Food and Agriculture Organization of the United Nations

An Overview of Feed and the Role of Fishmeal and Fish Oil

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COFI

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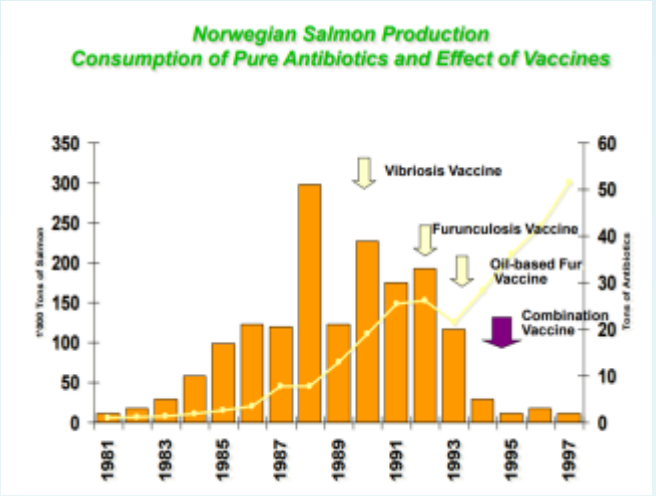
Fishmeal and Fish Oil (FMFO) created the modern aquaculture industry

Viable feeds for the early industry facilitated technological development in other fields such as engineering and health

Source:
http://www.worldfishing.net/news101/fish-farming/the-worlds-first-offshore-fish-farm-rig

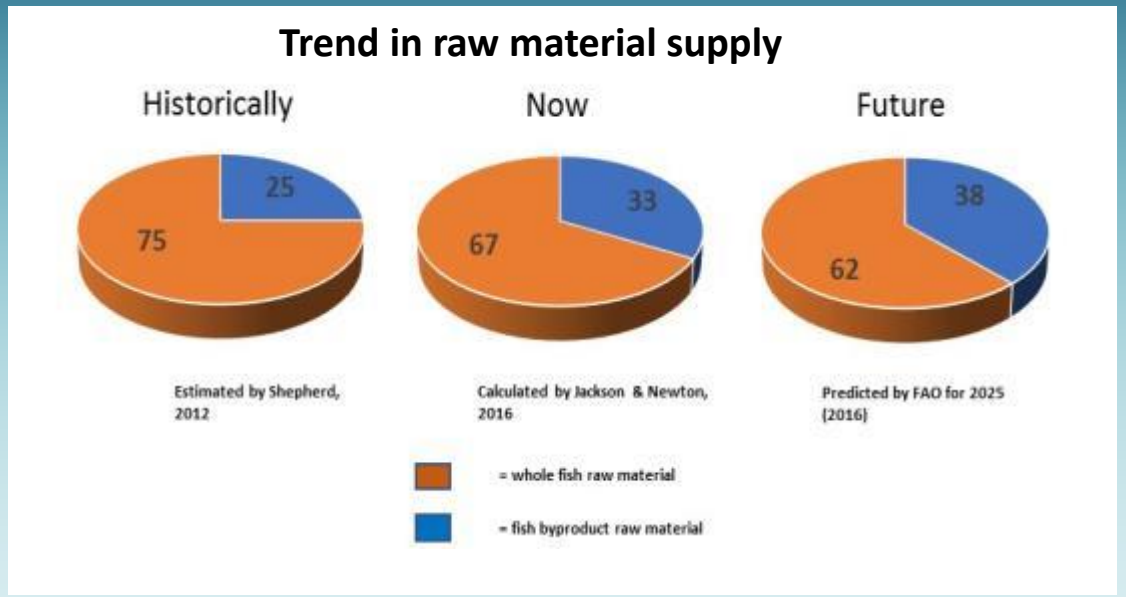
Source:
http://www.akvagroup.com/products/land-based-aquaculture/recirculation-systems



Source: Professor Patrick Smith Tethys Aquaculture Ltd Veterinary Vaccinology Network Meeting Birmingham ICC February 16th-17th 2015

The Production Process

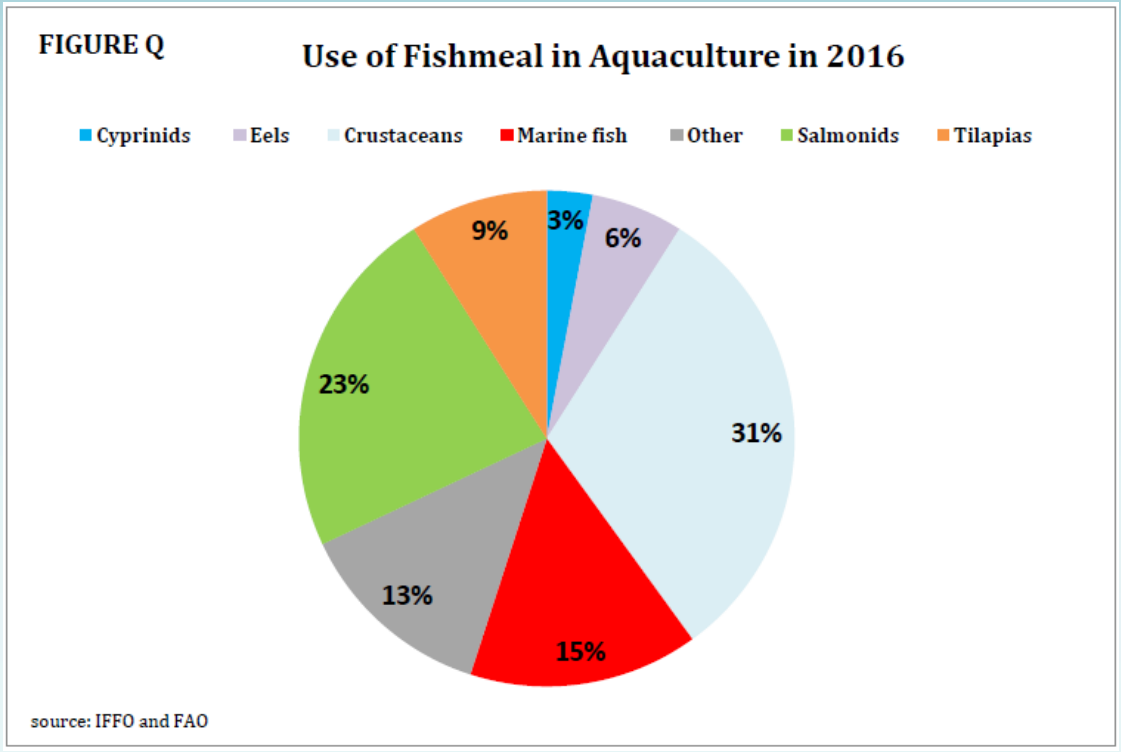
Mass Balance Marine Ingredients production (2010)

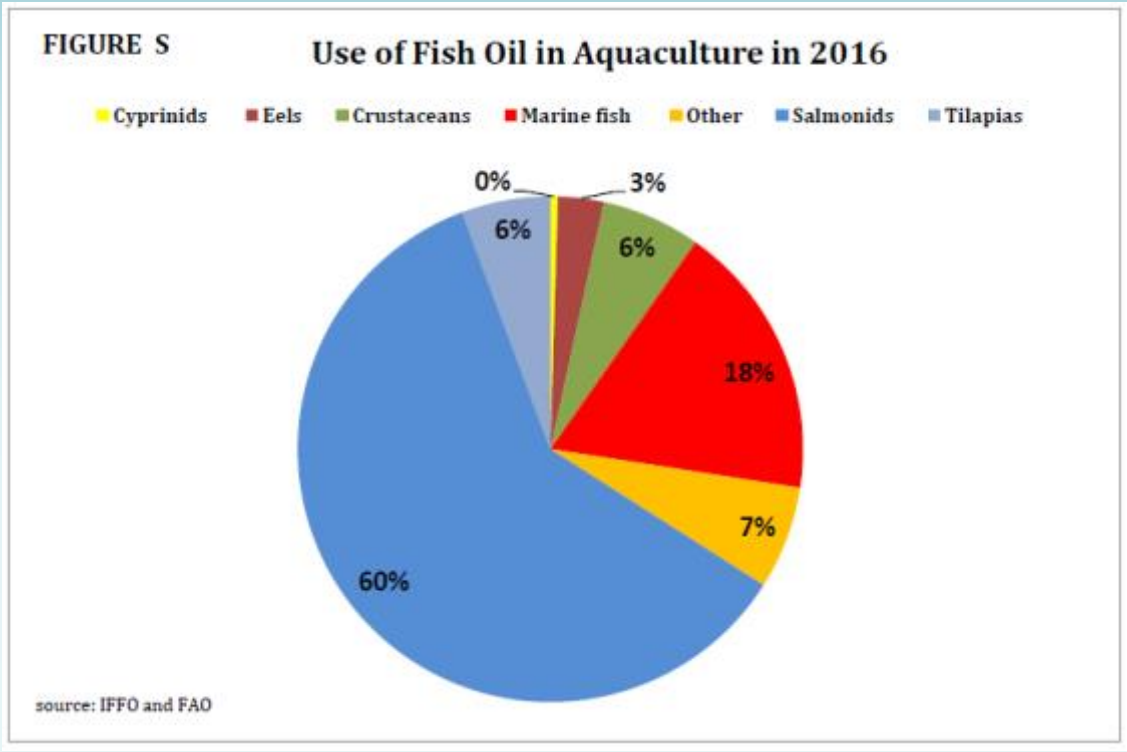


INDUSTRIAL GRADE FORAGE	Landings tonnes
Gulf menhaden (*Brevoortia patronus*)	479,000
Atlantic menhaden (*Brevoortia tyrannus*)	212,000
Sand-eel (*Ammodytes spp.*)	486,500
Total 1,175,000 tonnes of which 100% converted	
FOOD GRADE FORAGE	
Peruvian anchovy (*Engraulis ringens*)	8,468,000
Japanese anchovy (*Engraulis japonicus*)	1,567,000
South African anchovy (*Engraulis encrasicolus*)	228,000
Sprat (*Sprattus sprattus*)	262,000
Blue whiting (Micromesistius poutassou)	678,500
Capelin (*Mallotus villosus*)	958,500
Total 12,162,000 tonnes of which an estimated 90% was converted	
PRIME FOOD FISH	
Atlantic herring (*Clupea harengus*)	656,500
European sardine (*Sardina pilchardus*)	639,000
Chilean jack mackerel (*Trachurus murphyii*)	1,870,000
Japanese jack mackerel (*Trachurus japonicas*)	320,000
Chub mackerel (*Scomber japonicus*)	1,403,500
Californian sardine (*Sardina sagax caerulea*)	556,000
South African sardine (*Sardina sagax*)	263,000
Total 5,708,000 tonnes (average landings 2001 – 2006) of which an unknown percentage was converted	

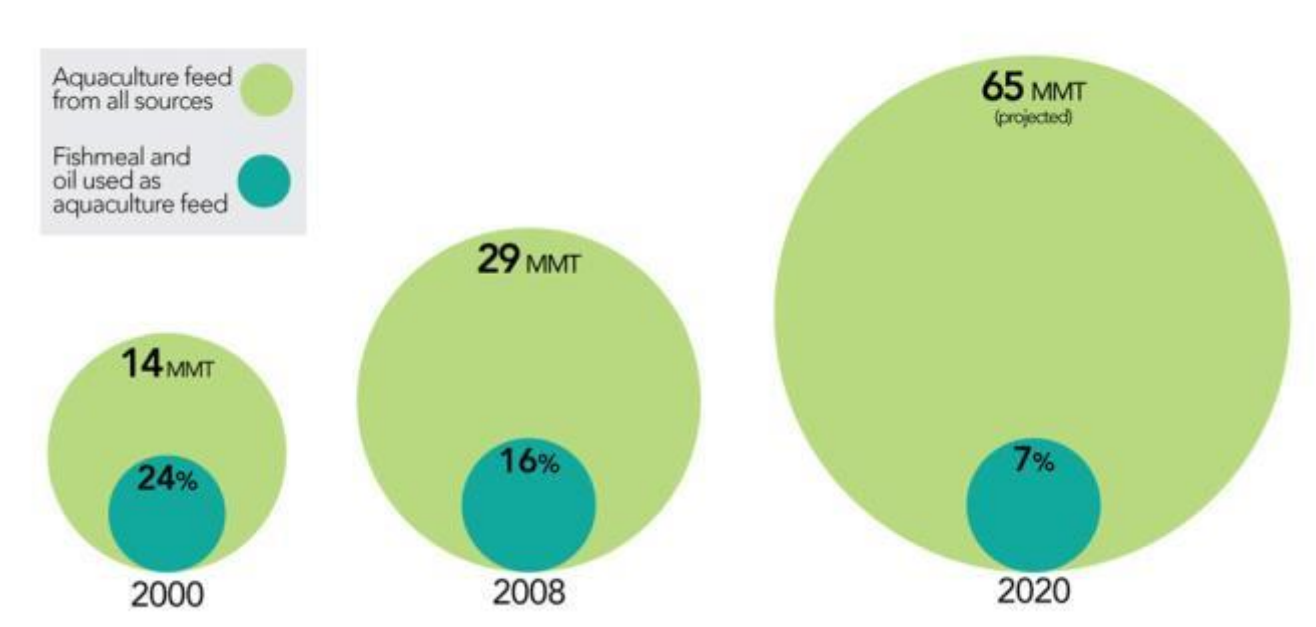
Source: Wijkström, 2011

Where does the FMFO go? Consumption in Aquaculture

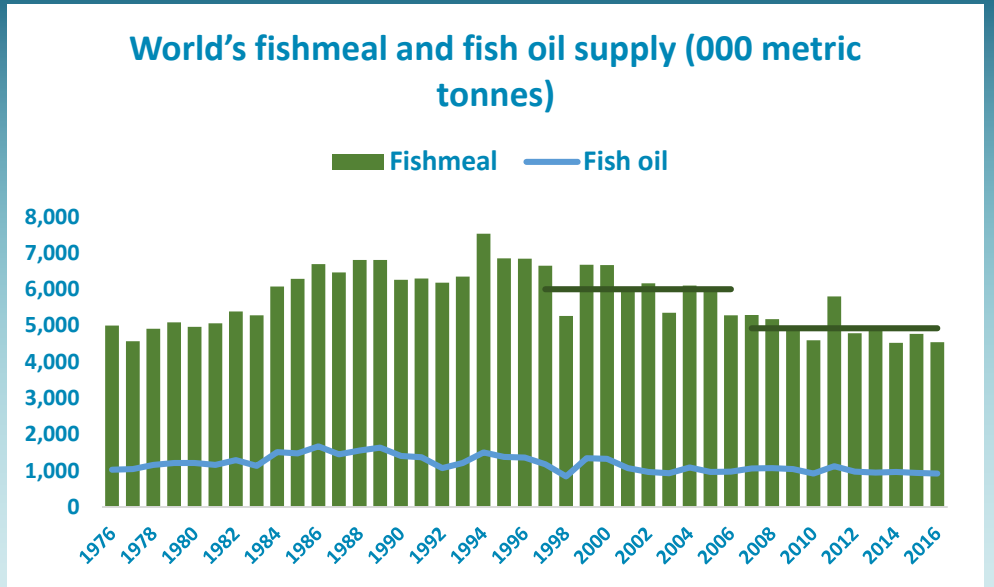




The reality of growing aquaculture production vs. finite supply of FMFO



Source: Fry, J.P. et al., 2016. Environmental health impacts of feeding crops to farmed fish. *Environment International*, 91, pp.201–214. Available at: http://dx.doi.org/10.1016/j.envint.2016.02.022



Source: IFFO

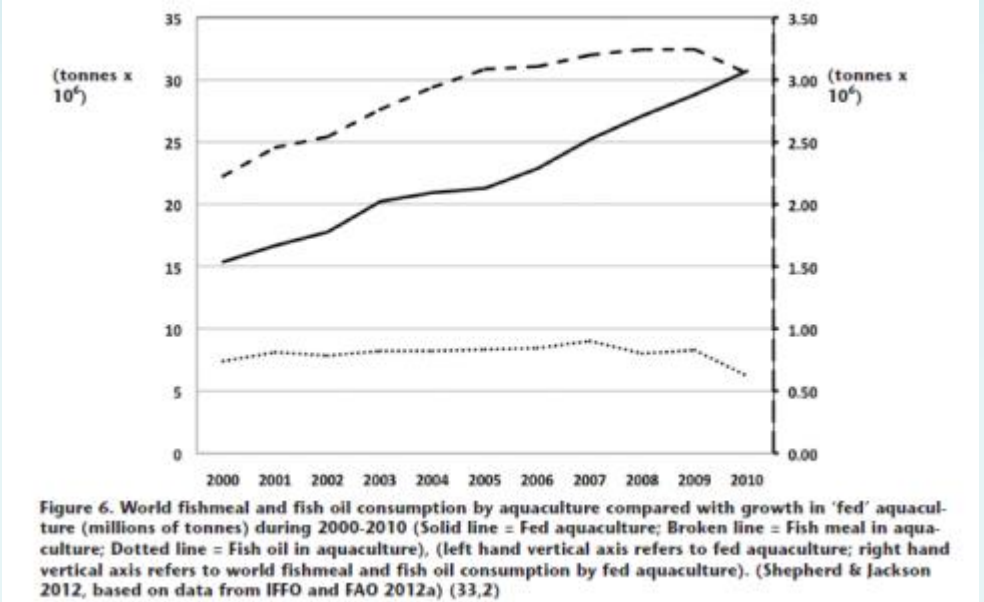


Figure 6. World fishmeal and fish oil consumption by aquaculture compared with growth in 'fed' aquaculture (millions of tonnes) during 2000-2010 (Solid line = Fed aquaculture; Broken line = Fish meal in aquaculture; Dotted line = Fish oil in aquaculture), (left hand vertical axis refers to fed aquaculture; right hand vertical axis refers to world fishmeal and fish oil consumption by fed aquaculture). (Shepherd & Jackson 2012, based on data from IFFO and FAO 2012a) (33,2)

Source: Shepherd, 2012

The outcome: other ingredients had to be used

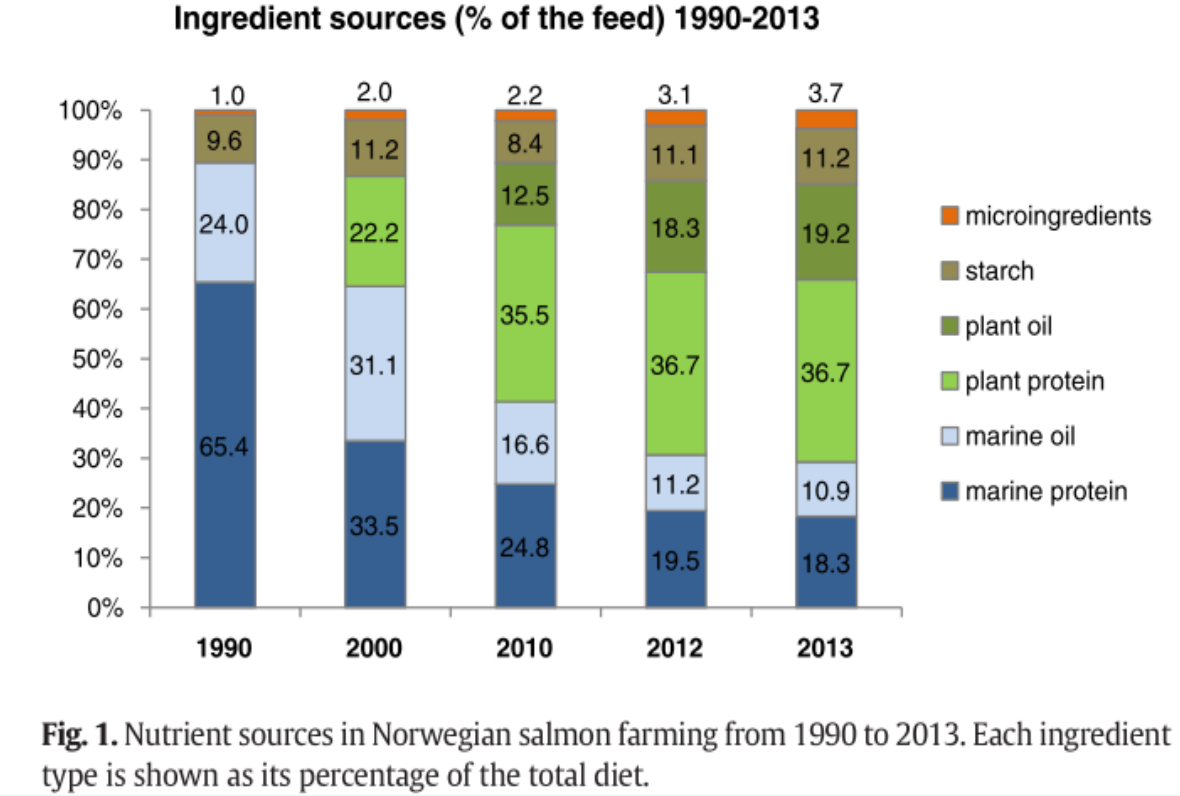
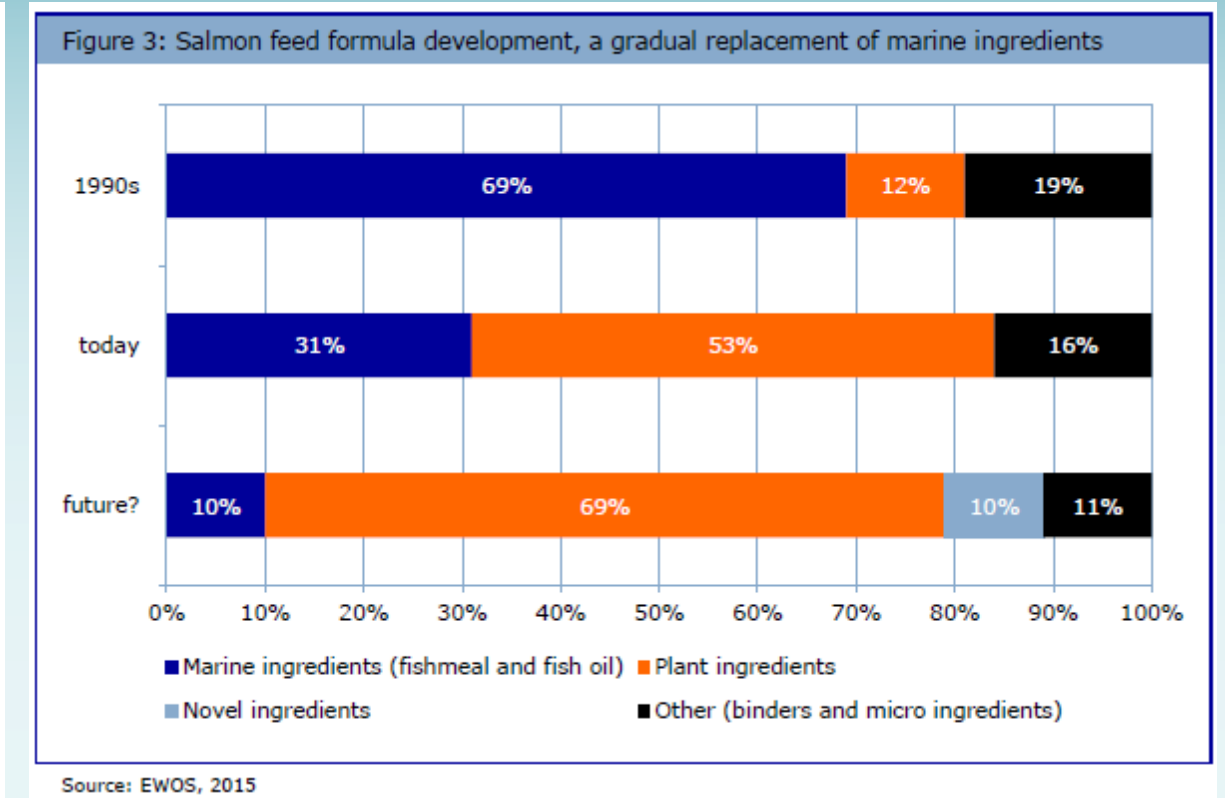


Fig. 1. Nutrient sources in Norwegian salmon farming from 1990 to 2013. Each ingredient type is shown as its percentage of the total diet.



Source: EWOS, 2015

Ytrestoyl, et al. (2015) Aquaculture 448 365–374
http://dx.doi.org/10.1016/j.aquaculture.2015.06.023

FMFO moves into strategic role in aquafeeds

Rabobank (2015)

Jackson (2012): "*Fishmeal will increasingly become a strategic ingredient used at critical stages of the life-cycle when optimum performance is required.*"

Parting Message

Shepherd (2006)

Fishmeal and fish oil, once commodities, are becoming high value strategic dietary ingredients, used at critical points in the life cycle of many aquaculture species.

This ensures that the fixed volumes of these renewable resources will be sufficient to meet the growing global demand for healthy sea food and reduce the pressure on over-exploited stocks of fish for human consumption.

Growing fish need nutrients

Protein, fat, carbohydrate (species dependent), micronutrients

But optimal nutrition requires:

- Good amino acid balance (including essential ααs)
- Provision of essential fatty acids (e.g. n-3s)
- Vitamins
- Minerals

FMFO provides:

- Good amino acid balance (including essential ααs)
- Provision of essential fatty acids (e.g. n-3s)
- Vitamins
- Minerals

Vitamins & Minerals

- Current evidence base is incomplete;
- Knowledge is based on deficiency studies;
- Avoiding deficiency is different to optimising nutrition;
- There is also the question of carryover of vitamins & minerals into the nutrition of the aquaculture product, and benefits to the consumer;
- FM is a rich source of these materials – reducing inclusion rates may well have impacts.

Vitamin requirements of salmon and growing chickens (IU or mg/kg dry diet)

Vitamin	Salmon/trout	Chickens
Vitamin A	2500	1500
Vitamin D	2400	200
Vitamin E	50	16
Vitamin K	unknown	0.5
Thiamin	1	1.3
Riboflavin	7	3.6
Pyridoxine	6	3.0
Pantothenic acid	20	10
Niacin	10	11
Biotin	0.15	0.10
Folic acid	2	0.25
Vitamin B_{12}	0.01	0.003
Ascorbic acid	50	not required
Choline	800	500
myo-Inositol	300	not required

*values in yellow are lower for chickens

Extracts from: Ronald W. Hardy, University of Idaho, Fish Nutrition Research Differences and similarities with livestock nutrition and what the future holds. Part I.: http://www.pitt.edu/~super4/33011-34001/33021.ppt

Mineral requirements of fish

Macrominerals (g/kg diet)	Microminerals (mg/kg diet) (trace elements)
Calcium	Iron
Phosphorus*	Manganese*
Sodium	Copper
Potassium*	Zinc*
Chlorine	Cobalt
Magnesium*	Selenium*
Sulfur	Iodine*
	Molybdenum

* Required in the diet, but not always supplemented in practical feeds

Marine Ingredients & Aquafeed Palatability

- Often overlooked;
- Very important in relation to feed intake;
- Fishmeal known to play an important role – presence of volatile compounds that are attractive to fish;

"Poor palatability is a limiting factor for replacing fishmeal with other protein sources in aquaculture"

Journal of Ocean University of China
June 2016, Volume 15, Issue 3, pp 561–567

Palatability of water-soluble extracts of protein sources and replacement of fishmeal by a selected mixture of protein sources for juvenile turbot (*Scophthalmus maximus*)

Authors Authors and affiliations

Chun Dong, Gen He, Kangsen Mai, Huihui Zhou, Wei Xu

"The feed-palatability issue may be overcome, perhaps through the inclusion of krill meal"

Wilding, T. A., Kelly, M. S. and Black, K. D. (2006) Alternative marine sources of protein and oil for aquaculture feeds: state of the art and recommendations for further research. The Crown Estate, 63 pages, December 2006. ISBN (10): 0-9553427-4-0, ISBN (13): 978-0-9553427-4-5.

Questions?