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FEASIBILITY STUDY FOR MASS PRODUCTION OF THE SILVER KOB, *ARGYROSOMUS INODORUS*, IN NAMIBIA

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ABSTRACT

The Silver Kob, *Argyrosomus inodorus*, belongs to the Sciaenidae family, which forms one of the largest perciform families and has attributes like fast growth that indicate its suitability for aquaculture. This feasibility study is aimed at determining the economic viability of silver kob aquaculture in Namibia. A production model for the species was developed. To evaluate the profitability of the envisaged farm, indicators of investment returns were determined such as net present value (NPV), internal rate of return (IRR), payback period and debt service coverage ratio. A sensitivity analysis on cost of feed, investment cost, sales price and sales quantity was also conducted. The findings of the analysis indicated that silver kob farming is financially feasible. The results obtained indicated a positive IRR of 13% on total capital and 30% on equity on discounting rates for total capital and equity of 10% and 15%, respectively. NPV on total is N$11 million (discounting rate 10%) and N$14 on equity (discounting rate 15%). A debt service coverage ratio with payment over 7 years at 10 year planning period was feasible. The cash flow was adequate. A sensitivity analysis on price, sales and investment obtained was performed. An improved FCR could dramatically reduce variable costs. It was established that it is more economical to operate a mass production unit (> 150 MT/year) due to gains from economies of scale.

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1 INTRODUCTION

1.1 Background

Namibia is located in southwest Africa between latitudes 17°S and 29°S and longitudes 11°E and 26°E with a surface area of 823 680 km² and population of 2.1 million people (UNDP 2011). It is surrounded by the Atlantic Ocean to the west, Angola and Zambia to the north, Botswana and Zimbabwe to the east and South Africa to the southeast (Figure 1). The Namibian coast is a hyper-arid desert, approximately 1500 km long. The coastal zone is sparsely populated and the desert is not suitable for agriculture. The coastal area is thus free from the levels of pollution commonly associated with large urban communities, and the coastline is relatively pristine.

Figure 1. Map of Namibia.

The nutrient rich Benguela upwelling system creates one of the most productive fishing grounds in the world with abundance of pelagic and demersal fish populations supported by plankton production driven by intense coastal upwelling (Shannon and O'Toole 1998).

The Namibian fishing sector is currently ranked 35th on the list of the world main fishing nations, fourth in Africa by production and among the top 10 fish exporting nations in the world (FAO 2010). Fishing represents Namibia's second largest foreign currency export earner (after mining) with 90% of the national fisheries output being exported (INFOSA 2009). The infrastructure for seafood processing is well developed with accreditations for export to the lucrative European market. Over the last decade, the country's total catches have been between 500 000 and 600 000 tonnes (INFOSA 2009). The fishery is strongly regulated and with all major stocks being fully exploited (FAO) 2010 no increases are expected in the near future (MFMR 2007). It is within this context that the Namibian government has in recent years identified aquaculture, especially marine aquaculture, as an important potential growth area within the fisheries sector.

1.2 Aquaculture in Namibia

Several conditions in Namibia are favourable for the development of the aquaculture sub-sector compared with other countries in the sub-region. These include the vast unpopulated coastline, abundant natural resources such as a large pool of potential aquaculture species, unpolluted waters and political support. In the last ten years, great strides have been made in creating a cohesive, clear and efficient legal and regulatory environment for the development of aquaculture in Namibia (Oellermann 2010). Of particular importance is the development of policy documents such as the Aquaculture Policy (MFMR 2001) and the Aquaculture Act (No.18 of 2002), which were followed by an Aquaculture Strategic Plan (MFMR 2004). It is expected that a Aquaculture Master Plan will be completed in 2012. There is an opportunity to exploit the conducive environment and the legal framework provided for the development of aquaculture.

Aquaculture in Namibia is currently a mixture of extensive and semi-intensive culture systems both in fresh and marine waters. Freshwater aquaculture in Namibia is primarily a government-funded initiative and is a community based, cooperative activity that requires a high degree of labour and relies on extensive culture methods. The main focus is on food security, income generation and improvement of rural livelihoods with the production aimed at the local and regional markets. Freshwater aquaculture production is very low. Data available indicate that in 2007 only 5 tonnes of tilapia and 11 tonnes of catfish were produced (MFMR 2007).

Aquaculture industry development in Namibia is high on the agenda both in the Government's Vision 2030 and the National Development Plan (NDP2) priority list (NPC 2004). Marine aquaculture in Namibia is characterized by extensive and semi-intensive culture systems most that require significant start-up capital and technical expertise. This is due to the fact that some aquaculture facilities are pump-ashore systems while others are in the few available bays and this requires boats to reach the long-lines and drum-suspended baskets. Private investors are involved in the marine aquaculture and only high value species are considered. At present the species being farmed are oysters (*Grassostrea gigas* and *Ostrea edulis*), abalone (*Haliotis midae*), which are not native to Namibia, and seaweeds (*Gracilaria verrucosa*).

Marine aquaculture is solely a domain of private investors. There are clear signs that marine aquaculture is destined to grow at a fast rate (MFMR 2009), given the number of applications for aquaculture licenses. For this sector's growth to be sustainable it needs to be founded on well-researched methods of farming and carefully planned business strategies. Unfortunately, there are a number of documented cases where aquaculture endeavours have failed and, even worse, led to negative public perceptions due to environmental impacts (Leung *et al*. 2007). Namibia has not been spared from failures in aquaculture development as some government constructed freshwater fish farms had to be abandoned as they were constructed in flood-prone areas (MFMR 2007). Therefore, detailed feasibility studies must be performed during the planning stage of any aquaculture operation based on a biological, technical and economic appraisal.

Oyster culture using long-lines, racks and baskets is mostly established in Walvis Bay, Swakopmund and Lüderitz. A flow-through, shore based farm in Lüderitz is culturing abalone and seaweed is grown in one of the few bays. In 2008, the oyster culture industry produced 434 tonnes, worth approximately N$40 million (€ 4 million) Abalone production was 3.6 tonnes valued at N$1.3 million (€ 130,000) (MFMR 2008). The challenge for mariculture in Namibia is the annual occurrences of toxic algal blooms and sulphur eruptions. However, marine finfish culture is attracting new interests and there are a number of indigenous species that show good potential for culture. At the moment marine aquaculture is mainly confined to the main coastal, harbour towns where infrastructure, labour and other amenities are well established.

The development of marine aquaculture is moving towards diversification into marine finfish, which can be viewed positively as a means to ease the pressure and reliance on capture fisheries.

Diversification to support stable industrial development is not a radical idea and has been a component of successful aquaculture development in many countries (Corbin and Young 1997).

There is an interest in the farming of silver kob by the traditionally capture oriented fisheries companies in Namibia. One such company, Kuiseb Fishing Enterprises has linked with the University of Namibia, through the Sam Nujoma Marine and Coastal Resources Research Centre (SANUMARC) to investigate the possibility of captive propagation and rearing of the species. Successful spawning of silver kob has been accomplished at SANUMARC and the larvae have been grown to more than 100g in 8 months (Tjipute and Oellermann 2010, unpublished data). SANUMARC has facilities needed to produce 300,000 fingerlings per month. The feasibility study is aimed at determining the economic viability of growing silver kob to market size, based mainly on preliminary findings of rearing experiments conducted so far as well as on information about culture of related species elsewhere.

Due to the unavailability of protected bays, the future development of marine aquaculture in Namibia will focus on land-based farming in ponds or tanks. This is relatively expensive and, therefore, limits cultivation to higher-value species, such as the silver kob, *Argyrosomus inodorus*.

The silver kob, *Argyrosomus inodorus*, belongs to the Sciaenidae, which forms one of the largest perciform family found in Namibia and South Africa. The silver kob has attributes that indicate its suitability for aquaculture. It has a rapid growth rate when held in seawater tanks or cages; a relatively high value and market demand is strong. Commercial demand is unlikely to decrease. It is highly palatable and constitutes about 70% of all recreational shore angling catches in Namibia (Kirchner, Sakko and Barnes, 2001). In addition, a commercial fishery of ski-boats and larger line-fishing boats exploits it. In total, silver kob contributes about 58 % of all Namibian line fish catches (Kirchner, Sakko and Barnes, 2001) and is becoming rare in the wild due to overfishing as the stock is not managed by total allowable catch (TAC) but by an arbitrarily chosen daily bag and size limit. Kirchner, Holtzhausen and Voges (pers. comm.) suggest that about 1000 tonnes are caught every year.

Although research on the culture of silver kob is just beginning, other members of the sciaenid family such as the red drum (*Sciaenops ocellatus*) in the United States of America (Davis 1991) and mulloway (*Argyrosomus japonicas*) in Australia (Battaglene and Fieldes 1997) are already produced in captivity for restocking. The husbandry techniques of another member of the sciaenid family, of the same genus as the silver kob, the meagre (*Argyrosomus regius*), are well established.

1.3 Envisaged Silver Kob Market

More than 20 fish species are commercially exploited in Namibia. The domestic market is limited due to the small size of the population and most of the country’s protein source is derived from a meat-based diet. At13.3 kg per capita Namibia is among the lowest fish consuming countries in Africa (FAO 2010).

The emphasis is generally on the export market, with the country exporting more than 90% of its fish products. Horse mackerel (the dominating species in terms of volume) and canned pelagic products are exported to the regional market (Egypt, Democratic Republic of Congo, South Africa, Angola, Zambia, Zimbabwe and Botswana); hake is mainly exported to the EU and over 70% goes to Spain, while fishmeal is exported to South Africa, Spain, Japan, Korea, China and Taiwan (INFOSA 2009).

Strong market demand will continue to grow because of reduced supplies from many other parts of the world due to over-fishing as well as increased demand of growing world population as well as consumer preference for fish and fisheries products due to health benefits. It is estimated that fish trade flows are predominantly from developing countries to developed countries (FAO 2010). Price should thus remain high and these factors present a good opportunity for Namibia to increase its exports. Additional production from aquaculture will complement Namibia's capture fisheries output.

By virtue of various trade arrangements, Namibia enjoys easy access to a regional market of over 350 million consumers in SADC as well as access to lucrative markets in the rest of the world through regional integration schemes and agreements. This is beneficial in terms of introducing a new product such as silver kob.

Namibia needs to diversify out of the traditional market in Spain and develop new markets elsewhere. The newly signed export agreements with China for meat and fish products (NCCI 2011) offer excellent opportunity for market diversification.

Silver kob is in high demand in Namibia, but it will be difficult to assess the export potential. One approach could be to study similar products (Engle 2010). Silver kob closely resembles meagre (*A. regius*) and could well be marketed as substitute to meagre in markets where this species is established. Meagre aquaculture started initially in 1990. Spain entered in meagre aquaculture business in 2004, Greece, Turkey and Egypt joined from 2007 onwards. Total aquaculture production of the species was 4000 tonnes in 2008 and over 10000 tonnes in 2010, which marked the appearance of a new culture species in world markets. Prices of meagre was €9/kg for export to the European markets in 2008 (FAO 2010). Farmed meagre is mainly sold fresh. A very small percentage of meagre are sold at sizes smaller than 1 kg (> 50% at size from 1kg – 2kg). Smaller than 1kg are considered to have too dark flesh and is regarded as not very attractive. Good prospects exist for the silver kob to enter the market segment of customers preferring fish of smaller size than 1 kg. The Japanese sushi market is also another prospect to explore as the silver kob meat can be eaten raw. Kuiseb Fishing Enterprises, company interested in the culture of silver kob, *A. inodorus*, already has markets where it can introduce the new product.

Silver kob could become an important aquaculture species and its culture will be made easier by the fact that it is relatively common in Namibia and the local market is already established. The white, lean, subtle and delicious meat is a sought-after delicacy in restaurants and hotels and it commands prices ranging between N$50 – 60 (€ 5 – 6) per kg, freshly caught (Hanganeni Fishing Association, Henties Bay, pers. comm.).

The silver kob also has firm flesh, low body fat content and does not have the rusty metallic odour that has been noticed with some sciaenid species such as *A. japonicus* (Schoombee 2006).

There are certain aspects, however, that need to be considered for the silver kob to succeed in the market. It is an unknown species in the export market and a marketing strategy needs to be developed that address the idea of how silver kob can be positioned, priced and promoted.

1.4 Rationale

Aquaculture accounts for 46% of total food fish supply worldwide (FAO 2010) and there are growth prospects with new entrants in business and species that are domesticated. In Namibia, aquaculture contributes less than 1% to the total fisheries. There are good prospects for finfish aquaculture in Namibia since markets are already established and also due to the stagnation of capture fisheries landings.

The commercial farming of any new fish species requires the development of appropriate husbandry systems that take into account the biology of the species concerned, in particular its reproductive and feeding behaviour, growth and survival. This demands the development of adequate technology to ensure optimal performance of the species and ensure maximum profit to justify the financial investment for the aquaculture business operation.

1.5 Objectives

The project involves the feasibility study of mass production of Silver Kob in Namibia. The specific objectives were to determine the:

- Biological requirements of the species.
- Most appropriate culture technology for the species and country
- Economic viability of the envisaged mass production.

2 MATERIALS AND METHODS

The feasibility study will aim to have a comprehensive investigation of the biological, technical and financial criteria that are necessary for the successful development of the mass production of Silver Kob, *Argyrosomus inodorus,* in Namibia. The study approach included the following tasks:

a) Desk study of the species biology, environmental conditions, and culture systems: that included literature review on previous studies on finfish aquaculture.
b) Collecting industry information on the price for setting up aquaculture facilities, price of feed and licences. This information was sourced through correspondence and telephone calls on the state of the aquaculture industry and other relevant information for input in the feasibility study. The respondents were farmers, traders, organised groups, Namibia Mariculture Association, Southern Africa Aquaculture Association (SARNISSA), Ministry of Fisheries and Marine Resources and the Ministry of Agriculture Water and Forestry, as well as stakeholders and partners in environment sections (Namibia Coastal Management Agency).

2.1 Biological Feasibility

A desk study of the species' biological requirements was undertaken. This involved a review of available literature on the species or other related species. Important factors considered included the reproduction and propagation ability of the species in captivity, the larval rearing and survival rate. Dissolved oxygen concentration for optimum growth and desired pH, salinity and ammonia levels were investigated. The feeding requirements of the species were also reviewed. Factors such as stocking densities and diseases of the species were taken into consideration and used to determine the economical optimization of the species in culture conditions. Ranges for key parameters were used in the analysis to reflect the risk arising from particular factors. Such may include seasonal factors, potential available technologies and scales of production units.

2.2 Economic Feasibility

2.2.1 Financial requirement

Financial requirement for the mass production of silver kob aquaculture system were estimated based on the start-up capital needed as well as operational costs and revenue. Sources for the start-up costs, fixed costs and variable cost were based on the assumptions on the biological requirements of the species as well as the technical aspect of the operation. Cost estimates for the 150 tonnes/year aquaculture farm set-up was obtained from industry sources. Sources consulted include AquaOptima a, Norwegian company that specializes in supplying Recirculation Aquaculture Systems (RAS) since 1993. The company is responsible for executing production plans and economic analysis, evaluating the feasibility of projects and study the sensitivity to parameters essential for profitability. Based on available water resources, water quality, desired production and production plans, AquaOptima designs systems to fit the needs of the client of complete onshore hatcheries and grow out farms for both cold and warm water fish species. The company also provide assistance at start-up and during operation. The other company consulted was Deep Blue Aquatic Systems, South Africa, that is involved in the design and installation for on-growing aquaculture facilities for both flow-through and recirculation systems. This company has designed and installed a number of aquaculture recirculating systems in Namibia, both marine and freshwater for the government as well as the University of Namibia. The cost to be used for the financial model was obtained by subjecting all costs to a three-point-cost-estimation method in order to determine the estimate to use. For each item 3 cost estimates were obtained, namely: optimistic (a), most likely (m), and pessimistic (b). Assuming a triangular distribution for each cost estimate an expected value (t) and standard deviation (s) were calculated as: $t=(a+4m+b)/6$; $s=(b-a)/6$. Assuming a probable distribution, at a 95% confidence level (*Z-factor* $= 1.645$) the Cost Estimate to use was determined as $t+Z*s$.

2.2.2 Assessment method

The financial feasibility of the mass production system was assessed using a profitability analysis calculating the net present value (NPV) and internal rate of return (IRR). The financial condition of silver kob farm for the 10 year period will be analysed using the balance sheet, income statement and cash-flow The balance sheet organised all that is owned (assets) and debts that are owed (liabilities). Income statement measured the profit or loss by summarizing the financial transactions of the silver kob farm. The sensitivity analysis evaluated the impact of one uncertain factor change at a time, such as change in selling price, cost of production or production quantity, equipment, variable cost and fixed costs that affect the feasibility of the project.

3 THE BUSINESS MODEL OF THE 150 TONNES/YEAR SILVER KOB FARM

Assessment of cost for a 150 tonnes/year has been provided by AquaOptima, Norway (Gaumet, pers. comm.) and Deep Blue Aquaculture Systems, South Africa (Simpson, pers. comm.). For this particular farm it will be safe to assume that construction of the farm will be carried out by specialized company that provide "turn-key" aquaculture facilities. Such a company will be responsible for designing and manufacturing the aquaculture system and provides training to staff on the operation.

3.1 Biological and Technical Considerations

3.1.1 The silver kob, brief description

The silver kob is a large sciaenid, attaining a maximum total length of about 130 cm. It is a carnivorous predator that feeds mostly on shrimps and prawns as a juvenile, and on a variety of fish, squid and octopus at larger size (Fig 2). The juvenile phase of the species is considered to be entirely dependent on estuary habitat for their first year of life (Kirchner and Voges 1999). Silver kob first matures at just over 1 year of age and the median age at maturity is 1.5 years.

Figure 2. Silver kob, *Argyrosomus inodorus*.

The spawning is protracted over 6 months (October – March), which coincides with the warmer water temperatures (> 15 ^{0}C) (Kirchner and Holtzhausen 2001). In Namibian waters (50%) of female silver kob attain sexual maturity at a length of 35cm, which is reached at the age of 1.5 years. Total maturity (100%) for female silver kob is attained at 43cm with corresponding age of 2.4 years. Kirchner et.al. (2001) estimated that 50% males reach sexual maturity at 36 cm (47cm for 100%), which corresponds to age 1.6 years (2.9 years for 100% males).

A number of studies carried out on the silver kob are available in the literature, but these are mainly concerned with management and conservation (Griffiths 1996, Holtzhausen and Kirchner 1998). However, this information does provide an understanding of the biology, reproductive and feeding behaviour of the species.

Studies on silver kob suitability as an aquaculture species has been conducted recently in Namibia and South Africa.

Table 1. Biological Assumptions for the Silver Kob farm in Namibia. The assumed values are based on literature reviews and interviews with industry members.

Parameter/Index	**Quantity**	**Unit**
Oxygen	8	mg/L
Temperature	23 - 25	°C
Sea-surface Temperatures	13.00	°C
pH	8	
Initial weight of fingerling	5	g
Fingerling Cost	1.50	N$per fingerling
Fingerlings required	172500	
Feeding rate	10	% Body weight/day
FCR	1.8	kg food/kg gain
Stocking density	50	kg/m³
Mortality	15	%
Protein content	45.00	%
Tank sizes	20,50,100	m³
Size at slaughter	897	g
Production cycle for a cohort	14	months

3.1.2 Fingerling supply

Silver kob farming is a complete new concept in Namibia. No hatchery exists and the propagation of the species is currently undertaken at research institutions. The farm model will assume that the fingerlings will be sourced most probably from SANUMARC.

Successful spawning, larval and juvenile rearing has been accomplish in 2009 at the Sam Nujoma Marine and Coastal Resources Research Centre (SANUMARC). Larvae hatched 2 – 3 days after spawning and feeding started on the day 4-post hatch. Rotifers formed the first feed and *Artemia nauplii* were introduced on day 25-post hatch, while weaning to inert feed was from day 40 onwards (Oellermann, Tjipute, unpublished data). The survival rate of the larvae was 90 % before weaning off live feed at 35 dph.

The centre has excellent facilities that will be able to produce in excess of 300,000 fingerlings in one batch. Such an arrangement is supported by the University of Namibia's strategic plans to engage into commercial activities in order to augment its revenues (UNAM 2005). Consultation with leading fish farm development firm in Denmark (Olsen, pers. Comm.) has made it clear that while it can be combined, fish hatcheries and grow-out facilities should, preferably, be operated separately. The argument is that hatchery operation requires highly specialized personnel and controlled environment and it is much cheaper to buy fingerlings. Most grow-out facilities in Europe are also buying their fingerlings from hatcheries for stocking.

For the 150 tonnes/year farm, 5g fingerlings of approximately 4 - 5 month age, that have been weaned off live food, will be stocked. The idea is to stock fingerlings 3 times per year in order to ensure continuous production line. A 150 tonnes/year production farm will need 172,500 fingerling yearly or 57,500 fingerlings for every 3rd stocking taking into consideration15% mortality rate for the grow-on period. Stocking will be done in the 1st, 7th and 12th month (Appendix 1 and 2). Fingerling cost is estimated at N$1.50 each.

3.1.3 Standing Stock

The production model for the land-based, silver kob on-growing farm will achieve equilibrium in the second year of operation. Equilibrium is the point at which the monthly input of silver kob fingerling is balanced by the off-take of product for market. At this point the farm will have a standing stock of 92 tonnes of silver kob, at various stages of growth (Appendix 2).

3.1.4 Feeding

A formulated diet for dusky kob, *A. japonicus*, juveniles was developed (Wooley 2006) with results suggesting a better growth performance and feed utilization in diets containing 46% dietary protein. In a study done in South Africa the averaged food conversion ratio was 2.3 at a feeding rate of 1.6% body weight per day (Ferreira *et al*. 2008). The suggested feeding rate is 10% body weight per day at which an average FCR of 1.8 is achieved. A number of feed experiments are being conducted to determine the best available feed for the species (Schoombe 2006). At present Marifeed (Pty) Ltd, a South African company, provides juvenile silver kob feed to SANUMARC. The company specialises in abalone feed and recently ventured into the manufacturing of silver kob feed. The feed cost, including transportation is N$30/kg.

3.1.3 Growth Rate of Silver Kob, (A. inodorus)

Table 2 provides information on the research that was carried out by Rhodes University and a South African fishing company’s (Irvin and Johnson Ltd.), commercial hatchery, which undertook a series of growth and survival trials in small-scale experimental cages (Schoombe 2006). This suggests that the species took 24 months to reach market size of 1.5 – 2 kg.). In this experiment the fish was fed 1.6% of body mass.

Table 2. Silver kob production information for the study carried out by I&J (Pty) Ltd.

Cage number	**Cage volume (m³)**	**Cohort age (months)**	**Months in cages**	**Sizes (g)**	**Number of fish**	**Biomass**
1	150	4	0	5	1000	5
				7	12000	84
				12	2000	24
2	500	16	12	270	2000	540
				340	3000	1020
				410	3000	1230
				510	2000	1020
				700	1700	1190
3	1200	28	24	900	1500	1350
				1180	3000	3540
				1350	3000	4050
				1600	1500	2400
				1850	900	1665

In an effort to estimate the time taken for silver kob to reach market size a combination of growth data from species biological references (Kirchner *et al*. 2001), growth under experimental conditions (Schoombe 2006) and growth of similar species such as dusky kob (Collett *et al*. 2008) have been used.

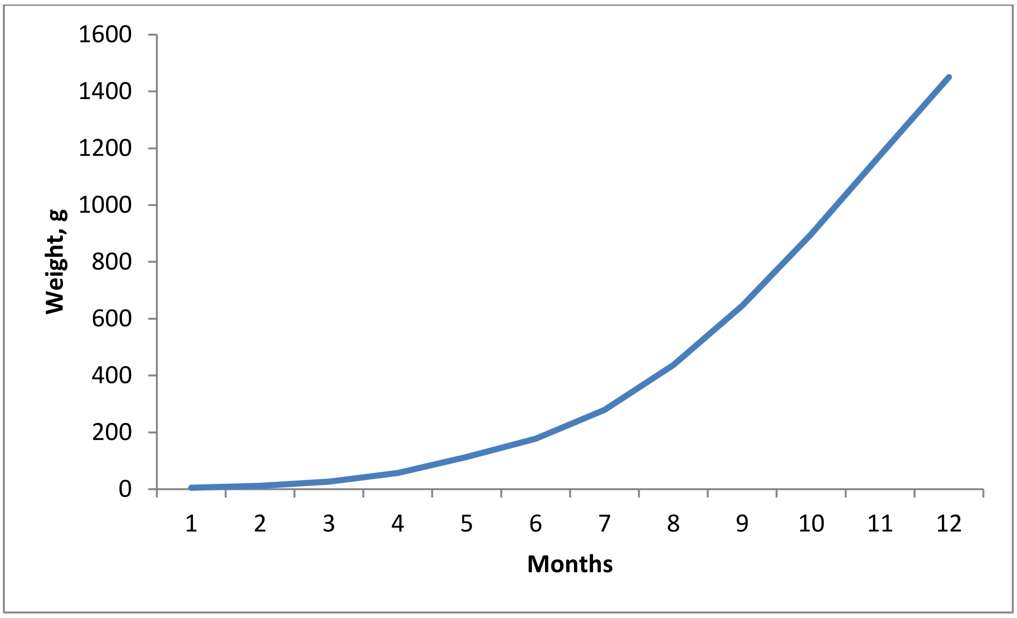

Figure 3. Expected growth of the silver kob farmed, based on the production model.

The two species, dusky kob (*A. japonicus*) and silver kob (occuring in both Namibia and South Africa, has overlaping habitat and feeding habits (Kirchner and Holtzhausen 2001). All the invistigated Sciaenid species grow well on feed containing 43 – 46% crude protein.

3.1.4 Density

The density at which a fish can be reared without causing negative side effects in growth and survival is species specific. Rearing densities in tanks range from about 10 - 35 kg/m^3 for salmon (Pillay and Kutty 2005) through to 200 kg/m^3 for eels. Studies on dusky kob suggested a stocking density of 50 - 60 kg/m^3 would not impair growth (Wooley 2006). Silver kob is a social fish that can be found in dense shoals (Van der Elst 1993). This suggests that they will tolerate high culture densities. For this study, however, it was decided to set the permissible culture density in tanks to 50 kg/m^3.

3.1.5 Farm activities

Recirculating aquaculture systems (RAS) are a type of flowing water fish culture technology in which a high percentage of water is reused after treatment (Summerfelt 1999) and consists of interacting processes that form a complex whole. Recirculating aquaculture systems and water re-use systems are mechanically very sophisticated and biologically complex and therefore need well-educated, experienced and dedicated staff to manage (Dunning *et al.* 1998). These systems also require high capital investments and poor designs or inferior management may lead to failures and the accompanying financial losses (Summerfelt *et al.* 2001). Proper design and financial calculations are therefore necessary to measure the economic viability. The feasibility study will be based on a production system above 150 tonnes/year due to the high capital necessary for recirculating aquaculture systems (Engle 2010). Larger farm have lower per-unit cost of production than smaller farms. The opinion expressed during consultations with the industry (Gaumet, Simpson, Olsen, pers.comm) also supported the idea that marine finfish aquaculture is economically feasible in volumes from 100 tonnes/year.

The farm is based on a production of 150 tonnes/annum. Procurement and stocking of silver kob fingerlings will take place every second month. This means that 6 cohorts will be stocked per year. The fingerlings will be held in quarantine tanks of 20 m^3 for the first months. First grow-out of fish 60 – 280 g will be in 50 m^3 tanks and the second grow-out to market size of fish 280 – 1000 g will be in 150 m^3 tanks. The farm will have 16 of 20 m^3 tanks, 16 of 50 m^3 tanks ^{and} 5 of 150 m^3 tanks. This is in consideration of grading of different size groups, including slow growers. Each unit of the nursery and grow-out departments will run separately to ensure that disease transfer is minimized.

The system will have common equipment per unit, with back-up, such as oxygen and ozone generators, automatic feeding systems, fish handling and grading equipment, monitoring and control PLC system including probes for automatic water quality logging and alarms. Assuming a standing stock of 98 tonnes and an average density of 50 kg/m^{-3}, the farm would require a volume of approximately 2,800 m^3 of impounded seawater at any one time. The production time for each cohort is 14 months. Sorting and grading will take place 6 times in a year, i.e. every 2nd month. The farm is assumed to reach full production within two years of operation (Appendix 2). The fish will be harvested from the (9^{th}) month at 645 g (Table 2).

Table 3. Production model of 1 cohort for the first year growth cycle.

Year 1														
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
SGR	**2.9**	**2.7**	**2.5**	**2.3**	**1.5**	**1.5**	**1.5**	**1.3**	**1.1**	**0.9**	**0.7**	**0.5**	**0.3**	**0.3**
Weight	5	11.9	26.8	56.8	113.2	177.6	278.5	436.8	645.1	897.3	1175.5	1450.2	1684.9	1843.5
Mortality rate(%)	2	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
Number of fish	57500	56350	55223	54119	53036	51975	51456	50941	50432	34426	22938	14431	7535	1600
Biomass (kg)	288	673	1482	3074	6005	9230	14331	22250	32535	30892	26964	20928	12696	2950
FCR	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Feeding (kg)/month	718	1511	2979	5498	6143	9442	14660	19103	22896	17236	11341	6096	2152	500
Feed cost/month @ N$33/kg	11484	24170	47660	87964	98293	151070	234556	305653	366335	275775	181462	97539	17217	4000
Density (kg/m³)	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Volume needed (m³)	5.8	13	30	61	120	185	287	445	651	618	539	419	254	59
Tanks size (m³)	20.0	20.0	20.0	50	50	50	50	150	150	150	150	150	150	150
Number of tanks	1.0	1.0	2.0	2	3	3	6	3	4	4	4	3	2	1
Volume harvested (kg)	0	0	0	0	0	0	0	0	10000	10000	10000	10000	10000	2950
Number of harvested fish	0	0	0	0	0	0	0	0	15501	11144	8507	6896	5935	1600
Total volum harvested	0	0	0	0	0	0	0	0	10000	20000	30000	40000	50000	52950

There is, however, the possibility for increased stocking densities provided that the limiting factors such as oxygen, waste removal are maintained at high levels. Produced fish will be sold whole through the normal distribution channel of Kuiseb Fishing Enterprise.

3.1.6 Labour requirements

The permanent staff of the farm will consist of a farm manager, 1 technician and 5 labourers would be required to maintain the 150 tonne operation, carrying out tasks such as cleaning tanks, size-sorting and re-distributing abalone amongst the tanks, feeding, harvesting and preparing the animals for transport to market. Five extra labourers will be needed during stocking, grading and harvesting (Table 2). The work plan of the farm will make provision for staff rotation during weekends and holidays. The total annual salary and wages amount to N$755,000. At a selling price of N$50/kg it will require a production of 15100 kg to cover salaries and wages before any other costs are considered.

Table 4. Labour requirements for a 150 tonnes/year land-based silver kob farm operation.

Category	Number	Annual Cost (N$)
Permanent Staff		
Manager	1	241,000
Technician	1	185,000
Labourers	5	293,000
Total	**7**	**719000**
Temporal Staff		
Labourers	5	7,200
Total	**5**	**36,000**
TOTAL SALARIES & WAGES	**15**	**755,000**

3.1.7 Water Quality

Water quality requirement is very important in the culture of any species. Silver kob tolerate different temperature range 13 – 25 ºC but grow best at 23 ºC. The optimum temperature for rearing the dusky kob was studied by Collet (as well as optimum temperature (Collet 2008). The study indicated that the species reach 1 kg in 12 months when held in tanks and 1 – 2 kg when held in cages, while the temperature preference falls within the range of 12 – 28 ˚C. The temperature for best growth was estimated at 25.3 ˚C while 21.4 ˚C was the temperature at which the best FCR was achieved. It is recommended to culture silver kob at temperature of 21 – 25 ˚C.

The ambient seawater temperature along the Namibian coastline fluctuate between 13 – 20 ºC. Nevertheless, recirculating technology will allow for the use of solar ponds if the water temperature of the system is too cool. Solar ponds are large, shallow, black plastic-lined ponds that are exposed to the sun. The water in these ponds heats up significantly above the ambient temperature. Variable amounts of seawater from the system can be diverted thorough these ponds, to take up heat as required. Oxygen concentration for the species need to be maintained at 100% saturation for optimum growth. Ammonia is the most important waste product of fish metabolism and growth. It is highly toxic to fish, and most species of fish are affected by dissolved ammonia concentrations in excess of 0.1 mg/L^{-1}. The biological filter, included in the RAS equipment list, will be able to keep ammonia concentrations low.

3.1.8 Effluent water treatment

Aquaculture development can be in conflict with other resource users of land, water and other resources. Several reports have extensively documented the environmental implications of aquaculture development (Barg 1995). Most of the documented negative effects include, among others, conversion of wetland habitats, nutrient and organic waste discharge, introduction of exotic species, chemical usage and water quality deterioration (Pillay 2007). The culture of silver kob will be designed such that the environmental impact will be minimal. For instance, in the land-base system, there is increased potential for the re-circulation and re-use of water. This reduces the total volume of water needed for production and minimizes the drainage of used water from farming units. The aim is also to pump effluent water in treatment ponds before being returning to the sea. The probability for fish to escape from land-based farms is also very low (Hefman 2007). Effluent treatment ponds will be built to rehabilitate the effluent water from the silver kob farm. Extra labourers will be needed during stocking, grading and harvesting operations before it returns to the ocean. The effluent treatment ponds can also be used for downstream activities, such as the culture of other bivalve species, algae and kelp.

4 PROFITABILITY MODEL

The profitability model is aimed at considering a 10 year planning horizon. The figures for costs were obtained by consulting industry members, conducting interviews as well as from publications (Table 1).To have a realistic estimation all the cost estimates for investment, fixed and variable costs have been subjected to a Three-Point Estimation method to determine the final cost estimate for use.

The land for set-up is assumed to have been acquired. This is based on the plans of the Directorate of Aquaculture, Ministry of Fisheries and Marine Resources, to establish demarcated aquaculture parks in most towns as a means of encouraging the development of aquaculture. The Aquaculture Master development Plan, currently, under developemnt is aimed identifying sites for aquaculture in regions and towns. Investment cost.

The cost of building for the recircualting system will form part of the capital set-up cost. For this study it was estimated that the investment for the building (construction of building and concrete works) is N$7.6 million and equipment (seawater intake and recirculating aquaculture systems (RAS)) is N$11.5 million. Other costs included the consultancy fee and staff training will amounts to N$1.8 million. Variable costs that included casual labour, electricity, fingerlings and feed are N$10.6 million. Fixed costs included salaries (N$1 million), licenses (N$1000), rates and taxes, and insurance (N$17000) each. Salaries constitute 97% of the total fixed costs. Total production cost (variable cost + fixed cost) for the 150 tonnes/year silver kob farm is N$17.9/kg. Feed cost alone is 53% of the production cost. The setting up of the 150 tonnes/year silver kob farm will require a total investment of N$22.16 million, consisting of N$20.916 for capital expenditure and about N$1.3 million as working capital over the 10 year planning period. The calculation of this feasibility study is based on 30% equity with additional 70% of finance to be borrowed (Appendix 4 and 5). The interest rate is 5% (Agricultural Bank of Namibia 2011).

Capital expenditure will be used to pay for the installation of water intake system, building and concrete works and the recirculating aquaculture systems (RAS) as outlined in Appendix 3 and 4. Other costs will include the training of staff in the operation of RAS and consultancy fees.

Table 5. Estimated capital expenditure.

Item	Cost N$('000)
Buildings	4,877
Concrete works	2,798
RAS Equipment	10,989
Water intake	498
Staff Training	688
Consultancy fee	1,066
Total Expenditure	**20,916**

4.2. WORKING OPERATIONAL CAPITAL

The working capital will cover cost of production and operational expenditure. The major cost contributors to the cost of production include fingerlings, feed, electricity, which form part of the variable costs. Among the fixed costs (operational capital) the major expenses are salaries for permanent staff (Table 4), insurance, license fees and rates and taxes (Appendix 3).

Table 6. Breakdown of Operational costs.

Item	Cost N$('000)
Fixed costs	
Casual labour	22
Electricity	2,024
Fingerlings	315
Feed	7,736
Variable Costs	
Permanent Staff Salaries	**719,000**
Administration cost	20
Insurance	19
License	1
Rates & Taxes	21
Total Operational cost	**11,306**

4.1 Cashflow

The income is generated from the sale of silver kob at a wholesale selling price. The initial expected price used was N$50 per kg at an exchange rate of N$10 per Euro. The price was assumed to increase annually by 3 %. The sales will be realized from the first year. Year 1 production was 40 tonnes, with subsequent increase from year 2 onwards (Appendix 4). The projected cash flow statement indicated that in the first two years there is no profit (Figure 4 and Appendix 6).

Figure 4. Investment and cash flow for the 150 tonnes/year silver kob farm.

4.2 Farm profitability

NPV and IRR were used to assess the profitability of the farm. The NVP is equal to the present value of future net cash flows, discounted at the cost of the capital. The NPV, calculated with 10% interest was positive, implying that the venture is feasible. The payback period (expected number of years required to recover the original investment) is seven years (Figure 5). There is some risk in payback period as many things can happen in the 7 years.

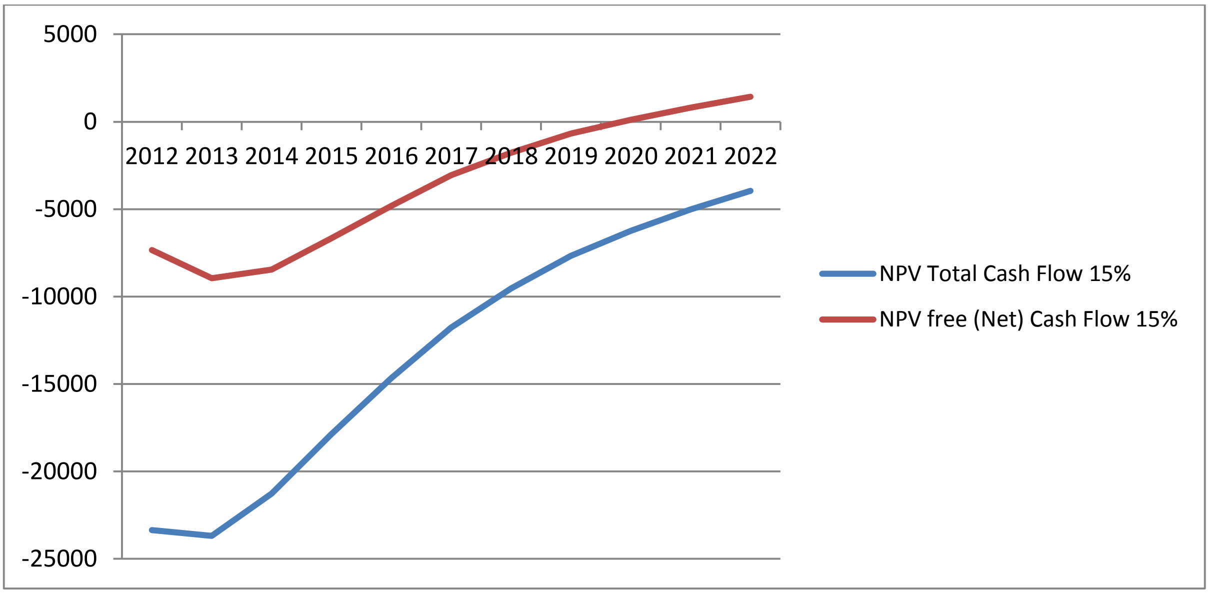

Figure 5. Accumulated Net Present Value of the 150 tonnes/year silver kob farm.

The internal rate of return (IRR) (as a measure of expected return) was estimated based on invested capital costs incurred and revenue flows in form of net profit before tax generated over the project period. It is estimated that the project has an internal rate of return (IRR) of 19 %, which is considered very good. The net present value of this investment is positive at 15% discount rate. Given that the average economic opportunity cost of capital in Namibia is about 7.2% (Hamavindu 2008), it can be said that this investment is economically feasible.

4.3 Sensitivity analysis

The profitability of the silver kob farm is particularly sensitive to the sales price of the products and sales quantity (Figure 7 and 8). A decrease of 35 % in sales price and a 40 % in sales quantity will render the farm not feasible. The variable cost could be drastically reduced by improving the cost of feed (Appendix 9). It will be safe to assume that such a scenario will be expected under the following conditions: improvement in feeding through better management, establishment of fish feed factory in the country that will enable cutting down on transport costs. There is currently a fish feed manufacturing centre, established by the Ministry of Fisheries and Marine Resources in Omahenene, which is catering for the freshwater aquaculture sector and its output is very low due to lack of human capacity. This centre could be put to good use by serving the marine finfish industry. This will make the cost of feed cheaper than sourcing from South Africa.

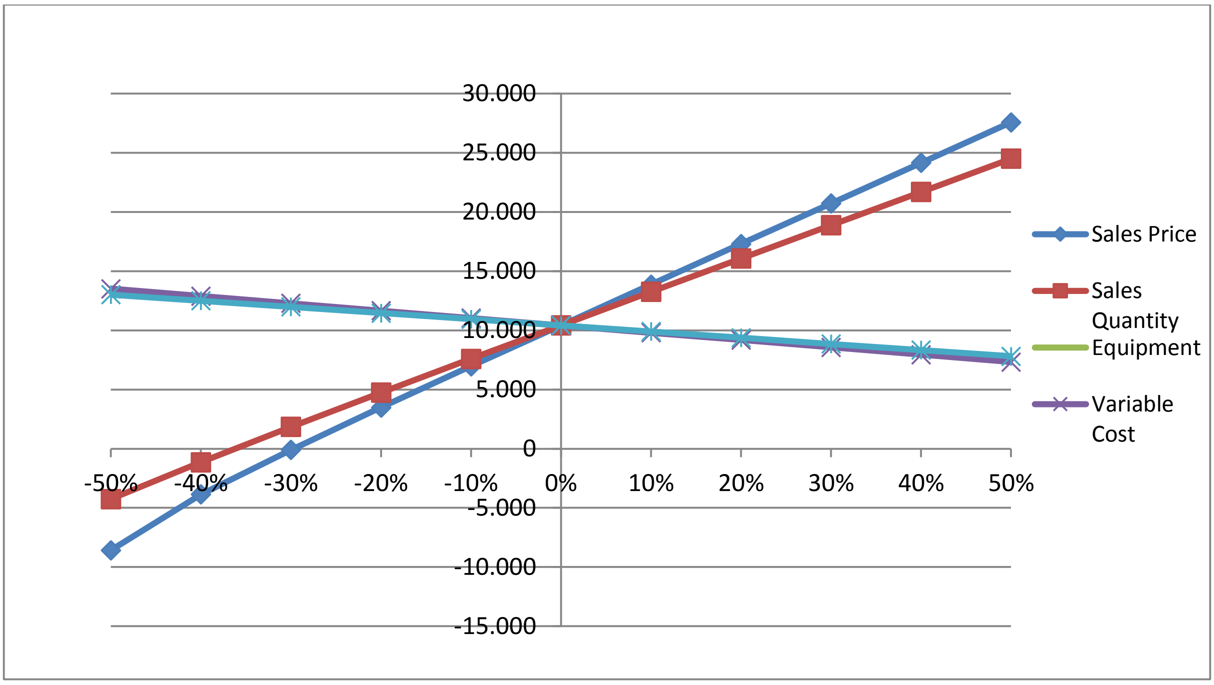

Figure 6. Sensitivity analysis of sales prices, quantity, equipment, variable and fixed costs.

4.4 Potential Strengths, Weaknesses, Opportunities and Threats of silver kob farming in Namibia

Strengths and weaknesses are determined by the internal environment of Namibia with regard to the farming of the species, while opportunities and threats are defined the external environment (export markets, competing producers of similar species in other countries and feed providing companies outside Namibia)

Strengths
• **Sites –** Most part of the Namibian coast is uninhabited. The Government of the Republic of Namibia is promoting for the establishment of aquaculture zones in all 13 regions and major municipal areas. This will be proposed in the Aquaculture Master Plan to be completed this year (2012) .
• **Environment –** Silver kob is a native species. Due to the energetic coastline, it will be cultured mainly in pump-ashore recirculating system and no danger of escape to the environment is expected. RAS provides for treatment of the effluent and the impact to the environment will thus be insignificant.
• **Technology –** RAS technology is continuously being developed and most of the problems have been addressed or are being addressed, making it the ideal time to enter the industry. Research on the species husbandry is on-going at the University of Namibia and the positive results obtained will assist the industry in the culture of the species.
• **Production –** Fingerlings will be acquired from the research institute in the initial stages. Additional procurement of fingerlings will encourage new entrants in the species hatchery operation once the demand is sufficient and economical feasible to warrant such. There is also great possibility for companies to establish in-house hatcheries.
Weakness
• **Sites –** Infrastructure is lacking. The provision of electricity and other amenities to aquaculture zones will be very costly. Access roads to the aquaculture sites will need to be upgraded.
• **Environment –** Namibia coastal environment is very unpredictable with algal blooms and sulphur eruptions posing a threat to the quality of the pumped seawater. Alternative measures must be put in place to cater for such occurrences which may be costly.
• **Technology –** RAS is very sophisticated technology that require competent personnel to manage it. The risk of system collapse due to faulty installation, power failure as well as human error is high. Stand-by generations, spare parts will thus form a component of the farming system and need to be budgeted for. Constant upgraded of personnel competencies forms part of the operation costs.
• **Production –** The lack of a hatchery may be interpreted as a weakness. Once the business is generating surplus income, it will be prudent for the business to invest in its own hatchery. This ensures access to seed stock, and allows the development of genetic bloodlines to select for desired characteristics. The husbandry techniques of the species will also take time to perfect and considerable investment need to be done in research and development (R&D) for species.
Opportunities
• **Markets –** Currently the market for fisheries products is huge. The opening of the Chinese markets provides for diversification of Namibia fisheries products. Namibia has an established access to markets.
Threats
• **Technology –** RAS technology is advanced and requires highly qualified human resources and reliable supplies and services. It may be difficult to attract and retain staff and ensure reliable services.
• **Production –** Unforeseen problems like the outbreak of diseases that can have an adverse effect on the production have not been fully studied.
• **Markets –** The species is new to the market and rigorous marketing strategy needs to be undertaken. Namibian fisheries sector is aimed at the export market and is thus vulnerable to the vagaries of the economies of the importing countries.

5 DISCUSSION

The Namibian aquaculture industry is predicted to grow fast in the next 5 – 10 years. This is mainly due to the existing legal framework and policies that are geared towards establishing a conducive environment. Interest in the finfish cultivation is growing in Namibia, with some fishing companies investing in the research and development of prospective aquaculture species, among them the silver kob. It is important, therefore, to investigate the economic viability of the targeted species. A feasibility study provides a thorough analysis of the viability of the business opportunity as well as looking at possible stumbling blocks that may stand in the way of success. The importance of such investigation is due to the fact that considerable capital is needed to venture in aquaculture. Silver kob aquaculture is feasible in Namibia. The species is having good growth and compares well with similar species of the sciaenid family such as the dusky kob (Collet 2008).

Fingerling production is one of the major uncertainties. Research institute will spearhead fingerling production until the rearing methods have been perfected for a private company to get involved. The cost of building for the recircualting system will form part of the capital set-up cost. For this study the total investment is N$20,9 million. Variable costs N$10.6 million. Fixed costs included salaries. Total production cost (variable cost + fixed cost) for the 150 tonnes/year silver kob farm is N$16.2/kg. Feed cost alone is 53% of the production cost. This agrees with another study (Rola and Hasan, 2007) carried out in Viet Nam and Thailand, indicating that the feed costs are about 50 - 80% of total catfish production costs. The farmer can improve FCR by providing the appropriate amount of feed, maintaining the proper feeding duration, feeding frequency and timing of the feeds. Appendix 9 indicates the effect of lowering of the FCR on production cost or rearing one cohort. The production cost for for silver kob farming compare well with some estimates provided by the aquaculture industry: At a French farm, Poissons du Soleil, the production cost of meagre is €3/kg (N$30.30), cost of juvenile is €1 (N$10.30) per piece. Production cost for grouper (*Epinephelus* sp.) is estimated at €2.91(N$29.97) (Pomeroy et al. 2004;) This figure was also confirmed during consultation with the industry (Frederik Gaumet 2012 pers. comm.).

The current feasibility study is based on assumptions of the information available to model the production and financial performance of the silver kob. Models provide a structure for continual analysis and evaluation of the business over time. It is imperative that such developed models have both long and short term planning which makes it easier to identify sources of problems and potential solutions. The production in the 1st year of operation will be minimal 40 tonnes and will to reach equilibrium at 165 tonnes from the 2nd year, slightly higher than the 150 tonnes/year. This scenario is excellent as it provides sufficient buffering for any drop in production (Appendix 2). Mass production of silver kob was the most preferred option due to the economies of scale.

The economic feasibility of the farm during operation was assessed using the profitability model. Indicators such as the cash flow, NPV, IRR, and payback time were determined. The payback time for the investment is 7 years. The cash flow indicated that positive cash was generated after the second year while the IRR (opportunity cost of capital over time) was positive 19% at a 15% discounted rate. In this study 2 discount rates were used: for total and equity (Appendix 4). This is not a uncommon exercise in economics and is prompted by the low interest rate on the loan. The Agricultural Bank of Namibia is encouraging farmers to venture into aquaculture as opposed to the mainstream agricultural sector and offers low interest rates of 5%.

The scenario, which the current feasibility study is based on, is:

- The farm site is selected to meet the physical and biological requirement of silver kob, and it is assumed that access to seawater is not a problem.
- The juveniles will be bought from a hatchery and will be grown to market size.
- Full production will be achieved within the first year and capital outlays are made in the first year of operation.

Studies on the species are on-going and the model provides the guidelines for input of realistic data based on the outcome of research results but in the laboratory and on-site.

6 CONCLUSION

The study helped to develop a production and financial model for silver kob, which can also apply to other aquatic animals in Namibia. This is very important because many Namibians are interested in aquaculture but lack the necessary know-how in developing their ideas for possible funding.

The results of this feasibility study indicate that:

- The farming of silver kob is financially feasible in Namibia, based on the assumptions and profitability model. Mass production seems to be the most viable as it takes advantage of the economics of scale. Safe estimates are set at production more than 100 tonnes/year.
- Capital investment is high at N$21 million. Financial loans are readily available in Namibia. Collateral required for such loans are the obstacle, however, a matter that receive great attention from the government through the Ministry of Fisheries and Marine Resources in the order to encourage aquaculture development in the country.
- Profitability indicators: NPV and IRR are positive. NPV of cash-flow on total capital is N$10 million and on equity N$13 million while the IRR on capital and on equity is 15% and 35%, respectively, compared to the discounting rate for total and equity being 10% and 15%, respectively.
- The sensitivity analysis shows that the profitability of the silver kob farming is most sensitive to feed cost, which is the largest part of variable cost, and sales price.
- RAS are complex aquaculture systems and beginners should plan on making a significant time commitment to learning how to operate a system. An amount N$500,000 has been budgeted for staff training.

Compared to other businesses, aquaculture is viewed as a risky enterprise by financiers (Ehlers 2011). These perceptions of high risks in aquaculture may lead to lending terms that are less favourable, higher interest rates or refusal to consider loans for aquaculture venture. As such, equity required is usually determined in the range of 30 – 40%. The lending environment in Namibia is currently favourable, coupled with low interest rates, but the situation might not remain as such.

Taking all aspects in consideration it can be concluded that the farming of silver kob is feasible. A detailed business plan that includes a comprehensive marketing plan, environmental impact assessment and human resource assessment is necessary.

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Appendix 1. Production model of silver kob for year 1. Six cohorts were stocked per year with fingerling stocking done every second month. The model for subsequent years follow the same pattern.

Year 1																									
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
SGR	**2.9**	**2.7**	**2.5**	**2.3**	**1.5**	**1.5**	**1.5**	**1.3**	**1.1**	**0.9**	**0.7**	**0.5**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**							
Weight	5	11.9	26.8	56.8	113.2	177.6	278.5	436.8	645.1	897.3	1175.5	1450.2	1684.9	1843.5	2017.1	2207.1	2415.0	2642.4							
Mortality rate(%)	2	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0							
Number of fish	57500	56350	55223	54119	53036	51975	51456	50941	50432	34426	22938	14431	7535	1600	0	0	0	0							
Biomass (kg)	288	673	1482	3074	6005	9230	14331	22250	32535	30892	26964	20928	12696	2950	0	0	0	0							
FCR	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8							
Feeding (kg)/month	718	1511	2979	5498	6143	9442	14660	19103	22896	17236	11341	6096	2152	500	0	0	0	0							
Feed cost/month @ N$30/kg	21532	49850	98298	181426	202728	311582	483772	630409	755567	568786	374266	201175	71021	16501	0	0	0	0							
Density (kg/m³)	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50							
Volume needed (m³)	5.8	13	30	61	120	185	287	445	651	618	539	419	254	59	0	0	0	0							
Tanks size (m³)	20.0	20.0	20.0	50	50	50	50	150	150	150	150	150	150	150											
Number of tanks	1	1	2	2	3	3	6	3	4	4	4	3	2	1											
Volume harvested (kg)	0	0	0	0	0	0	0	0	10000	10000	10000	10000	10000	2950	0	0		0							
Number of harvested fish	0	0	0	0	0	0	0	0	15501	11144	8507	6896	5935	1600	0	0	0	0							
Total volume harvested	0	0	0	0	0	0	0	0	10000	20000	30000	40000	50000	52950	52950	52950	52950	52950							
						SGR	**2.9**	**2.7**	**2.5**	**2.3**	**1.5**	**1.5**	**1.5**	**1.3**	**1.1**	**0.9**	**0.7**	**0.5**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	
						Weight	5	11.9	26.8	56.8	113.2	177.6	278.5	436.8	645.1	897.3	1175.5	1450.2	1684.9	1843.5	2017.1	2207.1	2415.0	2642.4	
						Mortality rate(%)	2	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
						Number of fish	57500	56350	55223	54119	53036	51975	51456	50941	50432	34426	22938	14431	7535	1600	0	0	0	0	
						Biomass (kg)	288	673	1482	3074	6005	9230	14331	22250	32535	30892	26964	20928	12696	2950	0	0	0	0	
						FCR	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	
						Feeding (kg)/month	718	1511	2979	5498	6143	9442	14660	19103	22896	17236	11341	6096	2152	500	0	0	0	0	

						Feed cost/month @ N$33/kg	21532	49850	98298	181426	202728	311582	483772	630409	755567	568786	374266	201175	71021	16501	0	0	0	0	
						Density (kg/m³)	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	
						Volume needed (m³)	5.8	13	30	61	120	185	287	445	651	618	539	419	254	59	0	0	0	0	
						Tanks size (m³)	20.0	20.0	20.0	50	50	50	50	150	150	150	150	150	150	150					
						Number of tanks	1	1	2	2	3	3	6	3	4	4	4	3	2	1					
						Volume harvested (kg)	0	0	0	0	0	0	0	0	10000	10000	10000	10000	10000	2950	0	0		0	
						Number of harvested fish	0	0	0	0	0	0	0	0	15501	11144	8507	6896	5935	1600	0	0	0	0	
						Total volum harvested	0	0	0	0	0	0	0	0	10000	20000	30000	40000	50000	52950	52950	52950	52950	52950	
											SGR	**2.9**	**2.7**	**2.5**	**2.3**	**1.5**	**1.5**	**1.5**	**1.3**	**1.1**	**0.9**	**0.7**	**0.5**	**0.3**	**0.3**
											Weight	5	11.9	26.8	56.8	113.2	177.6	278.5	436.8	645.1	897.3	1175.5	1450.2	1684.9	1843.5
											Mortality rate(%)	2	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
											Number of fish	57500	56350	55223	54119	53036	51975	51456	50941	50432	34426	22938	14431	7535	1600
											Biomass (kg)	288	673	1482	3074	6005	9230	14331	22250	32535	30892	26964	20928	12696	2950
											FCR	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
											Feeding (kg)/month	718	1511	2979	5498	6143	9442	14660	19103	22896	17236	11341	6096	2152	500
											Feed cost/month @ N$33/kg	21532	49850	98298	181426	202728	311582	483772	630409	755567	568786	374266	201175	71021	16501
											Density (kg/m³)	50	50	50	50	50	50	50	50	50	50	50	50	50	50
											Volume needed (m³)	5.8	13	30	61	120	185	287	445	651	618	539	419	254	59
											Tanks size (m³)	20.0	20.0	20.0	50	50	50	50	150	150	150	150	150	150	150
											Number of tanks	1	1	2	2	3	3	6	3	4	4	4	3	2	1
											Volume harvested (kg)	0	0	0	0	0	0	0	0	10000	10000	10000	10000	10000	2950
											Number of harvested fish	0	0	0	0	0	0	0	0	15501	11144	8507	6896	5935	1600
											Total volum harvested	0	0	0	0	0	0	0	0	10000	20000	30000	40000	50000	52950

Year 2																									
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
SGR	**2.9**	**2.7**	**2.5**	**2.3**	**1.5**	**1.5**	**1.5**	**1.3**	**1.1**	**0.9**	**0.7**	**0.5**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**							
Weight	5	11.9	26.8	56.8	113.2	177.6	278.5	436.8	645.1	897.3	1175.5	1450.2	1684.9	1843.5	2017.1	2207.1	2415.0	2642.4							
Mortality rate(%)	2	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0							
Number of fish	57500	56350	55223	54119	53036	51975	51456	50941	50432	34426	22938	14431	7535	1600	0	0	0	0							
Biomass (kg)	288	673	1482	3074	6005	9230	14331	22250	32535	30892	26964	20928	12696	2950	0	0	0	0							
FCR	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8							
Feeding (kg)/month	718	1511	2979	5498	6143	9442	14660	19103	22896	17236	11341	6096	2152	500	0	0	0	0							
Feed cost/month @ N$30/kg	21532	45319	89362	164933	184298	283257	439793	573099	686879	517078	340242	182887	64564	15001	0	0	0	0							
Density (kg/m³)	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50							
Volume needed (m³)	5.8	13	30	61	120	185	287	445	651	618	539	419	254	59	0	0	0	0							
Tanks size (m³)	20.0	20.0	20.0	50	50	50	50	150	150	150	150	150													
Number of tanks	1	1	2	2	3	3	6	3	4	4	4	3	2	1											
Volume harvested (kg)	0	0	0	0	0	0	0	0	10000	10000	10000	10000	10000	2950	0	0		0							
Number of harvested fish	0	0	0	0	0	0	0	0	15501	11144	8507	6896	5935	1600	0	0	0	0							
Total volume harvested	0	0	0	0	0	0	0	0	10000	20000	30000	40000	50000	52950	52950	52950	52950	52950							
						SGR	**2.9**	**2.7**	**2.5**	**2.3**	**1.5**	**1.5**	**1.5**	**1.3**	**1.1**	**0.9**	**0.7**	**0.5**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	
						Weight	5	11.9	26.8	56.8	113.2	177.6	278.5	436.8	645.1	897.3	1175.5	1450.2	1684.9	1843.5	2017.1	2207.1	2415.0	2642.4	
						Mortality rate(%)	2	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
						Number of fish	57500	56350	55223	54119	53036	51975	51456	50941	50432	34426	22938	14431	7535	1600	0	0	0	0	
						Biomass (kg)	288	673	1482	3074	6005	9230	14331	22250	32535	30892	26964	20928	12696	2950	0	0	0	0	
						FCR	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	
						Feeding (kg)/month	718	1511	2979	5498	6143	9442	14660	19103	22896	17236	11341	6096	2152	500	0	0	0	0	

						Feed cost/month @ N$30/kg	21532	45319	89362	164933	184298	283257	439793	573099	686879	517078	340242	182887	64564	15001	0	0	0	0	
						Density (kg/m³)	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	
						Volume needed (m³)	5.8	13	30	61	120	185	287	445	651	618	539	419	254	59	0	0	0	0	
						Tanks size (m³)	20.0	20.0	20.0	50	50	50	50	150	150	150	150	150	150	150					
						Number of tanks	1	1	2	2	3	3	6	3	4	4	4	3	2	1					
						Volume harvested (kg)	0	0	0	0	0	0	0	0	10000	10000	10000	10000	10000	2950	0	0		0	
						Number of harvested fish	0	0	0	0	0	0	0	0	15501	11144	8507	6896	5935	1600	0	0	0	0	
						Total volume harvested	0	0	0	0	0	0	0	0	10000	20000	30000	40000	50000	52950	52950	52950	52950	52950	
											SGR	**2.9**	**2.7**	**2.5**	**2.3**	**1.5**	**1.5**	**1.5**	**1.3**	**1.1**	**0.9**	**0.7**	**0.5**	**0.3**	**0.3**
											Weight	5	11.9	26.8	56.8	113.2	177.6	278.5	436.8	645.1	897.3	1175.5	1450.2	1684.9	1843.5
											Mortality rate(%)	2	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
											Number of fish	57500	56350	55223	54119	53036	51975	51456	50941	50432	34426	22938	14431	7535	1600
											Biomass (kg)	288	673	1482	3074	6005	9230	14331	22250	32535	30892	26964	20928	12696	2950
											FCR	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
											Feeding (kg)/month	718	1511	2979	5498	6143	9442	14660	19103	22896	17236	11341	6096	2152	500
											Feed cost/month @ N$30/kg	21532	45319	89362	164933	184298	283257	439793	573099	686879	517078	340242	182887	64564	15001
											Density (kg/m³)	50	50	50	50	50	50	50	50	50	50	50	50	50	50
											Volume needed (m³)	5.8	13	30	61	120	185	287	445	651	618	539	419	254	59
											Tanks size (m³)	20.0	20.0	20.0	50	50	50	50	150	150	150	150	150	150	150
											Number of tanks	1	1	2	2	3	3	6	3	4	4	4	3	2	1
											Volume harvested (kg)	0	0	0	0	0	0	0	0	10000	10000	10000	10000	10000	2950
											Number of harvested fish	0	0	0	0	0	0	0	0	15501	11144	8507	6896	5935	1600
											Total volume harvested	0	0	0	0	0	0	0	0	10000	20000	30000	40000	50000	52950

*Appendix 2***.** Production model total of the silver kob farm for two years. A total production for 5 years is presented**.**

Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Total number of fish	57,500	56,350	55,223	54,119	53,036	51,975	108,956	107,291	105,655	88,545	75,974	123,906	115,341	164,114	159,773	141,581	127,950	117,862	167,432	159,323	140,081	111,483	90,405	131442
Total biomass (kg)	288	673	1,482	3,074	6,005	9,230	14,618	22,923	34,016	33,966	32,969	30,445	27,314	25,873	37,090	39,971	42,199	44,488	49,564	69,450	63,427	33,966	47,891	43141
Total feed needed (kg)	718	1,511	5,498	6,143	9,442	14,660	15,377	20,614	25,875	22,734	17,485	16,256	19,040	24,093	31,372	28,877	26,927	30,198	36,633	44,010	43,111	34,075	23,581	18,408
Total feed cost @ 16 (NAD)	21,532	49,850	98,298	181,426	202,728	311,582	505,304	680,259	853,865	750,212	576,995	512,758	626,175	790,527	#######	936,447	870,147	968,204	1,162,754	1,390,486	1,345,026	1,150,507	725,716	558696
Total water volume needed (m³)	6	13	30	61	120	185	292	458	680	679	659	609	560	547	742	799	844	998	986	1,168	1,298	1,219	1,078	863
Total harvest (kg)	0	0	0	0	0	0	0	0	10,000	10,000	10,000	10,000	10,000	2,950	10,000	10,000	10,000	10,000	10,000	22,950	20,000	20,000	20,000	20,000
Total per year	**1**	**2**	**3**	**4**																				
Total number of fish	938,531	1,626,788	1,626,788	1,626,788																				
Total biomass (tonnes)	189,687	524,373	524,373	524,373																				

Total feed needed (kg)	156,311	360,324	360,324	360,324																				
Total feed cost (NAD)	4,744,809	11,551,037	11,994,351	11,994,351																				
Total water volume needed (m³)	3,794	11,101	11,101	11,101																				
Total harvest (kg)	40,000	165,900	165,900	165,900																				

Appendix 3. The Three-Point Cost Estimate Used for the 150 tonnes/year silver kob farm.

			Three Point Cost Estimation Method					
Investment Costs								
			a	**m**	**b**	**t**	**s**	**V**
	Buildings		**Optimistic**	**Most Likely**	**Pessimistic**	**Expected Value**	**Std. Dev**	**Variance**
		Building construction	4,700	4,800	4,950	**4,808**	42	1,736
		Concrete works	2,400	2,600	3,000	**2,633**	100	10,000
		Total	**7,100**	**7,400**	**7,950**	**7,442**	**108**	**11,736**
		We assume that the total follow normal distribution						
		Selected Confidence level		95%				
		This gives the Z factor		1.645				
		The Cost Estimation Used =		**7,620**				
	Equipment		**Optimistic**	**Most Likely**	**Pessimistic**	**Expected value**	**Std. Dev**	**Variance**
		RAS Equipment	9,000	10,000	12,000	**10,167**	500	250,000
		Water intake	440	480	510	**478**	12	136
		Total	**9,440**	**10,480**	**12,510**	**10,645**	**512**	**250,136**
		The cost estimate used =		**11,487**				
	Other	Staff Training	500	650	700	**633**	33	1,111
		Consultancy fee	800	1,000	1,100	**983**	50	2,500

		Total	1,300	1,650	1,800	**1,617**	83	3,611
		The cost estimate used =		**1,754**				
Operating Cost								
	Variable Cost		**Optimistic**	**Most Likely**	**Pessimistic**	**Expected value**	**Std. Dev**	**Variance**
		Casual labour	14	18	27	**19**	2	5
		Electricity	882	1,512	2,520	**1,575**	273	74,529
		Fingerlings	86	259	345	**244**	43	1,860
		Feed	5,294	6,040	9,060	**6,419**	628	393,967
		Total	6,276	7,829	11,952	**8,257**	946	470,361
		The cost estimate used=		**9,813**	000NAD/ton			
			a	m	b	t	s	v
	Fixed Cost		**Optimistic**	**Most Likely**	**Pessimistic**	**Expected value**	**Std. Dev**	**Variance**
		Salaries						
		1 x Manager	204	228	252	**228**	8	64
		1 x Technicians	132	156	216	**162**	14	196
		5 x Manual labourers	180	270	300	**260**	20	400
		Administration	18	19	20	**19**	0	0
		Insurance	15	17	20	**17**	1	1
		License	0	1	1	**1**	0	0
		Rates & Taxes	10	17	25	**17**	3	6
		Total	559	708	834	**704**	46	667
		The cost estimate used=		**779**	**('000)NAD/year**			

Appendix 4. Profitability model: Summary Assumptions and Results.

		Assumptions and Results						
				Discounting Rate for Total		**10%**		
		2012		**Discounting Rate for Equity**		**15%**		
Investment:		N$('000)		**Planning Horizon**		**10**	**years**	
Buildings		7,620						
Equipment	100 %	11,487				**Total Cap.**	**Equity**	
Other		1,754		**NPV of Cash Flow**		**4,161**	**10,417**	
Total		**20860**		**Internal Rate**		**13%**	**30%**	
Financing:								
Working Capital		2500		**Capital/Equity**				
Total Financing		23360		**after 10 years**				
Equity	100 %	30%						
Loan Repayments	100 %	15	years	Minimum Cash Account		1197		
Loan Interest	100 %	5%						
Operations:			**2013**	**2014**	**2015**	**2016**	**2017**	
Sales Quantity	100 %		37	164	164	164	164	ton/year
Sales Price	100 %		50	52	56	58	60	N$('000)/ton
Variable Cost	100 %	10	N$('000)/ton					
Fixed Cost	100 %	1190	N$('000)/year					
Inventory Build-up			**45**					

Debtors (Accounts receivable)	25%	of turnover			**Breakdown of Costs:**			
Creditors(Accounts Payable)	15%	of variable cost			**Variable cost**	15,323	26%	
Dividend	20%	of profit			**Fixed Cost**	11,896	20%	
Depreciation Buildings	4%				**Paid Taxes**	11,533	19%	
Depreciation Equipm.	15%				**Loan Interest**	6,541	11%	
Depreciation Other	20%				**Loan Repayment**	9,811	16%	
Loan Managem. Fees	2%				**Paid Divident**	4,931	8%	
Income Tax	35%				**Total**	**60,035**	**100%**	

Appendix 5. Investment for the 150 tonnes/year silver kob farm.

		Investment											
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
Investment and Financing			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Investment:													
Buildings construction concrete works		7,620	7,315	7,010	6,705	6,401	6,096	5,791	5,486	5,182	4,877	4,572	
RAS Equipment & water intake		11,487	9,764	8,041	6,318	4,595	2,872	1,149	1,149	1,149	1,149	1,149	
Other		1,754	1,403	1,052	701	351	0	0	0	0	0	0	
Booked Value		20,860	18,482	16,103	13,725	11,346	8,968	6,940	6,635	6,330	6,025	5,721	
Depreciation (Straight Line):													
Depreciation Buildings	4%		305	305	305	305	305	305	305	305	305	305	3,048
Depreciation Equipm.	15%		1,723	1,723	1,723	1,723	1,723	1,723					10,338
Depreciation Other	20%		351	351	351	351	351						1,754
Total Depreciation			2,379	2,379	2,379	2,379	2,379	2,028	305	305	305	305	15,140
Financing:		23,360											
Equity	30%	7,008											
Loans	70%	16,352											
Repayment	15			1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	9,811
Principal		16,352	16,352	15,262	14,172	13,082	11,992	10,901	9,811	8,721	7,631	6,541	
Interest	5%		818	818	763	709	654	600	545	491	436	382	6,214
Loan Managem. Fees	2.0%	327											

Appendix 6. Cash-flow for the silver kob farm for the 10 year period.

		Cash Flow											
		Year											
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
Cash Flow													
Operating Surplus (EBITDA)		**0**	**242**	**5,682**	**6,338**	**6,666**	**6,994**	**6,994**	**6,994**	**6,994**	**6,994**	**6,994**	**60,896**
Debtor Changes (Accounts Receivable)			463	1,670	164	82	82	0	0	0	0	0	**2,460**
Creditor Changes (Accounts Payable)			63	186	0	0	0	0	0	0	0	0	**248**
Cash Flow before Tax		**0**	**-158**	**4,199**	**6,174**	**6,584**	**6,912**	**6,994**	**6,994**	**6,994**	**6,994**	**6,994**	**58,684**
Paid Taxes			0	0	0	856	1,253	1,387	1,528	2,151	2,170	2,189	**11,533**
Cash Flow after Tax		**0**	**-158**	**4,199**	**6,174**	**5,728**	**5,660**	**5,608**	**5,466**	**4,844**	**4,825**	**4,806**	**47,151**
Financial Cost (Interest +LMFee)		327	818	818	763	709	654	600	545	491	436	382	**6,541**
Repayment		0	0	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	**9,811**
Free (Net) Cash Flow		**-327**	**-976**	**2,291**	**4,321**	**3,929**	**3,915**	**3,918**	**3,831**	**3,263**	**3,299**	**3,334**	**30,799**
Paid Dividend			0	0	497	468	465	515	568	799	806	813	**4,931**
Financing - Expenditure (Working Capital)		**2,500**											**2,500**
Cash Movement		**2,173**	**-976**	**2,291**	**3,824**	**3,461**	**3,450**	**3,403**	**3,263**	**2,464**	**2,493**	**2,521**	**28,368**

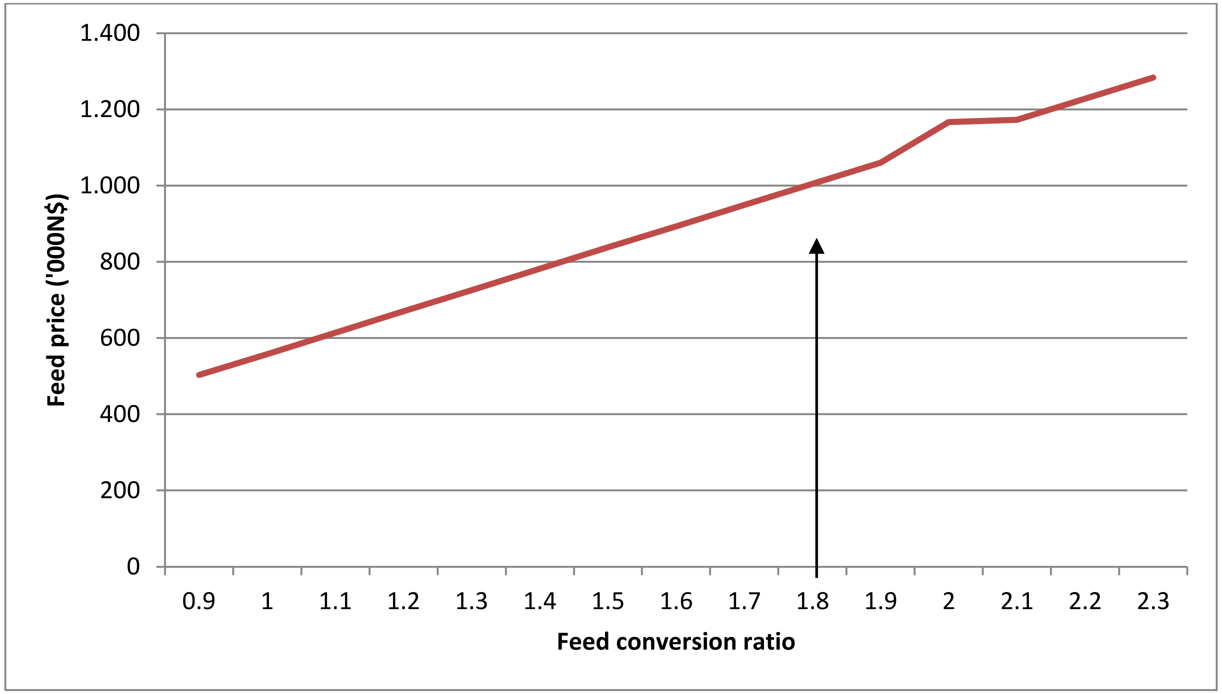
Appendix 7. Profitability analysis of the 150 tonnes/year silver kob farm.

		Profitability											
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
Profitability Measurements													
NPV and IRR of Total Cash Flow													**47,151**
Cash Flow after Taxes		0	-158	4,199	6,174	5,728	5,660	5,608	5,466	4,844	4,825	4,806	**-16352**
Loans		-16352											**-7008**
Equity		-7008											**23791**
Total Cash Flow & Capital		**-23360**	**-158**	**4,199**	**6,174**	**5,728**	**5,660**	**5,608**	**5,466**	**4,844**	**4,825**	**4,806**	
NPV Total Cash Flow	10%	-23360	-23,504	-20,034	-15,395	-11,483	-7,968	-4,803	-1,998	262	2,308	4,161	
IRR Total Cash Flow							0	0	0	0	0	0	
NPV and IRR of Net Cash Flow													
Net Cash Flow		-327	-976	2,291	4,321	3,929	3,915	3,918	3,831	3,263	3,299	3,334	**-7008**
Equity		-7008											**-7008**
Net Cash Flow & Equity		**-7335**	**-976**	**2,291**	**4,321**	**3,929**	**3,915**	**3,918**	**3,831**	**3,263**	**3,299**	**3,334**	**23791**
NPV free (Net) Cash Flow	15%	-7335	-8,222	-6,329	-3,082	-398	2,033	4,244	6,210	7,732	9,131	10,417	
IRR Net Cash Flow					0	0	0	0	0	0	0	0	

Appendix 8. The balance sheet for the 150 tonnes/year silver kob farm for 10 years.

		Balance									
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Balance Sheet											
Assets											
Cash Account	0	2,173	1,197	3,488	7,312	10,773	14,224	17,627	20,890	23,354	25,847	28,368
Debtors (Accounts Receivable)	25%	0	463	2,132	2,296	2,378	2,460	2,460	2,460	2,460	2,460	2,460
Stock (Inventory)	0	0	45	45	45	45	45	45	45	45	45	45
Current Assets		**2,173**	**1,705**	**5,665**	**9,653**	**13,196**	**16,729**	**20,132**	**23,395**	**25,859**	**28,352**	**30,873**
Fixed Assets (Book Value)		20,860	18,482	16,103	13,725	11,346	8,968	6,940	6,635	6,330	6,025	5,721
Total Assets		**23,033**	**20,187**	**21,768**	**23,378**	**24,542**	**25,696**	**27,071**	**30,030**	**32,189**	**34,377**	**36,593**
Debts											
Dividend Payable		0	0	497	468	465	515	568	799	806	813	820
Taxes Payable		0	0	0	856	1,253	1,387	1,528	2,151	2,170	2,189	2,208
Creditors (Accounts Payable)	15%	0	63	248	248	248	248	248	248	248	248	248
Next Year Repayment		0	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090
Current Liabilities (Short-Term Debt)		**0**	**1,153**	**1,836**	**2,663**	**3,057**	**3,240**	**3,435**	**4,288**	**4,314**	**4,340**	**4,366**
Long Term Loans		16,352	15,262	14,172	13,082	11,992	10,901	9,811	8,721	7,631	6,541	5,451
Total Debt		**16,352**	**16,415**	**16,008**	**15,745**	**15,048**	**14,142**	**13,246**	**13,009**	**11,945**	**10,881**	**9,817**
Equity	0	7,008	7,008	7,008	7,008	7,008	7,008	7,008	7,008	7,008	7,008	7,008
Profit & Loss Balance	0	-327	-3,236	-1,247	625	2,486	4,546	6,817	10,012	13,236	16,488	19,768
Total Capital		**6,681**	**3,772**	**5,761**	**7,633**	**9,494**	**11,554**	**13,825**	**17,020**	**20,244**	**23,496**	**26,776**
Debts and Capital		**23,033**	**20,187**	**21,768**	**23,378**	**24,542**	**25,696**	**27,071**	**30,030**	**32,189**	**34,377**	**36,593**

Appendix 9. Effect of FCR on the feed cost for rearing 1 cohort.



Appendix 10. People Consulted.

Institution	**Contact Person**	**Rank**
Ministry of Fisheries & Marine Resources	Ekkehard Klingelhoeffer	Deputy Director
Beira Aquaculture	Manuel Romero	Manager
Sam Nujoma Marine & Coastal Resources Resource Centre	Marthinus Kooitjie	Assistant Researcher (Mariculture)
Pure Ocean Aquaculture	Andre Bok	Production Manager
Marifeed	Densil May	Production Manager
AquaOptima	Rune Erikson	Project Engineer
AquaOptima	Frederic Gaumet	Fish Biologist
Billund Aquaculture Services ApS	Bjarne Hald Olsen	Managing Director
Billund Aquaculture Services ApS	Ole Sorensen	Technical Manager
Deep Blue Aquatic Services	Brynn Simpson	Manager
Namibia Mariculture Association	Dave Russel	
INFOSA	Blessing Mapfumo	Aquaculture Specialist