

Shift from marine to plant ingredients in salmon farming

– consequences for resource efficiency



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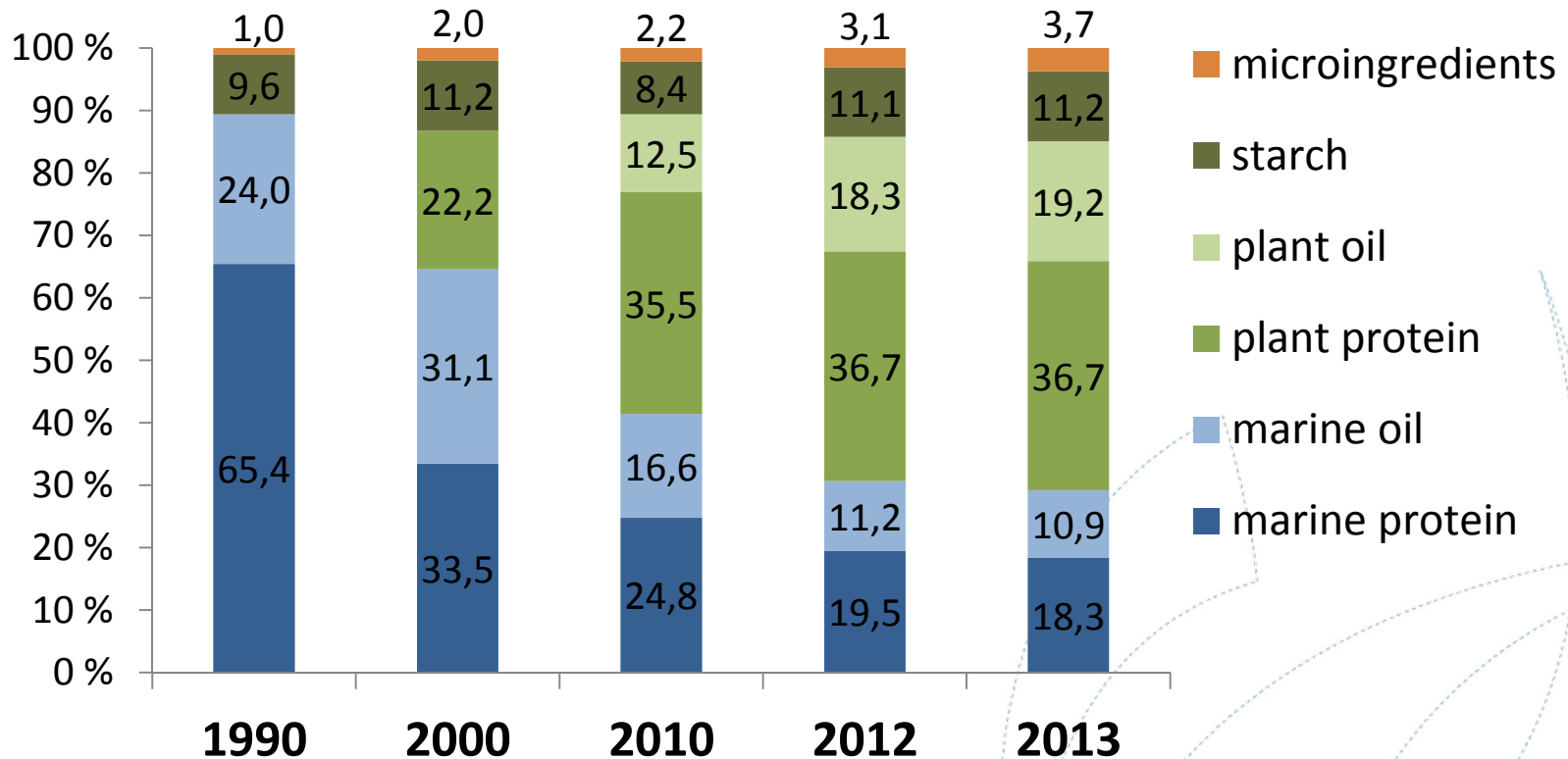
Turid Synnøve Aas, Bjarne Hatlen, Gerd Marit Berge
Bente Ruyter, Erik Skontorp Hognes, Friederike
Ziegler, Veronica Sund, Torbjørn Åsgård

1990: 90 % marine ingredients

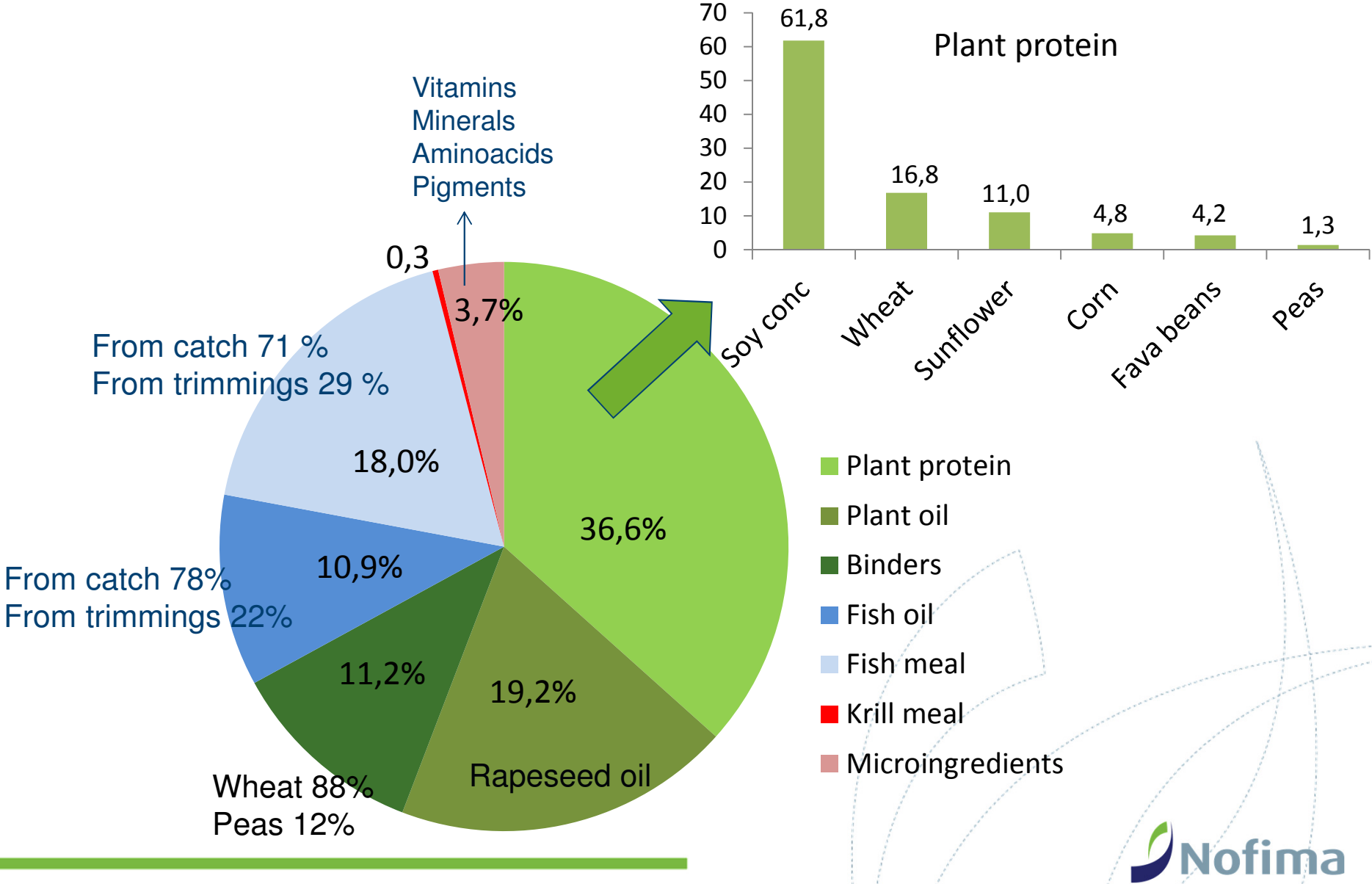
2013: 30 % marine ingredients

15 % reduction in marine ingredients between 2010 and 2012

Diet composition (%)



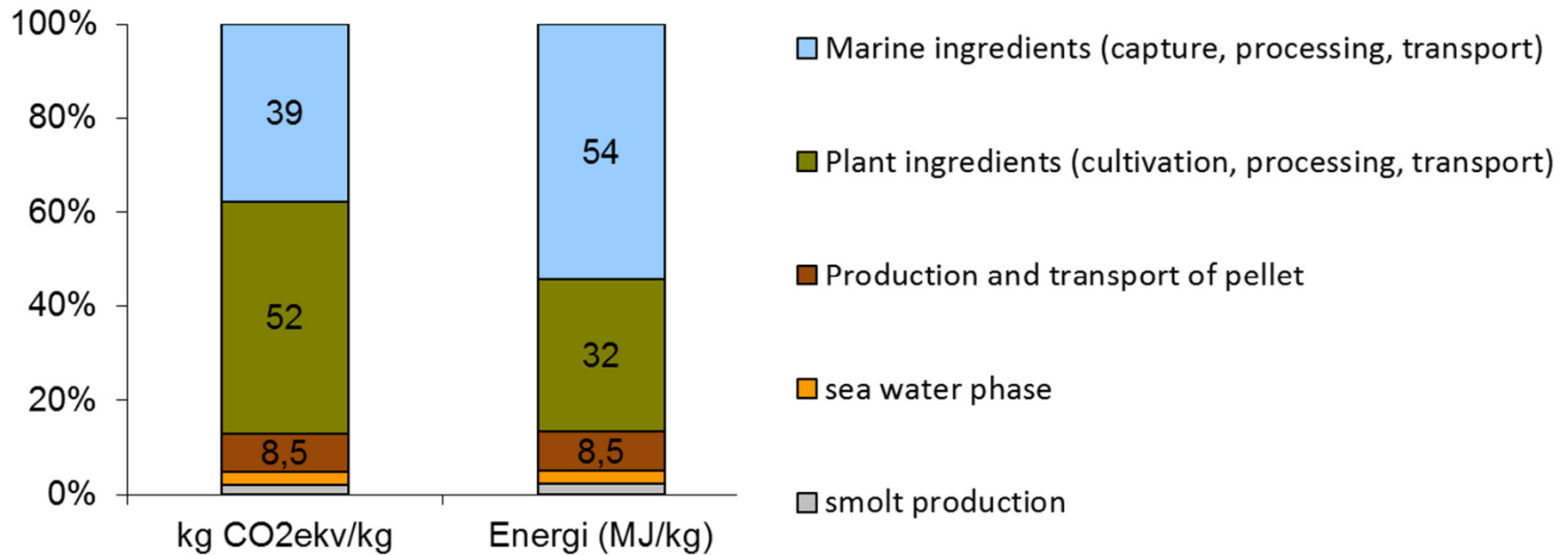
Ingredients in Norwegian salmon feed



Scope of the project

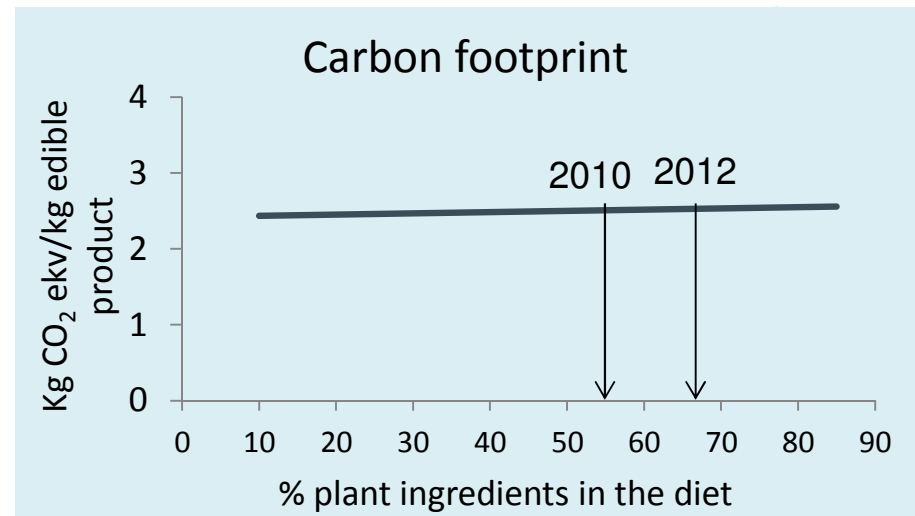
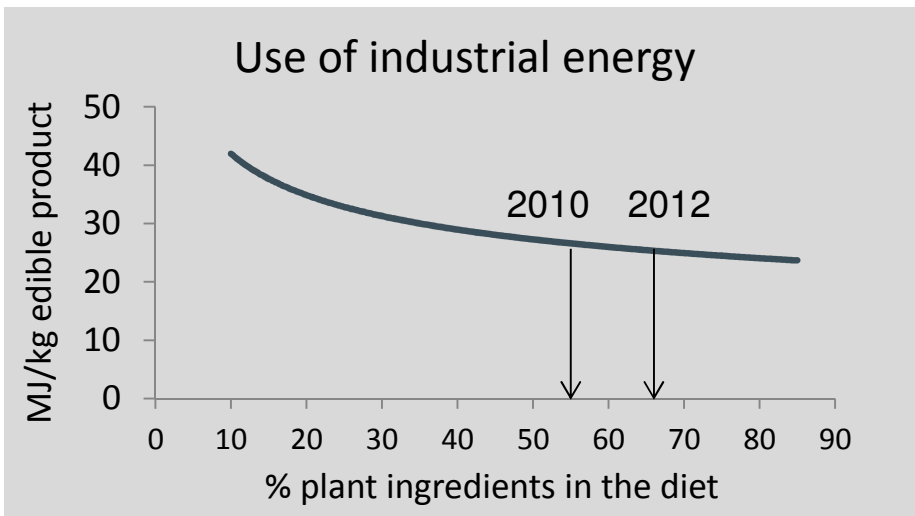
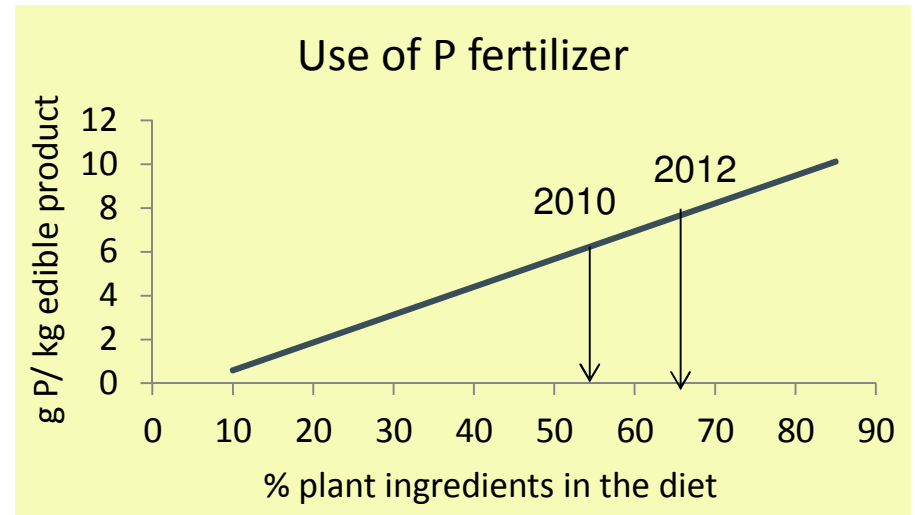
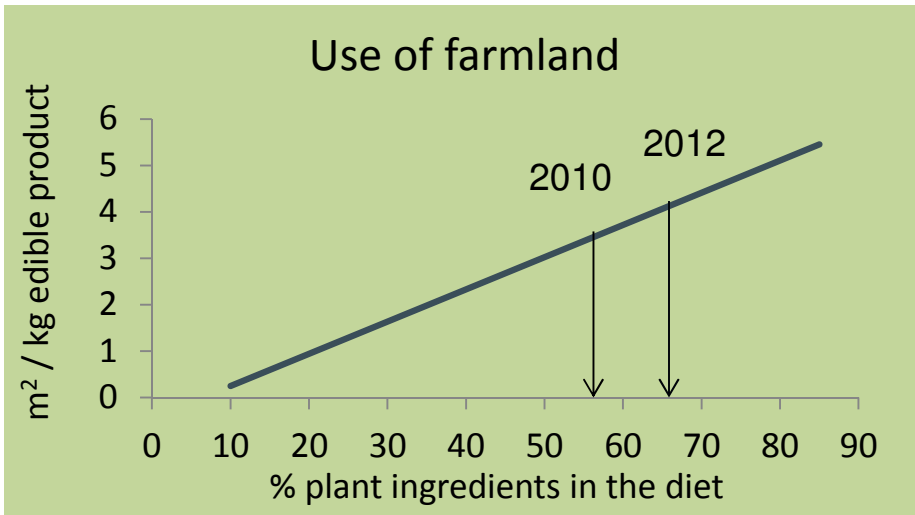
- Compare the Norwegian salmon production in 2010 and 2012 using the following indicators of sustainability:
 - Energy use
 - CO₂ footprint
 - Use of phosphorous and farm land
- Life Cycle Assessment
- Use of marine ingredients
 - Fish-in/Fish-out ratio (FIFO)
 - Dependency of marine protein and oil
 - 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

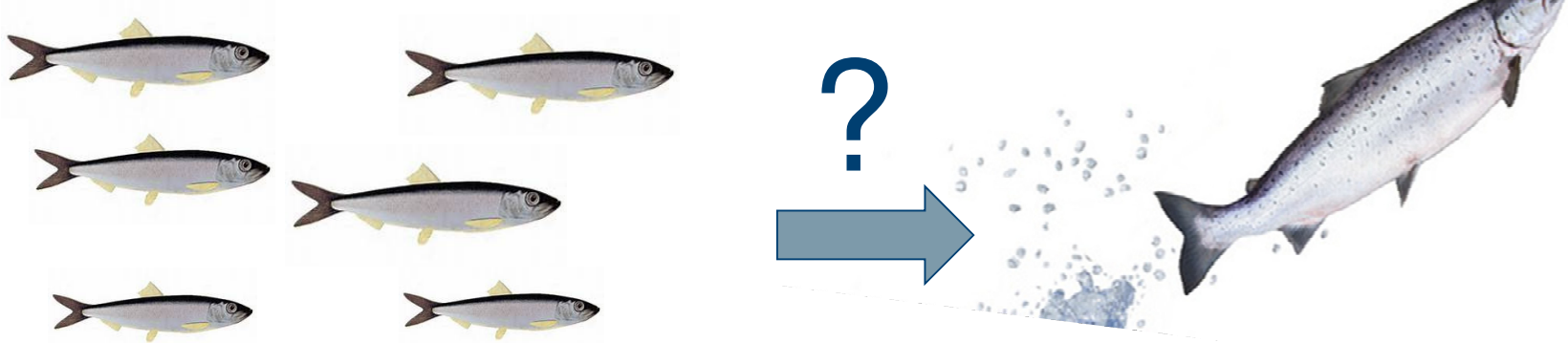


More than 90 % is related to the production and transport of feed ingredients and feed

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

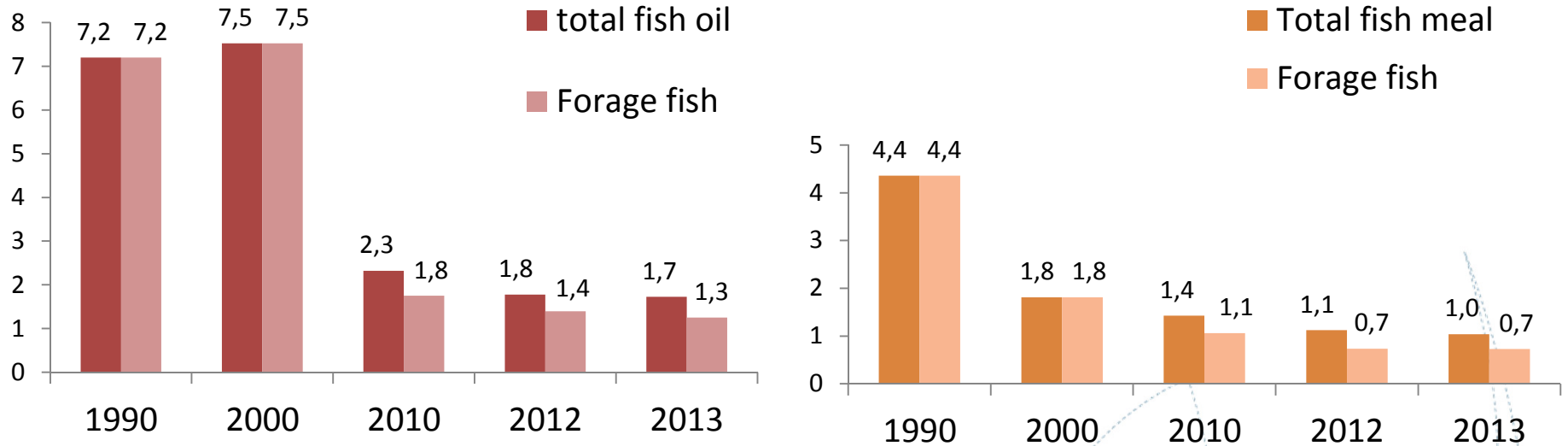


How much wild fish is used in the production of Norwegian salmon?



- 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

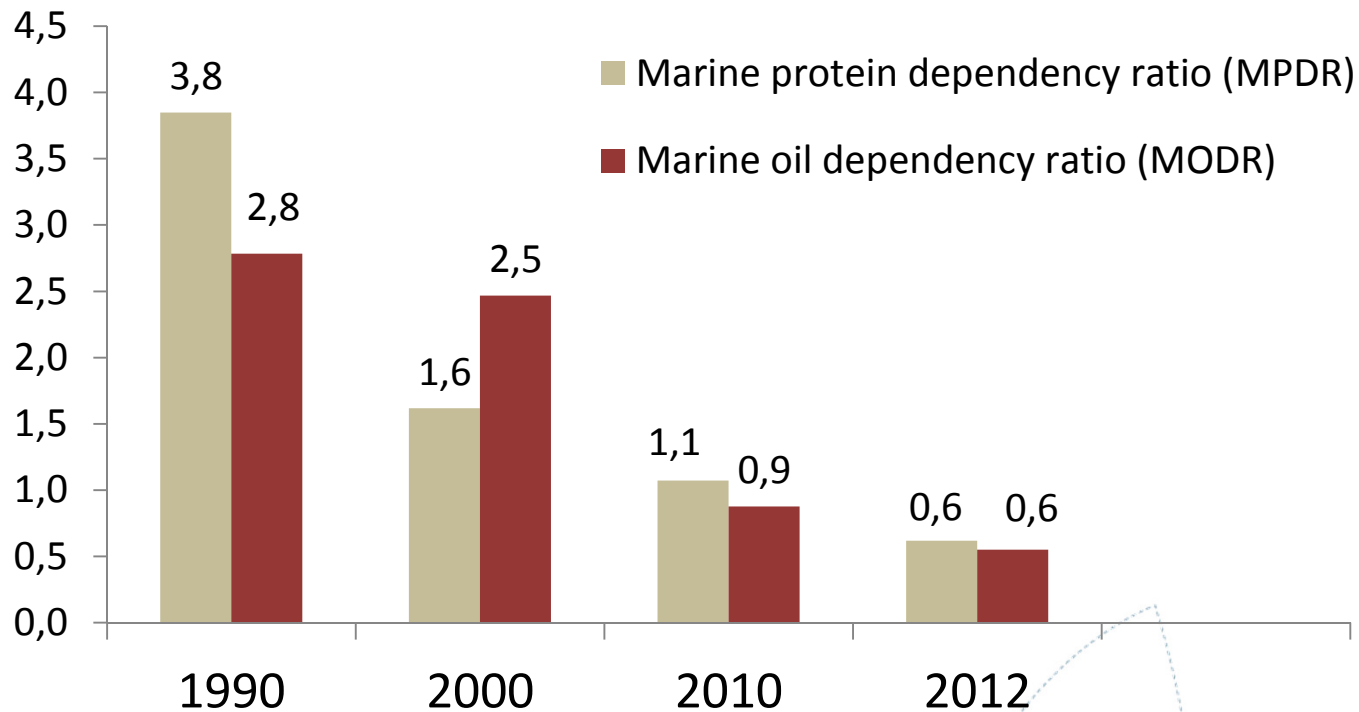
FIFO's for fish oil and meal i Norwegian salmon farming 1990-2013



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

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

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

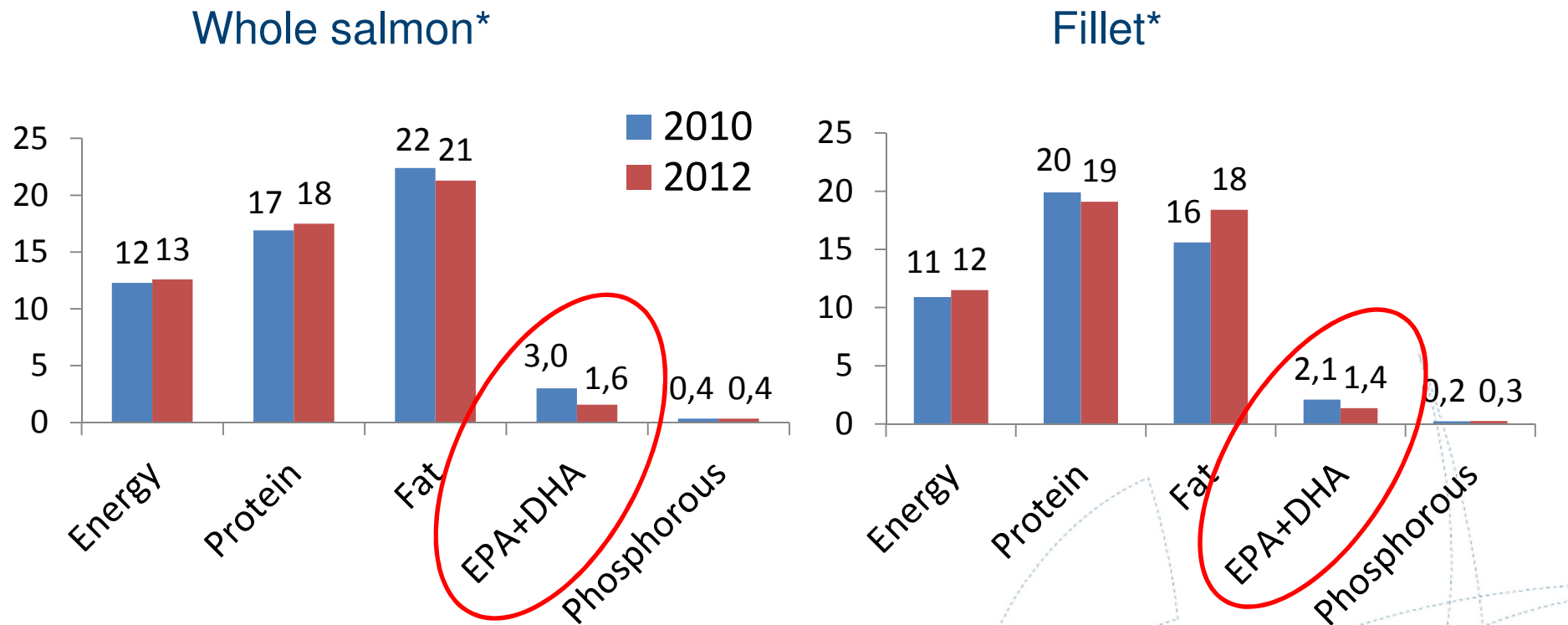
$$\text{MODR} = \frac{[\% \text{ FO in feed} + (\% \text{ FM in feed} \cdot \% \text{ fat in FM})] \cdot (\text{kg feed eaten})}{(\text{BW}(f) \cdot \% \text{ body fat}) - (\text{BW}(i) \cdot \% \text{ body fat})}$$

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

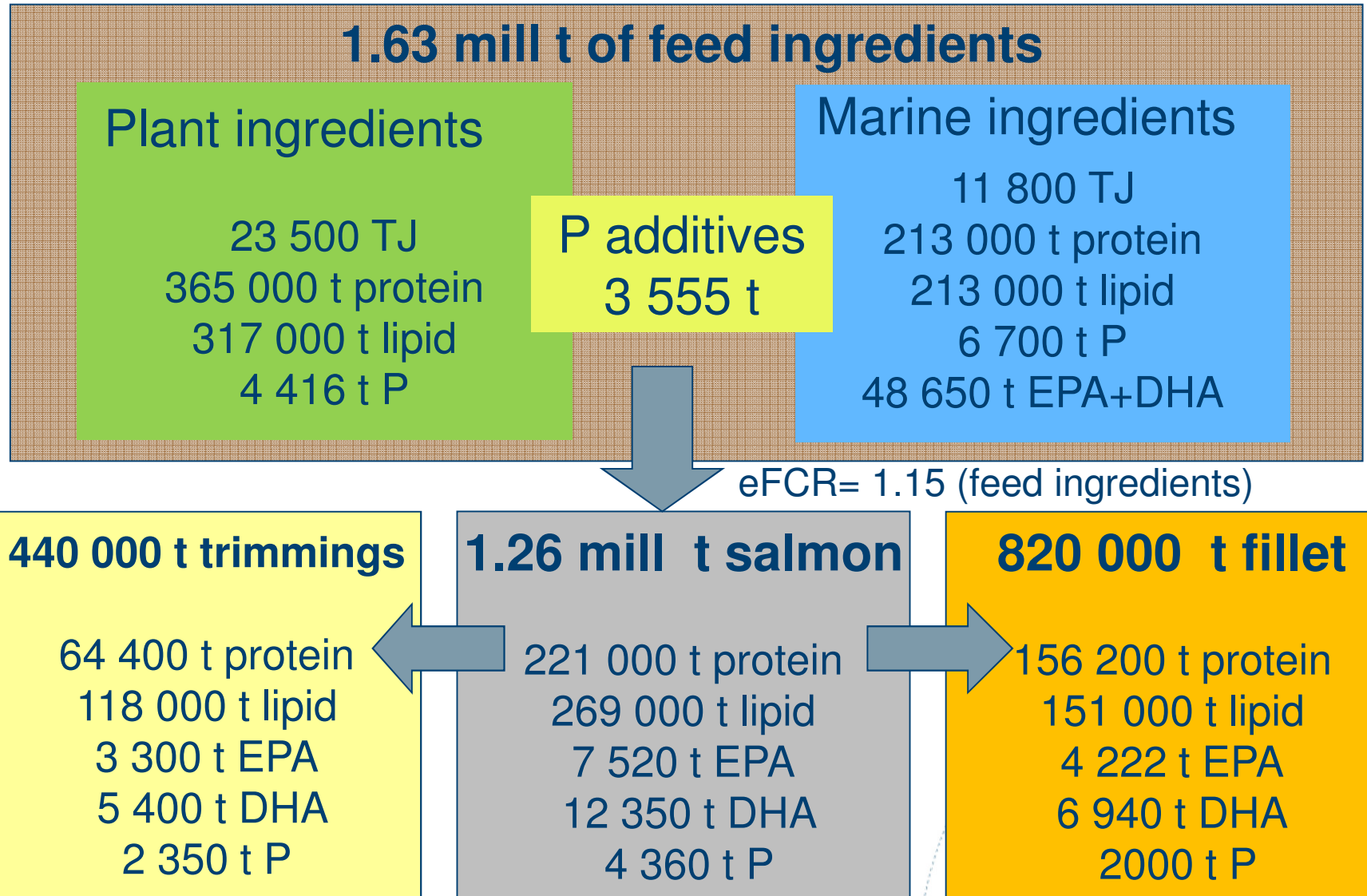
* Information on nutrient content in feed ingredients provided by Biomar, EWOS and Skretting

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

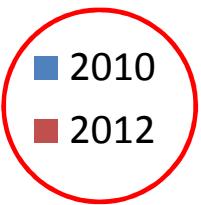
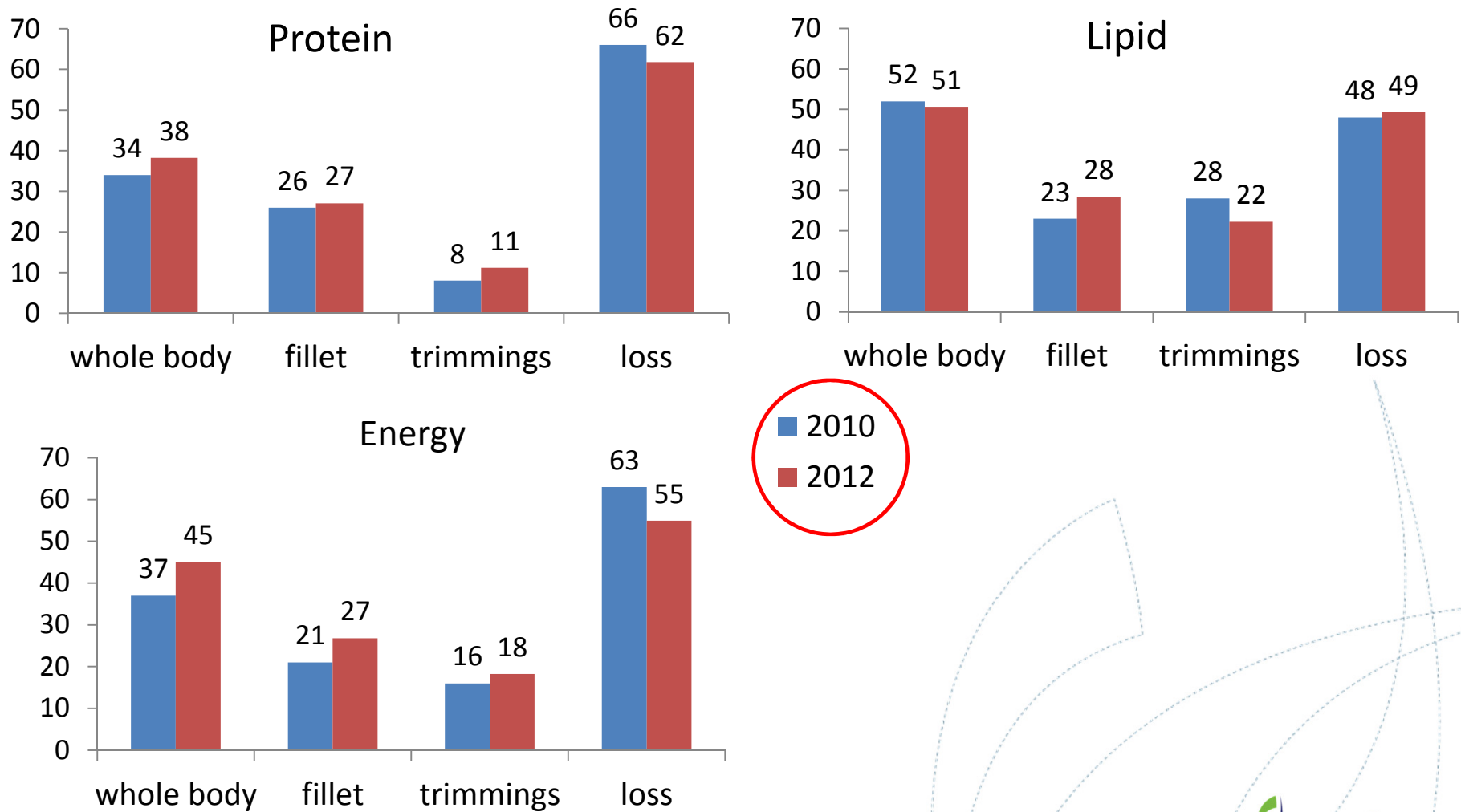
Nutrient flows in Norwegian salmon farming 2012



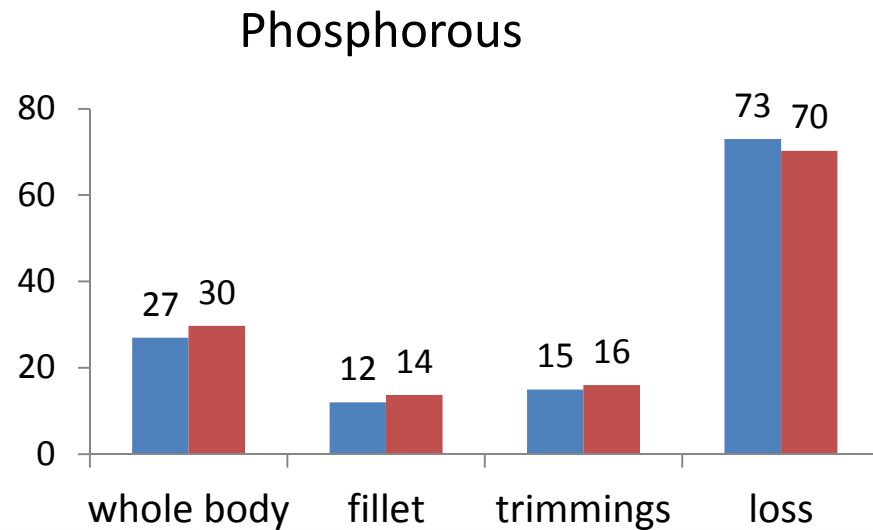
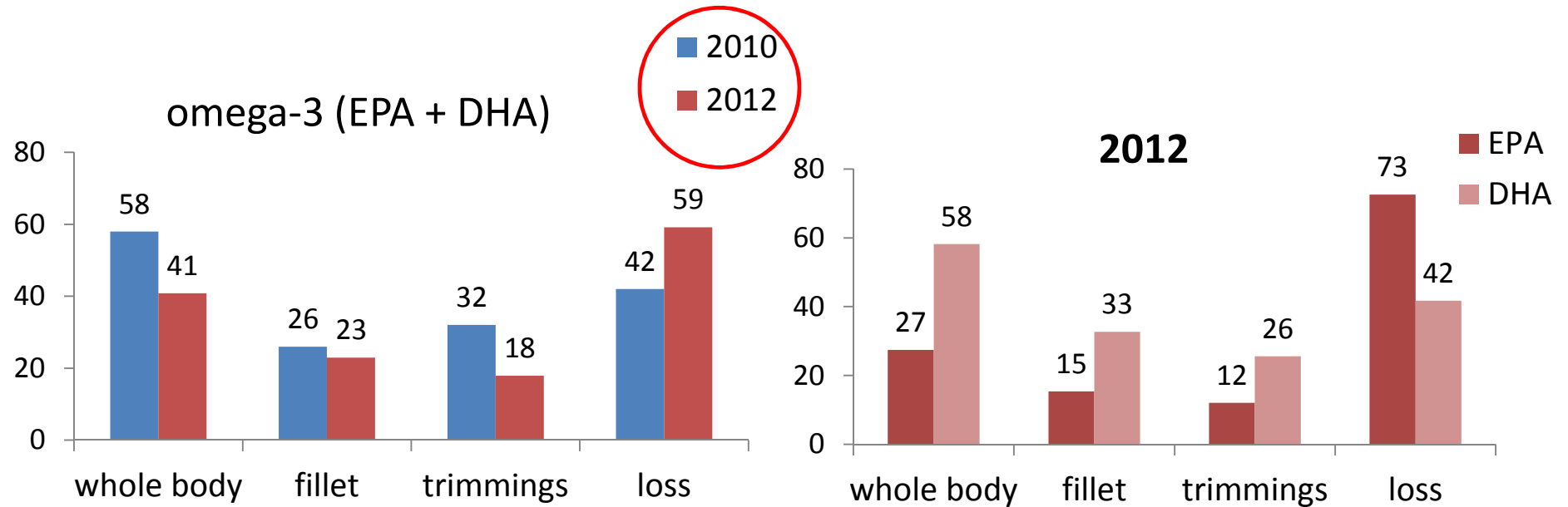
Sufficient EPA and DHA in Norwegian farmed salmon to cover the recommended daily intake for 123 million people for one year! (0.25 g/day)

Retention of nutrients in Norwegian salmon

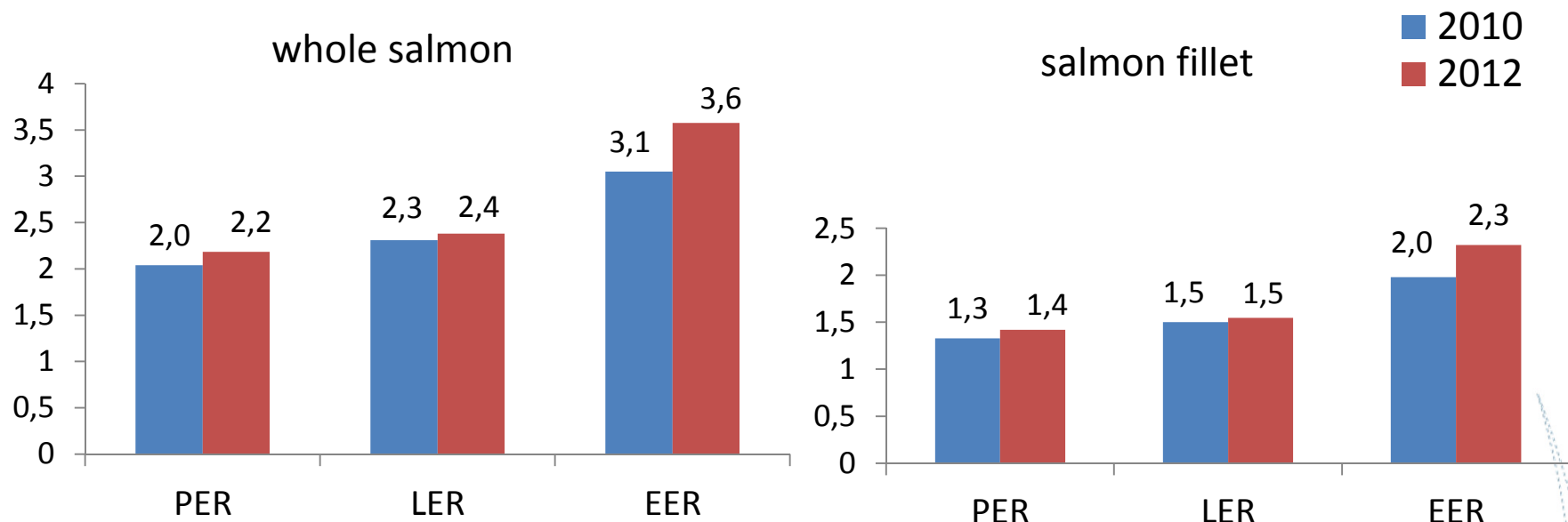
$$\text{Nutrient retention (\%)} = 100 \cdot \frac{\text{Amount of nutrient or energy incorporated in animal}}{\text{Amount of nutrient used in feed}}$$



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

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Thank you for your attention 😊

For more information:

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

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

<http://www.Nofima.no>