ALASKA SEAFOOD BY-PRODUCTS: POTENTIAL PRODUCTS, MARKETS AND COMPETING PRODUCTS. Revised 2008

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1. EXECUTIVE SUMMARY

Alaska accounts for about 51% of the total US landings of fish and shellfish with wild Alaska salmon representing about 8% and pollock 31% of the total US fish landings (1994-2007). According to an Alaska Dept. of Economic Development report, approximately 60% of the salmon harvested in Alaska is used for human consumption when the fish is canned, fresh or frozen. The remaining 40% is waste (head, fins, viscera, etc.). If salmon are harvested for roe (e.g. chums) as much as 90% of the fish by weight is waste. Chum salmon represent about 12.5% of the Alaska salmon landings. A 1988 University of Alaska report on seafood waste indicated that the amount of waste could vary from 31-38% in canning. Data for 2001 from the same

group reduces this figure for canning to around 28%. None of these figures include whole fish which may have been damaged or are otherwise not suitable for processing. Various researchers in Alaska (Bechtel, Crapo, Oliviera, Smiley and others) put the total fish waste figure at about 1.5 million tons annually. Our estimate based on 46% waste is 1.1 million metric tons average over the period 2000-2007.

There are many options for utilizing the by-products (wastes) generated by the seafood industry. Options that might work in one location or area will not be economical in another area. Generally, the options span the range from disposal of the seafood waste with no added value achieved (and perhaps involving a disposal and hauling cost) all the way to the development of high valued biochemical products. **The tendency throughout the global seafood industry has always been to select the options with the least investment and least penalties or consequences. Thus the conversion of seafood waste to by-products or co-products normally does not take on a high priority until the penalties or consequences of disposal outweigh the benefits.** In many areas the disposal of fish waste is a breakeven venture with the sales of any products balancing out the costs. In those areas, disposal has a defined cost which seems to increase each year. When there is sufficient waste in defined areas, the production of fishmeal and oil makes sense because there are existing markets for these products and demand continues to increase. Markets have been established in various livestock feeds here in the USA as well as in Europe, and Asia. These markets cover feeds for poultry, pigs, ruminants, fish, crustaceans, fur bearing animals and pets (or companion animals as they are now known). From season to season there is no "left-over" fishmeal and oil unless the producer wants to hold back material. In areas where the volume of waste is small and not concentrated in one area, other products geared towards the small processor or entrepreneur are more likely to be pursued although these products must generally be market driven.

The global aquaculture market is the major consumer of fishmeal and oil. However you cannot feed "same species" proteins so alternative species must be targeted for the fishmeal. The major aquaculture markets are in Asia, particularly China and this does offer Alaska some advantages over competing fishmeals. By-product fishmeals tend to be high in bone especially if they come from efficient edible processing plants. Data on the composition of the meals and some established standardization of quality will be important if one wishes to enter the premium markets.

Premium markets for fishmeal exist in aquaculture, early weaned pig feeds, milk replacer and ruminant diets (however the use in ruminants in the EU is still not resolved because of the BSE issue). Premium fishmeal is also used in designer eggs and designer poultry feeds where the omega 3 content of the eggs and meat is enhanced. A market for organic fishmeal and oil also exists. If Alaska salmon and pollock can be certified as organic this will add another unique dimension to the by-products. Alaska salmon and pollock are certified by the Marine Stewardship Council (MSC) as coming from a certified sustainable source. Assuming the MSC certification can be administratively extended to the salmon and pollock fishmeal and oil, it would offer an additional unique dimension to the products. Establishing premium markets for fishmeal and oil and or alternative products does not simply mean giving the product a premium name. It takes work to convince the market that the products are premium grade and should command premium prices. This type of research work includes composition data, feeding trials,

and more sophisticated testing when needed. It also requires a commitment to provide a uniform product over a long period of time. So, consistent quality and volume are important features of premium fishmeals. It took the global fishmeal and oil industry many many years to develop the premium fishmeal market, which today commands premium prices over the commodity grade fishmeal.

Fish oils are used in a variety of markets including industrial uses, food, feed, aquaculture and nutraceutical applications. The aquaculture market requires oils with low levels of oxidation, low levels of contaminants and consistent quality. The nutraceutical market wants oils low in oxidation and contaminants but also with high levels of omega 3 fatty acids. This market pays premiums for high levels of omega 3 and wild salmon oil might be able to command a premium in that market if only because of the name. However the omega 3 content of salmon oil might present problems. Recently the nutritional oil companies have revised their definition of Omega 3 to include the sum of C18:3, C18:4, C20:4, C20:5, C21:5, C22:5 and C22:6, all n-3 fatty acids. This revision might open the door for salmon oil.

Commodity prices for fishmeal and oil are published and historical data is easy to find. Prices for nutraceutical oils are not easy to find and generally the market price is what the buyer is willing to pay and the supplier is willing to accept. Prices for these oils vary from lows of US$1 -$2/kg up to and exceeding US$15/kg. The higher the omega 3 and the lower the level of oxidation and contaminants the higher the value of the oil. Companies are looking for wild salmon fish oil and anyone who can supply a product with consistent quality and availability will have no problem entering this market. Nutraceutical fish oil sales require special packaging and enhanced customer support over and above what is normally done with commodity fish oils.

One of the major issues in Alaska is logistics. The raw materials are spread out over wide areas, some of them inaccessible and in some areas the volume is very small. There are alternative products that can be produced. These products are market driven and in many cases contain high amounts of water so transportation costs become critical. These products include silage, hydrolyzates and compost. There is a tendency to interchange hydrolyzates, silage and digest nomenclature. There is less information available on prices for these products. Composts and liquid fertilizers (silage) are advertised on the internet and most information about fish silage and compost products seems to indicate that the manufacturer can't keep enough material in stock to supply the market. Liquid fertilizers are offered on the internet in small bottles, 5 gallon pails, drums and totes. The product is used for golf courses, cranberry bogs and other crops. Years ago it was used in mushroom compost. Normallly agricultural use may not be the best application for these products in Alaska but soil remediation after mining operations, landscaping, reforestation projects etc. might have some application for these products. A recent headline from Alaska indicates that fertilizers are in short supply and the prices have increased 400% so there could be a market for fish waste in agriculture now. Composts can take advantage of the availability of lumber waste (wood chips and sawdust). These products are market driven so it is important to approach the problem from the market end and not the other way around. A good portion of the Alaska fishmeal is deboned to increase the protein content. This results in a by-product bone meal. Some recent work, including a patent, has come to light and is discussed within the report. It would seem a natural fit for the issue of mining waste discharges vs. fishing operations.

One thing that became apparent in updating this report is that there has been consolidation in the global fishmeal industry and also the array of products within each company. For educational purposes only I ran a calculation for the entire state of Alaska, assuming 46% waste, a 5:1 ratio of waste to fishmeal and a nominal 2% of waste oil yield. The figures are an eye opener, assuming a 5 year running average for meal and oil prices, over the period 2000 – 2007 Alaska could have produced somewhere between $80 million and $170 million of fishmeal and $7 - $22 million of fish oil. Fishmeal and Oil prices have dropped off of their highs and are now back to the 5 year average figures but during the peak price period the dollar figures were quite high. Obviously not all of the waste is available but the figures are still rather interesting and raise the question of what if I had a plant operating instead of discharging the waste during that time period?

This report is broken down into 8 sections: 1. Statistics on the global situation covering fish landings, fishmeal and oil production compared to world protein meals and world fats and oils production, 2. Fishmeal and fish oil general markets, 3. Product categories for fishmeal and oil and descriptions of alternative as well as competing products, 4. Product quality and composition information for fishmeal and oil as well as alternative and competing products, 5. Geographical markets for fishmeal and oil, 6. Global as well as domestic pricing information for fishmeal and oil as well as alternative and competing products, 7. The Alaska situation and 8. Advantages and disadvantages of salmon by-products and 4 sections covering an Executive Summary, Introduction, Tables list and Figures list.

I've included Alaska products and companies where I could find an internet link. I am sure I missed some and if so I apologize.

The document is quite large. It is difficult to produce a one size fits all report. Hopefully, everyone who reads the report will be able to extract the information that is of value to their particular operation. The previous report was circulated globally and there are still requests for copies.

This report will primarily cover fishmeal and fish oil and their related markets because more information is available about these products and the markets are mature. Other potential fish derived products such as hydrolyzates, silage, bone meal, compost and fish solubles will also be covered. There is less commercial information available about these products, but there is more than what was available when we produced the first report. Hydrolyzates, silage and solubles can enter the same markets as fishmeal depending on quality and price. While fishmeal and fish oil are commodity products, the other potential fish derived products will be market driven i.e. the local demand should drive the production. In order to understand the various product types and markets it would first be necessary to understand a little about the fishmeal and oil industry, how it fits into the overall proteins and fats and oils markets and some basic statistics. As with most reports that use statistics, you find yourself in a Catch 22 situation. The longer you wait for statistics, the longer it takes to produce a report and then a new set of statistics comes out and you start all over again. This is as up to date as possible under those circumstances.

2. STATISTICS

World Fish Statistics

World fish catch statistics are somewhat misleading since they appear to be showing that there has been a sustained annual growth in fisheries of about 9% over the period 1950-2006 (the last year for which this data is available). This is represented in the following figure.

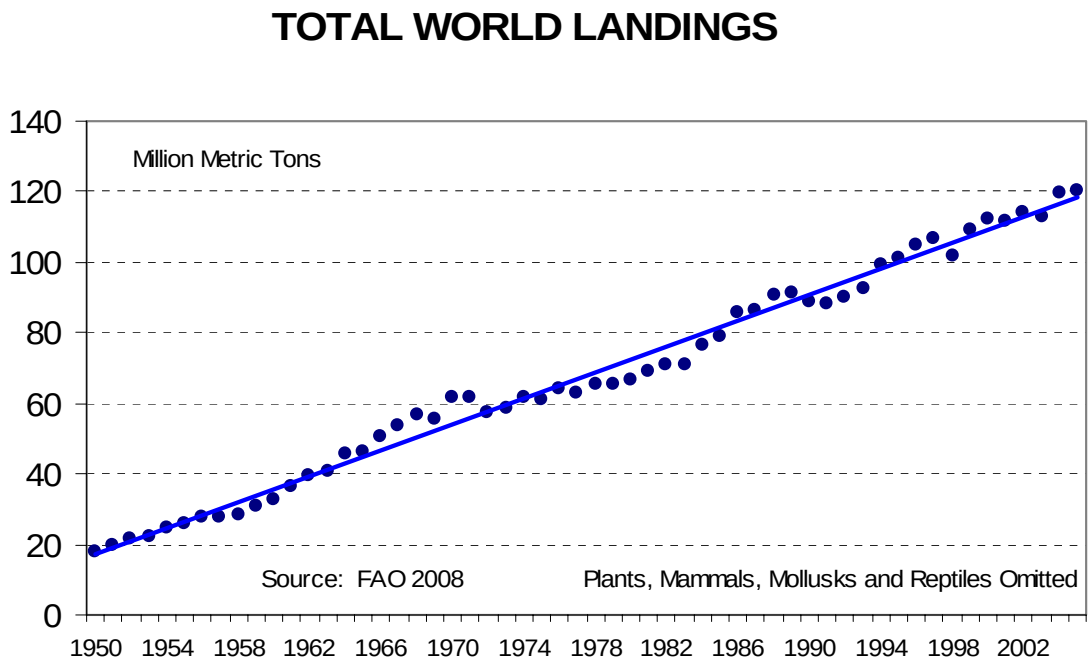


Figure 1 World landings of fish and shellfish.

According to Food and Agriculture Organization of the UN (FAO) data, between 1953 and 1970 the world catch of ocean fish rose at an overall rate of about 5.7% per year, and between 1971 and 1989 the growth dropped to 2.3% per year. Between 1990 and the present the growth has dropped even further to 0.3% per year. Closer examination of the data, however, reveals that while landings from the oceans have slowed down, freshwater landings and aquaculture production have been increasing. Data specific to aquaculture was not separated from fresh water landings until 1984. So while the world landings of fish and shellfish appear to be increasing and reached 122 million metric tons in 2006 (the last year for which statistics are available) a closer look at the data shows that the marine capture segment has been relatively static for a long period of time and all of the growth is coming from aquaculture development. This can be seen in the following figure.

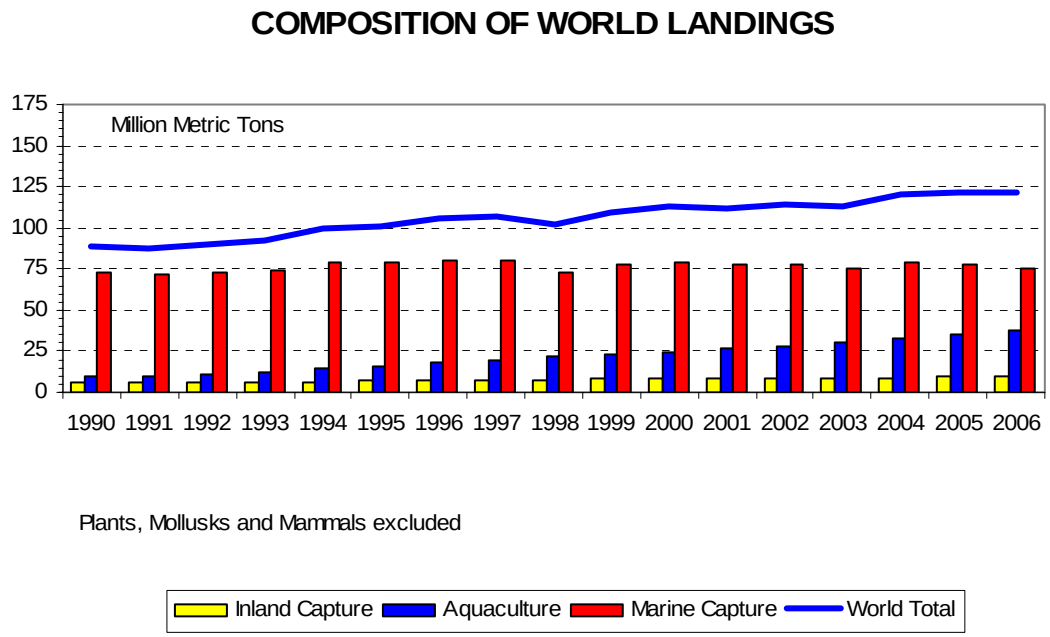


Figure 2 Composition of world landings.

The distribution of the world catch indicates that about 20-25% is specifically for fishmeal and oil production while the remaining 75-80% is distributed among fresh, canned, frozen, cured and other uses. This can be seen in the following figure.

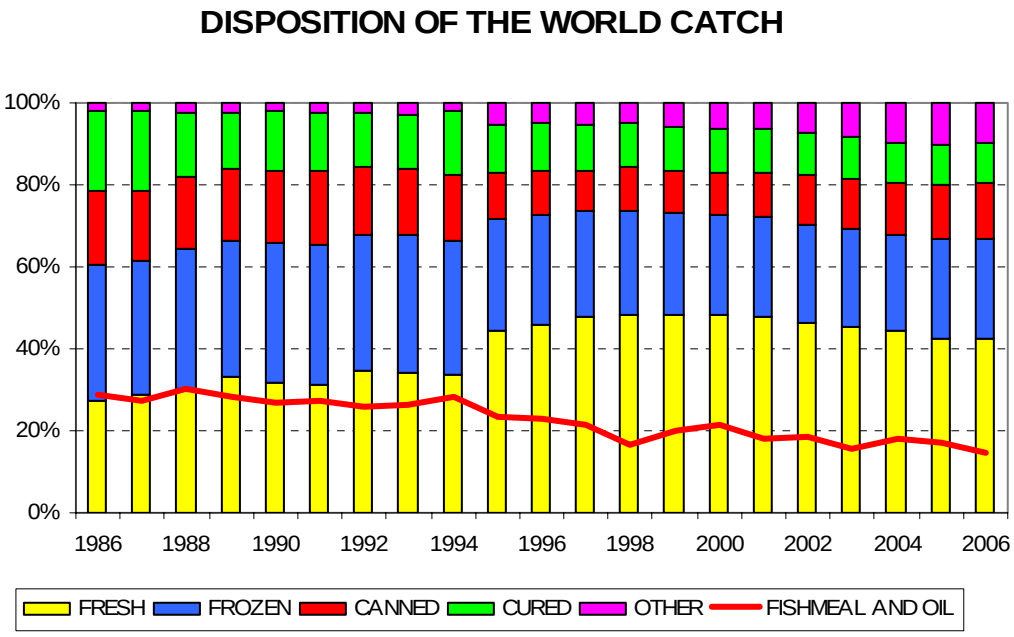


Figure 3 Distribution of the world fish catch.

These figures ignore the trimmings and offal that is also converted or potentially could be converted into fishmeal, oil or silage type products and discards that never make it to the dock. These food uses (other than fishmeal) offer opportunities for additional fishmeal and oil production as well as other products that can be extracted from the waste. Waste from the edible operations is conservatively estimated at 50%, but can range from 10%-90% depending upon the species of fish and the intended use. It is difficult to put an accurate figure to this waste since the fish sold as fresh, can be fish taken home by the consumer or sold to a restaurant. In that case the waste is simply discarded in the garbage for disposal and could not be easily recovered. The data clearly shows a trend away from the processed products (cured, frozen and canned) and towards the products sold fresh. Experts indicate that this is a trend demonstrating that as the third world countries continue to develop their populations demand more proteins including fish protein which is then consumed at home.

There are about 12 species of fish used for the production of fishmeal and oil. Some of these are listed in the following table along with the countries where these fish are caught.

SPECIES OF FISH CAUGHT FOR FISHMEAL AND OIL PRODUCTION.	
SPECIES	**COUNTRY**
Anchovy	Peru, Chile, So. Africa, Namibia, Mexico, Morocco
Jack Mackerel	Peru, Chile
Capelin	Norway, Iceland, Russian Federation
Menhaden	USA, Atlantic and Gulag of Mexico
Blue Whiting	Norway, UK, Russian Federation, Ireland
Sand eel	Denmark, Norway, Faeroe Islands
Norway Pout	Denmark, Norway, Faeroe Islands
Sprat	Denmark, Russian Federation

Table 1 Species of fish caught for fishmeal and oil production.

These fish are generally classified as pelagic. They are small, oily, bony fish not generally suited for food use now but might someday be upgraded when markets are developed and the technology to manufacture food products from them improves. For the present, they are indirectly transformed into human food products through the conversion to animal proteins in the form of feeds for poultry, pigs, ruminants, fish and crustaceans. The state of the utilization of the industrial fish species in the world has been reported by the FAO. On the basis of a classification of moderately fished, fully fished and depleted stocks, none of the industrial fish species are considered depleted. Industrial fishing is undertaken by conventional fishing vessels using conventional nets with government controlled mesh sizes. World wide nearly all of the industrial fish caught are subject to quotas. These are set by government bodies on the basis of scientific advice to ensure that the stocks are sustainable. No significant impact of industrial fisheries on availability of food for other predator species has been reported by independent scientific investigation. The industrial fisheries in Europe, North and South America are sustainable and ecologically sound. The fish oil and meal industry believes it is necessary that industrial fisheries continue to be controlled and managed, based on scientific advice, by elected representatives of society in order to maintain this resource in a manner that is biologically, economically and socially sound.

The following table shows the current regulatory and sustainability issues regarding the main species used for the production of fishmeal and fish oil.

Species	TACs	Area Catch Limits	Closed Areas	Seasonal Bans	By-catch Limits	Type of Gear*	Effect on Seabed	Minimum Mesh Size	Minimum Fish Landing Size	Vessel Registration	Satellite Tracking	ITQ System
SOUTH AMERICA												
Anchovy	√	√	√	√		P	None	√	√	√	√	
Jack Mackerel	√	√	√	√		P	None	√	√	√	√	
Sardine	√	√	√	√		P	None	√	√	√	√	
N.E. ATLANTIC and NORTH SEA												
Sandeel	√	√	√	√		T	Slight	√		√	√	
Sprat	√	√	√	√		P	None	√		√	√	
Norway Pout	√	√	√			P	None	√		√	√	
Blue whiting						MT	None	√		√	√	
Capelin	√	√	√	√		P, MT	None	√	√	√	√	√
Herring	√	√	√	√	√	P, MT	None	√	√	√	√	√
N.W ATLANTIC / GULF OF MEXICO												
Menhaden			√	√	√	P	None	√		√		
Source: http://www.iffo.net/default.asp?fname=1&sWebIdiomas=1&url=110												

***P=purse seine; T=light weight trawl: MT=mid-water trawl**

Table 2 Regulatory and sustainability issues with pelagic fish species.

A number of fish species are caught or raised principally for food use and their cuttings are then converted into fishmeal and oil or other products. These species are listed in the following table.

FISH TRIMMINGS USED FOR FISHMEAL AND OIL PRODUCTION.	
SPECIES	**COUNTRY**
Catfish	USA, Vietnam
Tuna sp.	Thailand, Japan, USA, Australia, South Korea, China, France, Ecuador, Maldive Islands and Others
Salmon	Norway, USA- Alaska (wild), UK, Ireland, Canada, Chile, Japan (wild)
Sardine/Pilchard	Peru, Chile, South Africa, Namibia, Japan, Spain, Mexico
White Fish sp.	UK, USA-Alaska, Canada, Chile
Dogfish	Canada, USA
Pollock	USA-Alaska
Horse Mackerel	Ireland, Norway, Denmark, Spain
Atlantic Herring	Iceland, Norway, Denmark, UK, Faeroe Islands, Sweden, Ireland, Canada
Mackerel sp.	UK, Peru, Chile, South Africa
Hoki (Blue Grenadier)	Australia, New Zealand

Table 3 Fish trimmings used for fishmeal and oil production

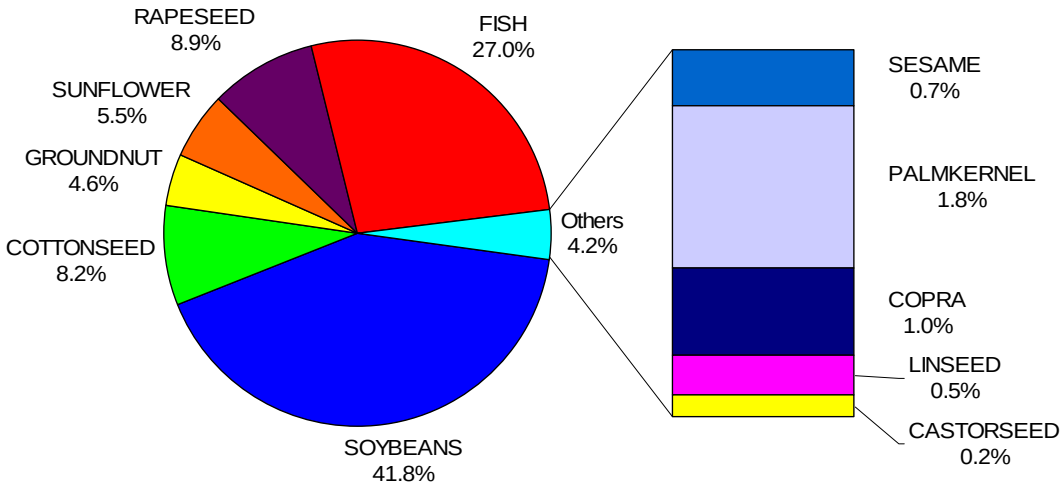
The USA represents about 4% of the world's fish landings and Alaska accounts for about 50% of the US landings. The rise in the Alaska landings coincides with the Alaska pollock fishery which accelerated in the mid 1980's. Pollock now accounts, on average, for about 31% of the US landings of fish.

At one time, the menhaden fishery accounted for almost 50% of the US landings. Menhaden are caught along the Atlantic and Gulf coasts of the USA and the fish are used entirely for fishmeal and oil production. Attempts to convert this fish to food use (surimi) were technologically successful, however yields were low and the technology was not pursued. Menhaden landings have been relatively static over a long period of time and their percentage of the US landings has decreased as the Pollock fishery has developed until today, menhaden (Atlantic + Gulf) represents about 18% of the US landings of fish and shellfish.

Oil Seeds vs. Fish Landings

The world harvests about 337 million metric tons of oilseeds per year. Fishing is the last major industry that relies on hunting and gathering and competes with agricultural products in a variety of markets. If one were to compare the production of oilseeds as a source of protein and oil to fish, we would find that fish landings represent about 27% of the total. A 5 year average comparison of fish landings to oilseed production is shown in the following figure.

GLOBAL OILSEED PRODUCTION COMPARED TO FISH LANDINGS



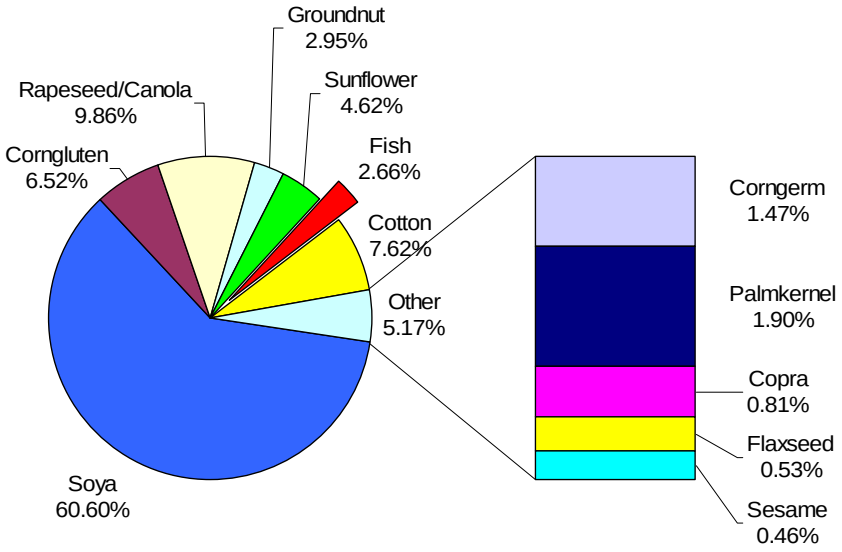
5 Year average harvest of oilseeds 379 million metric tons
5 Year average fish harvest 140 million metric tons

Figure 4 World oilseed harvest vs. fish landings, 5 year average.

Oil Meals Including Fishmeal

Oilseeds are processed into protein meals and fats or oils, while fishmeal is processed into fishmeal and oil. However only about 25% of the fish landings are processed into fishmeal and oil compared to most of the oilseed products. The world produces on average, about 159 million metric tons of protein meals per year. Fishmeal competes with these other protein meals on the world market and represents about 3% of the total availability of these proteins. This can be seen in the following figure.

FISHMEAL VS. OILSEED MEAL PRODUCTION
5 YEAR AVERAGE



5 Year average production of oilseed meals 218.5 million metric tons
5 Year average production of fishmeal 5.96 million metric tons

Figure 5 World protein meals compared to fishmeal, 5 year average.

Fats and Oils Including Fish Oil

The world produces about 92 million metric tons of fats and oils per year on average. When we compare the relative production of fish oil to that of the world's vegetable oils we find that fish oil only represents about 0.75% of the total world production of fats and oils. This can be seen in the following figure.

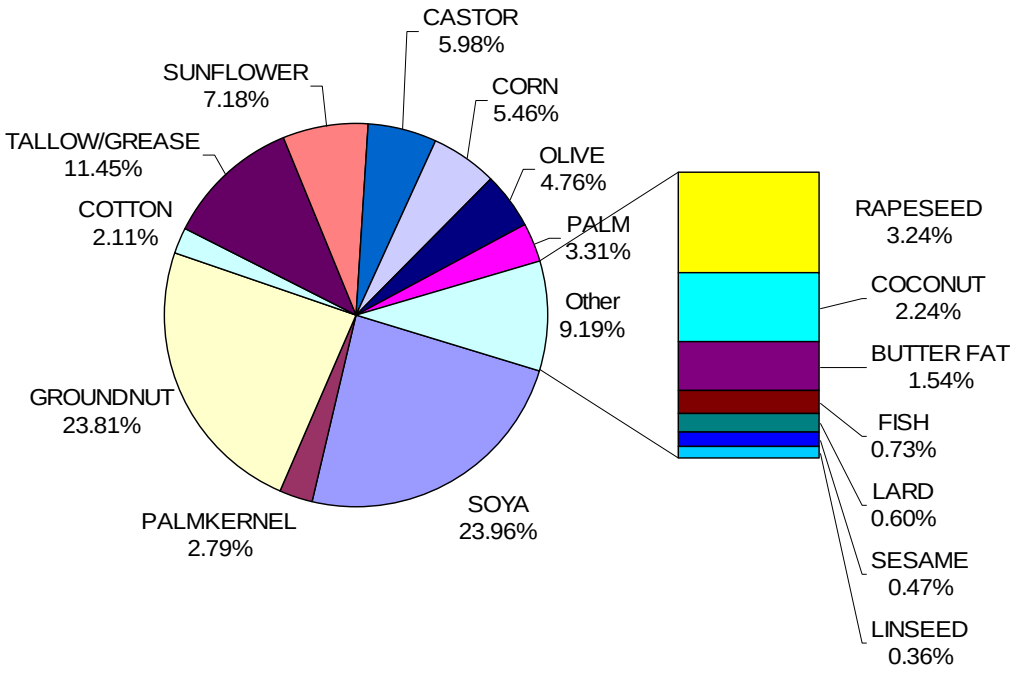


Figure 6 F ish oil production compared to world fats and oils, 5 year average.

If we were to segregate the commodity fats and oils from the specialty fats and oils, we would find that fish oil represents a small part of the specialty oils (4.2%). Specialty oils are defined as oils or fats with unique properties that cannot be easily replaced by other fats and oils. This can be seen in the following figure.

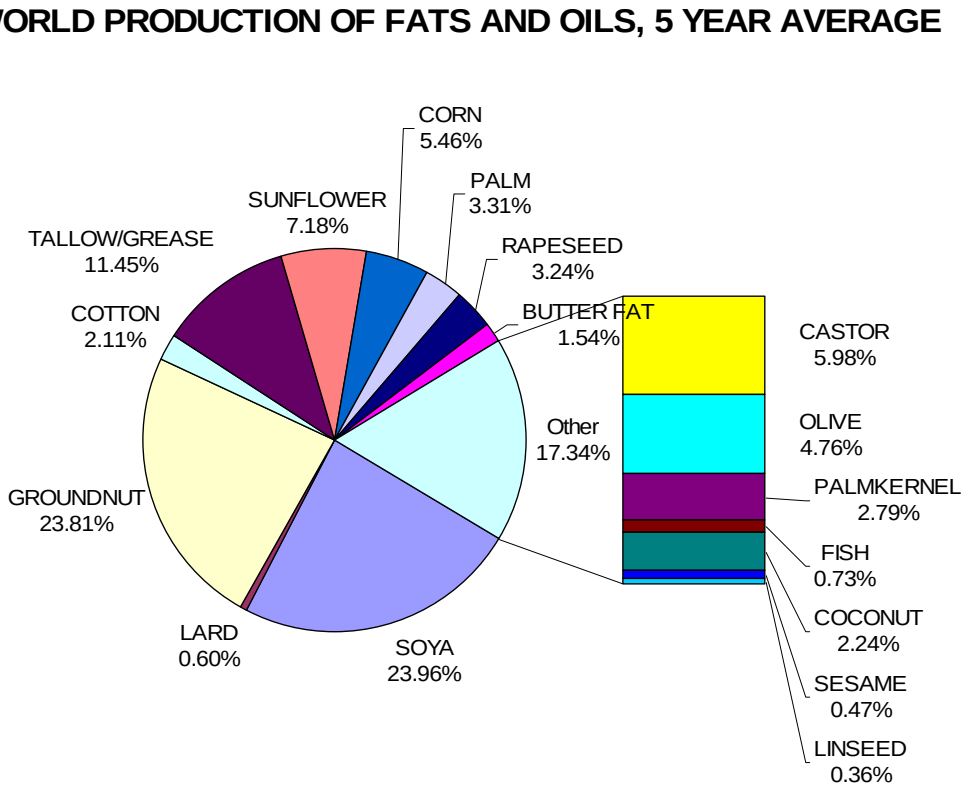


Figure 7 World specialty fats and oils vs. the commodity fats and oils, 5 year average.

3. FISHMEAL AND FISH OIL MARKETS

Fishmeal

Introduction

From a global perspective, most of the world's fishmeal is produced by 7 geographical entities and an "others" category. For this report, I've removed Denmark and Sweden from the EU27 and included them in Scandinavia. Fishmeal production is shown in the following figure.

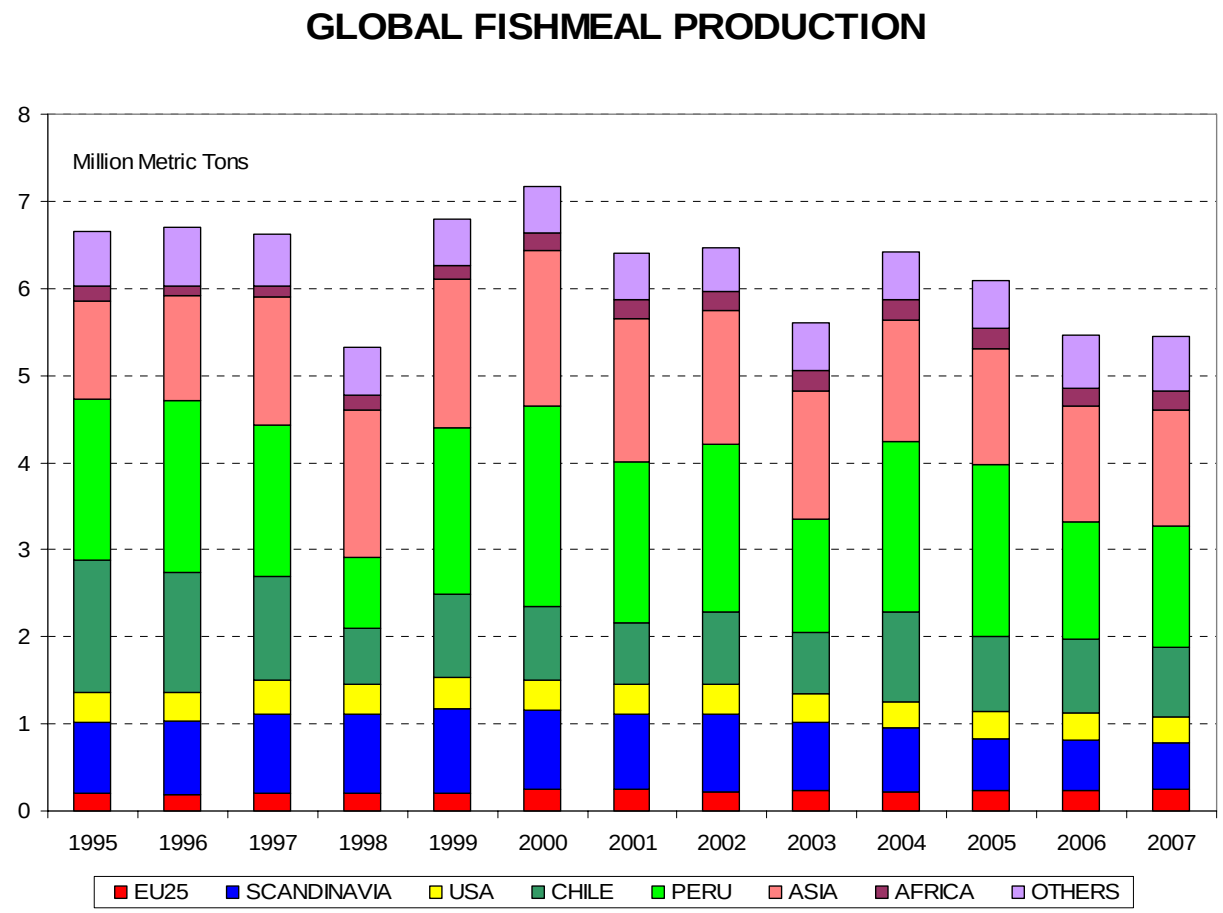


Figure 8 Global fishmeal production.

Fishmeal is used in feeds for poultry, pigs, ruminants, fish, crustaceans, pets and fur-bearing animals because it increases productivity and improves feed efficiency. Fishmeal has been used as a feed ingredient for farm animals in the USA for over a century. It provides a unique balance of essential amino acids, energy, vitamins, minerals and trace elements which complement other feed ingredients. It does this by correcting their deficiencies. Fishmeal is also a good source of the amino acid taurine and the fatty acid arachidonic acid (C20:4 n-6) which are essential for cat nutrition and health. In addition to being a major source of energy, the residual fat in the fishmeal is a rich source of omega 3 fatty acids, which represent over 35% of the total fatty acids present in the fat.

The introduction of new equipment and processing techniques and concepts in the production of fishmeal over the last 20 years continues to give the industry the flexibility to produce feed proteins that are tailored for particular animal species. This has become extremely important as the dynamics of the market has been constantly changing over this period of time. In fact, as will be seen later in this report, there is now very little FAQ grade fishmeal produced since most of it is now classified as premium grade product.

Special quality fishmeals are now available for ruminants, farmed fish, crustaceans, companion animals (pets) and early weaned pigs. When freshness of raw material is combined with gentle processing parameters fishmeals with excellent growth promoting efficiencies have been produced and have expanded to well over 50% of the total world production of fishmeal. In this context gentle processing may be defined as low temperature cooking, low temperature drying 60°- 80° C. max. and limitations on the quality of the stickwater concentrate that is added back to the fishmeal.

Apart from raw material freshness, monogastric animals have quite different requirements for feed ingredients. Trials in Norway among other places have shown that the processing temperature affects the digestibility of fishmeal when it is fed to young mink which are now considered the gold standard for measuring fishmeal quality. Because mink are not available in most countries, further testing has correlated the gold standard mink digestibility to the growth of salmon smolts which now provides an alternative test method for measuring the quality of the fishmeal. This comparison of mink digestibility and salmon growth is shown in the following figure.

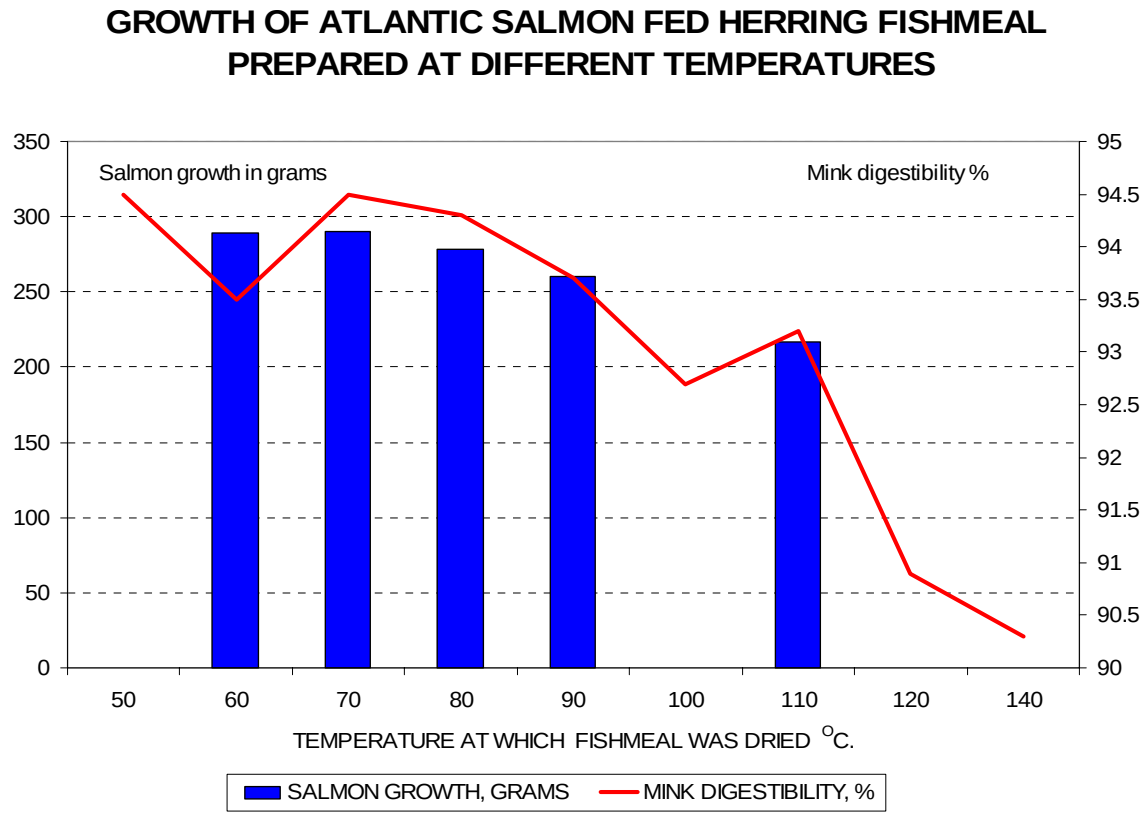


Figure 9 Mink digestibility and salmon growth vs. fishmeal drying temperature.

Fishmeal Specialty Uses

Poultry-broilers

Historically, the common broiler was a major consumer of fishmeal but poultry has not been a food that people recommend or think of as a rich source of omega 3 fatty acids in the diet. Generally poultry diets are formulated on a least cost basis and fishmeal is normally too expensive for inclusion in these diets. However for specialty diets this might not be the case. U.S. Department of Agriculture researchers evaluated the US food composition data and reported that the decline in the amount of the fish omega 3 fatty acids in the diet contributed by fatty fish has been offset by increased consumption of these fatty acids from poultry. They evaluated data for random periods from 1935-1985 and concluded that the increased poultry omega 3 content came from the use of fishmeal in the poultry feeds. Thus low concentrations of omega 3 fatty acids in foods consumed in large quantities can make an important contribution to omega 3 intake. There are now specialty poultry with high levels of omega 3 fatty acids in some countries. The US Dept. of Agriculture nutrition database (2008) indicates that raw poultry delivers about 60 mg of EPA +DPA+ DHA per 100 grams of raw meat. In comparison, the database shows raw cod delivering 194 mg of EPA + DPA + DHA per 100 grams of raw meat.

Research both in the US and Canada has shown that chicken can be comparable to cod as a source of omega 3 fatty acids if sufficient fishmeal or oil is added to the diet. Researchers have fed high levels of herring, white fish and red fish meals to broilers over extended periods of time and then evaluated the carcass meat for flavor and fatty acid composition by gas chromatography. Their results indicate that significant levels of omega 3 fatty acids can be incorporated into poultry meat without affecting meat flavor.

Canadian researchers have also shown that the consumption of fatty fish in North America has dropped significantly and that current fish consumption is of the white fish variety (cod, haddock etc). These fish typically contain 0.7 g/100 gm of lipid and 0.1-0.2 g omega 3/100 gm. Based on their calculations about half of the omega 3 in the North American diet comes from eating chicken. Therefore, enhancement of the fish omega 3 content of chicken could make it the main source of these fatty acids for humans. Their studies indicated that broiler chickens fed a diet with 5% fish meal have substantial amounts of fish omega 3 fatty acids deposited in the total carcass and edible meat lipids and all omega 3 fatty acids were significantly increased by feeding higher levels of redfish meal (15-30%) or red fish oil (2-4%). Taste panel tests in an unpublished report found off flavors in the meat of birds fed 15 or 30% redfish meal or 4.2% redfish oil, but the flavors detected were not described as fishy or as objectionable. In a more recent study they fed lower levels of redfish meal (12%) and calculated that an average meal of 100g of chicken without skin would contain 10.7% lipid and could contribute a total of 197 mg of omega 3 fatty acids, cod flesh would deliver about 138 mg of omega 3 fatty acids /100 grams.

Ruminants

The market for fishmeal in ruminant diets had been growing worldwide but came to an unexpected halt with the Mad Cow (BSE) issue. The animal proteins/animal feeds/BSE issue within the EU

has been going on for quite a few years now. A TSE Working Group reviewed a proposal to use fishmeal for the production of milk replacers for young farmed ruminants (calves). The EU Commission was expected to put a proposal to the Standing Committee for an opinion in April 2008. The proposal was supported by 50% of the EU member states and only 1 opposed it. If supported by a qualified majority the proposal would then go for a 3 month review process by the European Parliament/Council, accompanied by the experts report on the nutritional needs of young ruminants before it could be adopted. The soonest was expected sometime in 2009.

Unfortunately they are also looking at a tolerance principal for trace fishmeal and this could be a very long term project. Preliminary results from an interlaboratory ring test indicated that the revised analytical method was unreliable as far as measuring the tolerance level (they want 0.1% but the best they could achieve was 0.3%) and so the method could not be validated. If there is any risk of TSE in fishmeal, it would arise from the mammalian feed being fed to farmed fish or through fishmeal contaminated by meat and bone meal. If and when fishmeal is allowed back into the feed chain, in terms of public health, the concern remains at the level of the prevention of cross contamination with meat and bone meal. The risk of TSE in fish is remote. Implementing this provision would enable feeding fishmeal as a milk replacement protein probably to calves younger than 6 months however the control issues are particularly important since these calves are at the height of susceptibility to BSE infection.

Recent studies with 3 different methods shows sensitivity to detect 0.1% meat and bone meal in feed even in the presence of up to 5% fishmeal. They are now looking at classical microscopy and Near Infra-Red Microscopy (NIRM). The NIRM method is automated and computer analyzed and would hold more promise than the classical microscopy method but it will be well into 2009 before results are available.

Ruminants have always been important in the utilization of land for food use because of the micro flora that exists in their fore-stomach or rumen. Ruminants cannot efficiently utilize nutrients with a low fiber content such as grain and oilseed meals. The microorganisms allow the ruminant to utilize nutrients with a high crude fiber that cannot be used by monogastric animals. The microorganisms convert a substantial part of the fiber in the feed to volatile carboxylic acids. Proteins are also broken down into ammonia which is then used by the rumen microorganisms. These products of microbial metabolism are absorbed directly through the rumen wall, while the remaining microbial biomass and feed are passed to the abomassum where they are utilized in the same manner as in monogastric animals.

Feeding fishmeal to ruminants has been done for some time in the UK and northern Europe, and is a relatively new concept in the USA. Cooked proteins tend to be relatively resistant to degradation by rumen microorganisms, thus permitting that protein to escape or by-pass the rumen, and provide the animal with a source of high quality protein. Since fish meal is cooked it has a fairly high "by-pass" value. In cases where fishmeal has been added to the diets of high producing animals, some dramatic responses have been seen. Research at Cornell University has demonstrated significant increases in muscle size and the lean/fat ratio when 2-3% fish meal was added to the diets of lambs. Other researchers evaluated 3% menhaden fish meal in the diets of feedlot cattle and found that the fish meal fed cattle took 30 days less time to reach market weight.

Researchers in Scotland have reported that feeding lambs and heifers straw or straw supplemented with fishmeal demonstrated that the animals would utilize body fat for maintenance. Those on straw lost weight as fat and lean tissue but those on the fish meal supplement lost fat but gained lean tissue thus maintaining body weight. The lambs were given 75 g/day of fish meal while the heifers received 400 grams/day of fish meal.

The dairy cow presents a unique problem for fish meal producers in the US. Fishmeal initially appeared to depress butterfat production under some feeding circumstances. Recent studies, however, have demonstrated that fishmeal can be used successfully with high yielding dairy cows fed high alfalfa silage diets. Cows produced an additional 3 pounds or 1.4 quarts of milk daily when fed alfalfa silage mixed with 1 pound per day of fish meal protein. At the time of the study the fish meal cost 11 cents more per day than soybean meal but tests showed the cows were producing an additional 36 cents worth of milk per day. For the average dairy farm, this additional milk could be worth $12/day/cow. The cows also produced milk with 4% more protein.

Fishmeal has an excellent amino acid profile, close to that required for growth and milk production according to a review of animal by-products as protein supplements for cattle.

British researchers have reported on trials in Israel and Northern Ireland in which fish meal improved the fertility of dairy cows. Higher milk production, improved income from more calves, and reduced veterinary charges were documented. In the Northern Ireland trial, conception rate improved from 44-64%. The authors calculated that the combined cost benefit of improved fertility and improved production efficiency was worth £160-165 per cow per lactation at the time.

In a very recent study in the UK it was reported that a product rich in omega-3 fatty acids sourced from fish oil played a role in reducing prostaglandin production which plays an important part in embryo implantation by preventing embryonic loss. In one large-scale university-performed project with more than 500 cows, the group fed on the omega 3 feeds showed an improvement of 60-day pregnancy rates of 15%. This same group also recorded milk yields of 1kg higher than the control group. This level of improvement in fertility is estimated to improve margins by £2400 in a typical 100-cow herd. The feed is recommended at a rate of 115g/head/day for three weeks pre calving followed by a second product for the first four to six months of lactation.

Early Weaned Pigs

Intensive pig production methods require pigs to be early weaned at 3-4 weeks of age. At this age, young pigs are very sensitive to the form of protein in their diets. Many dietary proteins give an allergenic response in which diarrhea, reduced growth and increased mortality can result. With proteins from fish, this response is low. Fishmeal made from very fresh raw material is well tolerated by these young animals because it is highly digestible and palatable.

Studies conducted at Kansas State Univ. in 1986 evaluated the effect of a special quality menhaden fishmeal as a protein source in starter diets for pigs. Results from the study indicated that the addition of 8% of this menhaden meal to the diets of 3 week old weaned pigs resulted in an 11.5% increase in average daily gain by the end of the fifth week.

Breeding Sows

Flushing is the name given to an old technique of providing extra total feed or additional key nutrients to breeding female pigs up to the time of mating, with the aim of improving their reproductive performance. Based on research in Germany the positive effect of flushing seems to result from an abrupt increase in the supply of amino acids. In addition to the amount of amino acids, their availability and pattern seem to play an important role in the response of the sows.

Fish meal seems to be the ideal feeding stuff for an economic flushing. Based on results in Germany, an increase of 0.5 - 1 piglet per litter is possible from feeding 400-500 grams of fish meal per sow per day over a period of 7 days starting at the day of weaning, in addition to the normal ration.

Aquaculture

Fish differ from domestic animals in several ways. Their body temperature varies according to water temperature; they therefore, do not require energy to maintain a constant body temperature. They are efficient at eliminating waste through the gills in the form of soluble ammonium compounds therefore high protein feeds are readily digested and have higher metabolizable energy values for fish than for warm blooded animals.

The global use for fish meal in aquaculture in 1990 was 673,000 metric tons while today it is estimated to be 2.6 million metric tons. Aquaculture accounted for 12%-14% of the world's fisheries production in 1987. By the year 2012 that figure could rise to 45 %.

Farmed fish, especially young fast-growing cold water species such as salmon and trout are very sensitive to dietary protein quality since they require very high protein diets (40-50%). Fishmeal was used at high levels in these diets; 50-60% for salmon and around 30% for trout but because of economic issues these are expected to fall to 20% for salmon and 15% for trout. The quality of the fishmeal is critical; it should be produced from very fresh fish. Because most fish, especially coldwater fish, have a requirement for the long chain omega 3 polyunsaturated fatty acids present in fish oil and in the residual fat present in fishmeal, these products also supply omega 3's in the feeds of fish and crustaceans.

The recent run-up in the prices for fishmeal and oil have created incentives for researchers to find substitutes for fishmeal and oil in aquaculture diets. Many raw materials are being evaluated including animal and vegetable proteins. As well as animal and vegetable oils. None of these products offer the important omega 3 fatty acids EPA and DHA, although the vegetable oils can provide alpha linolenic acid (ALA). ALA can be converted to DHA by biochemical processes however the conversion is not very efficient in most animals.

Fish Oil

Introduction

From a global perspective, fish oil is produced by 6 geographical entities plus an "others" category. For this report, Denmark and Sweden have been removed from the EU27 and included in the Scandinavian group. This global fish oil production is shown in the following figure.

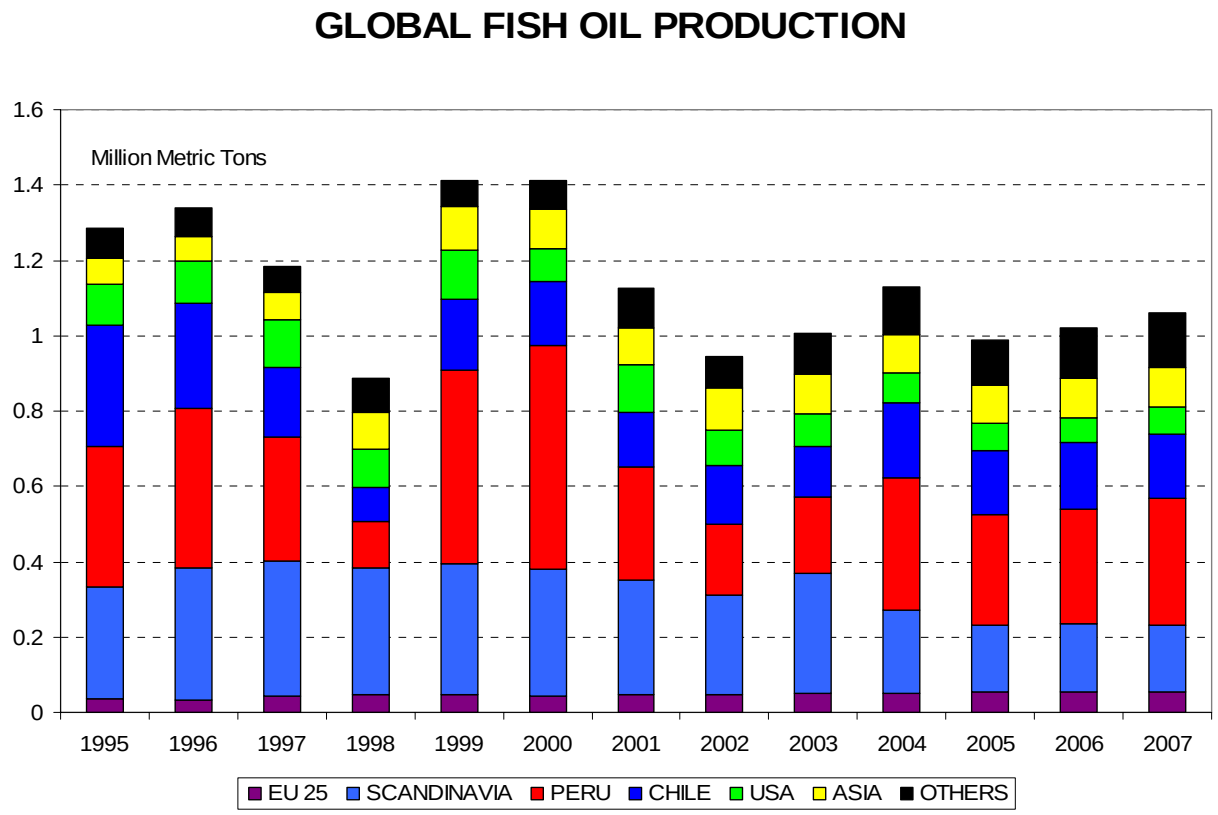


Figure 10 Global fish oil production.

Fish oil is a versatile product and finds many applications in the food, feed and technical industries of the world. Historically the largest use for fish oil was in the partially hydrogenated form in Europe in the baking industry. As was mentioned previously under fishmeal, in addition to being a major source of energy, fish oil is a rich source of omega 3 fatty acids, which represent over 30% of the total fatty acids present. Unlike fishmeal, fish oil is also used as an edible oil and in recent years much attention has been paid to the nutraceutical or health food supplement markets because of the omega 3 fatty acids.

Fish Oil Specialty Uses

Designer Eggs

The consumption of shell eggs has been decreasing because of recommendations by health professionals to reduce dietary cholesterol. Attempts to reduce the cholesterol level in eggs over the last 30 years have not been successful. A side effect of this work was a change in the fatty acid composition of the yolk. In 1987 an interesting area of feed fat research emerged. This involved the production of low cholesterol, high omega 3 fatty acid eggs now called designer eggs. While the cholesterol issue remains controversial, feeding 1.5%-3% fish oil in layer hen diets will increase the omega 3 levels in the egg yolk. Flavor is not affected until levels of 6% are used.

In one study in Texas, 3% menhaden oil was fed to layer hens over an 18 week period and compared to an isocaloric diet containing no added fat. The menhaden oil did not alter egg production, egg weight, total yolk fat or yolk cholesterol, but the content of omega 6 and omega 3 fatty acids was altered. After 1 week the omega 3 level increased and the final ratio of omega 6 to omega 3 changed from 18 to 3. Further studies evaluated consumer acceptance including tests for functionality, compositional stability, and sensory characteristics. A human clinical study with the eggs was also planned.

Researchers at the University of Rhode Island fed layer hens up to 3% menhaden oil for 4 weeks. Feed consumption, weight gain and feed conversion of hens in four different groups were measured. They concluded that omega 3 polyunsaturated fatty acids in the egg yolk can be increased without causing a fishy flavor by feeding up to 3% menhaden oil. They attributed the lack of fishy flavor in the eggs to the fact that the oil was stabilized with antioxidant.

Broilers

Some researchers are taking a different approach to animal nutrition. Dietary lipids are one class of nutrients that offer tremendous opportunity for modifying immune responses in animals. Research indicates that the prostaglandin E2 is immunosuppressive and that the omega 3 fatty acids in menhaden oil reduce its biosynthesis. Commercial application of this modulation will require further research especially with poultry since this is a new area of work. Potential improvements in flock health and disease resistance may be realized by manipulating the amounts and types of fat in the diet. Infectious diseases cause serious economic losses to the poultry industry every year. Evidence suggests that current nutrient guidelines for poultry do not optimize immune responses or disease resistance. The immune response of chickens has been shown to be influenced by a number of nutrients. Dietary fats, in addition to supplying energy, are modulators of the immune response. Broilers in Missouri were fed linseed, menhaden, lard, corn and canola oils. It was found that feeding chicks a diet containing 7% menhaden oil significantly enhanced antibody production. Further work was planned.

Fish oil also affects the composition of broiler meat. Different dietary lipid sources, fish oil, safflower oil and beef tallow, were fed to broilers for 18 weeks. The composition of breast, thigh and skin lipids was evaluated. Lipids in the meat reflected the lipid fed. Chickens fed the menhaden oil reflected the fish fatty acids not found in chickens fed the other diets.

In another study in Virginia, broilers were fed linseed, menhaden, soybean or chicken fat for 56 days. The researchers found that linseed oil and menhaden oil resulted in similar levels of omega 3 in the tissue. Chicken fat gave the highest level of saturates and soybean oil gave the highest levels of omega 6 fatty acids in the tissue.

Ruminants

Because of the bad publicity about red meats, several researchers have been attempting to decrease the saturated fatty acids and incorporate omega 3 fatty acids into the flesh of red meat animals. At Southern Illinois University researchers infused 1- 4% refined menhaden fish oil into the abomassum of beef cattle over a 60 day period. The results indicated that while there was no increase in carcass body fat, the omega 3 fatty acids were extensively incorporated into the muscle tissue at the expense of saturated fatty acids. There were no taste studies done and further research using protected fats is underway.

A US patent describes "split feeding" as a way to regulate the content and composition of fats in milk. The cows are trained to activate their esophageal groove reflex so that they can take liquid feed directly into the abomassum or concentrate into the rumen. In this way the unsaturated oils are not hydrogenated in the rumen and even with fish oils there is no off flavor in the milk.

Recently it was reported that a product rich in omega-3 fatty acids sourced from fish oil played a role in reducing prostaglandin production which plays an important part in embryo implantation by preventing embryonic loss. In one large-scale university-performed project with more than 500 cows, the group fed on the omega 3 feeds showed an improvement of 60-day pregnancy rates of 15%. This same group also recorded milk yields of 1kg higher than the control group. This level of improvement in fertility is estimated to improve margins by £2400 in a typical 100-cow herd. The feed is recommended at a rate of 115g/head/day for three weeks pre calving followed by a second product for the first four to six months of lactation.

Pigs

Supplementing practical sow diets (corn/soy) with menhaden oil at 3.5-7% of the diet late in gestation can significantly increase the content of omega 3 fatty acids in the sow's serum, colostrum and milk. The fatty acid profile of serum and tissues of the piglets was significantly affected by the fat source provided to the sow. Substituting menhaden oil for lard in a sow's late gestation and lactation diet greatly elevates the content of omega 3 fatty acids in the nursing pig and reduces PGE2 production of its immune cells, but had no effect on primary and secondary antibody responses of weanling piglets.

Aquaculture

Animals with all food provided under the management of a farmer have minimal choice of diet and will acquire a ratio of omega 6 / omega 3 that is controlled by the farmer. Thus farmers can indirectly influence the omega 3 / omega 6 balance in the people who eat their farm products. This makes an aquaculturist’s decisions about feeding fat to fish of more importance than just meeting the growth needs of the farmed animal. The supplies of long chain omega 3 fats that are currently

obtained by hunting fish in the oceans may not be adequate in the next century. But the marine food chain offers some unique ways to increase omega 3's in the diet by the feeding of fish.

Lipids from wild fish particularly marine fish contain comparatively high levels of omega 3 fatty acids which they obtain in the diet by consuming plankton, algae and other fish. Numerous investigators have demonstrated that fish are what they eat. The composition and flavor of the fat in the fish can be easily adjusted by the type of fat fed. Louisiana State University researchers reported on the difference in fat composition of fresh water prawn and marine shrimp. Canadian researchers have indicated that consumers are confused about whether to consume more high fat fish in order to increase their intake of omega 3 fatty acids or to avoid the extra fat and eat only lean white fleshed fish. They go on to say that farm raised salmon should provide at least 5 grams of fat containing 400 mg of C22:6 n-3 (DHA) and 200 mg of C20:5 n-3 (EPA) per 100 gram serving in order to mimic wild salmon.

Many farm-raised fish are low in omega 3 fatty acids because their diets are formulated primarily from agriculture products. This deficiency can be eliminated by adding fish oil containing high levels of omega 3 to their diet. The composition of shrimp, crayfish, catfish, eel, trout and carp have been reviewed and it is apparent that omega 3's are going to have an effect on the future of all commercial aquaculture. The public image of aquaculture could suffer if these omega 3 fatty acids are not included in the fish diet. It is important for the aquaculture industry to investigate the possibility of economically altering fish feeding programs to insure that the omega 3's are available in their products.

An in-depth study of the nutrients and chemical residues in Mississippi farm raised channel catfish has been reported. The total omega 3 content of these fish, 100 mg/100 grams, makes them an extremely poor source of these fatty acids, somewhat less than lean fish. The same can be said for Tilapia.

In a 12 week trial in Texas, catfish were fed menhaden oil at levels ranging from 1.5 to 6%. A practical diet supplemented with 3% menhaden oil is suitable for achieving maximum growth. At 6% menhaden oil and in the control treatments, fish did not grow as well as the 3% treatment. A trained taste panel said that the catfish on 3% menhaden oil tasted fishier but the flavor was not objectionable.

The consumption of fish and the fish oil it contains is believed to be beneficial to health. Some of the fatty acids in fish, in particular the EPA and DHA would appear to be of particular value. Using good quality fish oils which are adequately protected against oxidation, it should be possible to increase the content of these fatty acids in the fish lipids of farmed fish to similar or even higher concentrations than are found in the wild species.

The recent run-up in the prices for fishmeal and oil have created incentives for researchers to find substitutes for fishmeal and oil in aquaculture diets. Many raw materials are being evaluated including animal and vegetable proteins. As well as animal and vegetable oils. None of these products offer the important omega 3 fatty acids EPA and DHA, although the vegetable oils can provide alpha linolenic acid (ALA). ALA can be converted to DHA by biochemical processes however the conversion is not very efficient in most animals.

4. COMPETING PRODUCT CATEGORIES

Introduction

According to the Association of American Feed Control Officials Incorporated (AAFCO) the following table shows the official definitions for marine based products used in livestock and fish feeding.

AAFCO OFFICIAL DEFINITIONS FOR MARINE PRODUCTS USED IN LIVESTOCK AND FISH FEEDS.	
Fishmeal 51.14	The clean dried, ground tissue of undecomposed whole fish or fish cuttings either or both, with or without the extraction of part of the oil. If it contains more than 3% salt (NaCl), the amount of salt must constitute a part of the product name, provided that in no case must the salt content of this product exceed 7%. The label shall include guarantees for minimum crude protein, minimum crude fat, maximum crude fiber, minimum phosphorous (P), and minimum and maximum calcium (Ca). If it bears a name descriptive of its kind, it must correspond thereto. (Adopted 1933, Amended 1984, Amended 2003, 2004). IFN 5-01-977 Fishmeal mechanical extracted
Fish Residue Meal 51.24	The clean, dried, undecomposed residue from the manufacture of glue from non-oily fish. If it contains more than 3% salt (NaCl), the amount of salt must constitute a part of the product name, provided that in no case must the salt content of this product exceed 7%. (Adopted 1933, Amended 2003). IFN 5-01-977 Fish glue residue meal
Fish Liver and Glandular Meal 51.34	Obtained by drying the complete viscera of the fish. At least 50% of the dry weight of the product must be derived from fish liver and must contain at least 18 milligrams of riboflavin per pound. (Adopted 1944, Amended 1945). IFN 5-01-973 Fish viscera meal
Crab Meal 51.4	The undecomposed ground dried waste of the crab and contains the shell, viscera, and part or all of the flesh. It must contain not less than 25% crude protein. If it contains more than 3% salt (NaCl), the amount of salt must constitute a part of the product name, provided that in no case must the salt content of this product exceed 7%. (Adopted 1933, Amended 2003). IFN 5-01-633 Crab process residue meal
Shrimp Meal 51.5	The undecomposed ground dried waste of shrimp and contains parts and/or whole shrimp. If it contains more than 3% salt (NaCl), the amount of salt must constitute a part of the product name, provided that in no case must the salt content of this product exceed 7%. (Adopted 1933, Amended 1963, Amended 2003). IFN 5-04-226 Shrimp process residue meal

AAFCO OFFICIAL DEFINITIONS FOR MARINE PRODUCTS USED IN LIVESTOCK AND FISH FEEDS.	
Condensed Fish Solubles 51.6	Obtained by evaporating excess moisture from the stickwater, aqueous liquids, resulting from the wet rendering of fish into fishmeal with or without removal of part of the oil. Minimum percent of solids, minimum percent of crude protein and minimum percent of crude fat must be guaranteed. (Proposed 1993, Adopted 1996).
Dried Fish Solubles 51.7	Obtained by dehydrating the stickwater. It must contain not less than 60% crude protein. (Proposed 1963, Adopted 1964). IFN 5-01-971 Fish solubles dehydrated
Fish Oil 51.8	The oil from rendering whole fish or cannery waste. (Proposed 1963, Adopted 1964). IFN 7-01-965 Fish oil
Fish Protein Concentrate-Feed Grade 51.9	Prepared from clean, undecomposed whole fish or fish cuttings using the solvent extraction process developed for the production of edible whole fish protein concentrate. It must contain not less than 70% protein, and not more than 10% moisture. If the degree of fineness is stated, it conform thereto. Solvent residues are not to exceed those established in Food Additive Regulations. (Proposed 1969, Adopted 1970, Amended 1971) Reg. 573.440. IFN 5-09-334 Fish protein concentrate solvent extracted
Fish By-Products 51.10	Must consist of non-rendered, clean undecomposed portions of fish (such as, but not limited to (heads, fins, tails, ends, skin, bone, and viscera) which result from the fish processing industry. If it bears a name descriptive of its kind, it must correspond thereto. Any single constituent used as such may be labeled according to the common or usual name of the particular portion used (such as fish heads, fish tails, etc.) (Proposed 1974, Adopted 1975) IFN 5-14-509 Fish process residue fresh
Dried Fish Protein Digest 51.11	This is the dried enzymatic digest of clean undecomposed whole fish or fish cuttings using the enzyme hydrolysis process. The product must be free of bones, scales and undigested solids with or without the extraction of part of the oil. It must contain not less than 80% protein and not more than 10% moisture. If the degree of fineness is stated, it must conform thereto. (Proposed 1978, Adopted 1979) IFN 5-18-778 Fish Protein hydrolyzed dehydrated
Condensed Fish Protein Digest 51.12	This is the condensed enzymatic digest of clean undecomposed whole fish or fish cuttings using the enzyme hydrolysis process. The product must be free of bones, scales and undigested solids with or without extraction of part of the oil. It must contain not less than 30% protein. (Proposed 1978, Adopted 1979) IFN 5-17-779 Fish Protein hydrolyzed condensed
Fish Digest Residue 51.13	This is the clean, dried, undecomposed residue (bones-scales-undigested solids) of the enzymatic digest resulting from the enzyme hydrolysis process of producing fish protein digest. It must be designated according to its protein, calcium and phosphorous content. (Proposed 1978, Adopted 1979) IFN 5-27-467 Fish Protein Residue hydrolyzed dehydrated

AAFCO OFFICIAL DEFINITIONS FOR MARINE PRODUCTS USED IN LIVESTOCK AND FISH FEEDS.	
Fish Stock/Broth 51.15	Obtained by cooking fish and or other marine animal products, including bones, shells, parts, and or muscle, but not including fish solubles. The crude protein content of the stock/broth base material must be no less than 90% on a dry matter basis. In order for the stock/broth to be labeled as such, the moisture to crude protein ratio must not exceed 135:1 (135 parts water to 1 part crude protein). If the product bears a name descriptive of its kind, composition or origin, it must correspond thereto; and may be called either stock or broth. (Proposed 1999, Amended 2001, Adopted 2002).
Dried Shellfish Digest 51.16	The dried enzymatic digest of clean undecomposed shellfish (crustaceans and/or mollusks), using the enzyme hydrolysis process. The product may contain shells, viscera, and part or all of the flesh, and must be free of undigested solids, with or without extraction of all or part of the oil. It must contain not less than 50% crude protein, with not more than 10% moisture. If the degree of fines is stated, it must conform thereto. If the product bears a name descriptive of its kind, composition or origin, it must correspond thereto. (Proposed 2001, Adopted 2002).
Source: AAFCO 2008	

Table 4 Association of American Feed Control Officials Definitions for Marine Products.

While these definitions appear to be simple, the products in the marketplace are many and vary in quality and nomenclature. As an example, the following table shows the various possibilities for fishmeal products on the world market today.

SOME FISHMEAL DESIGNATIONS					
FAQ	Standard A, B	Prime	Steam Dried	Commercial	Commodity Grade
Super Standard		Steam Dried		Prime	
Taiwan Grade		Thailand Grade			
Prime	Select	Special		Quality Prime	
Super Prime	Special Select			Special Quality	
Special A or B		Vacuum Dried		Steam Dried	
LT		LT 94			
Other Modifiers That Can Be Used With The Above Fishmeal Types Include:					
Presscake Meal		Ruminant Grade		Aquaculture Grade	
Low Ash		Pet Food Grade		Natural	Organic
Certified From Sustainable Sources					

Table 5 Nomenclature for various fishmeal products on the world market.

Global Fishmeal Product Descriptions

Generally speaking, the fishmeal available on the world market can be divided into 2 groups; fair average quality (FAQ) and premium quality fishmeal. The FAQ grade of fishmeal is the commodity product and normally the lowest priced grade of fishmeal within a company or country's range of products. In the past, FAQ fishmeal was dried with direct flame dryers. As drying technology improved, steam dryers and indirect hot air dryers began to replace flame dryers. These products took on their own nomenclature to distinguish them from the direct fired flame dryers. Later, low temperature and vacuum dryers were developed which improved the quality of fishmeal and required additional nomenclature to distinguish the various quality grades of fishmeal. So the question becomes what's in a name? Certainly, a premium name does not necessarily indicate a premium quality product and in fact the industry (both buyers and sellers) have become more sophisticated and no longer sell fishmeal simply on its protein content.

There are as many fishmeal product variations as there are companies producing, selling or re-selling the products. In order to obtain premium prices for premium fishmeals you must be able to demonstrate consistent freshness of the raw material, consistent rapid gentle processing at low temperatures (both cooking and drying), stability of the product and use of antioxidants, and a consistent supply of product to meet the market needs. All of these concepts can be demonstrated through chemical and biological testing and the various premium products on the market today are generally defined by various parameters that reflect these concepts. However, if a premium product is consistently produced but the producer does not have the ability to store and supply the product over a long period of time, then the product will not achieve the "premium" price because it must be disposed of right away. The following tables give you some indication of the descriptions of various products on the world market today. The information was obtained from the supplier web sites in various countries.

Triple Nine (999) Danish Fishmeals	
Product Name	**Description**
Prime Quality	999 Prime Quality fish meal is made of fresh, but unspecified fish, as a wholemeal. 999 Prime Quality fish meal is especially intended for mixed feed for poultry and pigs. For early-weaned piglets, mink, aquaculture as well as pets we recommend our special fish meals. Please, study the specifications of our special »999« fish meals:
Aquality	999 Aquality is a wholemeal made of absolutely fresh fish, which ensures a low level of biogenic amines. Aquality is produced under mild conditions. 999 Aquality is especially intended for early-weaned piglets and aquaculture. 999 Aquality can also be used for mink and pets.
Con-Kix Fishmeal	Con-Kix is a wholemeal made of absolutely fresh fish. This ensures a specifically low level of biogenic amines. 999 Con-Kix is produced under very mild and gentle conditions at low temperature. The total process time is merely 15 minutes and the drying takes place in an air-dryer within few seconds.

Triple Nine (999) Danish Fishmeals	
Product Name	**Description**
	999 Con-Kix has a very high biological value, and the protein digestibility of Con-Kix is determined by biological tests with mink. 999 Con-Kix is especially suited for very young animals where the health of the animal is in focus. 999 Con-Kix is recommended for fingerlings, smolts, and pre-starters.
LT Fish Meal	999 LT is a wholemeal made of absolutely fresh fish. This ensures a specifically low level of biogenic amines. 999 LT is produced under very mild conditions. This includes gentle evaporation and low temperature vacuum drying. The protein digestibility of 999 LT is determined by biological tests with mink. 999 LT is especially suited for all aquaculture species and early-weaned piglets. 999 LT can also be used for young animals of other species.

Table 6 Triple Nine Danish fishmeal products

FF Skagen Danish Fishmeals	
Product Name	**Description**
FF Classic	A nutritional fish meal product which is well suited for many species of animals. The formulation of this fishmeal product gives it a very high biological value. The content of amino acids ensures high daily growth rates. Furthermore, FF classic is easily digestible. The meal contributes to better utilization of the feed and thus a more profitable operation.
Special A	Special A fishmeal is a highly nutritional protein concentrate. Special A is very close to the natural food of the animals and fish and is very easily digestible. Special A fishmeal therefore ensures high day-to-day growth for piglets, salmon, trout and mink. And it also ensures good economy for animal breeding and fish farming. With Special A fishmeal you achieve the optimal return on your feed investment.
LT Supreme	LT Supreme has been specially developed for piglets, trout, salmon and mink. LT Supreme is made of guaranteed fresh raw materials at very low temperature. The gentle method keeps a high protein content and gives extremely high digestibility. This also means that less feed is required and that the animals and fish grow faster. LT Supreme from FF Skagen thus ensures a good feed economy for all pig breeders, trout farmers, salmon farmers and mink farmers.

Table 7 FF Skagen Danish fishmeal products.

OMEGA PROTEIN USA FISHMEALS	
Product Name	**Description**
Regular (FAQ)	Regular fish meal is used in a wide variety of animal feed applications including catfish, pet food, poultry, and protein blends.
Sea-Lac™ Ruminant Grade Menhaden Meal	"Sea-Lac" Ruminant Grade by-pass meal differs from conventional commodity fish meal in the quality of the raw material and accompanying processing techniques. "Sea-Lac" is produced from a single species of fish, the Menhaden. The Menhaden are delivered chilled and whole to the processing facility in modern refrigerated vessels where they are immediately processed. Special processing techniques allow OPI to optimize the quality of the meal through low temperature drying conditions, removal of soluble protein, and stabilization at the time of manufacture. The product is therefore of high protein quality, showing enhanced digestibility and ruminal undegradability.
Special Select™ Menhaden Meal	Special Select Menhaden Meal is made from only the freshest fish processed at low temperature. This assures a finished product which is low in TVN (total volatile nitrogen) and histamine level, and high in digestibility. It was originally developed for the early weaned pig market and is now also being used in sow diets, aquaculture, pet foods, mink and poultry starters, and other markets demanding a high quality protein source. Special Select fish meal differs from conventional regular grade fish meal in the quality and freshness of the raw material. Special Select meal is produced from a single species of fish, the Menhaden. The Menhaden are delivered chilled and whole to the processing facility in modern refrigerated vessels where they are immediately processed. This immediate processing technique allows OPI to optimize the quality of the meal through low temperature drying conditions and stabilization at the time of manufacture. The product is therefore of high protein quality, showing enhanced digestibility.
Natural Nautic™	Natural Nautic is natural Menhaden meal, made from only the freshest fish and processed at a low temperature. This assures a finished product that is low in TVN (total volatile nitrogen) and histamine level, and is high in digestibility. Mixed tocopherols are then used as a stabilizer, instead of ethoxyquin, generally used in Special Select Menhaden meal. Natural Nautic was originally developed for the pet food industry and to meet the demands for the organic feed market. Natural Nautic fish meal differs from conventional regular grade fish meal in the quality and freshness of the raw material. The Menhaden are delivered chilled and whole to the processing facility in modern refrigerated vessels where they are immediately processed. This immediate processing technique allows Omega Protein to optimize the quality of the meal through low temperature drying conditions and stabilization at the time of manufacture. The product is therefore of high protein quality, showing enhanced digestibility.

Table 8 Omega Protein USA fishmeal products.

PESQUERA BIO BIO CHILEAN FISHMEALS	
Product Name	**Description**
Prime A Super Prime 500 Super Prime 1000	Produced with pelagic species which are carefully preserved on ice until processing. Leading-edge technology used in the processing of the fish catch guarantees high levels of protein, vitamin and digestibility. Used in aquaculture feedings and poultry.
LT	Bio Bio LT Fishmeal is a nutritious quality product directed to the most demanding markets. Our vacuum dry process at a temperature of 70ºC prevents the thermal degradation of the constituent amino acids especially lysine, enhancing its digestibility and securing a growth of salmon increase between 10 and 20%. An improvement of the color of the meal is reached through this process, getting a tone similar to White Fishmeal. The above mentioned features and its high growth potential, make Bio Bio LT an ideal food for minks, small pigs and aquaculture (trout, salmon, eel and turbot).
White Fishmeal	Pesquera Bio Bio´s White Fishmeal is produced with fresh raw material from white-meat fish caught in the austral waters of southern Chile. This product, obtained with high-technology processes, guarantees a quality product that can be used with very good results in aquaculture, especially eel farming.

Table 9 Pesquera Bio Bio Chilean fishmeal products.

SR MJOL ICELANDIC FISHMEALS	
Product Name	**Description**
Standard	The SR standard fishmeal is a whole meal produced from fresh capelin (Mallotus villosus), herring (Clupea harengus) and/or blue whiting (Micromesistius poutassou). The meal can be dried by indirect air dryers of the Hetland type or by direct hot air dryers. The SR fishmeal is recommended for grower feeds for land animals.
AquaStaR	The aquaStaR meal is a whole meal produced from very fresh catch. The fish utilized is capelin (Mallotus villosus) and/or herring (Clupea harengus) also blue whiting (Micromesistius poutassou). The meal is dried at low temperature by indirect air dryers. This ensures precise temperature control and produces fishmeal of the highest quality. The aquaStaR fishmeal is particularly recommended for aquaculture feeds, as well as weaning feeds for young animals.
AquaSalaR	The aquaSalaR meal is a whole meal produced from very fresh catch. The fish utilized is capelin (Mallotus villosus) and/or herring (Clupea harengus) also blue whiting (Micromesistius poutassou). The meal is dried at low temperature by indirect air dryers of the Hetland type. This ensures precise temperature control and produces fishmeal of high quality. The aquaSalaR fishmeal is recommended for aquaculture feeds, as well as petfoods and fur animals.

Table 10 SR Mjol Icelandic fishmeal products.

PESQUERA EL GOLFO CHILEAN FISHMEALS	
Product	**Recommended Use**
Standard	Poultry and Animal Feeds
Regular	Poultry, Shrimp, Young Animals and Birds
Prime	Shrimp, Young Animals, Birds, Eels, and Salmonids
Super Prime B	Shrimp, Young Animals, Birds, Eels, and Salmonids
Super Prime A	Young Animals, Birds, Eels and Salmonids

Table 11 Pesquera El Golfo Chilean fishmeals.

NORSILDMEL NORWEGIAN FISHMEALS	
Norse LT94	Norse-LT 94 is a special quality fishmeal produced from fresh, chilled raw material containing max. 50 mg. TVN/100 gr. at production. Norse-LT 94 is a whole meal produced with low drying temperatures and by factories that have been subjected to an extensive and strict program of approval. Norse-LT94 has a declared min. biological digestibility (mink).The most effective chemical, biological and salmonella control is carried out throughout and after the production process, ensuring that the meal is of approved quality before shipment. A significant growth increase by the use of Norse-LT 94 in mink, early weaned pigs, small and large salmon, turbot and halibut has been documented
NORSECO-LT	NorsECO-LT is a special quality fishmeal produced at factories certified by Debio. At least 50% of the protein in the fishmeal comes from fresh by-products, cut-off or other trimmings and/or material not used for human consumption. NorsECO-LT is produced without synthetic antioxidants and preservatives. This fishmeal is produced at low temperature drying conditions with a declared min. biological (mink) digestibility. According to Norwegian regulations NorsECO-LT is considered organic in regards to an organic production. NorsECO-LT is further recommended for use in pet food and in feeds for other animals where fishmeal without any synthetic antioxidants and preservatives is required/preferred. According to Norwegian regulations NorsECO-LT is considered organic in regards to an organic production.
NORSECO	NorsECO is a special fishmeal produced at factories certified by Debio. At least 50% of the protein in the fishmeal comes from by-products, cut-off or other trimmings and/or material not used for human consumption. NorsECO is produced without synthetic antioxidants and preservatives If the fishmeal is produced mostly from by-products/trimmings of cod and/or other white fish species, the protein content will be typical 65% +, and with a low fat content (below 5% Soxhlet fat). If the by-products/trimmings is of herring and/or other fat fish species, the typical chemical content will be as for Standard Fishmeal except salt (NaCl) which could be max. 4,5%. No synthetic antioxidant is added. According to Norwegian regulations NorsECO is considered organic in regards to an organic production. NorsECO-LT is further recommended for use in feeds for animals where fishmeal without any synthetic antioxidants and preservatives is required/preferred.
Source: http://www.norsildmel.no/	

Table 12 Norsildmel Norwegian fishmeals.

Global Fish Oil Product Descriptions

Fish oil has always been considered a by-product to fishmeal production. Up until about 10 years ago all or most of the world's fish oil went into Western Europe where it was further processed and hydrogenated. The finished product was then incorporated into various compounded cooking fats such as margarine, shortening and baking fats. But with the research reporting that *trans* fatty acids, which are produced during the hydrogenation process, are just as bad nutritionally as saturated fats, many end users began to move away from fish oils and into vegetable oils which needed less hydrogenation. As this market began to contract, fish oil began to move into aquaculture feeds where today it is the major use for fish oil. So, unlike fishmeal, fish oil is sold as a single product on the world market according to the various parameters in the contracts. There is a small volume of fish oil that goes into the pharmaceutical or nutraceutical market. This fish oil is usually defined by its omega 3 fatty acid composition, level of oxidation and amount of contaminants. Oils from pristine environments normally are low in contaminants and so are desired. Marketing jargon usually defines oils as coming from northern, cold pristine climates but generally these oils are not necessarily high in omega 3 when compared to temperate climates.

Like fishmeal, some companies have positioned their fish oils to compete in various niche markets. Some of these are shown in the following tables. This data was derived from company web sites.

TRIPLE NINE DANISH FISH OILS	
Product Name	**Description**
999 Fish Oil	999 Fish Oil is crude oil made of fresh raw material. The fish oil is in general customer tailor-made, i.e. 999 Fish Oil is produced and delivered according to the customer's individual demand. 999 Fish Oil is used for feed production and technical usages.

Table 13 Triple Nine Danish fish oil.

FF SKAGEN DANISH FISH OIL	
Product Name	**Description**
Golden Oil	FF Golden Oil is made from completely fresh fish where the only conservation is crushed ice. Rapid, hygienic and controlled production gives a pure, fresh product with an extremely low content of free fatty acids. The minimal quantity of free fatty acids means that the appetite of the fish is increased because the oil both smells good and tastes good. I.e. like the natural feed of the fish: fresh fish. The water content of max. 0.1-0.2% is further proof of the purity of the oil. FF Golden Oil gives high growth, firm flesh and healthy fish. Fish

FF SKAGEN DANISH FISH OIL	
Product Name	**Description**
	oil is an essential ingredient in the composition of fish feed which is rich in energy. The oil is the energy in the feed and ensures both rapid growth and the coveted marbling of fat in salmon. In addition to the flesh achieving the FF Golden Oil generally solidifies at lower temperatures than standard oils. And the lower the solidification point, the lower the risk that the oil will be deposited as fat in the gills of the fish so that they choke to death. However, the solidification point varies with the season. The summer oil solidifies a lower temperature than the winter oil. This applies to all fish oil, and the reason is that the catches of fish vary with the seasons. Like the solidification point, the colour of FF Golden Oil also varies with the seasons, depending on which fish the oil is made from. But even though the oil thus changes appearance in the course of the season, there is one thing that never changes: the quality.

Table 14 FF Skagen Danish fish oil.

OMEGA PROTEIN USA FISH OILS	
Product Name	**Description**
Crude Menhaden Fish Oil	The basic crude grade menhaden fish oil is polished to reduce the moisture content and is used when solid stearine content, flavor and odor are not a factor. Currently it is being used in some aquaculture and animal feed applications and is packaged in drums and totes and sold in full container loads. Our crude oil is available for both export and domestic use and sold in bulk shipments, including truck loads, railcars and vessels.
OmegaEquis Refined Menhaden Fish Oil	The only marine oil refinery in the USA and has a capacity of 100 mt per day. This oil has been fractionated for better handling characteristics such as flowability, alkali refined to reduce free fatty acids, and clay bleached to reduce color and odor bodies as well as oxidative precursors. This facility also has the ability to customize its products with various antioxidants and packaging requirements. Agricultural applications include pet food, larval aquaculture, omega-3 shell eggs, drilling fluids, rumen bypass feeds, equine performance & nutrition, better immune response, coat condition, and increased quality of life for critically ill companion animals. Industrial applications include leather tanning, alkyds for paints, drilling muds, lubricants, water proofing, dyes, deflocculants, releasants, and fatty acid production.

OMEGA PROTEIN USA FISH OILS	
Product Name	**Description**
Virginia Prime Gold	The only fully integrated marine oil refinery in the United States. This oil has been fractionated for better handling characteristics such as flowability, alkali refined to reduce free fatty acids, and clay bleached to reduce color and odor bodies as well as oxidative precursors. This facility also has the ability to customize its products with various antioxidants and packaging requirements. Agricultural applications include pet food, larval aquaculture, omega-3 shell eggs, rumen bypass feeds, equine performance & nutrition, better immune response, coat condition, and increased quality of life for critically ill companion animals. Industrial applications include leather tanning, alkyds for paints, drilling fluids, lubricants, water proofing, dyes, deflocculants, releasants, and fatty acid production.
Virginia Prime Platinum Vet Grade (Deodorized)	The only marine oil refinery in the United States with a capacity of 100 MT per day. This oil has been fractionated for better handling characteristics such as flowability, alkali refined to reduce free fatty acids, clay bleached to reduce color and odor bodies as well as oxidative precursors, and fully deodorized to remove fish flavor and odor. This facility also has the ability to customize its products with various antioxidants and packaging requirements. Agricultural applications include super premium pet food, veterinary nutraceuticals, high end treats, better immune response, coat condition, and increased quality of life for critically ill companion animals. Additionally, this product can be used in facilities that require products to be food grade.
OmegaPure™	Omega Protein Corporation is the largest producer of fish oil in North America, vertically integrated from catch to production. OmegaPure®, refined fish oil is derived from menhaden, which is a member of the herring family. Menhaden fish oil is a source of essential long-chain omega-3 fatty acids and meets the requirements of the GRAS regulation for use as a food ingredient and is OU (Orthodox Union) kosher certified. Supportive but not conclusive research shows that consumption of EPA and DHA omega-3 fatty acids may reduce the risk of heart disease and provide a variety of other health benefits.

Table 15 Omega Protein USA fish oils.

SR MJOL ICELANDIC FISH OILS	
Product Name	**Description**
Fish Oil for Aquaculture	Produced from fresh capelin (*Mallotus villosus*), herring (*Clupea harengus*) and/or blue whiting (*Micromesistius poutassou*).

Table 16 SR Mjol Icelandic fish oils.

PETFOOD ENTERPRISE TECHNOLOGIES NATURALLY STABILIZED ATLANTIC SALMON OIL	
Atlantic Salmon Oil	Xalar™ Atlantic Salmon Oil is extracted from freshly harvested Atlantic Salmon at our plant near Stavager on the south-western coast of Norway. In partnership with Marine Harvest, P.E.T. offers uniquely fresh salmon oil at our processing plant which is adjacent to the salmon harvesting station. The Norwegian Food Safety Authority has recently approved this facility for human grade production and is in accordance with the new EU-Pharmacopoeia for salmon oil (European Pharmacopoeia Commission Monograph Number 1910, November 2003). Xalar™ Atlantic Salmon Oil is rich in Omega-3 Long Chain Polyunsaturated Fatty Acids (LCPUFA) which offer the following benefits to companion animals. • Healthy Skin and Coat • Reduced Heart Disease • Improved Immune Function • Arthritis Relief • Improved Brain Development • Fertility Improvements

Table 17 Petfood Enterprise Technologies Atlantic salmon oil.

Alaska Fish Oil

ALASKA PROTEIN RECOVERY	
Wild Alaska Salmon Oil	Alaska Salmon contains among the highest natural sources of LC-PUFA's with over one third of the fat of an Alaska Salmon falling in the unsaturated category. The fatty acid content of Alaska Salmon may vary from year to year, and ultimately will depend on the type of fish the salmon eat prior to their harvest,
Source: http://alaskaproteinrecovery.com/index.html	

Table 18 Alaska Protein Recovery wild Alaska salmon oil.

Veterinary Resource Group, Inc.	
Wild Arctic Salmon Oil	Our fish oil contains ONLY pure Wild Alaskan Salmon Oil. Each 4650 mg teaspoon provides approximately 1256 mg of total omega-3 fatty acids, including 838 mg of EPA and DHA. In addition, laboratory analysis reveals an amazing 32 distinct additional fatty acid molecules you're unlikely to find in highly processed "purified" alternatives. Wild Arctic salmon oil is 100% natural. It is produced in a dedicated processing facility in Alaska from freshly caught, sustainably harvested salmon utilizing a "cold" extraction method that ensures the viability of our oil. Immediately after extraction natural mixed tocopherols (Vitamin E) are added to maintain freshness. The oil is immediately deep chilled and stored in airtight, lightproof containers until filtered and bottled. This thorough filtration process results in a pure, unadulterated extra virgin salmon oil rich in health-promoting omega-3s as well as a naturally balanced "formula" of **over 30** other distinct fatty acid molecules.
Source: http://vrg-usa.com/	

Table 19 Veterinary Resource Group wild Arctic salmon oil.

CANFISCO GOLDSEAL 100% PURE SOCKEYE SALMON OIL	
Sockeye Salmon Oil	*Dietary Supplement* *1000 mg / capsule - 120 Capsules* For the richest and purest source of Omega-3 we choose Wild Pacific Sockeye Salmon. Omega-3 is a family of polyunsaturated fatty acids that includes EPA and DHA and is essential for a healthy diet. The salmon oil is naturally red in colour and contains exactly the same levels of Omega-3 that are found in salmon, fresh from Pacific waters. Directions: Take two (2) to four (4) capsules a day, preferably with a meal. Do not exceed the stated dose. Caution: If you are under medical supervision please consult a doctor before use. Discontinue use and consult a doctor if adverse reactions occur. Ingredients: Pure Wild Pacific Sockeye Salmon Oil. Softgel capsule (gelatine, glycerine, purified water). Free from artificial preservatives, colour, dairy, starch, wheat or yeast.
Source: http://www.canfisco.com/products/salmon_oil.asp	

Table 20 Gold Seal pure sockeye salmon oil.

ARCTIC PAWS PREMIUM OMEGA MAINTENANCE SALMON OIL	
Premium Omega Maintenance Salmon Oil	Made from pure wild Alaskan Salmon, Nature's Best source of natural omega-3 and omega-6 Fatty Acids. 1 to 4 tablespoons onto your dogs food daily will promote a healthy coat, cardiovascular function, joint maintenance, and mobility. And of course it enhances the palatability of dog food! Cold pressed-healthy and nutritious- • Salmon are high in vitamins, minerals and essential fatty acids including Omega-3 and Omega-6! • Made with real alaskan salmon-We make our treats with ingredients dogs love! • Excellent show bait-Gives showers a competitive advantage! • Excellent training treats-Dog trainers across the U.S. and Canada use our treats in their classes! • For puppies and adult dogs- Dogs of all ages love our soft and chewy treats
Source: http://www.yummychummies.com/html/products.html	

Table 21 Arctic Paws omega maintenance salmon oil.

Other Competing Products Descriptions

There are a number of other fish and marine products on the market today. These products go under a variety of names, almost as many as fishmeal. They are used in commodity feeds, fertilizers and specialty feed markets. They can be liquids or powders. One major product is condensed fish solubles which is the concentrated stickwater from fishmeal production. This is normally added back onto the fishmeal and dried since it will then command the same price as fishmeal. The US menhaden industry produces condensed fish solubles and sells some of it as a separate product. The other products go under different classifications such as fish digest, hydrolyzates, silage both crude and cold processed and hot or concentrated, modified silage and fish emulsions. Unfortunately the names are sometimes interchanged as a marketing mechanism and in some cases it has been suggested that adding a cup of enzyme to fish solubles would convert it to a fish hydrolyzate and therefore increase the value. For our purposes, fish solubles is the concentrated stickwater from fishmeal production. Silage is the autolysate or fish digest using the internal enzymes in the fish plus acid for stability. The acid inhibits and destroys the bacteria allowing the internal fish enzymes to digest the fish mass. Cold silage is the product that represents the fish material in liquid form without removal of water or oil. Hot or concentrated or advanced silage involves oil and water removal and evaporation and results in a more concentrated product. If the raw material is low in fat, no oil removal is needed. Fish solubles are sometimes marketed as hydrolyzates or something similar. A new product category under development has been called modified silage. There are some variations in the process but essentially the fish material may or may not be deboned, it is then heated to pasteurize the material and destroy the natural enzymes. Less acid is added, typically 1-1.5% to stabilize the material. It can then be stored and dried. If a liquid is desired, then an external enzyme is added.

There is also a fermented fish product where the minced fish material is mixed with a carbohydrate source, molasses for example, and inoculated with a *Lactobacillus* sp. culture. The organism digests the carbohydrate source and produces lactic acid which lowers the pH of the fish material to 4.5 or lower resulting in a stable product. The enzymes in the fish continue to digest the protein during this process.

Other products might include fish compost and fish bone meal. There are also competing products produced by fermentation from natural gas, and fishmeal analog products (blended proteins that match the composition of fishmeal).

Silage And Hydrolyzate Flow Diagrams

The following figures outline block diagrams for the production of crude (cold) silage, advanced silage, modified silage, bacteria fermented silage and fish protein hydrolyzate. There are also several of processes in Alaska.

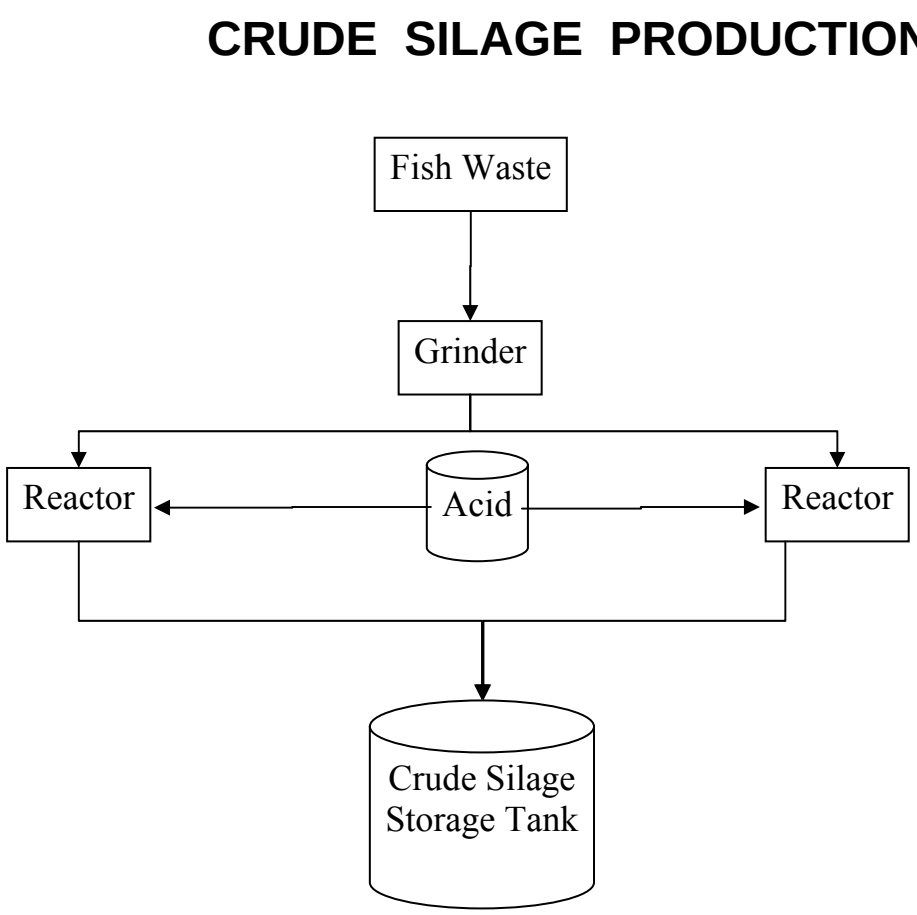


Figure 11 Flow diagram for production of crude (cold) silage.

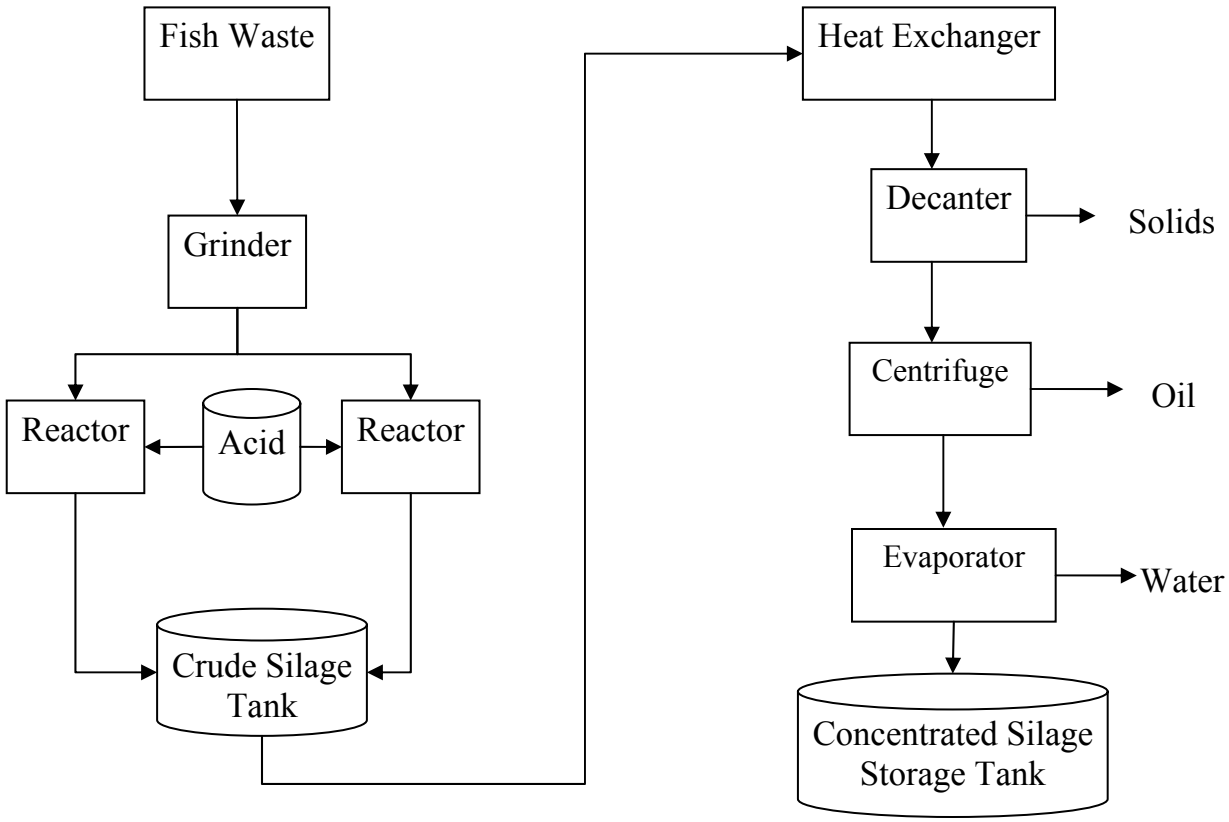


Figure 12 Flow diagram for production of advanced silage.

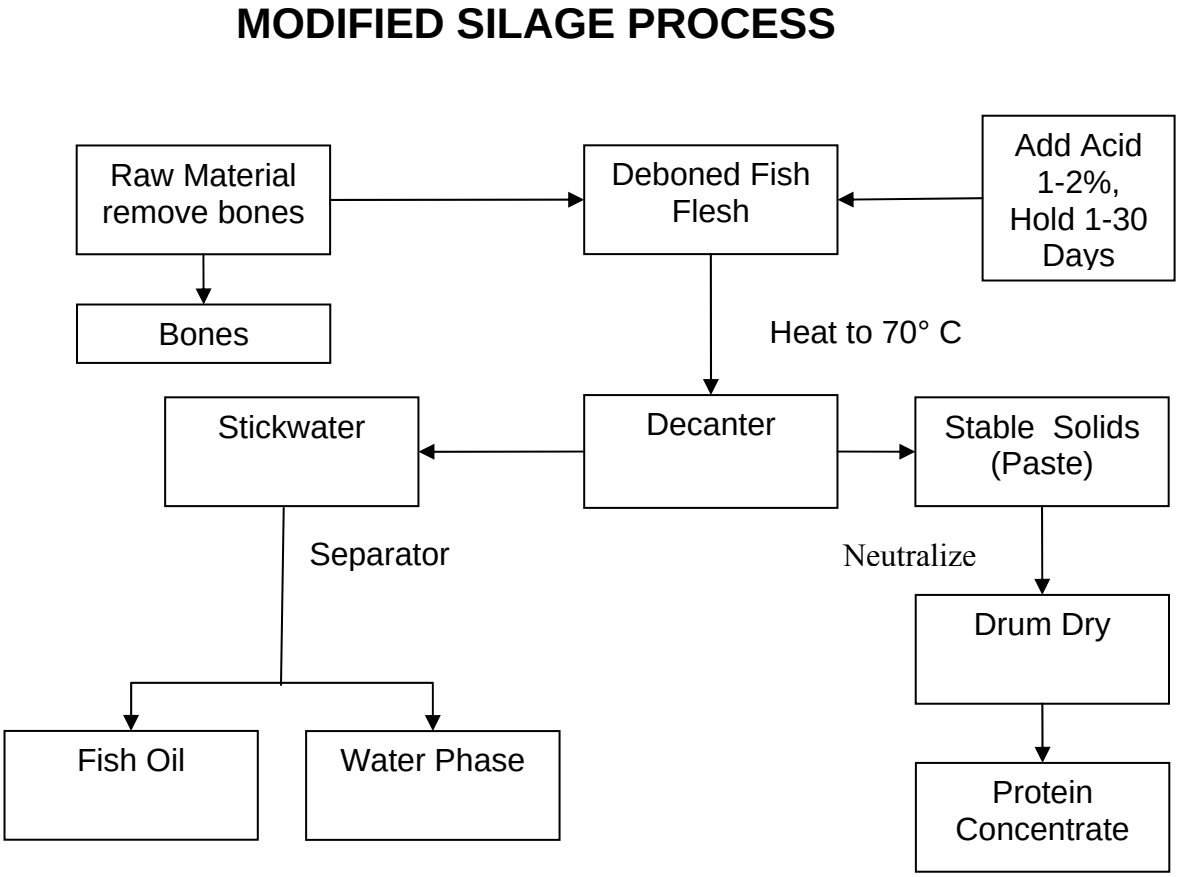


Figure 13 Modified silage process.

The modified silage process and protein concentrate process envisioned for small to medium sized communities in Alaska is shown in the following figure.

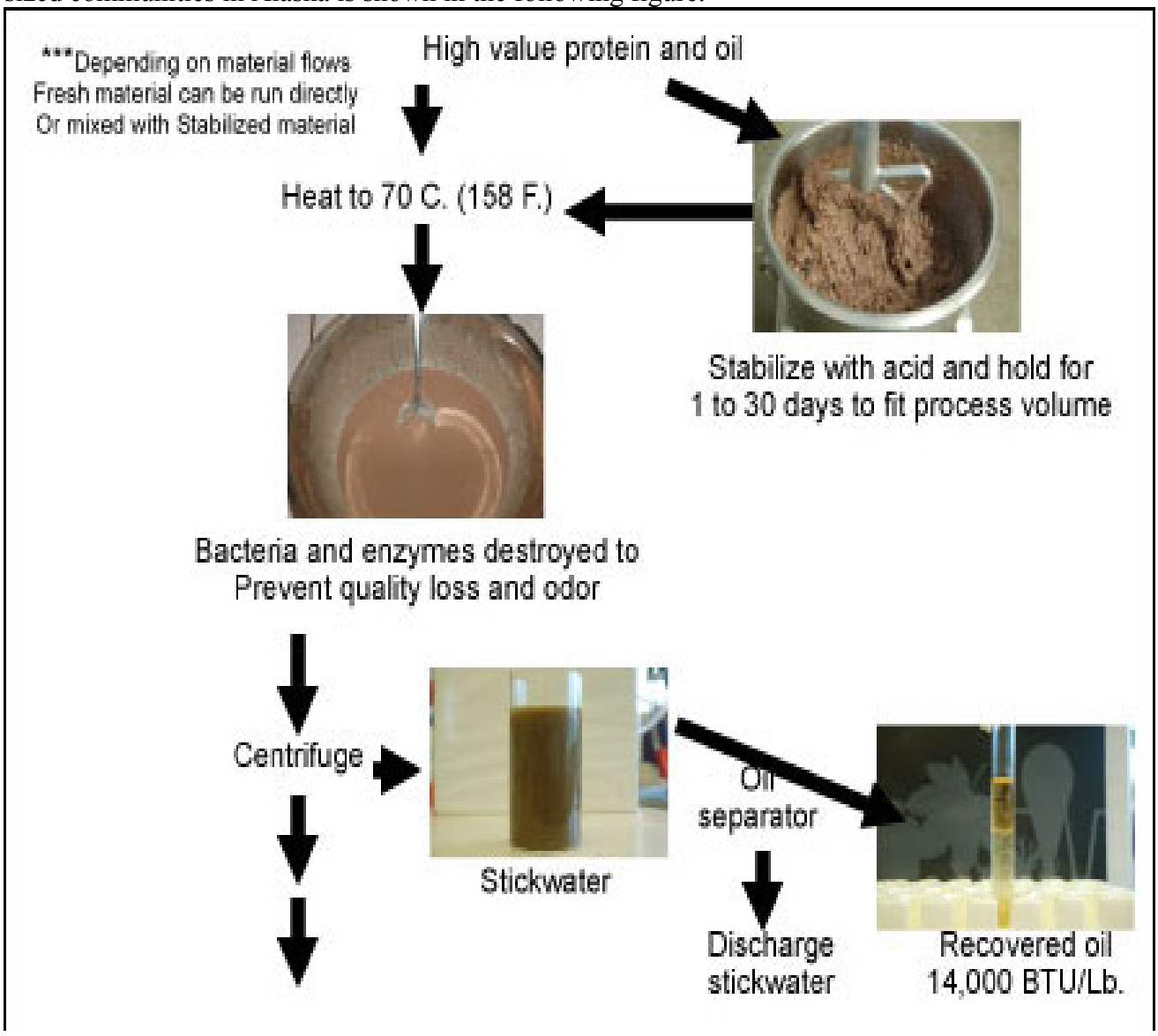
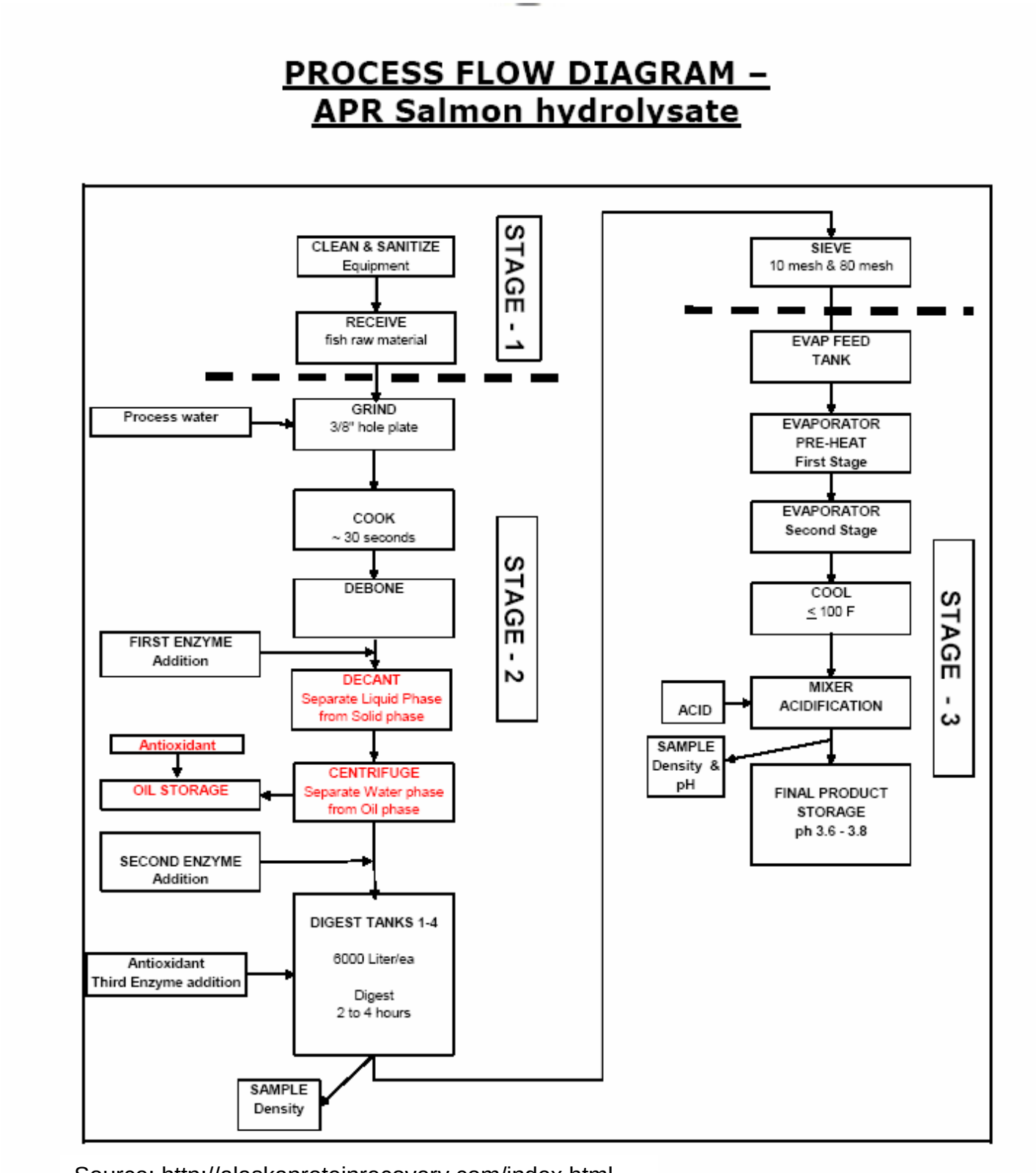


Figure 14 Modified silage process flow.

The process currently operating in Alaska is shown in the following figure.



Source: http://alaskaproteinrecovery.com/index.html

Figure 15 Alaska Protein Recovery process flow.

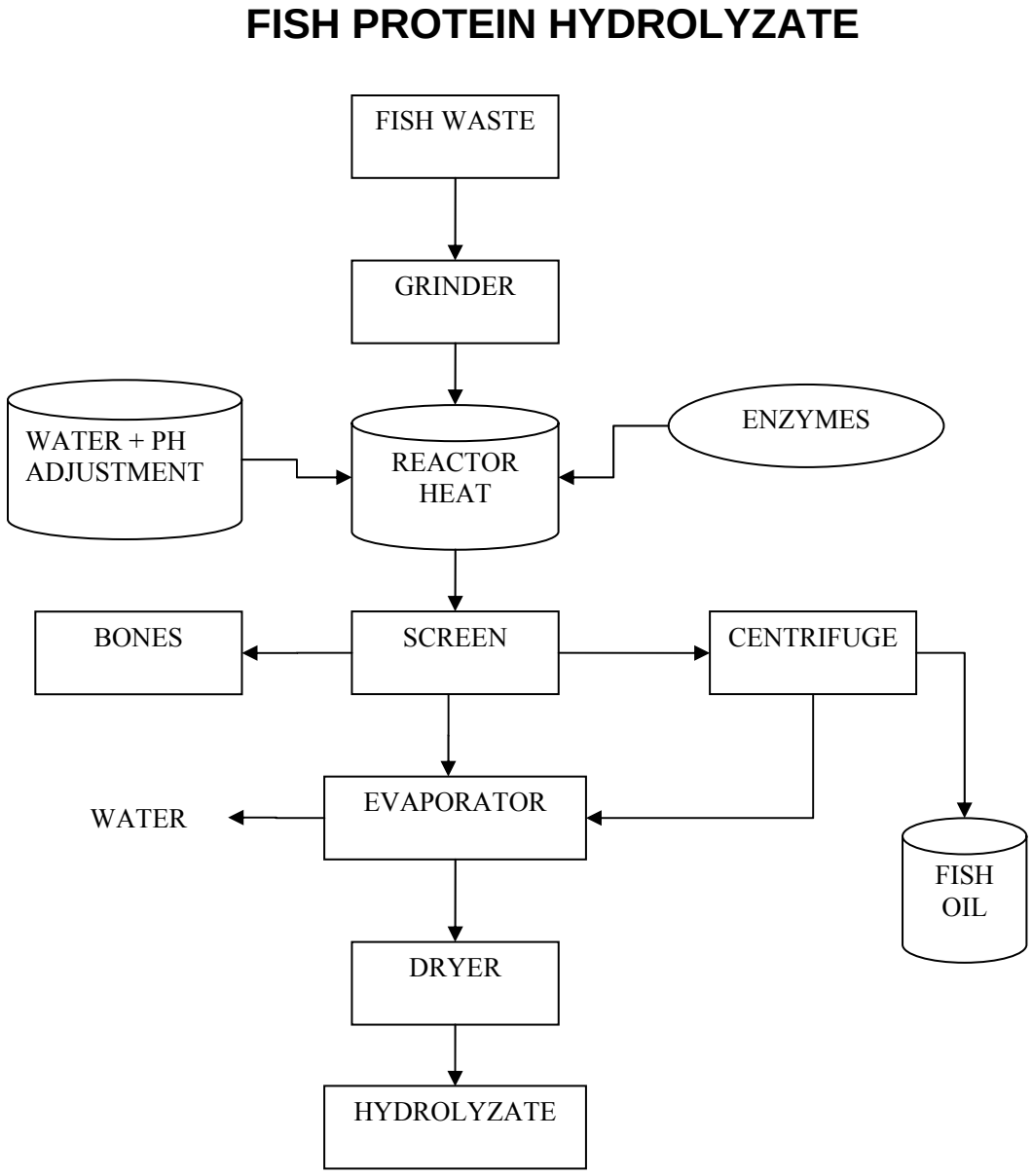


Figure 16 Flow diagram for production of fish protein hydrolyzate.

FISH SILAGE THROUGH BACTERIAL FERMENTATION

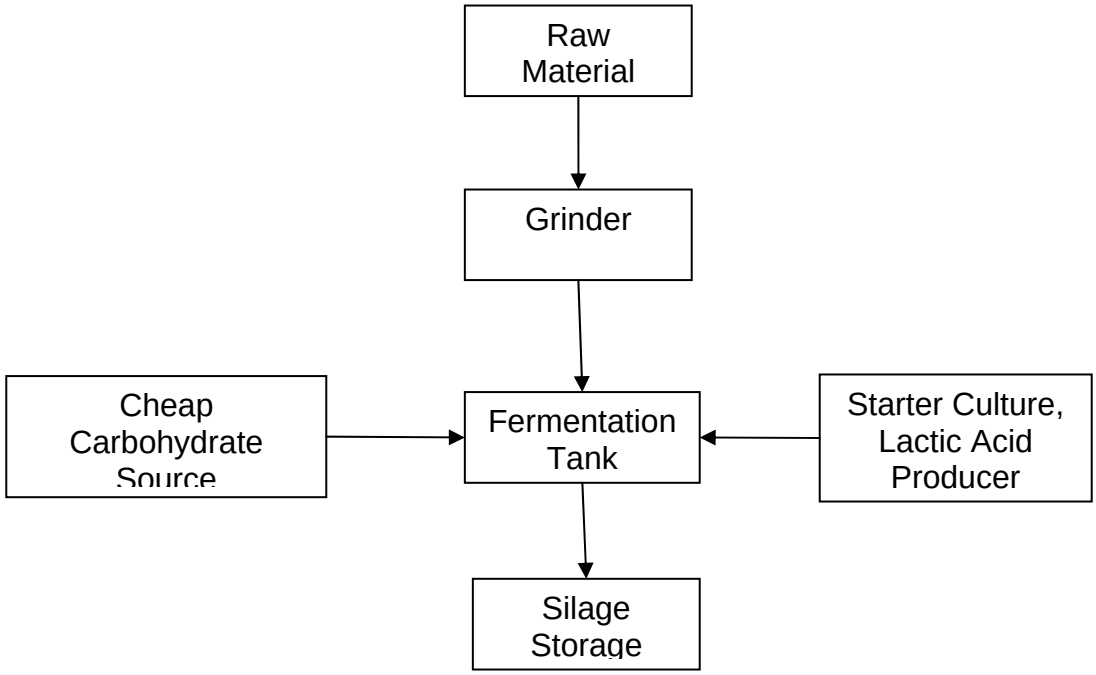


Figure 17 Bacterial fermentation silage process.

Other Competing Protein Products

On November 21, 2005 the Board of Directors of Norferm decided to close down the business effective March 1, 2006. The data for the Norwegian Bioproteins produced from natural gas has been retained in this report since it serves the useful purpose of showing what can be produced from this raw material and how those products compare to fish derived proteins.

NORFERM NORWEGIAN BIOPROTEINS FROM NATURAL GAS	
Basic BioProtein	A protein-rich biomass produced by a microbial culture with natural gas as sole nutrition and energy source
Pronin FS20	A dust-free, light brownish, spray-dried granulate with particle size of 150 – 200 µm. Its chemical composition and amino acid profile fulfils all essential requirements for a high quality protein source for salmon feed. In particular, the high content of tryptophan makes the product a valuable source of this essential amino acid.
Pronin AP5	A non-dusty, light brownish, spray-dried granulate with particle size of 150 – 200 mm. Its chemical composition and amino acid profile fulfills all essential requirements of a high quality protein source for pig feed. In particular, the high content of tryptophan makes the product a valuable source of this essential amino acid.
Pronin BC10	A dust-free, light brownish, spray-dried granulate with particle size of 150 – 200 µm. Its chemical composition and amino acid profile fulfills all essential requirements of a high quality protein source for chicken feed. In particular, the high content of tryptophan makes the product a valuable source of this essential amino acid.

Table 22 Norferm Norwegian BioProtein from natural gas.

H.J. BAKER AND BRO. FISHMEAL ANALOG PRODUCTS	
Pro-Pak	PRO-PAK® protein concentrate is the original feed industry fishmeal analog. Created over 40 years ago by H. J. Baker. Today it is used worldwide as a cost-efficient replacement for fishmeal in poultry and aquaculture feed formulations. It is a recognized and sought after ingredient, contributing a high level of amino-acids, metabolizable energy and digestibility to the diet at a fraction of the cost of traditional fishmeal. Its benefits have been successfully proven and affirmed repeatedly through continuous research performed by universities and independent nutritionists. PRO-PAK® protein concentrate contains no vegetable proteins; it is a combination of carefully screened marine and animal by-products, formulated to produce the same response as a high quality 60% protein fish meal, including all the essential amino acids. PRO-PAK® protein concentrate is produced in six plants strategically located throughout the United States under strict quality controls. All raw materials are

H.J. BAKER AND BRO. FISHMEAL ANALOG PRODUCTS	
	carefully inspected to ensure the highest quality standards are met. By using only the finest ingredients available, we can guarantee the consistency of every PRO-PAK® protein concentrate shipment. All finished material is tested and screened. Our uniform and consistent shipments eliminate lost production time and any need for costly reformulation.
Pro-Lak	PRO-LAK® dairy by-pass protein supplement is the dairy industry's leading animal and marine by-pass protein: precision formulated to increase milk and component production in modern high producing dairy cows. A cost effective high-protein concentrate with the by-pass benefits of fishmeal and bloodmeal. PRO-LAK® dairy by-pass protein supplement is a multi-source marine and animal by-pass protein supplement designed to compliment the protein from rumen microbial activity. This desired nutrient balance is accomplished by 72% of the protein bypassing rumen degradation and delivering the essential amino acid profile for maximum milk production. PRO-LAK® dairy by-pass protein supplement is readily available throughout the year. Delivery schedules can be programmed to fit your inventory and production requirements. Due to the standardized formulation of PRO-LAK® dairy by-pass protein supplement, the dairy industry can be assured of product uniformity in each and every shipment. This product is manufactured at dedicated (ruminant free) facilities located in Sanford, NC and Westville, OK.
Pro-Plus	H.J. BAKER'S PRO PLUS™ animal protein concentrate is a family of high-protein concentrates that can be easily customized to fit the precise needs of the nutritionist and the live production manager. H.J. BAKER'S PRO PLUS™ animal protein concentrate is currently produced at protein levels from 54% to 65%. This product was specifically developed in response to feed industry demand for the same inherent qualities as our PRO-PAK® protein concentrate –uniformity and nutrient density – but at a lower cost. H.J. BAKER'S PRO PLUS™ animal protein concentrate has earned a reputation for being extremely uniform and for being a very high-quality "no-frills" protein concentrate. It is often used as replacement or supplement in feed-grade poultry meal in broiler rations. And because it is easily customized, nutritionists use this remarkable product to "fine tune" their rations – hitting their optimal target nutritional levels without expensive nutrient overages or shortages.

Table 23 HJ Baker and Bro. fishmeal analog products.

ADVANCED BIONUTRITION MICROALGAE PRODUCTS FOR AQUACULTURE	
AquaGrow DHA	AquaGrow® **DHA** is composed of spray-dried algal extract that is high in Omega-3 DHA. It is a product of the heterotrophically grown alga, *Crypthecodinium*, a natural aquatic food source. The alga is cultivated in a GMP-regulated facility to ensure its quality, consistency, and safety. Clean, sustainable source of Omega-3 DHA Contains min. 15% DHA by weight Suitable for use as an ingredient in larval rearing and broodstock maturation diets Average 100 micro-particle size Long shelf-life at ambient temperatures Maintains stability through extrusions and other high-temperature feed manufacturing processes Blends well with other ingredients Made in the USA.
AquaGrow Gold	AquaGrow® **GOLD** maintains critical levels of Omega-3 DHA when fishmeal and fish oil are removed from aquafeeds. In the diets of several aquatic species, 0.5% AquaGrow GOLD, along with other sources of sustainable proteins and lipids, has proven successful in completely replacing fishmeal. AquaGrow GOLD is made from *Schizochytrium sp* algae, a heterotrophically grown, drum dried algal meal that contains 18% - 22% DHA by weight. It consists of the intact cells of the alga *Schizochytrium sp.*, a natural, environmentally sustainable, contaminant-free source of Omega-3 DHA. Green, sustainable source of Omega-3 DHA Contains 18% - 22% DHA by weight Can be used in extruded or pelletized feeds Optimizes HUFA levels in diets for all species Used in finishing diets to elevate levels of DHA Long shelf life at ambient temperatures Made in the USA .
AquaGrow ARA	AquaGrow® **ARA** is a spray-dried nutrition product for animal feeds that provides a high level of Arachidonic acid. It is produced by a GMP-regulated microbial fermentation process. Ideal for use as a component in broodstock maturation diets Suitable for use as a component in larval diets to increase egg hatching rates and decrease larval mortality Formulated to reduce residue, leaching, and foaming Contains min. 12% ARA by weight Made in the USA.
Source: http://www.advancedbionutrition.com/	

Table 24 Advanced BioNutrition microalgae products for aquaculture.

NOVUS DHA GOLD®	
Novus DHA Gold®	DHA GOLD® is a dried, whole cell algae product derived from the microorganism *Schizochytrium* that contains 18% minimum DHA by weight. Adding DHA GOLD® to poultry feed is a safe and effective route to nutritionally enhance DHA content of eggs and meat. DHA GOLD® has a greater efficiency of DHA incorporation when compared with fish oil, fish meal and flaxseed, therefore making DHA GOLD® a more economic source of DHA enrichment in food production. DHA GOLD® is a high quality source of omega-3 with consistent levels of DHA that offers many advantages over flaxseed and fish byproducts, including: • Sustainable supply • Vegetarian source of DHA • Non-GMO • Safe - no exposure to contaminants

Table 25 Novus DHA Gold.

PROFISH SA BIO CP 67 HYDROLYZATE	
Product Name	**Description**
BIO CP	A product resulting from highly controlled enzymatic action on very fresh whole fish. The nutritional characteristics of the fish are preserved and it has excellent properties of flavor and attraction. The protein chains are cut into polypeptides, peptides and small-size amino-acids (80 percent of the proteins are left between 2,500 and 10,000 D). Highly valued for attractant properties by a wide market, which includes aquaculture, swine and pets. Applicable for all kinds of animals in their early stages of development, when they are most susceptible to illnesses and high mortality rates caused by nutritional and microbiological problems. For aquaculture this product has been very successful as a result of its nutritional and pelletizing properties.

Table 26 Profish SA Chilean hydrolyzate.

CTPP SOPROPECHE FRENCH FISH HYDROLYZATES	
Product Name	**Description**
CPSP G 73% Protein CPSP 90 84% Protein	CTPP (Coopérative de Traitement des Produits de la Pêche) was founded in 1960 by an alliance of fishing industry businesses (ship owners, filleting plants, food processing plants) and is responsible for adding value to the by-products of these industries. With 300 000 tons per year of landed and processed fish, BOULOGNE-SUR-MER is Europe's leading port for processing. The CTPP thus has access to a wide variety of high-quality resources. Although originally fish meal producer, the CTPP has become specialised in marine molecule extraction : • Proteins in the form of meal with an excellent amino acid profile that promotes animal growth. • Highly digestible enzymatic protein hydrolysates promoting assimilation and nutritional efficiency. • Peptides, polysaccharides for cosmetics, diet foods, flavourings.

Table 27 Sopropeche French fish hydrolyzate.

In 2006 Bio-Oregon was acquired by Skretting and merged into their fishfeed business. The processing of fish waste which was quite successful and served as an outlet for smaller fisheries in the region was discontinued. The detailed data and information from the old Bio-Oregon products has been retained since it does show the detailed information that is needed to market these products.

BIO-OREGON FISH PROTEIN DIGESTS		
PRODUCT	**CONTENTS**	**USE**
BioGro 9:3:5	Derived from condensed fish protein digest, fishmeal, fish bone meal, feather meal, sulfate of potash, alfalfa meal and calcium sulfate.	Field Use: Apply 550 to 2,000 pounds per acre Orchards and Vineyards. Apply 550 to 1,100 lbs. per acre Nursery Crops.
BioGro 7:7:2	Nutrients derived from: condensed fish protein digest, fish meal, fish bone meal, feather meal, sulfate of potash, alfalfa meal, sulfate of potash magnesia, and limestone.	Field Use: Apply 500 to 2,600 pounds per acre Orchards and Vineyards. Apply 550 to 1,100 lbs. per acre Nursery Crops.

BIO-OREGON FISH PROTEIN DIGESTS		
PRODUCT	**CONTENTS**	**USE**
BioVita 5:3:2	BioVita is a natural biologically active soil amendment. The primary ingredients are fish protein digest, crab shell, feather meal, alfalfa meal, sulfate of potash and humic acid (from Humasol). BioVita contains non-plant food ingredients.	Garden use: Use 1 lb. per 100 sq. ft. of garden soil Field use: Apply 200-500 lbs. per acre
BioGan 4:3:2	Nutrients derived from: hydrolyzed marine fish by-product, blood meal, and sulfate of potash.	Vegetables and Flowers. Mix 1 part liquid fertilizer to 100 parts water (2 1/2 tablespoons fertilizer per gallon water).
BioGan 3:2:2	Nutrients derived from hydrolyzed marine fish by-product, and sulfate of potash. Stabilized with sulfuric acid and phosphoric acid.	Vegetables and Flowers. Mix 1 part liquid fertilizer to 75 parts water
BioGan 12:2:1	Nutrients derived from hydrolyzed marine fish by-product meal, and sulfate of potash.	Orchards and Vineyards- Mix 2 to 4 pounds of BioGan per 100 gallons of water. House Plants Mix 1 tablespoon (level) of BioGan per gallon of water.

Table 28 Bio-Oregon fish protein digests.

NEPTUNE'S HARVEST HYDROLYZED FISH	
2-4-1 Fish	Neptune's Harvest fish hydrolysate is an all organic, highly nutritional protein fertilizer, made utilizing naturally occurring enzymes present in fresh North Atlantic fish. We produce this using a cold process employing enzymes (natural biological catalysts) which break down fish, or fish frames (the part left after the fillet is removed for human consumption) to simpler protein complexes. This process is called Hydrolysis. No synthetic materials are mixed into the fish hydrolysate, and the only manipulation the product undergoes is grinding and hydrolysis. This process yields a stable, non-odorous, liquid fertilizer that is an easy to use, safe product. The nitrogen in Neptune's Harvest fish fertilizer is derived from fish protein in the form of amino acids which when added to the soil, slowly break down into basic nitrogen compounds. While a percentage of nitrogen becomes soluble due to the nature of the manufacturing process, no inorganic nitrogen has been added. In the past, there have been advantages in using manufactured chemical fertilizers, however as we now realize, this has been at the expense of the environment and depletion of many soil elements. The continued application of only concentrated

NEPTUNE'S HARVEST HYDROLYZED FISH	
	chemicals on the soil have reduced much of the biological life that contributes to the efficient utilization of many plant nutrients. Neptune's Harvest hydrolyzed fish does no biological damage to the soil and will promote the growth of beneficial bacteria making the soil less compact and better able to drain, yet hold moisture better for future plant use as it is needed. With our cold process, the vitamins, amino acids, enzymes, and growth hormones are not damaged or destroyed. Because no oils or proteins are removed, the nutrients remain in the soil longer, and lower N-P-K rates can be used to meet or exceed the results obtained by chemicals with much higher rates. Some advantages to using hydrolyzed fish fertilizer are that it rebuilds soil, gives excellent plant growth with increased yields, and is made from a renewable aquatic resource. Our hydrolysate fertilizer is filtered through an 165 mesh screen as a first step, and then through a 150 micron screen before it is packaged. This ensures an ease of application with most irrigation sprayer systems that is second to none. Beware of imitations. Neptune's Harvest is the leading manufacturer of fish hydrolysate fertilizers in the United States with extensive sales in the U.S. and throughout the world.
Source: http://www.neptunesharvest.com/	

Table 29 Neptune's Harvest hydrolyzed fish.

Fish Solubles

OMEGA PROTEIN USA FISH SOLUBLES PRODUCTS	
Product Name	**Description**
Liquid Fish Protein	This aqua grade liquid protein is composed of low molecular weight, water soluble compounds such as free amino acids, peptides and nucleotides that are proven to be very effective as an excellent attractant for a variety of aquaculture feeds. Typical inclusion levels are 3 to 5%.
Neptune™ Fish Concentrate	This aqua grade liquid protein is composed of low molecular weight, water soluble compounds such as free amino acids, peptides and nucleotides that are proven to be very effective as an excellent attractant for a variety of aquaculture feeds. Typical inclusion levels are 3 to 5%. Neptune™ is utilized in both shrimp and finfish diets to improve attractability and, thus, consumption and conversion. Feeding trials have shown that Neptune™ performs as well as squid and squid liver meal in shrimp diets. Neptune™ ; can also be added directly to grow out ponds as a fertilizer to help feed the plankton and other natural food sources.

OMEGA PROTEIN USA FISH SOLUBLES PRODUCTS	
Product Name	**Description**
	This product has also shown benefits in improved pellet quality and projects a strong fish odor and flavor. The last step in processing is to stabilize the liquid protein by reducing the pH to 3.8 - 4.0 giving us a secondary benefit of assuring it to be salmonella negative. The typical proximate analysis is 28-31% protein, 7-10% fat, and 50-55% moisture.

Table 30 Omega Protein USA fish solubles products.

Alaska Protein Products

ALASKA PROTEIN RECOVERY	
Salmon Protein Concentrate (SPC)	Our hydrolyzed salmon protein concentrate (SPC) is a highly nutritious, brown, viscous liquid with the taste and odor of fresh fish. It has the consistency and color of chocolate pudding and is stable at room temperature. SPC is ideally suited as a starter diet for weanling piglets and calves, as a larval fish and shellfish starter diet, as a pet food flavoring, and as a palatability enhancer aquaculture feeds. It is a very high quality source of protein in grow out feed formulations and an excellent source of nitrogen for organic agriculture and horticulture. All of the equipment used for our SPC production is made of food grade material. All of our products are made under the guidelines of a company Hazard Analysis Critical Control Point Plan (HACCP) which includes a Defect and Corrective Action Plan as well as a Standard Sanitary Operating Procedures (SSOP).
Source: http://alaskaproteinrecovery.com/index.html	

Table 31 Alaska Protein Recovery salmon protein concentrate.

PETFOOD ENTERPRISE TECHNOLOGIES ATLANTIC SALMON HYDROLYZATE	
Atlantic Salmon Hydrolyzate	Salmon Hydrolysate, made from 100% Scottish sourced salmon, is designed to improve palatability, enhance diet performance and meet hypoallergenic criteria. Traditional fish solubles are the by-products of fish meal manufacturing. Our Salmon Hydrolysate is the entire salmon protein that is liquefied by natural hydrolysis into peptides and amino acids and then double concentrated at very low temperatures to retain functionality and protein digestibility. Salmon Hydrolysate is acidified to pH 3.8 to ensure stability and microbiological safety.
Source: http://www.petfoodenterprise.com/	

Table 32 Petfood Enterprise Technologies Atlantic salmon hydrolyzate.

QUOTAMAX AND FISHTEK, INC. MODIFIED SILAGE	
Modified Silage and Protein Concentrate	Modified Silage is a potential bridge to full waste stream utilization. To date, the project has demonstrated the stabilized approach to 13 different companies, as well as state and federal researchers and NOAA fisheries scientists. Products developed to date include salmon meals with and without soluble proteins, gelatins, chondroitin rich cartilage powders, and bone meal. Fishery researchers are using the whole meal in fish growing experiments with Hawaiian threadfin. Interest in the suite of co-products have been expressed by pet food companies, nutrition companies and the product was shown at the USDA/NOAA Alternative Aquaculture Feed meeting in Silver Spring, MD in April 2008.
Source: http://www.afdf.org/current_projects/index.html	

Table 33 Quotamax and Fishtek Inc. modified silage.

Fish Bone Meal Product Descriptions

In recent years there has been mounting pressure from the aquaculture and pet food industry to remove bones from fishmeal. This has become necessary so that the phosphorous in the fishmeal can be reduced resulting in less phosphorus being excreted into the environment by fish and pigs. In the case of petfoods it is to increase the protein and reduce the ash content. In order to do this, fishmeal must be screened to remove the bones. The by-product from this screening operation is fish bone meal. Sometimes it is also necessary to remove the bones from by-product fishmeals so that the protein content will be more competitive with other products on the market. While many companies list fish bone meal on their web sites, there is very little data or descriptions available on the product. The following table compares some information on fish bone meal and animal bone meal. This data was taken off the internet.

VARIOUS BONE MEAL PRODUCTS AVAILABLE FOR SALE ON THE INTERNET	
Company	**Description**
Gaia Green	Gaia Green Fishbone Meal is made from 100% wild ocean fish and is a highly available phosphorus fertilizer. It also contains many trace minerals and 4% nitrogen. Our Fishbone Meal is an excellent alternative to other bone meal products in situations requiring high phosphorus, such as root and flower development. Ingredients: Fish Bone Meal from 100% wild Ocean Fish.
LaBudde Group, Inc.	Steamed Bone Meal is the most natural form of calcium and phosphorous for animal health. This dried and ground product is sterilized by cooking with steam under pressure. Packaged in 50 lb bags and 1 ton super sacks.
Down to Earth Distributors	3-16-0 Fish Bone Meal. A natural by-product of the fishing industry, fish bones are cooked and ground to create a high phosphorus fertilizer perfect for flowering and fruiting plants. Fish Bone Meal has replaced steamed Bone Meal in all of our Down To Earth Fertilizer Blends. Free of preservatives. 3-15-0 Bone Meal. Steamed and ground bone meal, which is rich in nutrients and low in fat, provides a high level of phosphorous for all stages of growth and flowering. An excellent source of calcium for healthy plant development Steamed Bone Meal is a wonderful food for bulbs and all flowering plants and trees.

Table 34 Various bone meal products available for sale on the internet.

In the US patent system the public does not see a patent application until the patent has been granted. In 1998 a patent titled "Treatment of metal contaminated leachates utilizing fish bones and fish hard parts" was filed by 2 inventors from Richland, Washington. Patent No. 6217775 was granted on April 17, 2001. According to the patent:

The present invention uses fish bones and fish hard parts to remediate, clean-up, stabilize, immobilize or otherwise treat meta-contaminated water, soil or waste of any sort. The fish bones and fish hard parts can be mixed in with soils and wastes or emplaced as a permeable reactive barrier in a trench or excavation, or emplaced as a liner or barrier surrounding a waste form, disposal site or contaminated site. All that is needed is intimate contact between the fish bones and fish hard parts and the contaminated waste form, soil particles or water. In a system of, for example, soil, waste, groundwater, surface water, waste streams or the digestive tracts of animals, the presence of fish bones and fish hard parts reduces the amount of metal that can mobilize and migrate out of the system. Fish bones and fish hard parts reduce bioavailability of metals to organisms coming into contact with the system and from water leaving the system. The fish bones and fish hard parts can be mixed with any other material, e.g. gravel, sand, clay, zeolites, soils of all types, iron filings, cement, compost, straw or organics or all types. The fish bones and fish hard parts act in several ways. They provide phosphate ions to solution that can combine with metals in solution to form new metal-phosphate solids that can precipitate. In addition, they buffer the pH and other aspects of the water chemistry to a degree that makes leaching of metals less likely and induces the precipitation of metals into new solids or induces adsorption of the metal onto existing solid surfaces. They can adsorb metals onto their own

surfaces. Some metals can also replace or exchange for other metals in the structure of the fish bones and hard parts. They actually treat the leachate or metals in solution as they leave the contaminated material and encounter the fish bones and hard parts. The fish bones and hard parts are not actually reacting with the contaminated solid. Therefore, the leaching solution containing the metals must come into intimate contact with the fish bones and fish hard parts in order to be treated.

In 2005 the inventors began promoting the fish bone material as Apatite II™, Phosphate Induced Metal Stabilization (PIMS).

APATITE II™ PHOSPHATE INDUCED METAL STABILIZATION WITH FISH BONES.	
Apatite II™	Phosphate-Induced Metal Stabilization (PIMS) is a technology that uses a special material, Apatite II, to clean-up soil and groundwater contaminated with metals. This method has many applications in the field including: • clean-up of Pb-contaminated soil at military bases by mixing a small amount of Apatite II into the soil, • clean-up of groundwater contaminated by Cd, Pb, Pu, U and Zn by trenching into the ground in front of the contaminated water and backfilling with Apatite II (called a permeable reactive barrier) that cleans the groundwater as it passes through the material. This can be acid mine drainage from mining activities • clean-up of U-contaminated soil by washing with bicarbonate of soda and then putting the wash water through the Apatite II to remove the U, as described in Uranium Remediation Using Soil Washing • clean-up of common non-metal pollutants such as nitrate and perchlorate through the special nature of the Apatite II, as described in Plutonium, Nitrate and Perchlorate Remediation using a Permeable Reactive Barrier • making hazardous waste into non-hazardous waste ready for disposal by mixing with Apatite II, • preventing wildlife from being harmed by metals in the soil and water by having Apatite II block the biological uptake of metals from soil, food and water (see Zinc, Lead, Cadmium and Copper Remediation of Acid Mine Drainage Using a Permeable Reactive Barrier and Soil Mixing).
Source: http://www.pimsnw.com/	

Table 35 Apatite II phosphate induced metal stabilization.

Since Alaska does not have a major "local" agricultural industry, the consumption of fishmeal would be low. Alaska does, however, have a large mining and petroleum industry and this application of fish bones might offer some local advantages in treating mining or petroleum wastewater discharges.

Fish Fertilizer Product Descriptions

Fertilizers are characterized by their Nitrogen-Phosphorous-Potassium content (N-P-K). Therefore all fish material will have some fertilizer value since fish contain protein which is Nitrogen, the bone contains Phosphorous and the flesh and bone contain Potassium. Generally, fish products are re-allocated to fertilizer use for any number of reasons including quality too poor for feeding, volume too small to convert to fishmeal and oil, and an available agricultural market in the vicinity of the waste material. Fish fertilizers are sometimes classified as organic or natural.

PACIFIC HARVEST PELLETED FISH FERTILIZERS	
Organic Lawn Food 8-3-5	A dry, pelleted natural, organic lawn fertilizer that is easy and safe to apply, and poses no environmental hazard. It is high in nitrogen and contains ideal levels of phosphorus, potassium, and calcium, along with a complete array of trace elements. Nutrients derived from**:** fish hydrolysate, fish meal, fish bone meal, feather meal, sunflower seed hull ash, alfalfa meal, and kelp meal.
All Purpose Plant Food 7-6-2	A dry, pelleted natural, organic all-purpose fertilizer that is easy and safe to apply, and poses no environmental hazard. It has an ideal ratio of nitrogen, phosphorus, and potassium, high levels of calcium, sulphur, and magnesium, and a complete array of trace elements. The perfect fertilizer for a whole variety of flowers, shrubs, vegetables, and trees. Nutrient s derived from**:** fish hydrolysate, fish meal, feather meal, sunflower seed hull ash, alfalfa meal, and kelp meal.
Bio-Gro 10-4-2	All Natural Fish Fertilizer, Uniform, Dust-Free Pellets, Safe and Easy to Handle and Apply, Poses No Environmental Hazard, when used as directed. Listed by the Organic Materials review Institute (OMRI) for use in Organic Production Nutrients derived from**:** condensed fish protein digest, fish meal, fish bone meal, feather meal, sulfate of potash, alfalfa meal, and sulfate of potash and magnesia.
Bio-Gro-9-3-5	All Natural Fish Fertilizer, Uniform, Dust-Free Pellets Safe and Easy to Handle and Apply, Poses No Environmental Hazard when used as directed, Listed by the Organic Materials review Institute (OMRI) for use in Organic Production. Nutrients derived from**:** condensed fish protein digest, fish meal, fish bone meal, feather meal, sulfate of potash, alfalfa meal, and calcium sulfate.

Table 36 Pacific Harvest pelleted fish fertilizers.

GREENSTAR PACIFIC FISH PLANT FOOD	
Pacific Fish Plant Food Earth Safe™ NPK: **3-1-1**	Earth Safe™ Pacific Fish Plant Food 3-1-1 is an organic fish fertilizer. The use of fish fertilizer dates back to ancient Egypt where farmers used fish remains to fertilize their crops. Great for use on all flowers, shrubs, fruits and vegetables to encourage early plant development.
Fishplus Grotek NPK 3-1-1	As a certified organic crop input, Fishplus is derived from hydrolyzed Pacific fish and can be used as a base fertilizer or added in lower quantities to supplement an existing fertilizer program. Fishplus is an excellent source of natural nitrogen and also provide the other primary nutrients. As with many ingredients that come from the ocean, our hydrolyzed fish contains numerous natural micronutrients and other helpful organic ingredients.

GREENSTAR PACIFIC FISH PLANT FOOD	
Fishplus Bloom Grotek NPK: **1-12-12**	Fishplus Bloom is a complete organic based liquid fertilizer with a base derived from hydrolyzed pacific fish charged with potassium phosphate and other ingredients to increase phosphorous and potassium to assist flower development and increase crop productivity.
Source: http://www.getgreenstar.com/	

Table 37 Greenstar Plant Products Pacific fish plant food.

GREAT PACIFIC BIOPRODUCTS LIQUID FISH FERTILIZER	
Pacific Natural® Liquid Organic Fresh Fish Fertilizer	**Pacific Natural® is:** an all-natural fresh fish **organic** liquid fertilizer manufactured by Great Pacific BioProducts Ltd. near Vancouver BC Canada. **It is a** high quality **organic** product that gives excellent plant growth, rebuilds soil, and offers higher production yields. **We** use a unique enzymatic low temperature process that produces a hyper-active bio-stimulant different from anything else on the market today. **It** is made from a marine renewable single-species raw material source (Pacific dogfish shark). **It** is an environmentally wise and healthy choice keeping this valuable and nutritional material out of overloaded landfills. **Pacific Natural® provides superior: Plant Health** It gives long lasting results with improvements in plant color, root development and overall tissue health. **Soil Health** Soil qualities are improved for deeper rooting and better penetration of water and nutrients. Unproductive soil is easily rebuilt and replenished. **Microbial Activity** Provides an excellent and fast-uptake source of food for the growth of beneficial soil microbes and other organisms as well as providing supplementary macro and micro nutrients. **Pest Resistance** Improved plant health leads to improved resistance to pests and fungal diseases. **Easy To Use** It **can be soil applied, foliar applied, or applied via drip systems** Can be applied universally depending on your needs. Applications of Pacific Natural® will not harm roots or leaves because of the slow release of nutrients. **Will not clog** Because of our strict double filtering process through 80-mesh screens, there is never a problem with drip line clogging or mixing Pacific Natural® with other material. **Costs less than other brands** Our manufacturing process takes significantly less time than our

GREAT PACIFIC BIOPRODUCTS LIQUID FISH FERTILIZER	
	competitors, resulting in lower processing costs, which we pass on to you, the customer.

Table 38 Great Pacific Bioproducts Inc. liquid fish fertilizer.

FOX FARMS MARINE CUISINE FERTILIZER	
FoxFarm Marine Cuisine 10-7-7 NPK	Seafood for your garden! Marine Cuisine is a powerful blend of balanced plant foods combined with Pacific Northwest sea-going fish, crab meal, shrimp meal, bat guano, and plenty of our own earthworm castings - natures' finest soil amendment. This all-purpose fertilizer is biologically active and will help encourage large populations of soil microbes which facilitate nutritional uptake by plants. Derived from: Cottonseed Meal, Blood Meal, Earthworm Castings, Fish Meal, Shrimp Meal, Crab Meal, Bat Guano, Seabird Guano, Kelp Meal, Urea, Ammonium sulphate, Calcium Nitrate, Ammonium Phosphate, Treble Phosphate, Potassium Sulphate, Potassium Chloride, Ferrous Sulphate, Iron Sucrate, Manganese Sucrate. This product is rich in organics but is not completely organic.

Table 39 Fox Farms Marine Cuisine fertilizer.

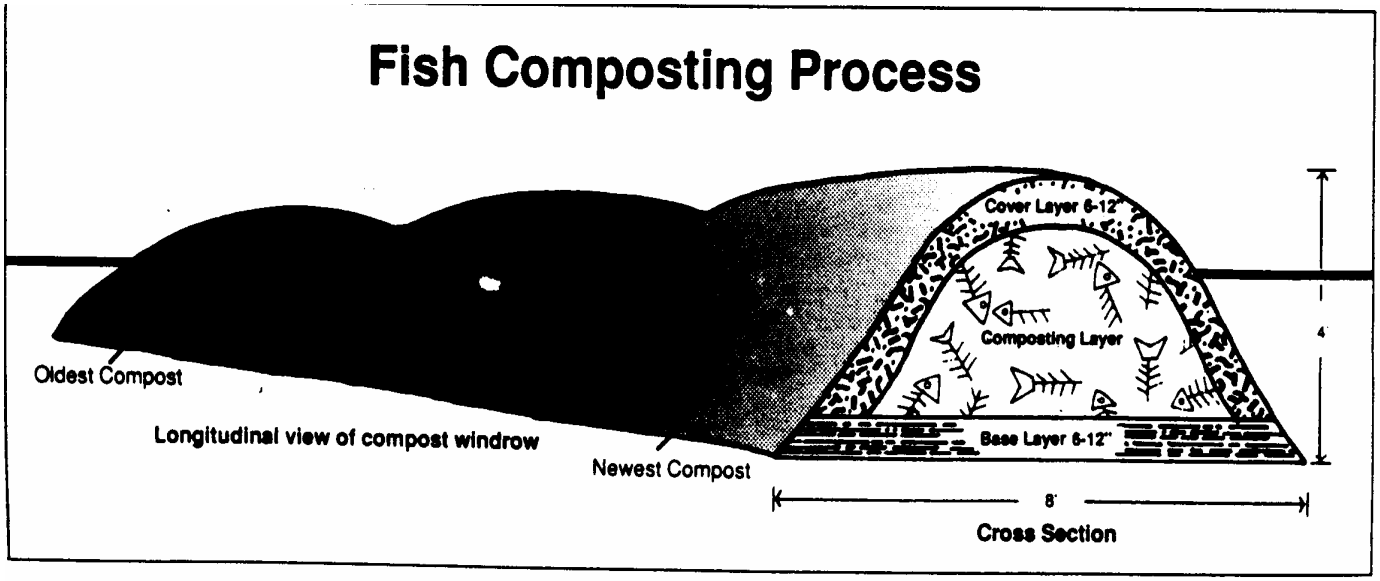
OMEGA PROTEIN USA LIQUID FISH FERTILIZER PRODUCTS	
Product Name	**Description**
OmegaGrow™ 5-1-1	This versatile liquid fertilizer is made from the same fish that the Pilgrims learned to fertilize their corn with from the local Indians. It is still an excellent source of plant nutrition. OmegaGrow is approved for organic uses by OMRI and can be used alone or in addition to your current organic or conventional fertilization program. University and widespread field trials have shown such benefits as faster germination, increased stands, increased yield, improved disease suppression and deeper root penetration. OmegaGrow is a free-flowing product that has been filtered through an 80-mesh screen and can be applied by sprayers or through irrigation systems. It works well for both soil application and as a foliar feed.
OmegaGrow Plus™ 3-1-1 with 25% oil	OmegaGrow Plus is a unique product developed exclusively by Omega Protein to provide growers with the same benefits as OmegaGrow, with the additional benefit of higher oil levels. OmegaGrow Plus enhances plant health and reduces stress and damage in crops caused by insects or disease. It works extremely well in conjunction with micro-nutrient, fertilizer and summer oil sprays and is highly economical for improving crop health and productivity. OmegeGrow Plus is all natural and organic. University and field trials show that the higher level of fish oil in this product is detrimental to soft-bodied insects as well as fungal diseases in citrus and vegetable crops. This can be used as a replacement for or in combination with petroleum oil sprays. Plant and environmental damage can be minimized and OmegaGrow Plus gives you the benefit of an additional foliar feeding of a 3-1-1 fertilizer.

Table 40 Omega Protein USA liquid fish fertilizer products.

Compost Product Descriptions

Composting offers an alternative to the conversion of by-products specifically for fertilizer or soil amendment products. Which of the methods a seafood processor chooses to handle his by-products is a decision based on volume, location, available market, energy costs and manpower. Composting uses natural processes to break down plant and animal material into its basic components. The material is broken down by microbes which require oxygen to live, grow and multiply. For seafood waste which is high in nitrogen, a source of carbohydrate is necessary to assist in the decomposition of the material. Therefore, composting will only work if there is a readily available source of vegetable waste material. This can be sawdust, corn cobs, soybean hulls, lumber waste, straw, corn stalks, potato tops and waste or any other vegetable material that is easily available, cheap or free and close to the source of fish waste. In Alaska, lumbering waste seems to be the material of choice. In some areas of the world, seaweed is blended to produce a product with many of the seawater trace elements. The ingredients in the compost

determine the nutrients that will be present. The following two figures show a typical design for a compost pile.



70 BioCycle

Figure 18 A fish compost pile design.

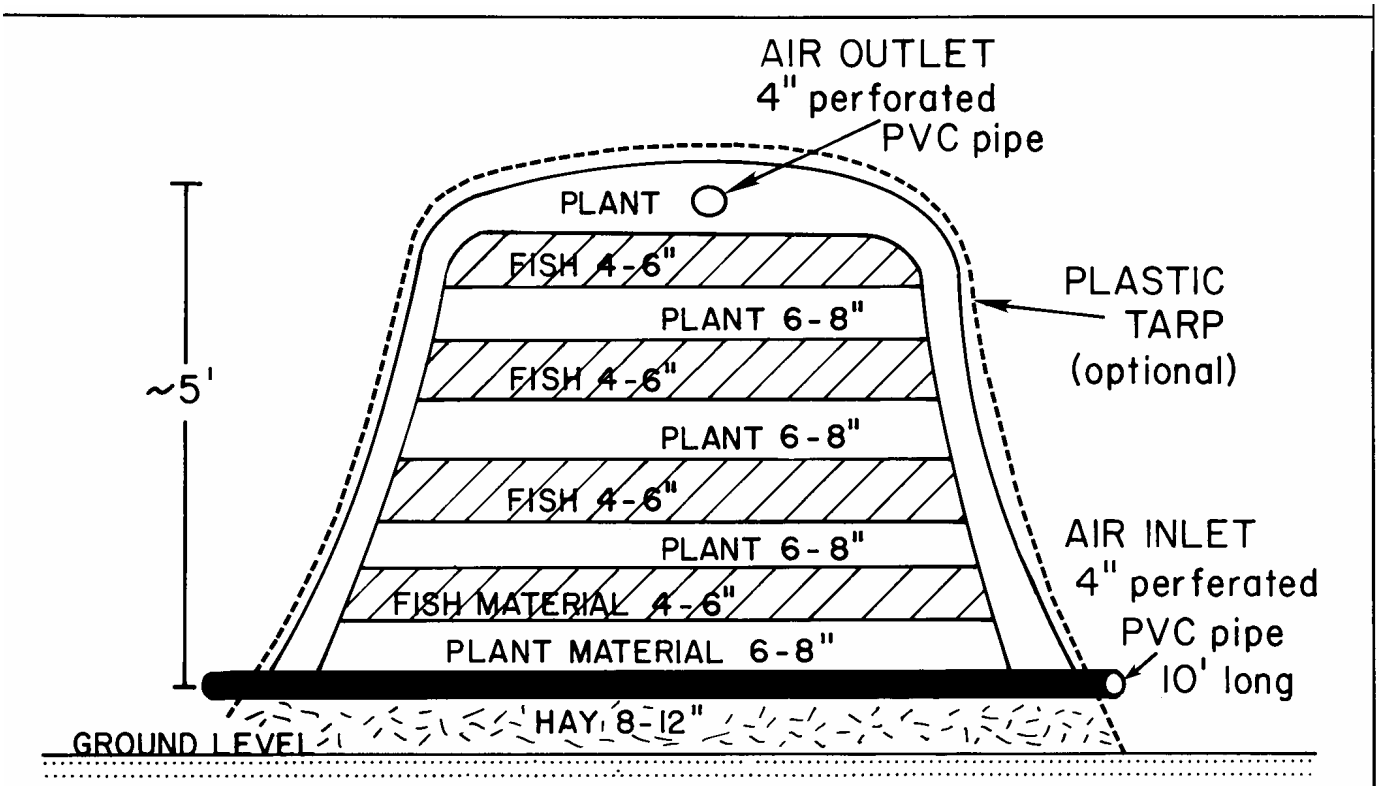


Figure 1. Cross-section of a typical static pile. The more the layers are mixed together, the better.

Figure 19 Fish compost pile cross-section.

SOURCE OF AVAILABLE NUTRIENTS IN COMPOST	
Feedstock Type (Compost Ingredients)	The nutrients in the feedstock will determine the available nutrients in the final product. Compost made from manures and biosolids is frequently higher in nitrogen (N) than that made primarily from yard trimmings or wood.
Effect of Composting Method	The anaerobic compost process (exposed to little or no oxygen) generates significant amounts of ammonia (NH_3) that are released into the atmosphere, leaving less nitrogen in the compost product. Compost that is produced through an aerobic process (exposed to adequate amounts of oxygen) generates less volatile ammonia.
Stability/Maturity	Stable and mature compost contains a variety of available macronutrients, such as carbon (C), nitrogen (N), phosphorus (P) and potassium (K). Compost also contains micronutrients, such as copper (Cu), iron (Fe) and zinc (Zn). Unstable compost can immobilize nitrogen and make it unavailable for plant use.

SOURCE OF AVAILABLE NUTRIENTS IN COMPOST	
Nutrients	Most compost suppliers will give an analysis of major nutrient content in compost. However, not all of the nutrients are available for plant use.
pH	The pH of the growing medium plays a large role in the availability of plant nutrients. In general, the pH of the compost should be greater than 5. However, pH of the soil should be taken into account.

Table 41 Source of available nutrients in compost.

BAY ORGANICS CHESAPEAKE BLUE CRAB COMPOST AND CHESAPEAKE GREEN POULTRY LITTER AND BYPRODUCTS COMPOST	
Chesapeake Blue Soil Enhancer	Chesapeake Blue is a premium soil enhancer with high calcium content that comes from the Maryland blue crab. The "leftovers" from the processing of this famous Chesapeake Bay crustacean are converted through composting, into a rich product that adds both, organic nutrients and a viable microbial population to your soil. The result is a growing media that produces sumptuous blooms, as well as tremendous yields from vegetable plants. Chesapeake Blue is especially good for tomatoes! It's high calcium content helps control "blossom end rot" and contributes to healthier stem growth to support larger fruit. The crab by-products are first analyzed for nutrient content. A computer model then builds a formula for blending them with various types of carbon, including wood chips and saw dust. After careful blending, the mixture is laid out in windrows, which are piles averaging 14 feet wide, 7 feet tall and up to 400 feet long. Within these windrows microbes go to work, breaking down the organic by-products, generating heat and water in the process. Throughout the process, the windrows are turned to maintain the proper temperature and oxygen levels for an eco-system that allows the fastest rate of decomposition. When the product is stable, it's screened and is then ready for bulk or packaged distribution throughout the Mid-Atlantic region.

BAY ORGANICS CHESAPEAKE BLUE CRAB COMPOST AND CHESAPEAKE GREEN POULTRY LITTER AND BYPRODUCTS COMPOST	
Chesapeake Green Soil Enhancer	Chesapeake Green is a nutrient-rich product that encourages vigorous, healthy lawn growth without threatening the Chesapeake Bay. It is superior as a top-dressing, a base for sod or seeding, and as a general soil enhancer for maintaining a lush, beautiful lawn. Chesapeake Green does have organic nutrients, but it is not really a fertilizer. It is designed to build healthy soil so you can grow a beautiful, "Bay Friendly" lawn. The poultry by-products are first analyzed for nutrient content. A computer model then builds a formula for blending them with various types of carbon, including wood chips and saw dust. After careful blending, the mixture is laid out in windrows, which are piles averaging 14 feet wide, 7 feet tall and up to 400 feet long. Within these windrows microbes go to work, breaking down the organic by-products, generating heat and water in the process. Throughout the process, the windrows are turned to maintain the proper temperature and oxygen levels for an eco-system that allows the fastest rate of decomposition. When the product is stable, it's screened and is then ready for bulk or packaged distribution throughout the Mid-Atlantic region.
Source: http://www.bayorganics.com/jsite/index.php?option=com_content&task=view&id=16&Itemid=9	

Table 42 Chesapeake Bay blue crab-wood chips compost.

COWSMO DAIRY FARM COMPOST	
Cowsmo Compost	We produce composted cow manure within the NOP guidelines from our dairy farm that is owned by Nettie Rosenow, my wife, Loren Wolfe, my neighbor and me. Our compost is unique because we flush our manure with recycled water from our lagoons and then we separate the liquids from the solids. We compost the solids on a blacktop surface designed for approval by the Wisconsin Department of Natural Resources. We monitor temperatures and turn when appropriate with a self propelled turner. We test to determined when the compost is done. We prefer to sell in bulk for environmental and practical reasons. **Why you should use** Cowsmo **compost.** Improves soil structure... Breaks up tightness of clay soils and adds organic matter to sandy soils. Reduces soil compaction Eases cultivation Helps suppress plant diseases Reduces erosion and leaching Increases microbial and earthworms populations Increases micronutrients and their availability Increases root structure and soil aeration Suppresses weeds when used as a mulch
Source: http://www.localharvest.org/farms/M14950	

Table 43 Cowsmo Dairy Farm compost.

SHIGAWAKE ORGANICS LTD. MARINE COMPOST MIX	
SeaGro Products	The prime ingredient in SEAGRO Marine Compost Mix, and SEAGRO Grower Mix is composted ocean fish and crustaceans; a naturally nutritious meal for all your plants, flowers and vegetables. Each bag of SEAGRO produced helps safeguard the environment through our innovations in processing fish offals. Fish processing plants produce tons of by-products consisting of the inedible and unmarketable portions of the seafood they process. SEAGRO solves this environmentally sensitive problem by using the fish by-products as the main ingredient in the composting process.
SeaGro Marine Compost Mix	**SEAGRO® Marine Compost Mix** Available in 31 litre & 11 litre bags (27 US Qts & 10 US Qts) A blend of composted ocean fish and crustaceans. Used as a soil conditioner

SHIGAWAKE ORGANICS LTD. MARINE COMPOST MIX	
	or potting medium it will ensure strong plant development essential for bright blooms and bountiful harvest. **Applications:** Flower gardens, container gardening, vegetable gardens, trees and shrubs, lawns. **Ingredients:** Canadian sphagnum peat moss, composted ocean fish, perlite, lime.
SeaGro Professional Organic Grower Mix	**SEAGRO® Professional Organic Grower Mix** Available in 31 litre bags (27 US Qts) Made from Canadian sphagnum peat moss composted with ocean fish and cattle manure, resulting in a nutrient rich compost mix which acts as a natural fertilizer, potting medium and excellent soil conditioner. **Applications:** Flower gardens, container gardening, vegetable gardens, trees and shrubs, lawns. **Ingredients:** Canadian sphagnum peat moss, composted ocean fish, composted cattle manure, perlite, lime.
Source: http://www.shigawakeorganics.com/products.htm	

Table 44 Shigawake Organics Ltd. marine compost mix.

CARDWELL FARMS (ATLANTIC CANADA) COMPOST PRODUCTS	
Cardwell Farms Compost	Cardwell Farms soil products will improve your garden. They improve soil water retention and water holding capacity. They Increase organic content of all soils and improve soil structure . They add natural organisms necessary for healthy plant development. They provide necessary nutrients without chemical additions. They act as a natural pH buffer. ***"PUT A LITTLE LOVE IN YOUR SOIL"***

Table 45 Cardwell Farms compost products.

THE ORIGINAL SEA SOIL	
Sea Soil™	Created from a mixture of fish and forest fines. This top-quality product is rich in colour and in nutrients while maintaining a neutral pH. SEA SOIL™ contains all necessary micro and macro nutrients to grow a healthy garden, is weed-free, and is an excellent way to retain moisture. SEA SOIL™ is approved by the B.C. Certified Organics Program as well as listed by the Organic Materials Review Institute (OMRI). With no fish odor, this two year composted soil is a complete soil for your garden. **SEA SOIL™ is a complete soil that will change the way your garden.** The rich black soil is full of micro-macro nutrients and trace elements to enrich your soil quality. Time between watering will increase. Fertilizers and other supplements can be eliminated. When using SEA SOIL™ with other supplements, follow the directions of all products being used.
http://www.seasoil.com/SeaSoil-OMRIlistedOriginalSeaSoil.html	

Table 46 The original sea soil.

MEEKER COMPOSTING FISH COMPOST	
Meekers Magic Mix Fish Compost	We utilize two former surplus products, fish waste and wood waste, in our operation. The fish waste consists of mainly farmed salmon offal from processing plants and farm mortalities from net pens. The wood waste consists of sawmill waste (mainly cedar sawdust). These are the ONLY materials used, so there are no non-organics in the finished product. The fish based component provides the protein feedstock and the wood-based component provides the carbohydrate feedstock to stimulate the culture of the microorganisms. The fish waste is placed in a turning drum and mixed until it is minced slurry, the wood waste is then added at a predetermined ratio. This mixture is turned in the drum until it is very homogeneous. To begin the active aeration stage, the mixture is placed in bags and stored in a covered building. Active aeration maintains a constant temperature between 50°C and 60°C during the thermophilic stage for a minimum of five days, killing all pathogens. These bags are "cured" for a period of approximately four to six weeks after the active aeration is removed. Final screening removes any non-conforming material. This compost can be used without restriction in all applications. It provides a nutrient rich and biologically active root medium that helps plants suppress disease and thrive. • Fish Compost is a powerful soil improvement including uses such turf/lawn top dressing, mulch, erosion control media, and it helps retain soil moisture. • Fish Compost is very rich averaging more than 2% total nitrogen. • Heavy metals have consistently tested very low in our compost. • Compost continues to release nutrients into the soil long after initial application. • It makes an important contribution to a rational management of

MEEKER COMPOSTING FISH COMPOST	
	waste, greatly reducing the use of landfills or incinerators
Source: http://www.meekersmagicmix.com/	

Table 47 Meekers Magic Fish compost.

EARTHBANK FISH COMPOST	
Earthbank Fish Compost	Earthbank utilizes exclusively fish waste and wood waste in our operation. The fish waste consists of mainly farmed salmon offal (some wild) from processing plants and farm mortalities from net pens mainly on the West Coast of Vancouver Island. Earthbank also provides the transportation service to haul the waste to our composting site. The wood waste consists of sawmill waste (mainly fir and hemlock bark), ground up land clearing debris and a small amount of sawdust. All materials from the mills are clean and uncontaminated. Only uncontaminated land clearing debris is accepted at our composting site. All land clearing debris is processed (i.e. ground up) before being incorporated for composting. The fish waste and wood waste are then blended together in a preset formula that can vary depending on the specific wood waste and other factors. The mixed material is then formed into a 'block' that is capped with a mixed blend of wood waste and partially cured compost to provide a biofilter for odour control of what we refer to as a 'primary block'. As fish waste is brought onto our site, this process is repeated and added to the pre-existing block until it reaches a pre-determined size and/or period of time. Then a new primary block is started. The Advantages of Using Our Product · Earthbank Fish Compost can be used without restriction in all applications. It provides a nutrient rich and biologically active root medium that helps plants suppress disease and thrive. · Fish Compost is a powerful soil amendment including use as a turf/lawn top dressing, mulch, and erosion control media, as it helps retain soil moisture. · Our compost is finely screened, mature and has been composting for a minimum of two years. · Fertilizer is generally not required if Earthbank Fish Compost is used in sufficient quantity. · Fish Compost is very rich averaging more than 2% total nitrogen.

EARTHBANK FISH COMPOST	
	· Feedstock used is exclusively fish offal, both wild and farmed, some farmed fish mortalities, and bark from fir and hemlock, ground up land clearing debris, and some sawdust from local sawmills. No other inputs are used. · Concerns about disease in farmed fish are unfounded. The high temperatures of composting (+60 degrees C) destroy all pathogens whether they are from fish, humans, or anything else. Further, fish diseases are harmless to humans. · Antibiotics in farmed fish are low when compared to other farmed products. Further, the composting process breaks down any remaining residue. · Earthbank's Fish Compost does not contain PCB's. Heavy metals have consistently tested very low in our compost. Test results are available upon request.
Source: http://www.fishcompost.com/	

Table 48 Earthbank fish compost.

Alaska Compost Products

ALASKA THUNDER DIRT
Kake Foods Inc., a subsidiary of the Kake Tribal Corporation, has a successful compost project in operation already, independent of the Alaska Wood Utilization Center. Kake a village of about 800 people on Kupreanof Island in southeast Alaska. The wood-and-fish compost project uses salmon gurry, seafood processing waste, sawdust, and other wood residues as inputs. Materials are mixed in windrows and turned regularly throughout the 75-day composting to aerate the piles and keep them moist. Some odor is created, so the project site is out of town and fenced to keep out bears. The final product is packaged in 25- and 50-pound bags for home gardeners, and marketed either as “Alaska Thunder Dirt” or under the private labels of some big chain stores. The enterprise creates jobs and strengthens the town’s existing businesses: salmon fishing, cannery, and sawmill. Kake Foods won a “showcase business” award for the compost project in 2002, received at the National Summit on Emerging Tribal Economies
http://www.fs.fed.us/pnw/pubs/science-update-5.pdf

Table 49 Alaska Thunder Dirt.

RIDOLFI INC. - TRIBAL INTEGRATED WASTE MANAGEMENT PROGRAM. Fish and Wood Waste Compost Pilot Project	
"Fish 'n Chips Compost™"	A pilot-scale demonstration of composting using fish and wood waste was conducted on Annette Island. The purpose of this pilot was to develop a process that would produce a pilot-scale quantity of compost material suitable for use as a soil amendment. The objective of the pilot was to demonstrate that producing suitable compost material from wood waste and fish waste is possible at Metlakatla. Design of the pilot included preparing a prescribed mixture of fish waste and wood waste, placing the mixture in a designed pile at a suitable location, and monitoring and controlling the composting process as necessary to convert the organic wastes into a usable compost material. Whole carcasses of king salmon, sawdust, and wood chips were used. The composting pile was designed with a ratio of three parts wood waste to one part fish waste (3:1) by volume to achieve a carbon/nitrogen weight ratio in the 15:1 to 40:1 range. The approximate quantities of each material were: Wood Chips 6.52 cubic yards = 3521 pounds Sawdust 4.89 cubic yards = 1453 pounds Fish (130 Salmon) 1.97 cubic yards = 2400 pounds
Source: http://www.ridolfi.com/Annette/IWMP/index.html	

Table 50 Ridolfi Inc. Tribal Integrated Waste Management Program.

In 1996 - 1998 the Sitka Tribal Enterprises group whose purpose is the development, support and management of economic activities that benefit Sitka Tribe of Alaska citizens, sought to develop a fish waste and wood debris composting facility. At the time 3000 tons of fish waste was generated per year but it was projected that the figure could go as high as 7200 tons. A detailed report was issued outlining costs, odor abatement and the feasibility of producing compost in Sitka. Odor abatement included the installation of a pilot biological filter to handle the off odors from the operation. Following is some of data on their results. The report can be viewed at http://209.85.215.104/search?q=cache:CWGZo9U2p6EJ:www.sitkatribe.org/environment/pdf/E_A_Final3_13_98.pdf+Sitka+Tribal+Enterprise+Fish+Waste+compost+project&hl=en&ct=clnk&cd=12&gl=us

SITKA TRIBAL ENTERPRISES FISH WASTE COMPOSTING PROJECT	
	Significant Findings
Initial Mix	Initial mix was wetter than optimum but no negative effect on process. Wood debris bulking material worked well but a drier material would be better. The 3:1 bulking ratio performed well.
Process Control	Near optimal conditions (moisture, oxygen, temperature) were maintained using the ASP process. Water should be added to the mix after about 3 weeks of composting.
Aeration	Aeration system requires a coarse textured pile base and a homogeneous initial mix in order to maintain consistent temperature throughout the pile. Aeration blowers should be sized to provide a maximum of 3000 CFH/dt of fish waste during the first 3 weeks of composting. Aeration blowers should be sized to provide a maximum of 500 CFH/dt of initial mix during curing.
Odor Control	Odor generation subsides significantly after 4 to 6 weeks of composting. The biofilter provided an odor removal efficiency of better than 89 percent and is effective for treating fish waste composting odors. Negative aeration was effective for capturing odor generated during composting.
Processing Period	Fish wastes, even in whole fish form decomposed beyond recognition in less than 8 weeks of composting. A stable compost product was produced in less than 10 weeks of compositing. An 8 week aerated composting/curing period is recommended followed by a 4 week unaerated curing/storage period.
Product Quality	An aesthetically pleasing high quality product was produced. The product's low pH <5.0 may require process modifications and or addition of limestone. The product has a very low trace metal and fecal Coliform content.

Table 51 Sitka Tribal Enterprises fish waste compost project findings.

5. PRODUCT QUALITY PARAMETERS

Introduction

Fishery products are characterized into four major areas; proximate composition, micro and macro minerals, amino acids, vitamins and biological data. The biological data might include digestibility and energy values for different species of animals. The average composition data for a number of fishery products is shown in the following table.

THE AVERAGE COMPOSITION OF VARIOUS FISHERY PRODUCTS.									
	Menhaden	**Anchovy Peru**	**Anchovy Chile**	**Herring, Atlantic**	**Herring, Norway**	**Tuna**	**King Crab**	**Blue Crab**	**Menhaden Solubles**
Proximate Composition, %									
Protein	62.0	65	67	72.6	75.3	59.5	39.7*	29.4*	31.8
Fat	10.2	10.4	5.5	9.7	6.0	7.4	7.4	2.1	8.9
Moisture	8.3	8.2	7.7	7.0	6.6	6.5	4.7	4.4	48.7

THE AVERAGE COMPOSITION OF VARIOUS FISHERY PRODUCTS.									
	Menhaden	**Anchovy Peru**	**Anchovy Chile**	**Herring, Atlantic**	**Herring, Norway**	**Tuna**	**King Crab**	**Blue Crab**	**Menhaden Solubles**
Ash	18.0	15.4	14.5	10.4	10.1	23.3	26.6	31.0	7.8
Macro Minerals, %									
Calcium	5.3	4.0	3.4	2.0	2.0	8.9	6.9	18.0	0.1
Phosphorous	3.0	2.6	2.2	1.5	1.5	4.7			0.6
Sodium	0.34	0.87	1.10	0.63	0.42	0.73	1.20	1.80	1.10
Potassium	0.72	0.65	0.89	1.12	1.20	0.73	1.20	1.80	1.10
Magnesium	0.14	0.25	0.27	0.14	0.11	0.23	3.5	1.3	0.1
Micro Minerals, ppm									
Iron	438	246	226	146	151	368	375	155	574
Copper	11	11	9	6	5	11	111	32	44
Zinc	151	111	100	121	120	213	251	102	18
Manganese	36	10	9	5	2	9	12	>400	5
Chromium	11	8	6	3	4	18	15	42	3
Boron	14	14	112	6	6	16	22	25	3
Barium	20	5	6	2	3	5	9	34	5
Strontium	63	88	59	37	71	>200	>200	>200	4
Aluminum	352	77	73	35	33	150	176	430	194
Selenium	2.2	1.4	1.4	2.0	2.8	4.6	0.25	3.8	2.03
Amino Acids as % of Sample									
Lysine	4.7	4.9	5.3	5.7	5.7	3.9	1.7	1.4	1.5
Methionine	1.8	1.9	2.0	2.2	2.1	1.5	0.7	0.5	0.5
Cystine	0.6	0.6	0.6	0.7	0.7	0.4	0.3	0.2	0.3
Tryptophan	0.7	0.7	0.8	0.8	0.8	0.6	0.5	0.4	0.1
Histidine	1.4	1.5	1.8	1.6	1.9	1.8	1.0	0.7	0.8
Arginine	3.8	3.7	3.9	4.2	4.4	3.4	2.4	1.8	1.3
Threonine	2.5	2.7	2.9	3.0	3.0	2.3	1.7	1.0	0.7
Valine	3.2	3.4	3.6	3.9	4.0	2.8	2.1	1.3	0.9
Isoleucine	2.7	3.0	3.2	3.3	3.4	2.4	1.6	1.0	0.6
Leucine	4.5	4.9	5.1	5.4	5.2	3.8	2.3	1.4	1.2
Tyrosine	2.0	2.2	2.3	2.4	2.3	1.8	1.6	1.0	0.7
Phenylalanine	2.5	2.8	2.9	2.9	2.8	2.2	1.6	1.1	0.3
Aspartic Acid	5.7	6.1	6.3	6.6	4.4	5.0	3.8	2.2	1.6
Serine	2.3	2.3	2.5	2.7	2.6	2.2	1.7	0.9	0.7
Glutamic Acid	7.9	8.3	8.6	9.2	9.2	6.4	4.6	3.0	2.6
Proline	2.9	2.6	2.7	2.8	3.1	2.9	1.9	1.3	1.4
Glycine	4.2	3.6	3.7	4.0	4.6	4.3	2.6	1.8	2.8
Alanine	3.7	4.0	4.2	4.4	6.5	3.6	1.9	1.4	1.8
M E kcal/lb	1530								922

*Protein adjusted for chitin nitrogen,
Source: Feedstuffs 1973

Table 52 The composition of various fishery products.

In general terms, fishmeal can be placed into one of four groups: herring type fishmeals, anchovy type fishmeals, white fish type fishmeals and menhaden type fishmeals. These general type fishmeals can be defined according to the composition data shown in the following table.

PROXIMATE COMPOSITION OF 4 DIFFERENT TYPES OF FISHMEAL.				
	HERRING	**WHITE FISH**	**ANCHOVY**	**MENHADEN**
Proximate Analysis, %				
Crude Protein	71.9	64.5	66.4	61.25
Ether Fat	7.5	4.9	9.7	9.1
Moisture	8.4	10	8.6	8
Ash	10.1	20	15.4	18.8
Protein Characteristics, % of Crude Protein				
Rumen Degradable	48.8	53.3	48.5	50.5
Water Soluble	19.8	8.9	18.3	15.5
ENERGY CONTENT, MJ/KG				
Poultry, M.E.	13.7	11.6	13.5	12.8
Pigs, D.E.	18.1	15.6	16.9	16.5
Ruminants, M.E.	16.4	13.4	13.1	12.8
Fish, M.E.	17.0	16.5	16.5	16
Amino Acids, % of Protein				
Lysine	7.73	6.90	7.75	7.43
Methionine	2.86	2.6	2.95	2.63
Cystine	0.97	0.93	0.94	0.90
Tryptophan	1.15	0.94	1.20	0.78
Arginine	5.84	6.37	5.82	6.01
Phenylalanine	3.91	3.29	4.21	3.55
Threonine	4.26	3.85	4.31	3.98
Minerals				
Calcium, %	1.95	8	3.95	4.87
Phosphorous, %	1.5	4.8	2.6	2.93

PROXIMATE COMPOSITION OF 4 DIFFERENT TYPES OF FISHMEAL.				
	HERRING	**WHITE FISH**	**ANCHOVY**	**MENHADEN**
Sodium, %	0.42	0.77	0.87	0.61
Magnesium, %	0.11	0.15	0.25	0.20
Potassium, %	1.20	0.90	0.65	0.81
Iron, ppm	150	300	246	1019
Copper, ppm	5.4	7.0	10.6	5.5
Zinc, ppm	120	100	111	84
Manganese, ppm	2.4	10	9.7	41
Selenium, ppm	2.78	1.5	1.39	2.21
Vitamins, ppm				
Panthothenic Acid	30.6	15	9.3	8.8
Riboflavin	7.3	6.5	2.5	4.8
Niacin	126	50	95	55
Choline	4396	4396	4396	4396
B12	.25	.07	.18	.06
Biotin	.42	.08	.26	.26
Essential Fatty Acids, % of Fatty Acids				
C18:2n-6	2	1	1	1
C18:3n-3	1	1	1	1
C18:4n-3	2	2	2	2
C20:4n-6	1	Na	1	1
C20:5n-3	6	12	16	12
C22:5n-3	1	2	2	3
C22:6N-3	13	19	14	9
TOTAL N-3 FATTY ACIDS	23	35	34	30

Table 53 Composition data for 4 general types of fishmeal.

It is easy to see that as you move through the groups, the protein is replaced by ash. Thus, if the product is sold on its protein basis, the herring meal would command a much higher price than the menhaden meal and the others would fall somewhere in between.

The most comprehensive data available for Alaska fishmeals comes from the groups associated with the Alaska Sea Grant College Program and stationed at the Univ. of Alaska Fairbanks and the Fishery Industrial Technology Center at Kodiak Alaska. Much of the data was published in the Proceedings of the 2002 Conference on Advances in Seafood Byproducts as well as in various presentations and publications since that conference. Some of the data is included here so that it can be compared to the global fishmeals available in the marketplace.

ALASKA WHITEFISH FISHMEALS												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Average**
PROXIMATE ANALYSIS												
Protein, %	72.3	66.8	69.7	69	68.8	71.8	65.2	69.8	67.2	67.1	74.3	69.3
Fat, %	8.2	5	6	7.4	7	7.4	6.3	9	6.3	9.5	11.3	7.6
Moisture, %	7.6	2.8	8	7.8	4.7	8.3	5.8	5.5	7.9	3.4	5.7	6.1
Ash, %	15.4	23.5	13.5	15.5	17.8	14.4	21.8	15.8	20.2	19.1	10.1	17
Ethoxyquin, ppm	79	150	130	100	91	75	56	57	46	94	84	87.5
MINERALS												
Calcium, %	4.63	7.5	4.58	5.51	5.88	3.64	8.51	5.21	7.5	6.7	2.67	5.67
Potassium, %	0.57	0.3	0.35	0.24	0.18	0.87	0.18	0.21	0.33	0.42	0.31	0.36
Magnesium, %	0.2	0.33	0.26	0.3	0.26	0.18	0.4	0.3	0.31	0.24	0.23	0.27
Sodium, %	1.01	1.21	0.65	0.88	0.78	1.05	0.98	0.86	1.06	0.74	0.82	0.92
Phosphorous, %	2.85	4.05	2.63	3	3.1	2.35	4.39	2.96	3.84	3.79	1.7	3.15
Silver, ppm	0.5	0.9	0.4	0.8	0.5	0.9	0.7	0.8	0.8	0.5	0.69	
Cadmium,												
Copper	4.2	2.1	3.1	2.9	4.4	4	2.5	4.2	1.9	4.7	3.5	3.41
Iron	48.8	39.4	98.4	64	94.5	72.5	74.9	65.2	37.1	49.9	66.9	64.69
Manganese	5	8.4	4.3	3.9	4.2	10.3	6.3	3.8	3.6	4	2.4	5.11
Nickel	0.7	1.4	0.7	0.8	0.8	0.9	0.7	0.8	0.9	0.5	0.8	0.2
Lead												
Strontium	240	390	236	285	363	209	380	288	389	327	155	297
Zinc	79	90	101	108	111	82	96	119	89	107	95	97.9
AMINO ACIDS, % of PROTEIN												
Alanine	8.48		7.97	8.13	8.02	8.54	7.96	7.95	8.28	8.24	7.88	8.15
Arginine	5.39		5.37	5.29	5	5.72	5.14	5.25	5.07	5.25	5.12	5.26
Aspartic Acid	14.1		14.24	15.41	15.1	13.48	14.44	14.33	14.85	14.39	15.66	14.6
Cystine												
Glutamic Acid	17.8		17.09	18.42	18.02	17.02	17.61	17.36	17.66	17.36	18.91	17.73
Glycine	13.28		10.22	10.31	10.3	14.05	11.3	10.76	11.29	11.66	8.58	11.18

ALASKA WHITEFISH FISHMEALS												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Average**
Histidine	1.63		1.9	1.86	1.82	1.67	1.8	1.9	1.71	1.75	1.78	1.78
Isoleucine	3.56		4.13	4.02	3.88	3.52	3.93	3.92	3.87	3.9	4.04	3.87
Leucine	6.4		7.35	7.17	6.99	6.3	7.05	7.09	6.99	6.97	7.15	6.05
Lysine	6.09		6.11	6.72	6.45	5.95	5.86	6.36	6.18	5.94	6.44	6.21
Methionine												
Phenylalanine	2.66		3.27	3.03	2.96	2.71	3	3.07	2.94	2.95	3.04	2.96
Proline	5.03		4.63	4.57	4.44	5.22	4.84	4.57	4.86	4.98	4.14	4.73
Serine	4.76		4.9	4.94	4.78	4.89	4.86	4.94	4.82	4.73	4.65	4.83
Threonine	4.27		4.98	4.8	4.68	4.33	4.78	4.77	4.53	4.54	4.88	4.66
Tyrosine	2.01		2.48		2.39	2.04	2.4	2.54	2.25	2.29	2.53	2.1
Valine	4.56		5.35	5.22	5.06	4.56	5.03	5.15	4.98	5.05	5.2	5.02
FATTY ACID COMPOSITION OF THE FAT IN THE FISHMEAL, MG/G OF EXTRACTED FAT												
C18:3	2.3	2.1	2.5	3.2	3.1	2.9	3.8	3.1	3.2	3.5	2.4	
C18:4	7.6	7	9.5	13.1	13.9	9.9	13.3	13.9	14.5	8.2	11.3	
C20:4	3.1	1.8	2.5	3.1	3.8	3.5	3.5	3.8	3.8	3.4	4.1	
C20:5	142.5	70.2	114.7	112.5	129.7	136.9	111.3	99.1	128.4	116.2	111.7	115.8
C21:5	5.5	3.1	4.4	4.1	4.9	5.6	4.2	4.8	5	4.8	4.9	
C22:5	7.9	6.9	5.9	7.4	7.8	13.8	7.1	7.3	6.8	6.3	10.7	
C22:6	55.4	54.3	83	91.2	87.7	78.1	80.9	80.7	71.8	63.2	92.5	76.3
Source: Advances in Seafood Byproducts, 2002 Conference Proceedings, Alaska Sea Grant College Program Univ. of Alaska Fairbanks												

Table 54 Alaska whitefish fishmeals composition data.

Fishmeal

The following tables give some composition data on various commercial fishmeals taken from company web sites. The purpose in using this data is to show that the quality parameters vary by company, country, species, product grade, and target end use. Generally, unique data is presented that depicts the best qualities of the specific product and demonstrates it's superiority over competing products of similar grade. It should be noted that since the previous report some companies have dropped special products from their portfolios while others seem to have dropped the standard FAQ quality and only offer special quality products.

TRIPLE 9 (999) DANISH PRIME QUALITY FISHMEALS				
	CON KIX	**999 AQUALITY**	**999 PRIME QUALITY**	**999 LT FISHMEAL**
Protein, %	Min 70%	Min 70%/72%/74% range 70% – 76%	Basis 72%/74%/76% range 69% - 76%	Min 70%
Crude Fat, %	Max 13.5% Acid Hydrolysis Max 11.5% Extraction	Max 13.5% Acid Hydrolysis Max 11.5% Extraction, range 6%-11%	Max 14% Acid Hydrolysis Max 12% Extraction, range 6% - 12%	Max 13.5 Acid Hydrolysis Max 11.5 Extraction
Moisture, %	Max 10% Min 6%	Max 10% Min 6% range 6% - 10%	Max 10% Min. 4%, range 4% - 10%	Max 10% Min 6%
True Digestibility, Mink	Min 92%			Min 90%
SALT (NaCl)	Max 2.5%	Max 3%, range 2% - 3%	Max 3%, range 2% - 3%	Max 3.0%
Ash	Max 14%			Max 14%
TVN, % NH_3-N	Max 0.18%			Max 0.18%
Water Soluble Protein, %	Min 18% Max 32%			Min 18% Max 32%
Cadaverine, ppm	Max 1000	Max 1500, range 700 - 1200		Max 1000
Histamine, ppm	Max 300	Max 150, range 10 - 100		Max 150
Antioxidant	150 ppm Ethoxyquin Added Before And After Drying	100- 150 ppm ethoxyquin added, range 50 – 150	100 – 150 ppm Ethoxyquin added, range 50 -150 ppm	150 ppm Ethoxyquin Added Before And After Drying
Raw Material Quality, Mg/100g	Max 45 MgN/100g At Entrance To Cooker	Max. 60 Mg N/100g, range 40 – 60 mgN/100g		50 ppm mgN/100g Max. At Entrance To Cooker
Salmonella	Not Detected	Not Detected	Not Detected	Not Detected
Enterobacteria	< 300/gram	< 300/gram	< 300/gram	< 300/gram

Table 55 Triple Nine Danish prime quality fishmeals.

FF SKAGEN DANISH FISHMEALS			
	SPECIAL A	**FF CLASSIC**	**LT SUPREME**
Crude Protein (basis)	71	72%	71%
Raw fat	Max 12	Max 12	Max 12
Moisture	Max 10	Max 10	Max 10
Salt	Max 3	Max 3	
Ash	10 – 16	10-16	Max 14
pH stat digestibility	Min 88		Min 88
Titration value	Max 80		Max 80
Free fatty acids	Max 12		Max 10
Vitamins (content mg per kg DM)			
Vitamin E	4	4	4
Thiamine	1	1	1
Riboflavin	7.50	7.50	7.5
Pyridoxine	2.50	2.50	2.5
Niacin	65	65	65
Biotin	8	8	8
Vitamin B-12	0.04	0.04	0.04
Amino acid content mean value in g/kg DM			
Alanine	49.57	47.55	48.43
Arginine	47.17	41.38	47.92
Aspartic acid	75.52	67.93	76.81
Cystine	7.43	6.29	8.24
Glutamic acid	111.82	101.99	106.22
Glycine	50.18	45.92	43.61
Histidine	15.48	14.94	20.66
Isoleucine	35.98	33.56	38.75
Leucine	60.59	55.90	62.47
Lysine	60.92	55.90	66.08
Methionine	23.55	21.76	26.07
Phenylalanine	30.19	27.93	34.42
Proline	33.44	30.09	34.66
Serine	34.02	31.15	35.51
Threonine	32.96	30.73	35.89
Tryptophan	8.49	7.53	9.31
Tyrosine	25.10	21.70	29.01
Valine	41.37	40.38	46.76
Mineral Content per kg DM			
Calcium, g	35.2	35.2	35.2
Phosphorus, g	23.9	23.9	23.9
Magnesium, g	2.2	2.2	2.2
Sodium, g	7.3	7.3	7.3
Potassium, g	13	13.0	13.00
Iron, mg	332	332	332.00
Manganese, mg	15	15	15.00
Cobber, mg	5	5	5.00
Zinc	106	106	106.00
Selenium	2.38	2.38	2.38

Table 56 FF Skagen Danish fishmeals.

Austral Group (Peru) Steam Dried Fishmeal (Plantas: Paita, Coishco, Chancay, Pisco & Ilo)						
			SuperPrime	**Prime**	**Aqua +**	**Estandar**
Protein	%	min	68-70	67-70	66-68	64-68
Fat	%	max	10	10	10	10
Moisture	%	max	10	10	10	10
FFA	%	max	7,5	10	10	-
Ash	%	max	16	17	20	-
Salt & Sand	%	max	4	4,5	5	5
TVN	mg/100gr	max	100	120	150	200
Histamine	ppm	max	500	1000	-	-
Digestibility	%	min	94	94	90	-
Antioxidant	ppm	min	150	150	150	-

Table 57 Austral Group steam dried Peruvian fishmeals.

Austral Group Peruvian Hot Air Dried Fishmeal (Planta: Huarmey)					
			Flame Dried	**FAQ**	**Sub Estandar**
Protein	%	min	67-70	64	< 64
Fat	%	max	10	10	> 10
Moisture	%	max	10	12	> 12
FFA	%	max	10	-	-
Ash	%	max	14.5	-	-
Salt & Sand	%	max	4.5	5	> 5
TVN	mg/100gr	max	120	200	> 200
Histamine	ppm	max	1000	-	-
Antioxidant	ppm	min	150	150	150

Table 58 Austral Group hot air dried fishmeals.

COPEINCA S.A. PERUVIAN FISHMEALS						
	FAQ	STEAM DRIED				
	STANDARD	PRIME	SUPER PRIME	TAIWAN	THAILAND	STANDARD
Protein, %	64	67	68	67	67	64
TBVN (TVN), mgN/100g		120 Max	100 Max	120 Max	150 Max	10
FFA, %		10 Max.	7.5 Max.	10 Max.	10 Max.	10
Histamina, ppm		1000	500			
Fat, %	12	10	10	10	10	0
Moisture, %	10	10	10	10	10	
Salt and Sand Combined, %	5	5	4	5	5	5
Salt, %	2	2	1	2	2	2
Antioxidant, ppm	150	150	150	150	150	150

Table 59 Copeinca S.A. Peruvian fishmeal.

PESQUERA HAYDUK S.A. PERUVIAN FISHMEALS								
			STEAM DRIED					OPEN FLAME
ANALYSIS	UNIT	RANGE	SUPER PRIME	TAIWAN	THAILAND	STANDARD	GIANT SQUID MEAL	FAQ
Protein	%	min.	68	67	67	66	80	64
Fat	%	max.	10	10	10	10	10	12
Moisture	%	min-max	7-10	7-10	7-10	10	10	8
Free Fatty Acids(FFA)	%	max.	7.5	10	10	-	10	-
Ash (Salt Free)	%	max.	13	-	-	-		-
Salt & Sand	%	max.	4	5	5	5	5	5
Sand	%	max.	1	2	2	2		2
TVN	mg/100g	max.	100	120	150	-	400	-
Histamine	Ppm	max.	500	-	-	-		-
Torry Modif. Digestibility	%	min.	94	-	-	-		-
Antioxidant	Ppm	min.	150	150	150	150	150	150

Table 60 Pesquera Hayduk S.A. Peruvian fishmeals.

OMEGA PROTEIN INC. USA MENHADEN FISHMEALS				
	SPECIAL SELECT	**FAQ**	**SEA LAC**	**Natural Nautic**
Crude Protein, %	64.2	60.4	63.7	64.2
Fat, %	8.9	9.4	8.4	8.9
Moisture, %	8.4	10.2	8.3	8.4
Ash, %	18.6	19.5	19.2	18.6
Pepsin Digest, 0.0002%	92.8		90.4	92.8
TVN, Mg/100 g	140			140
Histamine, ppm	250			250
Rumen Undegradability			70	
NEL (Mcal/Lb)			0.7	
Omega 3 Fatty Acids, %		2.50		
Amino Acids, % Of Sample				
Alanine	4.2	4.2	3.2	4.2
Arginine	4.0	4.0	4.0	4.0
Aspartic Acid	5.8	5.8	6.0	5.8
Cystine	0.6	0.6	0.7	0.6
Glutamic Acid	8.6	8.6	8.5	8.6
Glycine	4.8	4.8	4.5	4.8
Histidine	1.8	1.8	1.8	1.8
Hydroxyproline	1.4	1.4	1.2	1.4
Isoleucine	2.7	2.7	2.7	2.7
Leucine	4.6	4.6	4.6	4.6
Lysine	5.0	5.0	4.9	5.0
Methionine	2.2	2.2	2.1	2.2
Phenylalanine	2.5	2.5	2.5	2.5
Proline	3.3	3.3	3.2	3.3
Serine	2.5	2.5	2.6	2.5
Taurine	0.5	0.5	0.4	0.5
Threonine	2.7	2.7	2.8	2.7
Tryptophan	0.5	0.5	0.6	0.5
Tyrosine	2.1	2.1	2.1	2.1
Valine	3.2	3.2	3.2	3.2
Minerals				
Aluminum, ppm	760.8	803.5	747.9	760.8
Barium, ppm	16.9	16.0	17.6	16.9
Boron, ppm	5.0	4.2	4.8	5.0
Calcium,%	4.76	4.91	5.53	4.76
Chromium, ppm	4	3.9	4.2	4
Copper. ppm	4.3	7.1	4.5	4.3
Iron, ppm	801.1	946.7	797.9	801.1
Magnesium, %	0.21	0.21	0.20	0.21
Manganese, ppm	44.1	45.5	46.9	44.1
Phosphorous, %	3.01	2.97	3.3	3.01
Potassium, %	1.06	0.96	0.67	1.06

Selenium, ppm	2.2	2.1	1.9	2.2
Sodium, %	0.74	0.67	0.46	0.74
Strontium, ppm	63.3	64.9	74.9	63.3
Zinc, ppm	97.8	93.8	109.1	97.8
Antioxidant				Mixed Tocopherols

Table 61 Omega Protein Inc. USA menhaden fishmeals.

SR MJOL ICELANDIC FISHMEALS				
	BASIS	**STANDARD**	**AQUASALAR**	**AQUASTAR**
TVN in raw material:	min.		90 mgN/100 g.	50 mg N/100g
Crude protein:	Basis	70%	70%, min 68%	71%, min 68%
Fat (Soxhlet):	Max.	12%	12%	12%
Moisture:	Min.	6%, max. 10%	6%, max. 10%	6%, max. 10%
Salt (as NaCl):	Max.	4.5%	4.5%	4.5%
Salt free ash:	Max.		13%	13%
NH3-N:	Max.		0.18%	0.18%
Water soluble protein:	min.			20%, max. 32%
Cadaverine:	Max.		1800 ppm	1000 ppm
Histamine:	Max.		400 ppm	200 ppm
Mink Digestibility	min.			90%
Amino Acid Content based on a protein content of 70%, the amino acid content of our fishmeal is on average as follows on % of fishmeal basis:				
Lysine		5.4	5.4	5.4
Histidine		1.4	1.4	1.4
Arginine		4.0	4.0	4.0
Threonine		2.9	2.9	2.9
Serine		2.9	2.9	2.9
Cystine		0.6	0.6	0.6
Methionine		2.1	2.1	2.1
Isoleucine		3.0	3.0	3.0
Leucine		5.4	5.4	5.4
Tryptophan		0.7	0.7	0.7
Aspartic Acid		6.8	6.8	6.8
Glutamic Acid		9.8	9.8	9.8
Glycine		4.1	4.1	4.1
Alanine		4.4	4.4	4.4
Valine		3.7	3.7	3.7
Tyrosine		2.6	2.6	2.6
Phenylalanine		2.7	2.7	2.7
Proline		2.5	2.5	2.5
Taurine		0.6	0.6	0.6

Table 62 SR Mjol Icelandic fishmeals.

In March 2006 Grupo SIPESA was acquired by Grupo Brescia who also owns TASA (see later in this report). The data has been retained since it offers another data set for comparison.

GRUPO SIPESA PERUVIAN FISHMEALS				
	FLAME (FAQ)	STANDARD STEAM	PRIME	SUPERPRIME
Protein	64-66%	65-67%	Min 67%	Min 68%
Fat	Max 12%	10-12%	Max 10%	Max 10%
Moisture	Max 10%	Max 10%	Max 10%	Max 10%
Free Fatty Acids (FFA)	N/A	10-12%	Max 10%	Max 7.6%
Ash (Salt Free)	N/A	Max 15%	Max 14%	Max 14%
Salt And Sand	Max 5%	Max 4.5%	Max 4.5%	Max 4%
TVN (Mg/100 grams)	N/A	121 – 180	Max 120	Max 100
Histamine (ppm)	N/A	N/A	Max 1000	Max 500
Antioxidant (ppm)	Min 150	Min 150	Min 150	Min 150
Modified Torry Digestibility	N/A	N/A	Min 92%	Min 94%

Table 63 Grupo SIPESA Peruvian fishmeals.

PESQUERA BIO BIO CHILEAN FISHMEALS				
	PRIME A	SUPER PRIME	SUPER PRIME 1000	WHITE FISHMEAL
Protein, %	68-69	68- 69	68 – 69	65 - 66 %
Fat, %	7 - 10	7 - 10	7 – 10	5 - 8 %
Moisture, %	7 -10	7 -10	7 -10	7 - 10 %
Ash, %	13 – 17	13 - 17	13 - 17	16 - 20 %
Salt & Sand, %	2 - 3 %	2 - 3 %	2 - 3 %	2 - 3 %
TVN Mg/100 g	<120	<120	<120	100 - 120
FFA, %	<7.5	7.5 - 10	<7.5	< 7.5
Histamine, ppm		500 - 1000	<500	300 - 500
Digestibility, %	95	95	95	94 %
Water Soluble Protein, %	>20	>20	>20	18 - 22 %
Lysine, %	6 -7	6 -7	6 -7	6 - 7 %

Table 64 Pesquera Bio Bio Chilean fishmeals.

PESQUERA PACIFIC STAR CHILEAN SALMON FISHMEALS		
	SPECIAL SALMON MEAL	PREMIUM SALMON MEAL
Protein, %	60 - 64	64 - 66
Fat, %	14.0	9.5 - 12
TVN, mg N/100 g	120 - 150	100 – 120
Moisture, %	9 – 10	9 – 10
Ash, %	13 – 16	13 – 15
Salt, %	1.0 – 3.5	1 – 3
Antioxidant, ppm	150 - 400	150 – 400
FFA, %	12.0	7 – 12
Metabolizable Energy, Mcal/Kg	2.4 – 3.2	2.4 – 3.0
Digestibility, %	92 – 95	92 – 95
Biotox Score	0.1 – 0.3	0.1 – 0.3
Lysine, % Protein	6.5- 8.0	6.5 – 8.0
Soluble Protein, %	32 – 48	32 – 48
Iodine Value	175 – 180	175 – 180
Peroxide Value, Meq/Kg	1.8 – 2.5	1.8 – 2.5
Phosphorous, %	2.0 - 2.6	2.0 - 2.6
Calcium, %	2.5 – 2.7	2.5 – 2.7
Histamine, ppm	20 – 200	20 - 200
Lysine, % Protein	6.5 – 8.0	6.5 – 8.0
Aspartic Acid	7.0 – 9.2	7.0 – 9.5
Glutamic Acid	11.0 – 13.0	11.6 – 13.0
Serine	4.6 – 4.8	4.6 – 4.8
Glycine	7.0 – 9.5	7.0 – 9.5
Histidine	2.0 – 2.5	2.0 – 2.5
Arginine	4.3 – 7.0	4.3 – 7.0
Threonine	4.7 – 4.8	4.7 – 4.8
Alanine	5.0 – 6.7	5.0 – 6.7
Proline	3.0 – 5.3	3.0 – 5.3
Tyrosine	3.0 – 5.0	3.0 – 5.0
Valine	4.3 – 8.0	4.3 – 8.0
Methionine	3.0 – 5.3	3.0 – 5.3
Isoleucine	3.4 – 7.5	3.4 – 7.5
Leucine	6.0 – 11.0	6.0 – 11.0
Phenylalanine	6.1 – 6.8	6.1 – 6.8
Tryptophan	0.45 – 0.46	0.45 – 0.46

Table 65 Pesquera Pacific Star Chilean salmon fishmeals.

PESQUERA EL GOLFO CHILEAN FISHMEALS					
	Super Prime A	**Super Prime B**	**Prime**	**Regular**	**Standard**
Protein %, Min.	68%	68%	67%	67%	65%
Fat %, Max.	10%	10%	10%	10%	12%
Moisture, % Max	10%	10%	10%	10%	10%
Salt & Sand %, Max.	4%	4%	4%	5%	5%
Ash %, Max.	16%	16%	16%	17%	18%
TVN mg N/100 g, Max.	120	120	120	150	-
FFA %, Max.	7.5%	7.5%	7.5%	12%	-
Histamine ppm, Max.	500 ppm	1000 ppm	-	-	-
Free of Salmonella and Shigella.					

Table 66 Pesquera El Golfo Chilean fishmeals.

COLOSSO FISHING GROUP CHILEAN STEAM DRIED FISHMEALS					
Raw Material	**100% Jack Mackerel - 100% Anchovies - Mixed**				**Giant Squid**
	Super prime	**Prime**	**Super prime low protein**	**Standard**	**100% squid meal**
Protein	68% min	68% min	64% - 65% min	65%	78% min
Fat	10% max	10% max	10% max	12% max	10% max
Moisture	10% max	10% max	10% max	10% max	10% max
Salt&Sand	4% max	4% max	5% max	5% max	5% max
ASH	16% max	16% max	19% max	19% max	10% max
TVN	120% max	120 Max	120% max	-- --	500% max
FFA	7.5% max	7.5% max	7.5% max	-- --	18% max
Histamine	500 ppm max	1000 ppm max	500 ppm max	-- --	100 ppm max

Table 67 Colosso Fishing Group Chilean fishmeals.

CORMAR S.A. PERUVIAN FISHMEALS						
		STEAM DRIED				
	FAQ	PRIME	SUPER PRIME	TAIWAN	THAILAND	STANDARD STEAM
Protein, % min.	64	67	68	67	67	67
TVN, mg N/100 g		120	100	120	150	
FFA, %		10	7.5			
Histamina, ppm		1000	500			
Fat, %	12	10	10	10	10	10
Moisture, %	10	10	10	10	10	10
Salt and Sand Combined, %	5	4	4	4	4	4
Sand, %	2	1	1	1	1	1

Table 68 CORMAR S.A. Peruvian fishmeals.

CORPESCA S.A. CHILEAN FISHMEALS			
	FULL-MEAL	PRIME	SUPERPRIME
Protein	65% - 68%	67% - 70%	*68% - 70%*
Fat %, Max.	12%	10%	*10%*
Moisture, %	6% -10%	6% - 10%	*6% - 10%*
Free Fatty Acids (FFA), %	10% Max	Max 10%	*7.5% - 10%*
Ash, % Max.	17%	17%	*16%*
Salt, %	3.0% - 3.5%	Max 3.5%	*Max 4%*
TVN, mg N/100 grams	150 Max	Max 120	*100 - 120*
Histamine (ppm), Max.	N/A	1000	*500*
Digestibility, Dilute Pepsin %, Min.	N/A	94%	*94%*

Table 69 Corpesca SA Chilean fishmeals.

WEST COAST REDUCTION, CANADIAN FISHMEALS		
	MIXED FISH MEALS	HERRING FISHMEAL
Protein, %	64 Min	68 Min
Ash, %	21 Max.	20 Max.
Fat, %	15 Max.	15 Max.
Moisture, %	10 Max.	10 Max

Table 70 West Coast Reduction fishmeals.

FOODCORP CHILEAN FISHMEALS				
	HIGH STANDARD	STANDARD	PRIME	SUPERPRIME
Protein, %	≥67%	<67%	≥67%	≥ 68%
Fat, %	≤Max 10%	≤12%	≤10%	≤10%
Moisture, %	≤10%	≤10%	≤10%	≤10%
Free Fatty Acids (FFA)	N/A		≤10%	≤10%
Ash (Salt Free)	≤17%		≤16%	≤15%
Salt, %	≤4%		≤3%	≤3%
Sand, %	≤2%		≤2%	≤2%
Salt And Sand	≤5%	Max 5%	≤5%	≤4%
TVN, mgN/100 grams	≤120		≤120	≤120120
Histamine (ppm)	1000 - 1500		500 - 1000	≤500
Antioxidant (ppm)	Min 150	Min 150	Min 150	Min 150

Table 71 Foodcorp Chilean fishmeals.

NORSILDMEL NORWEGIAN FISHMEALS				
	NORSE- LT 94	NORSECO-LT	NORSEA MINK	STANDARD
Protein, %	68	68	71	71
TVN, % max	0.18	0.18	0.20	0.30
FFA, %				
Histamine, ppm max	500	500	700	
Cadaverine, ppm max.	1000	1000	1800	
Fat, % max.	11.5	11.5	13	13
Moisture, %	6 - 10	6 - 10	5 - 10	10
Salt Free Ash , max.	14	14	14	
Salt, % max.	3.5	4.5	3.5	3.5
Water-soluble protein, %	18 - 32	18 - 32		1
Mink Digestibility, % min.	90	90		
Salmonella	Not Detected	Not Detected	Not Detected	Not Detected
Antioxidant	Ethoxyquin	Natural	Ethoxyquin	Ethoxyquin

Table 72 Norsildmel Norwegian fishmeals.

PESQUERA ITATA S.A. CHILEAN FISHMEALS					
	HIGH QUALITY HQ-500	HIGH QUALITY HQ1000	PRIME	STANDARD A	STANDARD B
Crude Protein %, min.	68	68	68	67	66
Moisture, % max.	10	10	10	10	10
Crude Fat, % max.	10	10	10	10	12
Ash, % max.	15	15	16	16	18
Salt + Sand, % max.	4	4	4	5	5
Sand, % max.	1	1	1	1	2
TVN, mgN/100g max	100	120	120	150	
FFA, % max.	7.5	10	10	12	
Histamine, ppm max.	500	1000			

Table 73 Pesquera ITATA SA Chilean fishmeals.

TECHNOLOGICA DE ALIMENTOS SA (TASA) PERUVIAN FISHMEALS.					
	SUPERPRIME	PRIME	TAIWAN	THAILAND	STANDARD
Protein, % min.	68	67	67	67	67-66-65
Fat,% max.	10	10	10	10	12
Moisture, % max.	10	10	10	10	10
Salt + Sand, % max.	4	5	5	5	5
Only Sand, % max.	1	2	2	2	2
Ashes, % max.	16	17	17	17	
TVN, mgN/100g max.	100	120	120	150	
FFA, % max.	7.5	10	10	10	
Histamine, ppm max.	500	1000			
Antioxidant, ppm min.	150	150	150	150	150

Table 74 TASA Peruvian fishmeals.

PESQUERA TABOGUILLA S.A. PANAMANIAN FISHMEALS						
	Las Perlas Aquagrades			Oceano Pacifico Fishmeals		
	Standard 58/60%	Standard 60/62%	Standard 62/64%	Standard 60/62%	Standard Selected	Aquagrade 64/65%
Protein, % min.	58 – 60	60 – 62	62 - 64	60 – 62	62 – 64	64 - 65
Fat, % max.	13	12	10	13	12	12
Moisture, % max.	10	10	10	10	10	10
Salt & Sand, % max.	5	5	4	5	5	4
Sand Alone, % max.	2	2	1	2	2	1
TVN, mg/100g max.		150	150		150	120
FFA, % max.		12	10		12	10

Table 75 Pesquera Taboguilla SA Panamanian fishmeals.

SOUTH PACIFIC KORP CHILEAN FISHMEALS							
	QUALITY	PROTEIN % Min.	HISTAMINE ppm Max.	TVN, mgN/100 g Max.	FFA % Max.	FAT % Max.	MOIST-URE % Max.
Jack Mackerel	Super Prime	68	500	120	7.5	10	10
Jack Mackerel	Prime	67-68	1000	120	10	10	10
Hoki	Super Prime	68	500	120	7.5	10	10
Hoki	Prime	67-68	1000	120	10	10	10
Aqua Grade							
Sardine/Anchovy	Super Prime	68	500	120	7.5	10	10
Sardine/Anchovy	Prime	67-68	1000	120	10	10	10
Jack Mackerel /Sardine/Anchovy	Super Prime	68	500	120	7.5	10	10
Jack Mackerel /Sardine/Anchovy	Prime	67-68	1000	120	10	10	10
Fast Grow							
No species	Standard I	67-68	1000-2000	>120	10	10	10
No species	Standard II	67-68	>2500	120-150	10	10	10
No species	Standard III	<67	-	-	-	12	10

Table 76 South Pacific Korp Chilean fishmeals.

Alaska Fishmeal Products

KODIAK FISHMEAL COMPANY, ALASKAN FISHMEALS		
	WHITE FISH MEAL	**SALMON FISHMEAL**
Protein, %	65 Min	57 – 62
Ash, %	20 Max.	20 – 23 Max.
Fat, %	10 Max.	15 – 18 Max.
Moisture, %	10 Max.	10 Max
Free Fatty Acids, %	10 Max.	10 Max.
Salt, %	3 Max.	3 Max.

Table 77 Kodiak Fishmeal Co. Alaskan fishmeals.

What all this data shows us is that as you move from the commodity grade of fishmeal (FAQ) towards the high end premium products (super prime, LT94 etc), the level of testing and the sophistication of the testing increases. In other words you must develop the quality criteria that define the fishmeal as premium. One possible way to summarize this is shown in the following figure. Compared to standard fishmeal, the quality specifications for the premium fishmeals will be higher (+) or lower (-). With much higher (++ and +++) and much lower (--, ---) similarly designated.

ADDITIONAL QUALITY PARAMETERS THAT SHOULD BE CONSIDERED FOR FISHMEAL.				
	Standard Fishmeal (FAQ)	**Special Fishmeal**	**Prime Fishmeal**	**Super Prime Fishmeal**
RAW MATERIAL FRESHNESS	XXX	+	++	+++
TVN IN FISHMEAL	XXX	-	- -	- -
FFA IN FISHMEAL FAT	XXX	-	- -	- -
HISTAMINE IN FISHMEAL	XXX	-	- -	- - -
CADAVERINE IN FISHMEAL	XXX	-	- -	- - -
MINK DIGESTIBILITY	XXX			+

ADDITIONAL QUALITY PARAMETERS THAT SHOULD BE CONSIDERED FOR FISHMEAL.				
	Standard Fishmeal (FAQ)	**Special Fishmeal**	**Prime Fishmeal**	**Super Prime Fishmeal**
PEPSIN DIGESTIBILITY	XXX	+	++	++
BIOTOX SCORE	XXX	-	- -	- - -
Special quality fishmeal specifications vary by species.				
Source: Barlow and Bololanik 1996				

Table 78 Additional quality parameters- premium vs. faq fishmeal.

Fish Oil

Unlike fishmeal, fish oil quality specifications are not complicated. In general, the oil is sold as a commodity, competing with other fats and oils and usually priced according to level of free fatty acids, moisture and impurities, unsaponifiable matter (normally cholesterol, hydrocarbons and waxes in the fish fat) and sometimes color, peroxide value, anisidine number, and iodine value. For oils destined for the animal feed or aqua feed markets there are also requirements for levels of environmental contaminants such as the chlorinated pesticides, pcb's, and more recently dioxins and furans. All or most contaminants are regulated by either FDA or EPA and levels for these contaminants have been or are in the process of being developed (dioxins and furans). The following table gives the general ranges for commodity fish oil quality parameters.

QUALITY GUIDELINES FOR CRUDE FISH OILS AND THEIR PHYSICAL CHARACTERISTICS	
Moisture and Impurities, %	usually basis 0.5% up to 1% maximum
Free Fatty Acids, % oleic	range 1-7% but usually 2-5%
Peroxide Value (PV), meq/kg	3 - 20
Anisidine Number (AN)	4 - 60
Totox Value (2 x PV) + AN	10 - 60
Iodine Value	
Capelin	95 - 160
Herring	115 - 160

QUALITY GUIDELINES FOR CRUDE FISH OILS AND THEIR PHYSICAL CHARACTERISTICS	
Menhaden	120 - 200
Sardine	160 - 200
Anchovy	180 - 200
Jack Mackerel	160 - 190
Sand Eel	150 -190
Color, Gardner Scale	up to 14
Iron, ppm	0.5 - 7.0
Copper, ppm	less than 0.3
Phosphorus, ppm	5 - 100
PHYSICAL CHARACTERISTICS	
Specific Heat, cal/gm	0.50 - 0.55
Heat of Fusion, cal/gm	about 54
Caloric Value, cal/gm	about 9500
Slip Melting Point, °C.	10 - 15
Flash Point, °C.	
As Triglycerides	about 360
As Fatty Acids	about 220
Boiling Point, °C.	greater than 250
Specific Gravity at 15 °C.	about 0.92
at 30 °C.	about 0.91
at 45 °C.	about 0.90
Viscosity cp, at 20 °C.	60 - 90
at 50 °C.	20 - 30
at 90 °C.	about 10
Source: Inform Magazine (AOCS) Volume 9 No. 5 1998	

Table 79 Quality guidelines for crude fish oils.

As the market has moved away from hydrogenation and towards aquaculture, fish oils are being marketed specifically for the aqua feed market and oils high in omega 3's and low in oxidation compounds as measured by peroxide value and anisidine number are being offered. These oils are also being screened for dioxins and furans since the EU has established regulatory levels for these compounds for products sold within the EU. The USA is still evaluating the dioxin situation but some of the Asian countries do request data on oil shipments. The following tables give some of the quality specifications for fish oils being offered on the world market.

TRIPLE NINE (999) DANISH FISH OIL	
	STANDARD FISH OIL
Free Fatty Acids, %	3% - 7%
Moisture And Impurities, %	Max 1%
Iodine Value	140 – 190
Antioxidant	Optional
Unsaponifiable Matter, %	2% - 6%
Packaging	200 liter new metal drums, 1000 liter new bulk: 20' container , truck and ship.

Table 80 Triple Nine Danish fish oils.

PACIFIC STAR CHILEAN SALMON FISH OIL		
	MIN	**MAX**
Acidity, %	1.5	3.5
Peroxide Value, Meq/Kg	4	6
Moisture, %	0.1	0.7
Insoluble Impurities, %	0.01	0.09
Saponification Value	170	190
Unsaponifiable Matter, %	2.0	2.5
Iodine Value	170	175
Totox Value	18	19
Anisidine Value	6	9.5
Asthaxanthin, ppm	7	25
Gardner Color	12	13
C20:5 Omega 3 (EPA), %	8.9	9.5
C22:6 Omega 3 (DHA), %	8.9	13.8
EPA + DHA, %	17.8	23.3
Total Omega 3, %	23.9	30.8

Table 81 Pacific Star Chilean salmon oil.

SR MJOL ICELANDIC FISH OIL	
	AQUACULTURE GRADE FISH OIL
Free Fatty Acids	4.5% Max.
Moisture And Impurities	0.5% Max
Totox	20 Max
Unbleached, Untreated	Yes
Antioxidant	Optional

Table 82 SR Mjol Icelandic fish oils.

AUSTRAL GROUP SAA PERUVIAN FISH OILS.				
		Crude	Semi - Refined	RBWD
Free Fatty Acids (FFA)	max	3%	0.30%	0.30%
Moisture and Impurities	max	1%	0.30%	0.30%
Unsaponifiable Matters	max	2,50%	1.50%	1.50%
Peroxide	max	5-10	5-10	5-10
Anisidine	max	20-25	20-25	20-25
EPA + DHA	min	28	28.00%	30.00%

Table 83 Austral Group SAA Peruvian fish oils.

PESQUERA HAYDUK PERUVIAN FISH OIL.		
	BASIS	CRUDE FISH OIL
Free Fatty Acids, %	Max.	3.0
Moisture and Impurities, %	Max.	1.0
Unsaponifiables, %	Max.	2.5
Iodine Value		170 – 200
Color, Gardner Scale	Max.	16

Table 84 Pesquera Hayduk Peruvian fish oil.

OMEGA PROTEIN USA MENHADEN FISH OILS				
	CRUDE	**VIRGINIA PRIME GOLD**	**OMEGA EQUIS**	**VIRGINIA PRIME PLATINUM VET GRADE (DEOD)**
Free Fatty Acids, %	1 – 4	0.05 – 0.50	0.50	0.05
Iodine Value	150 – 185	170 – 200	170 – 200	180 – 220
Color, Gardner Scale	10.5 – 12.5	6 – 8	8	5
Moisture and Impurities, %	0.2 – 1.0	0.20 – 0.50	0.50	0.50
Total Omega 3, %	25 – 35	30 – 40	30 - 40	30 – 40
Total Omega 6, %	4 - 6	4 – 6	≈ 3	≈ 3
Omega 3 : Omega 6 Ratio	5.97	6.67		
EPA, %			11 - 15	11 – 15
DHA, %			11 - 15	11 – 15
TYPICAL FATTY ACIDS, %				
C12:0	0.20	0.12		
C13:0	0.08	0.06		
C14:0	9.98	8.48	6.85	6.85
C15:0	1.02	1.07	0.46	0.46
C16:0	20.07	17.52	14.83	14.83
C17:0	0.94	1.05	0.38	0.38
C18:0	3.24	3.10	2.55	2.55
C19:0			0.00	0.00
C20:0	0.22	0.30	0.17	0.17
C22:0	0.16	0.14	0.10	0.10
C23:0		0.05		
C24:0	0.09		0.60	0.60
C14:1		0.22		
C15:1		0.03		
C16:1	12.33	11.51	9.74	9.74
C17:1	0.21	0.64		
C18:1	9.35	9.52	9.58	9.58
C20:1	1.34	1.59	1.48	1.48
C22:1	0.32	0.73	0.33	0.33
C24:1	0.27	0.44	0.22	0.22
C16:2	1.93	1.49	1.62	1.62
C18:2	1.73	1.96	1.93	1.93
C20:2	0.42	0.32	0.18	0.18
C16:3	2.13	1.30	1.51	1.51
C18:3	2.03	2.18	1.48	1.48
C20:3	0.42	0.44	0.37	0.37
C16:4	1.23	1.02	1.53	1.53
C18:4	2.68	3.30	3.09	3.09
C20:4	2.41	2.55	2.09	2.09

OMEGA PROTEIN USA MENHADEN FISH OILS				
	CRUDE	VIRGINIA PRIME GOLD	OMEGA EQUIS	VIRGINIA PRIME PLATINUM VET GRADE (DEOD)
C22:4	0.34	0.36	0.24	0.24
C20:5	12.90	12.73	14.16	14.16
C21:5	0.69	0.64	0.76	0.76
C22:5	2.61	2.78	2.82	2.82
C22:6	8.17	12.31	12.2	12.2

Table 85 Omega Protein USA menhaden fish oils.

NORSILDMEL NORWEGIAN FISH OIL.		
	BASIS	NORSECOIL
Free Fatty Acids, %	Max.	5.0
Moisture and Impurities, %	Max.	0.05
Totox (anisidine +2xperoxide)	Max.	25
Contaminants		EU Limits
Antioxidant		Natural

Table 86 Norsildmel Norwegian fish oil.

GC RIEBER OILS AS (Formerly Alnaes Marine Oils)		
	Standard Fish Oil	Cod Liver Oil Eur 97 Type A
Free Fatty Acids, %	0.1 – 8.0	0.60 Max.
Acid Value, %	0.2 - 15	1.1 Max.
Peroxide Value, meq/kg	0.5 - 20	5 Max.
Anisidine Value	1 - 70	
Iodine Value		150-180
EPA (C20:5 n-3), %	5 - 25	.
DHA (C22:6 n-3), %	5 - 25	
Refractive Index (20°C)		1.477-1.482
Saponification Value		180-190
Specific Gravity (25°C)		0.917-0.930
Cold Test, hrs at 0°C	0 - 48	3.0
Vitamin A/D IU/g		1000/100

Table 87 GC Rieber Oils AS, Norwegian fish oiils.

DAYBROOK FISHERIES USA MENHADEN FISH OIL	
Free Fatty Acid	1 - 3 %
Unsaponifiable Matter	2 - 3 %
Moisture & Impurities	< 1 %
Colour Gardner	11 - 13
Iodine Value	150 - 180
Peroxide Value	< 5 meq/kg
Anisidine Number	< 10
Totox Value	< 20
Rich source of Omega-3 (% in FFA)	35 - 37 %

Table 88 Daybrook Fisheries Inc. USA menhaden fish oil.

EXAPESCA SA CHILE SOUTH FISH OIL	
Free Fatty Acids, % max	0.50- 3.50
Moisture, % max	1.00
Peroxide Value, meq/kg max	7
Anisidine Number	<25
Color, Gardner	<14
Index of Refraction	1.4811 – 1.4817
Saponification Value	170 – 200
Iodine Value, Wijs	160 – 190
Viscosity at 25 C	0.35 – 0.45
Unsaponifiable Matter, % max	3
Density, g/cm3	0.92 – 0.94

Table 89 Exapesca SA Chile South fish oil

TECHNOLIGICA DE ALIMENTOS S.A. (TASA) PERUVIAN FISH OIL		
Acidity, FFA %	3.00 basis	4.00 max.
Moisture and Impurities, % max.		1.00
Unsaponifiable Matter, % max.		2.50
Color, Gardner max		15
Iodine Value, Hanus	190 min.	190 max.

TECHNOLIGICA DE ALIMENTOS S.A. (TASA) PERUVIAN FISH OIL		
Peroxide Value, meq/kg		10 max.
Free from mineral oils		
Free from old smell		

Table 90 TASA Peruvian fish oil.

SOUTH PACIFIC KORP CHILEAN FISH OIL	
FFA, % Max.	3.0
Moisture and Impurities, % Max.	1.0
Peroxide Value, meq/Kg. Max.	5.0
Anisidine Number, Max.	20

Table 91 South Pacific Korp Chilean fish oil.

Alaska Fish Oils

COMMERCIAL ALASKA FISH OILS					
Fatty Acids (mg/ g oil)	**Pollock**	**Pink Salmon**	**Perch**	**Sockeye Salmon**	**Sablefish**
14:00	35.9	36.7	40.9	39.3	38.71
16:00	146.9	112	122	110.8	135.18
16:1 w 7	69.8	35.1	49.8	38.1	71.31
17:1 w 9	33.1	3	1.8	3.7	2.63
18:00	28.5	22.1	19.4	23.7	20.77
18:1 w 9 *cis*	183.8	103.5	121.8	140.1	227.81
18:1 w 7	79.8	18.7	40.6	24.5	61.86
18:2 w 6 *cis*	5.7	13	8.7	12.4	7.67
18:3 w 3	4	9.3	4.8	9.5	3.67
20:1 w 11	7	51	51.5	45	48.09
20:1 w 9	9	23.3	24.3	22.1	30.02
20:4 w 6	3	4.5	3.6	3.8	2.79
20:5 w 3	141.5	80.2	90.2	81.3	26.24
22:1 w 11	8.3	66.8	72.8	44.7	50.61
22:6 w 3	46.1	113	57.6	85.2	17.51
Sum All FA Identified	870.6	808.6	795.8	808.6	834.95
FA below 30 mg	67.2	116.6	86	119.5	86.08
Source: Alex. Oliveira - Fishery Industrial Technology Center, University of Alaska, Paper presented at the 2008 Annual AOCS meeting in Seattle Washington.					

Table 92 Fatty acid composition of Alaska fish oils.

ALASKA PROTEIN RECOVERY WILD ALASKA SALMON OIL	
Free Fatty Acids, %	0.10 – 0.80
Acid Value, %	0.50 – 1.00
Moisture and Volatiles, %	0.05 – 0.15
Insoluble Impurities, %	0.05 – 0.10
Unsaponifiable Matter, %	0.25 – 0.75
Iodine Value	130 – 160
Peroxide Value, meq/kg	0.50 – 8.00
Pathogenic Bacteria	Negative
Yeast and Molds	Negative
Fatty Acids, % of Sample	
C12:0	0.88
C14:0	4.67
C15:0	0.54
C16:0	12.79
C17:0	0.53
C18:0	3.32
C20:0	0.12
C24:0	2.98
C14:1	0.05
C16:1	5.21
C17:1	0.43
C18:1	18.02
C20:1	6.96
C22:1	6.65
C24:1	0.63
C18:2	2.10
C20:2	0.51
C18:3	1.63
C20:3	0.40
C18:4	2.63
C20:4	2.60
C20:5	10.12
C22:5	0.30
C22:6	13.82
Total Omega 3	30.01
Total Omega 6	3.64

Table 93 Alaska Protein Recovery wild Alaska salmon oil.

CANFISCO GOLD SEAL PURE SOCKEYE SALMON OIL

Supplement Facts / Informations sur le supplément
Serving Size 2 Capsules / Dose : 2 capsules

Two Capsules Contain / Deux capsules contiennent	% Daily Value / % valeur quotidienne
Calories 20	
Calories from Fat / 18 Calories provenant de matière grasse	
Total Fat/Matière grasse totale 2 g	3%
Saturated Fat/Gras saturé 0.5 g	2.5%
Cholesterol/Cholestérol 20 mg	7%
Wild Sockeye Salmon Oil / 2000mg Huile de saumon sockeye sauvage	
Omega-3 Fatty Acid/Acide gras oméga-3 - 20%	
EPA (Eicosapentaenoic Acid) / 160 mg EPA (acide eicosapentanoïque)	
DHA (Docosahexaenoic Acid) / 140 mg DHA (acide docosahexanoïque)	

* Percent Daily Values are based on 2000 calorie diet. / Les pourcentages de valeur quotidienne sont basés sur un régime de 2 000 calories.

Figure 20 CANFISCO sockeye salmon oil supplement.

Oils sold into the nutraceutical market normally obtain a premium price for high levels of the omega 3 fatty acids, and for different ratios of EPA to DHA. Oils are also sourced from geographical regions where the possibility of environmental contamination is the lowest.

The entire Omega 3 – Fish Oil Nutraceutical market has expanded quite dramatically since the last report. There has been a dramatic increase in food products fortified with omega 3 fatty acids from various fish sources. Pet foods are now fortified with omega 3 fatty acids and the feeds of layer hens, poultry, beef and sheep are being enhanced with omega 3 to present a more healthy finished product. In one case, pigs have been genetically altered to produce an omega 3 fat rather than the typical lard. For food and supplement use, the sourcing of these omega 3 oils has become quite active with the oils from sardines, anchovy, pilchards, hoki, tuna and jack mackerel being the most desired because of their unique content of the long chain omega 3 fatty acids..

A comparison of the principal fatty acids in major commercial fish oils is shown in the following two tables.

Fish Oil Specifications And Composition

TYPICAL[1] FATTY ACIDS IN SOME COMMERCIALLY AVAILABLE MARINE OILS, AS % OF THE FATTY ACIDS I							
	ANCHOVY	JACK MACKEREL	MENHADEN	CAPELIN	NORWAY POUT	SAND EEL	SPRAT
C14:0	9	8	9	7	5	7	-
C15:0	1	1	1			1	
C16:0	17	18	19	10	12	13	17
C16:1	13	8	12	10	4	5	7
C17:0	1	1	1				
C18:0	3	3	3	1	3	2	2
C18:1	10	16	11	14	10	7	16
C18:2	1	1	1	1	1	2	2
C18:3	1	1	1	1	1	1	2
C18:4	2	2	3	3	3	5	
C20:1	1	2	1	17	13	12	10
C22:1	1	1		15	17	18	14
C20:5	22	13	14	8	9	11	6
C22:5	2	2	2		1	1	1
C22:6	9	15	8	6	14	11	9
OTHERS[2]	7	8	14	7	7	4	14

1 The Fatty Acid Composition of fish oil can vary by season, area of the catch, food that the fish are consuming, sexual maturity of the fish and age of the fish. This data reflects some general fatty acid profiles
that should only be used to screen oils for possible use. In all cases, an updated fatty acid profile on the batch of oil to be used should be either supplied with the oil or performed by the researcher.

2 Other fatty acids: C16:2. C16:3, C16:4 and C20:4.

Source: Bimbo 1998

Table 94 Typical fatty acids in some commercial fish oils 1.

TYPICAL[1] FATTY ACIDS IN SOME COMMERCIALLY AVAILABLE MARINE OILS, AS % OF THE FATTY ACIDS II.												
	SARDINE/ PILCHARD	HERRING	MACKEREL	TUNA	SALMON	CATFISH	DOGFISH	POLLOCK	WHITE FISH	RED FISH	COD	BLUE WHITING
C14:0	8	7	8	3	4	2	4	4	4	3	4	5
C15:0	1			1			1		1			14
C16:0	18	17	14	22	13	19	14	14	14	17	10	
C16:1	10	6	7	3	4	6	6	7	5	8	2	6
C17:0	1			1								
C18:0	3	2	2	6	3	2	2	3	3	2	4	1
C18:1	13	14	13	21	18	52	15	20	17	28	9	17
C18:2	1	1	1	1	2	14	2	1	2	7	2	2
C18:3	1	2	1	1	1	1	1		1	1	1	1
C18:4	3	3	4	1	2		2	2	2	2	3	3
C20:1	4	15	12	1	10	1	15	9	8	2	7	12
C22:1	3	19	15	3	8		19	7	8		10	14
C20:5	16	6	7	6	9		5	9	9	8	6	7
C22:5	2	1	1	2	3		2	1	2	2	1	1
C22:6	9	6	8	22	15	1	7	6	13	6	8	8
OTHERS[2]	7	1	7	6	8	2	5	17	11	14	33	9

1 The Fatty Acid Composition of fish oil can vary by season, area of the catch, food that the fish are consuming, sexual maturity of the fish and age of the fish. This data reflects some general fatty acid profiles that should only be used to screen oils for possible use. In all cases, an updated fatty acid profile on the batch of oil to be used should be either supplied with the oil or performed by the researcher.

2 Other fatty acids: C16:2. C16:3, C16:4 and C20:4.
Source: Bimbo 1998

Table 95 Typical fatty acids in some commercial fish oils 2.

Oils destined for the nutraceutical market might also require other quality measurements in addition to the normal quality specifications, as shown in the following table.

CRN/GOED QUALITY STANDARDS FOR NUTRACEUTICAL GRADE FISH OILS	
Measures of Oxidation	
Peroxide Value (PV), meq/kg	5 Max
Anisidine Value (AV)	20 Max
TOTOX (2 x PV) + AV	26 Max
Purity	
Dioxins (PCDDs, PCDFs)	2 pg/g WHO-TEQ Max *
PCB's	<0.09 mg/kg (ppm)
Lead	<0.10 mg/kg (ppm)
Cadmium	<0.10 mg/kg (ppm)
Mercury	<0.10 mg/kg (ppm)
Arsenic	<0.10 mg/kg (ppm)
Omega 3 Fatty Acids	Expressed on a weight/weight basis (mg/g)
Acid Value	3 mg KOH/g Max
*pg is a picogram or 1 part in 1,000,000,000,000 parts	
Source: http://www.goedomega3.com/portals/0/pdfs/GOEDMonograph.pdf	

Table 96 CRN/GOED quality standards for nutraceutical grade fish oils.

Other Products

On November 21, 2005 the Board of Directors of Norferm decided to close down the business effective March 1, 2006. The data for the Norwegian Bioproteins produced from natural gas has been retained in this report since it serves the purpose of showing what can be produced from this raw material and how those products compare to fish derived proteins.

NORFERM NORWEGIAN BIOPROTEINS FROM NATURAL GAS				
	Basic BioProtein	**Pronin FS20**	**Pronin AP5**	**Pronin BC10**
Protein, %	70.6	70.0	70.0	70.0
Fat, %	9.8	10.0	10.0	10.0
Ash, %	7.1	7.0	7.0	7.0
Fiber, %	0.7			
N-Free Extract, %	11.8	10.0	10.0	10.0
Minerals, g/kg				
Phosphorous	19.5	18	18	18
Chloride	7.6			
Sulphur	5.4			
Calcium	4.7			
Potassium	3.7			
Magnesium	2.1			

NORFERM NORWEGIAN BIOPROTEINS FROM NATURAL GAS				
	Basic BioProtein	**Pronin FS20**	**Pronin AP5**	**Pronin BC10**
Sodium	0.9			
Iron	216	310	310	310
Copper	91	110	110	110
Zinc	17			
Arsenic, mg/kg	0.051			
Selenium, mg/kg	0.017			
Cobalt, mg/kg	3.4			
Nickel, mg/kg	2.0			
Amino Acids, g/kg				
Lysine	45.6	43.0	43.0	43.0
Methionine	19.8	18.7	18.7	18.7
Cystine	4.5	4.2	4.2	4.2
Threonine	32.9	31.0	31.0	31.0
Tryptophan	15.7	14.8	14.8	14.8
Leucine	54.9			
Isoleucine	33.6			
Valine	44.8			
Tyrosine	26.0			
Phenylalanine	32.9			
Histidine	18.0			
Arginine	43.8	41.3	41.3	41.3
Aspartic Acid	65.1			
Glutamic Acid	77.1			
Glycine	35.7			
Proline	31.7			
Serine	26.6			
Vitamins, mg/kg				
Nicotinic Acid	130.0			
Riboflavin B2	73.0			
Inositol	30.0			
Thiamin B1	12.1			
Vitamin E	<5.0			
Vitamin B12	1.7			
Biotin	2.8			
Other Data				
Gross Energy Mj/kg	22.1			
Color	Light Brown			
Flavor	Neutral			
Particle Size	150-200 μm			
Moisture, %	5.0			

Table 97 Norferm Norwegian bio-proteins from natural gas.

H.J. BAKER AND BRO. FISHMEAL ANALOG PRODUCTS			
	Pro-Pak	**Pro-Pak 65**	**Pro-Lak**
Protein, %	62.3	67.9	73.82
Soluble Protein, % of crude protein			8.30
Degradable Protein, % of Protein			28.00
DIP, %			20.66
UIP, %			53.15
Undegradable Protein, % of Protein			72.00
TDN, %			65.16
Fat, %	8.1	7.3	8.02
Crude Fiber, %			1.75
ADF, %			2.46
Phosphorous, %	3.24	2.81	1.90
Calcium, %	6.37	5.73	3.50
Ash, %	19.30	17.27	12.50
Moisture, %	8.36	7.46	
Salt, %	0.90	0.70	
Magnesium, %			0.10
Sodium, %			0.30
Chloride, %			0.52
Potassium, %			0.35
Sulfur, %			0.94
Iron, ppm			900
Copper, ppm			20
Manganese, ppm			14.58
Zinc, ppm			87.03
Pepsin Digestibility, %	92.10	93.23	91.80
M.E. (Kcal/Lb)	1300	1350	
Net Energy, (Mcal/lb)			0.68
Amino Acids, % of Sample			
Arginine, %	3.92	3.82	4.16
Glycine, %	5.83	6.25	
Proline, %	4.40	5.06	
Methionine, %	1.78	1.93	1.23
Cystine, %	1.37	1.29	1.54
Lysine, %	3.87	4.52	4.51
Leucine,%	5.40	6.20	6.50
Isoleucine, %	1.91	1.81	2.11
Threonine, %	2.65	2.91	3.04
Valine, %	3.68	4.43	4.75
Tryptophan, %	0.53	0.60	0.60
Phenylalanine, %			3.64
Histidine, %			2.38

Table 98 HJ Baker fishmeal analog products.

ADVANCED BIONUTRITON MICROALGAE PRODUCTS FOR AQUACULTURE			
	AquaGrow DHA	**AquaGrow Gold**	**AquaGrow ARA**
Proximate Composition %			
Fat	35.0 min	47.0	33.0
Protein	13.0 min	12.0	15.0
Carbohydrate	23.0 min	18.0	21.0
Moisture	5.0 max	5.0	5.0
Fiber	1.0 max	6.0	1.0
Ash	23.0 max	12.0	25.0
Vitamins and Pigments			
Vitamin A (IU/kg)	2117.2	6380.0	
Vitamin C (ppm)	250		210.0
Vitamin D (IU/kg)			7488.0
Vitamin E (ppm)	49.8		242
Asthaxanthin (mg/kg)			
Carotene (ppm)	4.2	15.2	0.18
Xanthophyll (ppm)	6.9	1.87	5.9
Major Minerals, %			
Calcium	0.11	0.07	0.07
Chloride	0.52	3.08	3.08
Potassium	0.47	0.31	0.31
Phosphorous	0.69	0.80	0.80
Magnesium	0.12	0.10	0.04
Sodium	3.40	2.64	2.64
Sulfur	0.12	0.22	0.22
Trace Minerals, ppm			
Iron	73.0	9.4	5.0
Manganese	10.0	3.7	1.0
Zinc	57.0	2.9	9.0
Copper	5.00	2.9	2.0
Cobalt	<0.10	<0.05.	<0.1
Iodine	1.5	<0.01	2.5
Amino Acid as % of Protein			
Methionine	1.7	1.7	2.3
Cysteine	1.1	1.5	0.07
Lysine	6.0	3.2	6.5
Phenylalanine	3.7	3.2	7.0
Leucine	8.9	5.2	13.7
Isoleucine	4.7	2.7	5.8
Threonine	4.4	4.0	4.2
Valine	4.7	5.7	6.2
Histidine	2.1	1.6	3.3
Arginine	4.4	9.0	5.4

Glycine	5.3	4.4	3.8
Aspartic Acid	10.1	9.4	8.2
Serine	5.2	4.3	4.2
Glutamic Acid	15.5	27.0	11.7
Proline	4.9	3.5	6.1
Hydroxyproline	0.7	6.1	0.1
Alanine	8.0	5.4	6.6
Tryptophan	2.6		
Tyrosine	5.9	2.1	3.5
Fatty Acids as % of Fat			
12:0 Lauric	2.9		
14:0 Myristic	10.9	8.1	
16:0 Palmitic	14.1	25.6	13.2
18:0 Stearic			10.3
18:1 Oleic	14.8		10.8
18:2 Linoleic	2.7		8.7
18:3 Linolenic			
20:4 ARA		2.3	37.6
20:5 EPA	0	2.3	0
22:5 DPA	0	16.8	0
22:6 DHA	35.0	40.0	2.4
Sterol Content ppt			
Brassicasterol		1.7	
Cholesterol		3.9	
Other Sterols		2.6	
Stigmasterol		1.4	

Table 99 Advanced BioNutrition microalgae products for aquaculture.

NOVUS DHA GOLD®	
NUTRIENT SPECIFICATIONS	
• Docosahexaenoic acid (DHA):	Minimum 18%
• Fat content:	Minimum 35%
PRODUCT CHARACTERISTICS	
Appearance:	Golden brown flakes
Odor:	Characteristic malt-like; slight marine
Packaging:	15 kg Kraft bags (50 bags per pallet)

NOVUS DHA GOLD®	
Shelf life:	2 years from date of manufacture in sealed packages
STORAGE	
Due to the high concentration of polyunsaturated fatty acids, the product is sensitive to air, heat, light and humidity. The	
product should be stored in dry, well-ventilated warehouse conditions in its original package. The product contains	
ethoxyquin (125-225 mg/kg) for oxidation management.	

Table 100 Novus DHA Gold.

The high fishmeal and oil prices have produced incentives for groups to evaluate other protein sources especially for aquaculture feeds. Plant-based proteins have been around for many years. Grains such as soybean, wheat, and corn are commonly incorporated in small amounts in many fish diets. Plant-based by-products such as the distilled dried grains with solubles (DDGS) from ethanol production, and other similar by-products from other bio-diesel operations are now becoming more available, however they are generally lower in protein than the original grains themselves. Seaweeds and algae have also been used on a limited basis in fish and shrimp diets, and further research is underway to evaluate the quality and quantity of different sources. In general, plant-based proteins are inferior in quality and amino acid profiles to animal proteins and therefore to date have not proven to be adequate substitutes in carnivorous fish/shrimp diets, as the digestibility and feed conversion ratios are generally lower. Research continues and thee has been some success in substituting larger quantities of these vegetable and animal proteins for fish proteins. Diets of omnivorous species such as catfish and tilapia however may incorporate plant proteins and achieve reasonable conversion ratios. Bacteria-based proteins are currently being researched and while the initial data on quality of the proteins appears favorable, the economics are in question.

Animal proteins typically used in fish diets include poultry meal, feather meal, blood meal, and with less frequency, beef heart, collagen protein, etc. Animal proteins have superior amino acid profiles to plant proteins, as well as higher overall protein content. While superior to plant protein, these animal proteins are not foods naturally eaten by fish, and therefore have certain nutritional shortcomings relative to fishmeal. Limiting amino acids such as Methionine, Lysine, and Arginine as well as omega-3 and -6 fatty acids are critical to fish growth, health and development.

Animal Invertebrate Meal

Another new source of protein is insect protein. These products have the advantages of:

- Broad diversity of species

- May hold the greatest potential for sustainable production
- Many have good amino acid and digestibility profiles
- Provide natural food sources in the wild
- Will commercial production be economical?

One class of invertebrates has drawn particular attention – Insects. Neptune Industries, Inc. (NI) has filed a process patent on the production protocol for a product called Ento-Protein. Ento-Protein is a high quality dry protein meal created from commercially raised and processed insects. Through a cooperative research effort with Mississippi State University (MSU), NI is in the beginning stages of assessing Ento- Protein's commercial feasibility. MSU was the pioneer in insect rearing methodology over 30 years ago, and remains one of the few Entomology programs worldwide to specialize in insect rearing. Research efforts began in April, 2007 with the first of three critical R & D stages.

The tables below compare the Ento Protein to menhaden fishmeal, soybean and poultry meal. The next table compares several lots of Ento Protein to three different fishmeals.

ENTO-PROTEIN™ COMPARED TO FISHMEAL, SOYBEAN MEAL AND POULTRY MEAL.				
	FISHMEAL	**SOYBEAN MEAL**	**POULTRY MEAL**	**ENTO-PROTEIN**
Crude Protein, %	62 – 67	47	67	41.58 – 62.47
Fat, %	8 – 12	1.56	10.87	20.21 – 51.48
Ash, %	16 – 21	5.80	13.98	2.41 – 9.03
Omega 6, %	0.89	0.40	2.00	3.90 – 10.74
Omega 3, %	2.02	0.05	0.10	0.15 – 0.39
Amino Acids, % of Sample				
Methionine, %	1.75	0.68	0.86 – 1.03	0.55 – 1.02
Lysine, %	4.88	3.03	2.65 – 2.81	2.01 – 3.60
Arginine, %	4.24	3.51	2.28 – 3.69	1.94 – 3.68
Source: Feed Technology Update Vol. 2 Issue 6 2007				

Table 101 Ento-Protein composition compared to several protein feed ingredients.

SEVERAL LOTS OF ENTO-PROTEIN™ COMPARED TO SEVERAL COMMERCIAL FISHMEALS							
	ENTO PROTEIN LOTS						
	Ento A	Ento B	Ento C	Ento D	Menhaden	Herring	Anchovy
Ash, %	4.7	3.1	16	2.3	20		17
Calcium, %	0.2	0.06	5.2	0.04	5.7	2.6	4.3
Phosphorous, %	0.9	0.7	1.2	0.4	3.3	1.9	2.8
Total Lipid, %	21	34	32	57	10	9.9	8.6
Linoleic Acid, % of Lipid	34	29	3.3	6.0	1.1	1.5	3.4
Crude Protein, %	66	49	43	36	68	73	70
Amino Acids, % of Protein							
Arginine, %	7.1	5.9	5.1	5.6	5.9	5.9	5.7
Methionine/Cystine %	2.7	2.4	3.3	2.6	3.8	4.0	4.0
Lysine, %	6.3	6.2	6.4	6.2	7.7	8.0	7.9
Source: Feed Technology Update Vol. 2 Issue 6 2007							

Table 102 Composition of several lots of Ento Protein compared to different fishmeals.

Hydrolyzates and Silages

BIOCP CHILEAN FISH PROTEIN HYDROLYZATE	
	BIOCP 67 FOR PIGLETS, PETS AND AQUACULTURE
Protein, %	67 Min.
Lipids, %	24 Max.
Moisture, %	6 Max.
Ash, %	6 Max.
Salt, %	1.5 Max.
FFA, %	10 Max.
Histamine, ppm	500 Max.
Antioxidant, ppm	300 Max.
Digestibility, %	98 Min.
Water Soluble Protein, % of Total Protein	65
Metabolizable Energy, kcal/kg	5000
Gross Energy, Kcal/kg	5781
Calcium, %	0.27
Phosphorous, %	0.79
Magnesium, %	0.13
Potassium, %	1.22
Sodium, %	0.70

BIOCP CHILEAN FISH PROTEIN HYDROLYZATE	
	BIOCP 67 FOR PIGLETS, PETS AND AQUACULTURE
Iron, ppm	130
Copper, ppm	4.5
Manganese, ppm	0.69
Selenium, ppm	4.5
Zinc, ppm	57
Iodine, ppm	0.69
Amino Acids, % of Sample	
Aspartic Acid	6.2
Glutamic Acid	9.4
Serine	2.7
Histidine	3.5
Glycine	4.2
Threonine	2.7
Arginine	4.5
Alanine	4.4
Tyrosine	2.2
Methionine	2.0
Valine	3.3
Phenylalanine	2.6
Isoleucine	2.9
Leucine	5.0
Lysine	5.8
Taurine	0.3
Tryptophan	1.3
Cystine	1.3
Proline	2.6
Particle Size Distribution	
<20μm, %	2.5
60-100μm, %	58
>100 μm, %	42
Fatty Acids, % of Lipids	
C14:0	4.99
C16:0	17.85
C18:0	6.29
C16:1n-7	4.99
C18:1 n-7, n-9	23.19
C18:2 n-6	3.77
C18:3 n-3	0.68
C18:3 n-4	1.80
C18:4 n-3	1.80
C20:3 n-6	1.98
C20:4 n-3	0.35

BIOCP CHILEAN FISH PROTEIN HYDROLYZATE	
	BIOCP 67 FOR PIGLETS, PETS AND AQUACULTURE
C20:5 n-3	7.90
C22:5 n-3	2.53
C22:6	12.14
Vitamins, Typical	
Biotin, mg/kg	0.135
Choline Chloride	4000
Folic Acid, mg/kg	0.545
Niacin, mg/kg	200
Panthothenic Acid, mg/kg	10.9
Thiamine, mg/kg	2.56
Riboflavin, mg/kg	5.82
Pyridoxine, mg/kg	7.37
Vitamin B12, mcg/kg	486
Vitamin A, IU/Kg	97
Vitamin D, IU/g	6.95

Table 103 BIOCP Chilean fish protein hydrolyzate.

HYDROLYZED FISH (CRUDE FISH SILAGE) FROM DOGFISH		
	As a Feed Ingredient	**As Fertilizer**
Protein, %	15.10	
Fat, %	17.60	
Moisture,%	65.40	
Ash, %	1.50	
TVN, %	0.11	
pH	3.70	3.70
Sodium, %	0.24	0.24
Calcium, %	0.17	0.17
Phosphorous%	0.24	0.24
Potassium, %	0.19	0.19
Magnesium, %	0.03	0.03
Aluminum, ppm	6.00	6.00
Manganese, ppm	1.11	1.11
Iron, ppm	61.40	61.40
Boron, ppm	<2.00	<2.00
Copper, ppm	4.72	4.72
Zinc, ppm	12.50	12.50
Chromium, ppm	<2.00	<2.00
Selenium, ppm	0.62	0.62

HYDROLYZED FISH (CRUDE FISH SILAGE) FROM DOGFISH		
	As a Feed Ingredient	**As Fertilizer**
Strontium, ppm	6.99	6.99
Barium, ppm	<1.00	<1.00
Amino Acids as % of Sample		
Lysine	0.79	
Histidine	0.27	
Arginine	0.57	
Threonine	0.51	
Serine	0.54	
Proline	0.52	
Glycine	0.74	
Valine	0.55	
Methionine	0.26	
Alanine	0.65	
Isoleucine	0.48	
Leucine	0.87	
Tyrosine	0.41	
Phenylalanine	0.48	
Tryptophan	0.07	
Cystine	0.14	
Taurine	0.51	
Aspartic Acid	0.98	
Glutamic Acid	1.43	
Total Carbohydrate, %	0.40	
Gross Energy, Cal/100 Grams	220	
Water Insoluble Protein, %	12	
Total Nitrogen, %		2.50
Ammonia Nitrogen, %		0.11
Nitrate Nitrogen, %		0.12
Water Insoluble Nitrogen, %		1.92
Available Phosphoric Acid (P_2O_5), %		0.50
Soluble Potash (K_2O), %		0.30
Chloride, Max.		0.50
Net Weight per Gallon, pounds		8.85

Table 104 Hydrolyzed fish (Dogfish) crude silage.

In 2006 Bio-Oregon was acquired by Skretting and merged into their fish feed business. The processing of fish waste which was quite successful and served as an outlet for smaller fisheries in the region was discontinued. The detailed data from the old Bio-Oregon products has been retained since it does show the detailed information that is needed to market these products.

BIO OREGON FISH PROTEIN HYDROLYZATES						
	BioGro 9:3:5	**BioGro 7:7:2**	**BioGro 7:7:2**	**BioGan 4:3:2**	**BioGan 3:2:2**	**BioGan 12:2:1**
Total Nitrogen, %	9.0	7.0	5.0	4.0	3.0	12.0
Ammonia Nitrogen, %	0.20	0.20	0.2	0.2	0.1	0.10
Water Soluble Nitrogen, %	2.3	1.8	2.8	2.0	1.6	6.3
Water Insoluble Nitrogen, %	6.5	5.0	2.0	1.8	1.3	5.6
Available Phosphorous (P_2O_5), %	3.0	7.0	3.0	3.0	2.0	2.0
Soluble Potash (K_2O), %	5.0	2.0	2.0	2.0	2.0	1.0
Calcium, %	3.0	7.0	3.5	0.3	0.30	1.5
Sulfur, %	2.5	1.5	1.0	1.2	1.0	0.8
Magnesium, ppm	4000	4000	5000	2000	1000	2000
Copper, ppm	10	12		5	5	5
Manganese, ppm	97	65		6	6	7
Zinc, ppm	133	110		25	20	80
Iron, ppm	1025	1270		385	385	250
Organic Matter, %	92.0	80		40		
Protein, %	58.0	44		25	18.8	75
Carbohydrate, %	2.0	4				
pH	6.2	6.2	6.3	3.8	3.8	
Salt Index	8.0	6.0	10.0	14.0	14.0	8.0
Bulk Density, lbs/cu ft	31 – 33	31 – 33	32	9.5 lbs/gal	9.5 lbs/gal	34
Pellet Diameter, mm	2.5	2.5	1.5			
Moisture, %				57.5	65	5.0
N Slow Release, %				100	100	100
Particle Size, mesh						60

Table 105 Bio-Oregon fish protein digests.

NEPTUNE'S HARVEST HYDROLYZED FISH	
Nitrogen, %	2.23
Phosphorous, %	4.35
Potassium, %	0.30
Calcium, %	0.75
Sulfur, %	0.17
Magnesium, %	0.04
Sodium, %	0.16
Iron, ppm	26.0
Manganese, ppm	3.0

NEPTUNE'S HARVEST HYDROLYZED FISH	
Copper, ppm	<0.10
Zinc, ppm	9.0
Boron, ppm	2.5
Molybdenum, ppm	<0.10
Aluminum, ppm	8.0
Lead, ppm,	<1.0
Amino Acids, % by weight	
Threonine	2.29
Aspartic Acid	5.41
Serine	2.74
Proline	3.07
Glutamic Acid	8.03
Glycine	6.22
Alanine	4.15
Cystine	0.38
Valine	2.17
Methionine	1.81
Isoleucine	1.60
Leucine	3.42
Phenylalanine	1.67
Lysine	4.16
Histidine	1.09
Arginine	3.74
Hydroxyproline	1.67
http://www.neptunesharvest.com/	

Table 106 Neptune's Harvest hydrolyzed fish.

Great Pacific BioProducts Ltd. Pacific Natural Liquid Fish Fertilizer From Pacific Dogfish	
Declared N-P-K, %	2-3-0
Total Nitrogen, %	2.36
Organic Nitrogen	2.18
Ammonia Nitrogen, %	0.18
Nitrate Nitrogen, %	>0.01
Available P2O5	2.82
Orthophosphate, %	1.16
Soluble K2O, %	0.28
Sulfur, %	0.10
Sodium, ppm	2520
Calcium, ppm	865
Zinc, ppm	3.7
Copper, ppm	0.30

Great Pacific BioProducts Ltd. Pacific Natural Liquid Fish Fertilizer From Pacific Dogfish	
Molybdenum, ppm	0.30
Cadmium, ppm	0.298
Selenium, ppm	0,033
Iron, ppm	9.8
Cobalt, ppm	0.38
pH	3.8
Moisture, %	84.60
Fat, %	7.10
Protein, %	14.4
Ash, %	3.90
Amino Acids, % of sample	
Serine	0.37
Glycine	0.81
Arginine	0.83
Alanine	0.61
Cystine	0.07
Valine	0.49
Lysine	0.83
Leucine	0.74
Tryptophan	ND
Aspartic Acid	0.71
Glutamic Acid	1.10
Histidine	0.25
Threonine	0.38
Proline	0.42
Tyrosine	0.16
Methionine	0.16
Isoleucine	0.43
Phenylalanine	0.34
Total Amino Acids	8.70

Table 107 Great Pacific BioProducts Ltd. Pacific natural liquid fish fertilizer.

Fish Solubles

OMEGA PROTEIN USA MENHADEN FISH SOLUBLES			
	Neptune Fish Concentrate	**Omega Grow 5-1-1-1**	**Omega Grow Plus 25% Oil 3-1-1**
Crude Protein, %	30 -34	27.2 – 34.4	17.5 – 25.0
Fat, %	6 – 10	6 – 10	24 – 29

OMEGA PROTEIN USA MENHADEN FISH SOLUBLES			
	Neptune Fish Concentrate	**Omega Grow 5-1-1-1**	**Omega Grow Plus 25% Oil 3-1-1**
Moisture, %	50 – 54	50 – 54	42 – 47
Ash, %	7 – 9		
Salt, %	1 – 3		
pH	3.8 – 4.0	3.8 – 4.0	3.8 – 4.0
TVN, %	0.30 – 0.60	0.30 – 0.60	0.3 – 0.6
Nitrogen, %		4.4 – 5.6	2.6 – 3.4
P_2O_5 ,%		0.80 – 2.2	0.9 – 1.1
K_2O, %		0.8 – 2.2	0.9 – 1.1
Sulfur, %		0.8 – 2.2	0.8 – 1.2
Omega 3 Fatty Acids, %	2.1		
Aluminum, ppm	332.7	332.7	223
Barium,	4.3	4.3	
Boron	<4.00	<4.00	0
Calcium	418	418	385.1
Chromium	<4.00	<4.00	
Copper	3.2	3.2	6.2
Iron	383.9	383.9	265
Magnesium	937.9	937.9	780.7
Manganese	9.0	9.0	6.1
Phosphorous	6456.7		
Potassium	15077.8		
Selenium	1.9	1.9	1.3
Sodium	10048.9	10048.9	
Strontium	2.20	2.20	
Zinc	17.4	17.4	14.7
Carbon, ppm		18692.1	18692.1
Carbon:Nitrogen Ratio		3.29 : 1	3.29 : 1
Weight/Gallon @70°F.		9.50	9.50
Particle Size		<80	<80
AMINO ACIDS, % OF SAMPLE			
Lysine	1.45	1.45	1.3
Histidine	0.66	0.66	0.56
Arginine	1.27	1.27	1.23
Threonine	0.66	0.66	0.58
Serine	0.78	0.78	0.66
Proline	1.43	1.43	1.17
Glycine	2.75	2.75	2.23
Valine	0.80	0.80	0.76
Methionine	0.46	0.46	0.38
Isoleucine	0.58	0.58	0.50

OMEGA PROTEIN USA MENHADEN FISH SOLUBLES			
	Neptune Fish Concentrate	**Omega Grow 5-1-1-1**	**Omega Grow Plus 25% Oil 3-1-1**
Leucine	1.25	1.25	1.06
Tyrosine	0.33	0.33	0.29
Phenylalanine	0.65	0.65	0.56
Tryptophan	0.07	0.07	0.08
Cystine	0.11	0.11	0.11
Taurine	0.84	0.84	0.72
Aspartic Acid	1.71	1.71	1.38
Glutamic Acid	2.72	2.72	2.29
Alanine	1.87	1.87	1.61

Table 108 Omega Protein USA menhaden fish solubles

Alaska Products

ALASKA PROTEIN RECOVERY SALMON PROTEIN CONCENTRATE (SPC)	
Protein, %	32
Moisture, %	56
Fat, %	7
Ash, %	4
TVN, mgN/100g	80
pH	3.6
Density @20°C	1.10 – 1,25 g/ml
Pepsin Digestible Protein, %	98
AMINO ACIDS, % OF PROTEIN	
Alanine	6.37
Arginine	7.79
Aspartic Acid	9.92
Cystine/2	1.56
Glutamic acid	13.91
Glycine	6.63
Histidine	3.29
Isoleucine	4.61
Lysine	8.21
Leucine	7.84
Methionine	3.08
Phenylalanine	4.60
Proline	4.08
Serine	4.109

ALASKA PROTEIN RECOVERY SALMON PROTEIN CONCENTRATE (SPC)	
Threonine	4.64
Tryptophan	0.05
Tyrosine	3.85
Valine	5.40
Total Omega 3, % of Fat	30.01
Total Omega 6, % of Fat	3.64

Table 109 Alaska Protein Recovery salmon protein concentrate.

QuotaMax and FishTek, Inc. Modified Silage and Salmon Protein Concentrates and Gelatin			
	Salmon Protein[1]	**Salmon Protein Concentrate[2]**	**Salmon Gelatin[3]**
Crude Protein, %	69 – 72		
Fat, % calc. to 10%	10		
Moisture, % calc. to 10%	10		
Ash, %	8 – 11		
Amino Acids, % of Sample			
Taurine	0.57	0.40	
Hydroxyproline	0.63	0.34	
Aspartic Acid	5.95	6.91	6.48
Threonine	2.59	3.05	2.37
Serine	2.22	2.36	3.62
Glutamic Acid	8.19	9.61	9.90
Proline	2.83	2.79	9.61
Lanthionine	0.00	0.00	
Glycine	4.87	4.37	22.00
Alanine	4.02	4.42	8.16
Cysteine	0.54	0.60	
Valine	3.29	4.05	1.91
Methionine	1.82	2.12	2.22
Isoleucine	2.85	3.59	1.55
Leucine	4.66	5.77	2.74
Tyrosine	2.26	2.93	0.90
Phenylalanine	2.45	3.16	2.16
Hydroxylysine	0.16	0.22	
Ornithine	0.11	0.15	
Lysine	4.99	5.71	3.51
Histidine	1.49	1.70	1.40
Arginine	4.57	5.42	7.45

QuotaMax and FishTek, Inc. Modified Silage and Salmon Protein Concentrates and Gelatin			
	Salmon Protein[1]	**Salmon Protein Concentrate[2]**	**Salmon Gelatin[3]**
Tryptophan	0.71	0.91	
Total	61.77	70.58	85.98
[1]From whole ground late season deboned fish. [2] From cooked and decanted late season deboned fish. [3]Extract from the deboner waste.			

Table 110 Quota Max and Fish Tek salmon protein products.

Fish Bone Meal

VARIOUS BONE MEAL PRODUCTS AVAILABLE FOR SALE ON THE INTERNET				
	Gaia Green	**Down to Earth**	**LaBudde Group**	
	4-22-1 Fish Bone Meal	**3-16-0 Fish Bone Meal**	**Bone Meal**	**Steamed Bone Meal**
Nitrogen, %	4	3		
Water Insoluble Nitrogen, %				
Water Soluble Nitrogen, %				
Protein, %				6 Min.
Phosphorous, %	22	16	14 Min	13 Min
Potash, %	1			
Calcium, %		14	23 Min	23% Min
Moisture, %			2 Max	7% Max
pH				
Fluorine, %			0.05 Max	
Iron, ppm			400	
Magnesium, ppm			120	
Manganese, ppm			50	
Molybdenum, ppm			5	
Copper, ppm			5	
Aluminum, ppm			200	

VARIOUS BONE MEAL PRODUCTS AVAILABLE FOR SALE ON THE INTERNET				
	Gaia Green	Down to Earth	LaBudde Group	
	4-22-1 Fish Bone Meal	3-16-0 Fish Bone Meal	Bone Meal	Steamed Bone Meal
Vanadium, ppm			5	
Sodium			300	
Sulfates, ppm			2000	
Potassium, ppm			20	
Cobalt, ppm			0.50	
Zinc, ppm			100	
Lead, ppm		2.1	2.5	
Mercury, ppm		<0.05	25	
Selenium, ppm			0.05	
Arsenic, ppm		<0.5	0.50	
Nickel, ppm		<4.3		
Cadmium, ppm		<0.1	0.80	
Chlorides, ppm			400	
Bulk Density, lbs/cu ft			40 – 50	
Particle Size			100% through 40 mesh, 98% through 100 mesh screen	
Ground Basalt Stonemeal, %		5		

Table 111 Various bone meal products available for sale on the internet.

The data in the following table comes from the 2002 Conference Proceedings on Advances in Seafood Byproducts and represents commercial Alaskan production of fish bonemeal from cod and pollock.

ALASKA FISH BONEMEAL FROM COD AND POLLOCK			
	1	2	3
PROXIMATE ANALYSIS DM BASIS			
Protein, %	46.3	40.6	45.7
Fat, %	5.7	9.3	7.4
Ash, %	48	50.1	46.9
MINERALS			
Calcium, %	14.6	16.16	15.23
Potassium, %	0.53	0.52	0.37
Magnesium, %	0.26	0.2	0.23
Sodium, %	1.14	1.12	1.37
Phosphorous, %	7.35	8.1	7.62
Copper μg/g	2	13	
Iron μg/g	380	46	55

ALASKA FISH BONEMEAL FROM COD AND POLLOCK			
	1	2	3
Manganese µg/g	49	18	34
Lead µg/g	0.31		
Strontium µg/g	1047	981	953
Zinc µg/g	165	114	147
Mercury µg/g	0.11		
Nitrogen Oxide, %	6.79	5.85	6.35
$P_2 O_{5,\%}$	16.8	18.6	17.5
$K_2 O$, %	0.64	0.62	0.44
AMINO ACIDS, % Of Sample			
Alanine	2.66	2.67	2.75
Arginine	2.56	2.59	2.94
Aspartic Acid	3.03	2.99	3.24
Cystine	0.27	0.27	0.32
Glutamic Acid	4.65	4.7	5.14
Glycine	5.1	5.19	5.25
Histidine	0.66	0.65	0.7
Hydroxylysine	0.22	0.24	0.23
Hydroxyproline	1.25	1.31	1.4
Isoleucine	1.13	1.12	1.18
Leucine	2.04	2.03	2.17
Lysine	2.06	2.06	2.23
Methionine	0.91	0.89	0.99
Ornithine	0.07	0.06	0.06
Phenylalanine	1.12	1.12	1.25
Proline	2.51	2.55	2.66
Serine	1.78	1.87	2.08
Taurine	0.37	0.37	0.42
Threonine	1.36	1.37	1.47
Tryptophan	0.29	0.3	0.32
Tyrosine	0.81	0.81	0.91
Valine	1.5	1.44	1.51
Fatty Acid Composition Of The Extracted Fat In The Fishmeal, mg/G			
C18:3	2.3	2.1	2.5
C18:4	7.6	7	9.5
C20:4	3.1	1.8	2.5
C20:5	142.5	70.2	114.7
C21:5	5.5	3.1	4.4
C22:5	7.9	6.9	5.9
C22:6	55.4	54.3	83
Source: Advances in Seafood Byproducts, 2002 Conference Proceedings, Alaska Sea Grant College Program Univ. of Alaska Fairbanks			

Table 112 Alaskan fish bonemeal composition.

Fish Fertilizers

PACIFIC HARVEST PELLETED FISH FERTILIZERS				
	Organic Lawn Food 8-3-5	All Purpose Plant Food 7-6-2	Bio-Gro 10-4-2	Bio-Gro-9-3-5
Total Nitrogen, %	8.0	7.0	10.0	9.0
Water Insoluble Nitrogen, %	6.0	5.0	7.0	6.5
Water Soluble Nitrogen, %	2.0	2.0	2.8	2.3
Ammonia Nitrogen, %			0.2	0.2
Available Phosphate (P2O5), %	3.0	6.0	4.0	3.0
Soluble Potash (K2O), %	5.0	2.0	2.0	5.0
Calcium, %	3.5	6.5	4.0	3.0
Sulphur, %	2.5	1.5	2.0	2.5
pH	6.2	6.2		
Magnesium, ppm			4000	4000
Copper, ppm			10	10
Manganese, ppm			97	97
Zinc, ppm			133	133
Iron, ppm			1025	1025

Table 113 Pacific Harvest pelleted fish fertilizers.

Great Pacific BioProducts Ltd. Pacific Natural Liquid Fish Fertilizer From Pacific Dogfish	
Declared N-P-K, %	2-3-0
Total Nitrogen, %	2.36
Organic Nitrogen	2.18
Ammonia Nitrogen, %	0.18
Nitrate Nitrogen, %	>0.01
Available P2O5	2.82
Orthophosphate, %	1.16
Soluble K2O, %	0.28
Sulfur, %	0.10
Sodium, ppm	2520
Calcium, ppm	865
Zinc, ppm	3.7
Copper, ppm	0.30
Molybdenum, ppm	0.30
Cadmium, ppm	0.298
Selenium, ppm	0,033

Great Pacific BioProducts Ltd. Pacific Natural Liquid Fish Fertilizer From Pacific Dogfish	
Iron, ppm	9.8
Cobalt, ppm	0.38
pH	3.8
Moisture, %	84.60
Fat, %	7.10
Protein, %	14.4
Ash, %	3.90
Amino Acids, % of sample	
Serine	0.37
Glycine	0.81
Arginine	0.83
Alanine	0.61
Cystine	0.07
Valine	0.49
Lysine	0.83
Leucine	0.74
Tryptophan	ND
Aspartic Acid	0.71
Glutamic Acid	1.10
Histidine	0.25
Threonine	0.38
Proline	0.42
Tyrosine	0.16
Methionine	0.16
Isoleucine	0.43
Phenylalanine	0.34
Total Amino Acids	8.70

Table 114 Great Pacific Bioproducts liquid fish fertilizer.

FOX FARM MARINE CUISINE FERTILIZER	
Nitrogen, %	10
Ammonia Nitrogen, %	3.18
Nitrate Nitrogen	0.02
Water Soluble Nitrogen, %	3.90
Water Insoluble Nitrogen, %	2.90
Available Phosphate, %	7.00
Soluble Potash, %	7.00
Calcium, %	4.34
Magnesium, %	0.05

FOX FARM MARINE CUISINE FERTILIZER	
Sulfur, %	5.80
Boron, %	0.03
Chlorine, %	3.75
Copper, %	0.05
Iron, %	1.91
Manganese, %	0.05
Sodium, %	0.46
Zinc, %	1.20

Table 115 Fox Farm marine vuisine fertilizer.

Compost

In the earlier version of this report we found very little data available on fish waste compost quality parameters. We reported that they are sold as fertilizers and that there may be certain state requirements that must be met when the product is registered. Compost Handbook data normally characterizes potential material that can be composted and an abbreviated table appears in the following tables.

CHARACTERISTICS OF RAW MATERIALS FOR COMPOSTING					
Material	**% N dry weight**		**C:N w/w**	**% Moisture**	**Bulk Density lbs/cu yard**
Corn Cobs	0.4 – 0.8		56 – 123	9 – 18	-
Corn Stalks	0.6 – 0.8		60 – 73	12	32
Fruit Wastes	0.9 – 2.6		20 – 49	62 – 88	-
Crab and Lobster Wastes	4.6 – 8.2		4.0 – 5.4	35 – 61	-
Fish Wastes	6.5 – 14.2		2.6 – 5.0	50 – 81	`-
Fish Processing Sludge	6.8		5.2	94	-
Bark-Hardwoods	0.10 – 0.41		116 – 436	-	-
Bark-Softwoods	0.04 – 0.39		131 – 1285	-	-
Lumbermill Waste	0.13		170	-	-
Sawdust	0.06 – 0.80		200 – 75-	19 – 65	350 – 450
Wood Chips	0.09		641	-	445 - 620
Tree Trimmings	3.1		16	70	1296
Seaweed	1.2 – 3.0		5 – 27	-	-
C:N Carbon:Nitrogen ratio Source: www.cfe.cornell.edu/compost/OnFarmHandbook					

Table 116 Characteristics of raw materials for composting.

PROPERTIES OF COMPOST RAW MATERIALS IN QUEBEC CANADA					
	Lameque Peat	Sawadust & Shavings	Herring waste	Crab Scrap	Shigawake Peat
pH	3.00	7.1	6.7	-	4.4
Moisture, %	50	22	73	35	75
Dry Matter, %	50	77.8	27	65	25
The Following Data is on a Dry Matter Basis					
Mineral Matter, %	4.0	8.43	11.0	43.7	1.28
Organic Matter, %	96	91.57	89	56.3	98.72
Carbon, %	43.7	45.05	44.22	27.7	54.84
Total Nitrogen, %	0.8	0.15	13.4	8.20	1.03
Ammonia Nitrogen, %	0.07	0.00	-	-	-
P_2O_5, Phosphate %	0.09	0.02	13.99	6.66	0.05
K_2O, Potash, %	0.06	0.14	0.45	0.39	<0.01
MgO, Magnesia %	0.16	0.36	0.44	1.48	0.05
CaO, Lime %	0.14	1.65	14.27	20.87	0.14
C/N Ratio	53.3	300.33	3.3	5.34	53.24
Source: http://www3.sympatico.ca/first/webdoc2.htm					

Table 117 Properties of compost raw materials from Quebec Canada.

PROPERTIES OF VARIOUS COMPOSTS PREPARED IN QUEBEC CANADA						
	Peat + Herring 1	Peat + Herring 2	Sawdust + Herring + Mature Compost	Sawdust + Herring + Peat Cover	Peat + Crab	Various Wastes
pH	7.83	7.51	7.02	7.30	7.52	6.95
Moisture, %	67.1	77.2	63.0	66.9	57.3	68.0
% Dry Matter	32.9	22.8	37.0	33.1	42.7	32.0
The Following Data is on a Dry Matter Basis						
Mineral Matter, %	44.7	31.58	50.8	37.46	75.2	50.0
Organic Matter, %	55.3	68.42	49.2	62.54	24.8	50.0
Carbon, %	30.72	38.01	27.33	41.69	13.78	27.7
Nitrogen, %	5.08	3.52	1.08	1.80	1.41	1.76
Ammonia Nitrogen, %	2.83	1.1	0.21	0.03	0.00	0.32
P_2O_5, Phosphate %	3.53	3.18	2.04	4.81	5.52	3.98
K_2O, Potash, %	0.63	0.89	0.42	0.45	0.22	0.31
MgO, Magnesia %	1.88	2.23	2.76	4.81	5.05	3.66
CaO, Lime %	3.02	3.39	5.6	7.84	17.6	11.88
C/N Ratio	6.05	10.8	25.3	11.56	9.77	15.94
Source: http://www3.sympatico.ca/first/webdoc2.htm						

Table 118 Properties of various fish composts prepared in Quebec Canada.

PROPERTIES OF VARIOUS PEAT OR SAWDUST COMPOSTS QUEBEC, CANADA					
	Composted with Peat Moss by PAWS*				Composted with Sawdust by Turning
	Herring, USA	Crab Scrap, NB Canada	Various Seafood Waste, USA	Various Seafood Waste, NB Canada	Fish Waste, USA 200 Days
pH	7.15	7.75	59.97-7.49	7.72-7.99	6.92
Moisture, %	60.72	60.0	29.0-69.8	59.1-64.8	69.2
% Dry Matter	29.3	40.0	30.2-71.0	35.2-40.9	30.8
The Following Data is on a Dry Matter Basis					
Mineral Matter, %	7.6	36.6	8.5-20.5	33.5-36.6	31.3
Organic Matter, %	92.4	63.4	79.5-91.5	63.4-66.5	68.7
Carbon, %	46.2	31.7	39.75-45.75	31.7-33.25	35.7
Nitrogen, %	4.47	2.61	3.38-5.12	2.7-3.52	1.35
Ammonia Nitrogen, %	?	?	?	?	0.01
P_2O_5, Phosphate %	?	4.00	?	2.01-4.51	1.58
K_2O, Potash, %	0.44	0.30	0.30-0.55	0.29-0.41	0.32
MgO, Magnesia %	?	0.99	?	0.25-0.99	?
CaO, Lime %	?	4.93	?	1.06-3.44	1.12
C/N Ratio	10.33	12.14	7.76-13.53	9.45-11.74	29.9
*PAWS Passively Aerated Windrows System					
Source: http://www3.sympatico.ca/first/webdoc2.htm					

Table 119 Properties of various fish and peat or sawdust composts prepared in Quebec Canada.

MEEKERS COMPOSTING FISH COMPOST				
	Soil and Nutrient			
	Compost 1	Compost 2	Compost 3	Compost 4
TKN % wet	0.642	0.435	0.579	0.662
Total Carbon, % dry	47.2	47.1	45.4	44.9
Inorganic Carbon, % dry	0.05	0.00	0.14	0.10
Organic Carbon, % dry	47.15	47.10	45.26	44.80
Potassium, % dry	0.34	<0.30	<0.30	0.33
Magnesium, % dry	0.11	0.12	0.19	0.15
Phosphorous, % dry	0.426	0.381	0.551	0.612
Calcium, % dry	1.16	1.32	1.60	1.51
Iron, mg/kg dry	556	1229	1506	619
Manganese, mg/kg dry	23	39	63	29
TKN Nitrogen, % dry	2.171	1.626	1.772	2.400
Trace Elements, mg/kg dry basis				

MEEKERS COMPOSTING FISH COMPOST				
	Soil and Nutrient			
	Compost 1	Compost 2	Compost 3	Compost 4
Arsenic	<1.0	<1.0	<1.0	<1.0
Cadmium	<1.0	<1.0	<1.0	<1.0
Cobalt	<1.5	<1.5	<1.5	<1.5
Chromium	3.1	5.1	16	2.8
Copper	5.6	8.5	11	6.5
Mercury	<0.05	<0.05	<0.05	<0.05
Molybdenum	<2.5	<2.5	<2.5	<2.5
Nickel	<4.0	<4.0	6.4	<4.0
Lead	<5.0	<5.0	<5.0	<5.0
Selenium	<1.0	<1.0	<1.0	<1.0
Zinc	36	55	73	44
Source: http://www.meekersmagicmix.com/				

Table 120 Meekers Magic fish compost.

THE ORIGINAL SEA SOIL™	
Organic Matter, %	67.96
Moisture, % Max.	57.80
Total Nitrogen, %	2.10
Available Phosphoric Acid (P2O5), %	0.16
Soluble Potash (K2O), %	0.05

Table 121 The Original Sea Soil.

CARDWELL FARMS ATLANTIC MARINE COMPOST AND OTHER COMPOST PRODUCTS				
	Atlantic Marine Compost	Cow manure Compost	Farm Blend Compost	Sheep Manure Compost
	Results as Received	Results as Received	Results as Received	Results as Received
Dry Matter %	41	46.0	43	42.5
Calcium %	5.13	1.55	.77	.80
Phosphorus %	0.12	0.45	.29	.26
pH	7.9	6.1	7.4	6.9
Magnesium %	0.14	0.27	0.17	0.19
Potassium %	.10	0.45	.45	.53
Copper PPM	13.3	44.2	.17.4	15.6
Iron PPM	1606	3795	2032	1950
Manganese PPM	135	358	155	163
Sodium %	0.11	0.09	0.08	.08
Zinc PPM	75	111	96	102
Boron PPM	12.45	19.9	25.7	17.1
Carbon %	13.63	11.32	14.3	12.6
Nitrogen %	0.62	0.55	.58	.52
C/N	21.98	20.58	24.66	24.23

Table 122 Cardwell Farms Atlantic marine compost.

Alaska Fish Compost Products

SITKA TRIBAL ENTERPRISES FISH WASTE COMPOST PROJECT							
	Mix Ratio Wood/Fish	Fish Waste		Wood Debris		Total	
		Cubic yards	Tons	Cubic Yards	Tons	Cubic Yards	Tons
Pile 1	4.1	10	7.2	81.5	42	91.5	49.2
Pile 2	3.7	12	8.8	94.4	48.6	106.6	57.4
Pile 3	2.9	17	12.4	100.7	51.8	117.7	64.2

Table 123 Sitka Tribal Enterprises fish waste compost project ratio wood to fish.

SITKA TRIBAL ENTERPRISES FISH WASTE COMPOST PROJECT RAW MATERIALS				
	Wood Debris	**Whole Coho Salmon**	**Red Snapper Heads**	**Black Cod Heads**
Moisture, %	62.1	79.0	64.0	71.7
Volatile Solids, %	96.9	91.0	83.2	90.6
Bulk Density, lb/cy	1030	1440	1400	1620
pH		5.0		
Total Nitrogen, %	0.35	12.3	6.1	3.5
C:N Ratio	154	4	8	14
Ammonia, mg/kg	10			
Nitrate, mg/kg	22			
Phosphorous, mg/kg	40			
Potassium, mg/kg	608			
Calcium, mg/kg	1109			
Magnesium, mg/kg	338			
Sieve Analysis (% passing through sieve)				
1 inch	93			
½ inch	88.8			
¼ inch	77.0			
3/16 inch	70.9			
3/32 inch	59.5			
1/25 inch	27.7			
1/50 inch	9.5			

Table 124 Sitka fish compost project raw materials.

SITKA TRIBAL ENTERPRISES FISH WASTE COMPOST PROJECT FINAL PRODUCT			
	Pile 1	**Pile 2**	**Pile 3**
Moisture, %	68.0	67.7	66.5
Volatile Solids, %	83.3	69.2	82.6
Bulk Density, lb/cy	1150	1200	1150
Moisture Holding Capacity, %	76	288	268
Air Filled Porosity, %	35.6	36.3	28.4
pH	4.5	4.5	6.2
Conductivity, mmhos/cm	2.2	2.0	2.0
Cation Exchange Capacity, mew/100g	37.4	33.5	39.6
Total Nitrogen, %	0.8	0.7	1.2
C:N Ratio	61	52	40
Ammonia, mg/kg	436	293	1639
Nitrate, mg/kg	400	291	251

SITKA TRIBAL ENTERPRISES FISH WASTE COMPOST PROJECT FINAL PRODUCT				
		Pile 1	**Pile 2**	**Pile 3**
Phosphorous, mg/kg		554	718	499
Potassium, mg/kg		1188	1486	1493
Calcium, mg/kg		2625	2848	2149
Magnesium, mg/kg		312	353	310
Iron, mg/kg		84	94	82
Sieve Analysis (% passing through sieve)				
1 inch		100	100	100
½ inch		100	95.0	91.8
¼ inch		86.8	85.0	86.7
3/16 inch		80.2	77.6	77.9
3/32 inch		60.4	50.5	52.2
1/25 inch		16.5	13.1	9.7
1/50 inch		1.1	2.8	2.7
Trace Metals, mg/kg	US EPA Limit			
Arsenic	41	ND	1.3	ND
Cadmium	39	0.09	0.05	0.11
Chromium	NR	6.4	10.6	7.2
Copper	1500	5.7	9.0	5.4
Lead	300	3.5	2.7	3.0
Mercury	100	ND	ND	ND
Molybdenum	NR	0.4	0.6	0.3
Nickel	420	3.1	4.4	3.3
Selenium	100	ND	ND	ND
Zinc	2800	24.7	25.0	37.1
Fecal Coliform, MPN/g	1000	ND	ND	251

Table 125 Sitka project final product.

6. GEOGRAPHICAL MARKETS

Introduction

Fishmeal and fish oil are used in a variety of animal feed, human food and miscellaneous other markets both in the USA and globally. Fishmeal and fish oil are commodities and compete with oilseed meals and other animal proteins as well as animal and vegetable fats and oils. Because of the unique fatty acid profile of fish oils they are rich in the long chain omega 3 fatty acids which are involved in a variety of biochemical functions within the human body and have been shown to be beneficial to health. For markets we will be looking specifically at the USA; where products are consumed, to whom they are exported;, and from whom they are imported. The USA is a net importer of fishmeal and a major importer of specialty fish oils for the nutraceutical market. Other fishery based products could target the same markets, however it becomes a question of nutrient density and freight to ship high moisture materials that are not in dried form.

Global Feed Production

TOP 10 COUNTRIES, GLOBAL FEED PRODUCTION, MILLION METRIC TONS (mmt)						
	2001	**2002**	**2003**	**2004**	**2005**	**2006**
USA	142.3	143.4	145.5	147.0	150.2	151.7
China	58.4	61.3	64.4	63.1	72.7	77.5
Brazil	35.4	38.8	41.1	43.4	47.2	48.4
Japan	23.5	23.7	24.1	23.9	23	23.4
France	22.9	22.5	21.1	21.8	0	0
Canada	20.4	21.5	22.0	22.1	22.4	22.9
Mexico	20	21.4	23.2	23.8	24.3	25
Germany	18.5	18.3	18.3	19.0	0	0
Spain	17.5	18	18.0	19.2	0	0
Netherlands	15.3	15.1	14.0	12.4	0	0
Russia			15.9	16.5	17.3	18.1
Korea					14.3	14.6
India					0.8	10.3
EU25					141	140.4
Totals	2375.2	2386	2410.6	2416.2	2518.2	2538.3

Table 126 Major countries with their annual feed production.

NORTH AMERICAN FEED PRODUCTION, MMT			
	2002	**2004**	**2006**
U S A	143.4	147	151.7
Canada	21.5	22.1	22.9
Mexico		23.8	25
Costa Rica			0.7
Dominican Republic			1.8
El Salvador			0.9
Guatemala			1.9
Honduras			1.0
Jamaica			0.9
Panama			1.3
Totals	165	193	209

Table 127 North American feed production.

EUROPEAN FEED PRODUCTION, MMT							
	2002	2004	2006		2002	2004	2006
EUROPEAN UNION TOP 10				NON-EU EUROPE TOP 10			
Spain	18	19.2	20.2	Russia	15.5	16.5	18.1
Poland	0	6.1	5.7	Romania	3.0	2.8	2.9
Portugal	3.5	0		Poland	6.0	0	0
Ireland	4.0	0		Hungary	5.2	0	0
Italy	11.2	12.3	13.5	Norway	1.9	1.9	1.8
Hungary	0	5.1	4.5	Belarus	0	1.0	1.0
Germany	18.3	19.0	20	Czech Repub.	3.2	0	0
France	21.5	21.8	21.4	Lithuania	0	0.8	0
Denmark	5.5	5.5	5.0	Bulgaria	1.7	1.5	1.5
Belgium	6.7	6.1	5.5	Ukraine	4.7	4.5	4.9
U K	11.3	13.5	14	Switzerland	1.3	1.4	1.4
Netherlands	15.1	12.4	13.4	Slovakia	1.1	0	00
				Latvia	0	0.7	0
				Serbia-Montenegro	0	0	0.10
				Croatia	0	0	0.20
				Turkey	0	0	5.3
Totals	115.1	121	123.2	Totals	43.6	31.1	37.2

Table 128 European feed production

LATIN AMERICA AND ASIA PACIFIC FEED PRODUCTION, MMT							
	2002	2004	2006		2002	2004	2006
ASIA-PACIFIC				LATIN AMERICA			
Korea	14.1	13.5	14.6	Ecuador	0.9	1.1	1.4
Japan	23.7	23.9	23.4	Colombia	2.0	2.3	3.0
Indonesia	3.0	3.2	7.1	Chile	3.5	3.6	3.9
India	8.0	9.1	10.3	Paraguay		0.5	0.3
China	61.3	63.1	77.5	Uruguay		0.8	0.5
Australia	8.1	8.5	9.0	Brazil	38.8	43.4	48.4
Thailand	8.5	8.1	9.1	Argentina	5.5	5.8	6.1
Taiwan	7.1	7.4	7.6	Venezuela	2.8	2.8	3.4
Philippines	4.6	4.8	5.7	Peru	1.5	1.6	1.8
Malaysia	4.2	3.8	4.9	Mexico	21.4	23.8	0
				Bolivia			0.4
Totals	142.6	145.4	169.2	Totals	80.9	85.7	69.2

Table 129 Latin American and Asia Pacific feed production.

MIDDLE EAST AND AFRICA FEED PRODUCTION, MMT		
	2002	2004
Algeria		1.1
Turkey	4.8	5.1
Tunisia	0.3	0.5
South Africa	7.2	8.0
Saudi Arabia	1.8	2.0
Nigeria	0.5	1.0
Morocco	1.2	1.3
Jordon	0.5	0.7
Israel	2.2	2.2
Iran	2.8	3.1
Egypt	4.7	4.5
Totals	26	29.5

Table 130 Middle East and Africa feed production

USA Livestock and Feed Production

The domestic markets for fishmeal will be situated near the areas that produce the livestock; poultry, pigs, dairy, beef cattle, and fish. These have been broken down into the following tables listing the major states and regions where the livestock are raised. Also included are statistics on the pet food market by product type.

POULTRY NUMBERS AND TOTAL FEED POTENTIAL BY STATE, 2005				
	LAYERS 1000	BROILERS 1000	TURKEYS 1000	TOTAL FEED POTENTIAL, 1000 TONS
Connecticut	3026			121
Maine	4138			166
New Jersey	1813		37	74
New York	4167	3000	620	212
Pennsylvania	23785	147300	11500	2253
Indiana	23596		13400	1594
Iowa	48760		9600	2416
Michigan	7867		4700	543
Minnesota	11038	46900	44500	2837
Missouri	7204		20500	1282
Nebraska	11987	4800		504
Ohio	28026	43100	5700	1615
Florida	10963	75900		822
Georgia	19489	1321200		7452

POULTRY NUMBERS AND TOTAL FEED POTENTIAL BY STATE, 2005				
	LAYERS 1000	BROILERS 1000	TURKEYS 1000	TOTAL FEED POTENTIAL, 1000 TONS
North Carolina	10955	735100	36000	5896
South Carolina	5042	213300	8000	1667
Alabama	9141	1057300		5705
Arkansas	14748	1214300	29000	8129
Texas	17703	627900		3879
California	19336		14900	1496
Totals	343505	8870350	256270	70965
Source: NASS, USDA, Feed Management Sept Oct 2006				

Table 131 USA poultry numbers and potential feed consumption by state.

US SWINE NUMBERS AND POTENTIAL SWINE FEED 2005				
STATE	OPERATIONS	SOWS FARROWED, 1000	PIGS FED, 1000	TOTAL SWINE FEED POTENTIAL, 1000 TONS
USA	67330	11505	100332	40,597
Illinois	3100	825	6527	2,669
Indiana	3000	540	5416	2,162
Iowa	8900	1785	28060	10,834
Minnesota	4900	1125	13073	5,154
Missouri	2200	685	4052	1,720
Nebraska	2600	700	5037	2,083
Ohio	3900	311	2772	1,119
N.Carolina	2400	2200	14631	6,110
Oklahoma	2500	765	3383	1,506
Texas	3800	175	1110	466
Oregon	1200	6	11	6
Source: NASS, USDA Feed Management Sept Oct 2008				

Table 132 USA swine production by state

USA BEEF CATTLE PRODUCTION AND POTENTIAL FEED CONSUMPTION 2005					
	OPERATIONS, 1000	BEEF COWS, 1000	BEEF REPLACEMENT, 1000	CATTLE MARKETED, 1000	TOTAL FEED POTENTIAL, 1000 TONS
USA	770170	32915	5691	22172	38846
Pennsylvania	12000	154	40		16
Illinois	14800	460	65		45
Indiana	12000	230	40		23
Iowa	25000	1013	120	780	1349
Kansas	27000	1530	245	5280	8616
Minnesota	15000	395	95		41
Missouri	54000	2121	290		208
Nebraska	20000	1909	300	4420	7275
Florida	15400	932	145		93
Georgia	19000	596	82		50
N. Carolina	18000	400	75		41
S. Carolina	9000	222	38		22
Virginia	22000	705	125		71
Alabama	23000	724	100		71
Arkansas	27000	964	170		109
Kentucky	38000	1100	170		109
Mississippi	18800	564	99		57
Oklahoma	48000	2015	375	727	1369
Tennessee	42000	1078	195		109
Texas	131000	5432	800	6755	9762
California	11500	720	130	707	1206
Colorado	9700	639	130	1985	3247
Alaska	90	5	1		1
Other States				564	904
Source: NASS, USDA, Feed Management Sept Oct 2006					

Table 133 USA beef cattle production by state

USA DAIRY COW PRODUCTION- 2005				
	MILK COWS 1000	CALVES TO 6 MONTHS 1000	OVER 6 MONTHS 1000	TOTAL DAIRY FEED POTENTIAL 1000
New York	648	333	325	2123
Pennsylvania	561	282	275	2072
Minnesota	453	272	285	1728
Wisconsin	1236	687	670	4860
California	1755	810	790	7351
Totals	9044	4385	4278	36166
Source: NASS, USDA, Feed Management Sept Oct 2006				

Table 134 USA dairy cow production by state 2005

Aquaculture

USA PRODUCTION OF TROUT, CATFISH AND TILAPIA			
	TROUT	CATFISH	TILAPIA
	Thousand Metric Tons		
1990	25.76	163.48	
1991	26.94	177.31	2.27
1992	25.49	207.48	4.31
1993	24.77	208.20	5.67
1994	23.63	199.22	5.89
1995	25.36	202.71	6.84
1996	24.31	214.14	7.24
1997	25.72	238.09	7.65
1998	24.99	256.01	8.25
1999	27.31	270.62	8.05
2000	26.76	269.26	9.07
2001	25.81	270.84	7.98
2002	24.72	286.04	8.98
2003	23.00	300.05	8.98
2004	24.95	285.99	9.07
2005	27.49	275.74	7.80
2006	27.90	256.78	8.48
2007	31.43	186.88	
Source: Fisheries of the United States 1990 - 2007.			

Table 135 USA aquaculture production, trout, catfish and tilapia

USA CATFISH PRODUCTION – 2007 - 2008				
	Number Of Operations		Food Size Fish Live Weight 1000 Lbs	
	2007	2008	2007	2008
Alabama	199	185	80100	75360
Arkansas	137	128	69610	65200
California	37	38	3320	2630
Mississippi	370	350	218400	209500
Louisiana	20	17	15970	11410
North Carolina	44	38	8120	8100
Texas	57	61	8990	12840
All Others	376	247	7731	6765
Total	1240	1064	412241	391805
Source: http://usda.mannlib.cornell.edu/MannUsda/browseAgency.do?action=searchByAgency&agency=nass&x=7&y=1				

Table 136 USA catfish production

USA TROUT PRODUCTION 2006 - 2007				
	2006		2007	
State	Number of Operations	1000 Pounds	Number of Operations	1000 Pounds
Arkansas	5		5	
California	34	2000	34	2145
Colorado	34	447	32	620
Georgia	15	250	14	*
Idaho	43	46500	46	50500
Michigan	23	304	19	211
Missouri	14	*	12	*
New York	34	72	29	40
North Carolina	47	4350	49	4240
Oregon	42	108	45	*
Pennsylvania	51	1400	54	1360
Utah	26	87	20	117
Virginia	24	641	22	630
Washington	96	3900	96	3670
West Virginia	28	100	27	*
Wisconsin	66	575	57	441
3 Other States	183	4612	186	5369
Total USA	765	65346	747	69343

USA TROUT PRODUCTION 2006 - 2007				
	2006		2007	
State	Number of Operations	1000 Pounds	Number of Operations	1000 Pounds
* Confidential Information				
Source: http://usda.mannlib.cornell.edu/usda/current/TrouProd/TrouProd-02-26-2008.txt				

Table 137 USA trout production 2006 and 2007.

Major Feed Manufacturers

TOP FEED MANUFACTURERS WORLDWIDE IN 2007		
COMPANY	HEADQUARTERS	INDUSTRIAL FEED PRODUCTION, MILLION TONS
Cargill/Agribrands	USA	16.8
Charoen Pokphand (CP Group)	Thailand	14.9
Land O'Lakes Purina	USA	12.0
Tyson Foods	USA	10.1
Nutreco	Netherlands	8.0
Zen-noh Co-operative	Japan	7.8
AB Agri	UK	4.6
Ucaab Co-operatives	France	4.0
Smithfield	USA	3.6
Sadia	Brazil	3.5
ADM Alliance Nutrition/AH&N	USA	3.2
Glon	France	3.2
Hope Group	China	3.2
Ridley	Australia	3.2
Perdigao	Brazil	3.0
Provimi	Netherlands	3.0
Bachoco	Mexico	2.9
Agravis Raiffeisen	Germany	2.6
Perdue Farms	USA	2.6
BOCM Pauls	UK	2.6
DLG	Denmark	2.5
Evialis	France	2.4
JD Heiskell	USA	2.4
Gold Kist	USA	2.4
Marubeni-Nisshin	Japan	2.3
Mitsubishi Nosan	Japan	2.3
Veronesi	Italy	2.3
Chubu	Japan	2.0

TOP FEED MANUFACTURERS WORLDWIDE IN 2007		
COMPANY	**HEADQUARTERS**	**INDUSTRIAL FEED PRODUCTION, MILLION TONS**
CJ Cheil Jedang	Korea	1.9
Cehave Landbouwbelang	Netherlands	1.8
De Heus Brokking Koudijs	Netherlands	1.8
Deuka	Germany	1.8
Kyodo Feed	Japan	1.8
Nutrea	France	1.8
Terrena	France	1.5
Agrifirm	Netherlands	1.4
For Farmers (prev. ABCTA)	Netherlands	1.3
Nippon Formula Feed	Japan	1.3
Itochu	Japan	1.2
Nichiwa Feed	Japan	0.9
Showa Sangyo	Japan	0.9
Coopagri Bretagne	France	0.8
Toyohashi	Japan	0.7
Source: Feed International, October 2007		

Table 138 Top global feed manufacturers 2007.

LEADING COMMERCIAL AND INTEGRATED FEED MANUFACTURERS						
COMPANY	**CAPACITY 1000 TONS/YEAR**	**NO. FEED MILLS**	**STATES SERVED**	**% FEED TYPE**		
				COMPLETE	**PELLETED**	**BULK**
Land O' Lakes	12881	121	48	64	54	71
Tyson Foods	12000	40		100	78	100
Cargill Inc.	9500	79	49	55	65	65
Smithfield Foods	4500			100	85	100
ADM Alliance Nutrition	3200	45	42	50	57	67
Pilgrims Pride	3190			100	100	100
Perdue Farms Inc.	3016	12		100	100	100
Gold Kist	3000	12	5	100	91	100

LEADING COMMERCIAL AND INTEGRATED FEED MANUFACTURERS						
COMPANY	CAPACITY 1000 TONS/YEAR	NO. FEED MILLS	STATES SERVED	% FEED TYPE		
				COMPLETE	PELLETED	BULK
Inc.						
Jd Haskell & Co.	2800	6		65	5	95
Conagra Poultry	2180			100	100	100
Westway Feed Products	2004	22	48	0	0	97
Kent Feeds Inc.	2000	23	28	5	45	58
Southern States Coop.	2747	13	6	86	40	65
PM Ag Products	1700	24	50	0	0	100
Roley Inc.	1640	434			66	80

Table 139 Leading commercial and integrated feed manufacturers in the US.

Pet Foods

The petfood market is an example of where value-added fish by-products can be utilized. In 2007 the global petfood market was valued at US$46 billion composed of 61% dog food ($28.3 billion), cat food 36% ($16.9 billion) and other 3% ($0.8 billion). The future looks good for the petfood market and this has been attributed to three trends: humanization, convenience and health. The growth in the value of the petfood market (retail sales) has increased from US$31.57 billion in 2002 to the current US$46 billion in 2007 and is projected to reach US$52 billion in 2012.

GLOBAL MARKET FOR PETFOODS, 2007 AND 2012 PROJECTED				
	Market Value billions US$ 2007	Market Share %	Projected Market Value billions US$ 2012	Market Share, %
North America	19.5	42.4	20.78	40
Latin America	5.04	10.97	6.37	12.25
Western Europe	14.47	31.5	15.57	29.94
Eastern	2.54	5.5	3.95	7.6

GLOBAL MARKET FOR PETFOODS, 2007 AND 2012 PROJECTED				
	Market Value billions US$ 2007	Market Share %	Projected Market Value billions US$ 2012	Market Share, %
Europe				
Asia Pacific	4.41	9.6	5.33	10.25
Totals	45.96		52	
Source: Petfood Industry July 2008				

Table 140 Global pet food sales.

MAJOR PET FOOD MANUFACTURERS, BRANDS AND MARKET SHARE 2007				
	Dry Dog Food	Wet Dog Food	Dry Cat Food	Wet Cat Food
Pedigree (Mars)	16%	37%		
Iams (P&G)	12%	6%	11%	4%
Ol" Roy (Wal Mart)	12%			
Kibbles n Bits (Del Monte)	11%			
Purina Dog Chow (Nestle Purina)	9%			
Hill's Science Diet (Colgate)	8%	6%		4%
Beneful (Nestle Purina)	8%			
Alpo (Nestle Purina		28%		
Mighty Dog (Nestle Purina)		11%		
Cesar (Mars)		7%		
Skippy (Del Monte)		3%		
Friskies (Nestle Purina)			17%	38%
Meow Mix(Del Monte)			15%	
Purina Cat Chow (Nestle Purina)			15%	
9 Lives (Del Monte)			8%	31%
Purina One (Nestle Purina)			8%	
Whiskas (Mars)			8%	18%
Fancy Feast (Nestle Purina)				30%
Sheba (Mars)				3%
Source: Petfood Industry July 2008				

Table 141 Major pet food manufacturers, brands and market share.

GLOBAL DOG AND CAT FOOD SALES							
		Year to year growth %					
	Retail sales in US$ billions 2007	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Dog and cat food	US$45.12	5.1	3.7	5.2	4.8	5.9	4.9
Dog food	US$28.25	5.8	4.4	6.1	4.9	6.6	5.2
Cat food	US$16.86	4.2	2.7	3.7	4.7	4.8	4.4
Source: Petfood Industry January 2008							

Table 142 Global dog and cat food sales 2007.

TOP TEN GLOBAL PET FOOD COMPANIES 2006								
	2006 retail sales	2006 market share	Year to year growth %					
	US$ billions	%	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Mars Inc.	$10.71	24.6	0	12.7	14.2	11.8	5.9	9.1
Nestle SA	$10.48	24.1	79	-0.80	9.1	10.7	5.5	7.1
Procter & Gamble Co.	$2.86	6.6	30.8	8.1	9.9	10.8	6.1	3.8
Colgate-Palmolive Co.	$2.77	6.4	-0.10	10.8	15.1	9.1	6.3	8.8
Del Monte Foods Co.	$1.67	3.9	NA	NA	0.40	2.5	-1.20	57.6
Agrolimen SA	$0.59	1.4	NA	NA	42.4	13.9	6.4	3.4
Nutro Products Inc.*	$0.56	1.3	14.8	15.5	2.1	-1.20	4.1	5.2
Uni-Charm Corp.	$0.29	0.7	-11.1	3.7	15.3	0.7	0.40	0.90
Total Alimentos SA	$0.20	0.5	-12.1	-10	34.6	41.9	62.4	30.4
Nutriara Alimentos Ltda.	$0.20	0.5	-5.2	-12.4	-10.4	22.3	36.4	38.7
* In May 2007 Nutro Products Inc. was acquired by Mars Inc.								
Source: Petfood Industry January 2008								

Table 143 Major global petfood manufacturers 2006.

Sales of Natural and Organic petfoods are also increasing and are expected to reach US$2 billion for the Natural category and US$188 million for the Organic category by 2012.

US SALES OF NATURAL AND ORGANIC PETFOODS		
	Natural Petfood Sales US$millions	**Organic Petfood Sales US$millions**
2003	$417	$14
2007	$1006	$67
2012	$2097	$188
Source: Petfood Industry March 2008		

Table 144 US natural and organic pet food sales 2003 – 2012.

Canadian Livestock Production

CANADIAN HOG INVENTORY, 1000 HEAD								
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Canada	13575	14375	14745	14725	14810	15110	14907	13810
Newfoundland and Labrador	3.2	2.4	2.5	2.3	2.1	1.8	1.9	1.4
Prince Edward Island	126	130	130	132	127	123	123.5	95.3
Nova Scotia	127	127	119	108	101	102	93	68
New Brunswick	132	131	122	124	115	104	105.5	91.3
Quebec	4082	4291	4280	4250	4280	4337	4174	3990
Ontario	3520	3533	3737	3781	3779	3951	3924	3652
Manitoba	2382	2688	2825	2852	2870	2940	2960	2810
Saskatchewan	1071	1180	1230	1265	1342	1375	1349	1180
Alberta	1965	2125	2140	2050	2045	2036	2045	1800
British Columbia	168	168	160	161	149	140	131	122
Source: Canadian Livestock Statistics www.statcan.ca								

Table 145 Canadian swine production.

CANADIAN BEEF CATTLE AND HEIFERS INVENTORY, 1000 HEAD							
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Canada	5289.7	5400.5	5707.1	5921.4	5875.5	5597.2	5576.9
Newfoundland and Labrador	1	0.9	0.9	0.8	0.9	0.9	0.8
Prince Edward Island	16.5	16.1	16.2	17.4	17.9	17.8	14.5
Nova Scotia	30.9	30.6	31.1	29.6	28.7	29	25.4
New Brunswick	24.8	23.9	23.4	23.6	24.5	24.5	21.2
Quebec	239.5	250.5	261	264	246	234	248

CANADIAN BEEF CATTLE AND HEIFERS INVENTORY, 1000 HEAD							
	2001	2002	2003	2004	2005	2006	2007
Ontario	451	462	480	458	447.5	408	418.5
Manitoba	601	631.5	718	730	750	685	676.5
Saskatchewan	1385	1478	1611	1711	1743	1654.5	1656
Alberta	2209	2165	2130.5	2345	2297	2253	2235
British Columbia	331	342	335	342	320	290.5	281
Source: Canadian Livestock Statistics www.statcan.ca							

Table 146 Canadian beef production.

CANADIAN DAIRY COW AND HEIFER INVENTORY, 1000's							
	2001	2002	2003	2004	2005	2006	2007
Canada	1591.4	1577.8	1559.2	1559.2	1514.2	1484.9	1459.6
Newfoundland	6.1	6.4	7.1	7.9	8.2	8.3	8.8
Prince Edward Island	21.4	21.7	21.2	20.9	20.6	20.5	20.1
Nova Scotia	35.3	35.1	34.7	34.3	34	34.1	36
New Brunswick	28.6	29.1	29.2	29.3	28.4	28.5	28.2
Quebec	594	575	566	581	572	570	602
Ontario	567	569	553.5	549.8	519	503	499
Manitoba	60.5	58.5	62	62	64	63	63.5
Saskatchewan	42	47	46	45	45.5	42	40
Alberta	128	122	121.5	119	122	114.5	119.5
British Columbia	108.5	114	118	114	105	102.5	105
Source: Canadian Livestock Statistics www.statcan.ca							

Table 147 Canadian dairy cow and heifer production.

CANADIAN CHICKEN PRODUCTION, 1000's					
	2003	2004	2005	2006	2007
Canada	615,939	613,527	626,251	622,261	640,342
Newfoundland	x	x	x	x	x
Prince Edward Island	x	x	x	x	x
Nova Scotia	21,469	21,913	22,048	21,720	22,355
New Brunswick	17,144	18,153	17,476	17,688	18,452
Quebec	163,838	168,456	162,642	164,913	169,815
Ontario	197,115	204,304	205,203	202,349	205,981

CANADIAN CHICKEN PRODUCTION, 1000's					
	2003	2004	2005	2006	2007
Manitoba	27,567	28,500	29,125	29,566	29,523
Saskatchewan	23,136	25,524	21,996	22,696	25,658
Alberta	52,142	54,785	53,285	53,854	55,098
British Columbia	102,354	80,134	102,686	98,016	101,553
Source: Canadian Livestock Statistics Source: http://www40.statcan.ca/l01/cst01/prim55a.htm					

Table 148 Canadian chicken production.

CANADIAN TURKEY PRODUCTION, 1000's					
	2003	2004	2005	2006	2007
Canada	19,834	19,526	20,492	21,172	21,756
Newfoundland	x	x	x		
Prince Edward Island	x	x	x	x	x
Nova Scotia	722	730	731	789	779
New Brunswick	327	330	362	365	406
Quebec	4,298	4,449	4,343	4,567	4,412
Ontario	8,406	8,371	8,500	8,939	9,231
Manitoba	1,480	1,368	1,432	1,413	1,589
Saskatchewan	791	795	674	802	886
Alberta	1,687	1,662	1,757	1,651	1,65
British Columbia	2,118	1,816	2,688	2,640	2,797
Source: Canadian Livestock Statistics http://www40.statcan.ca/l01/cst01/prim55a.htm					

Table 149 Canadian turkey production.

CANADIAN AQUACULTURE PRODUCTION IN METRIC TONS							
	2000	2001	2002	2003	2004	2005	2006
Newfoundland/Labrador	2,563	4,263	4,570	3,900	5,629	8,148	10,500
Prince Edward Island	20,702	20,338	19,554	19,886	20,931	18,921	20,147
Nova Scotia	10,456	8,067	4,197	7,513	4,994	8,917	x
New Brunswick	31,020	35,633	41,322	36,453	37,284	37,657	x
Quebec	1,354	1,362	1,184	999	974	1,215	710
Ontario	4,000	4,135	4,650	4,200	4,000	4,075	4,250

CANADIAN AQUACULTURE PRODUCTION IN METRIC TONS							
	2000	2001	2002	2003	2004	2005	2006
Manitoba	7	16	16	10	10	11	x
Saskatchewan	85	989	914	x	x	x	x
Alberta	x	x	x	x	x	x	x
British Columbia	55,650	77,010	93,090	75,126	65,666	73,528	79,638
Total Canada	127322	153,329	171,031	150,205	141,580	154,388	170,938
x contains confidential information							
Source: http://www.dfo-mpo.gc.ca/communic/statistics/aqua/index_e.htm							

Table 150 Canadian aquaculture production.

CANADIAN AQUACULTURE PRODUCTION BY SPECIES, IN METRIC TONS							
	2000	2001	2002	2003	2004	2005	2006
Salmon	82,195	105,606	126,321	99,961	90,646	98,369	118,058
Trout	6,514	6,513	6,833	5,253	4,858	4,878	5,033
Steelhead	5,523	4,705	2,034	1,150	0	0	0
Other	695	1,604	1,567	7,352	7,491	12,621	9,171
Total Finfish	95,003	118,428	136,755	113,716	102,995	115,777	132,262
Clams	1,000	1,400	1,500	1,589	1,599	1,831	1,600
Oysters	9,624	11,319	11,520	13,621	13,228	12,957	12,488
Mussels	21,262	21,515	20,572	20,590	22,863	22,930	23,822
Scallops	69	118	106	95	87	61	58
Other	364	549	578	594	808	832	708
Total Shellfish	32,319	34,901	34,276	36,489	38,585	38,611	38,676
Total Aquaculture	127,322	153,329	171,031	150,205	141,580	154,388	170,938
Source: http://www.dfo-mpo.gc.ca/communic/statistics/aqua/index_e.htm							

Table 151 Canadian aquaculture production by species.

Mexican Livestock Production

MEXICAN LIVESTOCK PRODUCTION					
	2004	2005	2006	2007	2008Apr
Beef and Veal, 1000 mt	2099	2125	2175	2200	2225
Milk Production, 1000 tons	9874	9855	10051	10290	10300
Pork, 1000 mt	1150	1195	1108	1150	1180
Turkeys, 1000 mt	13	14	14	15	15
Broilers, 1000 mt	2389	2498	2592	2730	2825
Cows Milk, 1000 mt	9874	9855	10051	10290	10300
Eggs, 1000 mt	1906	2025	2014		
Source: USDA, FAS http://www.fas.usda.gov/currwmt.asp					

Table 152 Mexican livestock production.

Fishmeal

Fishmeal is used in the feeds of livestock, fish, crustaceans, pets and fur bearing animals. The following figure shows the world market trend and projection to 2010.

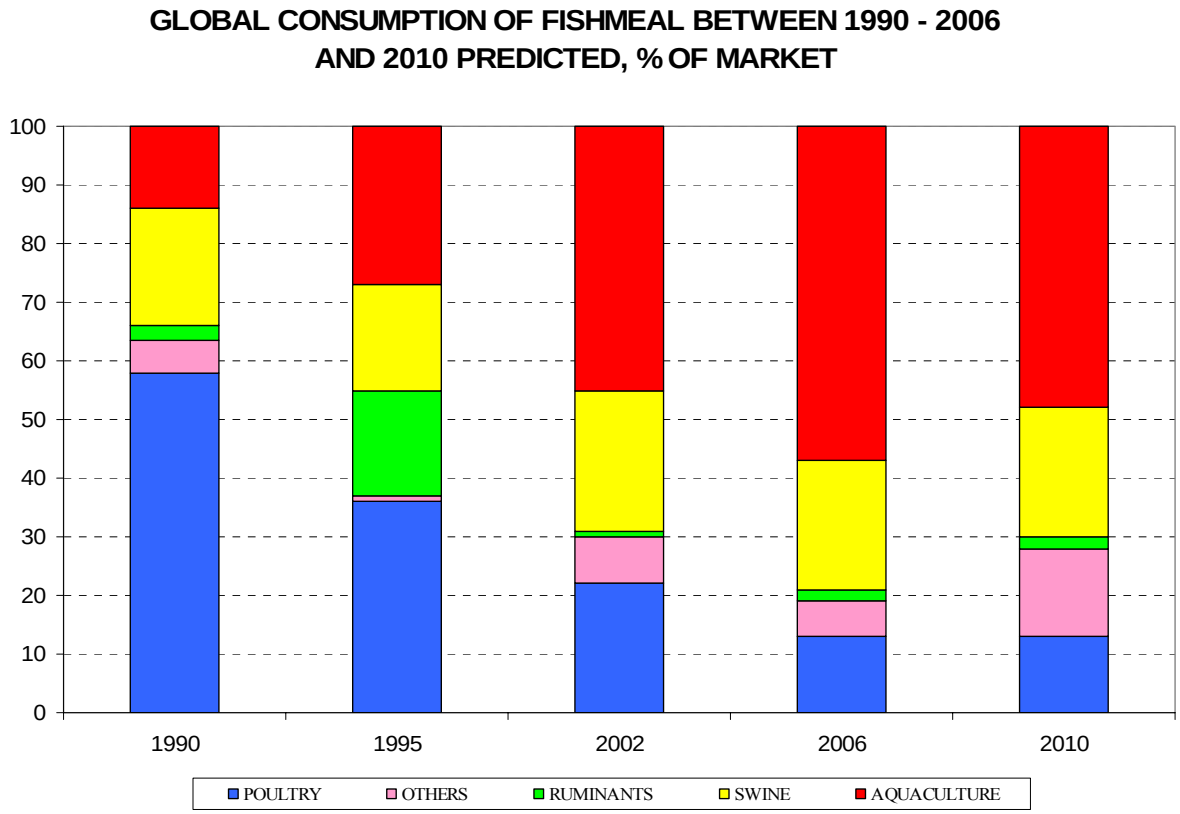


Figure 21 Global consumption of fishmeal 1990 – 2010 projected.

The poultry market is being gradually replaced by the aquaculture market and to a lesser extent the pet food market while the ruminant market was impacted by the world BSE crisis and still has not recovered. As mentioned earlier, the EU continues to evaluate the situation and nothing is expected in this area before 2009.

USA Fishmeal Imports and Exports

The USA is a net importer of fishmeal. Between 1999 and 2007 the volume has ranged from 33,000 to 70,000 metric tons with an overall average of about 51,000 tons over this period. Generally the meal is shipped in bulk and unloaded at strategic ports, for example Morehead City, North Carolina for Icelandic Fishmeal and Port Arthur, Texas for Latin American fishmeal. There is an increasing trend to ship fishmeal in ocean containers rather than bulk since they are

more easily handled both at the shipping and the receiving end and do not require the bulk storage facilities that have been used in the past.

Nine (9) countries account for 97% of the US imports while 23 countries account for the other 3%. The following figures give the average imports for the period 2002 – 2007 for both imports and exports of fishmeal.

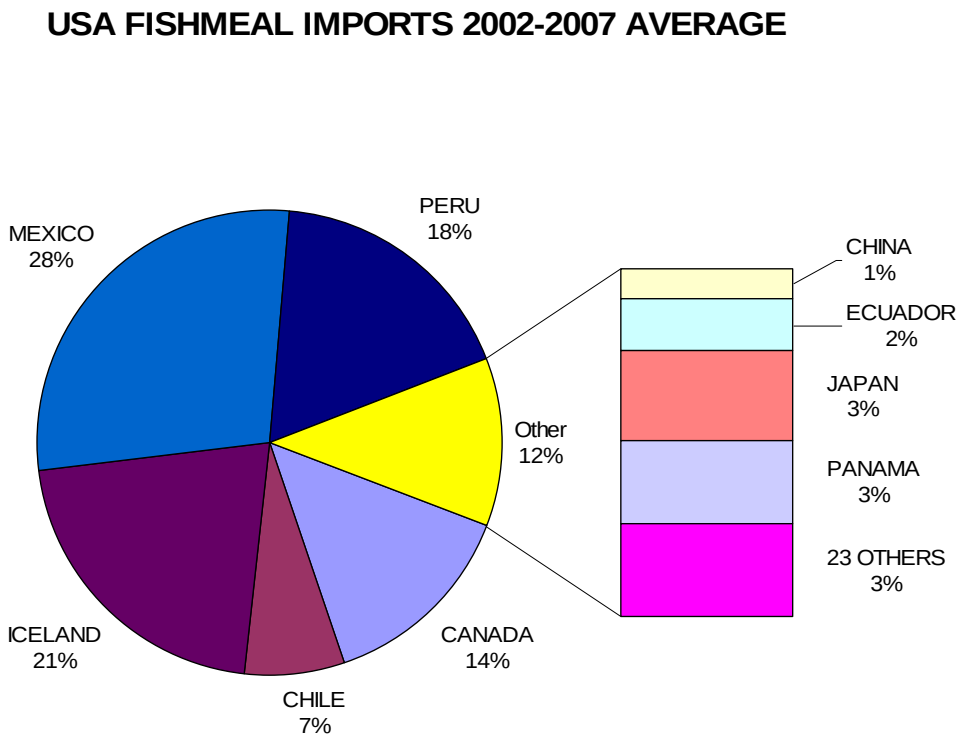


Figure 22 USA fishmeal imports by country, 2002-2007 average.

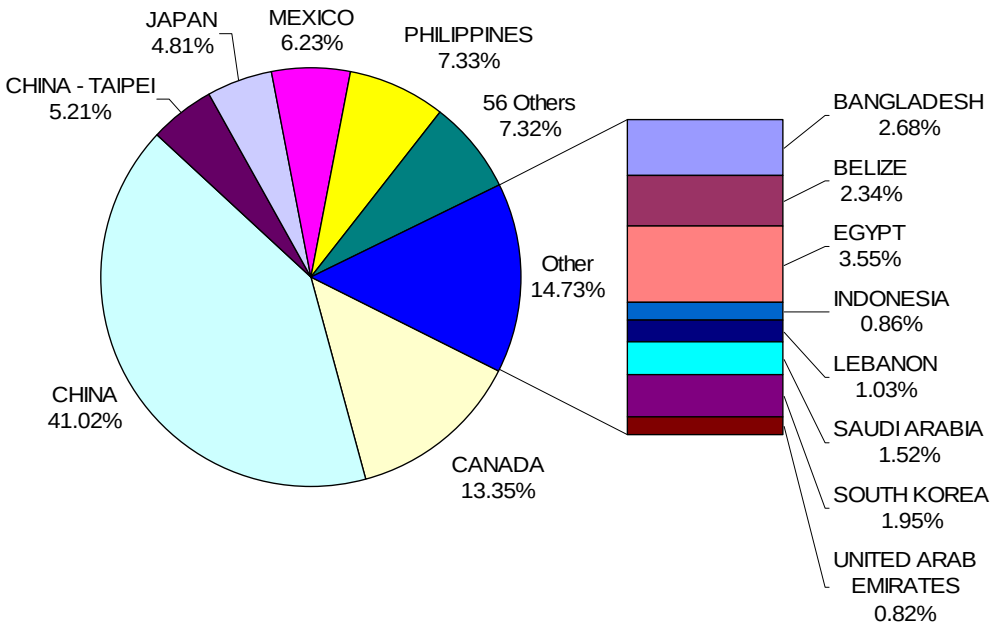


Figure 23 USA fishmeal exports by country, 2002 – 2007 average

Global Use of Fishmeal in Aquaculture Feeds

Since aquaculture represents 45-50% of the global fishmeal market, it would be important to know the projected market for fishmeal based on the various aquaculture species. This is shown in the following table.

PREDICTED USE OF FISHMEAL IN FISH FEEDS										
SPECIES	**% FISHMEAL INCLUSION IN FEED PRODUCED**					**1000 TONS OF FISHMEAL**				
	2002	**2003**	**2005**	**2010**	**2012**	**2002**	**2003**	**2005**	**2010**	**2012**
Shrimp	24	23	20	15	13	545	670	584	736	725
Freshwater Crustaceans	20	20	18	12	11	135	139	143	131	137
Marine Fish*	45				40	575	590	604	649	719
Salmon	35				20	552	573	499	425	422
Trout	30				15	168	216	127	108	99
Eel	47	45	40	30	28	179	171	145	113	112
Milkfish	8	7	5	2	2	38	36	27	13	15
Feeding Carp	5	5	4	2	2	415	438	364	229	263
Tilapia	7				2	67	79	55	52	61
Catfish	2					22	24	18	22	24
Carnivorous Fresh Water Fish	40				30	124				183
Totals						2696	2936	2666	2478	2577
Source: FAO Fisheries Circular No. 1018 2006										

*Bass, Bream, Yellowtail, Grouper, Jacks and Mullets, Flounder, Turbot, Halibut, Sole, Cod and Hake.

Table 153 Predicted use of fishmeal in aquaculture feeds.

Fish Oil

Fish oil is used in the feeds of livestock, fish, crustaceans and pets as well as in edible products such as margarine and shortenings and nutraceuticals. Fish oil also has a long and well developed industrial or technical market. The following figure shows the current breakdown of the world market and the projected world market in 2010.

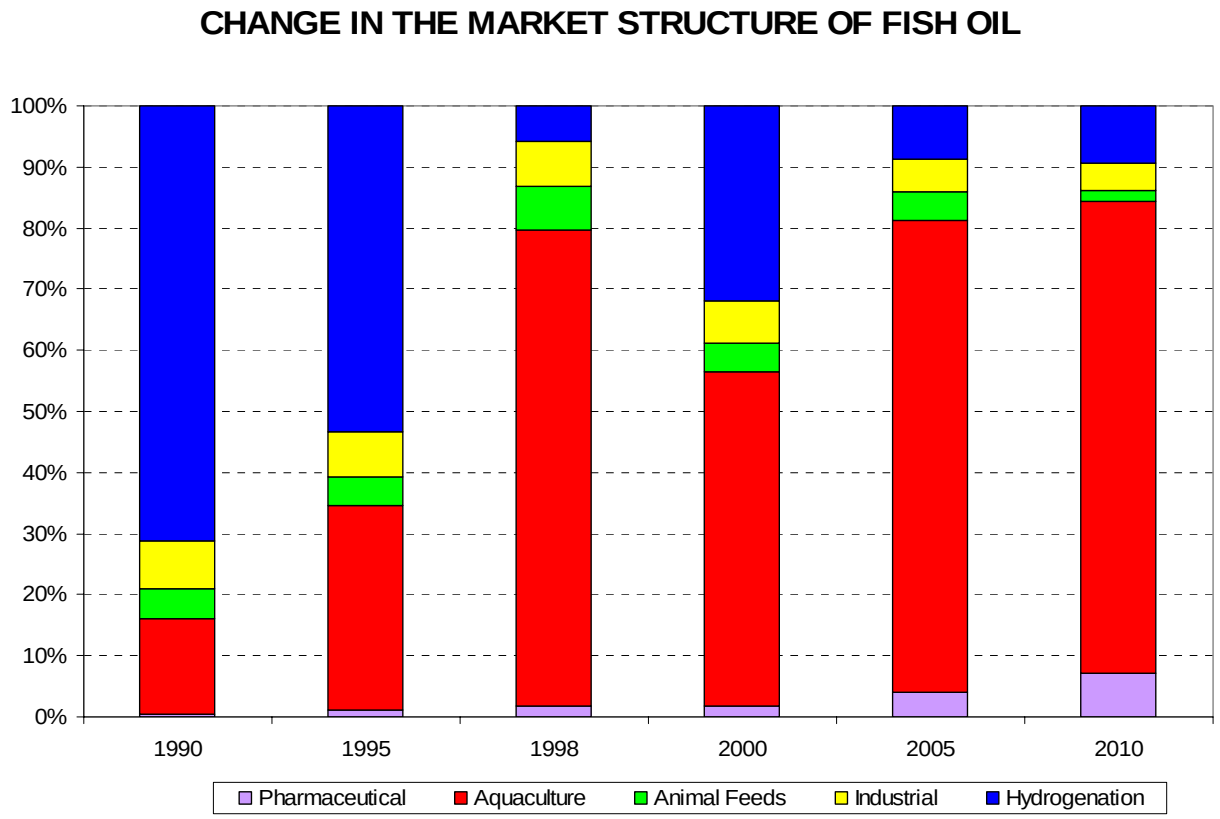


Figure 24 Current and projected world market for fish oil.

The fish oil hydrogenation market has been replaced by the aquaculture market almost to the point where aquaculture consumes all of the available fish oil. This is vividly demonstrated in the following figure which compares fish oil imports for Germany + UK + Netherlands (major hydrogenation processors with Norway + Chile + Canada + Asia (major aquaculture producing countries). Some people are predicting that the Pharmaceutical segment of the market will consume about 20% of the fish oil production within the next 5 years.

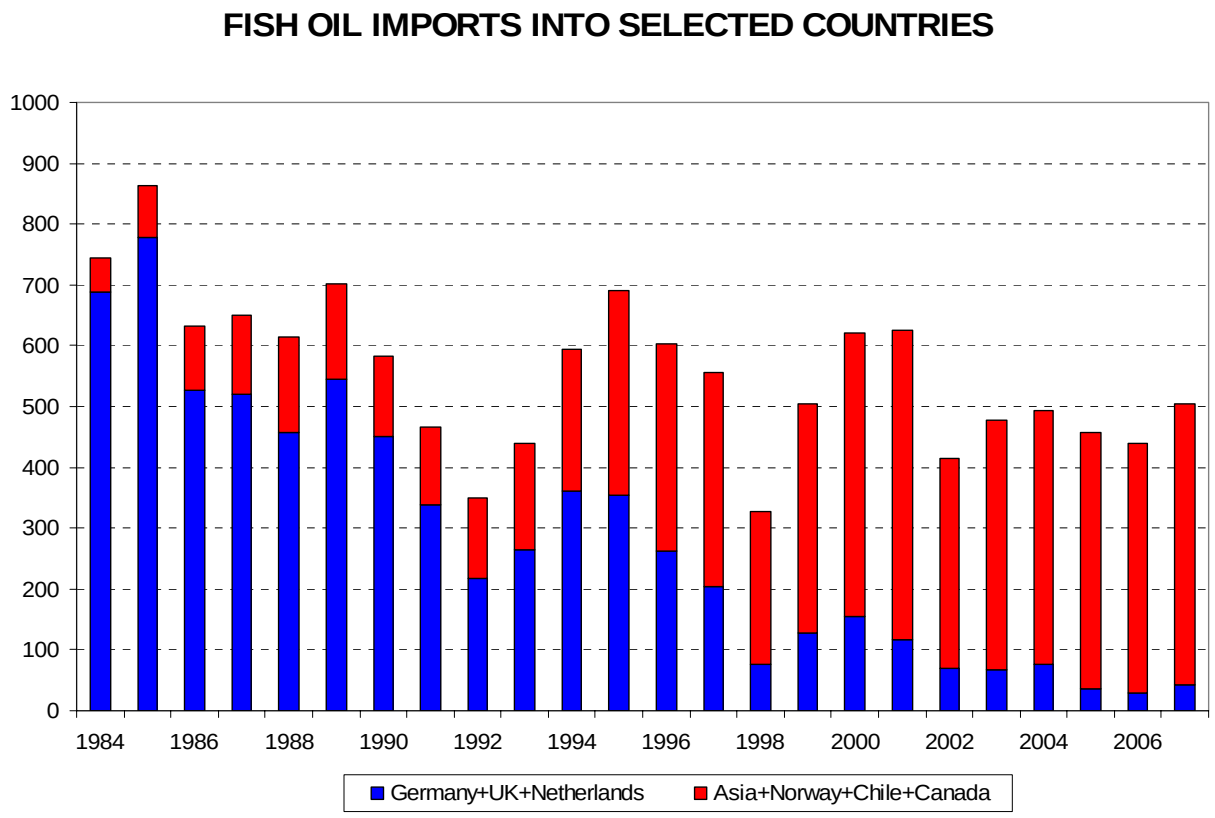


Figure 25 Fish oil imports into selected countries.

The preceding tables covering the global livestock feed production would also apply to fish oil. However, because the major market for fish oil is aquaculture, we will cover that market in more depth.

Global Aquaculture Production

World aquaculture production has been increasing at an average rate of 15.75% since 1988. This is shown in the following figure.

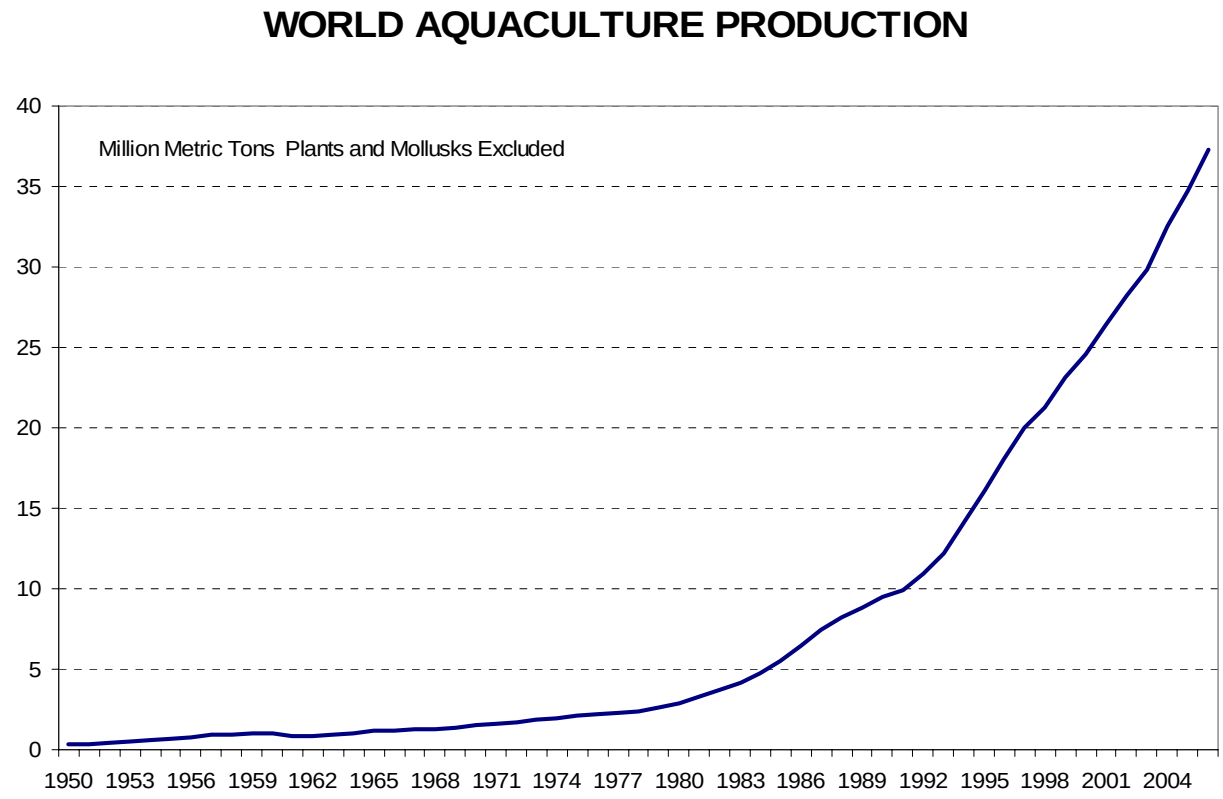


Figure 26 Global aquaculture production.

Many countries are involved in aquaculture but China by far is the major producer.. The following figure shows the top aquaculture producing countries. These countries could be identified as possible markets for both fishmeal and fish oil.

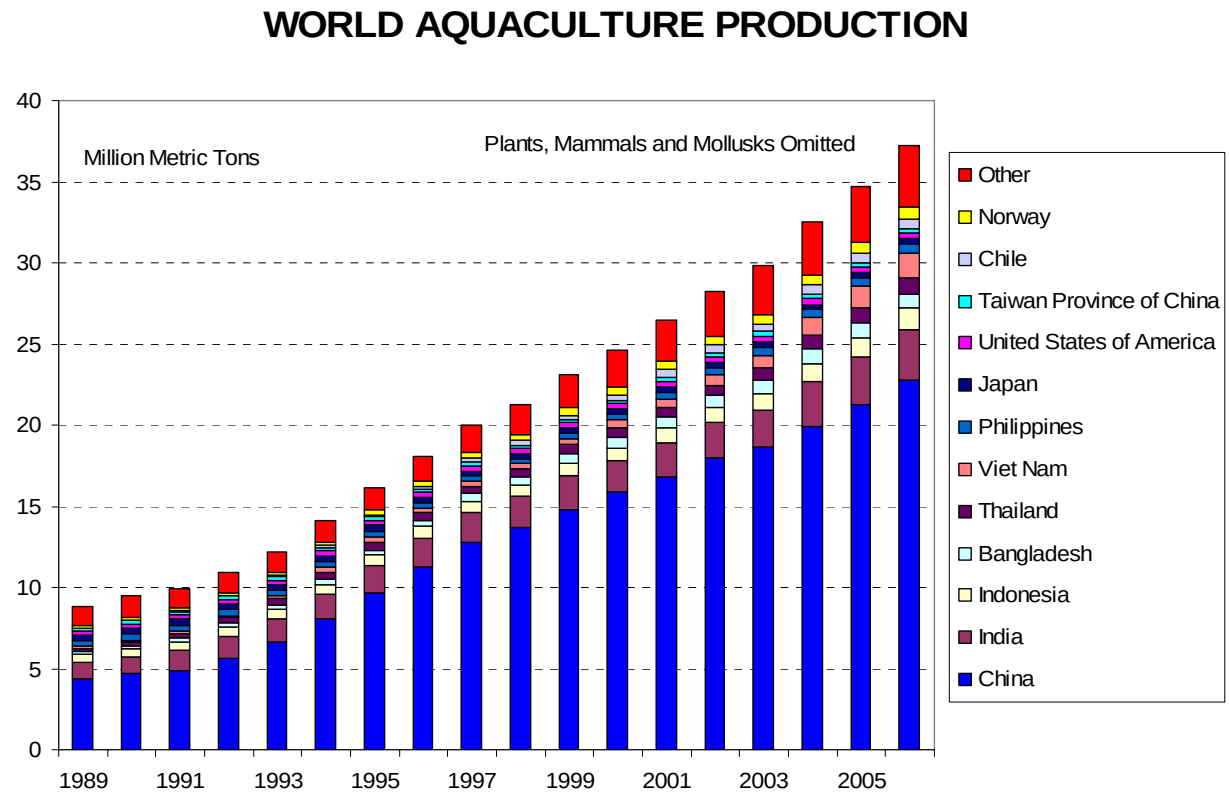


Figure 27 Major countries involved in aquaculture production.

China is the major producer of farmed fish and shellfish in the world. While aquaculture in China has always been associated with carp, there is a growing carnivorous farmed fish industry in China. The following table breaks out the farmed fish and crustacean species in China. Sixteen (16) species and groups account for 90% of China's farmed fish and shellfish production. If farmed aquatic plants were added to the table, there would be an additional 10 million metric tons of production.

CHINESE AQUACULTURE PRODUCTION, 1000 METRIC TONS							
	2000	2001	2002	2003	2004	2005	2006
Bighead carp	1614	1638	1701	1906	2080	2182	2373
Chinese river crab	232	286	340	368	416	438	475
Common carp	2120	2193	2236	2267	2367	2475	2590
Razor clam	553	597	635	672	676	714	679
Crucian carp	1375	1523	1697	1789	1946	2083	2095
Freshwater fishes	1378	1485	2026	571	533	639	751
Grass carp	3163	3311	3420	3493	3698	3857	3963
Japanese carpet shell	1616	2014	2301	2546	2799	2857	3019
Marine fishes	427	495	560	188	203	240	279
Marine mollusks	1493	1249	1253	860	846	901	1046
Nile tilapia	629	672	707	806	897	978	1111
Pacific cupped oyster	3292	3491	3626	3668	3751	3826	3892
Sea mussels	535	568	664	683	717	772	746
Silver carp	3228	3276	3402	3382	3467	3525	3715
Whiteleg shrimp	0	100	200	605	735	808	1022
Yesso scallop	920	960	936	898	910	1036	1149
Others	1920	2083	1953	3956	4331	4812	5240
Totals	24493	25942	27655	28660	30373	32144	34146
Source: FAO Fishstat Plus version 2.3 2000							

Table 154 Farmed fish and shellfish production in China.

The following five figures cover the global production of shrimp and salmon and compare growth in wild caught to farm raised species.

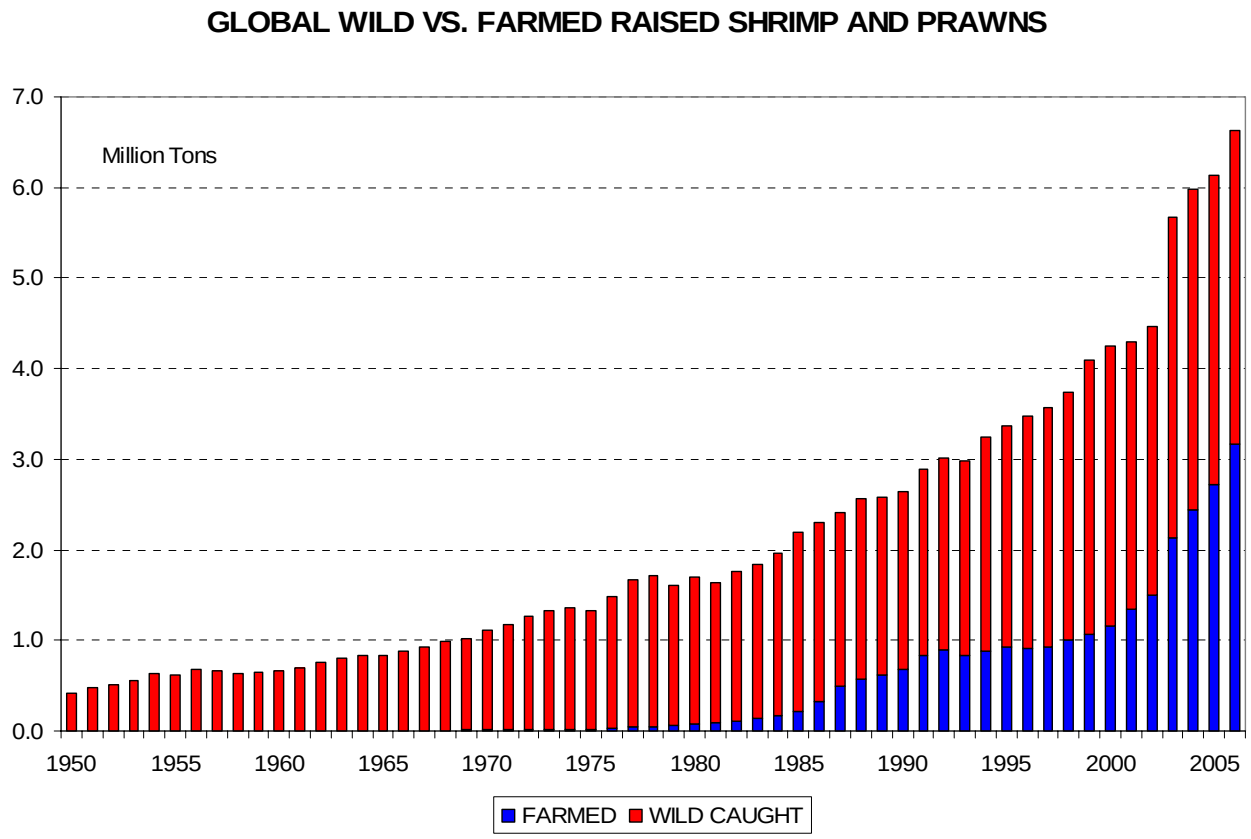


Figure 28 Global wild vs. farm raised shrimp production.

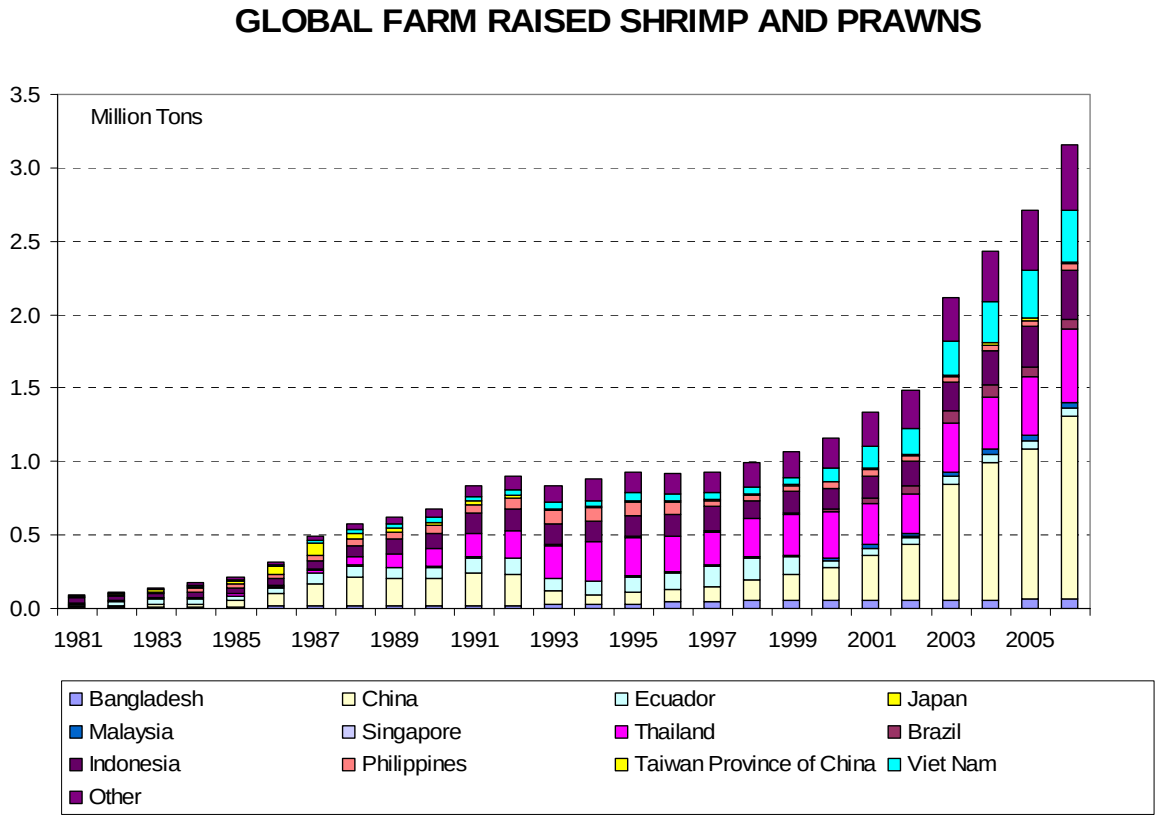


Figure 29 Global farmed raised shrimp production.

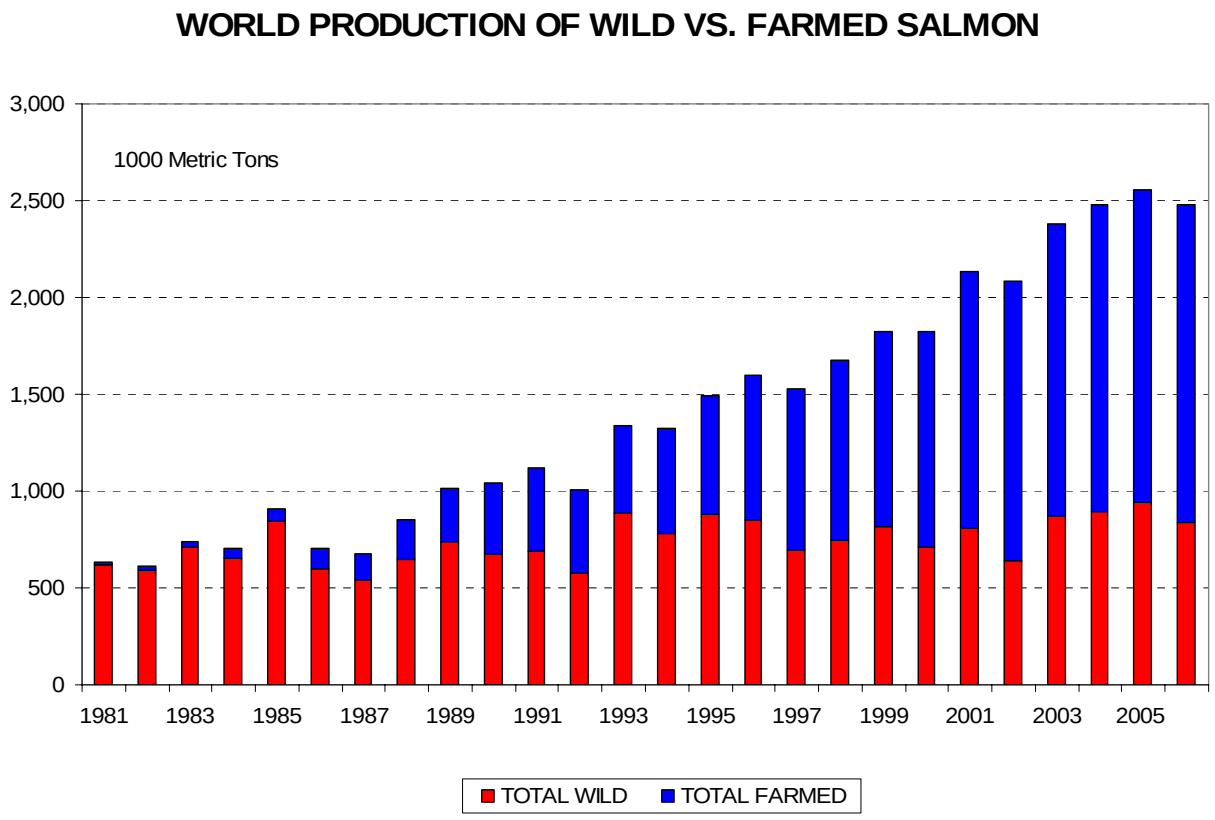


Figure 30 Global wild vs. farmed salmon production.

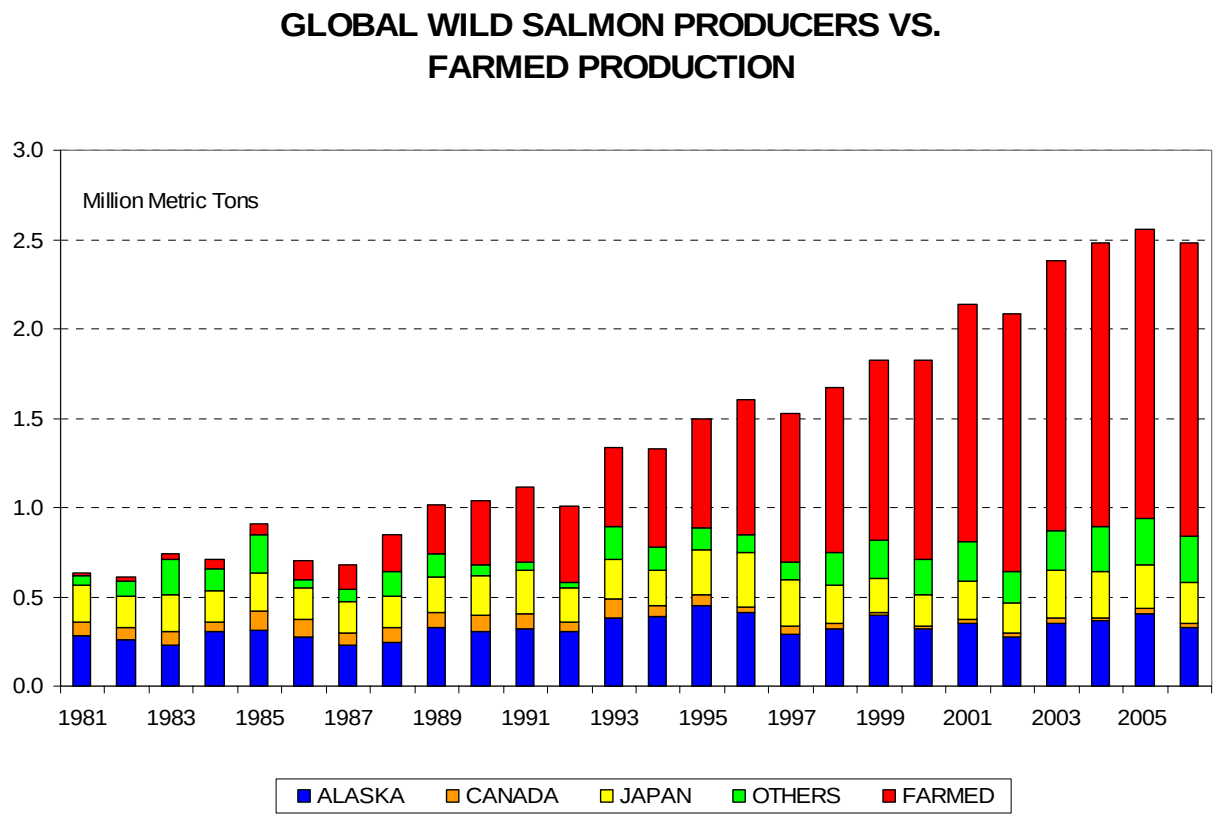


Figure 31 Global wild salmon producers vs. farmed production.

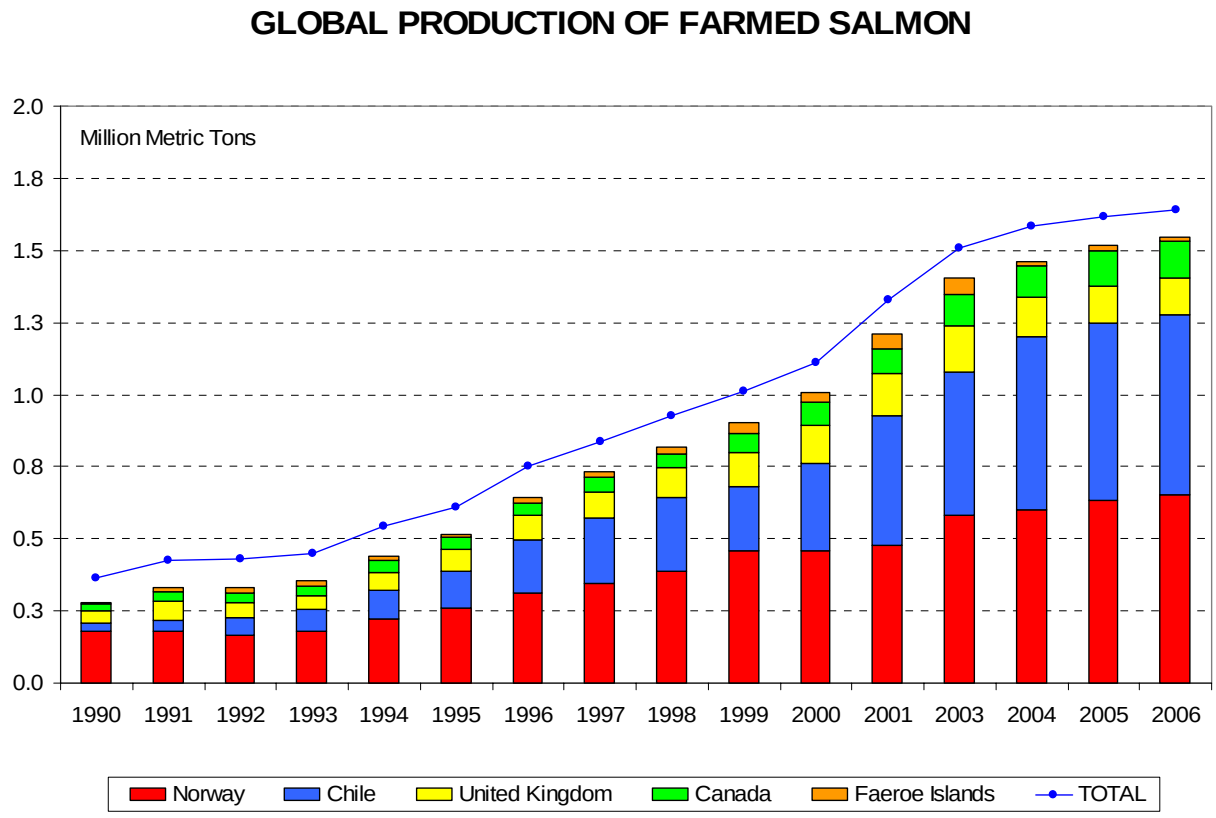


Figure 32 Global farmed salmon production

PREDICTED GLOBAL GROWTH OF FARMED FISH PRODUCTION						
	Growth	1000 METRIC TONS				
SPECIES	2002-2012 %/yr	2002	2003	2005	2010	2012
Shrimp	15.6	1405	1805	2184	3209	3605
Freshwater Crustaceans	11.34	652	688	802	1091	1392
Marine Fish *	10.35	1080	1101	1332	1957	2198
Salmon	6.1	1213	1259	1388	1771	1953
Trout	4.75	562	554	588	750	829
Eel	1.72	232	232	237	262	272
Milkfish	5.91	528	552	597	762	840
Carp	5.98	9881	10179	11222	14323	15791
Tilapia	12.55	1486	1678	2030	2938	3352
Catfish	7.38	527	569	651	831	916
Totals	8.07	17566	18617	21031	27939	31747
Source: FAO Fisheries Circular 1018						

*Bass, Bream, Yellowtail, Grouper, Jacks and Mullets, Flounder, Turbot, Halibut, Sole, Cod and Hake

Table 155 Predicted global growth of farmed fish production

USA Imports and Exports of Fish Oil

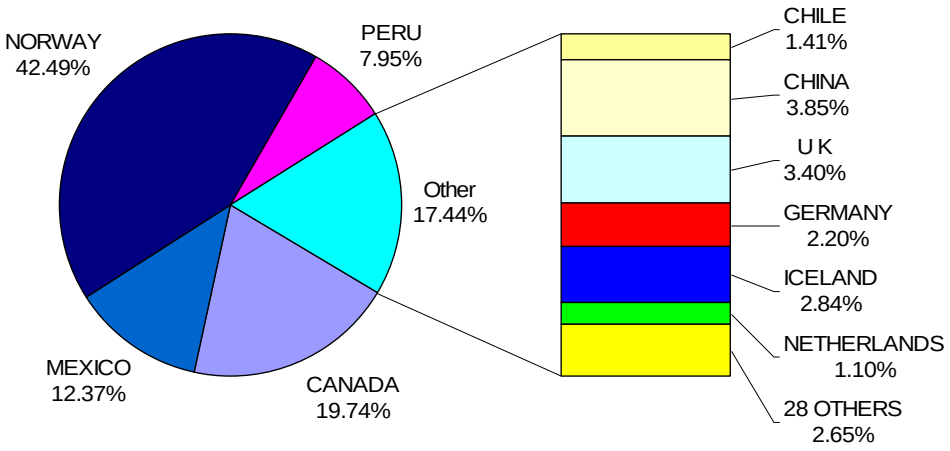


Figure 33 USA fish oil imports by country, 2002 - 2007 average.

USA FISH OIL EXPORTS 2002 - 2007 AVERAGE

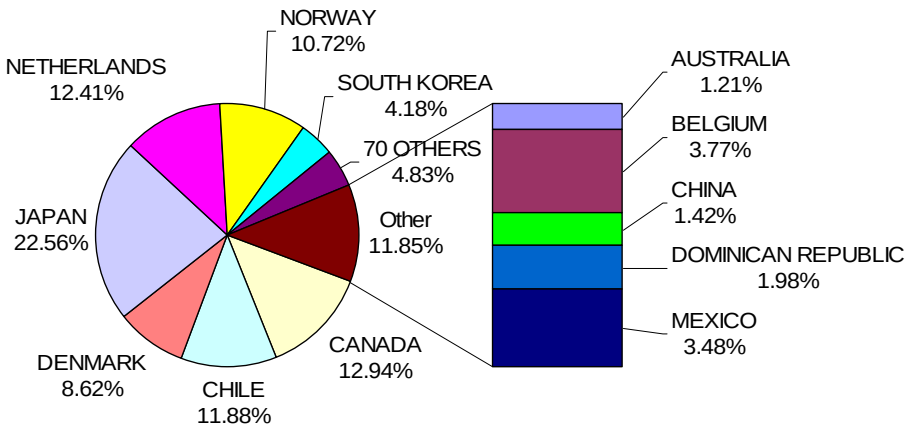


Figure 34 USA fish oil exports by country, 2002 - 2007 average.

Global Use of Fish Oil in Aquaculture Feeds

Since aquaculture represents about 80% of the global fish oil market, it would be important to know the projected market for fish oil based on the various aquaculture species. This is shown in the following figure.

PREDICTED USE OF FISH OIL IN FISH FEEDS										
SPECIES	**% FISH OIL INCLUSION IN FEED PRODUCED**					**1000 TONS OF FISH OIL**				
	2002	**2003**	**2005**	**2010**	**2012**	**2002**	**2003**	**2005**	**2010**	**2012**
Shrimp	2	2	2	2	2	45.4	58.3	68.4	98.2	111.5
Freshwater Crustaceans	2	2	1.5	1	1	13.5	13.9	11.9	10.9	5.9
Marine Fish*	8	7.5	6	6	5	112.3	110.6	100.7	149.7	143.8
Salmon	26	25	10	8	7	410	409	166	170	164
Trout	20	17.5	10	6	5	95	126	70.5	54	49.7

PREDICTED USE OF FISH OIL IN FISH FEEDS										
SPECIES	% FISH OIL INCLUSION IN FEED PRODUCED					1000 TONS OF FISH OIL				
	2002	2003	2005	2010	2012	2002	2003	2005	2010	2012
Eel	4	3	3	2	2	15.2	11.4	10.9	7.5	8
Milkfish	1	1	1	1	1	4.7	5.2	5.4	6.7	7.7
Feeding Carp	0.5	0.5	1	1	1	41.5	43.8	90.9	114.6	131.4
Tilapia	1	1	1	1	1	13.4	15.8	18.3	26.2	30.6
Catfish	1	1	1	1	1	7.3	8	8.8	10.9	12.2
Carnivorous Fresh Water Fish	6				7	19				43
Totals						777.3	802	551.8	648.7	707.8
Source: FAO Fisheries Circular 1018										

*Bass, Bream, Yellowtail, Grouper, Jacks and Mullets, Flounder, Turbot, Halibut, Sole, Cod and Hake

Table 156 Global use of fish oil in aquaculture feeds.

Nutraceutical Market For Fish Oils

Fish oils have been around for a very long time. Reports indicate that there are formal 800 year old Nordic regulations regarding fishing and in fact, the cod fishery in Scandinavia has been well established for more than a millennium and there is even mention of fish sources in the Bible and early Greek and Roman writings. The first known clinical investigation using cod liver oil was done by Dr. Samuel Kay at the Manchester Infirmary between 1752 and 1783. He found that cod liver oil gave relief to people suffering from rheumatism. Other work indicated it was effective in curing night blindness. These were published in a British scientific journal in 1783.

It was not until the early 1900's that cod liver oil was shown to be effective in the treatment of rickets. The active ingredients in the oil were found to be the vitamins and the use of this oil then moved from a curative agent to a preventative agent. Up through World War II cod liver oil was a primary source of Vitamins A and D and then when scientists managed to produce these vitamins synthetically, the demand dropped. People preferred vitamin tablets with no taste to that of liquid cod liver oil with its distinctive fishy flavor.

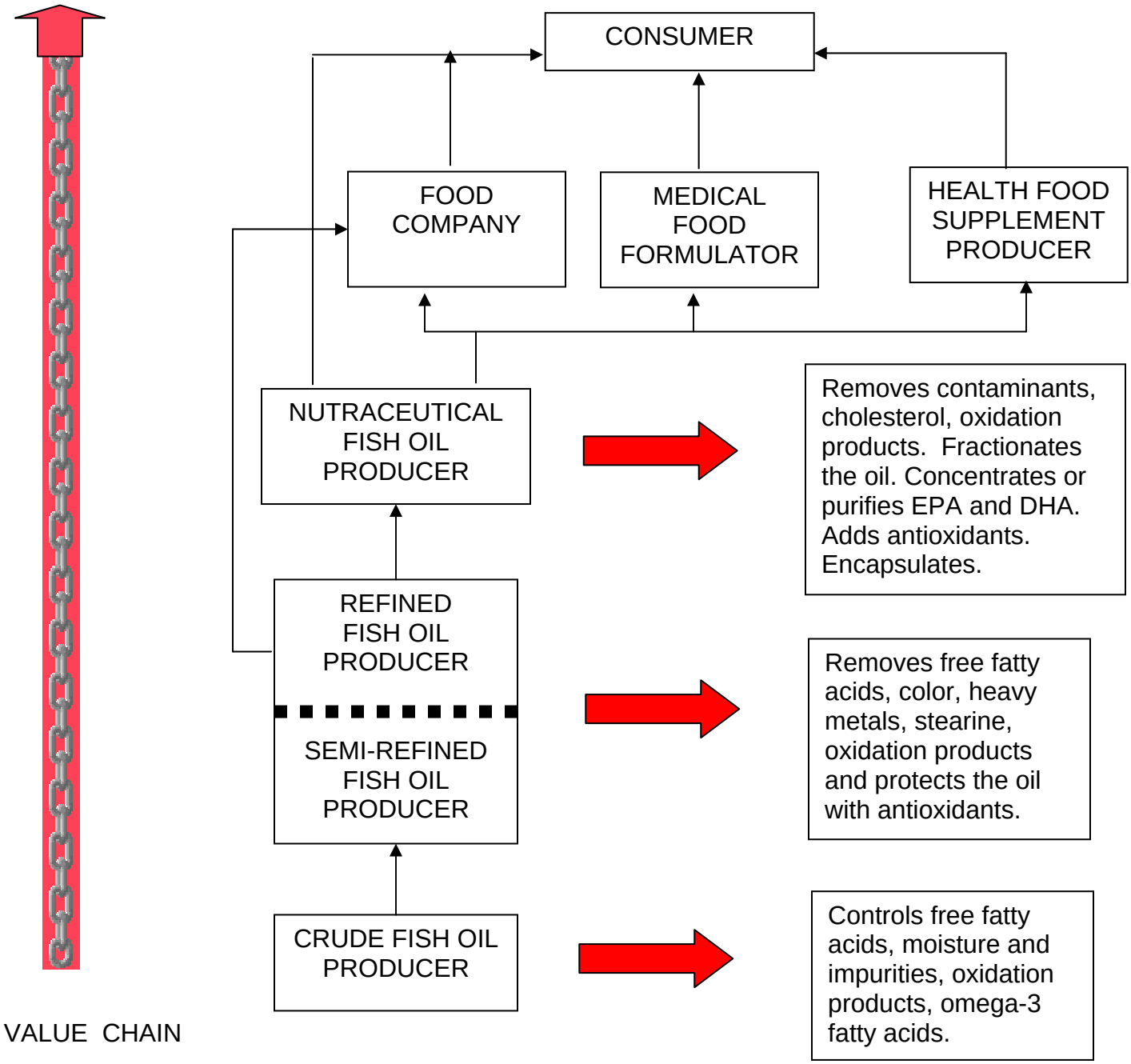
A 19-year human clinical trial was conducted by Dr. Avery Nelson in Seattle. Dr. Nelson had heard about the effects of fish and cod liver oil consumption in Norway during the second World War on the incidence of heart disease and decided to run similar tests in the US. His studies began in 1953 with patients referred to him by other physicians. His patients were advised to eat

fatty fish at least three times per week as a main course meal. His results showed 4.5 times more deaths from patients who did not adopt the diet of fish compared to those who did.

In 1979 Danish researchers published their data on the role of omega 3 fatty acids in the prevention of cardiovascular diseases. From that point forward the interest in fish oils as a source of these fatty acids has been increasing. Fish oil triglycerides have been offered in liquid form, capsules, tablets, and powders as natural products, reflecting the composition of the fish species processed.

Today, there are well over 16000 publications dealing with fish oils and the omega 3 fatty acids and their effects on human health. In fact, fish oil publications related to health far exceed similar publications and studies about Lipitor, the leading prescription grade statin on the market today. The idea that fish oil could be used as a pharmaceutical product brings up all kinds of wishes for high valued end products for the nutraceutical market as it is now called. Various barriers have been raised to the universal use of fish oils in food and pharmaceutical products but these have been falling. GRAS affirmation of menhaden oil in 1997 after 20 years of evaluations and negotiations, labeling requirements, kosher status, stability, flavor etc have all been solved. Yet the market, while very high value (prices ranging from US$2 – US$15+/kg) is still relatively small in volume (5% of world production of fish oil).

The nutraceutical market is actually layered into 4 segments. This is shown in the following figure.



OMEGA 3 MARKET STRUCTURE

Figure 35 Fish oil nutraceutical market structure.

As the value of the products increases so does the level of processing and the production of waste or by-products. Crude fish oil producers constantly express a desire to enter the Omega 3 market, sometimes with little or no thought to what that entails. As a first step, a company must

decide where in the previous figure does it wish to be. Generally the producer is already at the base and wants to enter the market at the point where the oil is sold to the consumer. Unfortunately to get from where they are to where they want to be requires a great deal of capital investment and there is no guarantee that their raw material is even suitable for the market. The following flow diagrams illustrate what is required to move from a crude oil producer to a value added level on the previous flow diagram of the market structure.

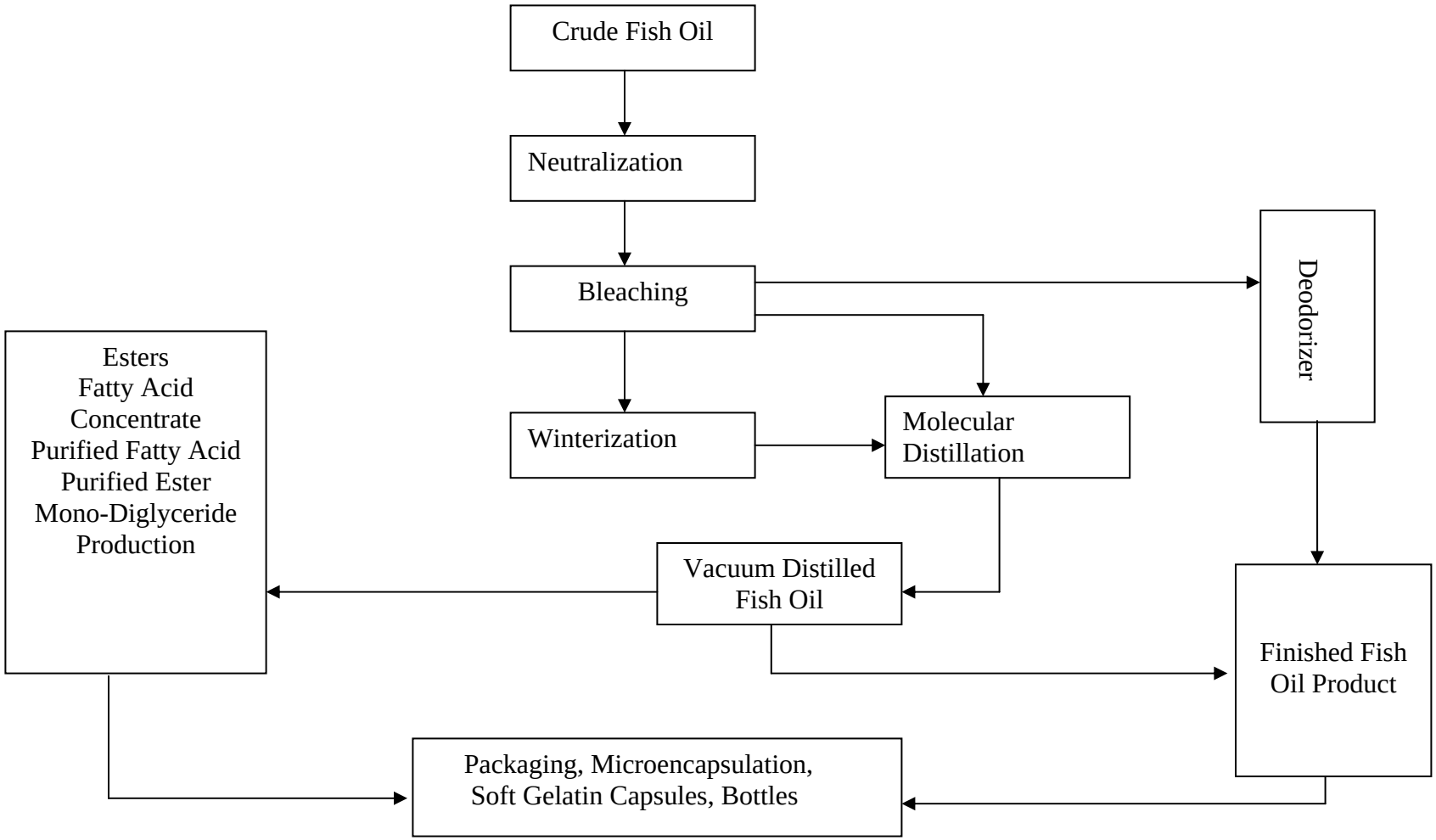


Figure 36 Production of food grade fish oil.

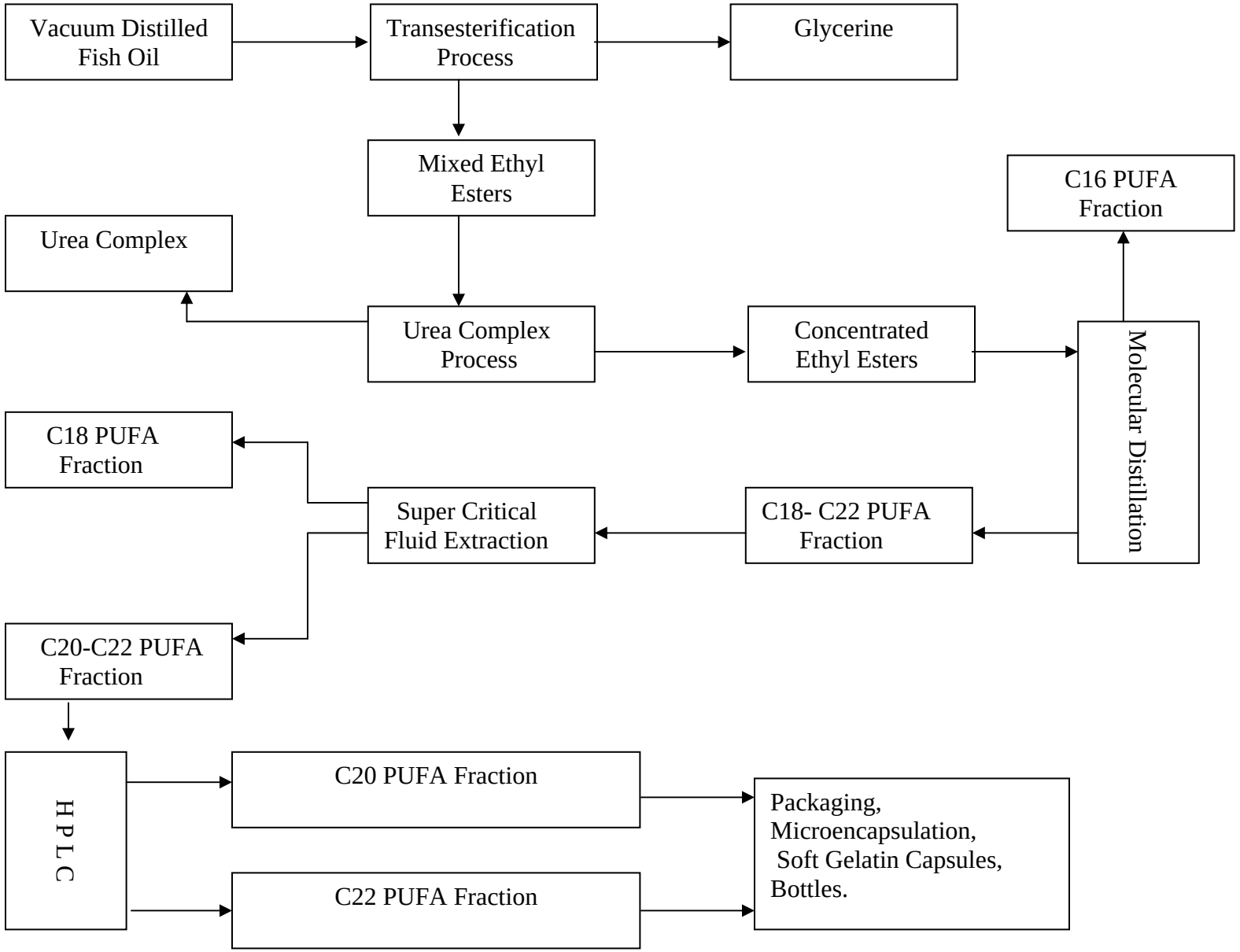

Vacuum Distilled Fish Oil
Transesterification Process
Glycerine
Mixed Ethyl Esters
C16 PUFA Fraction
Urea Complex
Urea Complex Process
Concentrated Ethyl Esters
Molecular Distillation
C18 PUFA Fraction
Super Critical Fluid Extraction
C18- C22 PUFA Fraction
C20-C22 PUFA Fraction
HPLC
C20 PUFA Fraction
Packaging, Microencapsulation, Soft Gelatin Capsules, Bottles.
C22 PUFA Fraction

Figure 37 Production of nutraceutical grade fish oil fractions.

Biofuels And Biodiesel Oleochemistry At Work

Oleochemistry is a very old branch of chemistry with some applications reaching very far back into history. The production of soap from fat is the most noted example. We can therefore regard oleochemistry as a mature branch of chemistry, with many applications for its products, but with few completely new fields.

Basic oleochemicals are produced by splitting oils and fats and reacting the split materials to produce glycerine, fatty acids, esters, amines, amides, alcohols and other compounds. Any reaction that can take place at the carboxyl end or the double bond offers the opportunity for a potential product or group of products but in actuality about 95% of the reactions take place at the carboxyl end and 5% at the double bond. These products are classified as natural oleochemicals to distinguish them from synthetic oleochemicals which are derived from petrochemicals such as ethylene, paraffins, and propylene. The following figure shows some of the pathways for oleochemicals. It should also be noted that the pathways are similar to the nutraceutical and food product pathways illustrated above, the only difference is the final product and how it will be used.

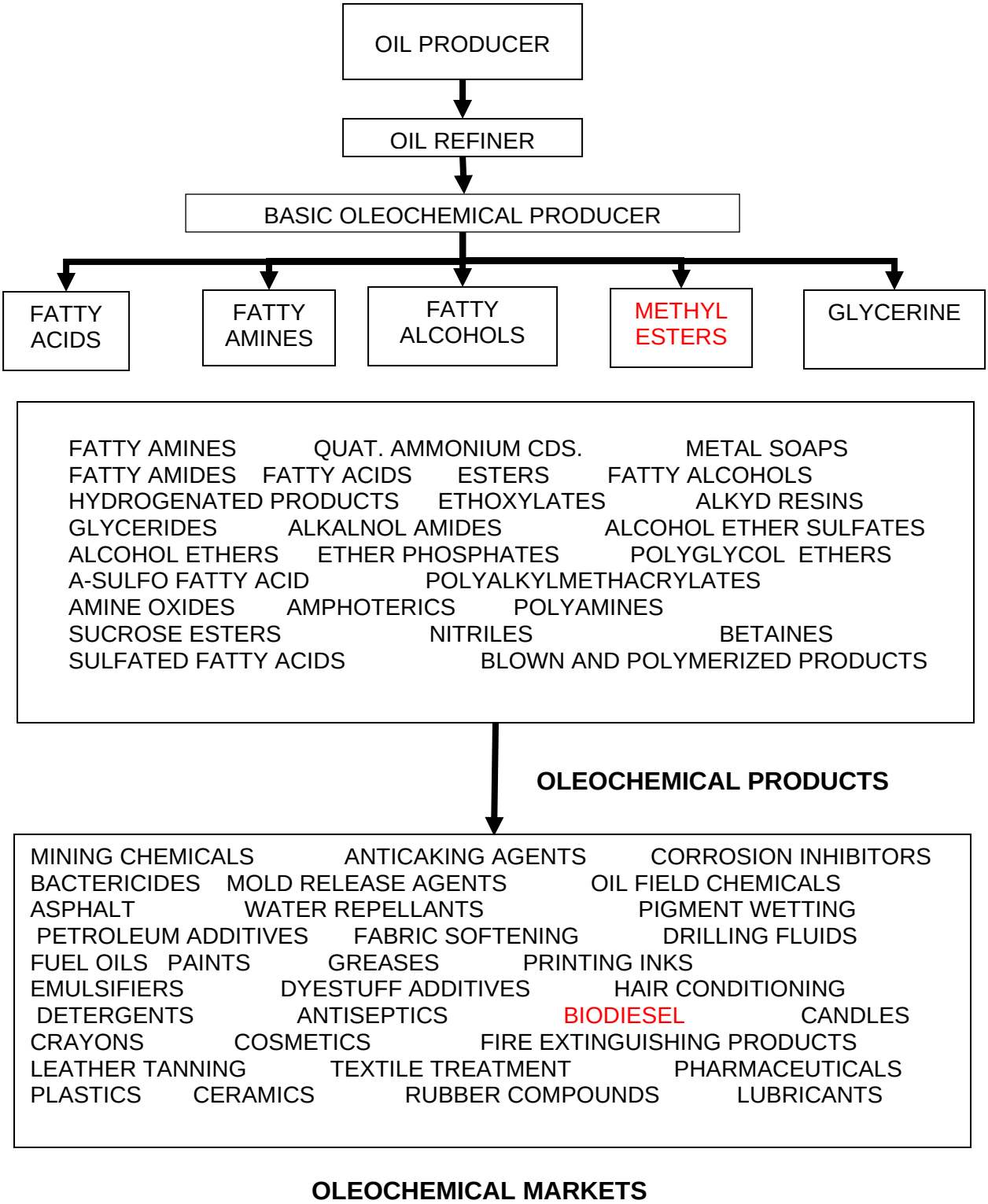


Figure 38 Oleochemical products and markets.

Traditionally tallow, coconut, palm and palm kernel oils are the major oleochemical raw materials and only about 20% of the total world production of fats and oils goes into the non-edible market. Other oils such as tung, castor and linseed have special uses in the industrial market but their relative volume is small. Oleochemicals are used across all markets including technical, food, personal care and agricultural uses therefore when one begins to look at quantities there is the potential for overlap.

The industrial applications for fish oils have never received much attention because of the general edible use of the oil throughout the world and the overwhelming and relatively recent interest in the Omega 3 fatty acids and their possible incorporation into foods. But marine oils have a long and respectable history in technical products. Some of these are shown in the following table which shows fuel oils, illuminating oils and biodiesel oils as some of the uses. Some of the other uses in "red" offer potentials for Alaska industry uses (petroleum, mining)

INDUSTRIAL USES FOR FISH OIL
ATTRACTANTS AND LURES AUTOMOTIVE GASKETS CAULKING COMPOUNDS
CERAMIC DEFLOCCULANTS CORE OILS CUTTING OILS FATTY ACIDS
OLEOCHEMICALS FERMENTATION SUBSTRATES FIRE RETARDANTS
FUEL OILS GLAZING COMPOUNDS ILLUMINATING OILS
LETHER TANNING LINOLEUM LUBRICANTS AND GREASES
MUSHROOM CULTURE OIL FIELD CHEMICALS ORE FLOATATION
PLASTICIZERS OILED FABRICS PRESSWOOD FIBER BOARDS
PRINTING INKS PROTECTIVE COATINGS REFRACTORY COMPOUNDS
PAINTS RUBBER MANUFACTURE RUSTPROOFING
SURFACTANTS AND EMULSIFIERS TIN PLATING FUNGICIDE COMPOUNDS
BIO-DIESEL FUELS AGRICULTURAL PRODUCTS MOLD RELEASE AGENTS
HYDRAULIC FLUID INSECTICIDAL COMPOUNDS SOAPS AND DETERGENTS

Table 157 Industrial uses for fish oil.

Because of the ongoing demand for biodegradable and or environmentally friendly sources of raw materials, these uses will have a place in the marketing of fish oils well into the future and will command premium prices if special niches for the oil can be developed. The competitiveness of the oleochemicals and their opportunities usually lie with economics but

today, there is a universal awareness of protection of the environment, now called the "green" revolution and in these cases economics becomes less important as we've recently seen with diverting edible corn to the production of ethanol for fuel.

As the world demand for energy increases there has been much in the news recently about producing biodiesel fuels from renewable resources and the vegetable and oil seed crop oils generally fall into this group. Biodiesel is also produced from waste cooking oils, frying fat wastes and low valued cheap oils which have included high free fatty acid oils and some fish oils. It is important to distinguish between biofuels and biodiesel at this point. Biodiesel is defined as the ester, usually methyl, of a fat or oil and has a defined ASTM specification (ASTM D 6751-02). A biofuel is an oil or fat that is burned as is with no conversion to the methyl ester. In this case it is usually mixed with a fuel oil for dilution and then burned. Currently in Alaska, much of the pollock oil is burned as a biofuel in the plant boilers in a 50-50 mix and over the years when fish oil was considered a cheap oil it was even burned in the diesel engines of the fishing vessels around the world. These uses are defined as biofuels.

Some global biodiesel specifications including the ASTM specification are shown in the following table.

COMPARISON OF VARIOUS BIODIESEL STANDARDS							
	Austria	**Czech Republic**	**France**	**Germany**	**Italy**	**Sweden**	**USA**
Standard/ Specification	ON C1191	CSN 65 6507	Official Journal	DIN E 51606	UNI 10635	SS 155436	ASTM D-6751-02
Date	07/01/1997	09/1998	09/14/1997	09/1997	04/21/1997	09/27/1996	01/2002
Application[a]	FAME	RME	VOME	FAME	VOME	VOME	FAME
Density 15°C g/cm^3	0.85-0.89	0.87-0.89	0.87-0.90	0.875-0.90	0.86-0.90	0.87-0.90	-
Viscosity 40°C mm^2/sec	3.5-5.0	3.5-5.0	3.5-5.0	3.5-5.0	3.5-5.0	3.5-5.0	1.9 – 6.0
Distillation 95% °C	-	-	<360	-	<360	-	360 max
Flashpoint °C	>100	>110	>100	>110	>100	>100	130
CFPP °C	0/-15	-5	-	0/-10/-20	-	-5	
Pourpoint °C	-	-	<-10	-	<0/<-15	-	
Sulfur % mass	<0.02	<0.02	-	<0.01	<0.01	<0.001	0.05 max
CCR 100% % mass	<0.05	<0.05		<0.05			0.05 max
10% Dist. Residue % mass			<0.30		<0.50	-	

COMPARISON OF VARIOUS BIODIESEL STANDARDS							
	Austria	**Czech Republic**	**France**	**Germany**	**Italy**	**Sweden**	**USA**
Sulfated Ash % mass	<0.02	<0.02	-	<0.03	-	-	0.02 max
(Oxid) Ash % mass	-	-	-	-	<0.01	<0.01	
Water mg/kg	-	<500	<200	<300	<700	<300	500 max
Total Contaminants mg/kg	-	<24	-	<20	-	<20	
Copper Corrosion 3h/50 °C		1	-	1	-	-	No. 3 max
Cetane No.	>49	>48	>49	>49	-	>48	47 min
Neutral No. mg KOH/g	<0.80	<0.50	<0.50	<0.50	<0.50	<0.60	0.80 max
Methanol % mass	<0.20	-	<0.10	<0.30	<0.20	<0.20	
Ester Content % mass	-	-	>96.5	-	>98	>98	
Monoglycerides % mass	-	-	<0.8	<0.8	<0.8	<0.8	
Diglycerides % mass	-	-	<0.20	<0.40	<0.20	<0.10	
Triglycerides % mass	-	-	<0.20	<0.40	<0.10	<0.10	
Free Glycerol % mass	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02	0.02 max
Total Glycerol % mass	<0.24	<0.24	<0.25	<0.25	-	-	0.24 max
Iodine Value	<120	-	<115	<115	-	<125	
C18:3 and Higher Unsat Acids % mass	<15	-	-	-	-	-	
Phosphorous mg/kg	<20	<20	<10	<10	<10	<10	<10
Alkaline Metals (Na, K) mg/kg	-	<10	<5	<5	-	<10	
Cloud Point °C							Report
Source: Render Magazine February 2004							

Table 158 Some global biodiesel standard specification.

The current US ASTM biodiesel standard for 100% product (B100) is shown in the following table.

SPECIFICATION FOR BIODIESEL (B100)- ASTM D6751-07B March 2007 ver.		
Biodiesel is defined as the mono alky esters of long chain fatty acids derived from vegetable or animal fats, for use in compression-ignition (diesel) engines. This specification is for pure (100%) biodiesel prior to use or blending with diesel fuel.		
PROPERTY	**ASTM METHOD**	**LIMITS**
Calcium & Magnesium combined, ppm	EN 14538	5 max
Flash Point (closed cup) °C	**D 93**	**93 min**
Alcohol Control (One of the following must be met)		
1. Methanol Content % volume	EN 14110	0.2 Max
2. Flash Point, °C	D 93	130 Min
Water & Sediment, % volume	**D 2709**	**0.05 Max**
Kinematic Viscosity, 40°C, mm^2/sec	D 445	1.9 – 6.0
Sulfated Ash, % mass	D 874	0.02 Max
Sulfur		
S 15 Grade % mass (ppm)	**D 5453**	**0.0015 Max (15 ppm)**
S 500 Grade % mass (ppm)	**D 5453**	**0.05 Max (500 ppm)**
Copper Strip Corrosion	D 130	No. 3 Max
Cetane	D 613	47 Min
Cloud Point, °C	**D 2500**	**Report**
Carbon Residue 100% sample, % mass	D 4530[1]	0.05
Acid Number, mgKOH/g	**D 664**	**0.50 Max**
Free Glycerin, % mass	**D 6584**	**0.020 Max**
Total Glycerin, % mass	**D 6584**	**0.240 Max**
Phosphorous Content, % mass	D 4951	0.001 Max
Distillation, T90 AET °C	D 1160	360 Max
Sodium/Potassium combined ppm	EN 14538	5 Max
Oxidation Stability, hours	**EN 14112**	**3 Min**
Workmanship	**Free of undissolved water, sediment and suspended matter**	
BOLDFACE = BQ-9000 Critical Specification Testing Once Production Process Under Control		
[1]The Carbon Residue shall be run on the 100% sample.		
Source: http://www.biodiesel.org/pdf_files/fuelfactsheets/BDSpec.pdf		

Table 159 ASTM D6751-07B biodiesel standard March 2007 version.

In the context of talking about biodiesel, a useful comparison is the growth or decline in per capita consumption of energy. For this purpose I've taken the total energy consumption of the

USA in billion of BTU's (http://www.eia.doe.gov/emeu/aer/txt/stb0103.xls) and converted that to Diesel Oil Equivalent in gallons using the conversion of 139,000 BTU's for a gallon of Diesel Oil divided by the US population. The following figure covers the period of 1995 to 2007 and actually shows a slight decline in US per capita consumption of energy over that period. Total energy use includes all sources nuclear, petroleum, wind, renewable, coal etc.

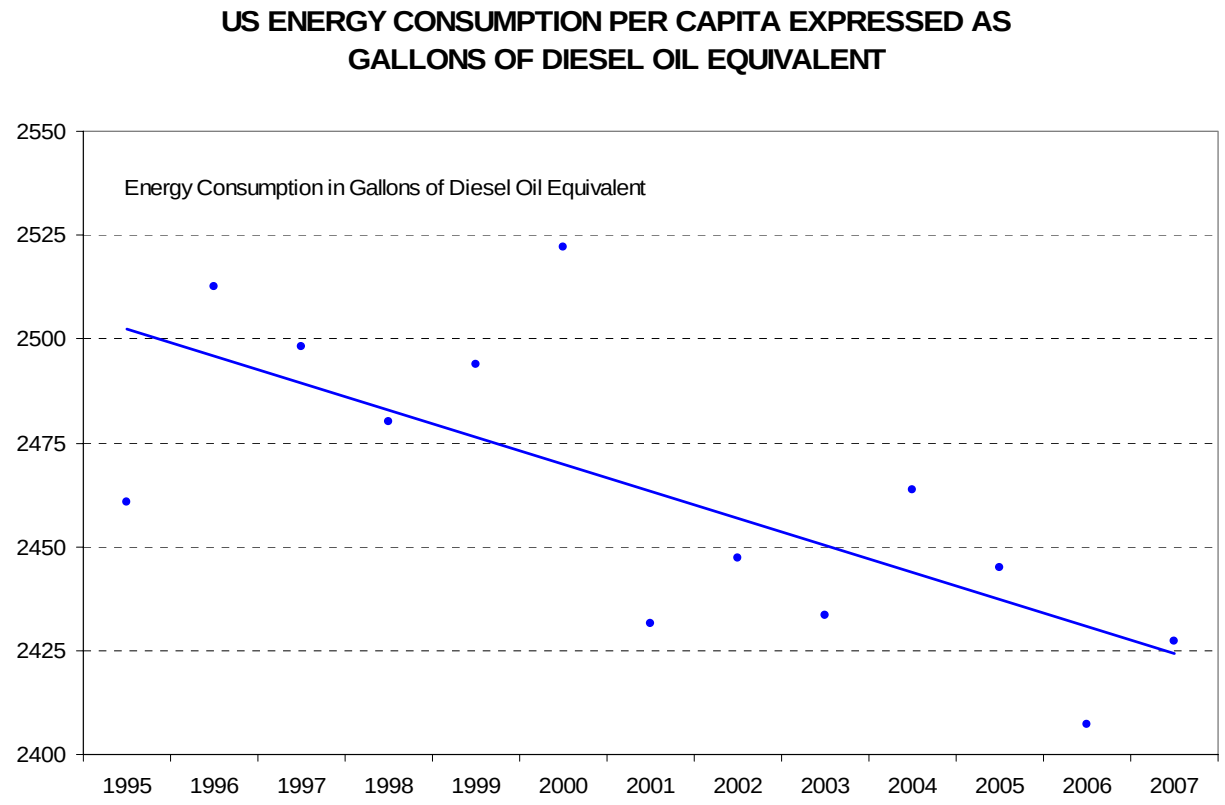


Figure 39 US energy consumption in gallons of diesel oil equivalent.

Nova Bioresource Fuels Inc. recently issued their 3rd quarter 2008 financial report. Nova's patented, proprietary process technology provides true multi- feedstock capabilities to consistently produce high quality biodiesel using lower cost feedstocks. The Nova process uses a heterogeneous catalytic conversion process that seamlessly and simultaneously reacts free fatty acids and the glyceride fraction of the feedstock to produce a crude methyl ester stream. This stream is then recovered through a proprietary distillation- based purification and refining process to produce high quality biodiesel that consistently exceeds ASTM D6751 specifications. Nova has produced over 9 million gallons of biodiesel at its refinery with every shipment exceeding ASTM D6751 specifications.

The report mentions that biodiesel production costs are highly dependent on feedstock prices, with feedstock representing approximately 75% to 85% of the finished product cost. Processing costs, including depreciation, capital costs and interest, net of co-product revenue are approximately $0.60 to $0.65 per gallon when operating at full capacity. Sales prices for pure

biodiesel (B100) produced from animal-derived fats typically range from approximately $0.60 to $1.10 over the wholesale prices for #2 petroleum diesel. The increased price of this B100 when compared to petroleum diesel is due, in part, to the federal biodiesel excise tax credit received by petroleum blenders, state tax incentives and biodiesel use mandates. In contrast, sales prices for B100 produced from soybean oil, canola oil or corn oil typically range from approximately $1.20 to $1.70 over the wholesale prices for #2 petroleum diesel. The higher spreads for these types of B100 are due, in part, to the perceived advantages of a lower cloud point of the finished product (http://www.earthtimes.org/articles/show/nova-biosource-fuels-announces-results-for-third-quarter-2008,539570.shtml).

The following figure compares the selling prices of feed grade menhaden oil, the average US retail price of No. 2 diesel oil and biodiesel prices for 5 different geographic regions of the USA over the period 2005 through mid-December 2008.

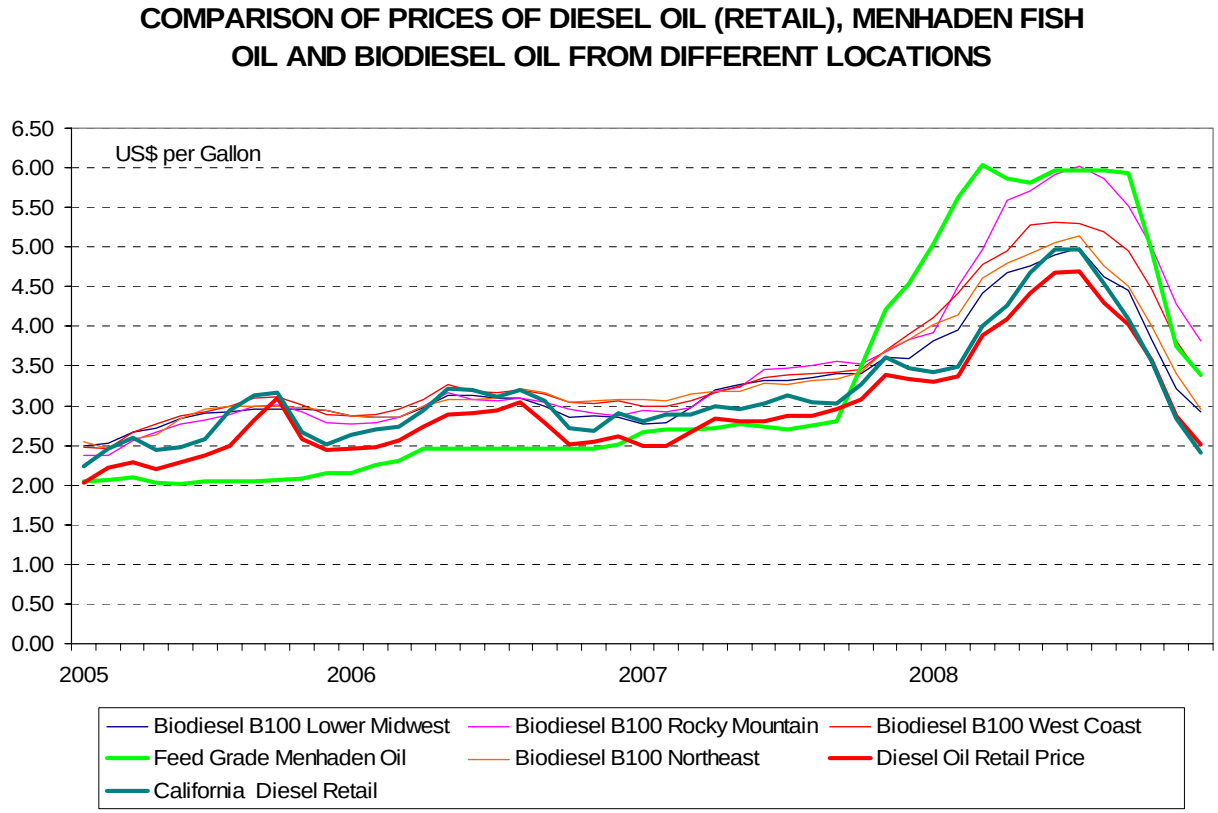
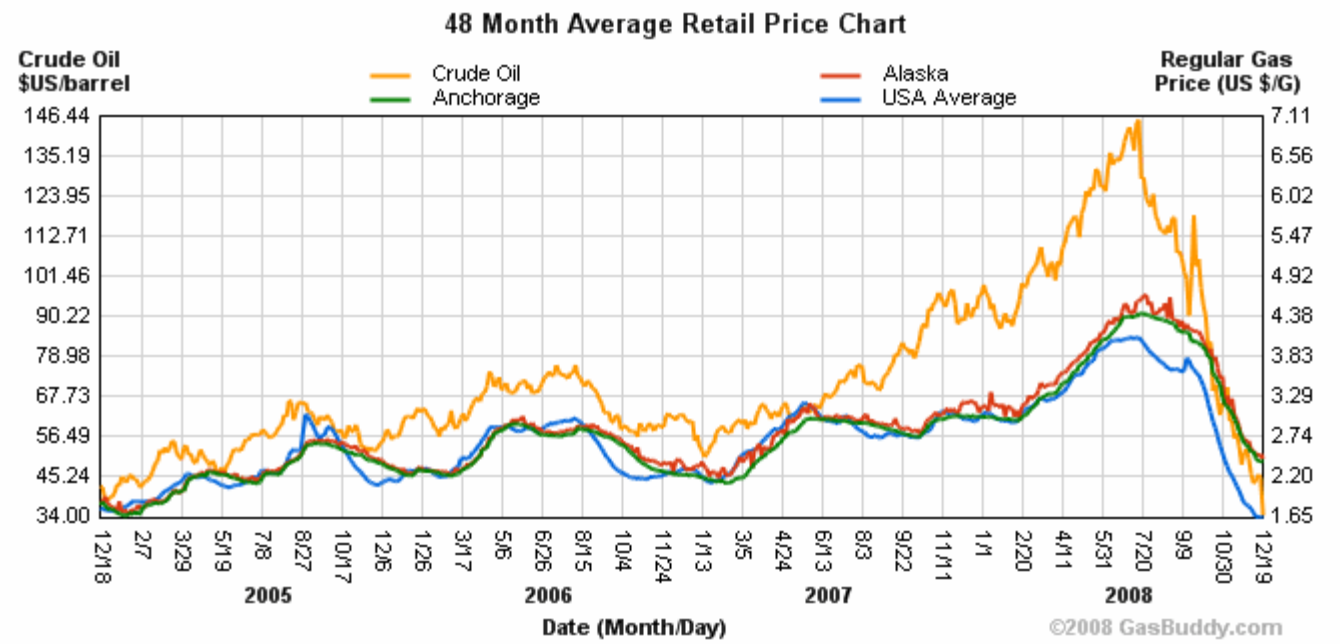


Figure 40 Comparison of fish oil, diesel oil and biodiesel prices.

I could not find data for Alaskan diesel oil over that period and substituted California diesel since it would generally be the highest in the 48 contiguous states. Below is a chart from Gas Buddy comparing the retail price of regular gasoline in Anchorage, the State of Alaska average and USA average compared to the price of a barrel of crude oil over roughly that same time period. According to the US Energy Information Administration Monthly Energy Review the average

retail price of No. 2 diesel fuel was about 1.0 – 1.07 times the average price of unleaded regular gasoline 1990-2007 (Source: http://tonto.eia.doe.gov/dnav/pet/xls/pet_pri_gnd_dcus_nus_a.xls)



Source: http://www.anchoragegasprices.com/retail_price_chart.aspx

Figure 41 Retail price of regular gasoline in Anchorage Alaska.

Other Products

There is very little information on the market structure for these other products. For the most part, the feed products will compete with the feed grade fishmeal and oil products while the fertilizer products will compete with fertilizers on an N-P-K basis. Some of the hydrolyzates and fermentation products have targeted the early weaned pig, milk replacer, pet food and aquaculture markets. The blended protein products have targeted aquaculture, poultry and the ruminant market. Bone meal and the fish fertilizers will compete with other fertilizers but may have an advantage if they can be certified as organic and from sustainable sources.

7. PRICING

Introduction

Fishmeal and fish oil are ultimately commodities which compete with other protein and oil products on the world market. These prices fluctuate according to supply and demand in the overall proteins and oil markets. The actual price that a supplier gets depends on the ability of the seller to convince the buyer that his product is as good as or better than a competitor's product. The information that will convince the buyer includes the type of data that has already

been presented here under quality, plus the availability of product in the market place. Buyers tend to lean towards suppliers that have products of consistent quality and that are available during the entire year. Many large companies have moved towards "just in time" inventories, that is, they take product from a seller as their inventory is depleted. This puts the pressure on the supplier to inventory his product so that he can supply it on demand. Companies that cannot meet this requirement are usually forced to sell at lower prices to intermediate groups who will then inventory and re-sell the product. Consistent quality and a reliable inventory then become critical parts of the pricing situation. The following figure shows the historical fishmeal and oil prices delivered to Europe as reported in Oil World. These are prices for commodity product shipped in bulk and form the price baseline from which to work.

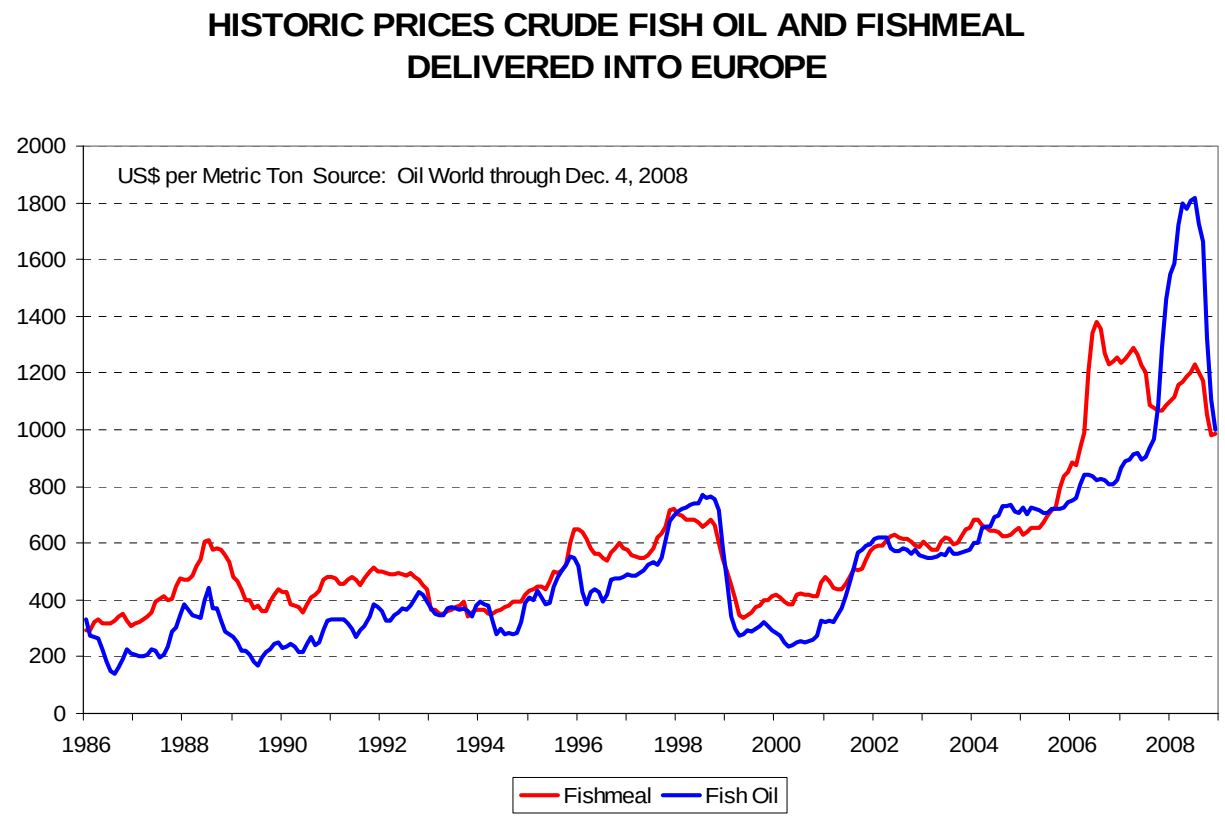


Figure 42 Oil World historical fishmeal and oil prices delivered to Europe

Fishmeal

Fishmeal is a major source of protein so it would be expected that some pricing would be based on a unit of protein. In this case, all other things being considered, a herring type fishmeal with 70% protein is going to sell for more than a fishmeal with 60% protein, and a fishmeal with 65% protein will sell for something in-between the two. However, sophisticated buyers also look at other components of the fishmeal and these have gradually been expanded to further define the quality of the protein in addition to its quantity. Most companies have more than one grade of fishmeal. These range from the commodity grade FAQ to the very high quality Super Prime or LT 94 grades. One would therefore also expect that within a specific species of fishmeal, there would also be a price range covering FAQ to Super Prime with the Super Prime achieving some premium price over the FAQ grade.

One way of tracking the price of fishmeal is to define the price in terms of a ratio to soybean meal. When we look at this historical comparison, using both fishmeal and soybean meal based on the price in Hamburg (Oil World data) now Bremen, we come up with the chart shown in the following figure.

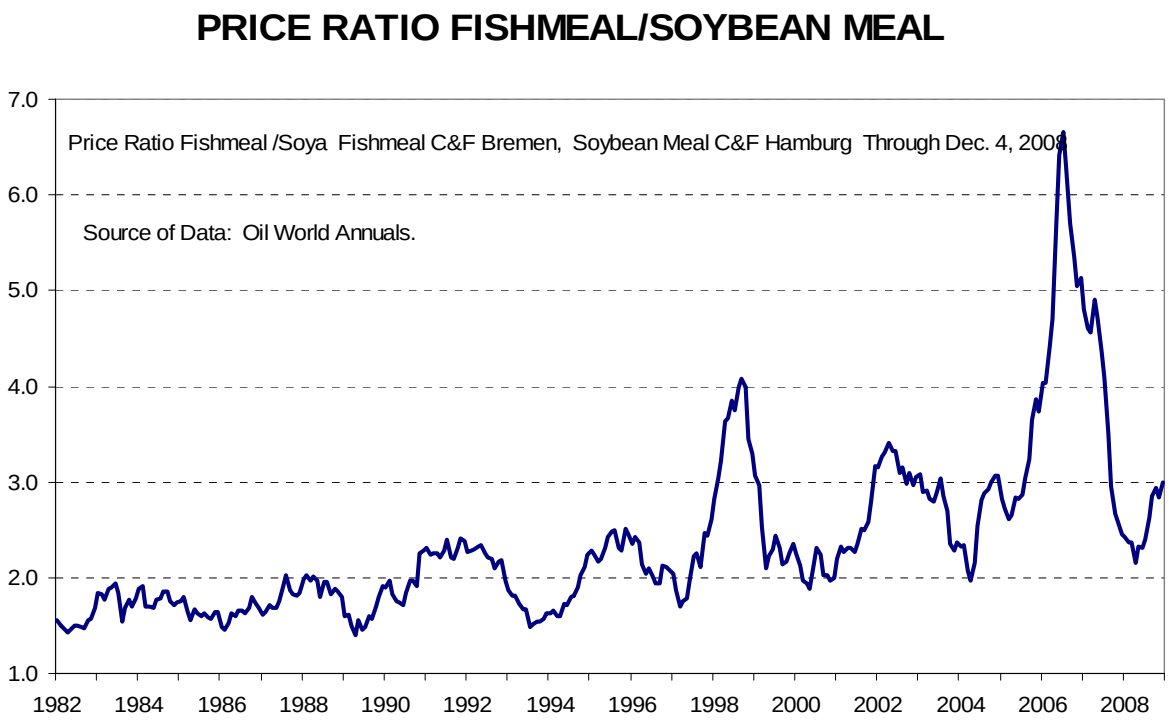


Figure 43 Fishmeal soybean meal price ratio basis Hamburg.

We should keep in mind that in 1998-1999 there was a major El Nino event in South America which disrupted the supply and demand balance. But we should also notice that the general trend is for an increase in the ratio. We should also keep in mind that while the spiral up in the ratio was due to the increase in the fishmeal price, the spiral down in the ratio is due to the increase in the soybean meal price, not a decrease in the fishmeal price.

If we look at the US Menhaden fishmeal chart vs. soybean meal basis Decatur, Illinois for a shorter period of time we get the chart shown in the following figure. This data was obtained from the US Publication, Feed Bulletin. Decatur, Illinois is used as the origin point for pricing US soybean meal.

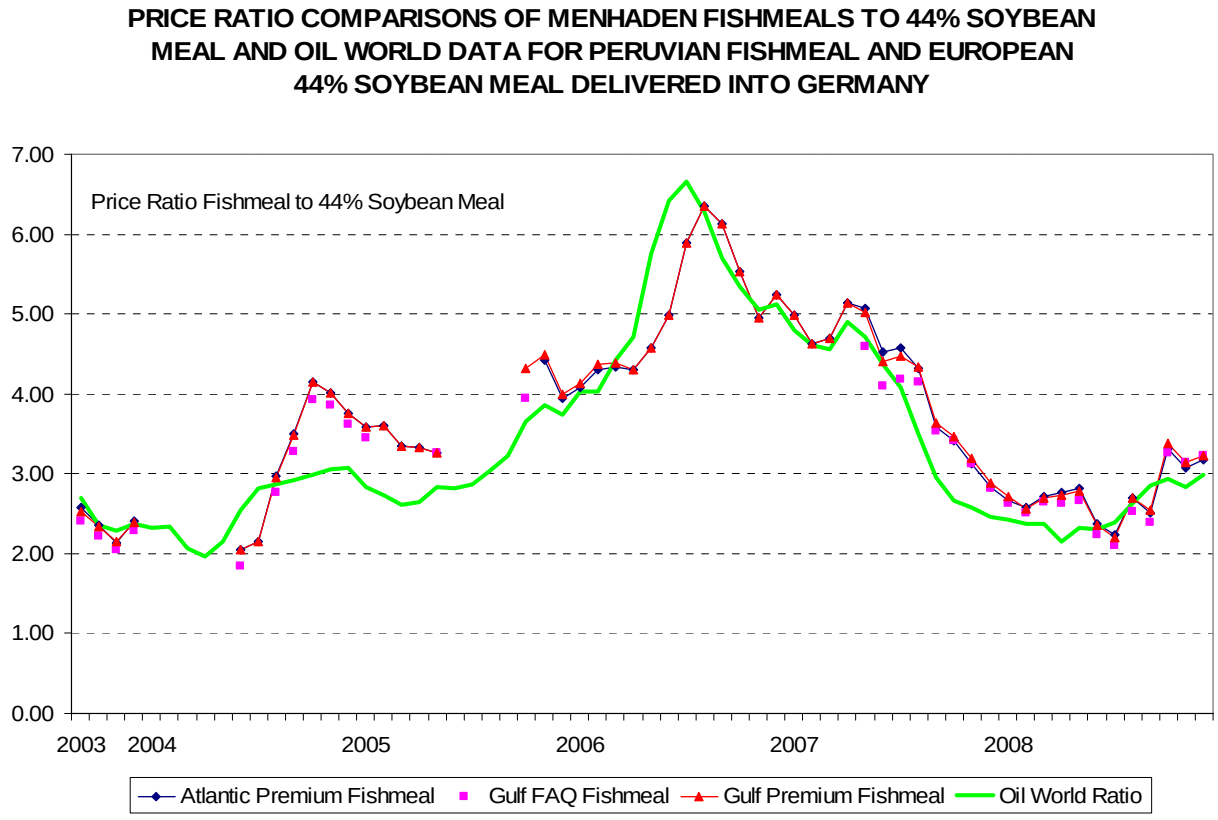


Figure 44 Price ratio menhaden fishmeal to 44% soybean meal vs. Oil World price ratio.

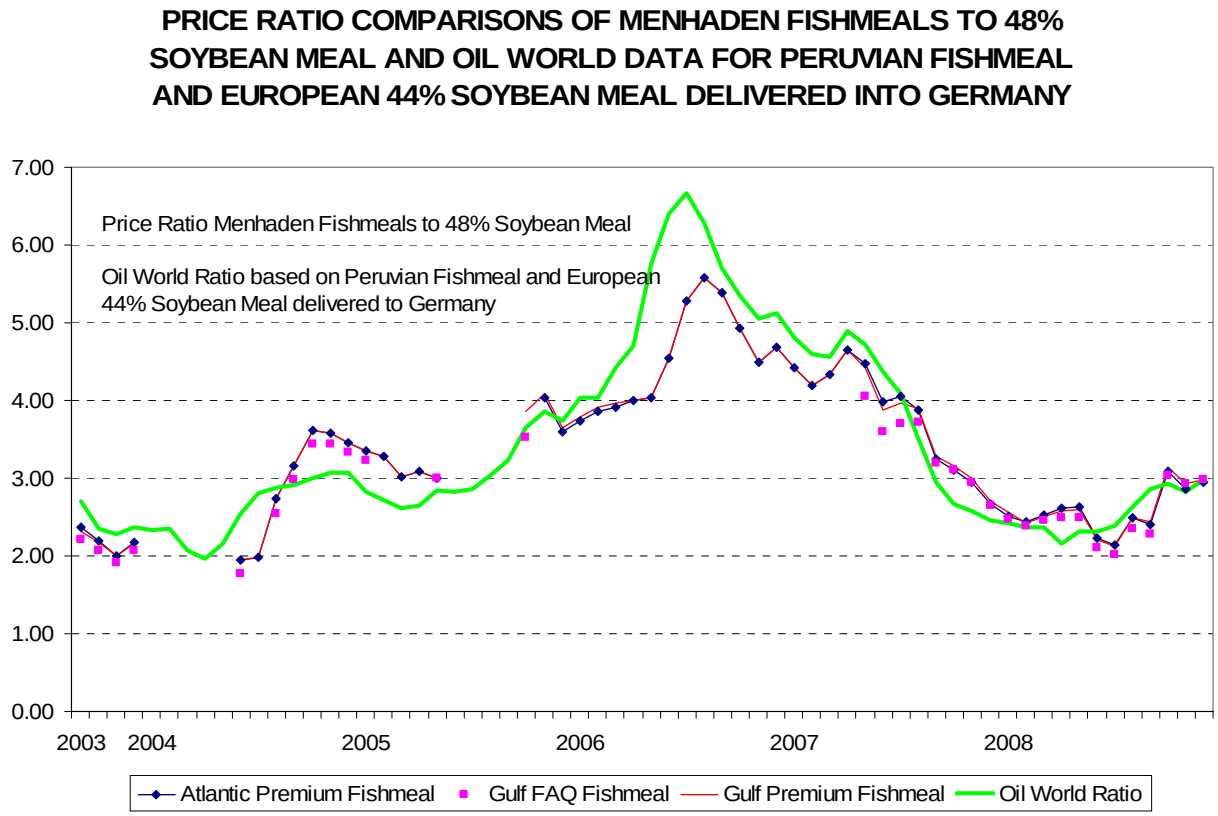


Figure 45 Price ratio menhaden fishmeal to 48% soybean meal vs. Oil World price ratio

As has already been mentioned, within a company or country there will normally be several different grades of fishmeal representing the range from FAQ to Super Prime or LT 94. These products will have a price spread which will be based on the end use for the fishmeal or the target animal that will consume the fishmeal. While the ratio has been relatively high in recent years, the overall or general ratio to soybean meal will depend on the end use of the fishmeal. This can be seen in the following figure.

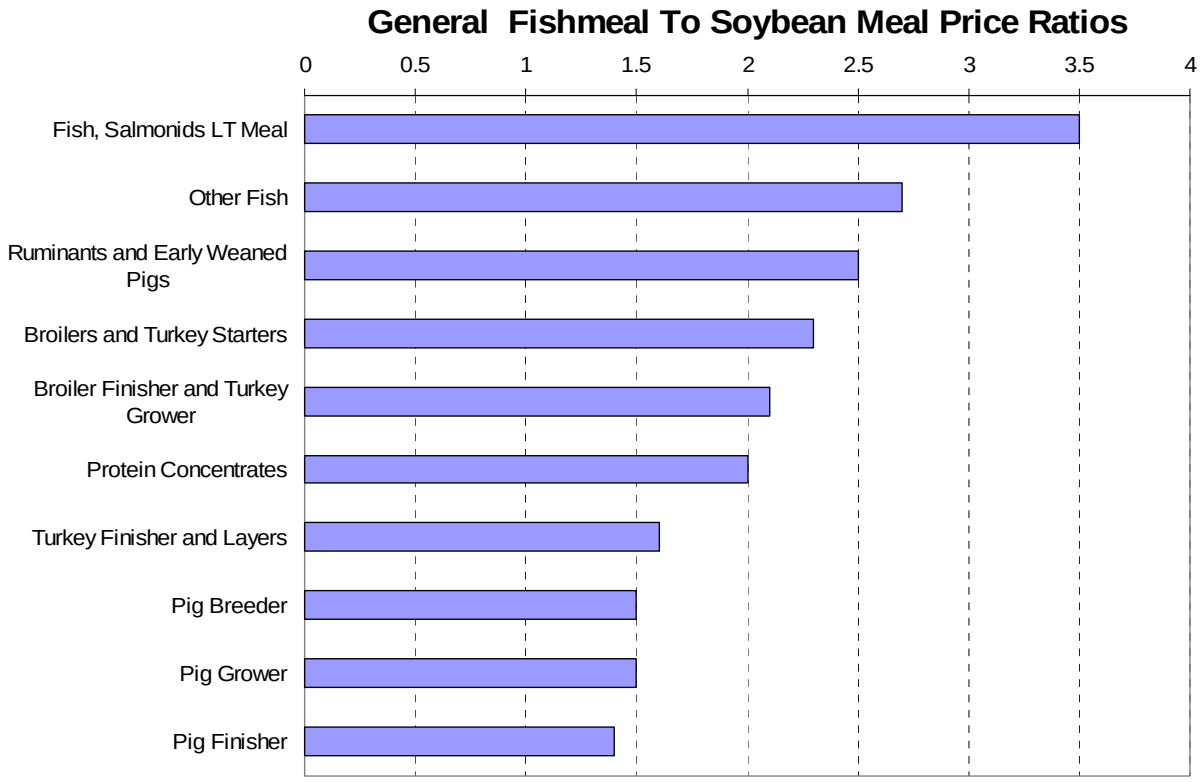


Figure 46 Variation in fishmeal soya price ratio according to end use for the fishmeal.

We can see from this that the premium products are targeting the aquaculture, early weaned pig, and ruminant markets. While not on this chart, the pet food market would also fall into the premium fishmeal price ratios. Another way to look at this is that if the target market is poultry and pigs then these markets would not be willing to pay a premium price since they could use a corn/soy diet.

In order to obtain these higher fishmeal:soybean meal price ratios, the fishmeal industry has embarked on a make over, moving away from the production of FAQ type products and towards

the premium products. By doing this a new price structure has evolved over the expanse of products. This can be seen in the following three figure

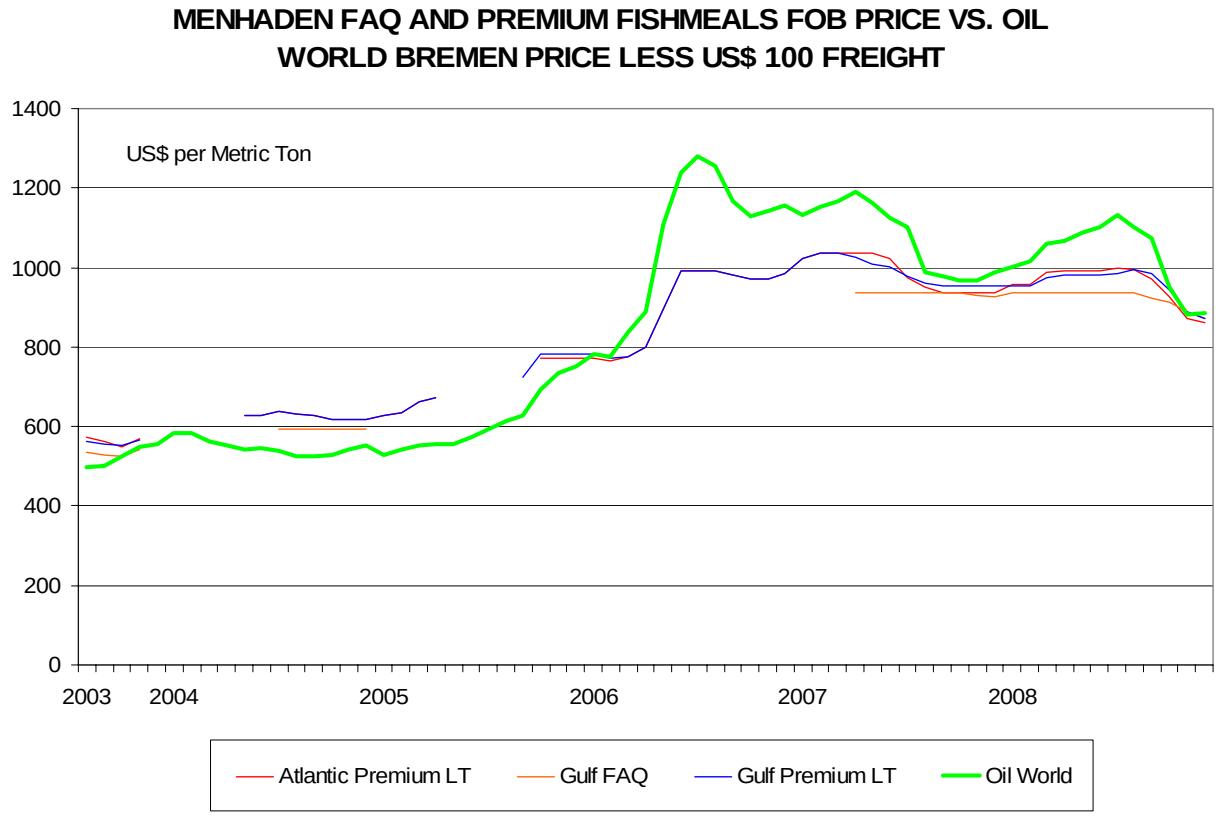


Figure 47 FAQ and LT menhaden meal prices vs. Bremen fishmeal price less $100 freight

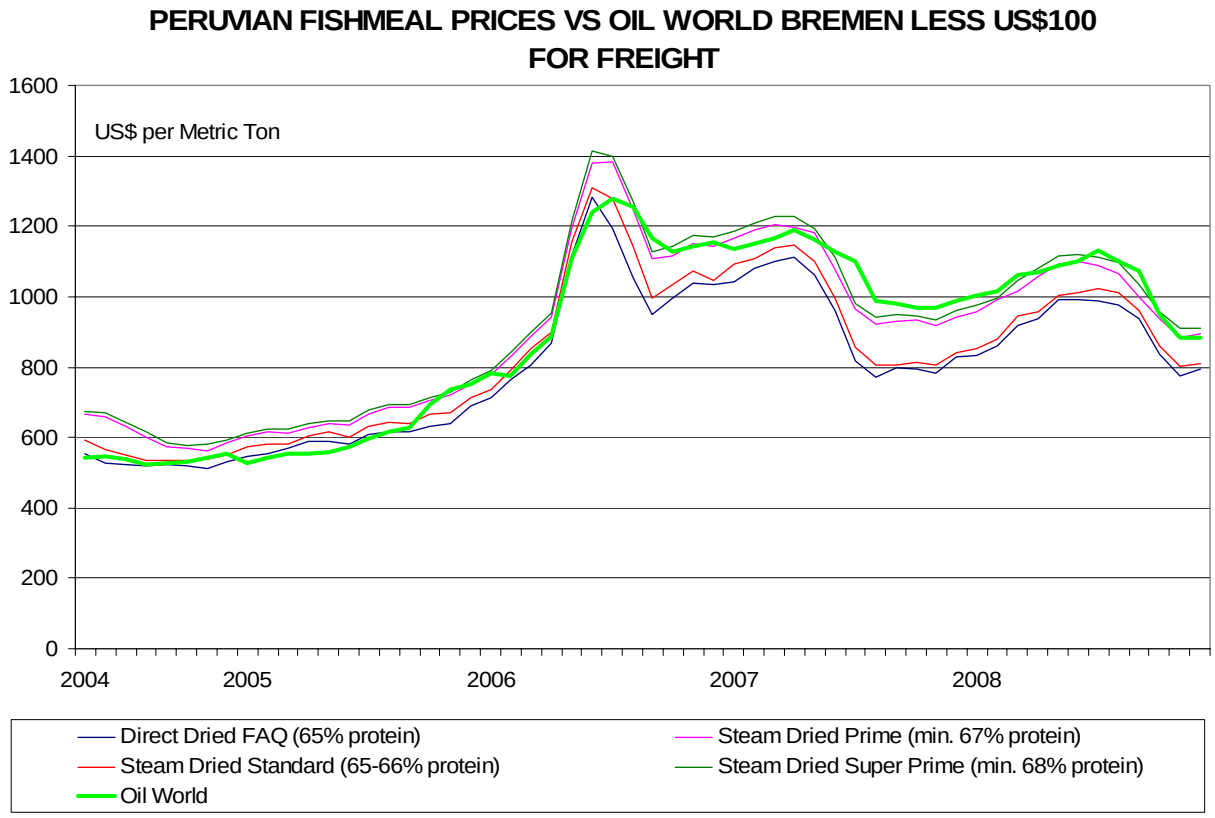


Figure 48 Peruvian fishmeal vs. Oil World Bremen price less $100 freight

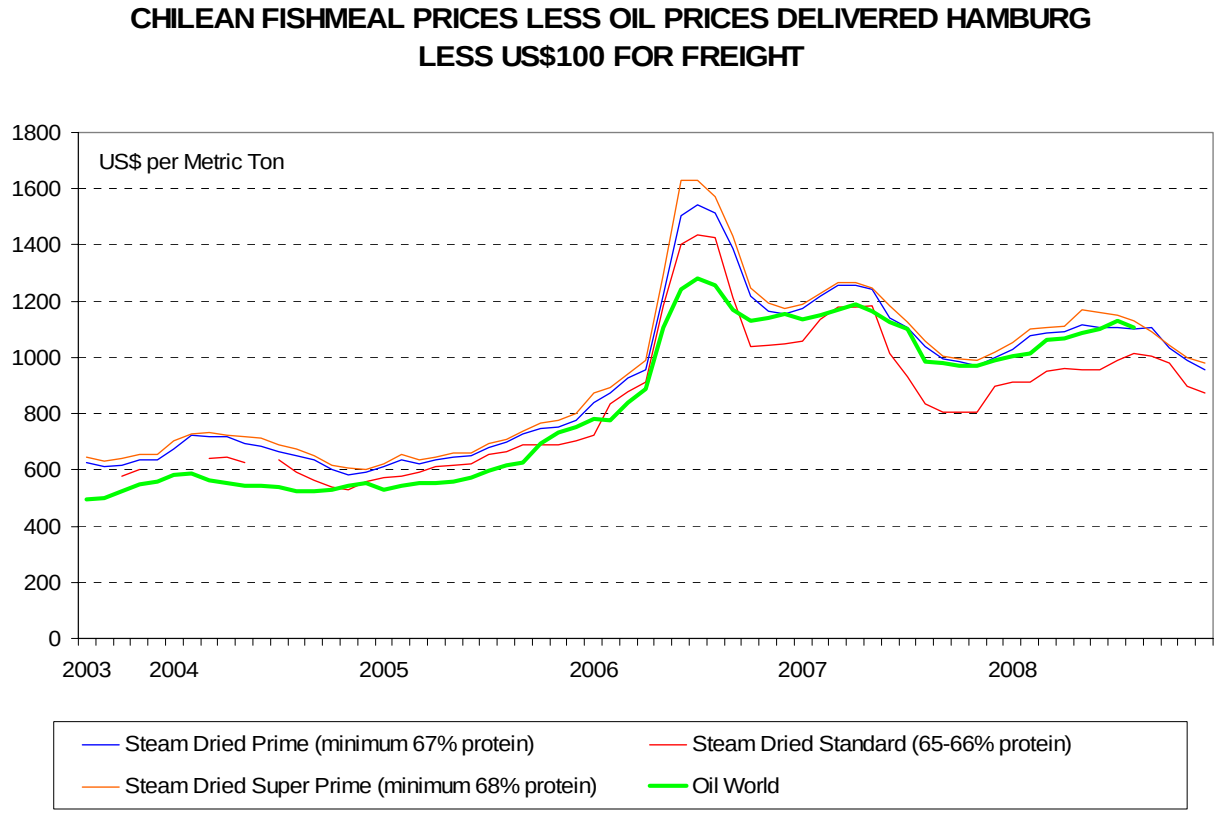


Figure 49 Chilean fishmeal prices vs. Oil World Bremen price less $100 freight

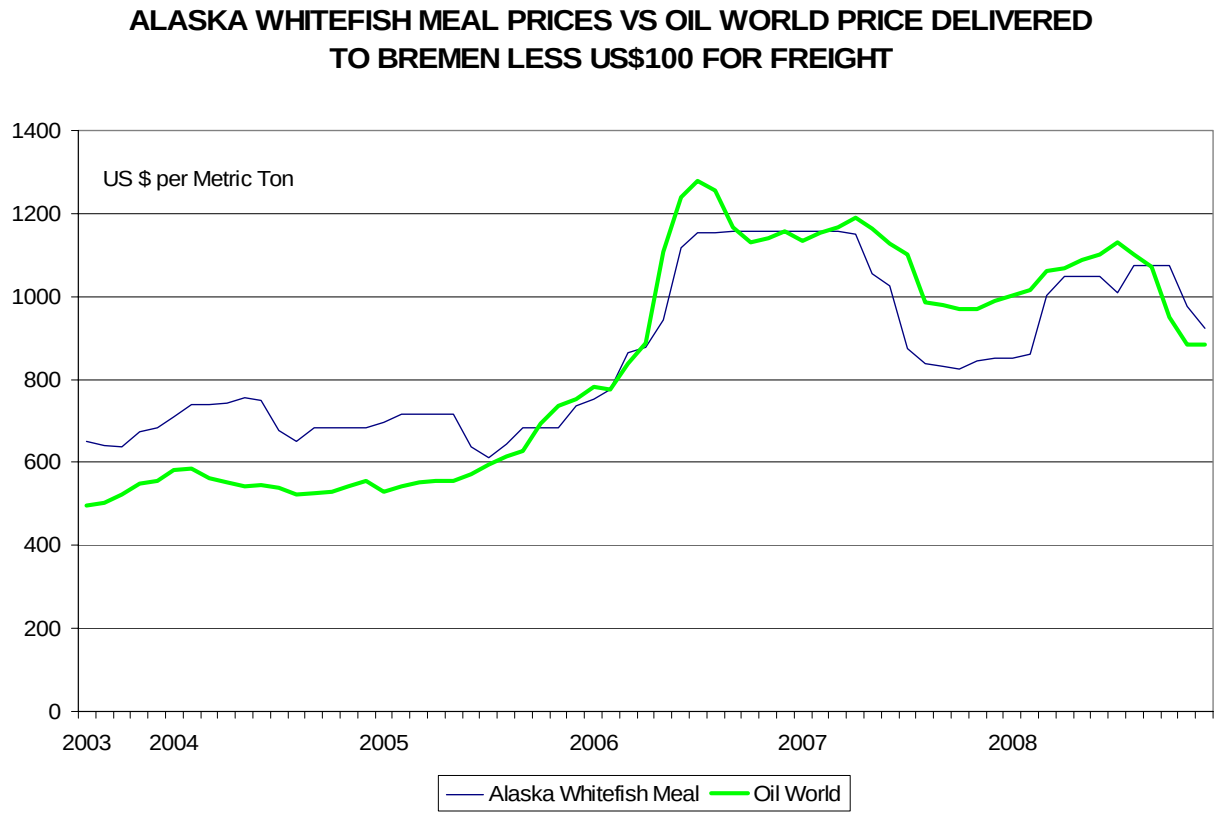


Figure 50 Alaska whitefish meal prices vs. Bremen prices less $100 Freight.

Another possible method of price comparison would be the US Customs value of fishmeal shipments through major Customs Ports compared to the Oil World commodity fishmeal price delivered to Hamburg or Bremen. In both cases the fishmeal shipped to Germany and the fishmeal exported through the US Customs Ports would include bulk as well as container shipments although containers are probably the predominant method of shipment. For information purposes, the ports of the mid-Atlantic and Gulf regions would include most of the US menhaden fishmeal shipments while the South Atlantic region would represent imported Icelandic fishmeal for the pet food industry. These are shown in the following figure. I have included shipments through Anchorage, Alaska and Seattle, WA for comparison. If you expand the zoom to 150% you can read the individual points.

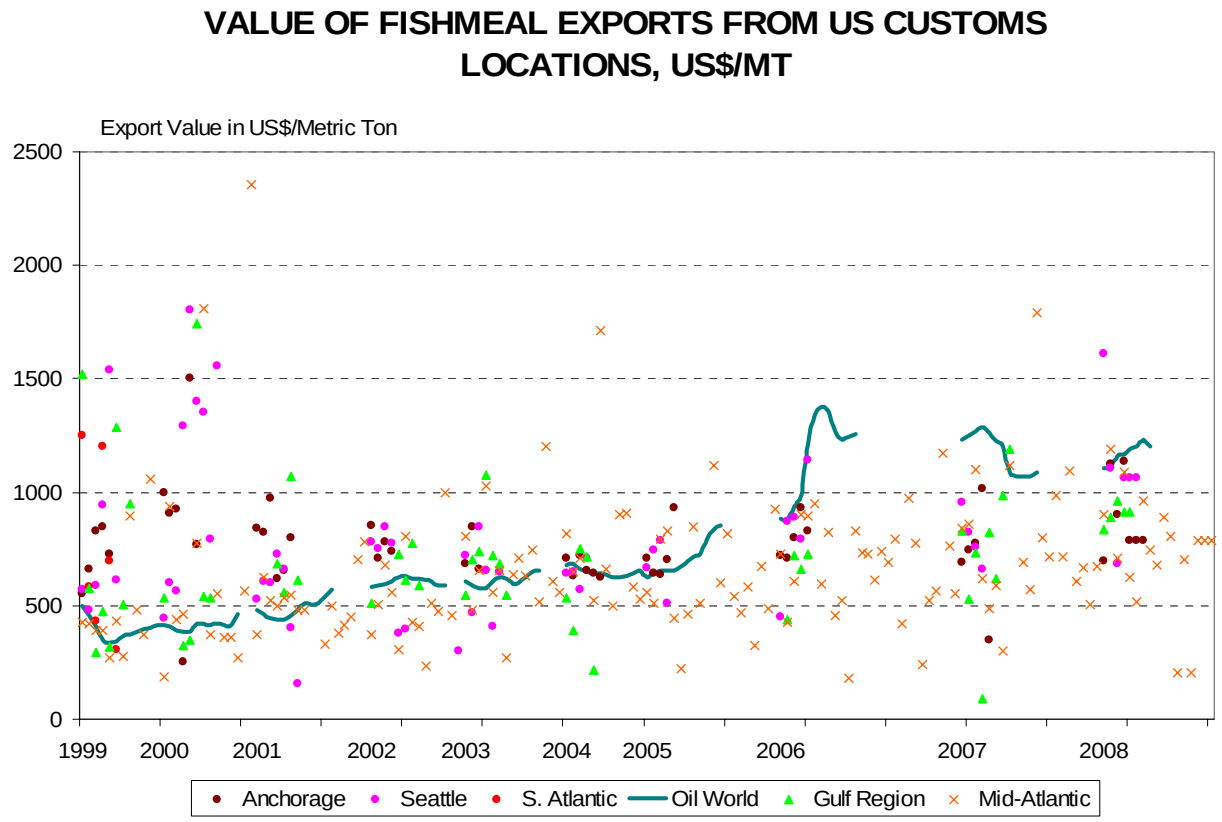


Figure 51 Fishmeal exports through US Customs sites compared to the Oil World price. ok

Fish Oil

Commodity Oils

Fish oil competes with other fats and oils on the world market. Up until the mid 1990's fish oil was primarily used in the hydrogenated form in margarines, shortenings and baking fats. Because of its unsaturation, it was necessary to process fish oil to make it chemically similar to vegetable oils. The increased processing resulted in fish oil always being sold at a discount to the major vegetable oils. As the market moved away from hydrogenation and towards aquaculture, the price of fish oil advanced. Fish oil converted from a commodity oil to a specialty oil. The following two figures compare the historical fish oil price to the historical commodity oils, the second figure compares fish oil to the specialty fats and oils.

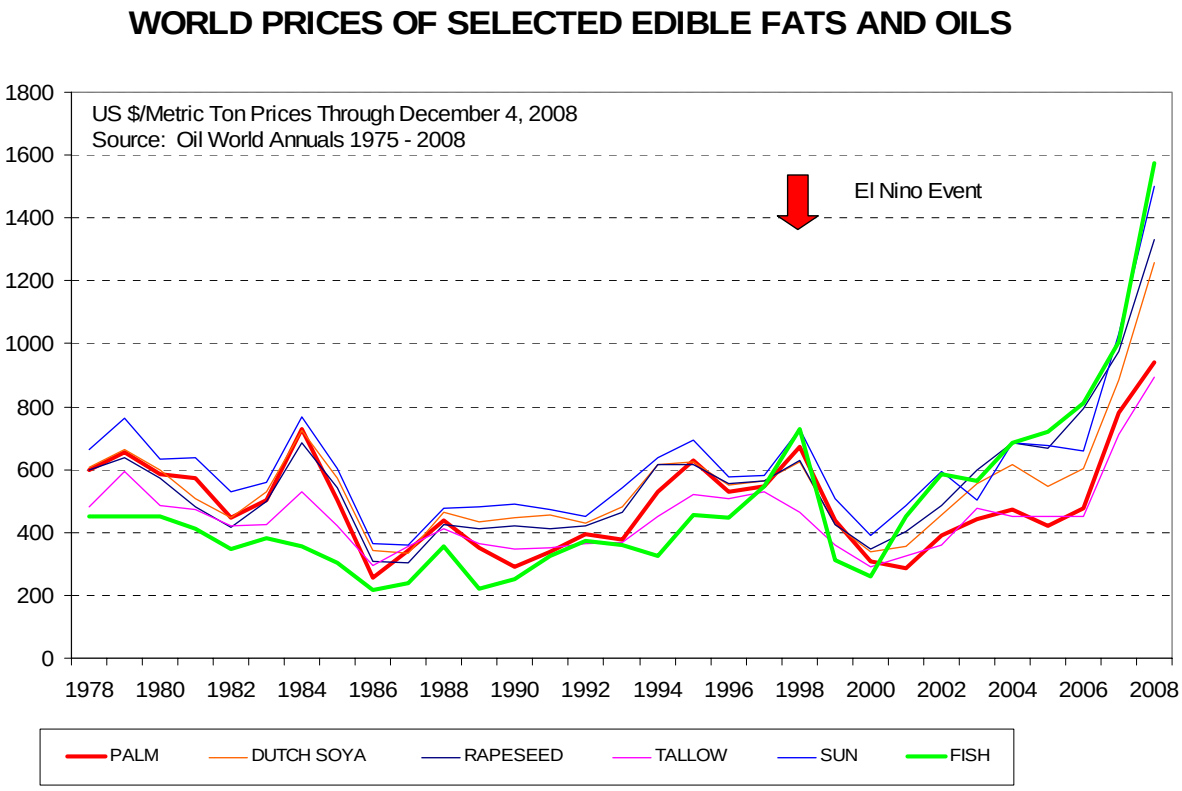


Figure 52 Fish oil price compared to commodity oil prices.

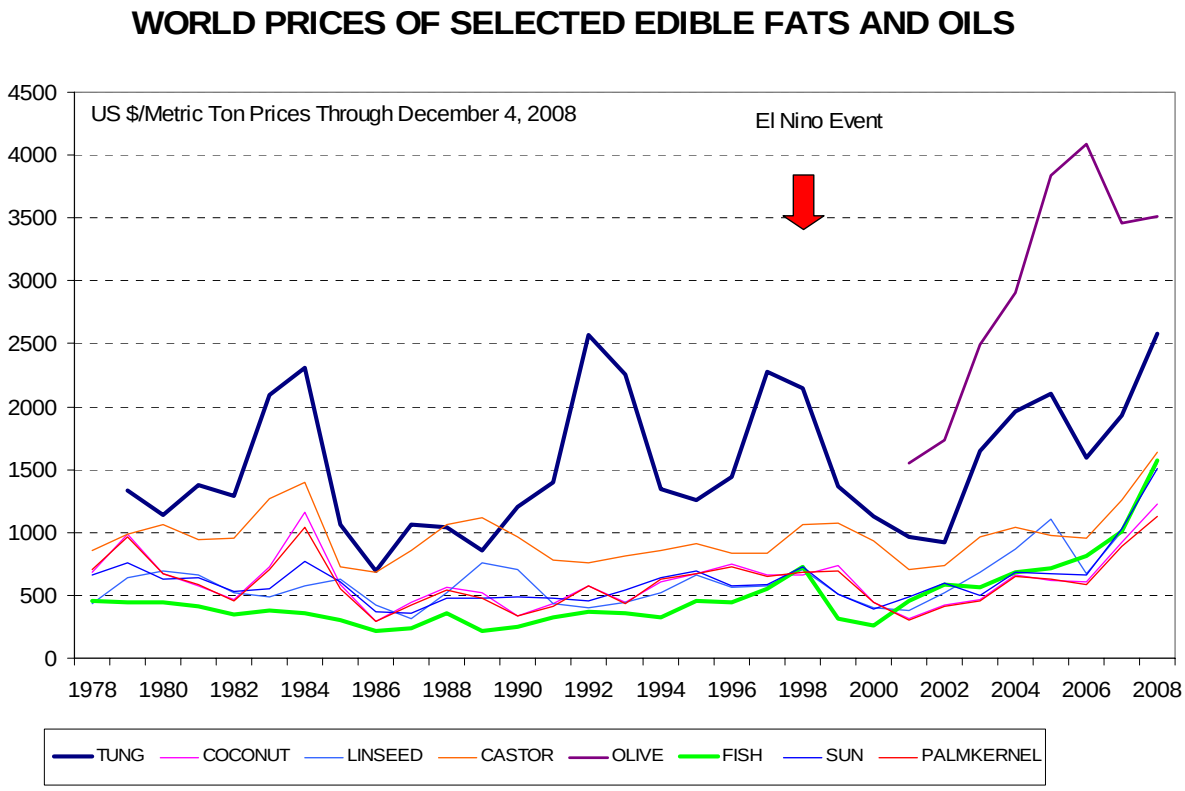


Figure 53 Prices of selected specialty oils.

We can also compare fish oil to a European edible oil index (35% Soya + 35% Rapeseed + 15%Sun + 15% Palm). While the following prices represent European prices and might not be directly applicable to Alaska, they do demonstrate trends and a base line for comparison.

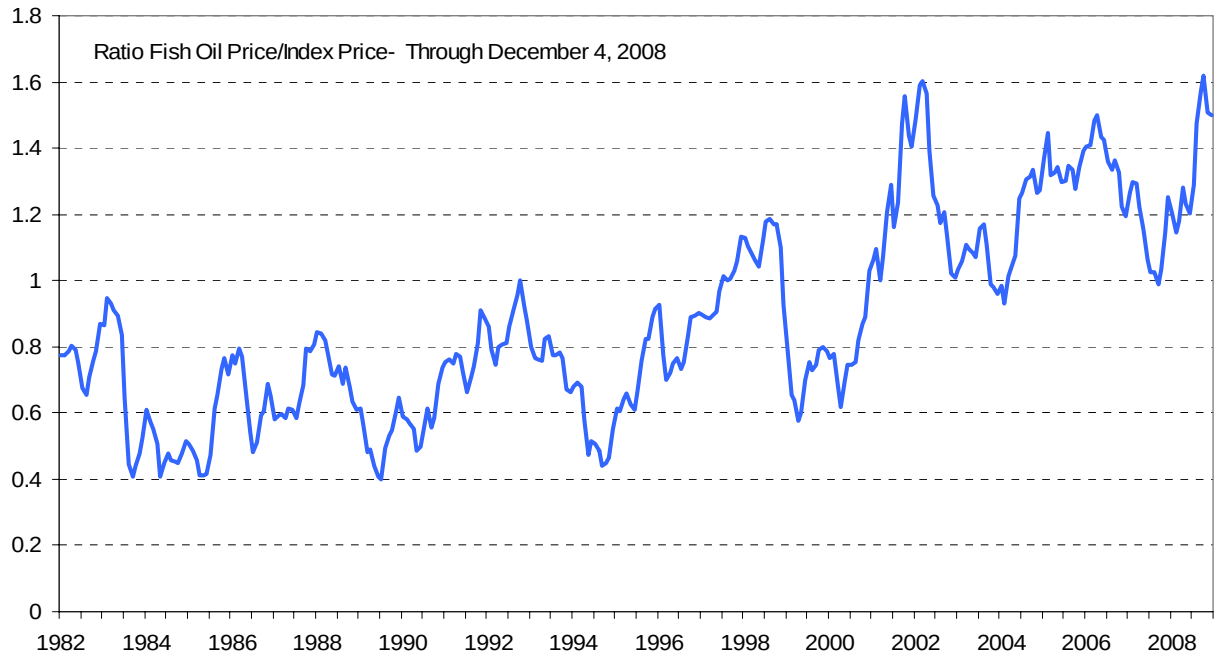


Figure 54 Ratio of the European fish oil price to the edible oil index price.

The price of fish oil can also be compared to the price of soybean oil, palm oil or rapeseed oil as shown in the following figure. These are based on European Prices as reported in Oil World.

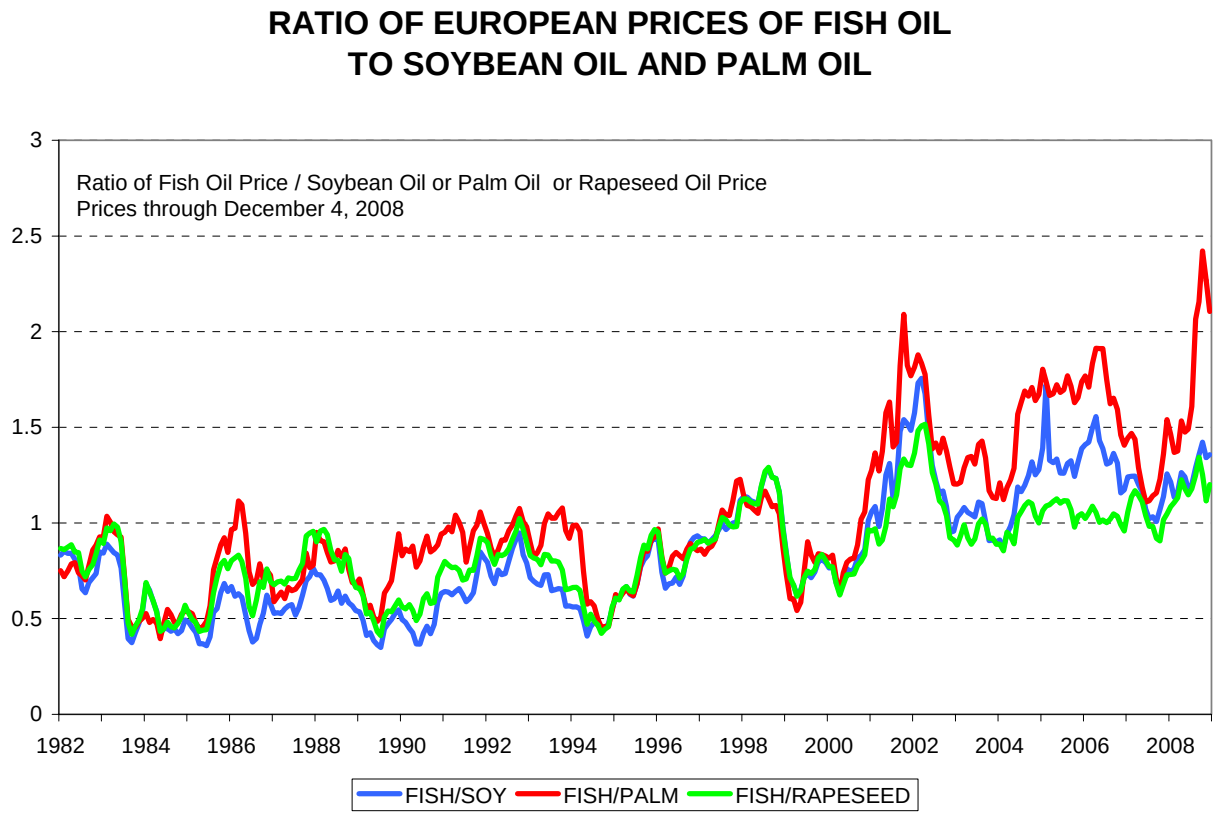


Figure 55 Ratio of European fish oil price to soybean oil, palm oil and rapeseed oil prices.

We could also compare the fish oil price to the fishmeal price. This data is also European prices as reported in Oil World. This is in the following figure.

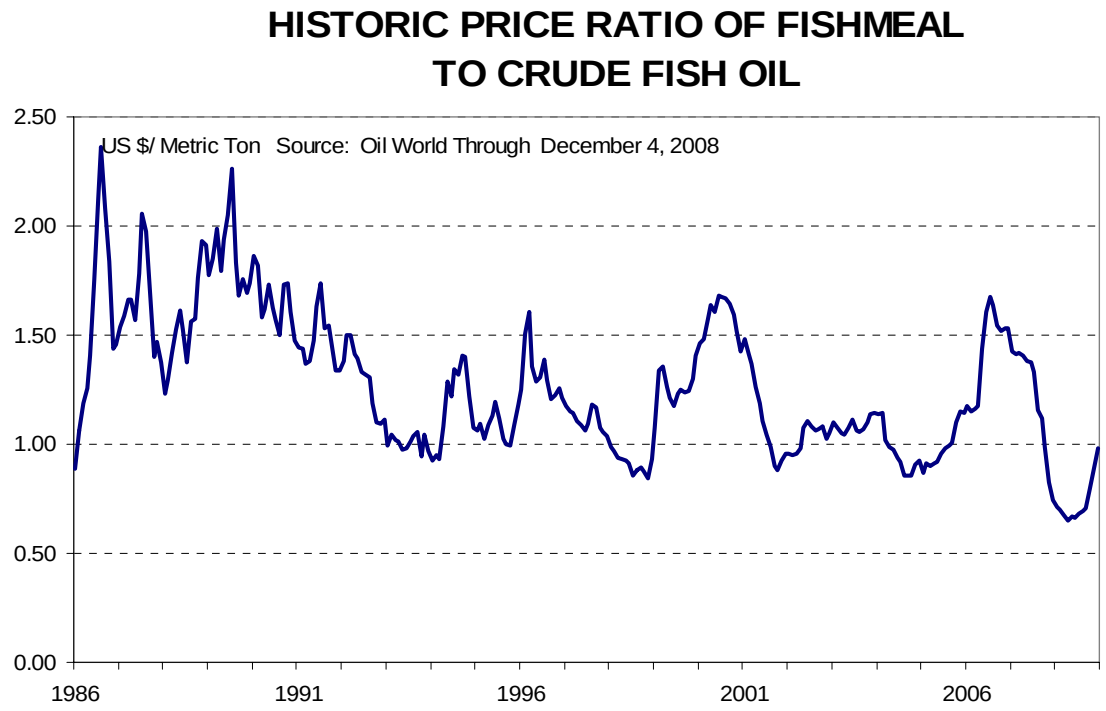


Figure 56 Ratio of the European fishmeal price to the European fish oil price.

Some price data does exist for the mainland USA and these are presented in the following figure.

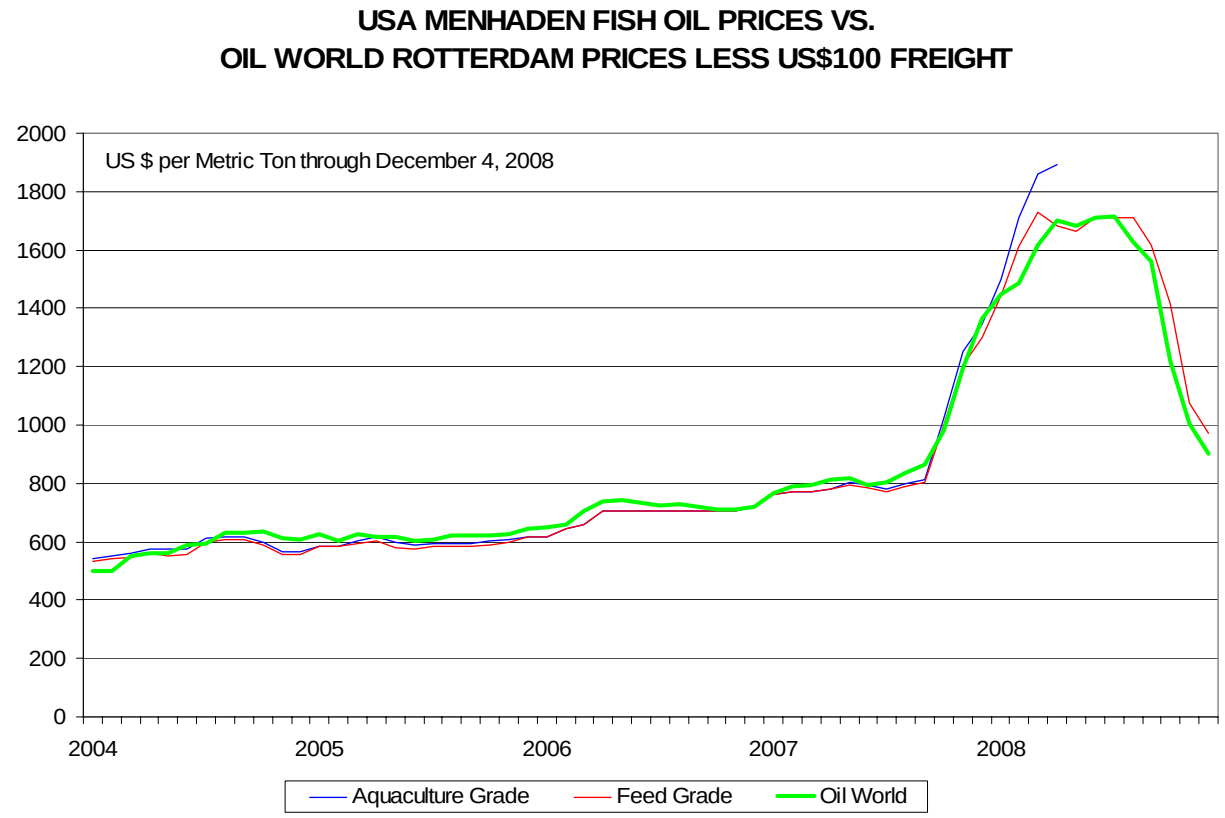


Figure 57 USA menhaden fish oil price vs. Oil World Rotterdam price less $100 freight.

Another possible method of price comparison would be the US Customs value of fish oil shipments through major customs ports compared to the Oil World Commodity Fish Oil price delivered to Rotterdam. The oil shipped to Rotterdam would represent bulk oil shipments while the oil through the US Customs Ports would include bulk as well as container shipments. For information purposes, the ports in the mid and south Atlantic and Gulf regions would include most of the US menhaden oil shipments while it is assumed that Anchorage and Seattle would cover the Alaska oil shipments. These are shown in the following figure.

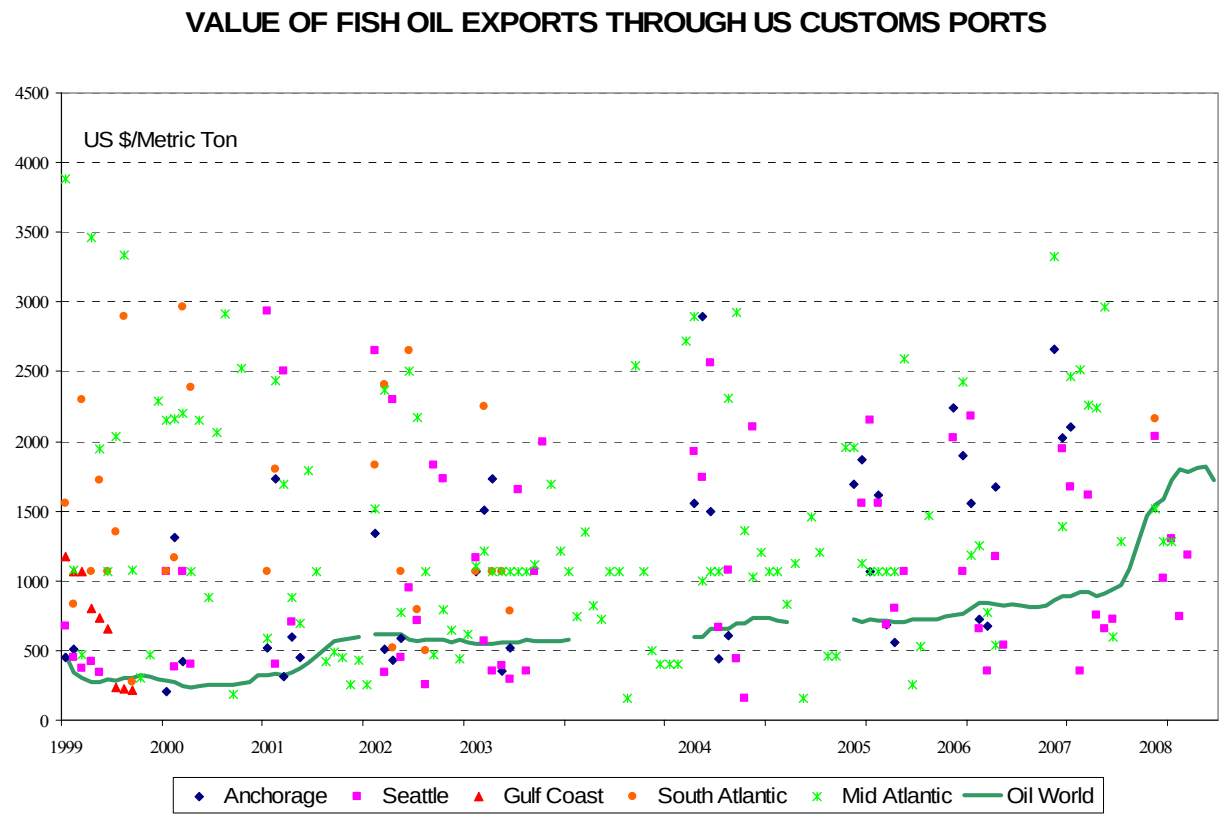


Figure 58 Value of fish oil exports through US Customs ports.

Nutraceutical Fish Oils

The nutraceutical fish oil market is relatively small representing only about 5-10% of the total fish oil production. Because the market is multi-layered, the bottom layer represents oils that are segregated because they have specific properties, such as red color, high iodine value which indicates high omega 3, or some specific species that might be of interest, such as tuna or liver oils or possibly wild salmon oil. These oils then move to semi-refiners who remove the gross impurities, moisture, and free fatty acids. The oils then move to the nutraceutical manufacturer who will do the more sophisticated processing of the oil including splitting out and concentrating the omega 3 fatty acids. These oils then move to the consumer or to a pharmaceutical manufacturer for more processing. Following is the Omega 3 seduction:

According to various market research groups:

- Omega-3 is a trend few ingredients firms with an interest in functional foods want to miss out on.
- Omega 3 will reach $7 billion in global sales by 2011.

- Packaged Facts has recently forecasted that the US Omega-3 food market will grow from $2 billion dollars USD in 2007 to $7 billion dollars USD in 2011.

- In 2007 the European market was about US$296 million and is expected to grow to US$1.3 billion by 2014, compound annual growth rate (CAGR) of 23.6%.

- Omega 3 sources come from marine oils 78%, flaxseed 13%, algae 3% and others 6%.

- Upcoming sources include krill oil, seal oil, and shark liver oil.

- In Europe 6 companies dominate the Omega 3-6 market; Pronova, EPAX, Ocean Nutrition Canada, Denomega, Croda and DSM.

- In 2006 there were 562 product launches in Europe and 584 in the USA.

- In 2008 there are so far 723 omega 3 product launches in Europe and 541 in the USA.

- 84% of the omega 3 raw materials come from marine oils.

- In 2007 97% of the omega 3 produced was used in animals which means about 3% of the raw materials is for the human food and food supplement market.

- Of the 3% destined for human foods, 78% goes to dietary supplements, and 13% for functional foods and beverages.

- 80% of the omega 3 is for cardiovascular health products and the remaining 20% is used in cognitive health products, infant nutritional products, bone health and immune health products.

- By 2014 functional foods and beverages will be at the same level or higher than dietary supplements.

- Nutraceuticals have reached the tipping point in North America, the adoption curve is speeding up and there will be increased interest from retailers and consumers.

- In the USA sales of **all Nutraceuticals** in capsule, liquid or powder form reached US$27 billion in 2007.

- The estimate of 3% of the world's production of fish oil going to the Omega 3 market seems low and it might indicate they are using finished product instead of raw crude oil. Other estimates put the crude oil being diverted to the Omega 3 market at about 10%.

The following figure gives an indication of the nutraceutical omega 3 type oils entering the USA. As the price increases, the level of omega 3 increases and the level of processing also increases.

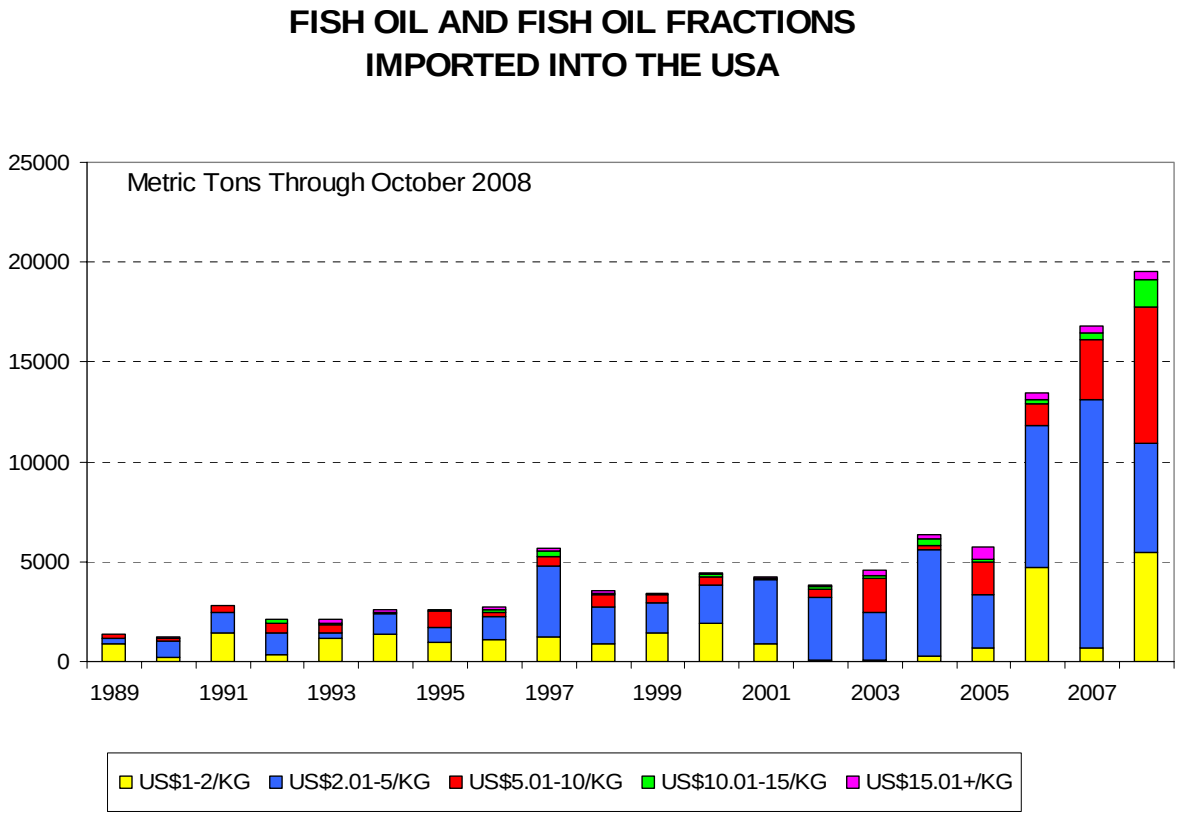


Figure 59 Nutraceutical type fish oils entering the USA.

Omega Protein Inc. is the only US refiner of fish oils. They are publicly traded and information is available from their SEC filings. For the period 1998- 2007 the revenue received from their crude oils and refined oils shows a differential which is essentially the value-added premium for the refined oils. Generally, as long as the crude oil is low in value the differential is high, however as the value of the crude oil increases the differential shrinks and might possibly disappear as it seems to have done in 1998 and 2006. This is shown in the following figure.

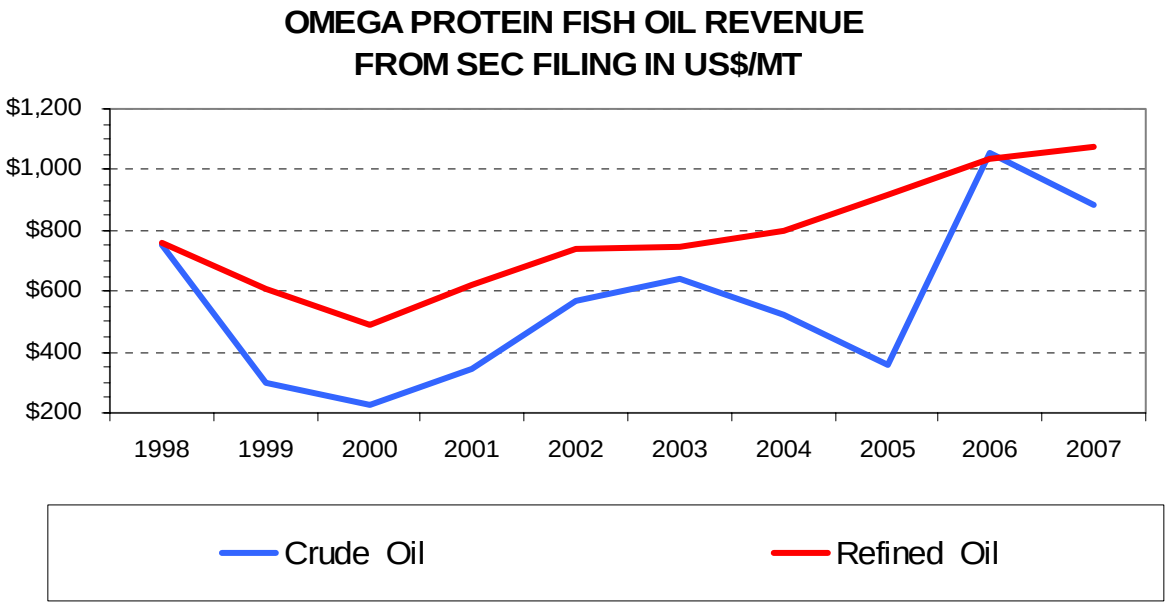


Figure 60 Omega Protein SEC filing for fish oils, revenue in $/mt.

The following figure gives an estimate of the nutraceutical fish oil (omega 3 oil) market structure. It is important to keep in mind that this market is very flexible and some people have described it as the price is whatever the buyer will pay at the time.

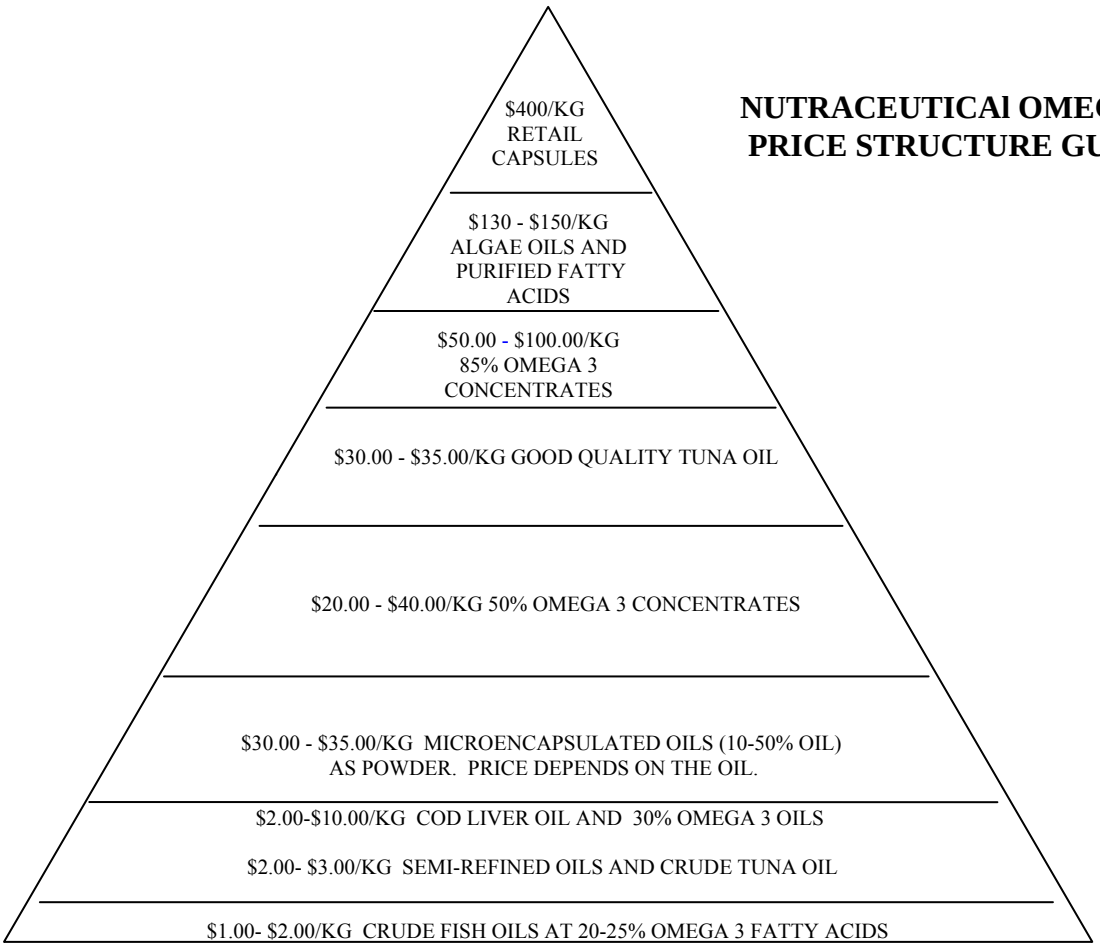


Figure 61 Structure of the nutraceutical fish oil market.

Fish Silage, Hydrolyzates And Fish Solubles

There is very little information available on the price structure for these other competing products. The only information is on the internet and this only reflects retail sales of products in pint and quart bottles and 5 gallon pails.

Some of the hydrolyzates from France have sold in the US$900+/ton range for early weaned pig and milk replacer diets. However, the early weaned pig market is only 8 weeks out of the life of the pig.

Omega Protein is the only company that sells fish solubles as a separate product. Based on their SEC filing, during the period 1998-2007 as shown in the following figure, fish solubles sold in the US$175 – $432/metric ton over that period.

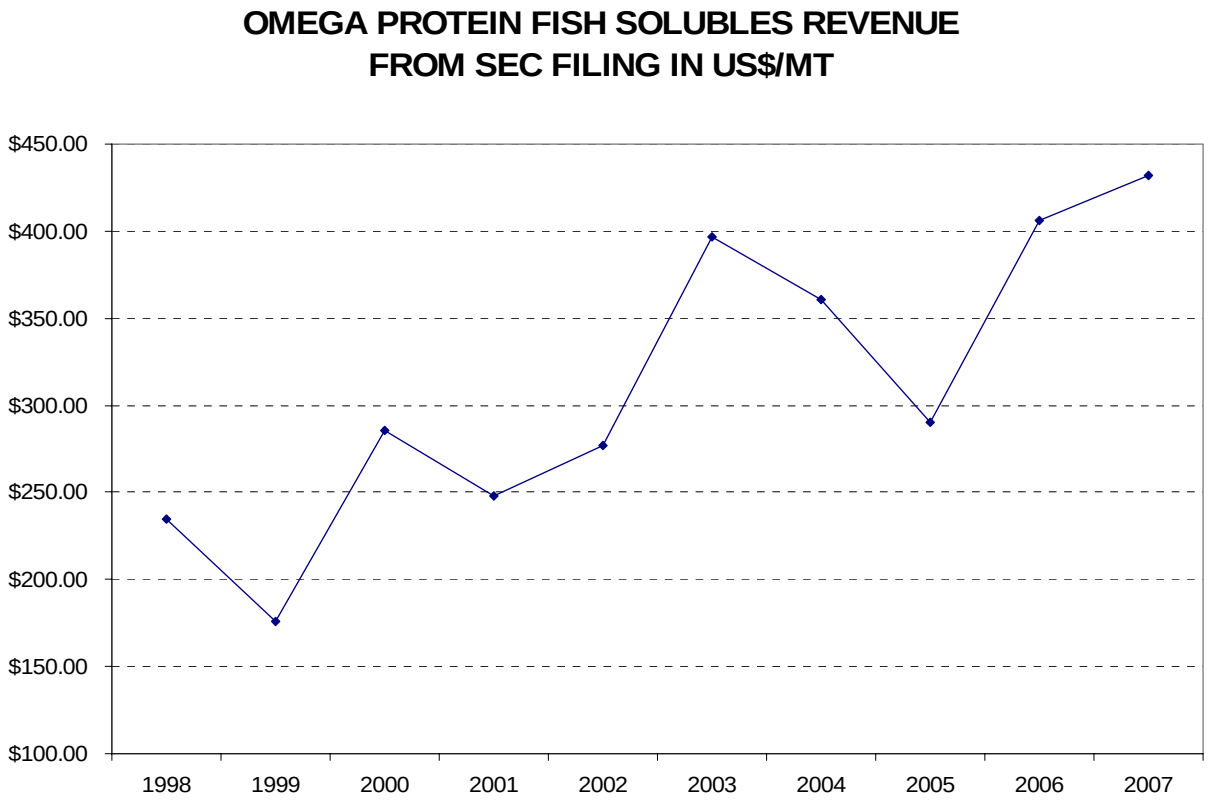


Figure 62 Omega Protein SEC filing for protein products.

If we assume that the fish solubles are 50% solids and that conventional cold silage is 20% solids and that the nutrient composition is comparable, we could estimate that over that same period of time, cold crude fish silage would have sold in the $70 - $173/metric ton.

Fish Bone Meal

Fish bone meal is used as a fertilizer and will compete with other fertilizers based on the nitrogen-phosphorous-potash content. In the previous Figure 49 one could assume that with the wide spread in prices for fishmeal exports that perhaps when the major part of the sales is in the $400-$500 per ton range that product in the $200-$300/ton range might be off-grade fishmeal and or fish bone meal. When fishmeal is in the $500 - $1200/ton range, you could assume that the bone meal might be in the $300 - $600/ton range.

APATITE II™ PHOSPHATE INDUCED METAL STABILIZATION WITH FISH BONES	
	PRICE INDICATIONS
Apatite II ™	**By Shipping Container(s)** - fluctuates seasonally with a minimum price of $675/Ton, plus shipping and handling. Each container is 20 Tons. **By Super Sack** - Price is $2.50 per pound, plus shipping and handling. Super sacks range in size from 1650 lbs. to 2200 lbs. depending on our availability. **By the Pound** - Price is $5.00 per pound, plus shipping and handling. This can be one pound up to a few barrels.
Source: http://www.pimsnw.com/	

Table 160 Apatite II prices 2008.

Fish Fertilizers And Compost

Price information on compost in bulk is not available. Compost at the retail level in bags sells for anywhere from $3.00 to $5.00/bag.

COWSMO DAIRY FARM COMPOST (NO FISH)	
Retail Prices	
Totes	$50.00
50 Pound Bags	$ 6.00
Per Cubic Yard: Payload Bucket = 1.5- 2.0 Yards Bobcat Bucket = ¾ Yard	$28.00
Delivery Cost $40 for 20 miles or less 2008 Prices.	
Delivery Cost $2.00 per mile for all other deliveries.	
Source: http://www.rwdairy.com/	

Table 161 Cowsmo Dairy Farm compost pricing.

The following data was taken from an Illinois statewide market assessment for compost (not fish based compost) that was done in 2001.

MEAN PRICE PAID FOR NON-FISH COMPOST	
Amount ($)/ton	**Response (%)**
25	54.6
30	10.7
35	4.0
40	12.0
50	10.7
60	0.0
70	4.0
80	0.0
90	0.0
100	4.0
110	0.0
120	0.0
Other	0.0

Table 162 Illinois 2001 price paid for compost.

8. THE ALASKA SITUATION

According to NOAA data, Alaska has about 6,640 miles of coastline and including islands 33,904 miles of shoreline.

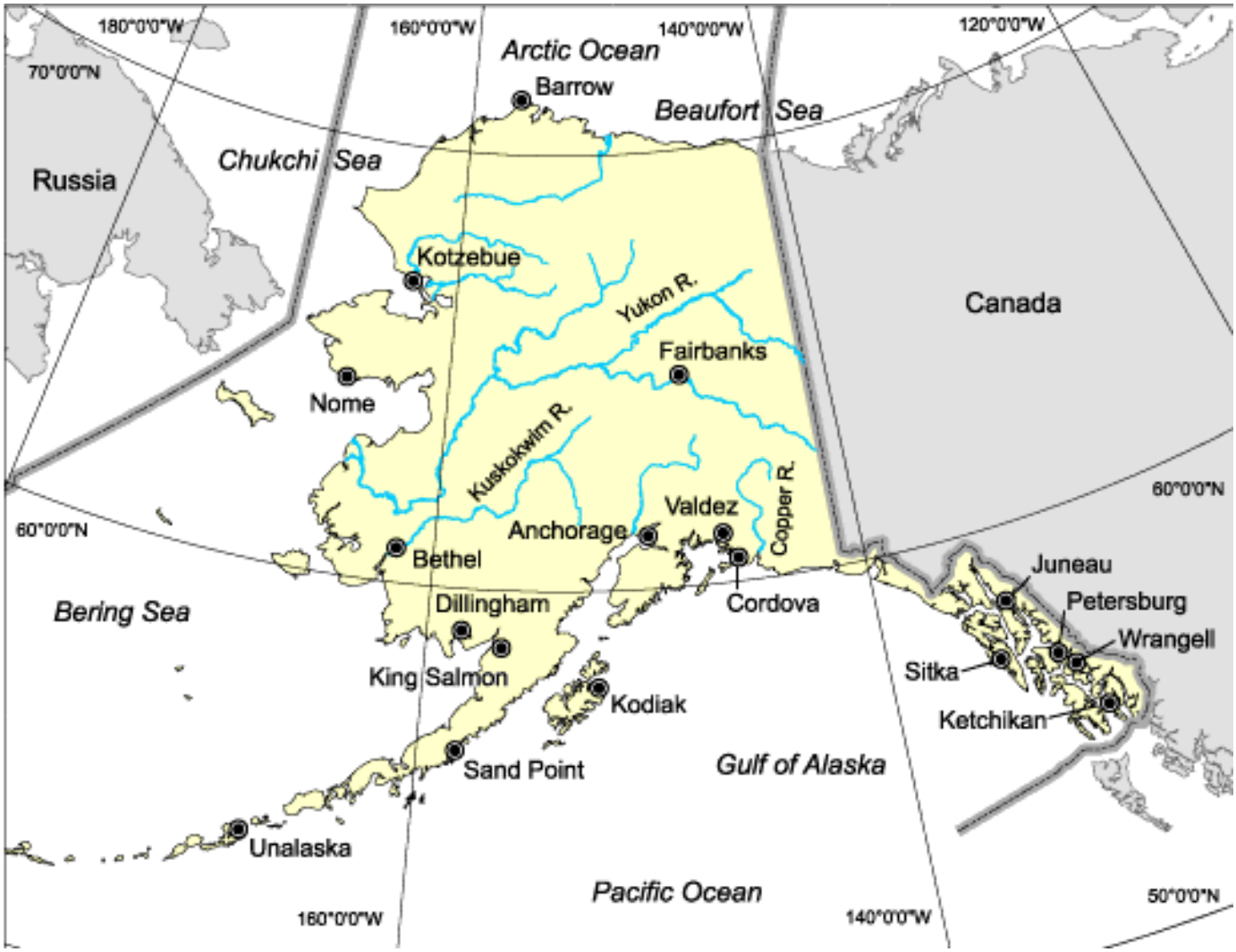


Figure 63 Alaska Map.

Alaska accounts for about 51% of the total US landings of fish and wild Alaska salmon represents about 8% of the total US fish landings and about 14% of the Alaska landings. A breakdown of the composition of the US landings is shown in the following figure.

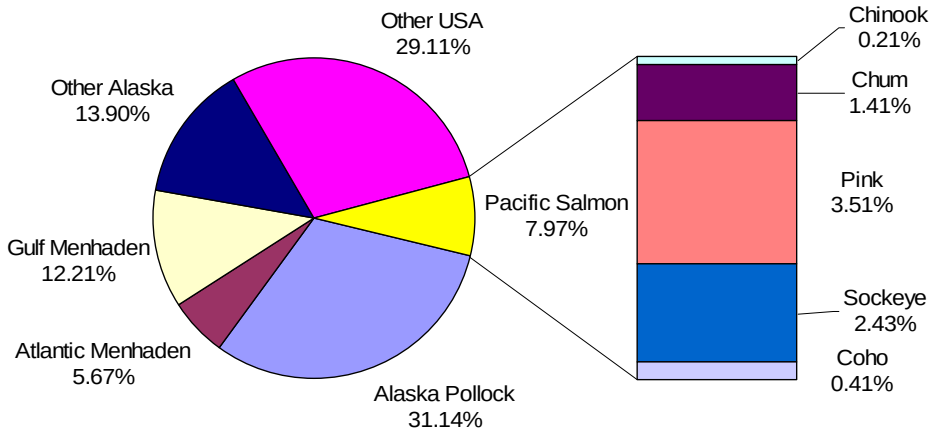


Figure 64 Composition of the US catch 1994-2007

Many communities in Alaska normally appear on the annual NOAA list of top 100 locations for fish landings. The following table shows these localities with their total landings for the years 1996 – 2007. It should be noted that landings in the EEZ are not included so the values are generally less than one half of what Alaska actually lands. Therefore, to put these figures into perspective I've included the Alaska pollock landings as a separate item in the table. There might be some overlap with pollock landings in some of the communities (Kodiak and Dutch Harbor for example) but as previously mentioned working with Alaska fisheries statistics is a nightmare with Federal, State and EEZ landings. So figures used in this section of the report should not be judged as absolute but rather as snapshots of what might be and baseline trends.

Top Commercial Fish Landing Locations in Alaska, metric tons												
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Dutch Harbor-Unalaska	262907	266626	270845	307677	317429	378529	411914	412186	402252	402615	378529	352536
Alaska Pollock	1151262	1159658	1248597	1055016	1182437	1441904	1512132	1524658	1521018	1546795	1542597	1390796
Kodiak	91945	125874	162207	150414	131363	129503	113581	119251	143973	152954	129503	145151
Naknek-King Salmon		18824	15468	28259	28622	15377	4445	9526	42003	47764	35517	52436
Ketchikan	62052	29575	45315	72304	25991	12247	33204	36197	43863	46494	23224	37875
Petersburg	47628	31797	33113	44997	14651	23224	24358	40325	46539	43047	29212	34201
Cordova	25129	26944	20593	28214		35517	26853	32206	18371	50440	15377	49351
Kenai	17191	16556	8482	8891	6124	6532	8891	11567	9888	7212	4491	4990
Sitka	14515	9662	8754	16420	43319	29212	31571	15695	16919	17282	19868	25175
Seward	13245	14878	20412	18960	12973	19868		19777	17509		12247	32568
Homer	9888	11159		7893		10433	13835	10524	8210	8119	6532	7167
Wrangell	11385	6078	8119	10524	3765	4491	5443	4854	3493	1996	3583	
Anchorage	3720	3447	3221	3266	680			408	499	499		
Juneau	2994	2404	2631	3447	3039	3583	2903	3810	6804	8392	10433	
Haines				3175	4491	2540	3856	2177				
Yakutat									1452	1769	2540	
Craig				2631	590		771	363	1406			
Total of Listed Locations	1,713,861	1,723,482	1,847,757	1,762,088	1,775,474	2,112,960	2,193,757	2,243,524	2,284,199	2,335,378	2,213,653	2,132,246
% of US Landings	39%	38%	44%	41%	43%	49%	51%	52%	52%	53%	51%	51%
Source: http://www.st.nmfs.noaa.gov/st1/commercial/landings/lport_yearp.html												

Table 163 Top Alaskan fishing ports

Eleven (11) species of fish and shellfish represent almost all of the Alaskan landings. This can be seen in the following figure.

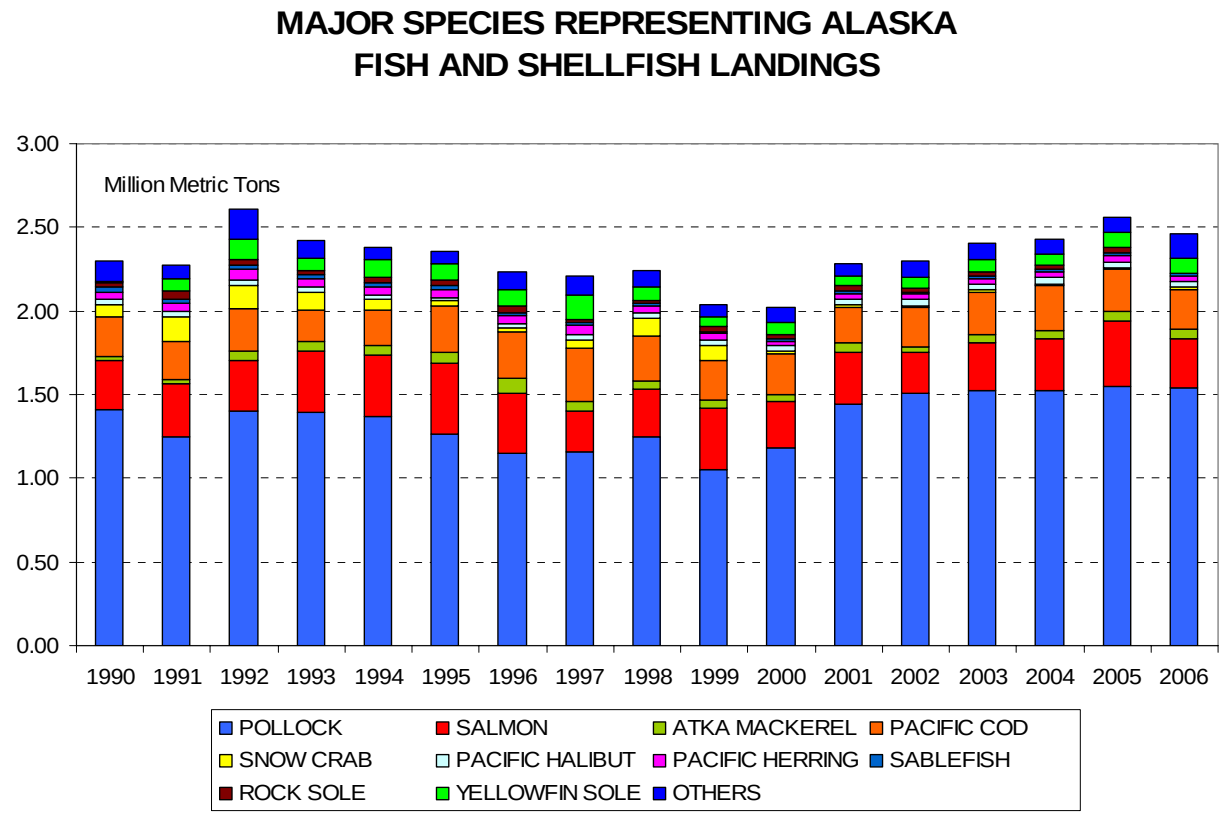


Figure 65 Major species of fish and shellfish landed in Alaska.

Walleye or Alaska pollock accounts for over 60% on average of the Alaskan landings.

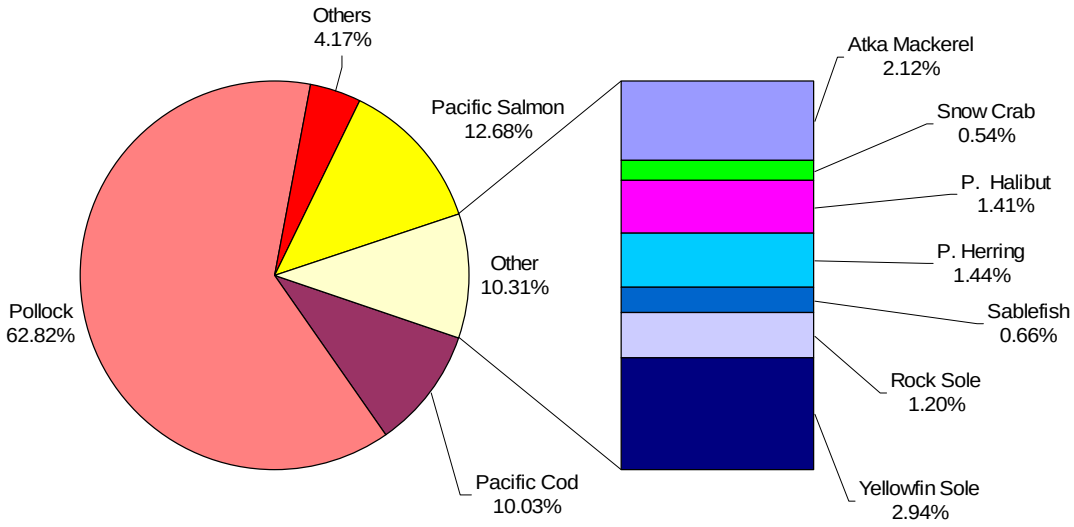


Figure 66 Species landed in Alaska 2001-2006.

Five (5) species make up the Pacific salmon fishery. Data for Alaska salmon landings by species is shown in the following figure. Sockeye, pink and chum salmon are the dominant species landed.

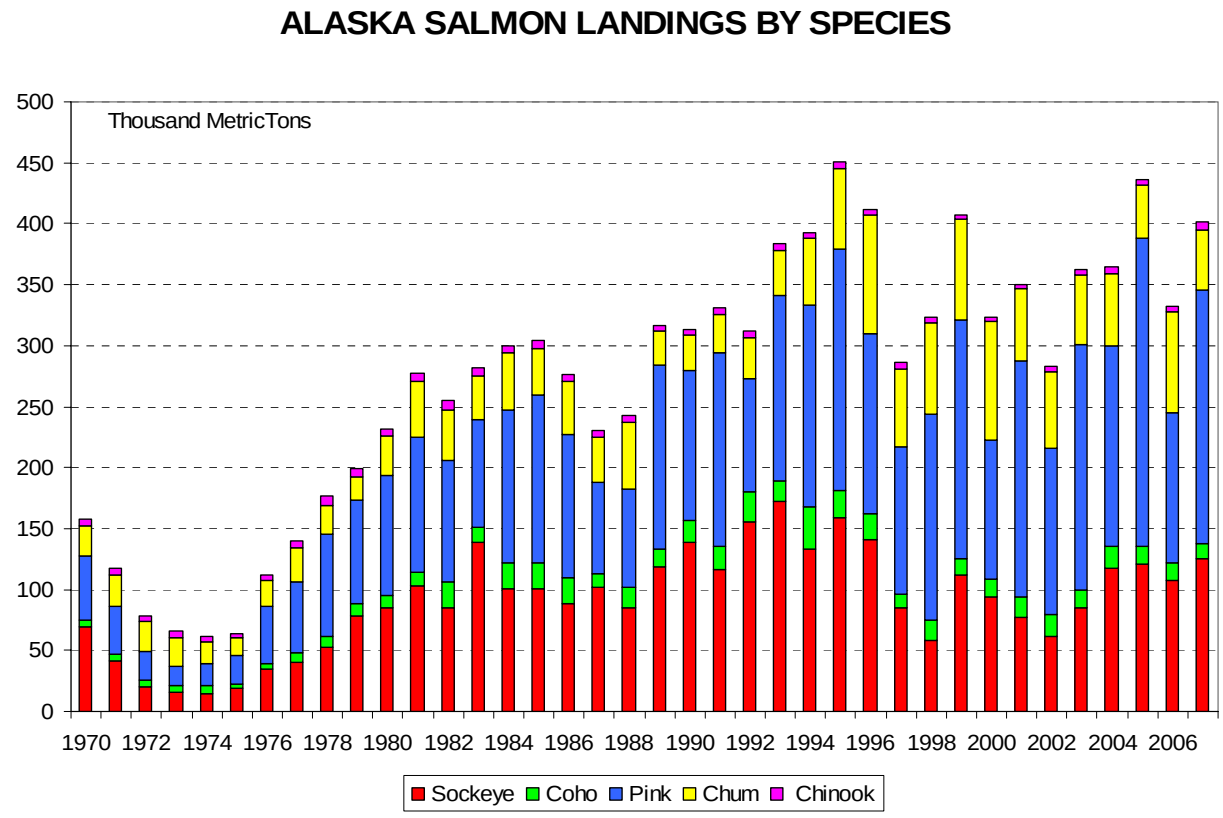


Figure 67 Alaska salmon landings by species 1970 - 2007

Alaska is divided into 11 statistical regions and each region can be divided into a number of districts. Some communities span more than 1 region which makes evaluation of the data somewhat difficult. It becomes even more difficult when there are 3 or less companies within an area since the data must then be kept confidential. The following figure shows the landings of Alaska Salmon by region over the period 1994-2007. Data was obtained from the Alaska Fish and Game Department database through Mike Plotnick and his valuable assistance is acknowledged and greatly appreciated.

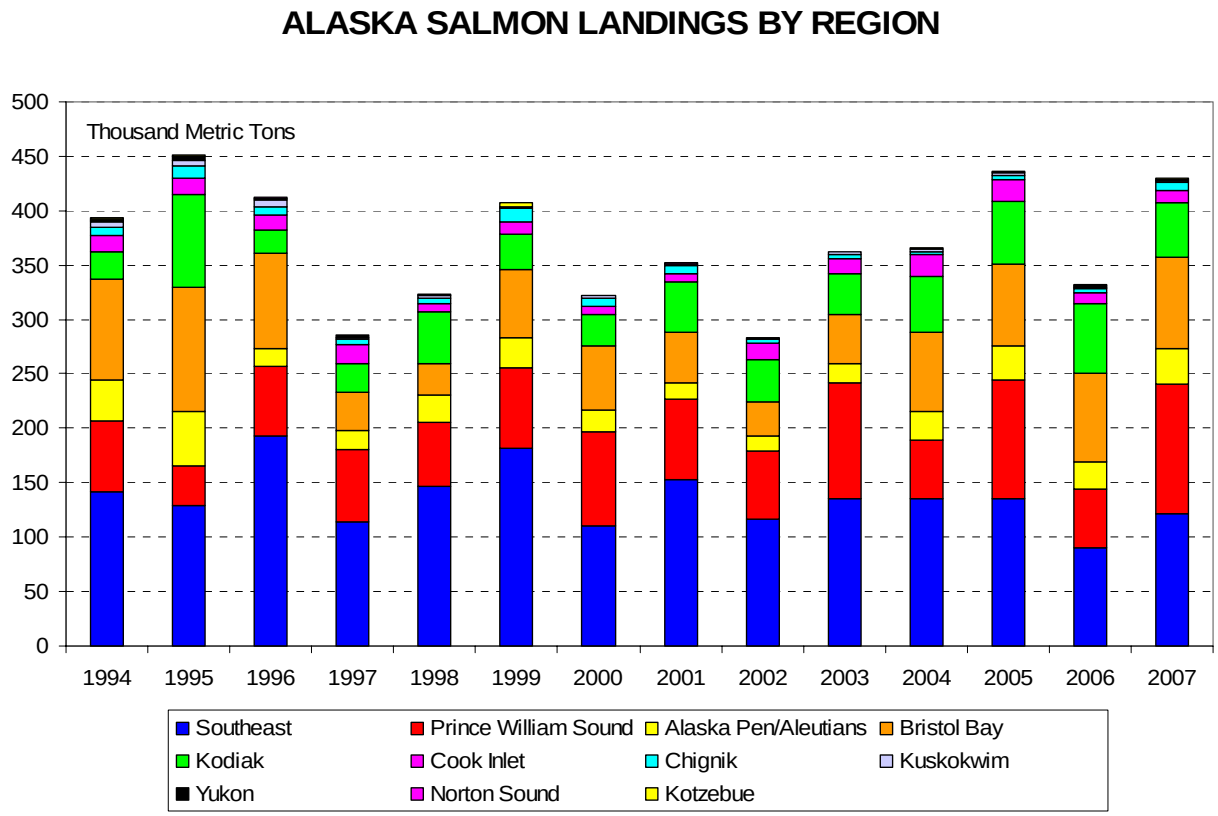


Figure 68 Alaska salmon landings by region 1994-2007.

The following figure shows the average regional landings as a % of the total. The Southeast Region is the largest salmon landing area followed by Prince William Sound and then the Bristol Bay region and Kodiak.

WILD ALASKA SALMON LANDINGS BY REGION, AVERAGE 2002-2007

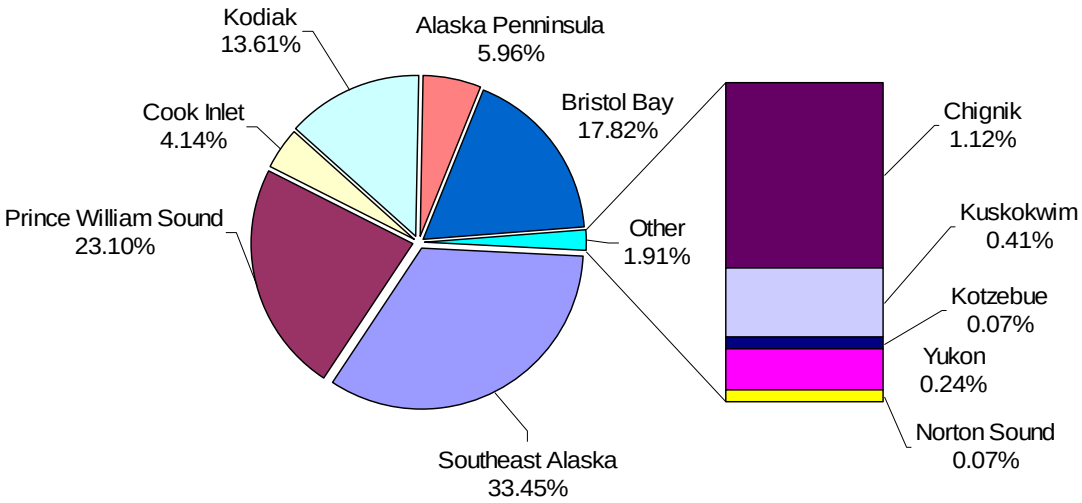


Figure 69 Average Alaskan regional landings % of total.

The Southeast Region is actually made up of 4 statistical regions. Because of the volume in the Southeast Region of Alaska, the following figure breaks out that region by the major community areas.

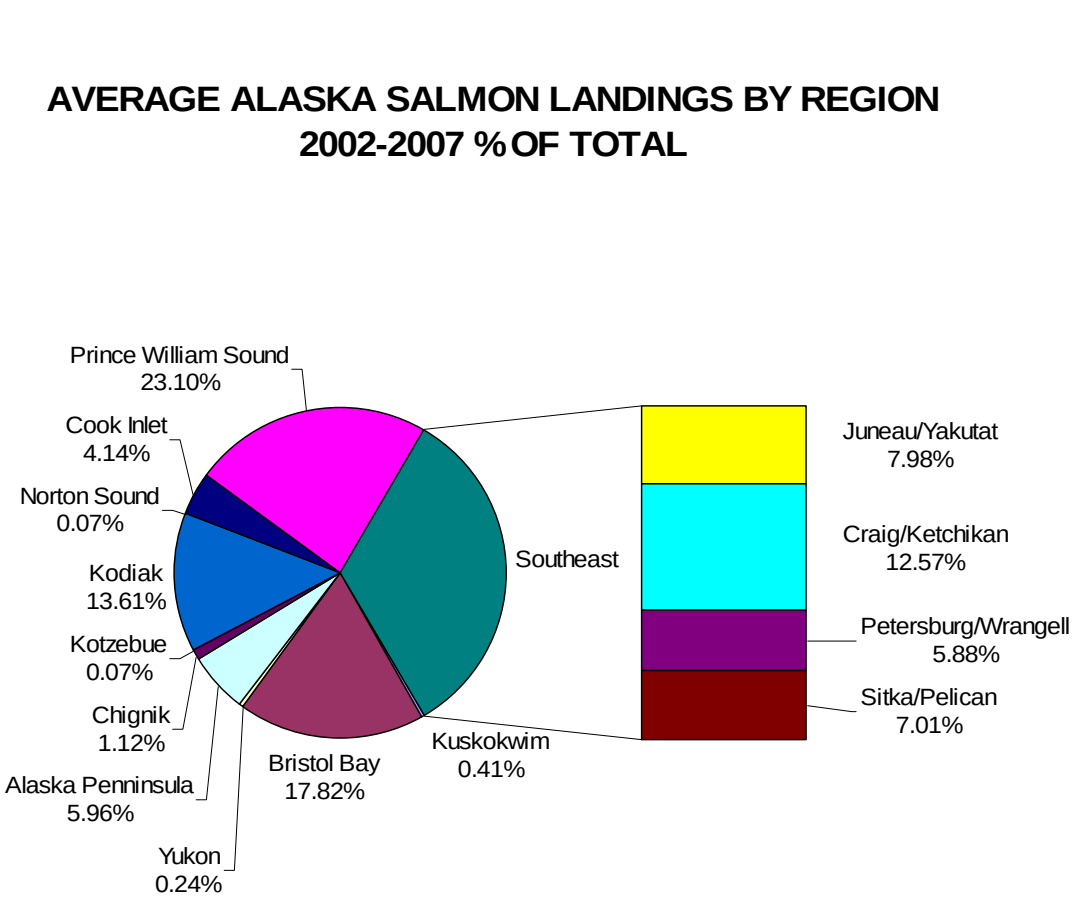


Figure 70 Alaska salmon landings by region with SE Alaska detail.

Data obtained from the Alaska Department of Fish and Game for the period 2002 - 2007 and covering the major Southeast Alaska areas is shown in the following figure.

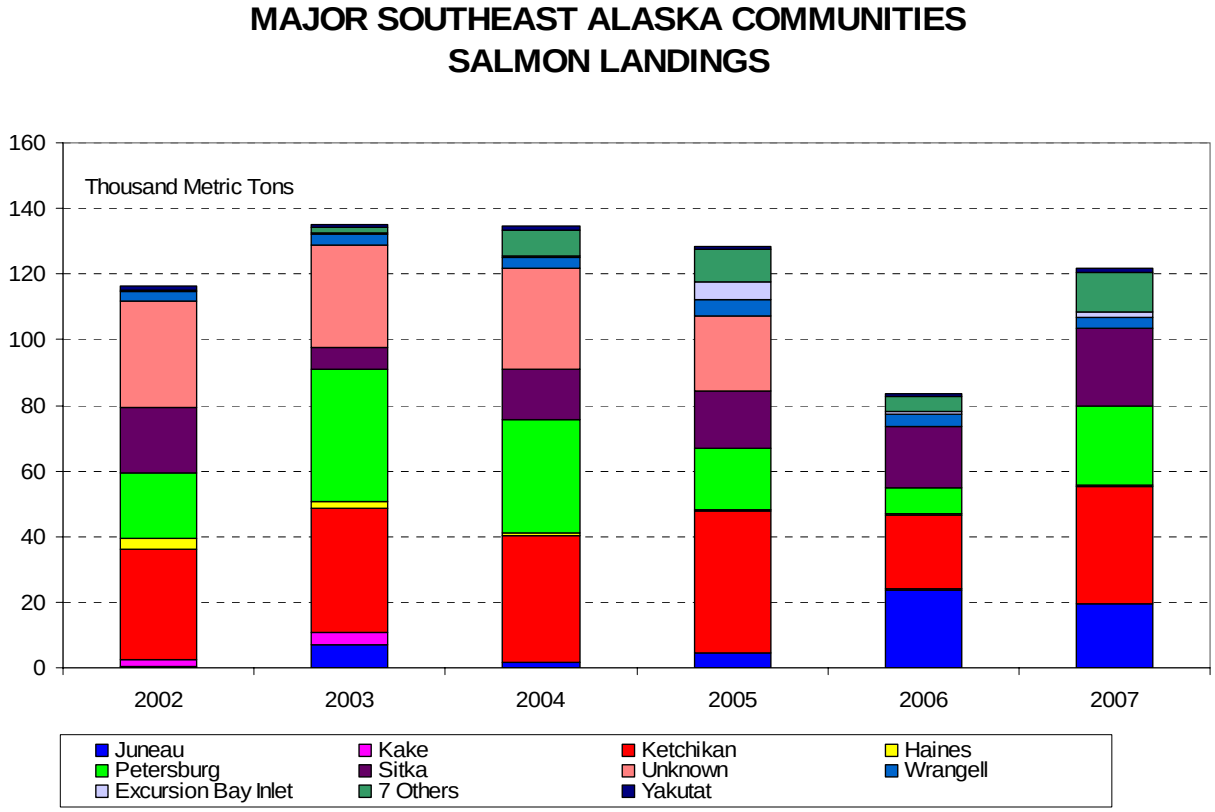


Figure 71 Southeast Alaska community salmon landings.

The following figure lays out the geographical areas where the salmon are landed in Alaska. The figures are an average of 2002 – 2007 expressed in metric tons.

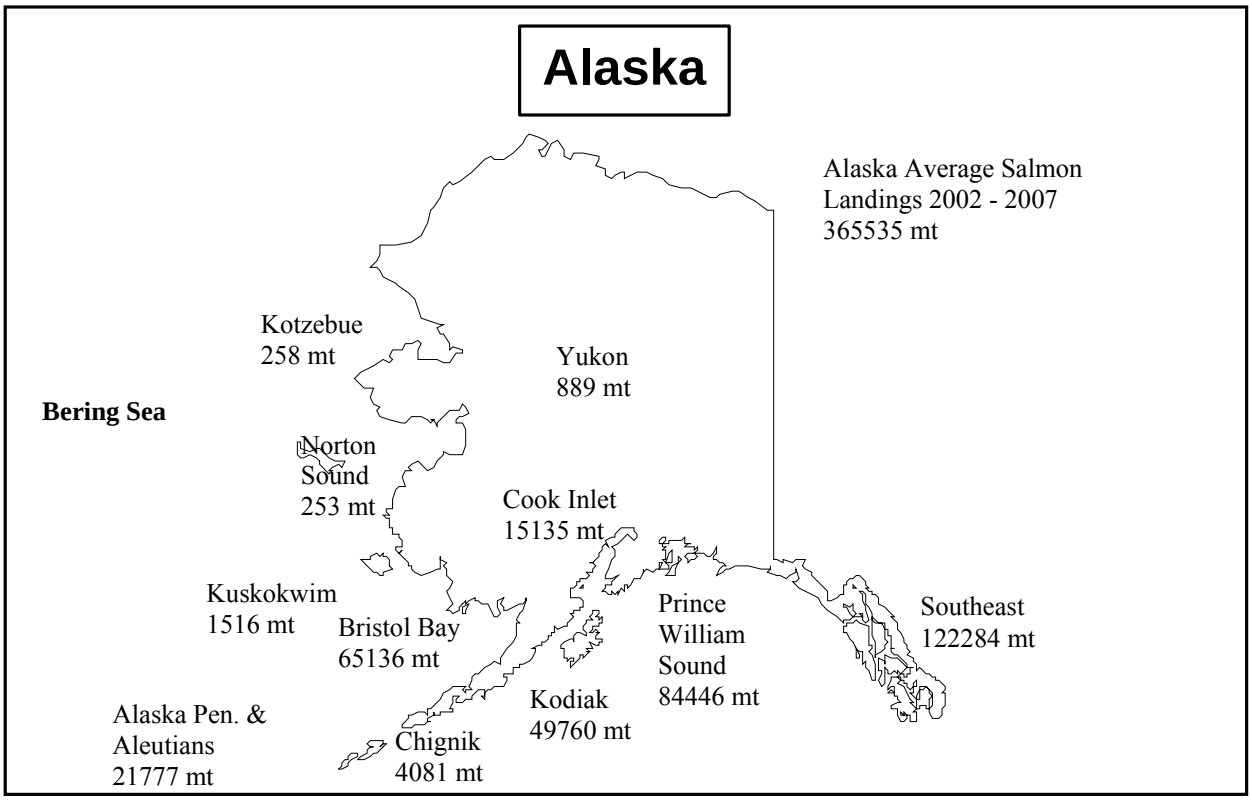


Figure 72 Locations of salmon landings in Alaska.

The following figure breaks out the Alaska Southeast Region salmon landings over the same period of time 2002 – 2007.

SOUTHEAST ALASKA AREAS SALMON LANDINGS

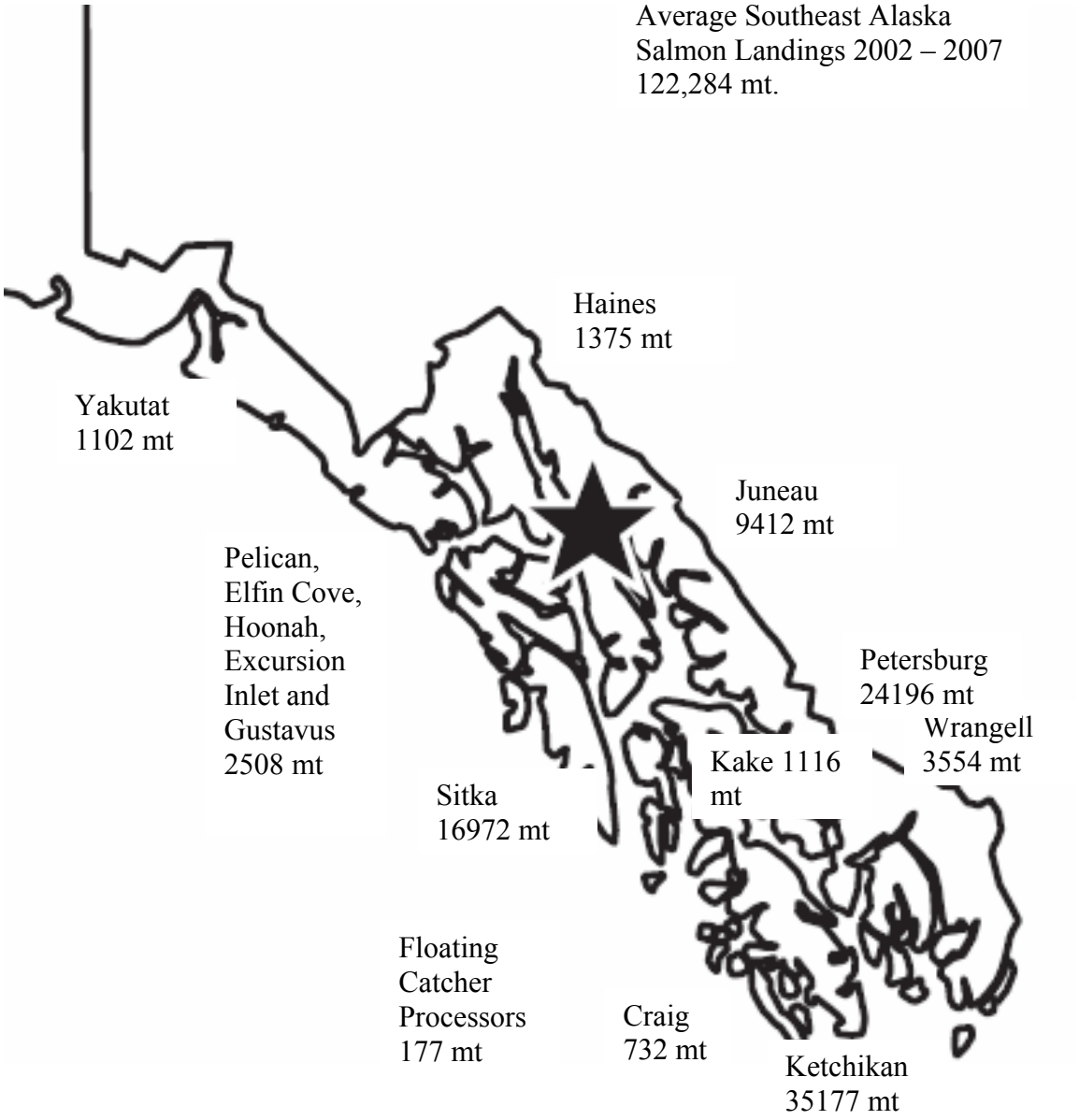


Figure 73 Salmon landings in the southeast area of Alaska.

According to an Alaska Dept. of Economic Development report, approximately 60% of the salmon harvested in Alaska is used for human consumption when the fish is canned, fresh or frozen. The remaining 40% is waste (head, fins, viscera, etc.). If salmon are harvested for roe (e.g. chums) as much as 90% of the fish by weight is waste. In the proceedings of the 2002

Conference on Advances in Seafood Byproducts, Crapo and Bechtel estimated the overall waste from Alaska fish processing at about 53%. Historically the waste products were dumped back into the ocean. A 1988 University of Alaska report on seafood waste indicated that the amount of waste could vary from 31-38% in canning. Data for 2001 from the same group reduces this figure for canning to around 28%. There are many options for utilizing these seafood by-products (wastes) available to the industry. Options that might work in one area will not be economical in another area. Generally, the options span the range from disposal of the seafood waste with no added value achieved (and perhaps a disposal and hauling cost) all the way to the development of high valued biochemical products. When there is sufficient waste in defined areas, the production of fishmeal and oil makes sense because there are existing markets for these products, demand continues to increase from aquaculture and petfoods and the price of the products is currently at an all time high. The fishmeal and oil markets exist in the lower 48 states as well as Canada, Europe and Asia (particularly China). Since the lower 48 states and Canada are importing fishmeal and oil from various places, it would make good sense to look at these markets. However logistics appears to be an issue with freight rates extremely high to move product to the lower 48 states. Perhaps western and central Canada and or the Asian countries would make better sense for these products. Another possibility would be to warehouse these products in Canada and ship by land (rail) to the lower 48 states. There are several groups in Canada who might be interested in high quality wild salmon fish oil.

In areas where the volume of waste is small and would not support the construction of a fishmeal plant, there are other options. For example, a floating processing plant capable of moving with the fish seasons might be an alternative. The fact that the floating catcher processor landings has increased since the last report would seem to bear this out. Other possibilities would include the production of silage products for feed and fertilizer, hydrolyzates for specialty feeds and food applications, composts for fertilizer, soil amendments and soil reclamation areas. Compost products have their own problems. For example, if there is sufficient fish waste to make compost a possibility, there must also be a relatively cheap or free source of vegetable waste material in the form of sawdust, agricultural waste, seaweed, wood chips etc to use with the fish waste. There must also be some agricultural, land reclamation (from mining or petroleum operations for example), re-forestation or landscaping industry in the vicinity to utilize the compost. Composts, hydrolyzates, digests and silage must be market driven since they are either very high in water content (silage) or bulky thus making transportation costs a key factor. Since the last report fuel prices have moved into the stratosphere thus making transportation costs even more critical. People don't want to pay high freight costs to ship water great distances unless the overall delivered price is very cheap. Liquid silages, fish solubles etc. are used as organic fertilizers and have found niche markets for golf courses, the growing of cranberries etc. A 2009 article in the NewsMiner was headlined Alaska Farmers Face Fertilizer Shortage. The article went on to discuss how fertilizer prices in Alaska had increased over 4005 and that many of the agricultural operations might have to shut down. This could offer an outlet for crude silage or compost products. Crude silages and compost do not require a high capital cost and they do utilize all of the waste material. On the other hand hydrolyzates must be further processed to remove bones, oil and insoluble materials before drying. This involves more capital costs, increased energy costs and further disposal issues with the residual by-products.

Crude silage and hydrolyzates offer some unique possibilities. While the salmon waste is spread out over a large area of Alaska including the Southeast Region it might be possible to set up small scale digestion and stabilization facilities near the waste generating facilities. The liquefied product could be stored in tanks and then routinely transported by land or sea to a central processing facility where the oil and water can be removed in a more continuous and commercial scale operation. The acid in the silage will preserve it for some time. Something similar to this is done in the area stretching from the Shetland Islands to Norway. Tank stations were set up at various points along this area and a collector vessel makes a routine trip to collect the crude stabilized silage. This is transported back to Norway where a central facility extracts the oil and finishes the processing. About 40,000 tons of raw silage is processed with finished products shipped to Norway, Finland, Denmark, France and Holland. A similar co-op set up could be put in place in Alaska as well but this must be market driven.

In producing this report I came across a company in Scotland who manufactures self-contained, portable silage plants of various sizes that can be moved from place to place. They even have a plant on a skid which can be used for emergency processing of a large volume of mortalities from aquaculture operations. Further information will appear later in this report.

In addition to the logistical problems, the fishing season in Alaska is short while the catch volume and waste is large during that short season. This presents problems with the magnitude of scale for a processing facility as well as stabilization and preservation of the raw material (waste). The data obtained from AFGD indicates a relatively narrow salmon season even when combining all statistical regions. The following figures compare the catch of salmon over time for the main Statistical regions of Alaska.

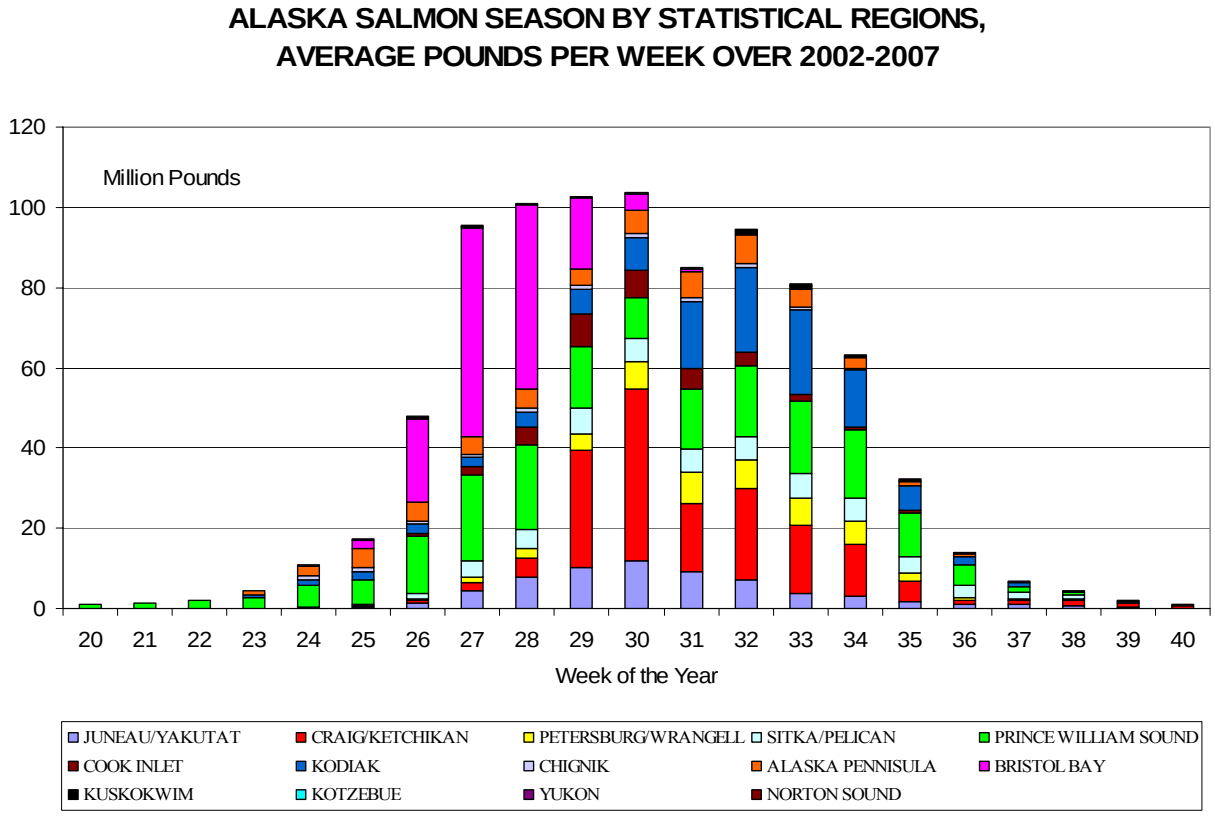


Figure 74 Seasonal landings for Alaska salmon by region.

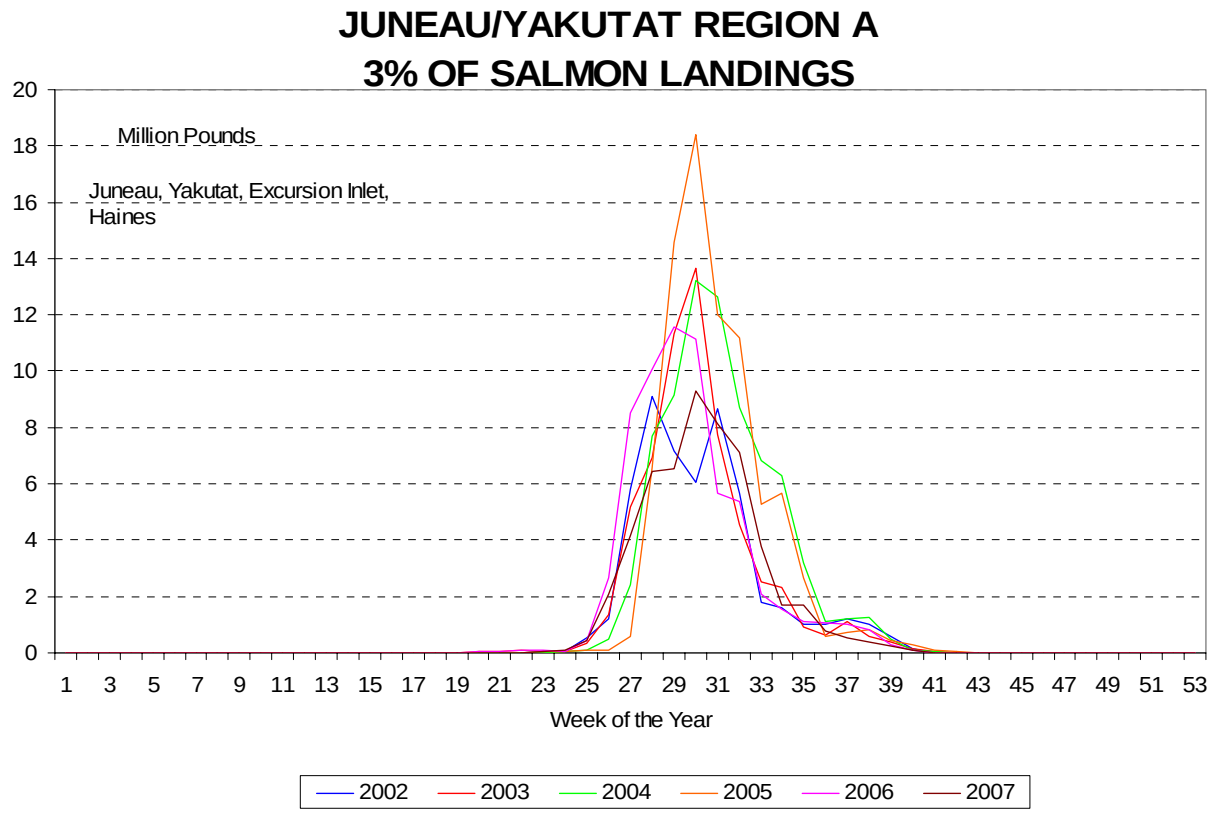


Figure 75 Region A Juneau/Yakutat landings by week.

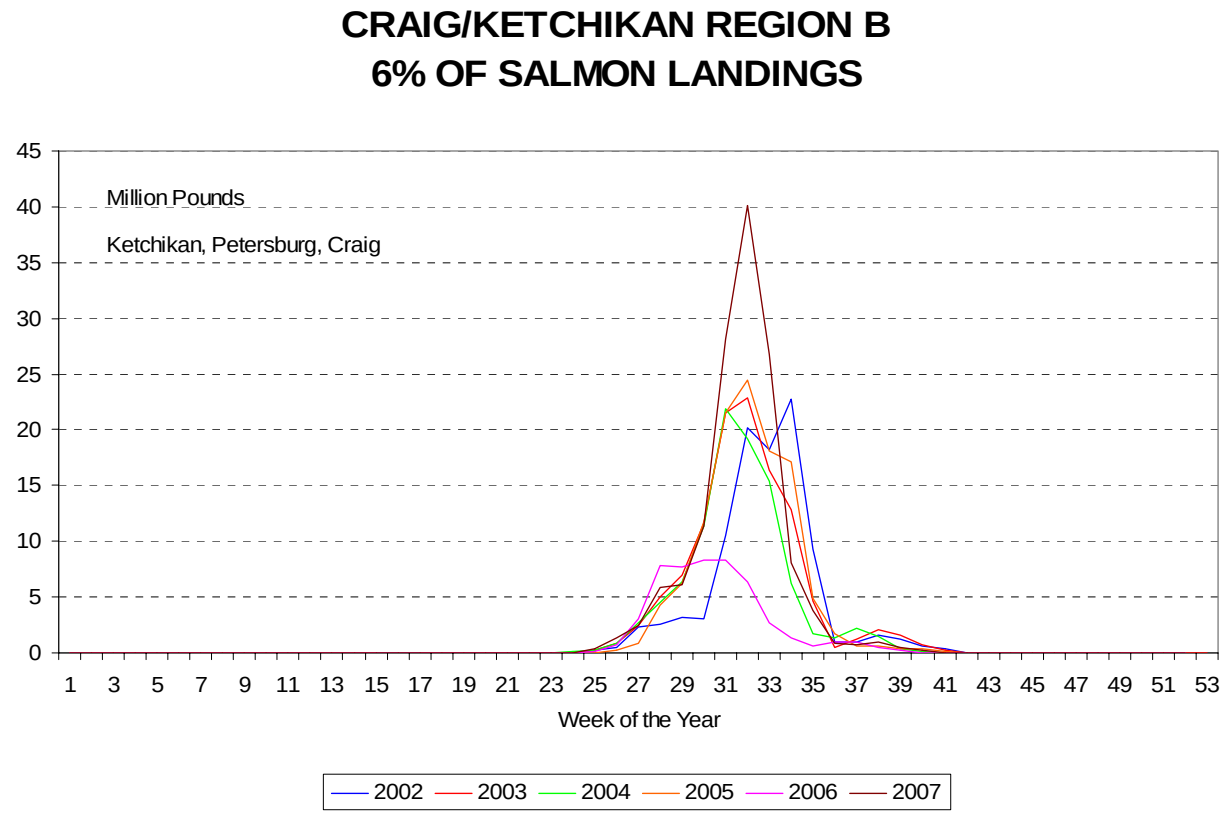


Figure 76 Region B Craig/Ketchikan landings by week.

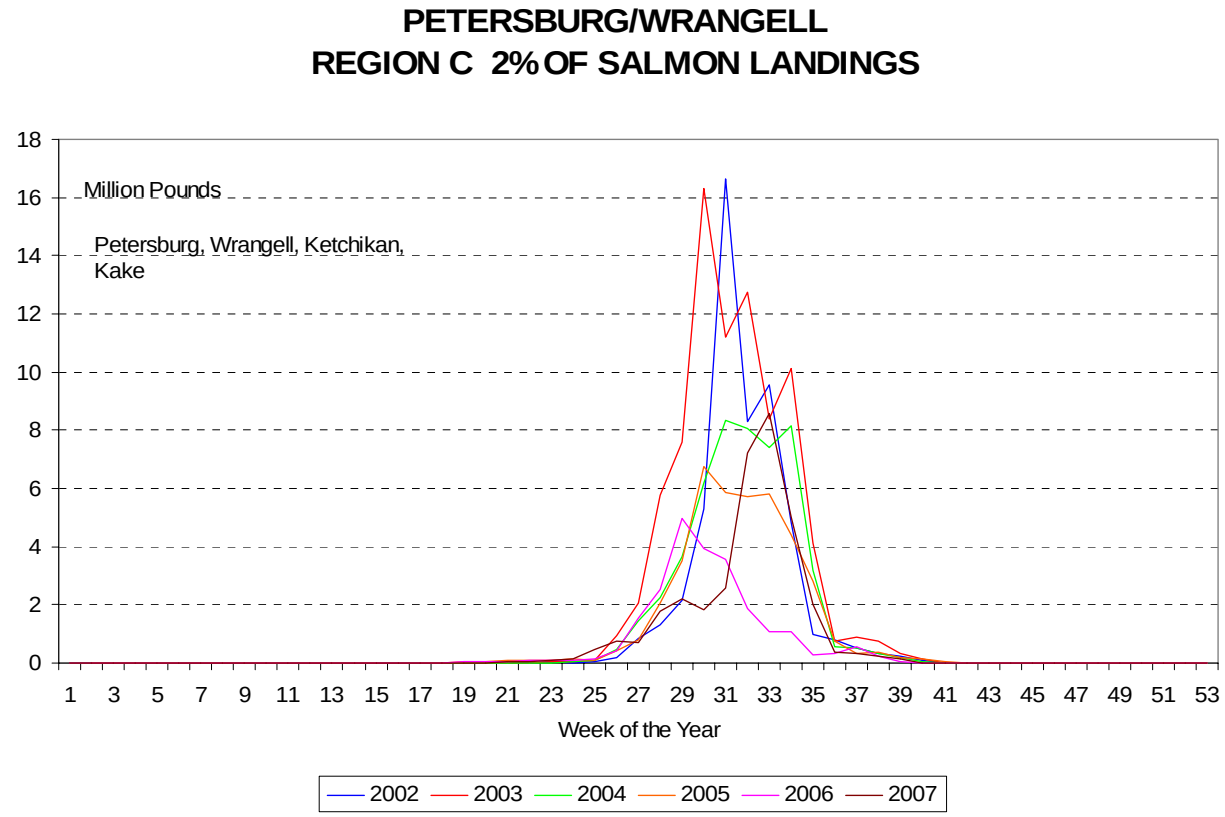


Figure 77 Region C Petersburg/Wrangell landings by week.

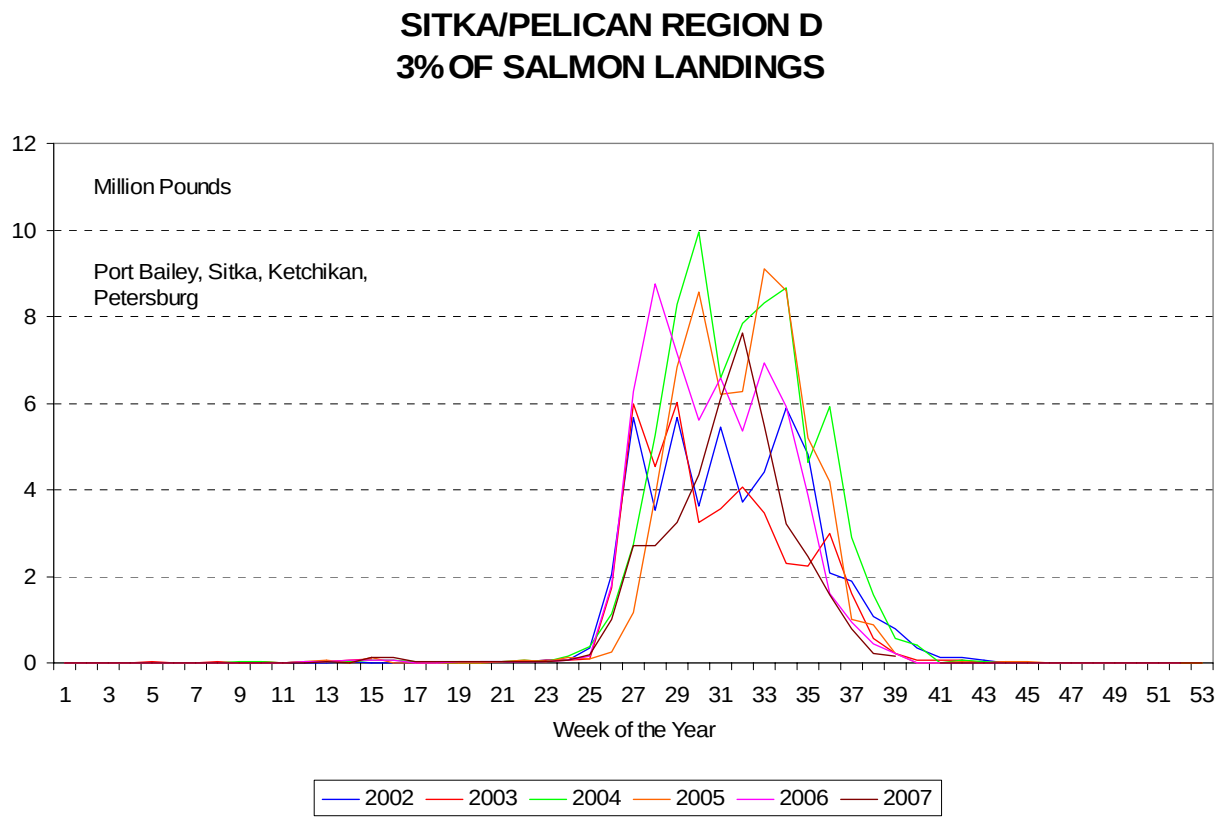


Figure 78 Region D Sitka/Pelican landings by week.

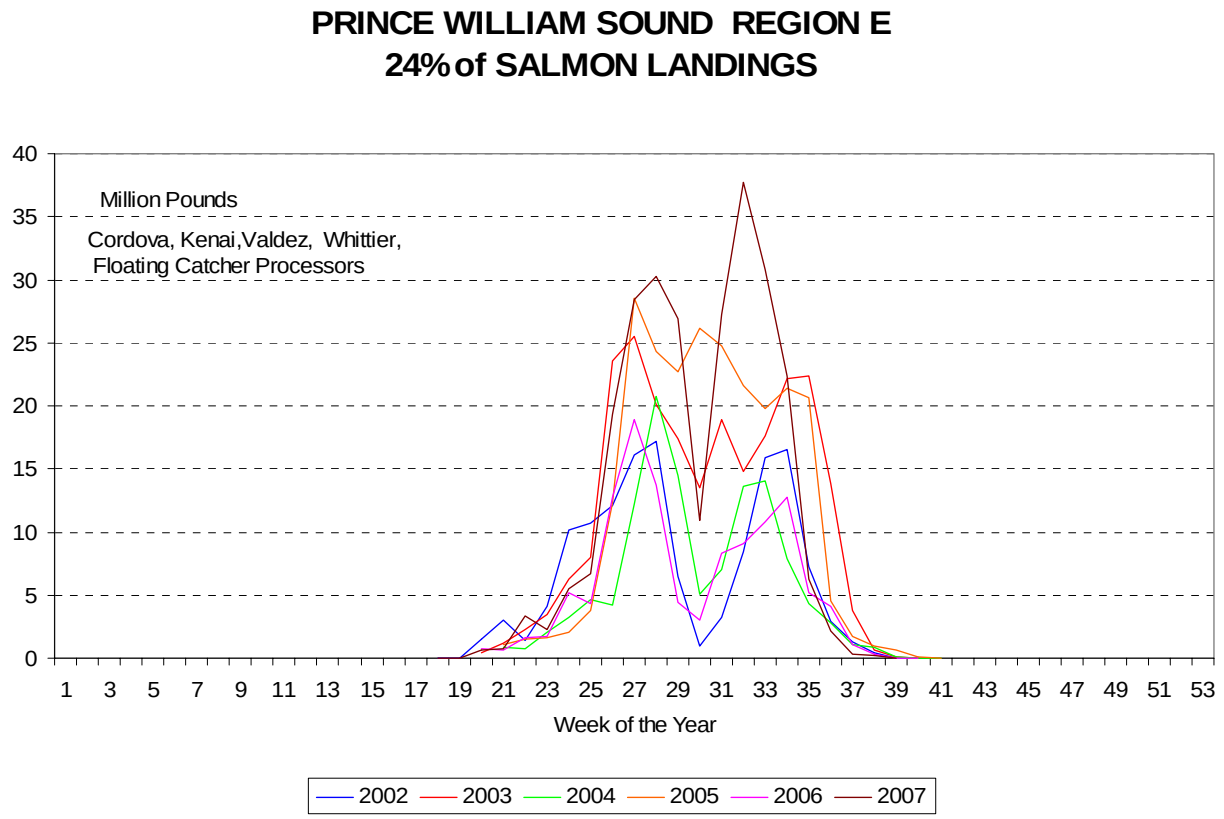


Figure 79 Region E Prince William Sound landings by week.

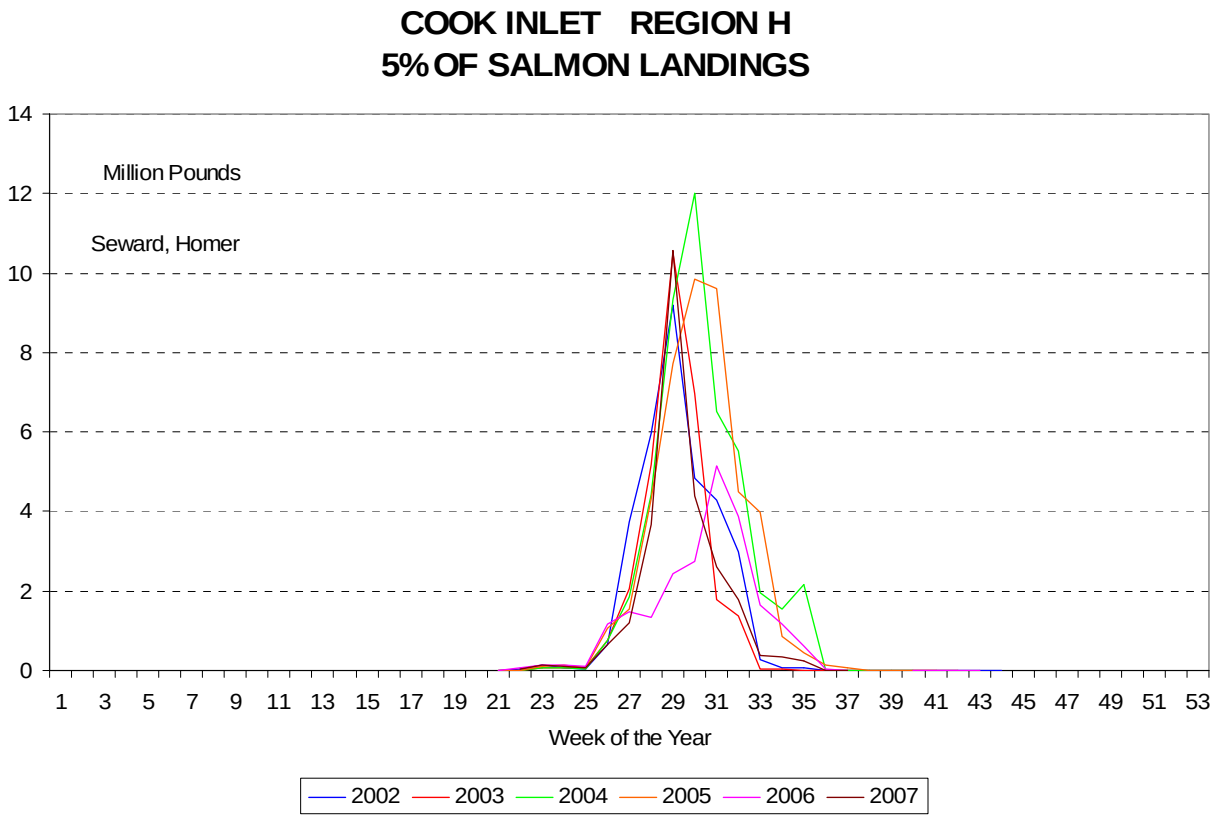


Figure 80 Region H Cook Inlet landings by week.

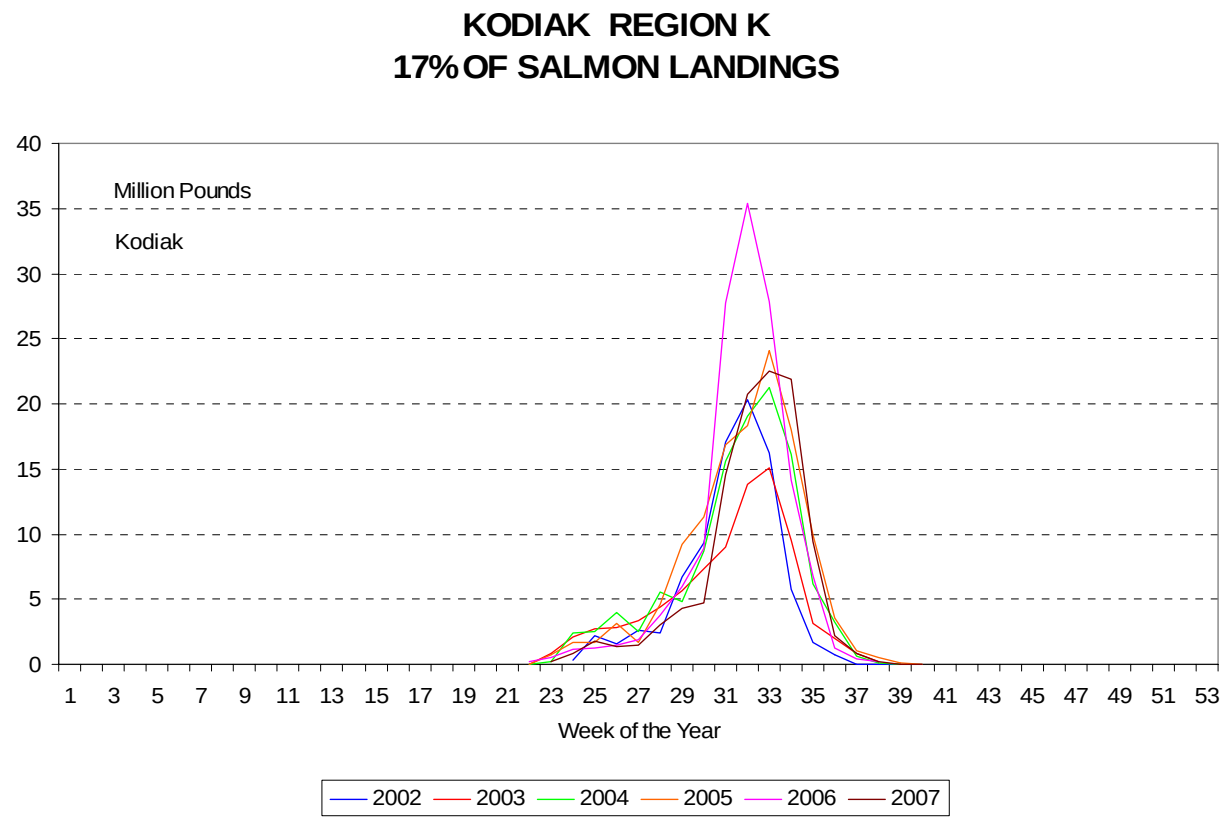


Figure 81 Region K Kodiak landings by week.

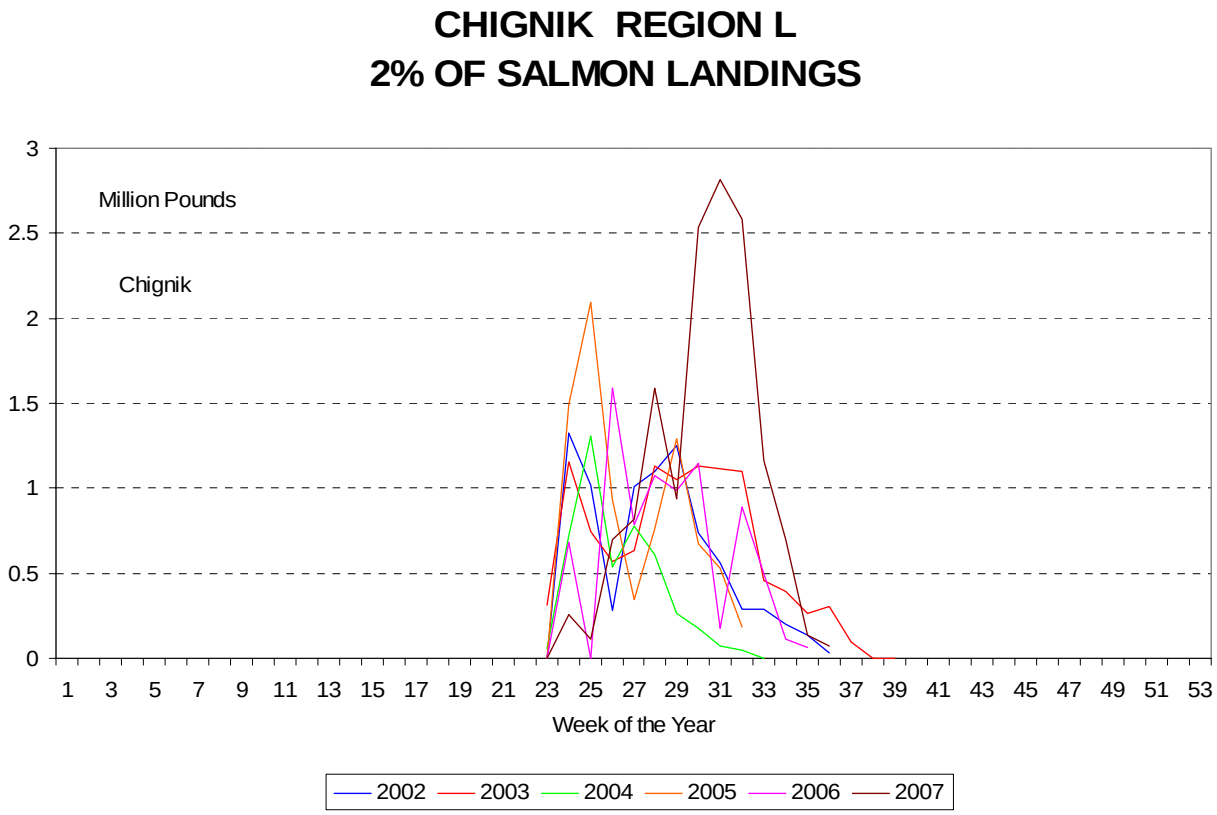


Figure 82 Region L Chignik landings by week.

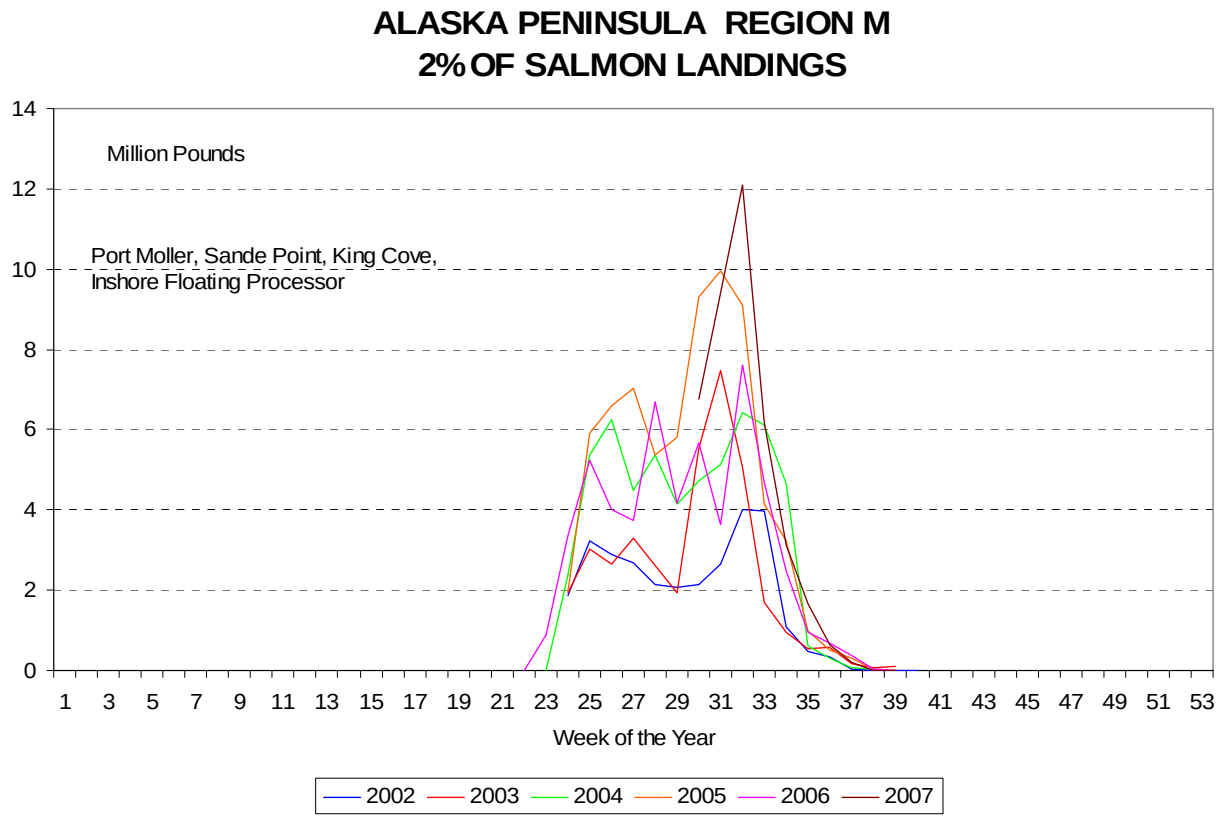


Figure 83 Region M Alaska Peninsula landings by week.

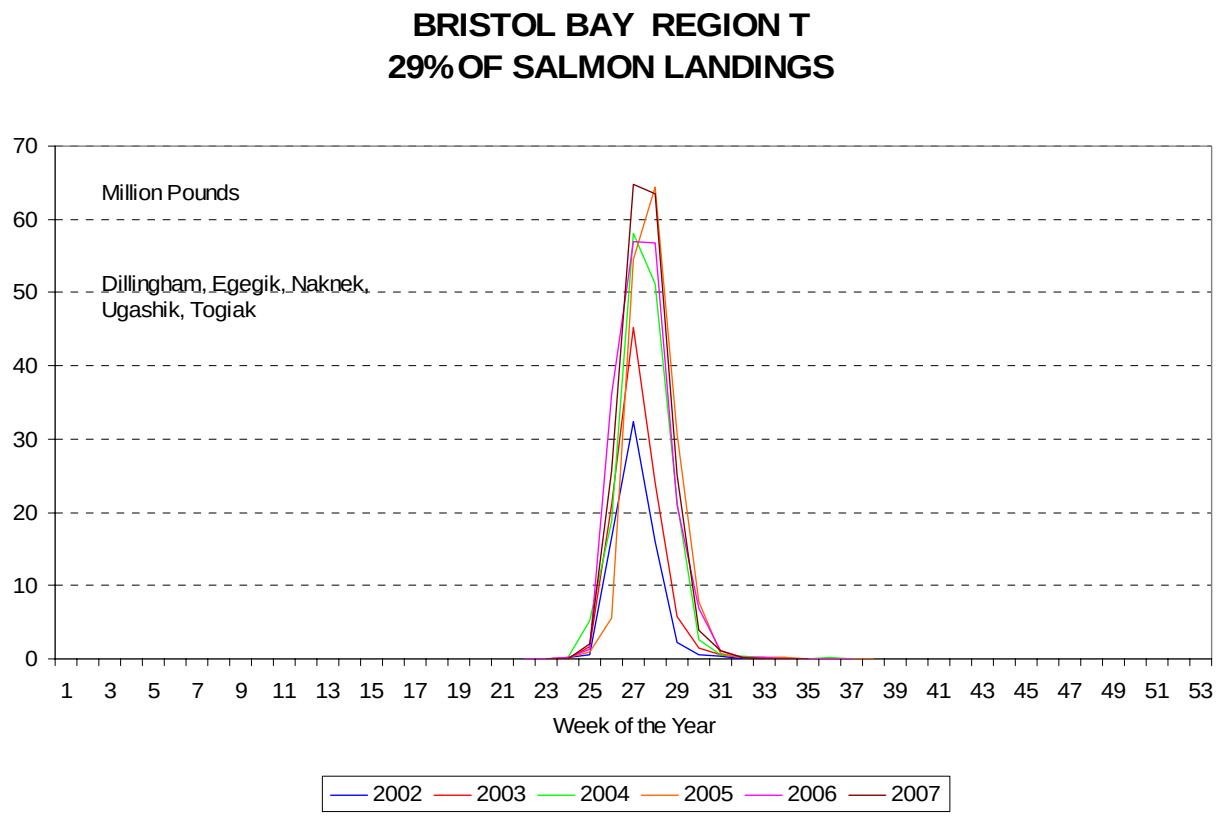


Figure 84 Region T Bristol Bay landings by week.

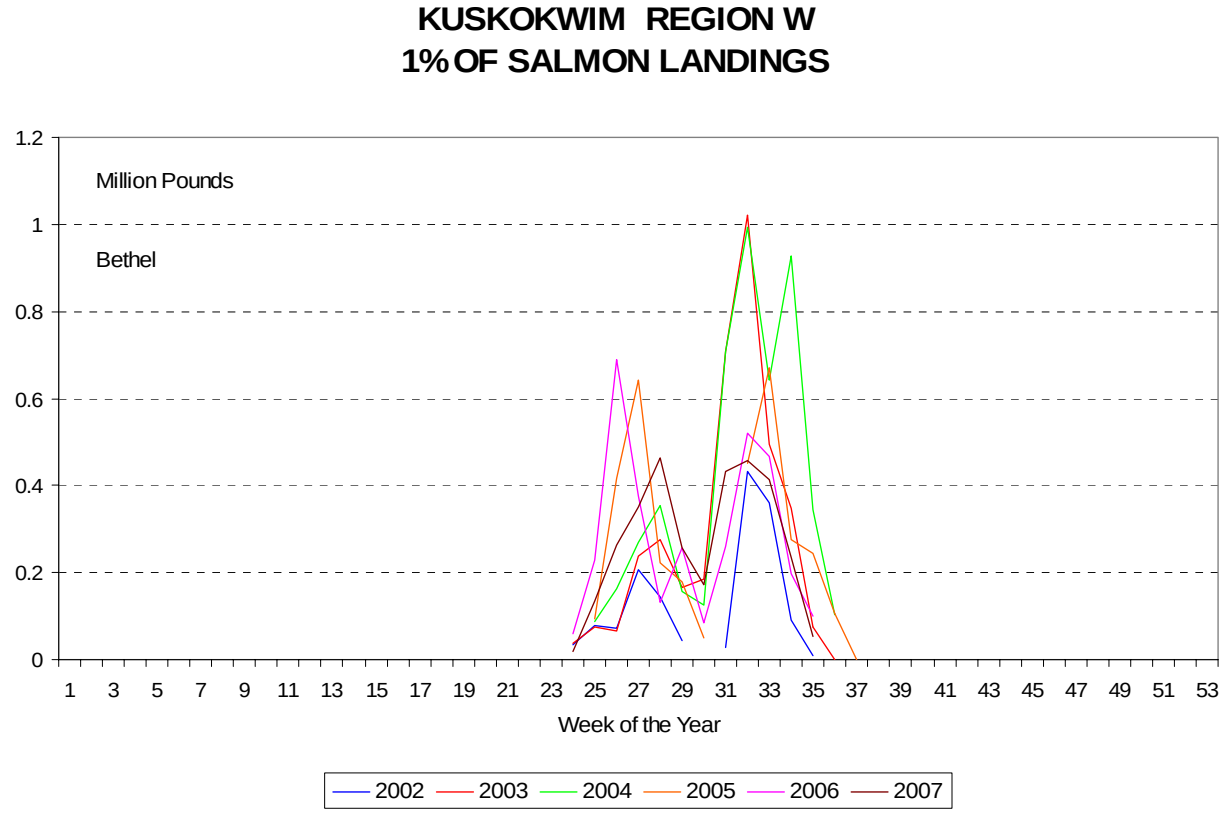


Figure 85 Region W Kuskokwim landings by week.

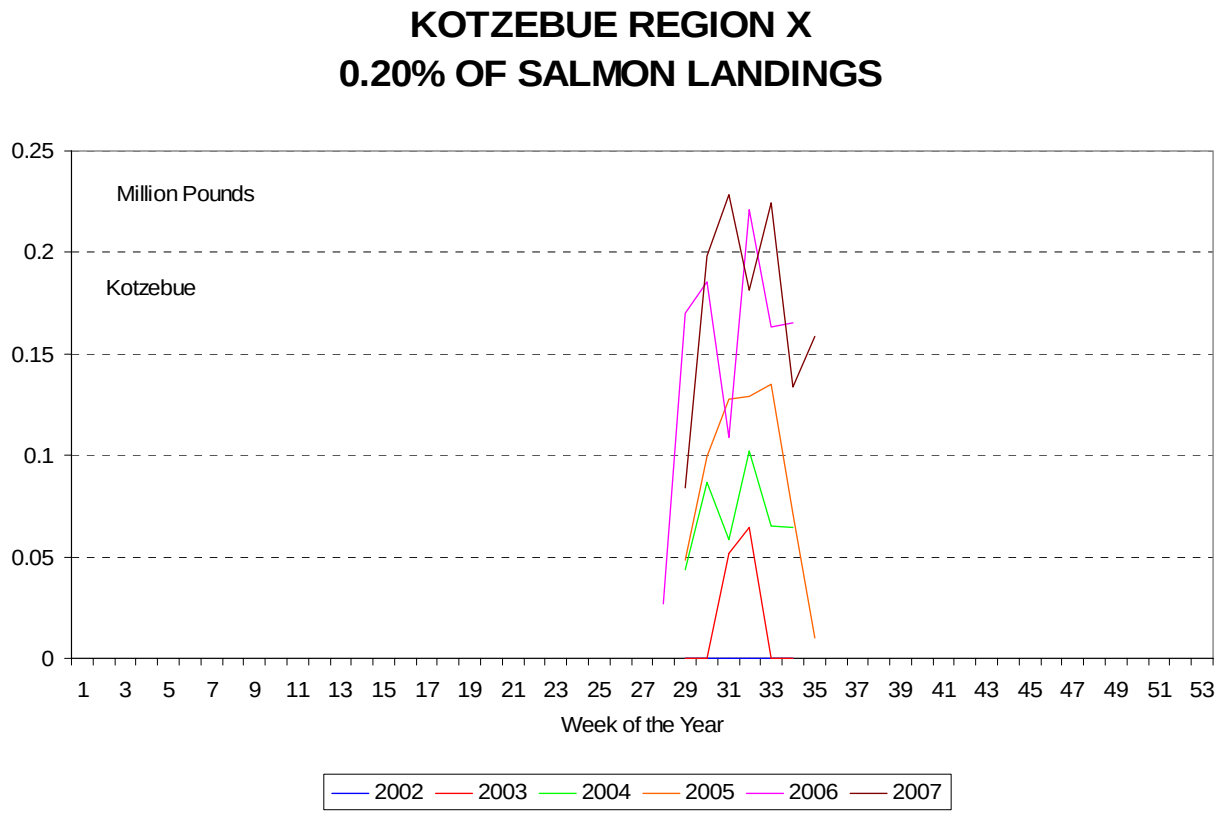


Figure 86 Region X Kotzebue landings by week.

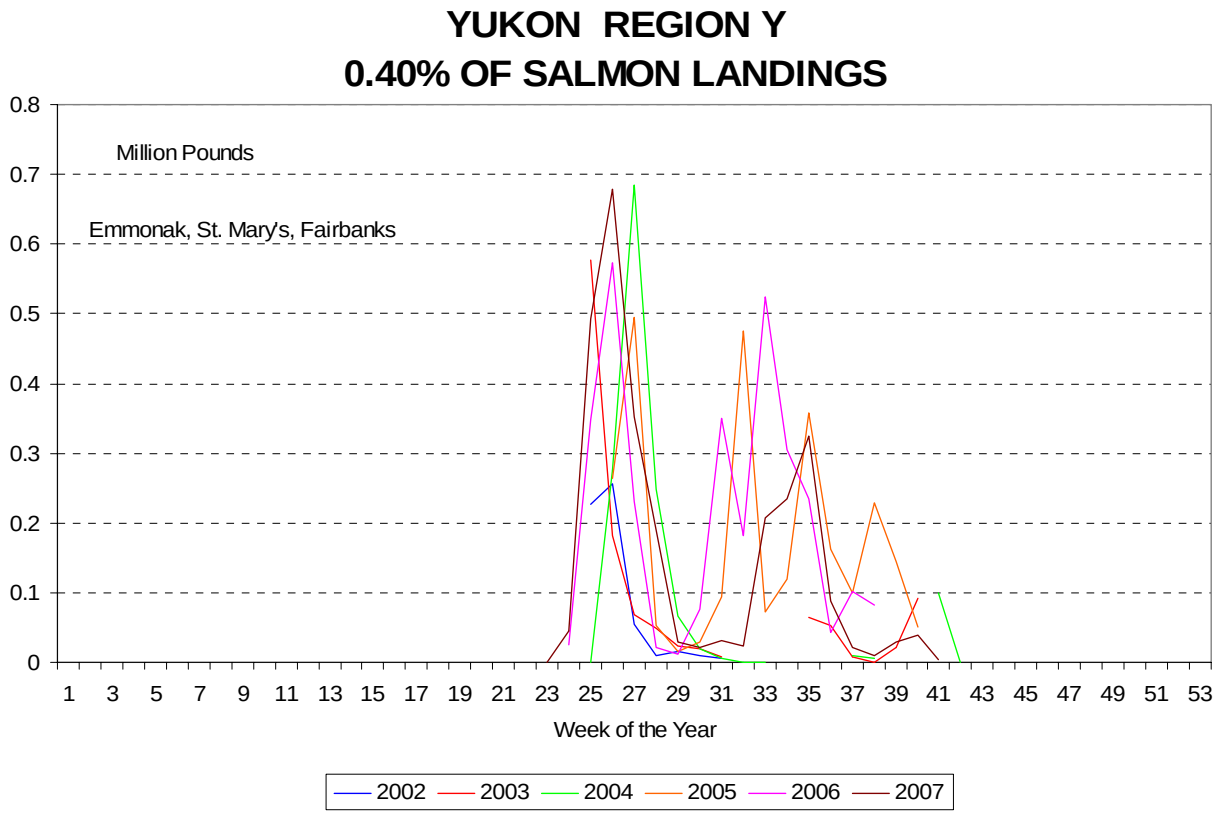


Figure 87 Region Y Yukon landings by week.

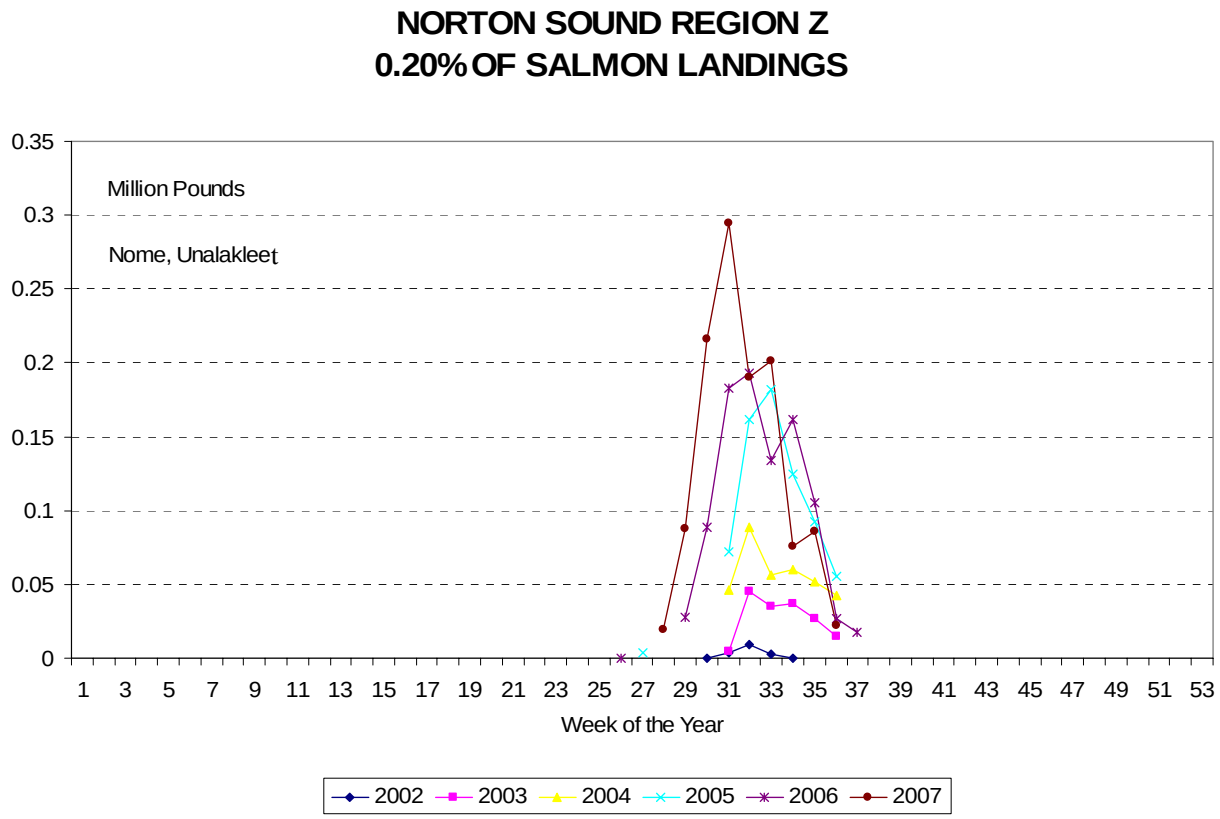


Figure 88 Region Z Norton Sound landings by week.

The options for processing the by-products depend upon the individual circumstances of the facility generating the by-products and the potential availability of combining by-products from different locations to "extend" the processing season and the plant capacity. A list of all or most of the major options available to seafood processors is shown in the following figure.

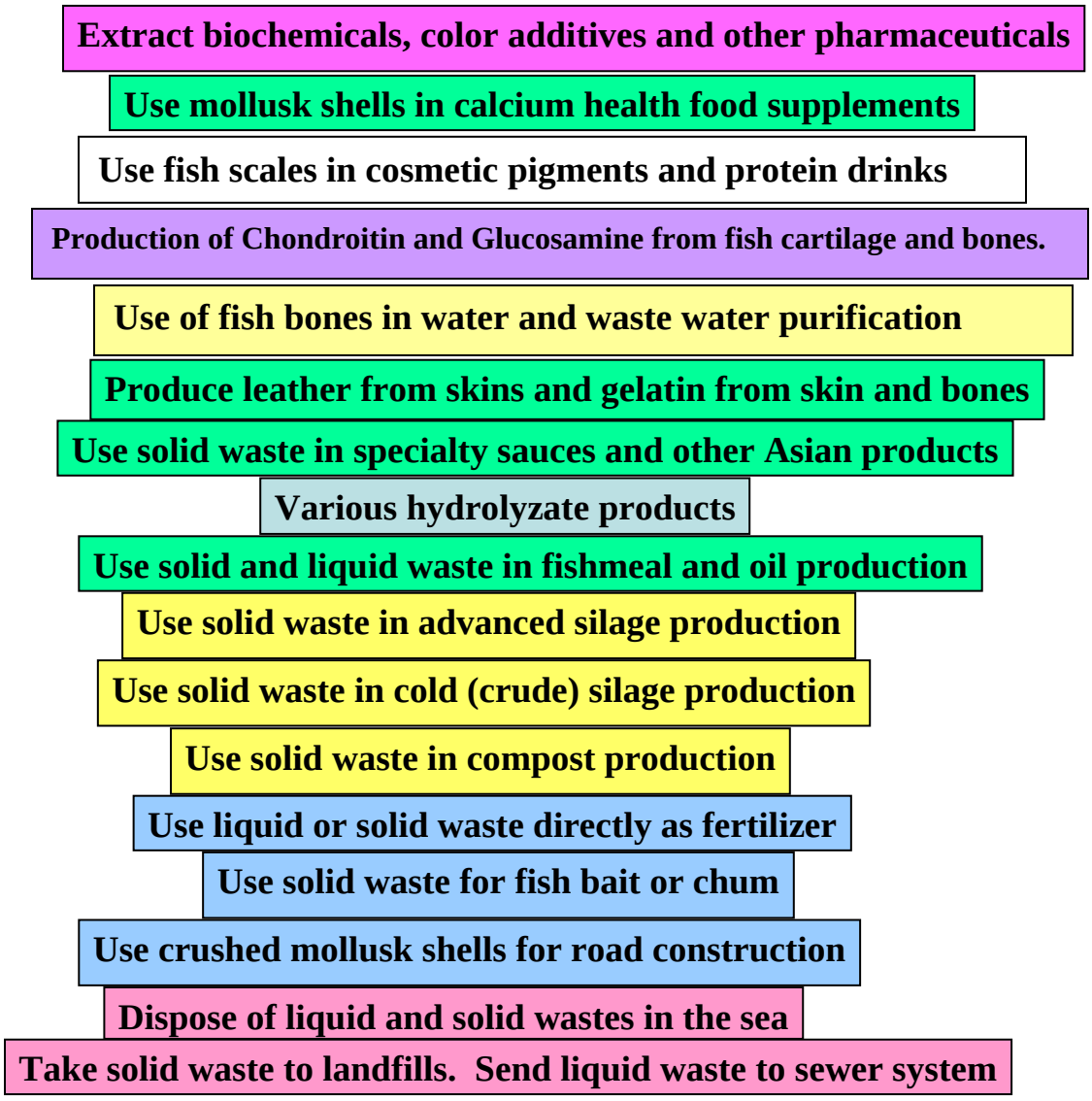


Figure 89 Options for utilizing seafood wastes.

It is this writer's experience with fisheries in South America, the Indian Ocean Island Nations, and the lower 48 States that companies tend to move towards the lower two options since they

require no investment and generate no penalties or consequences. The move towards the upper options only occurs when the penalties or consequences of the lower options force the generators of the byproducts and waste to consider the upper options. OR the cost of disposal tips the balance upwards, if only to break even. This is or has been happening globally for a very long time. One consideration when evaluating the options is to ask yourself :

"WHAT IF I WAS TOLD THAT STARTING NEXT WEEK OR NEXT MONTH I CAN NO LONGER DISCHARGE THE WASTE OVERBOARD OR AT SEA. DO I HAVE ANY VIABLE OPTIONS?"

Unfortunately, when that point is reached, it is too late to evaluate alternatives. With the new Administration taking over the 3 branches of Government there might be more pressure on the EPA to expand regulations to protect the pristine environment in the Arctic. The Peruvian industry never considered that the Government would force them to stop discharging their waste products until the "Environment Police" showed up with warrants and closed a number of plants down.

Alaska Fishmeal And Oil Production

It is difficult to quantify the Alaska fishmeal and oil production since the fisheries are divided between State and Federal jurisdictions and so there are different databases. The State of Alaska Fish and Game Department database does contain data for fishmeal and oil produced from pollock and cod and Yellowfin sole (meal), and pollock, cod and sockeye salmon (oil). However there is no data available on the production of salmon meal. The Federal statistics group all sources of fishmeal and oil together. Others reporting on the Alaska byproduct situation have had similar problems and everyone therefore estimates the figures. For this report we have compared the Alaska Fish and Game Dept. data with NMFS/ NOAA data for exports of fishmeal and oil from 3 West Coast Ports; Anchorage AK, Seattle WA and Portland OR. The assumption is that meal and oil will either be exported from Anchorage or shipped to Seattle or Portland and then either exported from there or sold domestically into the lower 48 states and Canada. If the meal is consumed domestically then it will not show up on the exports

The following figures show the ADFG data for production and the NMFS/NOAA data for exports.

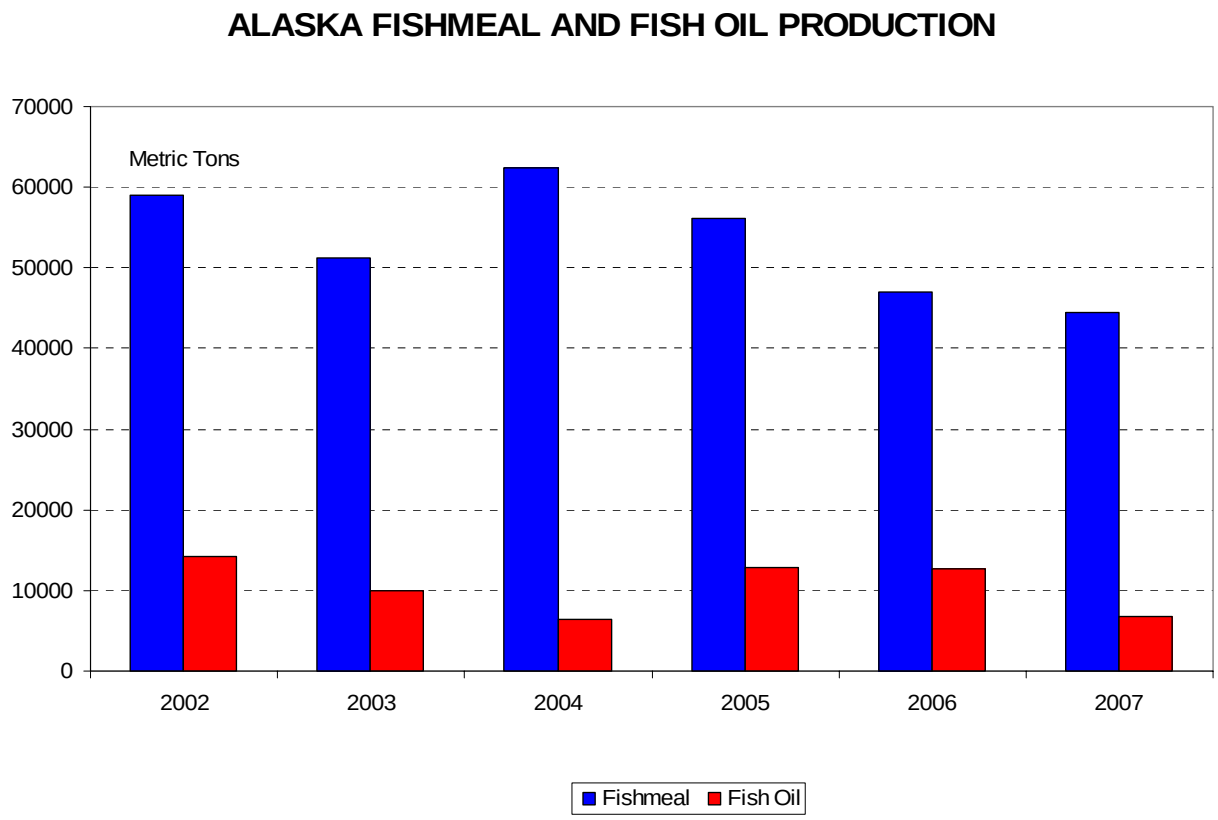


Figure 90 Alaska fishmeal and fish oil production from ADFG.

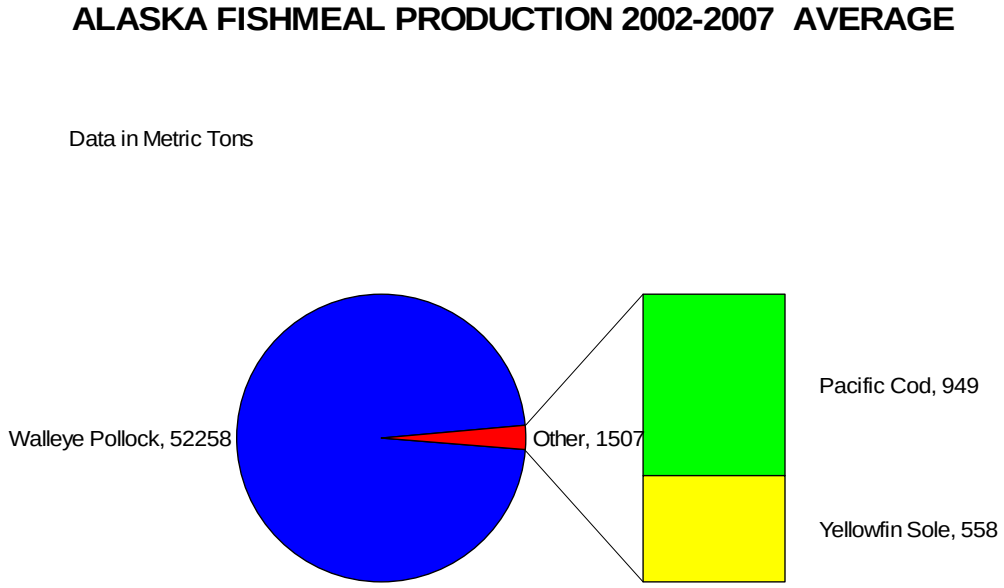


Figure 91 Alaska fishmeal production by species from ADFG.

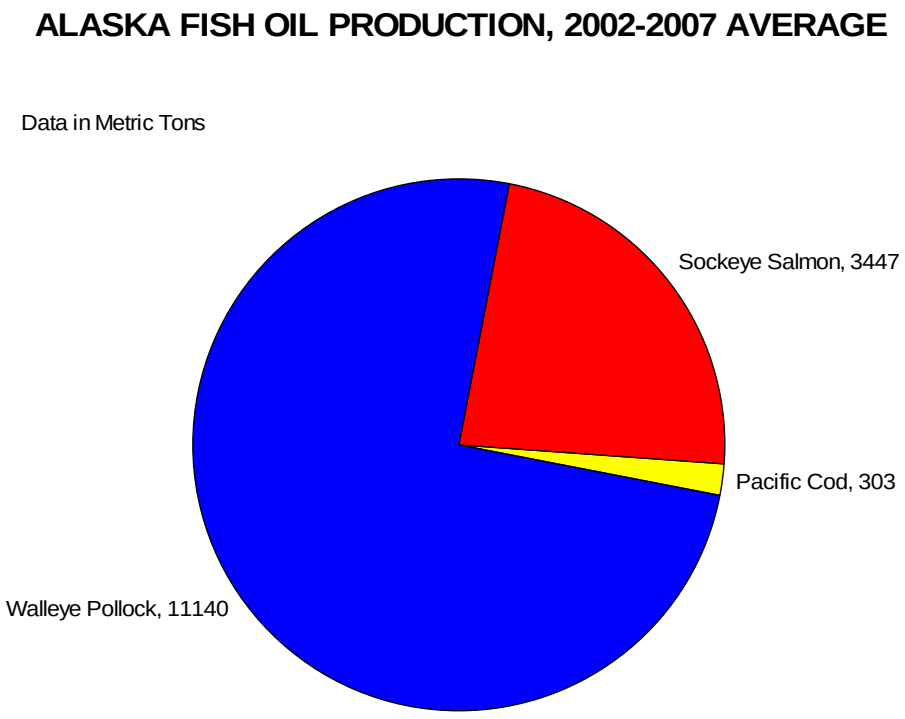


Figure 92 Alaska fish oil production by species from ADFG.

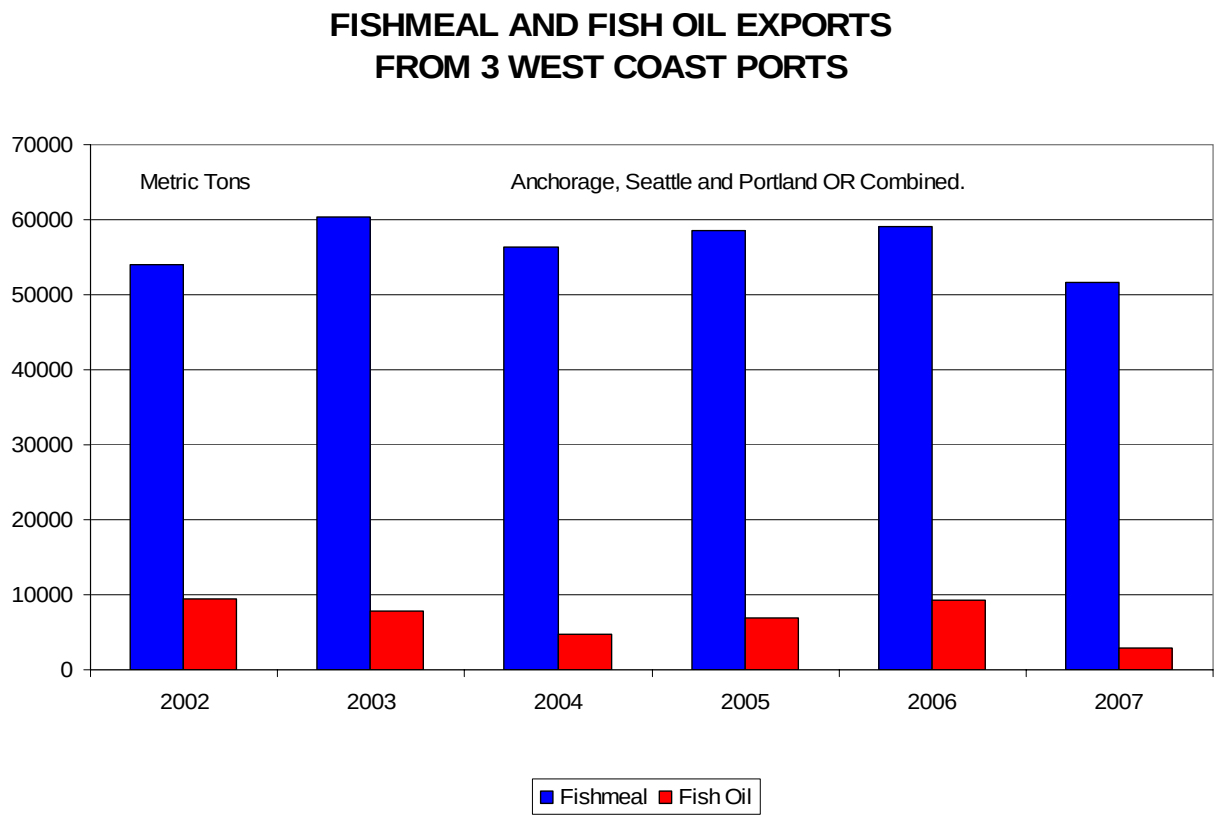


Figure 93 Estimated Alaska fishmeal and fish oil exports by port from NOAA NMFS.

Utilizing catch data in Alaska can get very confusing since landing data does not necessarily convert into consumption data. Fish are landed and then in some cases transported to other locations for processing. In order to convert landings to potential by-product or waste it is important to know how the fish were processed in each location since the % waste could vary considerably. For the purpose of this report as was done in the previous report , we have used an estimated figure of 46% as the amount of waste that will be generated in each area and an estimated ratio of 5:1 for conversion of waste to fishmeal, and an estimated fish oil yield of 2%. If we apply these conversions to the total landings for Alaska and use a conservative 5 year average value for fishmeal and oil delivered to Europe minus US$100 for freight and then the most recent value of fishmeal and oil we come up with the estimates that appear in the following table.

These should be considered as baseline estimates of what might have been if facilities had been in place to handle the waste. So these figures can be compared to what actually is the present situation in Alaska. All species are included, that is shellfish as well as fish so the figures might seem high, but the waste calculations and value calculations are very conservative.

STATE OF ALASKA WASTE CALCULATIONS USING 5 YEAR AVERAGE LANDING DATA ALL SPECIES								
	Landings all species Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
2000	2025759	931849	186370	$80,511,840	$67,652,310	18637	$ 6,690,683	$ 4,193,325
2001	2284468	1050855	210171	$86,590,452	$99,410,883	21017	$ 7,566,120	$10,466,466
2002	2298042	1057099	211420	$87,105,040	$77,802,560	21142	$10,317,296	$ 9,725,320
2003	2406768	1107113	221423	$89,012,046	$74,176,705	22142	$12,310,952	$10,517,450
2004	2428850	1117271	223454	$101,224,662	$91,392,686	22345	$12,379,130	$13,563,415
2005	2563416	1179171	235834	$120,747,008	$117,917,000	23583	$17,734,416	$15,234,618
2006	2459069	1131172	226234	$146,599,632	$128,727,146	22623	$26,152,188	$16,288,560
2007	2410751	1108945	221789	$169,003,218	$145,271,795	22179	$21,912,852	$30,229,977
[1] 5 Year Running Average Oil World Fishmeal Price C&F Hamburg/Bremen less US$100 for freight for that year.								
[2] The December 31 Oil World Fishmeal Price C&F Hamburg/Bremen less US$100 for freight for that year.								
[3]5 Year running average Oil World fish oil price CIF Rotterdam less US$100 for freight for that year.								
[4] The December 31 Oil World fish oil price CIF Rotterdam less US$100 for freight for that year.								

Table 164 Estimated Alaska fish waste converted to fishmeal and oil.

Based on the above average for fishmeal production over the period 2000-2007 the theoretical average fishmeal production for Alaska would be in the 217,000 ton range. Based on the data available from the State of Alaska statistics and the amount of fishmeal exported ranged from 50,000 – 60,000 tons or a difference of 157,000 tons. We don't know how much of the Alaska fishmeal is sold domestically but it will not come close to the 157,000 tons so we can assume quite a lot of raw material is discarded.

The following tables outline these same calculations for the various communities within the statistical regions of Alaska.

The purpose of these calculations is to give the reader and possible investor some indication of where in Alaska it would be advantageous to incorporate some processing. Obviously there will be locations where it is just not possible to include a fishmeal operation but there are other possibilities available. For example, crude hydrolyzate could be produced in these other locations and shipped to a central facility for deoiling, concentration and drying.

JUNEAU/YAKUTAT REGION A WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings, Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Haines	1360	626	125	$108,250	$110,500	13	$11,141	$11,700
Hoonah	841	387	77	$66,682	$68,068	8	$6,856	$7,200
Excursion Inlet	1973	908	182	$157,612	$160,888	18	$15,426	$16,200
Petersburg	672	309	62	$53,692	$54,808	6	$5,142	$5,400
Sitka	493	227	45	$38,970	$39,780	5	$4,285	$4,500
Juneau	8600	3956	791	$685,006	$699,244	79	$67,703	$71,100
Unknown	22283	10250	2050	$1,775,300	$1,812,200	205	$175,685	$184,500
Yakutat	1102	507	101	$87,466	$89,284	10	$8,570	$9,000
Region Total	30011	13805	2761	$2,391,026	$2,440,724	276	$236,532	$248,400
[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866								
[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884								
[3]5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857								
[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900								

Table 165 Estimated Region A (Juneau/Yakutat) salmon waste converted to fishmeal and oil

CRAIG/KETCHIKAN REGION B WASTE CALCULATIONS FOR SALMON USING 5YEAR AVERAGE LANDING DATA								
	Salmon Landings, Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Craig	946	435	87	$75,342	$76,908	9	$7,713	$8,100
Floating Domestic Mothership	305	141	28	$24,248	$24,752	3	$2,571	$2,700
Ketchikan	30188	13886	2777	$2,404,882	$2,454,868	278	$238,246	$250,200
Metlakatia	1296	596	119	$103,054	$105,196	12	$10,284	$10,800
Petersburg	6906	3177	635	$549,910	$561,340	64	$54,848	$57,600
Prudhoe Bay	1496	688	138	$119,508	$121,992	14	$11,998	$12,600
Seattle	2204	1014	203	$175,798	$179,452	20	$17,140	$18,000
Sitka	918	422	84	$72,744	$74,256	8	$6,856	$7,200
Unknown	6022	2770	554	$479,764	$489,736	55	$47,135	$49,500
Wrangell	787	362	72	$62,352	$63,648	7	$5,999	$6,300
Excursion Bay	261	120	24	$20,784	$21,216	2	$1,714	$1,800
Region Total	45966	21144	4229	$3,662,314	$3,738,436	423	$362,511	$380,700

[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866

[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884

[3] 5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957 - $100 = $857

[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900

Table 166 Estimated Region B (Craig/Ketchikan) salmon waste converted to fishmeal and oil.

REGION C PETERSBURG/WRANGELL WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings, Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Kake	1008	464	93	$80,538	$82,212	9	$7,713	$8,100
Ketchikan	3565	1640	328	$284,048	$289,952	33	$28,281	$29,700
Petersburg	13638	6274	1255	$1,086,830	$1,109,420	125	$107,125	$112,500
Seattle	349	161	32	$27,712	$28,288	3	$2,571	$2,700
Sitka	403	185	37	$32,042	$32,708	4	$3,428	$3,600
Unknown	916	422	84	$72,744	$74,256	8	$6,856	$7,200
Wrangell	2090	961	192	$166,272	$169,728	19	$16,283	$17,100
Region Total	21511	9895	1979	$1,713,814	$1,749,436	198	$169,686	$178,200
[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866								
[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884								
[3]5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857								
[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900								

Table 167 Estimated Region C (Petersburg/Wrangell) salmon waste converted to fishmeal and oil.

Note: When you combine the Petersburg Region B with Petersburg Region C waste the figure becomes more significant.

REGION D SITKA/PELICAN WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings, Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Hoonah	290	133	27	$23,382	$23,868	3	$2,571	$2,700
Juneau	849	390	78	$67,548	$68,952	8	$6,856	$7,200
Kake	322	148	30	$25,980	$26,520	3	$2,571	$2,700
Ketchikan	1573	724	145	$125,570	$128,180	14	$11,998	$12,600
Petersburg	3161	1454	291	$252,006	$257,244	29	$24,853	$26,100
Port Bailey	6656	3062	612	$529,992	$541,008	61	$52,277	$54,900
Sitka	15573	7164	1433	$1,240,978	$1,266,772	143	$122,551	$128,700
Unknown	1904	876	175	$151,550	$154,700	18	$15,426	$16,200
Wrangell	1007	463	93	$80,538	$82,212	9	$7,713	$8,100
Region Total	25621	11786	2357	$2,041,162	$2,083,588	236	$202,252	$212,400

[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866

[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884

[3] 5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857

[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900

Table 168 Estimated Region D (Sitka/Pelican Bay) salmon waste converted to fishmeal and oil.

PRINCE WILLIAM SOUND REGION E WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings, Metric Ton	**46% Waste, Metric Ton**	**5:1 Waste to Fishmeal Metric Ton**	**Fishmeal Value, US$ [1]**	**Fishmeal Value, US$ [2]**	**2% Fish Oil, Metric Ton**	**Fish Oil Value US$[3]**	**Fish Oil Value US$[4]**
Anchorage	143	66	13	$11,258	$11,258	1	$857	$900
Cordova	29565	13600	2720	$2,355,520	$2,355,520	272	$233,104	$244,800
Kenai	11202	5153	1031	$892,846	$892,846	103	$88,271	$92,700
Floating Catcher Processors	20851	9591	1918	$1,660,988	$1,660,988	192	$164,544	$172,800
Valdez	17245	7933	1587	$1,374,342	$1,374,342	159	$136,263	$143,100
Whittier	4856	2234	447	$387,102	$387,102	45	$38,565	$40,500
Total Region E	84479	38860	7772	$6,730,552	$6,730,552	777	$665,889	$699,300
[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866								
[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884								
[3]5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857								
[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900								

Table 169 Estimated Region E (Prince William Sound) salmon waste converted to fishmeal and oil.

COOK INLET REGION H WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings, Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Seward	11742	5402	1080	$935,280	$911,520	108	$92,556	$97,200
Homer	2883	1326	265	$229,490	$223,660	27	$23,139	$24,300
Kasilof	145	67	13	$11,258	$10,972	1	$857	$900
Total Region H	15135	6962	1392	$1,205,472	$1,174,848	139	$119,123	$125,100
[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866								
[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884								
[3] 5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857								
[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900								

Table 170 Estimated Region H (Cook Inlet) salmon waste converted to fishmeal and oil.

KODIAK REGION K WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Kodiak	49809	22912	4582	$3,968,012	$3,867,208	458	$392,506	$412,200
[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866								
[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884								
[3]5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857								
[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900								

Table 171 Estimated Region K (Kodiak) salmon waste converted to fishmeal and oil.

CHIGNIK REGION L WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Chignik	4050	1863	373	$323,018	$329,732	37	$31,709	$33,300
[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866								
[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884								
[3]5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857								
[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900								

Table 172 Estimated Region L (Chignik) salmon waste converted to fishmeal and oil.

ALASKA PENNINSULA REGION M WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings Metric Ton	**46% Waste, Metric Ton**	**5:1 Waste to Fishmeal Metric Ton**	**Fishmeal Value, US$ [1]**	**Fishmeal Value, US$ [2]**	**2% Fish Oil, Metric Ton**	**Fish Oil Value US$[3]**	**Fish Oil Value US$[4]**
Sande Point	6330	2912	582	$504,012	$514,488	58	$49,706	$52,200
King Cove	6978	3210	642	$555,972	$567,528	64	$54,848	$57,600
Port Moller	2529	1163	233	$201,778	$205,972	23	$19,711	$20,700
Inshore Floating Processor	123	56	11	$9,526	$9,724	1	$857	$900
Unknown	2067	951	190	$164,540	$167,960	19	$16,283	$17,100
Total Region M	24304	11180	2236	$1,873,726	$1,976,624	224	$191,968	$201,600
[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866								
[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884								
[3] 5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857								
[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900								

Table 173 Estimated Region M (Alaska Peninsula) salmon waste converted to fishmeal and oil.

BRISTOL BAY REGION T WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Dilingham	21656	9962	1992	$1,725,072	$1,760,928	199	$170,543	$179,100
Egegik	17965	8264	1653	$1,431,498	$1,461,252	165	$141,405	$148,500
Ugashik	7600	3496	699	$605,334	$617,916	70	$59,990	$63,000
Naknek	15417	7092	1418	$1,227,988	$1,253,512	142	$121,694	$127,800
Togiak	2347	1080	216	$187,056	$190,944	22	$18,854	$19,800
Total Region T	64996	29898	5980	$5,178,680	$5,286,320	598	$512,486	$538,200

[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866

[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884

[3] 5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857

[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900

Table 174 Estimated Region T (Bristol Bay) salmon waste converted to fishmeal and oil.

KUSKOKWIM REGION W WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Bethel	1524	701	140	$121,240	$123,760	14	$11,998	$12,600

[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866

[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884

[3] 5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857

[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900

Table 175 Estimated Region W (Kuskokwim) salmon waste converted to fishmeal and oil.

KOTZEBUE REGION X WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Kotzebue	271	125	25	$21,650	$22,100	2	$1,714	$1,800
Total Region X	319	147	29	$25,114	$25,636	3	$2,571	$2,700

[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866

[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884

[3] 5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857

[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900

Table 176 Estimated Region X (Kotzebue) salmon waste converted to fishmeal and oil.

YUKON REGION Y WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Emmonak	713	328	66	$57,156	$58,344	7	$5,999	$6,300
Fairbanks	136	63	13	$11,258	$11,492	1	$857	$900
St. Mary's	37	17	3	$2,598	$2,652	0	$0	$0
Total Region Y	887	408	82	$71,012	$72,488	8	$6,856	$7,200
[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866								
[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884								
[3] 5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857								
[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900								

Table 177 Estimated Region Y (Yukon) salmon waste converted to fishmeal and oil.

NORTON SOUND REGION Z WASTE CALCULATIONS FOR SALMON USING 5 YEAR AVERAGE LANDING DATA								
	Salmon Landings Metric Ton	46% Waste, Metric Ton	5:1 Waste to Fishmeal Metric Ton	Fishmeal Value, US$ [1]	Fishmeal Value, US$ [2]	2% Fish Oil, Metric Ton	Fish Oil Value US$[3]	Fish Oil Value US$[4]
Unalakleet	251	115	23	$19,918	$20,332	2	$1,714	$1,800
Nome	2	1	0	$0	$0	0	$0	$0
Total Region Z	253	117	23	$19,918	$20,332	2	$1,714	$1,800

[1] 5 Year Average Oil World Fishmeal Price C&F Bremen less US$100 for freight or $966 – $100 = $866

[2] The most recent Oil World Fishmeal Price C&F Bremen less US$100 for freight or US$984 –$ 100 = $884

[3] 5 Year Average Oil World Fish Oil Price CIF Rotterdam less US$100 for freight or US$957-$100 = $857

[4] The most recent Oil World Fish Oil Price CIF Rotterdam $1000 -$ 100 = $900

Table 178 Estimated Region Z (Norton Sound) salmon waste converted to fishmeal and oil.

Since we've used 5 year average price data for fishmeal and oil, the following figure shows the running 5 year average prices for both products.

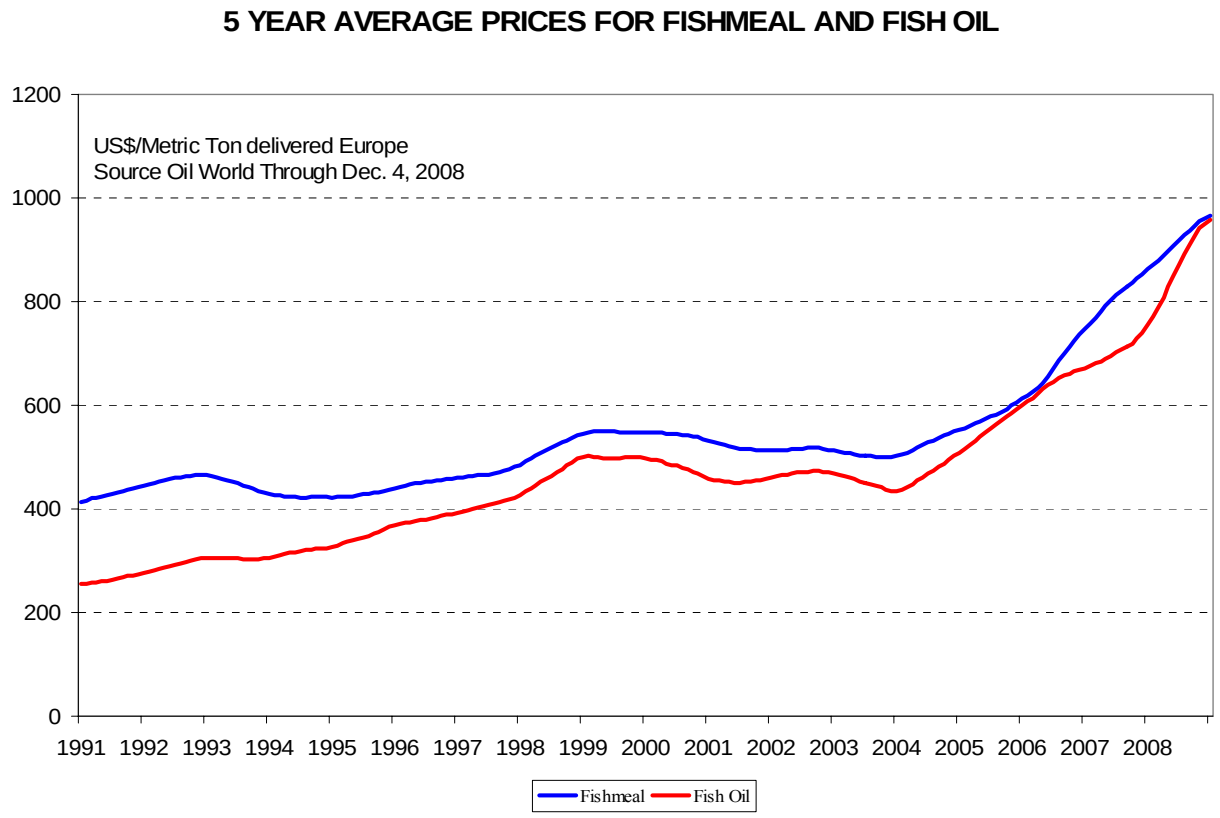


Figure 94 Five (5) year running average fishmeal and oil prices.

Based on the data it would appear that Regions W, X, Y and Z do not have sufficient raw material to produce fishmeal and alternative products and processes should be considered. The other regions of Alaska do have sufficient raw material and should the economics and logistics demonstrate that fishmeal can be produced economically, then this should be considered.

Based on the data in Figure 68 above and using the average figure for the amount of waste generated (46%) we have a potential for about 34,000 metric tons of salmon fishmeal for all of Alaska if all of the waste could be consolidated and converted to fishmeal and an additional 7,000 tons of salmon oil at a 2% yield. At the 5 year average price for fishmeal this equates to US$28.5 million for fishmeal and US$6 million for fish oil. However the logistics in Alaska is

another matter and there are many areas where the volume would not support fishmeal production. It might, however support satellite silage processing facilities and two or more central processing plants to complete the silage production.

In the lower 48 states, the menhaden industry produces fishmeal at 6 factories, 1 on the Atlantic coast in Virginia and 4 on the Gulf of Mexico (1 Mississippi, 3 Louisiana). The industry sells throughout the country as well as exporting product. Because of the high overland freight, the industry has procured outside warehouse space strategically located along the Mississippi River. Product is barged in bulk to these warehouses and then shipped by truck to customers within short distances of the warehouse. The barges hold about 1500 tons and the companies are able to supply their customers on a continuing basis during the year. The companies also have sufficient plant storage to service accounts in the vicinity of the processing plants.

One other possibility. Years ago (1960's-1970's) the menhaden fishery had a fall season which lasted about 8-10 weeks in North Carolina. Rather than outfit complete plants in the Carolina area, the companies had facilities set up with warehouse, processing building, dryers and boilers. When the Atlantic and Gulf of Mexico seasons ended, some of the equipment was broken down and moved to Carolina, installed and run for the short season. When the Carolina season ended, the equipment was moved back to the Atlantic plants in New Jersey and Virginia. A portion of the fleets from both the Atlantic and Gulf would move to Carolina to participate in the short season. We are beginning to see thinking along those lines in Alaska now with portable fish processing facilities and processor vessels.

9. ADVANTAGES AND DISADVANTAGES OF ALASKA BY-PRODUCTS

We have already seen that the growth in aquaculture has accounted for all or most of the growth in the production of fishery products. As the world population continues to grow and as the populations in developing countries improve their economic situation they will demand fish proteins for their diet. Since the wild catch of ocean fish does not appear to be able to support this continuing demand, the only source of fish protein that will be available must come from farm raised fish (aquaculture). Since farmed raised fish (especially the carnivorous fish) require fishmeal and oil in their diets, there will be a continuing demand for these products in the high end price range. There will always be some substitution of lower priced proteins and oils for fish proteins and oils but there is a limit to how much substitution can take place before the flavor and Omega 3 content of these fish is affected. We are already seeing these substitutions taking place because of the high fishmeal and oil prices. For example, recently Skretting reported that limits in the supply of marine raw materials do not need to frustrate future growth in the aquaculture industry, and that salmon farming can produce more fish protein than comes from

the wild fish used in the feed. This is the first time that large-scale trials on fish over an entire generation have been conducted showing, more fish protein in the form of salmon is gained than what was used to produce the fish feed. Increased level of alternative raw materials were tested. One of the groups was fed on feed that is almost identical to Skretting's normal diet, but with a slightly higher vegetable oil content. The other two groups were given feed where even more of the marine protein raw materials was replaced with vegetable raw materials. These two groups yielded more fish protein than what was used in production of the feed. Preliminary figures, showed that the feed that contained fewest marine resources gave just under 1.2 kg top quality fish protein in the form of salmon per kilogram fish protein used in the feed. Control of the fatty acid levels was one element of the trials and findings have been positive. The fish measurements that have been taken so far show normal levels of omega-3 fatty acids, including the long chain Omega-3 fatty acids EPA and DHA.

In the following figure I have charted the availability of edible fish (total catch less aquaculture raised fish less fish for reduction to meal and oil) vs. aquaculture production vs. demand (demand = population growth x per capita consumption of fish). While the aquaculture and available wild fish lines appear to cross at about 2049, the actual data points indicate that this will happen much sooner.

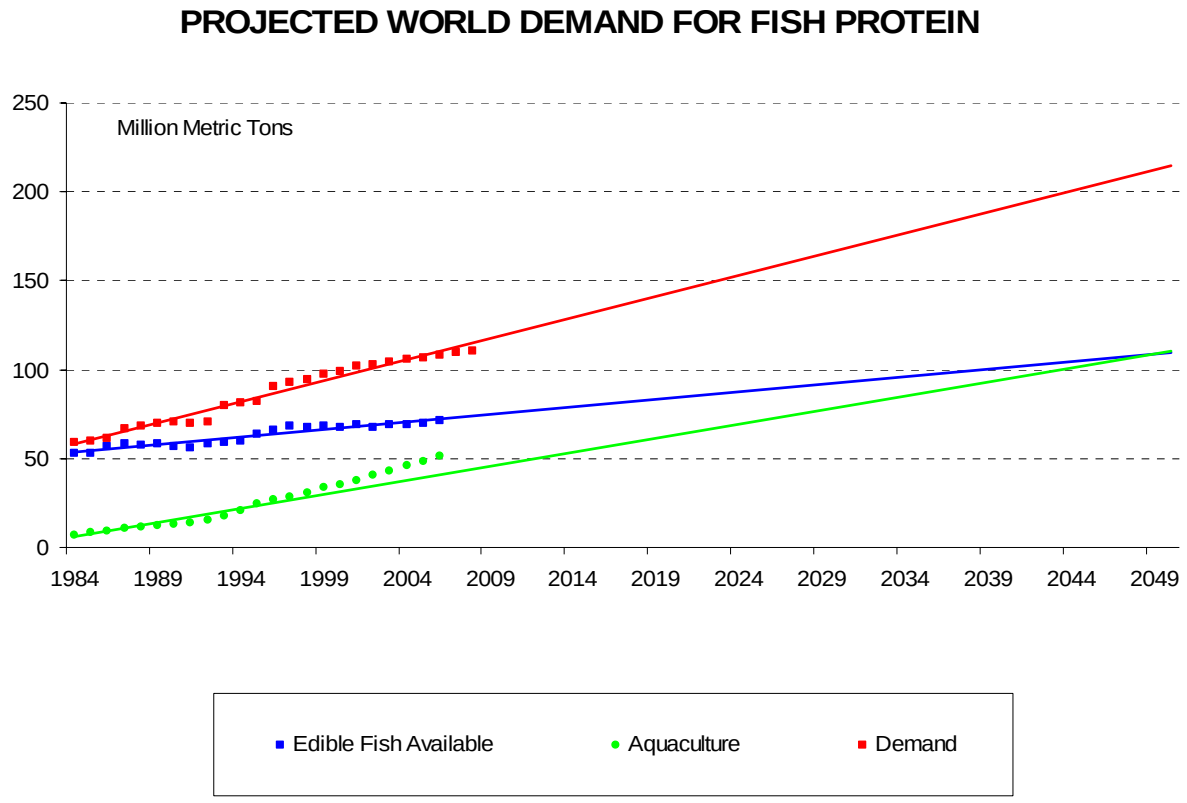


Figure 95 Projected world demand for fish proteins.

Wild Alaska seafood by-products would have some advantages in the overall aquaculture market (but not for salmon) while pollock by-products could be used for salmon feeds. Both fish have been certified by the MSC as sustainable and this certification could be quite valuable as we go forward. The concept of the Alaska environment is one of cold, clean pristine waters. The fish are caught in cold waters and if the by-products are processed immediately then the quality of the finished products should be excellent. One of the major criteria for producing premium products is raw material freshness. Salmon oil is considered a good source of omega 3 fatty acids, however it is not as high as some of the other available oils. Therefore a certain amount of marketing effort will be needed to promote the positive aspects of the oil; fresh raw material, very little processing, certified from a sustainable source. A market for organic fishmeal and oil exists. If Alaska salmon can be certified as organic this will add another unique advantage to the by-products. The Alaska area is not associated with environmental contamination as are areas where there is a great deal of industrial development. The demand for fishmeal and oil in general will always be greater than the supply especially in the high end markets. Currently, the low end markets; poultry and pig feeds are being replaced by the high end markets; aquaculture, early weaned pigs, and companion animal foods (pet food). These markets continue to grow and so the demand for fishmeal and oil will continue to grow as well.

There are some disadvantages. The fish, especially salmon, are caught in a relatively short season and handling the large volume of by-product in a short period of time becomes a major issue. Logistics in Alaska is probably it's biggest disadvantage. Perhaps the logistics problem is related to the fact that there is no consistent supply of finished product. If finished product was consistently available over a longer period of time, freight rates might become more competitive. In order to establish Alaska as a consistent supplier of high quality products you must be able to supply high quality products over the period that the consumer wants the product. This might require warehousing product for the off season as opposed to dumping it on the market as quickly as possible. This in turn puts a demand for logistics support over that same period. This also means that you must be in the market when prices are up and down. You can't drop out when prices are low and then expect to jump back into the market when the price goes up. This is an indication of whether you will be a reliable supplier of fishmeal and oil. There is also very little data on the composition of the Alaska by-product meals and oils, although this has improved since the last report. This report shows global corporate web sites that document their fishmeal and oil products, yet there is almost nothing from the Alaska producers, especially the pollock fishmeal and oil producers. Depending upon the market that you wish to enter and especially for the premium markets, you need more data than just chemical composition. Biological data on digestibility, feeding studies with target animals and a data base demonstrating that the products are free of heavy metals, pesticides, PCB's, dioxins, furans etc is

critical in today's marketplace. By-product meals, especially ones from efficient edible fisheries, tend to have more bone than meat, thus a lower protein content. It has become necessary to remove the bone fraction thus creating another by-product from a by-product. However, based on information reported here, there could be a local market for the bonemeal as a mining and petroleum waste water treatment to remove metals etc. The price in this market should be higher than selling the fish bone meal as a fertilizer.

It is important to characterize and standardize the Alaska fishmeal and oil products so that consistency in quality and composition is offered to the market place. A good example of this is the eel market for white fishmeal. This requires a functionality test to be sure the fishmeal will hold together for the baits. A high premium is paid for fishmeals that meet this criteria.

There is a nutraceutical market for salmon oil. However unless the oil is further processed in Alaska, the market will only be for the commodity grade oil. Some Alaska sockeye salmon oil is sold in the supplement market but there is a danger. The oil is crude, not refined. It is marketed as pure, virgin, unprocessed etc. But the refining steps remove metals as well as oxidation products. Crude fish oils are notorious for having high arsenic levels, sometimes as high as 35 ppm total arsenic. Most regulatory and testing labs test for total arsenic not inorganic arsenic which would be much lower. However, at some point, a consumer type organization is going to pick up some of this oil and run a test. If they find high levels of total arsenic the adverse publicity will ruin the salmon oil market. The Generally Recognized as Safe (GRAS) affirmation for salmon oil is for the refined oil, not the crude or virgin grade.

Wild Alaska salmon oil should have lower levels of omega 6 than farmed salmon especially if the farmed fish are receiving vegetable oil in their diets. This would be another selling point for the wild salmon oil.

The Alaska University Sea Grant program has a dedicated team of people in Fairbanks and at the technology center on Kodiak Island. They have been very active in characterizing the quantity and characteristics of the various waste streams in Alaska. I would suggest an on-going program to characterize the various types of Alaska fishmeals and oils. The best way to do this would be to collect shipment retain samples since these are representative of larger batches of product. These could be coded to protect individual companies. The shipment retains could be pooled by month or week depending on your economic situation and then tested for proximate composition, amino acids, micro and macro elements and fatty acid profile of the fat in the fishmeals. A data base could be set up as the generic Alaska fishmeal (by species) and fish oil (by species). Companies could then use this information for their marketing programs.

The same should be done for Alaska fish oils. The shipment retain composites could be tested for proximate composition (free fatty acids, moisture and impurities, iodine value, color, peroxide value, anisidine number), as well as fatty acid composition. Alaska pollock, for example, might have a very high omega 3 content at certain times during the season. If that is

known and documented, then that part of the production might be worth much more than oil produced at other times during the season. A similar data base to the fishmeal could be set up for marketing purposes. The third largest species of fish landed in Alaska after pollock and salmon is Pacific cod. There is a well developed and mature global market for liver oils. This should be considered as well. If Pacific cod liver or halibut liver oil was produced, even in crude form, I am positive there are companies who initially would purchase the oil and possibly further down the line might be willing to invest in upgrading the processing. It takes someone to produce some oil and offer it for testing and then let the market take over.

Not all the statistical regions of Alaska generate enough fish waste to warrant a fishmeal and oil plant. A million pounds of salmon per week is equivalent to about 454 metric tons of salmon and would generate about 209 metric tons of waste per week. This can be seen in the following figure.

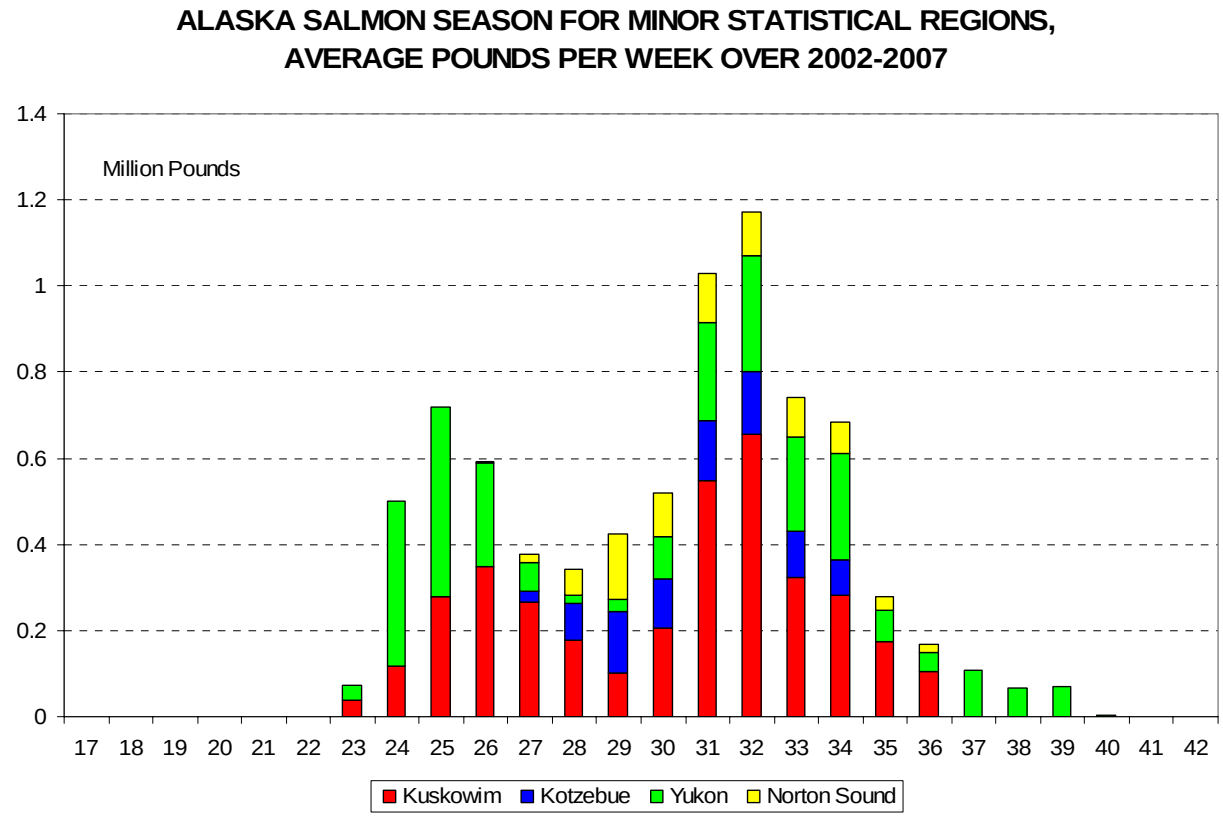


Figure 96 Salmon landings in minor statistical regions of Alaska.

It might be possible to set up silage operations in these areas and then collect the silage and transport to a central facility. In researching information for this report I came across a company in Scotland who manufactures off the shelf silage plants of all sizes and shapes. The plants are self contained and some even fit on a pallet. The information on this company's products appears below and is only included here because it might be of interest to the smaller processors.

SCANBIO SCOTLAND LTD ENSILER EQUIPMENT	
Supermort Ensiler	An ensiler that allows you to handle a harvest bin-full in one go, without fuss. Using our new filling method, once the morts are in the bin, it's all over, nobody touches them again. Quick - clean - easy. The ensiler employs a well-proven FLYGT® submersible chopper pump, housed in one of our own robust stainless steel tanks. We've worked hard to incorporate as many of the features our existing customers have suggested to us in recent years, to arrive at a system that is easy to use and to keep clean. The ensiler has the facility to re-mix through a valve mounted on the side, as well as to empty itself either into an IBC or tank. As with our smaller machines, we've stuck with a no-fuss diaphragm pump to dispense the formic acid into the tank. It works well and has proven itself safe and reliable over recent years and is above all cheap and simple. Filling the Supermort is easy. Most users simply tip a harvest bin of morts over the lip of the hopper by using the tilt forward action on their Loadall. It's clean and simple. As an alternative, we've designed an easy-to-use 'cod ended' bag (extra) that acts as a liner for a standard sized harvest bin into which the morts are put. Once full, the lined bin is handled in the normal way to take it ashore, and fork lifted to a position close beside the ensiler. The bag is picked up out of the bin by its ears, a strop through the cod end keeping the bottom closed until the bag is positioned inside the hopper of the ensiler. The strop is then slipped off the forks, allowing the cod end to open and dump the morts into the tank. An acid pump is mounted on the side of the tank and connects via a short hose. For safety reasons, a specially made plastic shroud covers the outside of the pump, so that in the unlikely event of a punctured diaphragm, the acid will be caught by the shroud.* The pump's suction hose is connected to the acid  Click to view a larger image

SCANBIO SCOTLAND LTD ENSILER EQUIPMENT	
	container by a 1" hose, camlock coupling and 2" screwed fitting.
Silamort Ensiler	The Silamort ensiler has a 940 litre stainless steel container and hinged hatch. Built into the top is a powerful motorised shaft assembly to drive the cutter. The cutter sits close to the bottom of the container, and acts both as a macerator and agitator. Also in the top is a hatch for the morts. A cutout device is mounted beside the hatch and connected through the hinge, so that the engine or electric motor cannot run unless the lid is closed.  Click to view a larger image An acid pump is mounted on the side of the tank and connects via a short hose. For safety reasons, a specially made plastic shroud covers the outside of the pump, so that in the unlikely event of a punctured diaphragm, the acid will be caught by the shroud.* The pump's suction hose is connected to the acid container by a 1" hose, camlock coupling and 2" screwed fitting. On system models, a discharge pump is mounted onto the chassis beside the ensiler and connects via a valved outlet. Freestanding ensilers are emptied by detaching the acid barrel and simply lifting the unit high enough to allow an IBC to sit under the outlet. Opening the valve allows ensiled liquid to be drained off. For sites lacking three phase power, we recommend the hydraulic powered machine as the ideal solution. We can supply the complete package of power pack and ensiler, giving you a go-anywhere unit for use on a raft, a barge or a remote shore base.
Minimort Ensiler	This is the latest in our comprehensive range of machines designed to turn foul dead fish into sweet smelling silage. The Minimort ensiler has a 300 litre stainless steel tank housing a purpose made shaft-driven cutter driven by a 4kW three

<table>
<tr><th colspan="2">SCANBIO SCOTLAND LTD ENSILER EQUIPMENT</th></tr>
<tr><td></td><td>protection overload is mounted on a bracket on the top. The ensiler is designed to sit on a small pallet.

The fish hatch is large enough to take a bucket full of morts without risk of spillage and has an interlocking switch attached to the hinge pin, so that when the hatch lid is open, the motor is isolated from the electrical supply and will not run.

An acid pump is mounted on the side of the tank and connects via a short hose. For safety reasons, a specially made plastic shroud covers the outside of the pump, so that in the unlikely event of a punctured diaphragm, the acid will be caught by the shroud.* The pump's suction hose is connected to the acid container by a 1" hose, camlock coupling and 2" screwed fitting.

Emptying the unit is simple. Un-plug the power supply and raise the Minimort with a fork lift to allow the outlet to empty into a storage vessel. The outlet is fitted with a bronze 2” gate valve.

For sites lacking three phase power, we offer the option of either a phase converter to give you a three phase supply from a single phase source, or a hydraulic powered machine. We can supply the complete package of phase converter and ensiler for a shore base, or power pack and ensiler, giving you a go-anywhere unit for use on a raft, a barge or a remote shore base.</td></tr>
<tr><td>Mort Muncher</td><td>The new Scanbio Mort Muncher is the ultimate answer to handling large fish kills due to disease, predation or sea conditions. Capable of mincing ten tonnes per hour and automatically dosing formic acid, the Mort Muncher can stand up to the heaviest demand and make light of a tough job. For all its size, it can deploy wherever it's needed, so that wherever a big loss occurs, the Mort Muncher can go</td></tr>
</table>

SCANBIO SCOTLAND LTD ENSILER EQUIPMENT	
	to work to solve the problem of ensiling harvest tubs full of morts of up to 8kg individual weight. On a kill site, the operational system will require a power supply, either mains or from a generator, a supply of acid to couple up to and a tanker to receive the acidified sludge. The design incorporates a remote control station, allowing the operator to stand back in a safe place, away from the fork lift truck working area and away from the bin rotator. This gives a clear view of what is happening at the same time as being completely secure. 
Source: http://www.scanbio.co.uk/enciliers.asp	

Table 179 Scanbio Ltd silage plants.

As already mentioned, there is a shortage of fertilizer in Alaska so perhaps silage production could fill that need.

In the previous report there was very little information on products produced in Alaska from the various fishery waste streams. This report has documented several markets and products that are being produced in Alaska. These include fishmeal, fish oils, silage, hydrolyzates and compost. If I have missed any products I apologize.

Alaska by-products are also going into pet foods as can be seen in the following table.

ARCTIC PAWS SALMON BASED PET FOOD PRODUCTS	
All Products	• Healthy and nutritious- Salmon are high in vitamins, minerals and essential fatty acids. Including Omega-3 and Omega-6! • Made with real Alaskan salmon-We make our treats with ingredients dogs love! • Excellent show bait-Gives showers a competitive advantage! • Excellent training treats-Dog trainers across the U.S. and Canada use our treats in their classes! • For puppies and adult dogs- Dogs of all ages love our soft and chewy treats
Yummy Chummies	**ORIGINAL PREMIUM SALMON DOG TREATS - Soft N' Chewy** Dogs go absolutely *crazy* for our salmon treats and your dog will too! We guarantee

ARCTIC PAWS SALMON BASED PET FOOD PRODUCTS	
	that your pet will love Yummy Chummies. We are the first company to begin manufacturing pet treats using Alaskan Salmon. Our goal is to make quality treats that give your pet and you the highest gratification! Ingredients: Wild Alaska Salmon, Wheat flour, Vegetable glycerine, Propionic Acid, Natural smoke flavor, Citric acid, Garlic, Calcium carbonate, Natural mixed tocopherols and rosemary extract.
Salmon Crunchies	**SALMON CRUNCHIES! PREMIUM DOG TREATS** Gives dogs the crunch they love, while helping to keep their teeth clean! We guarantee that your pet will love Yummy Chummies. We are the premier maker of dog treats using Alaskan salmon. Our goal is to make quality treats that give your pet and you the highest gratification! Ingredients: Wild Alaska Salmon, Rice flour, Vegetable glycerine, Propionic Acid, Natural smoke flavor,Citric acid, Garlic, Calcium carbonate, Natural mixed tocopherols and rosemary extract.
Smoked Salmon Jerky Treats	**SMOKED SALMON JERKY TREATS** Dogs absolutely *love* our salmon jerky treats and your dog will too! We guarantee that your pet will love Yummy Chummies. We are the first company to begin manufacturing pet treats using Alaskan Salmon. Our goal is to make quality treats that give your pet and you the highest gratification Ingredients: Wild Alaska Salmon, Wheat gluten, Vegetable glycerine, Propionic Acid, Natural smoke flavor,Citric acid, Garlic, Calcium carbonate, Natural mixed tocopherols and rosemary extract.
Vita Chummies Dog Treats	**VITA CHUMMIES: ALL NATURAL, VITAMIN ENRICHED, DOG TREATS** Made here in Alaska with wholesome and pure ingredients, these treats provide your dog with all the essential vitamins and minerals that Alaskans have long trusted for their dogs. Ingredients: Wild Alaska Salmon, Rice flour, Vegetable glycerine, Propionic Acid, Natural smoke flavor, Citric acid, Garlic, Calcium carbonate, Natural mixed tocopherols, rosemary extract and a vitamin and mineral premix containing: calcium carbonate, choline chloride, Vitamin E supplement, L-Ascorbic Acid, Iron Sulfate,

ARCTIC PAWS SALMON BASED PET FOOD PRODUCTS	
	Zinc Sulfate, Magnesium Oxide, Niacinamide, Mineral oil, Manganese Sulfate, d-calcium Pantothenate, Riboflavin B2, Viamin A Acetate, Copper Sulfate, Thiamine Mononitrate, Menadione Dimethylpyrimidinol Bisulfite, Pyridoxine Hydrochloride, Vitamin B12, Vitamin D3 Supplement, d-biotin Supplement, Folic Acid, Sodium Selenite(source of selenium) Calcium Iodate and Cobalt Sulfate.
Premium Salmon Cat Treats	**PREMIUM SALMON CAT TREATS** Cats go absolutely *crazy* for our salmon treats and your cat will too! We guarantee that your pet will love Yummy Chummies. We are the first company to begin manufacturing pet treats using Alaskan Salmon. Our goal is to make quality treats that give your pet and you the highest gratification Ingredients: Wild Alaska Salmon, Wheat flour, Vegetable glycerine, Propionic Acid, Natural smoke flavor,Citric acid, Garlic, Calcium carbonate, Natural mixed tocopherols and rosemary extract.
Source: http://www.yummychummies.com/html/products.html	

Table 180 Arctic Paws salmon based pet food products.

Alaska has a number of advantages in its fishery products and by-products not the least of which is the potential volume. There are also a number of disadvantages that must be overcome in order to succeed in developing markets for the by-products.

10. LIST OF TABLES

11. LIST OF FIGURES