04E012I

FEASIBILITY OF KABELJOU AQUACULTURE SYSTEMS IN NAMIBIA

An Interactive Qualifying Project Report
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfilment of the requirements for the
Degree of Bachelor of Science
by

Katherine A. Dunn
Michael D. Hands
Nicholas M. Lloyd

Date: May 5, 2004

Report Submitted to:
Professor Susan Vernon-Gerstenfeld, Co-Advisor
Professor Arthur Gerstenfeld, Co-Advisor
Dr. Ben Van Zyl, Liaison at the Ministry of Fisheries and Marine Resources of Namibia

Executive Summary

The economic situation and geography of Namibia has prompted the government to look towards aquaculture as a viable source of economic growth. While the government has established aquaculture policy, private industry must be involved in the development of aquaculture facilities in order to provide the necessary monetary support. Kabeljou was chosen as a potential species for aquaculture because it is popular in South Africa and wild Namibian stocks are declining.

Our analysis focused on the feasibility of kabeljou aquaculture in Namibia by assessing the most effective grow-out system. The two grow-out systems we analyzed were land-based flow-through tanks and open-ocean net cages. In order to perform a complete assessment of these systems we also researched the United States market for kabeljou and the best processing techniques to meet these American demands.

We began our analysis by performing two months of background research at Worcester Polytechnic Institute, in Worcester, Massachusetts, USA. After our arrival in Africa, we travelled to the Swakopmund National Marine Aquarium in Swakopmund, Namibia. The library at the aquarium contained a variety of documents which were important to our research on aquaculture and kabeljou. We also travelled to Walvis Bay, Namibia, which is one of the main ports in the country and the centre of the wild-caught and fish processing industries. Here, we visited three fish processing plants and interviewed individuals involved in the fishing industry. We also travelled to Port Alfred, South Africa in order to meet with Professor Tom Hecht of Rhodes University. Professor Hecht is one of the leading African experts on kabeljou. Finally, we travelled

to Rhodes University in Grahamstown, South Africa in order to use the fisheries library there.

We determined that before any aquaculture facility can be developed in Namibia, it is important to firmly establish a market in the United States. Importers in the United States agree that Americans prefer a fish that is white, flaky, and mild tasting. Fish should be in either fresh or frozen fillet form and free of preservatives. American fish importers also agree that local stocks of popular white fish like cod, orange roughy, and red snapper are declining and kabeljou would be a viable replacement as long as it is sold as a mid-range fish at around N$28.22 per kilogram. Importers in the Unites States demand, on average, 140 metric tons of kabeljou per month or 1,680 metric tons per year each.

Namibian kabeljou processing techniques must meet American demands in order to be accepted in the market. Portions should be about 255 gram (nine ounce) fillets free of bones or discoloration. The fish will be hand filleted because kabeljou does not have a highly structured rack like hake, and the bones will be difficult to remove with a machine. All of the fish importers we spoke with claim that shipping kabeljou frozen to the United States is acceptable, as long as it is plate frozen. Plate freezing preserves the quality of the fish by preventing crystallization. Also, American fish importers suggest that shatter packing in ten to fifteen pound (4.5 – 6.8 kilogram) boxes is the preferred method of packaging for kabeljou shipped to the United States.

Each kabeljou grow-out system has advantages and disadvantages associated with it. In flow-through tank systems, water is continually pumped through a tank, filtered, circulated, and pumped back into the ocean. One of the biggest advantages with land-based systems is the amount of control the operator has over the facility. Expenses associated with land-based systems include tanks, pumps, filters, and energy. We have determined we will need 411 tanks of 426 cubic metres each to fulfil the American demand.

Open-ocean systems utilize the natural environment of the fish, eliminating the need for temperature control, filtration, and pumps. However, these systems must exist underwater in the ocean, adapt to changes with tides, and resist strong ocean currents. Expenses associated with open-ocean aquaculture include cages, nets, and boating. We have determined we would need 515 cages of 340 cubic metres each to fulfil the American demand.

Along with the costs specific to each system, costs like feed, fingerlings, and labour are applicable to both systems. The total cost for each system is N$83.8 million per year. Fish feed accounts for over sixty-eight percent of the total cost with the shipping of the feed making up thirty-five percent of the total price. To meet the demands of one fish importer in the American market, 1,680 metric tons of kabeljou would have to be exported annually at N$28.22, resulting in an income of N$47.4 million. This would result in a significant loss of N$36.4 million. Kabeljou would have to be exported at N$48.51 per kilogram to break even and N$58.50 per kilogram to make a twenty percent profit. Selling kabeljou at these prices would put it into the high end of the market and would make the fish unaffordable to the majority of the American population.

Although it is not feasible to establish a kabeljou aquaculture facility in Namibia at this time, we have developed some recommendations for Namibia so that kabeljou aquaculture can become a reality. First, we recommend that if Namibia does decide kabeljou aquaculture will be pursued, a land-based system should be implemented. We recommend a land-based system because it will reduce risks by increasing control over the system.

We also recommend establishment of an aquaculture feed company in Namibia. This would eliminate high international feed shipping costs. We performed our calculations of the total cost of the aquaculture systems eliminating the cost for feed shipping. The new loss accrued selling kabeljou at N$28.22 per kilogram is only N$6.7 million. The breakeven point is N$30.91 per kilogram and to make a twenty percent profit, kabeljou would have to be sold at N$37.31 per kilogram. This places kabeljou in the mid-range of the American fish market and will make it affordable for the average consumer.

Another recommendation is the establishment of a hatchery in Namibia. Currently, the only kabeljou hatcheries that exist in Namibia are research sized and would not be able to support an aquaculture system of the scale to meet American demands.

Bioremediation is a technique in which organisms are combined in a system in a way which helps rid the environment of waste. We recommend further research into this technique as it could provide a natural filtration system and another source of income for an aquaculture facility.

Our final and most exciting recommendation is the development of an aquaculture research partnership through the Benguela Environment Fisheries Interaction and Training (BENEFIT) program. This program will combine research resources in Namibia, South Africa, and Angola, as well as university students from all three countries, in order to expand the knowledge base of each region.

Kabeljou aquaculture is an industry with major potential which will be able to provide Namibia not only with a place in the global economy, but with an expansion of local industries. However, this should only be pursued as a land-based system, coupled with a local feed company and a kabeljou hatchery. These partnerships will enable aquaculture to become a feasible enterprise and further boost the Namibian economy.

Abstract

The goal of our project was to assess the feasibility of kabeljou aquaculture in Namibia and to decide whether a land-based or an open-ocean system would be more economically feasible. In order to perform our analysis, it was important to work backwards, starting with a preliminary study of the fish market in the United States, then assessing the best processing methods, and finally analysing the costs associated with each aquaculture system. We found that kabeljou aquaculture is not currently feasible in Namibia, but could become profitable with the development of other support industries. Our liaison in Namibia was Dr. Ben Van Zyl, the Deputy Director of Resource Management for the Ministry of Fisheries and Marine Resources.

Authorship

The members of the project team, Katherine Dunn, Michael Hands, and Nicholas Lloyd, contributed equally to this Interactive Qualifying Project. Michael Hands concentrated on the analysis of the United States market for kabeljou. Katherine Dunn focused on fish processing as it pertains to kabeljou. Nicholas Lloyd collected the data related to the different grow-out aquaculture systems that may be employed in Namibia. All members analysed the data and created recommendations.

Acknowledgements

Throughout the four months that we worked on this Interactive Qualifying Project, many people contributed to our success. We would like to thank our liaison Dr. Ben Van Zyl, Deputy Director of Resource Management for the Ministry of Fisheries and Marine Resources in Swakopmund, Namibia. Dr. Van Zyl was instrumental in helping us contact companies and researchers in order to gather information. He also supplied us with information pertinent to our project. We would like to thank our advisors, Professors Gerstenfeld and Vernon-Gerstenfeld, for all of their support during this project. We would like to thank Dr. Thomas Hecht, Research Professor at Rhodes University in Grahamstown, South Africa. Dr. Hecht provided us with information on kabeljou and the growth of kabeljou in different aquaculture systems and also took the time to take us to the fisheries library at Rhodes University.

We would like to thank Mr. Hugo Viljoen of Gendev, Ms. Ruth Morrison of Gendor, and Dr. Gert Cloete of Blue Ocean Products for speaking with us about fish processing, as well as giving us a tour of their fish processing facilities. We would also like to acknowledge Mr. Wayne Hart and Ms. Louisa Maree of Freddie Fish Processors for the information they provided us regarding fish processing and the United States market.

We would like to thank Ms. Lizette Voges and Ms. Iana Iita of the Swakopmund National Marine Aquarium for providing information regarding environmental concerns with aquaculture systems in the Benguela current. We would also like to thank Ms. Anja Van Der Plas for lending her expertise in the field of sulphur eruptions and harmful algal blooms.

We would like to acknowledge Mr. Joe Johnson of Namibia Aquaculture for his assistance with the specific costs and risks associated with land-based and open-ocean aquaculture systems. We appreciate the help Mr. Frikkie Botes and Ms. Anneke Van der Westhuizen of Entheos Aquaculture. They gave us many contacts as well as information regarding aquaculture in Namibia. We would also like to thank Mr. Kobus Alberts, Chief Technician of the Swakopmund National Marine Aquarium, for his help in explaining land-based flow-through systems.

We would like to thank Mr. Ernest Mairs of Gulf Pacific Seafood, Mr. Dick Monroe of the Monroe Group, Ms. Patricia Schofield of Pescanova USA, and Mr. Mike Sullivan of FWBryce for their expertise regarding the American fish market.

We appreciate the assistance of Mr. Mark Riehmer of NEC Engineering for providing us with information regarding pumping systems for aquaculture facilities. We would like to acknowledge Mr. Wilfred Poaser, a representative of Porta Liners and Pools, for his help in determining prices and maintenance costs for suitable tanks. We would also like to acknowledge Mr. Dirk Van Der Linde of Aquanutro (pty) Ltd. in South Africa for providing us with fish feed pricing information as well as shipping information.

We would like to thank Dr. Willem Jankowitz, professor of botany at the Polytechnic of Namibia, and Dr. Daniel Theunissen, also of the Polytechnic of Namibia, for their knowledge of the status of kabeljou and general aquaculture in Namibia. We would also like to thank Dr. Joseph Bagshaw and Dr. Jeffrey Tyler, professors of biology at Worcester Polytechnic Institute, for providing us with information regarding aquaculture systems and the social impact of aquaculture. Also, we would like to acknowledge Professor Joe DeAlteris and Professor Michael Rice of the University of Rhode Island for lending us their expertise on aquaculture systems and the environmental impacts of aquaculture.

Contents

Tables

Figures

The Potential for Kabeljou Aquaculture in Namibia

In the struggle to lower poverty levels and raise the standard of living, developing nations search for viable options to stimulate local economic growth. Although various options are available to these developing countries, many nations are exploring the international food market through export of crops, livestock, and fish. Unfortunately for some countries, fresh water and fertile land are scarce. This makes agriculture, like livestock and crops, difficult to sustain. However, fish only require unpolluted water, a resource that is often regularly available in developing nations because of a lack of large industrial centres that are typically the source of pollution. This, coupled with dwindling fish populations around the globe, resulting from over fishing, has shifted the fishing industry from catch fisheries to the development of aquaculture facilities. Aquaculture provides a lucrative, sustainable resource that can be farmed year-round.

Namibia is one developing nation investigating aquaculture to improve the economy. While the basic foundation for aquaculture in Namibia is present, three main factors needed to be investigated. Our analysis focused on the feasibility of kabeljou aquaculture in Namibia and the most effective grow-out system. The two grow-out systems we investigated were land-based flow-through tanks and open-ocean cages. In order to complete a thorough assessment, we also performed a preliminary market study in the United States and determined the best processing techniques for kabeljou.

Namibian Interest in Aquaculture

The economic situation and geography of Namibia has prompted the government to look towards aquaculture as a viable source of economic growth through international trade. President of Namibia, Sam Nujoma, stated that the development of aquaculture is very important and a government priority (Nampa, 2004). This article can be found in Appendix F.

According to Dr. Ben Van Zyl, Deputy Director of Resource Management for the Ministry of Fisheries and Marine Resources of Namibia, Namibia wants to develop new international market relations with the United States by exporting kabeljou. The United States was chosen as a new market because Namibia already has strong, economic ties to Europe and would like to expand to other parts of the world. However, studies on product preference and United States fish consumption are necessary in order to determine if this is a realistic goal.

Namibia is a south-western African nation bordered by South Africa, Botswana, Angola and Zimbabwe. The 825,418 square kilometres of land is mainly composed of arid and semi-arid regions, with a large semi-arid plateau running down the centre. The southern portions of the country contain large tracts of plains with shrubs. The only significant rainfall occurs in the far north and only this region receives enough rain to maintain plant agriculture. The lack of plant agriculture necessitates finding new resources to provide food and export products. The limitations of available water require aquaculture facilities to be situated along the coastline, where water is not as scarce. Namibia has 1,572 kilometres of coastline on the Atlantic Ocean and claim to 200 nautical miles (370.4 kilometres) of exclusive economic zone offshore (http://www.cia.gov). The southern region of this large, unpolluted coastline is zoned for the diamond industry and the north is the protected Skeleton Coast National Park. These areas are unavailable for aquaculture development, but the coast along Walvis Bay and

Swakopmund is suitable. Dr. Van Zyl (personal communication, April 14, 2004) has indicated that the Namibian government has set aside 200 hectares of ocean along the coast in Walvis Bay specifically for aquaculture facilities.

While the government has established aquaculture policy, private industry must be involved in the development of aquaculture facilities. The Namibian government is unable to support large-scale aquaculture, despite continual economic growth over the past several years (Ballard & Sanctions, 1999). The gross domestic product (GDP) of Namibia was $13.15 billion (2002 est.), $6,900 (2002 est.) per capita (http://www.cia.gov). The unemployment rate was thirty-five percent according to the CIA World Factbook 2002. Industry, which consists primarily of mining, contributed twenty-eight percent, agriculture eleven percent, and services sixty-one percent in 2001 according to the CIA World Factbook for Namibia (http://www.cia.gov). Although agriculture only comprised eleven percent of the Namibian economy in 2003, nearly seventy percent of Namibians relied on subsistence agriculture (http://www.state.gov). Aquaculture can expand the economy by providing more jobs and increasing exports, giving Namibia global recognition.

The Namibian aquaculture industry is in the early stages of development, but there is potential for farmed marine species to become a major export. The fishing industry is well developed and yields 547,492 metric tons of fish, crustaceans, and molluscs by capture, but only fifty metric tons from aquaculture production (FAO Fishery Information, Data and Statistics Unit, 2001).

Although the Namibian economy is struggling, there is excellent infrastructure in place. Infrastructure is necessary to have a successful export industry. According to the

International Trade Center, the July - August 1999 Supply Survey by United Nations Conference on Trade and Development (UNCTAD) and the World Trade Organization (WTO) on Namibia's Fish and Fish Products, the road, water, and air transportation systems are more than adequate to provide timely shipping of products, while railroads are slightly less developed. Namibia has an excellent road system linking it to neighbouring countries and the Trans-Kalahari highway provides easy access to the South African business centre of Gauteng Province. Walvis Bay is the main deep-sea harbour in Namibia and a majority of the fishing industry is located in the area. Regular cargo liner services travel to Durban and Cape Town, South Africa. The other major Namibian harbour, located in Luderitz, also has regular liners to Cape Town and other South African ports. While the primary international airport of Namibia is in Windhoek, 470 kilometres from Walvis Bay, two other international airports exist in Walvis Bay and Keetmanshoop. According to Mr. Frikkie Botes (personal communication, April 14, 2004), the Managing Director of Entheos Aquaculture, Walvis Bay airport is currently being renovated to support international cargo planes. Products produced in Swakopmund and Walvis Bay can be easily shipped from the local airport, but most international exports are sent by sea by the port of Walvis Bay. Those originating in Luderitz must travel 300 kilometres inland to Keetmanshoop to access an airport.

Namibia's railroad system is the least developed method of travel. The main rail traverses South Africa, Keetmanshoop, and continues on to Walvis Bay. It is currently used primarily for transporting equipment, not exports (International Trade Centre UNCTAD/WTO, 1999).

The Namibian diet consists primarily of meats, with some vegetables. Oryx, kudu, ostrich, warthog, and other land animals are regularly eaten. Namibia is also a major meat producer with sheep, goats, and cattle. Fish such as kabeljou, kingklip, hake, steembras, galjoen, and sole are a part of the diet of coastal Namibians, though the annual per capita consumption is only nine kilograms, lower than most other fish producing nations (International Trade Centre UNCTAD/WTO, 1999). Therefore, the market for fish in Namibia is fairly small and restricted to coastal areas, so exporting fish would produce a higher profit than selling domestically.

Namibian interests in aquaculture are focused upon kabeljou (Argyrosomus coronus), a native finfish. Kabeljou is already popular along the coast of Namibia and in South Africa, so according to Dr. Van Zyl (personal communication, April 20, 2004) a small market exists. According to Mr. Wayne Hart (personal communication, April 7, 2004), owner of Freddie Fish Processors, and Dr. Willem Jankowitz (personal communication, March 16, 2004), professor of botany at the Polytechnic of Namibia, the native kabeljou populations have been steadily decreasing and are currently very low. They also indicated that kabeljou is a popular sport fish for tourists, which has contributed to these low wild stocks. Experiments have indicated that kabeljou would be suitable for aquaculture in Namibia and some kabeljou aquaculture is currently taking place in Australia (MFMR, 2004). In order to supply the market for this fish, aquaculture facilities would have to be established because wild-caught supplies are virtually nonexistent. Currently, this species does not have a strong place in the United States market (de Villiers, 2000). However, Namibia would like to target this lucrative market in order to start building a strong trade relationship.

General Aquaculture Techniques

Current developments in aquaculture have moved beyond early fish farming techniques that relied on pond-based systems. Modern aquaculture techniques and applications can be divided into three categories. These are coastal, land-based, and open-ocean aquaculture systems. According to Ms. Anja Van der Plas (personal communication, March 25th, 2004), a chemist at the Swakopmund National Marine Aquarium, coastal systems are not feasible for aquaculture along the coast of Namibia because of conditions like sulphur eruptions. In addition, Dr. Daniel Theunissen (personal communication, March 17th, 2004), professor at the Polytechnic of Namibia, has indicated that the coast of Namibia has a limited number of suitable and available bay areas that are ideal for coastal aquaculture facilities. He also stated that the majority of available coastline in Namibia is subject to strong currents and high-energy water, further limiting the capabilities and feasibility of coastal systems.

Land-based Systems.

All early fish cultivation occurred in ponds on land and many modern applications use pond-based systems. These systems are still suitable for small communities and can be adapted for individual use (Logsdon, 1978). However, Namibia is looking to export large quantities of kabeljou to the United States and pond-based systems are not feasible because of their inability to produce a sufficient amount of fish.

Modern land-based flow-through systems, which pump water from the ocean into tanks on land, are a feasible option for Namibia.. These systems are severely limited by land availability, but this will not be a concern in Namibia because of the large, sparsely utilized coastline. With tight enclosures and a controlled water supply system that is protected from the elements, tanks offer complete control over the environment of the fish, which can be grown in these systems from egg to adult (NRCCATOMA, 1992). Tanks are expensive to build and operate due to high equipment and filtration costs. Although tanks produce a greater number of fish and are more suitable for kabeljou than pond systems, the equipment, maintenance, and labour costs are higher (FAO, 2000).

Open-ocean Systems.

The newest form of fish culture is the open-ocean cage system. This system utilizes the natural environment of the fish, eliminating the need for filtration and pumps. However, these systems must exist underwater in the ocean, adapt to changes with tides, and resist strong ocean currents. These structures are restricted in Namibia to waters that the government has zoned exclusively for aquaculture use in Walvis Bay. Additional expenses associated with open-ocean aquaculture include cages, nets, and boating. The rough Benguela current flows off the coast of Namibia and will require net-cages to be extremely durable. Other concerns include biofouling, sulphur eruptions, and harmful algal blooms (HABs), which could be devastating to fish populations in the open-ocean (NRCCATOMA, 1992).

Kabeljou (Argyrosomus coronus)

Kabeljou (Argyrosomus coronus), kingklip, hake, steembras, galjoen, and sole are among the native fish off the coast of Namibia. As previously mentioned, kabeljou is a popular angling fish in southern Africa, so the Namibian government has selected it as a viable fish species for aquaculture and export.

Professor Thomas Hecht (personal communication, January 31, 2004), of Rhodes University in South Africa, has studied kabeljou extensively. He indicated that kabeljou can reach a maximum size of two metres, with a weight of seventy-one kilograms, though normally they average seven to thirty-five kilograms. According to Professor Hecht, in order to grow kabeljou to a marketable weight of 0.65 kilograms from a twenty-seven gram fingerling, eight months is required.

Kabeljou are predators that eat small aquatic organisms including small fish, crustaceans, and squid (http://www.prawns.co.za). They prefer cooler waters, such as those around the Southern Cape coast and the Atlantic at depths of up to 400 metres (Argyrosomus coronus, 2002). Hecht (personal communication, January 31, 2004) stated that the optimal temperature for growth for the purposes of aquaculture is twenty-four degrees Celsius, though the growth rate is similar for temperatures ranging from fourteen to twenty-two degrees Celsius. He also indicated that a salinity concentration of five to thirty-five parts per thousand is best.

Mr. Hugo Viljoen (personal communication, March 24, 2004), director of Gendev, a hake processing company located in Walvis Bay, Namibia, claims the bone structure of kabeljou as similar to that of orange roughy in that there is no structured rack. This means that the bones are not firmly fused to the spine. Mr. Ernest Mairs (personal communication, April 13, 2004), of Gulf Pacific Seafood, located in Odessa, Florida, describes the meat of kabeljou as white and mild tasting and fillets made from kabeljou as thin.

Namibian Aquaculture Regulations

By farming kabeljou, the Namibian government aims to provide domestic jobs and to increase exports. Current Namibian policies formulated by the Ministry of Fisheries and Marine Resources encourage further development of aquaculture, facilitate this development, and regulate practices. As stated in *Promulgation of Aquaculture Act, 2002* (2002), no one may practice aquaculture without a proper license issued by the Minister of Fisheries and Marine Resources. In order to aid the Minister in granting licenses, an Aquaculture Advisory Council was established. This council consists of the Permanent Secretary of the Ministry of Fisheries and Marine Resources (MFMR), two members of the MFMR staff appointed by the Minister, a nominee of the Association of Regional Councils, a nominee from the Association of Local Authorities, a nominee from the Council of Traditional Leaders, and four aquaculture experts appointed by the Minister. The role of the council is to advise the Minister on policy and issuance of aquaculture licenses (Office of the Prime Minster, 2002).

Aquaculture licenses are given to workers to farm, harvest, and sell a particular aquatic organism in a specific location. The licenses may include conditions that must be followed in order for the licensees to retain their license, such as quantities or type of organisms that can be farmed and practices that must be employed. Aquaculture licenses are set for a designated period of time and must be renewed prior to their expiration. The Minister may suspend, cancel, or take over an aquaculture facility if any regulations are broken, the facility is no longer operational, or if it is required for public safety. All aquaculture licenses must be registered with the Permanent Secretary of the MFMR.

These can be transferred, sold, traded, or used as collateral if approved by the appropriate authority (Office of the Prime Minister, 2002).

According to *Towards Responsible Development of Aquaculture: Namibia's Aquaculture Policy* (2001), written by the Ministry of Fisheries and Marine Resources, the two main types of aquaculture recognized by the Namibian government are commercial and communal. Rights granted to commercial ventures are accompanied by conditions regulating the establishment of farms and the transport of live organisms. Clear guidelines outline procedures under which aquaculture facilities must operate. In some cases, fees may be levied, particularly if the corporation uses government land or water and wild-caught stock is used. The MFMR has granted communal aquaculture rights to regional councils in order to reinforce the traditional role of a community in governing its resources (MFMR, 2001).

The MFMR must monitor water quality and alert licensees of potential pollution or natural phenomena that may have a detrimental affect on the aquaculture crop. In order to prevent loss of biodiversity, no one may introduce foreign or genetically modified species into Namibia or transfer organisms from one Namibian facility into another without prior written consent of the Minister of Fisheries and Marine Resources (Office of the Prime Minister, 2002).

Along with granting aquaculture rights, the government also plans on designating aquaculture zones as the industry further develops. These areas will be protected from pollution and other harmful activities and designated on a need basis. Environmental assessments will be employed to establish aquaculture zones. These assessments analyse potential environmental problems that may arise from the introduction of an aquaculture facility. In some cases, emergency preparedness plans may be implemented in a particular zone. These plans allow for the temporary shutdown or relocation of aquaculture facilities in the case of natural disasters, like harmful algal blooms and sulphur eruptions. Exclusion zones may also be established in sensitive environments to prevent aquaculture development in those areas (MFMR, 2001).

In order to promote the development of aquaculture, the government may provide incentives for the private sector to finance research, for efficient use of marine fish processing wastes, for culture of native endangered species, to establish hatcheries, to fund scholarships in aquaculture, to establish ventures to add value to products, and to hire staff from domestic communities. The MFMR is in charge of aquaculture development and enforcement of all regulations. It also collects statistical data on aquaculture in cooperation with the Food and Agriculture Organization of the United Nations and other international organizations (MFMR, 2001).

Along with the economic and political regulations associated with aquaculture, the *Aquaculture Act 2002* and the *Commencement of the Aquaculture Act, 2002* (MFMR, 2002) both establish environmental guidelines. Aquaculture workers must report to the MFMR at the first indication of any disease or harmful organism present in their facility. The Permanent Secretary, after consulting the Minister of Health, may order the quarantine, treatment, or destruction of any aquatic organisms infected (Office of the Prime Minister, 2002). The *Commencement of the Aquaculture Act, 2002* contains the National List of Diseases of Aquatic Organisms that indicates the most serious diseases, which must be reported. A list of drugs, antibiotics, and other chemicals used by facilities to treat their crops must be reported to the MFMR. The Ministry also must maintain a list of those chemicals that may not be used (MFMR, 2002).

Prevention of disease and genetic pollution caused by aquaculture facilities is one of the first priorities of the MFMR. In order to maintain health standards, disease-free zones are established, no organisms farmed in an aquaculture facility may be released into Namibian waters without authorization from the MFMR, and waste must be disposed of in a safe manner (Ministry of Fisheries and Marine Resources [MFMR], 2003). Also, any proposals to introduce non-native species into Namibia for aquaculture are heavily scrutinized, with special attention paid to the potential transfer of disease. Quarantine and health certificates from the government are needed for all imports of live aquatic organisms. The government also publishes a periodically updated list of non-native species known to be harmful to the environment (MFMR, 2001).

In order to enforce the various regulations, the Minister of Fisheries and Marine Resources may appoint an inspector. Inspectors may examine aquaculture facilities to assess if there are any violations. If they suspect an abuse, equipment or vessels that may have been used in the offence will be confiscated. Any violations must be reported to the Minister and then the proper course of action will be undertaken (Office of the Prime Minister, 2002).

Social Concerns with Aquaculture in Namibia

As is the case with any other industry, aquaculture presents a variety of social concerns. There are two main opposing points of view as to how aquaculture affects the fishing industry. Dr. Jeffery Tyler (personal communication, January 30, 2004), a professor of biology at Worcester Polytechnic Institute (WPI), represents one opinion, while Dr. Joseph Bagshaw (personal communication, January 30, 2004), also a professor of biology department at WPI, represents the other.

In general, aquaculture can pose a threat to any existing fishing industry because it is less expensive to grow fish in a controlled environment than it is to catch them. Dr. Tyler views aquaculture as an industry with various negative connotations. He thinks there are always environmental risks involved and it is difficult to see how the benefits will outweigh these risks. When aquaculture facilities develop in an area, Dr. Tyler states the local fishing industry is almost always threatened because those who have fished throughout their entire lives are vulnerable to large-scale aquaculture corporations. He also claims that experienced fishermen think of aquaculture as a "no skill" enterprise and that it is a dishonourable way to make money. An example of traditional fishing techniques used by communities on the Okavango river in Namibia is depicted in Appendix F.

In contrast, Dr. Bagshaw claims that fish farming and wild-caught industries are not always in direct competition. Often, as is the case with salmon in the United States, marine life is over fished and becomes rare in the wild. The only way to fulfil the market demand is to set up aquaculture facilities. Dr. Bagshaw claims that ninety-five percent of the salmon found in United States grocery stores are from fish farms. The five percent of wild-caught salmon is in high demand, and those who catch it can charge a high price. Those who were in the salmon industry and are now out of business cannot blame fish farming, but only over fishing. The farms are only a reaction to the problem, not a cause. Like salmon, kabeljou is also rare in the wild.

Mr. Hart (personal communication, April 7, 2004) exports kabeljou to Europe. He claims, like others, that kabeljou has become very scarce in the wild and lately he has not been able to catch enough to export. This means that kabeljou aquaculture will not put any fishing industry out of business because there is virtually no kabeljou industry in existence in Namibia.

Fish Marketing

In order to determine whether land-based or open-ocean aquaculture is a more viable grow-out system than the other, it was necessary to look at the United States market for kabeljou. While the ability to produce and process a product for consumption is important, it was also vital to analyse the market for that product. Before any enterprise like aquaculture can be established, the targeted market must be thoroughly researched because improper marketing can lead to reduced or nonexistent sales. The status of the market, consumer preferences, pricing, best method of introduction, and proper processing methods needed to be determined in order for any aquaculture business venture to be successful.

In order to assess these requirements, we consulted four fish importers into the United States and one seafood restaurant owner. Mr. Ernest Mairs (personal communication, April 13, 2004), Mr. Mike Sullivan (personal communication, April 13, 2004) of FW Bryce in Massachusetts, Ms. Patricia Schofield (personal communication, April 13, 2004) of Pescanova USA in Florida, and Mr. Dick Monroe (personal communication, April 14, 2004) of the Monroe Group, also in Florida, were the fish importers interviewed. We also interviewed Mr. Robb Ahlquist (personal communication, February 24, 2004), owner of the Sole Proprietor, a high-end seafood restaurant in Massachusetts. He has a more direct line of communication with high-end consumers than wholesalers and was also able to provide us with contact information for several seafood wholesalers. A full transcript of these interviews can be found in Appendix E.

The United States Fish Market

According to the Estimated Per Capita Fish Consumption in the United States, produced by the United States Environmental Protection Agency in August 2002, 4.58 ± 0.42 grams/person/day of finfish are consumed in the United States (Environmental Protection Agency [EPA], 2002). Therefore, Americans are already consuming large amounts of finfish, creating a strong market base for kabeljou.

Imports of fishery products to the United States in 2002 reached 4.4 billion pounds, valued at US$10.1 billion (National Oceanic and Atmospheric Administration [NOAA], 2002). Of this, 3.7 billion pounds were fresh and frozen products, 632.3 million pounds were canned product, 77.0 million pounds were cured products, 5.3 million pounds were caviar and roe products, and 42.3 million pounds were other products. The import of fresh and frozen fillets or steaks, other than tuna, amounted to 922.5 million pounds (NOAA, 2002).

The two most imported fishery products to the United States are tuna and shrimp. Tuna is shipped canned and whole in equal amounts. Shrimp is shipped fresh and frozen. Product preference heavily leans towards fresh and frozen goods, as opposed to canned, with 3.7 billion pounds imported fresh or frozen (NOAA, 2002).

While the United States imports much of its fishery products, only one percent originates from Africa (NOAA, 2002). South Africa is the major African exporter to the United States, sending 5,629 metric tons of hake and various crustaceans, valued at US$29 million. Morocco, Seychelles, and Tanzania are the major contributors of tilapia from Africa. The leading fishery product exporters to the United States include various Asian nations, which contribute forty-six percent of the total volume of imports. However, a large portion of this is shrimp and canned tuna.

Some popular fish eaten in the United States are becoming more difficult to obtain due to declining stocks. According to Dick Monroe, cod and hake are very difficult to obtain. Mike Sullivan states that orange roughy, red snapper, and hake supplies are low. Both agree that the market is open to new white fish to replace declining species in order to meet the large American demand.

United States Consumer Preferences

Whenever a new product is being offered to a market, consumer preferences must be determined to establish the best marketing techniques and preparation methods to employ. All experts whom we interviewed agreed that the salmon market is one of the fastest growing fish markets in the United States. Although salmon flesh has a pink colour, they concur that it is not the most favoured colour for fish. They believe that the general American fish consumer prefers a white, not oily, mild tasting, firm, and flaky fillet. The mild taste of the fish permits the consumer to prepare the meat so it will absorb other flavours like garlic, lemon, or mushroom, which is desirable in the American market. Every importer stated that any fish fillet shipped to the United States must be skinless and boneless with the nape, which is the neck and belly flap, removed. Mr. Ahlquist claimed that firm, fresh fillets are preferred over frozen fish. Although the other fish importers stated that Americans desire flaky, frozen fillets, Mr. Ahlquist disagreed. He also stated that aquaculture can have the advantage of providing fresher fish at a consistent rate, making it very desirable to consumers. All of the wholesalers agreed that fresh and frozen fillets would be acceptable in the United States market.

Mr. Mairs is originally from South Africa and is experienced with kabeljou. He claimed that it will be acceptable to the American market because it is a white, mild tasting fish. Mr. Mairs indicated that kabeljou is a fish similar in taste and appearance to grouper, which is already popular in the United States. As long as kabeljou is processed in a manner consistent with American preferences and is affordable, it should have no problem finding a market.

Pricing

While a fish product may be desirable to the public, if it is not affordable it will not sell. According to Mr. Monroe, inexpensive, generic fish such as pollock sell wholesale for US$1.20 per pound (N$16.96 per kilogram). Ms. Schofield states that premium fish, such as sea bass, sell wholesale for US$6.00 per pound (N$84.67 per kilogram). According to Mr. Mairs, a mid-range fish sells wholesale for US$2.00 per pound (N$28.22 per kilogram). Kabeljou would be targeted as a mid-range priced fish in order to reach middle class, United States consumers. However, pricing is affected by the costs required to produce a marketable product. This may cause an alteration in the price range for kabeljou, so if it is very expensive to produce kabeljou, it will have to sell for a high price. Also, the wholesale price for kabeljou may have to be very low initially to introduce it into the market before it can be raised to a level where the facility makes a profit according to Mr. Sullivan.

Marketing Methods for Kabeljou

Introducing a new fish product into a market is difficult because it is unclear how consumers will react. Mr. Ahlquist states that there has been fair success in introducing new fish species into the United States market, as exemplified by tilapia. He and Mr. Sullivan agree that possible strategies for marketing kabeljou would be through a seafood chain, such as Red Lobster, or through a processed fish company, such as Gorton's fish sticks. A small restaurant chain may be willing to test the new fish through its customers, thereby introducing kabeljou into the market. Retail establishments, such as grocery stores, are not a good option because they are hesitant to introduce new products. Consumers who do not know what kabeljou is or how to prepare it may not purchase it from a grocery store as readily as they would from a restaurant.

Both Mr. Mairs and Mr. Monroe recommend sending small quantities of kabeljou to the United States to test the market. While the American public is introduced to the fish, aquaculture facilities can be established to supply large quantities of kabeljou. The market will already be in place when production reaches full capacity. Mr. Monroe also suggests that introducing kabeljou exclusively to one corporation would be advisable. This develops good business relations for future contracts and makes the introduction more appealing because one company has exclusive rights.

In order to market kabeljou, it must be given a name that is easily understandable and recognizable by American consumers. The Food and Drug Administration (FDA) of the United States has regulations regarding the proper market names for fish. They must be consulted to provide kabeljou with an accurate, acceptable name that is easy to understand and pronounce.

As the kabeljou market develops, consistent supplies of high quality fillets will be required to supply demands. Mr. Monroe stated that many fish importers prefer forward contracting when dealing with aquaculture facilities. In this method of purchasing, an arrangement is made and a contract is signed between the wholesaler and the aquaculture facility concerning the quantity, quality, and size of fish that will be supplied over a period of time. This allows the wholesaler to make long-term business and marketing plans without worrying about supplies of fish.

Processing Specifications for the United States Market

On average, restaurants demand eight to ten ounce (227 – 283 gram) fillets according to Mr. Monroe. However, six to eight ounce (170 – 227 gram) and twelve to fourteen ounce (340 – 397 gram) fillets are also commonly used. Mr. Sullivan claims that any fillet in the eight to sixteen ounce (227 – 454 gram) range is acceptable. In our analysis, a size of nine ounces (255 gram) for fillets was used because it is an average restaurant portion.

All of the fish importers we spoke with claim that shipping kabeljou frozen to the United States is acceptable, as long as it is plate frozen. Plate freezing preserves the quality of the fish by preventing crystallization.

Mr. Mairs, Mr. Sullivan, and Mr. Monroe, suggest that shatter packing in ten to fifteen pound (4.5 – 6.8 kilogram) boxes is the preferred method of packaging for kabeljou that is going to be shipped to the United States. This type of packaging involves placing fillets next to one another, leaving space between fillets, on sheets of non-adhesive cellophane and then stacking these sheets on top of one another in boxes. This allows easy separation of fillets.

Based on amounts requested by the fish importers, the average demand for kabeljou in the United States would be 140 metric tons of fillets per month or 1,680 metric tons of fillets per year. This was the amount of kabeljou fillets that was used for the analysis.

Kabeljou Processing

The group researched the best processing methods for kabeljou in order to fulfil American market demands. In order to export nine ounce (255 gram) fillets to the United States, the processing yield must be determined. According to Van Zyl (personal communication, April 14, 2004), the yield for kabeljou has been estimated at forty percent, meaning that for every 100 grams of whole fish, forty grams of fillet are produced. Van Zyl has indicated that the remaining sixty percent of the fish will be sold to other companies as the raw material for fishmeal.

We visited a variety of fish processing companies located in Walvis Bay, Namibia in order to learn about the techniques they employ and to determine how these techniques can be applied to kabeljou. The group visited Blue Oceans Products, Gendor, Gendev of Namibia, and Freddie Fish Processors. Blue Oceans Products and Gendev of Namibia process hake, while Gendor processes hake and orange roughy, and Freddie Fish

Processors processes a wide variety of fish, including kabeljou, at sea. A detailed explanation of general finfish processing can be found in Appendix C.

All the processing companies we visited export to Europe and Gendor also has an orange roughy market in the United States. According to Ruth Morrison (personal communication, April 20, 2004), director of Gendor, the facility produces about nineteen metric tons per day of whole fish. For 140 metric tons of kabeljou fillets to be exported per month, processing capacity would have to be twelve metric tons whole fish per day. This is a reasonable amount that any of the plants we visited could feasibly process if the facility only processed kabeljou. The additional revenue generated from processing fishmeal amounts to an annual income of N$2,268,000.

Processing of finfish can be done either at sea or on land. At sea, processing ensures freshness and enables boats to stay out to sea for long periods of time (Attwood, 2001). However, many Namibian fisheries hire foreign boats to obtain their products. The crews of these foreign ships are generally less than half Namibian (Barnard, 2004). The Namibian Director of Aquaculture, Ekkehard Klingelhoeffer (personal communication, April 5, 2004), encourages fisheries, through incentives, to process hake on land because land processing provides more jobs to Namibians than processing at sea. Although currently these incentives only apply to hake, if these were extended to the kabeljou aquaculture industry, more jobs would be created in Namibia.

After visiting the four processing plants and consulting with American fish importers, we developed a set of recommendations for processing kabeljou to ship to the United States. Fillets must be of the highest quality and processed to American specifications. General finfish processing begins with descaling, followed by grading and filleting. Then, the fillets are packaged, frozen, and shipped to the market.

Kabeljou is different from hake and orange roughy, but can be processed similarly. While wild-caught fish must be graded based on mass when they arrive at the processing plant, a grading system for farmed kabeljou may not be necessary because the fish will be the same age and of similar size.

Kabeljou will be sold to the United States with the skin off, so descaling will not be necessary. Like orange roughy, it must be deep-skinned and hand filleted. According to Mairs, deep-skinning is necessary to remove the fishy tasting fat layer under the skin of kabeljou, which would not be acceptable in the American market. Mr. Viljoen (personal communication, March 24, 2004) indicated that hand filleting is required with kabeljou because it also does not have a highly structured rack and the bones are difficult to remove with a machine. He also stated that machine filleting would result in a low yield.

Kabeljou will be packaged either in individual cellophane wrappers, like hake at Blue Oceans Products, or shatter packed, like orange roughy at Gendor, to be shipped to the United States. Hake fillets at Blue Oceans Products are packed together in five kilogram boxes before plate freezing. Sullivan (personal communication, April 13, 2004) stated that kabeljou should be frozen similarly in 4.5 - 6.8 kilogram boxes (ten to fifteen pounds). Mairs (personal communication, April 13, 2004) indicated that kabeljou should be plate frozen because blast freezing can cause crystals to form on the fillets. Ice is only necessary in kabeljou processing for storage on the boat. Fillets are kept frozen until they reach the market in order to preserve freshness during shipping. It is extremely important for kabeljou to arrive in the United States with the taste and quality preserved. By freezing kabeljou fillets, freshness is maintained and the time required to ship it from Namibia to the United States is not as critical as it would be if the fillet were fresh.

Grow-Out Systems

A grow-out system is a system into which juvenile fish are placed, fed, and harvested when they reach a marketable weight. We analysed each grow-out system and decided which one would be more economically feasible to meet American demands. The two systems we analysed were land-based flow-through and open-ocean. Each has individual equipment and maintenance costs but the majority of the costs are independent of the grow-out system.

Land-based Systems

In flow-through systems, water is continually pumped through a tank, filtered, circulated, and pumped back into the ocean. In recirculation systems, water is constantly reused but continually lost due to evaporation, so a small amount of water is continually pumped in. Kabeljou will be cultured in flow-through systems because seawater is readily available and flow-through systems are less technologically intensive than a re-circulation system.

The artificial environment produced in these enclosed chambers must have the appropriate pH, dissolved oxygen content, nitrate level, carbon dioxide concentration, salinity, temperature, food, and ammonia-nitrogen concentrations to support the fish being produced (Losordo, Masser, and Rakocy, 1998).

Despite the high cost of maintaining these facilities, the control the systems provide holds several advantages. Fish feed and antibiotics can be carefully monitored for optimum distribution with minimum waste in these systems. The ability to manipulate temperature and other environmental factors in the tank allow for maximum growth. This results in a maximization of product yield, adding to overall profits. In addition to an increased yield, the closed environments are more easily accessible to workers for optimum quality control (Lazur & Britt, 1997). Prof. Tyler (personal communication, January 30, 2004) suggested that when coupled with the technique of bioremediation, where marine plants and bivalves are grown using the fish waste in adjacent tanks as food, an additional crop can be harvested, which will eliminate the need for sediment filtration systems.

General Equipment and System Design.

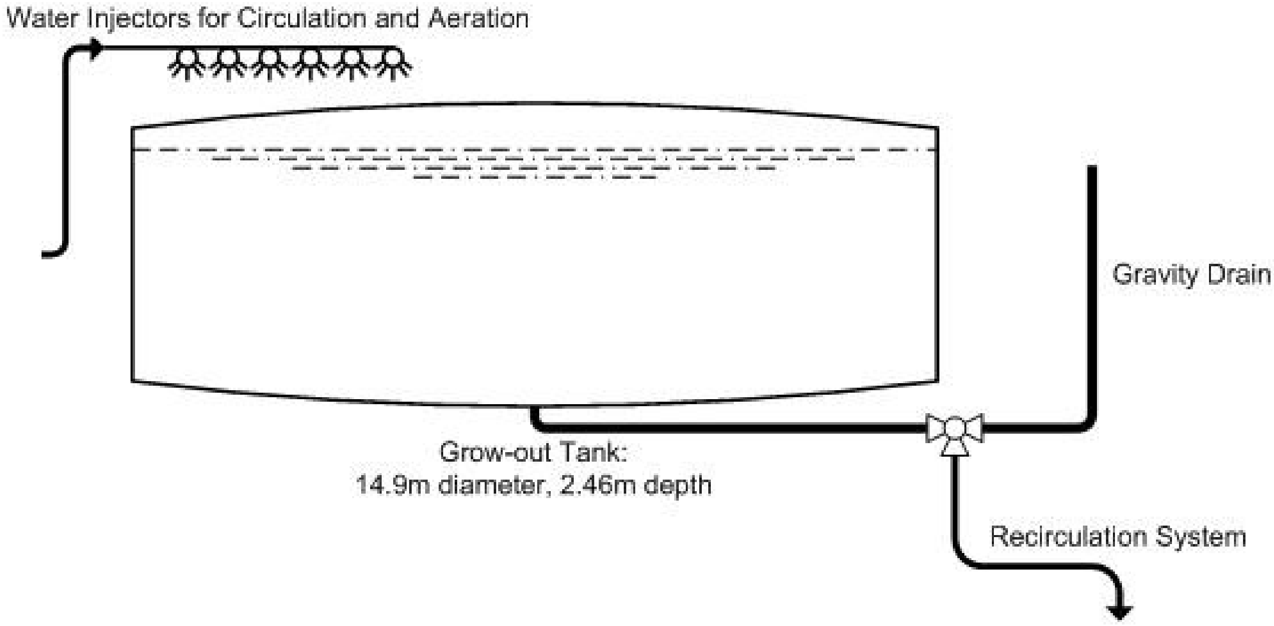
In order for aquaculture to be economically feasible, it is important to identify what resources are available. In Namibia, there are no companies that develop or market aquaculture equipment. Therefore, options available are either to purchase systems from other countries or to develop systems completely from components available in the country. Since the transport costs substantially increase the price of any system purchased internationally, it would be most economical to develop a system from the materials available locally.

According to Dr. Van Zyl (personal communication, April 7, 2004), a tank for kabeljou aquaculture should be 2.0 - 2.5 metres deep and circular for easy water circulation. The Porta Liners and Pools Company in Swakopmund, Namibia provide circular tanks suitable for marine aquaculture. According to Mr. Wilfred Poaser (personal communication, April 7, 2004), a representative of the Porta Liners and Pools Company, his company markets two tank sizes appropriate for kabeljou aquaculture. One is 12.7 metres in diameter and 2.45 metres deep for a water volume capacity of 300 cubic metres and the other is 14.9 metres in diameter and 2.46 metres deep for a water volume capacity of 426 cubic metres. The only regular maintenance that is required for these tanks is the replacement of the tank lining, which should occur every ten years.

In addition to the tanks, means of supplying water to the system and filtering it are necessary. According to Mr. Kobus Alberts (personal communication, April 7, 2004), chief technician of the Swakopmund National Marine Aquarium, the aquarium has a flow-through tank, containing kabeljou, in which twenty-five percent of the water volume is replaced with filtered seawater every day. For a 426 cubic metre tank, an incoming flow rate of approximately 13.3 cubic metres per hour for eight hours is necessary to meet this standard. Mr. Joe Johnson (personal communication, April 8, 2004), director of the Namibian aquaculture company NamAqua, provided us with information about a pump capable of supplying this flow rate to seven tanks simultaneously. Mr. J. Anton Kotzé (personal communication, April 7, 2004), of NEC Engineering, in Walvis Bay, Namibia has a 380 volt submersible pump that would be suitable for supplying the required water to one tank over an eight hour period. Poaser (personal communication, April 7, 2004) has indicated that his company also supplies a pump suitable for these requirements. Since these pumps are capable of supplying enough water to the tanks over an eight hour period, they could be connected to three times as many tanks and run over a twenty-four hour period, reducing the number of pumps needed for the whole system. Dr. Van Zyl (personal communication, April 7, 2004) indicated that the pumps must be able to move the water no more than thirty metres vertically and 100 metres horizontally from the water source and that a pipe 110 millimetres in diameter would suffice. Based on these specifications, we determined that the NEC Engineering pump would be the most economically feasible pump to use. Our calculations are done with this pump.

Other requirements of the system include aeration, circulation, and drainage of the water. Figure 1 depicts a system design suitable for providing for all of these processes without additional equipment or fuel costs. This tank design was proposed by Van Zyl (personal communication, April 7, 2004). For aeration, the water entering the system is sprayed through a capped pipe with slits along one of its sides positioned horizontally over one side of the tank. This causes the water to jet sideways into the tank resulting in turbulence and oxygenation of the tank environment. The one-sided injection of the water also provides circulation in the system. For drainage, the tank is designed with an inward sloping base leading to a large drainpipe. This pipe would lead out to a vertical pipe that is the same height as the maximum allowable water level in the tank. This pipe can then be physically lowered to provide gravity pumping to remove old water from the system. This water can then be sent back into the ocean through drainage canals. At the end of these canals will be large sandpits acting as sediment filters to clean the water before it returns to the ocean.

Figure 1 - Tank Circulation, Aeration, and Drainage Diagram



An example of a complete land-based tank facility can be seen in Figure 2. This is one of the largest aquaculture facilities in the world and is located in Spain. A land-based facility with a total of 411 tanks with a diameter of 14.9 metres each and a one metre space in between the tanks would require eleven hectares of land. Additional land would be needed for warehouses or other buildings as depicted in Figure 2.

Figure 2 - Aerial View of Stolz Aquaculture Facility in Spain

Catastrophe Control Equipment and System Design.

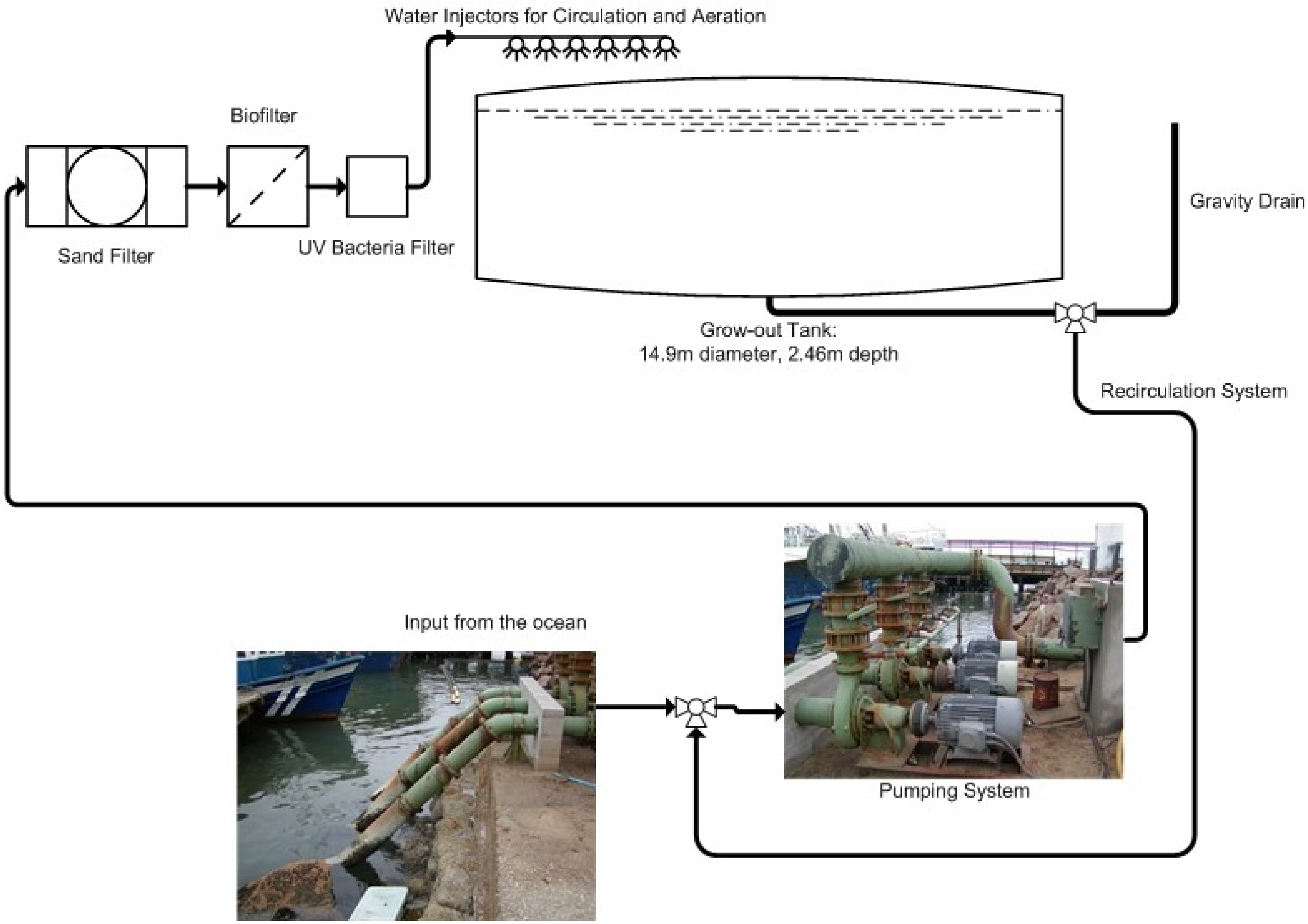
Since land-based systems rely heavily on the functioning of the equipment, precautionary measures need to be taken. While regular maintenance of the machinery will extend the life and optimum functionality of the system, backup equipment must be on standby. According to Dr. Van Zyl (personal communication, April 7, 2004), for every active pump in the system, there must be an inactive backup pump, so that in the event of the failure of one or all of the pumps, the backup can immediately be activated. He claims that this will prevent the loss of an entire crop of fish due to the unexpected failure of a pump.

In addition to pump redundancy, there must be adequate filtration so that any harmful contaminants and organisms are eliminated. As depicted in Figure 3, there are three types of filters necessary. These are sand filters, biological filters (bio filter), and ultraviolet light bacteria filters (UV filter). Alberts (personal communication, April 7,

2004) explained that the purpose of the sand filter is the removal of large sediment particles and can be cleaned simply by pumping water backwards through the system occasionally. Johnson (personal communication, April 8, 2004) stated that the bio filter is used to balance the ammonia and nitrate levels in the water and does not require any maintenance. He also indicated that the UV filter exterminates any harmful organisms before they enter the tank and requires a bulb replacement every two years. Other adjustments to the water, such as pH level, are unnecessary since the water is drawn directly from the natural habitat of kabeljou.

In the event of an environmental catastrophe that contaminates the seawater, such as a harmful algal bloom, the land-based facility can be switched over to temporary recirculation. The water from the tank would be diverted from the gravity drain by a valve attached below the vertical pipe, which would lead back to the pumping system. Water may be recirculated in this manner for up to one week until evaporation causes the tank to lose a substantial amount of water. This water must be replenished in order to keep the crop of fish healthy. After several days, the Benguela currents will carry the toxins from the harmful algal blooms away, allowing for fresh seawater to be pumped into the system.

Figure 3 - Land-based System Diagram



Open-ocean Systems

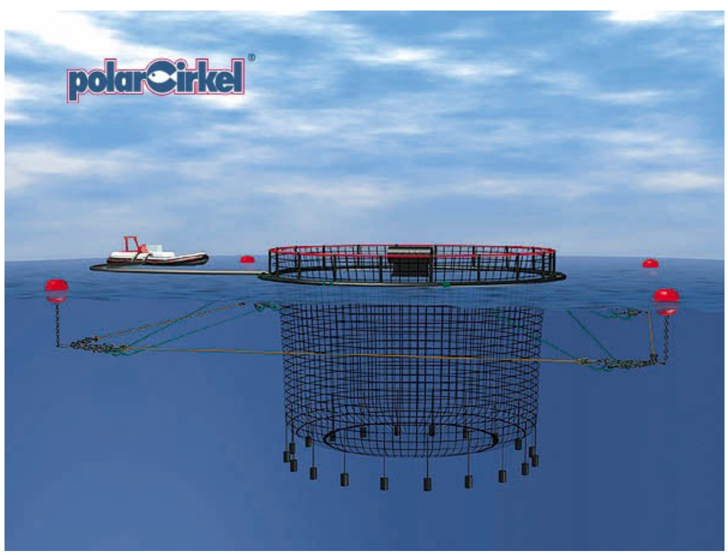
In mild currents like those in Walvis Bay, Namibia, open-ocean aquaculture systems will contain gravity cages. These are circular net enclosures with a pontoon like structure. This structure floats on the surface and nets of varying depths are held in place with heavy weights, some reaching the ocean floor. Unfortunately, while these structures are effective at providing a large volume of space for fish culture, they can only be used in areas with minimal water motion. In strong currents, the surface structure will fold in on itself and significant volume loss in the enclosure will result (Loverich & Gace, 1997). Dr. Van Zyl (personal communication, April 7, 2004) indicated that only some sections of the Namibian coastline, such as Walvis Bay, are suitable for surface floating gravity cages.

Cards Aquaculture Products Ltd. of the United States and polarCirkel of Norway produce circular, surface-floating, gravity cage culture systems for aquaculture use. These cages are typical of open-ocean cage systems. The designs from both companies include circular cage structures with a surface-floating rim. This rim is composed of two large rings, one of a slightly smaller circumference, floating on the surface with the additional, larger ring positioned less than one metre above the inside of the surface floating rings. The pipes used for these rings are composed of high-density polyethylene. This cage makes it relatively easy to access the fish since it is restricted to growing the fish close to the surface (http://www.cardsaqua.com, http://www.polarcirkel.com). Figure 4 shows the floating ring design of the polarCirkel net cages while Figure 5 shows how the entire polarCirkel floating cage system appears with a net.

Figure 4 - Surface Floating Structure of the polarCirkel Net Cages

Adapted from the polarCirkel company at http://www.polarcirkel.com

Figure 5 - Depiction of a Complete polarCirkel Net Cage System



Adapted from the polarCirkel company at http://www.polarcirkel.com

General Equipment and System Design.

In order to adequately compare land-based and open-ocean systems, they must both be similarly sized. A suitable net cage produced by the polarCirkel company from Norway has a total volume of 340 cubic metres. According to Dr. Van Zyl (personal communication, April 7, 2004), the net cage depth can be three metres, thus the diameter of the net cage ring must be twelve metres. The netting must also have a mesh size of twenty-five millimetres in order to contain kabeljou fingerlings. In addition to the surface floating ring, approximately 227 square metres of twenty-five millimetre mesh netting will be needed. The netting would also have to be knotless in order to reduce the pressure water currents apply to the netting (Ultra Cross® Knottless Netting, 2003). A mooring system, which would attach the cage to the ocean floor, would also be necessary in order to prevent the natural currents from moving the net cage.

An open-ocean facility with 515 cages of twelve metre diameter each and one metre between tanks would require an area of nine hectares. According to Van Zyl (personal communication, April 13, 2004), the Namibian government has designated 200 hectares in Walvis Bay specifically for aquaculture. Approximately twenty facilities of this size could fit in that designated area.

Potential Problems.

While open-ocean net cages require less equipment and machinery than land-based tanks, the exposure to the natural environment can cause problems for the kabeljou being cultured. The most significant concerns for open-ocean aquaculture systems in the Benguela currents are net biofouling, harmful algal blooms, and fish predators. Other, more minor concerns include poachers and sulphur eruptions.

Biofouling results from the growth of organisms on the netting of the cages. These build-ups are the reason continual cleaning is necessary. Recent studies on biofouling indicate that plants tend to grow on cages situated closer to the surface while animal life is more common at greater depths (Grizzle, Chambers, Mathieson, & Harris, 2002). Plant life is the primary cause of biofouling, as illustrated by Figure 6, which shows the biofouling on oyster cages after six weeks in Walvis Bay at one metre depth. Mussels are also a major problem in the Benguela current. This is the same location that will be used for open-ocean kabeljou aquaculture and it will be necessary to have a good plan for combating biofouling, such as the use of multiple nets or antifouling chemicals.

One popular method used to combat biofouling on aquaculture nets is the use of tributyltin (TBT) paint. This paint is very effective in killing both plant and animal organisms, but has been found to be toxic to marine life (Hossain, 2001). Mr. Johnson (personal communication, April 8, 2004) has indicated that the high salinity of the Benguela currents severely limits the effectiveness of antifouling chemicals. As a result, the only truly effective way to manage biofouling would be to have extra netting for each cage that would be rotated regularly for cleaning. He also stated that a high pressure water hose could even be used directly from a boat to clean biofouling from the netting on site. In order to keep the fish from escaping while cleaning, multiple nets are utilised. A clean net is secured around the outside of the fouled net and the inside net is removed from between the new clean net and the fish. This net is then sprayed with seawater, dried, and stored until it will replace the present netting.

Figure 6 - Clean oyster cage (left) and cage after 6 weeks in Walvis Bay at about 1 m depth (right)

Harmful algal blooms are another serious threat to marine-based aquaculture in Namibia. HABs are the sudden, tremendous growth of algae that result in environmental chaos. Not all algal blooms are harmful, but some emit toxins. These toxins can kill entire populations of fish, marine birds, and even whales. HABs also deplete dissolved oxygen levels in the water and can asphyxiate marine life. Additionally, they can accumulate in filter feeders like oysters and clams, poisoning whatever may eat them, including humans (Pitcher, 1999).

While many environmental disasters such as this might be avoided by monitoring environmental changes, this is not true for HABs. According to Lizette Voges (personal communication, March 25, 2004), the Marine Biodiversity Coordinator at the Swakopmund National Marine Aquarium, and Iana Iita (personal communication, March 25, 2004), a scientist at the Swakopmund National Marine Aquarium, HABs are not a regular occurrence and there is currently no warning system for them. This is a significant problem for open-ocean aquaculture systems in Namibia.

Natural finfish predators are also a threat to any open-ocean aquaculture system. Johnson (personal communication, April 8, 2004) indicated that cormorants and other predatory birds have been known to attack surface net cage fish cultures. According to Botes (personal communication, April 14, 2004) and Ms. Anneke Van der Westhuizen (personal communication, April 14, 2004), representatives of Entheos Aquaculture, seals are also known to be a threat to fish culture populations. Sharks are the most serious predatory threat to open-ocean systems because they can tear through aquaculture netting, resulting in fish loss from shark consumption and holes in the netting. Net enclosures over the top of the system can prevent bird attacks and underwater motion activated sonar systems can scare seals away. Mr. Johnson (personal communication, April 8, 2004) suggested that stainless steel caging around the fish netting may protect fish populations against shark attacks, but is expensive and would rust in the high salinity of the Benguela currents. Mr. Botes (personal communication, April 14, 2004) claims that shark attacks would only be a significant problem if the aquaculture systems were located in Luderitz Bay, far to the south of Walvis Bay on the Namibian coast. However, Mr. Botes feels that prevention systems, like stainless steel caging, should still be explored and incorporated into open-ocean systems.

A less significant concern to kabeljou aquaculture in the open-ocean is poaching. Aquaculture company directors Manuel Romero of the Beira Aquaculture Company and Mr. Johnson have both had their facilities vandalized. However, Johnson (personal communication, April 8, 2004) has indicated that since these incidents, the Namibian government has been adamant about catching and punishing poachers to prevent further destruction to the aquaculture industry.

Another factor affecting open-ocean aquaculture systems is sulphur eruptions, which are unique to the Benguela current. These events are caused by the decay of large amounts of plant life, including algae. When the plant matter sinks to the ocean floor, it is broken apart by bacteria, producing large amounts of hydrogen sulphide. This hydrogen sulphide that rises to the surface in a large cloud is the sulphur eruption. The sulphur gas is not harmful to humans, but smells rotten. A problem for marine life arises when this hydrogen sulphide combines with dissolved oxygen gas in the water. This causes a shortage of oxygen that asphyxiates thousands of fish (Weeks & Bronwen 2002).

Van Der Plas (personal communication, March 25, 2004), has indicated that sulphur eruptions are harmful only to some species of fish and kabeljou is not especially at risk. She stated that sulphur eruptions occur ten to twenty nautical miles from land and are most damaging to oxygen breathing creatures near the ocean floor, where the hydrogen sulphide gas is initially released. She indicated that as the hydrogen sulphide travels up to the surface it reacts with the oxygen in the ocean, losing its poisonous properties. She also claims that the hydrogen sulphide poisons fish that are at the bottom of the ocean, while fish in the mid-level areas are asphyxiated and fish at the surface are not affected. Therefore, kabeljou in open-ocean aquaculture systems are not at significant risk because they are located at the surface of the ocean.

Findings

In order to analyse the data collected over the course of our project, we used the aquaculture marketing analysis model presented in the FAO report entitled *Marketing the Products of Aquaculture* (FAO, 1986). The exchange rate we used in our analysis to convert Namibian dollars to United States dollars was N$6.40 to US$1.00. Although this was the average exchange rate in April 2004, we are aware that it may fluctuate in the future, which will affect income and costs related to aquaculture systems. Importation of cages and other equipment will rise if the Namibian dollar is devalued, while exports will become cheaper for Americans, which may increase sales. If the Namibian dollar becomes stronger, imported equipment costs will be lessened, while sales in the United States may decrease due to higher kabeljou wholesale prices.

There are various costs associated with aquaculture systems, both system specific and non-system specific. Specific costs associated with land-based systems, including tanks, pumps, and filters are shown in Table 1 and costs specific to open-ocean systems, including cages, netting, and boating, are shown in Table 2.

Table 1 - Costs Specific to Land-based Systems

Component	Type	Cost(US$)	Cost(N$)	Lifespan(years)
Tank	300 m^3	8,953.13	57,300	25
	426 m^3	10,796.88	69,100	25
	tank lining	2,812.5	18,000	10
Pump	1.5 kW pool pump	492.19	3,150	4
	monthly operation cost	20.31	130	NA
	380 volt	984.38	6,300	4
	monthly operation cost	7.50	48	NA
	30 hp pump	9,375	60,000	4
	monthly operation cost	390.63	2,500	NA
	monthly maintenance cost	78.13	500	NA
Sand Filter		15,625	100,000	25
Biological Filter		7812.5	50,000	25
UV Bacteria Filter	filter and UV bulb	156.25	1,000	25
	replacement UV bulb	78.13	500	2
Pipe	25 cm diameter per metre	7.81	50	25

The most expensive component specific to land-based systems is the tank because multiple tanks are required. The least expensive piece of equipment is the pipes for the pumping system.

Table 2 - Costs Specific to Open-ocean

Component	Type	Cost(US$)	Cost(N$)	Lifespan(years)
Surface floating ring	polarCirkel, 12 m diameter	5,747.97	36,787	25
Netting	227 m^2	2,155.47	13,795	25
Boat	8 m catamaran	28,125	180,000	20
	monthly insurance	140.63	900	NA
	monthly operation cost	257.81	1,650	NA
	monthly maintenance cost	12,500	80,000	NA

For open-ocean systems, the surface floating ring component of the cage is the most expensive piece of equipment. While boat costs are more expensive per item, many cages are needed, but only one boat is required.

In addition to the specific costs for each system, there are costs independent of system. Both systems require a truck to transport the equipment, fingerlings to stock the cages, fish feed to nourish the fish, and labourers to maintain the systems. After the kabeljou is cultured, it must be processed and shipped frozen. These costs are listed in Table 3.

Table 3 - Costs Independent of Grow-Out System

Component	Type	Cost(US$)	Cost(N$)	Lifespan(years)
Truck	pickup truck	18,750	120,000	5
	monthly insurance	93.75	600	NA
	monthly operation cost	312.50	2,000	NA
	monthly maintenance cost	78.13	500	NA
Fingerling	20 g fish	0.05	0.30	NA
Fish Feed (1 kg)	juvenile feed	0.85	5.45	NA
	juvenile feed transportation	0.94	6.00	NA
	adult feed	0.86	5.50	NA
	adult feed transportation	0.89	5.70	NA
Labour (monthly wages)	Supervisor	625	4,000	NA
	Attendant	312.50	2,000	NA
Production	per kg of fish produced	1.02	6.50	NA
Shipping Frozen	per kg of fillet	0.45	2.88	NA

In order to determine the yearly total cost of a kabeljou aquaculture system, we performed an analysis using the quantity of 140 metric tons of fillets per month (1680 metric tons of fillets per year). This equates to 350 metric tons of fish per month (4200 metric tons of fish per year) at a forty percent fillet yield. The fish need to be grown to approximately 640 grams to produce a nine ounce fillet, which takes eight months. These aquaculture systems will run on eight month cycles, meaning that fish will be grown from fingerling to adult in that time period. The optimal stocking density for kabeljou is sixteen kilograms per cubic metre. This means that each 340 cubic metre cage can hold 5440 kilograms of fish (2176 kilograms of fillets) and each 426 cubic metre tank can hold

6816 kilograms of fish (2726 kilograms of fillets). After comparing the two available tank sizes, it was concluded that the 426 cubic metres was more economical because it required less pumps and filters. In order to meet the quantity of fillets desired per year, 515 cages or 411 of the 426 cubic metre tanks are needed. This calculation can be found in Appendix D.

The number of fish harvested each year is equal to 6,562,500 and, assuming a fingerling mortality rate of ten percent, the number of fingerlings necessary per year is equal to 7,291,667. It takes a kabeljou three months to grow to an adult stage of 100 grams, and three eighths of the fish in the system at any time are fingerlings. Fingerlings are fed a forty-two percent protein diet, while adults are fed a less expensive thirty-eight percent protein diet. Table 4 shows the total cost of an aquaculture facility needed to produce 1680 metric tons of fillets per year. Table 5 shows the projected income selling the kabeljou fillets at US$2.00/lb or N$28.22/kg and from fishmeal.

Table 4 - Costs for 1680 metric tons of Kabeljou Fillets (one year)

COSTS: Land- Based	US dollars	Namibian dollars	COSTS: Open-ocean	US dollars	Namibian dollars
FIXED COSTS			**FIXED COSTS**		
truck insurance	1,125	7,200	boat insurance	1,688	10,800
depreciation on truck	3,750	24,000	truck insurance	1,125	7,200
truck fuel and maintenance	4,688	30,000	depreciation on truck	3,750	24,000
			truck fuel and maintenance	4,688	30,000
			depreciation on boat	2,813	18,000
			boat fuel, maintenance, and running	18,137	116,075
Subtotal	9,563	61,200	**Subtotal**	32,201	206,075
VARIABLE COSTS			**VARIABLE COSTS**		
Fingerlings	341,797	2,187,500	Fingerlings	341,797	2,187,500
Juvenile feed	808,822	5,176,458	juvenile feed	808,822	5,176,458
adult feed	8,261,393	52,872,917	adult feed	8,261,393	52,872,917
depreciation on tanks	177,501	1,136,004	Labour	1,237,500	7,920,000
depreciation on tank liner	115,594	739,800	depreciation on cages	207,095	1,325,409
Filters	129,228	827,057	Processing	1,443,750	9,240,000
filter maintenance	5,352	34,250	shipping frozen	756,000	4,838,400
Pumps	39,109	250,299			
Pipes	4,281	27,400			
pump operation costs	12,376	79,208			
Labour	990,000	6,336,000			
Processing	1,443,750	9,240,000			
Shipping frozen	756,000	4,838,400			
Subtotal	13,085,202	83,745,293	**Subtotal**	13,056,357	83,560,684
TOTAL	13,094,765	83,806,493	**TOTAL**	13,088,558	83,766,759

Table 5 - Projected Income

INCOME	US$	N$
wholesale US$2.00/lb or N$28.22/kg	7,407,532	47,408,205
fishmeal	354,375	2,268,000

Both systems cost approximately the same amount to operate every year. The total costs for each system are greater than the income generated by selling kabeljou wholesale as a mid-range fish at N$28.22 per kilogram. Kabeljou would have to be sold at N$48.51 per kilogram to break even in both systems. This is high for an American wholesale price and would put kabeljou at the upper limit of mid-range fish in the fish market. Table 6 shows the amount of money lost selling the fish at N$28.22 in each system and the breakeven points where the cost of production is equal to the income generated. Figure 7 shows the breakeven analysis for a land-based system graphically and Figure 8 shows the breakeven analysis for an open-ocean system graphically.

Table 6 - Income and Profits

			Open-ocean		Land-based	
Fish Market Price	**Income (US$)**	**Income (N$)**	**Profit (US$)**	**Profit (N$)**	**Profit (US$)**	**Profit (N$)**
US$2.00/lb or N$28.22/kg	7,761,907	49,676,205	-5,326,649	-34,090,554	-5,332,858	-34,130,288
US$2.25/lb or N$31.74/kg	8,687,848	55,602,227	-4,400,708	-28,164,532	-4,406,917	-28,204,266
US$2.50/lb or N$35.26/kg	9,613,789	61,528,250	-3,474,767	-22,238,509	-3,480,976	-22,278,243
US$2.75/lb or N$38.78/kg	10,539,731	67,454,278	-2,548,825	-16,312,481	-2,555,034	-16,352,215
US$3.00/lb or N$42.30/kg	11,465,672	73,380,301	-1,622,884	-10,386,458	-1,629,093	-10,426,192
Breakeven Open-ocean US$3.44/lb or N$48.51/kg	13,088,556	83,766,759	**0**	**0**	-6,208	-39,734
Breakeven Land-based US$3.44/lb or N$48.51/kg	13,094,765	83,806,493	6,208	39,734	**0**	**0**
20% Profit Open-ocean US$4.15/lb or N$58.50/kg	15,706,267	100,520,111	**2,617,711**	**16,753,352**	2,611,503	16,713,618
20% Profit Land-based US$4.15/lb or N$58.50/kg	15,713,717	100,567,792	2,625,161	16,801,033	**2,618,953**	**16,761,299**

Figure 7 - Breakeven Analysis of Land-based System

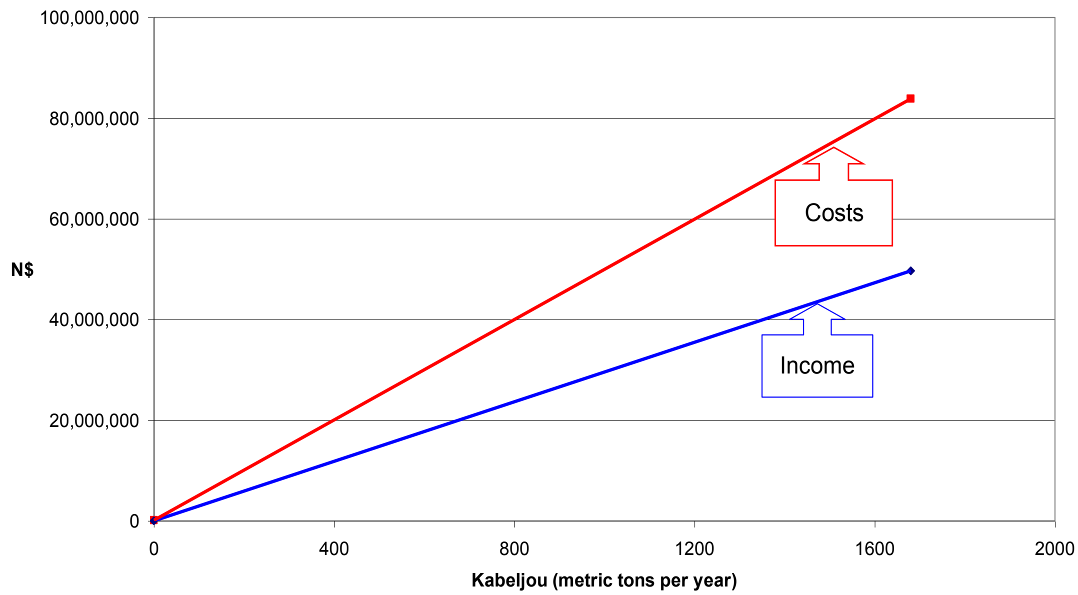
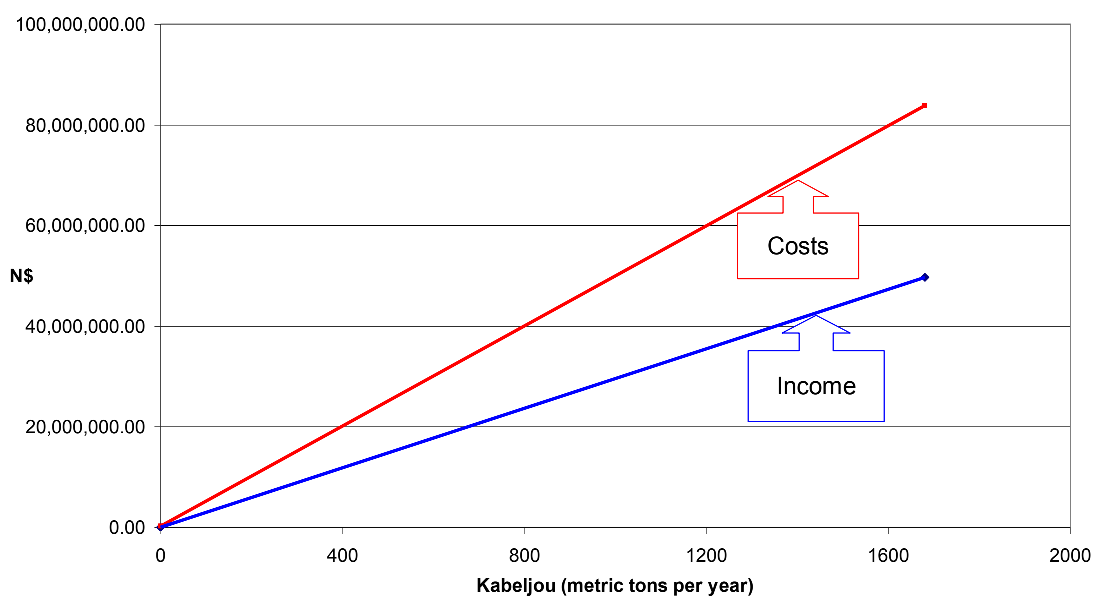


Figure 8 - Breakeven Analysis of Open-ocean System



We have determined that land-based and open-ocean kabeljou aquaculture systems cost the same amount of money to establish, differing by only 0.05 percent. Although the equipment prices for each system are different, the feed price is the same and very large. This large universal cost outweighs the lesser equipment costs. The equivalence in cost necessitates the need for a more in depth analysis of the advantages and disadvantages of each system.

Table 7 contains a list of advantages and disadvantages associated with each system. Open-ocean systems are more susceptible to catastrophes like harmful algal blooms than land-based systems because they are exposed to the natural environment of the Benguela current. Also, these systems waste more food because of the strong currents through the cage netting that quickly carry the food away. They are also less accessible than those located on land. The major advantage associated with open-ocean systems is that fish are grown in their natural environment with less technologically advanced equipment.

One disadvantage associated with land-based facilities is that they are more technologically intensive and complicated than those in the open-ocean. As a result, these systems require more energy and highly skilled labour to maintain. One major advantage is the amount of control the operator has over a land-based facility, maximizing fish growth. These facilities will also provide more jobs in the fish processing industry because all processing will be done on land.

Table 7 - Aquaculture System Advantages and Disadvantages

Land-based Facility	Open-ocean Facility
Advantages	**Advantages**
more control over fish environment	more natural environment for the fish
more high quality fish	less equipment
more easily accessible	less technologically intensive
more processing jobs provided	less maintenance
less exposure to harmful environment	less land required
Disadvantages	**Disadvantages**
more complicated systems	more exposure to harmful environment
more equipment needed	more feed waste
more energy required for operation	less high quality fish
more maintenance	less accessible

The most expensive variable cost in either aquaculture system is feed for the kabeljou, amounting to 69.3 percent of the cost for both the land-based system and the open-ocean system. Figure 9 depicts the cost distribution for land-based systems and Figure 10 depicts the cost distribution for open-ocean systems with the actual feed cost and feed shipping cost separated.

Figure 9 - Cost Distribution of Land-based System

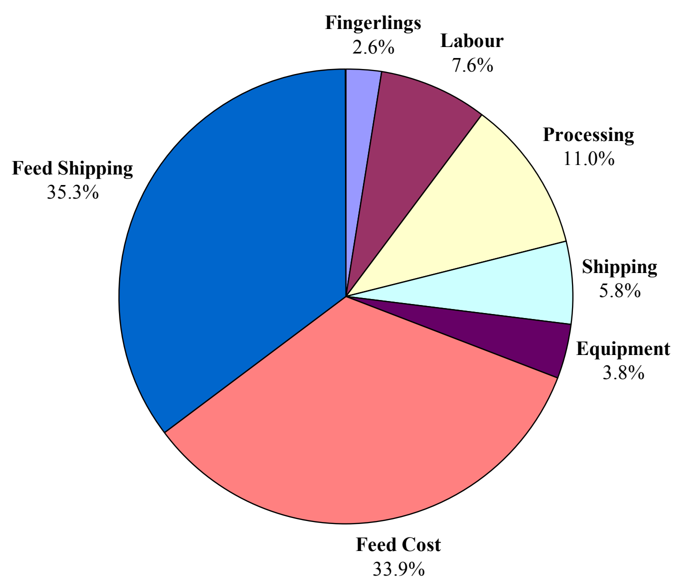
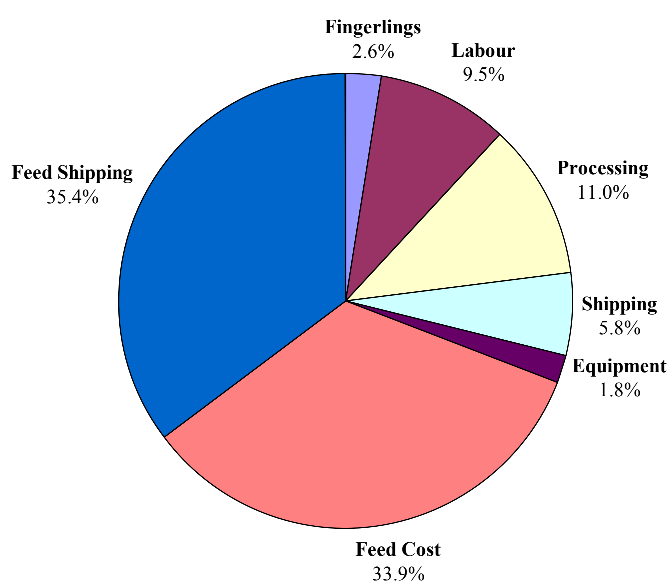


Figure 10 - Cost Distribution of Open-ocean Systems



Currently, there are no finfish feed manufacturing plants for aquaculture systems in Namibia and all feed is obtained from South Africa. Juvenile feed costs R5.45 per kilogram and adult feed costs R5.50 per kilogram. However, shipping costs for feed are R6.00 per kilogram and R5.70 per kilogram, respectively. Feed shipping expenses more than double the cost of fish feed and could be eliminated or greatly reduced if feed companies were established in Walvis Bay, near the majority of fish processing plants. This would allow aquaculture facilities to sell kabeljou at a much lower wholesale price to make a twenty percent profit. We performed our calculations again, eliminating the cost associated with feed shipping. Figure 11 portrays the cost distribution of a land-based system and Figure 12 depicts the cost distribution of an open-ocean system using this method of analysis. Table 8 shows the new breakeven and twenty percent profit points for both systems.

Figure 11 - Cost Distribution of Land-based System with Reduced Feed Cost

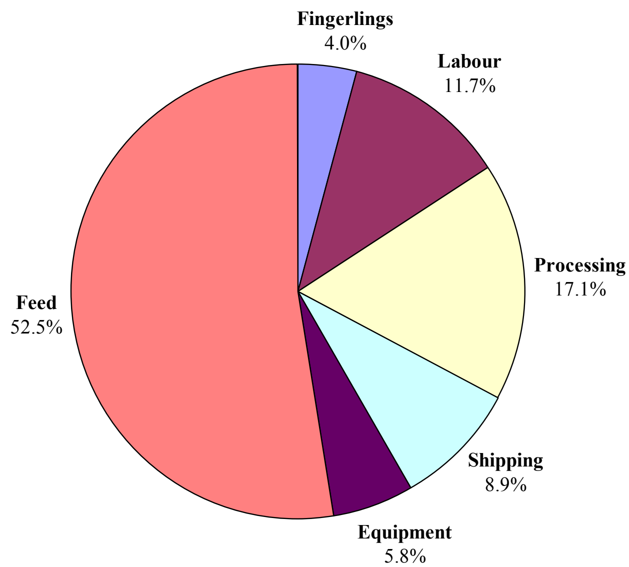


Figure 12 - Cost Distribution of Open-ocean System with Reduced Feed

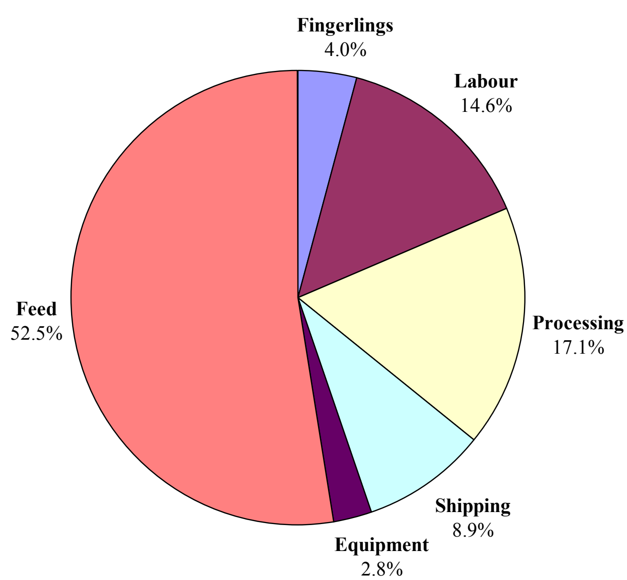


Table 8 - Income and Profits of Reduced Feed Scenario

			Open-ocean		Land-based	
Fish Market Price	**Income (US$)**	**Income (N$)**	**Profit (US$)**	**Profit (N$)**	**Profit (US$)**	**Profit (N$)**
US$2.00/lb or N$28.22/kg	7,761,907	49,676,205	-698,353	-4,469,461	-704,562	-4,509,195
US$2.25/lb or N$31.74/kg	8,687,848	55,602,227	227,588	1,456,561	221,379	1,416,827
US$2.50/lb or N$35.26/kg	9,613,789	61,528,250	1,153,529	7,382,584	1,147,320	7,342,850
US$2.75/lb or N$38.78/kg	10,539,731	67,454,278	2,079,471	13,308,612	2,073,262	13,268,878
US$3.00/lb or N$42.30/kg	11,465,672	73,380,301	3,005,412	19,234,635	2,999,203	19,194,901
Breakeven Open-ocean US$2.19/lb or N$30.91/kg	8,460,260	54,145,666	**0**	**0**	-6,208	-39,734
Breakeven Land-based US$2.19/lb or N$30.91/kg	8,466,469	54,185,400	6,208	39,734	**0**	**0**
20% Profit Open-ocean US$2.65/lb or N$37.31/kg	10,152,312	64,974,799	**1,692,052**	**10,829,133**	1,693,294	10,837,080
20% Profit Land-based US$2.65/lb or N$37.31/kg	10,159,763	65,022,480	1,699,502	10,876,814	**1,693,294**	**10,837,080**

One program we discovered during the course of our research was Benguela Environment and Fisheries Interaction and Training (BENEFIT). Their goal is to combine the resources of Namibia, South Africa, and Angola in order to further the development of each country in the field of aquatic sciences. In order to gain funding from BENEFIT, researchers from at least two of the three nations must be involved along with university students. In the past, BENEFIT has focused on studies of stock dynamics of hake, horse mackerel, and rock lobster and environmental impacts of the fishing industry. Currently, BENEFIT has expanded their focus to aquaculture because of the recent local interest (Sweijd & Britz, 2003).

Leaders of the BENEFIT program have decided to expand their funding to aquaculture because it is a potentially lucrative industry and can provide each nation with substantial income. Also, aquaculture is recognized as a high-risk industry in which investors may be hesitant to enter without government support. BENEFIT is currently eager to accept proposals for research in areas related to aquaculture. The funding supplied will cover transportation, running costs, and equipment. This funding will last for a maximum of three years with a chance for renewal. Students must be involved in research and will receive stipends, while researchers will receive no additional salary (Sweijd & Britz, 2003).

Conclusions

Currently, kabeljou aquaculture is not feasible in Namibia because of the high costs associated with each system. With the reduction of some large costs, like feed, by developing Namibian support industries, kabeljou aquaculture could become profitable.

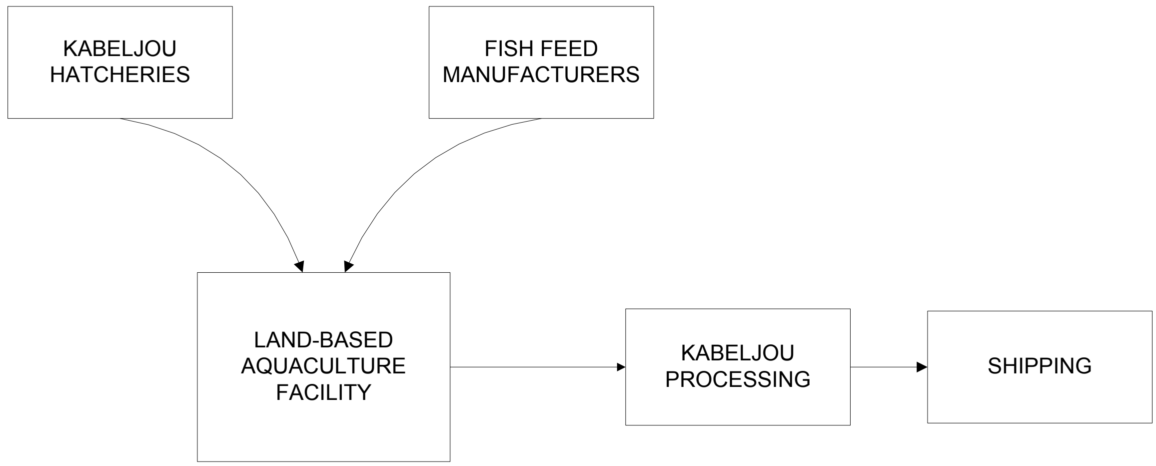
Given that the costs of both systems are equivalent, we recommend a land-based system rather than an open-ocean system because the operator has more control over the system, which minimizes environmental risks like predators and harmful algal blooms.

Land-based aquaculture facilities should eventually become a reality in Namibia. However in order for this to happen, support industries, including fish feed manufacturers and kabeljou hatcheries, must be developed. These industries are necessary in Namibia to reduce costs and provide a steady supply of materials vital for kabeljou growth.

If feed companies were established in Namibia and shipping costs were eliminated, farmed kabeljou could bring in a much higher profit. The price kabeljou would need to be sold at to make a twenty percent profit would be reduced from US$4.15 per pound to US$2.65 per pound. This brings kabeljou into the mid-range of the American fish market. Sales would increase with this lower market price because more consumers would be able to afford the kabeljou fillets.

The Namibian government should encourage the development of fish feed and kabeljou hatchery facilities by providing incentives to those interested in these new enterprises. These industries can be completely independent of one another, but both must exist in Namibia to make land-based aquaculture profitable Figure 13 shows a diagram of all aspects of the aquaculture industry that must be developed.

Figure 13 - Necessary Namibian Industries



Recommendations and Future Directions

After analysing land-based and open-ocean aquaculture systems, we developed six recommendations for future research or directions in which this project can be taken. These include:

1. Establishment of Market
2. Further Investigation of Land-based Facilities
3. Research of Namibian Fish Feed Manufacturer
4. Research of Namibian Kabeljou Hatchery
5. Assessment of Bioremediation
6. Benguela Environment Fisheries Interaction and Training (BENEFIT) Partnership

1. Establishment of Market

Although our preliminary research into the United States fish market has concluded that the American market will accept kabeljou, Mr. Mairs (personal communication, April 13, 2004) and Mr. Monroe (personal communication, April 14, 2004) both suggested sending samples of kabeljou to fish wholesalers in the United States. These samples should be processed in the same way kabeljou would be processed on a large-scale. This allows for market testing of kabeljou products on American consumers and the establishment of a demand for it in the United States. One good place to send kabeljou is to fish wholesalers like Mr. Mairs and Mr. Monroe so that they can send these samples on to their customers. Another way to get samples into the United States is to send them directly to restaurants. One such restaurant would be the Sole Proprietor in Worcester, Massachusetts because this restaurant has indicated interest in kabeljou. Sending samples to grocery stores or other fish retailers would not be as effective because the consumer would have to prepare the fish themselves and may be reluctant to do so because the fish is unfamiliar to them.

In addition to exporting kabeljou to the United States, other markets should be investigated. Domestic and other international markets may have a demand for kabeljou and could currently be more profitable than the American market. According to Dr. Van Zyl (personal communication, April 27, 2004), there exists a small domestic demand for kabeljou that may be capitalized upon.

2. Investigation into Land-based Facilities

In order to reduce costs of the aquaculture system, further investigation into land-based facilities should be performed. It is possible that new equipment may become available in the near future or that some companies would be interested in selling at a reduced cost if equipment was purchased in bulk. While we identified a variety of fees and major costs, but there may be other, minor costs which could be identified and studied further. Our main focus was on the sheer size of the feed costs. If this cost can be reduced, other costs will have a greater impact on the overall cost of the system.

An example of a technology to investigate is automatic feeders. These machines can be set to disperse quantities of fish feed at regular intervals over single or multiple tanks. These will reduce labour costs and may provide a more efficient means of feeding the fish crop.

3. Fish Feed Manufacturers

The high feed costs in kabeljou aquaculture systems result from international feed shipping costs. It is necessary for Namibia to buy feed from South Africa and Zambia because no local feed companies exist. We recommend investigating the feasibility of establishing a Namibian feed manufacturing plant in order to reduce the shipping fees. This will also provide jobs for Namibians and help the economy.

4. Hatcheries

In addition to the problem of high feed costs, there is no commercial hatchery for kabeljou in Namibia. Any hatcheries that already exist are research scale facilities containing only two or three fish. One reason it is important to have hatcheries in Namibia is that the native Namibian kabeljou population should be utilized. This will prevent genetic pollution of the native population which may occur if kabeljou fingerlings from South Africa or Australia were imported and escaped from an open-ocean aquaculture system. The Namibian government has strict regulations regarding the importation of live organisms, causing this method of supplying fingerlings to be difficult.

Another reason it is important to have Namibian hatcheries is that in order to operate an aquaculture facility and continually produce fish for export, the fish population must be replenished. Kabeljou will be harvested every month and fingerlings are needed to replace these fish. Hatcheries produce fish year-round and, without this steady supply of newly born fish fingerlings, an aquaculture facility will quickly go out of business.

A Namibian hatchery will also provide highly skilled jobs. This will encourage Namibians to receive a higher education in order to enter this job market. Hatcheries will also help the economy.

5. Bioremediation

We recommend investigation into bioremediation in order to increase kabeljou aquaculture profits. Dr. Tyler (personal communication, January 30, 2004) recommends this technique as a way in which organisms are combined in a system to help rid the environment of waste. In a kabeljou aquaculture system, bioremediation can be used to produce an additional product from the fish waste. This may be able to be done by placing filter feeders, like mussels or oysters or an aquatic plant species, into the tank with the kabeljou. One way bioremediation can be useful is by reducing filtering costs in a land-based facility. Organisms like plants and filter feeders, according to Dr. Theunissen (personal communication, March 17, 2004), will clean the water naturally. This technique can also provide another means of income to the facility. If an aquaculture facility is able to produce another marketable product, then it can also be sold for a profit.

6. Benguela Environment Fisheries Interaction and Training (BENEFIT) Partnership

The BENEFIT program will be a positive step for Namibian kabeljou aquaculture because it will allow for a combination of research resources and facilities. An international partnership will prevent unnecessary overlap of research and will also help to share knowledge of kabeljou. This program requires student involvement and training and will provide a chance for Namibian university students to gain practical experience.

Another advantage of the program is that when kabeljou aquaculture becomes feasible and lucrative, it will benefit each country involved in the partnership. There is also potential for the partnered countries to meet the large American demand for kabeljou by combining exports to the United States. This would reduce the size of the aquaculture facility necessary in Namibia.

Initiation of Future Directions

In order to start to implement some of our recommendations, we have contacted a fish feed manufacturer interested in establishing a company in Namibia and a kabeljou researcher interested in the BENEFIT program.

We contacted Mr. Dirk van der Linde (personal communication, April 22, 2004), the managing director of the Aquanutro (pty) Ltd. fish feed company of South Africa, and discussed the development of a fish feed factory in Namibia. He stated that they have made a strategic decision to establish them as the main supplier of fish feed throughout Africa. This goal can only be accomplished by developing more facilities in other

African countries. He also indicated that Aquanutro (pty) Ltd. already supplies several aquaculture facilities in Namibia and the developing aquaculture industry there is a high priority for the company.

Van der Linde claims that there are two ways these companies can be established. The first is by Aquanutro (pty) Ltd. directly investing in a new feed mill. The second, more preferred method is the development of a joint venture between Aquanutro (pty) Ltd. and a feed mill developed in Namibia. The Namibian Minister of Trade and Industry, Jessaya Nyamu, has indicated that joint ventures will benefit Namibia. He feels that they will help the economy and reduce poverty (Barnard, 2004). Aquanutro (pty) Ltd. is interested in sharing risk with and establishing business relationships in Namibia. Advantages of establishing this feed company include easy communication between the feed company and the client and a dramatic reduction of feed prices for Namibia.

We discussed developing a fish feed factory in Namibia and the interests of Mr. van der Linde with Dr. Van Zyl. We also provided Van Zyl with contact information for van der Linde so that they can discuss the development of a feed company. Van Zyl will also be able to direct Mr. van der Linde to companies along the coast of Namibia interested in a joint venture with Aquanutro (pty) Ltd.

In addition to initiating the contact for the development of a large-scale fish feed industry in Namibia, we have also encouraged the development of a research partnership for the study of kabeljou growth as it applies to a hatchery. Dr. Deon Horstmann in Cape Town, South Africa has expressed interest in a partnership with Dr. Van Zyl in order to research kabeljou hatcheries. Van Zyl is also interested in pursuing this partnership and we have established contact between them. In addition, we spoke with Dr. Neville

Sweijd, director of the BENEFIT program, about funding for joint research ventures between Namibia, South Africa, and Angola. Dr. Sweijd stated that BENEFIT is interested in funding aquaculture research projects between these countries and he thinks that a partnership between Horstmann and Van Zyl for kabeljou hatchery research would be an ideal candidate for this funding. Both Horstmann and Van Zyl agreed BENEFIT was an ideal method for establishing their partnership and plan to pursue funding together. Students from the Polytechnic of Namibia will be involved in this research project, along with a researcher from Angola.

References

Attwood, C. (2001, August). Processing at Sea. Fishing Industry News: Southern Africa, 9-10.

Barnard, M. (2004, April 19). New joint venture 'sign of confidence in Walvis Bay' The Namibian. pp. 5

Barnard, M. (2004, April 27). Scottish fishermen cast their nets in Namibia waters. The Namibian. pp. 3

Bureau, D. P., & Cho, C. Y. (1999). An Introduction to Nutrition and Feeding of Fish. Retrieved February 15, 2004, from the World Wide Web: http://www.uoguelph.ca/fishnutrition/feedint.html

CIA World Factbook: Namibia. (2003). Retrieved January 27, 2004 from the World Wide Web: http://www.cia.gov/cia/publications/factbook/geos/wa.html

Durborow, R., Mitchell, A. J., and Crosby, M. D. (1998). Ich (White Spot Disease). Southern Regional Aquaculture Center Publication No. 476. Retrieved February 15, 2004, from the World Wide Web: http://aquanic.org/publicat/usda_rac/efs/srac/476fs.pdf

FAO. (1986). Marketing the Products of Aquaculture. Rome: FAO.

FAO. (2000). Small Ponds Make a Big Difference: Integrating Fish with Crop and Livestock Farming. Rome: FAO.

FAO Fishery Information, Data and Statistics Unit. (2001). World fisheries production, by capture and aquaculture, by country. FAO Yearbook of Fishery Statistics, 92/1. Retrieved January 25, 2004 from the World Wide Web: ftp://ftp.fao.org/fi/stat/summ_01/a-0a.pdf

Fisheries Profile: Namibia. (2001). Retrieved January 25, 2004 from the World Wide Web: http://www.fao.org.fi/fcp/en/NAM/profile.htm

Grizzle, R. E., Chambers, M., Mathieson, A., & Harris, L. (2002) Characterization of the Development of Fish Cage Fouling Communities. CINEMAR/Open Ocean Aquaculture Annual Progress Report for the period 1/01/02 through 12/31/02. Retrieved February 15, 2004, from the World Wide Web: http://ooa.unh.edu/2002_reports/engineering/biofouling/index.html

Halver, J. E. (1970). Nutrition in Marine Aquiculture. In W. J. McNeil (Ed.), Marine Aquiculture (pp. 75-102). Newport, Oregon: Oregon State University Press.

Hossain, Md Shahadat. (2001). Effects of Tributyltin Antifouling Paints on Coastal Ecosystems. Infofish: Malaysia.

International Trade Centre UNCTAD/WTO. (1999). Subregional Trade Expansion in Southern Africa: Supply Survey on Namibia's Fish and Fish Products. Retrieved January 28, 2004 from the World Wide Web: http://www.intracen.org/iatp/surveys/fish/fishnam.html

Johnston, W.A., Nicholson, F.J., Roger, A., & Stroud, G.D. (1994). Freezing and Refrigerated Storage in Fisheries: FAO Fisheries Technical Paper 340. Rome: Food and Agricultural Organization of the United Nations.

Lazur, A. M., & Britt, D. C. (1997). Pond Recirculating Production Systems. Southern Regional Aquaculture Center, 455.

Logsdon, G. (1978). Getting Food From Water. Emmaus, Pennsylvania: Rodale Press.

Losordo, T. M., Masser, M. P., & Rakocy, J. (1998). Recirculating Aquaculture Tank Production Systems: An Overview of Critical Considerations. Southern Regional

Aquaculture Center, 451.

Loverich, G. F. & Gace, L. (1997) The Affect of Currents and Waves on Several Classes of Offshore Sea Cages. Open Ocean Aquaculture, 97. Retrieved February 13, 2004, from the World Wide Web: http://www.oceanspar.com/pages/class%20of%20cages.html

Matthews, S. (2001, April) From Fishing to Fish Fingers. Fishing Industry News: Southern Africa, 25-26.

Ministry of Fisheries and Marine Resources of the Republic of Namibia. (2003). Commencement of the Aquaculture Act, 2002. Windhoek, Namibia: Ministry of Fisheries and Marine Resources.

Ministry of Fisheries and Marine Resources of the Republic of Namibia. (2003). Development Opportunities in Namibia's Aquaculture Sector. Windhoek, Namibia: Ministry of Fisheries and Marine Resources.

Ministry of Fisheries and Marine Resources of the Republic of Namibia. (2004). Namibia's Aquaculture Strategic Plan (Version 6). Windhoek, Namibia: Ministry of Fisheries and Marine Resources.

Ministry of Fisheries and Marine Resources of the Republic of Namibia. (2001). Towards Responsible Development of Aquaculture: Namibia's Aquaculture Policy. Windhoek, Namibia: Ministry of Fisheries and Marine Resources.

The Namibian. (2004, March 31). Fish for Life. The Namibian. pp. 3

Nampa. (2004, April 16). President calls for investment in aquaculture. The Namibian. pp. 8

NRCCATOMA. (1992). Marine Aquaculture: Opportunities for Growth. Washington, D.C.: National Academy Press.

Office of the Prime Minister. (2002). Promulgation of Aquaculture Act. Windhoek, Namibia: Government Gazette of the Republic of Namibia.

Pitcher, G. C. (1999). Proposals for a Harmful Algal Bloom (HAB) Monitoring Programme for Namibia. Republic of Namibia.

Republic of Namibia. (2002). Aquaculture Act, 2002. Windhoek, Namibia: Government Gazette of the Republic of Namibia.

Sinderman, C. J. (1970). Disease and Parasite Problems in Marine Aquaculture. In W. J. McNeil (Ed.), Marine Aquiculture (pp. 103-134). Newport, Oregon: Oregon State University Press.

Subregional Trade Expansion in Southern Africa: Supply Survey on Namibia's Fish and Fish Products. (1999, July – August). International Trade Centre UNCTAD/WTO. Retrieved February 14, 2004, from the World Wide Web: http://www.intracen.org/iatp/surveys/fish/fishnam.html

Sweijd, N. & Britz, P. (2003). Regional Mariculture Research Programme (RMRP). Swakopmund, Namibia: Benguela Environment Fisheries Interaction & Training Programme

U.S. Department of State. (2003). Background Note: Namibia. Washington, DC: U.S. Government Printing Office. Retrieved January 25, 2004 from the World Wide Web: http://www.state.gov/r/pa/ei/bgn/5472.htm

U.S. Environmental Protection Agency. (2002). Estimated Per Capita Fish Consumption in the United States. Retrieved February 15, 2004, from the World Wide Web: http://www.epa.gov/waterscience/fish/consumption_report.pdf

U.S. National Oceanic and Atmospheric Administration, Fisheries Statistics & Economics Division. (2000). Foreign Trade. Retrieved February 15, 2004, from the World Wide Web: http://www.st.nmfs.gov/st1/fus/fus00/07_trade2000.pdf

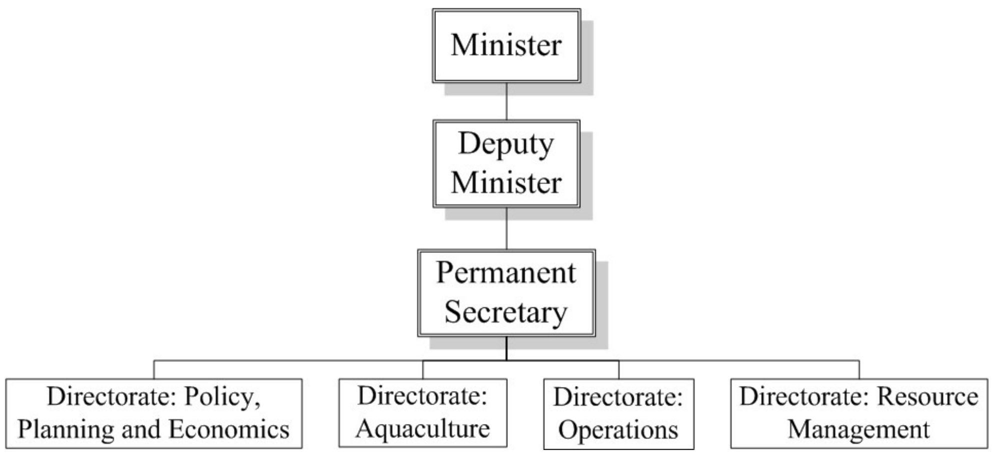
Ultra Cross® Knottless Netting. (2003). Ocean Spar Technologies, LLC. Retrieved February 15, 2004, from the World Wide Web: http://www.oceanspar.com/pages/Netting.html

Weeks, S. J., Bronwen, C., & Bakun, A. (2002, January). Satellite Imaging: Massive Emissions of Toxic Gas in the Atlantic. Nature,415, 493-494.

Appendix A - Ministry of Fisheries and Marine Resources Organization

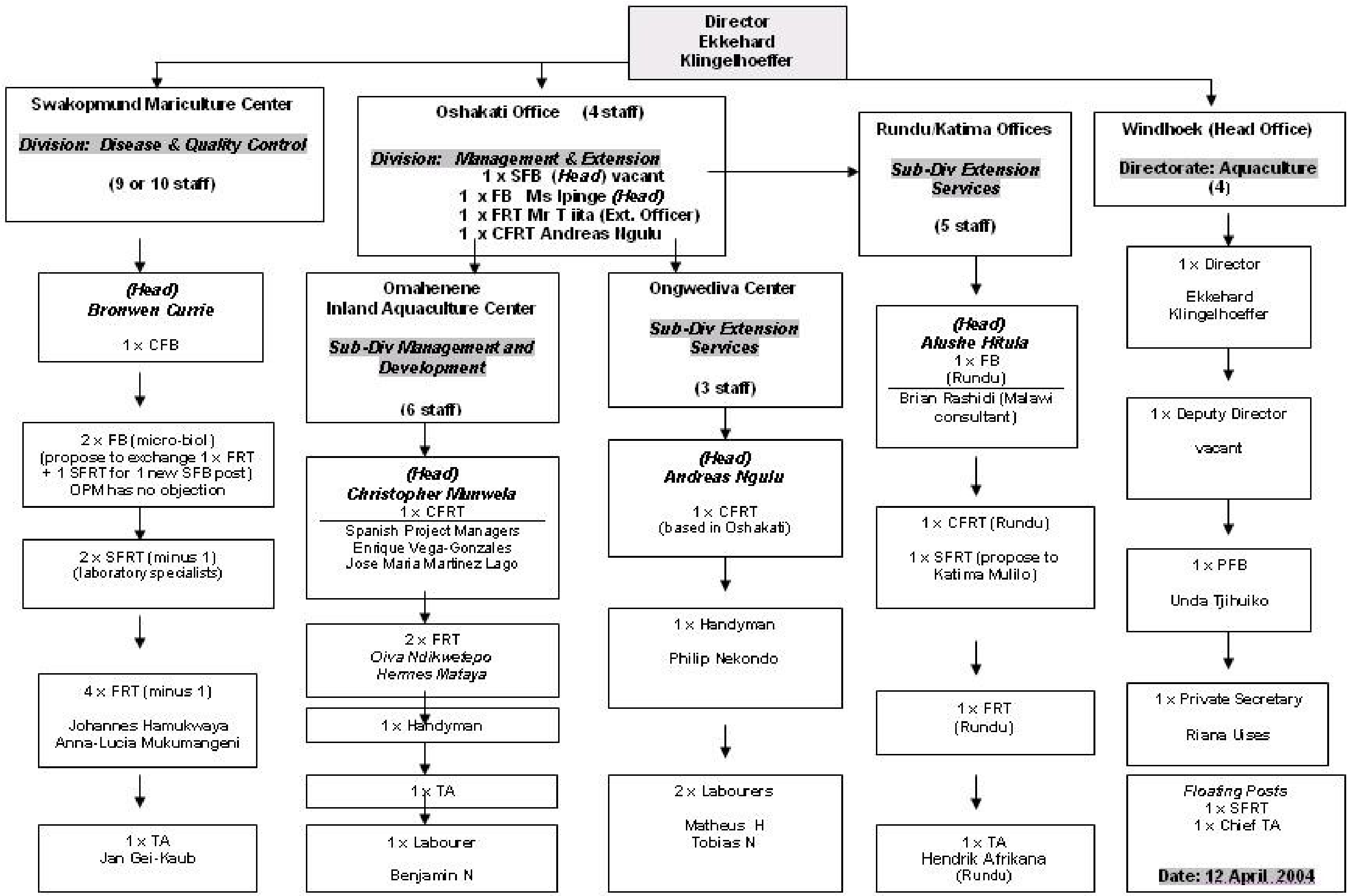
The mission of the Ministry of Fisheries and Marine Resources (MFMR) in Namibia is to "…strengthen Namibia's position as a leading fishing nation and contribute towards the achievement of our economic, social and conservation goals for the benefit of all Namibians" (http://www.mfmr.gov.na, 2004). The ministry is organized as displayed in Figure A1.

Figure A14 - Organizational Structure of MFMR



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 aquaculture facilities. The structure of the Directorate of Aquaculture is shown in Figure A2. 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 the 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. A recently created aquaculture unit does not appear in Figure A2. This unit, created in 2003, promotes aquaculture in Namibia and ensures that local facilities comply with international health standards.

Figure A2 - Organizational Structure of the Directorate of Aquaculture



Adapted from Namibia's Aquaculture Strategic Plan (Version 2)

Our liaison at the MFMR is Dr. Ben Van Zyl, who is a marine biologist and the Deputy Director of Resource Management. He is responsible for regional offices in Luderitz and in Swakopmund, where his office is located. Mr. Ekkehard Klingelhoeffer is the Director of the newly formed Aquaculture Unit and served as a contact at the main office of the MFMR in Windhoek.

Appendix B - Fish Health in Aquaculture

Proper nutrition is vital to any finfish species used in aquaculture. Without it, a variety of problems can arise, including inadequate weight gain, susceptibility to disease, deformation, and cannibalism. According to Prof. Joe DeAlteris (personal communication, February 11, 2004), a professor at the University of Rhode Island, every finfish has different dietary requirements and a feed that is successful in one species may not be successful in another. In addition, each species has a specific daily requirement for protein, vitamins, minerals, and lipids. These requirements can change based on temperature, water quality, and age of the fish (Halver, 1968).

Protein is the major component of fish flesh and is the most important constituent of fish feed (Halver 1968). Protein, a provider of essential amino acids, generally determines the rate of fish growth, so most feed is high in protein. Although protein is beneficial, it is possible for feed to contain excessive protein. This results in elevated concentrations of ammonia in fish excrement. Too much ammonia can create a lethal environment for fish populations in high density, so protein levels are monitored closely (Bureau & Cho, 1999).

Other important components of fish feed are vitamins, minerals, and lipids. Vitamins and minerals are necessary in trace amounts and work as catalysts in fish metabolism. Lipids make up the cell membranes of the finfish. Signs of nutrition deficiency range from stunted growth and skin lesions to shock (Bureau and Cho, 1999).

In order to ensure proper nutrition, fish in an aquaculture system must be fed high quality food that meets their specific dietary requirements. According to Dr. Michael Rice (personal communication, February 11, 2004), of the University of Rhode Island fisheries department, in any aquaculture business, feed accounts for almost one half of all money spent. Mr. Joe Johnson (personal communication, April 8, 2004) and Dr. Ben Van Zyl (personal communication, March 24, 2004), both concur with the assessment of Dr. Rice. There are a variety of fish feeds available for aquaculture systems. According to Dr. DeAlteris (personal communication, February 11, 2004), the two types of feed most commonly used are semi-moist and dry feeds. The article *An Introduction to Nutrition and Feeding of Fish* also emphasizes the two main types of feed, semi-moist and dry, and the advantages and disadvantages of each (Bureau & Cho, 1999).

DeAlteris (personal communication, February 11, 2004) stated that semi-moist feed is made from by-products of other fishing industries and generally contains the raw leftovers from fish processing plants or the local fishing industry. This type of feed is less expensive than a dry feed because it is less processed. Semi-moist feed used in a small-scale aquaculture facility may not be processed at all, while that used in a large-scale facility is subject to a small amount of heat treatment. This does not kill all pathogens, so semi-moist feed has the potential to transmit disease. It is also disadvantageous because it is less compact than traditional dry feed and harder to store. Another drawback of semi-moist feed is its sensitivity to temperature. This means it must be used quickly to prevent spoiling (Bureau & Cho, 1999).

According to DeAlteris (personal communication, February 11, 2004), dry feed is more commonly used in large-scale aquaculture facilities. It is sterilized at high temperatures during production and contains virtually no pathogens. This type of feed is also very easy to store for long periods of time and is resistant to drastic changes in temperature. A problem with dry feed is palatability. Every species of fish accepts a dry food differently and it must be tailored to meet their specific taste and nutritional needs. Another problem is the possibility of poor quality control in manufacturing plants, which could result in contaminated feed (Bureau and Cho, 1999).

Fish disease can occur suddenly and be highly detrimental to any finfish aquaculture facility. In the water, pathogens are able to spread from one organism to another with ease. High-density fish populations are especially susceptible to disease, not only because there are numerous fish capable of carrying a particular pathogen, but also because fish in these conditions are stressed and more susceptible to disease. Some common maladies include white spot disease (Ich), tail rot, and velvet disease (Sindermann, 1968).

Ich is caused by the parasite Ichthyophthyrius multifiliis. This disease is very common and can cause rapid death of entire fish populations. The parasite is usually hard to see until it has progressed to the final stages, where it appears in white spots all over the body of the fish. Symptoms of Ich, when it is in a treatable stage, include refusal to eat and erratic movements made in an attempt by the fish to scratch its body along a rock or ocean floor. Prevention of Ich is almost impossible, but careful introduction of new fish and filtration of land-based systems can decrease the chance of an outbreak. Treatments include chemicals like formalin and potassium permanganate (Durborow, Mitchell, & Crosby, 1998).

Tail rot is another common disease, especially in high-density finfish cultures. It is the most common type of lesion found on finfish. Two sources of tail rot are the pathogens Vibrio and Pseudomonas. Tail rot spreads throughout the tail fin of the fish quickly, causing complete erosion and eventually death. Even if the disease does not cause death, erosion of the tail reduces the quality of the fish. Treatments for tail rot are the same as that for Ich (Sindermann, 1986).

Velvet disease is caused by the parasite Oodinium ocellatum. This parasite usually targets the gills of the finfish, but can eventually spread all over the skin in a yellow, dust-like form which looks like velvet. Velvet disease causes death by interfering with respiration. Treatments include cyanide and copper sulphate (Sindermann 1968).

Appendix C - Finfish Processing

Processing of finfish is necessary for a variety of reasons, including preserving the freshness and shelf life. Another reason is that there is a small demand in the United States (US) for whole fish. Consumers prefer fish fillets, sticks, and patties, and processing provides the market with these products.

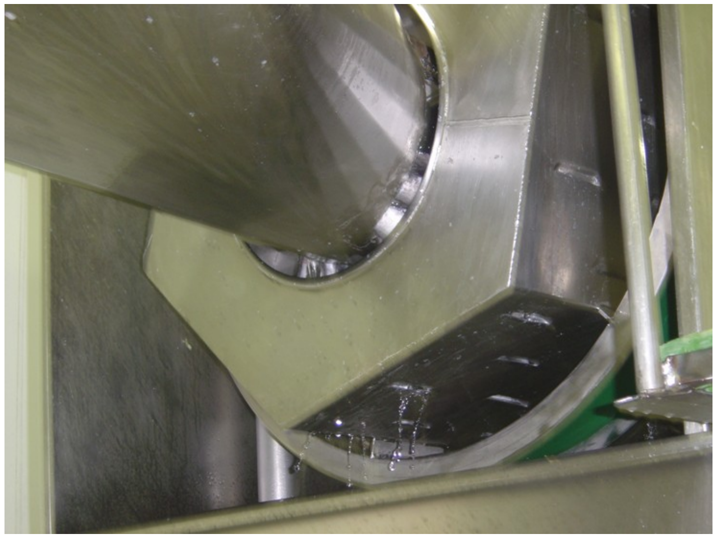
The first step in processing finfish, if it is to be sold in any form other than whole, is removal of guts, head and guts or head, tail, and guts. After this process, the fish is immediately placed on ice. Often, this is done on the boat before the fish arrives at the processing plant. Figure C1 shows the headed and gutted hake from Blue Oceans Products Ltd. and Figure C2 shows the gutted hake from Gendev of Namibia.

Figure C15 - Removal of Head and Guts, Blue Oceans Products, Ltd.

Figure C2 - Removal of Guts, Gendev of Namibia

The first process done in the plant is descaling of fish that are to be sold with the skin on. In order to descale, Blue Oceans Products place the hake in a rotary drum with sharp sides, which then rotates and completely remove all scales from the fish body. Other companies descale in a similar manner. Figure C3 shows the descaling machinery used by Blue Oceans Products Ltd.

Figure C3 - Descaling Machinery, Blue Oceans Products, Ltd.



After all scales are removed, the fish are graded. First, the fish is weighed and then automatically sorted into bins according to the assigned grade. At Blue Oceans Products, this system separates hake into seven categories, category one containing the smallest fish and category seven the largest. The fish are kept in small, plastic bins for a short amount of time. Figure C4 shows the grading scales, conveyer belt, and bins used by Blue Oceans Products. Sea Harvest, a fish processing plant in South Africa, also sorts fish based on grades but their fish are stored in refrigerated bins (Matthews, 2001). Irvine & Johnson, another hake processing company, specializes in on-board processing, which takes place on specially designed freezer boats. Their grading machines, developed by Goldmann Engineering, are highly technological and can store vast amounts of data on fish size and predicted production rates. These machines are extremely fast, with speeds of 100 fish/minute/machine (Attwood, 2001). Grading is necessary in order to ensure the efficiency of machine filleting and also to determine which processes the fish will undertake. If a fish is outside of the grading range, it is not suitable for filleting and will be made into fishmeal. At Gendev of Namibia, the hake is exported whole and is graded by hand with scales. The grading system at Gendev of Namibia includes five ranges 0-1, 1-2, 2-3, 3-4, and 4-5. This grading system is depicted in Figure C5.

Figure C4 - Automated Grading Scale (left) and Bins (right), Blue Oceans Products, Ltd.

Figure C5 - Grading by Hand, Gendev of Namibia

The next step in fish processing is filleting, which can be done either by hand or by machine. Machine filleting, like that shown in Figure C6 at Blue Oceans Products, is useful when a fish has a highly structured rack. Two types of fillet include the standard and the J-cut, which results from removal of the pin bone of the fish (Atwood, 2001). Hand filleting, done with orange roughy at Gendor of Walvis Bay, is useful for fish with less structured racks where careful attention is necessary to remove all bones. After orange roughy is hand filleted, it is deep-skinned by machine. Along with removing the skin, this process also removes a layer of fat under the skin. Ms. Morrison (personal communication, April 7, 2004) claims that this layer of fat does not taste good and is not easily digested. She also indicated that the fat deteriorates faster than the flesh of the fish and removing it extends the shelf life.

Figure C6 - Machine Filleting, Blue Oceans Products, Ltd.

After fillets are cut, they must be trimmed by hand. Trimming is necessary to remove excess skin or discoloration around the edges of the fillet. While a fillet is being trimmed, it is also being inspected for any leftover bones or poor quality. Figure C7 shows hand trimming at Blue Oceans Products. Hand trimming is necessary with all fish fillets.

Figure C7 - Hand Trimming, Blue Oceans Products, Ltd.

The trimmed fillets travel down the processing line and are separated by quality. At Blue Oceans Products Ltd, high quality fillets are wrapped in clear plastic while lower quality fillets are wrapped in translucent blue plastic.

Quality checks are done on packaged fish before freezing. At Blue Oceans Products, these quality checks are not done on every box but are done on random boxes. Fish fillets are removed, unwrapped and evaluated for size, texture, coloration, and contamination. At Gendev of Namibia, each fish is checked for quality by close inspection of gill colour as shown in Figure C8.

Figure C8 - Quality Inspection, Gendev of Namibia

The wrapped fillets from Blue Oceans Products are packaged together in a box. Boxes are imprinted with a company logo and are ready to be frozen immediately as shown in Figure C9. At Gendev of Namibia, whole hake are packaged together in insulated boxes filled with crushed ice. Gendor shatter packs orange roughy fillets for freezing and then separates them into one or two pound bags, which are ready for resale in supermarkets.

Figure C9 - Packaging, Blue Oceans Products, Ltd.

Importance of Cooling

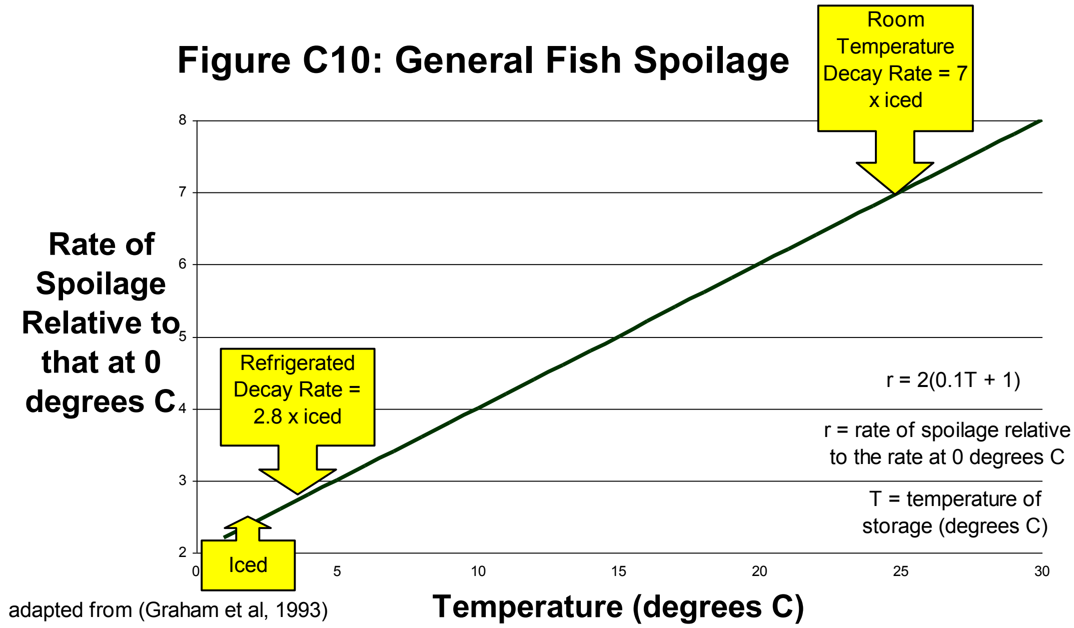
Cooling is one of the most important aspects of finfish processing. Without adequate cooling, fresh finfish will decompose rapidly. Fresh fish properly placed on ice without processing or deep-freezing will spoil within fourteen days. Table C1 shows the four stages of spoiling and by stage four, the fish is inedible. Therefore, it is necessary to keep it well cooled throughout these fourteen days in order to preserve the product in the early stages of freshness (Graham et al 1993).

Table C1 - Deterioration Phases of Marine Fish in Ice

	Time (days)	Characteristics
Phase 1	0-6	minor loss of natural taste and smell
Phase 2	7-10	major loss of natural taste and smell
Phase 3	11-14	stale taste, unpleasant smell, visible signs of spoilage present
Phase 4	over 14	rotten taste, putrid smell

adapted from (Graham et al, 1993)

Ideally, fresh fish should be kept at 0°C in order to preserve quality and taste. If preservation longer than fourteen days is necessary, as is the case with kabeljou, deep-freezing will keep fish edible for much longer periods of time. Often, deep-frozen products are processed more than the typical fresh-frozen fillet in order to preserve quality and taste. Figure C10 shows the decay rate of finfish at a range of temperatures relative to the decay rate of iced fish at 0°C. This rate is directly related to the temperature of the fish. At refrigerated temperatures, fish decays 2.8 times faster than iced fish and at room temperature, fish decays 7 times faster than iced fish (Graham et al 1993).

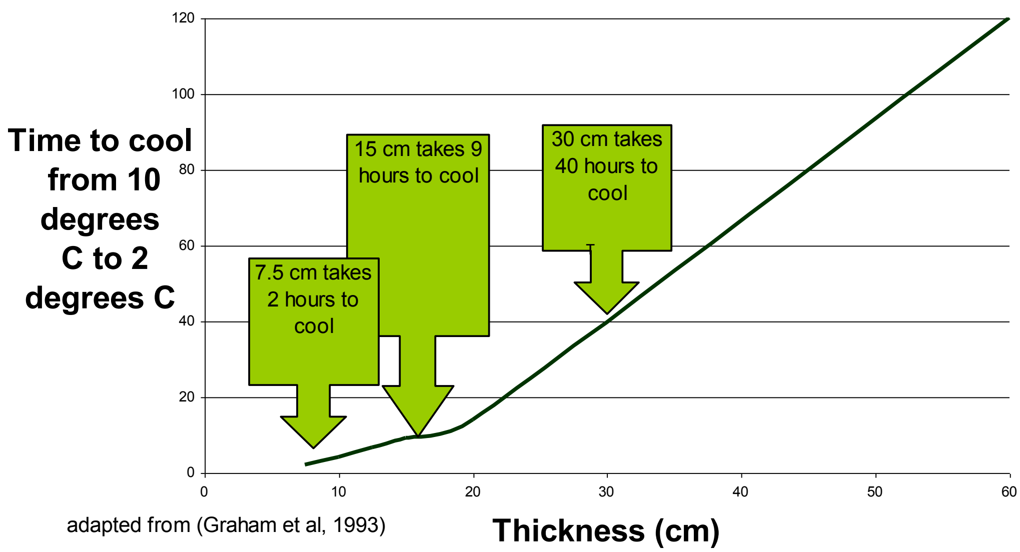


If fish is to be frozen for long-term storage, it must go from 0°C to -5°C within two hours after processing (Graham et al, 1993). According to Dr. Gert Cloete (personal communication, March 24, 2004) of Blue Oceans Products, fillets frozen for short-term storage should be brought to -24°C within 3 hours to prevent detrimental moisture loss.

Ice and Refrigeration

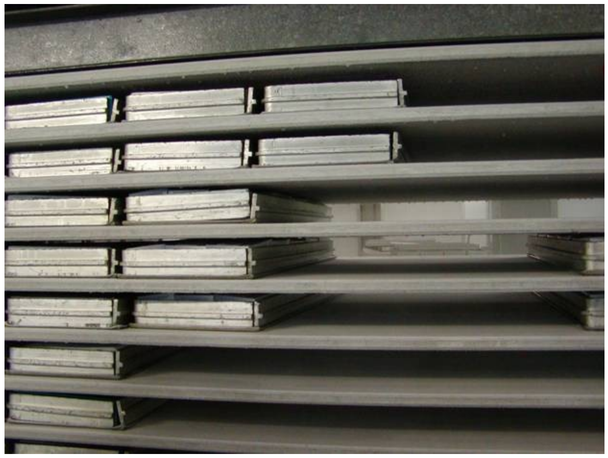
The most popular material to cool finfish is ice, which is available in a variety of forms including block, crushed, flake, tube, plate, and seawater. Forms like plate, block, and tube must be crushed before they can be used for fish. Flake and seawater ice are ready to use for finfish storage. Ice is used in three distinct stages, including when the fish is brought onto the boat, when it arrives at the processing plant, and when it is finished processing. It has been estimated that for every kilogram of fish processed, five kilograms of ice are required (Graham et al, 1993). Gendev of Namibia uses crushed ice on all surfaces of hake inside insulated boxes to keep it cool because layering crushed ice only on top of the product will not provide enough cooling to the fish on the insides of the stack due to the amount of material the heat must pass through. Figure C11 shows the rate of cooling for fish at the centre of different size stacks (Graham et al, 1993).

Figure C11: Thickness of Fish Versus Time to Cool



Two popular methods of freezing fish include plate freezers and blast freezers. A plate freezer is useful for finished boxes of hake fillets because this type of freezer presses all of the boxes to a uniform shape. The plate freezer used by Blue Ocean Products for hake fillets, is shown in Figure C12. According to Dr. Cloete (personal communication, March 24, 2004), these freezers have a high area of contact with the fish and they are able to cool to -25°C within three hours. At Gendor, hake fillets are placed in eleven kilogram boxes before plate freezing.

Figure C12 - Plate Freezer, Blue Oceans Products, Ltd.



The other popular freezer used in the fish processing industry is a blast freezer. These freezers are small rooms with a continuous flow of cool air. Fish product must be arranged in such a way that there is equal, fast cooling. Often, the best arrangement is found by experimentation (Johnston et al, 1994). Blast freezers are used at Gendor to freeze orange roughy because this fish cannot be pressed in a plate freezer. According to Morrison (personal communication, April 7, 2004), blast freezers do not provide the high area of contact possible in a plate freezer and are only cool to negative eighteen degrees Celsius within eight hours.

Appendix D - Data Analysis Calculations

Land-based system calculations

Tanks required for the System

Volume of tank: 426 m^3
Quantity of fillets required per month: 140 tons
Dressing percentage: 40%
Stocking Density: 16 kg/m^3
Cycles per year: 1.5

Number of tanks = (Quantity of fillets per month / Dressing Percentage x 12 months) / (Stocking Density x Volume of tank x Cycles per year) = (140 000 / 0.4 x 12) / (16 x 426 x 1.5) = 411 tanks

Tank Depreciation per Year

Initial cost of 426 m^3 volume tank: N$69 100
Useful life of tank: 25 years
Tanks: 411

Depreciation of 426 m^3 volume tank = (Cost of tank / lifespan of tank x Tanks) = N$69 100 / 25 x 411 = N$1 136 004

Tank Lining Depreciation per Year

Initial cost of tank lining: N$18 000
Useful life of tank lining: 10 years
Tanks: 411

Depreciation of tank lining = (Cost of tank lining / lifespan of tank lining x Tanks) = N$18 000 / 10 x 411 = N$739 800

Pumps required for the System

Tanks: 411
Pump Rated Flow: 17 m^3/hr
Tank Volume: 426 m^3
Percent Volume Replaced per Day: 25%

Pumps = (Tanks / (Pump Rated Flow / ((Tank Volume x Volume Replaced) / 24))) = (411 / (17 / ((426 x 0.25) / 24))) = 137

Pump Depreciation and Operation Cost per Year

Initial cost of Grundfos SP17-1, 380Volt submersible pump: N$6 300
Useful life of active pump: 4 years
Useful life of backup pump: 25 years
Monthly operation cost of active pump: N$48
Active Pumps: 137
Backup Pumps: 137

Depreciation of active pump = (Cost of pump / lifespan of active pump) x Active Pumps = (N$6 300 / 4) x 137 = N$215 775
Depreciation of backup pump = (Cost of pump / lifespan of backup pump) x Backup Pumps = N$6 300 / 25 x 137= N$34 524
Annual operation cost of active pump = (Monthly operation cost x 12 months x Active Pumps) = N$48 x 12 x 137 = N$78 912

Pump Electricity

Electricity Charge: N$0.12/kWhr
Pump Rated Power: 0.55 kW
Pumps: 137

Electricity = (Electricity Charge x Pump Rated Power x Pumps x 24 hrs/day x 365 days) = (N$0.12 x 0.55 x 137 x 24 x 365) = N$79 208

Filter Depreciation per Year

Initial cost of Sand Filter: N$100 000
Initial cost of Biological Filter: N$50 000
Initial cost of UV Bacteria Filter: N$1 000
Cost of replacement UV Bulb: N$500
Useful life of UV Bulb: 2 years
Useful life of Sand Filter, Biological Filter, and UV Bacteria Filter: 25 years

Depreciation of Sand Filter = N$100 000 / 25 = N$4 000
Depreciation of Biological Filter = N$50 000 / 25 = N$2 000
Depreciation of UV Bacteria Filter = N$1 000 / 25 = N$40
Annual UV Bacteria Filter maintenance cost = N$500 / 2 = N$250

Pipe Depreciation per Year

Initial cost per metre of 25 centimetre diameter pipe: N$50
Useful life of pipe: 25 years
Metres of pipe per pump: 100 m
Pumps: 137

Depreciation of pipe = (Cost of pipe / lifespan of pipe x Metres of pipe x Pumps)
= N$50 / 25 x 100 x 137 = N$27 400

Labour

Wage for Supervisor per month = N$4000
Wage for Attendant per month = N$2000
Number of Attendants for 411 tanks = 240
Number of Supervisors for 240 Attendants = 12

Total Labour Costs = (((Number of Attendants x Wage for Attendant per month) + (Number of Supervisors x Wage for Supervisor per month)) x 12 months) = (((240 x N$2000) + (12 x N$4000)) x 12 months) = N$6 336 000

Open-ocean system calculations

Cages Required for System

Volume of cage: 340 m^3
Quantity of fillets required per month: 140 tons
Dressing percentage: 40%
Stocking Density: 16 kg/m^3
Cycles per year: 1.5

Number of cages = (Quantity of fillets per month / Dressing Percentage x 12 months) / (Stocking Density x Volume of cage x Cycles per year) = (140 000 / 0.4 x 12) / (16 x 340 x 1.5) = 515 cages

Surface Floating Ring Depreciation per Year

Initial cost of 12 m diameter floating ring structure: N$36 787
Useful life of floating ring structure: 25 years
Cages: 515

Depreciation of floating ring structure = (Cost of ring / lifespan of ring x Cages)
= (N$36 787 / 25 x 515) = N$757 812

Netting Depreciation per Year

Initial cost of 227 m^2 of 25 mm mesh netting: N$13 795
Useful life of netting: 25 years
Cages: 515

Depreciation of netting = (Cost of netting / lifespan of netting x Cages) = (N$13 795 / 25 x 515) = N$284 177

Boat Depreciation, Insurance, and Operation Costs per Year

Initial cost of 8 metre catamaran: N$180 000
Monthly insurance cost: N$900
Monthly operation cost: N$1 650
Monthly maintenance cost: N$80 000
Useful life of catamaran: 20 years

Depreciation of catamaran = N$180 000 / 20 = N$9 000
Annual insurance cost = N$900 x 12 = N$10 800
Annual operation cost = N$1 650 x 12 = N$19 800
Annual maintenance cost = N$80 000 x 12 = N$960 000

Labour

Wage for Supervisor per month = N$4000
Wage for Attendant per month = N$2000
Number of Attendants for 520 cages or tanks = 300
Number of Supervisors for 300 Attendants = 15

Total Labour Costs = (((Number of Attendants x Wage for Attendant per month) + (Number of Supervisors x Wage for Supervisor per month)) x 12 months) = (((300 x N$2000) + (15 x N$4000)) x 12 months) = N$7 920 000

Universal cost calculations

Truck Depreciation, Insurance, and Operation Costs per Year

Initial cost of pickup truck: N$120 000
Monthly insurance cost: N$600
Monthly operation cost: N$2 000
Monthly maintenance cost: N$500
Useful life of truck: 5 years

Depreciation of truck = N$120 000 / 5 = N$24 000
Annual insurance cost = N$600 x 12 = N$7 200
Annual operation cost = N$2 000 x 12 = N$24 000
Annual maintenance cost = N$500 x 12 = N$6 000

Fingerlings

Initial kabeljou fingerling cost: N$0.30
Percent of surviving fingerlings: 90%
Total mass of fillets per year: 1 680 000
Dressing percentage: 40%
Mass of harvested fish: 0.64 kg

Quantity of fingerlings necessary per year = ((Total mass of fillets / Dressing percentage) / (Mass of fish x Survival rate)) = ((1 680 000 / 0.4) / (0.64 x 0.9)) = 7 291 667

Annual cost of fingerlings = Initial fingerling cost x Quantity of fingerlings necessary per year = 0.3 x 7 291 667 = N$2 187 500

Fish Feed

Ratio of kabeljou fingerlings to total kabeljou in one aquaculture system: 3/8
Ratio of kabeljou adult to total kabeljou in one aquaculture system: 5/8
Average number of total fish per year: 6 998 334
Mass of each fingerling: 100 g
Mass of each adult fish: 640 g
Food Conversion Ratio (FCR): 1.7:1
Cost of fingerling food with shipping per kg: N$11.45
Cost of adult food with shipping per kg: N$11.20

Cost of feed for fingerlings = (Ratio of kabeljou fingerlings x average total number of fish per year x mass of each fingerling x FCR x cost of fingerling food) = (3/8 x 6 998 334 fish x 0.100 kg/fish x 1.7 x N$11.45/kg) = N$5 176 458

Cost of feed for adults = (Ratio of kabeljou adults x average total number of fish per year x mass of each adult x FCR x cost of adult food) = (5/8 x 6 998 334 fish x 0.640 kg/fish x 1.7 x N$11.20/kg) = N$52 872 917

Cost of feed total = (Cost of feed for fingerlings + Cost of feed for adults) = (N$5 176 458 + N$52 872 917) = N$58 490 375

Production

Production cost per kg of fillet = N$5.50
Annual kg of fillet = 1 680 000

Total production cost = (Total kg of fillet x Production Cost per kg) = (1 680 000 x N$6.50) = N$9 240 000

Shipping Frozen

Cost to ship frozen per kg of fillet = N$2.88
Annual kg of fillet = 1 680 000

Total shipping cost = (Total kg of fillet x Shipping cost per kg) = (1 680 000 x N$2.88) = N$4 838 400

Appendix E - Interviews

Kobus Alberts

Position: Chief Technician of the Swakopmund National Marine Aquarium
Location: Swakopmund, Namibia
Date: April 7th, 2004 at 11:00am

Aquaculture system mechanics

The action of pumping increases the temperature of the water entering a system. In the aquarium, the water flow rate is 0.9 litres per second. The aquarium is semi re-circulatory, pumping in some water from the ocean while re-circulating a large quantity of water in the system. Approximately twenty-five percent of the water in the aquarium tank is replaced each day.

Water from the ocean needs to be filtered before entering the system and after leaving the system before entering the ocean again. The aquarium uses a flocculent column with foam fractionators to remove sediment particles from the ocean. The foam fractionators releases protein bubbles into the flocculent column where the water from the ocean passes through before entering the aquarium tank. The protein bubbles collect the sediment particles and rise to the surface of the flocculent column, preventing the sediment from entering the aquarium tank. This system is unnecessarily elaborate for an aquaculture facility and for such a facility a simple sand filter is acceptable for sediment filtration.

Frikkie Botes and Anneke Van der Westhuizen

Position: Managing Director of Entheos Aquaculture (Pty) Ltd.
Location: Swakopmund, Namibia
Telephone: (+264-64) 40-2273
E-mail: fwbotes@iway.na
Date: April 13, 2004 2:00pm

Potential Problems for Aquaculture in Namibia

The Swakopmund Municipality is not likely to give land close to the ocean to aquaculture facilities because it is a prime residential development area. As for predator protection, in Australia, double netting is used to protect the fish stock from cormorants. Sharks are not an issue around Walvis Bay and Swakopmund. The only shark in the area is the cow shark but it feeds on crustaceans. Sharks are only a problem in Luderitz. A problem for land-based flow-through systems is the variability of water quality.

Kabeljou characteristics

Kabeljou are not active swimmers.

Aquaculture and Industry

Land-based systems should be better for kabeljou aquaculture since they allow the farmer to have complete control over the environment of the fish for optimization of growth. There is a local demand for kabeljou along the coast. The Walvis Bay airport is currently being upgraded in order to support direct flight cargo planes to other countries. Hong Kong is interested in kabeljou but the interest is in bigger fish of six to eight kilograms in the form of chopped steaks.

Contacts

I&J Company, Nick C. Loubser, Farm Manager of the Abalone Culture Division is located in Cape Town. His email is nickl@ij.co.za and his telephone number is (+002-728) 384-1371.

For filtration systems in Namibia contact Christian Stöck, the Managing Director of Aqua Services and Engineering (Pty) Ltd.. His email address is ase@ase.com.na, his office number is (+264-61) 26-1143, and his cell phone number is (+264-81) 127-1143.

Another contact is Bernd Izko of the EcoTech Company in Windhoek. Another place to investigate is the AquaOptima company website at aquaoptima.com.

Dr. Gert Cloete

Position: Factory Manager of Blue Ocean Products (Pty) Ltd.
Location: Walvis Bay, Namibia
Telephone: (+264-64) 21-9100
E-mail: gert@erongo.co.za
Date: March 24, 2004 9:25am

Blue Oceans Products Ltd. information

Blue Oceans Products has been around since January of 2001. The company processes 7,000 tons of hake annually and ninety eight percent is exported to other countries. Half of the processed hake exits as fillets while the other half ends up as fish meal.

There are a total of 460 people employed including 180 day-shift workers and 120 night-shift workers. The other workers are employed on fishing vessels or in the offices. One shift lasts nine hours but when breaks are included, work is only done for about 7.5 hours per shift.

Hake Processing Specifics

The cost analysis of a process is determined by working backwards from the market to the fishing vessel. One major concern is transportation of the processed product. Blue

Oceans Products Ltd transports the majority of their product on anywhere from four to eight container ships each week.

The actual catching of the fish is sixty to seventy percent of the end cost. Blue Oceans Products Ltd. owns four fishing vessels, one holding 150 tons, two holding 105 tons, and a third holding sixty tons.

Kabeljou Processing

As far as processing kabeljou is concerned, hand filleting would be the most logical option. The structure and size of kabeljou will make it impossible to use machine filleting without a lot of unnecessary wasted meat. Bottlenecks in the process will most likely be time taken to hand fillet and freezing capacity. The fish must be brought down to negative twenty four degrees Celsius within three hours to prevent major dehydration.

Joe DeAlteris

Position: Professor at the University of Rhode Island East Farm Fisheries Facility
Location: South Kingstown, Rhode Island, USA
Date: February 11, 2004 2:00 pm

Fish Feed

Food accounts for about one third of the cost of any aquaculture facility. One major decision is the use of dry versus wet food. Larger enterprises must use dry food because it is available in huge quantities. Food must be nutritious and cheap. Filter feeders are the easiest to feed. PCB's are only a concern when you are getting your food from a polluted source. In a place like Namibia, where there is almost no pollution, there are not many concerns about PCB contamination in finfish. In places like Chile and Namibia, there are three advantages, including clean water, cheap labour, and abundant fish.

Land-based Systems

Land-based systems require a lot of electricity to run and this can be very costly. They are also highly technical and failures can be drastic. Net pens in the ocean are fairly easy to construct and not too hard to maintain. There is no energy cost associated with cages.

Open-ocean Systems

A good place for open-ocean systems is one without a lot of waves and without a strong current. There must be some sort of current to wash away waste. There needs to be a balance between the ecosystem and the fish.

Factors affecting aquaculture

The infrastructure of the country is very important. It is necessary to export the fish fresh, so regular plane service is a must. There must also be a good system of roads, refrigerated trucks, and a port. Canned fish have virtually no market in the US and EU, so that is not an option. A place like Namibia should try producing the fish for local consumption before attempting to globalise.

Wayne Hart and Louisa Maree

Position (Wayne Hart): Owner of Freddie Fish Processors
Position (Louisa Maree): General Manager of Freddie Fish Processors
Telephone: +264-64-204541
E-mail (Wayne Hart): namcoast@iway.na
E-mail (Louisa Maree): ffpmaree@iway.na
Location: Walvis Bay, Namibia
Date: April 7, 2004 10:00am

Methods of kabeljou processing

At Freddie Fish Processors, sea frozen kabeljou is processed head off, guts out, tail on. Wet kabeljou, meaning the fish is not frozen because there is no refrigeration on board, is processed head on, guts out. The tail is left on the fish because Freddie Fish mainly exports to Portugal and this is the Portuguese preference. The frozen kabeljou is processed at sea and one boat can stay out for one or two months at a time. About thirty tons of kabeljou are processed every month but there are only about three months each year when kabeljou can be found in the waters off the coast of Namibia. Kabeljou stocks are declining each year.

US fish preference

Americans prefer skinless, boneless, white meat. Kabeljou is a bony fish and the meat can be reddish from all the blood in the fish so the possibility of a US market is questionable. The taste of kabeljou is not dependent on whether it is grown on land or in the sea.

Thomas Hecht

Position: Professor of Ichthyology at Rhodes University
Email: T.Hecht@ru.ac.za
Location: Grahamstown, South Africa
Date: April 1, 2004 9:30 am

Aquaculture systems

In any open-ocean system, multiple cages are required in order to separate fish by size. At least three cages must be in operation. The cost of a twelve metre diameter cage is approximately R25,000 - 30,000, though these cages can be up to twenty five metres in diameter. Cages make it difficult to size sort fish and it is extremely important to have fish at the same market size. Cages are capable of producing huge volumes but it is hard to market when fish are different sizes. They may not be practical because of issues in product quality. Factors that need to be taken into account for an open-ocean system include current, rate of exchange, and depth. A three metres cage should be placed in fifteen to sixteen metres of water. The number of cages that are able to fit in Walvis Bay must be determined to quantify the amount of kabeljou that can theoretically be produced. Cage companies are mainly located in Norway, Denmark, and England. Cages are a fixed cost, with anchoring systems being the major variable cost. Anchoring systems depend on the height, frequency, and amplitude of waves. Boating costs are analogous to electricity costs in land-based systems and can be lowered through automation. Major costs of open-ocean systems are food, labour, and boating. Biofouling is a problem in open-ocean systems and can be combated with double netting and washing facilities. Other problems include seal and human predation.

Tank systems provide more control, but higher costs. The higher degree of control is necessary for Namibia because of the small quantity of fish that will be produced must be high quality. Most aquaculture is done in high quantity, such as salmon. Land-based abalone systems use 80,000 cubic metres of water each day. Pumps are required for these systems and can be axial, centrifugal, or solar. The electrical cost of the pumps depends on the head and pipe diameter. All water in the tanks must be replaced every two hours. Systems must be certified ISO 9000 in the United States. Land-based systems have major costs of food, labour, and electricity.

The cost of fish feed is a major cost for both systems and must be researched. The WPK/Aquanutro Company has information about feed costs. Transportation costs must also be factored into the analysis.

Industry Involvement

Aquaculture is a “dead duck” without industrial involvement. In places like South Africa and Australia, R500,000 has already been spent on spawning technology research. No government has adequate funds to fully finance all the research and development involved in establishing an aquaculture industry. Therefore, industry must be involved in the process through incentives. The government must find ways to encourage corporate involvement in development of kabeljou aquaculture. Government funds often disappear into over-engineering. Also, government workers are paid on salary, regardless of their level of success. Incentives can not be established for them because that would lead to corruption, so industry must pick up the slack. Research done by Dr. Van Zyl must be recognized in the corporate world as a starting point for development. The Namibian government has all the policies in place, but a strategy is required. The Norwegians are currently aiding Namibia in this aspect.

Aquaculture Benefits

Aquaculture will not serve as a means of poverty alleviation. Initially, some jobs may be provided, but successful enterprises quickly switch to a fully automated system. This results in an eighty-five percent reduction of the workforce. However, aquaculture may be linked to diamond mining towns so that the people that live there will have an alternative job opportunity when the mines run out of diamonds.

Kabeljou

Dusky kob (Argyrosomus coronus) reaches sexual maturity at four to five years, weighing ten to twelve kilograms. All kabeljou are harvested before sexual maturity because they are too large for any market when they reach maturity. The growth rate of kabeljou grown in tanks was slower than those grown in cages, but this may have been due to the size limitations of the tank. Cage-cultured fish can have reduction in quality from scale damage, fin rot, and blindness due to the fish swimming in a circle. The optimal stocking density of kabeljou is sixteen kilograms per cubic metre. The fingerling mortality rate is two percent prior to the twenty to thirty grams juvenile stage. The nutrition requirements for zero to three months (twenty to one hundred grams) are forty-two percent protein with twenty-five percent soy and seventy-five percent fish, nine percent lipid, AAA grade for European Union regulations and costs about R6,000/ton. Growing from 100 grams to market size, nutritional requirements are thirty-eight percent protein, nine percent lipids, and cost about R5,800 per ton. The diet of rainbow trout can serve as an analogue for kabeljou diet. The food conversion ratio for kabeljou is 1.7:1. They must be fed four percent of their body weight twice per day. Dusky kabeljou can reach a size of one kilogram in about ten months and 1.8 kg in sixteen months. Silver kabeljou (Argyrosomus japonicus) takes two years to grow to a size of one kilogram.

Processing kabeljou will most likely require hand filleting because their bone structure is less developed than other fish like hake. Machine filleting will be too wasteful and produce a lower quality product.

Market

France could be a large market for kabeljou because the supply of a similar local fish is declining and kabeljou could be used as a replacement. However, the French market is very strict in the quality of fish that is accepted. Any deformities in scales, eyesight, or fins cause the fish to be immediately cast aside. There also is a ten gram size difference that is allowable for salmon. The production and marketing of sea-bass in the Mediterranean is a good example of aquaculture. French land cultured sea-bass fetch three times the price that Greek cage cultured sea-bass does.

Every market has different preferences in preparation of fish. In the US, hake must be lightly skinned, while in the EU it is medium skinned and Australia prefers deep-skinned. A US market preference study must be performed. A smaller amount of fish sold to a sophisticated market may make more money than a larger quantity sold to a less sophisticated market. New York is a possible sophisticated market due to direct flights from Africa. Only 2,000 – 3,000 tonnes of kabeljou may be produced a year, so a niche market is more desirable. The most important concerns with marketing are identification and product maximization. The size of fish usually required range from 0.8 to 1.5 kilograms.

Dr. Willem Jankowitz

Position: Professor of botany at the Polytechnic of Namibia.
Location: Windhoek, Namibia
Date: March 16, 2004 11:00 am

Fishing in Namibia

The coast of Namibia has a variety of restrictions because of the mining industry. The entire skeleton coast is protected along with areas south of Walvis Bay. Fishable areas include Torra Bay in the Namibian summer, Terrace Bay, and Henties Bay. The Polytechnic of Namibia has a research facility at Henties Bay which is also a community fishing sight.

Fish populations along the coast are disappearing and it would be a good idea to shut down even more areas along the coast in order to let populations regulate themselves.

Many local fisherman use illegal bait, such as worms and white mussels. This is a problem because these populations are dwindling. Legal bait includes smaller fish like pilchards or sardines, but these are not as appealing to the fish as worms or mussels.

Kabeljou and Aquaculture

Kabeljou is the major angling fish of Namibia but it is being over-fished by South African tourists and community fishermen. Presently, Kabeljou must be at least forty centimetres to catch but current research is showing the fish should reach sixty centimetres in order to breed effectively. Aquaculture could provide a solution to this problem and provide fish to the tourism industry.

Joe Johnson

Position: Director of the Namibia Aquaculture Company (NamAqua)
Location: Walvis Bay, Namibia
Telephone: (+264-81) 124-5299
Email: namoyster@mweb.com.na
Date: April 8th, 2004 at 12:00pm

Aquaculture in the Benguela currents

A major issue with aquaculture systems in or using the water from the Benguela currents is the quantity of algae. In about three months mesh netting twenty-five millimetres in mesh size is half clogged, fully clogged in five months. He does not know of any antifouling coating that can survive the salinity of these waters. Even more of a concern with fouling is not the algae but an invading species of mussel known as Semi mytillus. By his reckoning it is ten times worse than plant fouling and is significantly worse in the winter season of Namibia. These mussels are known to attach to abalone fish, eventually resulting in the death of the abalone.

Predators are another concern for open-ocean systems. Seals are not as much of an issue since there are deterrent systems on the market. Sharks are an issue however since they will easily tear through netting. Double netting around cages will not help against shark attacks. Stainless steel mesh wire netting with six inch mesh positioned outside the fish cage might prevent shark entry, however the water salinity would require the steel to be replaced every three to four years. Stainless steel wire netting is expensive so alternatives should be explored, if they exist. Cormorants are also a concern as predators. Enclosed cages close to the surface will keep cormorants out, however the cormorants will watch the fish in the cage resulting in psychological trauma to the fish. This will adversely affect the quality of fish being produced, thus it is important to consider erecting cormorant deterrents.

Recirculation system costs

Recirculation system is the most economical for land-based systems. Flow-through system pumping on the large scale is not physically possible. For 6,500 kabeljou fingerlings per month over twelve months: 6,500 x 12 months x 350 g = 273 tons of kabeljou. Approximately 17,000 Litres of water are necessary, resulting in 4,265 cubic metres of water being pumped per day, 355 cubic metres of water per hour. This is not possible thus recirculation systems are the alternative.

Recirculation systems require sand filters (for sediment), biofilters (for nitrogen and ammonium), and Ultra Violet bacteria filter. Sand filters cost N$100,000 and biofilters cost N$50,000. Sand filters just need to be backwashed for cleaning while biofilters require no cleaning. Water should be pumped through these filters twice a day. As for bacteria filters, they should have a flow rate of no more than forty litres per minute filtering all of the water every forty-eight hours. The cost of the bacteria filter is N$1000 and every year the bulb needs to be changed; the bulb costs N$500. Thus the cost of the bacteria filter will be N$250 every year.

In addition to the system costs you also need to get the seawater to the system. For this it is important to have a powerful enough pump and enough piping. A pump for the systems we are looking at would need to be of thirty horsepower, capable of delivering seventy cubic metres of water per hour, and would cost N$60,000. Two would be needed, a main pump and a backup pump. With electricity costs being N$0.12 per kilowatt-hour, the monthly fuel cost would be N$2,500. These pumps last about four to five years and require N$500 per month for maintenance. The pipeline would be at most one kilometre from the ocean with a twenty-five centimetre diameter and 250 millilitres of throughput. This pipeline will cost about N$50 per metre.

Additional aquaculture costs and maintenance

With any aquaculture system you need hired labour to manage the facility operations and vehicles to transport equipment and fish to and from the facility. For both systems a supervisor and three attendants would at most be required. A supervisor costs N$4,000 per month while each attendant will cost N$2,000 per month. These costs are not very variable. A pickup truck will cost N$120,000 second hand with fuel costs equating to N$2,000 a month and maintenance costing an additional N$500 a month.

Open-ocean systems have additional costs through boats and boating equipment. For a facility of approximately 300 cubic metres, an eight metre catamaran is suitable. The whole boat will cost N$180,000. Daily running cost of the boat will be N$50-60 while fuel and maintenance will add N$8,000 per month to the cost of the system.

Kabeljou are plankton eaters when they are older, so biofouling will not be a considerable issue in the later stages of the grow-out phase. For the initial growth stages, the netting could be cleaned directly on the boat with a high pressure hose saving time and money in netting maintenance.

Insurance is another cost to be factored into the total system cost. Currently there is no insurance for aquaculture companies in Namibia. However, there are car and boat insurance costs. For a car costing N$120,000 the insurance will be N$600 per month. That conversion is equivalent for boat insurance costs. These costs are fairly constant.

Ernest Mairs

Position: Representative of Gulf Pacific Seafood
Location: Odessa, Florida, USA
Telephone: (001) 727-459-0711
Date: April 13, 2004 at 11:30 EST

American Consumer Fish Preference

Fish consumption has been increasing of late. Currently, it is fifteen to sixteen pounds per capita per year. American consumers favour skinless and boneless fillets when they purchase fish. The fish must be firm, flaky, white, and have a mild taste. Consumers prefer to flavour their fish with sauces, rather than taste the actual fish. A brand name that people know is also very important. The fish must have a name that people understand and recognize. The FDA has a list of names that are acceptable to use when marketing particular types of fish, so they should be consulted.

Kabeljou

The United States market will likely accept kabeljou as long as it is processed correctly. It must be deep-skinned to remove the layer of fat underneath the skin. Kabeljou should then be shatter-packed, which is placing the fillets in boxes, separated by a sheet of plastic wrap and then plate frozen. The boxes should be between ten to fifteen pounds. Blast freezing causes the fish to crystallize and is not desirable. All of the fish must be of a high quality consistently to build up a strong consumer following. Grouper is the most similar American equivalent to kabeljou. It would be wise to start exporting kabeljou now in small quantities to slowly introduce Americans to the fish. When aquaculture facilities are in place, there will already be a strong market for kabeljou in the United States.

Quantities and Price

An acceptable market price for a new fish product would be approximately $2.00 per pound. Gulf Pacific Seafood imports about six to seven containers per month of fish. Each container can hold up to twenty tons.

Dick Monroe

Position: Representative of the Monroe Group
Location: Orlando, Florida, USA
Telephone: (001) 407-876-1182
Date: April 14, 2004 at 11:30 EST

American Consumer Preferences

American consumers prefer deep-skinned, boneless fish fillets of around eight to ten ounce. The fillet should be “colourless, odourless, and tasteless” and not thick.

Restaurant portions for fish are usually grouped in three ranges, six to eight ounce, eight to ten ounce, and twelve to fourteen ounce. However, for restaurant and value-added products, eight to ten ounce is the optimal size. Bigger fillets may theoretically be more profitable, but a market may not exist in which they would be sold.

American cod and imported hake stocks are declining, so it is hard to obtain. Pollock is a "junk" fish that is not sold as fillets and only used in processed fish products. Tilapia is becoming popular to replace some of the fish products that are unavailable.

Pricing

Pacific pollock, a cheap fish, sells for less than \$2.00 per pound, for about \$1.20 per pound. Cod, when it is available, sells for more than \$2.00 per pound. The hake or hokey price will be a good indicator of what kabeljou would sell for. Orange roughy entered the market at \$0.80 per pound, though it was originally going to be targeted as a premium fish. The price rose to mid-range, and now is becoming a high priced fish because New Zealand stocks are declining. A market price of around \$2.00 per pound would be acceptable in the US market as a mid-range fish.

Processing and Shipping

Kabeljou shipped to the United States may be frozen and sent via boat. The fish should either be individually quick frozen (IQF) or shatter packed in ten pound boxes. As long as the packaging allows for easy portioning by restaurants, it would be acceptable in the US market. Shatter packed boxes should be plate frozen before shipping.

Red Lobster imports between one to two million pounds per year for not very popular fish and three to five million pounds per year for very popular fish.

Marketing Suggestions

In addition to sending frozen fillets, value-added fish may also be a viable option. Simple preparation of the fish into prefabricated meals also has a market in the US. One common value-added method is placing a layer of nicely trimmed scraps from the fish in a casserole dish, putting crab meat over it, placing the fillet on top, sealing the dish tightly, boxing, and shipping. The higher price that value-added products would be sold for may increase profits.

In order to create a market for kabeljou in the United States, samples should be sent immediately. The samples should be processed for the US and representative of how the fish would be shipped. Even small quantities of twenty-five pounds would be useful to send so that fish importers can do product testing to see how they wish to market the product. This would provide Namibia with information on whether or not kabeljou would be accepted in the US before spending lots of money of developing aquaculture facilities. If it is acceptable, then a market base can be established while the aquaculture industry is developing. The Monroe Group has many contacts in the food service industry that may be interested in testing kabeljou, while Sysco would be the major retail establishment to market it to.

If kabeljou has to be sold for a high price, then high-end restaurants may be interested in the fish. For the middle market, chains such as Red Lobster would be a good business to market to. In order to make kabeljou more attractive financially, the fish should initially be offered exclusively to one business. Marketing to supermarkets would follow the same strategy of sending samples and exclusive offerings. Many businesses are practicing what is known as forward contracting. In this purchasing technique, the quantity, quality, and price of the product is planned out years in advance and a contract is signed between the wholesaler and the supplier. This allows the wholesaler to do long-term pricing and marketing plans without worrying about the supply of fish.

It is very important to find a good, marketable name for kabeljou. The FDA must be consulted to determine what the fish may be called.

Aquaculture Facilities

In order to have a successful aquaculture facility, hatcheries are needed to supply a fresh stock of fish every breeding cycle. Land facilities are more susceptible to disease if not properly filtered and circulated. Underground saltwater wells contain uncontaminated water and would be a good option for a water source for a land facility if these wells exist in Namibia.

Ruth Morrison

Position: Director of Gendor
Location: Walvis Bay, Swakopmund
E-mail: RuthM@gendor.com
Date: April 7, 2004 2pm

Gendor Specifications

Gendor processes about 5000 metric tons of hake and 2000 metric tons orange roughy every year. Orange roughy has a twenty-six percent fillet yield because of its large head. Gendor employs 260 workers and the average wage is about N$10.55/hr. Hake costs about N$5.00 per kilogram of fillet to process with the skin on. Orange roughy costs about N$6.50 per kilogram to process with deep skinning. Orange roughy is frozen in blast freezers because the fillets cannot be flattened like those of hake, which are frozen in a plate freezer. The blast freezers can bring the fish to negative eighteen degrees Celsius within eight hours and plate freezers will bring the product to the same temperature within only three hours. Gendor has four plate freezers and five blast freezers. Orange roughy is exported to Florida or Los Angeles and is packaged in ready-to-sell freezer bags. Before the fillets are packages, they are glazed with ice to preserve freshness and maintain water content.

Shipping to the US

Gendor ships fish in forty-foot containers and about 18 metric tons fit in each container. These containers travel to Los Angeles, California and Miami, Florida and it takes about four weeks for the fish to arrive. The shelf life of the frozen fillets is about eighteen months. It costs about US$4.55 per pound to ship fresh fillets and US$0.22 per pound to ship fillets frozen.

Quality Control

Three different types of contamination can occur in fish. These are chemical contamination which can occur from the breakdown of oils in fish flesh, biological which results from bacteria, and physical which can happen when poor processing techniques are employed and an object becomes lodged into the fish flesh. Gendor has internal quality controls and the food and drug administration (FDA) audits the importer in the US.

Wilfred Poaser

Position: Representative of Porta Liners and Pools
Location: Swakopmund, Namibia
Telephone: (+264-61)220214
Date: April 7th, 2004 at 9:30am

Tank size costs

There are four different sizes of water reservoirs that are suitable for aquaculture. All are circular tanks. The smallest is 1.2 metres deep with a diameter of 12.2 metres, costing N$24,340. The next size up is 1.2 metres deep with a diameter of thirteen metres, costing N$27,020. The second largest tank is 2.45 metres deep with a diameter of 12.7 metres, costing N$57,300. The largest tank is 2.46 metres deep with a diameter of 14.9 metres, costing N$69,100. The reservoirs are composed of an outer steel wall with square tubing and the tank linings must be replaced every ten years. The only regular maintenance required is the tank lining and for all sizes the tank lining costs roughly N$18,000. The tank weights in order from smallest to largest are 552 kilograms, 595 kilograms, 1997 kilograms, and 2319 kilograms.

Pumps

Large pool pump suitable for replacing the volume of the largest marketed reservoir every twenty-four hours costs N$3,150. It is capable of pumping twenty cubic metres of water every hour. The pump is designed to have no water loss and has no issue with salt water. It is a 1.5 kilowatt, 380 volt pump.

Michael Rice

Position: Professor at the University of Rhode Island Department of Fisheries, Animals, and Veterinary Science
Location: South Kingstown, Rhode Island, USA
Date: February 11, 2004 1:00 pm

Environmental Concerns Relating to Aquaculture

The 1998 Journal of Shellfish Research contains information regarding environmental concerns. There is an article about the Saldahna Bay in South Africa. The bay experiences the Benguela current just like Walvis Bay. Although this article is about molluscs, it provides a basis for environmental factors to consider.

Fish waste, when it sits on the ocean floor, becomes a heap of decaying organic material. It uses up all the oxygen and promotes sulphur-oxidizing bacteria. This releases smelly, poisonous, sulphates into the atmosphere. This does not happen too often, but still should be monitored. One method of monitoring is to take the carbon load on sediment. This is done by extracting a core sample from below the net pen, weighing the sample, burning off the carbon, and then weighing the remaining material. Carbon is considered half of everything that was burned off. Fish waste can be used to feed molluscs and other filter feeders. This may be difficult to do in Namibia because of the strong currents.

Case Study

The Chilean salmon system is successful even though Chile has strong currents. Their success stems from their clean water and abundance of anchovies and other small, feeder fish. Northern Chile experiences currents and weather like Namibia. This area of Chile is mainly used for bivalve cultures.

Aquaculture Cages

Bridgestone, the same company that makes rubber and tires, produces pens used in the aquaculture industry. Brian Bowes, at Coastal Aquaculture supply, is a good person to talk to about net pens.

Patricia Schofield

Position: Representative of Pescanova USA
Location: Miami, Florida, USA
Telephone: (001) 305-577-4492
Date: April 13, 2004 1:00 pm EST

American Consumer Fish Preference

American consumers prefer fillets and whole fish products, with fillets being more desirable. Fillets must be headed and gutted, while most of the time the tail is also removed. Retail establishments prefer fish to be packaged in sellable condition. The method of freezing is not a big issue if it is packaged for retail businesses.

Quantities and Pricing

Pescanova USA imports six to eight containers a month of mixed species of fish. Each container holds twenty-two metric tons of fish. Sea bass currently sells for $6.00 per pound.

Mike Sullivan

Position: Representative of FWBryce
Location: Massachusetts, USA
Telephone: (001) 978-283-7080
Date: April 13, 2004 12:00 pm EST

American Consumer Fish Preference

American consumers prefer a white fish with no to mild flavour. Although salmon, which is pink, is the fastest growing fish product in the US market, generally consumers prefer white fish. Halibut, cod, haddock, and orange roughy are tasteless to medium taste white fish that are popular. The fish must be prepared as a skinless, boneless fillet. Consumers will not tolerate bones in their fish. Also, they are used to having the napes (belly flap) removed from fish. It is better if the fish are not treated with tripolyphosphate to retain water. All-natural fish are easier to market. The NFI and FDA have lists of approved names for marketing species of fish and must be consulted. The name given to the fish must be understood and recognized by consumers. The packaging must be descriptive and grab the shopper's attention.

Processing Preferences

Grading is very important in importing fish. They are usually sorted in five to eight ounce, eight to sixteen ounce, sixteen to thirty-two ounce, and over thirty-two ounce partitions. Food service businesses usually prefer fish in the eight to thirty-two ounce range to make standard serving sizes. Restaurants may buy fish of larger sizes, but will want to easily be able to make smaller portions from the large fillet. There is a small market for over thirty-two ounce fillets. The fish may be shipped by boat frozen and shatter-packed. They import about eight containers per month of fish by sea. Each container holds about 40,000 pounds of fish, which is the maximum allowed to be transported by land.

Quantities and Pricing

The amount of fish imported varies by species. Last year, FW Bryce imported between thirty-five and forty million pounds of Pacific pollock, while only importing 150,000 – 200,000 pounds of domestic pollock. It takes time to have a new species of fish accepted and it may be necessary to sell at a loss initially. Fish market prices vary widely due to supply and demand issues. Last year, cod sold for about $3.00 per pound, but is now selling for about $2.00 per pound. Frozen grouper has remained fairly constant at between $2.50 and $3.00 per pound. In order to introduce a new fish into the market, food service is the desirable route. Processed fish will not be able to introduce a new fish because consumers rarely know what types of fish are used. Retail establishments are hesitant to sell new species because customers will not be something they are not familiar with and do not know how to prepare. Ideally, a small chain should be contacted and market the fish in their restaurants.

US Fish Market

Fish consumption has been steadily increasing of late. However, orange roughy supplies from New Zealand are low. Also, red snapper supplies are declining, along with whiting from Argentina. Alternative sources are being investigated to meet the fish demand.

Daniel Theunissen

Position: Professor at the Polytechnic of Namibia
Location: Windhoek, Namibia
Telephone: (+264-61)2072173
Email: dtheunissen@polytechnic.edu.na
Date: March 17, 2004 at 9:00am

Aquaculture in Namibia

The coastline of Namibia is highly developed and holds strong marine aquaculture potential due to the presence of electricity, the absence of considerable human population, and a strong interest in land-based aquaculture. There are currently two students from the Polytechnic of Namibia working in aquaculture in Swakopmund.

Bioremediation

There is a small dam set up in Swakopmund with seven kabeljou, three male and four female, where it has been observed that the water temperature two degree Celsius higher than land water temperature results in algal growth that can only be controlled through crustacean and bivalve bioremediation. As a result there is a strong interest in kabeljou and crustacean integrated biosystems. It is anticipated that it takes eight months of growth for crayfish to reach marketable size and they require natural food and nutrients provided by the soil. Crayfish are of particular interest because they have an eighty percent survival rate when farmed and have an unlimited market to the east and the north in Namibia. Current cost per kilogram for crayfish in Namibia is N$1.46. Plants, such as lamia, are also being looked at because they are capable of being grown in brackish water and might be able to grow in salt water. Lamia can be provided as food for fishes and is high enough in protein to feed forty dairy cows per half acre. Lamia has a protein value of thirty-eight percent, which is ten percent higher than the protein value of soy. Integrated biosystems (bioremediation) are seen as an alternative to genetic engineering for enhancing production.

Land-based Versus Open-ocean Systems

Namibia is too arid anywhere outside of the coast and the far north to make land-based systems feasible. Water evaporation rates are very high, particularly in the south. Water tunnels are a possible solution, however they would be expensive to build and maintain. Open-ocean systems are at the mercy of the high energy waters off the coast of Namibia with ocean swells reaching fifty metres.

Namibian Diet

Namibian's typically don't eat fish, thus exportation is more viable for farmed produced fish. Animal livestock is much more important to Namibia and the quantity of livestock is a measurement of wealth in most parts of Namibia. As a result the integration of plants such as lamia into aquaculture systems are of great interest.

Anja Van Der Plas

Position: Chemist and Researcher at the Swakopmund National Marine Aquarium
Location: Swakopmund, Namibia
Date: March 25, 2004 9:15am

Sulphur Eruptions

Currently there is no known or theorized way to predict sulphur eruptions. Sulphur eruptions are, however, known to be more severe in the autumn season in Namibia.

Sulphur eruptions affect an area of ten to twenty nautical miles from the shore along the central Namibian coastline, around the Swakopmund and Walvis Bay area. The eruption of hydrogen sulphide gas from the benthic layer is only immediately toxic to fish at the lowest levels of the affected area because the gas immediately reacts with oxygen present in the ocean. The duration of the chemical change in the water column is not known, however there is a period of one to two days to a week of sulphur release in which it can affect fish. This period is not considered a significant threat to the fish.

Threat to Fish Populations

Since hydrogen sulphide reacts quickly with oxygen, and hydrogen sulphide is poisonous to fish, only fish dwelling at the lowest depths of the ocean are at risk of poisoning. Regarding asphyxiation, the bottom twenty to sixty metres of the ocean along the central Namibian coastline has persistently 0.5 millilitres of oxygen per litre of water, which is a very low concentration.

Hugo Viljoen

Position: Director of Gendev of Namibia, LTD.
Location: Walvis Bay, Namibia
Telephone: (+264-64)204452
E-mail: hugo@gendev.com.na
Date: March 24, 2004

General Fish Processing

Fish are frozen using either flow ice or flake ice in the plant. Horizontal freezers are also used to freeze the fish to negative twenty degrees Celsius in less than three hours in order to prevent water loss. Antioxidants must also be added to prevent darkening of the fish meat. The percentage of hake meat resulting from processing is forty five to fifty percent of the total weight of the fish before processing. For tilapia only thirty percent is left in fillet form. By-products of the fish can be processed into other marketable products, such as fish bones into fishmeal and fish oil sold to China.

Hake Fish Processing

The costs for hake coming from the fishing boat is N$9 per kilogram with a packing fee of N$3.55 and then a transport fee of N$50,000 per twenty-four tons to get to the processing plant. It takes approximately 18 hours to get from the boat to the processing plants. Hake's bone structure makes it easy to machine fillet. Hake currently sells for 2.50 euros.

Kabeljou Processing

Kabeljou has a different bone structure from hake, thus it is most likely better to hand fillet than machine fillet kabeljou. A concern with kabeljou aquaculture in the open ocean is not the currents but the risk from predators such as seals. Kabeljou being processed would be graded on a one to five system, similar to hake processing.

Aquaculture

Advantage of aquaculture is that fish produced are of similar size meaning that higher quantities of higher quality fish are sent to the processing plant. Unfortunately the capacity to repair net cages is hindered by the high plankton concentrations in the ocean.

Fishing Industry

There is a significant lack of qualified engineers for boats in Namibia. Currently flowers and grapes compete with fish for cargo space on airplanes. Swordfish and tuna are exported to the United States.

Lizette Voges and Iana Iita

Position (Lizette Voges): Marine Biodiversity Coordinator at the Swakopmund National Marine Aquarium
Position (Iana Iita): Scientist at the Swakopmund National Marine Aquarium
Location: Swakopmund, Namibia
Date: March 25, 2004 9:00am

Harmful Algal Blooms

Harmful Algal Blooms are a potential risk, though they are most likely a larger risk for Hake populations than for kabeljou populations. HABs do not occur regularly. Asphyxiation is not a considerable concern because from 200 metres and deeper the natural oxygen levels are very low.

It is suggested that Anja Van Der Plas and Bronwen Currie be contacted in the Swakopmund National Marine Aquarium offices for more information on natural environmental risks to aquaculture facilities.

Appendix F - The Namibian Articles

* TODAY: 'MOBUTU GUARDS BEHIND DRC ATTACK' * TOP U.N. OFFICIAL FIRED OVER IRAQ * NEW FRENCH GOVT *

18 YEARS OF INDEPENDENT REPORTING

the namibian

9 771560 602300

STILL TELLING IT LIKE IT IS! VOL.19 NO. 62

N$ 2 WEDNESDAY MARCH 31 2004

Photo: Courtesy of the *Okavango River: the flow of a lifeline*

FISH FOR LIFE ... Fishing in the Okavango River has been a serious business for a long time. Communities close to the river devote a considerable portion of their time to fishing and employ various simple, ingenious and highly effective contrivances for capturing the fish.

* TODAY: EUROPE REJECTS OSAMA OFFER * IRAQ HOSTAGE CRISIS WORSENS * 'BUSH FUELLING MIDEAST FIRE' *

18 YEARS OF INDEPENDENT REPORTING

the namibian

N$ 2 FRIDAY APRIL 16 2004

STILL TELLING IT LIKE IT IS! VOL.19 NO. 71

President calls for investment in aquaculture

PRESIDENT Sam Nujoma has called on local and international investors to explore new opportunities in the aquaculture industry.

Speaking during a visit to an Eco Fish Farm at Hardap dam outside Mariental yesterday, President Nujoma said he was impressed by the project.

He noted that aquaculture development was a Government priority and was in line with the country's national development strategies.

The President said aquaculture had a significant role to play in enhancing food security, alleviating poverty and creating employment.

- Nampa

New joint venture 'sign of confidence in Walvis Bay'

• MAGGI BARNARD
at WALVIS BAY

Photo: Maggi Barnard

JOINT VENTURE ... The Ohlthaver & List Group on Friday celebrated the inauguration of an international joint venture between Kraatz Marine and South African-based Dorbyl Marine at Walvis Bay. Pictured, from left, are Chief Emmanuel Ghaseb, O & L shareholder; Sven Thieme, O & L Chairperson and CEO; Martin Laubscher, GM Kraatz Marine; Jesaya Nyamu, Minister of Trade and Industry; Johann Venter, Executive Director of Dorbyl and Brian Mosehla, Director of Dorbyl.

WALVIS Bay is increasingly becoming a harbour of choice on Africa's west coast.

Of the five major ports on the western seaboard, it is now a key area for ship repairs and other marine engineering services, especially with the oil field growth in West Africa.

"There is a great future in the marine engineering business at Walvis Bay," Johann Venter, Executive Director of DCD-Dorbyl in South Africa, said at the inauguration of a joint venture between his company and the Ohlthaver and List (O&L) company, Kraatz Marine, on Friday.

Initiated in July 2002, the joint venture gives O&L 51 per cent shares and Dorbyl 49 per cent.

Chairperson and CEO of O&L, Sven Thieme, said the main objective was to secure the economic viability of Kraatz Welding and Engineering Works, as the company was previously known. "In Dorbyl Marine, we found a strong partner with extensive expertise in ship repair requirements on the South African seaboard."

Thieme said the joint venture had projected Kraatz Marine back into profitability after years of failing turnover. "This was mainly achieved through the benefits of mutual synergies and the application of new procedures to control costs," he said.

Minister of Trade and Industry, Jesaya Nyamu, who gave the keynote address, welcomed the concept of joint ventures.

He said while Government focused on streamlining and harmonising trade and economic relations through negotiations with various economic blocks "we should prepare ourselves for any eventuality by joining hands with established companies".

He said joint ventures should complement Government efforts by contributing to human resource development and poverty reduction.

Thieme said there would be increasing benefits for Kraatz Marine's 67 employees through the transfer of expertise and know-how.

An adult basic education programme had already proven successful and popular among the workforce, and would be implemented across the whole group.

Dorbyl Marine complies with the requirements of the ISO 9002 quality standard and adheres to international safety regulations.

The company is affiliated to Dorbyl Limited, which is listed on the Johannesburg Stock Exchange.

Kraatz Marine is one of the biggest marine engineering companies at Walvis Bay. Its core activities include ship repairs, mechanical engineering work, retail in steel and marine cleaning and painting.

* TODAY: HAMAS VOWS REVENGE * TENSION MOUNTS IN FALLUJAH, NAJAF * LONDON TERROR THREAT *

18 YEARS OF INDEPENDENT REPORTING

the namibian

STILL TELLING IT LIKE IT IS! VOL.19 No. 72 N$ 2 MONDAY APRIL 19 2004

* TODAY: MORE U.K. TROOPS FOR IRAQ * MULUZI THREATENS E.U. OBSERVERS * BRENDA FASSIE 'CRITICAL' *

18 YEARS OF INDEPENDENT REPORTING

the namibian

STILL TELLING IT LIKE IT IS! VOL.19 No. 78 N$ 2 TUESDAY APRIL 27 2004

Scottish fishermen cast their nets in Namibian waters

• MAGGI BARNARD at WALVIS BAY

TWO Scottish trawlers joined the fleet of foreign vessels catching fish for Namibian companies at the beginning of the year.

Both boats, the Resplendent and the Victory, are less than five years old and were built specifically to help open up a new deep-water fishery for Scottish white fish trawlers.

According to a report in *The Scotsman* the fishery was all but lost less than two years ago after the European Union imposed strict quotas on the deep-water white fish.

With even stricter quotas and a 15 days per-month fishing restriction imposed this year, the skippers and crews of the two vessels decided they had had enough.

Calling them "courageous crews" the report states they undertook a historic voyage, unprecedented in the annals of Scotland's fishing industry, and sailed more than 7 000 miles over 26 days to Namibia to try and make a new living.

The article described the conditions in Namibian waters as excellent with much better weather and better fishing. "It's like the fishing was in Scotland 20 years ago," said a major shareholder in one of the two trawlers.

The Victory has been contracted by Hangana to catch hake, while the Resplendent is contracted to Blue Ocean Products.

Kobus du Plessis, MD of Hangana confirmed to *The Namibian* that the Victory had been catching for his company since January. "We encouraged them to employ Namibian crew members, which they did." Six Namibians have joined the crew of approximately 12.

According to Du Plessis, it is common practice for Namibian companies to get foreign vessels to help catch their quota, but it was a relatively new venture for Hangana.

"The company used to work on a charter basis before, but about eight months ago a Russian vessel was first contracted." The Victory is the second one.

He said Hangana's fleet of seven wetfish trawlers and one large freezer trawler had the capacity to catch the full quota, but low catch rates experienced in recent times made it more difficult.

As a new vessel, the Victory has significantly more power on deck. "It is a twin trawler - enabling it to utilise two nets - which has not been used in Namibian waters before. The equipment is state-of-the-art which makes it very efficient to run and operate."

For Du Plessis this venture offers a second benefit of technical transfer to the Namibian crew on board. "That is one of the main reasons why we approached them as it would give the Namibians good exposure to such modern technology," he said.