

## Protein Production Advantages in the Face of Increasing Feed Costs: Identifying Opportunities within the Aquaculture Industry

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**Abstract** : This research provides an overview of the recent price trends of key feed ingredients. This includes a discussion of the current and future trends in production and prices for both agricultural (soybeans, corn) as well as marine-based (fishmeal, fish oil) sources. The focus then turns to a discussion of feed ingredients and feed costs as they relate to the production of key proteins, including both agriculture and aquaculture sources of production (e.g. broilers, shrimp, salmon, and catfish). It is then argued that the aquaculture sector is in a strong position to provide quality protein at competitive prices despite increases in raw feed materials prices. A critical factor is the degree to which the aquaculture sector, and further, certain species within the aquaculture sector, can substitute across key feed ingredients. Substitution gives farmers the opportunity to reduce feed costs in the face of rising feed prices by allowing them to find feed combinations that are both cost effective and nutritionally sufficient. Further, nutritional knowledge allows farmers the ability to take advantage of arbitrage opportunities when the relative prices of key ingredients change. Thus, aquaculture has the opportunity to manage feed costs in manner that is cost effective while also maintaining high quality protein production.

**Keywords** : aquaculture, fisheries, fish meal, fish oil, sustainability

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Aquaculture has been the fastest growing food sector over the past two decades and this steady and rising growth in the aquaculture sector is forecast to continue into the future (Anderson, 2003). This growth will in turn fuel increased demand for key raw materials for use in aquaculture feeds. These key ingredients include both agricultural (soybeans, corn) as well as marine based (fishmeal, fish oil) sources. The prices of these key feed ingredients have increased significantly over the past few years (Fig. 1). Not only have prices increased but the volatility in prices has increased as well.

### Key drivers of recent price trends

Both supply and demand side drivers have influenced the recent price fluctuations. On the

supply side, weather-related events including droughts in Australia have affected agricultural production, and in particular global wheat prices, while El Nino and La Nina events have influenced fish meal and fish oil landings and prices. On the demand side, growing global populations have increased the demand for grains, both as a commodity for direct human consumption and as a feed input in the production of animal proteins (pigs, chickens, and aquaculture). The emergence of economies such as China and India has also increased the demand for key feed ingredients as these populations not only grow in size, but also in wealth. More wealth allows these economies to not only consume more food but also, to consume a more protein-based diet. The aforementioned supply and demand side drivers are drivers that have

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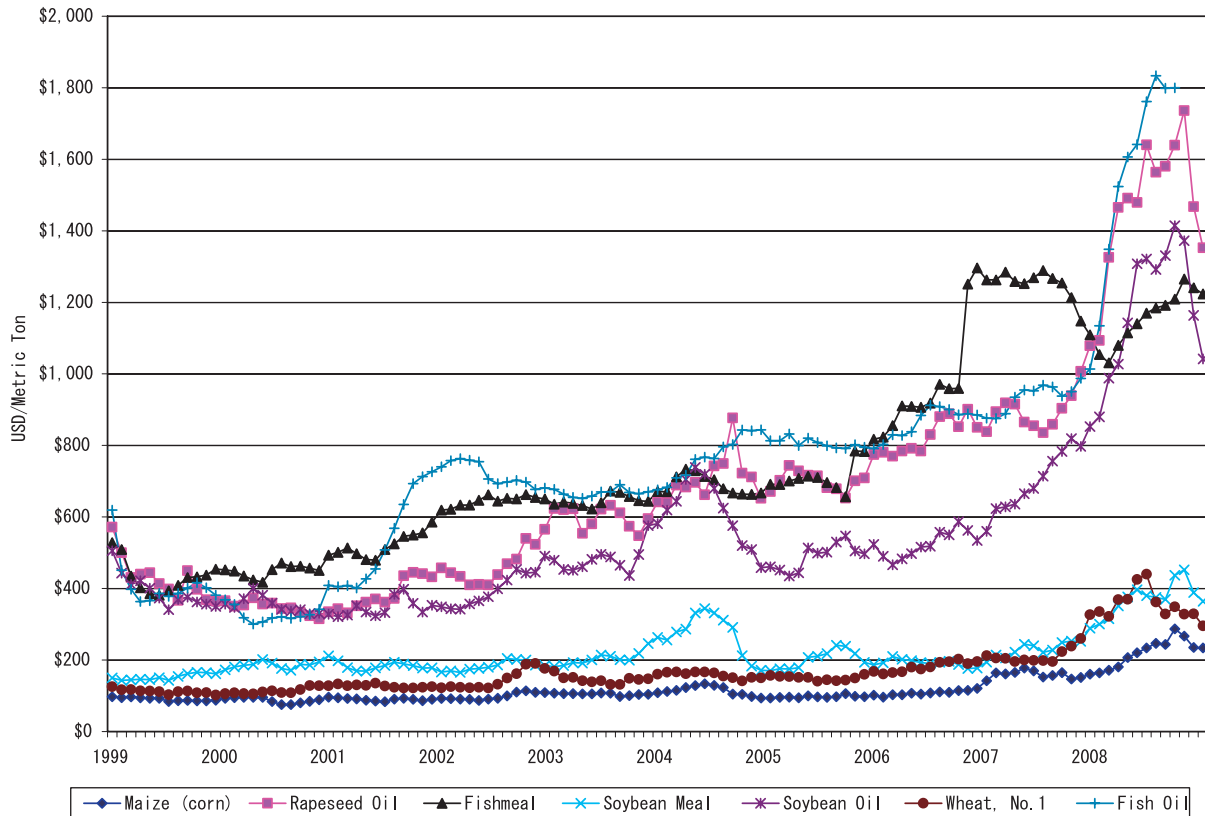


Fig. 1. Real price trends for key feed ingredients (US dollars per metric ton)

historically influenced prices; however, recent price increases can also be linked to two more recent and related phenomena: instability and volatility in global oil markets and the role of increased demand for biofuels as alternative energy sources.

#### The role of global oil markets

The global price of crude oil has increased rapidly over a two year period. This has led to increased on-farm fuel costs as well as increased transportation costs for farmers. Additionally, on-farm costs have increased due the rapid increase in fertilizer prices. In conjunction with sharp increases in global crude oil prices, global natural gas prices experienced a similar sharp increase in a relatively short period of time. Since natural gas can comprise up to 90% of fertilizer production costs, the sharp increase in natural gas prices had a significant impact on fertilizer prices. Fertilizer is an important input in the production of commodities such as corn and soybeans; therefore, farm level production costs

were further influenced by this increase in input prices. These increases in on-farm production costs influenced the production decisions of farmers, which in turn impacted plantings, harvest quantities, and ultimately prices.

Another key factor influencing the production and planting decisions of farmers was the increased demand for biofuels as alternative energy sources. As the price of crude oil rose, so too did the economic return associated with biofuel production, and in particular, ethanol production. Furthermore, ethanol mandates and ethanol subsidies in the United States provided farmers with an even greater incentive to transition production towards crops used in ethanol production (corn) at the expense of other crops. This led farmer to both divert corn harvests from human consumption towards ethanol production, as well as transition their fields towards greater corn production at the expense of other crops, including soybeans. This shift in crop composition and destination ultimately influenced the prices of these commodities.

These factors influenced the prices and production levels of key commodities, including corn and soybeans. Agricultural prices were driven higher as on-farm production costs increased and farmers attempted to reduce costs by substituting away from high cost inputs or away from crops with higher relative production costs. Reducing the use of fertilizer could reduce on-farm costs; however, it could also potentially result in lower harvest yields. Switching to crops with lower relative fuel and fertilizer costs or to crops with high economic returns would shift composition and number of crops planted. This would ultimately influence the supply of those commodities in the market, thereby driving prices upward. While the economic impact of these factors have yet to be discerned empirically, the fact remains that during this period of high crude oil prices, key feed ingredient prices were driven to all time record highs. The production decision of farmers to substitute towards corn production and away from high cost inputs helped fuel this increase.

#### Assessing the impact of recent price increases on protein production

Given this price environment, the next question to ask is: what effect has the recent price increases had on feed costs and production costs for selected animal proteins? Researchers in the US and Norway assessed the recent impact of rising feed and production costs for selected animal proteins and found that aquaculture species, and in particular salmon and shrimp, gained a cost competitiveness relative to broilers and catfish (Anderson *et al.*, 2008). This finding can be attributed to the fact that shrimp and salmon have diets that are more heavily based on marine based feed ingredients relative to catfish and broilers, which have diets that are more dominated by agricultural ingredients, including corn and soybeans. Since agriculturally based crops recently experienced sharper price increases relative to marine based ingredients, those diets were impacted more acutely relative to the more marine based diets. However, the cost competitiveness of salmon and shrimp can also be attributed to other key reasons.

#### Aquaculture and its relative advantages in protein production

The aquaculture industry has some production advantages relative to its agricultural counterparts. The first advantage is associated with the edible and premium meat yields of aquaculture species. For example, compared to poultry which has a final meat yield of less than 40% and a premium meat yield of approximately 15%, salmon have an edible meat yield of 60%, of which the majority of that fillet is considered premium cut (Forester, 1999). Another production advantage for aquaculture species is the feed conversion ratio (FCR) for some aquaculture species relative to land-based animals. For example, salmon and tilapia have FCRs that are lower than broilers, pork and ruminants (Table 1). This means that it takes fewer pounds of feed to produce one pound of animal growth. This is an important advantage given that feed costs compose a significant percentage of on-farm production costs (40-70%). Therefore, species that have lower feed requirements will have a competitive advantage, even if the overall prices of key feed ingredients rise.

**Table 1.** FCR for selected animal proteins

Salmon	~ 1.2
Tilapia	1.6 – 1.8
Broiler	2.0 – 4.0
Pork	3.4 – 3.6
Ruminants	~ 7 – 10

Source: FAO (2007), Guttormsen (2008), Pork.org (2008)

#### Incentives to innovate in the aquaculture industry

Following the sharp increases in fish meal and fish oil prices back in 2005, the farmed salmon industry invested in feed research and development to increase the substitution possibilities across key feed ingredient. Research focused on identifying alternative protein sources that allowed feed

manufactures to tailor diets that were both nutritionally balanced and cost competitive. In general, the identification of alternative feed ingredients expands the nutritional knowledge base for a given species. This is important for two reasons. First, the knowledge gained can be used to improve overall production of the species: improve growth rates, reduce mortality and improve the overall quality and yield of the species. These advancements are important for long-term growth and economic viability. Second, the nutritional knowledge gained through feed research is also very useful in the short-term, particularly in situations where the prices of key fed ingredients are high and/or volatile.

#### **Capitalizing on feed Ingredient price arbitrage opportunities**

Innovations that lead to increased feed knowledge and the identification of alternative feed ingredients or formulations are important because they afford producers the ability to capitalize on nutritional knowledge when the relative prices of key ingredients change. If the price of a key feed ingredient increases relative to a lower cost substitute, then producers who have the nutritional knowledge regarding potential substitution possibilities can take advantage of price differentials between ingredients by altering the feed diet in such a way that the nutritional integrity of the diet is maintained at a lower cost. Without this nutritional knowledge, producers cannot capitalize on short-term price fluctuations. This is why research that focuses on feed and nutritional development and the identification of alternative feed sources is so critical. Not only does it enhance long-term growth and economic performance, but it can also enhance short-term economic performance by allowing producers the flexibility to choose among a greater range of ingredients that have been identified through feed research. Feed research and innovation increases the portfolio of feed options available to a producer and creates feed ingredient arbitrage opportunities, allowing producers the ability to capitalize on nutritional knowledge when relative prices change. For example, Fig. 2 presents

the price ratios of soybean oil/fish oil and rapeseed oil/fish oil. For the majority of the 1990s, the price ratios for both series were greater than 1, indicating that fish oil had been the cheaper ingredient relative to either soybean oil or rapeseed oil. However, since 2001 the price ratios have fallen below 1. In particular, the price ratio for soybean oil/fish oil has been below 1 since 2005, indicating that the price of soybean oil is cheaper relative to fish oil. Thus, even if the prices of both fish and soybean oil increase, in relative terms, soybean oil has a cost advantage relative to fish oil. If a producer had nutritional knowledge regarding the substitution possibilities associated with substituting soybean oil for fish oil in the diet of a given species, then he or she could take advantage of this price differential. Therefore, feed knowledge can be used to smooth input price fluctuations so that output prices or profit margins do not fluctuate widely, even if there is a significant degree of price volatility in underlying key feed ingredients.

#### **Examples of innovation in the farmed salmon industry**

The farmed salmon industry has invested in feed and nutritional research which has allowed the industry to reduce its inclusion rate for fish meal and fish oil. It has done so in part by identifying alternative feed ingredients. In 1998, the inclusion rates for fish meal and fish oil were 45% and 25%, respectively. By 2008, the inclusions rates for fish meal and fish oil were 30% and 14%, respectively, and by 2018, the industry anticipates inclusion rates of 15% and 5%, respectively for fish meal and fish oil (Skretting, 2008). The industry was able to substitute away from fish meal and fish oil by identifying alternative ingredients and expanding the variety of ingredients that could be used to formulate a diet for Atlantic salmon. This allows producers the ability to dampen price fluctuations in key feed ingredient prices by substituting towards lower cost ingredients during periods of price volatility. Further, even if real prices ultimately decline, the innovations and the knowledge gained through feed research and the cost competitiveness associated with those developments will remain.

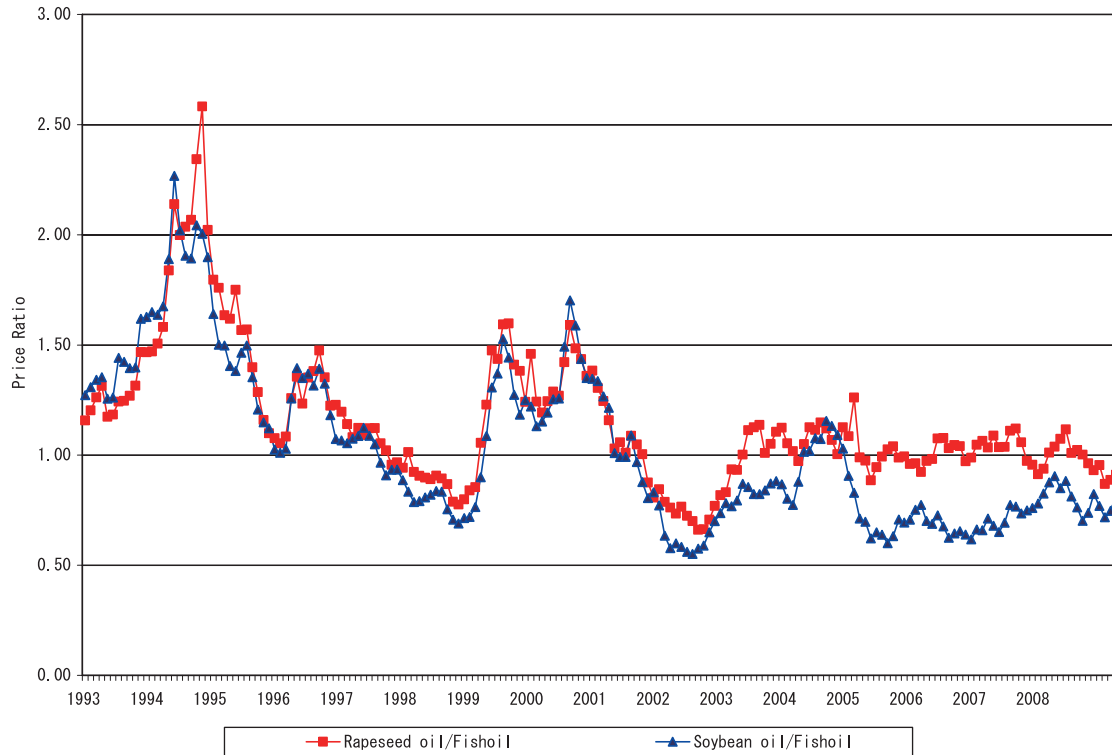


Fig. 2. Price ratios of key feed ingredients

#### Lessons from the U.S. poultry industry

Before the advent of the broiler industry, chicken meat was a by-product of the egg industry. Today, the U.S. broiler industry is the world's largest producer and one of the top exporters of poultry meat. The story of the U.S. poultry industry's ascendancy to the number one producer of poultry meat globally is a story of innovation in production, nutrition, processing and marketing. Fig. 3 depicts the long-run price trends for key feed ingredients (real prices) from 1914 to the present. While the long-term trend in real prices is downward, there are clear periods of volatility in key feed ingredient

prices. A question to ask is, how was the U.S. poultry industry able to weather these periods of price volatility. Fig. 4 depicts the real live-weight price trend for broilers over time since 1945. As one can see from Fig. 4, the real live-weight broiler price has trended downward over time. The industry was able to weather periods of price volatility and maintain a downward trend in prices through innovation in production and husbandry practices and through substitution across key feed ingredients. Table 2 presents a historical snapshot of key production parameters for the U.S. poultry industry. Improvements have been made across all parameters over time, reflecting improvement

Table 2. Improvements in the poultry industry

	1925	1945	1965	1985	2005
FCR	4.7	4.0	2.4	2.0	1.8
Mortality	18%	10%	6%	5%	4%
Age (days)	112	84	63	49	42
Live Weight (kg)	1.0	1.4	1.6	1.9	2.4

Source: P. Aho (2004) cited by C. Lohawatanakul (2008)

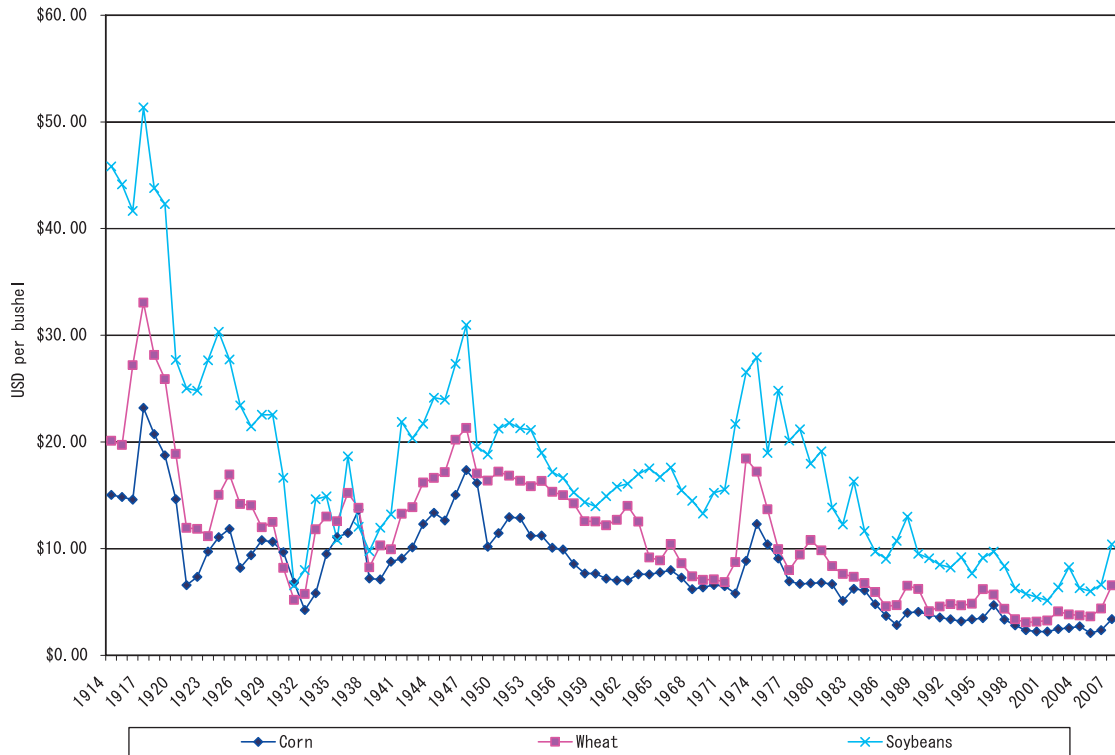


Fig. 3. Long run price trends for key feed ingredients (US dollars per bushel)

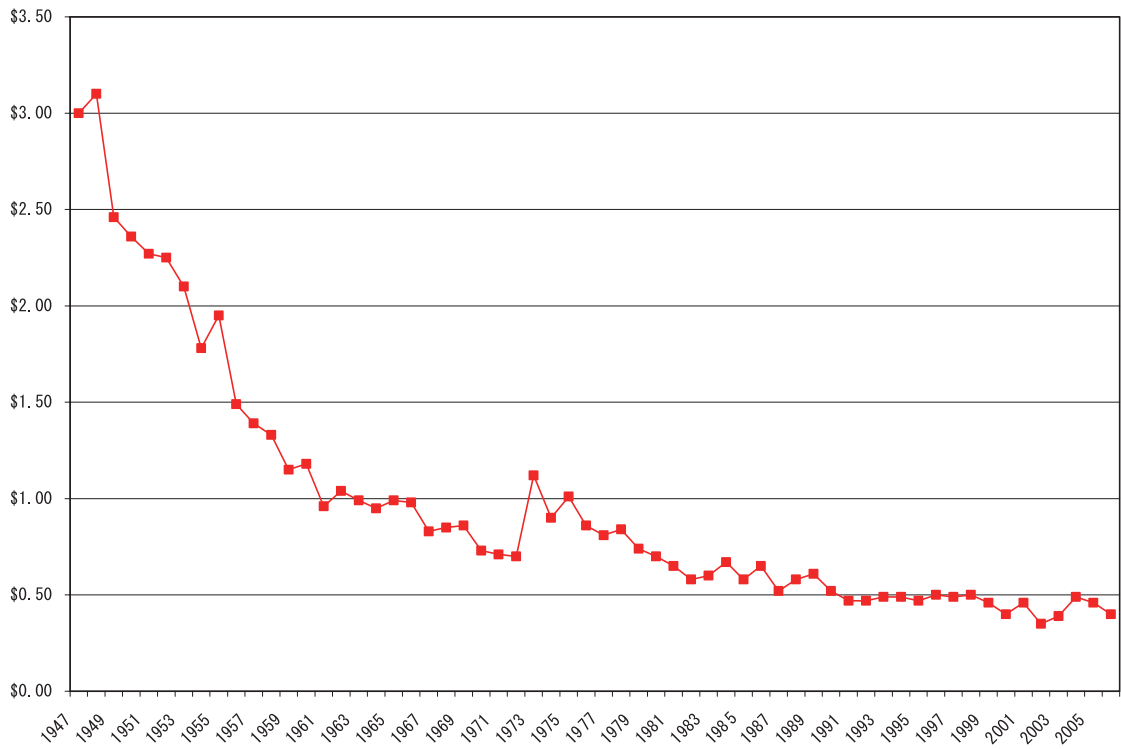


Fig. 4. Real average live weight price of broilers (US dollars per pound)

that benefited both the short-term and long-term viability of the industry. This explains in part how the industry was able to maintain declining real prices for broilers over time despite the presence of multiple periods of price volatility in key ingredients and on-farm costs.

### Conclusions

A key objective of this research was to emphasize the important of feed innovations and research in identifying alternative feed sources and in improving the existing nutritional knowledge base. Such developments benefit the industry in both the long and short-term. Short-term fluctuations in key ingredient prices can be controlled at the farm level if farmers have the nutritional knowledge regarding substitution possibilities across alternative feed ingredients. The current prices of key feed ingredients have retreated from their recent highs; however volatility has always been and will continue to be present in these commodities. Therefore, nutritional knowledge and the identification of alternative feed ingredients are critical in dealing with high and volatile prices for key ingredients. Innovations allow for substitution across feed ingredients, which will help make feed costs and production costs less volatile, despite any underlying volatility in primary ingredient prices.

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The report by leading fisheries and resource economists and business experts, *Offshore Aquaculture in the United States: Economic Considerations, Implications & Opportunities*, examined a range of topics on the industry's potential and found that a significant domestic offshore aquaculture industry could develop and be successful over the next 20 years with a clear regulatory framework. One chapter in particular (Chapter 4) examines the future of aquaculture feeds and feed costs by examining the role of fish meal and fish oil. The authors suggest that the limited supply of fish meal and fish oil is not likely to be a constraint on the expansion of U.S. aquaculture as alternative feed ingredients from soybeans and other plants, algae, yeasts, fish processing waste, and other products are being developed.

2. Jackson, Andrew. 2007. Challenges and Opportunities for the Fishmeal and Fish oil Industry. Feed Technology Update. Volume 2, Issue 1. January 2007.  
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This paper first examines the current state of the global fish meal and fish oil industry and then examines the claim that fish meal and fish oil might limit the future growth of the aquaculture industry. The author asserts that fishmeal and fish oil will become more strategic dietary ingredients, rather than limiting the growth of the aquaculture industry.

3. Kristofersson, Dadi. and James L. Anderson. 2006. "Is There a Relationship between Fisheries and Farming? Interdependence of Fisheries, Animal Production and Aquaculture" *Marine Policy*, Vol. 30, No. 6: 721-72

These authors examine the role of fishmeal as a critically important feed ingredient for use in animal (e.g., poultry and pork) and aquaculture production (e.g., salmon, trout, and shrimp). Their research suggests that since 1998 market for fishmeal has changed. An important explanation is likely to be the increasing use of specialized feed formulations in the pork, poultry and aquaculture sectors. It is clear that growth

in aquaculture production alone is insufficient to explain the structural change since growth in the use of fishmeal in aquaculture has slowed considerably despite the continued rapid growth in global aquaculture sector. The increasing relative price of fishmeal is likely to increase costs for animal producers, act as a stimulus for innovation and have considerable implications for the management of pelagic fisheries.