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Business Administration in the Faculty of Business at the
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*A case study of factors impacting on marketing of South
African fish oil in the Animal Feed Market.*

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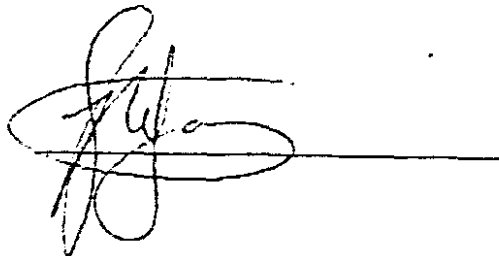
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Declaration: I, Titania Vaida Stefanus, identity number 7310280182086, declare that this is my original work and that all the data obtained has been accurately recorded and acknowledged, and that this document has not been submitted in whole or part thereof in order to obtain an academic qualification.

Signature:

A handwritten signature in black ink, appearing to be 'Titania Vaida Stefanus', written over a horizontal line. The signature is stylized and cursive.

Statement and acknowledgement

Special thanks to the people who made a significant contribution to the collection of data used in this dissertation especially to Rob Abandanon, Managing Director of South Commodities Limited, Gerrit Verster manager at Energy Oil, Hendrien Wiese logistics manager of Meadow Cape Mills, Jimmy Loubser raw material buyer of Pioneer in Malmesbury, Françoise Labuschagne, managing director of PSS Oil, Steve Malherbe of the South African Pelagic Fishing Industry Association, Mike Copeland, technical manager of Oceana Operations.

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Synopsis

The closure of Marine Oil Refiners (MOR) in 1999 was probably inevitable if results of the Greenpeace protests against the consumption of unsustainable fish oil in 1996 were evaluated. The world's largest biscuit factories excluded fish oil from their ingredients and companies like Unilever responded in a similar manner. However MOR's closure was unexpected and therefore the South African market shift did not align with the international market changes.

This research project explores one of the problems with which the fishing industry is confronted with. In particular, the research focuses on the distribution of the fish oil produced in the Fishing Industry after the closure of MOR in July 1999, which was the sole consumer of fish oil. The closure of MOR has effectively left South African and Namibian fish oil-producing companies without an established South African market to sell to.

This research deals with marketing strategies for the fish oil producing companies, the problems associated with these strategies and the examination of available alternative solutions to this problem. The effect of changes in the chicken feed market segment on the fishmeal & oil industry will also be addressed.

One of the aims of this research was to clarify the factors that impact on the consumption of the current South African fish oil market. The research concluded that the following are important factors that impact on the South African fish oil consumption:

- Quality of the oil
- The international fish oil price

- Comparative competitive prices of fish oil substitutes
- The growing and declining demand of the different fish oil application markets.
- The price of heavy furnace oil compared to fish oil selling price. (Heavy furnace oil is used to generate energy).

The research also investigated the impact of low price fish oil substitutes on the South African fish oil producers. The most important substitute in the current South African majority market, the animal feed market, is vegetable oils. The research finding is that the South African fish oil producers must follow the vegetable oil selling price trend.

The most important finding of the research is the high priority the fish oil quality achieves in all the fish oil market segments. The South African domestic market is limited in that it is only the animal feed market and the refinery. The alternative market to sell to is the export market. However, the international fish oil market perceives the South African fish oil to be of low quality. A mindset regarding the importance of fish oil quality has to start at the South African fish oil producers. It is vital that the South African fish oil producers institute quality systems to improve their fish oil quality. The South African fish oil producers must gear themselves to become globally competitive.

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CHAPTER 1

PROBLEM FORMULATION

1.1 Introduction

Whilst the fish in the coastal waters of South Africa is acknowledged as a valuable resource both by way of food for the inhabitants of the country as well as a large earner of foreign currency in the export markets, few South Africans realize that the body oil of the fish species inhabiting the waters around the coast is also a very useful product. The fish body oil extracted by South African fish processing factories was sold to a unique fish body oil converter, known as Marine Oil Refinery (MOR) outside Simons Town.

It is important to realize and understand that changes in the international and South African domestic market for fish body oil led to the closure in 1999 of this monopoly fish body oil products producer, Marine Oil Refinery (MOR).

This closure had major implications for the South African fish oil industry. This research attempts to develop marketing strategies given the change in the business landscape. This chapter focuses on the factors that have influenced the decline in consumption of fish oil.

1.2 International Change in fish oil Application

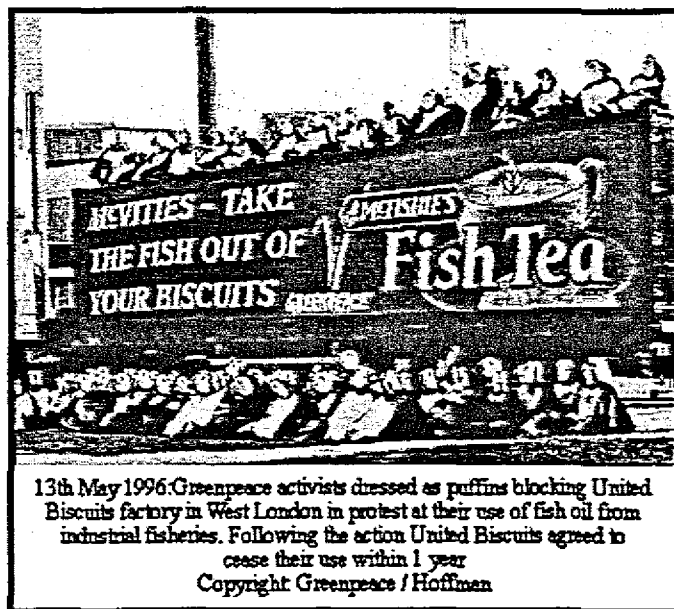
The production of fish body oil worldwide is stagnating and has very little growth potential, as natural resources cannot be influenced. Fish body oil has traditionally been used as a hardening agent for products like margarines. But the demand for fish body oil in this form has steadily declined.

Increased fish body oil usage, in aquaculture feeds, has compensated for the consumption drop off by hardeners (IFOMA: 2000).

The exception to the trend of decreasing production of fish oil, was Peru, in 2000, where the percentage of oil from fish more than doubled. Due to the unforeseen development, overproduction in Peru resulted in a lack of storage space for the excess fish oil. Approximately 120 000 tons of fish body oil (8 percent of world production) were burned in fishmeal plants around the world (IFOMA: 2000). The substitution of heavy furnace oil (HFO) with fish oil has been successfully done in Peruvian fish meal and oil manufacturing plants.

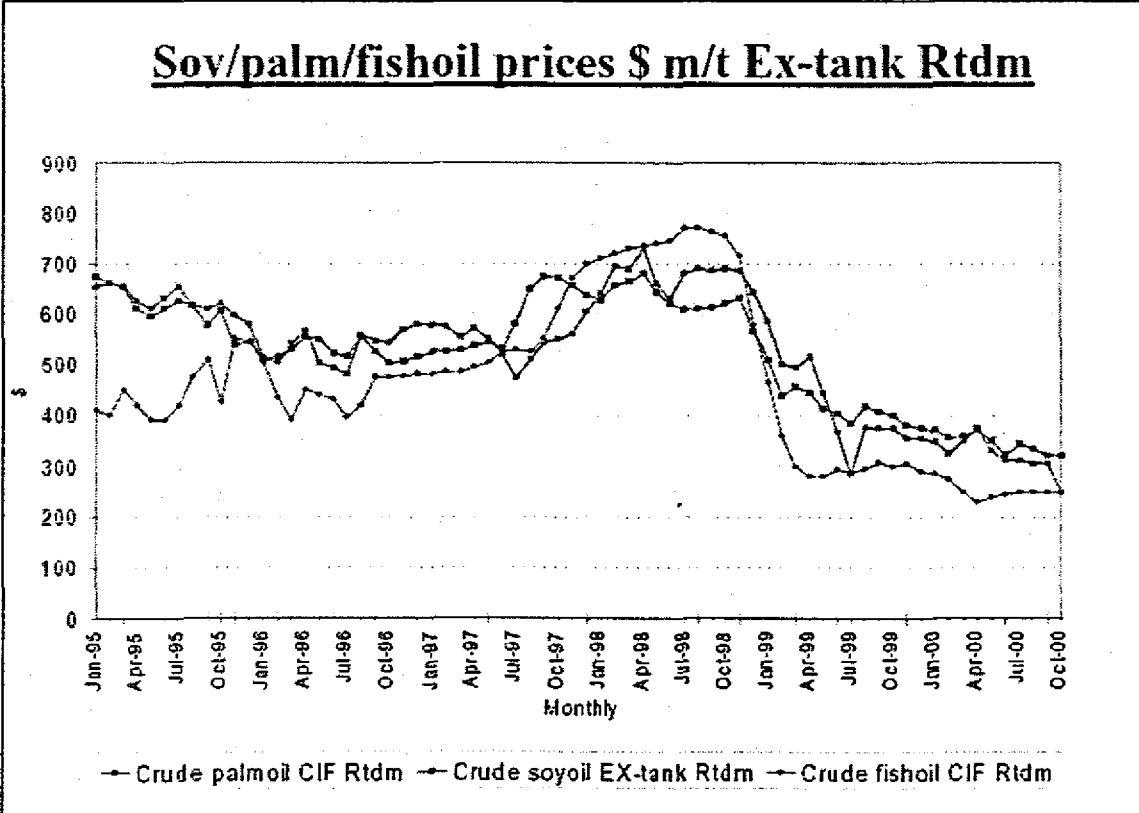
World Greenpeace Organisation protested on the morning of the 13th of May 1996 in front of McVitie's biscuit factory in Harlesden, West London. The protest (Photograph 1-1) was against the use of unsustainable industrial fish oil in the confectionary and other industrial applications.

Photograph 1-1



Source: Greenpeace Press Releases May 1996

The result of the Greenpeace protests was the declaration, from international giants such as United Biscuits, Unilever and Sainsburys, that the use of unsustainable fish oil should be discontinued. The substitution of vegetables into these traditional fish oil markets caused a shift in the price of fish oil. Fish oil had to compete with vegetable oil and the fish oil price started to follow the vegetable oil price trend.



GRAPH 1-1: SOYA, PALM AND FISH OIL PRICE TRENDS (IFOMA: 2000)

The fish oil price in graph 1-1 illustrates how the fish oil price started to follow the soya and palm oil price trend since June 1996. However, in 1997 and 1998 the fish oil price was above the soya and palm oil prices. The trend of the fish oil price still increased and decreased with the palm oil and soya oil prices. However, with the increase in consumption of fish oil in

the aquaculture market, the fish oil was valued higher than the soya and palm oils.

Demand for hydrogenated fish body oils has largely disappeared in food applications. Refiners in Europe and other places in the world have decided to take marine oils out of their formulas and have promoted vegetable oils instead.

Caused by the recent price rally, more switching from fish oil to vegetable oils has occurred, particularly in the Americas where imported soybean oil and palm products have been a lot more competitive. In Peru for instance local fish body oil consumption dropped from average 150 000 tons per annum to an estimated 25 000 tons for 2001. (IFOMA: 2000)

Margarine production in the Ukraine and Russia increased by an average of 23 percent during the first half of 2000 (IFOMA: 2000). During January to March 2000 some of this margarine was produced out of fish body oil. During Southern Hemisphere's summer months, fish body oil intake steadily declined as it was out-priced by soya. The papers presented at the Lima IFOMA conference indicated that the rate of growth in the baking fats sector in the remainder of 2000 would decrease but that the combined overall production of margarine in Russia and the Ukraine during the calendar year of 2000 will increase by 20 percent to a total estimated 1 million tons.

Sizeable reductions in imports occurred in 2000 in the European Union as well as in Mexico and China. This occurred mainly on account of reduced hardening demand. Fish body oil consumption in Mexico, mainly to the

advantage of palm stearin and tallow, dropped by 94 percent in 2000. In Europe, fish body oil use for edible and technical purposes, decreased by 39 percent this year to a total of 165 000 tons. This includes about 10 000 tons used for Omega 3 products. Omega 3 is a health product, which has been advocated as protection against heart attacks of human consumers.

The demand for hydrogenated fish oil has largely disappeared in all food applications. The market has switched from fish oil to vegetable oils (Franken, 2001).

European market fish oil use for edible and technical purposes decreased by 39% by 2001.

The fish body oil market will remain tight and trading will take place around current levels of US\$500 per ton. (Sotomayor, 2002) The upper or lower side of the range will depend on the replacement of fish body oil by vegetable oils in the aquaculture feeds and hardened products, on the yield of oil in the fish and, to some extent on consumer timing.

1.3 South African Market Change

For many years the entire South African and Namibian production output of fish body oil has been sold to the Cape-based company, Marine Oil Refiners (MOR). The fish body oil sold to MOR was converted into edible fats. These value-added products were sold to the industrial food markets. Although internationally fish body oil is extensively used as raw material for manufacturing of edible fats, in South Africa the hardening technology required for such conversion was available only at Marine Oil Refiners.

The South African and Namibian fish body oil producers sold a minimum of 4,045 metric tons and maximum of 12,818 tons per annum between 1994 and 1998. The average volume of fish body oil sold to MOR between 1994 and 1998 was 8,719 tons per annum (Malherbe, 2000).

South Africa had a protectionist trade policy that meant that the international changes and trends did not have an effect on the South African fish oil market before 1994. The political changes in 1994 resulted in the removal of the protective trade barriers and therefore exposed the South African market to the international changes and trends. The following factors impacted severely on the South African market.

- The high market growth rate of soya bean oil and palm oils increased the competitiveness of all vegetable oils.
- Vegetable oils were marketed internationally as a substitute for marine oils.
- The hardening technology of vegetable oils is easier and less expensive compared to the hardening technology of fish body oil.
- The decline in the fish resource and, therefore, the decrease in supply of fish oil compared to an increased demand for fish oil. The resultant effect was the ban and restriction of the use of fish oil in hardening market by several countries. After this political and environmental change the hardening market welcomed vegetable oil as a cost-effective substitute.

(Greenpeace press releases May 1996)

In July 1999 the directors of MOR decided to discontinue operations and withdrew from manufacturing products from

fish body oil. This decision left the South African and Namibian fish body oil-producing companies without an established local market to which to sell. This research deals with the options available to the companies, the problems associated with these options and the examination of the available alternative solutions to this problem.

Since the closure of Marine Oil Refiners, the fishing industry has been disposing of its oil in various ways. The options taken by most of the companies have not been profitable when compared to the income generated by the sales of fish body oil to Marine Oil Refiners before the closure in July 1999.

The sudden closure of this market not only left the fish body oil producers at the mercy of aggressive traders, but also initiated competition between the various fish body oil producers. A large fishing group examined various options in 1999 and, subsequently, spent a substantial amount of money investigating some of these options. These options were discussed with the rest of the fish body oil producing companies at the time (Przybylyk, 1999). However, 2¹/₂ years later it is clear that not all the options were carefully evaluated by the industry.

It is, therefore, essential for the fish body oil producers to re-evaluate the marketing of the fish oil. The research also focuses on the distribution of the fish body oil produced by the Fishing Industry after the closure of MOR in July 1999.

1.4 Formulation of research problem

The closure of the only fish oil buyer, MOR, has changed the marketing criteria from monopoly buyer to a competitive market for fish oil. This shift in the marketing environment has forced the industry to make hasty decisions. The business landscape that South African fish oil producers face is complex. Many variables need to be accounted for in choosing distribution channels. Currently most of the fish oil is sold locally in the animal feed market. The conditions in this market could change and consequently have a negative impact on the South African Fish Oil producers, as was the case with Marine Products. The different marketing options being pursued should be examined and explored.

The research will seek to simplify the factors influencing the Chicken Feed segment of the Animal Feed market and explain the impact of these factors on the fish oil producers.

1.5. Hypothesis

Low selling prices of fish oil substitutes in animal feed oils will force the South African fish oil producers to lower fish oil prices, burn the fish oil or explore other market segments for fish oil.

1.5.1 Hypothesis one

The selling price of fish oil in the animal feed market depends on various factors and variables as listed below:

- Quality of the oil
- The international fish oil price
- Comparative competitive prices of fish oil substitutes
- The balance between the supply and demand of fish oil
- The fish oil production volumes

- The growing and declining demand of the different fish oil application markets
- The price of heavy furnace oil compared to fish oil selling price. (Heavy furnace oil is used to generate energy)

1.5.2 Hypothesis two

High fish oil prices, relative to low substitute prices, will decrease the demand for fish oil in the animal feed industry. The fishing industry will be compelled to sell to alternative market segments or lower their price in order to compete with substitute price levels.

1.5.3 Hypothesis three

The fishing industry will have to ensure that their fish oil quality complies with the specifications of the export market or local fish oil refineries, depending on what the choice of market is for disposal of the fish oil; that is, whether the overseas or the domestic market.

1.6. Significance of the Research

Preliminary research illustrates that the uses for fish oil have changed over the years from traditional uses in margarines to the fast-growing demand in the aquaculture market.

However, the local aquaculture market is very small and cannot consume the regular oil supply. The largest current distribution outlet for fish oil is the animal feed market. The research should assist fish oil producers to understand the factors that influence the fish oil consumption and selling price in the animal feed market segment. Understanding these factors should also assist fish oil producers to understand and, therefore, promote planning and marketing strategies. Understanding the factors will, moreover, assist the fishing industry to optimise income generated from fish oil.

1.7 Conclusion

The international trend of switching fish oil applications from traditional baking fats to aqua feed has made an impact on South Africa's fish oil producers. It is important to understand the changes that the fish oil industry experienced after the closure of MOR in 1999. However, more importantly, the current situation regarding the South African fish oil market must be assessed.

The changes in demand for fish oil in the international markets have undoubtedly impacted on the production by South African fish oil producers. Vegetable oil has become a cheaper option and consequently fish oil can no longer command the former prices. This is but one factor

of many that has brought about the enforced changes in the market for fish body oil.

Chapter Two explains the research methodology used in the case study.

Chapter 2

Research Design and methodology

2.1 Introduction

This chapter deals with the method used to answer the questions raised in Chapter One. Initial literature research was done to identify the major role players. The second part of the research was conducted through in-depth interviews with all the major role players. A case study was used as part of the investigation.

2.2 Data Collection

A series of writings and information from experts from the fish oil manufacturers, animal feed-oil blenders and animal feed manufactures was reviewed. This information was used to identify the factors that influence the consumption and demand of fish oil in the animal feed industry.

Individual in-depth interviews were conducted with representatives of the following companies; Meadow Mill Feeds, Pioneer, Energy Oil, PSS Oils and South Commodities Limited, South African Fishing Industry Association and St Helena Bay Fishing Industries Limited; all above companies to interrogate the research questions. These representatives were procurement and marketing personnel as they were identified by the companies. Interviews were conducted telephonically with trading companies that export fish oil and with a refinery in Gauteng.

The questionnaire was designed to:

- a) Focus on all the factors that the research set out to address, and
- b) To cover the views and collect data from all the role players in the industry.

2.2.1 Animal Feed-Oil Producers and Consumers

A structured questionnaire was distributed to all the animal feed companies in the Western Cape as well as non-fishing companies that supply the animal feed industry. The focus of these interviews was to solicit information regarding the demand and factors that impacted on the demand and consumption by the animal feed companies. The questions were constructed to solicit information regarding the substitutes that fish oil competed with in that specific market segment, the volume demand and also the economic factors in the Animal Feed Market segment.

2.2.2 Fish Meal & Oil Manufacturers

Fish meal and oil manufacturers traditionally sold all fish meal and oil through the South African Fish Meal and Oil Association. However, one group who began doing its own marketing of their products owns three of the eight fish meal and oil factories. In-depth interview were conducted with representatives of the fishing industry companies on the West Coast. These interviews focused on information regarding the quality of the oil produced at these factories and the economic value of the oil.

2.2.3 Export and Oil Refineries

Telephonic interviews were conducted with the two trading companies and one refinery. These interviews focused on determining the major factors that impacted on fish oil

selling prices on the export market and to refineries. These telephone interviews were followed by questionnaires via electronic mail.

2.3 Questionnaire

The questionnaires were constructed to address the three original hypothesis statements. The three questionnaires according to each hypothesis are tabulated in the appendix.

2.3.1 Hypothesis one

Original Hypothesis Statement

The selling price of fish oil in the animal feed market depends on different factors and variables as listed below:

- Quality of the oil
- The international fish oil price
- Comparative competitive prices of fish oil substitutes
- The balance between the supply and demand of fish oil.
- The fish oil production volumes.
- The growing and declining demand of the different fish oil application markets.
- The price of heavy furnace oil compared to fish oil selling price. (Heavy furnace oil is used to generate energy).

The questions in Appendix 1.1 include all the factors and variables that impact the selling price of fish oil as stated in hypothesis one.

2.3.2 Hypothesis two

Original Hypothesis Statement

High fish oil prices relative to low substitute prices will decrease the demand for fish oil in the animal feed industry. The fishing industry will have to sell to alternative market segments or lower their price to meet substitute price levels.

The effect of high fish oil prices relative to low substitutes have been tabulated in a questionnaire in Appendix 1.2. This is in relation to hypothesis two.

2.3.3 Hypothesis Three

Original Statement

The fishing industry will have to ensure that their fish oil quality complies with the specifications of the export market or local fish oil refineries depending on what the choice of market is for disposal of the fish oil i.e. the overseas or the domestic market.

Appendix 1.3 includes questions to determine the importance of fish oil quality on the international market and fish oil refineries of the domestic market related to hypothesis three.

2.4 Delimitation of the research

The study focused on fish meal and oil industry in the Western Cape and the Animal feed industry in particular. The fishing industry companies included in the case study are South African Sea Products (SASP), St Helena Bay Fishing Industries (SHBFI), Lamberts Bay Fishing company (LBFC), West Point Processors, Suid Orange Fishing, Southern Seas Fishing and Marine Products. The fish oil from all the producers was formerly sold through the

pelagic fishing industry association's marketing company (SAFAMCO). The first three companies are part of the group, which markets their fish oil separately from the rest of the industry.

The three Animal Feed companies in the Western Cape are included in the questionnaire interrogation. The research also focused on the intermediate companies that buy from the industry and sell into the animal feed industry. The two major companies were approached. These companies are not locally based but sell into Western Cape animal feed market.

2.4 Conclusion

The questionnaire layout accommodated all the role players that the South African fish oil industry impacts upon.

Chapter Three explains the South African fishing industry and places emphasises on the South African pelagic industry, which is the source of the fish oil.

Chapter 3

South African Fishing Industry

A Background

3.1 Introduction

This chapter provides an overview of the complex South African fishing industry. Each sector of the industry is explained briefly and the historical trend of the size of each of these sectors is tabled. Management of this important resource by the government is dealt with as well as the quota system that is used to distribute the resources as evenly as possible. The chapter ends with a summary of the fish meal and oil industry and manufacturing process.

3.2 Available South African Fishing Resources

South Africa has a coastline of some 2,798 kilometers, extending from the Orange River in the west, on the border with Namibia, to Ponta do Ouro in the east, on the Mozambican border. The western coastal shelf has a high biomass of fish resources while the east coast yields considerably less fish but has high species diversity, including both endemic and Indo-Pacific species.

All the fish around the west and south east coast of South Africa falls into various categories within South African fishing industry. The fishing industry may be subdivided into the following categories: Demersal, Pelagic, Rock Lobster, Crustacea, Line and small nets (Marine Policy for South Africa White Paper 1997).

3.2.1 Demersal

South Africa's most valuable commercial resource is the demersal sector. Demersal fishing includes deep-sea trawling, inshore trawling and long line fishing. This sector is dominated by deep-sea trawling for Cape hake. Hake fishing has been controlled largely by means of company-allocated quotas within a Total Allowable Catch (TAC), limitations on the number of vessels, and closed areas. In 1998, the TAC on hake was 151,000 tons which is below the anticipated maximum sustainable yield of 180 000-200 000 tons (Marine Policy for South Africa White Paper 1997).

Longlining for kingklip was stopped in 1990 and, as a result, landings have halved and now constitutes approximately 1.5% of demersal landings.

Inshore trawl fishing operates along the south coast and largely comprises small side trawlers working in shallow waters. About 6% of the national hake catch and virtually 100% of the national sole catch is caught using this method. Sole is, by far, the most valuable species of fin fish per unit mass landed in South Africa, although it constitutes only 0.5% of the total demersal catch. The midwater trawl sector is relatively small and targets exclusively adult horse mackerel. The inshore and deep-sea trawlers also catch horse mackerel.

3.2.2 Pelagic

Pelagic fishing consists of species used for canned fish, fishmeal, fish oil and bait. In terms of volume landed, pelagic fishing is South Africa's largest. Catches have, however, declined with the average catch in the early

1990's fluctuating between 350,000 and 450,000 tons and declining to 214,000 tons in 1996. The catch in 1997 showed a marginal improvement to 286,000 tons. This decline has largely been the result of the decline in the anchovy catch as anchovy stocks have reached a record low as a result of over-fishing. The anchovy catch which has historically accounted for between 50 -65% of the total pelagic catch declined to 60,000 tons in 1997, a mere 20% of the total pelagic catch. Pilchard catches have shown steady increases over the last decade with the total pilchard catch increasing by 188% between 1987 to 1997. The profile of the pelagic catch has consequently changed quite dramatically. In 1987, the pilchard catch accounted for 6% of the total pelagic catch. In 1997, this figure increased to 41%. A recovery in the pelagic sector depends on the pilchard catch.

The only other species making up a significant part of the pelagic catch is round herring (red eye). This is an off-shore species, which shoals deeper than anchovy and pilchard, and it is, therefore, largely out of the range of the present purse-seine fleets. Catches are infrequent and highly variable and, although it has been estimated that this species could support a fishery of 100,000 tons, little progress has been made in developing reliable methods to ensure more consistent catches. Juvenile horse mackerel and lantern fish are other variable catches which, in good years, yield a few thousand tons.

3.2.3 Rock Lobster

South Africa's commercial rock lobster industry is based on two species: the South Coast rock lobster and the West Coast rock lobster. The West Coast variety is caught

inshore by traps and hoopnets deployed from small vessels and also by recreational divers. The South Coast species is a deep-water species caught by means of long-lines of traps set by larger freezer vessels. The total rock lobster catch has more than halved over the past decade from 5924 tons in 1987 to 2582 tons in 1997. (<http://www.environment.gov.za/mcm>). This is largely the result of a severe decline in the average somatic growth rate believed to be a consequence of an unknown environmental anomaly, which has led to decreasing catches and a reduction in the TAC.

3.2.4 Crustacea, molluscs

This category covers a wider spectrum of fish and consists of trawling for squid, jigging, abalone, wild oysters, cultivated oysters, cultivated mussels, cultivated prawns and red bait.

South Africa's commercial abalone catches have remained relatively stable for many years, being controlled by a whole mass quota of some 600 tons. Licensed commercial divers operate from small boats and use the "hookah" system of air supply. Most of the catch is canned or frozen and exported to the Far East, although legislation (Marine Living and Resources Act 1998, Act 18 of 1998) stipulates that 10% must be sold in South Africa.

3.2.5 Line and small nets

This is the category best known by the public. It consists of snoek fishing, tuna fishing, hand line fishing and small net fishing.

South Africa's line fishing industry is split into three main sectors: squid jigging, tuna fishing and general recreational and commercial fishing. The squid-jigging industry targets chokka squid. The jig-fishing fleet consists of about 300, mostly small, vessels, such as skiboats and catamarans. The resource is protected by a closed season of 3 - 5 weeks when spawning is at its peak (usually November). Trawled squid make a small contribution to the total catches of chokka squid, but have been declining consistently since 1979. South African trawlers also land red squid. Virtually all South African squid finds its way onto the export market. The principal markets are in Europe. Local demand is satisfied by imports.

The tuna industry is principally focused on albacore (long fin tuna), with smaller contributions from yellow fin, bigeye and skipjack. Catches range between 4,000 and 6,000 tons per annum. Catches have decreased in recent years to around the 3,000-ton mark. No tuna is canned in South Africa. The unprocessed fish is exported and the canned product imported almost solely from the Philippines and Thailand. Of concern to the tuna industry is the fact that the total Atlantic Ocean albacore catches exceed the maximum sustainable yield of 25,000 tons. This makes a decrease in catches inevitable.

3.2.6 Historical Resource Data

The following table provides detail on South African catches, by species, over the latest available five-year period (South Africa Business Guidebook 2000 / 2001).

The table illustrates that the pelagic industry has landed 55% of the total industry catches. The pelagic industry has landed more than any other sector every year.

TABLE 3-1: FISH CATCHES PER YEAR

| Type | Volume (tons nominal mass) | | | | | Percentage of total catch |
|---------------------|----------------------------|---------|---------|---------|---------|---------------------------|
| | 1993 | 1994 | 1995 | 1996 | 1997 | |
| Demersal | | | | | | |
| Total | 211,885 | 188,632 | 179,577 | 205,874 | 204,300 | 40% |
| Hakes | 141,202 | 146,375 | 139,228 | 158,785 | 147,569 | 29% |
| Kingklip | 2,567 | 2,867 | 2,860 | 3,372 | 3,927 | 1% |
| Monk | 4,281 | 5,047 | 5,941 | 6,161 | 7,639 | 1% |
| Panga, reds | 798 | 1,161 | 1,221 | 898 | 926 | 0% |
| Sole | 846 | 978 | 769 | 959 | 860 | 0% |
| Snoek | 12,519 | 6,149 | 6,923 | 5,739 | 5,252 | 1% |
| Horse Mackerel | 12,348 | 11,987 | 9,321 | 15,307 | 22,922 | 4% |
| Orange Roughy | 0 | 0 | 5 | 3 | 1 | 0% |
| Oreo Dory | 0 | 0 | 19 | 365 | 630 | 0% |
| Tooth fish | 0 | 0 | 0 | 997 | 1,365 | 0% |
| Other | 37,324 | 14,068 | 13,290 | 13,288 | 13,209 | 3% |
| Pelagic | | | | | | |
| Total | 357,040 | 314,461 | 367,983 | 213,723 | 286,442 | 55% |
| Pilchard | 50,717 | 92,806 | 115,104 | 105,208 | 116,992 | 23% |
| Horse Mackerel | 11,646 | 8,210 | 1,982 | 18,982 | 12,727 | 2% |
| Chub Mackerel | 371 | 2,037 | 2,667 | 1,101 | 3,748 | 1% |
| Anchovy | 235,830 | 155,554 | 170,270 | 40,712 | 60,095 | 12% |
| Redeye | 56,331 | 54,145 | 76,664 | 47,117 | 92,209 | 18% |
| Other | 2,145 | 1,709 | 1,296 | 603 | 671 | 0% |
| Rock Lobster | | | | | | |
| Total | 3,194 | 3,223 | 2,935 | 2,444 | 2,582 | 0% |
| East coast | 33 | 10 | 13 | 10 | 10 | 0% |
| South coast | 985 | 1,021 | 966 | 918 | 892 | 0% |

TABLE 3-1: FISH CATCHES PER YEAR (continued)

| Line, small net | | | | | | |
|-------------------------|----------------|----------------|----------------|----------------|----------------|-------------|
| Total | 21,857 | 25,123 | 26,504 | 23,334 | 20,528 | 15% |
| Snoek | 2,757 | 7,754 | 9,174 | 6,725 | 6,479 | 181% |
| Tuna | 4,903 | 4,069 | 4,309 | 2,715 | 3,158 | -17% |
| Yellowtail | 818 | 867 | 778 | 451 | 466 | 6% |
| Mullet | 1,310 | 1,153 | 1,061 | 1,086 | 982 | -12% |
| Squid | 6,308 | 6,441 | 6,850 | 7,111 | 3,538 | 2% |
| Other | 5,761 | 4,839 | 4,332 | 5,246 | 5,905 | -16% |
| Other activities | | | | | | |
| Total | 4,404 | 5,023 | 2,362 | 2,985 | 3,117 | 14% |
| Prawn, langoustine | 521 | 265 | 498 | 411 | 368 | -49% |
| Abalone | 599 | 613 | 614 | 613 | 536 | 2% |
| Other, guano, seaweed | 3,284 | 4,145 | 1,250 | 1,961 | 2,213 | 26% |
| GRAND TOTAL | 598,380 | 536,462 | 579,321 | 448,360 | 516,969 | -10% |

(South Africa Business Guidebook 2000 / 2001)

3.2.7 Department of Environmental Affairs and Tourism

The South African Fishing Industry falls under the administration control of the Minister of Environmental Affairs and Tourism. The fishing industry however contributes the least of all the sectors within this portfolio. The South African fishing industry is worth about R2.4 billion every year. This figure does not include secondary industries such as fish processing, boat building and transportation of fish products.

Millions of tourists visit South Africa's beaches and coastal resorts every year. It is estimated that coastal tourism generate R13.5 billion, on average, for the South African economy every year. South Africa's ports and harbours link our country to the world. The coastal shipping industry generates R4.2 billion every year.

The Minister of Environmental Affairs and Tourism initiated the process of developing a national marine fisheries policy at a public launch on 27 October 1994. Some of the main policy objectives outlined were as follows (Marine Policy for South Africa White Paper 1997):

- Optimisation of long-term social and economic benefits to the nation
- Promotion of sustainable utilization and the replenishment of living marine resources
- Management and development of fisheries shall in all material aspects comply with the principles of the Constitution of South Africa and the long-term objectives and principles of the Reconstruction and Development Programme (RDP)
- Transparency and accountability in marine resource management.
- Fair and equitable access
- Management of living marine resources will be based on the best available knowledge and multidisciplinary research within the context of sustainable utilization

- There should be a holistic approach to fisheries and the utilization of marine resources, including the following goals:
 - Participation in resource management
 - Acceptable conditions of employment

The Department has a statutory obligation (Marine Living and Resources Act 1998, Act 18 of 1998) to protect the marine environment. The objective of the Act states: "To provide for the conservation of the marine ecosystem, the long-term sustainable utilisation of marine living resources and the orderly access to exploitation, utilisation and protection of certain marine living resources; and for these purposes to provide for the exercise of control over marine living resources in a fair and equitable manner to the benefit of all citizens of South Africa; and to provide for matters connected therewith." Marine and coastal management is the department within the ministry of Environmental Affairs and Tourism that protects the marine environment. The highly sophisticated and accurate satellite tracking equipment helps the department to track vessels fitted with a vessel monitoring system (VSM) (FINSAs, April 2002).

- Marine and coastal management has to ensure the compliance to the Marine Living and Resources Act 18, 1998 and the compliance of quota holders to the permit conditions.

The South African fishing industry had a total annual catch of some 450,000 tons with a wholesale value in 1996 of R1, 9 billion. (South Africa Business Guidebook 2000 / 2001) South Africa was, as far as can be ascertained, successful in optimising the output of its major fisheries by way of landing quotas and ever since, the Authorities (Marine Living and Resources Act 18,1998) have tended to rely heavily on this form of regulation. Sensitive or important commercial species are subject to stringent output controls. In the pelagic fish industry, total allowable catch (TAC) controls are at present in force for pilchards and anchovies. The pelagic fish resources are well-managed and to a very large extent fully developed i.e. there are initially no major opportunities to develop additional resources in order to increase volume.

The Minister of Environmental Affairs and Tourism, Minister Valli Moosa, implemented plans in 2000 to restructure and transform the allocation of fishing rights to bring stability, certainty and transparency to the fishing industry.

At the core of this plan was the setting up of a dedicated allocations unit, with the capacity to verify all the applications for fishing rights and to allocate the resource TAC for more than twenty species in terms of measurable criteria and conditions. Secondly, the catch in each species is priced according to both effort and size. This allowed for setting out the relative quotas for large, medium, small and subsistence fishermen, and removes purely discretionary and ad hoc decision-making from the allocation process.

3.3 Fish meal & Oil Industry

3.3.1 Background

The South African pelagic fishing industry only really started developing in 1940, after the Second World War. (Malherbe, 2001). However it was also observed that the fishing activities were described in the early 1900's. These activities were not industrialized. Pilchards, also known as sardines, were canned and sold. However, the offal from the canned product was not put to any use. The first fishmeal plant was built in 1945 to process the offal from a canning plant. Because imports were not allowed, the plant was built from an old grape press, the back axle of motor vehicle and other equipment obtained in South Africa. This equipment brought the first ton per hour fishmeal plant in operation (Malherbe,2001).

Today the fishmeal & oil industry is a modern industry with 9 fishmeal plants and 6 canning plants along the South East and West Coast of South Africa. Approximately 70 purse seine vessels operate along the South East and West Coast to supply the fishmeal processing plants with pelagic fish species. The pelagic species is predominantly anchovy, pilchards, round herring (red eye) and horse mackerel (maasbanker). The cannery plants process and can the pilchards while the fishmeal plants virtually totally process all the other pelagic fish of the species. Steve Malherbe's estimation of the pelagic fishing infrastructure was R1200 million in 2001 (FINSA 2001).

The pelagic industry is the largest sector of the fishing industry in terms of mass of fish landed. The average total landing from years 1990 to 2000 was 375 000 tons, which represents more than 60% of total fish landings.

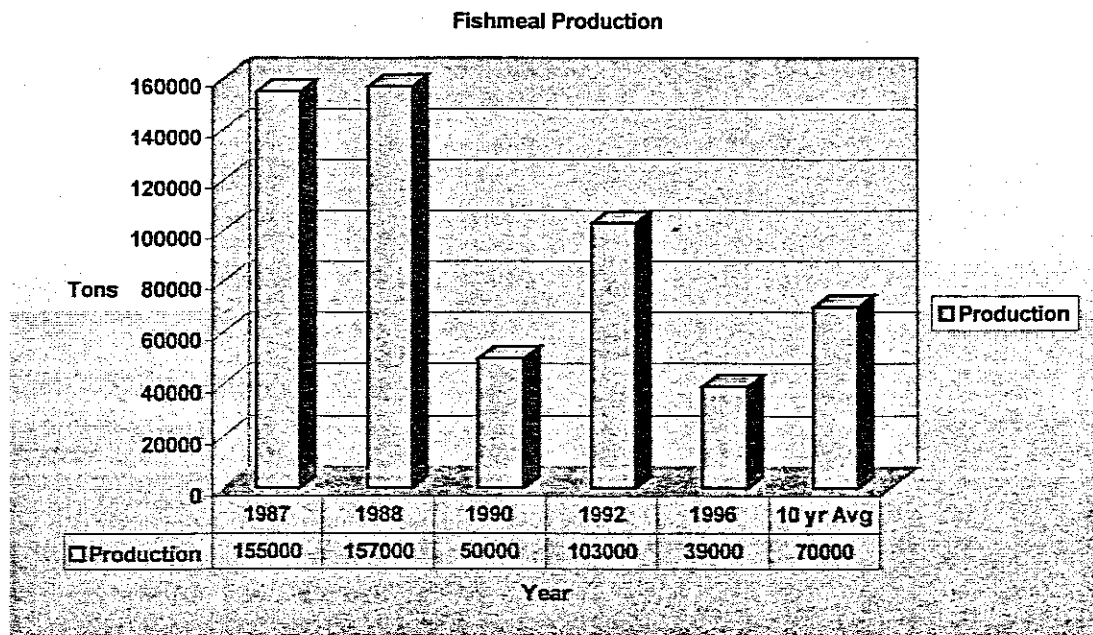
The industry is heavily dependent on the seasonal availability of the traditional species. " The pelagic fish species have a relatively short life span and quite dramatic fluctuations in availability could and do occur from year to year. The industry is extremely dependent on volume and these fluctuations, which are most of the times not predictable, have a huge impact on profitability and the viability of the participants in the industry" (Malherbe, S 2001:29).

Anchovy has a short life-span approximately 3 to 4 years. The anchovy resources are extremely dependent on environmental conditions, which, as a consequence, causes fluctuations in the biomass from one year to another. The anchovy spawns off the Agulhas bank on the South East Coast from where the eggs and larvae are transported via the Benguela cold current to the West Coast nursery grounds, as far north as the (Orange River). The eggs hatch here and the recruits then swim south, back to the East Coast grounds. On the way back they develop and grow where the fishing fleet makes catches. Numerous biological and environmental factors influence the strength of the resource in a particular year, which affects the size of a Total Allowable Catch (TAC). Environmental factors make it virtually impossible to forecast the abundance of fish hence the availability of fishmeal and oil cannot be anticipated with accuracy. The TAC for anchovy fluctuated from a high of 600,000 tons in 1987 and 1988 to a low of 60,000 tons in 1997, with several shorter-term fluctuations in between (Malherbe, 2001:29) .

The pelagic total allowable catch (TAC) for 2002 was announced by the Minister of Environmental Affairs and Tourism to be 662,183 tons, of which pilchards are 257,978 tons, anchovy 359,729 tons and pilchards by-catch 44,476 tons (FINSA, 2002).

The average fishmeal production during 1990 to 2000 was about 70,000 tons per annum. The graph 3-1 below illustrates how the yearly fishmeal production fluctuates within this 10-year period. The graph also includes the maximum fishmeal production recorded for South Africa.

GRAPH 3-1: COMPARISONS OF ANNUAL FISHMEAL PRODUCTION



Source :Malherbe, S 2001:27

The South African fishmeal industry was estimated to contribute only 1,5% of the total world production. Peru produced 2,28 million tons from the total world's production of 6,5 million tons in 2000 (FINSA, 2002).

The consumption of fishmeal in South Africa has declined substantially over the last 5 years. This was mainly due to a reduction in the inclusion rate¹ of fish meal in animal feed as a result of the unfavourable price ratio between soya meal and fishmeal. The usage pattern, however, has remained fairly constant i.e. most of the fishmeal is still used for poultry.

However, internationally the usage pattern has changed dramatically over the last years and it is expected that it will continue to change over the next 10 years. Aquaculture has become the number one client of fish meal producers. The estimated consumption for this industry was about 1,2 million tons less than 5 years ago. The International Fish Meal and Oil Manufacturing Association (IFOMA) estimated consumption in 2000 at 2,3 million tons and it is estimated that this will grow to 2.9 million tons by 2005 and 3,7 million tons by 2010. In other words, the present consumption of the aquaculture industry is 35% of world production and it will increase to 45% in 2005 and 57% in 2010 (IFOMA: 2000).

South Africa is hardly likely to have an aquaculture industry of any magnitude and the local production of fish meal and fish oil will remain available for the local animal feed industry as a substitute for imported soya meal (Brink, 2001:2).

3.3.2 Fish meal and Oil manufacturing Process

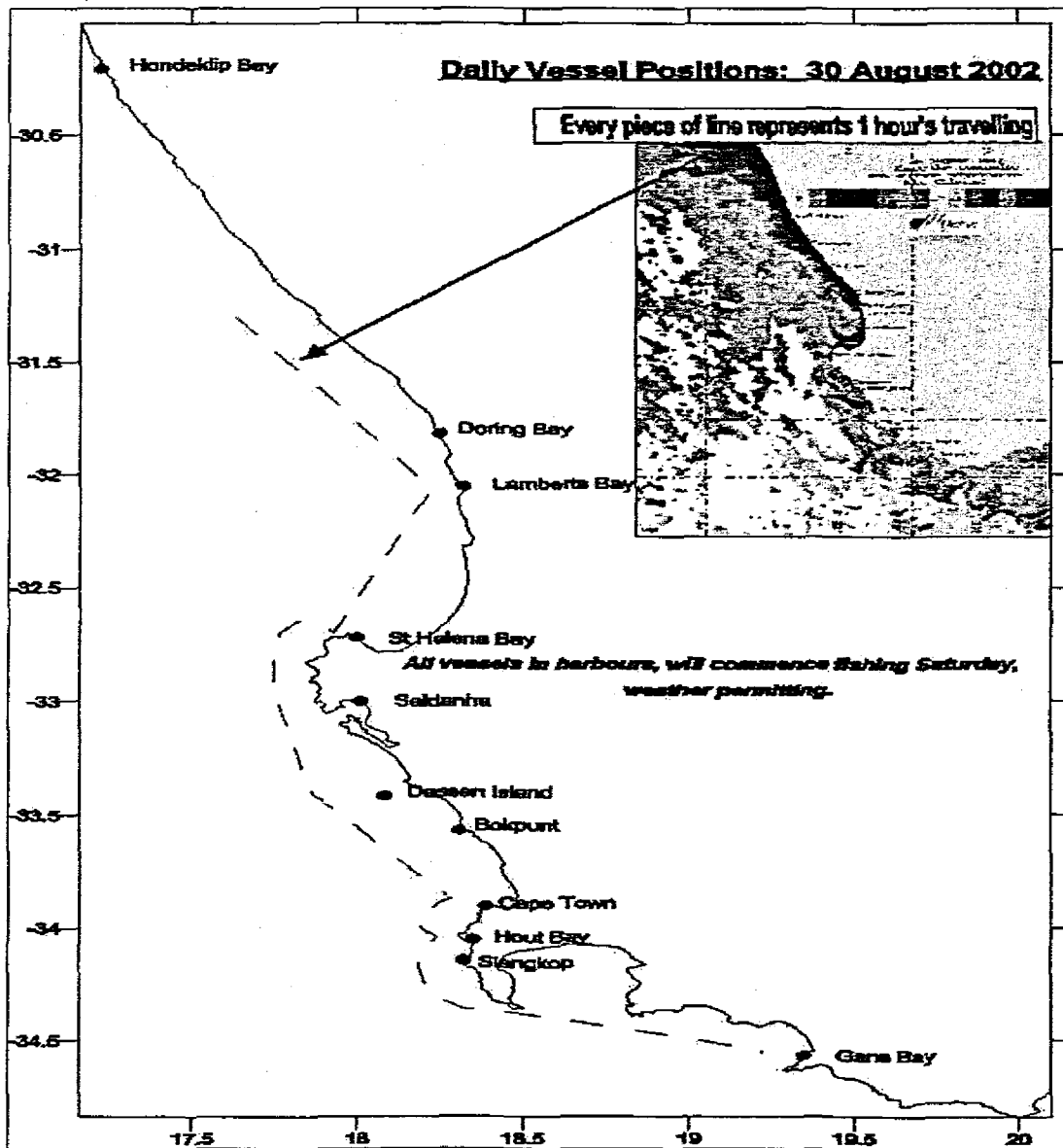
According to the Oceana Technical Fishmeal and Oil Video the fishmeal manufacturing process consists of the following stages:

¹ Inclusion rate is the percentage of fish meal added to the feed mixture.

3.3.2.1 Supply of raw fish

Diagram 3-1 that follows is a typical map used to indicate the position of the vessels and catch areas. The map also has the water surface temperatures, which is used as a guide to determine if the conditions are favourable for the different fish species.

DIAGRAM 3-1: DAILY VESSEL INDICATION



Source: Daily vessel report. St Helena Bay Fishing industries

The average yield of tons of raw fish varies depending on the species, the area and the distance from the factory as well as certain production factors. A 23% yield has been accepted as a fair average i.e. 4.25 tons of raw fish is required to produce one ton of fish meal. The fish oil yield is dependent on the fat content, size and specie of the fish.

Vessels catch the pelagic fish in fishing nets. Most of these vessels are equipped with sophisticated satellite tracking equipment, which assists in their search for the different fish species. The pilchard is caught and put on ice before being off loaded at the cannery plants. The anchovy and other fish species, destined for the fishmeal plants are caught and off loaded without the addition of any preservatives.

Fish is pumped from the vessels over weighing platforms and transferred into the fishmeal fish pits. An inspector from the Department of Marine and Coastal Management checks the mass of the fish offloaded and the compliance with all the permit conditions. The quantity of fish off loaded is deducted from the total quota of the permit holder.

The offal from the canneries is pumped to the fishpits at the fishmeal plants. The mass of offal is determined by the usability of the pilchards landed at the canneries. The lower the usability and quality of the pilchard the larger the percentage of offal that is sent to the fish meal plants.

3.3.2.2 Cookers

The fish is transported through screw conveyors from the fish pits into the cooking vessels. Depending on the quality of the fish, formaldehyde is added to the fish for preservation. The fish is cooked for 20 minutes to ensure that all the bacteria are killed. The fat of the fish is converted into liquid during this process.

3.3.2.3 Press and decanters

From the cookers the fish pass through a strainer conveyor to separate the liquid from the solids. The liquid phase, 78% of the fish, is sent to a decanter where it awaits further processing. The liquid phase is transported to a separating centrifuge where the liquid is further split into water and oil. The solids are conveyed to the press, which consists of two converting screws that press the solids together to squeeze out virtually all liquid. The solids are conveyed to the wet mills. The liquid, called stickwater is pumped to the decanter. The decanter separates the liquid from the sludge. The liquid is sent to the oil plant to remove the oil from the water. The sludge is pumped to the stick water plant.

3.3.2.4 Fish Oil Plant

The liquid is separated in a centrifugal separator, which operates, on the principle of density difference. The oil and stick water are separated in this stage. The water is pumped to the stick water plant where it is concentrated and then added to the solids before drying.

The fish oil, a very dark colour is further "polished" by the addition of hot water. The hot water removes the impurities. The water and oil are sent through a centrifuge, which then produces a lighter colour oil and waste water with these impurities. The oil is pumped to storage tanks. The free fatty acid content of the oil is tested every hour.

3.3.2.5 Stick Water Plant

The content of the decanter is concentrated in an evaporator. The concentrate, 35 to 40% total suspended solids, is added to the press cake from the press.

3.3.2.6 Drying

The blended press cake, sludge and concentrate are put into the dryers. The solids are dried to 10% moisture, in steam or flame dryers.

3.3.2.7 Mills

The dried product is put through hammer mills to reduce the fishmeal to a sawdust-like texture. The fishmeal is bagged or put in bulk storage.

3.3 Conclusion

This chapter offers an explanation of the South African fishing industry and contributes to a more precise understanding of the pelagic and fish meal and oil industry. The major sectors of the South African fishing industries are: demersal, pelagic, rock lobster, crustacea and line and small net fishing. The pelagic industry supplies the raw material for the production of fish meal and oil. The production process of fish meal and fish oil consists of cooking of the fish, solid and liquid separation, water and oil separation, liquid concentration, drying of fish meal and the milling of the fishmeal.

Chapter Three briefly introduces the production of fish oil and Chapter Four continues to explain the properties of fish oil. Chapter four also explains the different fish oil applications.

Chapter 4

Fish oil Properties and Applications

4.1 Introduction

This chapter discusses the physical and chemical properties, composition and quality of fish oil. The second section of the chapter deals with the various applications of fish oil and the quality needed for successful applications.

4.2 Fish Oil Properties

4.2.1 Origin of Fish Oil

Fish oil is produced as a by-product in the manufacturing of fish meal. South African fish meal and oil is primarily produced from the reduction process of fish species like anchovy, red herring, pilchard, horse mackerel and other small fish species.

4.2.2. Background

Fish body oil, previously the main product from raw material having high oil contents, is now of secondary value. The product, however, is versatile and finds many applications in the food and technical industries and remains of considerable economic importance to producers.

Table 4-1 shows some statistics of production of fish body oil during a number of years. (Food and Agriculture Organisation of the United Nations (FAO) 1986) The South African fish oil production showed a downward trend while that of the Japanese showed a steep increasing trend.

TABLE 4-1: PRODUCTION OF FISH BODY OILS (IN '000 METRIC TONS)

| Country | 1968 | 1970 | 1975 | 1980 | 1983 |
|-------------------|------|------|------|------|------|
| Norway | 236 | 180 | 176 | 182 | 213 |
| Japan | 40 | 87 | 136 | 223 | 335 |
| USA | 78 | 93 | 111 | 142 | 167 |
| South Africa | 125 | 79 | 42 | 38 | 38 |
| Denmark | 70 | 51 | 107 | 123 | 81 |
| USSR | 57 | 60 | NA | 39 | 56 |
| Peru | 292 | 311 | 212 | 78 | 6 |
| Iceland | 16 | 7 | 27 | 82 | 24 |
| Canada | 34 | 27 | NA | 12 | 9 |
| Germany Fed. Rep. | 15 | 14 | NA | 10 | 17 |
| UK | 0 | 0 | NA | 14 | 9 |
| Morocco | 11 | 5 | NA | 4 | 5 |
| Chile | 34 | 23 | 24 | 111 | 57 |
| Sweden | 4 | 3 | NA | 5 | 3 |
| Faeroe Islands | 7 | 6 | NA | 7 | 7 |
| Spain | 4 | 4 | NA | 7 | 5 |
| Mexico | 1 | 1 | NA | 17 | 12 |
| World | 1041 | 971 | 1921 | 1141 | 1115 |

(FAO: vol.142)

4.2.3 The production of fishmeal and oil

The complexity of the different applications requires the understanding of all the parameters regarding fish body oil. It is therefore very important to have insight into the background and origin of fish body oil, the processing of the fish body oil, and its different uses.

Fish body oil is produced during the reduction process of fish into fishmeal and fish body oil. The fish used for reduction to meal and oil may be divided into three categories (Young F.V.K 1986: 1);

- Fish caught for the sole purpose of fishmeal production (for example by Chile, Peru, Norway, Denmark, South Africa and the USA);
- By-catches from another fishery (in most fish-producing countries);
- Fish off cuts and offal from the consumption industry. (The UK and Germany use these materials to produce white fishmeal; South Africa makes rock lobster meal from the carapaces and other part, which are not utilized.)

The above categorization is important as the different sources of fish delivers different quality of fish body oil and therefore has an impact on the physical and chemical properties of the fish body oil. These differences give rise to the application in different end product uses.

Practically all fish species as well as most other marine animal life may, on principle be converted into fishmeal and fish body oil. A wide variety of fish species is, used for the production of fishmeal and oil in different countries. The composition and quality of the raw materials are predominant factors in determining the properties and yield of the products. A separation of fatty substances (lipids), from the other constituents of fatty marine animals, is one of the major operations in the manufacturing of fishmeal and oil (Young F.V.K, 1979:1).

4.2.4 Fish Body Oil Composition

The oils contain mainly triglycerides of fatty acids with variable amounts of phospholipids, glycerol ethers and wax esters. It is characteristic of the oils that they contain a wide range of long-chain fatty acids with the number carbon atoms ranging mainly from 14 to 22, and a high degree of reactivity (unsaturation) wrapped to six double bonds per molecule (Young, 1986).

4.2.5 Fish body oil properties

The complex nature of fish body oil depends upon a number of factors. The fatty acid patterns of the oils vary widely with the fish species and, to some extent, with the composition of the plankton eaten by the fish and the time of year the fish is caught. These factors influence the properties of the oils, both in regard to edibility as well as technical applications (Young, 1986). The oils contain variable, but small amounts of unsaponifiable components, such as hydrocarbons, fatty alcohols, waxes and ethers, and these also influence the properties of the oils to some extent.

The condition of the fish at the time of processing affects the oil physically, chemically and nutritionally. Fish of poor quality yield malodorous oil with high content of free fatty acids (FFA) and sulphur. These latter, undesirable properties, affect both the economic value and the application of the oil. Some sulphur compounds have an inactivating effect on the nickel catalyst used for hydrogenation in the hardening process of fish body oil.

In order to manufacture oil of desirable properties, one should observe the following:

- The fish should be as fresh as possible.
- The oil should be cooled, before delivery to the storage tank, and should be pumped in near the bottom of the tank but removed from the top.
- The sludge and water should be regularly drained from the bottom in order to prevent an increase in FFA during storage.

4.2.6 Fish body oil Quality

A number of chemical, physical and sensory methods have been developed for the assessment of quality. Analytical work is made difficult due to the slippery and changeable nature of the labile unsaturated fatty acids; oil sampled should be stored at low temperature in an inert atmosphere before analysis. Saturated oil fractions tend to precipitate during cold seasons in large storage vessels. This necessitates thorough mixing of the oil before sampling.

The test methods employed by the user of fish body oil, for hardening purposes, are often divided into two groups. The first is applied on receipt of a consignment to check the fundamental parameters, and the second, more detailed, examination as soon as possible thereafter, but before the oil is used in the refinery. The purpose of this second examination is to determine the refining procedures.

The initial testing involves the following

- Moisture
- Dirt
- Appearance
- FFA
- Soap
- Iodine value

The second examination normally includes

- Peroxide value
- Ultra violet
- Trace Metals
- Sulphur
- Phosphorous

These quality tests are important to establish the cost of processing the oil and determining the application suitability.

4.3 Fish Oil Applications

4.3.1 Traditional Applications

4.3.1.1 Edible applications

Fish body oils have been used as edible oils for the past sixty-five years (Young: 20:1986). In 1986 over 95% of fish body oil production was used for human food. The oils are refined and hydrogenated and result in hard fat with a number of desirable characteristics. The fat is palatable and is a concentrated source of energy. Margarines and shortening require the characteristics of smoothness and plasticity, which are described by the beta crystal form. This is the stable form for hydrogenated fish body oils and they influence any blends of which they are a part in that crystalline form.

Hardened fish body oil in the melting point of 30°C - 38°C helps the production of a clean melting domestic margarine (Young 1986:20). More highly hydrogenated oils with 40°C - 50°C melting point, are used in small quantities (5 - 10%) in table and creaming margarines, and in larger amounts (30% - 60%), in puff pastry blends. Fat blends containing substantial quantities of hydrogenated fish body oil have particularly good creaming performance, which is air-incorporation properties, when used in cake batters.

In South America lightly hardened fish body oils are used as the base stock of a compound cooking and salad oil (Young: 20:1986). The world production of fish body oils over the past twenty-five years has remained more or less static, at about one million metric tons.

Their nutritional and physical properties have made hardened fish body oil attractive constituents in diets for man. Hardened fish body oil was used almost entirely in margarines and shortenings. Margarines, prepared from hardened vegetable oil, sometimes recrystallize on storage. This makes the margarine crumbly and hard. Because fish body oils have a wide chain length, margarine prepared from them has an excellent plastic consistency. Shortening and bakery margarines have properties different from those of table margarines. The value of hardened fish body oils lies in its creaming power, particularly for the baking of cake.

Refined fish body oils are rich in polyunsaturated fatty acids of the linolenic acid family. Medical research suggests that these fatty acids have a unique role to play in prevention of coronary artery disease and the growth of different types of cancers.

4.3.1.2 Technical applications

The highly unsaturated properties make the oils suitable for a number of technical applications, particularly as drying oils and varnishes. The saturated fatty acid fraction is a disadvantage for these purposes and is reduced.

Fish body oils are a significant source for production of fatty acids with a wide spectrum of chain lengths. These acids are the source of several types of metallic soaps, some of which are used in lubricating greases while others are used as waterproofing agents. Small quantities of fatty acids are used pharmaceutically and medicinally, as well as for scientific research purposes.

4.3.1.3 Commercial value

The market value of fish body oil depends on its chemical analysis. Normally, a basic sales value is established for oil containing a certain level of free fatty acids (2% to 3%), unsaponifiable matter (3.5%), water and dirt (0.3%). When the levels are exceeded, the price is reduced accordingly. The price may also be reduced if the oil is dark coloured or malodorous.

4.3.1.4 Refining and hydrogenation

i) Introduction

All crude oils and fats, which are used for edible purposes must contain non-triglyceride, a national or international specification, whilst retaining the desirable substances. These substances detract from the acceptability of the oil or fat as foodstuff, because of the flavour or colour which they give to the oil, or because they reduce its stability or shelf life.

The purpose of a refining is to remove the undesirable components as to achieve national or international specifications whilst retaining the desirable features (Young, 1986).

Fish body oils contain significant quantities of polyunsaturated fatty acids having three or more double bonds in the fatty acid chain. These fatty acids are mainly combined with glycerol, forming the triglycerides of the natural oil. The polyunsaturated fatty acids are highly susceptible to oxidation, giving rise to the rapid production of compounds responsible for the "fishy" smells and taste of the oil.

ii) Quality Determination

The tests are of significance to determine crude fish body oil quality. In addition to these tests, many refineries have found it useful to carry out laboratory refining, bleaching and hydrogenation tests on oils received prior to plant processing. From the results of such tests problems can be foreseen and measures taken to minimize them (Young, 1986).

iii) Pre-hydrogenation refining

For the pre-refined crude oil in a refinery in which vegetable and fish body oils are processed, the pumps, pipe-work, storage tanks and plant for unhydrogenated fish body oil must be separated from those used for vegetable oils and other animal fats (Young F.V.K, 1986:7) The unsaturation of fish body oil is such that only traces occurring in other oils will produce a fishy taste. Above all, no fitting in contact with oil, should be made of copper or copper-bearing alloy.

Storage tanks should be insulated and equipped with a heating coil because fish body oil contains high-melting triglycerides, which, in cold climates, settle to the bottom of the storage tank. Free fatty acid (FFA) values of crude oils stored in individual tanks, should be checked weekly. The poorest oil should be used first and this way the consistency of product quality is maintained. Fresh intake oil should be pumped to empty tanks, as remnants of oil accelerate the oxidation of the new oil.

Table 4-2 lists the stages in the method of fish body oil pre-refining.

TABLE 4-2: PRE-REFINING CRUDE FISH BODY OIL - UNIT PROCESSES

| Stage | Purpose |
|------------------|---|
| Gum Conditioning | Modifying phospholipids, trace metals, pigments, protein, for removal in aqueous phase. |
| Neutralization | Reduction removal of fatty acids, phospholipids, trace metals, pigments, sulphur, oil insolubles, and water solubles. |
| Washing | Removal of soap. |
| Drying | Evaporation of water. |
| Bleaching | Reduction of pigments, oxidation products, trace metals, sulphur, removal of traces of soap. |
| Filtration earth | Removal of spent bleaching |

(Young F.V.K, 17:1986)

Fish body oil contains between 0.015% and 0.3% of phosphatides. Over 0.03% phosphatides will have a significant effect on soap stock separation and therefore, the addition of 0.05% to 0.1% phosphoric acid is needed for this purpose. Below 0.03% phosphatides, phosphoric acid at a level of 0.05% should still be added in order to effect removal of trace metals.

The concentration of caustic soda used for neutralisation of fish body oil is usually strong because the FFA is normally greater than 1.5% and because of the effect of strong caustic soda solutions on pigments in the oil. Batch neutralisation and bleaching should be carried out in a neutraliser and bleacher plant. After the continuous neutralization process, the oil may be bleached by batch method or by using one of the semi-continuous or continuous methods, available. Pre-refined oil is starting material for the hydrogenation process. For ease of hydrogenation and the production of a high quality end product, the oil at this stage should have the analyses as shown in table 4-3.

TABLE 4-3: ANALYSIS OF PRE-REFINED FISH BODY OIL

| | |
|------------|-----------------|
| FFA | 0.15% Maximum |
| Soap | Nil |
| Phosphorus | 4 µg/g maximum |
| Sulphur | 15 µg/g maximum |

(Young F.V.K, 17:1986)

iv) Hydrogenation

During hydrogenation, in order to produce a fat of satisfactory oxidative stability for margarines and shortenings, it is necessary to eliminate the six, five and four double bonds acids and preferably also the trienes. Customarily dry or wet reduced, supported nickel catalyst is used. The nickel content lies between 17% and 25% of the catalyst and is supported on a similar proportion of natural earth (Young, 1986). Catalyst consumption for fish body oil normally lies between 0.5% and 1.0kg nickel per ton oil. Heating is started with the reaction vessel under vacuum, thus drying the oil. At 140°C the catalyst slurry is sucked into a vessel below the oil surface. Care is taken that air is not sucked into the vessel.

v) Post hydrogenation

The FFA of the oil rises during the hardening process. The increase depends on the quality of the starting oil and the melting point of the product. The nickel content of the oil after efficient filtration should not be higher than 2.0 -2.5 ppm. The purpose of post-refining is to reduce the FFA level to less than 0.1%, preferably less than 0.05%, reduce the nickel content to less than 0.2 ppm, produce an acceptable colour, bland odour and flavour and remove as far as possible the oxidation products responsible for poor shelf-life stability. After deodorization, hardened fish body oils should be handled with the same care as other oils.

vi) The extra effort and cost to the refiner in dealing with poorer grade quality fish body oil.

It is necessary to discuss the quality parameters of fish body oil with particular reference to those which affect the usage and "shelf-life" i.e. stability to oxidation, of the hydrogenated edible product. It is high levels of these contaminants, which necessitate the use of extra refining treatment, with consequent increase in refining costs. From this discussion definitions arise which have formed the basis of the increased cost calculations. These calculations are used to determine the balance between the quality of the raw material and the revenue generated by the refined fish oil.

vii) **Quality classification**

Table 4-4 below gives the parameters against which oil is classified as good or poor.

TABLE 4-4: QUALITY CLASSIFICATION

| | Good Quality | Poor Quality |
|----------------------------------|-------------------------|-------------------------|
| Moisture % | 0.1 | 0.4 |
| Impurities % | 0.03 | 0.1 |
| FFA % | 2.0 | 4.0 |
| Peroxide Value (m.equiv s/Kg) | 2.0 | 9.0 |
| Anisidine Value | 5.0 | 15.0 |
| UV Specific Extinction | 1.0 | 5.0 |
| Iron ppm | 1.0 | 6.0 |
| Copper ppm | 0.1 | 0.5 |
| Sulphur ppm | 15.0 | 60.0 |

(IAFMM 1980)

The processing stages and chemicals used for processing poor and good quality oil differ. These stages are illustrated in the table below.

TABLE 4-5: DIFFERENT REFINING STAGES

| Stage | Poor Quality | Good Quality |
|---------------------|--|---|
| Neutralising | <ul style="list-style-type: none"> - Citric acid washes 2% of 10% solution. - Phosphoric acid 0.2%. - 1st refine, 4N NaOH 20% excess (for 4% FFA) - 2nd refine, 4N NaOH (for 0.75% FFA) - 3 washes - Dry | <p>Not applicable</p> <p>0.1% solution Same (for 2% FFA)</p> <p>Not applicable</p> <p>Same Same</p> |
| Bleaching | <ul style="list-style-type: none"> - 2% high activity earth - Filter | <p>1% standard earth</p> <p>Same</p> |
| Hydrogenation | <ul style="list-style-type: none"> - Catalyst 0.15% as nickel - Hydrogen extra 10% | <p>0.1%</p> <p>Not applicable</p> |
| Post refining | <ul style="list-style-type: none"> - Phosphoric acid 0.05% - 1N NaOH (for 0.75% FFA) - 2 washes - Dry | <p>Not applicable</p> <p>Not applicable</p> <p>Not applicable</p> <p>Not applicable</p> |
| Bleaching | <ul style="list-style-type: none"> - Citric acid 0.02% as 10% solution - 1% high activity earth | <p>Same</p> <p>0.5% standard earth</p> |
| Deodorizing (Batch) | <ul style="list-style-type: none"> - 7 hrs at 190^oC - Citric acid 0.2% before deodorizing - Citric acid 0.02% on cooling | <p>5 hrs at 190^oC</p> <p>Not applicable</p> <p>Same</p> |

(IAFMM: 1980)

These additional stages and chemicals make the refining of poor quality oil economically unfeasible. The quality of the oil produced during the production process of fishmeal and oil has a direct impact on the final production cost of a refinery.

4.3.2 New Applications

4.3.2.1 South African Aquaculture Production

According to Brink (2001) aquaculture refers to the farming of finfish, shellfish, crustaceans and aquatic plants. The limited supply of fish from marine and freshwater capture fisheries together with efforts aimed at generating foreign currency, food security and economic growth have resulted in the continued expansion of the aquaculture sector since the 1980's.

Aquaculture has been practised since the earliest record of human history, dating back over 4000 years. In the last 50 years aquaculture has developed into a worldwide industry with a total production of 36 million tons and a net value of US\$52 billion in 1998. The world total fisheries production amounted to 117 million tons in 1998, consisting of 86 million tons of captured fish and 29 million tons of cultured fish. The captured fish in turn consisted of 62 million tons of food fish and 24 million tons of non-food fish (fishmeal and oil). The aquaculture industry thus contributes about 30% to world total production and equal proportion to total food fish production. Aquaculture production has realised an increase of more than 40 percent over the previous two decades, with aquaculture making up the difference between rising demand and the stagnant supplies from capture fisheries.

Aquaculture has demonstrated its ability to contribute towards food security and economic growth, and to generate employment and foreign exchange. Aquaculture has been the world's fastest growing food production system over the past decade. The demand for fish body oil for aquaculture is growing as fast as the aquaculture industry.

4.3.2.2 International Aquaculture

The aquaculture industry enjoys a regular development, generating a sustained demand for fish body oil. In the European aquaculture industry, the production reached 1.3 millions tons in 2000, of which 600,000 tons was salmon (since 1994 the salmon production increased on average by 13% on a yearly basis).

The fish body oil requirements of the aquaculture industry are presently between 600,000 and 700,000 tons and is expected to double by 2010. The potential demand far exceeds the potential available supply.

Fish body oil prices were higher than Fair Average Quality (FAQ) fish meal prices in 2001. They enjoy presently a US\$200 premium over the soybean oil. The inclusion in fish feeds will reach 900 thousand MT this year. The present fish oil price is at the level of US\$500, basis FOB Peru. (Sotomayor, 2002).

The table below was presented at the IFOMA annual conference in LIMA in 2000. The table illustrates the predicted fish body oil requirements for aquaculture market up to 2010.

TABLE 4-6: FISH OIL REQUIREMENTS

Fish Oil Required

| Species | % Fish Oil | | Fish Oil Required | |
|--------------|-------------|-------------|-------------------|---------------|
| | 2000 | 2010 | 2000 | 2010 |
| Carp | 1.0% | 0.5% | 88.7 | 130.9 |
| Tilapia | 1.0% | 0.5% | 9.8 | 16.6 |
| Shrimp | 2.0% | 3.0% | 34.0 | 139.8 |
| Salmon | 25.0% | 17.0% | 318.1 | 420.8 |
| Marine fish | 12.0% | 15.0% | 170.7 | 854.3 |
| Trout | 15.0% | 18.0% | 106.0 | 107.4 |
| Catfish | 1.0% | 1.0% | 7.3 | 11.2 |
| Milkfish | 3.0% | 2.0% | 6.8 | 9.4 |
| Flatfish | 10.0% | 12.0% | 8.8 | 61.3 |
| Eel | 5.0% | 10.0% | 18.8 | 35.1 |
| TOTAL | 7.5% | 7.9% | 769.1 | 1786.7 |

(IFOMA: 2000)

The papers presented at the IFOMA Lima 2000 conference re-emphasized the high growth rate of the aquacultural industry. The decline of fish body oil demand in the hardening market is overshadowed by this fast growth of the aquaculture market and the consequential high demand for fish body oil from this industry.

4.4 Conclusion

Understanding the complexity of fish oil in terms of its properties, composition and wide range of traditional applications catalyses the full understanding of the impact of changes within fish oil application. The importance of the quality of fish oil is apparent from this chapter. Now that fish oil, in its entirety, is better understood, the next chapter will deal with answers to the questionnaires in Appendix 1 that were conducted via telephonic and personal interviews.

Chapter 5

Research Results

5.1 Introduction

Not all the role players intended to be part of the study were available. The content that follows deals with the actual interviews that were conducted and the data from each of these interviewees. The data are presented per industry sector under each of the hypothesis headings.

Although the companies have been identified, for ethical reasons and autonomist company A and B has been used to label the different respondents in all the data tables in this chapter.

5.2 Hypothesis One

This section consists of the answers to the questions that interrogate the factors that influence the selling price of fish oil in the animal feed industry.

5.2.1 Animal Feed Manufacturers.

Interviews were conducted with two of the three animal feed companies in the Western Cape.

The respondent rate was 66%. Two of the three Western Cape Feed mills were interviewed.

TABLE 5-1: ANIMAL FEED MANUFACTURERS ANSWERS-HYPOTHESIS ONE

| Questions | Company A | Company B |
|---|---|---|
| 1.Monthly and annual fish oil consumption. (tons) | 550 tons | 200 tons. |
| 2.Factors that influence monthly and annual consumption. | Digestibility, calorific value and price | Price |
| 3.Feed oil suppliers. | Energy Oil | Energy Oil & Cape Oil |
| 4.Who do you regard as the major role players in the feed oil industry? | Energy Oil; PSS Oils | Energy Oil; PSS Oils; Cape Oil |
| 5.Inclusion rate of fish oil in the feed mix. | 15% inclusion rate of feed oil. | 5% inclusion rate of feed oil. |
| 6.Factors that influence the inclusion rate. | Protein, moisture and fat content of other raw materials. | Protein, moisture and fat content of other raw materials. |

5.2.2 Feed Oil Suppliers and Producers

The Feed oil companies purchase fish oil from the fishing industry. The feed oil companies produce different feed oil, which is sold to the Animal Feed companies.

The two major feed oil producers were interviewed. The respondent rate can be regarded as 80%. The market share of one of the companies was given as 75% (see table 5-5 question number 10.) The companies interviewed were regarded by the animal feed manufacturers as the main role players in the feed oil producing industry.

TABLE 5-2: FEED OIL MANUFACTURERS ANSWERS - HYPOTHESIS ONE

| Questions | Company A | Company B |
|---|--|--|
| 1. Average monthly and annual fish oil consumption. | Range from 500 to 1000 tons per annum. | 250 tons per month; 2600 tons per annum. |
| 2. Factors that influence monthly and annual consumption. | Availability and price | Availability and price |
| 3. Raw material suppliers. | For fish oil, the South African Fish oil producers. | SA Fish Oil Producers |
| 5. Inclusion rate of fish oil in the feed mix. | 0% to 10%. | 8% to 20%. |
| 6. Factors that influence the inclusion rate of fish oil into feed mixes. | Quality of feed oil, price of raw materials. | Mostly Free Fatty acid content. |
| 7. Feed Oil products sold to Animal Feed manufacturers. | Eight different feed mixes. Confidential not willing to give more detail). | Three different feed mixes: Feed Fat F20 Micro Feed Fat |
| 8. Major factors that influence feed oil prices. | Price of raw materials. | Price of raw materials. |

5.2.3 Fish Oil Producers

The pelagic fishing companies outside of the Oceana group were not willing to disclose the information. The pelagic fishing association was willing to answer most of the questions sent to the fishmeal and oil producers. Steve Malherbe General Manager of the Fishing Association and the South African Fish Meal and Oil Marketing Company were interviewed.

The respondent rate of these role players is difficult to measure. The South African fish meal and oil industry consists of eight fish meal factories. One group owns three of the factories, it agreed to answer the questionnaire. The other companies were not available.

However, the South African Pelagic Fishing Industry Association agreed to answer the questions. The respondent rate is estimated to be 50%.

TABLE 5-3: FISH OIL PRODUCERS ANSWERS HYPOTHESIS ONE

| Questions | Pelagic Fishing industry Association | Fish Oil Producing Group |
|--|--|---|
| 9. Annual production of fish oil for the last five years? | 1996: 3265 tons 1997: 3609 tons 1998: 5408 tons 1999: 2788 tons | Three factories Combined) 1996: 1324 tons 1997: 1601 tons 1998: 2192 tons 1999: 1190 tons 2000: 2357 tons 2001: 1470 tons |
| 10. Annual fish oil yield for the last five years? | Not Available | 1996 not available 1997: not available 1998: not available 1999: not available 2000: 2,87% 2001: 1,2% |
| 11. Current fish oil production volumes and yields for 2002? | Volume not available for industry. Yield below 1% for most of the year. | SASP: 270 tons and 0.6% yield LBFC: 160 tons and 0.7% yield SHBF: 1426 tons and 1.5% yield |

5.3 Hypothesis Two

This section consists of the answers to the questions that interrogate the effect of high fish oil prices relative to low substitutes.

The role players interviewed for the validation of Hypothesis Two are the same as Hypothesis One. The respondent rate is therefore also 65%, which is acceptable for validation purposes. The second hypothesis has been proven to be true. Low selling prices of substitutes in 2000 forced the industry to decrease fish oil prices to an all time low in order to sell into the animal feed industry.

Low selling prices of substitutes in the future will compel producers to burn the oil or sell into alternative market segment if they are not willing to lower the selling price.

5.3.1 Animal Feed manufacturers

Interviews were conducted with two of the three animal feed companies in the Western Cape.

TABLE 5-4: ANIMAL FEED MANUFACTURERS ANSWERS-HYPOTHESIS TWO

| Questions | Company A | Company B |
|--|---|---|
| 1.Fish oil substitutes. | Maize bran. However feed oil is used as bonding agent. | Product with high-energy value, However acid oils have no substitute? |
| 2.Substitutes available domestically. | Maize | Full fat soya |
| 3.Substitutes that have to be imported | None | None |
| 4.Animal feed mixes to which fish oil is added. | Currently Chicken feed only | Poultry Chicken feed only, no layer feeding. |
| 5.Quality criteria needed for the fish oil. | Digestibility, calorific value, Free fatty acid content | Free Fatty acid content, peroxide value, moisture, calorific value, liquid has to mix easy. |
| 6.The quality criteria needed for the substitutes. | Protein, moisture and fat content | Protein, moisture and fat content |
| 7.Nutritional advantages and values of the fish oil. | Presence of Omega 3 fatty acids. | Presence of Omega 3 fatty acids. |

5.3.2 Feed oil producers

The respondent rate of these role players is difficult to measure. The South African Fish Meal and Oil Industry consists of eight fish meal factories.

One group owns three of the factories, and agreed to answer the questionnaire. Responses from the other companies were not available. However, the South African Pelagic Fishing Industry Association agreed to answer most of the questions. The respondent rate is estimated to be 50%.

TABLE 5-5 FEED OIL PRODUCERS ANSWERS - HYPOTHESIS TWO

| Questions | Company A | Company B |
|--|---|--|
| 1. Fish oil substitutes. | All Vegetable based oils; soya, canola, palm oil. | Used vegetable oils Animal Fat Tallow |
| 2. Substitutes that are locally available. | Soya, canola | All |
| 3. Substitutes that have to be imported. | Confidential, not willing to provide info. | None |
| 4. Animal feed mixes into which fish oil is added. | Eight different feed mixes. (Confidential not willing to give more detail). | Three different mixes: Feed Fat F20 Micro Feed Fat |
| 5. Quality criteria needed for the fish oil. | Free Fatty acid: 10% Total fatty matter: 98% Peroxide: max 10% pH: 5 to 7 Long Chain 14, 16 and 18 bond: 70% unsaturated fats and 30% saturated. | Total Fatty matter content Free Fatty Acid content Moisture Fatty profile Saturated versus unsaturated fat Polymerized Tri-glycerides |
| 6. Quality criteria needed for the substitutes. | Similar to fish oil criteria | Total Fatty matter content Free Fatty Acid content Moisture Fatty profile Saturated versus unsaturated fat Polymerized Tri-glycerides |

**TABLE 5-5 FEED OIL PRODUCERS ANSWERS - HYPOTHESIS TWO
(continued)**

| Questions | Company A | Company B |
|---|--|--|
| 7.Nutritional advantages and values of the fish oil. | Confidential not prepared to reveal information. Note please fishy odour in eggs. | Energy value high compared to substitutes The Omega-3 fatty acids. Please note that negative effect ^a is strong fish oil odour in chickens and eggs. |
| 8.Nutritional advantages and values of other substitutes. | Confidential not prepared to reveal information. | Not Sure |
| 9.Your market share? | Confidential not prepared to reveal information. | 75% |
| 10.Percentage and tons of own feed oil production in terms of your core business. | 84% | 95% |
| 11.Quality criteria for the feed oil | Animal feed nutrients according to AFMA & international specifications | Free Fatty acid: 20 to 60% Total fatty matter: 98% Double stomach animals: High % saturated fats and low % unsaturated fat. Single stomach animals: High percentage of low unsaturated fats (60%) |

5.3.3 Fish Oil Producers

TABLE 5-6 FISH OIL PRODUCERS ANSWERS - HYPOTHESIS TWO

| Questions | Pelagic Fishing industry Association | Fish Oil Producing Group |
|---|---|---|
| 10. Economic value of the fish oil prior to the closure of Marine Oil in Simons Town in 1999. | R 2,300 to R2, 400 per ton. (1999) R500 and R750 for years 2000 and 2001 respectively. | R2,300 (1999) |
| 11. Current economical value of the fish oil. | R2, 500 per ton for 2002. | 5% to 8% FFA -at R2, 500 and R2, 800 per ton. Above 10% FFA - at R2, 000 to R 2,400 per ton. Below 5% FFA at 320 to 360 US\$ per ton FOB Cape Town. |

5.4 Hypothesis Three

The average respondent rate is 50%, which is acceptable to validate Hypothesis Three. Hypothesis Three has been proved correct.

5.4.1 Fish Oil Producers

The respondent rate of these role players is difficult to measure. The South African fish meal and oil industry consist of eight fish meal factories. One group owns three of the factories, and agreed to answer the questionnaire. The other companies were not available. However the South African Pelagic Fishing Industry Association agreed to answer the questions. The respondent rate is estimated to be 50%.

TABLE 5-7: FISH OIL PRODUCERS ANSWERS HYPOTHESIS THREE

| Questions | Pelagic Fishing industry Association | Fish Oil Producing Group |
|--|---|---|
| 1. Average Free Fatty Acid content of the fish oil per annum for the last five years. | Not Available | Not Available |
| 2. Average free fatty acid content of the fish oil for 2002. | Not Available | SASP: 4.3% FFA LBFC: 3.5% FFA SHBF: 7.6% FFA |
| 3. Percentage of fish oil sold directly to animal feed companies or to suppliers of animal feed manufacturers. | 90% | 75% |
| 4. Largest fish oil market segment that you selling into. | Animal Feed market | Animal Feed market |
| 5. Other segments you sell fish oil into. | Export | Export, leather tanning, shark watching, bird watching, crocodile farms, omega 3 market. |
| 6. Size of these segments as a percentage of the total fish oil consumption market. | Not sure, but animal feed market consumes all fish oil. | Export can use all SA fish oil. Leather tanning: 2 tons per month. Shark watching: 1 ton per month. Crocodile Farms: 1 ton per month Omega 3 market: 2 to 10 tons every six months. |

TABLE 5-7: FISH OIL PRODUCERS ANSWERS HYPOTHESIS THREE

(continued)

| Questions | Pelagic Fishing industry Association | Fish Oil Producing Group |
|--|--|---|
| 7. Does higher quality oil give a better return and how much? | Yes. Price variance depended on FFA. | Oil below 5% FFA receive between R560 per tons to R980 per ton more on export market than on local market. |
| 8. Under what conditions will you stop selling your fish oil to local users? | High Transport prices. Low fish oil volumes increase logistical problems. Fish oil substitute prices decreases fish oil price to below Heavy furnace oil prices. | High volumes of good quality oil can be sold to the export market. Low vegetable oil prices, which results in a decrease demand in fish oil. An increase in heavy furnace oil price to a level higher than fish oil selling prices. |
| 9. Percentage of your fish oil sold into the export market. | 10% (Year 2002) | 25%. (Year 2002) |
| 10. Quality specifications used for the export market. | FFA Moisture | Between 3 and 5% FFA Moisture and impurities below 0,5% |
| 11. Percentage revenue from fish oil as a percentage of your fish meal & oil business. | Not Available | 2% of total sales turnover. 20% of total net contribution |

5.4.2 Fish Oil Export Companies

Two export companies were approached for interviews. However, only one of the two companies was willing to answer the questionnaire. The company is based in Gauteng. The questionnaire interrogation was conducted at their premises in Woodlands, Gauteng with the managing director of the company.

The respondent rate was 50%. However the company interviewed played a major and active role in the fish oil consumer markets before the closure of MOR.

TABLE 5-8: FISH OIL EXPORTER ANSWERS - HYPOTHESIS THREE

| Questions | Company A |
|---|---|
| 12. Major international market segments into which South African Fish oil can be sold to. | Aqua feed (Salmon): Holland, Scandinavia, Denmark, Japan Industrial Leather Tanning: Rotterdam Pharmaceutical (Omega 3): Japan Confectionery: Hardening/margarine/baking fats are lessening every year. Paints and Putty industry |
| 13. Quality specifications for each of these segments. | Aqua feed: Maximum FFA of 2 - 3 % Freshness of oil TOTOX Levels (Time between fish caught and processed) Dioxin levels Omega-3 Fatty acids: High EPA/DHA % Industrial Leather Tanning: Maximum FFA of 7-8% Colour must not be too red or too dark Confectionery: Maximum FFA of 0.1% Hardened Deodorized |
| 14. Economical difference in value of fish oil in major segments as per question 1. | The price differential changes with time. A premium is paid in Aquafeed and omega 3 markets |

**TABLE 5-8: FISH OIL EXPORTER ANSWERS - HYPOTHESIS THREE
(continued)**

| Questions | Company A |
|---|--|
| 15. Substitutes that can be used in each of these segments. | Crude Rape oil is feasible, but not preferred |
| 16. Factors that influence the consumption of fish oil vs. substitutes in these segments. | Long chain fatty acid important for Leather Tanning and Aquafeed markets. |
| 17. Factors that influence the exporting of fish oil. | Availability of supply Consistent quality Dioxin levels Totox levels Price of fish oil The high growth rate of aquafeed and increasing demand |
| 18. Volumes of crude and refined fish oil that have been exported for the last 5 years. | Do not have last five years exporting figures. However doing about 1000 tons per year for last two years. (Ten years ago imported 25000 ton into South Africa from Japan. When fish oil was used in baking fats.) |
| 19. Difficulties experienced with the exporting of South African fish oil. | High FFA content and quality in general Lack of consistent supply Poor processing of fish which leads to high TOTOX, which means that oil has to be blended with better quality oils to become acceptable in fishfeed High stearin content Greenish colour |
| 20. Percentage of core business that trading of fish oil holds. | Very, very small (1000 tons/annum of fish oil out of 350 000 tons/annum of other oils) |
| 21. Does the export market regard South African fish oil as high quality oil? | No |

**TABLE 5-8: FISH OIL EXPORTER ANSWERS - HYPOTHESIS THREE
(continued)**

| Questions | Company A |
|---|---|
| 22.How does the South African fish oil compete with the rest of the world's fish oil producers? | SA oil is discounted against Peruvian oil The freight cost is high due to low volumes Peruvian oil volumes higher and better quality reputation and track record. |
| Comment made by interviewee | Anti-oxidant can be added in the Aquafeed sector. Between 100 - 500 ppm of BHT or Ethoxyquin. |

5.4.3 Fish Oil Refinery

The thirteen refineries operating in South Africa all refine vegetable oil. However two, of these refineries PPS Oil and Energy oil refine the fish oil during the process of manufacturing feed oil. However, the refining process is restricted to removing traces of impurities.

Energy Oil, however, has expanded its operation to include the neutralising of fish oil for final use in applications other than animal feed. The other fish oil refinery at Sandy Point, St Helena Bay, is currently not operational.

One of two fish oil refineries was interviewed. The oil refinery that was not available has not been operational since December 2000. The respondent rate is also 50% for this role player.

TABLE 5-5: FISH OIL REFINERY ANSWERS

| Questions | Energy Oil Refinery |
|---|---|
| 23. Average monthly and annual fish oil consumption. | Between 250 tons and 2000 per month. |
| 24. Factors that influence monthly and annual consumption? | Price of crude oil. Availability of fish oil. |
| 25. Major production costs of business. | Cost of crude fish body oil Transport Energy to heat the oil |
| 26. Process parameters. | Maximum Free Fatty Acid Content of fish oil: 10% |
| 27. Major market segments for your refined oil and acid oil. | Specialized niche markets Toll manufacturing for other producers Baking fats for human consumption Other animal feed |
| 28. Substitutes you competing against in each of these segments. | Palmastearine in Baking fat market Vegetable oils and full fat soya in animal feed market |
| 29. Conditions will you not refine fish oil. | High fish oil price Low substitute prices |
| 30. Quality specification of fish oil as your raw material. | FFA: below 10% Moisture: Below 0.5% Impurities: Below 0.5% |
| 31. Quality specifications of your refined oil and acid oil. | Refined oil: Human consumption: Below 0.1% FFA Hydrogenated Colour of oil Deodorizing Acid Oil: Animal Feed market: High percentage FFA |
| 32. Relationship between your quality of your fish oil and production losses. | The higher the FFA the higher the loss Below 2% FFA gives 1.5 % times FFA percentage Between 2% and 5 % FFA gives 2 to 3 times FFA percentage. Between 5% and 10% gives 3 to 5 times the FFA percentage. |

Chapter 6

Discussion, Conclusion and Recommendations

6.1 Introduction

The content of this chapter discusses the answers tabulated in Chapter Five. The results from Chapter Five are concluded by re-emphasizing the contributing factors to current situation and the factors that impact the South African fish oil producers.

The chapter finishes with recommendations that are made regarding the key issues; Vegetable oil price trends, International Fish Oil Applications Trends, Optimize South African Fish Oil Quality, Heavy Furnace Oil and other important issues.

6.2 Discussion of results

6.2.1 Factors that influence the selling price and consumption of fish oil.

- Price

The fish oil-selling price has a direct impact on the consumption of fish oil. The lower the selling price relative to substitute prices, the higher the consumption of fish oil.

- Calorific value

The energy value of the fish oil is the primary reason for usage in feed mixes. High calorific value of fish oil reduces the inclusion of other energy sources into the feed mixes.

- Digestibility

The digestibility refers to how the nutrients are absorbed by the animal. High digestibility is beneficial to the growth rate of the animal being fed with the specific feed mix. Low digestibility of fish oil decreases the consumption of fish oil and increases the inclusion rate of substitutes with higher digestibility.

6.2.2 Factors that have an impact on the consumption of fish oil

- The raw material cost of feed oil

The relative cost of fish oil has a direct impact on the consumption of fish oil.

- The substitution cost of maize, full fat soya and canola seeds

Low substitute prices will decrease the consumption of fish oil.

- The import parity

The cost of importing better-priced substitutes will decrease the consumption of fish oil.

- The quality of fish oil.

The quality of fish oil is generally measured by the free fatty acid content of the fish oil. High FFA fish oil limits the inclusion rate of the fish oil in the feed mixes. Low quality fish oil decreases the consumption of the fish oil on domestic and export markets.

6.2.3 Quality related factors for fish oil

- Free fatty content of the fish oil
- Peroxide value of the fish oil
- Moisture
- Calorific value
- A lower FFA signifies higher quality fish oil, which has an effect on the inclusion rate of the fish oil in the feed oil. The higher the quality of fish oils the greater the consumption of the fish oil in the chicken feed market.

6.2.4 Factors that determine the selling price.

The pelagic fishing industry association indicated that the quality of fish oil is a major factor in the determination of the selling price. The higher the quality the better the return on fish oil.

6.2.5 The effect of low selling prices of substitutes

The animal feed manufacturers have indicated that they need to use feed oil as a bonding agent. Consumption can however be influenced by low prices of alternative energy sources like maize and full fat soya. The consequence of the problems experienced with the smell of fish oil is the limitation on the inclusion rate of fish oil into feed oil mixtures.

The feed oil suppliers and manufacturers indicated that their consumption of fish oil would decrease if the prices of the following substitutes decrease drastically:

- full fat soya
- tallow

- animal fat
- imported animal fat
- vegetable acid oil
- vegetable oil
- palm oil

Low selling prices of fish oil will cause a diversion of fish oil from animal feed market to the export market. However the quality of South African fish oil needs to comply with the export quality specifications. Alternatively the pelagic industry association will be forced to sell their fish oil at extremely reduced prices as in the case of year 2000 when fish oil was sold between R500 per ton and R750 per ton. The association will encourage their members to use the fish oil as energy in their manufacturing process. However some of the factories have coal boilers and do not have the facilities to burn the fish oil. The fish oil factories, equipped with the facilities to burn fish oil, burn the fish oil if the quality is poor. The three factories that form part of the one group interviewed has the facilities to substitute the heavy furnace oil with fish oil in their fish meal manufacturing process. Alternatively the fish oil will be collected and sold on the export market.

6.2.6 The importance of fish oil quality

The quality of fish oil is one of the most important factors identified by all role players.

The factors that influence the consumption of South African fish oil on the export market are:

- Consistency and availability of supply
- Consistent quality of fish oil
- Dioxin levels
- TOTOX levels
- Price of fish oil and the high growth rate and increasing demand of aqua feed.

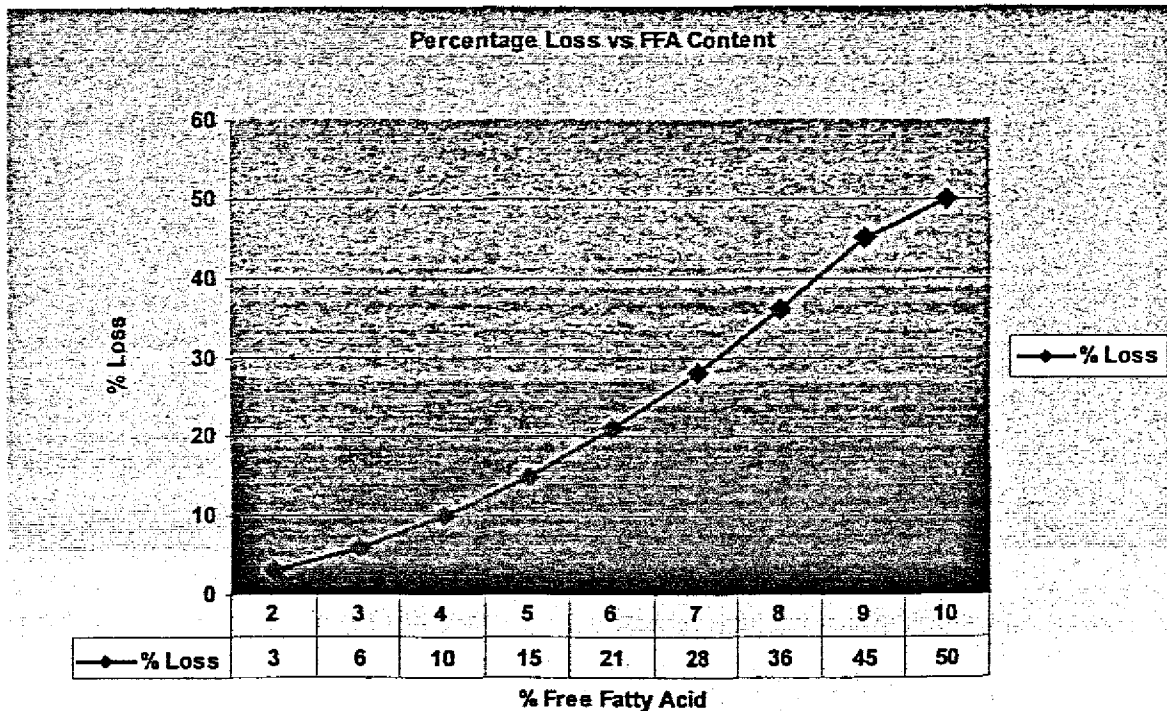
The first two factors have impacted negatively on the South African fish oil producers negatively. The South African fish oil is discounted on the international market due to the inconsistent quality and uncertainty of supply. Low volumes of fish oil available per shipment increase the freight cost and, therefore, reduce the revenue generated by the fish oil on the export market.

The quality of fish oil also determines the economic value of fish oil. Higher quality oil receives a relatively higher return on the export market. A consistency in the quality of South African oil will further restore positive international perceptions.

The refinery emphasized that the lower the quality of fish oils the higher their production cost. In fact if the FFA content of the fish oil is above 10% it is not economically feasible to process the fish oil through the refinery. Graph 6-1 illustrates the fish body oil that is lost in the refining process due to high free fatty acid content. At FFA levels of above 10%, the final product is only 50% of the initial volume of fish oil put into the process.

The production losses in the refinery process are a direct consequence of the use of poor quality of fish oil as raw material. The relationship between the production loss and the free fatty acid content of the fish oil experienced by the refinery is illustrated in the graph 6-1. FFA content of 3% results in a 6% loss of fish oil during the refining process. However, the relationship between the FFA content and the fish oil lost during the refining process is not linear. It is therefore more economical to refine fish oil with lower FFA in order to maximize the output and the revenue generated per ton of fish oil input.

GRAPH 6-1 PERCENTAGE FISH OIL LOSS VS FFA CONTENT



However, oil that is of a consistently higher quality ensures that fish oil producers will be able to sell to any market segment.

The quality of the fish oil does not receive enough attention due to the fact that relatively high prices are achieved in the animal feed industry. However, the only criteria that ensure that the fish oil achieves similar or higher return is the quality of the fish oil. The only other markets able to consume high volumes of fish oil are the export market and the refinery in Gauteng. However, the quality of the fish oil has a direct relationship to the price in these market segments.

6.3 Conclusion

6.3.1 Change in international application of fish oil

The literature search illustrates that South African fish body oil production is minimal compared to the world fish body oil production. The uses for fish body oil have changed over the years from traditional uses in margarines to fast growing demand in the aquaculture market. The smaller industrial and technical applications are specialised and continue to reduce the consumption of fish oil. The other growing market is the Omega 3 and specialised medical market. The literature also highlights the successful burning of excess fish body oil as an energy alternative in the fish meal plants. No literature is available on burning of fish body oil in South Africa.

6.3.2 Inconsistency in supply of quality fish oil.

The literature research indicates the dependency of the fish oil producers on the government and the natural resources of the oceans surrounding the South African coast. It is evident that no guarantee exists on how much fish caught in any given year. This increases the difficulty and complexity of planning for the fish meal and oil producers. Fish oil production depends on the volume of fish caught and the fat content, of the fish.

The higher the fat content the higher the fish oil yield will be.

" South African pelagic fishing industry is enjoying one its best catch in years, and the oceanographic surveys conducted by researchers have demonstrated that, since these were first started during the early 1980s, the population of pilchards and anchovies in local waters have never been higher." (FINSA June 2002,5). Despite the high volume of fish of 2002 the relative volume of fish oil has been low. The fish was very lean resulting in an average fish oil yield of below 1% for the industry.

One of the main factors that influences the consumption of South African fish oil is the availability and consistency of the supply of the fish oil. However, the total allowable catch allocated at the beginning of the year by the Minister of Tourism and Environmental Affairs does not guarantee high volumes of fish oil for the different fish oil markets.

6.3.3 Substitute Selling Price

The bulk of South African fish oil is consumed domestically, but consumption has changed from the confectionery industry to the animal feed industry. The possibility remains that fish oil consumption in the animal feed industry could be restricted for various reasons. The biggest factor will be the price of substitutes. A decrease in the selling price of vegetable oils will decrease the consumption of fish oil in the animal feed industry unless fish oil producers lower the fish oil selling price to the level of the substitute prices or burn the fish oil or explore other market segments for fish oil.

6.3.4 The importance of the Fish Oil Quality

The international market has switched in large measure to the aquaculture market. The aquaculture market requires more stringent quality specification for fish oil. It is necessary for South African fish oil producers to keep track of international trends in order to remain competitive. Although South African fish oil production is a very low percentage of total world production, the producers still need an outlet for their oil. The quality of the fish oil is therefore the major factor that fish oil producers must optimise.

High quality fish oil optimises the profitability of fish oil producers regardless of which market segment is sold into. However, the other important benefit is that high quality fish oil increases the marketing options.

6.3.5 Conclusion summary

The Greenpeace protests against the consumption of unsustainable fish oil in 1996 probably made the closure of MOR in 1999 inevitable. The world's largest biscuit factories excluded fish oil from their ingredients and companies like Unilever responded in a similar manner. The closure of MOR's seemed to have not been pre-empted; therefore the South African market shift did not align with the international market changes.

One of aims of this research was to clarify the factors that impact on the consumption of the current South African fish oil market. The research concludes that the following are important factors that impact on the South African fish oil consumption:

- Quality of the oil
- The international fish oil price

- Comparative competitive prices of fish oil substitutes
- The balance between the supply and demand of fish oil.
- The fish oil production volumes.
- The growing and declining demand of the different fish oil application markets.
- The price of heavy furnace oil compared to fish oil selling price. (Heavy furnace oil is used to generate energy).

The research also investigated the impact of low selling prices of fish oil substitutes on the South African fish oil producers. Currently the most important substitute in South African's major market, the animal feed market, is vegetable oils. The research finding is that the South African fish oil producers must follow the vegetable oil selling price trend in order to remain competitive.

The most important finding of the research is the high priority the fish oil quality achieves in all the fish oil market segments. The South African domestic market is limited in that it is only the animal feed market and the refinery. The alternative market to sell to is the export market. However, the international fish oil market perceives the South African fish oil to be of low quality. A mindset regarding the importance of fish oil quality has to be begin with the South African fish oil producers. It is vital that the South African fish oil producers institute quality systems to improve their fish oil quality.

The South African fish oil producers must gear themselves to become globally competitive.

6.4 Recommendations

6.4.1 Vegetable oil price trends

The South African fish oil producers must follow the international price trends of all vegetable oils. These trends should be used for planning and marketing strategies to optimize economic return on South African fish oil. The fish oil producers should take cognizance of what the impact on their industry will be if the fish oil substitutes' prices decrease drastically.

6.4.2 International Fish Oil Applications Trends

The most important and significant trend is the rapid growth rate of the aquaculture market. The current global supply of fish oil is 1,2 million tons and the demand for fish oil exceeds the supply due to the rapid growth of the aquaculture market. However the single most important factor that influences the consumption in this sector is the quality of the fish oil.

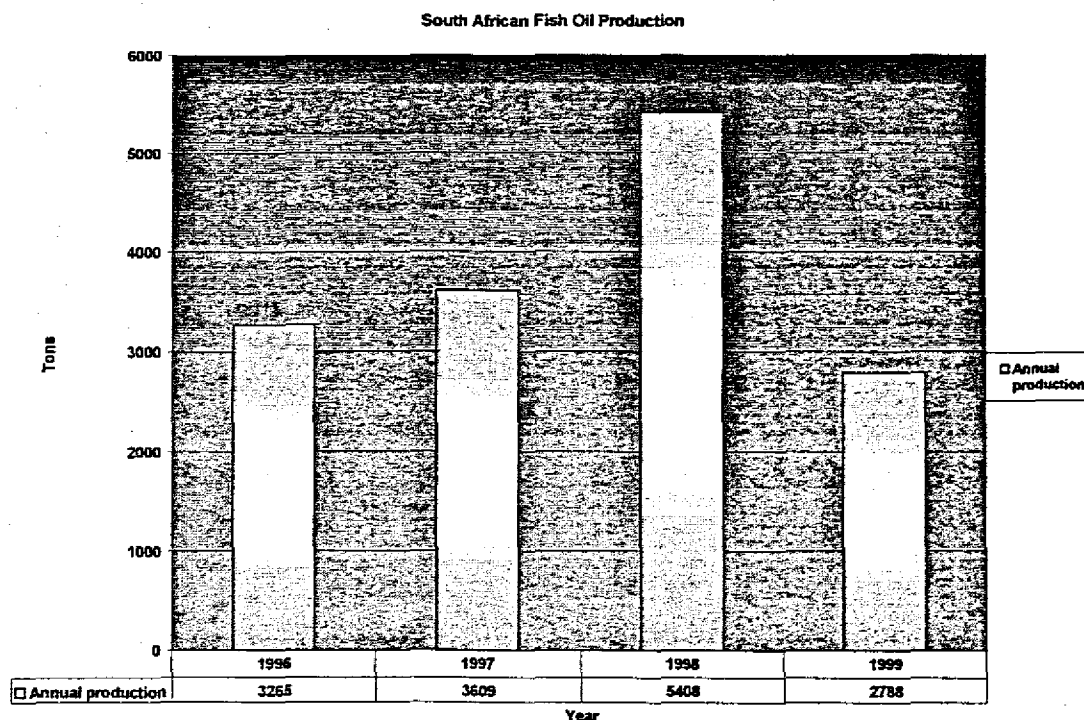
The best United Kingdom fish oil selling prices before August 2002 were 575 US dollars per ton for Danish oil, 595 US dollars per ton for Peruvian oil and 575 US dollars per ton for US Menhaden fish oil (World Fish Report). These prices are obtained for high quality fish oil. The Peruvian oil is achieving the best selling prices, because of their established high quality supplier status.

6.3.3 Optimize South African Fish Oil Quality

Optimizing the quality of South African fish oil will increase its profitability. The implementation of quality management systems, like International Standard Organisation (ISO); Good Manufacturing Practices (GMP), that ensure the highest quality of oil in production and storage are essential.

The following graph illustrates the inconsistency of the fish oil production in South Africa. The annual production of fish oils varies from year to year.

GRAPH 6-2: SOUTH AFRICAN FISH OIL PRODUCTION



Source :Malherbe, S 2001:28

High quality oil should be stored and collectively sold on the export market. Establishing the South African fish oil on the international market will soften the effects of any sudden decrease of consumption in the animal feed industry.

6.4.4 Heavy Furnace Oil

Some of the fish oil producers use heavy furnace oil (HFO) as an energy source in their fish meal and oil production process. HFO can be substituted with fish oil when fish oil selling price decreases below the equivalent factory delivered price of HFO. The difference in calorific value between HFO and fish oil must however be taken into account. The table below illustrates the equivalent fish oil monetary value when used as HFO substitute for energy generation in fish meal and oil manufacturing process.

The table illustrates that when the HFO price is at R2000 per ton the equivalent value of the fish oil as energy source is only R 1,767 per metric ton. It is therefore beneficial to burn the fish oil when the selling price is below R1, 767 per ton.

TABLE 6-1: HFO VS FISH OIL EQUIVALENT MONETARY VALUE

Source :Matrix St Helena Bay Fishing Industries

| <u>HFO VS FISH OIL SELLING PRICE</u> | |
|---|--------------|
| HFO Calorific Value | 43 |
| Fish Oil Calorific Value | 38 |
| <u>HFO</u> | <u>CRUDE</u> |
| R 2,000 | R 1,767 |
| R 1,750 | R 1,547 |
| R 1,500 | R 1,326 |
| R 1,250 | R 1,105 |
| R 1,000 | R 884 |
| R 750 | R 663 |
| R 500 | R 442 |

6.3.5 Other

South African fish oil producers regard fish oil yields and quality as less important as than a few years ago. It is very important that the fish oil producers evaluate their annual fish oil yield and free fatty content to strategies and plan for the years ahead. The statistical information can be used to determine trends and these trends can be used to forecast and budget more accurately if they are used in conjunction with the scientific information from Marine and Coastal management.

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APPENDIX 1: QUESTIONNAIRE

**APPENDIX 1-1:QUESTIONNAIRE-
HYPOTHESIS ONE**

| Questions | Animal Feed Manufacturers | Feed Oil Producers | Fish Oil Export Company | Fish Oil Refineries | Fish Oil Producers |
|--|------------------------------|-----------------------|----------------------------|------------------------|-----------------------|
| 1.What is your average monthly and annual fish oil consumption? | X | X | | X | |
| 2.What factors influence your monthly and annual consumption? | X | X | | | |
| 3.Who are your feed oil suppliers? | X | X | | | |
| 4.Who do you regard as the major role players in the feed oil industry? | X | | | | |
| 5.What is the inclusion rate of fish oil in the feed mix? | X | X | | | |
| 6.What factors will influence the inclusion rate? | X | X | | | |
| 7.What Feed Oil products are sold to Animal Feed manufacturers? | | X | | | |
| 8.What is the composition of the feed mixes, which includes fish oil? | | X | | | |
| 9.What was your annual production of fish oil for the last five years? | | | | | X |
| 10.What was your annual fish oil yield for the last five years? | | | | | X |
| 11.What is your current fish oil production volumes and yields for 2002? | | | | | X |
| 12.Does higher quality oil give a better return and how much? | | X | | | X |

**APPENDIX 1-2:QUESTIONNAIRE-
HYPOTHESIS TWO**

| Questions | Animal Feed Manufacturers | Feed Oil Producers | Fish Oil Export Company | Fish Oil Refineries | Fish Oil Producers |
|---|------------------------------|--------------------|----------------------------|------------------------|--------------------|
| 1.Name the fish oil substitutes. | X | X | | | |
| 2.Which of the substitutes are domestically available? | X | X | | | |
| 3.Which of the substitutes have to be imported? | X | X | | | |
| 4.Into which animal feed mixes is fish oil added? | X | X | | | |
| 5.What is the quality criteria needed for the fish oil? | X | X | | | |
| 6.What is the quality criteria needed for the substitutes? | X | X | | | |
| 7.What are the nutritional advantages and values of the fish oil? | X | X | | | |
| 8.What are the nutritional advantages and values of other substitutes? | X | X | | | |
| 9.What is your market share? | | X | | | |
| 10.What is the percentage and tons of own feed oil production in terms of your core business? | | X | | | |
| 11.What is the quality specification for the feed oil? | X | X | | | |
| 9.What are the major factors that influence feed oil prices? | | X | | | |
| 10.What was the economical value of the fish oil prior to the closure of Marine Oil in Simons Town in 1999? | | | | | X |
| 11.What is the current economical value of the fish oil? | | | | | X |

**APPENDIX 1-3:QUESTIONNAIRE-
HYPOTHESIS THREE**

Questions

| | Animal Feed Manufacturers | Feed Oil Producers | Fish Oil Export Company | Fish Oil Refineries | Fish Oil Producers |
|---|------------------------------|--------------------|----------------------------|------------------------|--------------------|
| 1.What was the average Free Fatty Acid content of the fish oil per annum for the last five years? | | | | | X |
| 2.What is the average free fatty acid content of the fish oil for 2002? | | | | | X |
| 3.What percentage of fish oil is sold directly to animal feed companies or to suppliers of animal feed manufacturers? | | | | | X |
| 4.What is the largest fish oil market segment that you selling into? | | | | | X |
| 5.What other segments do you sell fish oil into? | | | | | X |
| 6.What is the size of these segments as a percentage of the total fish oil consumption market? | | | | | X |
| 7.Does higher quality oil give a better return and how much? | | | | | X |
| 8.Under what conditions will you stop selling your fish oil to domestic markets? | | | | | X |
| 9.What percentage of your fish oil is sold into the export market? | | | | | X |
| 10.What quality specifications are used for the export market? | | | X | | X |
| 11.What is the percentage revenue from fish oil as a percentage of your fishmeal and oil business? | | | | | X |
| 12.What are the major international market segments into which South African Fish oil can be sold to? | | | X | | |

**APPENDIX 1-3:QUESTIONNAIRE--
HYPOTHESIS THREE**

| Questions | Animal Feed Manufacturers | Feed Oil Producers | Fish Oil Export Company | Fish Oil Refineries | Fish Oil Producers |
|---|------------------------------|--------------------|----------------------------|------------------------|--------------------|
| 13.What are the quality specifications for each of these segments? | | | X | | |
| 14.What is the economical difference in value of fish oil in major segments as per question 1? | | | X | | |
| 15.What are the substitutes that can be used in each of these segments? | | | X | | |
| 16.What are the factors that influence the consumption of fish oil vs. substitutes in these segments? | | | X | | |
| 17.What are the factors that influence the exporting of fish oil? | | | X | | |
| 18.What volumes of crude and refined fish oil have been exported for the last five years? | | | X | | |
| 19.What difficulties have you experienced with the exporting of South African fish oil? | | | X | | |
| 20.What percentage of your core business does trading of fish oil hold? | | | X | | |
| 21.Does the export market regard South African fish oil as high quality oil? | | | X | | |
| 22.How does the South African fish oil compete with the rest of the world's fish oil producers? | | | X | | |

**APPENDIX 1-3:QUESTIONNAIRE-
HYPOTHESIS THREE**

Questions

| | Animal Feed Manufacturers | Feed Oil Producers | Fish Oil Export Company | Fish Oil Refineries | Fish Oil Producers |
|--|------------------------------|--------------------|----------------------------|------------------------|--------------------|
| 23.What is your average monthly and annual fish oil consumption? | | | | X | |
| 24.What factors influence your monthly and annual consumption? | | | | X | |
| 23.What are the major production costs of your business? | | | | X | |
| 25.What are your process parameters? | | | | X | |
| 26.What is your major market segments for your refined oil and acid oil? | | | | X | |
| 27.What substitutes are you competing against in each of these segments? | | | | X | |
| 28.Under what conditions will you not refine fish oil? | | | | X | |
| 29.What is your quality specification of fish oil as your raw material? | | | | X | |
| 30.What are your quality specifications of your refined oil and acid oil? | | | | X | |
| 31.What is the relationship between the quality of the fish oil and the production losses? | | | | X | |
| 32.What are the major production costs of your business? | | | | X | |