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One fish, two fish, feed fish, food fish

Meeting nutritional challenges in aquaculture and aquatic natural resources management

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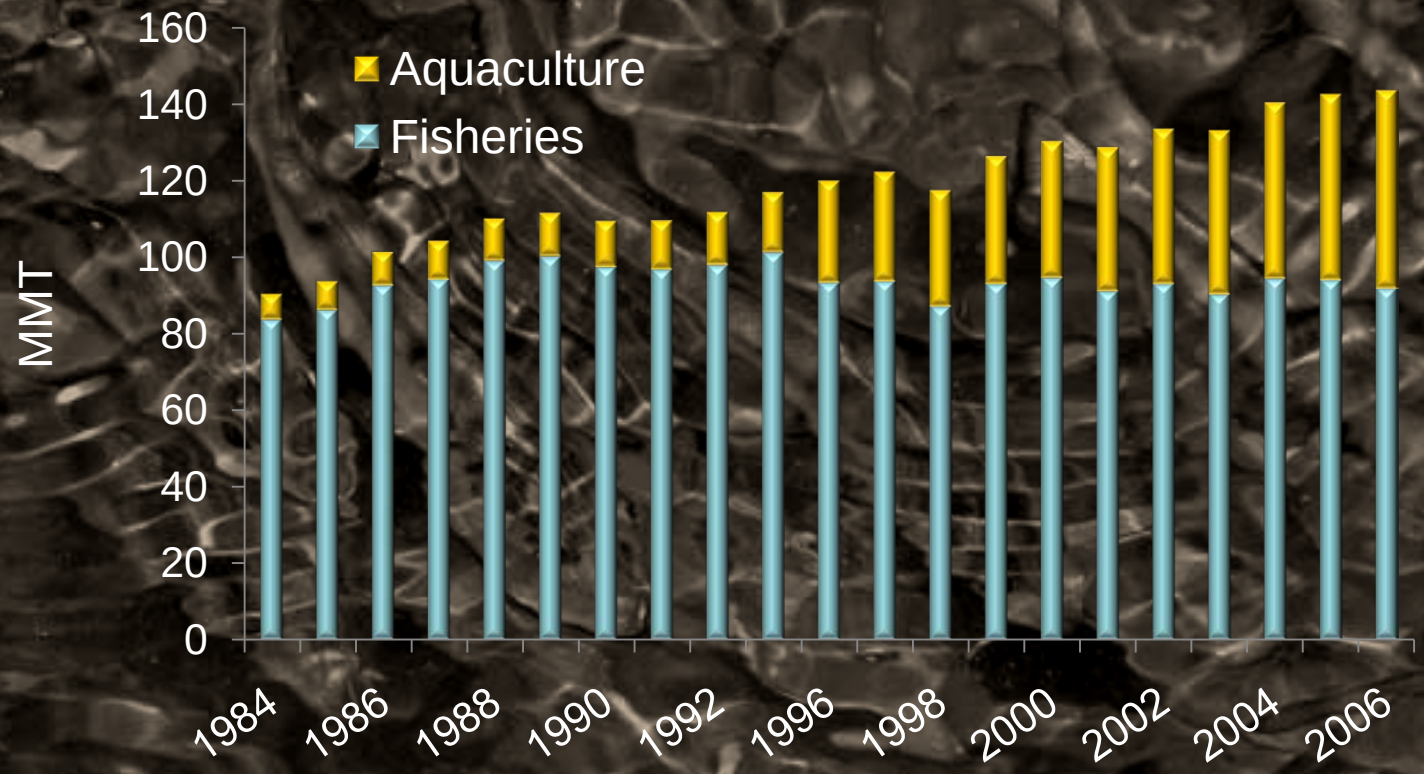
Aquaculture production has continually outstripped projections, and there is little reason to believe that it will not continue to do so. *–World Bank 2006*



FAO SOFIA Reports - 99E-2008

Rainbow Trout

Yellow Perch

Nile Tilapia

Channel Catfish

Hybrid Striped Bass

Minnows

Atlantic Salmon

Largemouth Bass

Cobia

304,000 MT of food fish were raised in the U.S. in 2007

$672 million in food fish sales
$18 million in sport fish sales
$38 million in bait fish sales

U.S. aquaculture is a billion dollar industry

NOAA 2009

Rainbow Trout

Hybrid Striped Bass

Bluegill

Channel Catfish

Chum Salmon

Chinook Salmon

American Shad

Largemouth Bass

Walleye

12,931 MT	coldwater sportfish
294 MT	coolwater sportfish
1,012 MT	warmwater sportfish
5,424 MT	salmon and steelhead
158 MT	rare or declining
198 MT	forage

~1.75 billion fish stocked by federal & state agencies in 2004

Halverson 2008


Nutritional Demands
Omnivores
Carnivores

Fish have high protein demands…

Species	Dietary Protein (%)
Asian Sea Bass	45
Atlantic Halibut	51
Atlantic salmon	55
Tilapias	30-40
Pacific salmonids	40-45
Carps	31-43
Eels	40-45
Sea Basses	45-50
Sea Breams	50-55

Species	Dietary Protein (%)
Freshwater Basses	35-47
Trouts	40-53
Flatfishes	50-51
Catfish	32-36
Beef Cattle	7-18
Dairy Cattle	12-18
Sheep	9-15
Swine	12-13
Poultry	14-28

…but require amino acids, not protein

Halver and Hardy, 2002

Essential amino acid requirements…

Essential Amino Acids	Estimated Requirement (Rainbow Trout)	Fish Meal Composition
Arginine	3.3-5.9	6.2
Histidine	1.6	2.8
Isoleucine	2.4	4.2
Leucine	4.4	7.2
Lysine	3.7-6.1	7.8
Methionine	1.8-3.0	3.4
Phenylalanine	4.3-5.2	3.9
Threonine	3.2-3.7	4.2
Tryptophan	0.5-1.4	0.8
Valine	3.1	5.0
All data expressed as % crude protein		

Halver and Hardy, 2002; Omega Protein, Inc., 2006

Fish have high lipid demands too…

Species	Dietary Lipid (%)
Trout	18-20
Other Salmonids	20-30
Tilapia	<10
Sea Breams	10-15
Carp	<18
Sea Basses	12-18
Yellow tail	11
Red drum	7-11
Grouper	13-14

Species	Dietary Lipid (%)
Milk Fish	7-10
Catfish	5-6
Turbot	<15
Sole	5
Beef Cattle	1-2
Dairy Cattle	1-2.5
Sheep	2.5-3
Swine	2-6
Poultry	~3

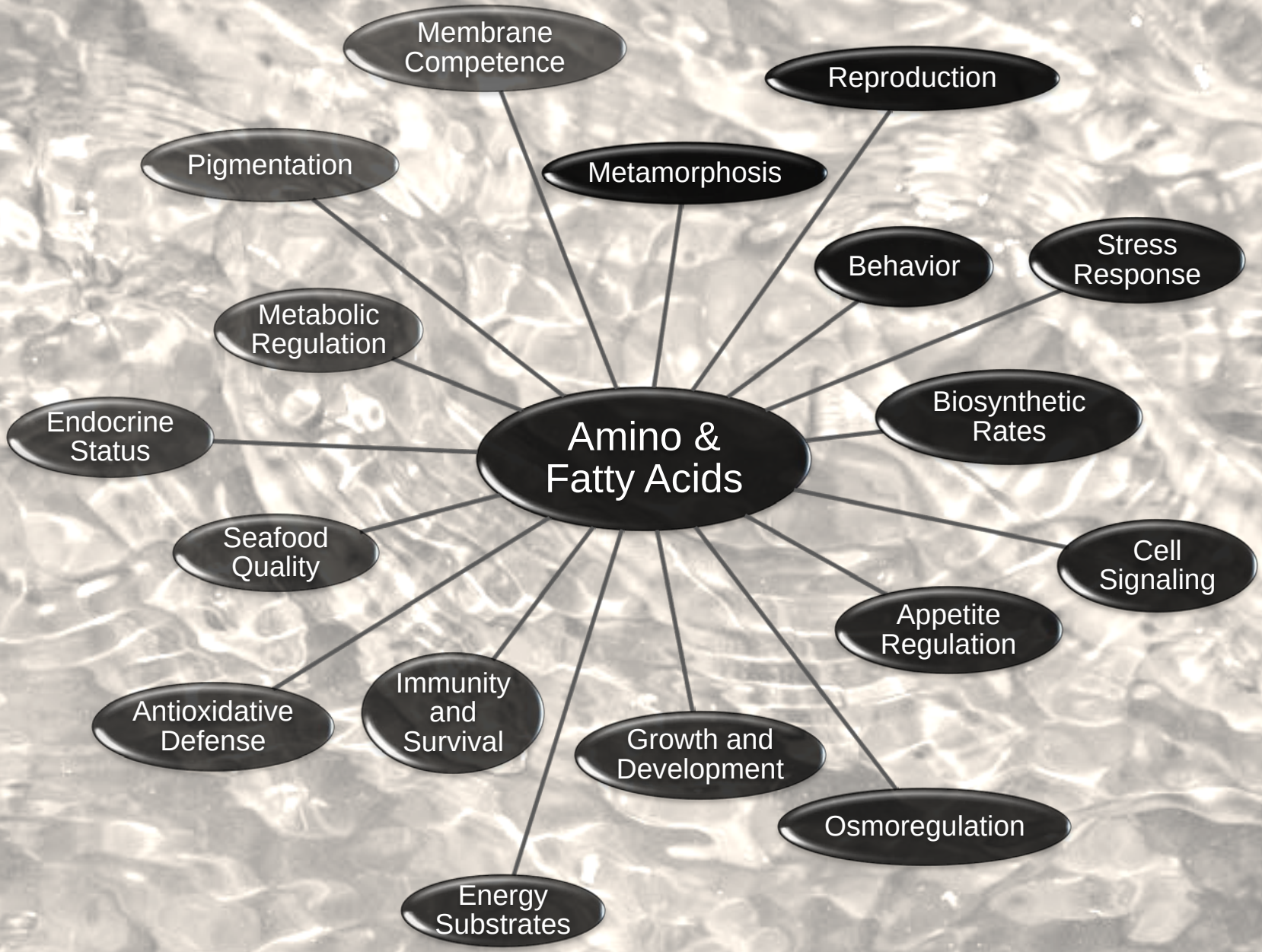
…but require fatty acids, not lipid

Guillaume et al. 2001

Essential fatty acid requirements…

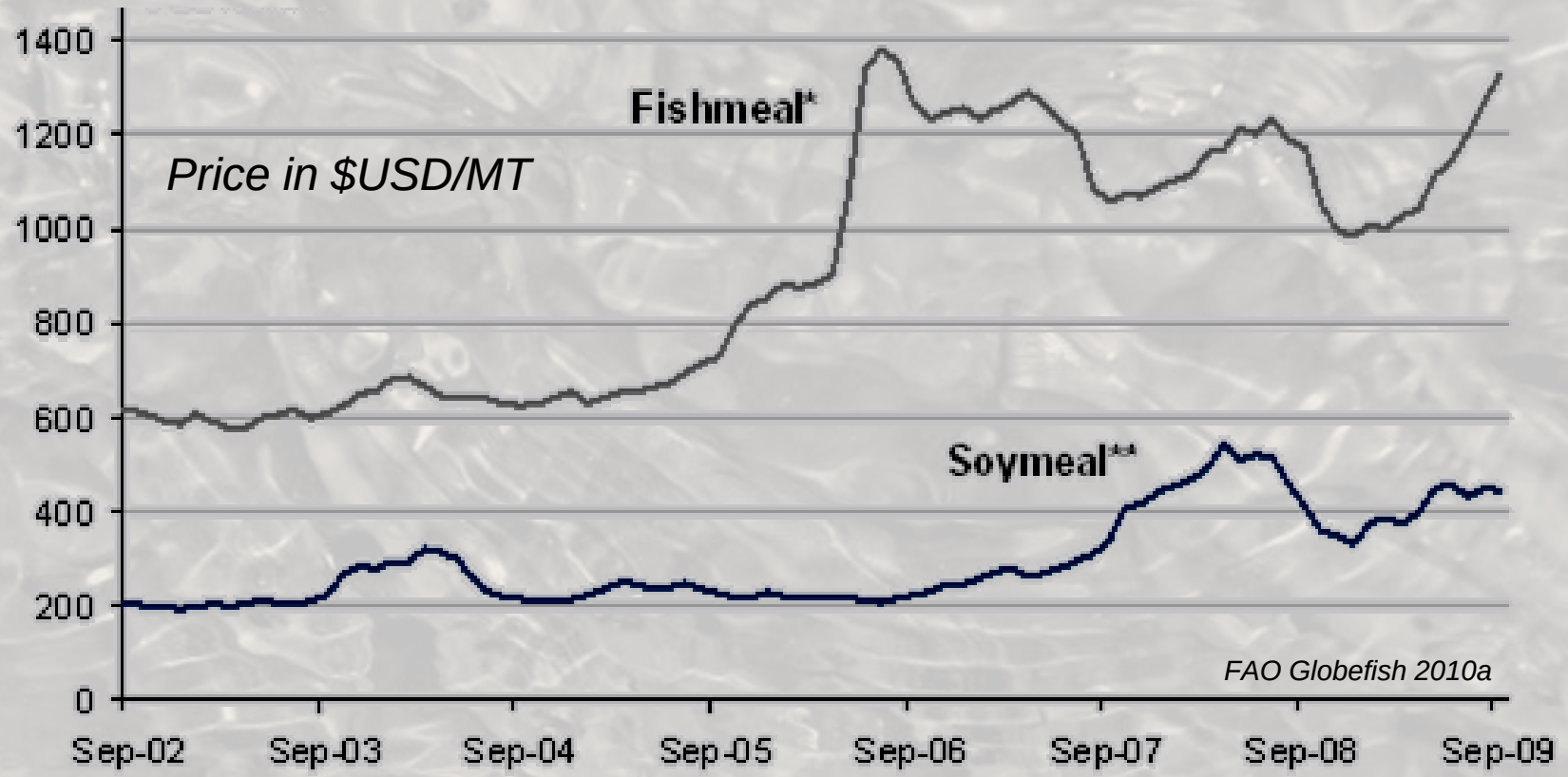
Species	Advanced Juvenile/ Adult Requirement	Fish Oil Composition
Rainbow Trout	18:3n-3 (0.7-1.0%) n-3 LC-PUFA (0.4-0.5%)	18:2n-6 (~1.7%)
Common Carp	18:2n-6 (1.0%) 18:3n-3 (0.5-1.0%)	18:3n-3 (~2.0%)
Tilapia	18:2n-6 (0.5-1.0%)	
Various Pacific Salmonids	18:2n-6 (1.0%) 18:3n-3 (1.0%)	20:5n-3 (~13%)
Gilthead Seabream	n-3 LC-PUFA (0.9-1.9%)	22:6n-3 (~15%)
Red Seabream	22:6n-3 (0.5%) 20:5n-3 (1.0%)	LC-PUFA (~30%)
Striped Jack	22:6n-3 (1.7%)	
All values reported as % of dry diet		

Halver and Hardy 2002



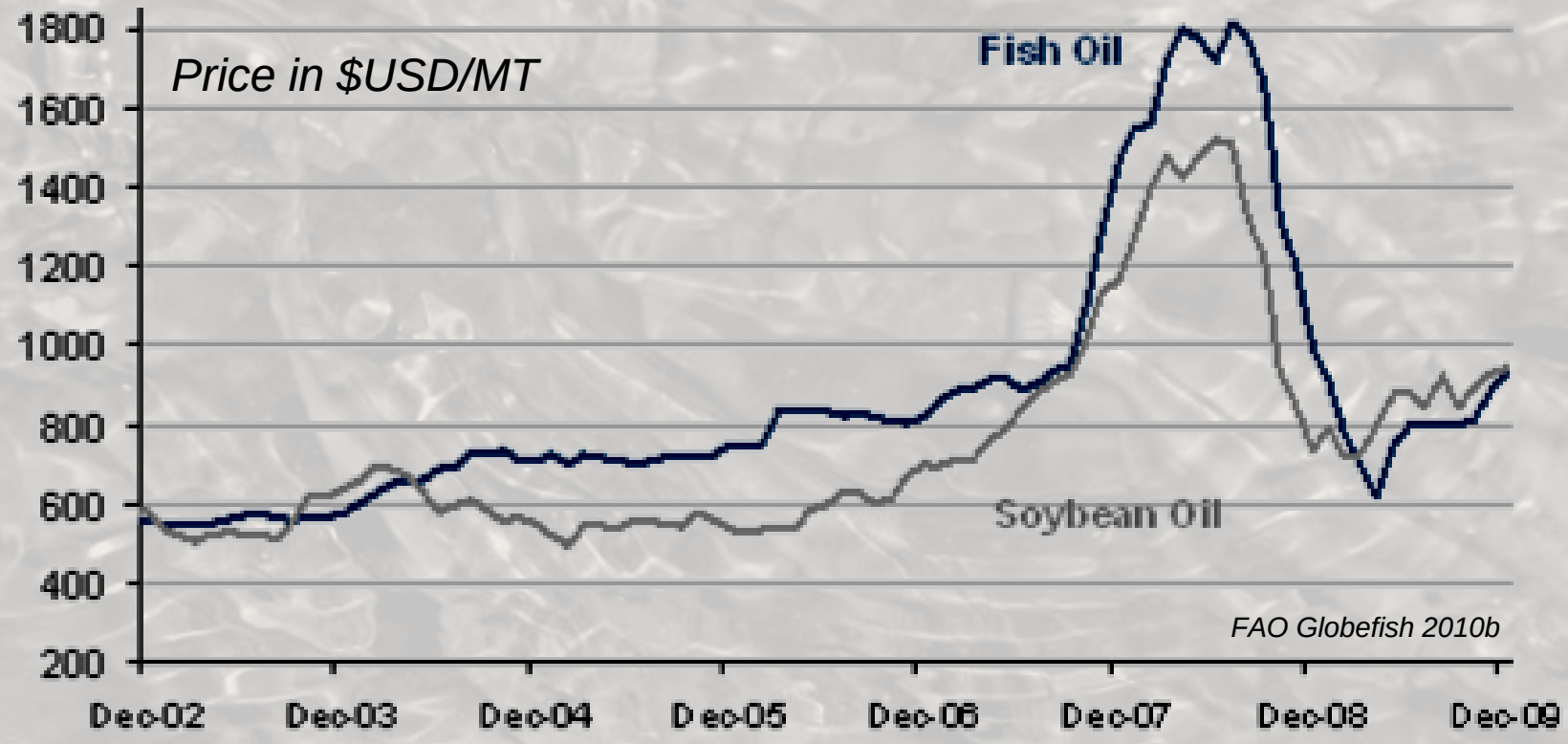
Tocher 2003, Li et al. 2008

What will limit the growth of aquaculture?



"…much research has focused on finding replacements for fish meal… Partial replacements have been achieved. However, no dramatic breakthroughs have been reported, and the share of fish meal and fish oil used in aquaculture is increasing…" (FAO 2008)

What will limit the growth of aquaculture?



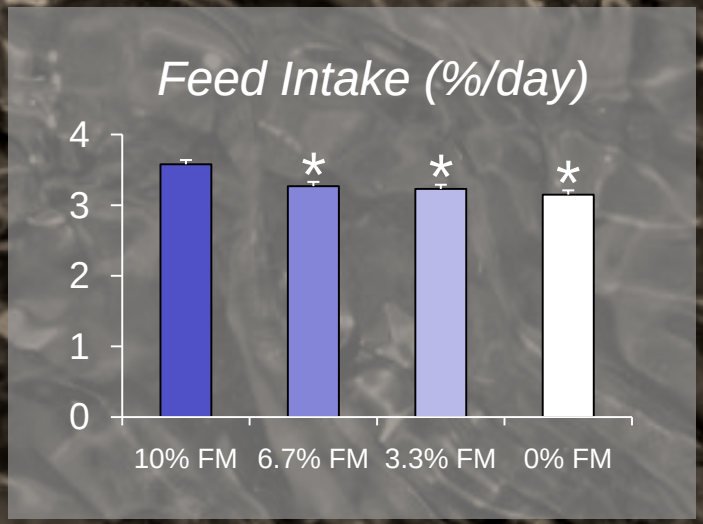
FAO Globefish 2010b

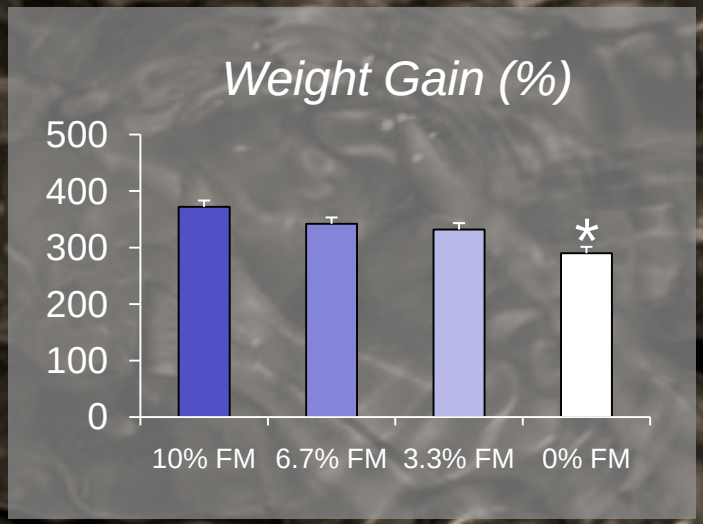
"[G]iven the difficulty in replacing fish oils…it is clear that competition for fish oil is likely to be a more serious obstacle for some sections of the aquaculture industry." (FAO 2008)


Marine Feedstuffs
?
Alternative Feedstuffs
Lower feed costs
EAA, EFA, etc. may be low or absent
High levels of EAA, EFA, etc.
Palatable, nutrient dense, highly digestible
Maintain integrity of product
Readily available, sustainable
Decreased cost of production
Safer products?

Replacing fish meal…production effects

Case study with soy protein concentrate in HSB feeds



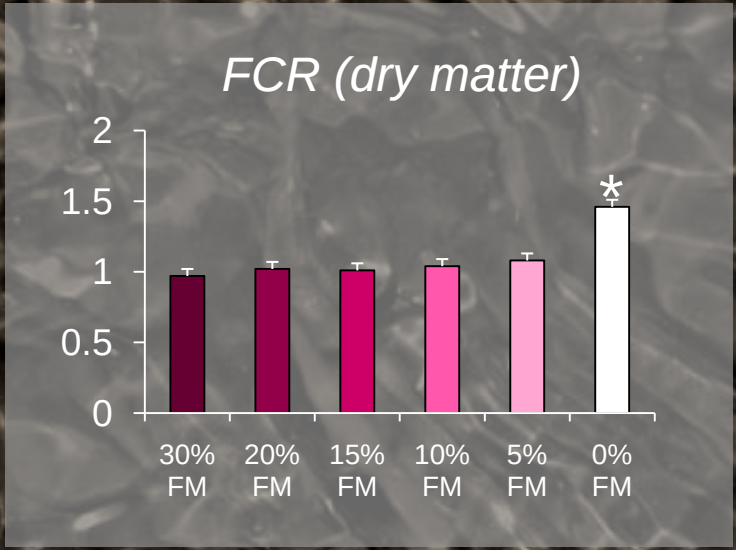


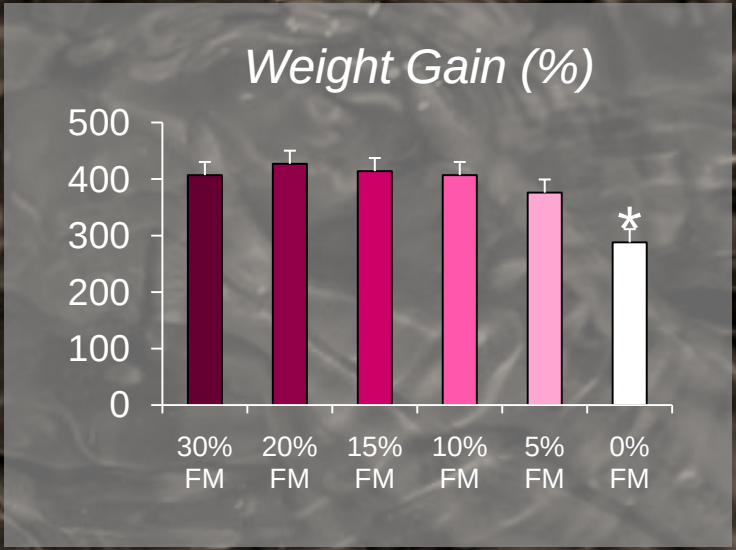
Fish meal sparing can reduce the palatability of feeds, especially for carnivorous fish

Blaufuss and Trushenski, in preparation

Replacing fish meal…production effects

Case study with soybean meal in HSB feeds



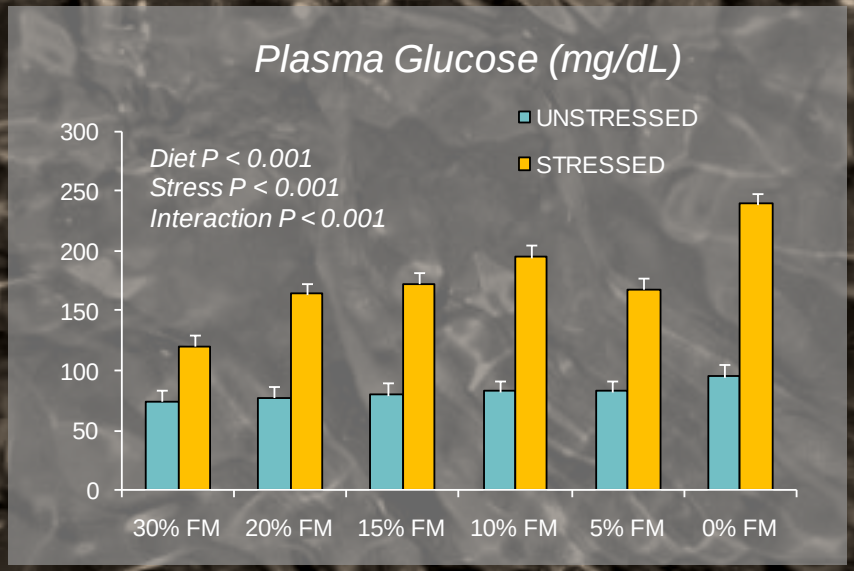


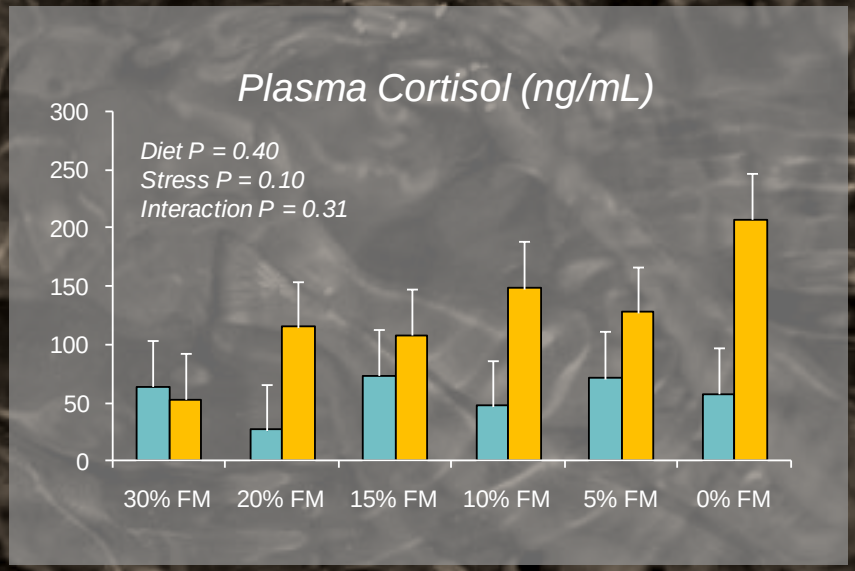
Even when intake is good, EAA deficiencies and utilization problems can still develop with reduced fish meal feeds

Laporte and Trushenski, in preparation

Replacing fish meal…stress effects

Case study with soybean meal in HSB feeds



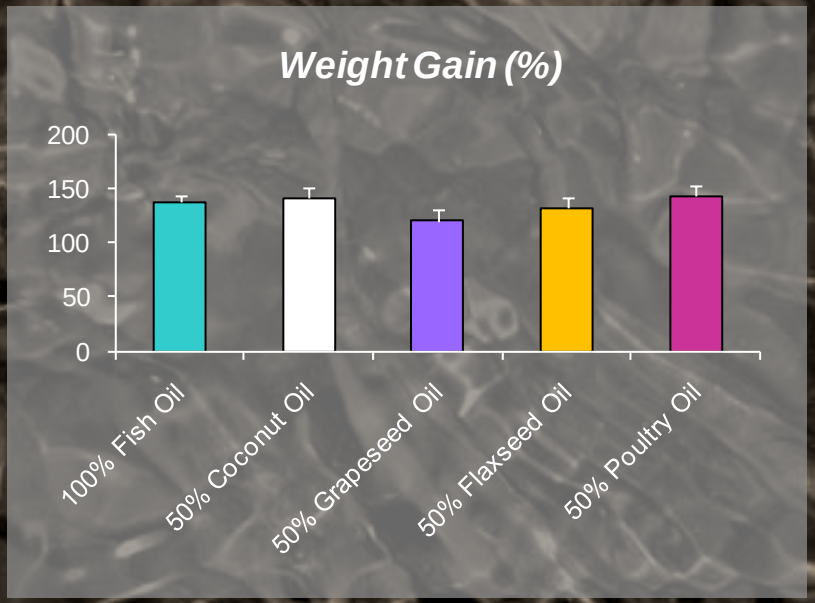


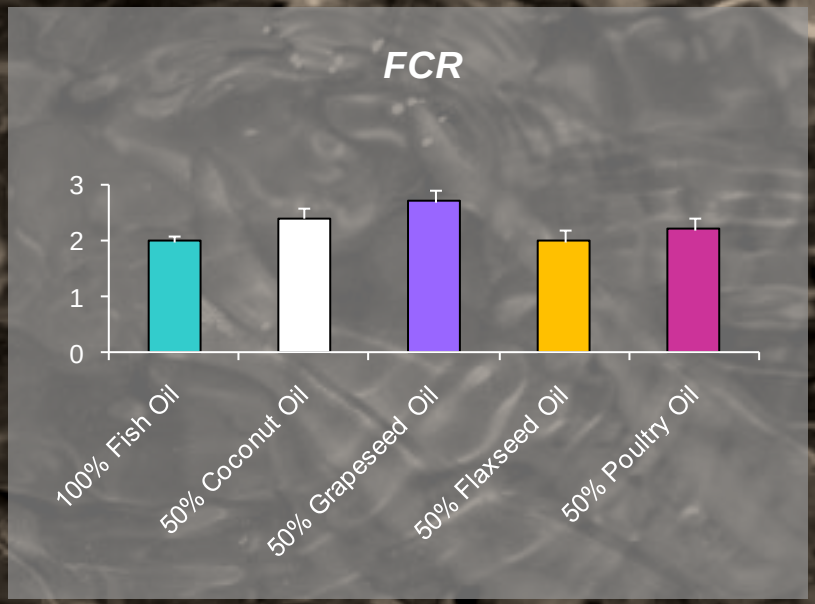
Fish meal sparing may lead to unintended consequences in terms of livestock resilience

Laporte and Trushenski, in preparation

Replacing fish oil…production effects

Case study with various oils in HSB feeds



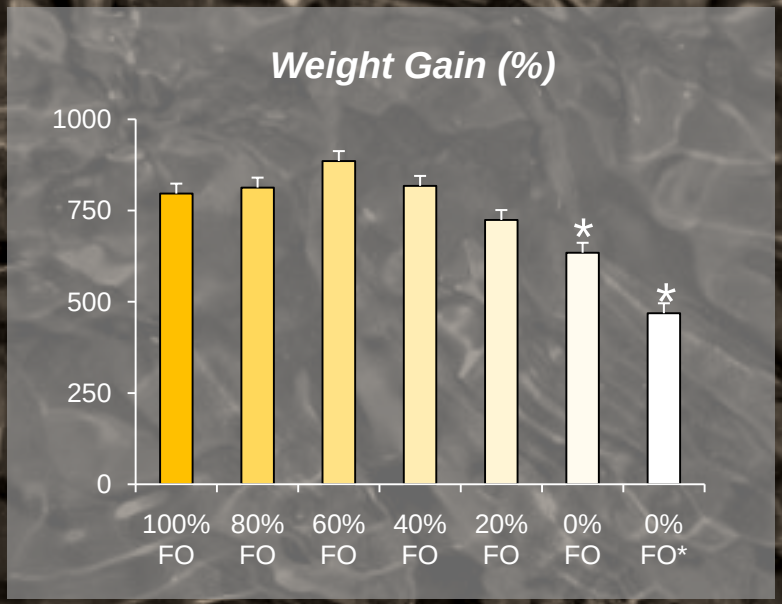


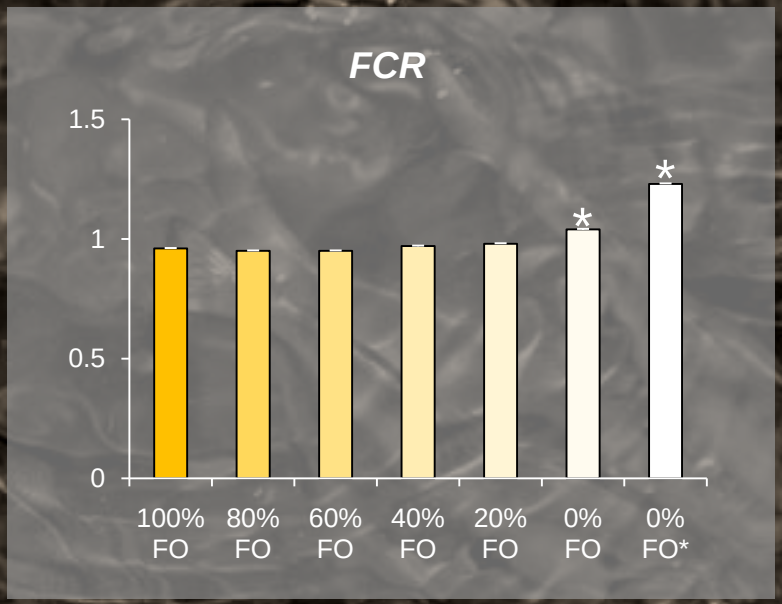
Fish oil sparing doesn't typically impact production performance

Trushenski et al. 2008

Replacing fish oil…production effects

Case study with canola oil in HSB feeds



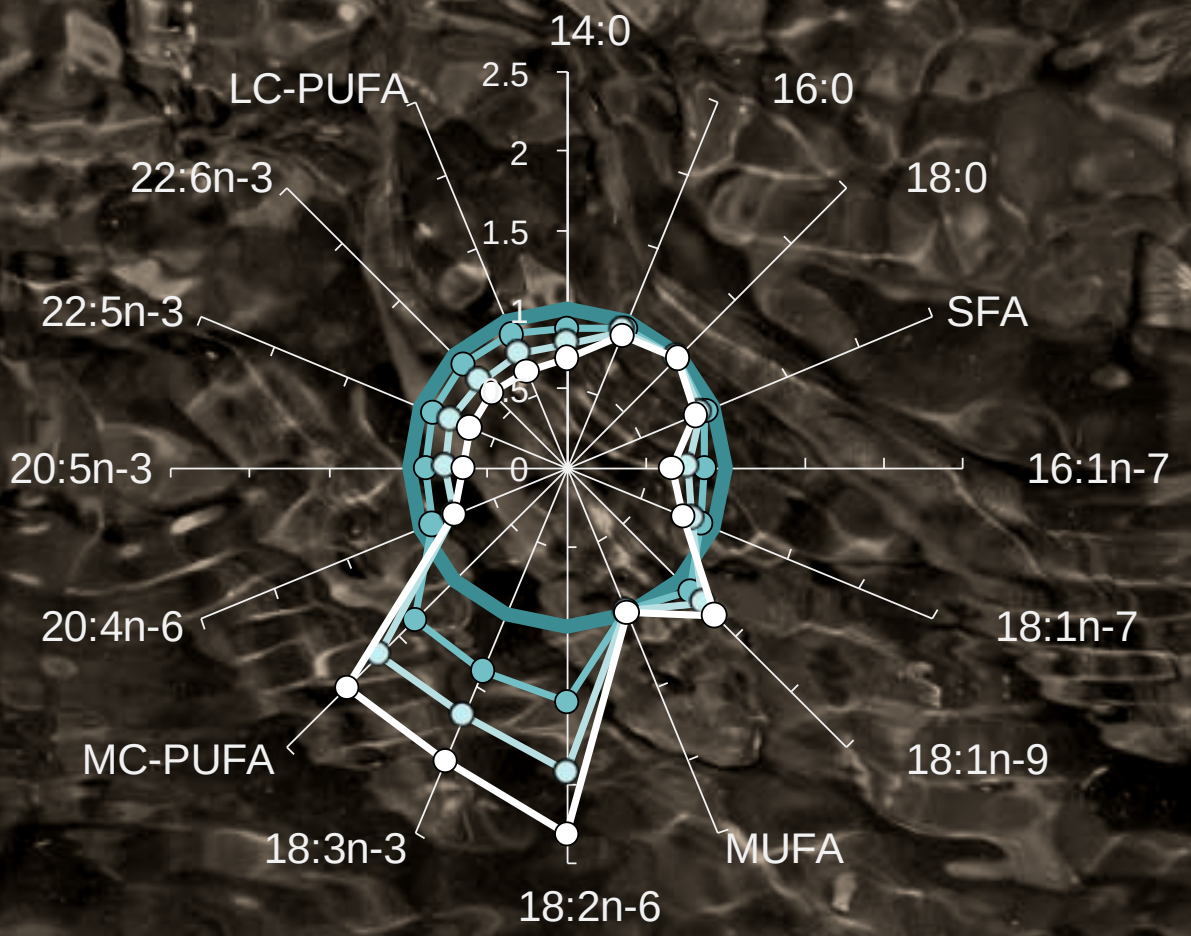


EFA deficiencies associated with fish oil replacement can lead to impaired production

Lewis and Kohler 2008

Replacing fish oil…fillet effects

Case study with soy oil in cobia feeds



Line of Equality

67% FO

33% FO

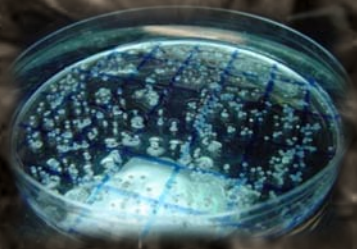
0% FO

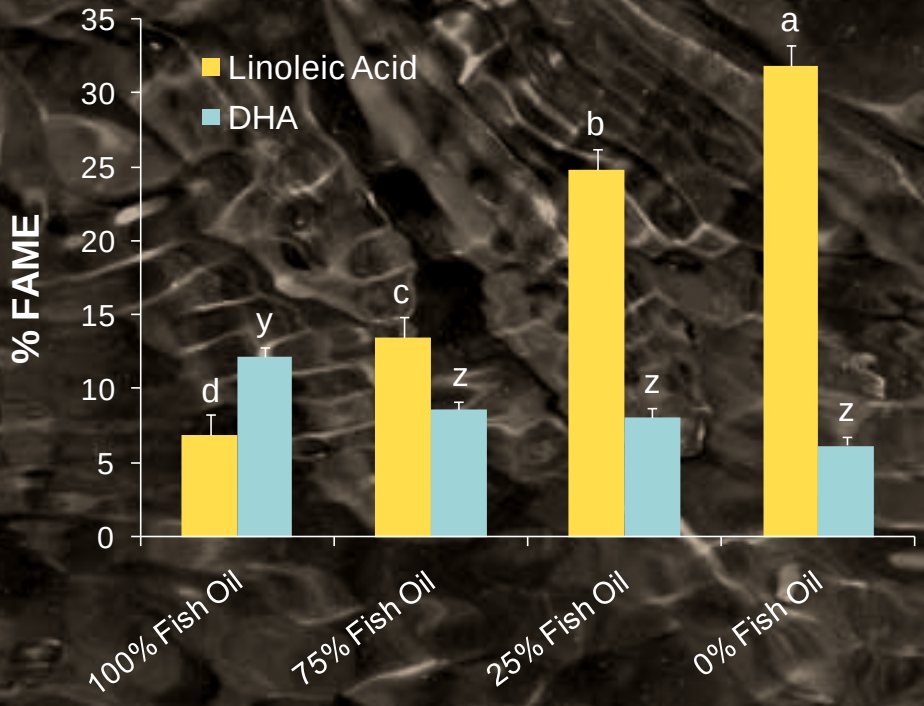
Fish oil sparing affects fillet composition and associated nutritional value

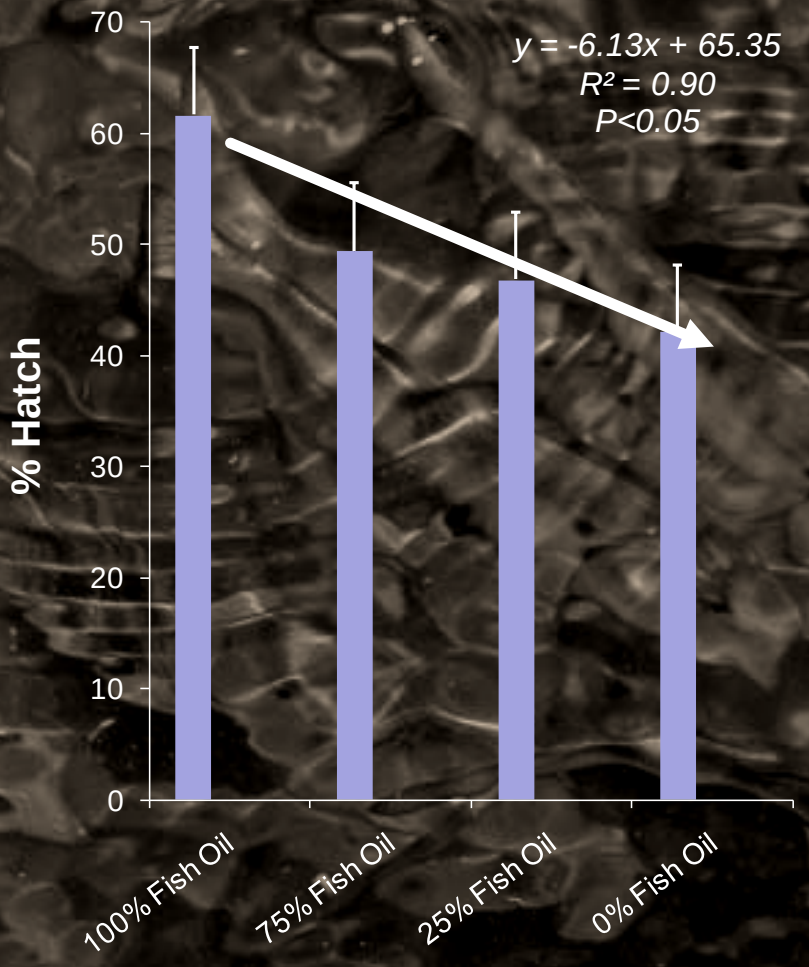
Trushenski et al., in press

Replacing fish oil…reproductive effects

Case study with corn oil in white bass broodstock feeds







Lane and Kohler, 2006

The challenges…

Fish meal and oil are finite resources which aquaculture increasingly monopolizes

Sources of amino acids abound, but may be improperly balanced, unpalatable

- *Alternative proteins impact production performance, possibly livestock resilience*

Sources of essential fatty acids can be limiting

- *Alternative lipids affect fillet nutritional value, reproductive performance*

The challenges…

Nutritional research and understanding of requirements in fishes is meager relative to other livestock

The challenges…

USDA ars Agricultural Research Service

www.ars.usda.gov

Aquaculture Projects = <2% of ~1000

USDA

United States Department of Agriculture

National Institute of Food and Agriculture

Total R & D funding (2007) = $654 million

Total Aquaculture R & D: $17.6 million

Aquaculture = 2.7% of research investments

Gary Jensen, National Program Leader for Aquaculture, USDA NIFA, pers. comm. March 2010

The opportunities…

Novel feedstuffs with greater performance in aquafeeds

Tailoring of 'traditional' feedstuffs for aquatic livestock, investigation of new resources

Palatants, attractants, and 'nutriceuticals'

Reduced feed intake can be corrected, resilience improved through dietary modification

Finishing feeds, novel fatty acid sources to tailor fillets

Have your n-3 long-chain PUFA and eat it too

The opportunities…

Seafood demand continues to rise

Roughly half of seafood consumed is farm-raised

Food security for 9 billion people by 2050

Seafood provides 1/3 of the population with 15% or more of daily protein

Aquaculture produces protein efficiently

Swine
3 to1

Beef Cattle
8 to 1

Poultry
2 to 1

Fish
1-2 to 1

The way forward…

Greater and consistent funding of nutrition research in aquaculture

- *Basic research to understand requirements, interactions, etc. for long-term solutions*
- *Applied research to demonstrate effectiveness, provide practical short-term solutions*

Linkage with other industries

- *Utilize existing agribusiness infrastructure, knowledge*

Acknowledgments

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