Fish In – Fish Out Ratios

[Explained]

25th October 2019

Neil Auchterlonie

Workshop on sustainability and responsible sourcing of fishmeal and fish oil

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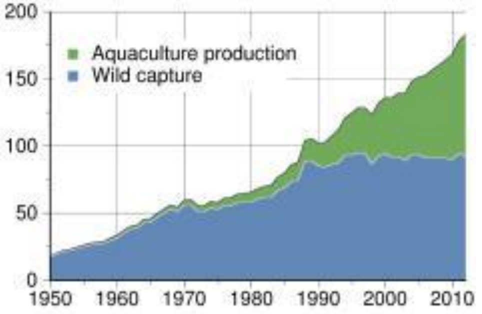
EU fishmeal

Fish In – Fish Out Ratios

[Explained]



1. History

- Concern in late 1990s about aquafeed volume growth
- A perception that aquaculture was driving additional pressure on fisheries stocks
- Original use in 2000 by Naylor *et al*
- Method to account for FMFO use in aquafeed, calculated back to whole fish equivalents
- FIFO is often cited by NGOs, academics and consumer groups
- Evolved into different versions
- Incorporated into certification standards

review article

Effect of aquaculture on world fish supplies

Rosamond L. Naylor, Rebecca J. Goldburg, Jurgenne H. Primavera, Nils Kautsky, Malcolm C. M. Beveridge, Jason Clay, Carl Folke, Jane Lubchenco, Harold Mooney & Max Troell

Global production of farmed fish and shellfish has more than doubled in the past 15 years. Many people believe that such growth relieves pressure on ocean fisheries, but the opposite is true for some types of aquaculture. Farming carnivorous species requires large inputs of wild fish for feed. Some aquaculture systems also reduce wild fish supplies through habitat modification, wild seedstock collection and other ecological impacts. On balance, global aquaculture production still adds to world fish supplies; however, if the growing aquaculture industry is to sustain its contribution to world fish supplies, it must reduce wild fish inputs in feed and adopt more ecologically sound management practices.

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[Explained]

2. Rationale

- A method of calculating how much wild fish was used in producing farmed fish, kg:kg
- Monitoring the amount of fishmeal and fish oil in aquafeed *was thought to* mitigate against additional pressure on reduction fisheries……
- In reality, mainly applied to farmed salmon

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[Explained]

3. Science (hypothetical)

- Tacon & Metian (2008) – original calculation
- Jackson (2009) – refined calculation
- Byelashov & Griffin (2014) – critique
- Terpstra (2015)

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3. Science (hypothetical)

$$\text{FIFO Ratio} = \frac{\text{Level of fishmeal in the diet} + \text{Level of fish oil in the diet}}{\text{Yield of fishmeal from wild fish} + \text{Yield of fish oil from wild fish}} \times \text{FCR}$$

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4. Amended calculation, Jackson (2009)

- Takes into account global market for FMFO
- Products not produced in isolation (salmon utilize more FO, less FM; shrimp utilize more FM, less FO)
- Accounted for byproduct use (currently c.34% of raw material)

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4. Calculations, according to the method of Jackson (2009)

	2000	2010	2015
Crustaceans	0.91	0.45	0.46
Marine Fish	1.48	0.88	0.53
Salmon & Trout	2.57	1.38	0.82
Eels	2.98	1.81	1.75
Cyprinids	0.07	0.03	0.02
Tilapias	0.27	0.18	0.15
Other Freshwater	0.60	0.15	0.13
Aquaculture total	0.63	0.33	0.22

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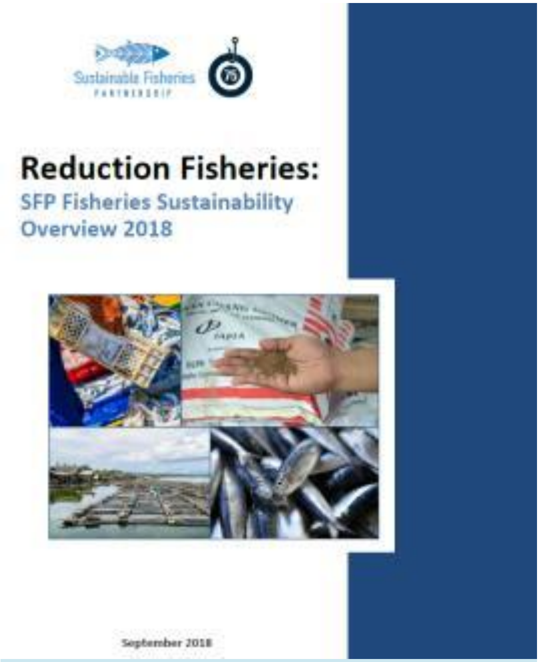
5. Does FIFO achieve what it set out to do (mitigate against overfishing of reduction fisheries)?

- Monitoring the amount of fishmeal and fish oil in aquafeed, and extending back through supply chains to the management of fisheries?
- The lack of specific links between FMFO production and use made this highly unlikely.....

Fishery performance, or why the rationale for FIFO does not hold

5. Does FIFO achieve what it set out to do (mitigate against overfishing of reduction fisheries)?

- Fisheries are managed irrespective of, and unrelated to, the FIFO concept
- Reduction fisheries differ from other (food) fisheries (species, life history, ecology)
- These can be highly productive fisheries and environmental factors play an important role in stock biomass



"**Ninety-one percent** of the total catch volume in this analysis comes from stocks that are reasonably well-managed (or better)"……

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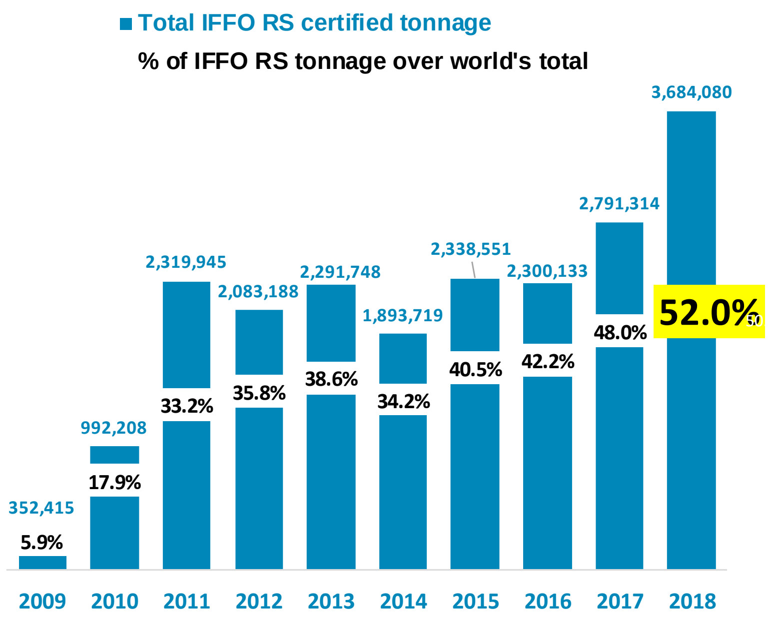
The role of Certification

5. Does FIFO achieve what it set out to do (mitigate against overfishing of reduction fisheries)?



- Importantly, Certification can exist even where regulations are not effectively implemented;
- Independently-audited schemes objectively review performance;
- Standards promote traceability, thereby strengthening those specific links between production and use that are an important feedback into fishery management…..

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[Explained]

6. Other issues

- FIFO does not take into account the nutritional value of FMFO in aquafeeds (e.g. amino acids, omega-3 fatty acids);
- Also that fish nutritional requirements change with life stage (FMFO increasingly used strategically where nutrition needs optimized);
- Commercially, feed companies were changing formulations in response to FMFO supply, not on the basis of FIFO.

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Importance of nutrition: amino acids

Amino Acids
DOI 10.1007/s00726-008-0171-1

REVIEW ARTICLE

New developments in fish amino acid nutrition: towards functional and environmentally oriented aquafeeds

Peng Li · Kangsen Mai · Jesse Trushenski · Guoyao Wu

Received: 25 June 2008 / Accepted: 3 August 2008

6. Other issues

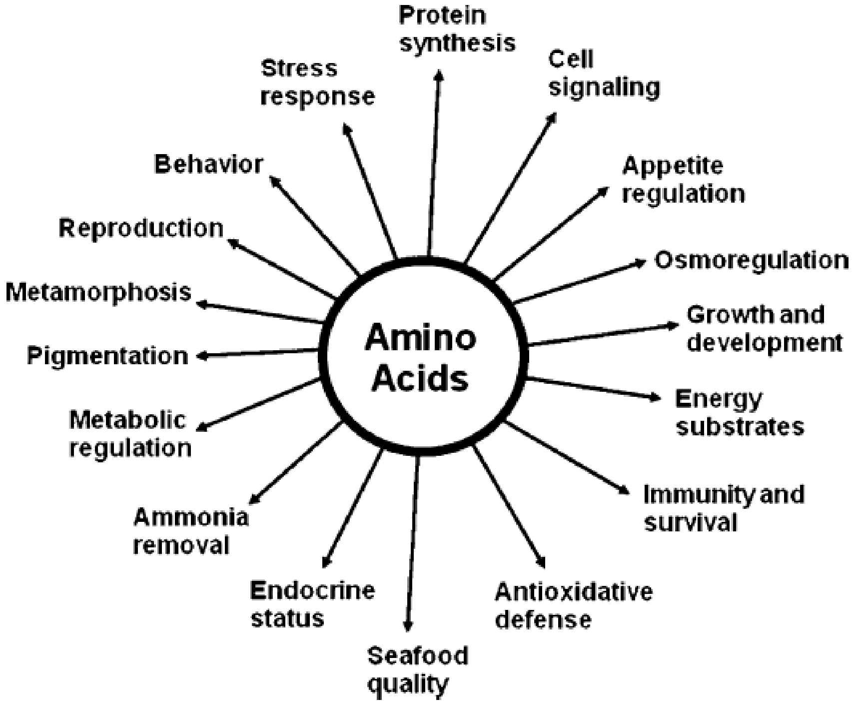

Fig. 1 Roles of amino acids in growth, development and health of fish

Table 2 Roles of amino acids in physiological functions and metabolism of aquatic animals

Amino acid	Product	Function	Species	Reference
Amino acids	Various proteins	Structure, transport, regulation, immunity, signaling, and fuels	All animals	Li et al. (2007)
Ala, Glu and Ser	Directly	Appetite	Many fishes	Shamushaki et al. (2007)
Arg	NO	Kill invaded microorganisms	Channel Catfish	Buentello and Gatlin (1999)
Arg	NO	Facilitate neurological function and development	Tilapia	Bordieri et al. (2005)
Arg	NO	Regulate vascular tone, blood flow, osmolarity in gill, and cell signaling	Killifish	Hyndman et al. (2006)
Arg and Met	Spermine	Induce larval intestinal maturation	Sea bass	Péres et al. (1997)
Arg, Met, and Gly	Creatine	High energy storage; antioxidant	Arctic charr	Bystriansky et al. (2007)
Cys, Glu, and Gly	Glutathione	Antioxidant and cell signaling	All animals	Wu et al. (2004)
Glu and Gln	Directly	Ammonia removal	Rainbow trout	Anderson et al. (2002)
Glu	GABA	Promote metamorphosis	Abalone	Morse et al. (1979)
Glu	GABA	Regulate food intake	Japanese flounder	Kim et al. (2003)
Gln	Directly	Increase growth, feed efficiency and gut development	Carp	Lin and Zhou (2006)
Gln	Directly	Fuel for macrophage; Cell signaling	Channel catfish	Buentello and Gatlin (1999)
Gln, Gly, and Asp	Nucleotides	Genetic information storage and expression, biosynthesis, immunity and reproduction	Various fishes	Li and Gatlin (2006)
Gly	Directly	Increase hepatic T4 5'monodeiodinase	Rainbow trout	Riley et al. (1996)
Gly	Directly	Osmoregulation	Oyster	Takeuchi (2007)
His	Directly and carnosine	Protection against pH change	Salmon	Mommsen et al. (1980)
Leu	HMB	Immunity modulation; Cell signaling	Various fishes	Li and Gatlin (2007)
Lys and Met	Carnitine	Lipid transporter on mitochondrial membrane	Various fishes	Harpaz (2005)
Met	Choline	Structure in membrane; neurotransmitter; betaine synthesis	Various fishes	Mai et al. (2006b)
Proline	P5C	Redox regulation; Cell signaling	Possibly in fish	Phang et al. (2008)
Proline	Hydroxyproline	Enhance growth; Collagen function	Salmon	Aksnes et al. (2008)
Phe and Tyr	T4, T3	Influence metamorphosis	Sole	Pinto et al. (2008)
Phe and Tyr	T4, T3	Enhance growth performance	Channel catfish	Garg (2007)
Phe and Tyr	T4, T3	Influence pigmentation	Japanese flounder	Yoo et al. (2000)
	Melanin	Influence pigmentation	Rainbow trout	Boonanuntanasarn et al. (2004)
Phe and Tyr	Epinephrine, norepinephrine	Neurotransmitters that modulate stress responses	Flounder	Damasceno-Oliveira et al. (2007)
Phe and Tyr	Dopamine	Down-regulated immunity	Shrimp	Chang et al. (2007)
Trp	Serotonin	Modulate cortisol release, behavior and feeding	Rainbow trout	Lepage et al. (2003)
Trp	Melatonin	Improve testicular development	Masu salmon	Amano et al. (2006)
Taurine	Directly	Osmotic pressure regulation	Carp	Zhang et al. (2006)
Taurine	Directly	Hardness adaptation	Channel catfish	Buentello and Gatlin (2002)
Taurine	Directly	Gut development	Cobia	Salze et al. (2008)
Taurine	Directly	Retinal development	Glass eel	Omura and Inagaki (2000)

HMB hydroxyl-β-methyl-butyrate; *NO* nitric oxide; *P5C* pyrroline-5-carboxylate; *T3* triiodothyronine; *T4* thyroxine

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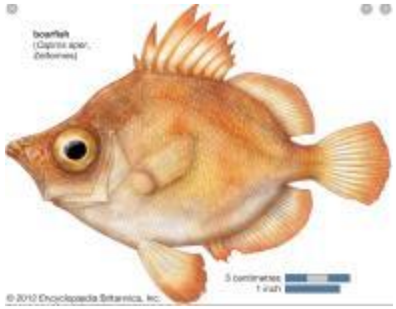
7. Additional points

- FIFO does not account for the weak food market for the fish species used in FMFO production (incorrectly assumes they would/could all be eaten as food)



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7. Additional points

- A focus on FIFO, particularly within certification standards, has an impact on end-product quality (e.g. omega-3 content of farmed salmon) *even if* the FMFO is responsibly sourced
- This is not what it was designed to do…..

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Aquafeed volume

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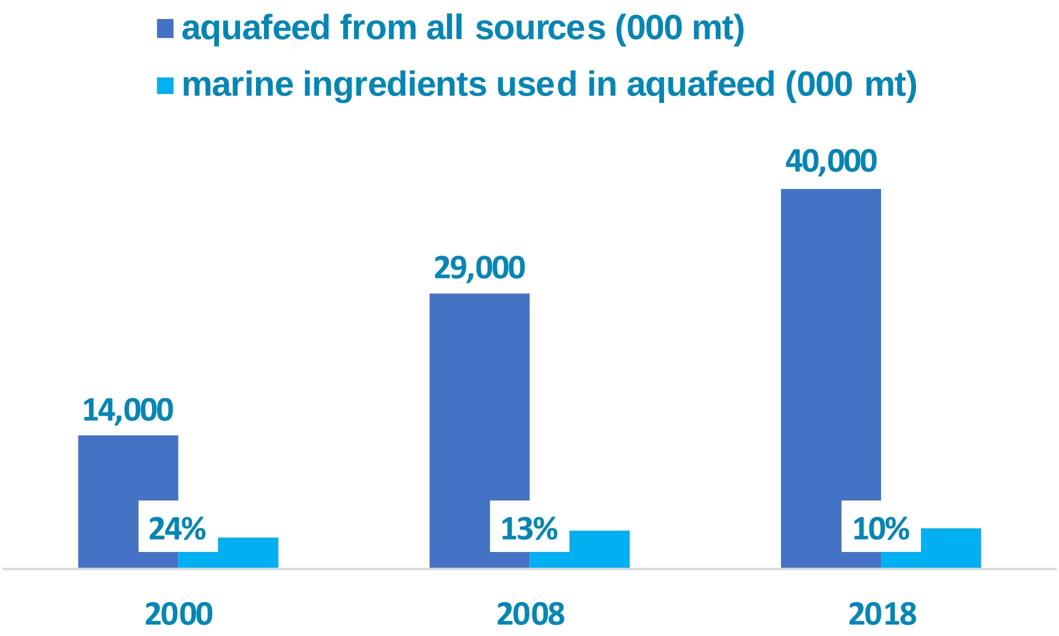
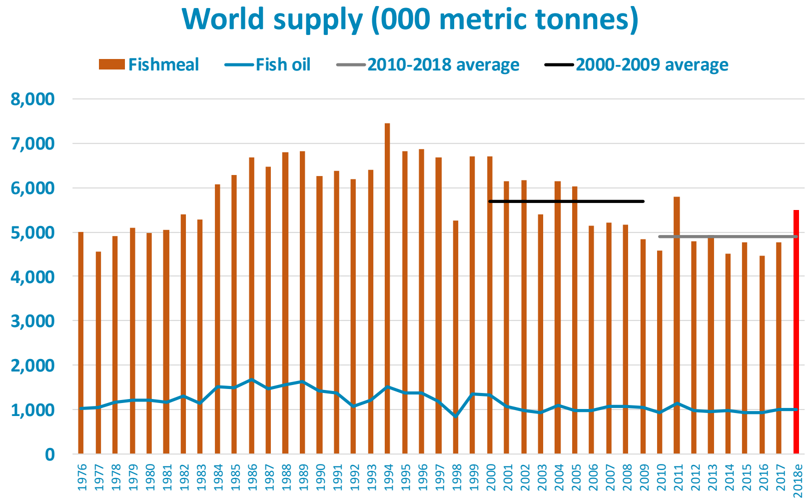
7. Additional points





- FMFO production flat over time, as aquafeed volume & aquaculture has grown, there is therefore no additional pressure on fisheries resulting from FMFO sourcing as aquaculture has grown – because fisheries are (largely) managed

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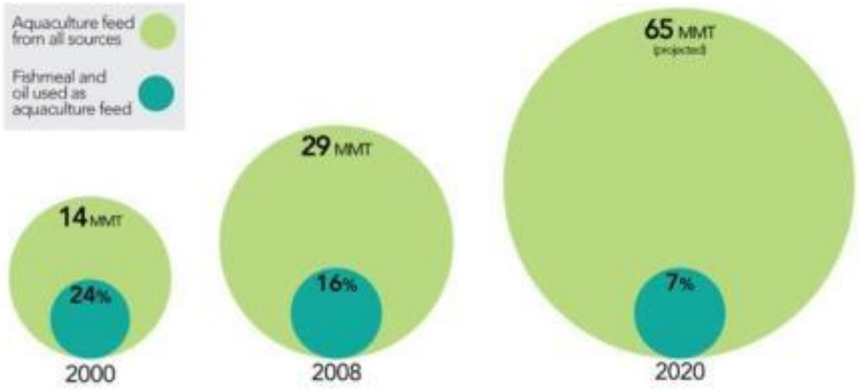
7. Additional points

- Inclusion rates declined as aquafeed has grown, anyway….
- Feed companies changed formulations to take FMFO supply into account



- 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

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7. Additional points

- FIFO is an oversimplification, because there are other factors involved:
  - Nutritional value FMFO the “FI” is more than just protein and energy
  - Health (& welfare) benefits to farmed fish
  - Health benefits to the consumer
  - Aquaculture product is more than edible portion – the “FO” part of the ratio has a series of byproducts/coproducts

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8. Summary

- FIFO does not achieve what it was conceived to do, i.e. improve fisheries management and FMFO sourcing
- There are better ways of doing this (regulations, certification), and it is/was already happening
- FIFO underestimates the nutritional contribution from FMFO, the “FI”
- FIFO underestimates the value of the aquaculture product, the “FO”

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Thank you
for your attention

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