Global Conference on Aquaculture 2010

Farming the waters for People and Food

22-25 September 2010, Phuket, Thailand

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Global Conference on Aquaculture 2010

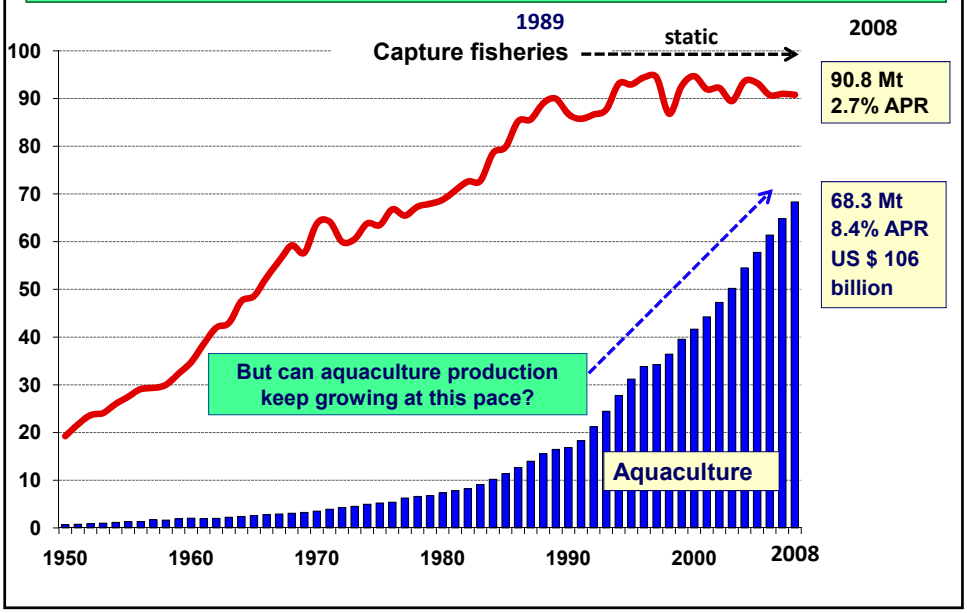
Expert Panel Presentation 1.3:

Aquaculture feeds: addressing the long term sustainable of the sector

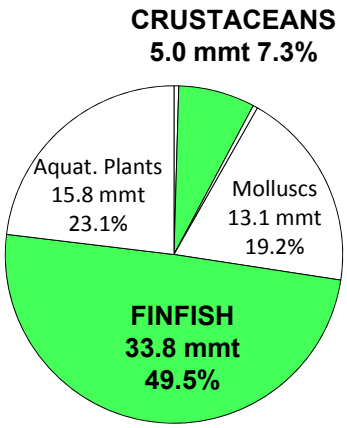
Presented by Dr. Albert G.J. Tacon

22–25 September 2010, Phuket, Thailand

Rapid growth of aquaculture has been due in part to the availability of feed inputs within producing countries

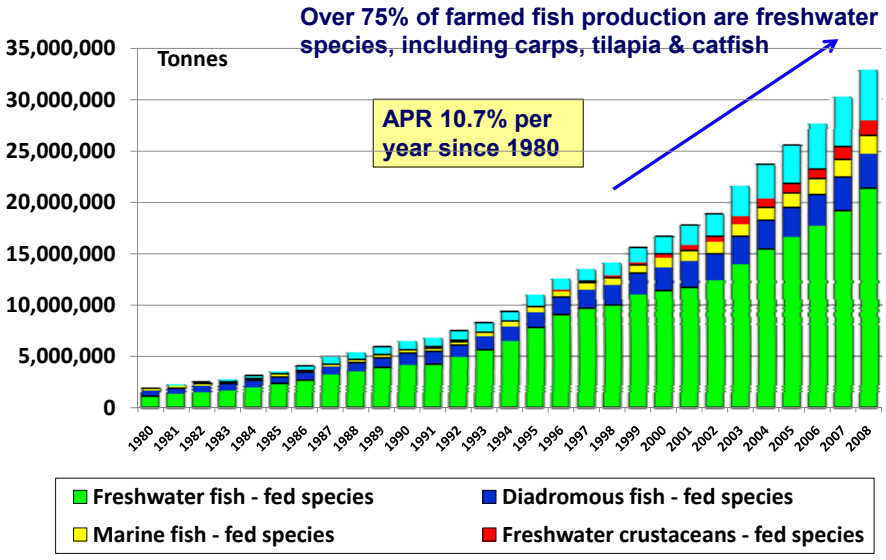


Fed aquaculture species production – 2008
(commercial feeds, farm made feeds, fresh feeds)



Total fish & crustaceans: 38.8 million tonnes
Fed species: 31.5 million tonnes or 46.1% of total global aquaculture production in 2008

Total global production of fed fish & crustacean species
FAO - FISHSTAT (2010)



Top fed aquaculture & livestock producers – 2008

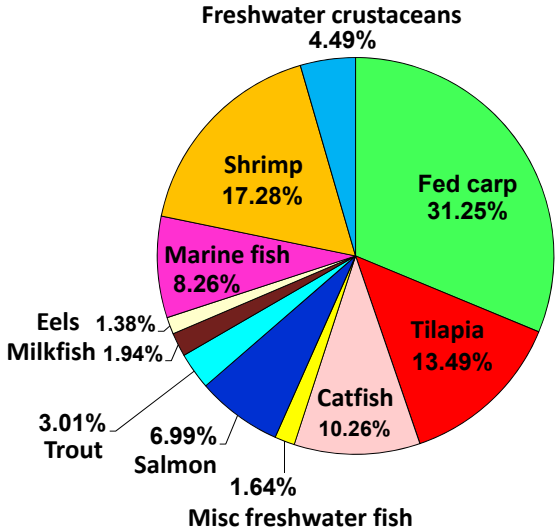
(FAO – FISHSTAT/FAOSTAT, 2010)

Values in million tonnes - Mt

Top 8 fed aquaculture species	
Grass carp	3,775,267 t
Common carp	2,987,433 t
Nile tilapia	2,334,432 t
Catla	2,281,838 t
Whiteleg shrimp	2,259,183 t
Crucian carp	1,957,337 t
Atlantic salmon	1,456,721 t
Pangasius catfish	1.38 Mt∑58%
Total fed sp production – 31.5 Mt	
APR 10.59% since 1980	

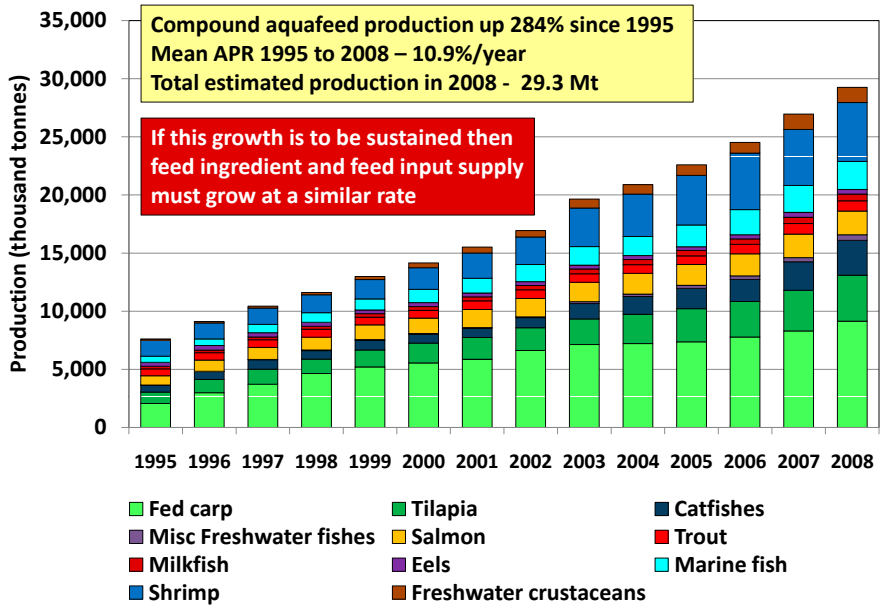
Top 8 fed livestock species	
Pig	103.2 Mt
Chicken	79.4
Cattle	62.4
Sheep	8.3
Turkey	6.1
Goat	4.9
Duck	3.8
Buffalo	3.4 ∑ 97%
Total meat production - 280 Mt	
APR 2.59% since 1980	

Estimated global production of commercial aquaculture feeds by major species grouping in 2008: 29.3 million tonnes (Mt)



Fed carp	9.14 Mt
Shrimp	5.06 Mt
Tilapia	3.95 Mt
Catfish	3.00 Mt
Marine fish	2.42 Mt
Salmon	2.04 Mt
FW crustaceans	1.31 Mt
Trout	880 Tt
Milkfish	568 Tt
Misc FW fish	480 Tt
Eels	403 Tt

Estimated production of compound aquafeeds 1995-2008

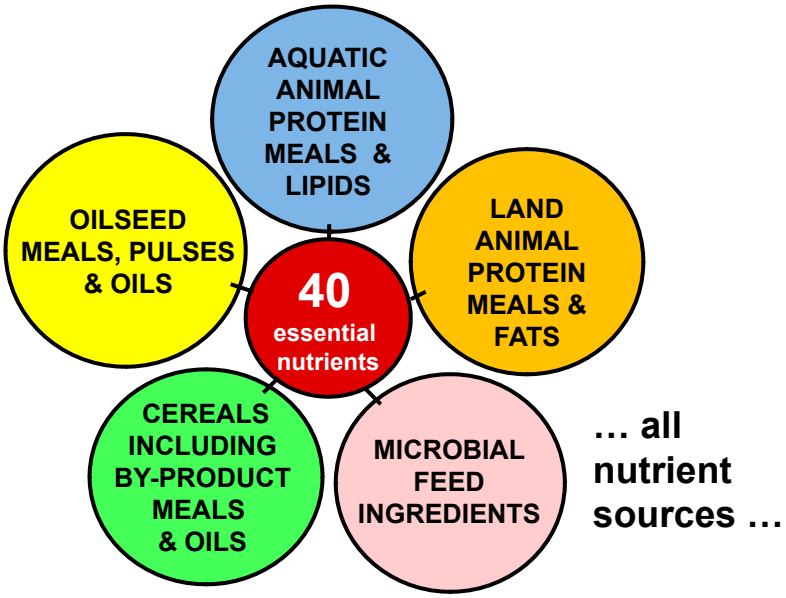


Top 10 country producers of commercial aquaculture feeds

Country	*Production estimate (tonnes)*
China (2008)	13,000,000 – 15,000,000
Vietnam (2008/2009)	1,625,000 – 2,800,000
Thailand (2008/2009)	1,210,327 – 1,445,829
Norway (2008/2010)	1,136,800 – 1,382,000
Indonesia (2008/2009)	1,030,000 – 1,184,500
Chile (2008)	883,305 – 1,050,000
USA (2008)	700,000 – 750,000
Japan (2008)	500,000
Philippines (2007)	400,000 – 450,000
Taiwan (2007)	345,054

Aquafeed production by types

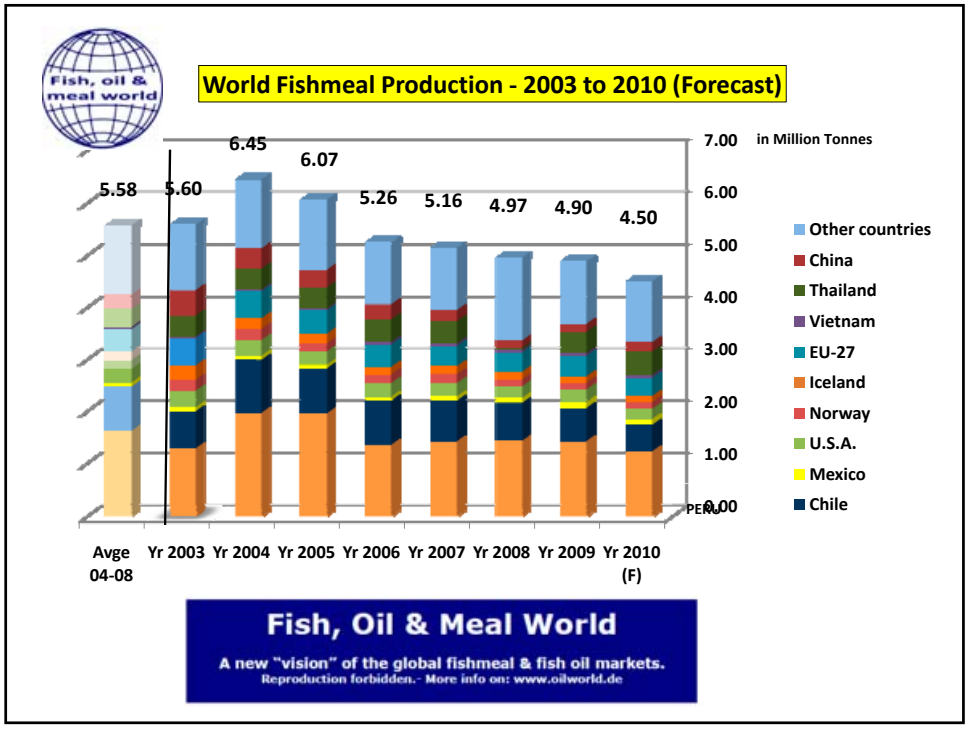
- **Industrial compound aquafeed: 24.4-28.9 Mt**
  - 4% of total global animal feed production of over 708 million tonnes in 2009
- **No comprehensive info on the production of farm-made aquafeeds or use of low-value fish**
  - Estimated global production of farm-made aquafeeds: 18.7-30.7 Mt in 2006
  - Current estimates for low-value fish use within China alone in 2008: 6-8 Mt

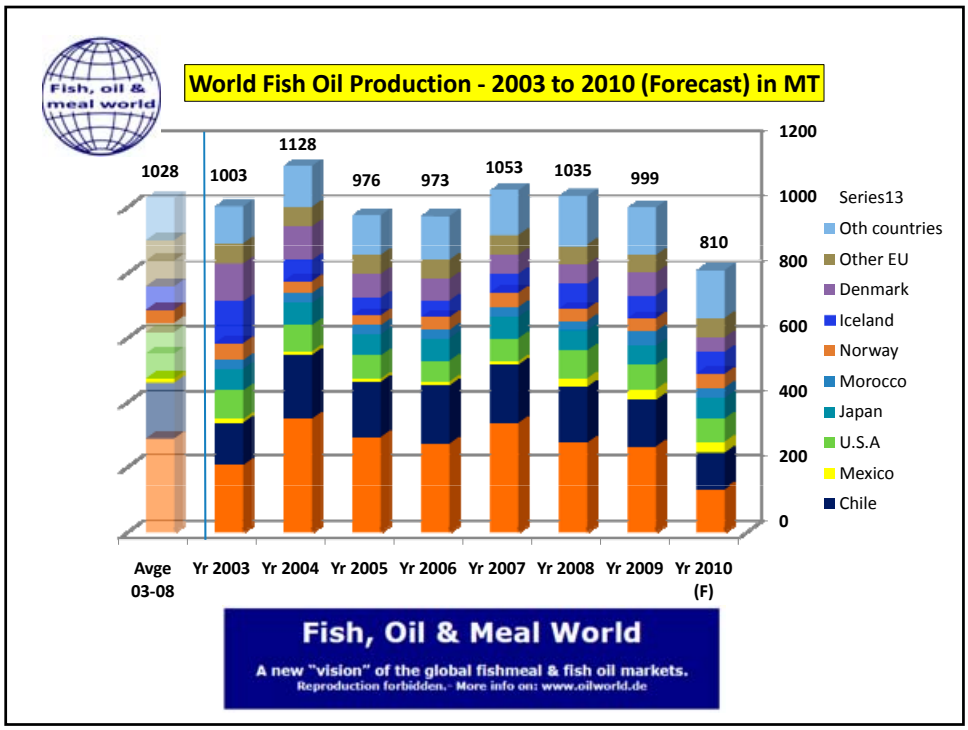


Major ingredients used in aquaculture aquafeeds

Current feed ingredient usage & constraints

- Continued use of fishmeal & fish oil as major dietary protein and lipid sources
  - Eel (FM 55-65%, FO 3-18%)
  - Marine finfish (FM 20-65%, FO 5-20%)
  - Salmon (FM 25-40%, FO 10-25%)
  - Trout (FM 18-40, FO 5-25%)
  - Shrimp (FM 5-40%, 1-9%), and
  - Freshwater prawn (FM 20-65%, FO 0-7%).



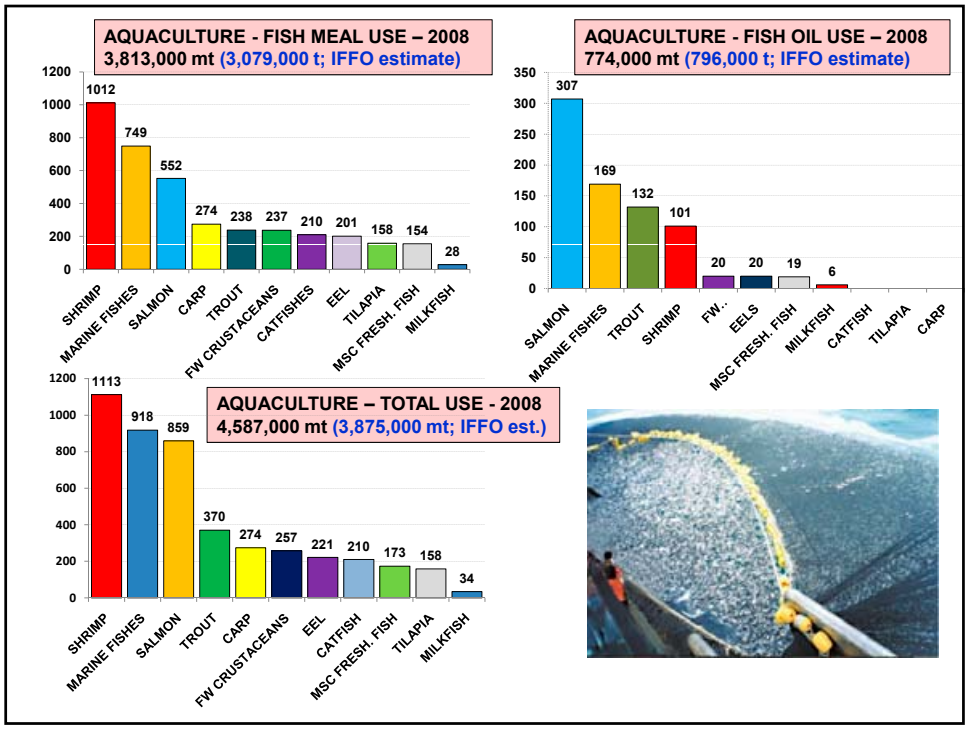


Use of fishmeal & fish oil as dietary protein & lipid sources

According to the ingredient survey conducted for this paper, is was estimated that the aquaculture sector consumed over 4.66 million tonnes of fishmeal & fish oil in 2007

- 3.84 million tonnes of fishmeal (68.4 % global)
- 0.82 million tonnes of fish oil (81.3 % global)

However, there is a wide variation in fishmeal & fish oil usage between major producing countries for individual species.



Use of fishmeal by the aquaculture sector

- **Use of fishmeal by the aquaculture sector is expected to decrease in the long term**
  - From a high of 4.22 million tonnes (Mt) in 2005 to **3.84 Mt in 2007 (14.2% of total aquafeeds)**
  - Expected use: 3.69 Mt (5.2% of total aquafeeds) in 2020
- **The reason being**
  - more of the raw material goes for direct human consumption & increasing fishmeal prices
  - **increased use of less expensive fishmeal replacers**

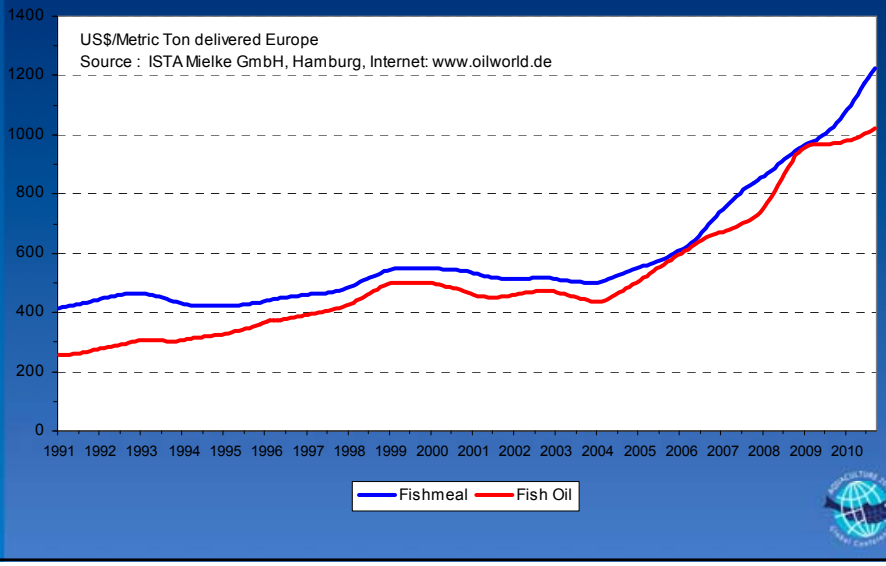
Jonathan Shepherd

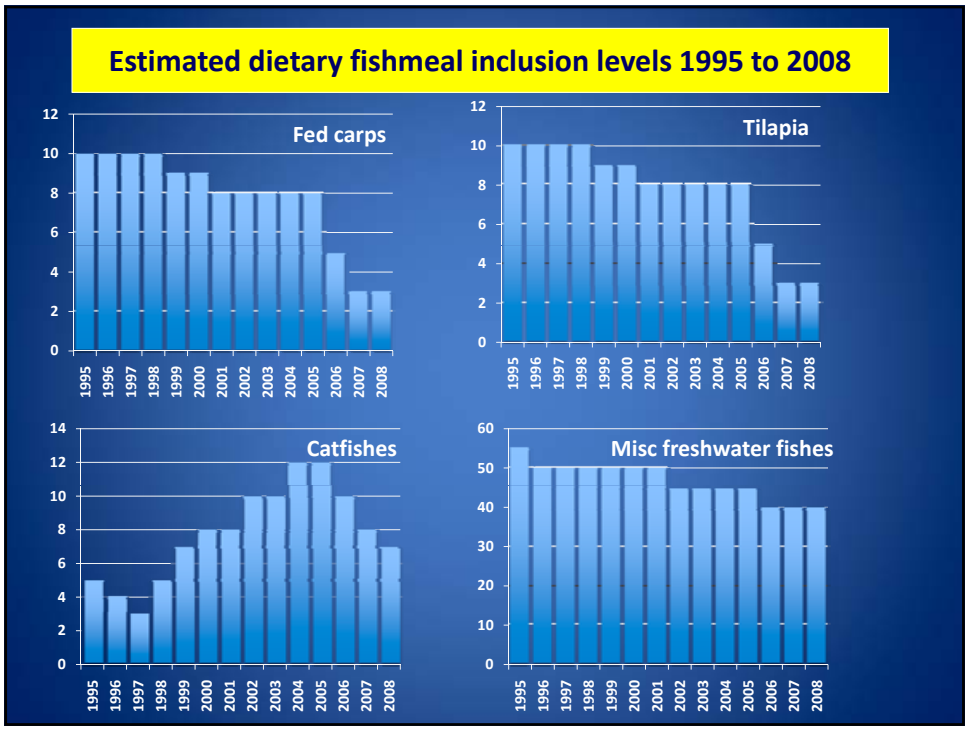
Increased use of raw material for direct human consumption

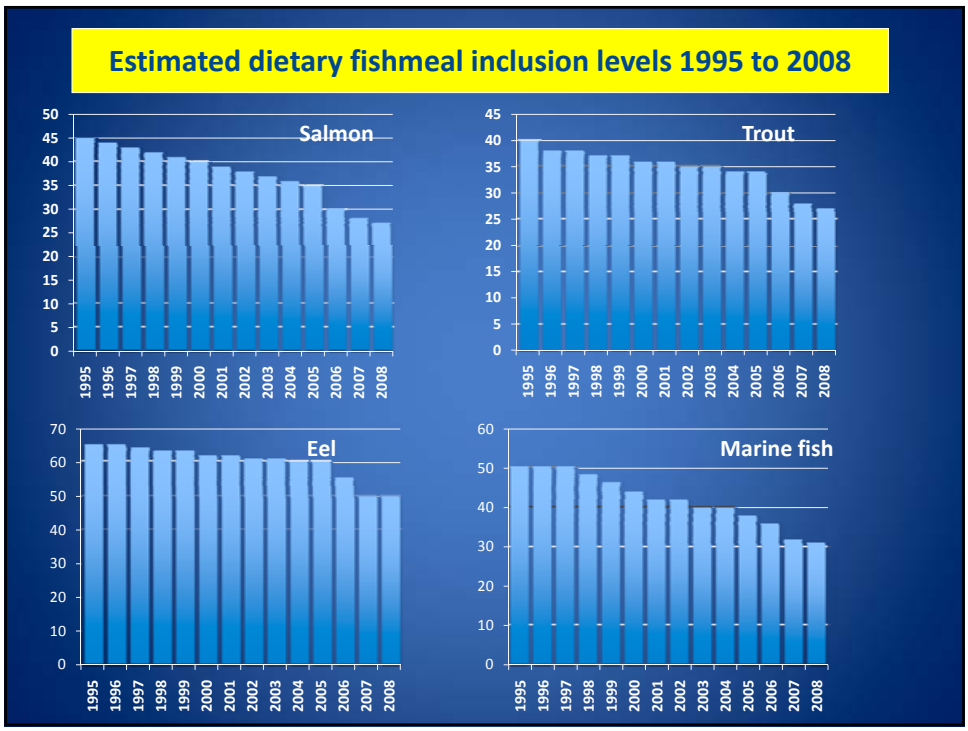
- Norway - Capelin, Herring & Blue Whiting
- Denmark - Herring & Blue Whiting
- Chile - Jack Mackerel & Chub Mackerel
- Peru – Last year approx. 190,000 tonnes of anchovy went for human consumption (3%)

Negative effect on fishmeal & fish oil production volumes

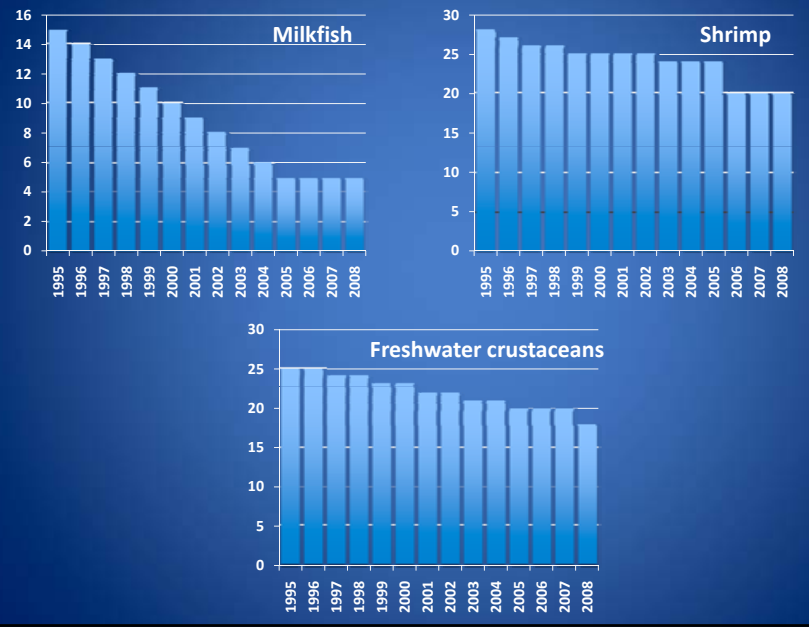
5 year annual average prices for fishmeal and fish oil
Anthony P Bimbo (2010)




Estimated dietary fishmeal inclusion levels 1995 to 2008
Fed carps
Tilapia
Catfishes
Misc freshwater fishes


Estimated dietary fishmeal inclusion levels 1995 to 2008
Salmon
Trout
Eel
Marine fish

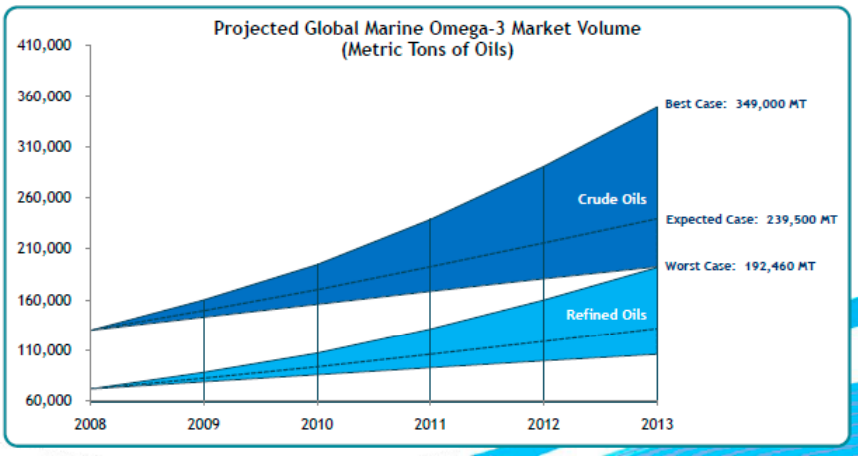
Estimated dietary fishmeal inclusion levels 1995 to 2008



Use of fish oil within aquafeeds

- **There will continue to be a strong demand for fish oil in aquaculture diets, but production volumes to remain static or fall with a reduction in raw material.**
- **There is a growing demand for the use of fish oil for direct use as human supplements or pharmaceutical medicines. This market is likely to be able to pay a premium for oil resulting in aquaculture to reduce its usage of fish oil.**

If forecasts are accurate, nearly all anchovy and sardine oil will be used for omega-3s



Source: GOED Frost & Sullivan Annual Market Overview; Crude Oil Forecasts from GOED Analysis

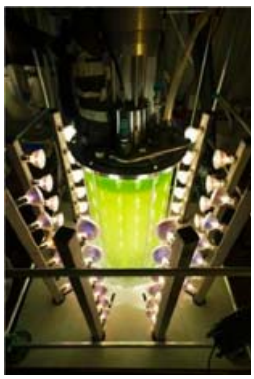
Use of fish oil as dietary lipid sources

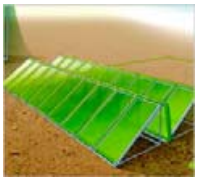
- **The reduction in fish oil availability combined with rapid aquaculture growth would mean a considerable reduction in dietary inclusion levels.**
- **This would not necessarily have any deleterious effect on the health of the farmed target species**
- **However, there may be reduced health giving benefits of the final products to consumers in terms of reduced eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) content**

Alternatives to fish oil

- **Key alternatives to fish oil**
  - Vegetable oils, preferably those with high omega-3 contents (soya, canola, palm) and poultry oil
  - oil from farmed fish offal is also a potential omega-3 sources for other farmed fish
- **Other alternative lipid sources**
  - Single cell proteins (algae, yeast, bacteria) with high HUFA content. Currently expensive for most aquaculture feeds but situation is likely to change as production increases.

Single Cell Oils





Martek's Life DHA 40-50% DHA
Martek's DHA-S 32-38% DHA
LonzaDHA *Ulkenia* 32% min DHA
Dupont's NewHarvest Yeast *yarrowia lipolytica* 50% EPA
Also Syngenta, Dow Agrisciences
Numerous crossover bioenergy companies BioCentric, Aurora, Solazyme

Anthony P. Bimbo, 2010

Increased use of terrestrial animal protein meals and oils as dietary nutrient sources

- Increased use within non-European countries, including
  - Poultry by-product meal – PBM,
  - Hydrolyzed feather meal – HFM,
  - Blood meal – BM,
  - Meat meal – MM,
  - Meat and bone meal - MBM and
  - Lipids (Poultry oil – PO)

- Salmon (PBM 10-30%, HFM 5-12%, BM 1-8%, MM 10-30%; PO 1-15)
- Trout (PBM 5-30%, HFM 5-20%, BM 1-8%, MM 10-30%; PO 1-15%),
- Marine finfish (PBM 10-30%, BM 1-10%, MM 10-30%; PO 1-10%)
- Shrimp (PBM 2-30%, HFM 5-10%, MM 2-30%),
- Catfish (PBM 2-4%)
- Tilapia (MBM 5-10%, PO 2-4%)
- Freshwater crayfish (MM 10-30%, MBM 10-30%)
- Carp (MBM 5-10%), and
- Grey mullet (MBM 5-10%).

COUNTRY RESPONSES REGARDING FEED INGREDIENT USAGE FOR SALMON

(FAO/Tacon in prep – 2009 survey)

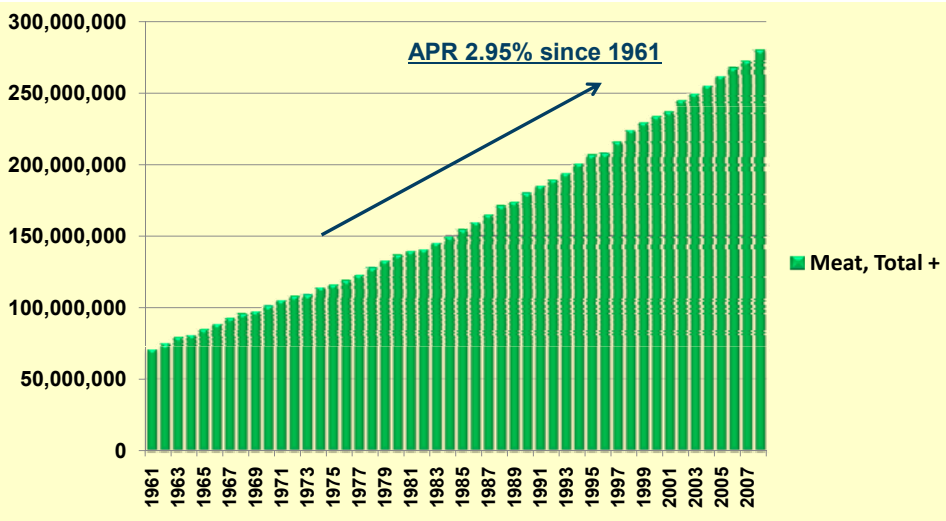
Country/ Year	Australia 2008/09	Canada 2008	Chile 2008	Chile 2010	Norway 2008	Norway 2010	UK 2008	UK 2010
Fishmeal	25-40	25-35	25	20-25	26-30	25	35	35
Fish oil	10-25	15-25	12	15	17-19	15	25	25
Krill meal	5-10	-	-	-	-	-	-	-
Rape oil	-	-	12 (2.8)	15	11-13	15	5	
Poultry oil	0-10	10-15	-	-	-	-	-	
Poultry bm	10-30	15-25	<8	Animal	-	-	-	
Blood meal	1-5	6-8	<7	by-prod	-	-	-	
Meat bypm	10-30	-	-	10-20	-	-	-	
Feather m	-	-	<12		-	-	-	
Soybean m	-	3-10	<12/8	Plant	8-12	12	10	
C.gluten m	-	10-40	<10	protein	-	Other	-	
W.gluten m	2-10	-	-	25	3-4	plant	-	
Rape/C m	-	3-10	<6		-	protein	5	
Lupin k m	5-15	-	<6		-	20	-	
Sunflower	-	-	-		7-9		5	
Pea/bean	-	-	-		-		8	
Cottonseed	-	-	<12		-		-	
Wheatflour	10-20	12-18			10-14	12	10	12

Terrestrial animal protein meals and oils as dietary nutrient sources

- **Estimated global production of rendered animal protein meals and fats in 2008 was about 13.0 and 10.2 million tonnes, respectively**
- **Estimated total usage of terrestrial animal by-product meals and oils within compound aquafeeds was between 150,000 and 300,000 tonnes or less than 1% of total global compound aquafeed feed production**
- **Clearly there is considerable room for further growth and expansion for the increased use of these products**

Global production of terrestrial meat products

(expressed in tonnes; FAO, 2009)



Continued and increased use of plant protein meals and oils as dietary nutrient sources

- Plant protein meals (soybean meal, wheat gluten meal, corn gluten meal, rapeseed/canola meal, cottonseed meal, sunflower seed meal, groundnut/peanut meal, mustard seed cake, lupin kernel meal, faba bean meal) and
- Plant oils Oils (rapeseed/canola oil, soybean oil, palm oil)

Use of plant protein meals and oils as dietary nutrient sources

- These plant proteins and oils represent
  - the major dietary protein and lipid source used within feeds for lower trophic level fish species (tilapia, carp, catfish) and
  - the second major source of dietary protein and lipid source after fishmeal and fish oil within shrimp feeds and European high trophic level fish species

Tilapia (SBM 20-60%, CGM 5-10%, R/CM 20-40%, CSM 1-25%, SO 1-8%),

Carp (SBM 5-25%, R/CM 20-40%, G/PM 30%, MC 10%),

Shrimp (SBM 5-40%, WGM 2-10%, CGM 2-4%, R/CM 3-20%, LKM 5-15%),

Marine fishes (SBM 10-25%, SO 3-6%, WGM 2-13%, CGM 4-18%, SSM 5-8%, R/CM 7-20%, CPC 10-15%),

Trout (SBM 3-35%, WGM 2-10%, SSM 5-9%, CGM 3-40%, R/CM 2-10%, LKM 5-15%, FBM 8%, FPM 3-10%, R/CO 5-15%, SO 5-10%),

Salmon (SBM 3-12%, WGM 2-10%, SSM 5-9%, CGM 10-40%, R/CM 3-10%, LKM 5-15%, FBM 5%, FPM 3%, R/CO 5-15%, SO 5-10%),

Milkfish (SBM 35-40%),

Grey mullet (SBM 20-25%),

Freshwater prawns (SBM 15-25%),

Colossoma (SBM 13%, CGM 6%),

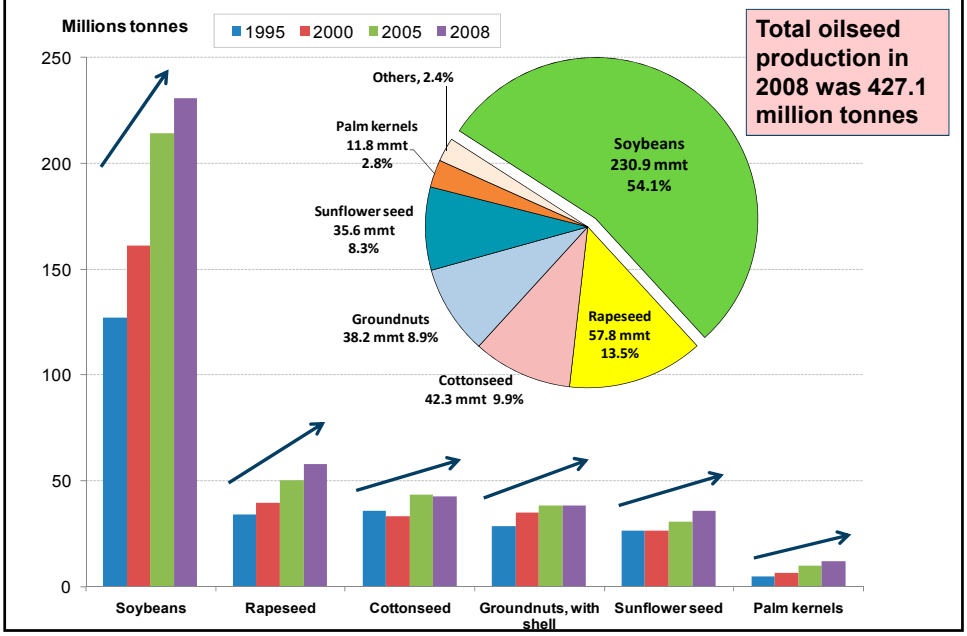
Freshwater crayfish (WGM 2-10%, LKM 5-30%), and

Eel (SBM 8-10%).

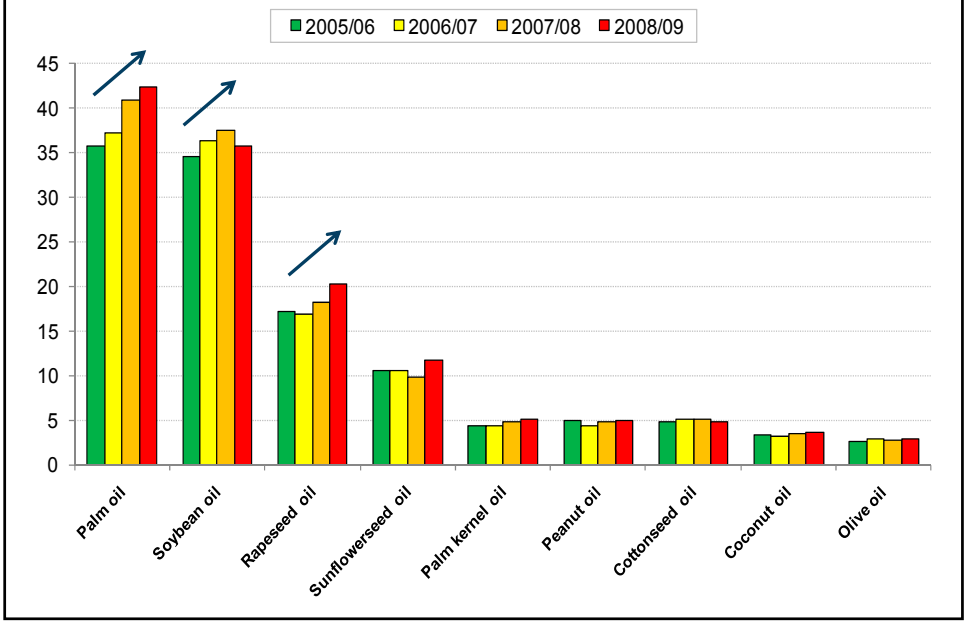
Use of soybean meal as dietary protein source

- Total global production of oilseeds in 2008 was 427 million tonnes, with soybean being the largest and fastest growing oilseed crop: 230.9 million tonnes
- Soybean meal is the commonest source of plant protein used in compound aquafeeds
- Feeds for herbivorous and omnivorous fish and crustaceans contains about 15 to 30% soybean meal, with a mean of 25%.
- Aquafeed sector consumed about 6.8 million tonnes of soybean meal (25.1% of total compound aquafeed)

Global production of major plant oilcrops
(Values given in million tonnes: FAOSTAT, 2009)



Global production of major oilseed oils
(Values given in million tonnes: USDA, 2010)

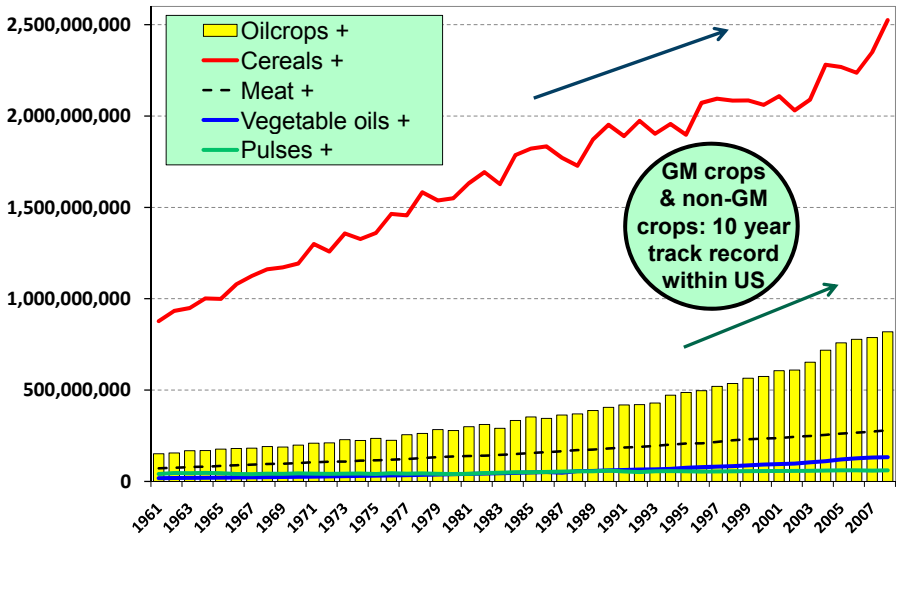


Use of plant protein in aquafeed

- At present, plant protein and oil choice and selection is based upon
  - a combination of local market availability & cost
  - the nutritional profile (including ANF content and level) of the protein meal and/or plant oil
- With the rise in the price of fishmeal, plant protein concentrates will be preferred over regular plant protein meals in aquafeeds for high TL species
- For example, the forecast demand for Soybean Protein Concentrates within aquafeeds has been estimated at over 2.8 million tonnes by 2020

Global production of agricultural crops and meat

(expressed in tonnes; FAO, 2009)



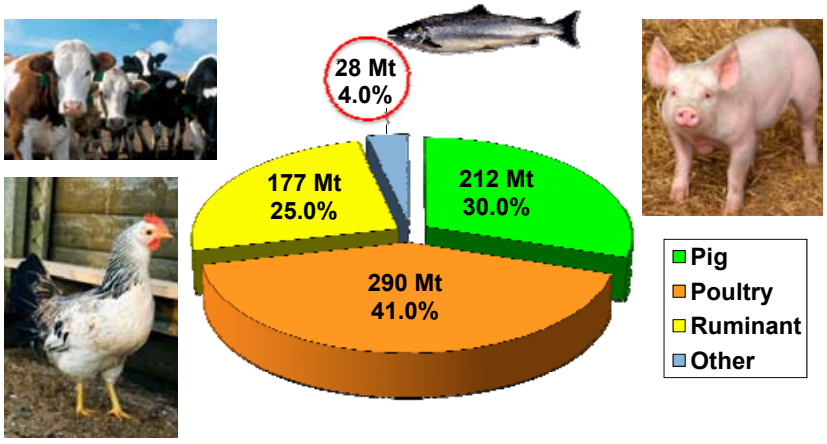
Ingredient competition with other users

- Aquaculture, like any other animal production system, has to compete with other users for nutrient inputs, including specific feed ingredients and fresh food items.

- Competition with livestock
  - total global livestock and animal feed production estimated at 708 million tonnes in 2009 with total global feed production up by 20% since 1995 and growing at an average annual compound rate of 1.3% per year since 1995 .

Total global compound feed production – 2009

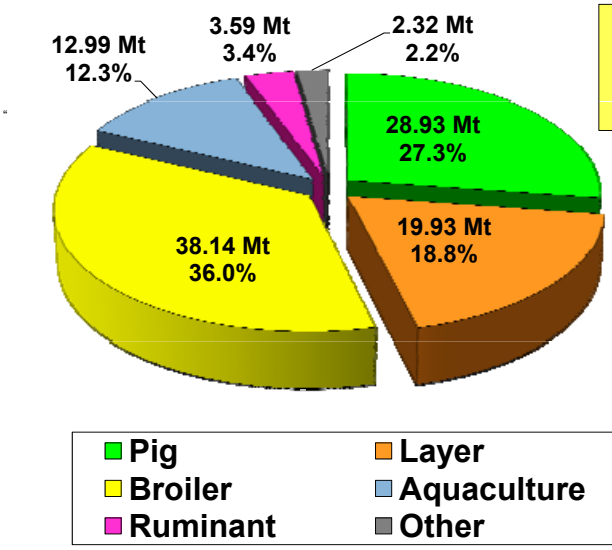
(Million tonnes: Peter Best – pers com. March 2010)



Total compound animal feed production in 2009 was 708 million tonnes with production up 20% since 1995 & growing with an average APR of 1.3%/year

Total compound feed production in China – 2008

(Million tonnes: Source: JCI China)



Total compound feed production in 2008 105.9 million tonnes (+13.6% from 2007)

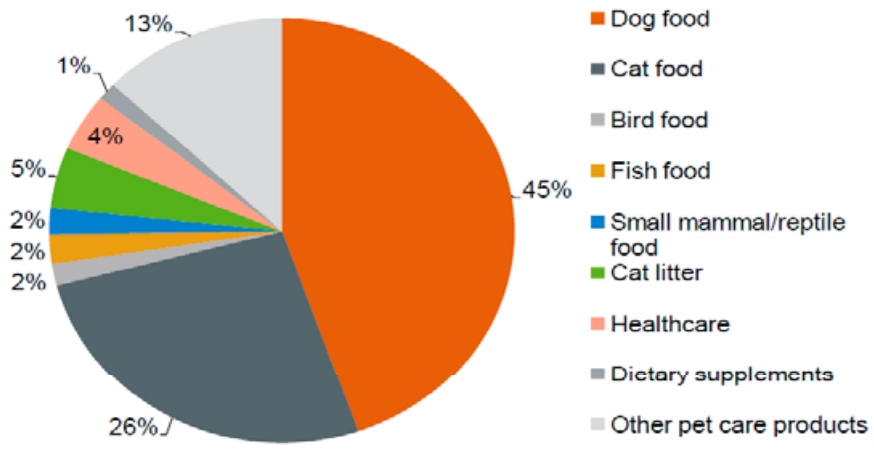
In-country competition by other feed sectors

- **Competition with pet food**

- **The pet food industry is a new and rapidly growing non-food animal sector, with dog and cat feed sales totalling US $49 billion in 2008.**

- **One of the largest consumers of terrestrial & aquatic animal protein meals and fats, including poultry by-product meal , meat & bone meal, and salmon meal;**

Global retail sales of pet foods by category, 2008 (US$ million)

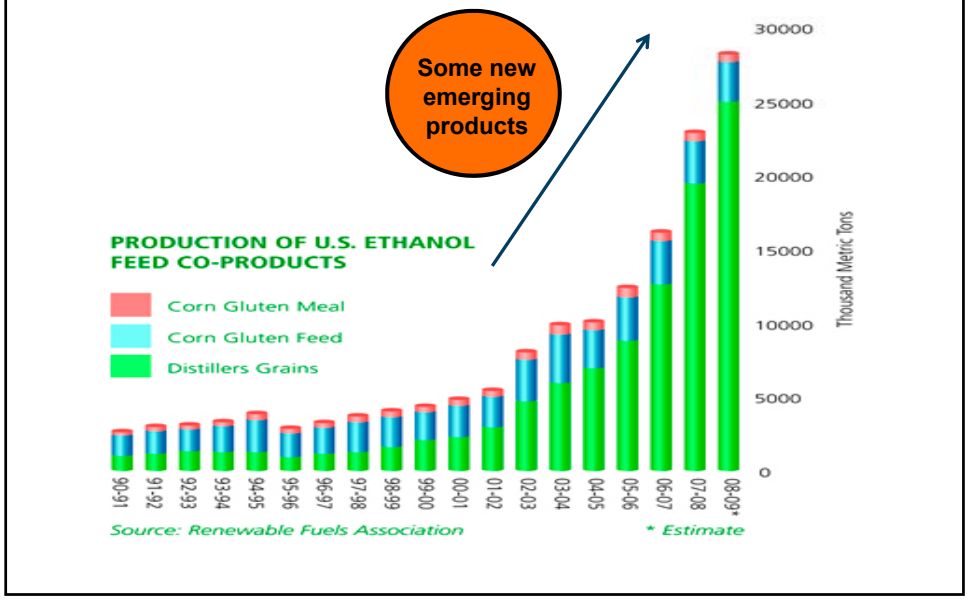


- A market currently estimated at US $ 60 billion
- Mean annual growth 2.8% per year over last 10 years
- Dog and cat food represents 72% of the business
- Gianni Carniglia, 2009

- **Competition with biofuels**

- Diversion of potential existing food grains and crops from direct human consumption to more profitable biofuel production as a `greener' petroleum substitute.
- Leads to less grains and crops being available for direct human consumption and increased demand for these commodities and consequent increased food prices.
- On the positive side, a variety of new feed by-product meals will be produced and be available from ethanol bio-refineries and algal products

Production of corn feed by-products from alcohol bio-refineries within the US (Renewable Fuels Association)



- **Competition with humans**

- **Direct competition between the use of fish for aquafeeds and the use of the same resources as food for humans**
- **Use of low-value fish as direct feed source in aquaculture (estimated usage in China between 6 and 8 million tonnes in 2008)**
- **Use of potentially food grade forage fish used for production of fishmeal and fish oil**

Use of lower value captured fish as a direct feed by the aquaculture sector




Use of pelagics for tuna feeding


Higher value export HTL aquaculture species


Marine fishes
Pangasius
Lobster
Amphibians

Continued and growing importance of feed and food safety

- Reported food safety risks associated with the use of contaminated aquaculture feeds, either within the feed ingredients used or from the external contamination of the feed on prolonged storage.
- Major potential feed contaminants have included Salmonellae, mycotoxins, veterinary drug residues, persistent organic pollutants, agricultural and other chemicals (solvent residues, melamine), heavy metals (Hg, Pd, Cd) and excess mineral salts (As, Se. F, Cr), and possible transmissible spongiform encephalopathies (TSEs).

- Apart from the direct negative effect of these possible contaminants on the health of the cultured target species, there is also a risk that some of these feed contaminants may be passed along the food chain, via contaminated aquaculture produce, to consumers.

- In recent years, public concern regarding food safety has increased as a consequence of the increasing prevalence and/or reporting of antibiotic residues, persistent organic pollutants, and chemicals in farmed seafood

Recommended approaches to feed ingredient selection & use

1. Reduce country dependence upon imported feed ingredient sources

On the basis of the results of the feed survey conducted for this paper, it is apparent that many aquaculture producing countries are currently highly dependent upon imports for souring the feed ingredients.

Countries who reportedly import less than 25% of their feed ingredients used in compound aquafeeds:
Argentina [0-10%], Brazil [0-10%], USA [5-10%];

Countries who reportedly import 25 to 50% of their feed ingredients used in compound aquafeeds:
Australia [25-35%], Canada [40%], Denmark [30%], India [0-44%], Mexico [20-45%]

Countries who reportedly import 50 to 75% of their feed ingredients used in compound aquafeeds:
Chile [30-80%], China [>50%], Ecuador [60-70%], Egypt [54-75%], France [50-78%], Italy [70-75%], Turkey [70%], UK [60-90%], Vietnam [30-70%];

Countries who reportedly import 75 to 100% of their feed ingredients used in compound aquafeeds:
Greece [90%], Korea Rep. [90-100%], Norway [80-90%], Peru [70-90%], Taiwan [50-100%], Tahiti [100%], UK [60-90%];

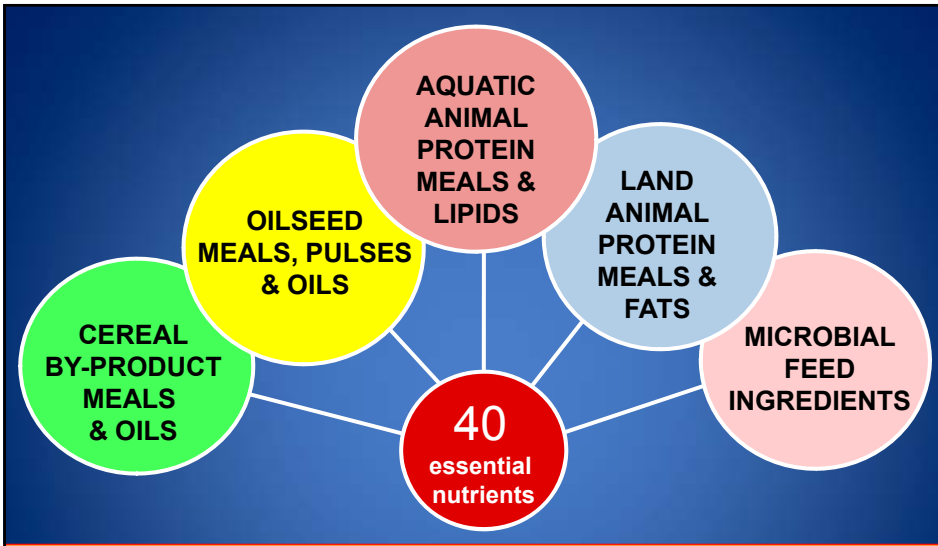
Feed ingredient availability and usage within most developing countries is usually biased toward energy-rich rather than protein-rich ingredient sources, with greatest usage of local non-imported ingredients being within feeds for freshwater and brackish water fish feeds targeted for domestic consumption and within farm-made aquafeeds.

There is promotion by some governments to reduce the current dependency of their national animal feed manufacturing industries upon imported feed ingredient sources by developing more competitive protein and energy sources from locally available agricultural products, including cassava, rice, oil palm, copra etc.

2. Select feed ingredients that can be sustainably produced and can grow with the sector

Included within these ingredient sources are:

- Fishery & aquaculture by-product meals & oils;
- Invertebrate fishery by-product meals & oils;
- Terrestrial animal by-product meals & fats;
- Cereals, including by-product meals & oils;
- Oilseed meals & oils;
- Pulses & protein concentrate meals; and
- Microbial ingredient sources or SCP.



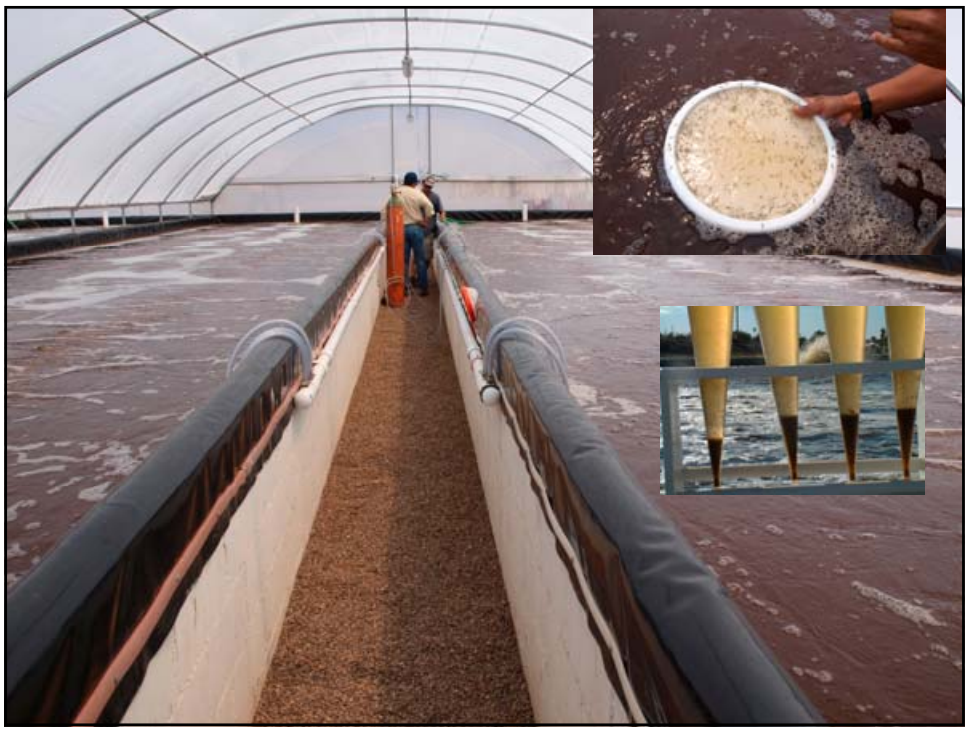
We need to be able to use ALL of the above listed feed ingredient sources: and in particular those feed-grade ingredient sources that can be sustainably produced and keep pace with the growth of the aquaculture sector

3. Minimize environmental and ecosystem impact of feeds and feeding regimes

One of major criteria for ingredient selection is nutrient density and nutrient digestibility. It follows therefore, that the higher the nutrient digestibility of a particular ingredient or feed, the higher its nutrient utilization efficiency and consequent resultant growth of the target species. Moreover, by using highly digestible feed ingredient sources and feeds, nutrient loss and feed wastage are kept to a minimum, thereby also minimizing any possible negative environmental and ecosystem impacts.

In addition to the selection of highly digestible feed ingredient sources, nutrient loss & impacts can also be reduced by integrating production with other cultured species which can benefit from these nutrient waste streams or by culturing the species under closed floc-based zero-water exchange farming systems.


Ecuador



4. Give special attention to small scale farmers using farm-made aquafeeds

It is widely recognized that small-scale farmers still form the backbone of Asian aquaculture, and in particular for the production of freshwater fish species for domestic consumption. One of the hallmarks and characteristics of this sector is the use of farm-made aquafeeds. However, apart from the general absence of statistical information on the size and extent of this sector, little or no guidance and attention is usually give to this sector to better help farmers formulate and manage their feeds.

To a large extent this has been due to the push by government agencies and feed manufacturers to move the sector away from the use of farm-made to the purchase of commercial aquafeeds.

Despite the relative merits and demerits of using farm-made aquafeeds, there is an urgent need to better assist the generally resource-poor farmers using farm-made aquafeeds, not only by improving feed formulation, minimizing the use of unnecessary feed additives and chemicals, and by improving on-farm feed management and thereby reducing feed wastage and potential deleterious environmental impacts.

We acknowledge those panel members who actively contributed to the preparation of the this review and the paper presented today including many who have provided data and information included herein