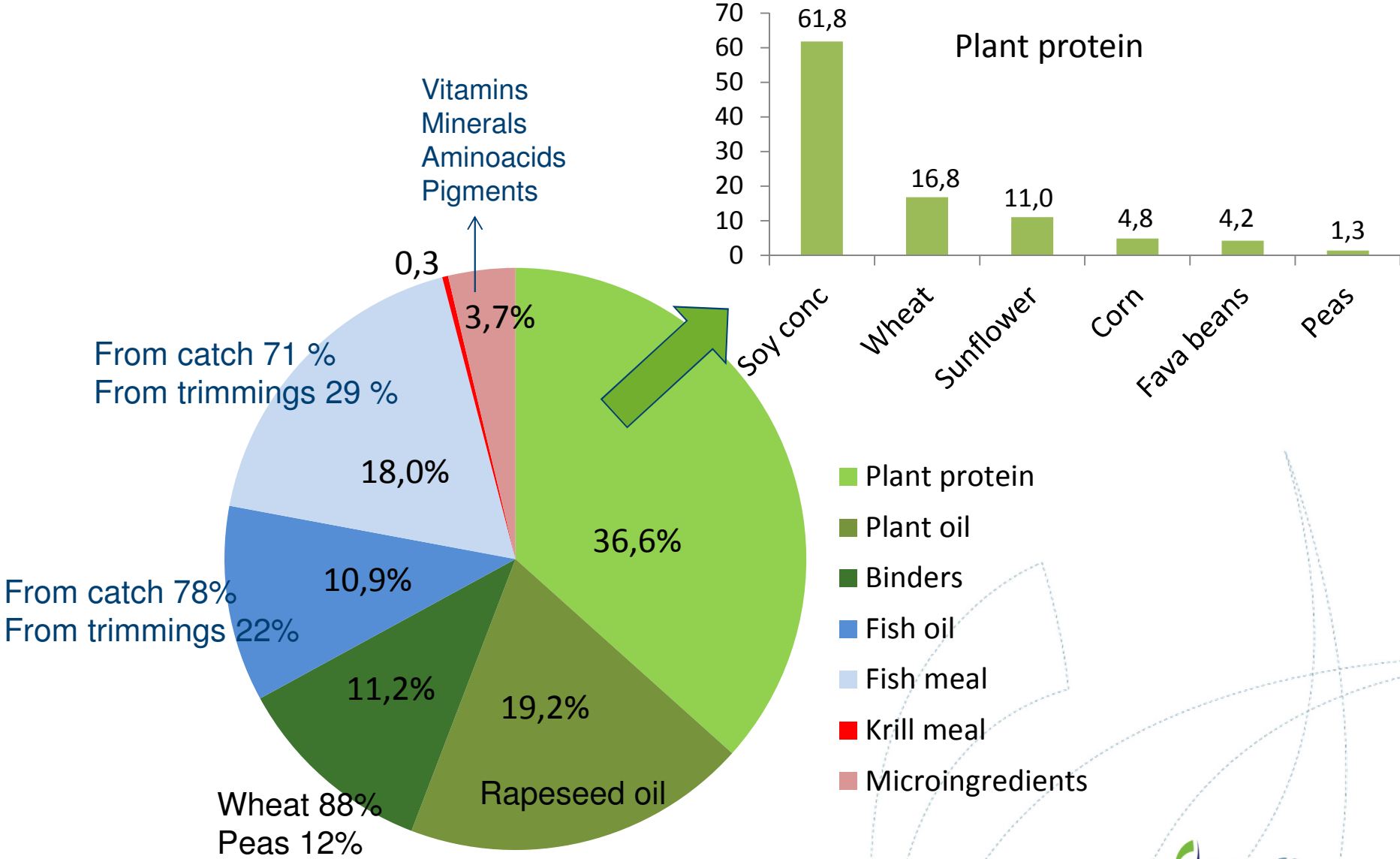
2013: 30 % marine ingredients

15 % reduction in marine ingredients between 2010 and 2012

Diet composition (%)



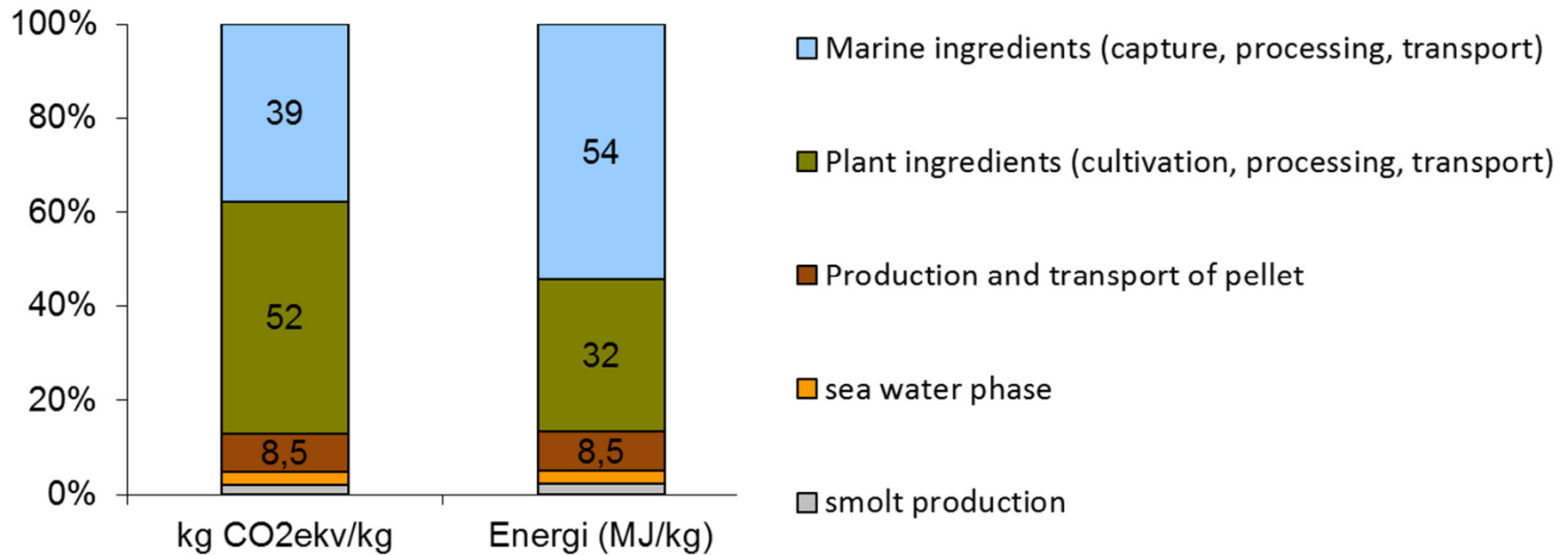
Ingredients in Norwegian salmon feed



Scope of the project

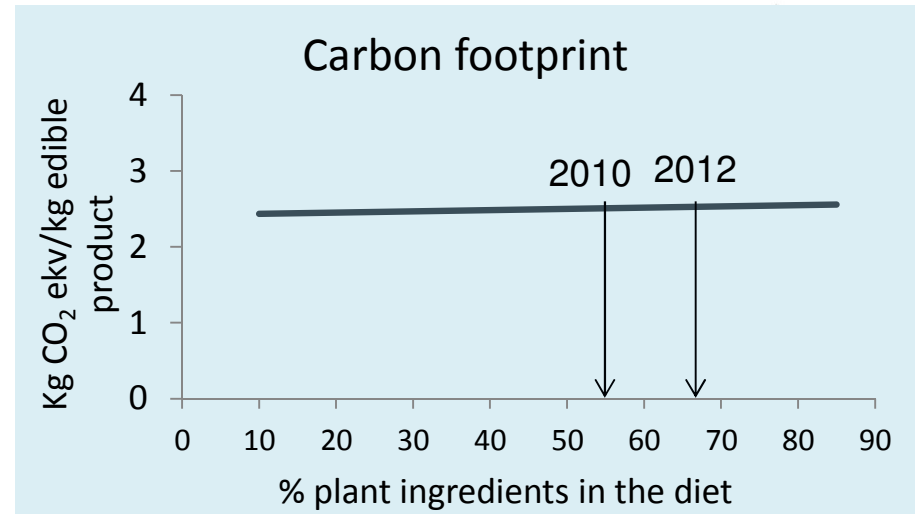
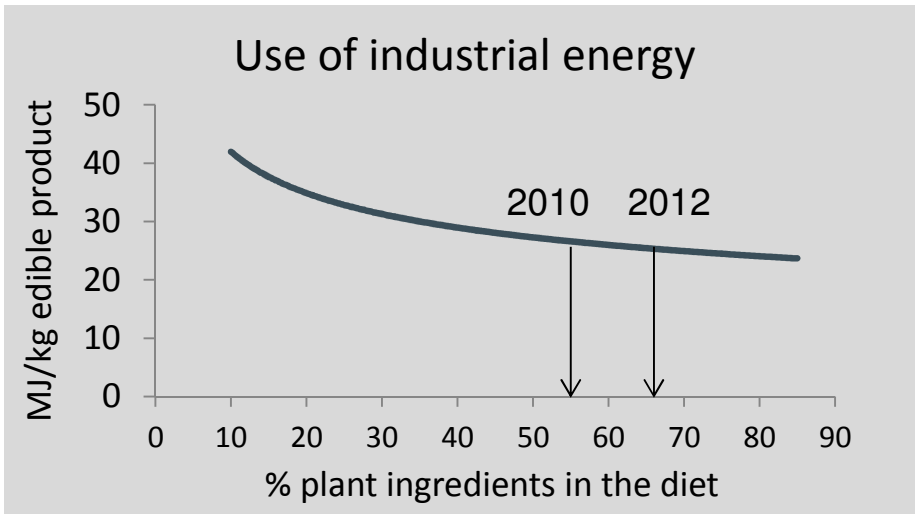
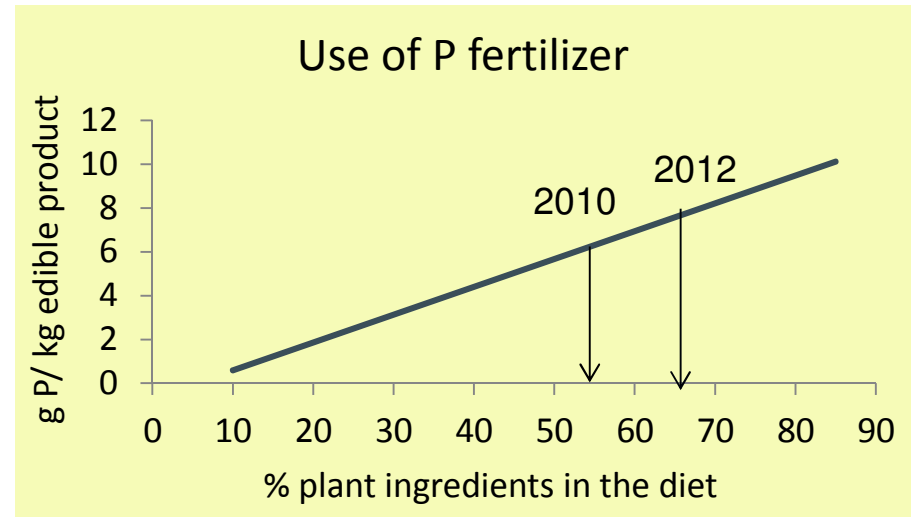
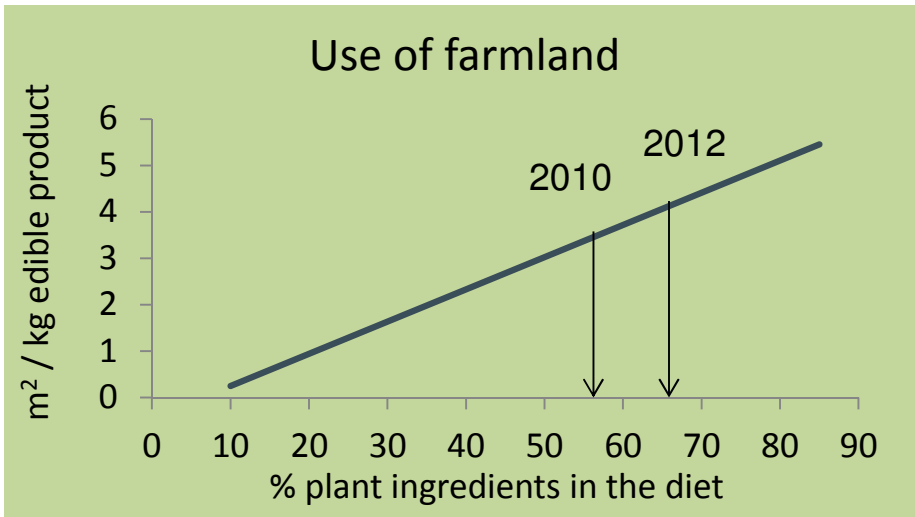
- Compare the Norwegian salmon production in 2010 and 2012 using the following indicators of sustainability:
 - Energy use
 - CO₂ footprint
 - Use of phosphorous and farm land
- Life Cycle Assessment
- Use of marine ingredients
 - Fish-in/Fish-out ratio (FIFO)
 - Dependency of marine protein and oil
 - Retention efficiency (from feed ingredients to salmon produced)
 - Nutrient efficiency ratios (Protein, Lipid, Energy efficiency ratios)

Distribution of energy use and CO₂ release along the production chain

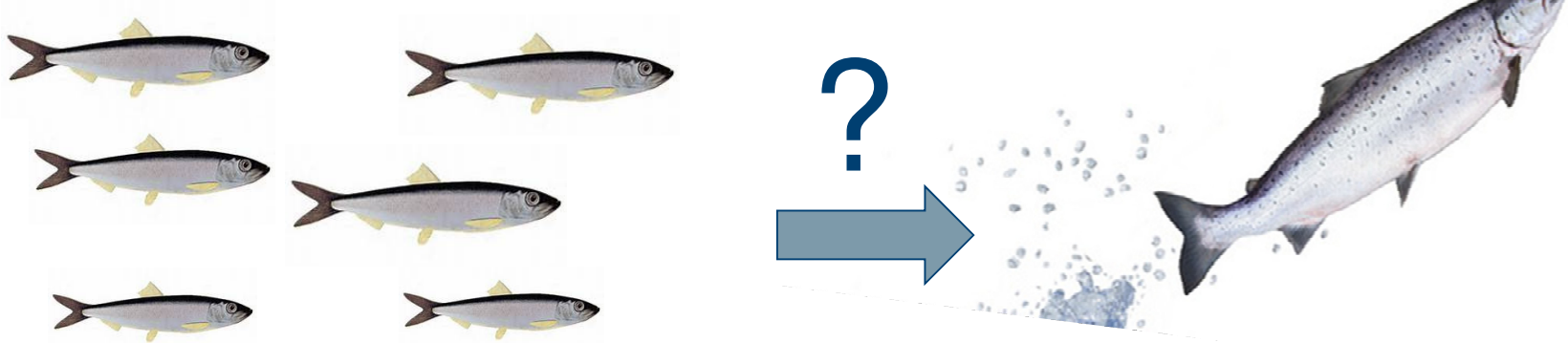


More than 90 % is related to the production and transport of feed ingredients and feed

Use of farm land, P fertilizer, energy and reelease of CO₂ (per kg edible product)

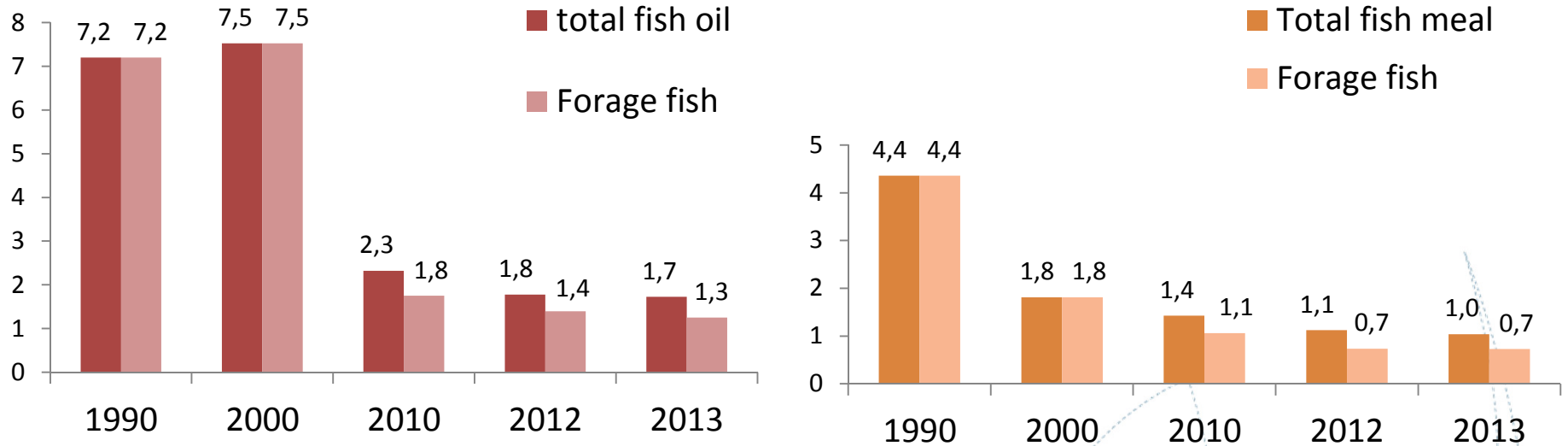


How much wild fish is used in the production of Norwegian salmon?



- Estimated as the **Fish-in/Fish-out ratio (FIFO)**
- FIFO calculates how many kg of forage fish that must be harvested for the production of fish meal and oil used to produce 1 kg of salmon
- 1 kg of forage fish gives on average 70 g of oil and 225 g of fish meal

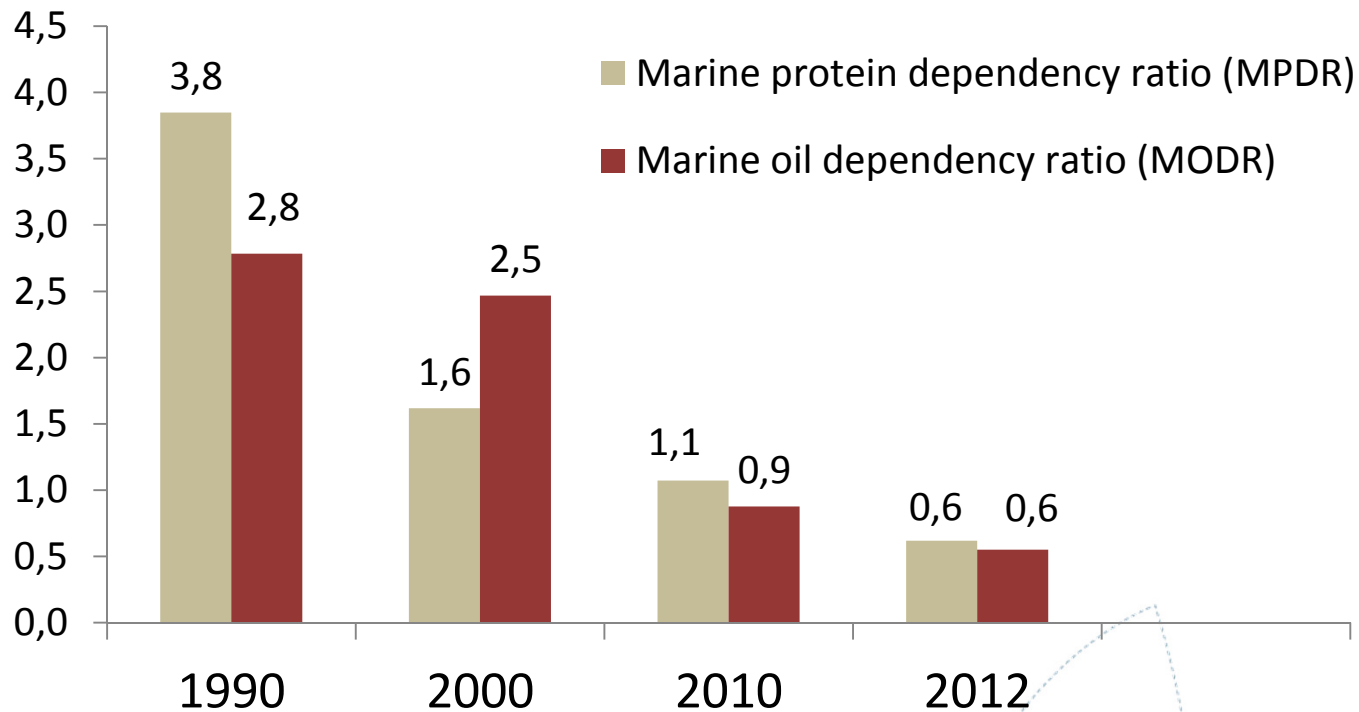
FIFO's for fish oil and meal i Norwegian salmon farming 1990-2013



$$FIFO_{(FM \text{ or } FO)} = \left[\frac{\text{Diet FM or FO (g/kg)}}{\text{FM or FO reduction efficiency (g/kg)}} + \right] \cdot eFCR$$

Marine protein and oil dependency ratios: (forage fish)

= marine protein and oil spent/marine protein and oil produced



Norwegian salmon has become a net producer of marine protein and lipid

$$\text{MPDR} = \frac{(\% \text{ MP in feed}) \cdot (\% \text{ protein in MP}) \cdot (\text{kg feed eaten})}{(\text{BW}(f) \cdot \% \text{ body protein}) - (\text{BW}(i) \cdot \% \text{ body protein})}$$

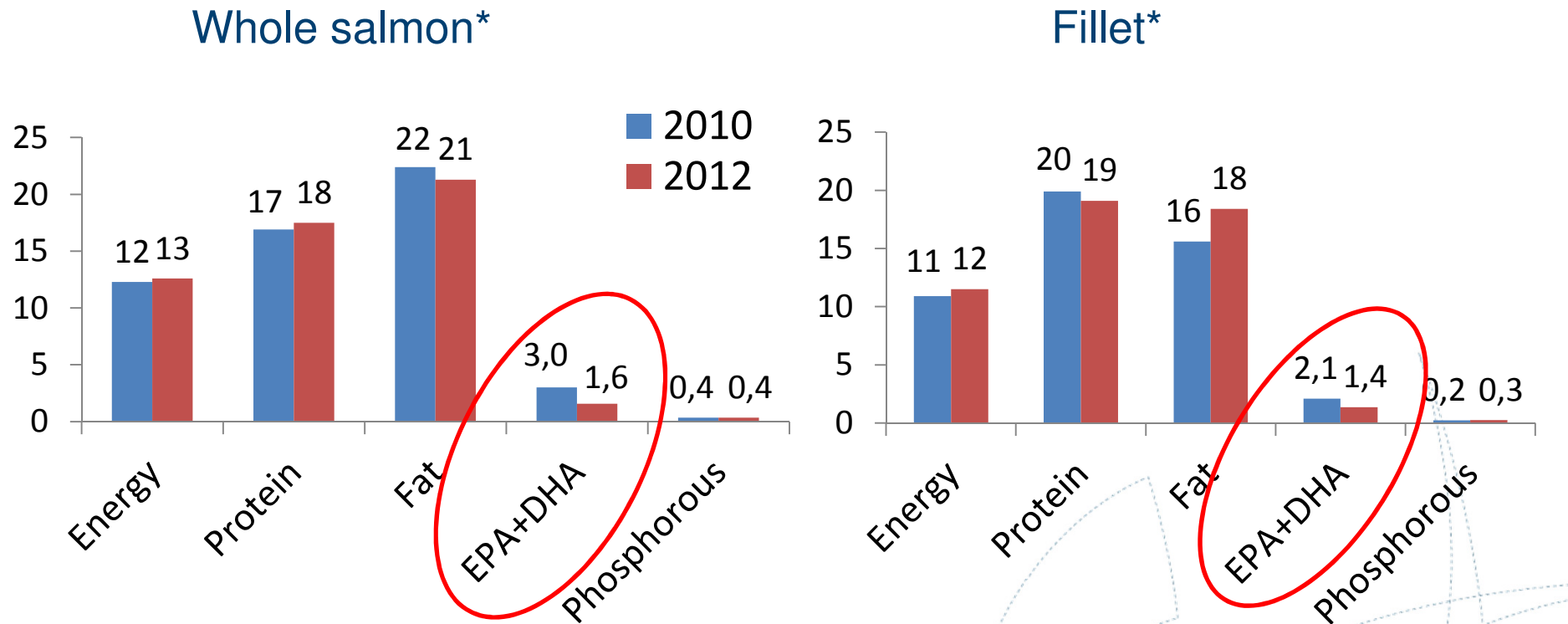
$$\text{MODR} = \frac{[\% \text{ FO in feed} + (\% \text{ FM in feed} \cdot \% \text{ fat in FM})] \cdot (\text{kg feed eaten})}{(\text{BW}(f) \cdot \% \text{ body fat}) - (\text{BW}(i) \cdot \% \text{ body fat})}$$

Average composition of salmon feed in 2010 and 2012

% or MJ/kg	2010*	2012*
Energy	25.0	21.6
Protein (Nx6.25)	37.3	35.4
Lipid	33.0	32.5
EPA	2.2	1.7
DHA	1.8	1.3
Phosphorus	1.0	0.90

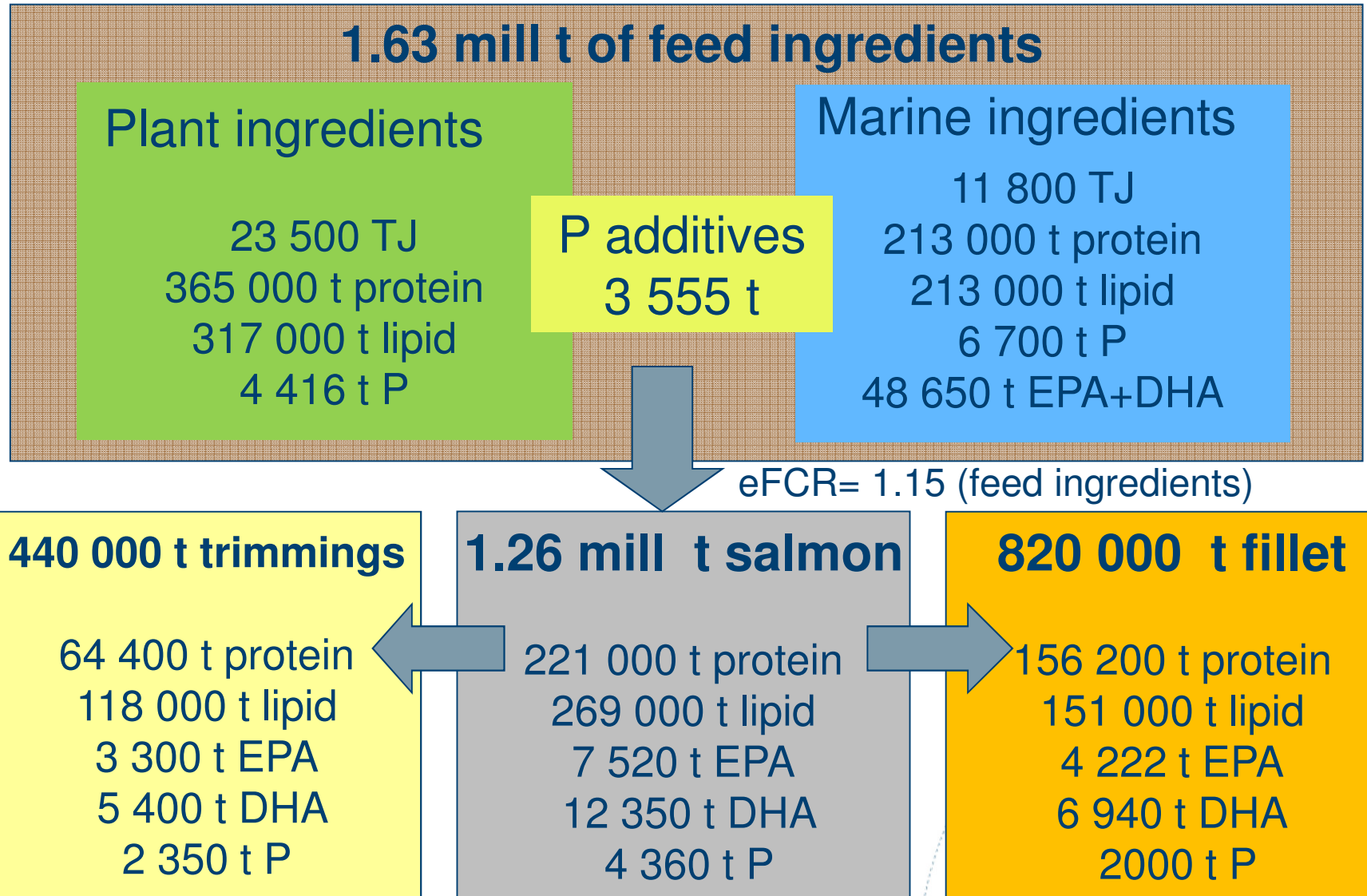
* Information on nutrient content in feed ingredients provided by Biomar, EWOS and Skretting

Nutrient content in salmon 2010 and 2012 (% or MJ/kg)



* Data from bench mark trial where salmon where fed diets fro Biomar, EWOS and Skretting to a final weight of 5 kg

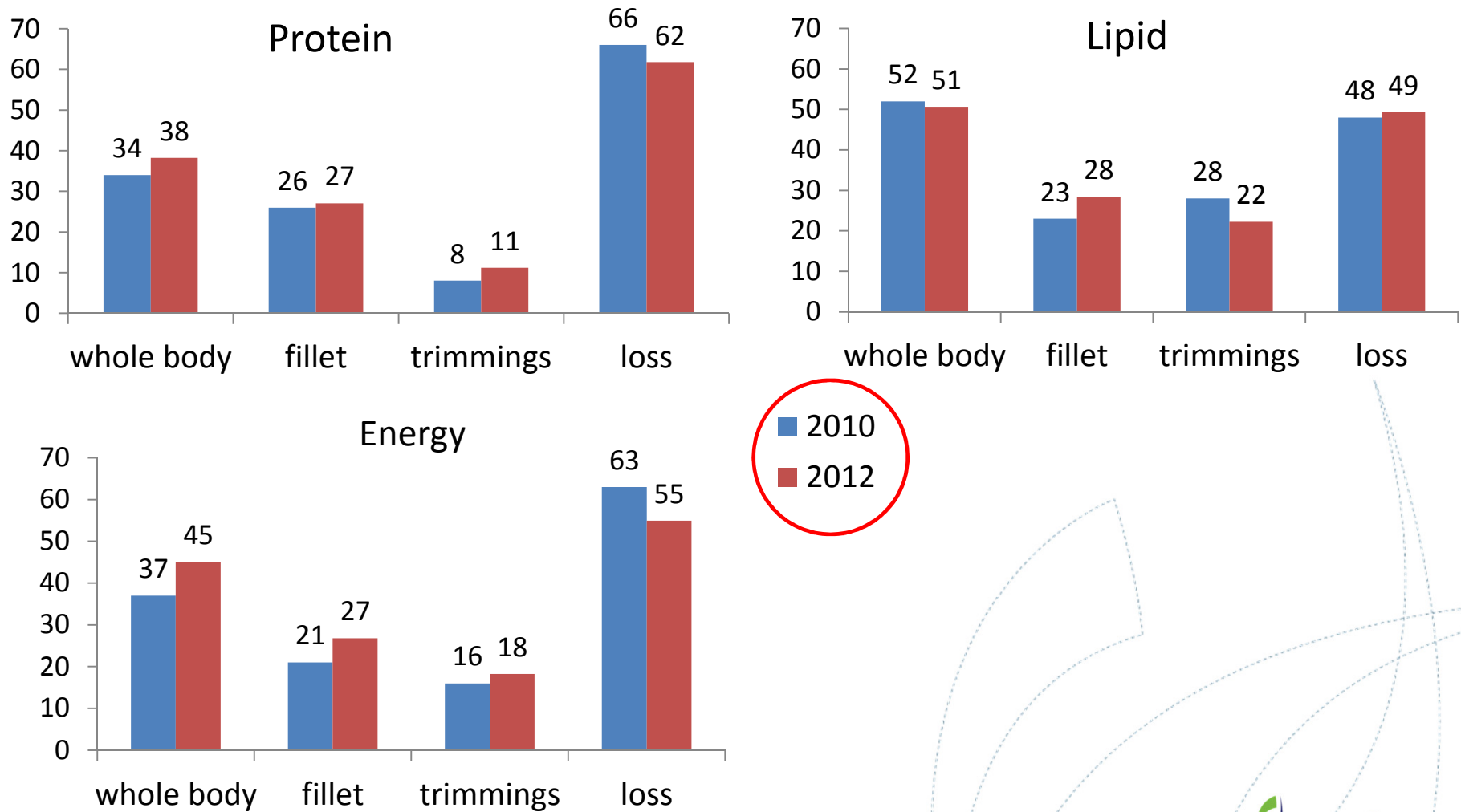
Nutrient flows in Norwegian salmon farming 2012



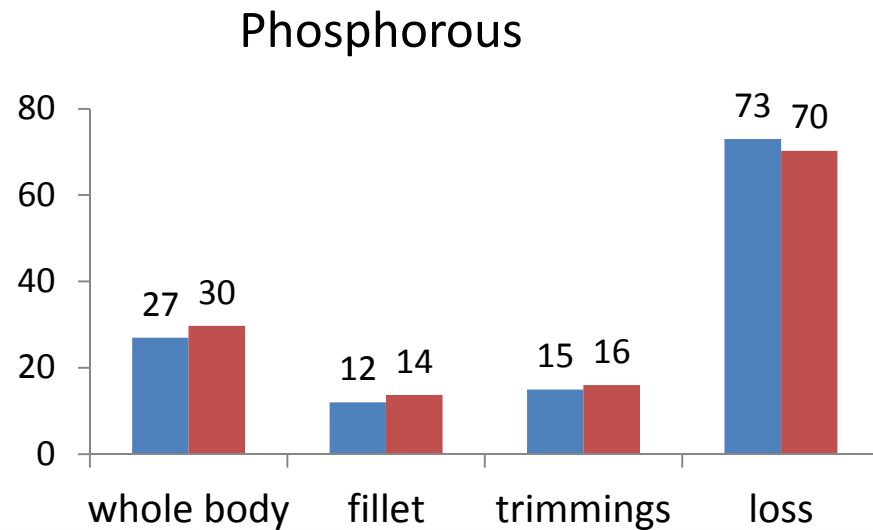
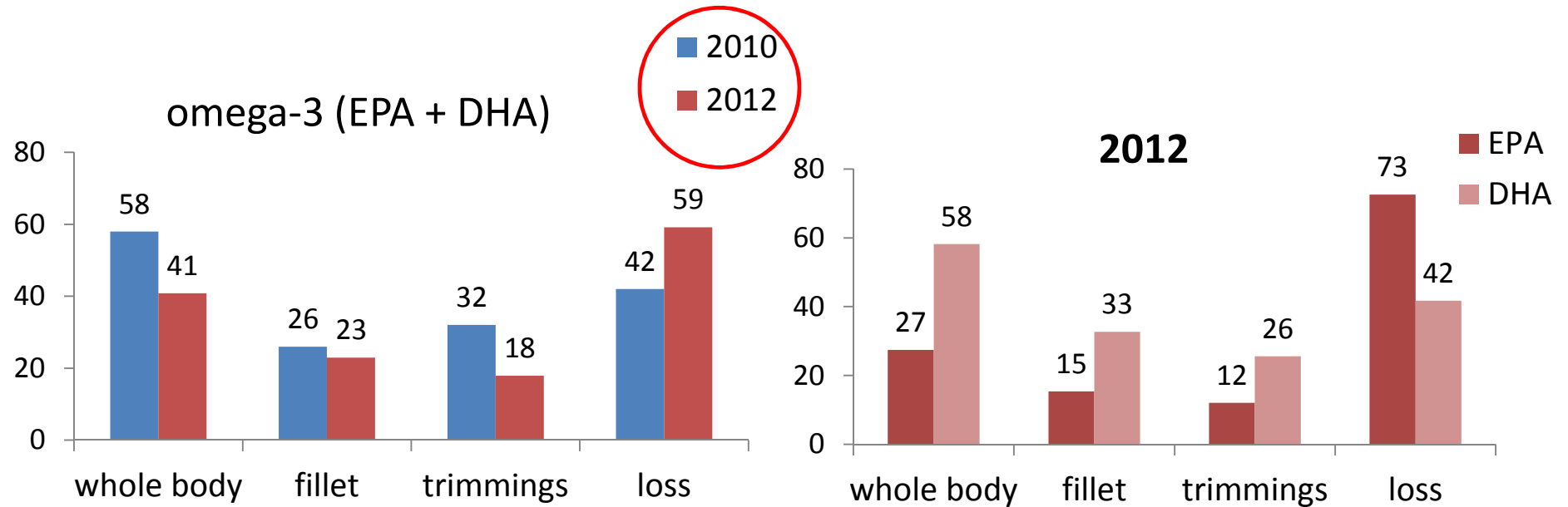
Sufficient EPA and DHA in Norwegian farmed salmon to cover the recommended daily intake for 123 million people for one year! (0.25 g/day)

Retention of nutrients in Norwegian salmon

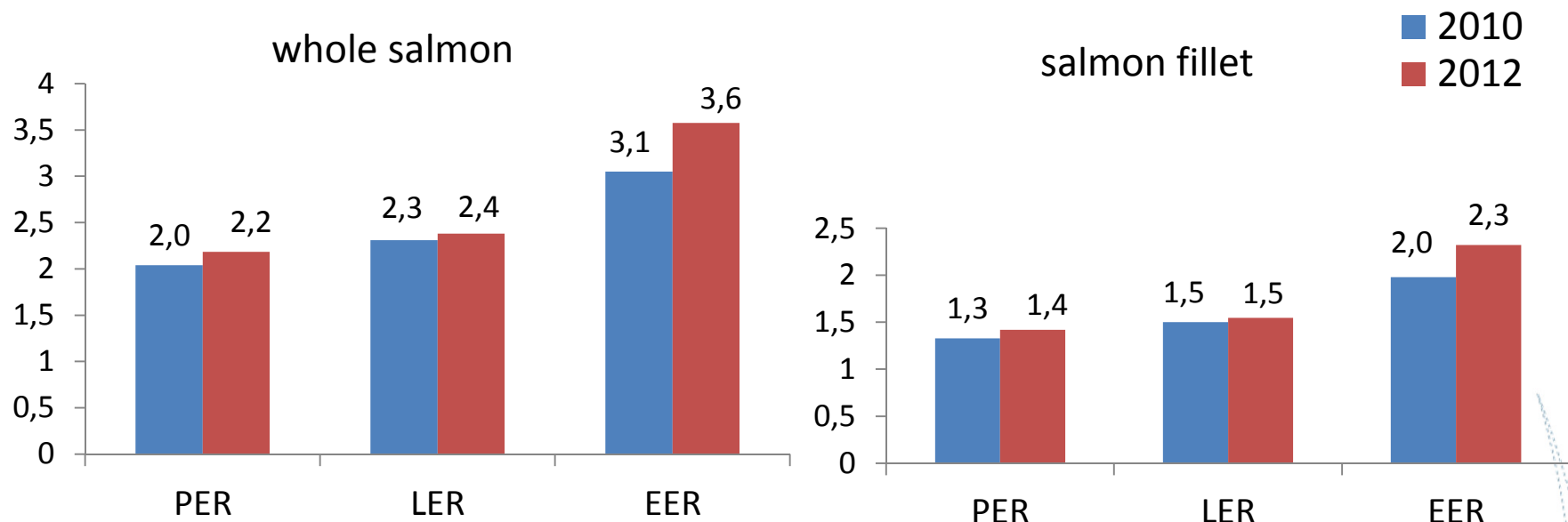
$$\text{Nutrient retention (\%)} = 100 \cdot \frac{\text{Amount of nutrient or energy incorporated in animal}}{\text{Amount of nutrient used in feed}}$$



Retention of nutrients in Norwegian salmon



Nutrient efficiency ratios: protein, lipid and energy



$$\text{NER} = \frac{\text{Biomass produced (tons)}}{\text{nutrient fed (tons)}}$$

PER = Protein efficiency ratio
LER = Lipid efficiency ratio
EER = Energy efficiency ratio

Summary

- Assessing sustainability is complex
- Nutrient assimilation efficiency may be the best sustainability indicator
- The 15% reduction in marine ingredients in the diet from 2010 to 2012 did not have any negative effects on the retention of energy, fat, protein and P
- The retention and content of EPA og DHA was reduced between 2010 and 2012
- Norwegian farmed salmon is still a good source of omega-3
- Norwegian salmon is a net producer of marine protein and oil

I would like to thank Biomar, EWOS, Skretting, Marine Harvest and Lerøy Seafood for providing data on nutrient composition in feed ingredients and salmon

The project was funded by the Norwegian Seafood Research Fund (FHF)

Thank you for your attention 😊

For more information:

<http://www.fhf.no/prosjektdetaljer/?projectNumber=900912>

<http://www.fiskerifond.no/>

<http://www.Nofima.no>