



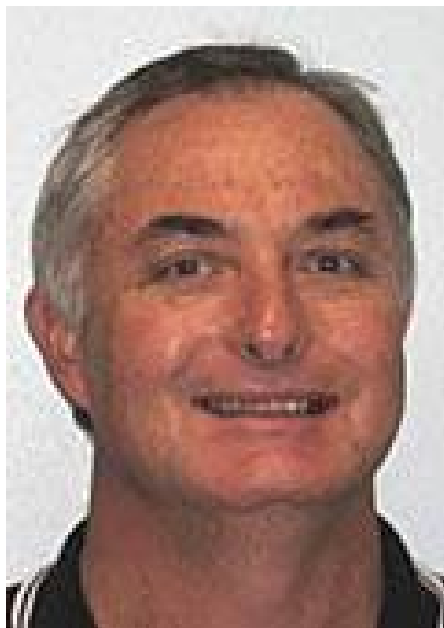
Industry &
Investment



Sustainable Aquaculture Feeds

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global aquaculture
the alliance

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- **Dr. Geoff Allan is the manager of aquaculture research conducted by the New South Wales Department of Primary Industries at the Port Stephens Fisheries Centre, Grafton Aquaculture Centre and Inland Saline Aquaculture Research Centre. Allan is also a program consultant to the Australia Centre for International Agricultural Research and a principal investigator in Aquafin Cooperative Research Centre projects on snapper aquaculture and feed technology for temperate finfish species.**
- **Allan has over 20 years experience in aquaculture and fish biology. His primary research interests include aquaculture and feed technology, diet development and inland saline aquaculture. He is chairman of the NSW Fisheries Animal Care and Ethics Committee.**

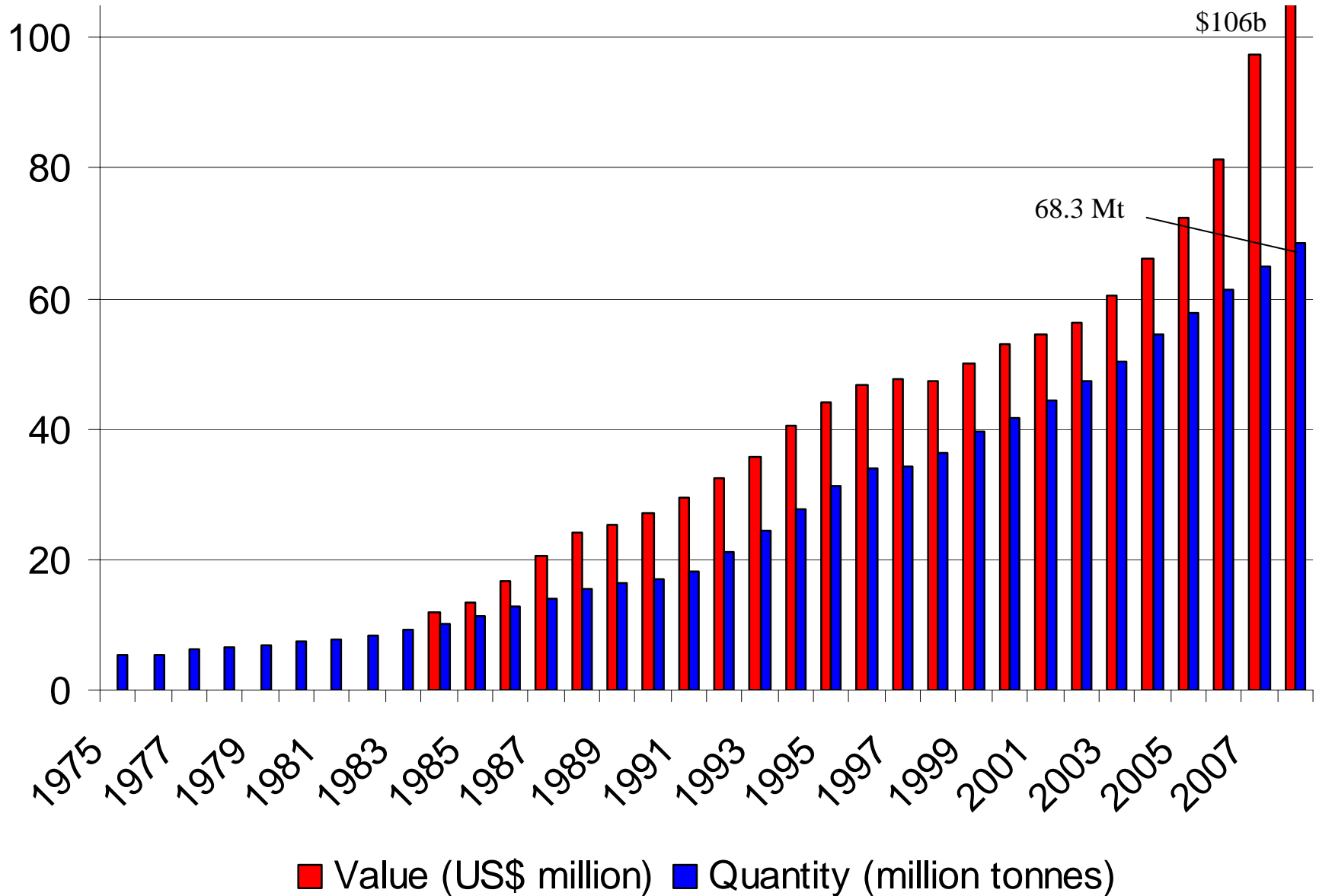
Plan

- Aquaculture and aquafeeds – production and predictions
- Challenges for aquafeeds:
 -  ingredients
 -  summary of success with alternatives
- Process for understanding requirements & formulation with new ingredients
- Conclusions

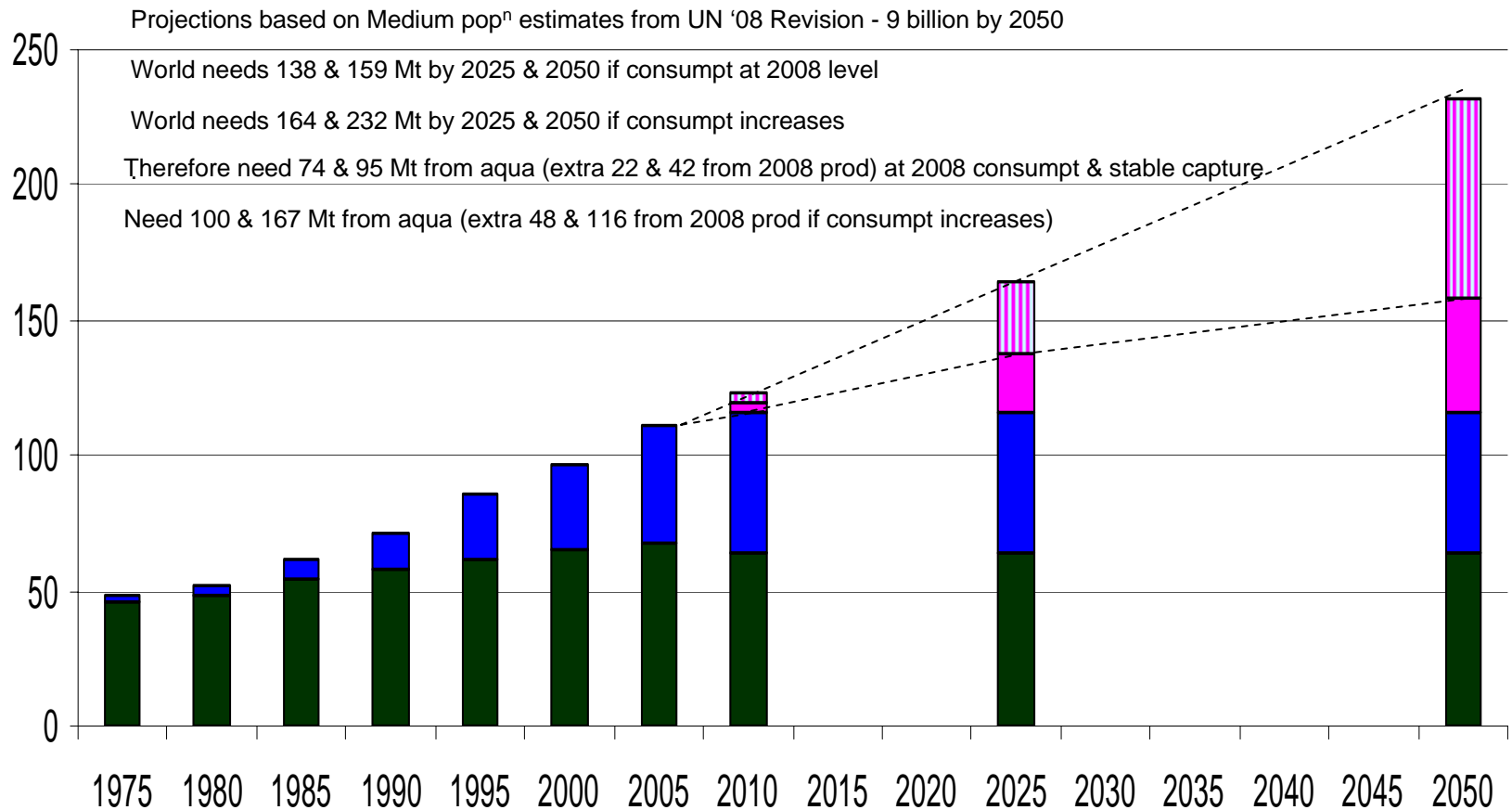


Global Aquaculture (million tonnes & US\$ million)

(FAO FishStat 2009)



Global Seafood Requirements (million tonnes)



- Additional demand if consumption increases at same rate as from 1975-2008
- Additional demand if consumption stable at 2008 level - 17.2 kg/capita whole fish
- Aquaculture production less plants (assume stable production past 2008 - 52 Mt)
- Capture production less non-food (assume stable production past 2008 - 64Mt)

More & better aquafeeds have fuelled the increase in aquaculture production

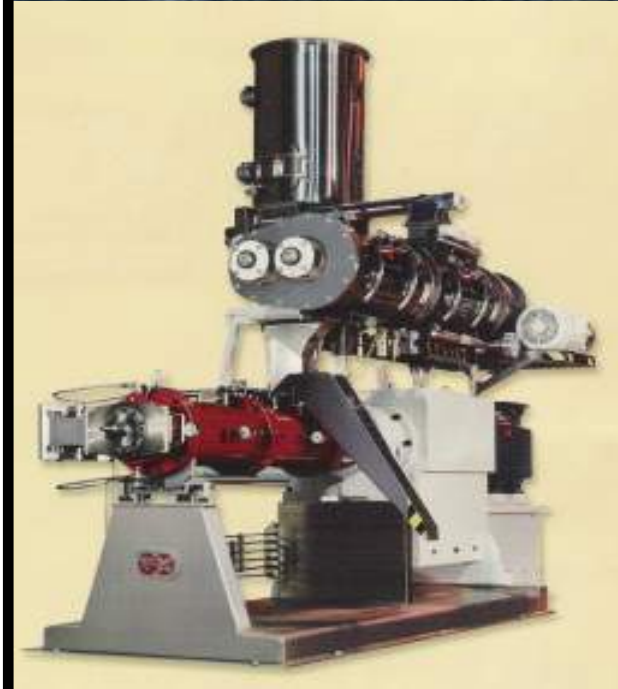
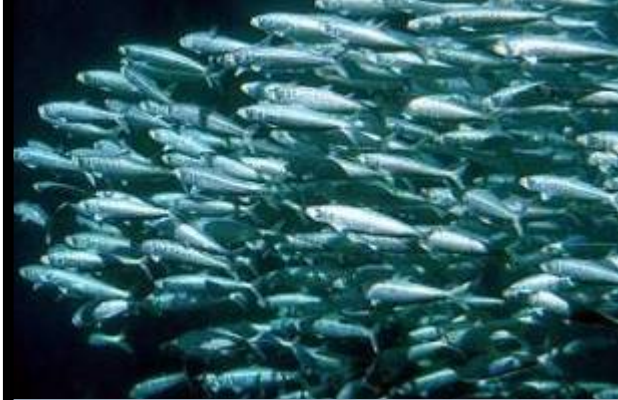
	Aquaculture	Aquafeeds
Production 1994 (Mt)	26	4
Production 2007 (Mt)	65	27
% Increase	150	578

*Mt = million tonnes; FAO Fisheries Statistics,
Tacon et al, various publ.

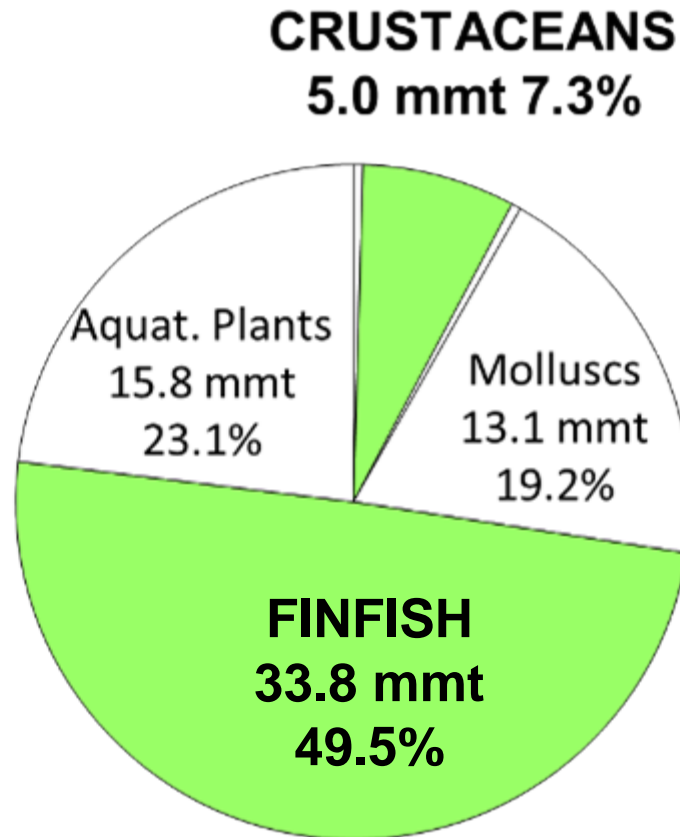


Basis of recent success with aquafeeds

- Better understanding of ingredients (excellence of fishmeal & fish oil)
- Increases in transport & global trade
- Improvements in knowledge of nutritional requirements
- Much better processing – esp extrusion technology



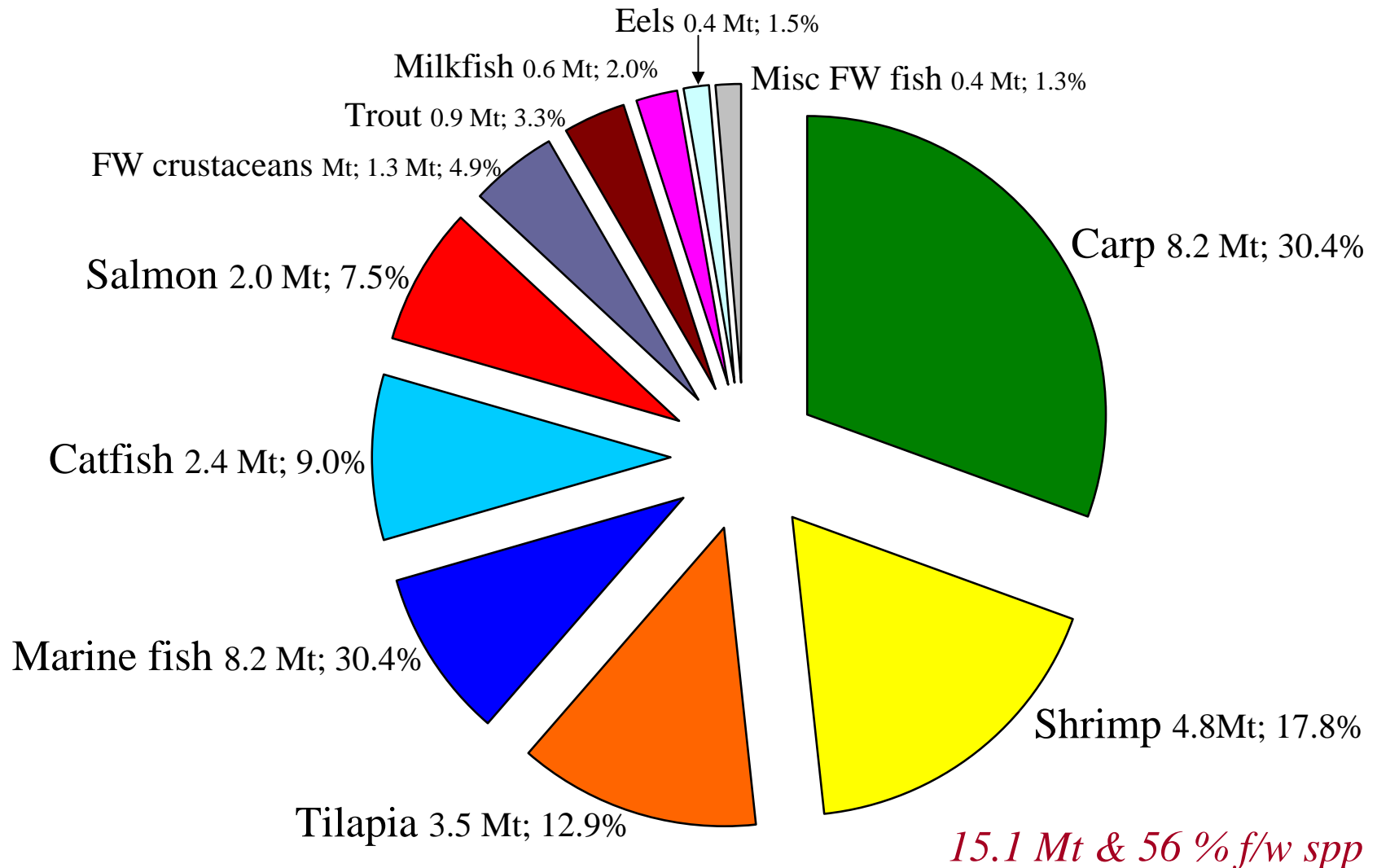
Fed aquaculture species prod in 2008; *Tacon, 2010*



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

Global aquafeed production in 2007

27.1 million tonnes (Tacon et al, 2010)



Farm-made feeds

- Estimates unreliable
- 19.3 Mt in 2003 (De Silva & Hasan, 2007)
- 18.7 – 30.7 Mt 2006 (Tacon 2008)
 - China – 10-20 Mt
 - India – 6.5 – 7.5 Mt
 - Vietnam – 1 – 1.5 Mt
 - Thailand – 0.7 – 0.75 Mt
 - Japan – 0.65 – 0.8 Mt
- Feeding continuum – primary productivity only, single ingredients, farm-made feeds, formulated pellets
- Will continue to provide essential nutrition for many species for many farms
- Economic necessity for some farms
- Anticipate increased use of formulated feeds as aquaculture grows



Direct feeding of low value fish = trash fish

- Includes discards & low value fish used for animal feeds & fish sauce
- Many aquaculture industries depend on low value fish as feed - competition with use as direct food for humans (eg fish sauce)
- Estimated use between 5.6 and 8.8 million tonnes in 2009 (Tacon et al, 2010)
- China: 4-5 million tonnes in 2005
- Vietnam: 137,000–324,000 t for aquaculture in 2004 (Edwards et al, 2004)
- Total capture fishery production in Asia = 40 mt in 2003 Estimate 25% or ~10 mt used for fish/livestock feeds (Funge-Smith *et al.*, 2005)
- Anticipate replacement of direct feeding with low value fish with formulated feeds



Aquafeeds in Southeast Asia – future trends

- Formulated aquafeeds will replace increasing amounts of farm-made feeds and low-value fish species used for aquaculture feeding
- Aquafeed production will increase faster than aquaculture production
- ***Tacon et al, 2010 predicts aquafeed production may increase to > 70 million tonnes by 2020***
- **Ingredients**
 - Increasing competition for ingredients

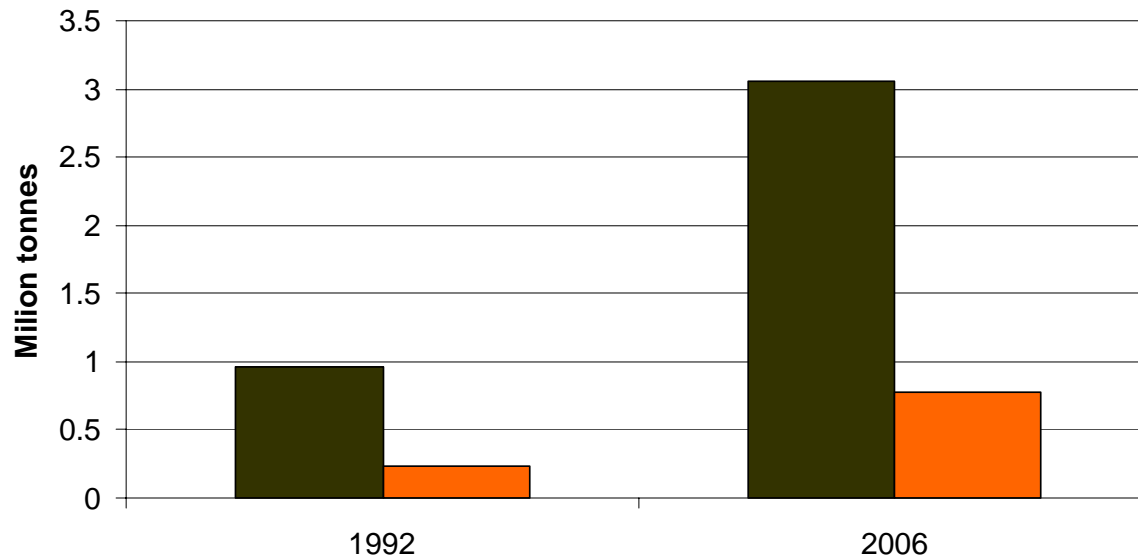


Challenges to increased production and use of aquafeeds

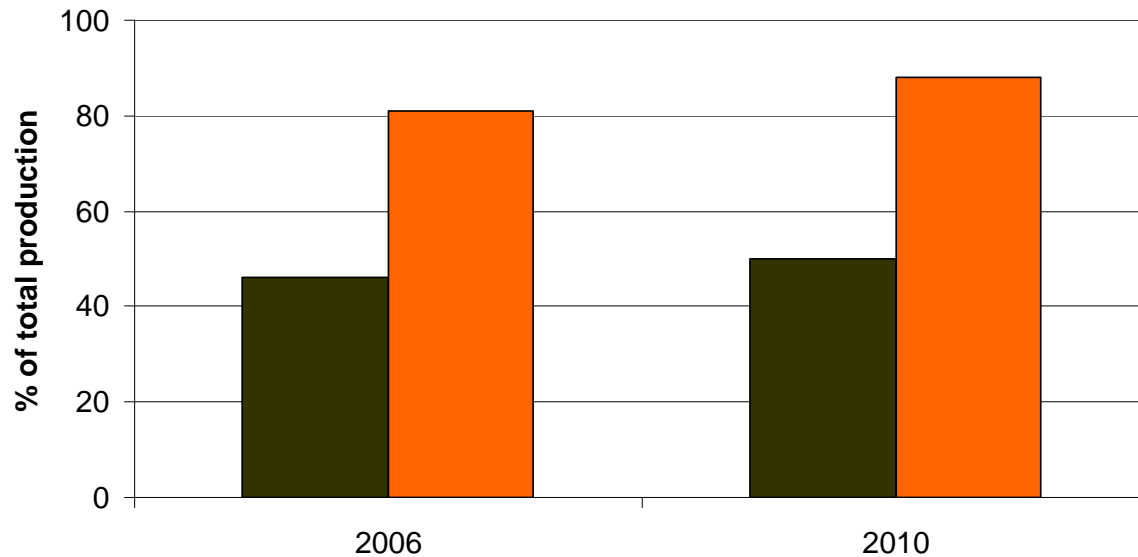
- **Primary challenge is supply & cost of ingredients**
- Fishmeal & fish oil – will there be enough?
- What other protein & energy sources are available?
- Competition with ingredients for other feeds:
 - Other animal feeds (e.g. poultry, pigs)
 - Pet feeds
- Competition with biofuels
- Competition with humans



Fishmeal and fish oil use in aquafeeds



■ Fishmeal use (million tonnes) ■ Fish oil use (million tonnes)

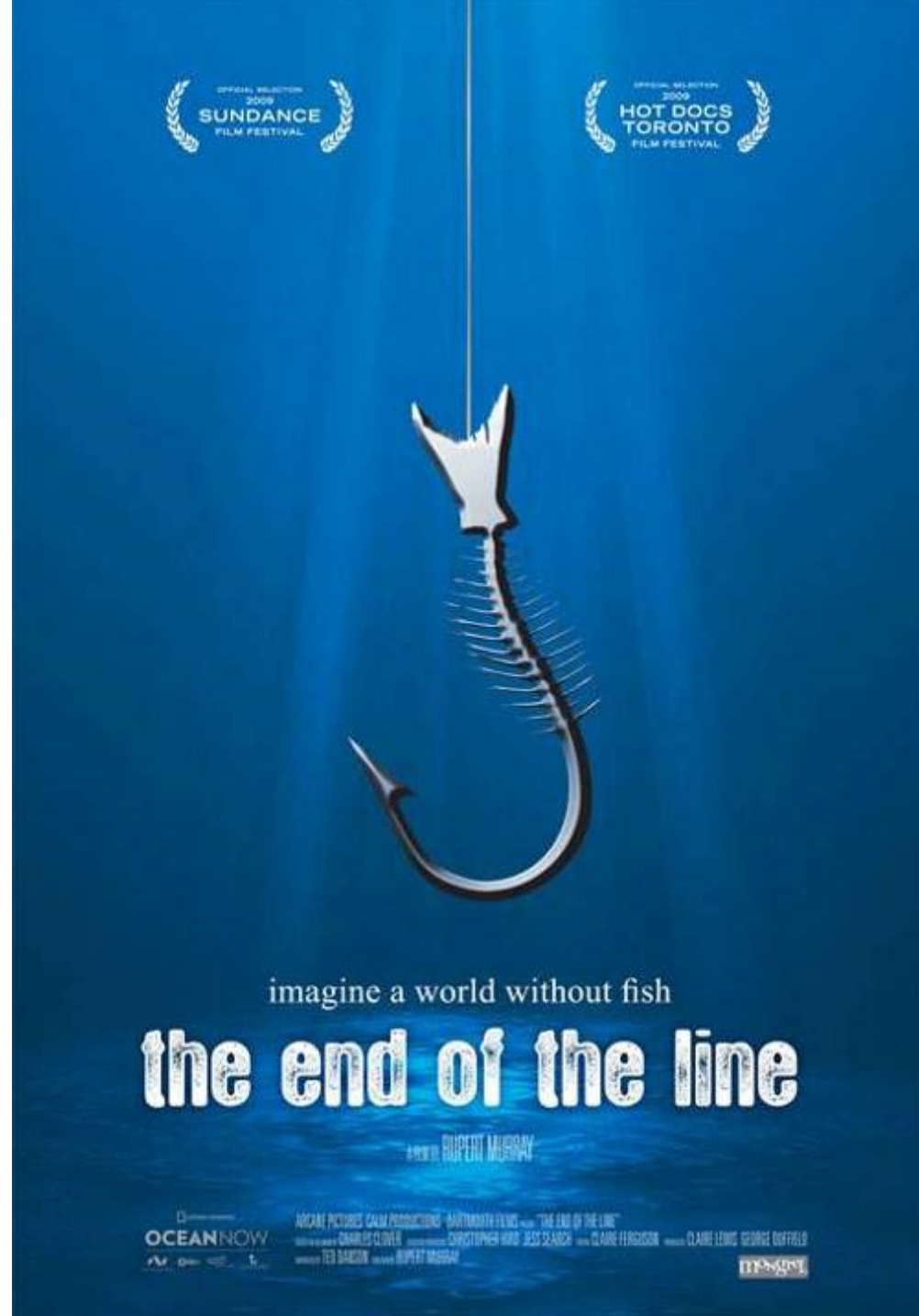


■ Fishmeal (% used in aquafeeds) ■ Fish oil (% used in aquafeeds)



**For aquaculture,
particularly in Europe,
Northern America and
Australia, concerns persist
about sustainability of
fishmeal and fish oil**

**Not helped by alarmist
documentaries like “the
end of the line” and some
NGO aquaculture
certification programs**



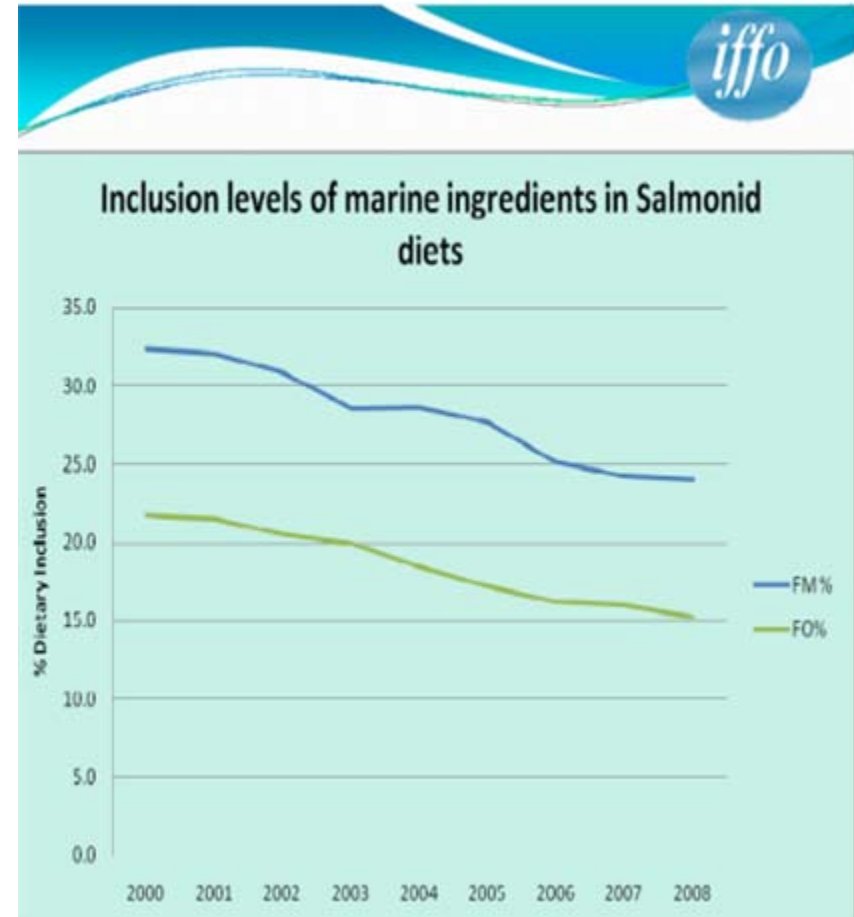
But...

- Predictions - production of fishmeal & fish oil will remain stable at 5 million tonnes fishmeal & 1 million tonnes fish oil
- No evidence that use in aquafeeds threatens sustainability of resource
- IFFO certification scheme to help protect resource
- Increasing use of fishmeal & fish oil for humans will reduce amount available for animal feeds
- But, offset by increasing use of fishmeal and fish oil from processing wastes (already estimated at around 25% of source product)

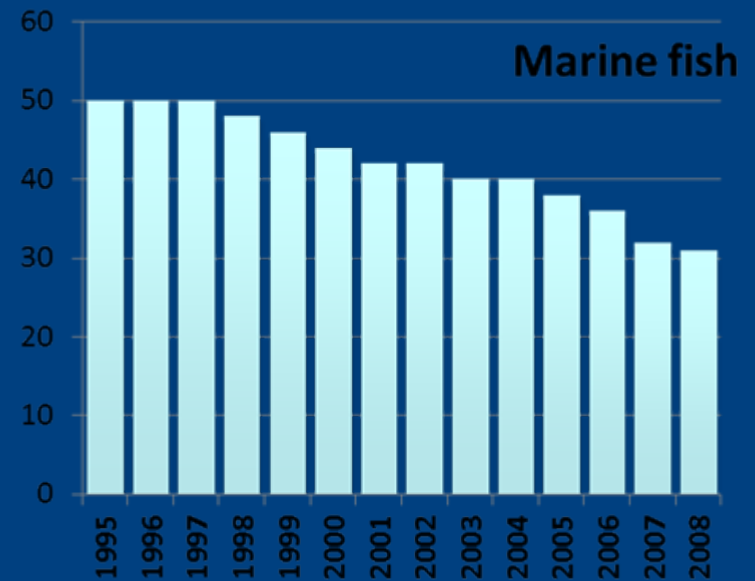
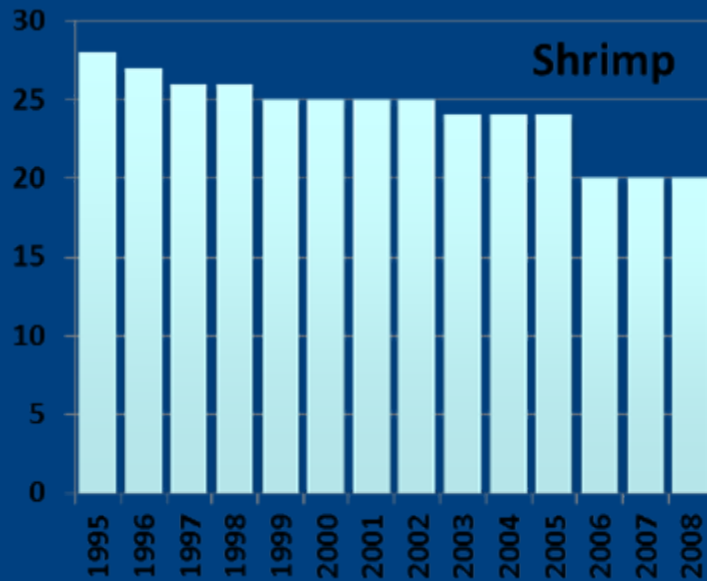
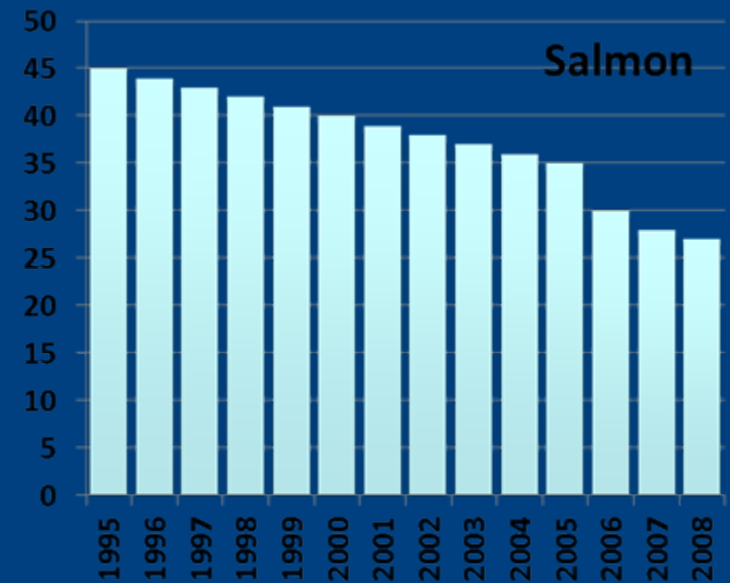
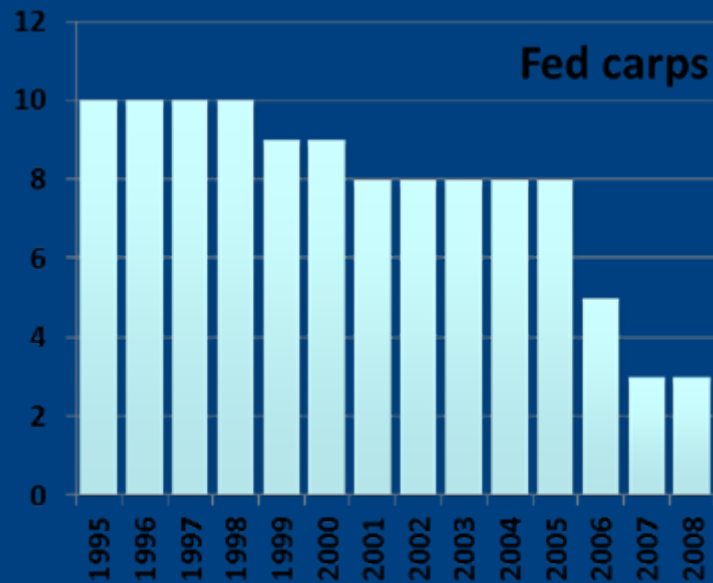


and...

- Concerns of availability for aquafeeds are moderated by success with reduction in use of fish meal for many species
- Stable or declining total use for aquafeeds despite increases in total aquaculture production
- Excellent products, need ongoing effort to allay sustainability fears & ensure continued use for aquafeeds
- ***Fishmeal & fish oil will remain key ingredients for aquafeeds***
- ***Will increasingly be used for speciality & finisher feeds***



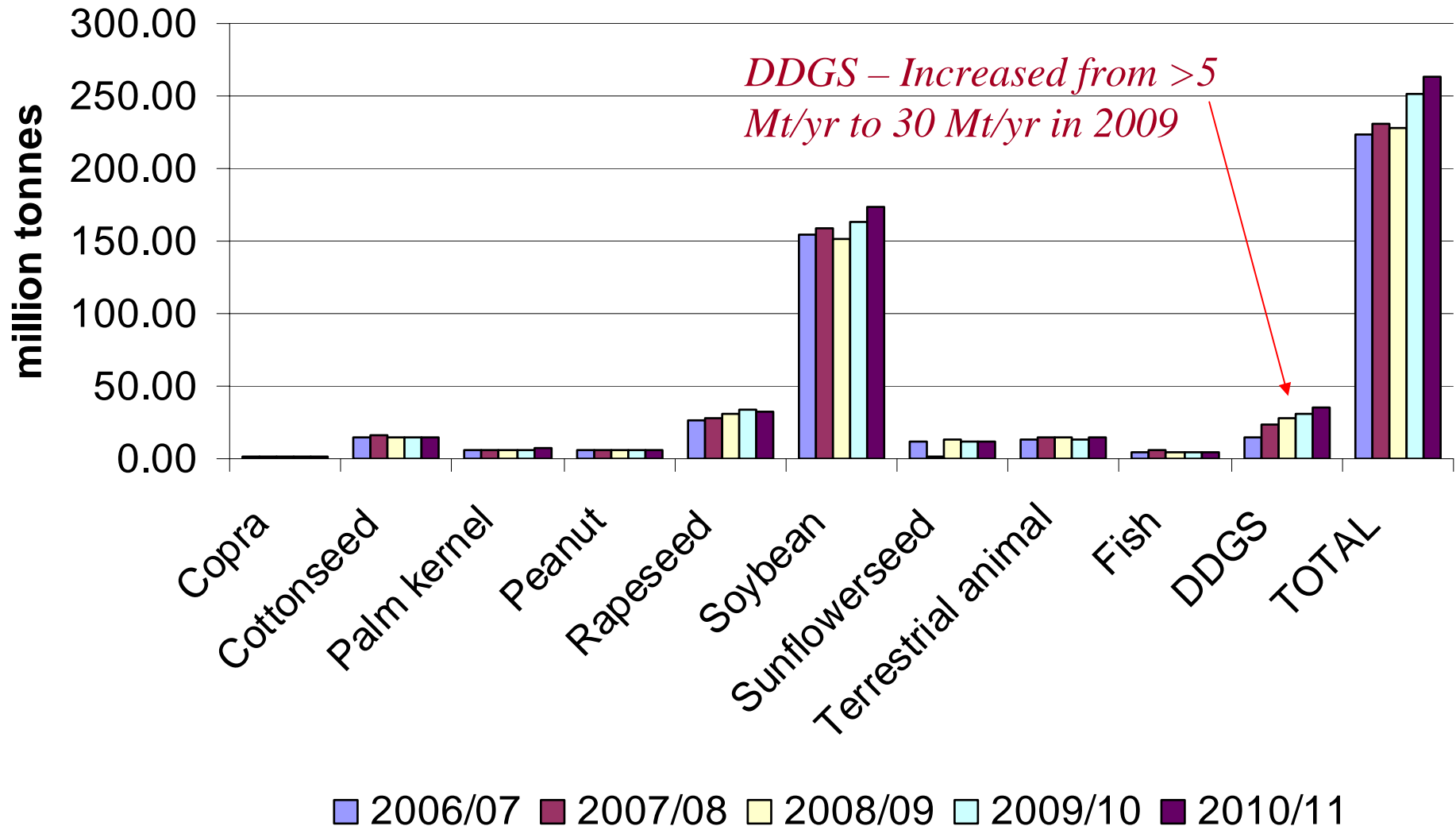
Estimated dietary fishmeal inclusion levels 1995 to 2008; Tacon, 2010



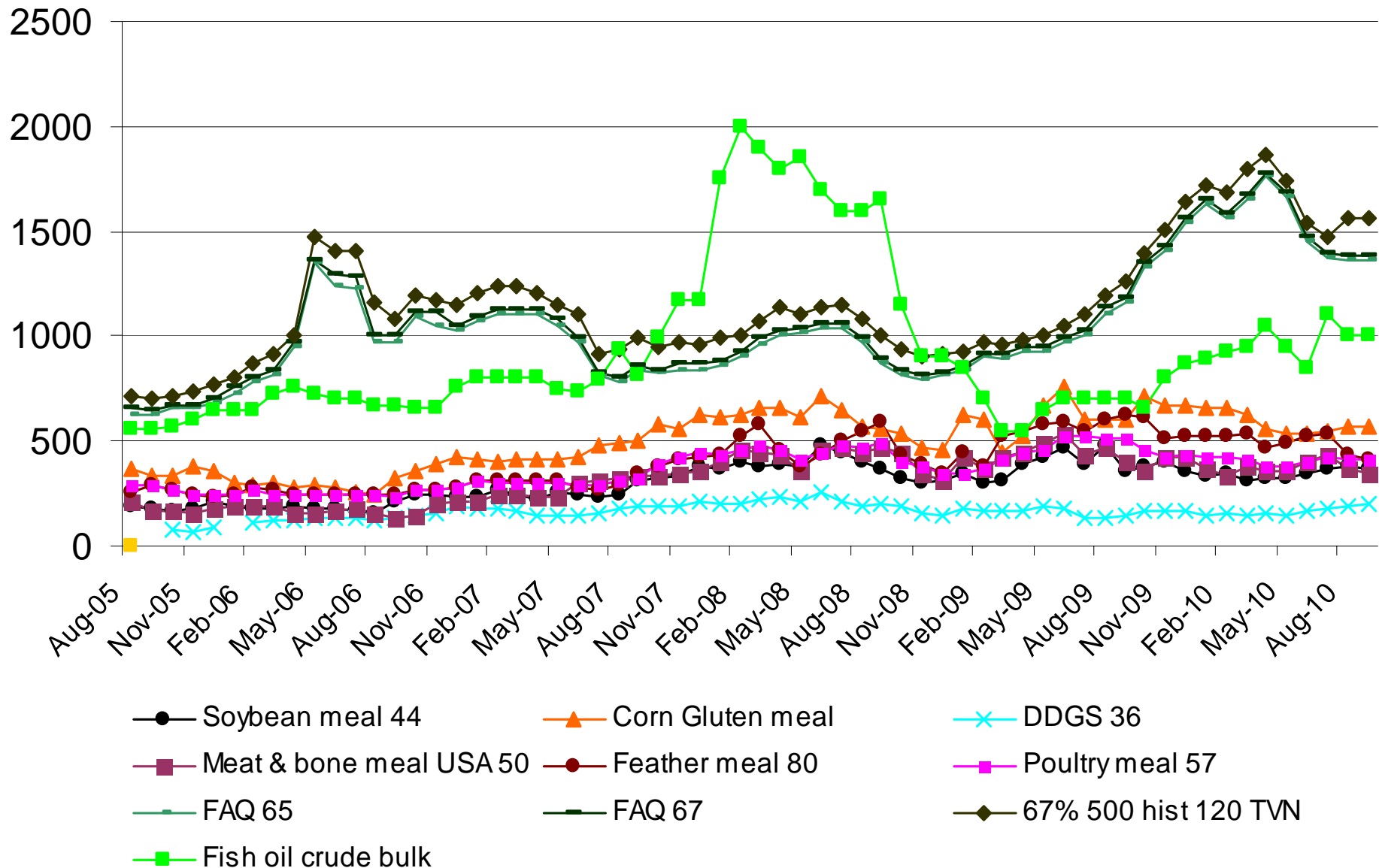
What other protein meals are there?

Global production

USDA Oilseeds:World Markets & Trade 2010; DDGS -Ethanol Producer Mag, 2/9/2010

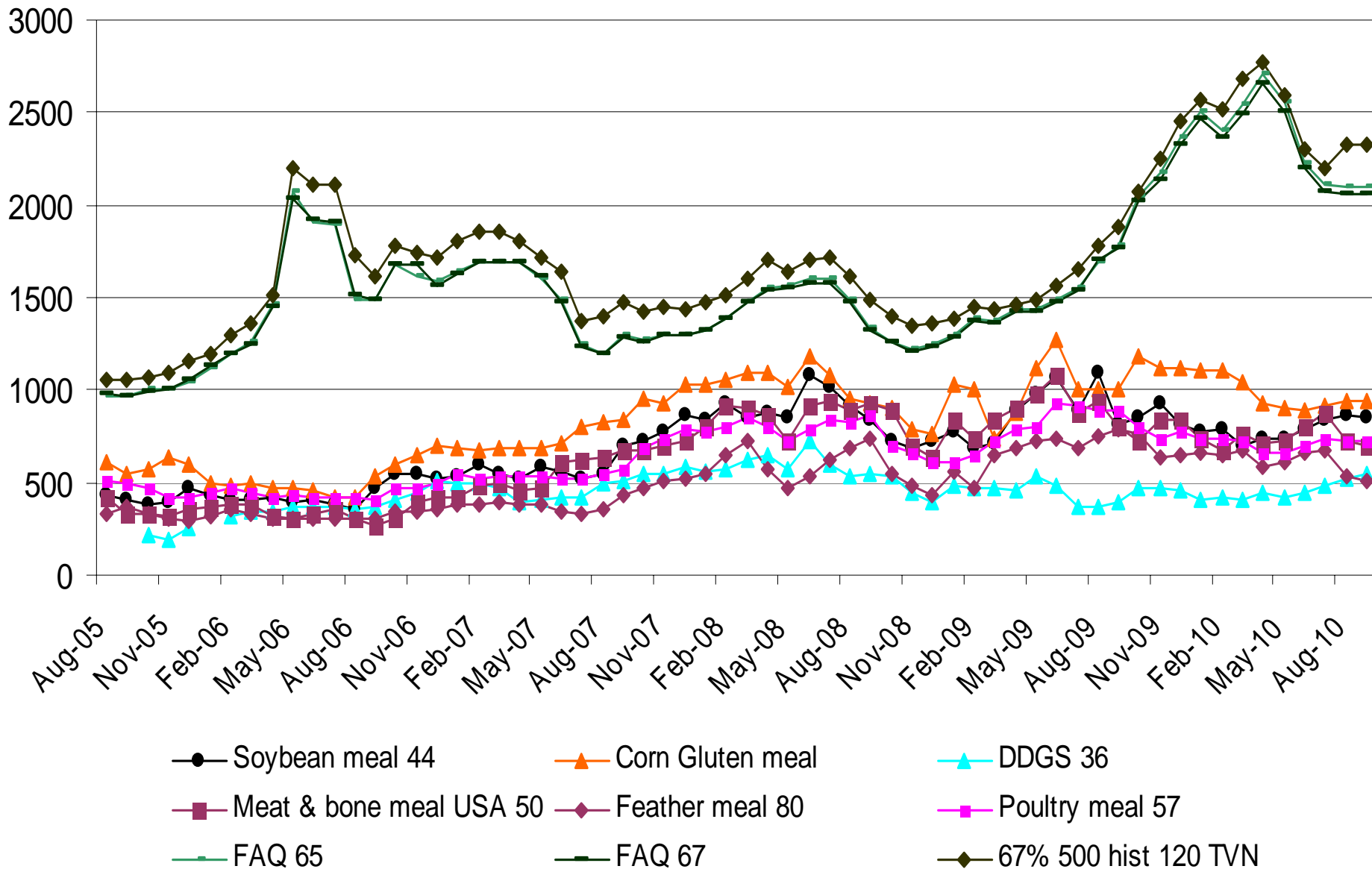


<http://hammersmithltd.blogspot.com.html>



Ingredient prices (US\$/t crude protein)

<http://hammersmithltd.blogspot.com.html>



Gross nutrient value – fish meal vs unprocessed ingredients

	Ash	N	Protein	Fat	GE
fish meal	14	11	68	10	20
blood meal	3	13	84	0	21
meat and bone	33	8	53	7	16
meat low ash	3	13	81	10	26
poultry meal	14	9	57	17	21
feather meal	3	12	74	10	22
soybean	8	7	45	3	16
lupin	3	5	32	5	17
field pea	3	4	24	1	16
cow pea	3	4	22	2	16
wheat gluten	1	12	72	0	22
corn gluten	1	9	58	0	22
wheat	1	2	11	2	17
sorghum	2	2	13	4	17



Rendered animal protein meals

- **Production >14 million t/yr (Swisher, 2007)**
- **Variety of product types**
- **Low or absent anti-nutritional factors**
- **Low CHO**
- **Widely available**
- **BSE does not affect fish**



Results with rendered animal products

- Trout: up to 100% replacement of FM, 35% in diet
- Red sea bream: up to 73% repl, 38% in diet
- Shrimp: up to 80% repl, 30% in diet



Results for rendered products in aquafeeds – Tacon, 2010

- Salmon & trout (PBM 10-30%, HFM 5-12%, 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%),
- Tilapia, carp & mullet (MBM 5-10%, PO 2-4%)
- Freshwater crayfish (MM 10-30%, MBM 10-30%)

Soybean meal and other soy products

- Most abundant vegetable protein 427 Mt oilseeds, 231 Mt soybeans in 2007
- Most abundant vegetable protein in aquafeeds, subject of most replacement studies
- Approx 6.8 Mt soybean meal used in aquafeeds (Tacon, 2010)



Results for soybean & other vegetable ingredients in aquafeeds – Tacon, 2010

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

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

Grey mullet (SBM 20-25%), F/W prawns (SBM 15-25%),

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%, R/CM 7-20%, CPC 10-15%),

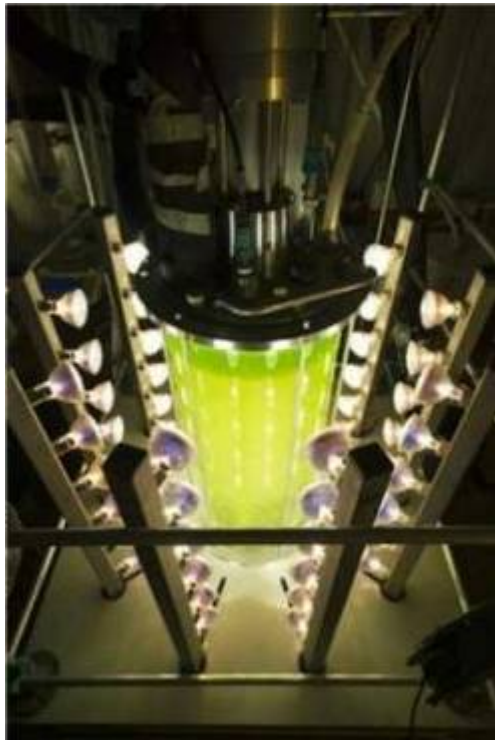
SBM – soybean meal; CGM – corn gluten meal; CSM – cottonseed meal; R/CM – rapeseed/canola meal; G/PM – groundnut/peanut meal; MC – mustard seed cake; LKM – lupin kernel meal; WGM – wheat gluten meal; FBM – faba bean meal; SO – soy oil; R/CO – rapeseed/canola oil

Alternatives to fish oil

- Fish oil used for energy and EFA (essential fatty acids)
- For some species, energy can be sourced from CHO
- Energy from lipid can be sourced from:
 - 🐟 vegetable oils (some have high omega-3 contents e.g. soya & canola)
 - 🐟 animal fats, especially poultry oil
- EFA
 - 🐟 oil from fish processing (inc. from farmed fish) (excellent source omega-3)
- 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

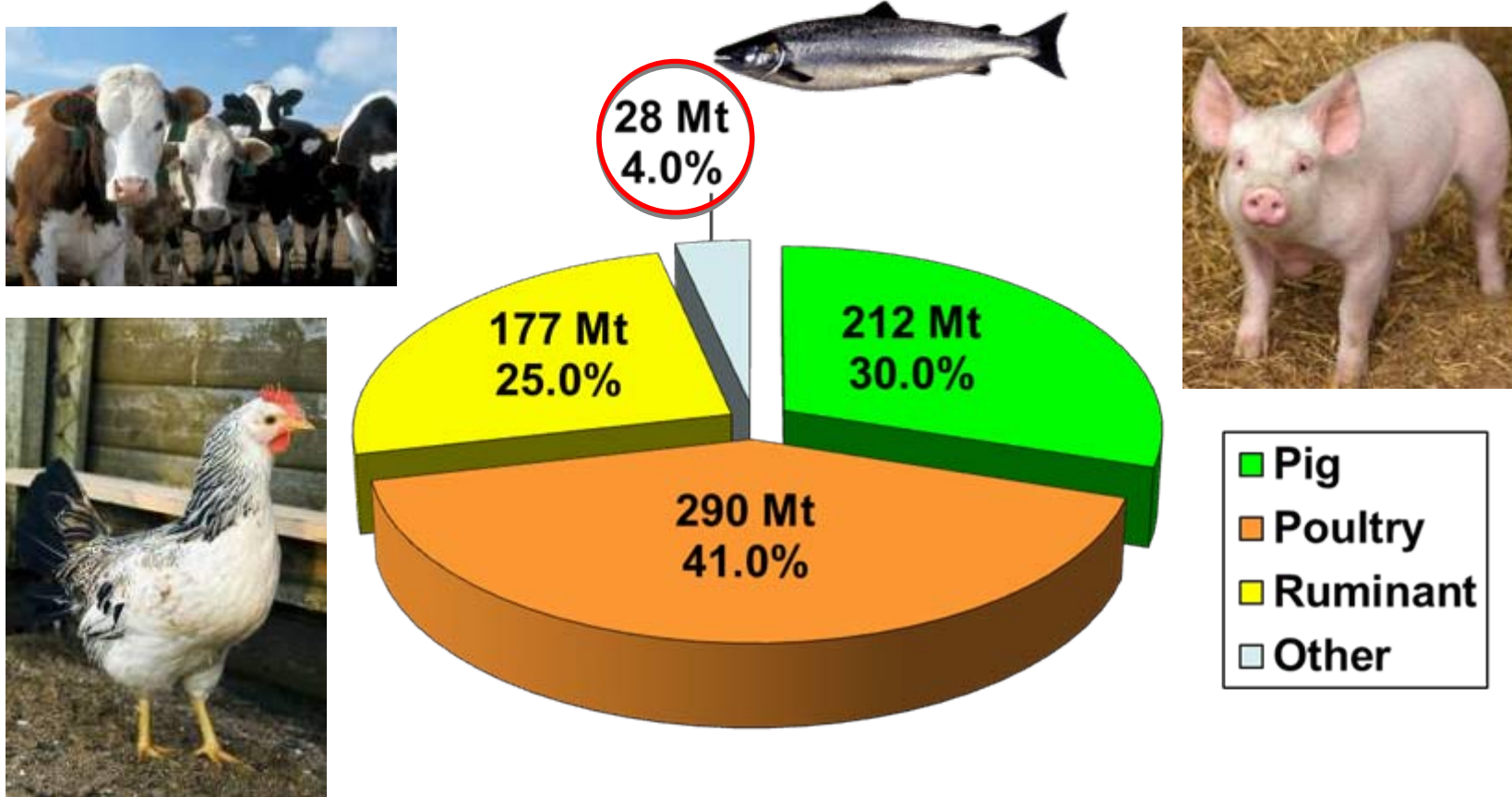


Anthony P. Bimbo, 2010;
Tacon, 2010

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

Total global compound feed production – 2009

(Million tonnes: Peter Best – pers com. March 2010; via Tacon; 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

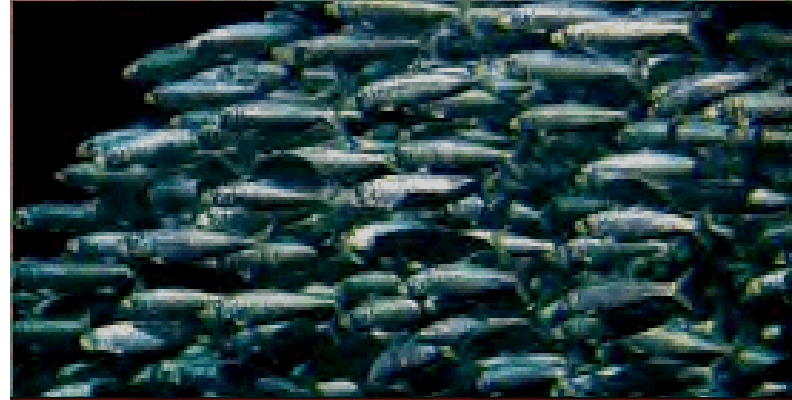
Challenges with Ingredients

- Food safety
- GMOs
- BSE
- Carbon footprint
- Water and nutrients
- Nutrient limitations
- Ecological impacts of farming – e.g. rainforest depletion



Conclusions

- Aquaculture must continue to increase to meet global requirements
- Fishmeal & fish oil excellent ingredients
- Use in aquafeeds not ecologically irresponsible, but continued search for additional protein and lipid sources critical to maintain growth in aquaculture production
- Farm-made feeds will continue to provide nutrition to expanding aquaculture, but be replaced by formulated feeds for many farms
- Low-value fish as direct feed – limited supply and will be increasingly replaced by formulated feeds



Conclusions

- Total replacement of fishmeal for many fish & partial replacement for crustaceans a reality
- Significant reduction in fishmeal and fish oil has occurred for many spp; more reduction possible
- Ingredients are available – market will determine where they are used
- Opportunity for grains & animal meals – protein concentration important
- Increase use of grains for biofuels presents challenges & opportunities for aquafeeds
- Fishoil substitution more difficult
- Vegetable oil blends, marine algae & finisher diets possible solutions

