Outlook for Fishmeal and Fish Oil Demand: The Role of Aquaculture

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Abstract. The rapid growth of aquaculture and concomitant growth in the use of compound aquafeeds have resulted in aquaculture using 35% of global fishmeal and 54% of global fish oil in 2000, up from just 10% and 16% respectively in 1988. Meanwhile, landings of reduction fish have hovered near 30 mmt, and fishmeal production has remained near 6 mmt for nearly two decades. Aquaculture has increased its share of use as the terrestrial livestock sector, which generally is more price-responsive than aquaculture for fishmeal in feed, has decreased its share of use from 82% in 1988 to 56% in 2000. Projections with IFPRI's IMPACT model, which allows for endogenously determined fishmeal and oil demand, show rapid growth in aquaculture associated with higher prices for fishmeal and oil. Rising production of marine finfish and shrimp, with rigid requirements for fishmeal and oil in their diets, will eventually drive demand higher in the absence of technical change. Rising relative prices are likely to be associated with growth in the share of fishmeal consumption by aquaculture, as end-users with more flexible demand exit the supply-limited market. This in turn is likely to increase the overall price inelasticity of demand for fishmeal and oil. However, if price pressures induce innovations in substitutes for fishmeal and oil in compound aquafeeds, IMPACT scenarios show lower real prices for these feed inputs, releasing a potential constraint to aquaculture production growth and possibly easing pressure on reduction stocks.

Keywords: Fishmeal demand, fish oil, aquafeeds, substitution, aquaculture

1. INTRODUCTION

A large share of the world's wild-caught fish is not consumed directly by humans, but rather is consumed indirectly as a feed ingredient for farm-raised animals such as chickens, pigs, and other fish. The wild-caught fish that are reduced to fishmeal and fish oil each year amount to approximately 4-5 kg (live weight) for every person on the planet. Although fish destined for reduction to meal and oil are generally undesirable for human consumption, the practice of feeding fish to fish has raised questions about aquaculture's impact on wild fish stocks. In recent years, aquaculture has grown at an explosive rate. As the industry has expanded production, aquaculture has commanded an increasing share of fishmeal and fish oil use. With the continued growth in production of aquatic organisms with relatively strong feed requirements for fishmeal, this share will continue to grow.

The International Food Policy Research Institute's (IFPRI) International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) permits examination of future trends in fishmeal and oil demand. The model allows for competition among sectors for feed inputs, and prices of these inputs are the consequence of numerous factors including output levels, feed efficiency, prices of substitutes, demand elasticities, and exogenous supply trends. As aquaculture expands its share of demand for fishmeal and oil, and terrestrial livestock sectors decrease their share, the possibility exists that aquaculture may influence the prices of fishmeal and oil. This possibility has caused some concern among those who fear that higher fishmeal and oil demand will lead to greater fishing pressure on stocks of reduction fish (Naylor *et al*. 2000).

2. TRENDS IN USE OF FISHMEAL AND OIL

2.1 Overall importance of fishmeal use

Fishmeal is created from the cooking, pressing, drying, and milling of wild-caught pelagic fish; fish oil is largely a by-product of this process. A remarkably large share of global capture fisheries production is used to produce these feed ingredients. Approximately 30% of the global annual fish catch, and about 80% of wild-caught pelagic catch (Durand 1998), are reduced to meal and oil. The quantity of landed fish from capture fisheries destined for reduction into meals and oils has grown since 1970 but remained relatively static over the past ten years, fluctuating from a low of 15.6 million metric tons (mmt) in 1973 to a high of 30.5 mmt in 1994. In 1999, it was reported that 26.5 mmt or 28.5% of the total fish and shellfish catch was used for reduction (FAO 2001). However, this figure only refers to whole fish destined for reduction, and so excludes other fish scraps and processing wastes. Industry estimates for the quantity of fish reduced into meals and oils are therefore higher, at around 30 mmt.

Roughly two-thirds of all fishmeal production comes from fisheries that are specifically equipped and integrated with production chains in order to produce fishmeal (New and Wijkstrom 2002). Small pelagic fish species that are not generally consumed directly by humans form the bulk of capture fisheries landings destined for reduction, with anchovies (Family *Engraulidae*) forming 46.4%; and herrings, pilchards, sprats, sardines, and menhaden (Family *Clupeidae*) forming 40.0% of estimated landings for reduction in 1999 (FAO 2002). Although yields of fishmeal and fish oil vary according to species, season (depending upon the nutrient composition and moisture content of the target fish species), and the fish processing method employed, 20-22% fishmeal and 4-5% fish oil are typically obtained by processing. Fishmeal production grew from the 1970s to the 1980s, following the collapse of the Peruvian anchoveta stock in 1972-73, but has remained near 6-7 mmt since the mid-1980s. Fish oil production has remained slightly above 1 mmt during this period.

The vast majority of fishmeal is destined for indirect human consumption through farmed poultry, pigs, carnivorous aquatic species, and non-carnivorous aquatic species. Although data are scarce, indications are that aquaculture's share of fishmeal demand has been rising rapidly in the past two decades (Table 1). In 1984, aquaculture represented 8% of world fishmeal consumption (New and Wijkstrom 2002). Barlow and Pike (2001) estimate that in 1988, aquaculture used 10% of the world's fishmeal as opposed to poultry's 60%. In 1994, aquaculture used an estimated 17% of the world's fishmeal, with poultry feeds using 55% and pig feeds using 20% (Pike 1997). By 2000, it is estimated that aquaculture consumed 35% of the world's fishmeal compared to 24% for poultry and 29% for pigs.

Fish oil has non-food uses as well as uses for direct human consumption. However, with fish oil as well, aquaculture has become an increasingly large end-user. In 1988, aquaculture's share was 16%, and this share had grown to an estimated 54% by 2000 (Barlow and Pike 2001). The increasing farmed production of high-value carnivorous species such as salmon has led to increased use of fish oil within aquafeeds, as fish oil provides essential n-3 fatty acids for fish that are unavailable elsewhere.

2.2 Geographic concentrations of fishmeal production and use and resultant trade flows

A large share of fishmeal production comes from the harvest of just one species of fish, the Peruvian anchoveta (*Engraulis ringens*), by Peru and Chile. Since 1976, the combined share of Peru and Chile in world fishmeal production has ranged from a low of 13% in 1977 to a peak of 54% in 1994, with an average share of 34% (FAO 2002). China has become the next largest fishmeal producer during the past decade, with an 11% share of global production in 1999. Japan, Thailand, Denmark, the United States, Norway, and Iceland together accounted for 31% of global production in 1999. Japan's production of fishmeal has dropped significantly during the 1990s as a consequence of the rapid decline of the pilchard fishery. The patterns of fish oil production are similar, with Peru and Chile consistently commanding over 50% of production, though China is much less important than in the case of fishmeal.

China is by far the largest consumer of fishmeal, rising from relatively low levels to over 1 mmt per year from 1996-98, though it consumes only small amounts of fish oil. With the exceptions of Peru and Chile (and Thailand in the case of fishmeal), the countries with high levels of fishmeal and oil consumption are in the developed world, reflecting the intensive production of livestock and aquaculture in these countries. As a consequence of these production and consumption patterns, net trade in both fishmeal and fish oil flows from the developing world to the developed world (Table 2). Overall fishmeal exports have doubled since the mid-1970s, with total exports recently totaling about half of total production. In 1999, as in most years, the largest exporters of fishmeal were the same as those who led production. However, the amount of fishmeal and fish oil available for export has been steadily decreasing within those exporting countries (including Chile, Norway, Thailand, and Japan) with a rapidly growing domestic aquaculture sector and consequently increasing domestic fishmeal and fish oil demands. China led fishmeal importers by a large margin, with Japan and Germany also large importers. As with fishmeal, about half of fish oil production is generally traded. Latin America, primarily Peru and Chile, is the largest source of fish oil exports.

2.3 Trends in global fishmeal prices and price volatility

Fishmeal is not traded on a centralized market or a futures market; transactions between buyers and sellers are generally private, sometimes on a forward contract basis (Durand 1998). Because of the general unsuitability of reduction fish for human consumption, it is likely that markets for fishmeal and for low-value food fish are separate (New and Wijkstrom 2002); there is no evidence in the literature of price linkages between the two sectors. In contrast, the price of fishmeal has historically maintained a close relationship with the price of soymeal, another high-protein feed ingredient (Asche and Tveteras 2000). Soymeal is the primary substitute for fishmeal in animal feeds (Vukina and Anderson 1993); the price ratio of fishmeal to soymeal has stayed near 2:1 for the past three decades, the difference being due in part to fishmeal's higher protein content (Durand 1998). The market for soymeal is over ten times larger than the fishmeal market; annual soymeal production has grown four times faster than annual fishmeal production over the past decade. The growing size disparity between the industries has likely muted any soymeal price response to the fishmeal production shocks that occur quasiperiodically as a consequence of climatic variability.

The Peruvian anchoveta fishery, which represented over a third of the total estimated landings destined for reduction in 1999, not only faces heavy fishing pressure, but also has exhibited extreme volatility due to environmental conditions. El Niño events, which reduce upwelling along the Peruvian coast that provides nutrients for the anchoveta, are linked to catastrophic declines in the fishery, with landings over the last 30 years ranging from a high of 13 mmt in 1970 to under 0.1 mmt following the 1982-1983 El Niño. The synergistic effect of El Niño events and fishing pressure has been blamed for past anchoveta declines. Furthermore, high prices can create the perverse incentive to increase fishing effort when anchoveta are scarce, although poor management in the fishery has improved somewhat during the past decade (Asche and Tveteras 2000).

Drastic declines in the catch of the Peruvian anchoveta have been associated with temporary fishmeal price increases. Substitution to soymeal and other vegetable meals has likely buffered these shocks, keeping the price ratio stable over time. The most recent El Niño event, however, coincided with a significant perturbation in the ratio of fishmeal prices to soymeal prices. Figure 1 shows this price ratio from 1980-1999; the ratio has stayed near 2:1, but soared to 4:1 in September 1998.

3. FACTORS EXPLAINING DEMAND FOR FISHMEAL AND FISH OIL

3.1 Nutritional properties of fishmeal and fish oil

Fishmeal has a number of favorable nutritional properties for the growth and survival of farmed pigs, poultry, fish, and crustaceans. Fishmeal is a dense source of high-quality animal protein with a well-balanced essential amino acid profile. It is also a good source of digestible energy, minerals, trace elements, and vitamins. Importantly, fishmeal provides omega-3 fatty acids that monogastric animals like poultry and pigs cannot synthesize. Lysine, methionine, and cysteine levels are all higher in fishmeal than in vegetable protein meals (Lim, Klesius, and Dominy 1998). Strictly as a supplier of vitamins, minerals, and energy, however, fishmeal faces relatively broader competition from other feedstuffs. Omega-3 fatty acids are particularly rich within fish oils, and therefore play an important role in immune function and health in fish. Fish oil is at present the only commercially available and utilizable source of highly unsaturated fatty acids required for carnivorous fish species.

In general, regular fishmeals (about 60% of total global fishmeal production) are used as dietary protein sources for poultry, pigs, and omnivorous farmed aquatic species such as carp, tilapia, and catfish. By contrast, the higher-quality and higher-priced fishmeals are used primarily by carnivorous finfish and crustacean farming systems. The amount of fishmeal included in diets of farmed species differ among farming systems, depending on the market value of the farmed species and ingredient availability and cost. Typically, however, carnivorous fish (such as salmon) in intensive aquaculture systems consume aquafeeds with 30-70% fishmeal, while omnivorous fish (such as carp and tilapia) may in some cases consume up to 25% fishmeal, though lower inclusion levels are more common (Tacon 2002). Marine shrimp, such as black tiger prawns, consume aquafeeds with 20-50% fishmeal. These proportions of fishmeal inclusion dwarf the amounts contained in the feeds of terrestrial animals. Poultry and pigs, the two other leading consumers of fishmeal, consume 1-10% in their feeds.

3.2 Demand characteristics for fishmeal and fish oil in aquaculture

As aquaculture expands its production over the coming years, its use of inputs derived from capture fisheries will become an increasingly important issue. The aquaculture sector as a whole consumed the equivalent of approximately 11.5 mmt of wild-caught pelagic fish in 1999. Intensive cultivation, especially of carnivorous species, requires the supply of supplementary and/or nutritionally complete artificially compounded aquafeeds. The price and availability of fishmeal and fish oil inputs is not a trivial issue to aquaculturists practicing intensive culture, for whom feed costs represent a large share of total operating costs.

The richness of fishmeal and fish oil in energy, amino acids, and fatty acids accounts for their inclusion in many aquafeeds, especially those destined for carnivorous species such as salmon and shrimp. Though these two categories represent only 13% by weight of all aquaculture production, they use 41% of the fishmeal and 47% of the fish oil consumed by the industry. Marine fish, in general, require higher levels of n-3 fatty acids than do freshwater fish (Sargent *et al*. 1995). Herbivorous and omnivorous freshwater fish are better able to process vegetable-based proteins and oils, and thus require less fishmeal and fish oil in their diets; however, even feeds for freshwater fish like carp and tilapia frequently contain fishmeal to boost growth.

Table 3 presents the estimated utilization of fishmeal and fish oil within compound aquafeeds for each of the major species groups in 1999. Compound aquafeeds consumed about 2.3 mmt of fishmeal and 0.6 mmt of fish oil in 1999, or the equivalent of about 35% and 46% of the total global production of fishmeal and fish oil. Carnivorous finfish species consume the bulk of fishmeal and fish oil used within aquafeeds; the amount of fishmeal fed to salmon equals the amount fed to carp, tilapia, and catfish combined.

3.3 Aquaculture's competition for fishmeal use with terrestrial livestock

The proportion of fishmeal and fish oil in feed is typically governed by dozens of considerations for nutrition and growth using the least-cost method (Vondruska 1981). A hypothetical demand curve for fishmeal in animal feed, therefore, has several elastic and inelastic regions, each reflecting a different role in growth. Within the terrestrial livestock sector, substitution to and from fishmeal occurs in response to price changes. Estimates of the long-run price elasticity of demand for fishmeal ranged from –0.48 to –3.0 around 1970, long before aquaculture represented a significant fraction of fishmeal demand (Roemer 1970).

Substitution to non-fishmeal protein sources is significantly more constrained in aquaculture than in poultry or pig farming. In times of high fishmeal and oil prices, many aquaculturists have little latitude in their feed composition choices. Studies have shown lower growth rates and higher mortality in different aquatic species when vegetable protein is substituted for fishmeal in varying amounts (Lim, Klesius, and Dominy 1993). Fishmeal has higher digestibility coefficients (the proportion of energy utilized by the animal) than its competitors for many carnivorous species (Allan 1998).

Although poultry is in most years the largest end-user of fishmeal, aquaculture's share has grown considerably over recent years (Table 1). The growing share of aquaculture in fishmeal demand cannot be explained by the industry's growth alone. Global poultry production grew at over 5% per year from 1985-1997, a rate slower than aquaculture's growth, but still considerable. However, the poultry sector has actually reduced its consumption of fishmeal over the past decade. Technological innovations, especially the use of processed plant protein, have reduced the proportion of fishmeal in poultry feeds, though double the amount of poultry feed is now produced. Fishmeal has been reallocated to the aquaculture sector because as overall demand has grown, supply has remained roughly the same, and terrestrial livestock producers have switched to vegetable-based meals.

Increasing demand for fishmeal by the booming aquaculture sector has not caused a proportionate increase in the overall fishmeal demand; instead, the high price elasticity for fishmeal in the livestock sector has historically allowed a distributional change in the end-uses of fishmeal. As aquaculture has consumed more fishmeal, the terrestrial livestock sector, which in general has greater latitude with regard to fishmeal substitutes, has consumed less. A similar situation exists with fish oil, though in this case, usage has shifted from the edible food industry to the aquaculture sector. Some project that aquaculture will become the sole consumer of the world's fish oil within the next two decades (New and Wijkstrom 2002).

3.4 Likely increased overall price inelasticity of demand for fishmeal and oil in the future

Because substitution away from fishmeal in the terrestrial livestock feed sector has compensated for increased demand from aquaculture, there is little clear evidence that aquaculture's growth is responsible for placing sustained, increased pressure on small pelagic fisheries thus far. Many of these fisheries are heavily exploited, and some are in decline, but the overall demand for oilseeds (of which fishmeal represents less than 5%) has historically driven the demand for fishmeal. Asche and Tveteras (2000) and others (Durand 1998; Vukina and Anderson 1993) have shown that fishmeal and soymeal behave as substitutes, with their relative prices historically stable. However, this relationship may be changing due to aquaculture's rapid growth in its share of fishmeal demand. Aquaculture's relatively inelastic demand for fishmeal could lead to price spikes during times of shortage, such as the severe price spike (Figure 1) that occurred during the 1997-98 El Niño event. As prices soared due to fishmeal shortages, substitution to less expensive plant-based meals occurred extensively among poultry and pig feeds, but only to a limited extent in aquaculture feeds (IFOMA 1998). As a consequence, aquaculture was the largest end-user of fishmeal in 1998 (IFOMA 1999), most likely for the first time ever. This compares to aquaculture's modest 8% share of fishmeal demand just twelve years earlier in 1986 (New and Wijkstrom, 2002). More volatility can be expected, given that El Niño events occur at irregular intervals every 3-7 years.

Without technological change in aquaculture, its share of demand for fishmeal and fish oil is likely to continue increasing. Demand from aquaculture may eventually drive prices higher and thus place pressure on wild fish populations in the absence of effective regulations (Asche and Tveteras 2000). This concern is not confined to environmental advocates; a report from the Chilean fishing industry predicts that future growth in farmed salmon production will push fishmeal prices higher over the next few years (Worldcatch News 6/13/01). There is general concern that supply cannot keep pace with demand, and that the prices of these finite commodities will increase in the long term.

4. THE RELATIVE PRICE OUTLOOK FOR FISHMEAL AND PROSPECTS FOR REPLACEMENT OF FISHMEAL AND FISH OIL IN AQUAFEEDS

Projections using the IMPACT model allow for endogenous determination of regionally specific fishmeal and fish oil demand, along with demand for other feed ingredients, using feed conversion ratios and demand elasticities to approximate demand functions by sector. Prices for commodities are determined iteratively by balancing supply, demand, and trade for each subregion in the model. In adding fisheries commodities to the model, parameters were specified using available literature, with consideration given to the nutritional factors considered above and the magnitude of parameters specified for established commodities in the model. In general, own-price feed demand elasticities for fishmeal and fish oil use in carnivorous aquaculture were set at approximately half the corresponding values for other sectors of demand. Also included in the model is a technological change parameter, allowing for yearly improvements in feed conversion efficiency.

IMPACT projections suggest that real fishmeal and fish oil prices will increase by about 18% from 1997-2020 under the baseline scenario. In this scenario, production of both crustaceans and of high value finfish from aquaculture nearly doubles by 2020, contributing to higher demand for feed inputs. Scenarios with both higher and lower growth in aquaculture were also run, with resulting prices shown in Table 4. Strikingly, under the higher aquaculture growth scenario, real fishmeal and fish oil prices increase by about 50% by 2020. Slower growth in aquaculture results in a real price decline for fish oil, and no change for fishmeal, by 2020. A scenario with rapid technological change (doubling the rate of improvement in feed conversion efficiency) results in real price declines for both fishmeal and fish oil, and even slightly lower prices for aquaculture commodities than in the baseline. Further discussion of the projections and methodology can be found in Delgado *et al*., 2002.

These results demonstrates the crucial role that aquaculture will play in determining demand for reduction fishery commodities in the coming decades. The fear that such a price rise will rob food fish from the diets of the world's poor seems unfounded—most of the world's fishmeal comes from specialized fisheries (New and Wijkstrom 2002), and it appears that there is little overlap between food fish and reduction fish at present. However, fishmeal price increases should be worrisome both to aquaculturists, for whom feed costs are a significant proportion of operating expenses, and to those concerned with increasing pressure on the resource base.

Technology can reduce the risk of higher prices and over-fishing by providing alternatives to the use of capture fishery-derived inputs. Replacement of fishmeal and oil in aquafeeds with nutritionally comparable feedstuffs would remove the dependence of many forms of aquaculture on wild stocks. Such replacement may also, in the long run, diminish pressure on prices of feed inputs derived from capture fisheries, as demonstrated by the IMPACT scenarios. Fishmeal inclusion rates in aquafeeds have declined in recent years; promising results have been obtained by substituting protein-rich oilseed and grain by-product meals for fishmeal in the diets of carnivorous finfish and marine shrimp. Such vegetable-based substitutes include soybean, rapeseed, corn gluten, wheat gluten, and to a lesser extent pea and lupin meals. Other prospects for replacement include terrestrial animal byproduct meals such as meat and bone meal, although these bring with them real and perceived risks for the spread of disease. In fact, bans on meat and bone meal as the result of BSE fears might create additional demand for fishmeal (New and Wijkstrom 2002).

The main factor limiting the replacement of fishmeal with vegetable meals is the presence of factors inhibiting nutrition within these meals, and the consequent need to minimize their effects either through genetic selection of the cultivated species or through the use of improved feed processing techniques (Francis et al. 2001). However, in addition to the productivity of the cultivated species, factors such as flavor, appearance, and nutritional content must be considered by producers when attempting to substitute for fishmeal and fish oil.

The total replacement of fish oil with commercially available plant and animal oils is more problematic than that for fishmeal. For many carnivorous fish species, fish oils serve as the only readily available source of essential fatty acids for these species, and their total deletion from rations would have a negative effect on the final gastronomic and nutritional properties of the flesh (Sargent and Tacon 1999). Some plant oils have achieved a degree of success as fish oil replacers (depending upon the species farmed), including soybean, rapeseed, and linseed oils. At present, the most likely avenues for the commercial production of oils rich in highly unsaturated fatty acids are micro-organisms such as the microalga *Phaeodactylum tricornulum* produced through controlled fermentation processes (Reis *et al*. 1996), or extraction from largely untapped fishery resources such as krill (Farstad 1999).

5. CONCLUSIONS

A changing profile of fishmeal and oil use over time is likely to be associated with changing price responsiveness of demand. If this demand becomes less price-responsive, the price of fishmeal, which has been historically linked with that of its substitute soymeal, will experience greater volatility during the supply shocks that characterize the market. Fishmeal prices may even become de-linked with the price of soymeal if the structure of demand continues to change rapidly. The other major users of fishmeal, the poultry industry and the pork industry, have relatively greater latitude in their feed composition choice and are thus more likely to substitute away from fishmeal when relative prices rise, leading to a larger share of demand for aquaculture. IMPACT projections suggest that there will be upward pressure on the prices of fishmeal and fish oil during the next two decades, and demonstrate the importance of aquaculture in driving demand in the future. Alternate IMPACT scenarios also underscore the key point that technological development in aquaculture and aquafeeds will be a major determining factor in future prices of fishmeal and fish oil relative to output prices.

6. FIGURES

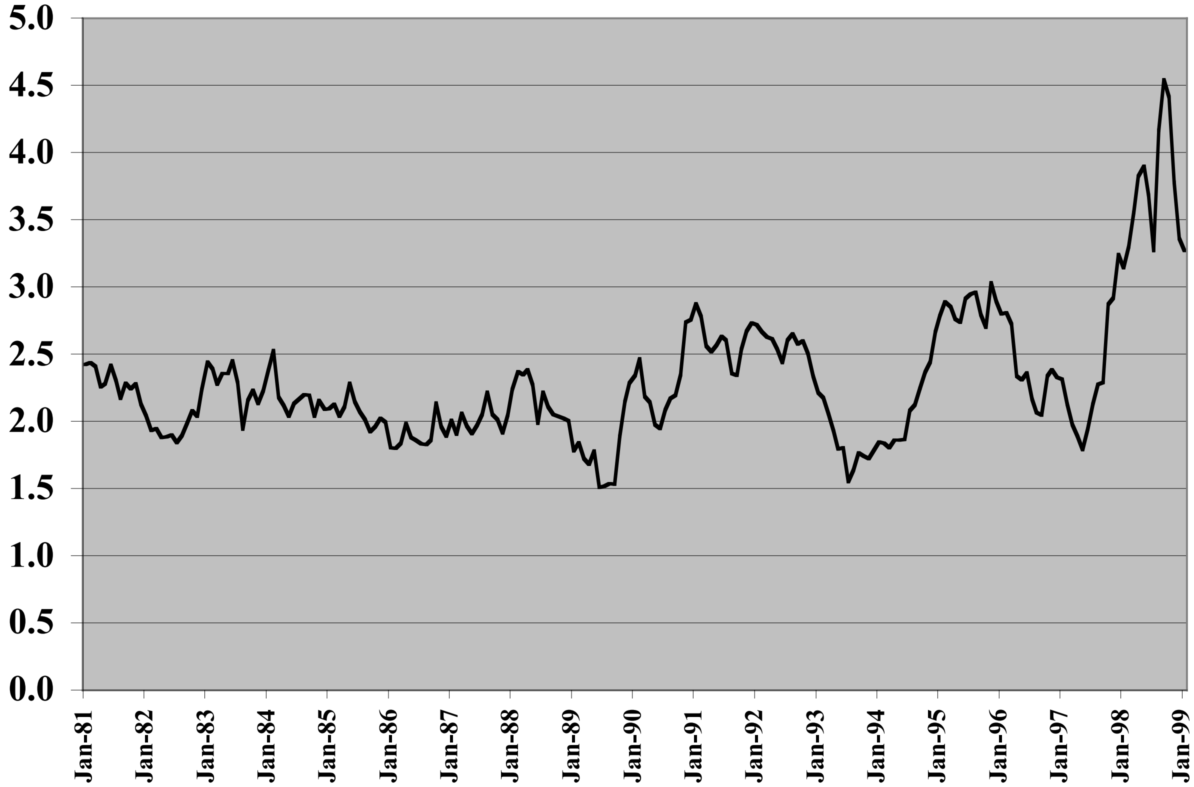

Figure 1. Ratio of fishmeal price to soymeal price, 1962-1999

Notes: Fishmeal prices are CIF Hamburg, any origin (OilWorld). Soymeal prices are 48% protein at Decatur, IL.

	1984	1988	1994	2000
		(percent of total use)		
Aquaculture	8	10	17	35
Poultry	n/a	60	55	24
Pigs	n/a	20	20	29
Other	n/a	10	8	12

Table 1. Estimated shares of fishmeal use by sector

Sources: 1984: New and Wijkstrom 2002; 1988,2000: Barlow and Pike 2001; 1994: Pike 1997.

Region	Fishmeal	Fish oil
	(thousand metric tons)	
China	-1,031	-13
Southeast Asia	-270	-7
India	-9	0
Other South Asia	-4	0
Latin America	2,312	175
WANA	-157	3
SSA	31	3
United States	33	80
Japan	-372	-59
EU-15	-443	-145
E. Europe & former USSR	-144	0
Other developed	67	-29
Developing world	859	154
Developing world excl. China	1,890	167
Developed world	-859	-154

Table 2. Net exports of fishmeal and fish oil, 1997

Notes: Data are three-year averages centered on 1997, calculated from FAO (2002). Negative sign indicates net imports.

	Fishmeal use	Fish oil use
	(% of total in aquafeeds)	
Salmon	21%	41%
Marine shrimp	20%	6%
Marine fish	20%	19%
Carp	14%	11%
Trout	7%	16%
Eels	7%	3%
Freshwater crustaceans	4%	1%
Tilapia	3%	1%
Catfish	2%	1%
Milkfish	1%	1%
Total used in aquafeeds	2,312,558	626,333
Share of aquaculture in total use	35%	46%

Table 3. Use of fishmeal and fish oil in aquafeeds for various fish groupings, 1999

Commodity	Most likely (baseline)	Faster aquaculture growth	Slower aquaculture growth	Fishmeal and oil efficiency
		(overall percent change)		
High value finfish	+15	+9	+19	+14
Crustaceans	+16	+4	+26	+15
Fishmeal	+18	+42	-0	-16
Fish oil	+18	+50	-4	-5
Poultry meat	-2	-5	+0	-3

Table 4. Projected real price change of fisheries commodities under various scenarios, 1997-2020
Source: Projections for 2020 are from IFPRI's IMPACT model (Delgado *et al*. 2002).

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