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Aquaculture of the Kabeljou in Namibia

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Aquaculture of the Kabeljou in Namibia

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by

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EXECUTIVE SUMMARY

Aquaculture is defined as the breeding of aquatic organisms, such as fish, plants, or crustaceans, in a controlled environment for human consumption. Over time, it has proven to be an extremely lucrative industry. In 2002, aquaculture industries worldwide earned an estimated US$ 56.8 trillion. Aquaculture started in Namibia in the early 1800s, when native Namibians used carp and other species to stock cattle and water dams. In modern times, Namibia’s most successful aquaculture industries are tilapia and oyster farms. Because aquaculture holds the promise of creating jobs and revenue, the Ministry of Fisheries and Marine Resources (MFMR) has been investigating the possibility of cultivating kabeljou through aquaculture.

Kabeljou are subtropical marine fish indigenous to Namibia. In 2004, WPI students conducted a feasibility study of kabeljou aquaculture in Namibia. They concluded that the establishment of an industry was not economically feasible at that time due to the costs. However, since the potential for a Namibian kabeljou aquaculture industry remains strong, the goal of our project was to expand upon previous research by investigating different cost cutting options to make a land-based cultivation system possible. We worked in conjunction with our liaison, Dr. Ben van Zyl, Deputy Director of Resource Management for the MFMR. Our study encompassed the evaluation of three major areas in an aquaculture industry where costs could be reduced; live feed, inert feed, and fish container options. To assess which methods of cultivation were most cost effective, we performed a cost benefit analysis comparing the following options:

- Growing live feed on-site vs. buying fingerlings (juvenile kabeljou) and juvenile inert feed
• Buying inert feed from a Namibian fish meal plant vs. importing fish feed

• Constructing raceways vs. constructing ponds vs. purchasing tanks

In order to address these issues, it was first necessary to understand the biological requirements of the kabeljou, including its behaviors and the food it eats. In early stages of development, the kabeljou are fed live feed, beginning with rotifers and eventually transitioning to artemia. Raising live feed involves crucial and complicated processes, and must be done on-site to maintain the feed’s nutritional value. For this reason, we determined the costs associated with establishing a live feed facility within a Namibian aquaculture industry.

Using parameters from the 2004 WPI study showing a potential US demand for 7.2 million kabeljou, the amount of feed needed per fish per day and equipment costs for a facility of this scale were used to project the initial (N$ 10.8 million) and yearly costs (N$ 5.4 million) of a live feed facility. When compared to the initial purchasing of fingerlings and juvenile inert feed from an external source (N$ 7.4 million), the initial cost of a live feed facility (N$ 10.8 million) is higher. However, when we compared the yearly costs of both options, a live feed facility saves N$ 1.9 million per year. Therefore, an on-site facility will become more cost effective after six years.

After thirty days of the kabeljou’s life cycle, they are developed enough to be gradually weaned off live feed and onto processed inert feed. Currently, Namibia sells fish meal to South Africa, only to buy back processed fish feed for two to three times the original price. We compared the costs of importing a sufficient amount of fish feed from an outside source to the projected costs of buying feed from a local Namibian fish feed
plant. Buying local fish feed would reduce yearly costs by N$ 8 million and would always be more cost effective.

We also performed a cost benefit analysis on the different types of containers that might be used to hold the kabeljou. Previous WPI research calculated the costs for using tanks in a land-based aquaculture system to be N$ 28.4 million initially, and N$ 1.9 million yearly in operating expenses. We expanded upon this research by investigating the use of raceways or ponds instead of tanks. We took into consideration the construction costs, the sizes of each container, and the efficiency of a new pumping system. We determined that raceways were the most expensive at N$ 377 million, followed by ponds at N$ 33.2 million. Tanks were the least expensive option at N$ 28.4 million. For this reason, we concluded that tanks should be used in a kabeljou aquaculture facility.

In our final analysis, we compared costs of the kabeljou aquaculture system proposed in 2004 to our own findings. While both systems incorporated the use of tanks, our aquaculture facility plan included a more efficient pumping system, an on-site live feed grow-out system, and the establishment of a local fish feed plant for the manufacturing of inert feed. Our overall cultivation system would cost N$ 72.9 million per year while the 2004 system would cost N$ 83.8 million per year. Therefore, the potential yearly costs were reduced by over N$ 10 million in our study. Even though more cost effective methods were proposed in our study, an aquaculture industry would still not be economically feasible at this time in Namibia.

In conclusion, our report proposes additional recommendations that could be explored in the future. These recommendations include obtaining a loan from a private
investor or bank (such as the Agricultural Bank of Namibia), exploring larger but achievable markets (including expanding businesses such as the seafood restaurant Ocean Basket), and most importantly establishing a Namibian fish feed plant. Kabeljou aquaculture still holds the promise of being profitable in the future and it is necessary that steps be taken to make this industry a reality. If an industry can be established not only would various jobs be created for Namibians, but Namibia would also be taking steps towards furthering its economic independence.
ABSTRACT

Since gaining sovereignty, Namibia has been striving for further economic independence by attempting to establish domestic industries that will generate additional revenue for the country. Working in conjunction with our sponsor, the Ministry of Fisheries and Marine Resources of Namibia, we made recommendations for lowering the costs of a land-based kabeljou aquaculture industry. We performed a cost benefit analysis on three major areas of a kabeljou aquaculture industry, which are live feed, inert feed, and fish containment units. Although we were able to recommend methods that would reduce yearly costs by N$ 10.9 million, we concluded that a kabeljou aquaculture industry is still not feasible in Namibia at this time.
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  - Kabeljou: Decoteau
  - Live Feed: Weiser
  - Fish Meal: Ragusa
  - Marketing Kabeljou: Decoteau
  - Export Rules and Regulations: Decoteau
Methodology: Decoteau, Weiser
Results: Ragusa, Weiser
Conclusions and Recommendations: Decoteau, Flannery
Appendix A – MFMR Organization: Weiser
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Appendix D – Professional Interviews: Flannery
Appendix E – Raceway Calculations: Ragusa
Appendix F – Pond Calculations: Ragusa
Appendix G – 2004 Tank Calculations: Dunn et al.
Appendix H – Kob Rearing Proposal: MFMR
Appendix I – Live Feed Calculations: Weiser
Appendix J – David Koh Fish Feed Plant Proposal: Koh
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CHAPTER 1: INTRODUCTION

Since gaining sovereignty from South Africa in 1990, the Namibian government has aspired to gain economic independence and become a more developed nation. If Namibia could use its natural marine resources to its advantage and create a successful aquaculture industry, it would provide a viable source of income for the young country. Establishing an aquaculture industry in Namibia would supplement the diet of Namibians with fish, counteract over-fishing of the kabeljou, create jobs, support other industries, and bring profits into the economy.

On average, Namibians consume more fish per capita than people in most African countries. Namibians consume approximately 14 kg of fish per year per capita. In comparison, the average amount of fish consumed in Africa per year is 8 kg per capita. Namibia also sells 24,300 metric tons of its produced fish back to its people. Other countries bordering Namibia, such as South Africa and Angola, consume 7 kg and 17 kg per year per capita of fish, respectively (FAOSTAT data-Fishery data, 2004). An aquaculture industry could feed into the demand for fish in both the domestic and international markets.

Namibia is also one of the leading exporters of fish in the world. In 2002, Namibia was ranked second in Africa behind Morocco, and thirty-fourth in the world, in the exportation of fish and fishery products with a total profit of US$ 352 million (FAOSTAT data, 2004). Agriculture, hunting, forestry and fishing make up about nine percent of the country’s total income, while another twenty-five percent comes from the mining industry (UN Statistical Division, 2004). Farming kabeljou could further
contribute to Namibia’s export market by creating added income for the country and its people.

Although Namibia is ranked among the top forty countries in the world for the exportation of fish, the Namibian fish processing industry has been experiencing severe financial trouble since January 2005. High crude oil prices, decrease in exchange rates, decrease in hake demand on the European market, and erratic fishing conditions have caused financial difficulty in recent months (Barnard, 2005, January 10). Furthermore, a representative from Blue Ocean Products, a major hake fish processing plant based in Walvis Bay, has stated the company would not be able to fulfill fish quotas for the year and therefore would not be able to process continuously for an entire fishing season (Barnard, 2005 January 3). Aquaculture of the kabeljou could rejuvenate the fish processing industry by filling the void that the lack of hake has caused.

Over-fishing to meet the demand for fresh seafood has also resulted in dwindling kabeljou populations off the Namibian and South African coasts. In 2001, the South African government addressed this issue by establishing new regulations based on the Marine Living Resources Act to protect linefish (GCIS, 2005). However, the Act was only a temporary solution, since it merely regulated the rate at which the fish were caught. Freddie Fish Processors of Walvis Bay had previously caught upwards of 40 tons of kabeljou per season, but over the past two years has only caught 1.6 tons of kabeljou per season (L. Maree, interview, 30 March 2005). Aquaculture is not only a way of producing kabeljou in captivity for human consumption, but also a way of replenishing diminishing fish population through a breeding and cultivation system.

An aquaculture industry could even help alleviate a portion of Namibia’s national
debt. In March of 2004, the government’s national debt stood at N$ 10.2 billion (US$ 1.8 billion), which is 30.9% of the gross domestic product (GDP) (Dentlinger, 2004). In 2002, aquaculture industries worldwide took in an estimated US$ 56.8 trillion (FAO Inland Water Resources and Aquaculture Service, 2003). Namibia’s involvement in this lucrative industry could generate income for the country as well as create jobs for Namibians.

The fishing industry currently provides jobs for 14,000 Namibians (US Department of Labor, 2003). However, in 2000, the unemployment rate in Namibia reached 37.5%, an increase of 8.7% over 1999 (Foreign Labor Trends, 2003). The establishment of an aquaculture industry could reduce the unemployment rate by increasing the number of jobs in the fishing industry. Aquaculture would not only create jobs in an aquaculture facility, but also create jobs in the shipping, packaging, and processing fields.

The goal of our project was to make recommendations to lower the cost of land-based kabeljou aquaculture in Namibia. Pressing issues such as national unemployment and hunger are impeding the country’s development. While possible alleviating these problems, aquaculture could also help establish the future economic stability of Namibia. In May of 2004, WPI research concluded that establishing a land-based kabeljou aquaculture industry to meet US demand was not economically feasible at that time due to extensive costs. Our project explored different options for fish meal; live fish feed, and fish containers, since they are major variables that contribute significantly to initial and yearly costs. Because aquaculture holds the promise of gaining Namibia greater
economic independence, it is imperative research continues in order to make the establishment of an aquaculture industry possible.
CHAPTER 2: LITERATURE REVIEW/BACKGROUND

Our goal was to investigate different options to make land-based aquaculture of the kabeljou feasible in Namibia. Making recommendations for lowering the cost of establishing an aquaculture industry requires background research into a variety of areas. First, we examined the history and current state of Namibian aquaculture. Then the biology of the kabeljou was considered, including the food it eats and how it behaves. Once the nutritional and biological requirements of the kabeljou had been taken into account, the market for selling kabeljou was researched. We explored which countries kabeljou would sell best in, as well as health regulations involved with exporting fish. Most importantly, a focus was placed on the economics behind starting and maintaining a successful fish farming industry. Since our goal was to make aquaculture of the kabeljou feasible, the economic aspects will show whether Namibia is capable of sustaining costs and generating profits.

History of Namibian Aquaculture

Namibian aquaculture dates back to the early 1800s, when carp and other species were used to stock both cattle and water dams. In the 1980s, aquaculture emerged from small-scale productions as private farmers became increasingly interested in commercial level businesses. Over the years, aquaculture farms in Namibia expanded in size and diversity. By 1996, there were numerous freshwater and marine species being grown in tanks and ponds, including oysters, mussels, seaweed, and tilapia. At that time, the
volume of aquaculture production within Namibia was estimated to be 422 tons (Ministry of Fisheries and Marine Resources, 2001).

Interest in aquaculture industries continued to grow due to Namibia’s growing local market for fish, and improving transport services to the world’s seafood markets. However, despite obvious potential for aquaculture, the government felt it was not a high priority. In the early years of independence, the Namibian government focused more on exploiting its wild fish resources. Consequently, as more fishing companies began to fish on commercial levels, linefish populations began depleting. Decreasing fish populations called for the establishment of conservation policies and fishing regulations. Although fishing restrictions proved effective for temporary periods of time, they are still not permanent solutions to over-fishing (Ministry of Fisheries and Marine Resources, 2001).

In an attempt to preserve Namibia’s natural marine resources, the Ministry of Fisheries and Marine Resources began regarding aquaculture as a higher priority. In March of 2001, the Ministry presented Namibia’s Aquaculture Policy to the National Assembly. This document was written with the main objective of promoting the responsible and sustainable development of aquaculture while achieving socio-economic benefits for all Namibians and securing environmental sustainability. The Ministry expressed its desire to implement a suitable legislative and administrative framework for aquaculture with tenure and rights for commercial aquaculture. In addition, the act referred to establishing institutional arrangements for aquaculture and ensuring responsible aquaculture production practices. Other points of importance in this document were maintaining genetic diversity and the integrity of aquatic ecosystems, giving Namibian citizens preference in aquaculture ventures, and ensuring all ventures
are self-sustainable (Ministry of Fisheries and Marine Resources, 2001). The Ministry’s interest in aquaculture, as well as its steps to promote aquaculture endeavors, suggests the potential for such an industry.

**Kabeljou**

Kabeljou (*Argyrosomus inodorus*), also known as silver kob (see Figure 2), are subtropical fish native to the shores of Namibia and South Africa. Kabeljou are the most important of the Namibian linefish species, which include albacore, tuna, and snoek (Boyer and Hampton, 2001). They are regarded as commercial and game fish, which are typically marketed fresh, rather than frozen. Kabeljou are most abundant in the southeast Atlantic Ocean off the Namibian coast, southwards around the Cape of Good Hope, and northwards as far as the Great Kei River in South Africa. The white arrows in Figure 1 mark these locations.
Figure 1: Silver Kob Distribution in Southern Africa
(Hammond Maps, 1995, Microsoft Bookshelf '95 Atlas)

In their natural environment, kabeljou can remain in a depth up to one hundred meters. However, due to the oxygen deficient conditions in deeper Namibian waters, kabeljou are normally found in depths up to only twenty meters. Kabeljou may grow up to six feet in length, weighing up to forty-six kilograms. All but the largest kabeljou have delicate tasty flesh. They are generally silvery grey/brown in color and have dark patches on their scales, giving illusion of oblique stripes. Kabeljou are carnivorous and possess strong canine teeth for feeding on small fish, crabs, squid, and prawns (Griffiths, 1995).
The scientific community originally thought there was only one species of kabeljou (*A. hololepidotus*) ranging from South African to northern Angolan waters. However in 1995, ichthyologists discovered that there were actually two different species, the silver kob (*A. inodorus*) and the dusky kob (*A. coronus*). Dusky kob inhabit the waters of northern Namibia and Angola and therefore are not targeted by fishermen as often as silver kob. Nevertheless, these two species are still easily confused for one another (Holtzhausen et al, 2001).

**Live Fish Feed**

Live feed is an integral part of the beginning stages of the aquaculture process. Kabeljou fry and fingerlings must begin their lives by eating live food, such as rotifers and artemia, before being weaned onto inert food, such as pellets.

For the first two days of life, kabeljou larvae feed only on their embryonic egg sacs. From day three to day twelve, the kabeljou begin to feed on rotifers (*Brachionus*
*plicatilis*, unicellular organisms seen in Figure 3 (Ministry of Fisheries and Marine Resources, 2005). The rotifer’s small size, slow swimming speed, and habit of staying suspended in water make it an easy meal for a growing fish. Rotifers have a high fertility rate, can be raised at high densities (up to 1000 rotifers per mL), and have a high tolerance to salinity. For these reasons, they are fairly easy to culture. Rotifers typically live for seven days, with females reaching sexual maturity after 0.5-1.5 days and beginning to produce fertilized eggs asexually every four hours (Moretti et al, 1999).

![Figure 3: Rotifer under Magnification](image)

When the kabeljou’s mouths reach a large enough size, rotifers are replaced by artemia, or brine shrimp seen in Figure 4. They are widely available commercially and have a high nutritional value. Artemia are fed to the kabeljou from day thirteen to day thirty (Ministry of Fisheries and Marine Resources, 2005). While it only takes eight days for the artemia to reach an adult size of 10 mm, they are able to live for several months.
Artemia eggs or cysts can also be stored in a dry state for years until they are needed (Moretti et al, 1999).

![Figure 4: Artemia under Magnification](image)

Both rotifers and artemia are non-selective filter feeders, which means they can be used to transfer specific nutritional factors and drugs to fish larvae. The principal diet of rotifers and artemia is algae or phytoplankton. Good algae have a high nutritional value, no toxicity, a high reproduction rate, and are reliable and affordable to mass-produce (Moretti et al, 1999). Two of the most common types of algae used in aquaculture are *Nannocloropsis oculata* and *Tetraselmis suecica*. Rotifer and artemia’s diets may also be supplemented with commercially available feed, the most common of which is SELCO. SELCO contains vitamins and nutrients that are invaluable to fish growth. Their ability to absorb nutrients from outside sources makes rotifers and artemia ideal types of live food for juvenile fish (personal communication with Mr. Mike Batty, 29 March 2005).
The three most common ways of culturing algae are the continuous culture, the semi-continuous culture, and the batch culture methods. The easiest and most reliable technique is the batch culture method, where algae growth is started on a small level and scaled up into larger containers until it is time to harvest. Temperature, light, pH, and turbulence must be controlled at all times in order to ensure proper algal growth. If the culture is contaminated, a new strain of unwanted algae could form and ruin an entire batch. The batch culture method is also used to culture rotifers and artemia (Moretti et al, 1999).

Although live feed has a high nutritional value, it is too expensive to rear a fish crop on live feed alone. As a result, kabeljou fingerlings are weaned off of live feed and onto fish feed pellets after only thirty days. By day fifty, kabeljou should be fully weaned onto inert food (Ministry of Fisheries and Marine Resources, 2005).

**Fish Meal**

Fish feed is a lucrative market with an ever-increasing demand. In 1994, approximately 18% of all fish meal worldwide was produced for aquaculture. In 2001, the production increased to roughly 34%, and by 2010, it is projected to increase to 42% (Hardy and Tacon, 2002). Previous WPI research determined the overall cost of feed was 69% of the total cost of land-based aquaculture production (Dunn, Hands, Lloyd, 2004). Therefore, financially and biologically, fish feed is a vital aspect of aquaculture, especially for developing industries.

In the wild, kabeljou receive all of their protein from live food. Consequently, their food in captivity must be able to meet this high nutritional demand. Fish meal that
contains the appropriate amino acid composition and plant protein concentration can be used to supplement the kabeljou’s diet, allowing for rapid growth rate from fry to maturity to be maintained (Hardy and Tacon, 2002).

Australia is currently farming mulloway, a close relative of the kabeljou. It has successfully used feed designed for tilapia to adequately supplement the mulloway diet. This same feed could possibly be used in kabeljou aquaculture. However, one of the major constraints is the cost of importing the appropriate fish feed. Currently, Namibia exports hundreds of tons of fish meal to South Africa, Malawi, Zimbabwe, China, and Japan only to buy back the finished feed from these countries at up to three times the cost (personal communication with Dr. Alec Forbes, 5 April 2005). The establishment of a fish feed plant in Namibia could produce a less expensive, higher quality feed for kabeljou aquaculture and possibly other aquaculture programs in southern Africa.

The cost of fish feed production plants can vary drastically depending on the production capabilities and types of feed produced. Experts estimate the future demand for fish meal to exceed the constant annual worldwide production (Hardy and Tacon, 2002). In order to sustain a successful kabeljou aquaculture industry, Namibia would benefit in creating its own supply system by building local feed production plants that would produce a more cost effective source of fish feed.

Marketing and Exporting Kabeljou

The United States (US) and European Union (EU) import billions of dollars worth of fish every year. In 2003, the US imported US$ 11 billion in fishery products, an increase of US$ 975 million and 480 million lbs. from 2002. The EU also plays a major
role in importing fish, representing 34% of the world import market. More than 81% of the total world market was geared towards developed countries in 2001. Both the EU and US were two of the major three countries targeted for importing fish. Figure 5 shows the small amount of fish Africa exported to the US, therefore resulting in minimal profits gained on the global market (Pritchard, 2003).

Figure 5: US Trading Results with Various Nations

If Namibia could export kabeljou to the US, it would not only generate revenue for the country, but also increase the trade balance between the US and Africa. Previous WPI research has indicated a potential consumer demand for kabeljou in the United States. Figure 6 illustrates the minute contribution Africa makes to US fish imports (Pritchard, 2003).
Namibia currently benefits by exporting its fishery products to the EU. Namibia is already in compliance with EU regulations for exporting fish and in 2003 the EU made up 79% of Namibia’s fishery product export market. Fish farming kabeljou could factor into this export market and promote greater economic independence for Namibia (FAO Inland Water Resources and Aquaculture Service, 2003).

Namibia may also consider marketing kabeljou to South Africa. In 1998, South Africa imported R$ 402 million of fish and fish products, with about 50% of its imports consisting of prepared or preserved fish. Figure 7 illustrates South Africa’s imports during 1998 (South Africa Whitehouse and Associates, 1999).
Figure 7: South Africa's Imports of Fish and Fish Products by Broad Category, 1998

Prepared and preserved fish, crustaceans, frozen fish, molluscs, and prepared and preserved crustaceans and molluscs account for 92% of all imports of fish and fishery products. The remaining 8% of these imports is fish meal (5%), imported from Angola, Brazil, the Seychelles and Uruguay, and frozen herring and dried codfish (3%) (South Africa Whitehouse and Associates, 1999). Exporting kabeljou from Namibia to South Africa would contribute to South Africa’s imports of prepared and preserved fish in addition to creating revenue for Namibia’s growing economy.
Export Rules and Regulations

Externalities, quality, tariffs, and food security are all variables in importing fishery products. Safety and health regulations are the most important of these variables. In 2003, imports of non-edible fish products to the US resulted in the loss of US$ 10 billion, compared to the amount of edible fishery products bought totaling US$ 21 billion. It is important that Namibia comply with the US regulations for exporting fish so that revenue is not lost on inedible products. EU regulations need not be addressed, since Namibia is already in compliance with them (Pritchard, 2003).

In order for Namibia to export kabeljou to the United States, it must first take into consideration the regulations and requirements established by the United States Food and Drug Administration (USFDA). Since seafood is imported from about 159 countries into the United States, it has become important for the FDA to implement seafood regulations because many of these countries do not have regulatory systems for seafood. All products must be processed in accordance with both the Hazard Analysis Critical Control Point (HACCP) regulations (see Appendix B) and sanitation prerequisites listed within the Safe and Sanitary Processing and Importing of Fish and Fishery Products regulations (Department of Health and Human Services, 2005).

Importers may satisfy their verification requirements in two ways. They may import products from a country with an active equivalence or compliance agreement with USFDA Processing and Importing Fish and Fishery Products regulations. In this case, the FDA determines whether the government of a foreign country is operating under acceptable conditions. If no such agreement exists, the country must take its own “affirmative steps,” which will verify if products are processed in accordance with the
FDA regulations. The FDA must then inspect these steps to ensure their adequacy. An example of an “affirmative step” is having certification from a competent private party or foreign inspection authority that the confirming products were produced in accordance with USFDA requirements (Department of Health and Human Services, 2005).

Although the USFDA provides two possibilities for product verification, it suggests importers use caution with companies exercising the second method as a means of accreditation. Importers must look at accreditation of companies claiming to have processed fish in accordance with FDA regulations. Governments in these countries may provide the importer with a list of accredited companies, but often fail to update it on a regular basis. With this in mind, the FDA recommends importers carefully research companies before deciding to import any products (Department of Health and Human Services, 2005).

The European Union is one organization recognized by the USFDA as having a program equivalent to its own (Department of Health and Human Services, 2005.). Since Namibia currently exports to the European Union and abides by its importing policies, exporting to the United States could pose little difficulty. South Africa is another country Namibia is in compliance with its regulations for importing seafood. Therefore, further exporting of fish and fish products to South Africa possesses great potential (South Africa Whitehouse and Associates, 1999).
CHAPTER 3: METHODOLOGY

The goal of this project was to investigate different options to make land-based aquaculture of the kabeljou feasible in Namibia. In order to achieve this goal, we accomplished the following objectives:

1. Assessed the domestic market for the kabeljou
2. Performed a cost benefit analysis to determine the point at which an aquaculture industry of the kabeljou could become profitable
   a. Explored the use of raceways versus ponds versus tanks in the grow-out system
   b. Investigated the logistics of buying fish meal from a company in Namibia versus importing fish meal
   c. Investigated growing live feed (algae, rotifers, artemia) on-site versus buying fingerlings and juvenile fish feed
3. Investigated Agricultural Bank (AgriBank) aquaculture loans

All calculations were performed using current fixed prices. In addition, the exchange rate, as of March 2005 (US$ 1: N$ 6), was taken into consideration. The calculations do not reflect variations in the exchange rate.
Assessing the Domestic Market

To verify that a domestic market for kabeljou exists, our project team conducted a number of interviews. Our first task in assessing the domestic market was to determine the extent of the demand for fish in Namibia. We approached local upscale hotels and a seafood restaurant chain in both Windhoek and Swakopmund. Contacts included Hotel Safari, Kalahari Sands Hotel and Casino, Windhoek Country Club, Hansa Hotel, and Ocean Basket. Our interviews encompassed questions concerning the supply of and demand for the kabeljou. We asked our contacts if they serve kabeljou, and if so, at what price they purchase it. We also asked what other kinds of fish they buy and which fish are consumer favorites.

Performing a Cost Benefit Analysis

We determined the most cost effective method for establishing an aquaculture industry by looking into three different cost cutting measures. We used previous WPI research on a land-based kabeljou aquaculture grow-out system as a basis for our calculations. The three cost cutting measures we considered were the following: using raceways versus using ponds versus using tanks; buying fish feed from a locally established fish feed plant versus importing fish feed; growing live feed on-site versus buying fingerlings and juvenile food. By comparing all expenses - including processing, shipping, and equipment - to the profits gained from selling kabeljou, we then determined how much a kabeljou aquaculture facility would initially cost and at what point it would become profitable.
Raceways versus Ponds versus Tanks in the Grow-out System

Previous WPI research evaluated using tanks to house the kabeljou. This year we looked at alternative housing options, including raceways and ponds. Based on the number of kabeljou needed to meet a potential US demand, as determined by previous WPI research, we calculated how big each raceway and pond should be, how many containers the facility would house, and how many kabeljou each would hold. We contacted a local general contractor to price concrete and other materials, as well as determined construction and excavation costs. From this information, we compared the building cost of raceways versus the cost in creating ponds versus the cost of purchasing tanks.

Buying Fish Meal from a Company in Namibia versus Importing Fish Meal

Roughly 69% of the cost of establishing a land-based aquaculture system is a result of having to import fish feed (Dunn, Hands, Lloyd, 2004). We calculated how much feed would need to be supplied on a daily basis to sustain a kabeljou aquaculture crop. We contacted Mr. David Koh (see Appendix J), owner of King Aqua, an aquaculture supply company, and determined if his proposed fish meal plant could produce enough feed to meet the demand of our proposed kabeljou farming facility. After talking to Dr. Alec Forbes, Special Advisor to the Minister of Fisheries and Marine Resources, and Mr. Mike Batty, Director of the University of Namibia (UNAM) Research Center at Henties Bay, we estimated a price for the fish feed.
Growing Live Feed On-Site versus Buying Fingerlings and Juvenile Fish Feed

Based on Dr. van Zyl’s research, we determined what type of food kabeljou eat during each stage of growth and estimated how much food they would need per day. We calculated the overall cost of setting up and running on-site algae, rotifer, and artemia culture facilities large enough to provide adequate live feed for the kabeljou crop on a daily basis. We then compared this cost to the cost of buying fingerlings and juvenile inert feed.

Investigating Agricultural Bank (AgriBank) Aquaculture Loans

In order to implement a sustainable aquaculture industry, money must first be invested from an outside source. AgriBank of Namibia has stated it will now fund aquaculture ventures. In order to understand the logistics behind these loans, we visited the Windhoek branch and asked about the requirements for obtaining loans.
CHAPTER 4: RESULTS

After conducting several interviews and investigating different options for cutting the cost of establishing a kabeljou aquaculture industry, we were able to perform a cost benefit analysis of the following areas:

- purchasing tanks versus constructing raceways versus constructing ponds
- buying fish meal from a company in Namibia versus importing fish meal
- growing live feed on-site versus buying fingerlings and juvenile feed from an outside source

We also investigated AgriBank’s new loan policy regarding aquaculture ventures. Lastly, we assessed the domestic market, by conducting interviews with restaurants and hotels, in order to determine if the local demand would be substantial enough to begin a kabeljou aquaculture industry.

Tanks, Raceways, and Ponds

We used the data collected through previous 2004 WPI research as a basis for our calculations. These calculations are based on growing 4,200,000 kg of kabeljou per year; the amount needed to supply the demand of one US fish wholesaler.

In order to compare our results to the results calculated in 2004, we used similar parameters, such as stocking density. However, some of 2004’s parameters, such as pumping capacities, had to first be modified to fit our new research (see Table 1).
### Table 1: Tank, Pump, and Filter Parameters

<table>
<thead>
<tr>
<th>Year</th>
<th>Stocking density (kg/m³)</th>
<th>Grow-out period (months)</th>
<th>Number of grow-out periods/year</th>
<th>Fillet (kg/year)</th>
<th>Dressing fraction</th>
<th>Whole fish (kg/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>16</td>
<td>8</td>
<td>1.5</td>
<td>1,680,000</td>
<td>0.4</td>
<td>4,200,000</td>
</tr>
<tr>
<td>2005</td>
<td>16</td>
<td>8</td>
<td>1.5</td>
<td>1,680,000</td>
<td>0.4</td>
<td>4,200,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Daily water replacement fraction</th>
<th>Working hours/day</th>
<th>Working days/year</th>
<th>Pump rate (m³/hr)</th>
<th>Pump costs (N$)</th>
<th>Useful life (years)</th>
<th>Replacement tank liner (N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>0.25</td>
<td>24</td>
<td>365</td>
<td>16</td>
<td>6,300</td>
<td>4</td>
<td>18,000</td>
</tr>
<tr>
<td>2005</td>
<td>0.25</td>
<td>24</td>
<td>365</td>
<td>95,000</td>
<td>95,000</td>
<td>4</td>
<td>115,840</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Tank liner replacement frequency (years)</th>
<th>Electricity costs (N$)/kW/hr</th>
<th>Pump load (kW)</th>
<th>Pump running cost/hr (N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>10</td>
<td>0.12</td>
<td>0.55</td>
<td>0.066</td>
</tr>
<tr>
<td>2005</td>
<td>20</td>
<td>0.12</td>
<td>45</td>
<td>5.4</td>
</tr>
</tbody>
</table>

The size and containment capacities of raceways and ponds were evaluated after obtaining information from various sources. The dimension and construction costs of each raceway were based on recommendations made by Dr. van Zyl and Mr. Rudy van der Plaas of Supreme Construction of Swakopmund (see Appendix E). Pond dimensions and costs were based on values from Mr. Johann Slabbert of Namibia Oysters (see Appendix F). This information aided us in performing a cost benefit analysis which shows raceways are the most expensive option. This is because raceways hold the smallest volume of water at 70 m³ and the smallest amount of fish at 1120 kg per raceway. Therefore, more raceways are needed to meet 2004’s predicted US demand (see Table 2).

Another area of comparison was the liners used in tanks versus those used in ponds. Pond liners are much larger than the tank liners and are made of HDPE, which
costs N$ 100 per m². Even though the lifespan of HDPE liners is longer than tank liners, the initial cost increased significantly.

<table>
<thead>
<tr>
<th>Table 2: Tank, Raceway, and Pond Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Volume (m³)</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Useful life (years)</strong></td>
</tr>
<tr>
<td><strong>Fish per container (kg)</strong></td>
</tr>
<tr>
<td><strong>Number of container volumes utilized in one year</strong></td>
</tr>
<tr>
<td><strong>Number of containers needed</strong></td>
</tr>
<tr>
<td><strong>Yearly liner replacement (N$)</strong></td>
</tr>
<tr>
<td><strong>Cost per container (N$)</strong></td>
</tr>
<tr>
<td><strong>Total cost of containers (N$)</strong></td>
</tr>
<tr>
<td><strong>Total depreciative cost of containers (N$)</strong></td>
</tr>
</tbody>
</table>

The pumps used in 2004’s aquaculture system were another factor which greatly contributed to operation costs. The previous 2004 tank system incorporated 0.55 kW pumps which cost N$ 6,300 each and pumped at a rate of 16 m³ per hr. In order to increase water pumping efficiency, we looked into using 45 kW pumps which cost N$ 95,000, pump 600 m³ per hr. While these 45 kW pumps are more expensive to buy and
run, far fewer would be needed to meet the pumping demands of an aquaculture facility, making them the more cost effective option (see Table 3).

<table>
<thead>
<tr>
<th>Table 3: Pump Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Container volume (m³)</td>
</tr>
<tr>
<td>Replacement per hour</td>
</tr>
<tr>
<td>Containers/pump</td>
</tr>
<tr>
<td>Pumps/system</td>
</tr>
<tr>
<td>Total cost of pumps per system (N$)</td>
</tr>
<tr>
<td>Yearly pump running costs</td>
</tr>
<tr>
<td>Total depreciative cost of pumps (N$)</td>
</tr>
</tbody>
</table>

Filter analysis completed by 2004 research (see Table 4) was not modified. The depreciative costs for raceways, ponds and tanks were comparable to one another because each system uses the same number of pumps and therefore the filters.
Table 4: Filter Analysis

<table>
<thead>
<tr>
<th></th>
<th>Sand</th>
<th>Biological</th>
<th>UV</th>
<th>Total Cost (N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Cost (N$)</td>
<td>100,000</td>
<td>50,000</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Useful Life (years)</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Yearly Maintenance (N$)</td>
<td>0</td>
<td>0</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>Depreciative Cost (N$)</td>
<td>4000</td>
<td>2000</td>
<td>290</td>
<td></td>
</tr>
<tr>
<td>Depreciative Cost for tanks (N$)</td>
<td>12,172</td>
<td>6,086</td>
<td>882</td>
<td>19,140</td>
</tr>
<tr>
<td>Depreciative Cost for raceways (N$)</td>
<td>12,165</td>
<td>6,083</td>
<td>882</td>
<td>19,130</td>
</tr>
<tr>
<td>Depreciative Cost for ponds (N$)</td>
<td>12,153</td>
<td>6,076</td>
<td>881</td>
<td>19,110</td>
</tr>
</tbody>
</table>

Our results show raceways were the most expensive option and tanks were the least expensive option overall for the grow-out system (see Table 5). According to 2004’s calculations, the final depreciative price for tanks was N$ 3,031,027 per year (see Appendix G). However, when 45 kW pumps were incorporated into the 2004 tank system, the cost was decreased by 30% and proved to be the lowest at N$ 2,110,236. In conclusion, a tank system using 45 kW pumps is the most cost effective option.
Table 5: Tank, Raceway, and Pond Costs

<table>
<thead>
<tr>
<th></th>
<th>TOTAL DEPRECIATIVE COST/YEAR(N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanks</td>
<td>2,110,236</td>
</tr>
<tr>
<td>Raceways</td>
<td>7,765,181</td>
</tr>
<tr>
<td>Ponds</td>
<td>3,323,056</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>TOTAL INITIAL COST(N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanks</td>
<td>29,128,230</td>
</tr>
<tr>
<td>Raceways</td>
<td>377,239,429</td>
</tr>
<tr>
<td>Ponds</td>
<td>37,163,028</td>
</tr>
</tbody>
</table>

Live Feed

Table 6: Kabeljou Feeding Schedule

<table>
<thead>
<tr>
<th>Day</th>
<th>Feed</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>No food</td>
<td>3</td>
</tr>
<tr>
<td>3-11</td>
<td>Rotifers</td>
<td>9</td>
</tr>
<tr>
<td>12-30</td>
<td>Artemia</td>
<td>19</td>
</tr>
<tr>
<td>30-50</td>
<td>Artemia and pellets</td>
<td>21</td>
</tr>
<tr>
<td>50 on</td>
<td>Pellets</td>
<td></td>
</tr>
</tbody>
</table>

The 2004 research determined the cost of purchasing kabeljou fingerlings and juvenile inert feed. In our analysis, we evaluated growing live feed on-site an aquaculture facility. We conducted several interviews with industry professionals and visited rotifer, artemia, and algae grow-out systems to gather equipment, material, and system costs which were then used to project adequate live feed expenses. After interviewing Mr. Mike Batty (UNAM research center at Henties Bay), we concluded that buying and importing live food to feed young kabeljou was not logistically or biologically possible. Because rotifers and artemia lose their nutritional value very quickly, they are rendered useless to the kabeljou after only a few hours, which makes
transportation a complicated process. Therefore, we concluded that growing live feed on-site was the only option to provide adequate nutrition for the kabeljou during its important early growing period.

To perform the cost analysis on growing live feed for 7.2 million juvenile fish, we determined how many rotifers and artemia would be needed for each fish per day and each day per cycle. All values for rotifer and artemia culture are based on information from the Kob Larval Rearing Proposal (Appendix H) and information provided by Mr. Mike Batty (Appendix D). We factored in the cost of rotifer cysts, tanks, other scientific equipment, and vitamin supplements to calculate the initial cost of a rotifer setup. By taking the number of rotifers per cycle and dividing by the optimal rotifer concentration (1000 rotifers per mL), we determined the volume of water needed per day (900 L per day). We then divided the volume of water needed by the number of days in the rotifer grow-out period (6 days) in order to determine the volume of water needed per grow-out period. This volume was multiplied by the volume of each tank (50 L) to get the appropriate number of tanks needed (109 tanks). We then calculated the total initial cost of the tanks, with each tank costing N$ 1560. By combining the initial cost of buying these tanks, as well as chemicals needed per year, initial price of equipment, and vitamin supplements, we were able to determine the yearly cost (Table 7).
To determine the initial and yearly cost of growing artemia, we used the same criteria as with the rotifer calculations. We calculated how many artemia would be needed per day per cycle, factored in the concentration of artemia (300 artemia per mL) and calculated the volume of water needed each day (1,013 L/day). Taking an eight day grow-out period into consideration, we arrived at the number of conical tanks needed to sustain the artemia culture (162 tanks). By multiplying the number tanks by the price of one tank, we calculated the initial cost of tanks for the artemia (N$ 252,778). Lastly, we determined the yearly cost of maintaining an artemia grow-out system (see Table 8).

<table>
<thead>
<tr>
<th>Table 7: Rotifer Culture Cost Breakdown</th>
<th>Number of rotifers/ kob/ day</th>
<th>1500</th>
<th>Rotifers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of rotifers/day /cycle</td>
<td>911,458,375</td>
<td>Rotifers</td>
<td></td>
</tr>
<tr>
<td>Number rotifers / mL in water</td>
<td>1000</td>
<td>Rotifer/mL</td>
<td></td>
</tr>
<tr>
<td>Number of L of water needed/day</td>
<td>911</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Number of days in grow-out period</td>
<td>6</td>
<td>Days</td>
<td></td>
</tr>
<tr>
<td>Number of 50 L conical tanks</td>
<td>109</td>
<td>Tanks</td>
<td></td>
</tr>
<tr>
<td>Price of 1 50 L conical tank</td>
<td>$1,560</td>
<td>N$</td>
<td></td>
</tr>
<tr>
<td>Total price of tanks</td>
<td>$170,625</td>
<td>N$</td>
<td></td>
</tr>
<tr>
<td>Total cost of rotifer cysts</td>
<td>$9,110</td>
<td>N$</td>
<td></td>
</tr>
<tr>
<td>Cost of chemicals / year</td>
<td>$1,097,907</td>
<td>N$</td>
<td></td>
</tr>
<tr>
<td>Initial price of equipment</td>
<td>$1,005,440</td>
<td>N$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 8: Artemia Culture Cost Breakdown</th>
<th>Number of artemia/ kob/ day</th>
<th>500</th>
<th>Artemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of artemia/day /cycle</td>
<td>303,819,458</td>
<td>Artemia</td>
<td></td>
</tr>
<tr>
<td>Number artemia / mL in water</td>
<td>300</td>
<td>Artemia/mL</td>
<td></td>
</tr>
<tr>
<td>Number of L of water needed/day</td>
<td>1,013</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Number of days in grow-out period</td>
<td>8</td>
<td>Days</td>
<td></td>
</tr>
<tr>
<td>Number of 50 L conical tanks</td>
<td>162</td>
<td>Tanks</td>
<td></td>
</tr>
<tr>
<td>Price of 1 50 L conical tank</td>
<td>$1,560</td>
<td>N$</td>
<td></td>
</tr>
<tr>
<td>Total price of tanks</td>
<td>$252,778</td>
<td>N$</td>
<td></td>
</tr>
<tr>
<td>Cost of artemia cysts</td>
<td>$480</td>
<td>N$/500g</td>
<td></td>
</tr>
<tr>
<td>Cost of chemicals / year</td>
<td>$1,095,497</td>
<td>N$</td>
<td></td>
</tr>
<tr>
<td>Initial price of equipment</td>
<td>$1,003,233</td>
<td>N$</td>
<td></td>
</tr>
</tbody>
</table>
To determine the initial and yearly cost of an algae culture system, we used the same criteria as the rotifer and artemia calculations. We determined how much algae would be needed per day per cycle based on the larger scaled version (911 L) of Mr. Batty’s culture at UNAM. We calculated the number of bags (182 bags) needed to sustain the algae culture by multiplying the number of liters needed each day by the number of days in the grow-out period (10 days), and dividing this number by size of one culture bag (50 L). The initial cost of the bags was then calculated by multiplying the number bags needed by the price of one bag. Combining the initial cost of buying the bags, total cost of lighting, and price of lab equipment, we calculated the total initial cost as well as yearly cost for the on-site algae grow-out system for the kabeljou (Table 9).

<table>
<thead>
<tr>
<th>Table 9: Algae Culture Cost Breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of algae used per day</td>
</tr>
<tr>
<td>Number of days of grow-out period</td>
</tr>
<tr>
<td>Number of 50 L bags</td>
</tr>
<tr>
<td>Total cost of algal culture discs</td>
</tr>
<tr>
<td>Total cost of 50 L bags</td>
</tr>
<tr>
<td>Total cost of lighting</td>
</tr>
<tr>
<td>Lab equipment and other</td>
</tr>
</tbody>
</table>

To determine the yearly cost of SELCO, we considered the amount of SELCO required each day per rotifer and artemia. We then multiplied the amount of SELCO consumption by the projected total number of rotifers and artemia to determine the total amount of SELCO needed per day. Once this value was calculated, we multiplied the daily value by the number of days included in the live feed cycle to gain a yearly value of SELCO. After determining the total quantity of SELCO, we calculated a total yearly cost...
to supply both the rotifer culture and the artemia culture adequately (Tables 10 and 11).

More in depth calculations can be found in Appendix I.

### Table 10: SELCO Cost Breakdown

<table>
<thead>
<tr>
<th>SELCO</th>
<th>$</th>
<th>NS/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of SELCO required per rotifer</td>
<td>0.5</td>
<td>kg/million rotifer/day</td>
</tr>
<tr>
<td>Amount of SELCO required per artemia</td>
<td>1.5</td>
<td>kg/million artemia/day</td>
</tr>
<tr>
<td>Amount of SELCO required per day</td>
<td>911.5</td>
<td>kg/SELCO/day</td>
</tr>
<tr>
<td>Cost of SELCO per year</td>
<td>$3,281,250</td>
<td>NS</td>
</tr>
</tbody>
</table>

### Table 11: Total Initial and Yearly Costs of Live Feed Culture

<table>
<thead>
<tr>
<th></th>
<th>Total Initial Cost (NS)</th>
<th>Total Yearly Cost (NS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotifer culture</td>
<td>$3,923,707</td>
<td>$2,738,532</td>
</tr>
<tr>
<td>Artemia culture</td>
<td>$3,992,612</td>
<td>$2,736,122</td>
</tr>
<tr>
<td>Algae culture</td>
<td>$2,866,998</td>
<td>$5,474,653</td>
</tr>
<tr>
<td>Total cost</td>
<td>$10,783,317</td>
<td>$5,474,653</td>
</tr>
</tbody>
</table>

Fish Feed Results

In order to compare buying fish feed from a local plant versus importing feed from an outside source; we projected the cost buying fish meal domestically. Because fish meal is the major component in inert pellet fish feed, we researched the cost of purchasing fish meal (NS 3,500 per metric ton) to supply a local Namibian feed production mill.

Currently, there is not a Namibian fish feed plant, therefore we could not obtain selling prices for domestically produced fish feed. Using the buying cost of fish meal and
the production ratio of two parts fish meal to one part feed, we extrapolated a potential selling price for Namibian produced fish feed (N$ 7,500 per metric ton). This price would be profitable for the fish feed plant and more advantageous for the kabeljou system than importing feed (N$ 11,200 per metric ton), which includes expensive shipping costs (see Table 12). To supply the proposed kabeljou system, the plant would need to produce 7,833 metric tons of fish feed per year, requiring 15,666 metric tons of fish meal.

Making calculations based on sales to a kabeljou aquaculture industry alone, a Namibian fish feed plant could still become profitable after its first year of operation.

**Table 12: Inert Fish Meal Cost Breakdown**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of fish</td>
<td>7,200,000</td>
</tr>
<tr>
<td>Food conversion ratio (FCR)</td>
<td>1.7</td>
</tr>
<tr>
<td>Adult fish weight</td>
<td>0.64 kg</td>
</tr>
<tr>
<td>Amount of fish feed needed per year</td>
<td>7,834 MT</td>
</tr>
<tr>
<td>Imported fish feed</td>
<td>11,200 N$/MT</td>
</tr>
<tr>
<td>Total cost of imported fish feed per year</td>
<td>$87,736,320 N$</td>
</tr>
<tr>
<td>Namibian fish feed</td>
<td>7,500 N$/MT</td>
</tr>
<tr>
<td>Total cost of Namibian fish feed per year</td>
<td>$58,752,000 N$</td>
</tr>
</tbody>
</table>

**Overall Results**

Upon completing our cost-benefit analysis, we projected an overall cost for our kabeljou aquaculture system. The new system was then compared to that proposed in 2004 in order to assess the success in reducing the costs of an aquaculture industry.

While both systems incorporated the use of tanks, the aquaculture facility we proposed included a more efficient pumping system, an on-site live feed grow-out system, and the establishment of a local fish feed plant for the purchasing of inert feed. The following
chart shows 2004’s pricing results highlighted in blue, and our pricing results highlighted in yellow.

### Table 13: Overall Results

<table>
<thead>
<tr>
<th>Cost Cutting Option</th>
<th>Costs (in million N$)</th>
<th>Initial</th>
<th>Yearly</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Live Feed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingerling and juvenile feed</td>
<td>7.4</td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>Live feed</td>
<td>10.8</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td><strong>Inert Feed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imported fish feed</td>
<td>24.0</td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td>Namibian fish feed</td>
<td>16.0</td>
<td>16.0</td>
<td></td>
</tr>
<tr>
<td><strong>Fish Container Options</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanks (2004)</td>
<td>28.4</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Tanks (2005)</td>
<td>29.1</td>
<td>0.9</td>
<td></td>
</tr>
</tbody>
</table>

Although the initial costs were not reduced in all cases, the yearly costs were substantially reduced in every case, due to our suggested cost cutting measures.

In comparing the 2004 and 2005 tank systems, Table 14 shows the projected yearly savings of N$ 10.9 million between 2004 and 2005.

### Table 14: Comparative Yearly Costs

<table>
<thead>
<tr>
<th>Total Yearly Cost (in million N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004 System</td>
</tr>
<tr>
<td>83.8</td>
</tr>
</tbody>
</table>
To further illustrate the success of all of these cost cutting methods, we created a graph that projected the yearly savings of the 2005 aquaculture system over a ten year period. Table 15 shows a projected N$ 115 million savings in costs over ten years.

Table 15: 10 Year Projected Yearly Savings

<table>
<thead>
<tr>
<th>Years from start-up</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>million N$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$120</td>
<td>$100</td>
<td>$80</td>
<td>$60</td>
<td>$40</td>
<td>$20</td>
<td>$0</td>
<td>$100</td>
<td>$120</td>
<td></td>
</tr>
</tbody>
</table>


CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

After evaluating the results of our project, we determined that a kabeljou aquaculture industry is still not feasible in Namibia at this time. Even though we were able to recommend cost cutting methods that reduced yearly costs by over N$ 10 million, the initial facility set-up costs are still extremely extensive. However, we have made necessary recommendations for future progress in kabeljou aquaculture research. We investigated funding, alternate markets, and the establishment of a Namibian fish feed plant.

**AgriBank**

In 2003, AgriBank drafted a new act, known as Act 5 of 2003, which allowed the bank to administer loans for aquaculture ventures. However, after visiting the bank, we learned that no policies or procedures are yet in place for approving aquaculture related proposals. In the past AgriBank has only approved farming finances, therefore fish farming is a new field in which they have little experience.

A major problem is that the bank does not have a qualified staff to assess the sustainability or profitability of an aquaculture endeavor. Currently, AgriBank requires that the Ministry of Fisheries and Marine Resources first approve all aquaculture proposals. This means the Ministry must not only assess the self-sustaining nature of an aquaculture venture but also guarantee the bank that each business enterprise will be profitable and able to repay its loan. While the Ministry can provide technical support
upon request, it does not offer any financial guarantees on aquaculture projects at this time.

In order to be able to provide financial guarantees in the future, the Ministry of Fisheries and Marine Resources must satisfy AgriBank need for monetary security. The Ministry of Agriculture has its own approach to providing this security for private agricultural loans. The Ministry of Agriculture has created a separate bank account, which accrues interest that is used to compensate the bank for any failed agricultural endeavors. If the Ministry of Fisheries and Marine Resources could implement a similar system, they would be able to meet security concerns of AgriBank and ensure loan repayment in the event that a developing aquaculture project cannot sustain itself. If the Ministry adopts this strategy, AgriBank could start approving loans for aquaculture and the industry could begin to be established.

Alternate Markets

In order to verify the local market for the kabeljou, we interviewed upscale hotels in Windhoek and Swakopmund, including Windhoek Country Club, Kalahari Sands Hotel & Casino, Hotel Safari and the Hansa Hotel. In most cases, hotels served kabeljou as a main dish all year round, and some stated if it were more readily available, would purchase larger quantities. Danro van Schalkwyk, from Kalahari Sands Hotel & Casino, stated that since kabeljou populations are dwindling, one wholesaler cannot meet its demands, so instead it must buy from multiple companies (G. Bernard, interview, 22 March 2005, D. van Schalkwyk, interview, 23 March 2005, F. Sutil, interview, 22 March 2005, D. van Schalkwyk, interview, 23 March 2005, F. Sutil, interview, 22 March
A kabeljou aquaculture industry could help supply the hotels’ demands for fish.

Unfortunately, because the initial costs of an aquaculture facility are so extensive, the small-scale size of the local demand for the kabeljou will not be sufficient in sustaining an entire industry. For this reason, a larger, yet reasonable market must be considered, so that a developing aquaculture facility would be able to supply the demand, but also sell enough to eventually earn profits.

Targeting growing restaurants such as Ocean Basket, an expanding South African seafood chain, could provide a wider market for a kabeljou aquaculture industry. Currently, 9% of the fish Ocean Basket buys and sells is line-fish, including the kabeljou. Ocean Basket has sixty nine restaurants in South Africa, in addition to one restaurant in Windhoek. By the end of the year, the growing company plans to have 110 restaurants between South Africa and Namibia, and over the next five years, would like to further its international expansion. If a kabeljou aquaculture industry was established and it could sell its fish to restaurant chains, such as Ocean Basket, industry productions could increase with the increasing demand (T. Oates, interview, 07 April 2005).

**Namibian Fish Feed Plant**

As previously stated, fish feed incorporates approximately 69% of the costs of a kabeljou aquaculture industry, making it necessary to specifically focus on reducing costs in this area (Dunn, Hands, Lloyd, 2004). The high costs of feed can be partially attributed to the lack of a Namibian fish feed plant.
Because there is not a local feed plant, Namibia must sell its fish meal to South Africa, only to buy it back for two to three times the price. For example, tilapia farms, in Namibia’s Caprivi Strip, buy fish feed for N$ 1.80 per kg. Since each tilapia consumes one kilogram of feed per day, the price of feed amounts to a major expenditure. This is not only extremely expensive, but it is also an inefficient method of purchasing fish feed. Namibia possesses all the raw materials needed to produce prime quality fish feed, however it is forced to settle for over priced feed of lesser quality.

In order to assess the possibility of establishing a Namibian fish feed plant, we considered all costs, including the structure and equipment, as well as the prices at which fish feed can be produced and sold. The cost of fish feed production plants can vary drastically depending on the production capabilities and types of feed produced. A potential Namibian fish feed plant was quoted at US$ 740,000 (see Appendix J). This price includes all equipment and machinery necessary to produce feed, but does not include the construction costs needed to erect the structure. At full capacity the plant needs four metric tons of raw fish meal, including required supplements and binder, in order to produce two metric tons of fish feed per hour (D. Koh, personal communication, 23 March 2005).

After calculations concerning these numbers were performed, they were then compared to buying fish feed from an outside source. The following graph projects when a Namibian fish feed plant will become profitable. Although the initial costs of the feed plant are more expensive than importing fish feed, the graph shows that at year four a fish feed plant’s profits will surpass its expenses.
Since a Namibian feed plant will begin returning profits after only four years, we recommend that its establishment be seriously considered. However, this recommendation is not restricted to the production of kabeljou feed alone. In fact, it would be more beneficial for a fish feed plant to be established even before a kabeljou aquaculture industry. Fish feed could be sold to tilapia farms in Namibia and other fish farms in southern Africa, creating income as well as helping reduce these industries’ expenses. This could provide for the generation and accumulation of revenue that could possibly aid in financing capital for kabeljou aquaculture. Furthermore, a Namibian fish feed plant would be another domestic industry; therefore it would not only increase Namibia’s gross national product, but also address unemployment by creating jobs.
Future Research

Although we have made progress in cutting the cost of establishing a kabeljou aquaculture industry in Namibia, future research is still needed to evaluate other cost cutting methods. For this reason, we recommend additional investigation on the following topics:

- Alternative Power Sources (solar, wind, hydropower, electrical, fossil fuel)
- Trickle Filter Bioremediation
- Farming Alternative Fish Species

After potential savings based on these methods is calculated a business proposal should be formulated.

Alternative Power Sources

Running and maintaining a sustainable land-based aquaculture facility requires a great deal of electricity. Pumps involved in the aquaculture grow-out system, ultra violet bulbs used in culturing algae and live feed, water heaters, as well as lighting for the facility must all be powered by an energy source. Solar, wind, hydropower, electric and fossil fuel sources may be used to power aquaculture facilities. Namibia’s hot and dry climate is ideal for an alternative energy source such as solar power. Namibia’s coastal regions also are ideal for both wind and hydropower alternatives. Since electricity is another area providing an opportunity to reduce the cost of maintaining aquaculture facilities, a comparison of these energy alternatives may prove beneficial in future research.
Trickle Filter Bioremediation

Fish farming produces wastes in the forms of nutrients, solid particles, chemicals and medicines. A re-circulating in-land aquaculture facility must remove this waste in order to assure the healthy life of its fish and prevent water pollution. Nutrients, such as phosphorus and nitrogen contained in fish feed, become harmful when they are released from fish into the water. When excess levels of phosphorus and nitrogen are released into the environment, they often result in blooms of noxious algae and excessive growth of higher plants. The eutrophication, or nutrient enrichment, of this water can cause smaller plants to die. As a result, the decaying organic matter depletes the water of oxygen and is detrimental to the health of the fish (Garling, 2005).

In addition to the phosphorus and nitrogen role in eutrophication, the primary wastes produced from fish farming are from fish excretion and uneaten feed. Therefore, it is important to fully understand the biology of the farmed fish in order to develop a feed that meets the nutritional demands of the fish and has a minor impact on the surrounding environment. Figure below illustrates the distribution outcome of nitrogen and phosphorus from fish feed (Garling, 2005).
Since roughly 80% of phosphorus in wastes is from uneaten fish feed and fish excretion, it becomes important to manage solids removal. Bioremediation is one means of removing aquaculture wastes and returning water back to its original state. Through the use of microorganisms bioremediation can purify polluted water. Trickle filters use bioremediation techniques to clean water and are optimal for indoor re-circulating aquaculture systems due to their aeration and degassing properties. When properly managed, re-circulating aquaculture systems can result in little environmental damage, which will become increasingly important as Namibian aquaculture regulations are developed (Garling, 2005).

More research on the integration of trickle filters into fish farming of the kabeljou is needed. A re-circulating system, which makes use of a trickle filter, could potentially cut the filtration and pumping costs of running an aquaculture facility. Using trickle
filters to remove aquaculture wastes may not only be financially beneficial to the establishment of a kabeljou aquaculture facility, but also environmentally beneficial to Namibia and its people.

**Farming Alternative Fish Species**

In order to begin a sustainable aquaculture industry, the best types of species of fish to be farmed must be investigated. Although kabeljou have a high growth rate and are indigenous to Namibia, broodstock have proven difficult to capture in the wild. For this reason we recommend researching other appropriate fish species to be used for fish farming. An ideal species is one that has a high market sale price, high market demand and is approved or may easily be approved for culturing by the Ministry of Fisheries and Marine Resources.

**Formulating a Business Proposal**

Due to the extensive costs of establishing a kabeljou aquaculture industry, money must first be obtained before the industry may be developed. In order to acquire money from a private investor, a business proposal should be formulated. Additional research on creating a business proposal for aquaculture of the kabeljou could be used to generate interest in this potentially lucrative venture and establish the funds needed for instituting a fish farming facility in Namibia.
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http://www.cfsan.fda.gov/~frf/sfimport.html


FAOSTAT data-Fisheries Data, last updated 04 Feb 2004.


Hammond Maps, 1995, Microsoft Bookshelf '95 Atlas


Appendix A- Ministry of Fisheries and Marine Resources (MFMR) Organization

The Ministry of Fisheries and Marine Resources (MFMR) was created to “strengthen Namibia's position as a leading fishing nation and contribute towards the achievement of its economic, social, and conservation goals for the benefit of all Namibians.” After its independence, Namibia set out to restrict and protect its young fishing industry through new, stricter commercial fishing rules and regulations mandated by the MFMR.

In December, 1991 an article entitled *Towards Responsible Development of the Fisheries Sector* (Ministry of Fisheries and Marine Resources, 2005) profiled policies regarding the fishing industry that soon after became legislation in the Sea Fisheries Act (October 1, 1992). For the first time after years of over-fishing by foreign vessels and mismanagement, the country had an opportunity to develop and protect its fisheries by putting restrictions on how its waters could be fished. Special rights and privileges were granted to native Namibians to avoid monopolization by foreign fishing powers over the Namibian industry. By placing strict regulations on logistically necessary aspects of commercial fishing (such as licenses, fish quotas, higher prices, and total allowable catch (TAC), foreign competitors could not easily obtain legal rights to fish in Namibia. This gave local establishments the window of opportunity to potentially flourish. In addition to stricter regulations, documents were drawn up to benefit Namibia in future joint endeavors it might pursue. The ministry is organized as displayed in Figure 9.
The Directorate of Policy, Planning, and Economics maintains relationships between fisheries in the local and international population. It also drafts new policies regarding fisheries. The Directorate of Aquaculture manages research in aquaculture and the development of new policies pertaining to the aquaculture facilities. The Directorate of Operations upholds and enforces license and permit regulations. This position is also responsible for monitoring all fishing vessels off the coast and collecting payment from industry. The Directorate of Resource Management provides advice on environmental concerns related to fishing, researches fish stocks, and offers recommendations on maintaining native fish populations.

Figure 9: Organizational Structure of the MFMR
Appendix B- HACCP Regulations

Countries who want to export their seafood products to the United States must comply with the USFDA Seafood HACCP regulations, or some other plan that encompasses the main aspects of the HACCP program. The HACCP regulations were established on December 18, 1997 to ensure safety of seafood products by identifying and preventing hazards that cause food borne illness (Center of Food Safety and Applied Nutrition, 2005).

HACCP regulations apply to domestic as well as imported seafood. Foreign processors from Canada, Japan, New Zealand, and Thailand are the only processors that are currently in good standing and are meeting the requirements of the FDA seafood HACCP regulations. These regulations have improved the safety of seafood consumed by the public in the United States by increasing inspection frequency and helping companies to better understand food safety hazards and how to control them (USFDA HACCP Policy, 1997). Therefore, it is important for Namibia to establish an aquaculture industry which upholds the HACCP regulations in order to safely export their products to the United States.

As partial fulfillment of the HACCP regulations, Namibian fisheries must also adapt the HACCP mid-course correction program, which focuses on firms whose products present the highest risk to consumers. This program draws attention to firms who have no HAACP plans and need to control for pathogens and histamines. The HAACP program has improved guidance and training to the industry and regulators on control of pathogens and histamines. It has also developed three programs that
emphasize knowledge of the controls for pathogens and histamines, and provide guidance for fish vessel and aquaculture operators (USFDA HACCP Policy, 1997).
Appendix C- Hotel and Restaurant Interviews

Country Club

Interviewee: Mr. Gilles Bernard
Professional Title: Executive Head Chef
Location: Windhoek, Namibia
Date: 22 March 05

What kinds of fish do you buy?
   Kingclip, Kabeljou, Shark and Salmon

What type of fish is a consumer favorite?
   Kingclip and Kabeljou

How much fish (kabeljou) does your restaurant buy?
   20 kilograms per week

At what price do you buy kabeljou?
   N$ 32 per kilogram of filleted kabeljou

Is kabeljou bought from one or more wholesalers?
   The fish is bought from three wholesalers, Blue Marine, West Marine, and Sea Pride. Blue Marine is located in Windhoek, whereas West Marine and Sea Pride are located in Swakopmund and Walvis Bay respectively. West Marine is the major supplier of kabeljou out of the three.

Is kabeljou bought seasonally?
   No, kabeljou is bought all year round.

If kabeljou was widely available, would you be interested in buying more of it? If not, why?
   There is no interest in buying more kabeljou, as there is no lack of fish supplied to the hotel.

How much kabeljou would you need (or like) to buy on a weekly/monthly basis?
   Same amount as stated previously, 20 kilograms per week.
What kinds of fish do you buy?
Barracuda, Kabeljou, Shark, Salmon and Shrimp

How much fish (kabeljou) does your restaurant buy?
In 2004 the hotel averaged 24 kilograms per week of kabeljou. As of 23 March 05, the hotel has bought a total of 43 kilograms of kabeljou.

At what price do you buy kabeljou?
N$ 22 per kilogram of whole kabeljou

Is kabeljou bought from one or more wholesalers?
The fish is bought from Blue Marine.

Is kabeljou bought seasonally?
No, kabeljou is bought all year round.

If kabeljou was widely available, would you be interested in buying more of it? If not, why?
Yes, if the kabeljou was widely available, they would buy more of it. However, the hotel must pay an import fee for the kabeljou, since it is exported to other African countries and they are forced to buy in on the export market. It is not legal for them to buy from local wholesalers, so they find it rather expensive to buy the kabeljou. If it was widely available, and the cost of buying the kabeljou was less expensive, then they would certainly buy more of it.
Hotel Safari

Interviewee: Mr. Franz Sutil
Professional Title: Restaurant Manager
Location: Windhoek, Namibia
Date: 22 March 05

What kinds of fish do you buy?
   Kingclip, Kabeljou, Sole and Hake

What type of fish is a consumer favorite?
   Kingclip, Sole and Hake

How much fish (kabeljou) does your restaurant buy?
   20 kilograms per week

At what price do you buy kabeljou?
   N$ 22 per kilogram of whole kabeljou

Is kabeljou bought from one or more wholesalers?
   The fish is bought from Sea Pride, located in Walvis Bay.

Is kabeljou bought seasonally?
   No, kabeljou is bought all year round.

If kabeljou was widely available, would you be interested in buying more of it? If not, why?
   Yes, there is interest in buying more kabeljou.

How much kabeljou would you need (or like) to buy on a weekly/monthly basis?
   The restaurant currently buys a greater amount of hake in comparison to kabeljou. If kabeljou was widely available, they would buy less hake and more kabeljou to even out the difference between the two fish.
Interviewee: Mr. Tobias Hein
Professional Title: Deputy General Manager
Location: Swakopmund, Namibia
Date: 29 March 05

What kinds of fish do you buy?
   Monk, Hake, Kingclip, Kabeljou, Sole, and Orange Roughy

What type of fish is a consumer favorite?
   Kingclip, Hake and Kabeljou

How much fish (kabeljou) does your restaurant buy?
   100 kilograms per month

At what price do you buy kabeljou?
   N$ 20 per kilogram of whole kabeljou

Is kabeljou bought from one or more wholesalers?
   The fish is bought from various local suppliers.

Is kabeljou bought seasonally?
   No, kabeljou is bought all year round as it is permanently on the restaurant’s menu.

If kabeljou was widely available, would you be interested in buying more of it? If not, why?
   There is not interest in buying more kabeljou, as there is no lack of the fish supplied to the hotel.
Interviewee: Mr. Trevor Oates  
Professional Title: Restaurant Manager  
Location: Windhoek, Namibia  
Date: 07 April 05

**What kinds of fish do you buy?**  
Kingclip, Kabeljou, Bluefish, Angelfish, Salmon

**What type of fish is a consumer favorite?**  
Linefish: Bluefish, Angelfish, Kabeljou

**How much fish (kabeljou) does your restaurant buy?**  
20-30 kilograms per week (fillet)

**At what price do you buy kabeljou?**  
N$ 29.95 per kilogram of whole kabeljou  
N$ 12.95 per kilogram of baby fillet

**Is kabeljou bought from one or more wholesalers?**  
The fish is bought from Tanguana (South Africa), Blue Marine (Swakopmund), and Lucitania (Cape Town).

**Is kabeljou bought seasonally?**  
No, kabeljou is bought all year around, however is sold on a rotational linefish schedule with the changing menu.

**If kabeljou was widely available, would you be interested in buying more of it? If not, why?**  
No, they believe that they get a decent amount of kabeljou.

**Other notes:**  
Ocean Basket is an expanding South African seafood chain. There are currently 69 restaurants in Cape Town and 1 restaurant in Windhoek. However by the end of the year, the chain hopes to build 3 more restaurants in Windhoek and have a total of 110 restaurants overall. Therefore, there will be an increasing need for more fish intake, including the kabeljou.
Appendix D- Professional Interviews

Mr. Mike Batty

Position: Mariculture Advisor
Company: Henties Bay Marine and Coastal Resources Research Centre
Location: Henties Bay, Namibia
Email: mbatty@mweb.com.na
Date: 11 April 2005

Figure 10: Rotifer Culture

Feeding Cycle of the Kabeljou
The kabeljou life cycle begins with feeding off the egg sacs for the first 3 days, then the larvae move to rotifers for 5-7 days, then to artemia for 7 days, and for the last stages the fish are fed pellets. The eggs are held in suspension until they are hatched and then are not fed until the egg sacs are consumed. Rotifers are used in the next stage because they are small enough for the larvae’s mouth to eat. Rotifers also work well because they will consume any proteins or unsaturated fatty acids that the fish may need, and as the fish eat the rotifers their diets are being supplemented as well. The rotifers are fed in tanks with cultured algae solutions and the population is allowed to multiply freely. There are currently 60million rotifers in the lab. It is estimated that there are 10 rotifers per mL in solution, and each larvae will eat 1000 rotifers/day. Therefore, if you have 2,000 larvae then you will need 2,000,000 rotifers per day. Rotifers must also be fed to the fish within hours after they are fed because they will lose the nutrients over time. The larval stage is the most expensive stage in the life cycle because of the need to use live feed. There may also be a problem with the pellets that are fed at the end stages of growth because they lack movement. The whole fingerling stage lasts from 30-70 days. The kabeljou are sexually mature at 40cm.

Using Kabeljou for Aquaculture
One of the main reasons that the kabeljou is being explored for aquaculture is because of its fast growth rate. Currently there are only tests being done with the silver kabeljou, however the dusty kabeljou has a better growth rate and can grow to larger mature sizes. The problem lies in catching a healthy brood stock, due to the dwindling kabeljou population in the wild. Another reason the kabeljou is desired is because it is a local fish, so it is familiar to the community and people will not be worried about parasites.
Aquaculture Start-Up Problems
A major factor in starting aquaculture of the kabeljou is that the life cycle has not been closed in captivity. Mr. Batty was supposed to provide the live feed for Dr. van Zyl’s eggs, however the kabeljou were spawned before a sufficient food supply was ready. The fingerlings starved because the only food available was artemia and at the young stage, their mouths were too small to eat the larger feed. Now however, there the feed is plentiful, but there are no fish left in order use the feed. Mr. Batty stills hopes to catch kabeljou this year and if spawning is not possible, then he plans to remove the gonads and attempt laboratory fertilization. Another set back is finding the proper location for a facility. Mile 4 in Swakopmund had been explored as an option however it does not appear that enough water would be able to be pumped to the site. Areas along Henties Bay and Walvis Bay have also been considered, but sulfur eruptions in conjunction with the coastline structures cause issues. Swakopmund, Walvis Bay, and Henties Bay are all at lower elevations and there are no natural structures that would hold pipes out of the water, therefore jetties would have to be built. The best location would seem to be down in Luderitz, however at this time costs are still high, due to electricity and pumping.
Ms. Louisa Maree

Position: General Manager of Freddie Fish Processors
Company: Freddie Fish Processors
Location: Walvis Bay, Namibia
Email: ffpmaree@iway.na
Date: 30 March 2005

Figure 11: Freddie Fish Processors

Linefishing
Due to weather conditions, Freddie Fish Processors has not had a decent catch of kabeljou in the past two years. Normally the kabeljou is caught between the months of May-September and fishers will go out on two to three week trips. Prior to two years ago the fishers would come in with 1.6 tons of kabeljou, which is still considered an insufficient catch. Ms. Maree stressed that weather was important, mentioning that the amount of swells and winds as well as water temperatures being too cold for the kabeljou to live could be detrimental to their catch size. When conditions were ideal, fishers were at sea for two and a half weeks and brought in 17-40 tons of kabeljou. The average size of the kabeljou that is caught ranges between 2½ -4 kilos.

Processing at Sea
Freddie Fish Processors currently have two types of vessels they use at sea: sea-frozen vessels and ice vessels. With the sea-frozen vessels there is an onboard freezer where the fish are placed after the heads are removed and the fish is gutted. With ice vessels, the fish are put on ice after being headed and gutted and brought in as wet/fresh fish. Among all the vessels, Freddie Fish Processors employs 117 people.

Marketing
Most fish sales go out to South Africa and Cadilu Processing, which is located in Walvis Bay. Kabeljou is favored in sales because it is considered a luxury fish and can be sold at more expensive prices. Ms. Maree mentioned that there is no local market because Namibians will generally buy less expensive fish. It is also not found to be profitable to have on-site processing, since most of their consumers have their own processing facilities.
Mr. Jan Meier

Position: Co-owner and Right Holder
Company: Fox Fishing Co.
Location: Walvis Bay, Namibia
Telephone: +264 81 129 0143

Figure 12: Fishing Vessels

Kabeljou Fishing
The kabeljou is mostly fished in the winter seasons and anywhere from 150-200 tons of kabeljou can be brought in per season. Three vessels employing up to 67 people will go out between 10-12 days at a time. When fish are taken onto freezer vessels they are headed and gutted and can be stored at -18°C for up to 6-7 months.

Marketing Kabeljou
Fox Fishing Co. mainly sells their fish to South Africa or Portugal and Spain. A kabeljou can be sold for an average of N$20 per kilo. Jan Meier also expressed that he believed aquaculture of the kabeljou would be extremely profitable and greatly replenish the kabeljou stock.
Marketing
Gendev is a packaging/processing plant of a wide variety of fish, including kingclip, hake, mackerel, sharks, kabeljou, and more. They export mainly to Malaysia, Indonesia, Japan, and South Africa. It will normally take 2-3 days to export a package to the Spanish market. They used to export fresh swordfish and tuna to the US; however that market fell through in 2001 due to the inability to sustain US standards.

Filleting of Line-fish
Gendev possesses a fillet machine, which is used for hake and kingclip. Trolling fish are preferable fish to fillet because their scales are already removed. In order to fillet the kabeljou, the scales would first have to be removed, the fish would have to be washed, and then they must be split up into size groups before being fed through the fillet machine. Once through the fillet machine another person would have to feel for any stray bones. This process can employ up to 80 people and is continuous as one fish is fed through at a time. From one fish there is a 40% fillet production, so a kilo fish can produce a 400-500 gram fillet. A newer fillet machine can cost between N$230-300 thousand. The fillet machine is not currently running at Gendev because it is not really viable to make fillets due to the costs, time, and labor included in production. It was said that consumers sometimes prefer the whole fish because they can immediately tell freshness levels, as well as prepare the fish a certain way on-site.

Fish meal
In order to start a fish meal plant, a processing would have to collect between 100-200 tons of fish guts/hour. However after processing 70 tons of fish only 2-3 tons of guts are extruded. Although they will not start their own processing plant, Gendev currently sells the guts that are produced to existing fish meal plants as another source of income.

Employment/ Production
Gendev currently employs 10-15 people permanently, and has 30 addition seasonal employees. There are two vessels that go out seasonally and year round. The seasonal vessels will go out for 3-4 months and bring in 700 tons of fish/month. The other vessels will go out for 2-3 months and bring in 500-600 tons fish/month.
Mr. Renaldo Ricardo

Position: Owner  
Company: Walvis Bay Salt Refiners  
Location: Walvis Bay, Namibia  
Telephone: +264 81 127 9766  
Date: 31 March 2005

Figure 14: Oyster Shuckers

Oyster Marketing
Walvis Bay Salt Refiners Oyster Farm has been in existence for over 8 years has 2.4-2.5 million oysters, and 80% of its market is to South Africa. Mr. Ricardo currently buys 10mm oysters from Chile and then proceeds to grow them to 4 different marketable sizes: cocktail (40-50g), medium (60-80g), large (80-100g), and extra large (120g). The cocktail size can be sold for N$2 each, medium can be sold for N$2.35 each, large can be sold for N$2.70 each, and extra large can be sold N$3 each. It can up to 7 months to grow the oysters to a marketable size and sales are made daily. Mr. Ricardo currently has 9 employees that sort the oysters, however he says as more oysters are farmed more people will be needed.

Pumping System
Walvis Salt Refiners has 2 pumps that pump 240m$^3$/min of water to the two ponds. Mr. Ricardo rents the pumps from Walvis Bay Salt Refiners and says that for a starting oyster farming industry a much smaller amount of pumped water would suffice. The two ponds are separated by size: one for the baby oysters (20x100m) and one for the grow-out system (40x200m). The pumps are sufficient climate control for the land-based system as temperature and tide can be monitored by pumping more or less water through the ponds.
Mr. Manuel Romero

Position: Owner
Company: Beira Aquaculture
Location: Walvis Bay, Namibia
Telephone: +264 81 127 1762
Email: beiraw@iway.na
Date: 31 March 2005

Figure 15: Algae Culture

Algae Culturing
Beira Aquaculture has a unique system in Namibia, because unlike other oyster farms Beira Aquaculture grows the oysters from the larval stage as well as producing its own algae for feed. The algae are cultured at 18-20°C and are supplemented with nitrates, phosphates, some metals, and vitamins. The algae start in test tubes and as they multiply are moved to flasks, then bottles, and eventually larger bags, where they are left to multiply more in under lights. It normally takes 10-15 days for the algae to reach a sufficient concentration in order to be moved to the larger bags.

Oyster Grow-out
The oyster larvae are bought from Washington, USA, and have a 20% survival rate after shipping. The oyster larvae are also put into test tubes and after multiplication are moved to flasks then bottles then tanks. The tanks are sifted through every 48 hours with varying screen sizes. The growing oysters are kept and moved to segregated tanks, while the oysters that are not growing are discarded. Once the oysters are at a substantial size they are moved to the sea. On average it takes the oysters 9-12 months to grow to maturity and around 5-7 months before they are moved to the ocean. The ocean is the final grow-out system where they are allowed to grow to maturity by feeding off the nutrients that are naturally in the water. Mr. Romero sells around 20,000 oysters per week, mainly to South Africa, for N$2 each. There are 18 employees for the whole process from larvae to full-grown oyster.
Mr. Johann Slabbert

Position: Owner
Company: Namibia Oysters
Location: Swakopmund, Namibia
Telephone: +264 81 242 7177
Email: hbestate@iway.na
Date: 30 March 2005

Figure 16: Pump House

Oyster Marketing
Namibia Oysters is still in the beginning stages of aquaculture development. The oysters that are being harvested are not yet at a marketable size but they should grow to a profitable stage within 9-12 months. Currently Mr. Slabbert has 9 employees that aid in sorting and weighing the oysters at their different stages of growth. The oysters are kept in ponds in stationary baskets (2kg of oysters/basket) where they are left to feed off of the nutrients from water taken directly from the ocean. It is estimated that Namibia Oysters is harvesting 2.3 million oysters, which they import at a smaller size from South America. For about 770,000 (3-4mm) oysters bought from South America at N$30,000, when full grown they can be sold for N$1.5 million. In order to sell out the oysters, the Ministry of Fisheries and Marine Resources will conduct flesh analyses to examine the quality of the oysters. Mr. Slabbert would like to sell his oysters to the South African market. At this point he has spent around N$4.5 million on his oysters, ponds, and pumping systems, and estimates another N$5 million before his business is at full running capacity.

Pond/ Dam Set-Up
Namibia Oysters has two free flow oyster ponds (40x20x1m each) and one header dam (50x60x3m). Each pond holds approximately 1 million oysters. The header dam is at a higher elevation than the two oyster ponds and water is taken from the dam and pumped into the two smaller ponds. Each pond and the dam have two paddle aerator wheels each bought from Taiwan that oxygenate and re-circulate the water. The paddle aerators cost US$250 each. The ponds are lined with a 2mm liner and the dam is lined with a 1.5mm liner, both made of HDPE. The liners cost N$100/m² and in order to line one pond 120m² of lining was needed. The liners are guaranteed to last between 15-20 years.

Pumping System
There is a pump house on the shore alongside a jetty, which contains two 45kW pumps. The pumps were bought at N$95000 each and pump 600m$^3$ of water per hour through all the pipes in the system. Each month N$7000 is spent on electricity, and when the system is at full running capacity electricity should cost N$20000/month. There are 12in pipes used to transport water from the pump house to the header dam and 8in and 6in pipes are used to transport water from the header dam to the oyster ponds. For the current set up there are 250m of 12in piping, 250m of 8in piping, and 180m of 6in piping. By Namibian regulations, two permits are required: one for pumping and one for dumping. Mr. Slabbert has received his pumping permit, however has not received his dumping permit despite three years of trying.
Appendix E- Raceway Calculations

In order to determine the overall cost of constructing a raceway system, we determined the cost of materials needed to construct enough raceways to house enough fish for a kabeljou grow-out system to meet a potential US demand. We used size requirements provided by Dr. van Zyl and combined it with construction information provided by Mr. Rudy van der Plaas to come up with a 70 m$^3$ per raceway design. To determine the total amount of concrete needed, we based our calculations on the inside dimensions (28m x 2.5m x 1.5m) of each raceway and incorporated eight inch (200mm) thick walls. To save on materials, space, and cost, we combined each raceway with the adjacent raceways so that they share at least one wall and at most two walls. To avoid excavation costs, these raceways were designed to be built on a concrete base footing platform, for structural purposes following Mr. van der Plaas’s professional construction opinion. The total volume of concrete needed for this system is 290 cubic meters, at a cost of N$ 347,616. The total amount of steel rebar (12 mm - 16 mm) needed for the raceway system is 23.2 MT (80 kg/m$^3$), at a cost of N$ 2,204,400 (N$ 9.5/kg steel).

Table 17: Concrete Parameters

<table>
<thead>
<tr>
<th>Dimensions</th>
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<tr>
<td>Raceway:</td>
<td>Meters</td>
</tr>
<tr>
<td>Outer:</td>
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<td>Length:</td>
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</tr>
<tr>
<td>Width:</td>
<td>2.9</td>
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<tr>
<td>Height:</td>
<td>1.5</td>
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<tr>
<td>Inner:</td>
<td></td>
</tr>
<tr>
<td>Length:</td>
<td>28</td>
</tr>
<tr>
<td>Width:</td>
<td>2.5</td>
</tr>
<tr>
<td>Height:</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Base Footing:
- Length: 28.8 m
- Width: 33 m
- Height: 0.25 m

Volumes

Raceway:

Long Side:
- Length: 28.4 m
- Width: 0.2 m
- Height: 1.5 m
- Volume: 8.52 m³

Volume: 8.52 m³ x 4 sections = 34.08 m³

Short Side:
- Length: 0.2 m
- Width: 10 m
- Height: 1.5 m
- Volume: 3 m³

Volume: 3 m³ x 6 sections = 18 m³

Base Footing:
- Length: 28.8 m
- Width: 33 m
- Height: 0.25 m
- Volume: 237.6 m³

Volume: 237.6 m³ x 1 section = 237.6 m³

Total = 289.68 m³

Table 18: Concrete Raceway Cost

Concrete Raceway Cost

Formwork

Footage:

Outer:

1 28.8 m x 2 sections = 57.6 m²
2 33 m x 2 sections = 66 m²
Total = 123.6 m²

Inner: Total = 352 m
1  28 m x 6 sections  =  168 M^2
2  10 m x 6 sections  =  60 M^2
Total  =  228 M^2

Rate = N$200/m^2
Cost:
351.6 m x N 200 = $70,320

**Concrete** (includes material, labor, and casting)
Volume:
315.24 m^3

Rate = N$1200/m^3
Cost:
289.68 m^3 x $1,200 = N $347,616

Formwork+Concrete N $417,936
Appendix F- Pond Calculations

Table 19: Pond Parameters

<table>
<thead>
<tr>
<th>Ponds</th>
<th></th>
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<tr>
<td>Square Volume</td>
<td>800 m³</td>
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<tr>
<td>Side Volume</td>
<td>120 m³</td>
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<tr>
<td>Total Excavation/Pond</td>
<td>920 m³</td>
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<tr>
<td>Number of Ponds</td>
<td>219 ponds</td>
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<tr>
<td>Total Excavation</td>
<td>201,480 m³</td>
</tr>
<tr>
<td>Excavation Cost</td>
<td>$55 N$/m³</td>
</tr>
<tr>
<td>Total Excavation Cost/ Pond</td>
<td>$11,081,400 N$</td>
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<tr>
<td>Total Excavation Cost</td>
<td>$25,368,960 N$</td>
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Table 20: Pond Volume

<table>
<thead>
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<tr>
<td>20 sides</td>
<td>89.6</td>
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<tr>
<td>40 sides</td>
<td>179.2</td>
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<tr>
<td>total/pond</td>
<td>268.8</td>
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To determine an accurate calculation of excavation and HDPE plastic liner quantities we calculated accordingly. To create the 800 m³ pond volume, we laid out a 40x20x1 (L x W x H) design. For the angled sides of the ponds, we took a 90 degree right triangle with legs of one meter and two meters and used basic trigonometry to calculate the length of the hypotenuse (2.24 m). With this value we were able to calculate the remaining excavation volumes for each pond; volumes for both 20 m sides and both 40 m sides (20 m³ and 40 m³ respectively). From these figures, we calculated the total excavation volume per pond to be 920 cubic meters of soil. Therefore, for 219 ponds the total excavation area is 201,480 cubic meters. Using the excavation quote from Rudi van der Plaas of Superior Construction (Swakopmund, Namibia) of N$ 55 per cubic
meter of soft soil (no rock, which would require blasting), the total cost to excavate all 219 ponds would be N$ 11,081,400.

To determine the area used for the HDPE pond liner, we made the following calculations. Using the length and width of each pond, we determined the area of the bottom of each pond to be 800 square meters. From the same triangle calculations used for the excavation volumes, we took the hypotenuse (2.24m) and multiplied it by the length of each side to determine the amount of liner needed to cover the sides (269 square meters). According to Mr. Slabbert from the Mile 4 Oyster farm, at least two meters of extra lining were needed along each edge in order to securely install the entire lining system. For each pond, this liner edging proved to be 240 square meters. To save on cost, we subtracted each corner area where the two sides would overlap, which was a value of 16 square meters per pond. Therefore, the overall amount of lining needed for one pond is 1,158 square meters of HDPE. The final cost of lining a single pond at N$ 100 per square meter is N$ 115,840, and the overall cost for 219 ponds is N$ 25,368,960.
Appendix G- 2004 Tank Calculations

### Table 21: 2004 Tank, Pump, and Filter Parameters

<table>
<thead>
<tr>
<th>stocking density (kg/m³)</th>
<th>grow out period (months)</th>
<th>number of grow out periods/year</th>
<th>fillet (kg/year)</th>
<th>dressing fraction</th>
<th>whole fish (kg/year)</th>
<th>daily water replacement fraction</th>
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<tr>
<td>16</td>
<td>8</td>
<td>1.5</td>
<td>1,680,000</td>
<td>0.4</td>
<td>4,200,000</td>
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<tr>
<td>working hours/day</td>
<td>working days/year</td>
<td>pump rate (m³/hr)</td>
<td>pump costs (N$)</td>
<td>useful life (years)</td>
<td>Replacement tank liner (N$)</td>
<td>tank liner replacement frequency (years)</td>
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<tr>
<td>24</td>
<td>365</td>
<td>17</td>
<td>6300</td>
<td>4</td>
<td>18,000</td>
<td>10</td>
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<tr>
<td>electricity costs (N$/kWh)</td>
<td>pump load (kW)</td>
<td>pump running cost/hr (N$)</td>
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<td></td>
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<tr>
<td>0.12</td>
<td>0.55</td>
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### Table 22: 2004 Tanks

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<th>TANKS</th>
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<tbody>
<tr>
<td>tank</td>
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<tr>
<td>tank volume (m³)</td>
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<tr>
<td>useful life (years)</td>
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<tr>
<td>fish per tank (kg)</td>
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<tr>
<td>number of tank volumes utilized in one year</td>
</tr>
<tr>
<td>number of tanks needed</td>
</tr>
<tr>
<td>yearly liner replacement (N$)</td>
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<tr>
<td>cost per tank (N$)</td>
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</table>

<table>
<thead>
<tr>
<th>ran</th>
<th>A</th>
<th>B</th>
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<tbody>
<tr>
<td>tank volume (m³)</td>
<td>300</td>
<td>426</td>
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<tr>
<td>useful life (years)</td>
<td>25</td>
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<tr>
<td>fish per tank (kg)</td>
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<td>6816</td>
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<tr>
<td>number of tank volumes utilized in one year</td>
<td>875</td>
<td>616</td>
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<tr>
<td>number of tanks needed</td>
<td>583</td>
<td>411</td>
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<tr>
<td>yearly liner replacement (N$)</td>
<td>1,050,000</td>
<td>739,437</td>
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<td>cost per tank (N$)</td>
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<td>2004 Pumps</td>
<td>2004 Filters</td>
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<td>------------------------------</td>
<td>------------</td>
<td>--------------</td>
</tr>
<tr>
<td><strong>PUMPS</strong></td>
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<td>tank volume (m³)</td>
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<td>pumps/system</td>
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<td>total cost of pumps per system (N$)</td>
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<td>yearly pump running costs</td>
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<td>total deprecivtive cost of pumps (N$)</td>
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<table>
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<tr>
<th><strong>FILTERS</strong></th>
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<td>Useful Life (years)</td>
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<td>25</td>
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<td>Yearly Maintenance (N$)</td>
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<td>Depreciative Cost (N$)</td>
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<td>2000</td>
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<tr>
<td>Depreciative Cost for A (N$)</td>
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<td>-------------------------------</td>
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</tr>
<tr>
<td>Depreciative Cost for B (N$)</td>
<td>547,731</td>
<td>273,865</td>
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Table 25: 2004 Tank Analysis Results

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<thead>
<tr>
<th>TOTAL COST (N$)</th>
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<tbody>
<tr>
<td>Tank A</td>
<td>3,499,509</td>
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<tr>
<td>Tank B</td>
<td>2,903,554</td>
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Appendix H- Kob Larval Rearing Proposal

Kob Larval Rearing Proposal

Technical details, equipment and materials list

Objective:

To rear batches of approximately 2000 Kob from eggs and wean the larvae from live feed onto a particulate diet.

Feed Requirements:

From day 3 to day 11 post hatch: feeding with rotifer *Brachionus plicatilis*, reared on *Nannochloropsis* and *Tetraselmis* algae supplemented with Selco CS and enriched with DHA Protein Selco on day before feeding. Production target is 6 million rotifers per day.

From day 12 to day 30: *Artemia* nauplii introduced, AF strain if available. Feeding with rotifers decreased. Requirement is 1 million nauplii per day (from approximately 8 g of cysts assuming 50% hatch rate).

From day 30 onwards, a particulate larval feed with particle sizes of 200 µm or less will be introduced in increasing quantities as live feeding is reduced. A larger strain of *Artemia* (EG strain) with enrichment will also be used. Larvae will be graded to reduce cannibalism during weaning. By day 50 it is expected that the larvae will be fully weaned onto inert food.

Algal culture:

A batch culture system will be used for culture of two algal species – *Nannochloropsis oculata* and *Tetraselmis suecica*. The Guilard culture medium will be used. Anexic stock cultures on agar plates will be obtained from overseas and held in 100 mL conical flasks in a reserved area of the tank room at 16 - 18º C. In the event of contamination/collapse of stock cultures, the Centre has the facilities to isolate individual algal cells using the agar plate method, and should be able to re-establish monospecific cultures. The maintenance of stock cultures at the Centre will benefit other commercials aquaculture operations in Namibia, notably the Pacific Oyster hatchery in Walvis Bay.

Upscaling will be in 2 litre pyrex flasks, filled with seawater diluted to 20 ppt with untreated borehole water and autoclaved. 2 flasks are allowed for each species of algae. These will be held in the larval feed room, maintained at a temperature of 25º C. Aeration will be provided through glass pipettes. Production will be in 15 litre polyethylene bags, with four to six in use at any one time. These will be filled with diluted and hypochlorite sterilised seawater (20 ppt), with aeration through small
airstones. Light for the algal cultures will be provided 24 hrs a day, by a bank of 4 fluorescent tubes, mounted behind the bench on which the culture are held.

In the event of a collapse of algal cultures, algal paste will be held in reserve and used for feeding of rotifers and/or green water while the cultures are re-established.

**Rotifer culture:**

A semi-continuous system will be used for amictic populations of the rotifer *Brachionus plicatilis* (S-strain), also sometimes classified as *B. Rotundiformis*. Algal cultures and a commercial enrichment medium will be sued to feed the rotifers. Rotifer stock cultures will be established from rotifer cysts brought from overseas, and maintained in 100 mL flasks in the tank room. These flasks are inoculated with a low algal density and no vitamin B supplement to discourage population growth. In the event of a collapse of these stock cultures, fresh cultures will be established from cysts.

Upscaling will be carried out in 4 x 5 litre flasks, filled with single-species algal culture from the 20 litre bags, drawn off at the log growth phase. 1 mL/L of 1 ppm vitamin B12 solution is added at the same time as the inoculum of rotifer stock solution. Air will be bubbled through these flasks and illumination provided as for culture of microalgae.

Production will be in 3 x 40 litre conical tanks filled with U-V sterilized seawater, made up to 20 ppt with borehole water; the vitamin B12 supplement; and a mixture of the algal cultures. After day 1 CS Selco will be added twice daily, to provide between 0.5 and 0.3 g/million rotifers/day, depending on density. Aeration will be provided through 1 diffuser per tank. Bottled oxygen will be available if necessary.

Rotifers will be harvested from around day 6 onwards, using a 50µ nitex sieve, with a 250µ screen over to remove debris. As rotifers are drained out, the tanks will be made up with fresh culture medium until production declines. Fresh cultures will be started in one tank at intervals of about 7 days, to ensure that at least one tank is in full production at any time.

**Artemia:**

Artemia cysts, preferably of a small strain such as INVE AF, will be purchased from a commercial supplier. About 0.5 kg should be sufficient for the trial and some future work. Cysts of a larger and cheaper strain will be purchased for feeding of the larger larvae – 1 kg will be required. The possibility of obtaining *Artemia* from local saltworks will be investigated. Worked on artemia will be carried out in the laboratory, due to the need to use caustic chemicals.

Cysts will be rehydrated in an Imhoff cone (1 litre) filled with borehole water, and aerated through a pipette. The rehydrated cysts will be incubated in the same cone and collected when ready on a 100 µ screen and washed before feeding to the Kob larvae.
For feeding of large larvae, Artemia will be transferred to a conical tank, allowed to develop to instar II stage (at which feeding commences) and enriched with DHA Protein Selco at least 4 hours before feeding.

**Larvae:**

Eggs will be obtained from the broodstock/spawning facilities in Swakopmund soon after fertilisation, and transported to Henties Bay (50 minutes drive) in 20 litre plastic bags half filled with water and topped up with pure oxygen. On arrival they will be disinfected with active iodine – 10 minutes in 10 ppt “Buffodine” – and then rinsed thoroughly in sterilized seawater.

Hatching will take place in a 40 litre conical tank with approximately 4000 eggs. A small airstone will provide aeration and circulation. When the majority of the eggs hatch, they can be siphoned out into buckets, while debris can be discharged through the valve at the base of the conical tank.

Larvae will be held in the 250 litre tanks, filled with filtered and U-V sterilised seawater, (35 ppt). Water temperature will be maintained at 19 - 20º C, with illumination from overhead fluorescent lights for around 14 hours per day (Namibian summer conditions). Gentle aeration will be provided through airstones, increased as the larvae develop. It is intended to stock 2,000 – 3,000 larvae per tank, depending on the hatch rate and survival. Feeding will commence at day 3, with water in the tanks behind changed in the evening each day, drained out through a 5000 µ screen. As the larvae develop, the water exchange will be increased. The tank bottom will be cleaned by siphoning. If more thorough cleaning and sterilization seems to be needed, water and larvae can be siphoned and bucketed into an adjacent clean tank. Larvae will be graded as necessary, and in any case before weaning starts, using graders with bar separations of 2.5, 3.5, and 4.5 mm.

An alternative system using green water for larval rearing will be tested, either in parallel with or subsequent to the first trials.

**Monitoring for diseases and parasites**

Samples of apparently healthy Kob larvae will be taken every 10 days and sent to the Institute of Aquaculture for examination. In the event of significant mortality during the rearing process, further samples will be sent to establish the cause.
### Equipment and Materials Needed

**Table 26: Equipment and Materials**

<table>
<thead>
<tr>
<th>Qty</th>
<th>Description</th>
<th>Cost Na$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equipment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>50 litre conical fiberglass tanks</td>
<td>7,800</td>
</tr>
<tr>
<td>10</td>
<td>2 litre pyrex flasks</td>
<td>750</td>
</tr>
<tr>
<td>2</td>
<td>Haemocytometer slides</td>
<td>706</td>
</tr>
<tr>
<td>2</td>
<td>Graduated microscope slides 0.5 mm grid</td>
<td>300</td>
</tr>
<tr>
<td>2</td>
<td>Twin tube weatherproof fluorescent light fittings</td>
<td>600</td>
</tr>
<tr>
<td>1</td>
<td>Oxygen cylinder (12 mths rental + 11 kgs O₂)</td>
<td>1,320</td>
</tr>
<tr>
<td>1</td>
<td>Pin regulator and hose</td>
<td>1,670</td>
</tr>
<tr>
<td>Misc</td>
<td>Electrical fittings, wire, pipework</td>
<td>1000(say)</td>
</tr>
<tr>
<td>10</td>
<td>Airstones - various sizes</td>
<td>in stock</td>
</tr>
<tr>
<td>1</td>
<td>Imhoff Cone, 1 litre</td>
<td>276</td>
</tr>
<tr>
<td><strong>Laboratory Chemicals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 kg</td>
<td>Sodium nitrate NaNO₃</td>
<td>1,740</td>
</tr>
<tr>
<td>1 kg</td>
<td>Potassium phosphate KH₂PO₄</td>
<td>95</td>
</tr>
<tr>
<td>1 kg</td>
<td>Ammonium chloride NH₄Cl</td>
<td>67</td>
</tr>
<tr>
<td>500 g</td>
<td>Zinc Sulphate ZnSO₄ ·H₂O</td>
<td>70</td>
</tr>
<tr>
<td>500 g</td>
<td>Copper Sulphate CuSO₄ ·H₂O</td>
<td>248</td>
</tr>
<tr>
<td>500 g</td>
<td>Cobalt Sulphate CoSO₄ ·7H₂O</td>
<td>189</td>
</tr>
<tr>
<td>250 g</td>
<td>Manganese Sulphate MnSO₄ ·H₂O</td>
<td>124</td>
</tr>
<tr>
<td>500 g</td>
<td>Ferric Chloride FeCl₃ 6 ·H₂O</td>
<td>48</td>
</tr>
<tr>
<td>250 g</td>
<td>Sodium Molybdate Na₂MoO₄ ·H₂O</td>
<td>}</td>
</tr>
<tr>
<td>500 g</td>
<td>EDTA ·2H₂O</td>
<td>}</td>
</tr>
<tr>
<td>2 g</td>
<td>Vitamin B12 Cyanocobalamin</td>
<td>}</td>
</tr>
<tr>
<td>50 g</td>
<td>Vitamin B1 Thiamin</td>
<td>}</td>
</tr>
<tr>
<td>5 g</td>
<td>Biotin</td>
<td>}</td>
</tr>
<tr>
<td>2 litres</td>
<td>Sodium Hypochlorite 15%</td>
<td>125</td>
</tr>
<tr>
<td>4 kg</td>
<td>Sodium Hydroxide 40%</td>
<td>384</td>
</tr>
<tr>
<td>5 litres</td>
<td>Sodium Thiosulphate 0.1N</td>
<td>102</td>
</tr>
<tr>
<td>100 mL</td>
<td>Lugols Iodine</td>
<td>39</td>
</tr>
<tr>
<td><strong>Aquaculture Supplies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 mL</td>
<td>Buffered iodophor ('Buffiodine' or equivalent)</td>
<td>}</td>
</tr>
<tr>
<td>4 only</td>
<td>Agar plate inoculant - Nannochloropsis</td>
<td>}</td>
</tr>
<tr>
<td>4 only</td>
<td>Agar plate inoculant - Tetraselmis</td>
<td>}</td>
</tr>
<tr>
<td>4 only</td>
<td>25 g vials Rotifer cysts (3-5,000 cysts)</td>
<td>}</td>
</tr>
<tr>
<td>450 g</td>
<td>Artemia cysts - AF strain</td>
<td>}</td>
</tr>
<tr>
<td>900 g</td>
<td>Artemia cysts - EG strain</td>
<td>}</td>
</tr>
<tr>
<td>1.5 kg</td>
<td>Selco CS rotifer enrichment diet</td>
<td>}</td>
</tr>
<tr>
<td>0.5 kg</td>
<td>DHA Protein Selco</td>
<td>}</td>
</tr>
<tr>
<td>2 kg</td>
<td>Marine finfish weaning diet INVE NRD or equiv.</td>
<td>}</td>
</tr>
<tr>
<td>1 kg</td>
<td>Algal Paste</td>
<td>}</td>
</tr>
<tr>
<td>Each of Nitex Screen material 50u, 100u, 250u,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 sq. m</td>
<td>500u</td>
<td>}</td>
</tr>
</tbody>
</table>
Appendix I - Live Feed Calculations

### Table 6: Kabeljou Feeding Schedule

<table>
<thead>
<tr>
<th>Day</th>
<th>Feed Type</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 0-2</td>
<td>No food</td>
<td>3 days</td>
</tr>
<tr>
<td>Day 3-11</td>
<td>Rotifers</td>
<td>9 days</td>
</tr>
<tr>
<td>Day 12-30</td>
<td>Artemia</td>
<td>19 days</td>
</tr>
<tr>
<td>Day 30-50</td>
<td>Artemia and pellets</td>
<td>21 days</td>
</tr>
<tr>
<td>Day 50 on</td>
<td>Pellets</td>
<td></td>
</tr>
</tbody>
</table>

All these values are based on the MINISTRY OF FISHERIES AND MARINE RESOURCES’s Kob Larval Rearing Proposal (see Appendix H)

### Table 27: Rotifer Culture

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number</th>
<th>Units</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of fingerlings per year</td>
<td>7,291,667</td>
<td>fingerlings</td>
<td>1</td>
</tr>
<tr>
<td>number of rotifers/kob/day</td>
<td>1500</td>
<td>Rotifiers</td>
<td>2</td>
</tr>
<tr>
<td>number of rotifers/day/cycle</td>
<td>911,458,375</td>
<td>Rotifiers</td>
<td></td>
</tr>
<tr>
<td>concentration of rotifers/mL in water</td>
<td>1000</td>
<td>Rotifer/mL</td>
<td>2</td>
</tr>
<tr>
<td>volume of water needed/day</td>
<td>911</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>number of days in grow-out period</td>
<td>6</td>
<td>Days</td>
<td>2</td>
</tr>
<tr>
<td>number of 50 L conical tanks</td>
<td>109</td>
<td>Tanks</td>
<td></td>
</tr>
<tr>
<td>Price of 1 50 L conical tank</td>
<td>$1,560</td>
<td>N$</td>
<td>3</td>
</tr>
<tr>
<td>Total price of tanks</td>
<td>$170,625</td>
<td>N$</td>
<td></td>
</tr>
<tr>
<td>Total cost of rotifer cysts</td>
<td>$9,110</td>
<td>N$</td>
<td>2</td>
</tr>
<tr>
<td>Cost of chemicals/year</td>
<td>$1,097,907</td>
<td>N$</td>
<td>3</td>
</tr>
<tr>
<td>initial price of equipment</td>
<td>$1,005,440</td>
<td>N$</td>
<td>3</td>
</tr>
</tbody>
</table>

Number of rotifers per day of each cycle:

\[
\text{Number of rotifers per day} = \frac{\text{number of fingerlings needed per year} \times \text{number of rotifers per kob per day}}{12 \text{ months/year}}
\]

\[
(7,291,667 \times 1500) \div 12 = 911,458,375 \text{ rotifers}
\]

Volume of water needed per day:

\[
\text{Volume of water needed per day} = \frac{\text{number of rotifers per day of each cycle} \times \text{concentration of rotifers in 1 mL of water}}{1000 \text{ mL per 1 liter}}
\]

\[
(911,458,375 \times 1000) \div 1000 = 911 \text{ L}
\]

Number of 50 L conical tanks:

---

1. Based on potential US market demand determined by 2004 WPI research. (Dunn et al., 2004)
2. Based on numbers provided by Mike Batty, UNAM research center at Henties Bay
(volume of water needed per day ÷ volume of each tank) × number of days in rotifer grow-out period\(^2\)
\((911 ÷ 50) × 6 = 109\) tanks

Total price of tanks:
number of 50 L conical tanks × price of 1 50 L conical tanks\(^3\)
\(109 × 1,560 = \text{N}\$ 170,625\)

Total cost of rotifer cysts:
cost of rotifer cysts\(^2\) × (number of rotifers per day of each cycle ÷ number of rotifers in Proposal\(^3\))
\(60 × (911,458,375 ÷ 6,000,000) = \text{N}\$ 9,110\)

Total cost of chemicals per year:
cost of chemicals used in Proposal\(^3\) × (number of rotifers per day of each cycle ÷ number of rotifers in Proposal\(^3\))
\(7,231 × (911,458,375 ÷ 6,000,000) = \text{N}\$ 1,097,907\)

Total initial price of equipment:
initial cost of equipment\(^3\) × (number of rotifers per day of each cycle ÷ number of rotifers in Proposal\(^3\))
\(6622 × (911,458,375 ÷ 6,000,000) = \text{N}\$ 1,005,440\)

### Table 28: Artemia Culture

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number</th>
<th>Units</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of artemia/ kob/ day</td>
<td>500</td>
<td>Artemia</td>
<td>2</td>
</tr>
<tr>
<td>Number of artemia/day /cycle</td>
<td>303,819,458</td>
<td>Artemia</td>
<td></td>
</tr>
<tr>
<td>Number artemia / mL in water</td>
<td>300</td>
<td>Artemia/mL</td>
<td>2</td>
</tr>
<tr>
<td>Number of L of water needed/day</td>
<td>1,013</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Number of days in grow-out period</td>
<td>8</td>
<td>Days</td>
<td>2</td>
</tr>
<tr>
<td>Number of 50 L conical tanks</td>
<td>162</td>
<td>Tanks</td>
<td></td>
</tr>
<tr>
<td>Price of 1 50 L conical tank</td>
<td>$ 1,560</td>
<td>N$</td>
<td>3</td>
</tr>
<tr>
<td>Total price of tanks</td>
<td>$ 252,778</td>
<td>N$</td>
<td>1</td>
</tr>
<tr>
<td>Cost of artemia cysts</td>
<td>$ 480</td>
<td>N$/500g</td>
<td>2</td>
</tr>
<tr>
<td>Cost of chemicals / year</td>
<td>$ 1,095,497</td>
<td>N$</td>
<td>3</td>
</tr>
<tr>
<td>Initial price of equipment</td>
<td>$ 1,003,233</td>
<td>N$</td>
<td>3</td>
</tr>
</tbody>
</table>

Number of artemia per day per cycle:
(number of fingerlings needed per year\(^1\) × number of artemia per kob per day\(^2\)) ÷ 12 months in a year
\((7,291,667 × 500 ) ÷ 12 = 303,819,458\) artemia

\(^3\) Based on MFMR Kob Larval Rearing Proposal (Appendix H)
Volume of water needed per day:
\[
\text{(number of artemia per day of each cycle } \times \text{ concentration of artemia in 1 mL of water)}^2 \div 1000 \text{ mL per liter} \\
(303,819,458 \times 1000) \div 1000 = 1,013 \text{ L}
\]

Number of 50 L conical tanks:
\[
\text{(volume of water needed per day } \div \text{ volume of each tank)} \times \text{ number of days in artemia grow-out period}^2 \\
(1,013 \div 50) \times 8 = 162 \text{ tanks}
\]

Total price of tanks:
\[
\text{number of 50 L conical tanks } \times \text{ price of 1 50 L conical tanks}^3 \\
162 \times 1,560 = \$ 252,778
\]

Total cost of chemicals per year:
\[
\text{cost of chemicals used in Proposal}^3 \times \left(\text{number of artemia per day of each cycle } \div \text{ number of rotifers in Proposal}^3\right) \div 3 \text{ times the size of rotifers} \\
7,231 \times (303,819,458 \div 6,000,000) \div 3 = \$ 1,095,497
\]

Total initial price of equipment:
\[
\text{initial cost of equipment}^3 \times \left(\text{number of artemia per day of each cycle } \div \text{ number of rotifers in Proposal}^3\right) \div 3 \text{ times the size of rotifers} \\
6622 \times (303,819,458 \div 6,000,000) \div 3 = \$ 1,003,233
\]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of algae used per day</td>
<td>911 L</td>
<td></td>
</tr>
<tr>
<td>Number of days of grow-out period</td>
<td>10 Days</td>
<td>2</td>
</tr>
<tr>
<td>Number of 50 L bags</td>
<td>182 Bags</td>
<td></td>
</tr>
<tr>
<td>Cost per algal culture disc</td>
<td>$ 60</td>
<td>N$ 2</td>
</tr>
<tr>
<td>Total cost of algal culture discs</td>
<td>$ 18,220</td>
<td>N$</td>
</tr>
<tr>
<td>Cost per 50 L grow-out bag</td>
<td>$ 750</td>
<td>N$ 4</td>
</tr>
<tr>
<td>Total cost of 50 L grow-out bags</td>
<td>$ 136,719</td>
<td>N$</td>
</tr>
<tr>
<td>Total cost of lighting</td>
<td>$ 136,719</td>
<td>N$ 4</td>
</tr>
<tr>
<td>Lab equipment and other</td>
<td>$ 2,593,500</td>
<td>N$ 4</td>
</tr>
</tbody>
</table>

Amount of algae used per day:
\[
\text{(number of rotifers needed per cycle } \div \text{ number of rotifers in Proposal}^3\right) \times \text{ volume of algae used per day in Proposal}^2 \times 2 \text{ (for artemia)} \\
(911,458,375 \div 6,000,000) \times 3 \times 2 = 911 \text{ L}
\]

Number of 50 L bags used:
\[
\text{(number of days in the grow-out period } \times \text{ amount of algae used per day) } \div 50 \text{ L per bag} \\
(10 \times 911) \div 50 = 182 \text{ 50 L bags}
\]
Total cost of algal culture discs:
\[
\text{cost per algal disc}^4 \times (\text{number of rotifers needed per cycle} \div \text{number of rotifers in Proposal}^3) \times 2 \text{ for artemia}
\]
\[
60 \times (911,458,375 \div 6,000,000) \times 2 = \text{N} \$ 18,220
\]

Total cost of 50 L plastic bags:
\[
(\text{number of 50 L bags} \times \text{price of 1 50 L bag}^4) \times 750 = \text{N} \$ 136,719
\]

Total cost of lighting and other lab equipment based on information provided by Manuel Romero of Beira Aquaculture and scaled up using the same method as above.

Table 10: SELCO Cost Breakdown

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number</th>
<th>Units</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>SELCO</td>
<td>$300</td>
<td>N$/kg</td>
<td>2</td>
</tr>
<tr>
<td>Amount of SELCO required per rotifer</td>
<td>0.5</td>
<td>kg/million rotifer/day</td>
<td>2</td>
</tr>
<tr>
<td>Amount of SELCO required per artemia</td>
<td>1.5</td>
<td>kg/million artemia/day</td>
<td></td>
</tr>
<tr>
<td>Amount of SELCO required per day</td>
<td>911.5</td>
<td>kg/SELCO/day</td>
<td></td>
</tr>
<tr>
<td>Cost of SELCO per year</td>
<td>$3,281,250</td>
<td>N$</td>
<td></td>
</tr>
</tbody>
</table>

---

^4Based on values provided by Manuel Romero, Beira Aquaculture
# Appendix J - David Koh Fish Feed Plant Proposal

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
</table>
| G01  | (1) FINE GRINDING AND MIXING  
- INTAKE PIT WITH SCREW CONVEYOR  
- PIT SIZE 0.6M*0.6M*0.6M (L*W*D)  
- STEEL HOPPER COVERED WITH STEEL GRID  
- SCREW CONVEYOR MODEL CSC080  
- 8'*3.0 M LONG WITH 2HP GEAR MOTOR |
| G02  | 1 BUCKET ELEVATOR  
- MODEL CB062  
- 6'*13 METER HEIGHT  
- WITH 3HP GEAR MOTOR |
| G03  | 1 FEED CLEANER  
- MODEL CFC140  
- WITH 7.5HP MOTOR FOR CAPACITY 10 TPH |
| G04  | 1 TUBE MAGNET  
- MODEL CTM200  
- 8' PERMANENT MAGNET CONE WITH STAINLESS STEEL HOUSING |
| G05  | 1 VERTICAL MIXER  
- MODEL CVL005 VERTICAL TYPE MIXING  
- CAPACITY 500KG WITH 3HP MOTOR |
| G06  | 1 DISCHARGE GATE  
- MODEL CGDA200  
- PNEUMATIC TYPE |
| G07  | 1 HOPPER WITH LEVEL INDICATOR |
| G08  | 1 PULVERIZER  
- MODEL CPR150  
- HIGH SPEED TYPE  
- CAPACITY 2 TON/HOUR AT 90%  
- PASS 40 MESH  
- WITH 150HP MOTOR |
| G09  | 1 BAG FILTER  
- MODEL CBFS2  
- 52 FILTER BAGS WITH REVERSED PULSE AIR SELF-CLEAN DEVICE |
| G10  | 1 FAN  
- MODEL CFB30  
- CENTRIFUGAL TYPE  
- WITH 30HP MOTOR |
| G11  | 1 AIR LOCK  
- MODEL CAL200  
- WITH 1HP GEAR MOTOR |
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| G12 | 1 | PLAN SHIFTER  
- MODEL CO91205  
- 5 DECKS OF 40 MESH SCREEN  
- WITH 3HP MOTOR FOR CAPACITY 2 TPH |
| G13 | 1 | SCREW CONVEYOR  
- MODEL CSC040  
- 4"x2.0M  
- WITH 1/2 HP GEAR MOTOR |
| G14 | 1 | STORAGE BIN  
- CAPACITY 0.5 TON |
| G15 | 1 | LOW LEVEL INDICATOR |
| G16 | 1 | PNEUMATIC VIBRATOR |
| G17 | 1 | DISCHARGE GATE  
- MODEL CODA400  
- PNEUMATIC TYPE |
| G18 | 1 | PREMIX INTAKE  
- INTAKE HOPPER CAPACITY 30KG  
- WITH SAFETY GRID AND COVER |
| G19 | 1 | HORIZONTAL MIXER  
- MODEL CMBS010 FOR CAPACITY 1.0 M3  
OR 300KG/BATCH  
- DOUBLE RIBBER TYPE  
- WITH 10HP MOTOR |
| G20 | 1 | SLIDE GATE  
- MODEL CODA250  
- PNEUMATIC TYPE |
| G21 | 1 | SCREW CONVEYOR  
- MODEL CSC200  
- 8"x3.0 METER LONG  
- WITH 2HP GEAR MOTOR |
| G22 | 1 | FAT APPLICATION SYSTEM  
- WITH DAY TANK CAPACITY 1000 LITERS  
- CONSTANT GEAR PUMP WITH 1HP MOTOR  
- WITH ELECTRONIC WEIGHING DOSING CONTROL  
- WITH STRAINER AND NECESSARY FITTING |
(7) 2 TONS IR EXTRUSION PLANT

E01 1 BUCKET ELEVATOR
-6" * 13M HEIGHT
-WITH HIP GEAR MOTOR

E02 1 LIVE BIN DISCHARGER
-AGITATOR PADDLE FOR ANTI-BRIDGING
-WITH HIP MOTOR
-CAPACITY 0.5 TON
-STAINLESS STEEL MADE

E03 1 HIGH LEVEL INDICATOR
-ELECTRONIC SENSOR TYPE

E04 1 LOW LEVEL INDICATOR
-ELECTRONIC SENSOR TYPE

E05 1 SCREW FEEDER
-6"*2.3M LONG
-STAINLESS STEEL MADE
-WITH HIP GEAR MOTOR

E06 1 CONDITIONER BLENDER
-SUS304 STAINLESS STEEL MADE
-DOUBLE SHAFT BLENDING CONDITIONER
-WITH 7.5HP MOTOR

E07 1 EXTRUDER
-MODEL CTWE125 WITH 6 HEAD EXTRUDER
-WITH 125HP FOR CAPACITY 2 TON
-AT PELLET SIZE 3.0-10mm
-WITH FLOW ROTOMETER FOR WATER APPLICATION

E08 1 CUTTER
-STAINLESS STEEL MADE HOUSING AND BASE
-WITH HIP MOTOR AND VARIABLE SPEED CONTROL

E08-1 1 SUCTION HEAD AND FAN
-STAINLESS STEEL MADE WITH 1 HP FAN

E09 1 DISCHARGE CHUTE WITH BY-PASS DAMPER
-STAINLESS STEEL MADE

C01 1 SWING SPRADER
SWING CHUTE STAINLESS STEEL MADE
-WITH HIP GEAR MOTOR
C02  1  HORIZONTAL DRYER
   MODEL CTBD300
   -STEAM HEAT EXCHANGER TYPE
   -DIMENSION 2.1M*10M
   -WITH 2 PASS FOR DRYING AREA 20 M2
   -CAPACITY 2.0 TON/HR WITH 2PCS
   1HP GEAR MOTOR & VARIABLE SPEED CONTROL
   -CARBON STEEL CHAIN AND
   GALVANIZED STEEL DECK
   -WITH GLASS WOOL HEAD INSULATION
   -WITH 2PCS 10HP DISTRIBUTION FAN AND
   RE-CIRCULATION AIR DUCTING

C03  1  CYCLONE
   - MODEL CDC100
   - STAINLESS STEEL MADE

C04  1  EXHAUSTED FAN
   - MODEL CFBC100
   - CENTRIFUGAL TYPE WITH 10HP MOTOR

C05  1  AIR LOCK
   - MODEL CAC200
   - WITH 1HP GEAR MOTOR

C06  1  BELT CONVEYOR
   - 14"*4.0 METER WITH 2HP MOTOR
   - HIGH TEMPERATURE RESISTANT RUBBER
   BELT

C07  1  BUCKET ELEVATOR
   - MODEL CBE062
   - 6"*14 METER WITH 3HP GEAR MOTOR
   - STAINLESS STEEL CASING AND PLASTIC
   BUCKETS

C08  1  STORAGE BIN
   - CAPACITY 1 TON OR 2.5 M3

C09  1  HIGH LEVEL INDICATOR

C10  1  LOW LEVEL INDICATOR

C11  1  PELLET COATER
   - MODEL CPCB100 FOR CAPACITY 5 TPH
   - WITH DRAG CHAIN FEEDER AND 2HP GEAR
   MOTOR
   - FAT SPRAYING CHAMBER WITH STEAM JACKET
   - MIXING BLENDING RIBBON WITH 3HP MOTOR
<table>
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| D12  | BAG CLOSING MACHINE  
-NEW LONG NP-7  
-PORTABLE TYPE |
| F01  | STEAM BOILER  
-CAPACITY 1500KG AT 10KG/CM2 PRESSURE  
-FULLY AUTOMATIC TYPE WITH  
CONTROL PANEL  
-WITH 6 METER CHIMNEY |
| F02  | WATER SOFTENER CAPACITY 1500 KG/HR |
| F03  | FUEL STORAGE TANK  
-CAPACITY 15 M3 |
| F04  | WATER APPLICATION SYSTEM  
-WITH 1000KG STAINLESS STEEL TANK  
-1HP GEAR PUMP |
| F05  | CENTRAL CONTROL PANEL  
-COMPLETE WITH MIMIC PROCESS  
FLOW CONTROL  
-WITH MOTOR STARTER AND  
OVER LOAD PROTECTION  
-WITH INDICATION LAMP AND  
OPERATION SWITCH  
-R.P.M. INDICATION  
-DUST TIGHT PANEL BOX |
| F06  | AIR COMPRESSOR  
-FULLY AUTOMATIC TYPE  
-WITH 15HP MOTOR |
| F07  | AIR DRYER  
-REFRIGERATION TYPE FOR  
15HP COMPRESSOR |
| F09  | PACKAGE OF SPARE PARTS FOR EXTRUDER  
10 EA.850201-003 KNIFE BLADE HOLDER  
20 KNIFE BLADE  
1 EA.850450-001 KNIFE ASSEMBLY  
1 EA.825227-001 DIE PLATE  
1 EA.750118-001 STEAM INJECTOR  
1 EA.750115-003 STEAM LOCK 6.75"  
1 EA.750114-001 STEAM LOCK 5.50"  
1 EA.750115-001 STEAM LOCK 6.25"  
30 EA........... INSERTS |
C12  1  FAT COATING CONTROL
     - WITH STORAGE BIN 1000KG
     - WITH FILTER AND 1HP PUMP
     AND VARIABLE SPEED CONTROL
     - WITH ELECTRONIC FLOW
     INDICATOR AND TOTALIZER

D01  1  HOPPER WITH AIR LOCK
     - MODEL CAL.200
     - WITH 1HP GEAR MOTOR

D02  1  COOLER
     - MODEL CVC140
     - WITH 2HP GEAR MOTOR

D03  1  CYCLONE
     - DIAMETER 800mm

D04  1  FAN
     - MODEL CFBC075
     - WITH 7.5HP MOTOR

D05  1  AIR LOCK
     - MODEL CAL.200
     - WITH 1HP GEAR MOTOR

D06  1  VIBRATION SIEVE
     - MODEL CVS1001
     - SINGLE DECKS WITH STAINLESS
     STEEL SCREEN
     - WITH 1/2HP MOTOR

D07  1  BUCKET ELEVATOR
     - MODEL CB6062
     - 6*10 METER WITH 2HP GEAR MOTOR

D08  1  STORAGE TANK
     - CAPACITY 2 TON OR 5 M3

D09  1  HIGH LEVEL
     - ELECTRONIC SENSOR TYPE

D10  1  SLIDE GATE
     - MODEL CGP500*500
     - MANUAL TYPE

D11  1  PLATFORM SCALE
     - ELECTRONICAL SCALE 100KG
1 1 MACHINE TOWER AND STEEL STRUCTURE
FOR TOWER DIMENSION 12M*6M*14M (L*W*H)
-STEEL STRUCTURE AND FLOORING
AND LADDERS FOR OPERATION
AND MAINTENANCE PURPOSE
- WITH 0.5MM THICKNESS CURROGATED DECK
TYPE WALL CLADDING AND ROOFING

2 1 ELECTRICAL WIRING (INTERNAL)
-START FROM CENTRAL CONTROL PANEL
TO EVERY MOTORS AND ELECTRICAL PARTS
-WITH CABLE TRAYS AND CONDUITS
AND PUC CABLES
-THERE IS 30CM LONG PLASTIC FLEXIABLE
LOSE FROM CABLE TRAYS TO MOTOR
TERMINALS

3 1 PNEUMATIC AIR PIPING
-COMPLETE GALVANIZE STEEL PIPING
WITH 40CM PLASTIC HOUSE BEFORE
CONNECT TO VALVES
-ONE STOP VALVE BEFORE VALVE
FOR MAINTENANCE PURPOSE
-3 UNITS OF FILTER AND LUBRICATOR

4 1 CONNECTION CHUTES JOINT HOPPERS
AND AIR DUCTS
-CONNECTION CHUTES AND JOINT HOPPER
BETWEEN MACHINES TO MACHINES
-AIR DUCTING FOR DRYING, COOLING
AND VENTILATION

5 1 STEAM PIPING AND WATER PIPING
-STEAM PIPING START FROM OUT-PUT
OF BOILER (15 METER LONG)
-WITH NECESSARY HEAT INSULATOR
(GLASS WOOL)
-STEAM HEADER AND NECESSARY
VALVES PRESSURE REGULATOR,
GAUGES AND TRAPS
-WATER PIPING FOR COOLING AND
CIRCULATION
(4) ENGINEERING AND SUPERVISION CHARGES

| 1 | 1 | ENGINEERING WORKS  
- COMPLETE PLANT ENGINEERING DESIGN INCLUDES  
- MECHANICAL INSTALLATION DESIGN  
- FOUNDATION AND STEEL STRUCTURE  
- ELECTRICAL DESIGN AND WIRING  
- STEAM SYSTEM AND PIPING  
- PNEUMATIC AIR SYSTEM AND PIPING |
|---|---|---|
| 2 | 1 | SUPERVISION CHARGE OF  
INSTALLATION FOR 45 DAYS AND START-UP WITH 10 DAYS OPERATION AND MAINTENANCE TRAINING |