THE MARKET FOR FISH MEAL AND OIL IN THE UNITED STATES: 1960–1988 AND FUTURE PROSPECTS

CYNTHIA J. THOMSON
National Marine Fisheries Service
Southwest Fisheries Center
P.O. Box 271
La Jolla, California 92038

ABSTRACT

Fish meal is used in the United States largely as a high-protein ingredient in poultry feed. Prices of domestic fish meal are determined by world market conditions for fish meal as well as other oil meals. Faced with limited fish meal supplies and little control over prices, the U.S. poultry industry has substituted other ingredients and made use of technological advances to satisfy the nation's growing demand for table birds.

A number of factors have been identified that may significantly affect future demand, supply, and prices of fish meal and oil, both in the United States and abroad. These include (1) increases in world aquaculture production, (2) possible development of a domestic market for hydrogenated fish oil, (3) recent changes in the Alaska pollock fishery, (4) efforts to develop marketable products for direct human consumption from reduction species, and (5) the status of the Japanese and South American sardine fisheries.

RESUMEN

La harina de pescado es un ingrediente de alto contenido proteico utilizado corrientemente en la alimentación de aves de corral en los Estados Unidos de Norteamérica. El mercado mundial determina el precio de la harina, como así también el de otras harinas de orujo. Ante el problema de un limitado abastecimiento de harina de pescado y un reducido control en los precios, la industria de la pollería se vió obligada a sustituír otros ingredientes y hacer uso de los avances tecnológicos con el fin de satisfacer la creciente demanda de estas aves de corral.

Se han identificado un número de factores que pueden afectar significativamente la futura demanda, el abastecimiento y el precio de la harina de pescado y otros aceites, tanto en los Estados Unidos como en el exterior, a saber: (1) el aumento en la producción de las piscifactorías, (2) el posible desarrollo de un mercado doméstico de aceite de pescado hidrogenado, (3) los cambios recientes en la pesquería del bacalao de Alaska, (4) los esfuerzos para desarrollar productos de consumo directo por el ser humano, y por último (5) el estado de las pesquerías en el Japón y en Sudamérica.

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INTRODUCTION

The fish meal and oil industry began in the nineteenth century in northern Europe and North America. The oil was manufactured from surplus fish caught in the herring fishery, and was used to tan leather and as an ingredient in products such as soap. The residue was originally used as fertilizer. However, since the turn of this century, the use of fish for fertilizer has diminished considerably because increasing amounts have been diverted to the production of fish meal (FAO 1986).

The fish meal production process, which is known as reduction, involves cooking the fish, removing the water and oil from it, drying the solid material left behind, and grinding it into a meal. Fish meal is used in the United States largely as a high-protein ingredient in poultry feed. It is also used in feeds for pigs, farmed fish, fur-producing animals, laboratory animals, and household pets.

The oil that is removed in the reduction process is marketed as an ingredient for industrial products (such as paints and lubricants) and foods (such as margarines and shortenings). Most of the fish oil produced in the United States has historically been exported to Europe for use in margarines. Until very recently, the U.S. Food and Drug Administration did not allow the use of fish oil in products for domestic human consumption.

Approximately one metric ton (MT) of fish meal is produced from each 4–5 MT of fish harvested. The oil yield is more variable and depends on the species and the time of year when the fish are caught (Vondruska 1980). For example, the oil content of northern anchovy is low during the winter and spring spawning period, and highest in late summer (Lasker and Smith 1977). The wholesale value of U.S. fish meal production has historically exceeded the value of oil production by a factor of two to four (table 1).

TABLE 1
Quantity and Value of Fish Meal and Oil Produced in the United States

Year	Production quantity (1000's of metric tons)		Value (millions of dollars)	
	Fish meal	Fish oil	Fish meal	Fish oil
1960	263.2	94.8	25.3	13.0
1961	282.4	117.1	31.9	14.3
1962	283.3	113.4	35.6	11.0
1963	232.2	84.3	30.2	10.9
1964	213.5	81.7	28.0	13.3
1965	230.5	88.7	35.7	14.9
1966	203.4	74.7	32.3	12.5
1967	191.6	55.5	26.0	6.1
1968	213.3	79.0	30.3	7.3
1969	229.2	77.0	39.8	9.3
1970	244.2	93.5	46.4	18.2
1971	265.6	120.4	44.5	20.8
1972	259.0	85.5	48.3	13.1
1973	253.2	101.9	119.1	25.6
1974	264.6	107.9	83.5	49.2
1975	253.4	111.4	64.6	32.6
1976	271.3	92.8	95.7	31.2
1977	248.4	60.7	96.5	28.4
1978	320.9	134.4	120.2	60.7
1979	329.2	121.4	133.3	54.1
1980	322.3	141.8	132.9	57.9
1981	281.3	83.6	117.6	33.1
1982	330.4	157.6	121.2	53.6
1983	339.0	181.1	129.1	66.8
1984	334.7	169.1	112.6	61.0
1985	319.6	129.3	83.1	41.9
1986	308.1	152.8	82.4	43.7
1987	349.6	135.4	120.9	35.5
1988	283.5	101.9	129.2	43.6

References: U.S. Department of the Interior 1960–1970; U.S. Department of Commerce 1971–1988.

Fish and shellfish landed commercially in the United States are used for human consumption and industrial products. Over 85% of industrial use is attributable to reduction; the remainder consists of bait and animal food. Since 1960, industrial uses have accounted for 36%–53% of total landings but only 4%–11% of total ex-vessel revenues on an annual basis (table 2). Reduction landings tend to be large in quantity but low in value relative to landings used for direct human consumption.

SUPPLY

Production

The species used for reduction are small, oily, pelagic fishes that are not marketable in large quantities for human consumption. In the United States, these include northern anchovy *(Engraulis mordax)* on the Pacific Coast and menhaden *(Brevoortia tyrannus* and *B. patronus)* on the Atlantic and Gulf coasts. A substantial reduction fishery once existed in California for Pacific sardine *(Sardinops sagax)*, but the fishery collapsed in the early 1950s (Radovich 1981). The state of California lifted its moratorium on sardine landings in 1986, but so far has allowed modest harvests to be taken for nonreduction uses only.

Although most fish meal is produced from whole fish, about 10% is produced from the by-catches and byproducts of other fisheries. Examples are tuna-mackerel and pollock meals, which are produced from the scraps remaining after these species are processed into other market products.

As indicated in table 3, U.S. fish meal production ranged from 200 to 350 thousand MT per year from 1960 through 1988. Before 1982, menhaden meal constituted 55%–80% of annual production. Since 1982, menhaden's share has been even higher, averaging 85% of total production. Tuna-mackerel meal contributes 20,000–45,000 MT per year.

Anchovy meal production peaked in 1975 at 25,100 MT, when its share of total production was 10%. However, meal production from this species has been much lower in most other years and has been negligible since 1983, largely because of economic factors rather than low abundance. From 1983 through 1988 the fish meal price ranged from $240 to $440 per MT, and the ex-vessel price received by the menhaden fleet ranged from $80 to $115 per MT. However, for reasons that are not clear, the ex-vessel anchovy price offered by California processors has remained at record low levels (below $35 per MT). As a result, the California reduction fleet has not found it profitable to target on anchovy and has directed increasing amounts of effort to more lucrative species such as mackerel, tuna, and squid (Thomson et al. 1989).

Imports and Exports

Figure 1 describes the contributions of Peru and Chile to world exports of fish meal. From 1960 to 1972 Peruvian anchoveta *(Engraulis ringens)* accounted for 50%–63% of all the fish meal traded in international markets. A combination of overfishing and poor recruitment led to the collapse of the fishery during the 1972–73 El Niño (Glantz 1979). The recovery of the fishery has enabled Peru to significantly increase its exports in the 1980s, though not to the high levels of the 1960s and early 1970s. Chile's fish meal exports began to increase in the early 1970s, as a result of its developing sardine *(Sardinops sagax)* and jack mackerel *(Trachurus murphyi)* fisheries. Since 1980 Chile's exports have exceeded Peru's.

TABLE 2
U.S. Commercial Finfish and Shellfish Landings and Ex-Vessel Value (Millions of Dollars) by Disposition of Catch

	Human food		Industrial use[b]		Total	
Year	Landings[a]	Value	Landings	Value	Landings	Value
1960	1133.1	—	1108.6	—	2241.7	354
1961	1129.5	—	1223.4	—	2352.8	362
1962	1152.1	—	1276.4	—	2428.6	396
1963	1159.4	—	1039.2	—	2198.6	377
1964	1132.6	—	927.2	—	2059.8	389
1965	1173.6	408	993.2	29	2166.8	446
1966	1166.9	437	813.5	24	1980.4	472
1967	1073.9	414	765.3	17	1839.1	440
1968	1064.1	468	822.8	29	1887.0	497
1969	1052.8	492	914.5	35	1967.3	527
1970	1150.8	565	1079.6	48	2230.3	613
1971	1107.2	604	1168.9	47	2276.1	651
1972	1104.5	702	1075.3	46	2180.0	748
1973	1087.7	836	1115.8	101	2203.6	937
1974	1132.2	844	1120.8	88	2253.0	932
1975	1118.1	904	1094.1	73	2212.2	977
1976	1258.7	1257	1185.2	92	2444.0	1349
1977	1339.0	1440	1051.9	114	2390.9	1554
1978	1441.1	1733	1293.2	121	2734.3	1854
1979	1505.0	2093	1337.7	141	2842.7	2234
1980	1657.4	2092	1282.8	145	2940.2	2237
1981	1608.9	2277	1102.2	111	2711.1	2388
1982	1490.1	2247	1398.0	143	2888.1	2390
1983	1468.7	2203	1452.0	152	2920.7	2355
1984	1505.9	2206	1414.3	144	2920.3	2350
1985	1494.1	2198	1344.5	128	2838.6	2326
1986	1539.1	2641	1196.6	122	2735.6	2763
1987	1789.9	2979	1338.1	136	3128.0	3115
1988	2081.1	3362	1181.2	158	3262.3	3520

[a]Thousands of metric tons, round weight; excludes weight of mollusk shells.
[b] Over 85% processed into meal, oil, and solubles. The remainder is used for shell products, bait, and animal food.
References: U.S. Department of the Interior 1960–1970; U.S. Department of Commerce 1971–1988.

The two countries together account for 40%–50% of world fish meal exports in the 1980s.

U.S. imports of fish meal have tended to follow the worldwide pattern of availability. As indicated in table 4, Peru provided us with 52%–90% of our imported supplies from 1960 through 1972. Peruvian imports declined significantly after the collapse of the anchoveta fishery, and the resulting void was not substantially filled by anyone else until the mid-1980s. In recent years, Chile has emerged as our major foreign supplier. We also import a modest but fairly steady amount of meal (averaging about 30,000 MT annually) from Canada, and smaller and more variable amounts from miscellaneous other countries.

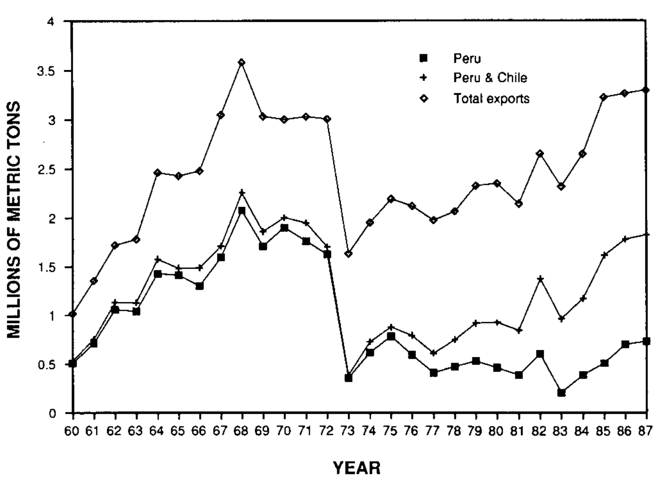

Figure 1. Fish meal exports by Peru, Chile, and all countries, 1960–87.

Up until 1970, U.S. fish meal exports were negligible and tended to be disregarded in published statistics. Exports have fluctuated widely from 4,300 to 77,400 MT during 1970–88. Exports exceeded imports in 1978, 1980, and 1983 (table 4).

Total fish meal supply (i.e., production plus imports minus exports) has declined somewhat in the post-1972 period relative to earlier years (figure 2). The variability in supply closely parallels the variability in net imports (i.e., imports minus exports). Domestic production (depicted by the difference between supply and net imports) has been much more stable by comparison.

TABLE 3
Fish Meal Production in the United States by Species (Thousands of Metric Tons)

Year	Menhaden	Tuna-Mack	Anchovy	Other	Total
1960	198.1	24.0	0.0	41.0	263.2
1961	224.6	19.2	0.0	38.6	282.4
1962	217.5	24.1	0.0	41.7	283.3
1963	167.1	24.5	0.0	40.6	232.2
1964	145.4	19.1	0.0	48.9	213.5
1965	159.7	23.0	0.0	47.8	230.5
1966	122.5	23.0	4.1	53.9	203.4
1967	108.0	23.1	5.1	55.3	191.6
1968	129.9	26.1	2.5	54.7	213.3
1969	144.7	24.4	10.3	49.8	229.2
1970	171.1	24.2	14.7	34.2	244.2
1971	200.5	26.6	7.0	31.6	265.6
1972	175.6	39.2	10.1	34.1	259.0
1973	171.3	39.6	20.0	22.4	253.2
1974	185.0	43.7	12.8	23.1	264.6
1975	173.6	33.7	25.1	20.9	253.4
1976	192.9	36.4	20.1	21.9	271.3
1977	175.4	36.1	17.3	19.6	248.4
1978	250.8	45.9	1.9	22.2	320.9
1979	254.7	43.0	9.0	22.5	329.2
1980	246.0	42.6	7.1	26.6	322.3
1981	209.4	42.8	9.3	19.9	281.3
1982	273.9	32.1	7.3	17.1	330.4
1983	286.6	37.8	0.5	14.2	339.0
1984	285.7	33.7	0.0	15.3	334.7
1985	279.0	31.3	0.0	9.3	319.6
1986	268.8	33.7	0.0	5.6	308.1
1987	303.4	38.3	0.0	8.0	349.6
1988	228.9	34.5	0.0	20.1	283.5

References: U.S. Department of the Interior 1960–1970; U.S. Department of Commerce 1971–1988.

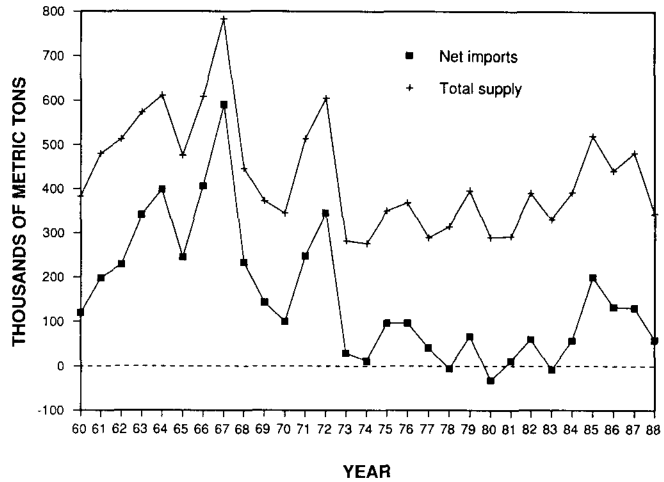

Figure 2. U.S. supply and net imports of fish meal, 1960–88.

PRICES

High-protein oil meals, like fish meal, are traded in a very competitive international market. The soybean meal price is generally considered to be a leading indicator for fish meal and other oil meal prices. Figure 3 is a graph of U.S. soybean meal and menhaden meal prices, both corrected for inflation to 1988 dollars. The prices are highly correlated, with the price differential largely attributable to the difference in protein content.

TABLE 4
U.S. Fish Meal Imports, Exports, and Net Imports (Thousands of Metric Tons)

Year	Imports by country of origin: Peru	Chile	Canada	Other	Total	Exports	Net imports
1960	61.7	19.1	28.1	10.8	119.7	—	119.7
1961	137.3	11.0	34.7	14.6	197.6	—	197.6
1962	168.9	8.3	38.8	12.9	228.9	—	228.9
1963	258.9	21.4	46.3	14.8	341.4	—	341.4
1964	315.7	11.7	49.7	21.2	398.3	—	398.3
1965	190.3	5.2	39.7	10.4	245.6	—	245.6
1966	250.9	81.1	39.6	34.6	406.2	—	406.2
1967	401.4	37.1	42.3	110.2	591.0	—	591.0
1968	182.6	18.3	13.0	19.2	233.1	—	233.1
1969	99.8	19.6	19.2	4.7	143.3	—	143.3
1970	73.9	6.4	22.4	2.4	105.1	4.3	100.8
1971	181.1	0.0	52.3	23.5	256.9	9.2	247.7
1972	319.5	0.0	25.0	11.1	355.6	9.4	346.2
1973	37.9	0.0	22.3	1.9	62.1	33.3	28.8
1974	26.7	0.0	27.5	7.8	62.0	50.3	11.7
1975	68.5	7.0	30.8	1.1	107.4	10.7	96.7
1976	72.0	0.0	30.8	24.6	127.4	30.0	97.4
1977	14.2	2.0	22.5	35.2	73.9	32.7	41.2
1978	6.0	0.0	29.7	4.1	39.8	46.0	−6.2
1979	25.6	7.5	24.7	23.5	81.3	14.2	67.1
1980	6.0	0.0	22.0	16.9	44.9	77.4	−32.5
1981	0.0	24.3	22.0	7.6	53.9	42.6	11.3
1982	4.7	42.8	22.4	6.6	76.5	16.2	60.3
1983	6.5	23.4	20.9	10.8	61.6	70.2	−8.6
1984	0.0	43.5	21.4	10.8	75.7	18.3	57.4
1985	0.0	131.6	23.0	77.0	231.6	31.4	200.2
1986	12.4	105.6	16.3	33.8	168.1	34.9	133.2
1987	27.9	94.4	29.2	27.1	178.6	46.9	131.7
1988	46.7	25.4	32.0	16.3	120.4	68.0[a]	59.4

[a]Error in published statistics corrected per Steve Koplin, NMFS, Washington, D.C., pers. comm.
References: U.S. Department of the Interior 1960–1970; U.S. Department of Commerce 1971–1988.

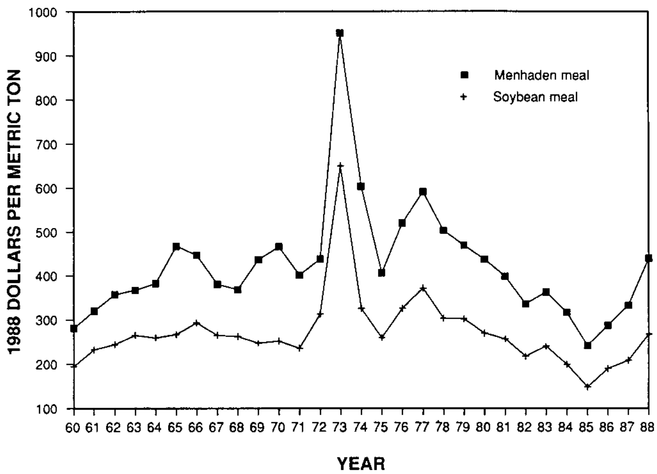

Figure 3. U.S. menhaden meal price (60% protein, bulk, f.o.b., East Coast/Gulf plants) and soybean meal price (50% protein, bulk, Decatur, Illinois) in 1988 dollars, 1960–88.

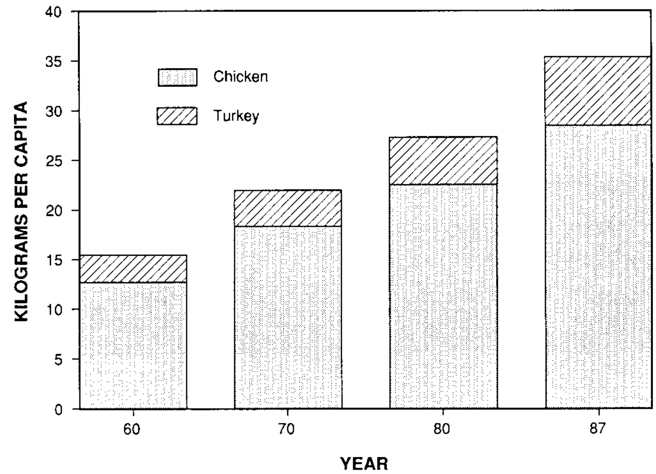

Figure 4. U.S. per capita consumption of chickens and turkeys in 1960, 1970, 1980, and 1987.

A notable feature of the graph is the 1973 price increase, which resulted from a serious worldwide shortage of oil meals. Several factors contributed to this shortage, including (1) major failures of oil meal crops around the world, (2) increases in fuel-related production costs due to the Arab oil embargo, and (3) the collapse of the Peruvian anchoveta fishery.

DEMAND

Demand for Poultry Products

In the years since World War II, the average American diet has shifted away from grain products in favor of more animal protein. This increased demand for protein is partially reflected in the shift from farm production of chickens to the factory-style mass production of commercial broilers that we see today. Approximately 80% of the fish meal consumed in the United States is used as an ingredient in poultry feed (Vondruska 1980). The final demand for poultry products is an indicator of poultry feed usage and the demand for fish meal.

U.S. egg production increased steadily from 61 billion eggs in 1960 to 70 billion eggs in 1967. In the twenty years since 1967, annual egg production has not exceeded the 1967 production level. This leveling of production is due to two offsetting factors: (1) a decline in per capita egg consumption, and (2) an increase in population. Because of increased productivity per layer, the stock of laying hens has declined slightly from 295 million hens in 1960 to 280 millions hens in 1987 (U.S. Department of Agriculture 1960–1988; Rogers 1978). These trends suggest that total feed usage by laying hens has not changed significantly since 1960.

The situation with regard to table birds is quite different (figure 4). Poultry consumption, measured in ready-to-cook weight, has more than doubled from 15.5 kilograms (kg) per person in 1960 to 35.3 kg in 1987. This change, compounded by the increase in population over this same period, has resulted in a dramatic increase in poultry production. Table birds slaughtered under federal inspection increased almost fourfold from 3.1 million MT (live weight) in 1960 to 12.2 million MT in 1987 (U.S. Department of Agriculture 1960–1988).

Accommodation of Poultry Industry to Limited Fish Meal Supplies

The large increase in poultry production has not been accompanied by a commensurate increase in fish meal usage. The poultry industry has accommodated itself to limited fish meal supplies by substituting other ingredients in poultry feed mixes, and by making technological changes to promote rapid growth of chicks.

Over 70% of the cost of producing chickens and turkeys, excluding processing and marketing costs, consists of feed (Vondruska 1980). As a result, small changes in feed prices can have a major effect on total costs. U.S. poultry feed mixers are very sophisticated in their use of linear programming techniques to determine least-cost combinations of ingredients (Hansen 1981/1982). They are also very quick to change feed composition in response to changes in prices (Huppert 1980; Thomson 1984).

The role of fish meal in these linear programming models is best understood by examining its nutritional contribution to poultry feed. All fish meal contains lysine and methionine, which are essential for the development and rapid growth of chicks. These amino acids are not found in grain meals, except for soybean meal, which contains high levels of lysine. Lysine and methionine are also available in synthetic form. The synthetic versions can be used to obtain a proper amino acid balance in feed mixes that do not contain fish meal (Titus and Fritz 1971; Vondruska 1980; Hansen 1981/1982).

Including fish meal in the diet of laying hens reduces mortality by retarding the accumulation of fat in their livers (Ralph Ernst, USDA/UC Cooperative Extension, Oakland, Calif., pers. comm.). Fish meal also produces a significant growth response in table birds. Nutritional requirements for table birds depend upon a bird's stage of growth, so feed composition varies accordingly. For chickens and turkeys, the maximum inclusion rate for fish meal is about 8%–9% for starter rations and 7% for grower rations. Higher rates than this tend to give a "fishy" flavor to the final product. Desirable minimum inclusion rates are 1%–2% for starter rations and 0%–1% for grower rations (Vondruska 1980).

Thus, one way that feed mixers have been able to satisfy the increased demand for poultry feed in spite of having smaller amounts of fish meal has been by substituting other ingredients. For table birds, they have reduced fish meal from maximum to minimum recommended levels in starter rations and eliminated fish meal entirely from grower rations. They have also largely eliminated fish meal from layer rations (Ralph Ernst, USDA/UC Cooperative Extension, Oakland, Calif., pers. comm.). These changes are consistent with Kolhonen's (1974) prediction that, "In the long run fish meal will be used as a unique small-quantity ingredient in high-quality feeds rather than as a high-amount protein source."

Fish meal use has also been reduced by technological improvements resulting in shorter time to market for chickens and turkeys. In 1960 it took approximately nine weeks to bring a three-pound broiler to market; today it takes six weeks (Ralph Ernst, USDA/UC Cooperative Extension, Oakland, Calif., pers. comm.). As a result, feed requirements (including fish meal requirements) per bird have declined.

FUTURE TRENDS

Aquaculture Demand for Fish Meal

Aquaculture production in the United States almost tripled from 1980 to 1985 (table 5). World production has also increased dramatically, from 4.6 million MT in 1975 to 8.9 million MT in 1985 (table 6). Currently about 10% of the world's fish meal production is used to feed farm-raised finfish and shellfish (FAO 1989). By one estimate (Rhodes 1988), world aquaculture production will reach 22 million MT by the year 2000 and account for about 25% of the world's aquatic harvest. This and other similar projections suggest a long-term increase in demand for fish meal in aquaculture.

TABLE 5
U.S. Aquaculture Production, 1980 and 1985, by Species Group (Metric Tons)

Species group	1980	1985
Catfish	34,855	123,344
Salmon	3,455	38,320
Crawfish	10,849	29,545
Trout	21,836	23,000
Baitfish	10,000	11,276
Oysters	10,755	10,215
Other finfish	–	6,364
Other shellfish	391	1,411
Total	92,141	243,675

Reference: Rhodes 1988.

TABLE 6
World Aquaculture Production in 1975, 1980, and 1985, by Species Group (Thousands of Metric Tons)

Species group	1975	1980	1985
Finfishes	2628.8	3206.8	5697.2
Crustaceans	29.7	75.0	281.6
Mollusks	1961.2	3299.7	2885.7
Subtotal	4619.7	6581.5	8864.5
Seaweeds & other	NA	NA	3565.1
Total	NA	NA	12429.6

Reference: Rhodes 1989.

Alternative Uses for Fish Oil

The National Fish Meal and Oil Association submitted a petition to the U.S. Food and Drug Administration in 1986 requesting approval to use hydrogenated and refined fish oils in products for human consumption. The FDA recently granted approval for the hydrogenated oil, paving the way for its use in products such as shortenings and pastries. However, because of U.S. Department of Agriculture standards for margarine, fish oil still cannot be used in margarines.

The portion of the petition pertaining to refined fish oil is still pending. Unlike hydrogenated oil, refined oil contains omega-3 fatty acids, which have been shown to provide a wide variety of health benefits (Pique 1986). Adding refined fish oil to products such as salad dressings could enhance their nutritional value and marketability. However, the long-term prospects for this are uncertain, since (1) FDA approval may or may not be forthcoming, and (2) the technology necessary to address the problem of rancidity in refined oil is not well developed (Paul Bauersfeld, NMFS, Charleston, S.C., pers. comm.).

Japanese and South American Sardine Fisheries

Japan has historically been a major world producer of fish meal. From 1960 through 1971 Japan produced 9%–15% of the world's fish meal; its share of production increased to 15%–21% from 1972 through 1987. Until the mid-1980s Japan was also a net importer of meal (table 7).

Japan derives most of its fish meal from its sardine *(Sardinops melanosticta)* fishery, which has produced two periods of high yield in this century. Japan's sardine landings increased through the early 1900s to a peak of 1.75 million MT in 1935, then gradually declined to 9,200 MT by 1965 (Lluch-Belda et al., in press). Since 1965, landings have again increased dramatically (figure 5). Although Japan continues to take most of the harvest, the Soviet Union and South Korea have also participated in the fishery since the late 1970s.

TABLE 7
World Production and Japanese Production, Imports, and Exports of Meals and Solubles from Animals of Aquatic Origin (Thousands of Metric Tons)

Year	World production	Japan Production	Japan Imports	Japan Exports
1960	2,076.0	312.7	19.4	6.3
1961	2,580.0	362.2	23.3	4.9
1962	2,900.0	390.0	38.5	18.1
1963	2,902.0	328.4	84.3	3.6
1964	3,666.0	353.1	102.3	6.2
1965	3,615.0	344.5	112.6	13.1
1966	4,170.0	423.5	95.6	15.8
1967	4,660.0	420.3	86.8	11.3
1968	5,060.0	500.5	150.2	6.8
1969	4,750.0	594.2	108.0	183.0
1970	5,450.0	671.0	94.7	24.5
1971	5,400.0	692.0	21.7	37.7
1972	4,320.0	735.9	56.8	28.6
1973	4,020.0	791.0	87.3	17.8
1974	4,570.0	773.7	74.5	31.3
1975	4,510.0	839.6	70.6	49.3
1976	4,890.0	745.9	59.5	49.0
1977	4,575.4	857.2	181.1	37.5
1978	4,916.1	890.2	84.9	64.3
1979	5,089.9	895.6	101.6	57.7
1980	4,971.9	879.9	141.0	43.3
1981	5,056.2	898.9	84.1	73.7
1982	5,394.1	1,004.1	44.3	135.7
1983	5,282.6	1,133.5	95.1	79.6
1984	6,097.7	1,262.7	61.6	135.3
1985	6,275.2	1,166.6	80.3	157.4
1986	6,661.3	1,179.1	161.5	167.2
1987	6,394.6	1,112.7	187.3	216.6

Reference: Food and Agriculture Organization 1960–1987.

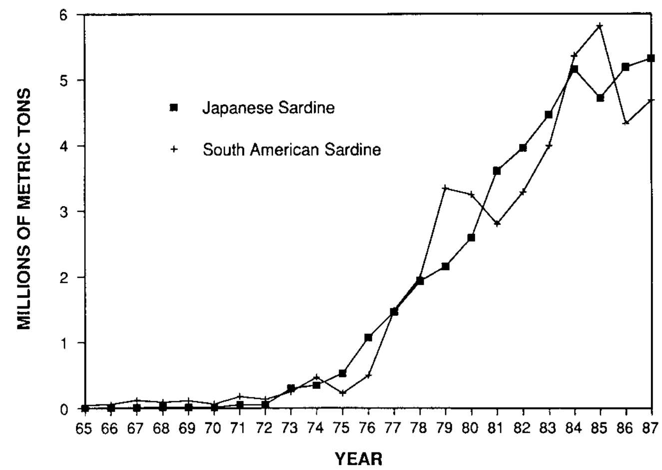

Figure 5. Landings of Japanese and South American sardine, 1965–87.

The South American sardine *(Sardinops sagax)* fishery has experienced similar rapid growth in the past two decades. Annual sardine landings by Chile and Peru have increased from negligible amounts in the mid-1960s to approximately 5 million MT (figure 5).

Given the record harvests experienced in recent years, the sardine fisheries of Japan and South America warrant close attention. A change in the status of these stocks could significantly affect the availability and price of fish meal.

New Products from Reduction Species

Efforts are ongoing to develop marketable products for direct human consumption from species traditionally used for reduction. For instance, a processor in Virginia has been exploring the economic feasibility of making a marketable surimi from menhaden (Malcolm Hale, NMFS, Charleston, S.C., pers. comm.). The Fishermen's Cooperative in San Pedro, California, is test-marketing canned sardines for human consumption. Although the ultimate outcome of these enterprises is uncertain, the expectation is that alternative uses will be found for reduction species over the long term.

Americanization of the Alaska Pollock Fishery

Significant increases in U.S. harvesting of and processing capacity for the Alaska pollock *(Theragra chalcogramma)* have resulted in a drastic curtailment of foreign landings and joint venture operations in recent years. As indicated in table 8, landings of Alaska pollock by foreign vessels declined from an

TABLE 8
Landings of Alaska Pollock (Metric Tons)

Year	Domestic	Joint venture	Foreign	Total
1977	323	0	1,009,826	1,010,149
1978	1,765	0	1,074,077	1,075,842
1979	2,551	0	1,047,150	1,049,701
1980	1,409	11,800	1,119,126	1,132,335
1981	1,741	58,950	1,117,455	1,178,146
1982	1,479	128,886	1,051,949	1,182,314
1983	1,382	283,104	973,050	1,257,536
1984	10,894	444,256	1,032,249	1,487,399
1985	42,109	614,337	851,870	1,508,316
1986	59,160	904,111	352,682	1,315,953
1987	250,407	1,057,315	3,596	1,311,318
1988	570,285	826,564	0	1,396,849

Reference: U.S. Department of Commerce 1977–1988.

approximate annual average of one million MT during 1977–85 to zero in 1988. Joint venture landings, which peaked at one million MT in 1987, are also expected to decline to zero in 1990, and domestic landings are expected to increase commensurately.

With the Americanization of the fishery and recent increases in fish meal processing capacity in shoreside plants and aboard U.S. factory trawlers, pollock meal is expected to become an increasingly large component of U.S. fish meal production. Additional impetus may be provided by the North Pacific Fishery Management Council, which is currently considering a change in regulations to require full use of the resource. Should such an amendment be adopted, it could lead to similar requirements for other Alaska groundfish species.

In 1988, the United States produced approximately 15,000 MT of pollock meal from the offal generated in the preparation of surimi and fillets/blocks (Vondruska et al. 1989). Assuming a fish meal yield of 10% from round weight (Steve Koplin, NMFS, Washington, D.C., pers. comm.) and an average annual harvest of 1.2 million MT, U.S. pollock meal production could reach 120,000 MT annually. This would be a significant addition to the 200,000 to 350,000 MT of fish meal that we currently produce each year.

Much of the pollock meal produced in recent years has been exported to Taiwan's eel farms (Jerry Babbitt, NMFS, Kodiak, Alaska, pers. comm.). Future increases in pollock meal production may also be exported abroad rather than absorbed into the U.S. market. Depending on the magnitude of this trade, the United States could reverse its long-standing status as a net importer of fish meal and become a net exporter.

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