[Explained]

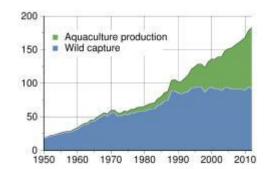
25th October 2019 Neil Auchterlonie



Workshop on sustainability and responsible sourcing of fishmeal and fish oil



[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

Renament L. Naylor', Robecco J. Coldburg', Jurgeme N. Primavera', Mis Kautsky J., Malcolm C. M. Bov Carl Folkeri, Jane Labohenco', Haraki Monney' & Max Treelisi

Significal Distancing Distinguis for Incorregational Studies, Amorea Half #605, Stanford Distancing, Stanford, California 94505-4655, USA

Don't managed Dallogo, 207 April Avenue Sough, Stree York, Nive 2nd, 18000, USA

Aquai alture Department, Smaleust Asian Fisheria Development Caster, Tightaan, Fishs, 8021, Philippine Department of Systems Ecology, Stockholm University, S-100 91 Stockholm, Swadon

The Beior Sentines, Stockholm, Seculor

Shoothur of Aquarahum University of Striling, Striling FEE SEA, GE

FWirtid Wildfille Fund, 1239 24th Street MM, Westington DC 20037, USA

Squeezer of Zoology, Oregon State University, Cornellin, Oregon 87:891-2914, USA

Global production of farmed fish and shellfish has more than doubled in the past 15 years. Many people believe that such growtl relieves pressure on ocean fisheries, but the opposite is true for some types of equaculture. Farming correvorous species requires large inputs of wild fish for feed. Some equaculture 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 centribution to world fish supplies, it must reduce wild fish input feed and adapt more ecologically sound management practices.

The worldwide decline of ocean fisheries stocks has provided impetus for rapid growth in fish and shelfish farming, or squaculture. Between 1987 and 1997, global production of farmed fish and shellfish (collectively called 'fish') more than doubled in weight and value, as did its contribution to world fish supplies', Fish produced from farming activities currently accounts for over onemarter of all fish directly consumed by humans. As the human of these connections is examined below. population continues to expand beyond 6 hillion, its reliance on

Growth in aquaculture production is a mixed blessing, however, for the sustainability of ocean fatheries. For some types of aquaculture activity, including shrintp and salmon farming, potential duringe to ocean and countal resources through babitat destruction, waste disposal, exotic species and pathogen invasions, and large fish rodo". For other aquaculture species, such as carp and mollascs, which are herbiverous or filter feeders, the net contribution to global fish supplies and food security is great'. The diversity of production systems leads to an underlying parades; equaculture in a . Aquaculture is a diverse activity possible solution, but also a contributing factor, to the collapse of fisheries stocks worldwide.

Here we examine marine and freelreater fish farming activities sh—the available fish supply! This is an important scientific and policy issue, and one that also addresses the common perception that aquaculture is an 'add on' to current ocean fish productivity. Many people believe that aquaculture production will compensate for the shortfall in social harvests as ocean fisheries dateriorate, or that fish farming will entore wild populations by relieving pressure is correct for some aquiculture practices but unfounded for others. We do not find evidence that supports the restoration argument.

wars—a period of heightened ecological and economic integration potential for the spread of pathogens. between capture fisheries and aquaculture activities. We limit our discussion to finish, bivalves and crustacram, which collectively make up three-quarters of global aquaculture production by weight, wild or batchery-cound and are grown on the subted bottom or it

ing the provision of habitat and nunery areas, feed and seed (larvae supplies, and assimilation of waste products. Aquaculture and ocean foliation are further linked economically through competi tion in world markets for the sale of their products, and biologically through entic species invasions and pathogen transmission, fac-

As aguaculture production continues to increase and interarmed fish production as an important assess of protein will also both its reliance and its impact on occur fisheries are likely to expand even further. The balance between farmed and wild-caught fish, as well as the total eapply of fish available for human consumption, will depend on future aquiculture practices. In th final section, we explore technological, management and policy options for sustaining aquaculture production. We argue the farming can contribute to global (net.) fish supplies only if curren meal and fish oil requirements may further depicte wild fisheries trends in fish meal and fish oil use for aquaculture are reversed and policies are enforced to protect constal areas from environmenta

More than 2.20 associes of feeligh and shellfult are farmed: the run includes giant clams, which obtain most of their numicots from symbiotic algae musuls, which filter plankton; carps, which are around the world and side does aquaculture enhance-or dimin-mainly herbivorous and salmon, which are carnivorous. Two lay criteria, ownership of stock and deliberate intervention in the production cycle (hashandry), distinguish aquaculture from cap ture fisheries. Fish farming typically involves the endosure of fish it a secure system under conditions in which they can thrive. Into ventions in fish life cycles range from exclusion of predators and control of competitors (extensive aquaculture) to enhancement of on capture fisheries. We conclude that the compensation argument—fixed supply (semi-intensive) to the provision of all nutritional requirements (intensive), between implies increasing the density of individuals, which requires greater use and managemen Our graduit focuses on aquaculture trends in the part 10-15 of inputs, greater generation of waits products and increases

Production reaction and their impacts on marine ecosyvary widely. Molluses are generally farmed along courtlines where and exclude seasond proclaction. Occan fisheries and aquaculture suspended nets, ropes or other structures. The animals rely entirely

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 <u>was thought to</u> mitigate against additional pressure on reduction fisheries......
- In reality, mainly applied to farmed salmon



3. Science (hypothetical)

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



3. Science (hypothetical)

FIFO Ratio = Level of fishmeal in the diet + Level of fish oil in the diet X FCR

Yield of fishmeal from wild fish + Yield of fish oil from wild fish



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)



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



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



Reduction Fisheries: SFP Fisheries Sustainability Overview 2018



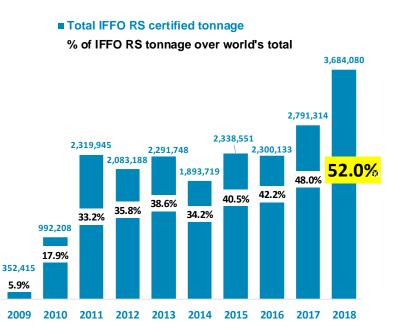
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"Ninety-one percent of the total catch volume in this analysis comes from stocks that are reasonably wellmanaged (or better)"......



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.....



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, <u>not</u> on the basis of FIFO.



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

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Protein synthesis Cell Stress signaling response Appetite Behavior regulation Reproduction Osmoregulation Metamorphosis Growth and **Amino** development Pigmentation + Acids Energy Metabolic 4 substrates regulation Immunity and Ammonia survival removal **Endocrine Antioxidative** status defense Seafood quality

6. Other issues

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



Ansno acid	Product	Function	Species.	Reference
Anno acide	Various proteins	Structure, transport, regulation, immunity, signaling, and fault	Al animals	Li et al. (2007)
Ala, Olu and Ser	Directly	Appetite	Many fabor	Shamahaki et al. (2007)
Ang	NO	Kill invaded microorganisms	Classel Cadida	Bombillo and Gallin (1999)
Arg	NO	Facilitate neurological function and development	Titopia	Bordieri et al. (2005)
Ang	NO	Regulate vacuular tone, blood flow, ourselarity in gill, and cell signaling	KHifeh	Hyndrous et al. (2006)
Arg and Mot	Sperrokae	ledge level intertion materation.	Sea hum	Pénes et al. (1997)
Arg. Mer, and Gly	Crostine	High energy storage; autoxidant	Artic due	Bysotansky et al. (2007)
Cys. Gh., and Gly	Gistatrione	Antimidat and cell signaling	All animals	Wa et al. (2004)
Cite and Cite	Directly	Ammonia temoval	Rainbow trout	Anderson et al. (2002)
Gla	GABA	Promote mitamosphosis	Abalone	Morse et al. (1979)
Cita	GABA	Regulate food intake	Ispanese Rounder	Kim et al. (2003)
Glin.	Directly	Increase growth, feed efficiency	Curp	Lie and Zhou (2006)
		and gut development		
Gh.	Directly	Facil for macrophage; Cell signaling	Charsel cathib	Buestello and Gallin (1999)
Ole, Gly, and Asp	Nuclootidos	Genetic information storage and expension, biospathesis, increasity and reproduction	Various fishes	Li and Gulin (2006)
Oly .	Directly	Increase hapatic T4 Fenomodeisodinase	Rainbow total	Riky et al. (1996)
Gly:	Directly	Omercgulation	Oyea	Taksechi (2007)
His	Directly and carnotine	Protection against pH change	Salaton	Monumen et al. (1980)
Leu	НМВ	Immunity modulation; Gill agealing	Vatous fishes	Li and Gattin (2007)
Lyn and Met	Camition	Ligid transporter on mitochondrial receibrate	Valous fishes	Harpar (2005)
Met	Choline	Structure in morehrane; recontransmitter, betaine synthesis.	Valous tishes	Mai et al. (2000)
Proline	PSC	Bedox regulation, Coll signaling	Possibly in fish	Phong et al. (2008)
Proline	Hydroxyproline	Habanca growth; Collagen function	Salmon	Akonos et al. (2008)
Pho and Tyr	TA.Th	Influence meramorphosis	Solo	Pieco et al. (2008)
Pho and Tyr	TA, TE	Enhance growth performance	Charriel carlido	Garg (2007)
Phe and Tye	T4, T3	Influence pigmentation	Japanese Boundar	You et al. (2000)
	Melanis	Influence pigmentation	Rainbow trout	Boommintamoun et al. (2004)
Phu and Tyr	Epinephriae, accopinephriae	Neuronamonities that condulate stress responses	Hounder	Danusceno-Oliveira et al. (2000
Phy and Tyr	Dopamine	Down-regulated immenty	Shripp	Chang et al. (2007)
Tep	Sectorie	Modulate cortisol release, behavior and finding	Rainbow tout	Lepuge et al. (2003)
Try	Melainein	Insperse testicular development	Mon alrees	Amano et al. (2000)
Tautee	Directly	Osnotic pressure regulation	Carp	Zhang et al. (2006)
Tapine	Directly	Raebow adaptation	Change cation	Beantofle and Gullin (2002)
Tautes	Directly	Out development	Cobia	Subse et al. (2000)
Taurine	Directly	Retinal development	Gless act	Omara and Inagaki (2000)

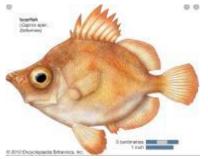


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7. Additional points

 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)









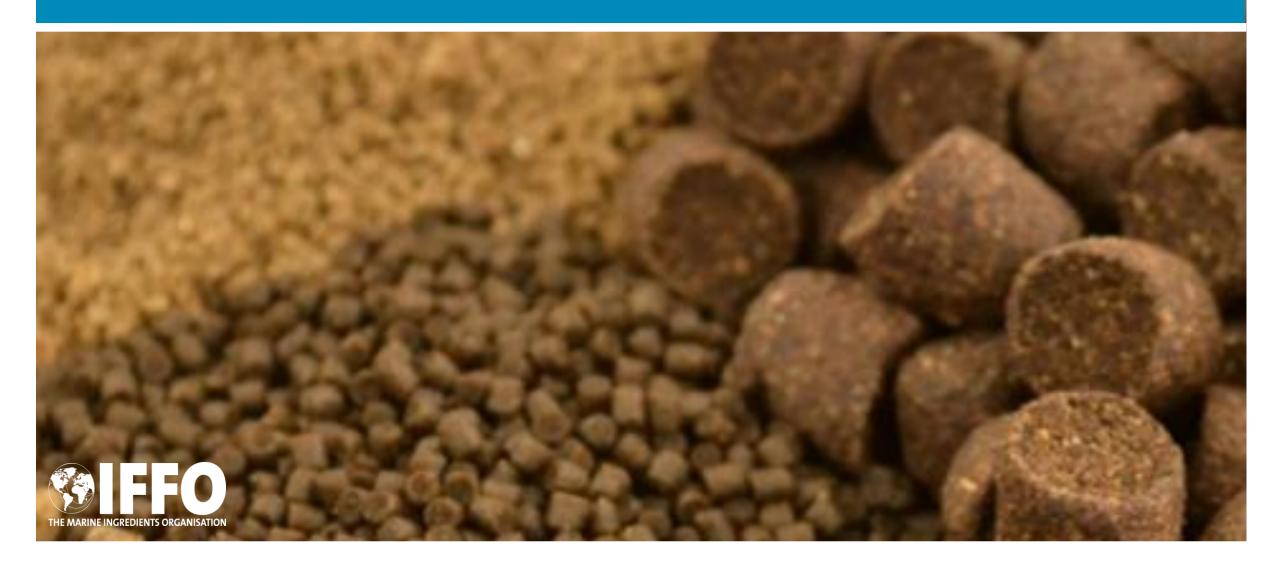
7. Additional points

- 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.....



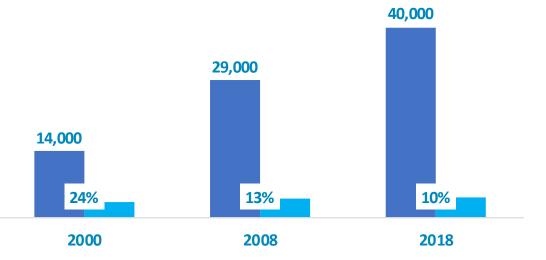


Aquafeed volume

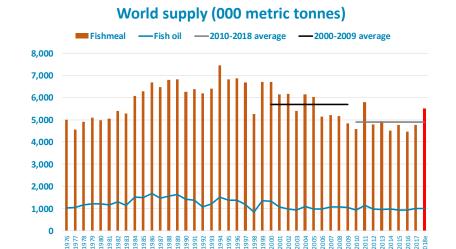


7. Additional points

- aquafeed from all sources (000 mt)
- marine ingredients used in aquafeed (000 mt)



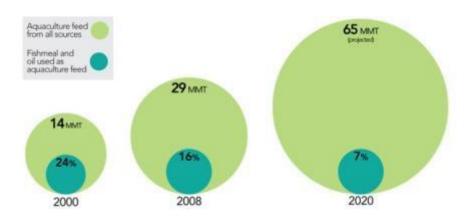




 FMFO production flat over time, as aquafeed volume & aquaculture has grown, there is therefore no additional pressure on fisheries resulting from FMFO sourcing as aquaculture has grown – because fisheries are (largely) managed

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

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



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"



Thank you for your attention

