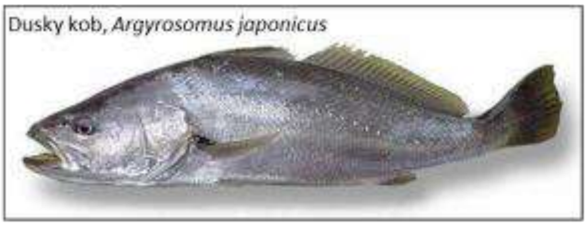
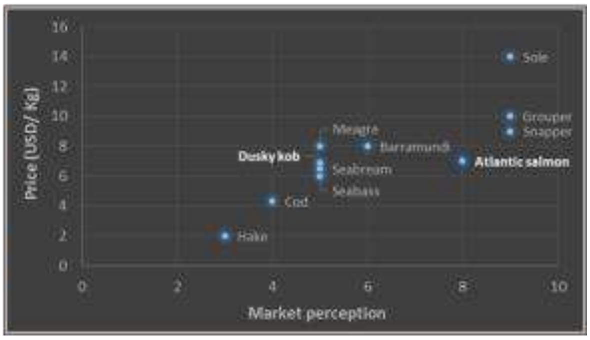
Feasibility Study of Marine Finfish (Dusky kob and Atlantic salmon) Aquaculture in South Africa

June 2017

(Reviewed by DAFF and Industry)



Feasibility Study of Marine Finfish (Dusky kob and Atlantic salmon) Aquaculture in South Africa

agriculture,
forestry & fisheries

Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

EXECUTIVE SUMMARY

World fish stocks are currently under considerable pressure, with 29% classified as overfished and a further 61% as fully exploited, with no ability to produce greater harvests (FAO, 2014). The total global capture production of 93.7 million tonnes in 2011 was the second highest ever. However, these recent results should not raise expectations of significant catch increases. Rather, they represent a continuation of the generally stable situation.

With only 6.5% of the global protein consumption currently being produced in water, replacing fish with alternative land-based sources of protein is an unlikely solution to addressing future needs. The recognition of fish as the preferred protein will continue to drive global demand and **aquaculture represents the only sustainable option to addressing a widening supply-demand gap**.

Global aquaculture production has made significant progress over the past 3 decades, sustaining an average growth rate of 8.6% per annum and is now the fastest growing animal-based food producing sector and has a crucial role to play in reducing pressure on wild fish stocks. In 2014, global aquaculture production stood at 44% of the total world fish supply (FAO, 2016) with finfish aquaculture production contributing 67% to this. In Africa, the contribution by aquaculture to total production in 2014 was a mere 2.3%. Africa's low aquaculture productivity is mirrored in South Africa where less than 5 000 tonnes of fish per year comes from aquaculture, while over 600 000 tonnes is from capture fisheries (Britz, 2007). Even at continental level, South Africa contributes less than 1% to Africa's aquaculture production.

Through a combination of national-level strategy setting and prioritisation, private-sector investment, and multilateral assistance and support, a strong and vibrant aquaculture sector could begin to emerge in key African countries and contribute to the strong global growth that has already been occurring in recent decades.

In South Africa, the Department of Agriculture, Forestry and Fisheries (DAFF) sees the potential for commercial aquaculture to contribute to this global growth and expand the range of aquatic food products on the market, and consequently improve food security, job creation, economic development and export opportunities.

It is on this basis that the DAFF have invested into research and development for aquaculture industry growth. Part of this initiative was the undertaking of several feasibility studies to assess the technical and commercial viability of specific species for aquaculture production in South Africa.

This high-level, non-site specific, feasibility study evaluates the technical and financial feasibility of dusky kob (*Argyrosomus japonicus*) and Atlantic salmon (*Salmo salar*) aquaculture in South Africa. The study provides a background on the biology and environmental requirements of these species, different aquaculture systems used to culture them, and has investigated the operational scale, timeframe, and financial resources required for a commercially viable operation.

Dusky Kob

The dusky kob is a euryhaline, carnivorous fish usually found in shallow coastal and estuarine waters and well represented in the Indo-Pacific, the Caribbean and in the temperate waters of the Atlantic- and Pacific Oceans (Froese & Pauly, 2016). In Southern Africa it occurs on the east coast from Cape Point to Mozambique and is especially abundant between Cape Agulhas and KwaZulu-Natal (Griffiths, 1996). In South Africa, the species exhibits rapid growth and can reach a maximum length of 1.8m, weight of 75kg and 40+ years of age (Griffiths & Hecht, 1995).

Due to its large size, palatability, and food value, dusky kob is targeted by recreational and commercial fisheries throughout its natural distribution. In South Africa, per-recruit analyses have revealed that the dusky kob has been severely over fished (Griffiths *et al.* 2003).

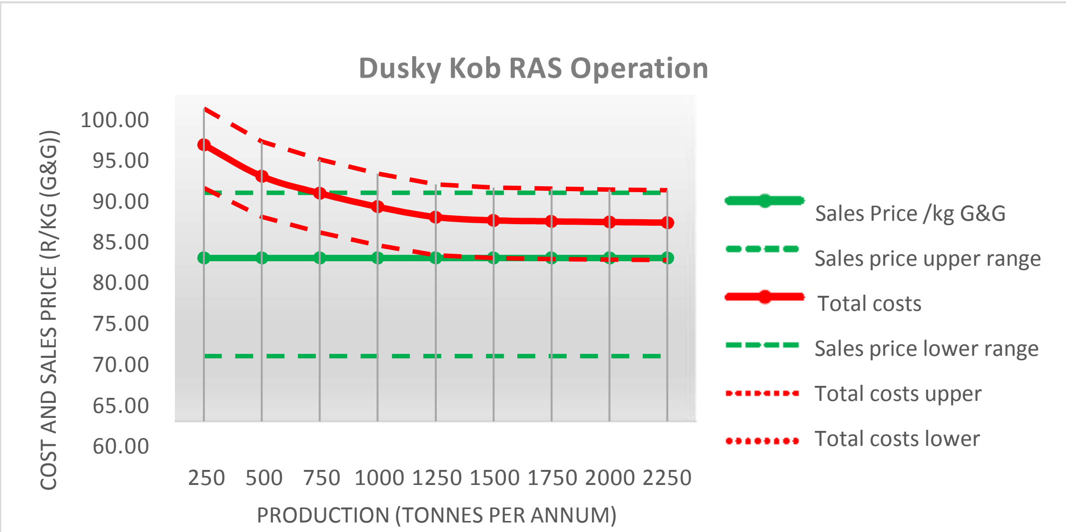
Because of its rapid growth rate, late maturity, declining commercial catches, and high market demand, the species was identified as a suitable aquaculture candidate species in Australia (O'Sullivan & Ryan, 2001) and subsequently in South Africa (Hecht *et al*., 2015). Production technologies for dusky kob in South Africa have been established, the life cycle has been closed and the species is farmed on a semi-commercial scale in RAS systems and earthen ponds. Geographically, dusky kob can be farmed along the entirety of the east coast of South Africa. However, favourable areas for flow-through, pond, and cage systems are located from the Eastern Cape northwards where water temperatures are more suitable.

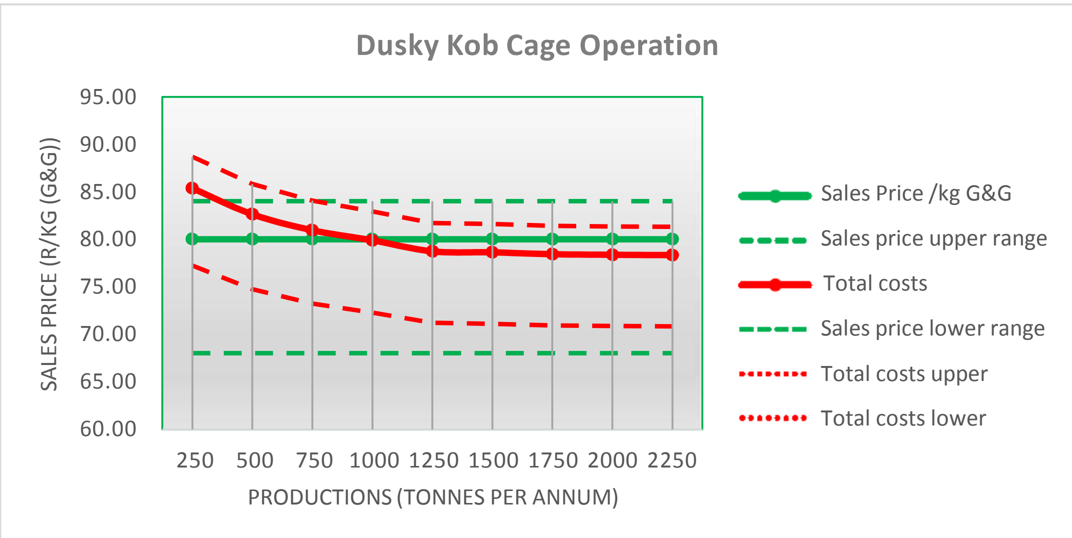
The market for South African linefish, including dusky kob, is characterised by a decline in supply and increasing prices. Despite this, there is currently a limited local market opportunity for farmed dusky kob as production costs are high, local sales prices (driven primarily by wild harvest supply) remain relatively low and current linefish demand volumes do not justify scale aquaculture production (>1,000tpa).

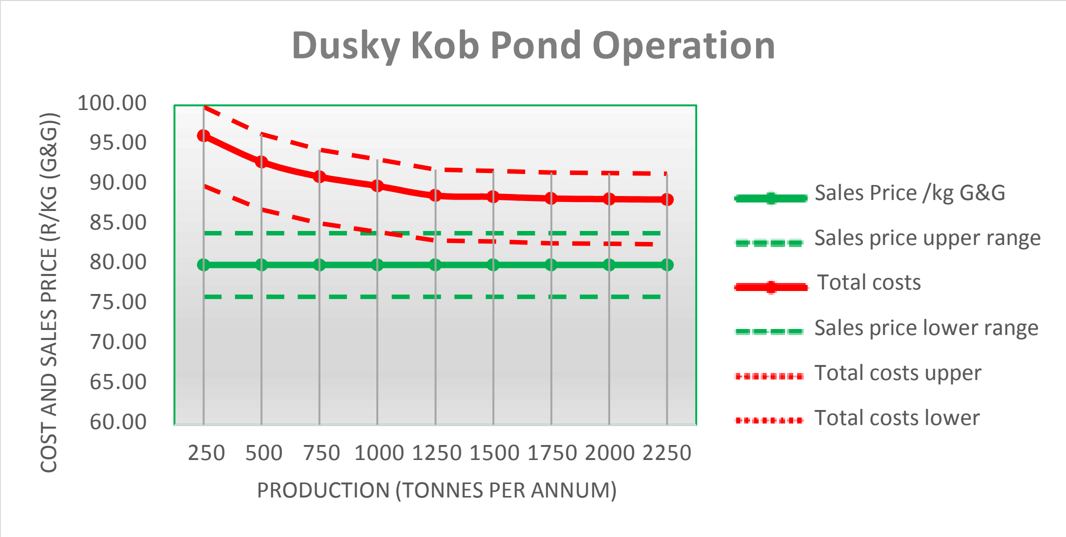
Under the above current status quo the scale aquaculture production of dusky kob does not present a financially viable investment case (see table below) with key detractors being the inability to achieve scale economies due to domestic market demand limitations and a local market price that is too low to support small-scale production inefficiencies. As such, the primary limitation to the development of scale kob aquaculture in South Africa is access to a high-value export market. The market component of this feasibility study concludes that as a product South African dusky kob could be positioned in a cluster with seabass, seabream, meagre and barramundi under a successfully managed market entry. If accepted in the marketplace as an equivalent quality product prices ranging between USD7.00-9.00/kg could be achieved and profitable production supported in projects of +1,000tpa scale. This is illustrated in the sensitivity analyses (see figures below) which demonstrate the impact of an upper limit or favourable sales price on the viability of farming dusky kob at volumes > 1000 tpa. The establishment of multiple scale projects would substantially improve the vertical bargaining power of producers leading to the reduced cost of inputs and added profitability.

It is unlikely that the existing semi-commercial kob farms have the resources required to grow product to the larger sizes required in the global marketplace or to competitively position dusky kob into the target market cluster. Government interventions including detailed international market assessments, state-owned or state-supported hatchery and processing facilities, engagements with global feed producers with the aim of reducing feed prices and improving access to high-quality feed, and increased institutional support from governmental departments should be considered as a means of addressing this impasse and opening up the export markets required to support scale production.

Production assumption			
Production system	**RAS hatchery & RAS grow-out**	**RAS hatchery & cage grow-out**	**RAS hatchery & pond grow-out**
Production scale	**500**	**500**	**500**
Financial indicator			
Capex (ZAR '000)	140 794	46 403	110 968
IRR (%)	-27	-22	-36
Max. cash outflow (ZAR '000)	197 044	78 963	152 635
NPV over 10 years (ZAR '000)	-29 027	-32 322	-77 379
Break-even point (yr)	4	4	+10
Pay-back period (yr)	+10	+10	+10
Sensitivity analysis			
Base sales price	ZAR 80.00 /kg	ZAR 80.00 /kg	ZAR 80.00 /kg
Minimum viable scale at base sales price	-	1 000 tpa	-
Upper range sales price	ZAR 88.00 /kg	ZAR 84.00 /kg	ZAR 84.00 /kg
Minimum viable scale at upper range sales price	750 tpa	350 tpa	-







Atlantic salmon

The Atlantic salmon is a carnivorous salmonid species that is naturally distributed in the northern Atlantic Ocean, from Canada to the West of the United States of America (USA), to the White and Barents Sea basins in the East, through North-eastern Europe to the Baltic and North Sea basins in North-eastern Europe (Froese & Pauly, 2016). It has been introduced to New Zealand, Chile, Argentina, Australia and South Africa (Froese & Pauly, 2016).

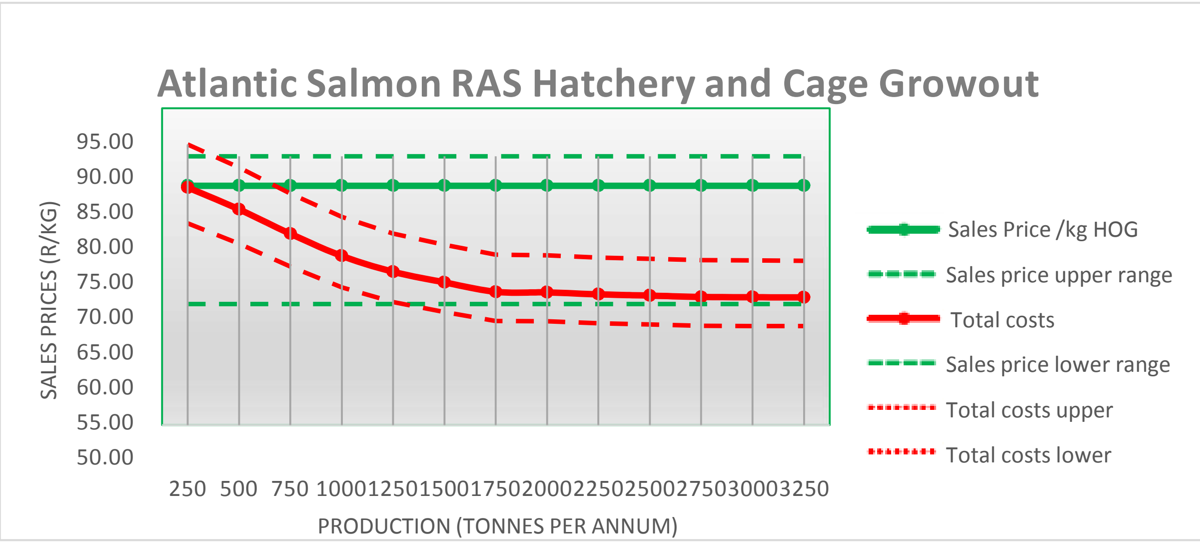
Atlantic salmon has been targeted by fisheries for over 1000 years (Chase, 2003) but a combination of overfishing, habitat alteration (dam building) and destruction, pollution, and poaching, led to "precipitous declines" in wild salmon populations and the closure of the US and Canadian Atlantic salmon fisheries in the late 20th century (Chase, 2003). Currently, commercial fisheries for Atlantic salmon are operational in Greenland and the Faroe Islands, with a small number in EU member states (Potter *et al.*, 2004). Their contribution to global Atlantic salmon production has declined significantly such that almost all commercially available Atlantic salmon is now farmed (Marine Harvest, 2015).

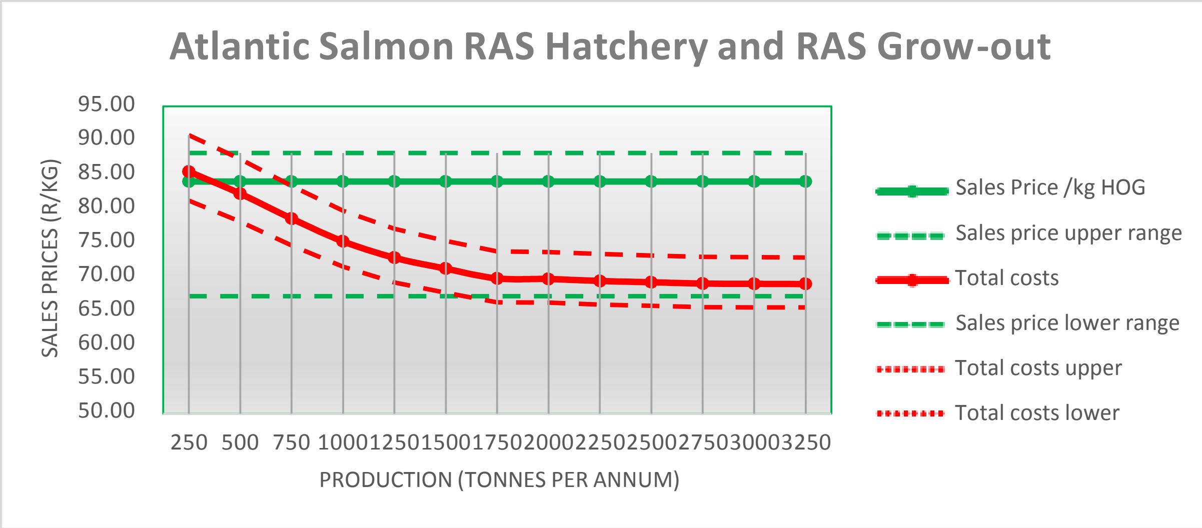
Aquaculture production of Atlantic salmon is established on an industrial scale in countries such as Norway, Scotland, New Zealand, Tasmania and Chile. South Africa has yet to achieve consistent results with this species. In South Africa, the production of Atlantic salmon smolts is restricted to inland areas, specifically the Cape Fold Mountains and Eastern Escarpment, which have perennial sources of high-quality freshwater. Although much of the South African west coast offers potential for the land-based grow-out of Atlantic salmon these systems remain new in the industry and are not yet established anywhere at scale. Possible zones for Atlantic salmon cage culture based on water temperature, upwelling cells, wave exposure, and turbidity events are Gansbaai and Saldanha Bay.

The international market for salmonid species is well developed and levels of product innovation are high. In the South African domestic market there is significant opportunity for locally produced Atlantic salmon as demand is steadily increasing and supply is currently met entirely by imports. Local aquaculture production thus has the opportunity to sell into the domestic market at import parity or to export product into the well-developed global marketplace. This combination allows for production at scale as well as the ability to sell at premium prices.

Atlantic salmon production offers a viable investment opportunity in South Africa (see table below). The opportunity for scale cage-culture is limited to 2 potential production locations but offers the greatest return on investment. Land-based culture is marginally viable under current assumptions but technological improvements in RAS will continue adding to the efficiency of these systems and the existing viability gap is likely to narrow with time.

Production assumption		
Production system	**RAS hatchery & cage grow-out**	**RAS hatchery & RAS grow-out**
Production scale	**2 000**	**2 000**
Financial indicator		
Capex (ZAR '000)	112 589	216 673
IRR (%)	19	8
Max. cash outflow (ZAR '000)	207 995	325 707
NPV over 10 years (ZAR '000)	7 426	-36 859
Break-even point (yr)	4	5
Pay-back period (yr)	9	9
Sensitivity analysis		
Minimum viable size (tpa)	500	500




Atlantic Salmon RAS Hatchery and RAS Grow-out
95.00
90.00
85.00
80.00
75.00
70.00
65.00
60.00
55.00
50.00
SALES PRICES (R/KG)
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
PRODUCTION (TONNES PER ANNUM)
Sales Price /kg HOG
Sales price upper range
Total costs
Sales price lower range
Total costs upper
Total costs lower

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LIST OF ACRONYMS

ADA	Animal Diseases Act
ADEP	Aquaculture Enhancement and Development Programme
ADZ	Aquaculture Development Zone
B-BBEE	Broad-based Black Economic Empowerment
DAFF	Department of Agriculture, Forestry and Fisheries
DAH	Days after hatch
DEAT	Department of Environmental Affairs and Tourism
DO	Dissolved oxygen
DSBD	Department of Small Business Development
DTI	Department of Trade and Industry
EIA	Environmental Impact Assessment
EFCR	Economic feed conversion ratio
EMP	Environmental Management Plan
EU	European Union
FAO	Food and Agriculture Organisation
FCR	Feed conversion ratio
FOB	Free on board
G&G	Gilled and gutted
GMO	Genetically modified organism
H&G	Headed and gutted
HAB	Harmful algal bloom
HACCP	Hazard Analysis and Critical Control Points
IDZ	Industrial Development Zone
IPAP	Industrial Policy Action Plan
IRR	Internal Rate of Return
ISA	Infectious salmon anaemia
MPA	Marine Protected Area
NASF	National Aquaculture Strategic Framework
NEF	National Empowerment Fund
NEMA	National Environmental Management Act
NPV	Net Present Value
NRCS	National Regulator for Compulsory Specifications
RAS	Recirculating aquaculture system
SARS	South African Revenue Service
SEZ	Special Economic Zone
SMME	Small, Medium and Micro-sized Enterprise

USA	United States of America
USD	United States Dollar
UV	Ultraviolet
WRG	Whole, round, gutted
ZAR	South African Rand

GLOSSARY

Age-zero smolts	Salmon that have undergone smoltification before the age of 1 year.
Alevin	A newly spawned salmon still carrying a yolk sac.
Anadromous	Migrating up rivers from the sea to spawn
Euryhaline	Organisms capable of adapting to a wide range of salinities.
Flow-through system	Single-pass production systems where a continuous supply of water is passed through the system before being drained with no re-use.
Fry	Developmental phase following alevin stage. Juvenile salmon approximately 0.02-2g in weight.
Grilse	Atlantic salmon which mature after one winter at sea
Grow-out	The period during which juveniles are grown to harvest size.
Head	The height to which a pump can raise water to.
Land-based	Any aquaculture facility that is situated on land.
Make-up water	Water fed to a system to replace that which is lost
Nephelometric Turbidity Units (NTU)	Measurement unit for turbidity
Parr	Developmental phase following fry stage and before smolt stage.
Perennial	Continuous flow in parts of the stream bed all year round during years of normal rainfall.
pH	pH is a measure of how acidic/basic water is. The range goes from 0 - 14, with 7 being neutral. pHs of less than 7 indicates acidity, whereas a pH of greater than 7 indicates a base.
Photoperiod	The period of time each day during which an organism receives illumination; day length.
Pond-based aquaculture	Production of fish in earthen ponds.
Pump-ashore	Refers to water abstracted from the ocean and pumped onto land.
Recirculating aquaculture system (RAS)	Multiple-pass production systems where water is passed through the systems and re-used before being drained.
Salinity	Salinity is the measure of all the salts dissolved in water. Salinity is usually measured in parts per thousand (ppt)
Salmonid	Fish belonging to the family Salmonidae including salmon, trout, chars and grayling
Significant wave height	The mean wave height (trough to crest) of the highest third of the waves (H1/3).
Slope	Slope is the measure of steepness or the degree of inclination of a feature relative to the horizontal plane.
Smolt	A young salmon after the parr stage, when it becomes silvery and migrates to the sea for the first time. Typically 50-160g.
Smoltification	Smoltification is the series of physiological changes where juvenile salmonid fish adapt from living in fresh water to living in seawater.
Spawner biomass	The total weight of fish in a stock that are old enough to spawn

1. INTRODUCTION

1.1. Background

This high-level, non-site specific, feasibility study evaluates the technical and financial feasibility of dusky kob (*Argyrosomus japonicus*) and Atlantic salmon (*Salmo salar*) aquaculture in South Africa. This study provides a background on the biology and environmental requirements of these species, different aquaculture systems used to produce them, and investigated the operational scale, timeframe, and financial requirements of a commercially viable operation.

While the focus is on an economic assessment, it was also necessary to consider stakeholders and community impacts. A realistic and sustainable feasibility study requires knowledge and understanding of the following key elements:

- Geographic location, physical environment and social aspects
- Technical aspects of the aquaculture system
- Analysis of local and international markets
- Economic assessment and financial modelling
- Development, construction and project management needs

1.2. Aims and objectives

The overall goal of this study was to determine the feasibility of marine finfish aquaculture in South Africa, specifically dusky kob and Atlantic salmon, by considering the environmental, financial and market conditions in South Africa and abroad.

The following aspects are addressed within this study:

- Description of dusky kob and Atlantic salmon biology and aquaculture including historical background, production techniques and systems in use;
- Suitable regions where dusky kob and Atlantic salmon can be farmed based on environmental and logistical criteria;
- The socio-economic context of aquaculture in South Africa with a focus on overall impacts;
- Market conditions for dusky kob and Atlantic salmon in South Africa and internationally;
- Conceptual production system designs for dusky kob and Atlantic salmon;
- Model the financial viability of these conceptual production systems designs;
- Risks associated with the culture of the candidate species based on the viability assessment; and
- Recommendations on the best way forward for the sustainable development of the aquaculture of these species in South Africa.

To place this study into perspective, a brief overview of the current state of play of marine aquaculture (mariculture) development in South Africa is presented in the following section.

1.3. Summary of current status of mariculture in South Africa

In general, total aquaculture production in South Africa has increased over the period 1987 – 2013 (Figure 1), with temporal fluctuations as certain farms became inactive or operational over this period (DAFF, 2012a). In 2013, production from marine species contributes 70% of total aquaculture production within the country. Geographically, marine aquaculture production is highest in the Western Cape (87%) followed by the Eastern Cape (12%) (DAFF, 2014a).

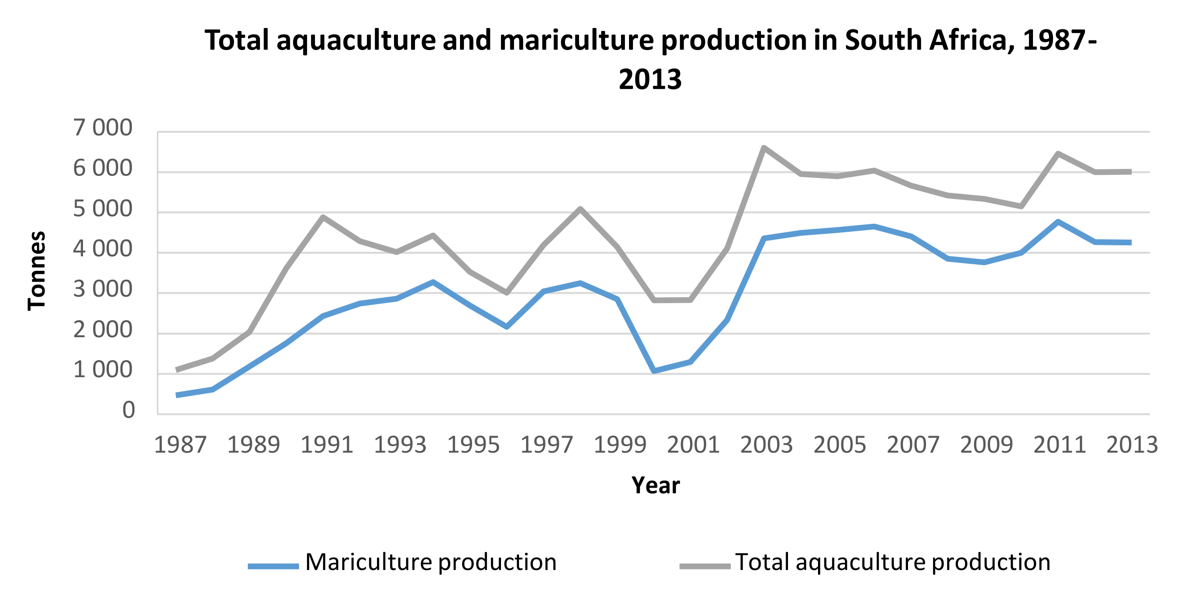


Figure 1: Total aquaculture and mariculture production in South Africa (1987-2013) (FAO FishstatJ, 2016).

Species cultured in the South African mariculture industry include abalone (*Haliotis midae*), Pacific oyster (*Crassostrea gigas*), Mediterranean- (*Mytilus galloprovincialis*) and black mussels (*Choromytilus meridionalis*), dusky kob and seaweed (*Ulva* spp. and *Gracilaria* spp.) (DAFF, 2014a). Marine finfish production has been relatively low and contributed only 4.1% to total mariculture production in the country in 2013 (Table 1), with dusky kob being the only commercial marine finfish species (DAFF, 2014a). In 2013, there were only 4 operational finfish farms in South Africa with these located in the Western Cape, Eastern Cape and KwaZulu-Natal (DAFF, 2014a).

Table 1: Mariculture production per species group per province in South Africa (2013) (DAFF, 2014a).

Species	W. Cape	E. Cape	N. Cape	KZN	Total
Abalone	1 299.78	170	0	0	**1 469.78**
Marine finfish	0	122.55	0	0	**122.55**
Mussels	1 116.14	0	0	0	**1 116.14**
Oysters	193.23 (40)	84	0 (30)	0	**277.23**
Total	**2 609.15**	**376.55**	**0**	**0**	**2 985.7**
() Oysters sold or moved to other provinces for grow out to market size					

1.3.1. Aquaculture Development Zones

Nine Aquaculture Development Zones (ADZs) have been identified, with eight for marine and one for freshwater aquaculture in South Africa and the location of these is illustrated in Figure 2. An ADZ refers to any zone or area, in water or on land, set aside for the purpose of exclusive use by the aquaculture sector and in which specific measures are taken to encourage the sustainable development of aquaculture. The objectives of ADZs are to facilitate aquaculture development by providing incentives and services for industry development that encourage investment, reduce risks, and provide skills development and employment for surrounding communities. ADZs are subject to undergoing Environmental Impact Assessment (EIA) processes and receiving Environmental Authorisation, as well as installation of basic infrastructure prior to being declared ADZs. Once declared, a major advantage of developing a project within an ADZ is that there is no requirement for a project-specific EIA. In South Africa, the establishment of ADZs is supported by the Department of Trade and Industry (DTI) Policy on the Development of Special Economic Zones (SEZ) which, through investment incentives, promotes trade, economic growth and industrialisation.

FIGURE 2: GEOGRAPHIC LOCATION OF ADZS IN SOUTH AFRICA.

The Department of Environmental Affairs and Tourism (DEAT) completed a Strategic Environmental Assessment aimed at identifying suitable land and sea space surrounding South Africa's coastal provinces for the establishment of ADZs (Jooste, 2009). Subsequent refinement of these areas, for offshore-based marine finfish cage aquaculture, was undertaken by Hutchings *et al*. (2011). In 2011, the Qolora land-based ADZ in the Eastern Cape received a positive Environmental Authorisation from the Eastern Cape provincial Department of Economic Development, Environmental Affairs and Tourism and will be the first promulgated ADZ once relevant infrastructure has been installed (DAFF, 2012a). To date, no ADZs have been officially promulgated.

1.4. Need for economic feasibility studies

Production from capture fisheries has stagnated in recent years (FAO, 2016) while global population numbers, and overall consumption of fish, is increasing. Aquaculture will play a significant role in providing much needed animal protein to feed future generations. However, extensive research is required to plan, develop, establish and operate a commercially viable aquaculture operation. It generally requires a large investment of time and money over a period of several years. By conducting a feasibility study before starting an aquaculture venture, prospective developers and operators will gain a clearer understanding of the proposed operation from an environmental suitability and financial viability perspective (Bloom *et al*., 2013). Furthermore, financial modelling and market analysis can highlight the scope for product diversification rather than confining operations to traditional farming and product offerings (Sathiadhas *et al*., 2009).

The viability of a typical aquaculture venture depends on:

- suitable environmental conditions to support production;
- availability of seed stock;
- access to feeds and production technology;
- access to equipment and supplies such as boats, farm platforms, etc.;
- access to markets;
- access to health management services, consultants and technical services
- a supportive regulatory environment that facilitates aquaculture development; and
- public acceptance of the environmental impacts associated with aquaculture development and production.

Ultimately, the decision whether to proceed with a given project should be based on a thorough feasibility study that takes into account location, site characteristics, environmental parameters, available technologies, financial and human resources, environmental impacts, market opportunities and risk factors. It is envisaged that the Department of Agriculture, Forestry and Fisheries (DAFF) will use the results of this study in an advisory manner in order to focus efforts and funds for aquaculture of the candidate species. Furthermore, the results of the study, in terms of return on investment, cost of start-up, time to break even, will assist the government in determining the time period of leases and permits in order to support and secure investment. Lastly, the results can be used by government and financing institutions as a tool to captivate interest in the aquaculture sector and unlock financing schemes for the development thereof, based on sound economic principles.

2. REGULATORY FRAMEWORK

2.1. Legal aspects related to aquaculture in South Africa

The various legislative frameworks and policies which regulate or influence the aquaculture industry in South Africa are shown in Table 2 below:

TABLE 2: LEGISLATION, GUIDELINES, MANUALS AND FRAMEWORKS RELEVANT TO AQUACULTURE IN SOUTH AFRICA.

EXISTING LEGISLATION RELEVANT TO AQUACULTURE	
1.	Marine Living Resources Act (Act No. 18 of 1998)
2.	National Environmental Management Amendment Act (Act No. 25 of 2014)
3.	National Environmental Management Biodiversity Act (Act No. 10 of 2004)
4.	National Environmental Management: Integrated Coastal Management Amendment Act (Act No. 36 of 2014)
5.	National Environmental Management: Protected Areas Amendment (Act No. 15 of 2009)
6.	National Environmental Management: Waste Act (Act No. 59 of 2008)
7.	Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (Act No. 36 of 1947)
8.	The Health Act (Act No. 63 of 1977)
9.	Animal Diseases Act (Act No. 35 of 1984)
10.	Genetically Modified Organisms Act (Act No. 15 of 1997)
11.	National Health Act (Act No. 61 of 2003)
12.	The National Regulator for Compulsory Specifications Act (Act No.5 of 2008)
13.	Standards Act (Act No. 8 of 2008)
14.	The Animal Improvement Act (Act No. 62 of 1998)
15.	The Water Services Act (Act No. 108 of 1997)
16.	The Foodstuffs, Cosmetics and Disinfectants Act (Act No. 54 of 1972)
17.	The Sea Birds and Seals Protection Act (Act No. 46 of 1973)
18.	Medicines and Related Substances Act (Act No. 101 of 1965)
EXISTING GUIDELINES/MANUALS/FRAMEWORKS RELEVANT TO AQUACULTURE	
19.	The Draft Policy for the Development of a Sustainable Aquaculture Sector in South Africa (DEAT, 2006a)
20.	Draft Policy and Guidelines for Finfish, Marine Aquaculture Experiments and Pilot Projects in South Africa (DEAT, 2006b)
21.	Marine Aquaculture Sector Development Plan (DEAT, 2006c)
22.	General Guidelines for Marine Ranching and Stock Enhancement in South Africa (DAFF, 2010)
23.	Environmental Integrity Framework for Marine Aquaculture (DAFF, 2012b)
24.	Aquaculture Research and Technology Development Programme (DAFF, 2012c)
25.	National Aquaculture Policy Framework (DAFF, 2013a)
26.	Aquatic Animal Health Strategic Framework (DAFF, 2013b)
27.	Environmental Impact Assessment Guideline for Aquaculture in South Africa (DEA, 2013)
28.	South African Aquaculture Fish Monitoring and Control Programme (DAFF, 2016)

A brief description of the key legislations and guidelines is provided below:

- ***National Environmental Management Amendment Act (NEMA) (Act No. 25 of 2014)***

The NEMA is the cornerstone of South Africa's environmental management legislation. NEMA also outlines the principles for integrated environmental management, which has led to the development of the EIA Regulations (R543, R544, R545 and R546 of 2010, with due consideration of subsequent amendments). At present, a number of aquaculture-related activities trigger the requirement for an environmental authorisation in terms of NEMA and EIA Regulations. According to the recently amended

EIA Regulations Listing Notice 1 of 2014, only a Basic Assessment is required for primary aquaculture activities.

- ***National Environmental Management Biodiversity Act (NEMBA) (Act No. 10 of 2004)***

The authorisations for the NEMBA, although complementary, are independent of the requirement for environmental authorisation in terms of NEMA. The NEMBA prescribes specific protocols for the management and culture of exotic/alien organisms and, therefore, has a direct bearing on those aquaculture activities based on non-native species. Where the introduction of an exotic/alien species for aquaculture is proposed, this Act (through the Alien and Invasive Species Regulations – GN No R. 69 of 2008) requires that a risk assessment be completed to determine the environmental implications. Where the introduction of an endangered or threatened species for aquaculture is proposed, this Act (through the Threatened or Protected Species Regulations) requires that certain authorisation procedures are followed.

- ***National Environmental Management: Integrated Coastal Management Amendment Act (NEMICMA) (Act No. 36 of 2014)***

This Act provides norms, standards, and policies to promote the conservation of the coastal environment, and to ensure that the development and use of the coastal zone is socially and economically justifiable and ecologically sustainable. The Act defines rights and duties in relation to the coastal zone as well as the responsibilities of organs of state.

The discharge of any effluent into the coastal environment from a land-based process in which it has been heated must be authorised by the DEA in terms of section 69 of the NEMICMA. Any discharge of land-based effluent to the coastal environment from an activity triggering any of the Listing Notices in the EIA Regulations under the NEMA, is subject to the applicable environmental authorisation issued under the NEMA: EIA Regulations (2014) administered by the DEA and / or a Coastal Waters Discharge Permit (CWDP) or a General Authorisation in terms of Section 69 of the NEMICMA, unless the activity conforms to a standard as prescribed in section 24 of the NEMA and in terms of the NEMICMA.

- ***National Environmental Management: Waste Act (NEMWA) (Act No. 59 of 2008)***

This Act governs minimisation, recovery, re-use, recycling, treatment, disposal, and integrated management of waste. A number of listed waste management activities have been promulgated in Government Notice 718 (2009) and require authorisation by means of either a Basic Assessment or Scoping & Environmental Impact Report (more details about these different authorisations in Section 4). Although few of these listed waste management activities are directly applicable to aquaculture, the onus is on the aquaculture proponent to fully investigate all of the waste producing activities that may arise. A waste authorisation may be required for the treatment and/ or on-site disposal of aquaculture by products, especially in relation to processing.

- ***Marine Living Resources Act (MLRA) (Act No. 18 of 1998)***

Section 18 of the Act provides for the granting of a compulsory “right” to engage in marine aquaculture. Permission to exercise such a “right” is granted by means of a permit issued in terms of Section 13 of the Act. Chapter 6 of the Act covers the requirement for applications, general permit conditions, environmental impacts, genetically modified organisms (GMOs), EIA's, food safety issues, use of chemicals and notifiable diseases.

In response to the Act and related legislation, the DAFF have developed comprehensive guidelines, food safety programmes and permit frameworks to allow, guide and regulate marine aquaculture projects in compliance related matters. One of these guidelines is the South African Aquacultured Marine Fish Monitoring and Control Programme, described on page 8.

- ***Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (Act No. 36 of 1947)***

The Act requires that all processed animal feeds and stock remedies (therapeutants) meet certain specifications and are registered for use in farming. In this regard, fish feeds must meet certain minimum specifications and the minimum proximal composition must be declared on the packaging.

- ***Animal Diseases Act (ADA) (Act No. 35 of 1984)***

Aquaculture is recognised as an agricultural activity and, hence, the State Veterinary Services have a mandate to protect the industry in terms of the Animal Diseases Act. This Act includes various measures for the control and management of disease.

- ***Genetically Modified Organisms Act (Act No. 15 of 1997)***

The Act aims to provide for measures to promote the responsible development, production, use and application of GMOs. This Act is applicable in the event that exotic/alien species are considered for an aquaculture operation. In this case, all relevant permits and licenses must be obtained prior to any introduction. This Act may be applicable for Atlantic salmon aquaculture projects.

Other applicable acts include Health & Safety, Water and Animal protection regulations such as:

- National Health Act (Act No. 61 of 2003)
- The National Regulator for Compulsory Specifications Act (Act No.5 of 2008)
- Standards Act (Act No. 8 of 2008)
- The Animal Improvement Act (Act No. 62 of 1998)
- The Water Services Act (Act No. 108 of 1997)
- The Foodstuffs, Cosmetics and Disinfectants Act (Act No. 54 of 1972)
- The Sea Birds and Seals Protection Act (Act No. 46 of 1973)
- Medicines and Related Substances Act (Act No. 101 of 1965)

Various Government departments have compiled guidelines and manuals to assist in the development of an aquaculture in South Africa. A few of these guidelines/manuals are described below.

- ***South African Aquacultured Marine Fish Monitoring and Control Programme (DAFF, 2016)***

The South African Aquacultured Marine Fish Monitoring and Control Programme manual provides the necessary guarantees to both foreign and local consumers that disease and contamination risks related to the consumption of farmed marine fish are mitigated and appropriately managed. The manual also contains the audit specifications for aquaculture production facilities.

- ***Draft Policy for the Development of a Sustainable Aquaculture Sector in South Africa (DEAT, 2006a)***

The Draft Policy aims: (1) to create an enabling environment that will increase the contribution of aquaculture to economic growth within the Accelerated and Shared Growth Initiative for South Africa; (2) to transform and encourage broader participation in the aquaculture sector; (3) to develop regulatory and management mechanisms aimed at minimising adverse environmental impacts associated with aquaculture practices (e.g. sea ranching, sea-based cage farming etc.); and (4) to increase the resource base of aquaculture from the few species that are being farmed currently to a more diverse suite of species.

- ***General Guidelines for Marine Ranching and Stock Enhancement in South Africa (DAFF, 2010),***

This marine ranching policy provides guidelines for submitting proposals to undertake marine ranching and stock enhancement, assessment of proposals, and management and regulation of the sector.

- ***Marine Aquaculture Sector Development Plan (DEAT, 2006c)***

The plan outlines strategies that will give practical development effect to the mariculture policy objectives. Some of the objectives are: (1) to create an enabling environment that will promote increased contribution from mariculture to economic growth; (2) to ensure that mariculture adheres to internationally accepted environmental and fisheries standards; (3) to develop regulatory and management mechanisms; and (4) to encourage research aimed at increasing the resource base of mariculture.

- ***National Aquaculture Policy Framework (DAFF, 2013a):***

The National Aquaculture Strategic Framework (NASF) was developed as a roadmap to help Government facilitate the development of the aquaculture industry. The National Aquaculture Policy Framework was thereafter compiled as an implementation guideline for the NASF. The Policy aims to ensure that an appropriate enabling regulatory environment is created to optimise opportunities and to contribute to national food security, national wealth and job creation. An Aquaculture Act is still to be drafted; however, this policy framework is the document to guide development of the industry.

- ***Environmental Integrity Framework for Marine Aquaculture (DAFF, 2012b)***

The Framework is an informative tool and platform for project level to sector level, for the planning of marine aquaculture and monitoring approach for EIAs.

- ***Environmental Impact Assessment Guideline for Aquaculture in South Africa (DEA, 2013)***

This EIA Guideline aims to assist with environmental authorisations and to provide a framework for sound environmental management in the sector. The guideline describes the pathway towards improved management of potential impacts and emphasises the importance of ensuring that development is aligned with environmental legislation. Further details are described in Section 2.3. It must be noted, however, that there have been numerous amendments to other relevant legislation and regulations (e.g. EIA Regulations), and this guideline is outdated with amendments required.

2.2. Permitting requirements

To promote the sustainable development of the aquaculture sector there are a variety of aquaculture rights under the MLRA which will need to be approved. Such a right is valid for 15 years and is required to be renewed annually. Pilot operations are currently issued with aquaculture rights. Permits are required to undertake aquaculture-related scientific investigations and practical experiments e.g. research institutions, private companies.

In future, licenses will be issued under the Aquaculture Act which will be valid for a period dependent on the activity and scale of operations e.g. pilot, commercial, research.

The licenses required will be wholly dependent on the project components (scale, location, operational model etc.). All operational-specific permits and licenses must be obtained by the individual project proponents before commencement of any activities.

Various guidelines on applications and other legal requirements for aquaculture developments are available. These include:

- Guidelines and Requirements on Applying for a Marine Aquaculture Right
- Guidelines for Aquaculture Better Management Practices in South Africa
- Guide to the authorisations requirements for aquaculture in South Africa (DAFF, 2015)
- Legal guide for the aquaculture sector in South Africa (DAFF, 2013d)
- Guidelines for Marine Finfish Farming in South Africa
- Guideline for Ornamental Fish Farming in South Africa
- General Guidelines for Marine Ranching and Stock Enhancement in South Africa

There are various permits/licences which may apply to an aquaculture operation and these include[1]:

- Water use licence
- Land use rezoning
- Permit to engage in marine aquaculture activity (e.g. grow out, nursery)
- Permit to operate a marine aquaculture fish processing establishment
- Import and export permits for marine aquaculture fish and fish products and marine ornamentals
- Permit to collect broodstock for marine aquaculture purposes
- Permit to possess broodstock and operate a hatchery
- Permit to undertake marine aquaculture scientific investigations and practical experiments
- Permit to transport marine aquaculture products
- Marine aquaculture export permit
- Marine aquaculture import permit
- Kob Sales Protocol

[1] All such licences can be found on the DAFF website: http://www.daff.gov.za/daffweb3/Branches/Fisheries-Management/Aquaculture-and-Economic-Development/aaquaculture-sustainable-management/Authorisation

Applications for a Marine Aquaculture Right can be submitted to the DAFF on a continuous basis. The applicant must meet the criteria as set out in the application form and submit the relevant supporting documentation.

2.3. Environmental Impact Assessment requirements

The EIA Regulations (2014) are guided by NEMA (Act No. 107 of 1998) and are largely dependent on the nature and scale of the aquaculture project. The EIA consists of a Basic Assessment if a less rigorous assessment is required. Alternatively, Scoping and Environmental Impact Reporting will entail a more detailed investigation. According to the EIA Regulations Listing Notice 1 of 2014, the development and related operation of facilities, infrastructure or structures for aquaculture of finfish with a production output exceeding 20 tpa (wet weight) are subject to a Basic Assessment. In the case of sea-based cage culture of finfish the production threshold is 50 tpa (wet weight). The construction of a hatchery outside of industrial complexes where the development footprint covers an area of 2 000 m^2 or more is also subject to a Basic Assessment.

Other triggers may exist for marine aquaculture operations which will require additional activities to be conducted by the project proponent. Some example of additional activities include: The clearance of 300 m^2 of 75% indigenous vegetation; construction 100 m from a watercourse/ in an estuary/ protected area; expansion of existing facilities.

Within the environmental assessment (both Basic Assessment and Scoping exercises) there is a mandatory public participation process which requires that interested or affected parties be provided with an opportunity to comment about a proposed project. Social Impacts are also identified during an EIA and mitigating factors to minimize negative social impacts are addressed within the EIA.

Environmental authorisation requires the compilation and submission of an Environmental Management Programme (EMPr). The purpose of the programme is to plan and document the management approach that will best avoid or minimise potential environmental impacts in the construction, operation and decommissioning phase of a project. The EMPr is a legally binding document and implementation and compliance of the EMPr are a condition for project authorisation.

Provincial-level environmental departments are typically responsible for receiving and evaluating applications for environmental authorisation. A suitably qualified Environmental Assessment Practitioner is required to perform the tasks associated with the respective EIA processes.

There are various impacts which will be assessed in an EIA process. Some of these impacts include:

- Indigenous habitat destruction
- Public safety
- Genetic impact of escapees on wild populations
- Effluent discharge (feed waste and fish faeces)
- Disease, parasites and species health
- Reduction of available phytoplankton
- Nutrient dynamics/loading around offshore sites
- Anti-fouling products
- Medication, antibiotics and pesticide

- Human health issues
- Resource conflicts
- Infrastructure construction (access roads, noise, erosion)
- Chemicals and antibiotics

2.4. Import and export regulations

Best practice guidelines for import and export of food stuffs are contained in global health and safety regulations. Many export standards are based on the Hazard Analysis and Critical Control Points (HACCP) standards, which are internationally recognised and structured operating methods that help organisations in the food and beverage industry identify their food safety risks, prevent food safety hazards and address legal compliance. The National Regulator for Compulsory Specifications (NRCS) is established in terms of the National Regulator for Compulsory Specifications Act, 2008 (Act No. 5 of 2008). The NCRS is responsible for the administration and maintenance of compulsory specifications and the implementation of regulatory and compliance systems for compulsory specifications. In particular, the NRCS is responsible for monitoring and auditing the applications of the HACCP standards which guarantees the health of food products through the whole food production process from “farm to fork”.

For the export of aquaculture products, the NRCS certifies live, fresh, frozen and canned products. HACCP standards regulate the entire production process from the live production tank/cage to the processing plant to the buyer. For non-export items, the NCRS verifies products (the individual responsible is Ms. Meisie Katz (Meisie.Katz@nrcs.org.za).)

The CODEX Committee on Fish and Fishery Products of the Food and Agriculture Organisation (FAO) provide internationally recognised standards for fresh, frozen or otherwise processed fish, crustaceans and molluscs. South Africa is a signatory to CODEX and thus incorporates these standards into the South African regulatory framework and implementation programmes. The NRCS makes use of agents such as DAFF and other state veterinarians to provide guarantees in respect of specialized analyses such as the monitoring of shellfish toxins, microbiological contamination, drug residues, chemical residues, radio-nuclides and residues in fish and animal health and welfare aspects[2]. Operators planning to produce finfish for human consumption are required to comply with the requirements of the South African Aquaculture Marine Fish Monitoring and Control Programme implemented in terms of the permit conditions and thus the MLRA.

Accessing the EU market is complex. There is a risk with regard to the use of formulated feed as a potential source for the introduction of drugs into abalone and finfish. Though there is no EU legislation to regulate the introduction of drugs in abalone at this stage, the EU is currently drafting regulations, which South Africa will need to comply with. It is imperative that farms that produce fish for the local and international consumers ensure that the feed and the feed producers that supply the feed are registered with Department of Agriculture, Forestry and Fisheries and that the feed used will not pose a risk to consumers of the final fish products.

Farms are required to comply with the South African Aquacultured Marine Fish Monitoring and Control Programme to market their product locally and internationally, which includes a section on veterinary

[2] Additional permits which may need to be obtained for import and export operations and these are available online at: http://www.daff.gov.za/daffweb3/Branches/Fisheries-Management/Aquaculture-and-Economic-Development/aaquaculture-sustainable-management/Authorisation

drug management. The drug residue programme, however is a separate programme. It is complex and expensive but is also required by current international markets as well as the EU. The use of certain drugs are also regulated through the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972). Drugs that are banned in the EU and other international markets are accessible to production facilities without a veterinary prescription due to certain provisions of the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act 1947 (Act No. 36 of 1947), which is a concern to importing countries. There are furthermore no laboratories in South Africa, or internationally, that the South African Competent Authority has access to, that have all the required drug residue methods validated. The Department is currently in the process of rectifying this situation through discussions with a number of laboratories.

South Africa is currently banned from exporting aquacultured product to the EU. However, on the basis of the development and implementation of the drug residue programme and the effective implementation of the SAAFM&CP South Africa has requested authorisation to market fish in the EU.

3. SOCIO-ECONOMIC ASSESSMENT

3.1. Overview

South Africa has a medium human development ranking (value of 0.666) and is ranked 116th out of 188 countries according to the United Nations Development Programme (UNDP) Human Development Index. The UNDP Human Development Index judges a country's social and economic development status according to key indicators such as life expectancy at birth, mean years of schooling, expected years of schooling and gross national income per capita (UNDP, 2015). Gross Domestic Product (GDP) is approximately USD 360.1 billion and the economy is distributed between the main sectors as follows (World Bank, 2014):

- Agriculture: 2.49%
- Industry: 29.47%
- Services: 68.05%

TABLE 3: SOUTH AFRICA'S HUMAN DEVELOPMENT INDICATORS.

Indicator		Year	Source
GDP Growth Rate	1.52%	2014	World Bank, 2014
GDP Per Capita	USD 6 482.82	2014	World Bank, 2014
Unemployment	25.10%	2014	World Bank, 2014
Youth Unemployment (ages 15-24)	52.60%	2014	World Bank, 2014
Adult Literacy	94.3%	2015	CIA World Factbook, 2016
Life Expectancy	57 years	2013	World Bank, 2014

South Africa is characterised by a high unemployment rate (Table 3) with more than 50% of the labour force characterised as unskilled and semi-skilled. Furthermore, 45.5% of South Africans are living in poverty (Stats SA, 2014). Food security remains a pressing issue. In 2011, 23% of households did not have adequate access to food and 13% experienced hunger. Many of the rural coastal communities are largely reliant on subsistence from coastal food sources, indicating the importance of job creation within isolated coastal communities. While the government is implementing important programmes to reduce poverty and improve access to social services, high inequality levels profoundly affect social cohesion (Kumo *et al.*, 2015).

3.2. Socio-economic impacts of aquaculture in South Africa

Direct permanent employment in the South African aquaculture industry has had a large local impact in previously disadvantaged coastal communities where any increase in employment is valuable and necessary, as indicated by the unemployment rates in the Section 3.1. Aquaculture is an industry where environmental and socio-economic systems are intertwined. Therefore, information about the ecological and economic impacts of different practices is required for sustainable development. This implies communication between the commercial, scientific, management and policy-making communities, and integration among disciplines using mutually understandable concepts.

The financial feasibility and long-term viability of a venture is essential as positive economic impacts can only flow from a project that is financially viable. Any operation must also be compatible with current legislation, policy, and guidelines that address the development of aquaculture facilities. These requirements are a critical aspect relating to economic desirability, ensuring that the proposed venture compliments economic development and planning as reflected in existing policy and development guidelines for aquaculture. In addition, the development of an aquaculture operation should also be desirable from a societal cost-benefit perspective.

Aquaculture can result in several social benefits including employment, income and food security, which are particularly important to poor, rural coastal communities worldwide. A summary of the main socio-economic impacts of aquaculture are provided below:

- ***Benefits***
    - Increase in fish supplies
    - Improved food security
    - Export earnings
    - Creation of employment
    - Conservation of social structure
    - Improved infrastructure in rural areas
    - Creation of local business opportunities for entrepreneurs
    - Skills development in surrounding communities

- ***Costs***
    - Environmental damage
    - Conflict over resource usage
    - Market competition between aquaculture and fisheries sectors
    - Creation of a resource sink
    - Disruption of social structure
    - Loss of traditional occupations

An important condition for aquaculture development is public acceptance i.e. that attitudes towards aquaculture are at least neutral (Barrington *et al.*, 2010). There is significant evidence that demonstrates the detrimental effect of hostile social perceptions on aquaculture industries. For example, shrimp (prawn) farming in India resulted in sabotage and litigation (Ridler & Hishamunda, 2001). In North America, individual homeowners and communities opposed salmon farming because of perceived environmental damage or for aesthetic reasons (Ridler & Hishamunda, 2001). Other negative perceptions associated with aquaculture include the presence of heavy metals and toxins in cultured shellfish and fish, GMOs, sea lice, and genetic pollution of wild fish populations. If aquaculture is to be acceptable to the general public, the biological potential of the candidate species must be appropriate to the environment, the local communities should benefit, and consumers must be willing to purchase the end product. Negative perceptions need to be addressed by creating awareness which emphasises that many of the impacts are species- and location-specific.

Aquaculture addresses poverty and food insecurity in a variety of ways and at different scales. For small-scale farmers, it offers a means to diversify production, providing nutritious food for their own families (and sometimes those of their neighbours) while potentially generating surplus product for sale. Larger commercial enterprises create farm income and employment opportunities throughout the value chain and provide affordable, highly nutritious food in response to market demand.

Many of the negative impacts associated with aquaculture could be mitigated, and/ or positive impacts generated, by introducing measures proposed within an EIA or EMPr, which the developer and/or operator must implement. Monitoring and evaluation of socio-economic obligations will further enhance the contribution of farms to community upliftment and development. The socio-economic risks associated with aquaculture are addressed in Section 9 of this report.

3.3. Employment opportunities

South Africa has a high unemployment rate with economic growth required to absorb the unemployed through job creation. Direct permanent employment in the South African aquaculture industry has had a local impact in previously disadvantaged coastal communities, where any increase in employment is valuable.

Marine and freshwater aquaculture was one of the top 5 contributors to employment in the South African fisheries sector in 2013 (Table 4). In comparison to other sub-sectors, aquaculture was characterised by high employment per ton of production (approximately 1 direct job per 3 tonnes production), with high quality jobs and high growth potential. By comparison, employment in the capture fisheries sector shrunk by 17% between 2000 and 2008. Some socio-economic indicators for the various subsectors are presented in Table 5.

The South African marine aquaculture industry employed 1 607 people on a permanent basis in 2013 (DAFF, 2014a). The majority of jobs were created by the abalone sub-sector whereas the finfish sub-sector accounted for only 9.5% of job opportunities.

As marine aquaculture generates small profits per unit production, is highly labour-intensive and requires unpredictable and often exceptionally long work-hours, particularly during peak seasons, its sustainable development requires a local community with a high proportion of unskilled and semi-skilled labourers living relatively close to their place of employment. This workforce also needs to be flexible in their approach to work-hours and highly dependable (Olivier *et al*., 2013).

TABLE 4: CATCH, VALUE AND EMPLOYMENT IN THE RSA FISHERY SECTOR (2013)

	Tonnage per annum	Value (ZAR million)	Employment (direct jobs)
Hake	126 000	1 977	8 350
Small pelagics	526 000	911	5 204
Aquaculture	7 489	470	2 676 direct
WC Rock lobster	2 895	390	1 283
Squid	4 500	391	2 998

TABLE 5: SOCIO-ECONOMIC INDICATORS OF VARIOUS FISHERIES SUB-SECTORS INCLUDING AQUACULTURE (2013)

	Jobs/ 100 tonnes	Value/ tonne	Product value/ job
Hake	7	15,690	236,766
Small pelagics	1	1,732	175,058
Aquaculture	36	62,753	175,635
WC Rock lobster	43	130,653	303,975
Squid	67	86,889	130,420

When assessing the economic and employment opportunities provided by aquaculture, it is evident that the impact is relatively small. For example, the Mnquma Municipality, which incorporates the Qolora ADZ, had a population of approximately 252 390 people and a 44% unemployment rate in 2011 (Stats SA, 2012). It has been estimated that the ADZ has an area of 7.38ha available for production with the potential to create 600 jobs through abalone production (at 600 tpa) or 245 jobs through finfish production (at 2 750 tpa) (Hunter *et al*., 2014). Therefore, assuming the full production potential of the Qolora ADZ is realised and a maximum of 600 jobs are created within the production sector, this will have a 0.5% impact on unemployment within the Mnquma Municipality.

In a previous feasibility study conducted by Hecht et al. (2015) within the Qolora ADZ, it was estimated that a 10ha aquaculture project incorporating an integrated multi-trophic aquaculture (IMTA) system with 180 tpa abalone, 146 tpa dusky kob, and a 1 280 tpa seaweed production would employ 121 people.

Therefore, the direct employment generated in relation to the level of unemployment in the greater municipality is relatively low.

In terms of marine finfish production in South Africa, the expected employment opportunities are detailed in Section 7 based on the conceptual designs for this study. Under the model assumptions, the predicted employment opportunities for dusky kob and Atlantic salmon using different production systems is presented in Table 6 and Table 7.

TABLE 6: EMPLOYMENT OPPORTUNITIES BASED ON PRODUCTION VOLUME AND PRODUCTION SYSTEM FOR DUSKY KOB.

Dusky kob	Number of Employees		
Production (TPA)	**RAS**	**RAS + Cages**	**RAS + Ponds**
500	60	63	62
1500	116	125	121
3000	195	215	204

TABLE 7: EMPLOYMENT OPPORTUNITIES BASED ON PRODUCTION VOLUME AND PRODUCTION SYSTEM FOR ATLANTIC SALMON.

Atlantic salmon	Number of Employees	
Production (TPA)	**RAS**	**RAS + Cages**
500	56	63
1500	111	115
3000	192	194

It is evident that aquaculture, alone, cannot fulfil the demand for job creation in South Africa. However, it has the potential to contribute meaningfully to employment and economic growth for local communities and the country. This is particularly relevant where unemployment is not only an economic issue but also a socio-political concern.

Although aquaculture may not solve a country's socio-economic issues, it can make a difference at the level of individual lives. An example of this is provided for in the case study on page 17; where Highlands Trout, a commercial rainbow trout farm in Lesotho, has had a large social focus towards its local communities.

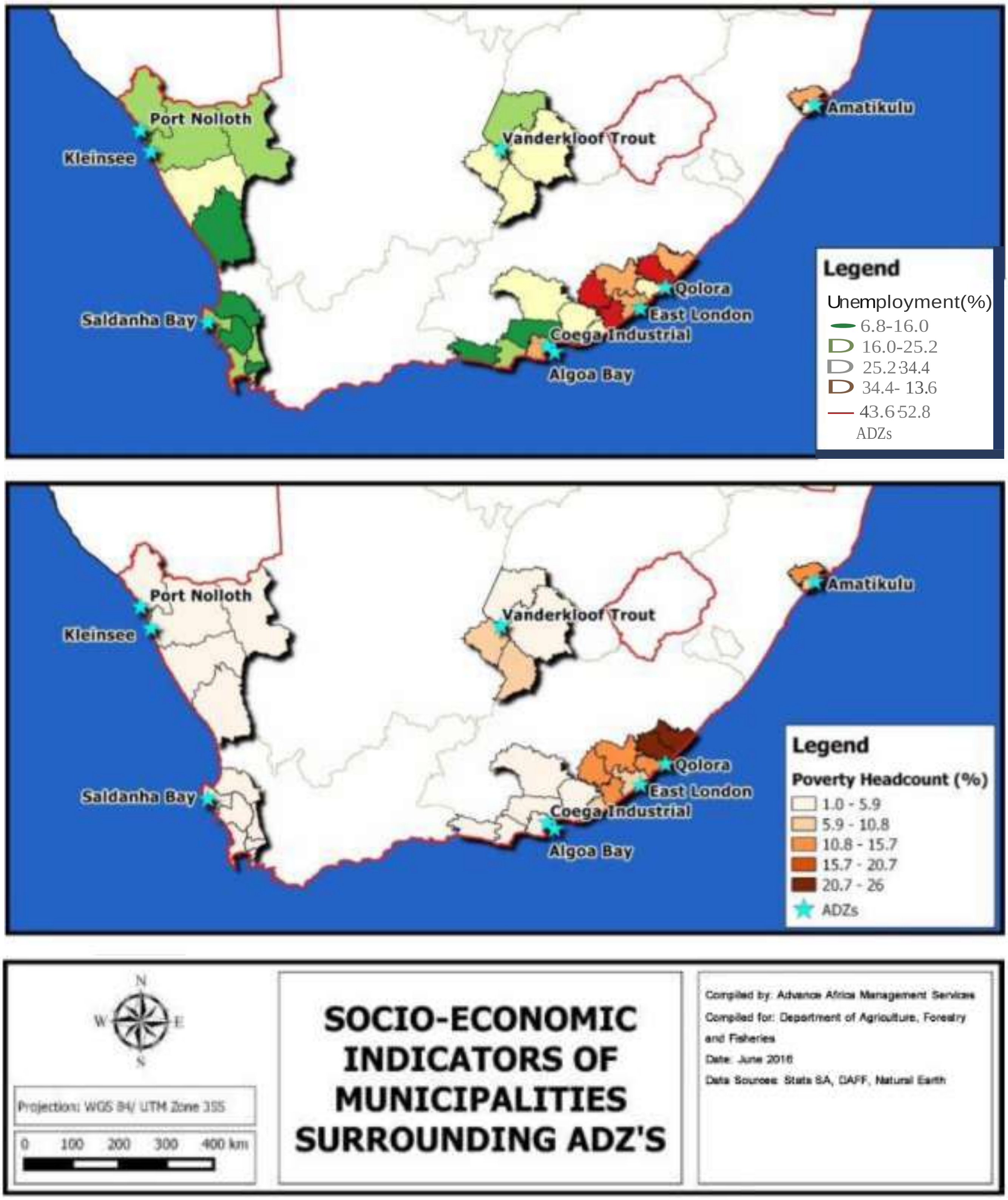


FIGURE 3: SOCIO-ECONOMIC INDICATORS (UNEMPLOYMENT AND POVERTY) OF MUNICIPALITIES SURROUNDING ADZ's (2012).

Case Study | HIGHLANDS TROUT

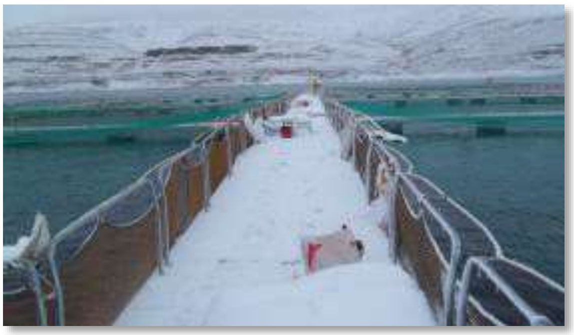
Overview

Highlands Trout (Pty) LTD is the largest aquaculture operation in Lesotho and was conceptualised based on social commitments by Gold Fields LTD (within its subsidiary Agrihold (Pty) LTD) to its labour sending areas (including Lesotho). Highlands Trout is fully committed to making socio-economic contributions to the communities around its project area at Katse Dam. The process began by carefully understanding the stakeholders, communities and community structures involved and an assessment of needs in those communities. The ongoing communication and hands-on relationships that Highlands Trout has fostered with the communities surrounding the project area has resulted in many positive projects.

Not only have local communities benefitted from the project due to employment opportunities and skills transfer, there have also been training, indirect employment, tourism and fisheries benefits in the area. Furthermore, Highlands Trout embarked on a comprehensive community impact programme.

Socio-economic benefits

- Over ZAR 150 million expenditure to date
- Highlands Trout's exports comprise 24% of national food exports in Lesotho
- Direct contributor to 2nd fastest growing export category (fish, crustaceans, molluscs and aquatic invertebrates)
- 107 permanent employees including general workers, scientists and middle and upper management level employees
- More than 50% of employees are female and 50% of management positions are held by females
- Contributes significantly to meat shortages in Lesotho by providing 5% of its harvested product, in the form of production grade, to the Lesotho market
- Numerous community projects from support to sport events and athletes, to donations of food and equipment to schools and clinics



Community projects

Katse schools projects

Katse weavers

Katse Marathon

3.4. B-BBEE opportunities

Broad-based Black Economic Empowerment (B-BBEE) is the South African Government's policy aimed at accelerating economic transformation. The policy is directed at empowering "black" people and redressing the inequalities caused by Apartheid. The term "black" refers to Africans, Indians, and persons of mixed race. The policy also promotes the empowerment of designated groups, which include women, youth, people living with disabilities and rural communities.

3.4.1. National Empowerment Fund

The National Empowerment Fund (NEF) was established by the National Empowerment Fund Act No. 105 of 1998 (NEF Act) to promote and facilitate black economic equality and transformation. Its mandate and mission is to be the catalyst of B-BBEE.

The Fund seeks to take the lead in the expansion of new industrial and manufacturing capacity, warehousing equity for the future benefit of B-BBEE in national strategic projects, increasing South Africa's export earning potential, and reducing South Africa's dependency on imports. Investors are urged to invest in the NEF to support job creation and the growth of the economy.

The NEF's role is to support B-BBEE. As the debate concerning what constitutes meaningful and sustainable B-BBEE evolves, the NEF anticipates future funding and investment requirements to help black individuals, communities and businesses achieve each element of the Codes of Good Practice. These include a focus on preferential procurement, broadening the reach of black equity ownership, transformation in management and staff and preventing the dilution of black shareholding within entities.

The NEF differentiates itself not only with a focused mandate for B-BBEE but also by assuming a predominantly equity-based risk to maximise the "Empowerment Dividend". Reward should balance the risk with the application of sound commercial decisions to support national priorities and Government policy such as the Accelerated and Shared Growth Initiative for South Africa (AsgiSA) or targeted investments through the DTI's Industrial Policy Framework. The work of the NEF therefore straddles and complements other development finance institutions by allowing the organisations to work in close collaboration.

Products and services

- ***The iMbewu fund***

This fund is designed to promote the creation of new businesses and the provision of expansion capital to early stage businesses. The iMbewu Fund aims to cultivate a culture of entrepreneurship by offering debt, quasi-equity and equity finance of up to R10 million comprising:

- Entrepreneurship finance
- Procurement finance
- Franchise finance

- ***Rural and community development fund***

The rural and community development fund facilitates community involvement in projects that promote social and economic upliftment. In accordance with the B-BBEE Act, it aims to increase the extent to which workers, cooperatives and other collective enterprises own and manage business enterprises. It also supports the B-BBEE Act objectives of empowering local and rural communities. It has four components: Project Finance, Business Acquisition, Expansion Capital and Start-up/"Greenfields" with funding thresholds between R1 million and R50 million.

- ***The uMnotho fund***

The uMnotho Fund is designed to improve access to B-BBEE capital for black-owned or black-managed businesses who are buying equity shares in black- or white-owned businesses, starting new ventures, looking to expand and/or be listed on the Johannesburg Stock Exchange. In other words, this Fund provides financing for those entrepreneurs who wish to buy into an already established business and aims to increase the number of entrepreneurs in the country. Funding ranges from R5 million to R50 million.

- ***Strategic projects fund***

It provides "Venture Capital Finance" to develop South Africa's new and strategic industrial capacity within sectors identified by Government as the key drivers to economic growth. The Fund aims to increase the participation of black people in early-stage projects. This Fund acts to stimulate economic activity. Some of the areas where NEF has invested this funding are renewable energy, mining and minerals beneficiation, agro-processing, tourism, business process outsourcing and infrastructure.

The Funds' focus is informed by Government's strategies on industrial development through the DTI's National Industrial Policy Framework and the corresponding Industrial Policy Action Plan (IPAP). The sectors identified in the Framework and IPAP are as follows:

- Agriculture
- Business Process Outsourcing Textiles
- Mining, Mineral Processing and Mineral Beneficiation
- Automobiles
- Renewable Energy and Biofuels
- Plastics
- Pharmaceuticals and Chemicals
- Forestry, Pulp and Paper
- Infrastructure
- Manufacturing
- Tourism

3.5. SMME opportunities

Government has prioritised entrepreneurship and the advancement of Small, Medium and Micro-sized Enterprises (SMMEs) as a catalyst to achieving economic growth and development. With the assistance of other government departments and institutions, the newly created Department of Small Business

Development (DSBD) and the DTI take the lead in implementing SMME-related policies to ensure that adequate financial and non-financial assistance is provided to the sector for its long-term prosperity.

3.6. Incentives and industrial financing opportunities

South African government departments offer an array of incentive schemes to stimulate and facilitate the development of sustainable, competitive enterprises (DTI, 2015). These incentive schemes seek to support the development and/or growth of commercially viable and sustainable enterprises through the provision of either funding or tax relief. Most of the incentives are housed within the DTI, with a few others in other government departments. These incentive schemes are broadly classified into three categories:

1. **Concept and Research & Development Incentives:** These are incentives available to private sector enterprises that invest in the creation, design and improvement of new products and processes. Such businesses conduct investigative activities with the intention of making a discovery that can either lead to the development of new products and processes or to the improvement of existing products;
2. **Capital Expenditure Incentives:** These are incentives for companies that want to acquire or upgrade assets in order to either establish or expand the business' productive capacity;
3. **Competitiveness Enhancement Incentives:** These are investments that facilitate increased competitiveness, sustainable economic growth and development in a specific sector.

Aquaculture has been identified as one of the priority sectors in South Africa that can contribute to food security, job creation, promote economic development and export opportunities (DAFF, 2013c). Aquaculture is a technology-driven industry that requires substantial and sustained capital investment. The majority of aquaculture businesses are faced with limited access to finance and, therefore, cannot afford to invest in research and development projects on the scale required. In countries where aquaculture has experienced rapid growth in the past, governments have provided financial assistance to make aquaculture producers more competitive, both locally and internationally. Therefore, Government assistance in the form of funding will play a vital role in the development of commercial aquaculture in South Africa. Various investment schemes are applicable in terms of aquaculture development, and B-BBEE and SMME opportunities, and these are summarised in Table 8 below:

TABLE 8: RELEVANT FUNDING OPPORTUNITIES FOR AQUACULTURE DEVELOPMENT IN SOUTH AFRICA.

Capital Expenditure Incentives: Aquaculture Development and Enhancement Programme (ADEP)	
Objective	Investment in the aquaculture sector.
Applicability	SA entities involved in fish hatcheries and fish farms (primary aquaculture), processing and preserving of aquaculture fish (secondary aquaculture), service activities to operators of hatcheries and fish farms (ancillary aquaculture).
Benefit	20% - 45% grant for investment in land, and buildings, machinery and equipment, commercial vehicles and work boats and bulk infrastructure capped at R40 million per application.
Managed by	DTI
Competitiveness Enhancement Incentives: Special Economic Zones (SEZs)	
Objective	To promote targeted investment to facilitate economic growth and job creation.
Applicability	Qualifying projects located in SEZs.
Benefit	• 15% corporate tax rate. • Accelerated write-off of buildings over a 10 year period.

	• Employment tax allowance per job created. • Customs controlled area for duty-free rebate and VAT exemption for importing inputs of export products. • One-stop-shop for investment facilitation.
Managed by	DTI
Competitiveness Enhancement Incentives: Agro-industries	
Objective	Provide support to agro-processing and aquaculture sectors.
Applicability	Focus areas are: • Horticulture primary agricultural sector • Food processing sector • Agro-industrial sector • Beverage sector • Fishing and aquaculture sectors
Minimum finance requirement	More than R1 million in debt and/or more than R5 million in equity.
Benefit	Competitive, risk-related interest rates are based on the prime bank overdraft rate.
Managed by	Industrial Development Corporation
Competitiveness Enhancement Incentives: Incubation Support Programme	
Objective	To develop and nurture sustainable SMME's that can provide jobs.
Applicability	South African registered legal entities. Specifically, registered higher education or further education institutions in partnership with private sector; and licensed and/or registered science councils in partnership with private sector.
Benefit	A grant of 50% or 60% of the qualifying costs of the incubator limited to R30 million per application.
Managed by	DTI
Competitiveness Enhancement Incentives: Jobs Fund	
Objective	To co-finance public and private sector projects that will significantly contribute to job creation.
Applicability	The Fund will, on a competitive basis, consider co-financing proposals from private sector, non-governmental organisations, government departments and municipalities that show economic development potential linked to sustainable job creation.
Benefit	Matching grant funding for the following windows: • Enterprise development initiatives: Initiatives that reduce risk, remove barriers to market access and broaden supply chains; • Infrastructure initiatives: Light infrastructure initiatives necessary to unlock job creation; and • Work-seekers initiatives: Initiatives linking work-seekers to the formal employment sector.
Managed by	National Treasury's Government Technical Advisory Centre
Rural and Community Development Fund	
Objective	To promote sustainable change in social and economic relations and supporting the goals of growth and development in the rural economy.
Applicability	Minimum black ownership of 25.1% is a requirement.
Benefit	A minimum of R1 million to R50 million
Managed by	NEF
Competitiveness Enhancement Incentives: Black Business Supplier Development Programme	
Objective	To improve the sustainability of black-owned enterprises by providing funding to increase the competitiveness of the businesses.
Applicability	Companies that are majority black-owned (51% or more), have an annual turnover of between R250 000 and R35 million and have a predominantly black management team. The entity must have a minimum trading history of one year.
Benefit	The programme provides grants up to a maximum of R1 million in total that will be limited to a payment of R800 000 for tools, machinery and equipment

	and limited to a payment of R200 000 for business development and training interventions.
Managed by	DSBD
Competitiveness Enhancement Incentives: The Cooperative Incentive Scheme	
Objective	To promote cooperatives by improving the viability and competitiveness of the cooperative enterprises by lowering the cost of doing business.
Applicability	Any entity incorporated and registered in South Africa in terms of the Cooperatives Act. Target is cooperatives operating in the emerging sector, and manufacturing, retail and services sector.
Benefit	Cost-sharing grant of 100% paid by the DTI up to a maximum of R350 000 for costs relating to business development services, business profile development, feasibility studies/market research, start-up requirements etc.
Managed by	DSBD

The Marine Living Resources Fund was established in terms of the MLRA (1998). The fund's mandate and core business is to manage the development and sustainable use of South Africa's marine resources and to protect the integrity and quality of the marine ecosystem (National Treasury, 2015).

The Working for Fisheries projects, in the State's expanded Public Works Programme, entail resource management initiatives that employ ecosystem approaches to fisheries and aquaculture development by encouraging communities to responsibly manage and conserve their aquatic environments. These projects are expected to result in the creation of 1 693 job opportunities by 2017/18 in the fisheries sector, as well as environmental sustainability in rural coastal communities as part of sustaining South Africa's ecosystems and using natural resources efficiently, in line with the national development plan's vision. These projects will be funded through a monitoring, compliance and surveillance programme, with an allocation of R365.2 million over the medium term (National Treasury, 2015).

Operation Phakisa is the vehicle through which government aims to implement its policies and programmes more efficiently and effectively (National Treasury, 2015). Operation Phakisa aims to implement economic and social programmes within the "Ocean Economy", of which aquaculture is one of the priority sectors. Aquaculture projects can seek implementation support through the Operation Phakisa Aquaculture Development Fund. To date, this fund has yet to be developed, although is catered for in the Aquaculture Bill (Andrea Bernatzeder; personal communication).

To date, efforts to enhance the growth of SMMEs have been widespread; however, challenges still remain. There is a lack of state support and access to funding remains a challenge for SMMEs. Furthermore, there is a lack of coordination between various governmental departments which makes support of SMME operations difficult and ineffective (Olivier *et al*., 2013). Economies of scale and operational pressures often make it extremely difficult for SMMEs to generate enough profit to expand, increase efficiency, and upgrade infrastructure in order to remain competitive on national and international markets.

4. CANDIDATE SPECIES

4.1. Dusky kob

4.1.1. Biological characteristics

The dusky kob (Figure 4), is a euryhaline, carnivorous fish usually found in shallow coastal and estuarine waters and well represented in the Indo-Pacific, the Caribbean and in the temperate waters of the Atlantic- and Pacific Oceans (Froese & Pauly, 2016). The dusky kob occurs in the Southern and Northern hemispheres, along the entire South and East coasts of Australia (where it is known as mulloway) and from Hong Kong northwards along the Chinese coast to Southern Korea and Japan (Figure 5) (Griffiths & Heemstra, 1995).

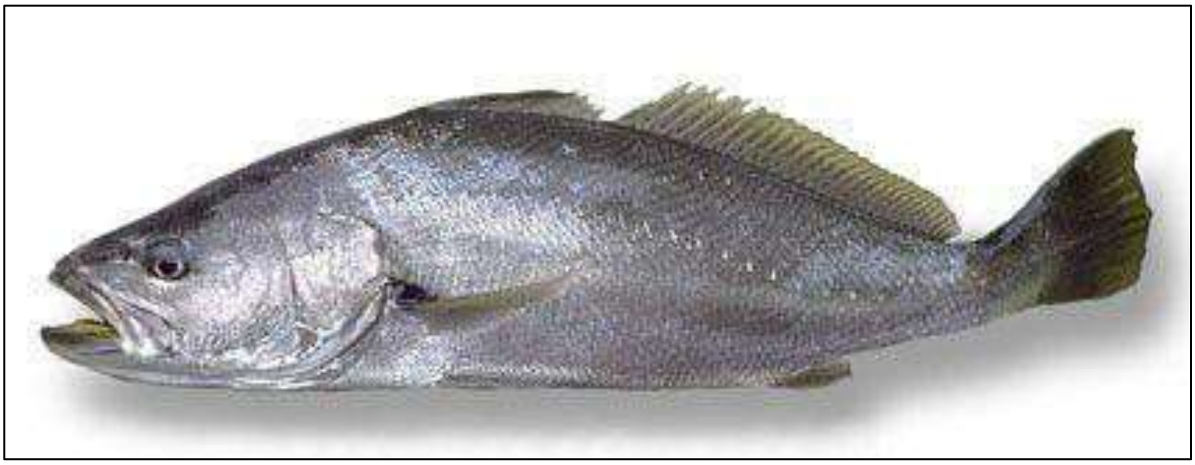


FIGURE 4: DUSKY KOB (SOURCE: BENCHMARK FOODS, 2016).

In Southern Africa it occurs on the east coast from Cape Point to Mozambique (Figure 5) and is especially abundant between Cape Agulhas and KwaZulu-Natal (Griffiths, 1996). Early juveniles (<10 total length (TL) cm) recruit into the upper reaches of mainly turbid estuaries (Ter Morshuizen *et al*., 1996), where salinities are low to moderate, and later move to the lower reaches and into shallow, coastal waters (Griffiths, 1996). The absence of early juvenile dusky kob from non-turbid estuaries such as the Swartvlei and Knysna estuaries (Whitfield *et al*., 1981) suggests the species' preference for turbid estuaries as nursery areas, as they provide increased protection from predators and adequate supplies of food (Griffiths, 1996). However, recent research suggests that the preference for turbid estuaries may be a direct result of lower salinity levels. Adults are found in estuaries, the surf zone, and inshore coastal waters but are generally restricted to the near-shore zone to a maximum depth of around 100m (Griffiths, 1996). In South Africa, the species exhibits rapid growth and can reach a maximum length of 1.8m, weight of 75kg and 40+ years of age (Griffiths & Hecht, 1995). Length-at-50% maturity is attained at a total length of 107cm (Griffiths, 1996).

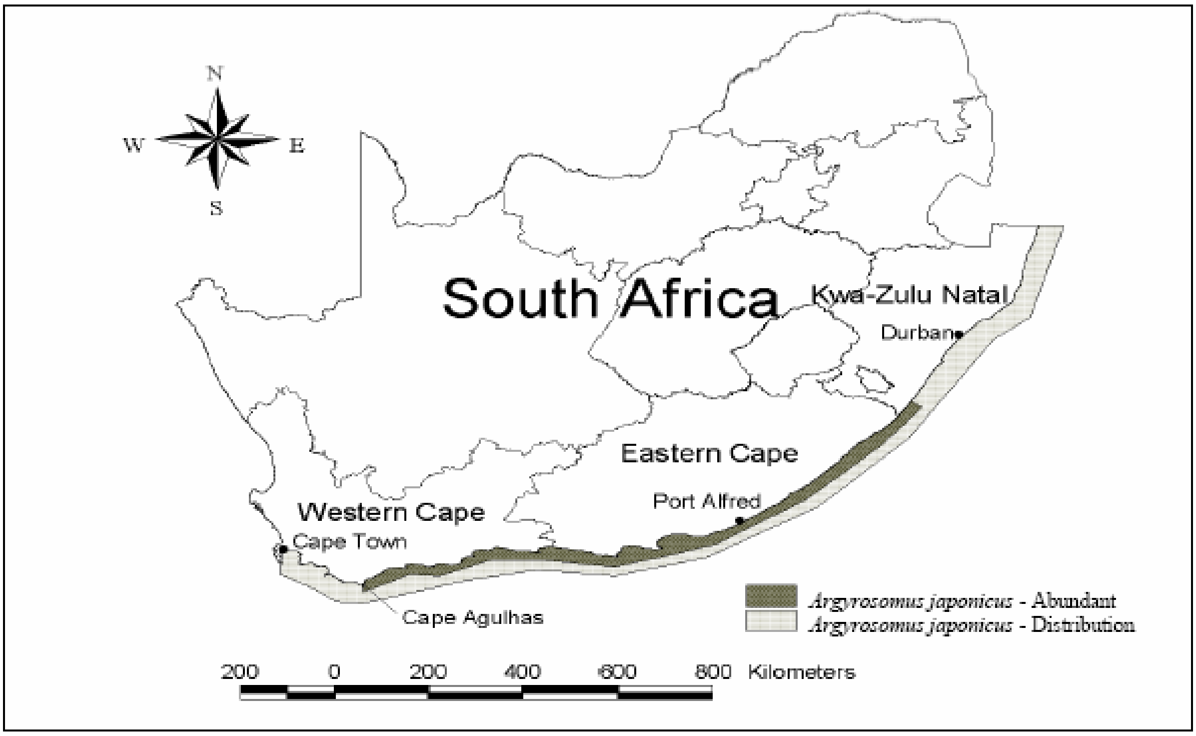


FIGURE 5: DISTRIBUTION OF DUSKY KOB IN SOUTH AFRICA (SOURCE: GRIFFITHS, 1996)

There is good evidence to suggest that a large proportion of the adult population in the Cape region migrate to Kwazulu-Natal to spawn (Griffiths, 1996). However, some spawning also occurs in the Cape waters in spring and summer and is thought to be induced by changes in water temperature (Griffiths, 1996). Despite different spawning areas, Mirimin *et al* (2015) confirmed that there is low population genetic structuring and gene flow is strong in dusky kob along South Africa's coastline. They are therefore regarded as a single stock. Mirimin *et al* (2015) also concluded that there are low numbers of adult dusky kob present along the southern African coastline and that this was due to the effects of "prolonged and strong size selective pressure". This highlights the difficulty that prospective aquaculture operators may face in sourcing mature broodstock for their farms.

4.1.2. Fisheries

Due to its large size, palatability, and food value, dusky kob is targeted by recreational and commercial fisheries throughout its natural distribution. In South Africa, per-recruit analyses have revealed that the dusky kob has been severely over fished and that the spawner biomass has collapsed to about 2.3% of pristine levels (Griffiths *et al.* 2003).

4.1.3. Aquaculture development

Because of its rapid growth rate, late maturity, declining commercial catches, and high market demand, the species was identified as a suitable aquaculture candidate species in Australia (O'Sullivan & Ryan, 2001) and subsequently in South Africa (Hecht *et al*., 2015). The attributes for aquaculture of kob are listed in Table 9.

TABLE 9: POSITIVE AND NEGATIVE ATTRIBUTES OF DUSKY KOB FOR AQUACULTURE.

Positive attributes	**Comment**
Broodstock	Not easy to acquire, but adapt well to captivity
Spawning	Protocols have been developed for successful breeding of the species and spawns regularly in captivity
Larval rearing	Larval rearing, in comparison to other species, is relatively easy and survival rate is medium-high, though still somewhat unpredictable
Behaviour	Show little activity under culture conditions, resulting in improved Feed Conversion Ratios (FCR) (Hecht & Mperdempes 2001)
Growth	Growth is rapid and the species can be grown from 23 g to 1.5kg in 15-16 months. The species matures at around 4-5 years at a length of around 1m. Growth is rapid up to sexual maturation.
Feeding	Dusky kob readily accepts pelleted feeds.
Euryhaline	Dusky kob can be grown successfully in a wide range of salinities and can be immersed into freshwater for several hours as treatment against ectoparasites.
Technology	Technology for tank based culture has been developed successfully.
Negative attributes	**Comment**
Cannibalism	Kob are cannibalistic during the larval and early juvenile phase leading to high mortalities.

In the last decade there has been substantial research focussed on spawning, larval rearing and juvenile production in Australia and South Africa (Battaglene & Talbot, 1994; Musson, 2004). The species is euryhaline (Whitfield *et al.,* 1981) and Fielder and Bardsley (1999) reported that dusky kob larvae and early juveniles grew well in salinities ranging from 5 to 35 ppt and that growth trials in brackish water ponds in New South Wales, Australia were encouraging (O'Sullivan & Ryan, 2001).

Hecht and Mperdempes (2001) showed that the fish readily accepts pelleted feeds and can be grown from 21g to 2.2kg in 22 months (see Figure 6, page 27). These growth rates under experimental conditions are very similar to growth rates recorded in a commercial dusky kob farm (3.5g per day).

Kob farming in South Africa

Research on dusky kob culture in South Africa began in 1998/9. Since then, other laboratories have joined the endeavour. Laboratory findings have now been tested on a pilot scale and since 2004 the technology has been commercialised. The protocols for dusky kob spawning, larval rearing, fingerling production, and live transport of fingerlings were developed by Oceanwise (formerly Espadon Marine) and Irvin and Johnson (commonly known as I&J). These protocols are now generally well established although much still needs to be done to ensure a consistent supply of fingerlings. Dusky kob fingerlings (0.3g) can now be purchased from several hatcheries at an average price of between R2.10 – R2.50 (ungraded) (Hecht *et al.*, 2015).

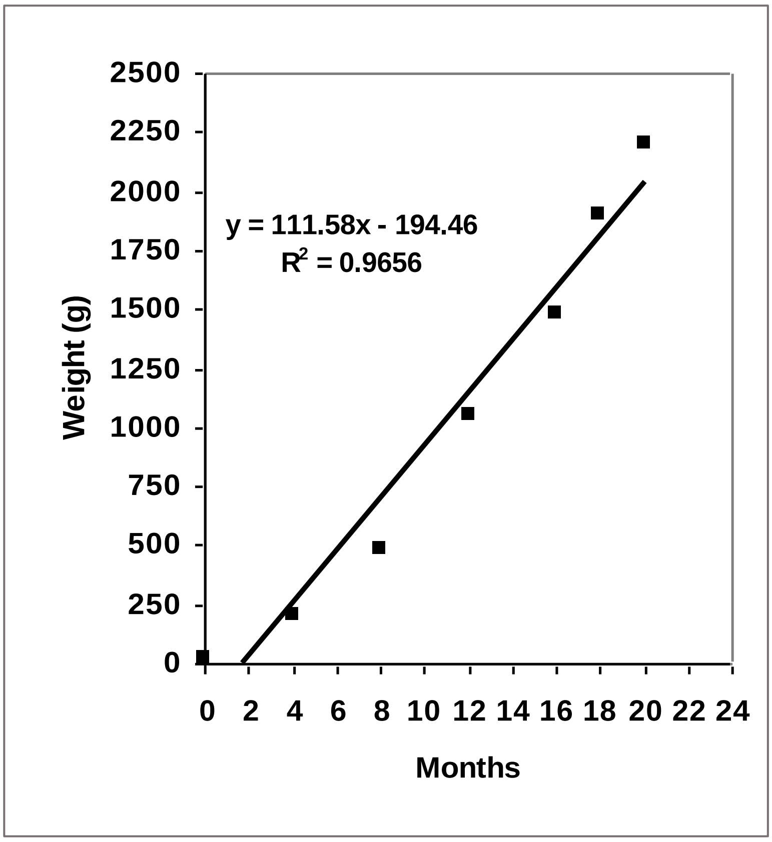


FIGURE 6: GROWTH OF DUSKY KOB IN CAGES UNDER AMBIENT CONDITIONS, PORT ALFRED (SOURCE: HECHT & MPERDEMPES 2001).

4.1.4. Dusky kob farming technology

Production systems

Production systems for dusky kob can be broadly categorised as either land-based or offshore-based (Figure 7).

Land-based production involves:

1. Holding and conditioning of broodstock in tanks or ponds for spawning and egg production in hatcheries. Spawning and egg production is conducted in tanks with egg collectors.
2. Larval rearing in tanks or ponds (from 3 days after hatch (DAH) in ponds).
3. Live-feed production for larvae.
4. Nursery stage rearing in tanks or ponds.
5. The on-growing of juveniles in tanks or ponds.

Offshore-based production may involve:

1. The transfer of broodstock from offshore cages to holding and conditioning facilities on land.
2. Grow-out of fingerlings in nursery (size of 50g) and grow-out offshore cages (to market size).

Land-based tank facilities operate on a single-pass flow-through basis (tanks and ponds) or a partial or complete recirculating aquaculture system (RAS) basis (tanks).

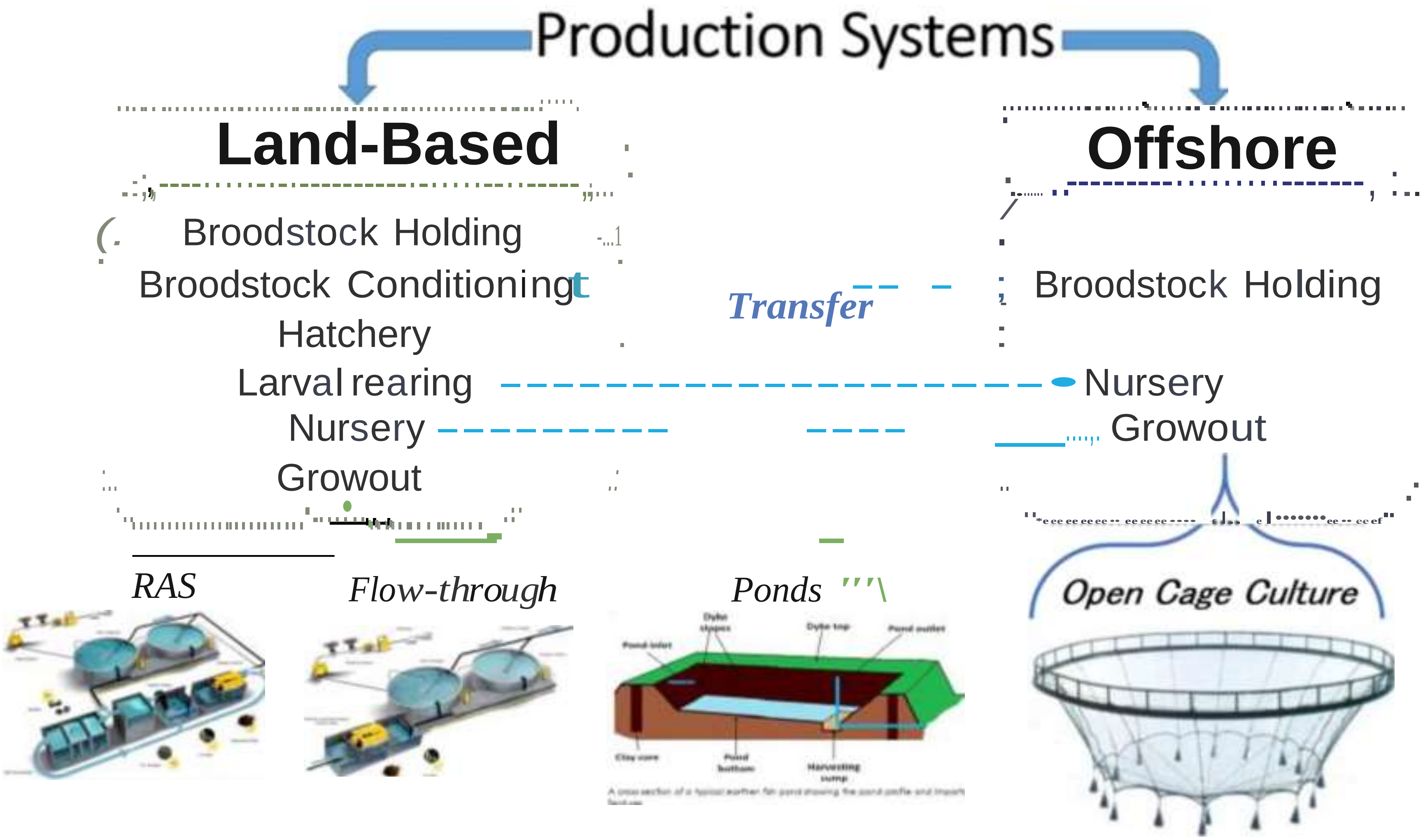


FIGURE 7: PRODUCTION SYSTEMS FOR AQUACULTURE OF DUSKY KOB.

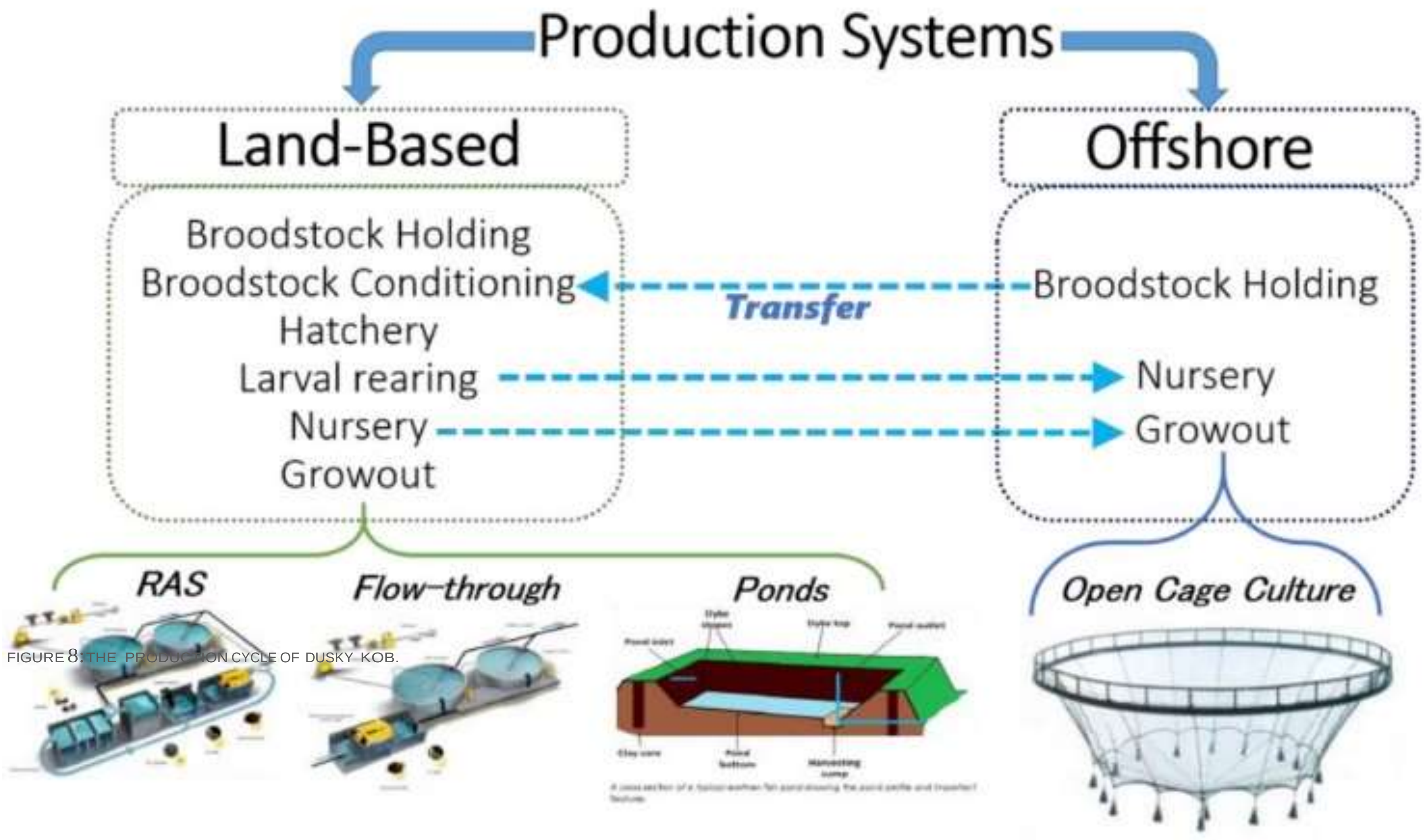


FIGURE 8: THE PRODUCTION CYCLE OF DUSKY KOB.

Broodstock capture, conditioning, spawning, larval rearing and fingerling production

Broodstock (fish greater than 1m) are caught by hook and line and then immediately transferred, using a stretcher, to a temporary holding facility on the shore. In South Africa, this may consist of a plastic 3m diameter porta-pool rigged to a sand filter and 1.1kw pump. Seawater is pumped into the pool via a submersible pump and re-circulated through the sand filter. If necessary, the fish are anaesthetised with 2-phenoxyethanol at 0.2ml per litre to facilitate removal of the barbless hook. The fish are normally held in the tank for a period of 24 hrs prior to transfer to the broodstock facility. The fish are transported in an 800-litre transport tank supplied with oxygen at a saturation level of 120% and ice packs are added to the water if temperatures exceed 20°C during the transport period. Before the fish are introduced into the broodstock holding facility, they are subjected to a freshwater bath and then quarantined in the system for a period of 16 days during which they are treated with an antibiotic and dewormed (Hecht *et al*., 2015).

Broodstock holding facilities are variable; tanks are typically at least 25m^3 and can be much larger (250m^3) while ponds may vary from 0.05-1ha (Fielder & Heasman, 2011). Broodstock tanks are fitted with a biofilter, sand filter, ultraviolet (UV) filter and heating unit. The water is re-circulated through the filtration units once every 45 minutes. The broodstock tanks are covered with a "zero light" PVC cover to allow for photoperiod control and maintained at a temperature of between 18°C and 20°C. Supplementary oxygen is added to maintain the saturation levels at ca. 105%. The water flow system should be monitored by a telephonic alarm to the duty technician (Hecht *et al*., 2015).

Broodstock kept in ponds are maintained under ambient water temperature and salinity conditions with additional aeration provided by paddlewheels.

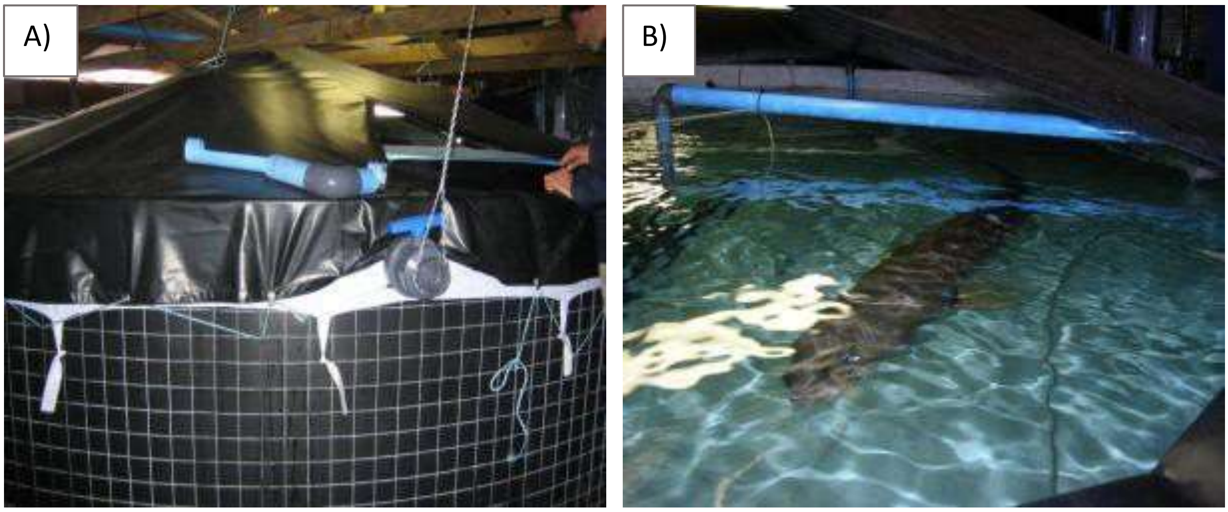


FIGURE 9: A) KOB BROODSTOCK HOLDING FACILITY; AND NOTICE IN B) THE ZERO LIGHT COVER WHICH CONTROLS PHOTOPERIOD (SOURCE: HECHT ET AL., 2015).

FIGURE 10: KOB REARED IN OUTDOOR PONDS IN AUSTRALIA (SOURCE: BRENDAN RAY, 2012).

To produce 250 000 fingerlings per annum requires hatchery facilities to hold three batches of six fish (four females and two males). Fish are sexed by inserting a cannula into the genital opening and undertaking microscopic examination of the gonads. Broodstock are fed a mixed diet of pilchards and squid at 2% of total fish mass in the tank every second day. The pilchards are injected with Mirra-cote (vitamin and fatty acid supplement) at 3ml per pilchard. In addition, an encapsulated fish vitamin and mineral premix is added to each pilchard (Hecht *et al.*, 2015). Figure 11 illustrates some aspects of broodstock capture and acclimation.

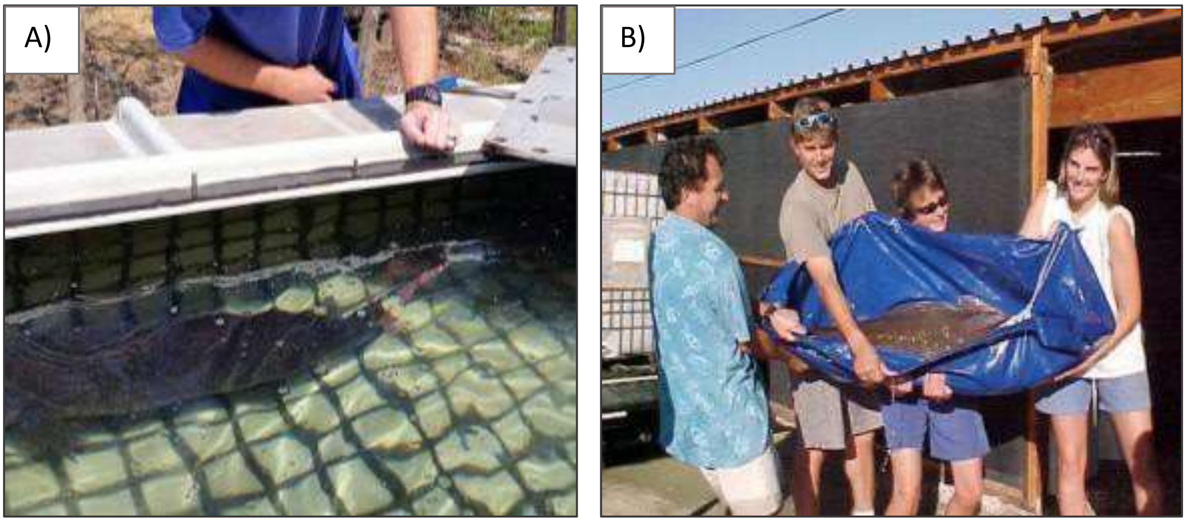


FIGURE 11: A) KOB BROODSTOCK READY FOR TRANSPORT TO AQUACULTURE FACILITY (SOURCE: MTUNZINI FISH FARMS, 2016); AND B) ARRIVAL OF NEW FEMALE KOB (SOURCE: HECHT ET AL., 2015).

It is possible to spawn the kob over an 8-9 month period, such that fingerlings can be provided on an almost continuous basis. Further photoperiod conditioning of the broodstock will lead to year-round production of eggs. The fish spawn naturally in the tanks and the floating fertilised eggs are collected with specially designed egg collectors inserted into the drainage system, which during the time of spawning drains from the surface of the tank (Hecht *et al*., 2015).

Eggs are incubated in 0.3m³ round black larval rearing tanks at stocking densities of 100 eggs per litre, at 22 °C, salinity of 32ppt, minimal air-flow (less than 0.1 litre per minute) and a water-flow rate of 5 litres per minute (turnover rate of once per hour).Hatching generally occurs after 20 hours and hatching rates can be as high as 100%. In intensive hatchery production, the larvae are reared in the incubation tanks for 12 days before they are transferred to larger ($4m^3$) tanks. During this period, light levels are kept low and photoperiod is maintained at a 14L: 10D cycle with “moonlight” during the dark phase. Water quality is monitored throughout and maintained at pre-determined levels (22 °C, dissolved oxygen (DO) >85% saturation, pH 8.12, ammonia < 0.1ppm, nitrite <0.1ppm, nitrate <0.5ppm and salinity at 32ppt). Water flow is maintained at a four times per hour exchange rate. The hatchery system is a recirculation system that incorporates mechanical sand filtration, biofiltration, foam fractionation and sterilisation with ozone and UV at a make-up water replacement rate of 10% per day. After metamorphosis, and up to the weaning stage, the larvae are regularly size-graded to minimise cannibalism (Hecht *et al*., 2015).

In extensive pond culture, dusky kob larvae can be introduced into the ponds as early as 3 DAH (Fielder & Heasman, 2011). Survival and growth rates can be significantly higher in ponds than in intensive hatchery larviculture although results can be highly inconsistent (Fielder & Heasman, 2011). This is dependent on factors such as water supply and whether ambient temperatures and quality are suitable (Guy and Cowden, 2012). Larviculture of dusky kob in extensive ponds is not practised in South Africa. In Australia, intensive rearing protocols are generally favoured over pond culture as production is more consistent (Fielder & Heasman, 2011).

In intensive and semi-intensive green water production, larvae are fed an integrated diet 8 times per day, starting at 05h00 in the morning and ending at 18h00 in the evening. The diet consists of live cultures rotifers, copepods and brine shrimp (*Artemia*) (Hecht *et al*., 2015).

TABLE 10: EXAMPLE OF A FEEDING ROUTINE OF DUSKY KOB LARVAE.

0 – 2 days after hatch (DAH):	No food (endogenous food supply from yolk sac)
2 – 10 DAH:	Cultured rotifers (50 – 120 microns) (*Brachionus plicatalis*) fed on different algae (*Chlorella, Isochrysis (T), Nannochloropsis and Tetraselmis*). Rotifers are boosted with Algamac 2000 prior to feeding at a density of 3 000 to 5 000 per litre in the larval rearing tank.
5 – 20 DAH:	Cultured copepods supplemented with EPA and DHA enriched, newly hatched *Artemia* nauplii fed at a density of 500 to 1 000 per litre.
12 – 33 DAH:	48-hr old *Artemia* nauplii enriched with Algamac 2 000. From 25 DAH to 33 DAH, *Artemia* are only provided during the afternoon feeds, while the microparticulate diet would be offered during the morning feeds.
15 – 23 DAH:	Microparticulate diet produced by Aquafauna (100 micron)
20 – 28 DAH:	Microparticulate diet (300 – 500 micron)
25 – 35 DAH:	Microparticulate diet (500 – 800 micron)
30 – 50 DAH:	Microparticulate diet (800 – 1 000 micron)
40 – 50 DAH:	Seabass crumble produced by Inve Feeds

25 – 40 DAH:	Finely chopped defrosted pilchard, squid and prawn.
At 50 DAH:	Fish are transferred to fingerling rearing (2 to 3m diameter) tanks or ponds for the initial stages of on-growing (Figure 12).

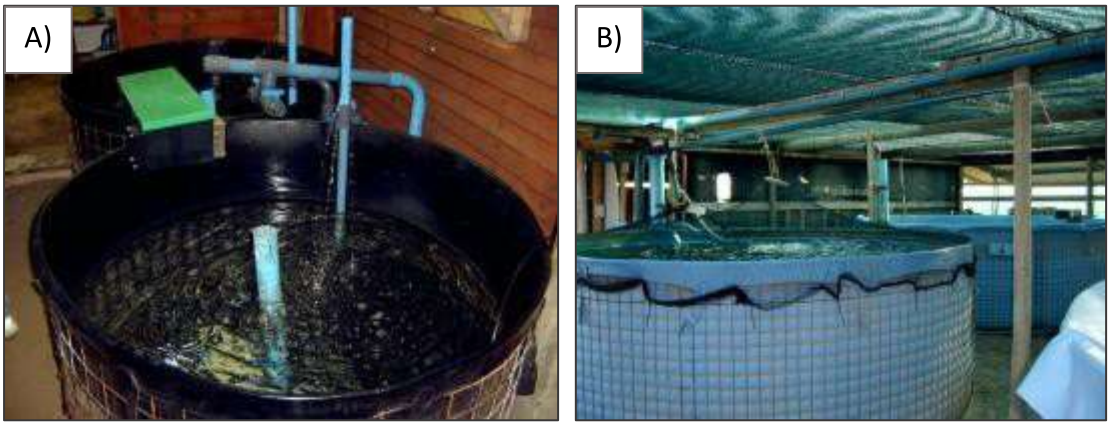


FIGURE 12: A) LARVAL REARING TANKS; AND B) JUVENILE ON-GROWING TANKS FOR KOB (SOURCE: HECHT ET AL., 2015).

Grow-out, feeding and harvest

- ***Tanks***

Juvenile fish are stocked at an initial weight of 2.5g into 4m diameter circular tanks and fed 4 times per day for an initial period of 2-3 weeks, after which feeding frequency is reduced to 2 times per day. At 50g the fish are transferred to circular (6-8m diameter) or D-ended tanks with a central baffle (10x4x1.5m) for grow-out. Fish density is maintained at around 25 kg/m^3 (Hecht *et al*., 2015). In Europe, seabass and seabream are reared at densities exceeding 50 kg/m^3 (Lara & Piccinini, 2006). Stocking density can be increased to around 40-50 kg/m^3 once staff are well versed in production operations. However, this may require higher flow rates or increasing dissolved oxygen flow (using additional oxygen generators) (Hecht *et al*., 2015).

During the grow-out period, the fish are size graded at 2-3 monthly intervals such that the final harvest consists of uniformly size fish. Daily ration is size- and temperature dependent and decreases to between 3-5% of body mass per day towards the end of the production cycle. Throughout the grow-out period the fish are checked daily for abnormal behaviour, whereupon corrective action is taken. At harvest the water is drained from the tank and the fish are immediately transferred into slush ice and transferred to the processing facility (Hecht *et al*., 2015).

- ***Ponds***

In Australia, juvenile kob (1-2.5 g) are stocked into ponds (0.5-1 ha) at a density of 15 000 fish/ha (Guy & Cowden, 2012). The ponds are covered with netting to exclude predators. After approximately 12 months, the pond is drained and the fish (500-600 g) are graded and stocked into two ponds, based on a large and small grade, at a density of 6 500 fish per pond. The fish are harvested 12 months later at an approximate weight of 2 kg. Survival rates are approximately 90-95% over the two year period (Guy & Cowden, 2012). Production averages around 12-14 tonnes/ha (Guy & Cowden, 2012), significantly lower than that achieved with flow-through or RAS grow-out technologies.

4.1.5. Environmental impacts

Environmental risks from land-based production are typically less significant than those from offshore cage culture which may include impacts on water quality, benthic effects, impacts on marine life and the introduction of chemicals from aquacultural activity (Price & Morris Jr, 2013). The impacts are briefly discussed below:

- ***Water quality***

Potential effects include increased levels of dissolved nitrogen and phosphorus, increased turbidity, accumulation of lipids, as well as fluctuating dissolved oxygen levels. In well-flushed areas, measurable effects from aquaculture are usually only recorded within 30 metres of the cages (Price & Morris Jr, 2013).

- ***Benthic effects and impacts on marine life***

Impacts on benthic sediments include alteration of chemical processes, such as nutrient assimilation and decomposition, from accumulation of excess discharged wastes from fish and feed (Wang *et al*., 2012). Accumulated organic matter can push the benthos in an area into an anaerobic state and these conditions may extend hundreds of metres beyond the farm perimeter. Remediation of the altered benthos may take several years (Price & Morris Jr, 2013). Impacts can be mitigated by locating farms in deep, well-flushed areas, setting aside areas and periods for fallowing, and implementing sediment monitoring programmes (Price & Morris Jr, 2013). Sediments that become enriched with organic farm waste nutrients may result in changes in the benthic invertebrate community, with increased species diversity and abundance observed in enriched areas (Wang *et al*., 2012). Excess feed and faecal matter may attract other organisms, particularly benthic feeders (Olsen & Olsen, 2008) and wild fishes, which in turn may attract large predatory animals such as sharks and seals (Price & Morris Jr, 2013).

- ***Eutrophication***

Impacts are primarily related to excess nutrients discharged to the aquatic environment from aquaculture operations. Excess nutrients which cannot be assimilated may result in eutrophication, although direct causal links to algal blooms may be difficult to confirm given the natural variability associated with algal bloom events as well as other anthropogenically-derived nutrient inputs present in coastal waters e.g. from industrial activity (Price & Morris Jr, 2013). Appropriate site selection is the primary mitigation measure to this.

- ***Introduction of chemicals***

Secondary harmful effects have been documented from the introduction of antibiotics (Beveridge, 2004; Halwart *et al*., 2007), therapeutants (Pittenger *et al*., 2007), and antifoulants (Burridge *et al*., 2010) into the environment. Potential impacts from antibiotics include increased disease resistance in fish pathogens (Armstrong *et al*., 2005), toxic effects on marine phytoplankton (Halling-Sorensen *et al*., 1998), and assimilation of antibiotics in wild fish from ingestion of feed and faecal matter (Armstrong *et al*., 2005). Administering therapeutic chemicals may result in direct mortality, increasingly resistant strains of pathogens, and accumulation of these chemicals in the sediments (Burridge *et al*., 2010). Antifouling treatments that incorporate tin compounds have toxic effects on both fishes and mollusks (Meng *et al*., 2005; Dimitriou *et al*., 2003).

4.1.6. Diseases and parasites

At this stage, very little is known about specific infections and diseases of kob. However, it can be expected that similar diseases as experienced in seabass and seabream culture will manifest themselves with time and increasing stocking density. Fortunately, there is voluminous literature on diseases and treatments of seabass and seabream (Sobhana, 2009; Christofilogiannis, 2013). To date there have been few reports of any health associated problems with dusky kob (Hecht *et al*., 2015).

4.2. Atlantic salmon

4.2.1. Biological characteristics

The Atlantic salmon is a carnivorous salmonid species (Figure 13) that is naturally distributed in the northern Atlantic Ocean, from Canada to the West of the United States of America (USA), to the White and Barents Sea basins in the East, through North-eastern Europe to the Baltic and North Sea basins in North-eastern Europe (Figure 14) (Froese & Pauly, 2016). It has been introduced to New Zealand, Chile, Argentina, Australia and South Africa (Froese & Pauly, 2016).

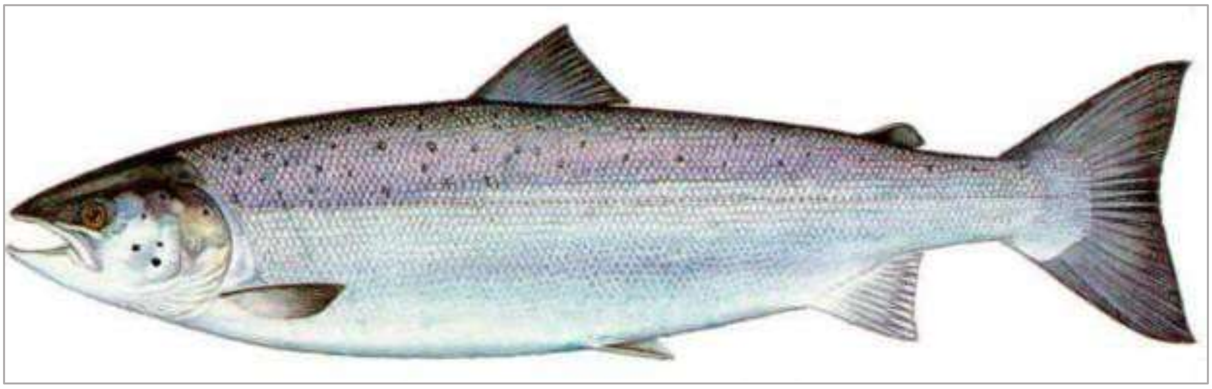


FIGURE 13: ATLANTIC SALMON (SOURCE: FISHERIES AND OCEANS CANADA, 2016).

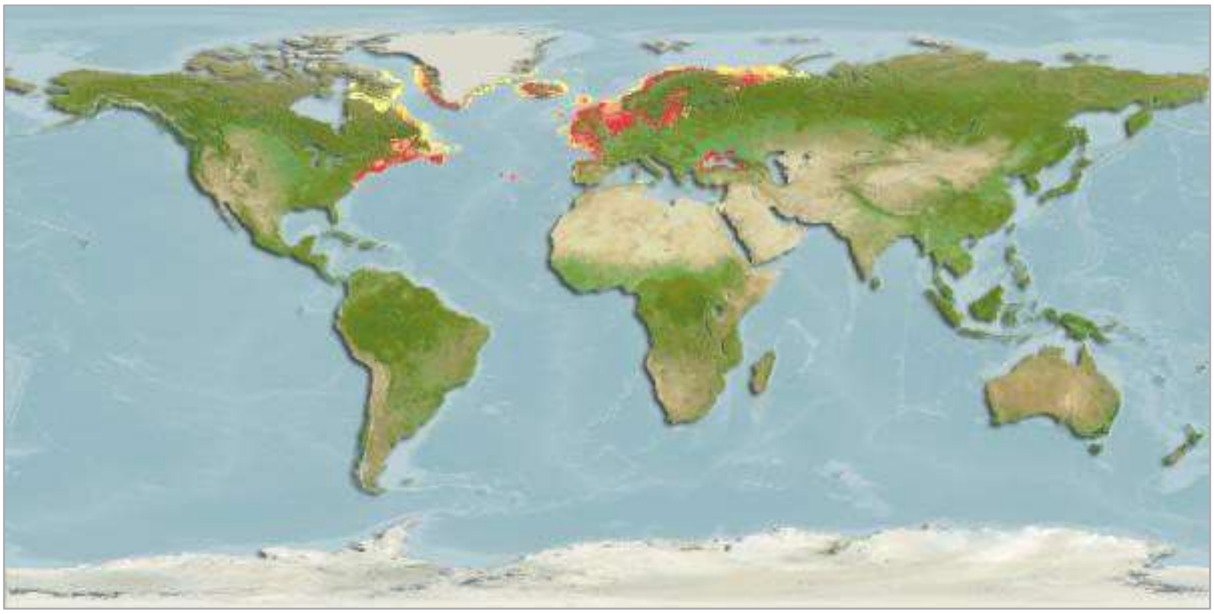


FIGURE 14: NATURAL DISTRIBUTION OF ATLANTIC SALMON (SOURCE: AQUAMAPS, 2013).

Atlantic salmon have a complex life cycle and life-history styles may be highly variable among regions, rivers, and within populations (Hutchings & Jones, 1998; Klemetsen *et al*., 2003). The majority of Atlantic salmon are anadromous – fish that spend 1-8 years in their natal river (longer durations at higher latitudes), migrate to the ocean as smolts where they may spend 1-7 years, and subsequently return to their natal river to spawn (Hutchings & Jones, 1998; FAO, 2004; ICES, 2009; ICES, 2011). Some Atlantic salmon individuals do not exhibit anadromy; these fish mature and spawn without ever migrating to the sea (NASCO, 2011). Landlocked populations of Atlantic salmon also complete their entire life cycle in freshwater (Helfman *et al*., 2009).

Anadromous fish undertake spawning migrations from June-November when sexually mature fish (average age-at-maturity 4-6 years; length-at-maturity 70-100cm) move upstream to gravel spawning beds that are highly oxygenated with moderate to strong currents (Hutchings & Jones, 1998). Females dig several depressions (redds) in the gravel and deposit eggs into these depressions, after which they are fertilised and guarded by the males. Spawning is completed in 1-2 weeks (FAO, 2004). Most males die after spawning whereas 10-40% of females may survive and return to the sea as "kelts" after spawning. Some females may overwinter in their natal river after spawning, feed in summer, and return to the sea the following autumn (Bley & Moring, 1988).

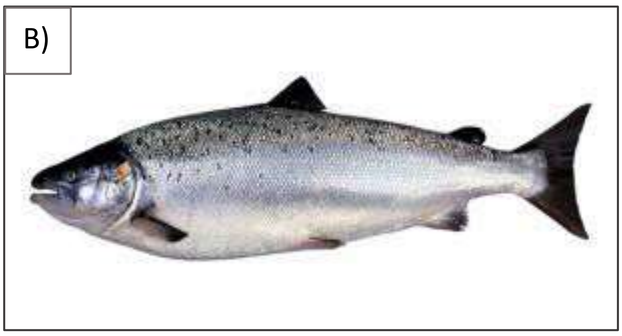


FIGURE 15: A) AN ATLANTIC SALMON ON ITS SPAWNING RUN IN ICELAND (SOURCE: RTE, 2016); AND B) FARMED ATLANTIC SALMON (SOURCE: NORWEGIAN MINISTRY OF TRADE, INDUSTRY AND FISHERIES, 2016).

Only 0.5 - 6% of these females spawn a second time and very few spawn a third or fourth time (Shelton, 1986; Mills, 1989). Eggs hatch in spring after a period of 70-160 days; the high variability in hatching time is associated with latitudinal differences in temperature, with eggs hatching faster at lower latitudes (Solomon & Lightfoot, 2008). The newly-hatched alevins move into the gravel substrate and remain there for approximately 1 month, relying on their yolk sacs for nutrition before emerging to occupy shallow riffles downstream of their redd (FAO, 2004). Parr (juveniles) may remain in freshwater for 1-6 years, depending on temperature and feeding conditions, but most stay for 2-3 years feeding primarily on aquatic insects (Stefansson *et al*., 2008). Before migrating downstream towards coastal waters, juveniles undergo both morphological and physiological changes in a process known as *smoltification* which prepares them for life in the sea (Folmar & Dickhoff, 1980; Stefansson *et al*., 2008). Between March-June, the smolts migrate toward estuaries and eventually the open ocean (FAO, 2004).

At sea, Atlantic salmon eat a variety of marine organisms including crustaceans such as euphausiids, amphipods and decapods, and fishes including sand lance, smelt, alewives, herring, capelin, small mackerel and small cod (Scott & Crossman, 1973). Feeding ceases when sexually mature fish begin their journey up rivers (Johansen *et al.,* 2011). Growth is generally slow during the freshwater phase of the life cycle and rapid once fish enter the sea; i.e. fish are approximately 10-20cm in length when beginning their migration from freshwater to the sea and reach a size of approximately 50 - 70cm after 1 year at sea (Hutchings & Jones, 1998). Growth rate, as denoted by the Brody growth coefficient *K*, has been estimated to range from 0.13 - 0.76, with faster growth being recorded in wild populations from mainland Europe (Froese & Pauly, 2016).

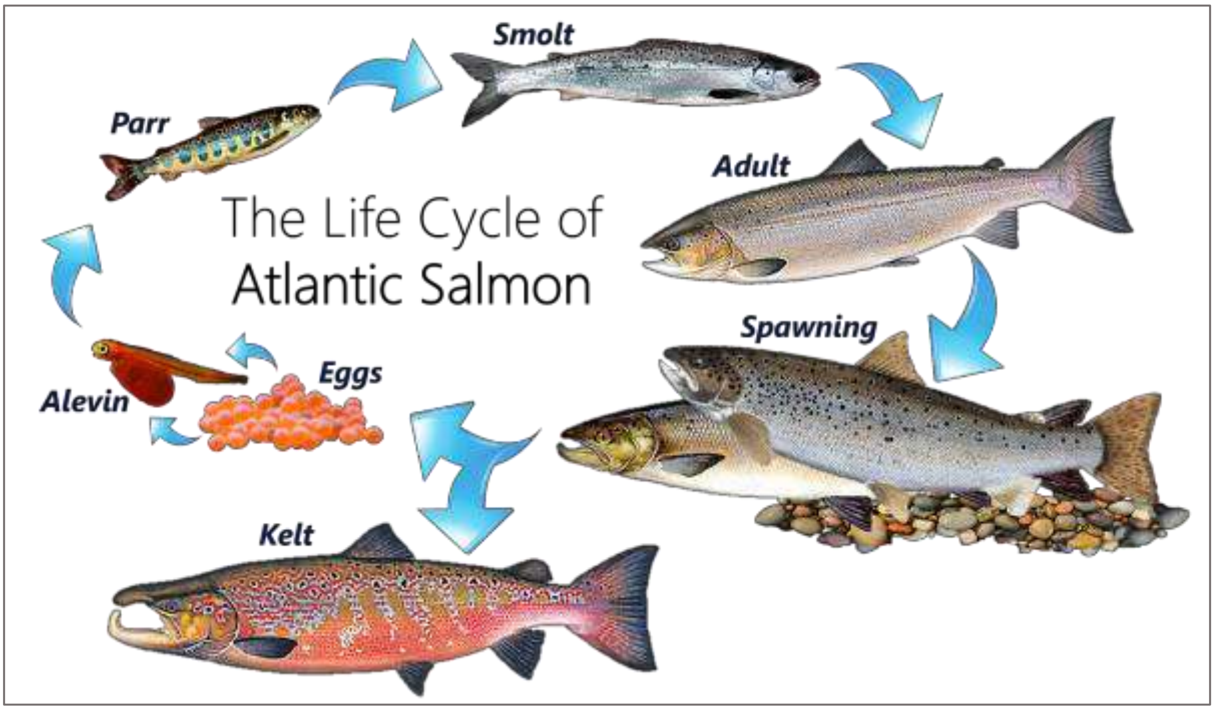


FIGURE 16: THE LIFE CYCLE OF ATLANTIC SALMON.

Sexual maturity is attained between 3 - 7 years of age (2.5 – 9kg) and after 1-4 years at sea (Froese & Pauly, 2016; Scott & Crossman, 1973). Atlantic salmon may attain maximum length of 150cm, a weight of approximately 46kg, and a maximum reported age of 13 years (Froese & Pauly, 2016).

4.2.2. Fisheries

Due to its large size, palatability, food value, as well as the diversity of habitats it occupies (freshwater rivers, estuaries, and coastal waters); Atlantic salmon has been targeted by fisheries for over 1000 years (Chase, 2003). Up until the 1990s, Atlantic salmon was the target of significant commercial fisheries in Europe, the USA and Canada where it was second in value to cod (Chase, 2003). A combination of overfishing, habitat alteration (dam building) and destruction, pollution, and poaching, led to "precipitous declines" in wild salmon populations and the closure of the US and Canadian Atlantic salmon fisheries in the late 20th century (Chase, 2003). Currently, commercial fisheries for Atlantic salmon are operational in Greenland and the Faroe Islands, with a small number in EU member states (Potter *et al*., 2004). Their contribution to global Atlantic salmon production has declined significantly (Figure 17) such that almost all commercially available Atlantic salmon is now farmed (Marine Harvest, 2015).

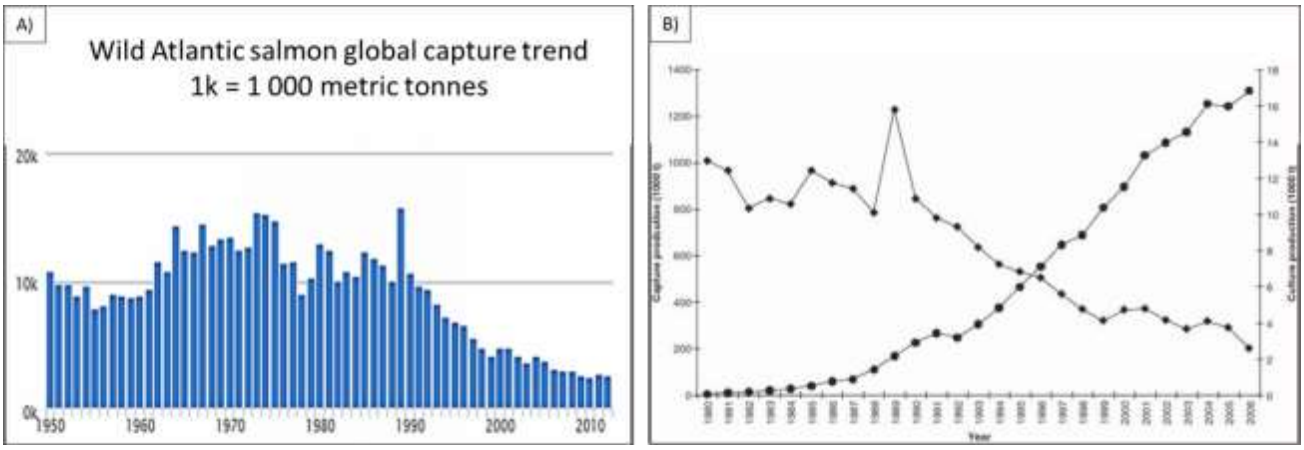


FIGURE 17: CONTRASTING TRENDS IN WILD-CAPTURE AND AQUACULTURE PRODUCTION FOR ATLANTIC SALMON (SOURCE: A- SEAFISH, 2015; B - SOLAR, 2009).

4.2.3. Atlantic salmon farming technology

Brief historical outline

Aquaculture of Atlantic salmon began in the 19th century in the United Kingdom with the production and stocking of parr (juveniles) to enhance recreational angling opportunities (FAO, 2004). However, it was only in the late 1960's and 1970's that commercial aquaculture using sea cages was pioneered and later established in Norway (Beveridge, 2004; Tacon & Halwart, 2007), leading to the development of salmon aquaculture in Scotland, Ireland, the Faroe Islands, Canada, the Northeast seaboard of the USA, Chile and Australia, with minor production in New Zealand, France, and Spain (FAO, 2004). Currently, aquaculture production of Atlantic salmon constitutes >70% of all global salmon production (wild caught and farmed) (Seafish, 2015).

TABLE 10: POSITIVE AND NEGATIVE ATTRIBUTES OF ATLANTIC SALMON FOR AQUACULTURE

Positive attributes	**Comment**
Broodstock	Easy to acquire, adapt well to captivity
Spawning	Protocols have been developed for successful breeding of the species
Eggs	Commercially available from producers on the global market
Larval rearing	No larval rearing stage
Growth	Growth is rapid. The species matures at around 2-4 years
Feeding	Atlantic salmon readily accept pelleted feeds
Technology	Proven successful technology for land-based and offshore-based culture has been developed
Market	Established market with opportunities for growth
Negative attributes	**Comment**
Diseases and parasites	Prone to sea louse infection
Environmental requirements	High water quality (e.g. optimum dissolved oxygen >7mgL; minimal turbidity <25NTU)
Environmental concerns	Increasing concern over environmental impacts of offshore open-net cage culture

Salmon farming in South Africa

There is very little information on the history of Atlantic salmon introductions and its aquaculture in South Africa. Anecdotal records suggest the first introduction took place in 1892 when hatchery-raised fry were stocked into the Umkomaas River, Kwazulu-Natal, in a failed attempt to establish a breeding population in Africa (Newton, 2013). Unlike rainbow trout *Oncorhynchus mykiss* and brown trout *Salmo trutta*, which have managed to establish wild breeding populations, there are no self-sustaining wild populations of Atlantic salmon in South Africa (Skelton, 2013). This may be related to adverse environmental conditions in the lower reaches of South African rivers which may be polluted and/or have undergone habitat alteration and degradation, which would inhibit anadromous behaviour.

In 2001, Salmon Salar Sea Farming (Pty) Ltd. drafted a proposal to develop a pilot project to farm Atlantic salmon in cages at Gansbaai in the Western Cape (Doug Jeffery Environmental Consultants, 2001; Hutchings *et al*., 2011). Despite vociferous opposition from environmental groups (Scholl & Pade, 2005), the pilot project went ahead. Eggs were imported from Norway, hatched and grown out to smolt size in a land-based freshwater facility in the Western Cape, and transferred to grow-out cages in Gansbaai. The project failed when the cages sunk in strong seas due to high biofouling and a resultant vulnerability to storm waves (Hutchings *et al*., 2011).

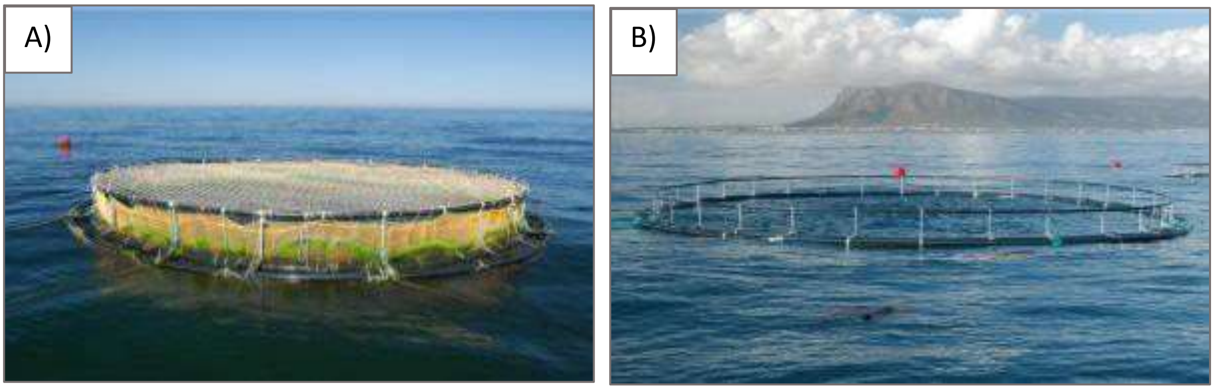
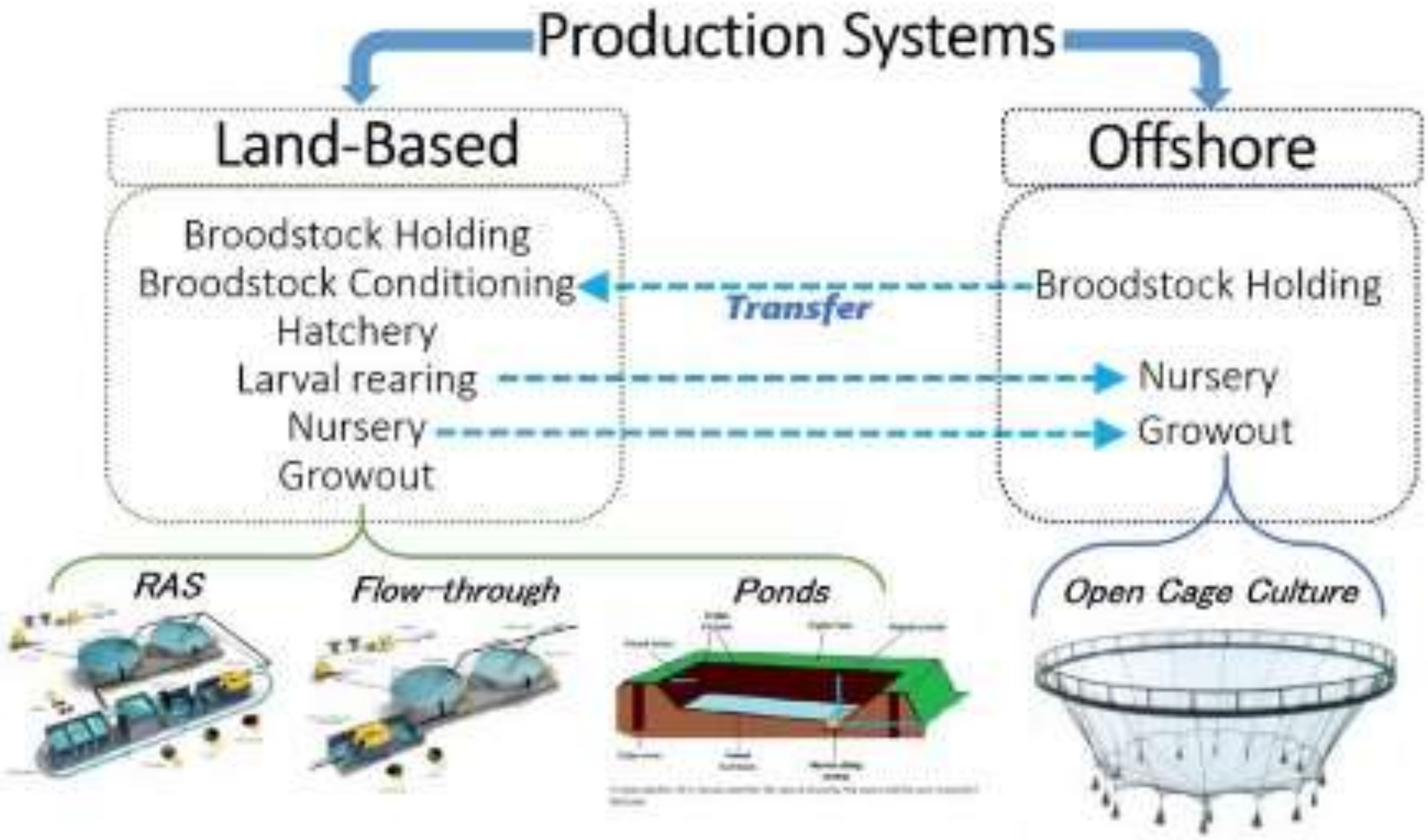


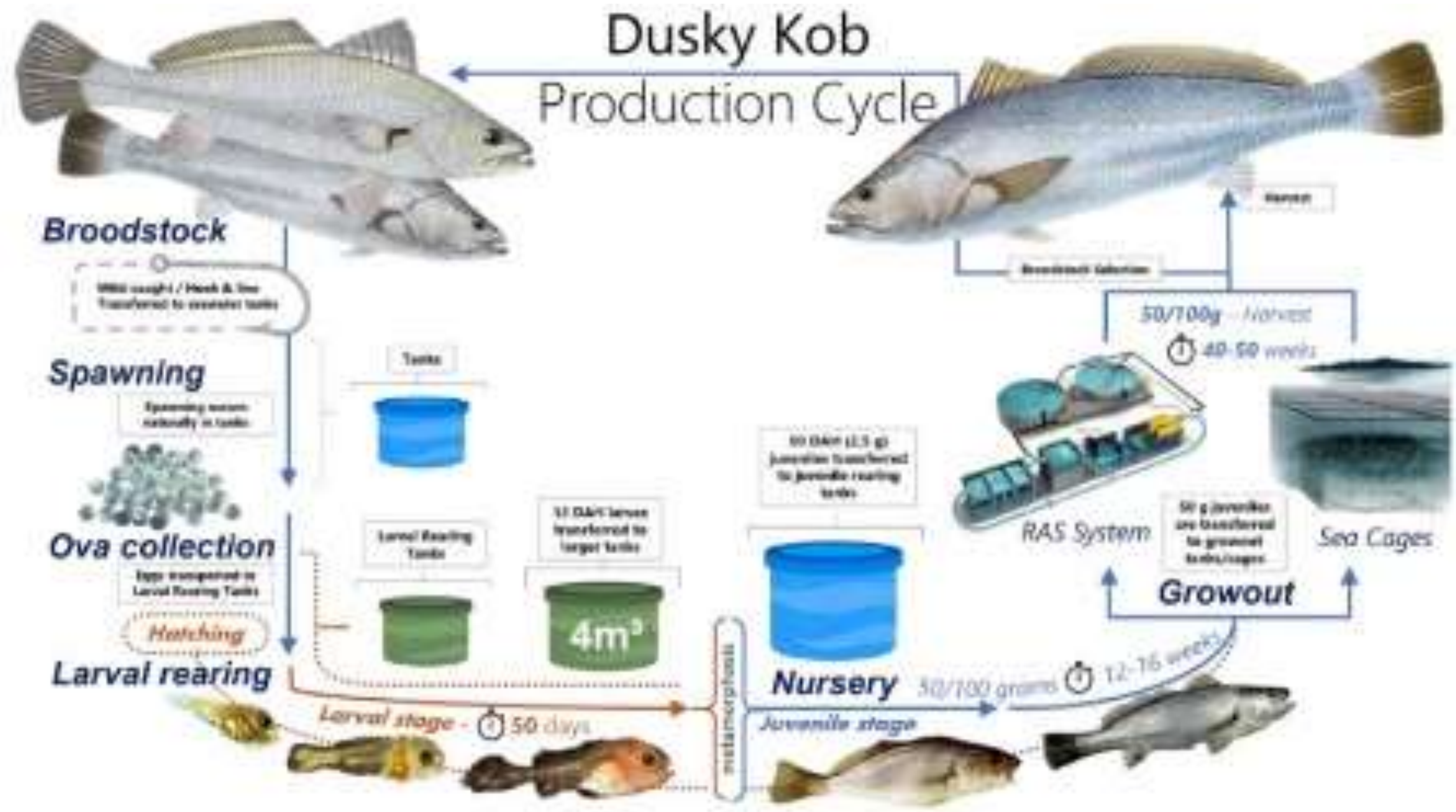
FIGURE 18: ATLANTIC SALMON CAGES LOCATED IN GANSBAAI. THESE CAGES SUBSEQUENTLY SUNK DUE TO STORM WAVES AND EXCESSIVE BIOFOULING (SOURCE: SCHOLL & PADE, 2005).

Southern Atlantic Sea Farms, a subsidiary of Three Streams Holdings (Pty) Ltd., is a research and development company which aimed to establish Atlantic salmon farming in the Saldanha Bay area (Scansa Trade, 2016). The company began a pilot project in June 2014 to grow out smolts of 200g in two marine cages in Saldanha Bay. The smolts were raised in the Three Streams Holdings (Pty) Ltd. hatchery in Franschoek, Western Cape, before being stocked into the cages. After a period of 7 months, the fish were harvested early due to a low oxygen event resulting from upwelling activity. The fish were approximately 1kg in size and the total harvest was 15 tons. Due to adverse environmental conditions, particularly low oxygen levels at certain times of the year, the company decided to terminate the pilot project in 2015. Further plans for Atlantic salmon production are currently on hold. The rest of the smolts were sold to Viking Aquaculture who are currently holding them in an abalone facility (Krijn Resoort, Personal Communication, June 2016).


Production Systems
Land-Based
Offshore
Broodstock Holding
Broodstock Conditioning
Hatchery
Larval rearing
Nursery
Growout
Transfer
Broodstock Holding
Nursery
Growout
RAS
Flow-through
Ponds
Open Cage Culture

Production cycle

The production cycle of dusky kob is shown in Figure 8.



Land-based production may involve:

1. The holding and conditioning of broodstock for spawning and egg production
2. Egg incubation and hatching
3. On-growing of alevins to first-feeding fry
4. On-growing of fry to parr and, finally, to smolts
5. Grow-out of smolts to harvest size.

Almost all smolt production in Northern Europe is practiced in land-based hatcheries and nurseries, although Scotland still uses cages in freshwater lakes to produce 40% of its smolts (Bergheim *et al*., 2009). Land-based production facilities usually operate on single-pass flow-through water supply systems although there is increasing use of partial or complete RAS (Bergheim *et al*., 2009; Martins *et al*., 2010).

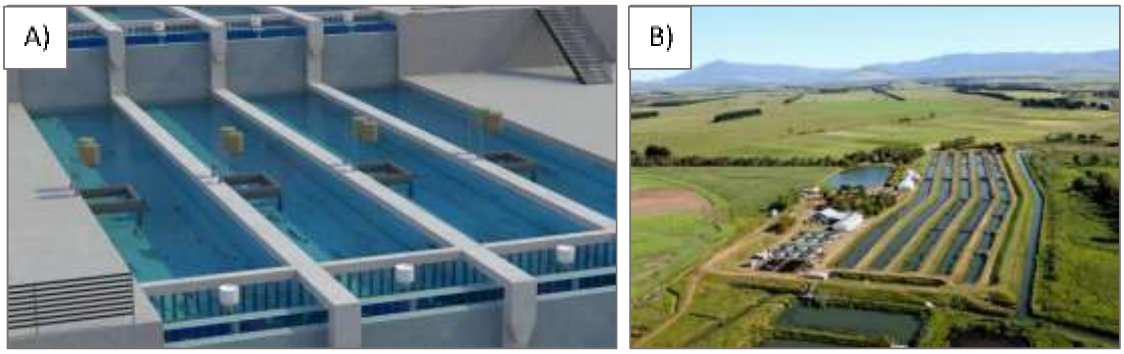


FIGURE 20: A) A CONCEPTUAL RACEWAY PRODUCTION SYSTEM OPERATED USING FLOW-THROUGH TECHNOLOGY (SOURCE: SEAFOOD WATCH, 2016); AND B) A FLOW-THROUGH ATLANTIC SALMON FARM IN TASMANIA, AUSTRALIA (SOURCE: PETUNA SEAFOODS, 2016).

Offshore-based production involves:

1. The grow-out of smolts to harvest size in cages and, less commonly, solid wall grow-out systems.

At present, the majority of commercial salmon farming is based on offshore open-net cage culture grow-out of smolts that are produced in land-based facilities (FAO, 2004; Bergheim *et al*., 2009; Marine Harvest, 2015). More recently, and in response to decreased availability of suitable offshore cage sites and increasing pressure from environmental groups and the general public, there has been increased interest in moving towards land-based grow-out operations as well as offshore solid wall grow-out systems (Figure 21). Currently, these "closed containment" technologies are still associated with higher capital investment and operating costs, and greater risk, than "traditional" open net cage culture grow-out practices (Forster & Slaski, 2008).

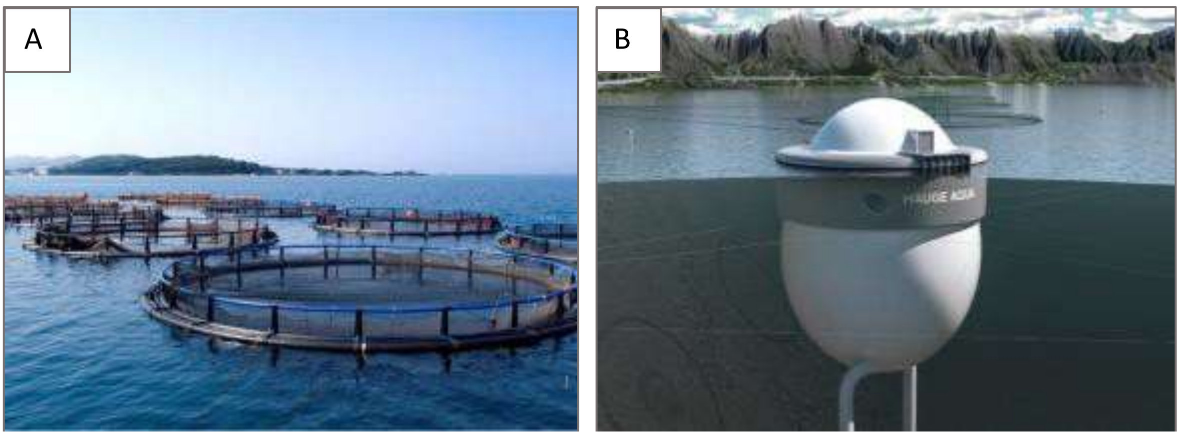


FIGURE 21: OFFSHORE-BASED ATLANTIC SALMON PRODUCTION SYSTEMS: A) OPEN-NET PEN CAGES (SOURCE: FAO, 2004); AND B) CLOSED CONTAINMENT "EGG" PRODUCTION SYSTEM (SOURCE: INTRAFISH, 2016).

Production cycle

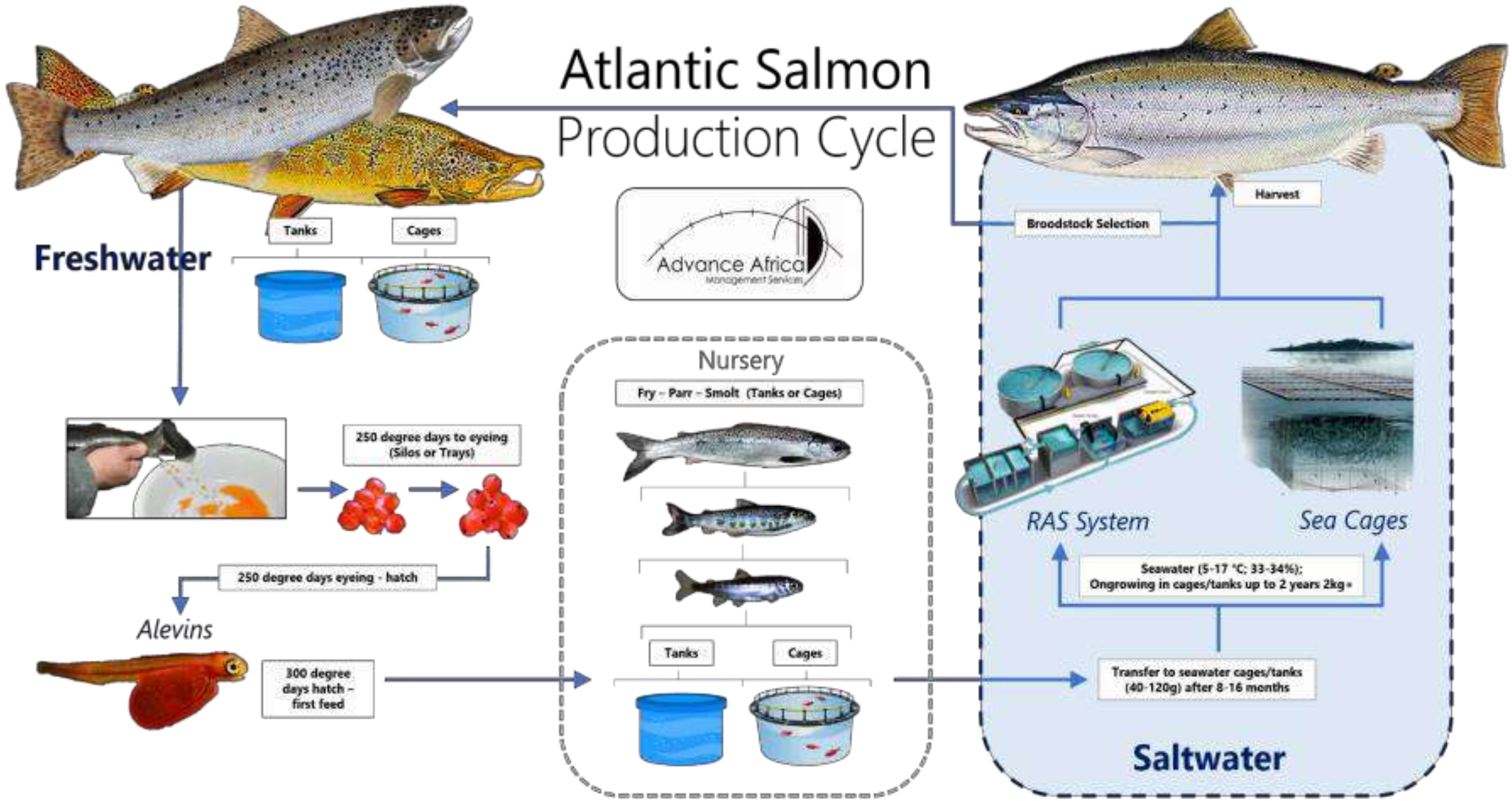


FIGURE 22: ATLANTIC SALMON PRODUCTION CYCLE.

Broodstock capture, conditioning and spawning

Broodstock are typically selected from existing stock held in offshore grow-out cages, land-based tanks, (FAO, 2004; Marine Harvest, 2015) or, less commonly and mostly for stock enhancement or breeding programmes, from fish captured while migrating upstream to spawning grounds (Anderson, 1987; Kincaid & Stanley, 1989). Broodstock are moved into freshwater tanks or raceways in autumn, approximately 2 months prior to stripping (FAO, 2004). Tanks and raceways may range from 40-300m^3 and are operated on a flow-through or recirculating (RAS) basis (Wolters *et al.*, 2009). During late autumn, eggs are stripped from mature females into plastic or metal mixing bowls and mixed thoroughly and quickly using a clean hand with sperm stripped from males (Stead & Laird, 2002). The fertilised eggs are then washed using clean fresh water and either transferred directly to an incubator or placed in a bucket of clean water for water hardening (Stead & Laird, 2002).

FIGURE 23: A) BROODSTOCK HOLDING TANK (SOURCE: HOLYOKE, 2015); B) LARGE MALE ATLANTIC SALMON BROODSTOCK AT A BROODSTOCK FACILITY (SOURCE: SALMON FISHING FORUM, 2013); C) EGGS BEING STRIPPED FROM A GRAVID FEMALE (SOURCE: LATTI, 2010); D) EGGS ARE FERTILISED BY STRIPPING MILT FROM MATURE MALES (SOURCE: LATTI, 2010).

After water hardening, the eggs are disinfected using a solution of 90g sodium chloride and 100ml Buffodine in 10L of water and transferred to an incubator (Stead & Laird, 2002). Incubators vary but most commercial operations use vertical incubator trays (Figure 24). Eggs are usually incubated at temperatures of < 10° C (FAO, 2004).

FIGURE 24: A) ATLANTIC SALMON EGG SILOS USED FOR INCUBATION (SOURCE: STEAD & LAIRD, 2002); AND B) VERTICAL INCUBATOR TRAYS (SOURCE: AUBURN UNIVERSITY, 2013).

Some farms do not house their own broodstock nor produce their own eggs. Instead, eggs are imported from commercial egg producers who specialise in the large-scale production of eggs for distribution on global markets. Examples of commercial egg producers include Aquagen in Norway (www.aquagen.no) and TroutLodge in the USA (www.troutlodge.com). These eggs are then incubated and hatched after arrival at the farm.

Hatchings and first feeding

After a period of 2-3 months, hatching takes place in hatchery trays or following transfer to alevin tanks (Jobling *et al*., 2010) (Figure 25). These tanks are usually circular, vary in size (0.5 – 6m diameter), provided with a matting or stony "substrate" to mimic the natural gravel, and maintained in darkened conditions and low water levels (10-30cm) (Jobling *et al*., 2010; Lucas & Southgate, 2012). Following yolk sac absorption, alevins will "swim up" in the water column, indicating readiness to first feed. First-feeding is then carried out using inert feeds that are available from commercial feed producers (e.g. Skretting). Successful first-feeding depends on strictly controlled environmental conditions including continuous light exposure (<50 lux), constant flow patterns, pH levels between 6 and 7, and water temperatures between 12-15 °C (if possible) (Lucas & Southgate, 2012). During this period, tanks must also be cleaned regularly to ensure adequate hygiene and waste removal (Lucas & Southgate, 2012). At first, fish do not actively seek feed and instead rely on water flow to bring feed particles towards them. After a few days, fish will begin to actively feed at which stage water levels in the tanks are raised. At the completion of the first-feeding stage, the juveniles or "fry" have attained a body weight of approximately 0.2g. Depending on the size of the tanks, fry may be grown-on into smolts in the same tank or will have to be transferred to larger tanks (Jobling *et al*., 2010; Lucas & Southgate, 2012). "Feeding fry" can be grown on in tanks, either using flow-through or various recirculation systems, or subsequently in lake cage systems, through parr stages to smolt (FAO, 2004).

Figure 25: A) Atlantic salmon alevin with yolk sac (source: Wageningen University, 2014); and B) Alevin tank with stony substrate and low water levels (source: Kronbauer, 2016).

Parr and smoltification

Once the fry have reached a weight of 2-3g, they develop characteristic dark markings on their flanks and are thereafter referred to as "parr" (Jobling *et al.*, 2010). Parr are held under conditions of continuous light (24L: 0D) until a body weight of approximately 8g when a shorter day length is introduced in order to induce smoltification (Jobling *et al.*, 2010). During this period, parr are provided with sufficient feed and current is maintained to prevent aggressive behaviour. Fish are regularly size-graded and transferred to new tanks throughout the on-growing process to improve growth and reduce aggressive behaviour (Jobling *et al.*, 2010). Stocking densities during this production phase are usually maintained at approximately 20-60kg/m^3, although they can be as high as 100kg/m^3 in RAS (Martins *et al.*, 2010; Jobling *et al.*, 2010).

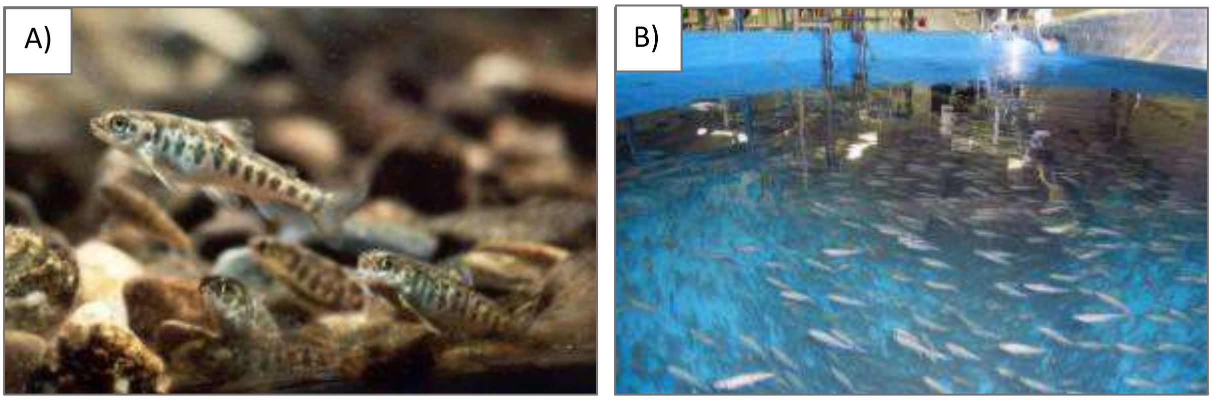


Figure 26: A) Atlantic salmon parr (source: Scanlan *et al.*, 2015); and B) Atlantic salmon parr in a RAS (source: Marine Harvest, 2016).

Parr will eventually undergo parr-smolt transformation, a complex process that occurs over several months (FAO, 2004; Lucas & Southgate, 2012). This occurs in large tanks (100-500m^3) operated on a flow-through system, partial reuse system or, increasingly in new smolt production facilities, RAS (Dalsgaard *et al*, 2013).

In the wild, smoltification takes approximately 16 months at which age fish are approximately 70-140g. In hatcheries, smolt production traditionally involved the rearing of smolts for at least one year after hatching (S1 smolts) and their subsequent release into grow-out cages in the spring (Lysfjord *et al.*, 2004). However, in the 1990's, photoperiod control techniques were perfected such that smolts could be produced in six-eight months (S0 smolts). S0 smolts reduce rearing time and inputs such as freshwater supply and labour, and bring forward the stocking time from spring to autumn allowing for production of market size fish throughout the year (Lysfjord *et al.*, 2004; Goncalves *et al.*, 2013). Photoperiodic regulation of smoltification is achieved by enforcing a “winter-reduction” and “spring-increase” light regime (Bromage *et al.*, 1984). Therefore, in hatcheries under controlled conditions, fish may reach the smolt stage within one year at a size of 50-80g (FAO, 2004; Asche & Bjorndal, 2011) at which stage they are ready to be transferred to the grow-out facilities as S0 smolts. The production of S0 smolts is particularly beneficial in areas where seawater temperatures remain favourable for growth during winter, as is the case in South Africa.

Offshore grow-out

Sea cages

Commercial-scale Atlantic salmon farming entails the transfer of smolts to sea cages for grow-out. The grow-out process lasts approximately 18-24 months (FAO, 2004; Marine Harvest, 2015). Prior to transfer, fish may undergo seawater challenge tests (Pennell & Barton, 1996). If deemed ready for seawater grow-out, smolts are transferred to cage sites using specialised well-boats equipped with wells that circulate seawater (FAO, 2004). The grow-out cages are either square or circular in design and come in a variety of sizes (up to 100m in diameter and 15-18m deep). Cages are arranged in groups that constitute a site (FAO, 2004). Sea sites are selected based on their suitability with regard to water temperature, salinity, flow and exchange rates, proximity to other farms and/or wild fisheries, and in compliance with local licensing regulations (FAO, 2004). Cage culture requirements for Atlantic salmon are shown in Table 11**.**

TABLE 11: PHYSICAL AND ENVIRONMENTAL REQUIREMENTS FOR CAGE CULTURE OF ATLANTIC SALMON (SOURCE: DANIEL, 2011).

Parameter	Salmon culture requirement
Exposure to waves	Minimal wave action
Current speed	> 10 cm/s
Water depth	Dependant on cage depth (> 15m)
Substrate	Firm. Minimal mud
Turbidity	< 10mg/L
Temperature	12-16°C optimal
Upwelling	Not ideal
Dissolved oxygen	>7.0 mg/ L (min 5 mg/L)
Salinity	33-35 ppt
pH	7.5-8.5
Lead	< 0.5 ppm
Cadmium	< 3 ppm
Hydrocarbons	None
Fouling	Minimal
Phytoplankton	Minimal
E-coli	< 20 cells/ ml
Predators	Minimal

Stocking densities are maintained at approximately 15-20kg/m^3 and fish are graded to ensure some uniformity of size, better growth and FCR’s, and to reduce aggressive behaviour (Woo *et al.*, 2002). Fish are generally harvested from 2kg upwards and before they become sexually mature (with the exception of broodstock) (FAO, 2004).

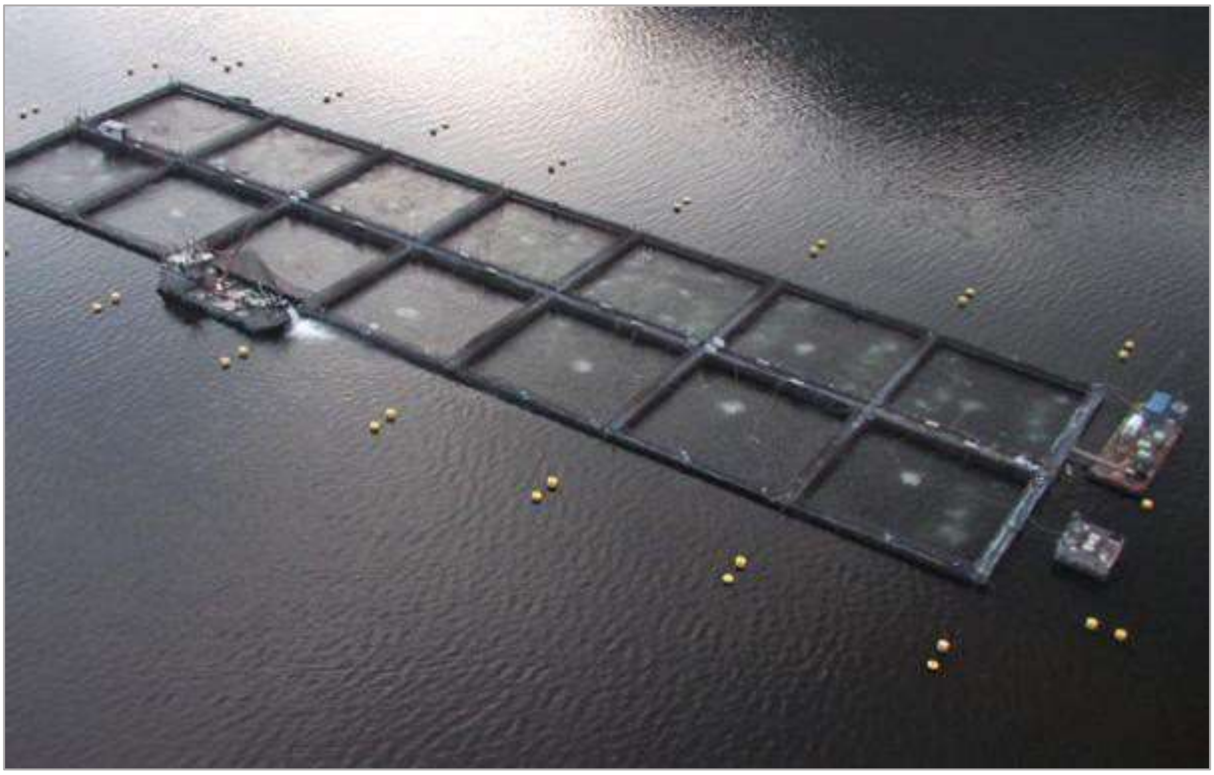


FIGURE 27: ATLANTIC SALMON CAGE FARMING OPERATION IN NORWAY (SOURCE: REID, 2013).

Land-based grow-out

RAS

Grow-out of Atlantic salmon in land-based RAS systems is a relatively new method in the salmon industry that arose out of the desire to minimise water consumption, optimise production through greater control of rearing conditions such that multiple batches of salmon could be produced throughout the year (Dalsgaard *et al*., 2013), and to reduce environmental impacts (real or perceived) associated with more traditional cage culture operations (Milewski, 2001).

All production is carried out on land. Smolts are transferred to large grow-out tanks (100-3000m^3) where they are held under strictly controlled temperature (optimum 15°C), dissolved oxygen (10mg/L), and flow conditions. Stocking densities in RAS systems vary from 50kg-100kg/m^3, far more than that of offshore-based cage culture operations. Salmon are harvested after approximately 15 months at approximately 4.5-5.5 kg (Dekhtyarev, 2014). Environmental parameters maintained during the RAS grow-out phase are shown in Table 12.

TABLE 12: WATER QUALITY PARAMETERS MAINTAINED IN GROW-OUT OF ATLANTIC SALMON IN RAS.

Parameter	RAS operating conditions
Temperature (°C)	15° C
Dissolved oxygen (mg/L)	10
Carbon dioxide (mg/L)	9
TAN (mg/L)	0.14-0.2
Nitrite (mg/L)	0.02-0.05
Nitrate (mg/L)	7-38
Alkalinity (mg/L)	250
pH	7.5-7.7

Parameter	RAS operating conditions
Chloride (mg/L)	18-23
Total suspended solids (mg/L)	2.4-3.3
Biochemical oxygen demand (BOD)	1.4-2.1
Heterotrophic bacteria (cfu/mL)	381-750
Color (Pt-Co units)	5-24
UV Transmittance (%)	77-94
ORP (mV)	221-274
Copper (mg/L)	0.002-0.009
Potassium (mg/L)	2.4-4.5
Zinc (mg/L)	0.038-0.052
Conductivity (µS/cm)	604-899

In some experimental facilities, the entire production cycle has been completed in freshwater, eliminating the need for seawater at any stage (Summerfelt *et al*., 2012). Land-based grow-out of Atlantic salmon in partial reuse or RAS systems is still very much in its infancy (Warrer-Hansen, 2015), although experimental results do look promising (Liu *et al*., 2016).

FIGURE 28: A LAND-BASED RAS FOR ATLANTIC SALMON GROW-OUT (SOURCE: AQUABOUNTY, 2016).

Food and feeding

Atlantic salmon feeds are readily available and produced by a few large companies (FAO, 2004). Salmon feeds are classified as:

1. Freshwater – starter; grower; smolt transfer,
2. Seawater grower, and
3. Broodstock.

Protein content in the feeds is highest in the freshwater phase of the life cycle (45-54%), with lipid content being between 16-24%. Conversely, lipid content in feeds for grow-out is high (30-40%) with protein constituting between 36-42% of the feed (FAO, 2016). Smolt transfer feeds, containing betaine, amino acids, nucleotides and other supplements, are used prior to transfer in freshwater to improve the osmotic adaptation of smolts to seawater for better survival (Skretting, 2016).

Feeding at the alevin stage is initially frequent (8 - 12 times a day) and decreases as fish grow into the parr-fingerling stage (3 - 4 times a day) (FAO, 2016). Feeding during the grow-out phase typically occurs in the early morning and in the evening and is carried out either by hand or by automated feeders equipped with video monitoring systems (FAO, 2016).

4.2.4. Environmental impacts

The rapid development of offshore-based salmon aquaculture "has been accompanied by a growing and vociferous host of criticisms, largely related to the potential impacts of intensive net pens on local ecosystems" (Pelletier & Tyedmers, 2007; Colt *et al*., 2008). Environmental risks from offshore cage culture include impacts on water quality, benthic effects, impacts on marine life, the introduction of chemicals from aquacultural activity (Price & Morris Jr, 2013) and the biodiversity risk from the introduction and establishment of wild populations in areas where they are non-native. The impacts are briefly discussed below:

- ***Water quality***

Potential effects include increased levels of dissolved nitrogen and phosphorus, increased turbidity, accumulation of lipids, as well as fluctuating dissolved oxygen levels. In well-flushed areas, measurable effects from aquaculture are usually only recorded within 30 metres of the cages (Price & Morris Jr, 2013).

- ***Benthic effects and impacts on marine life***

Impacts on benthic sediments include alteration of chemical processes such as nutrient assimilation and decomposition from accumulation of excess discharged wastes from fish and feed (Wang *et al*., 2012). Accumulated organic matter can push the benthos in an area into an anaerobic state and these conditions may extend hundreds of metres beyond the farm perimeter and remediation of the altered benthos may take several years (Price & Morris Jr, 2013). Impacts can be mitigated by locating farms in deep, well-flushed areas, setting aside areas and periods for fallowing, and implementing sediment monitoring programmes (Price & Morris Jr, 2013). Sediments that become enriched with organic farm waste nutrients result in changes in the benthic invertebrate community with increased species diversity and abundance observed in enriched areas (Wang *et al*., 2012). Excess feed and faecal matter may attract other organisms, particularly benthic feeders (Olsen & Olsen, 2008) and wild fishes which in turn may attract large predatory animals such as sharks and seals (Price & Morris Jr, 2013).

- ***Eutrophication***

Impacts are primarily related to excess nutrients discharged to the aquatic environment from aquaculture operations. Excess nutrients which cannot be assimilated may result in eutrophication although direct causal links to algal blooms may be difficult to confirm given the natural variability associated with algal bloom events as well as other anthropogenically-derived nutrient inputs present in coastal waters e.g. from industrial activity (Price & Morris Jr, 2013).

➢ ***Introduction of chemicals***

Secondary harmful effects have been documented from the introduction of antibiotics (Beveridge, 2004; Halwart *et al*., 2007), therapeutants (Pittenger *et al*., 2007), and antifoulants (Burridge *et al*., 2010) into the environment. Potential impacts from antibiotics include increased disease resistance in fish pathogens (Armstrong *et al*., 2005), toxic effects on marine phytoplankton (Halling-Sorensen *et al*., 1998), and assimilation of antibiotics in wild fish from ingestion of feed and faecal matter (Armstrong *et al*., 2005). Administering therapeutic chemicals may result in direct mortality, increasingly resistant strains of pathogens, and accumulation of these chemicals in the sediments (Burridge *et al*., 2010). Antifouling treatments that incorporate tin compounds have toxic effects on both fishes and mollusks (Meng *et al*., 2005; Dimitriou *et al*., 2003).

➢ ***Biodiversity risks***

In Norway, Ireland, eastern North America, the United Kingdom, farmed Atlantic salmon have escaped and established successful breeding populations (Hansen *et al*., 1999). Potential impacts in these areas, where wild populations of salmon occur, include genetic pollution and associated fitness effects (Hindar *et al*., 1991). In areas where salmon are non-native e.g. Tasmania, escaped Atlantic salmon have been shown to have poor colonisation ability, lose condition rapidly after escaping from cages, and do not predate upon native fauna (Abrantes *et al*., 2011). In a region such as South Africa, these impacts are likely to be similar and therefore also negligible.

Environmental organisations have suggested the replacement of cages with either offshore solid-wall closed-containment technology (Figure 28), land-based flow-through systems, partial reuse systems or RAS (Colt *et al*., 2008). Potential advantages of these systems include better isolation of the culture fish from the environment, reduced disease transmission and escapes, and the capture and treatment of fish wastes (Colt *et al*., 2008).

4.2.5. Diseases and parasites

A comprehensive summary of diseases and parasites, symptoms and treatments/measures, adapted from the FAO (2004) and Dhar *et al* (2015), is shown in Table 13.

TABLE 13: SUMMARY OF ATLANTIC SALMON DISEASES AND PARASITES (SOURCE: FAO, 2004 AND DHAR *ET AL*., 2015).

Disease	Type	Agent	Symptoms	Treatment/Measures
Infectious salmon anaemia (ISA)	Virus	Orthomyxovirus	Lethargy; loss of appetite; gasping at water surface; pale gills and heart; fluid in body cavity; dark liver; haemorrhages in internal organs	Vaccination; operational controls; increased biosecurity; bloodwater treatment
Viral	Virus	Rhabdovirus	Bulging/bleeding	No treatment; vaccines

haemorrhagic septicaemia (VHS)			eyes; pale gills; swollen abdomen; lethargy	being developed; operational controls; increased biosecurity
Infectious pancreatic necrosis (IPN)	Virus	Birnavirus	Erratic swimming; death at bottom of tank	Vaccination; operational controls; increased biosecurity; broodstock screening
Pancreatic Disease (PD)	Virus	Togavirus	Weight loss; emaciation; mortalities	Vaccination; withholding feed
Furunculosis	Bacterium	*Aeromonas salmonicida*	Inflammation of intestine; reddening of fins; boils on body; pectoral fins infected; tissues die back	Vaccination; antibiotics
Bacterial kidney disease (BKD)	Bacterium	*Renibacterium salmoninarum*	Whitish lesions in the kidney; bleeding from kidneys and liver; loss of appetite; darkish colouration	Operational controls; increased biosecurity; broodstock screening
Winter sores	Bacterium	*Moritella viscose* (multifactorial)	Ulcers	Vaccination; antibiotics
Enteric redmouth (ERM)	Bacterium	*Yersinia ruckeri*	Dark, lethargic fish; haemorrhages of mouth and gills; abdominal distension as a result of fluid accumulation; exophthalmia	Vaccination; antibiotics
Salmon Rickettsial Disease	Bacterium	*Piscirickettsia salmonis*	Mortality; anorexia; pale gills; swollen abdomen; dark, lethargic fish	Antibiotics
Saprolegniasis	Fungus	*Saprolegnia*	White/grey patches of filamentous threads on epidermis; cotton-like appearance; usually begins on head or fins	Bronopol/formalin bath
Sea lice	Ectoparasite	Different species in different regions	Reduced growth; haemorrhaging of fins and eyes; loss of scales	Paraciticides (bath – Azamethiphos; in feed – Emamectin); Thermolicer treatments (immersed in 32°C water)
Gill amoeba	Ectoparasite	*Paramoeba pemaquidensis*	Gill infestation	Freshwater baths

Tapeworms	Endoparasite	*Eubothrium* spp.; *Diphillobothrium* spp.	Reduced growth and condition factor	Fenbendazole/praziquantel in feed for *Eubothrium*
Freshwater protozoa	Ectoparasite	*Ichthyoboda*; *Trichodina*; *Ichthyophthirius*	Heavy, laboured operculum response; flashing, rubbing; lethargy; focal redness; sin cloudiness	Formalin baths
Algal/Jellyfish blooms	Various	Various	Various	Algal monitoring programmes; relocate cages; skirts
Production diseases	Various (congenital, nutritional, environmental)	Various	Various	Improved management

5. GEOGRAPHIC LOCATION AND SUITABILITY

The evaluation criteria for selecting the ideal site for an aquaculture operation relate principally to the environmental requirements of the species to be farmed and other bio-physical and economic factors that determine the practicality and the economic feasibility of a particular site. While water temperature can be completely (at a high cost) or partially controlled in land-based aquaculture systems, the selection of a site with seasonal water temperature profiles that fit the optimal thermal requirements of the candidate species is a distinct natural strategic advantage. Other factors that determine the suitability of a land-based site include water quality, proximity to water supply, the nature of the shore (rocky or sandy), proximity to heavy industry (petro-chemical, steel, shipping), proximity to large rivers and river discharge, proximity to transport infrastructure and electricity, slope, the potential impact on the terrestrial ecosystem and possible user conflict with other shore-based human activities (real estate, recreation, tourism, Marine Protected Areas (MPAs)). Factors that determine the suitability of offshore-based aquaculture systems relate primarily to water temperature, water quality, current, wave action and significant wave heights, the presence of harmful algal blooms (HABs) and, similarly to land-based systems, conflicts with other user groups.

A rapid assessment exercise was conducted to provide an overview of the key criteria and site requirements for dusky kob and Atlantic salmon aquaculture. As production is land- and/or offshore-based, key location and site requirements are detailed for both. The exercise did not allow for detailed site visits in different locations to determine their suitability. As a result, the areas selected and the maps provided are purely indicative.

5.1. Dusky kob

5.1.1. Land-based production

Possible production systems:

1. Flow-through
2. RAS
3. Ponds

Production system: Flow-through

TABLE 14: SITE SELECTION CRITERIA FOR FLOW-THROUGH AQUACULTURE OF DUSKY KOB.

Site selection parameters	Criteria
Water supply	Constant supply of high quality saltwater; adequate supply of freshwater
Water temperature	18-26.4 °C; 21-25 °C optimal
Water quality	Salinity 33-35ppm; pH 6.5-8.5
Logistics	Located close to transportation network

The following broadly-defined regions were identified as suitable for land-based, pump-ashore, flow-through production of dusky kob:

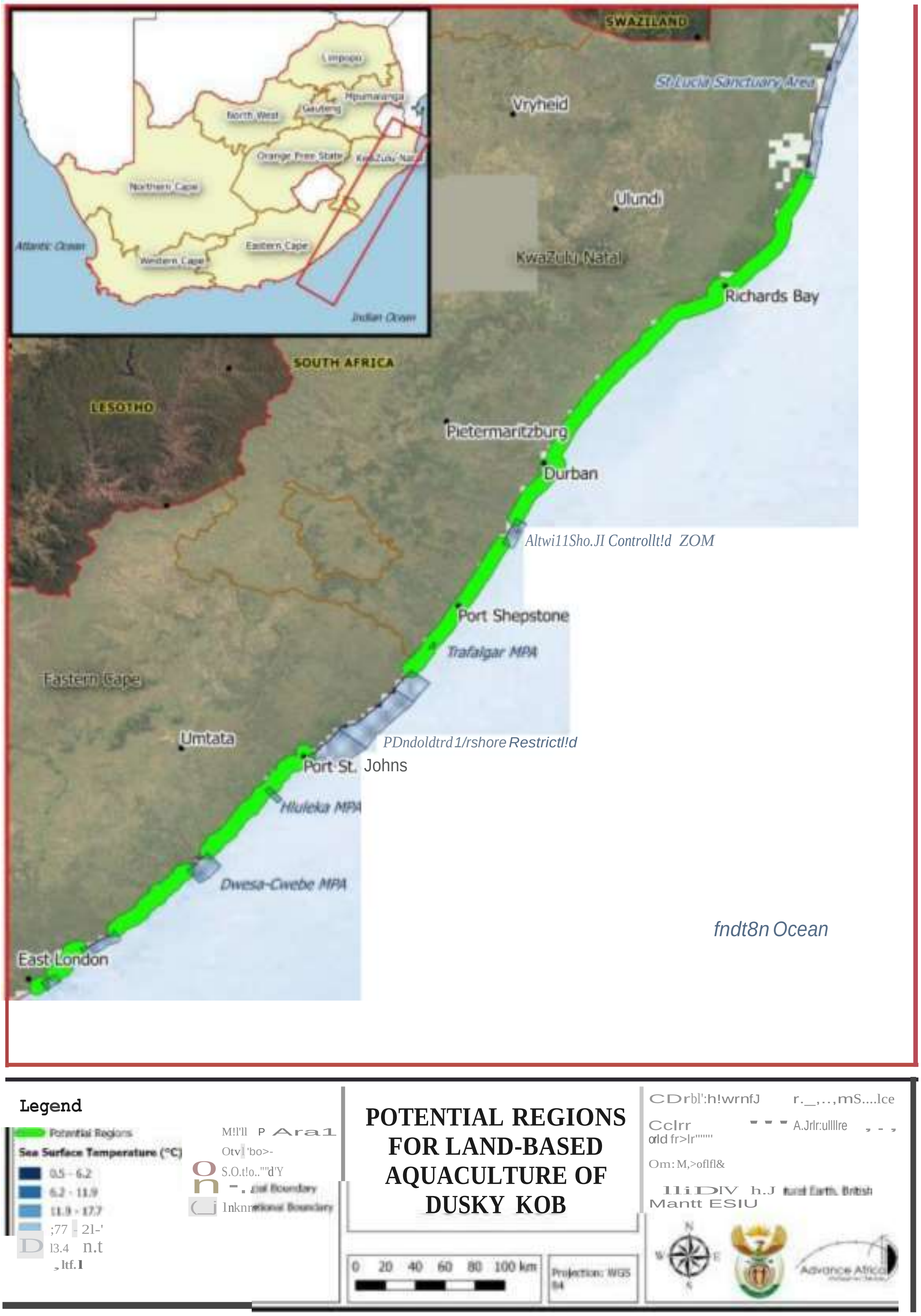


FIGURE 29: POTENTIAL REGIONS FOR LAND-BASED DUSKY KOB PRODUCTION.

As flow-through production systems rely on ambient water temperatures, areas along the coast from East London north were demarcated as broadly suitable for pump-ashore, flow-through production of dusky kob. At a more focused level, this area will be restricted by factors such as available land, head and associated pumping costs, slope, and conflicts with other user groups. MPAs have been included in the map although there is currently ongoing discussion into demarcating zones within MPAs for aquaculture activities. However, this has not been resolved for all MPAs.

Production system: RAS

TABLE 15: SITE SELECTION CRITERIA RAS AQUACULTURE OF DUSKY KOB.

Site selection parameters	Criteria
Water supply	Constant supply of high quality saltwater; adequate supply of freshwater
Water temperature	18-26.4 °C; 21-25 °C optimal
Water quality	Salinity 33-35ppm; pH 6.5-8.5
Logistics	Located close to transportation network

The water requirements for RAS farms differ to those of flow-through systems. RAS technology enables one to treat water that may be outside of environmental tolerance limits of the candidate species. However, RAS systems may still require up to 20 - 30% make-up water (water lost during the recirculation process) from the site's water source. It is therefore a natural strategic advantage to be located next to water sources that are within the environmental preference limits of dusky kob.

Based on these requirements, Figure 29 illustrates potential regions identified as suitable for RAS culture of dusky kob in South Africa.

The areas are similar to those suitable for flow-through grow-out of dusky kob. Despite the potential to heat and/or cool water for use in RAS, the associated costs are prohibitive. Therefore, potential regions shown are restricted to areas with environmental conditions that are within the preferred thermal preference limits for dusky kob.

Production system: Ponds

TABLE 16: SITE SELECTION CRITERIA FOR POND-BASED AQUACULTURE OF DUSKY KOB.

Site selection parameters	Criteria
Water supply	Supply of saline/brackish water
Water temperature	18-26.4 °C; 21-25 °C optimal
Water quality	Estuarine water – outside of areas with concentration of agriculture/industry in catchment area. Saltwater - Salinity 33-35ppm; pH 6.5-8.5
Land availability	500 ton production (15 ton/pond hectare) = 35 hectares minimum

Logistics	Located close to transportation network

Based on these requirements, Figure 29 illustrates those areas identified as potential regions for pond culture of dusky kob in South Africa. An important additional consideration for pond aquaculture, as opposed to flow-through or RAS, is the requirement for greater tracts of land to develop ponds which hold fish at far lower densities than RAS systems. A pond may produce 15-30 tonnes per hectare which, assuming a pond size of 100 x 100 x 1.5m, equates to a production of 1-2kg/m^3. This is far lower than RAS systems which may produce fish at 50kg/m^3.

5.1.2. Offshore-based production

Possible production systems:

1. Cage culture

Production system: Offshore cage culture

TABLE 17: BROAD SELECTION CRITERIA FOR OFFSHORE BASED KOB AQUACULTURE.

Site selection parameters	Criteria
Natural distribution	Exclude areas outside of dusky kob natural distribution
Mean annual water temperature	Exclude areas with average sea surface temperature <20 °C
Location and frequency of upwelling events	Exclude areas within known upwelling cells
Exposure to waves	Exclude areas with significant wave heights >3m and maximum recorded wave height >10m
Exposure to harmful algal bloom (HAB) events	Exclude areas where HABs are known to occur

Possible zones for dusky kob farming based on water temperature, upwelling cells, wave exposure, and turbidity events are shown in Figure 30.

These areas are located in Port Elizabeth and Richards Bay. Due to the dynamic nature of the majority of South Africa's coastline which is prone to high significant wave heights and severe storm events, suitable sites for cage-based aquaculture of dusky kob within thermal preference limits are restricted to sheltered areas within Algoa Bay and Richards Bay. Technology for cage aquaculture in highly exposed, offshore environments is currently being developed although this is associated with higher risk, capital and operational costs.

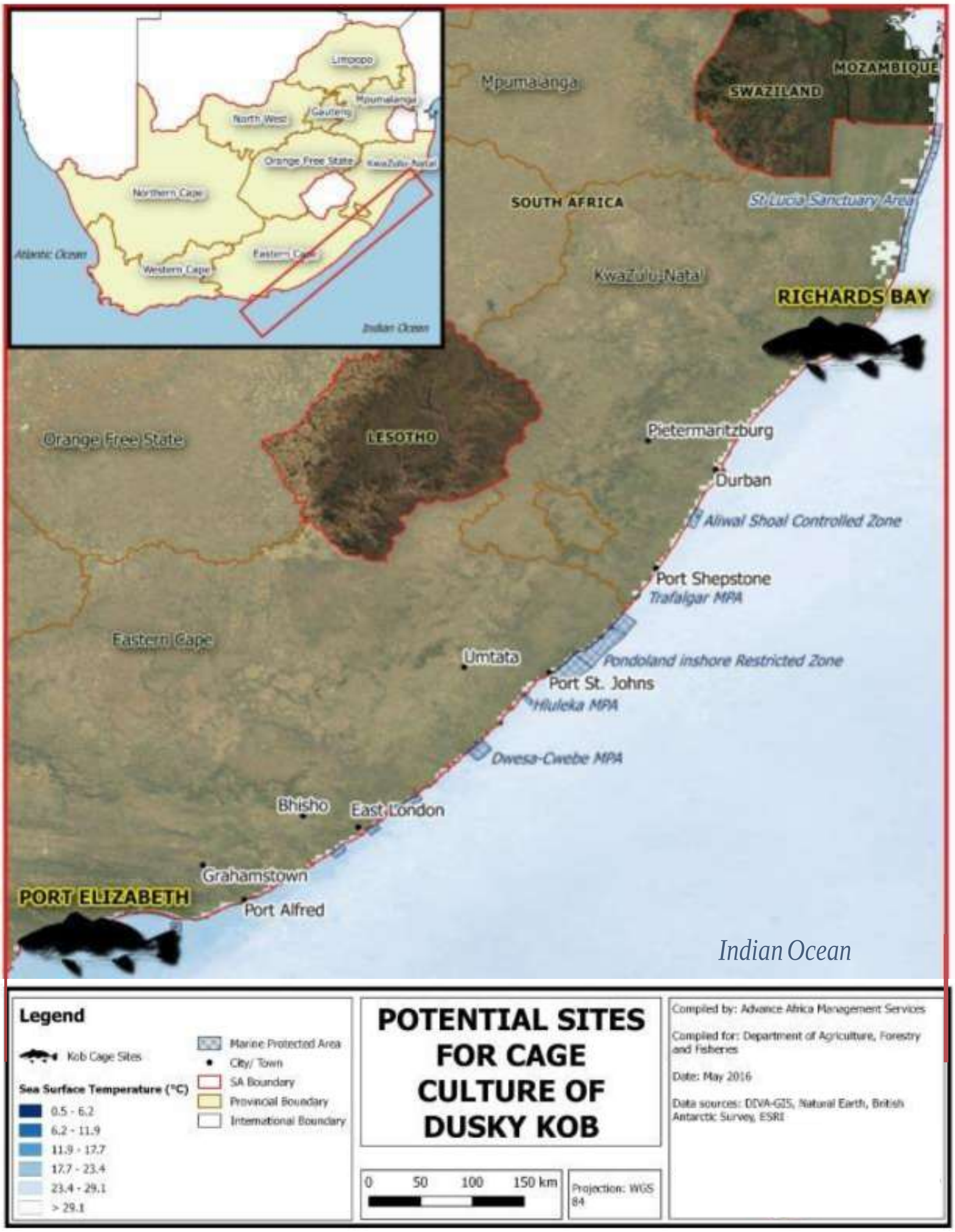


FIGURE 30: POTENTIAL SITES FOR CAGE CULTURE OF DUSKY KOB.

5.2. Atlantic salmon

5.2.1. Land-based production

Possible production systems:

1. Flow-through production of smolts
2. Flow-through grow-out systems
3. RAS production of smolts
4. RAS grow-out systems

Production system: Flow-through production of smolts

TABLE 18: SITE SELECTION CRITERIA FOR FLOW-THROUGH PRODUCTION OF ATLANTIC SALMON SMOLTS.

Site selection parameters	Criteria
Water supply	Perennial river/spring with constant supply. Minimal flow fluctuations.
Water temperature	Temperature range 8-20 °C, 12-16 °C optimal
Water quality	High dissolved oxygen levels; minimal turbidity (<25 nephelometric turbidity units)
Logistics	Located close to transportation network for transport to grow-out facilities
Existing salmonid production	Salmonid production in the surrounding areas

Regions identified as potentially suitable for flow-through production of Atlantic salmon smolts are shown in Figure 31.

Two broad areas have been identified: the Cape Fold Mountains and the Eastern Escarpment. Headwater tributary streams in these areas may possess the minimum environmental requirements for flow-through production of Atlantic salmon smolts. The majority of salmonid production in South Africa is currently practiced in these regions (Stander & Brink, 2009). Unfortunately, there is a paucity of water temperature data in South Africa (Dallas, 2008). From the data that is available, water temperatures within these streams may increase significantly in summer. For example, the Molenaars River in the Western Cape, which currently supports a trout hatchery and a population of established rainbow trout, has temperatures that vary from 7.9°C to 28.4°C with a median of approximately 15.6°C (Dallas, 2008). Similar temperatures have been recorded in another Western Cape rainbow trout stream, the Berg River (9-29°C) (Harrison, 1965). Based on the thermal requirements of Atlantic salmon at different life stages, flow-through production will therefore be restricted by ambient water temperatures at different times of the year.

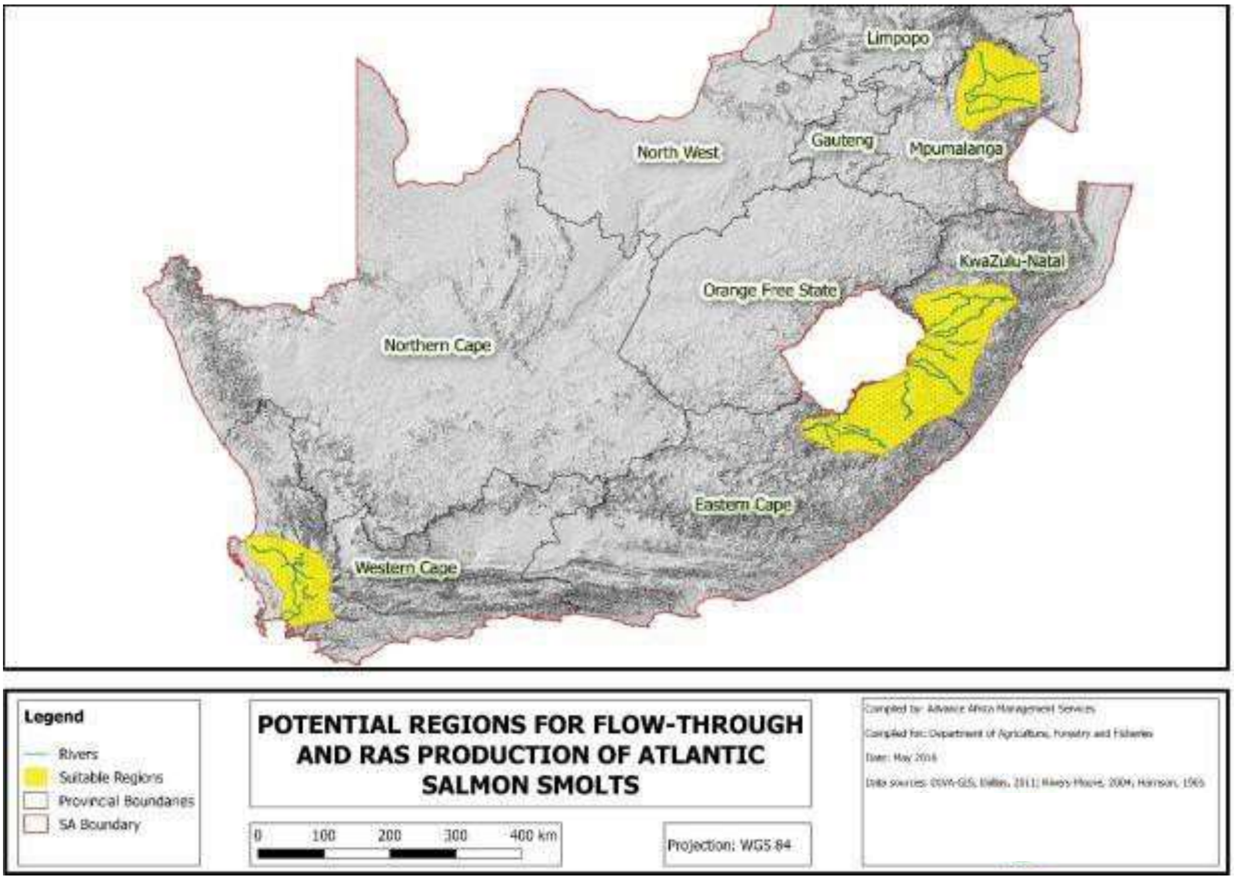


FIGURE 31: POTENTIAL REGIONS FOR FLOW-THROUGH AND RAS PRODUCTION.

TABLE 19: THERMAL LIMITS FOR SURVIVAL OF ATLANTIC SALMON (SOURCE: JONSSON AND JONSSON, 2011).

Life stage	Temperature limits
Egg incubation and hatching	0-16°C (>12°C results in high mortalities and deformities (Solomon & Lightfoot, 2008))
Alevins	0-24°C (growth reduced after 22°C)
Fry and parr	0-29°C (growth reduced after 22°C)
Smolts	0-29°C (growth reduced after 22°C)

While the water temperature conditions in upper foothill rivers such as those in the Cape Fold Mountains and the Eastern Escarpment are just within the upper lethal limits for Atlantic salmon, the high summer temperatures will certainly influence the timing of different stages of production as well as growth and mortality (Table 19). Egg incubation and hatching in flow-through systems will be restricted to the winter months (May – August) where ambient temperatures are suitable. The parr-smolt life stages will therefore begin during the warmer summer months (October - December) associated with elevated water temperatures. The onset of smoltification is likely to occur only after periods of extended decreased photoperiod in winter and a subsequent increase in water temperatures in spring (September - October). The inability to regulate water temperature in flow-through systems will therefore restrict smolt production to specific periods that will not allow for production of age-zero smolts (S0 smolts).

Furthermore, these streams are subject to inconsistent flows including periodic flooding (and turbidity) events and low flow conditions during winter and summer, respectively, in the Cape Fold Mountains (Mantel *et al*., 2010) and vice versa on the Eastern Escarpment (Dedekind *et al*., 2016).

Conclusion: Flow-through production of Atlantic salmon smolts is restricted to inland areas, specifically the Cape Fold Mountains and Eastern Escarpment, which have perennial sources of high-quality water. Suitable areas for production will be significantly constrained by adequate water supply as well as logistical considerations, specifically the distance from the smolt facility to the grow-out operations. Suitability of exact areas will require detailed site visits.

NOTE: Salmon can be grown out in freshwater. However, given the volumes of high-quality water required in a flow-through grow-out operation, the high capital investment costs associated with increased production volumes, risks associated with relatively new production technology, and because Atlantic salmon has yet to be grown out successfully in South Africa on land, this is probably not commercially viable at this stage and is therefore not considered for the site selection exercise.

Production systems: Flow-through grow-out production

TABLE 20: SITE SELECTION FOR FLOW-THROUGH GROW-OUT OF ATLANTIC SALMON.

Site selection parameters	Criteria
Water supply	Constant supply of high quality saltwater
Water temperature	8-20 °C, 12-16 °C optimal
Water quality	Salinity 33-35ppm; pH 6.5-8.5
Logistics	Located close to transportation network

Figure 32 illustrates potential areas identified as suitable for land-based, pump-ashore, flow-through grow-out production of Atlantic salmon

These areas are located from Gansbaai and along the west coast of South Africa. Due to the increased prevalence of HABs north of Cape Columbine (Hutchings *et al*., 2011), the suitability of sites in this region will be dependent on beach wells to act as backups during HAB events. Site suitability will also be restricted by available land, the slope of the land and the associated head (pump-ashore costs will be significantly higher in areas where water must be pumped up a high head).

Conclusion: The significant water requirements for land-based, flow-through, grow-out of Atlantic salmon are such that pump-ashore costs are likely to be substantial. In addition, given the success of offshore grow-out operations in areas where Atlantic salmon aquaculture has been established for many years e.g. Norway, Chile, it is advisable that potential operators consider these systems before land-based grow-out systems which are relatively new and are not yet established on a similar scale. However, given the relative scarcity of suitable bays for offshore grow-out operations, and the potential to provide suitable water during periods of HABs through the installation of beach wells, pump-ashore flow-through systems may represent a viable, albeit costly, alternative.

FIGU RE 32: POTENTIAL REGIONS FOR FLOW-THROUGH AND RAS PRODUCTION OF ATLANTIC SALMON.

Production systems: RAS production of smolts

TABLE 21: SITE SELECTION CRITERIA FOR RAS PRODUCTION OF ATLANTIC SALMON SMOLTS.

Site selection parameters	Criteria
Water supply	Perennial river/spring with constant supply. Minimal flow fluctuations.
Water temperature	Temperature range 8-20 °C, 12-16 °C optimal
Water quality	High dissolved oxygen levels; minimal turbidity (<25 nephelometric turbidity units)
Logistics	Located close to transportation network for transport to grow-out facilities
Existing salmonid production	Salmonid production in the surrounding areas

The water requirements for RAS farms differ to those of flow-through systems. RAS technology enables one to treat water that may be outside of environmental tolerance limits of the candidate species. However, RAS systems may still require up to 20-30% make-up water (water lost during the recirculation process) from the site's water source. It is therefore a natural strategic advantage to be located next to water sources that are within the environmental preference limits of Atlantic salmon.

Based on these requirements, Figure 32 illustrates those areas identified as potential regions for RAS culture of Atlantic salmon smolts in South Africa.

The areas are the same as those suitable for flow-through grow-out of Atlantic salmon smolts. Despite the potential to heat and/or cool water for use in RAS, the associated costs are substantial. Therefore, potential regions are restricted to areas with environmental conditions that are within the limits for Atlantic salmon smolts.

Production systems: RAS grow-out production

TABLE 22: SITE SELECTION CRITERIA FOR RAS GROW-OUT OF ATLANTIC SALMON.

Site selection parameters	Criteria
Water supply	Supply of seawater
Water temperature	8-20 °C, 12-16 °C optimal
Water quality	Salinity 33-35ppm; pH 6.5-8.5
Logistics	Located close to transportation network

Based on these requirements, Figure 32 illustrates regions identified as potential regions for RAS grow-out of Atlantic salmon in South Africa.

Commercial production of Atlantic salmon in land-based grow-out operations is still in its infancy and capital and operational costs may be prohibitive especially in comparison to offshore-based cage culture.

5.2.2. Offshore-based production

Possible production systems:

1. Cage culture

Production system: Offshore cage culture

TABLE 23: SITE SELECTION CRITERIA FOR OFFSHORE CAGE CULTURE OF ATLANTIC SALMON.

Site selection parameters	Criteria
Mean annual water temperature	Exclude areas with average sea surface temperature >20 °C
Location and frequency of upwelling events	Exclude areas within known upwelling cells
Exposure to waves	Exclude areas with significant wave heights >3m and maximum recorded wave height >10m
Exposure to turbidity events	Exclude areas located adjacent to estuaries with high run-off.
Exposure to harmful algal bloom (HAB) events	Exclude areas where HABs are known to occur

Possible zones for Atlantic salmon farming based on water temperature, upwelling cells, wave exposure, and turbidity events are shown in Figure 33.

These areas are: Gansbaai and Saldanha Bay. Due to the increased prevalence of HABs north of Cape Columbine, this area of coastline has been excluded (Hutchings *et al*., 2011).

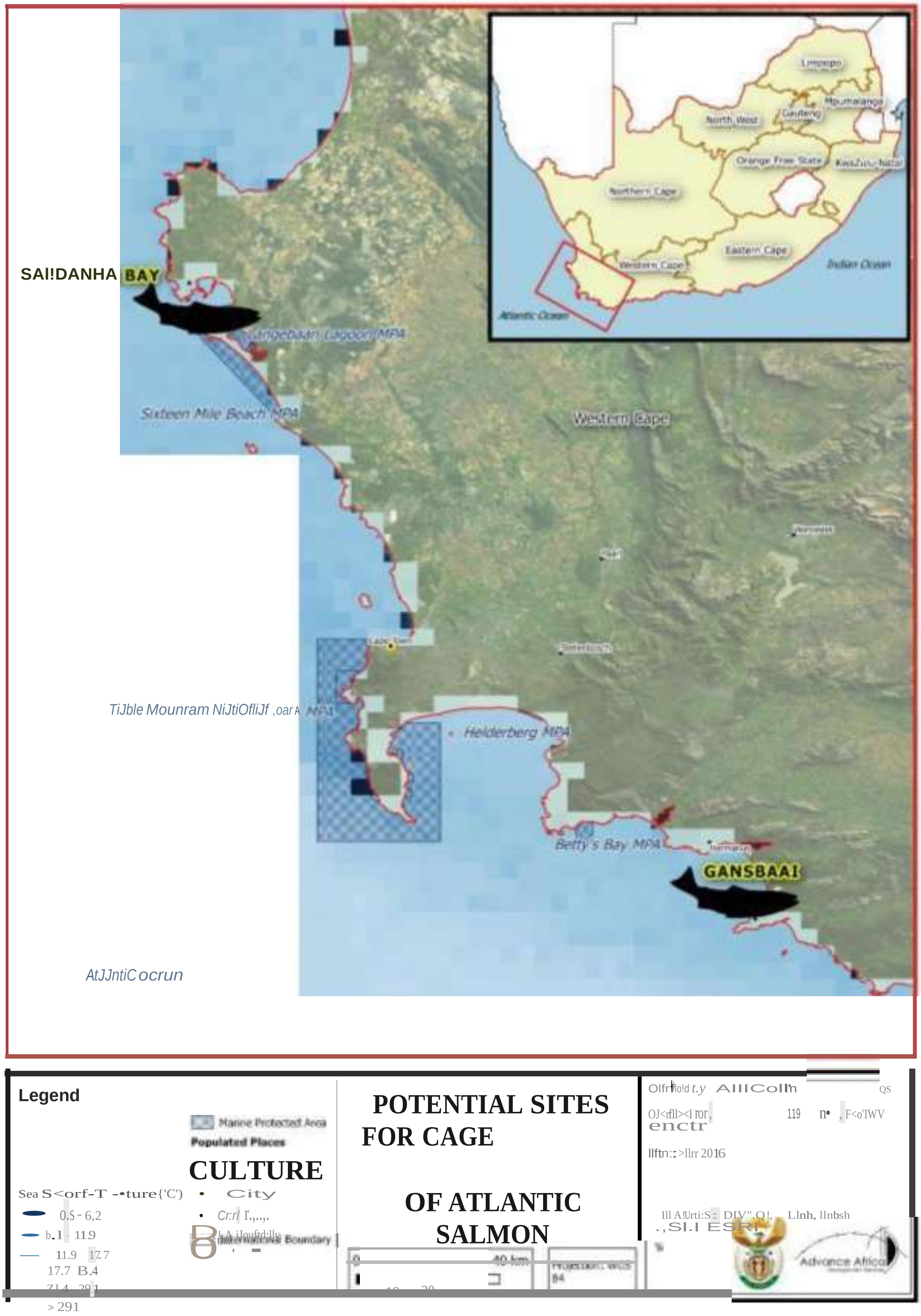


FIGURE 33: POTENTIAL SITES FOR SALMON CAGE CULTURE.

6. MARKET ASSESSMENT

Production from global capture fisheries has stagnated and forecasts of global demand for fishery products suggest that aquaculture output will need to increase to meet the projected demand. Demand for food (and food fish) is primarily determined by four variables: demography, living standards, urbanisation and price.

6.1. Dusky kob

6.1.1. Fisheries production

Stocks of both dusky and silver kob (*Argyrosomus inodorus*) have declined to critical levels. Given the overall decline in catches from the linefishery in South Africa, regulations to reduce commercial linefishing effort by 70% were implemented in 2005 and these included stringent output controls (bag and size limits) for most traditional linefish species. This has created a shortage of linefish (including dusky kob) on the market. In future, increasing demand for South African linefish species can only be met through aquaculture production.

6.1.2. Aquaculture production

Global aquaculture production statistics have not been recorded for dusky kob with the exception of Mozambique, which produced 130 tonnes in 2013 (FishstatJ, 2016). In Australia, the dusky kob (commonly known as mulloway) aquaculture industry is emerging and, in 2011, production was approximately 72 tonnes (Treneman, 2011). In South Africa, it is estimated that 122.5 tonnes of kob was produced in 2013 (DAFF, 2014a).

6.1.3. Substitute product comparison

As “dusky kob” is a linefish product known only to the local South African market, it was decided to include other similar species in the market assessment that are product substitutes competing with dusky kob. This allowed us to contextualise how dusky kob could be positioned as a product on international markets. These species are as follows (see Figure 34):

- Meagre: *Argryosomus regius*
- Barramundi: *Lates calcarifer*
- European seabass: *Dicentrarchus labrax*
- Gilthead seabream: *Sparus aurata*

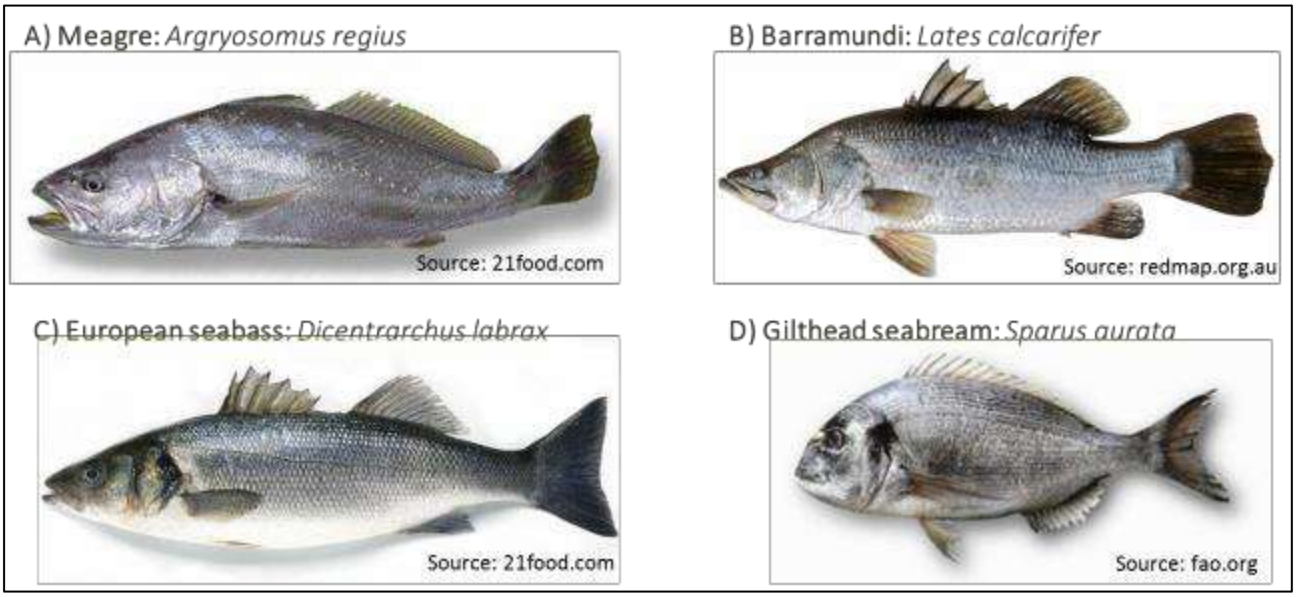


FIGURE 34: SUBSTITUTE PRODUCT SPECIES USED IN THIS MARKET ASSESSMENT, A) MEAGRE; B) BARRAMUNDI; C) EUROPEAN SEABASS; AND D) GILTHEAD SEABREAM.

Total aquaculture production, top importing and exporting countries, and average prices for each of these species are presented in Figures 35, 36, and 37 respectively.

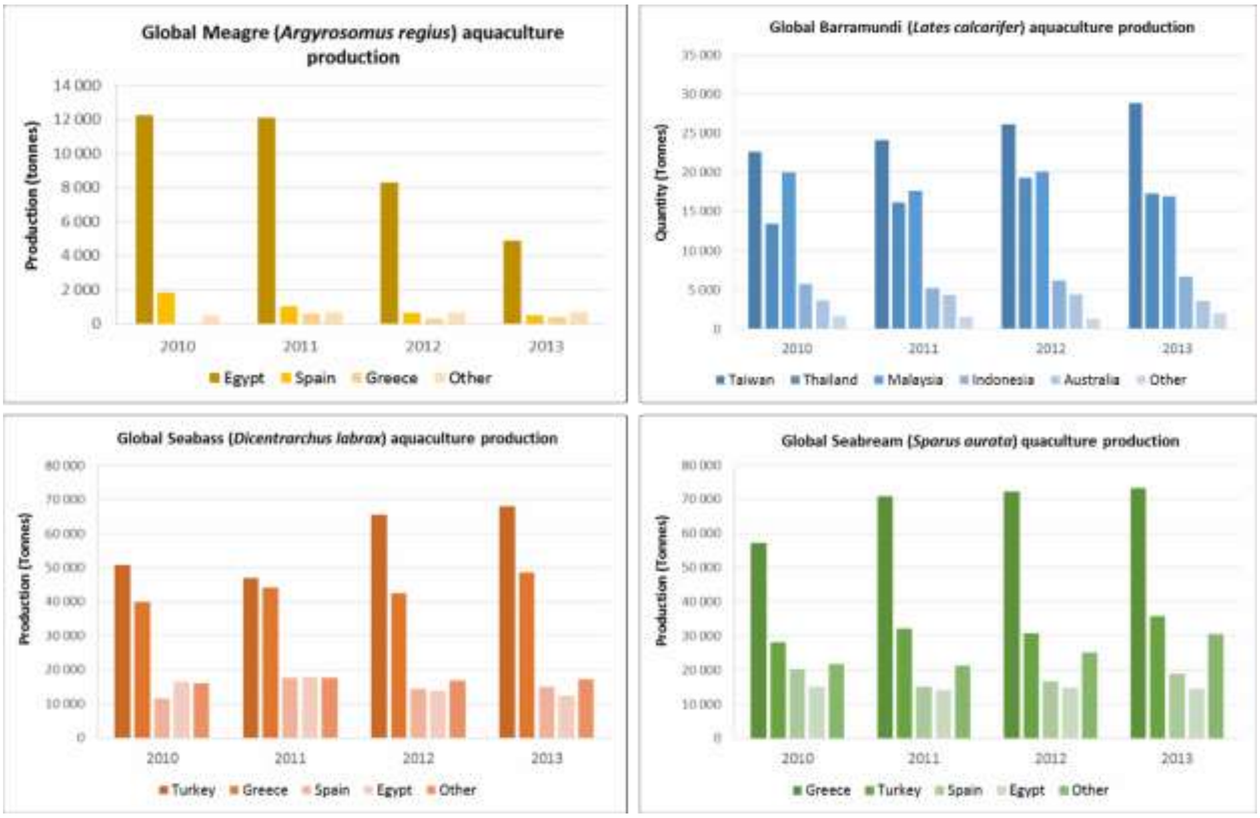


FIGURE 35: GLOBAL AQUACULTURE PRODUCTION OF A) MEAGRE; B) BARRAMUNDI; C) EUROPEAN SEABASS; AND C) GILTHEAD SEABREAM.

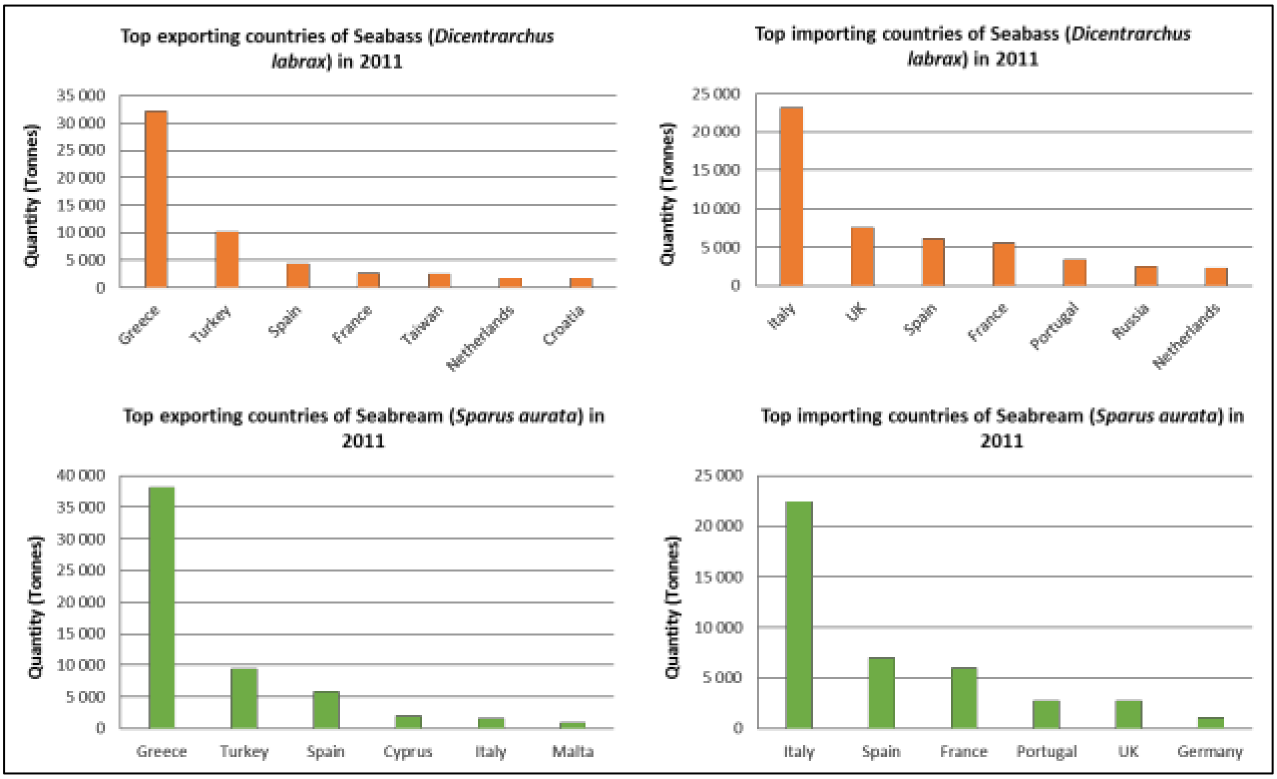


FIGURE 36: TOP IMPORTING AND EXPORTING COUNTRIES OF EUROPEAN SEABASS AND GILTHEAD SEABREAM BY WEIGHT IN 2011.

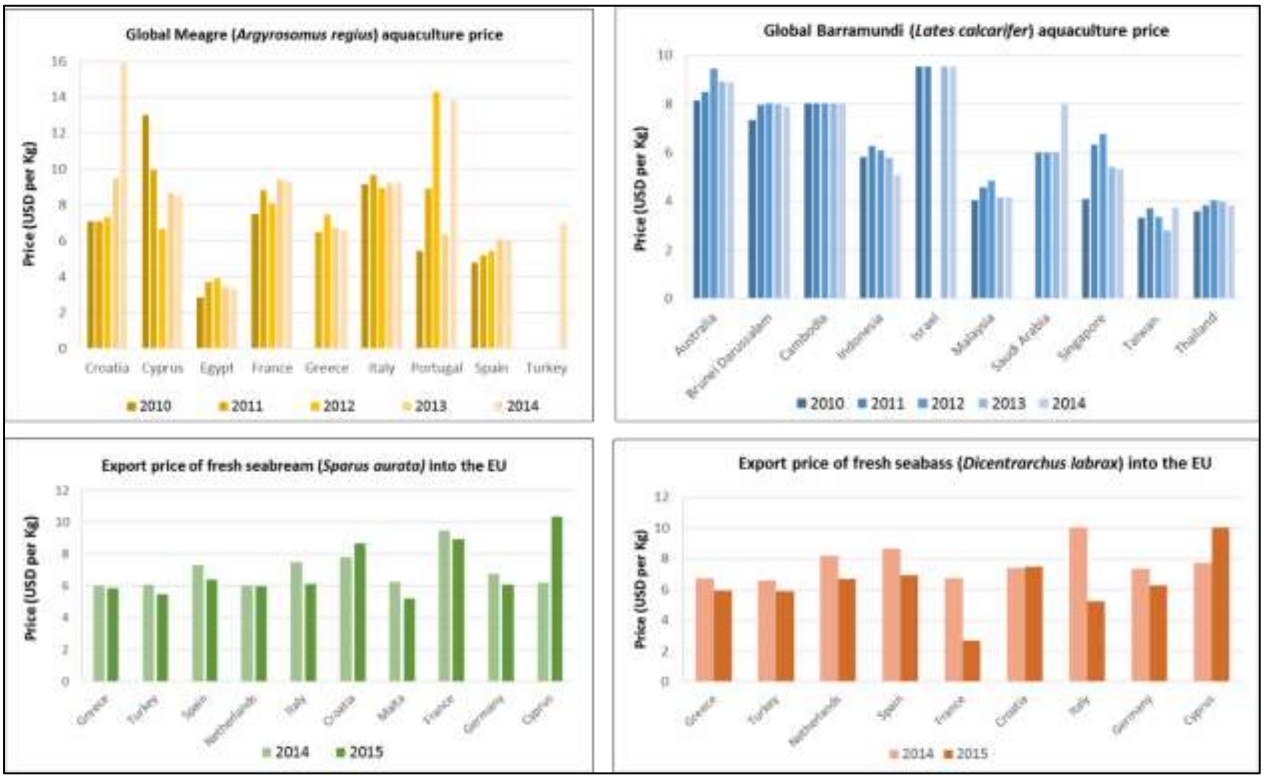


FIGURE 37: AVERAGE PRICE OF A) MEAGRE; B) BARRAMUNDI; C) GILTHEAD SEABREAM; AND D) EUROPEAN SEABASS.

A summary of the key production and trade statistics and information is provided below.

- ***Meagre***

- Global aquaculture production of meagre in 2013 was 6 431 tonnes (FishstatJ, 2016).
- Global aquaculture production of meagre has decreased (from 14 595 tonnes in 2010 to 6 431 tonnes in 2013) primarily as a result of decreasing production from Egypt, the main producer country (Figure 35).
- The market value for meagre varies between countries (Figure 37), but reaches a higher value in Croatia and Portugal, at USD 15.92 and 13.85 per kg in 2014, respectively.
- Farmed meagre is mainly sold fresh. The bulk is traded whole, head on, and ungutted or gutted depending on the end market. Few fish are sold at a size below 1 kg; over 50% is sold at a size from 1 - 2kg; a third at a size above 2 kg. Portion-sized fish (400 – 700g) are not considered suitable for market as these fish have large heads, large bones, little flesh, and are not very tasty (Monfort, 2010).
- The majority of production is sold to commercial caterers through wholesalers. Restaurants constitute the number one outlet in Italy, Spain, and France. Restaurants purchase meagre whole or purchase pre-cut portions processed in the farming unit (Monfort, 2010).

- ***Barramundi***

- Global aquaculture production of barramundi in 2013 was 73 726 tonnes (FishstatJ, 2016).
- The dominant producer countries in 2013 were Asian countries including Taiwan (28 803 tonnes), Thailand (17 313 tonnes), and Malaysia (16 981 tonnes) (Figure 35).
- The majority of barramundi production is consumed domestically in producing countries with only minor quantities being exported (e.g., Australia: 97% domestic, 3% export). However, as the profile of barramundi increases worldwide, production for export is expected to increase in Australia, Southeast Asia (Indonesia, Singapore), and Taiwan (Peet, 2006).
- Barramundi is well known and relatively well established in seafood markets. Farmed barramundi is sold live (400-800g), plate-size whole (300-500g), filleted or as larger whole fish (2kg) products.
- Prices remain cheaper in Taiwan and Thailand who are the largest producers.
- There has been little effort spent on developing value-added products for barramundi. In Australia, there are a few suppliers of smoked barramundi. Throughout its cultured range, live barramundi are sold to restaurants that specialize in live seafood products but this is a relatively small portion of the total market (Peet, 2006).

- ***European seabass***

- Global aquaculture production of European seabass in 2013 was 161 059 tonnes (FishstatJ, 2016).
- The dominant producer countries in 2013 were Turkey (67 912 tonnes), Greece (48 600 tonnes), Spain (14 945 tonnes) and Egypt (12 328 tonnes) (Figure 35).
- The southern European market is the dominant consumer of European seabass products where it has a strong culinary tradition.
- Italy was the largest importing country in 2011, importing 23 189 (Figure 36).

- The average export price of fresh seabass in 2015 was USD 6.35/kg (Figure 37) and the average import price was USD 6.87/kg.
- Compared to other species of farmed fish, such as salmon or trout, the majority of seabass is marketed whole and fresh (on ice) with only limited volumes undergoing any form of processing or value-addition.
- The production of fillets at competitive prices has been a challenge for the industry. The cost of producing large size fish and fillet yields have so-far inhibited product diversification (Barazi-Yeroulanos, 2010).

➢ ***Gilthead seabream***

- Global aquaculture production of gilthead seabream in 2013 was 173 062 tonnes (FishstatJ, 2016).
- The dominant producer countries in 2013 were Greece (73 300 tonnes), Turkey (35 701 tonnes), Spain (18 897 tonnes) and Egypt (14 537 tonnes) (Figure 35)
- Greece produced 73 300 tonnes of gilthead seabream in 2013 and exported 53% (38 850 tonnes) of its production (Figure 36).
- The European market dominates the gilthead seabream trade in terms of exports and imports (Figure 36).
- Italy is the largest importing country, importing 22 407 tonnes in 2011 (Figure 36).
- The average export price of fresh gilthead seabream in 2015 was USD 6.90/ kg (Figure 37) and the average import price into the EU was USD 6.4/ kg.
- The majority of gilthead seabream production in the Mediterranean is sold fresh, whole and head-on (Barazi-Yeroulanos, 2010).

6.1.4. Global/local demand and price

There is a steadily growing local demand for seafood in South Africa due to growing exposure of South Africans to an increasing variety of fishery products. Seafood has now become a well-established commodity and is well established on restaurant menus. In the retail sector, fresh fish counters at major supermarkets have improved, and many independent retailers specialise in seafood, both fresh and frozen. The majority of consumers remain relatively "ignorant", particularly compared to European or Asian consumers, of the product characteristics of various fish species and are wary of purchasing whole fresh fish as they don't know how to prepare them (Kaiser EDP & Enviro-fish Africa, 2011). Freshness is always an issue with non-frozen fish and a further deterrent to many consumers. Consequently, there is a trend among suppliers to move towards pre-packaged and value-added fresh fish products. Advances in aseptic packaging now make it possible to present fresh fish in evacuated plastic with an extended shelf life. This is seen as a growth area for local demand for fish products and it is expected that producers culturing marine finfish will target this market niche to capitalise on their product characteristics (Shipton & Britz, 2007).

The fresh on board price of high quality, line caught silver kob (>2kg) in Cape Town currently stands at R52/kg (R48 in Port Alfred) and retails at R98 / kg in Port Alfred and around R112 / kg in Cape Town (Table 24). Of particular and greater importance, however, is the increase in the price of fish. Retailers are of the opinion that the current rate of increase will escalate at approximately 20% per annum.

There is a mismatch between the wholesale and/or retail prices for wild-caught kob and farmed kob. Currently, the price for wild-caught kob (± ZAR 50/ kg, see Table 24) is lower than that of farmed kob (± ZAR 65 - 75/ kg, see Table 24), due to the high operational costs associated with the production of kob. For a local farmed kob market to be established and successful, there is a reliance on the seafood distributor and end consumer to favour an aquaculture product and be willing to pay an increased price for such a farmed product, which is still lacking (undeveloped) in South Africa. This has been a barrier to operators within the local industry who have had challenges in being able to sell their product at a higher price to wild-caught fishery products. It is on this premise that the South African mariculture industry focuses efforts on farmed kob to become an export product on international markets.

TABLE 24: GLOBAL AND LOCAL PRICE OF KOB PRODUCTS.

Location	Product	Price (Local currency)	Price (USD/ kg)[3]	Source
Cape Town	Fresh on board price	ZAR 52/ kg	USD 3.8/ kg	Hecht *et al*., 2015
Cape Town	Retail	ZAR 112/ kg	USD 8.34/ kg	Hecht *et al*., 2015
Port Alfred	Fresh on board price	ZAR 48/ kg	USD 3.58/ kg	Hecht *et al*., 2015
Port Alfred	Retail	ZAR 98/ kg	USD 7.31/ kg	Hecht *et al*., 2015
East London	Wholesale farmed	ZAR 65 – 75/ kg	USD 4.8 – 5.6/ kg	A. Bok; pers. communication
European Union	Retail	EUR 6/ kg	USD 6.74/ kg	Mutter, 2015
Australia	Wholesale	AUD 9.51/ kg	USD 9.73/ kg	Trenaman, 2011

Based on the product substitute comparison in Section 6.1.3, Figure 38 illustrates how dusky kob is likely to be positioned on the global market in terms of market value and quality perception. It is evident that dusky kob falls within the European seabass and gilthead seabream product price range (± USD 6.00 – 7.00/ kg). Ultimately, one would aim to position dusky kob to have the same market perception, and therefore value, as a product such as barramundi and thus achieve a higher market price closer to USD 8.00/kg. It is on this basis that an international market assessment is conducted to gain a more accurate understanding of what prices farmed dusky kob may achieve on international markets.

[3] Currency exchange rates are as of the recorded date and year (August 2016; source: xe.com).

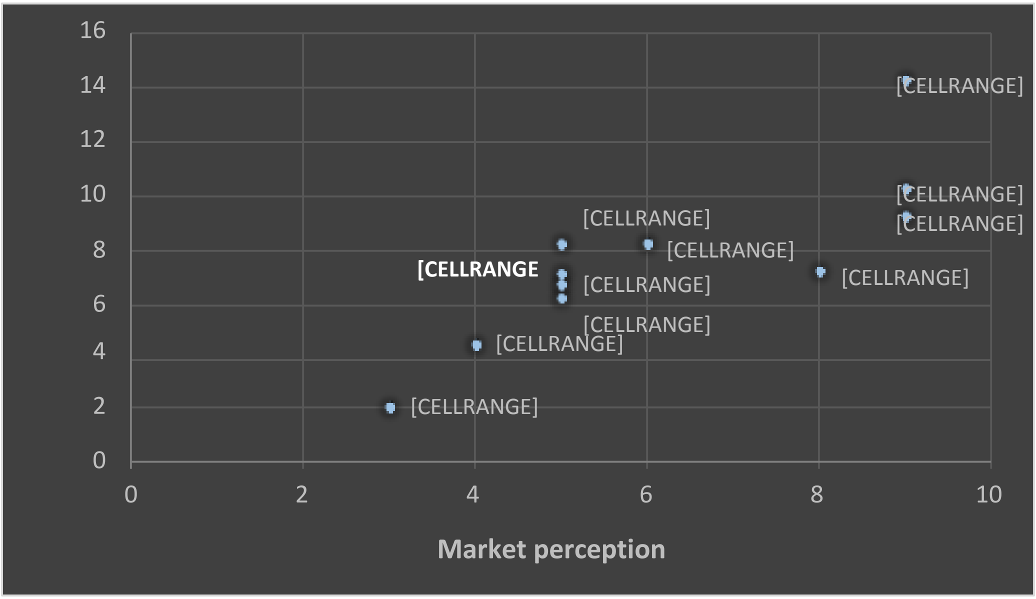


FIGURE 38: MARKET VALUE AND PERCEPTION OF VARIOUS MARINE FINFISH PRODUCTS.

Assuming that the South African mariculture industry focuses on the development of high-value marine finfish species, and taking cognisance of South Africa's geographical position with respect to other fish producing nations, it is reasonable to suggest that the most likely high -value markets that could be accessed by South African producers are those in Europe and Asia. However, entry into European markets is not currently possible due to high standards for hygiene and consumer safety governed by the European Food Law.

Imports of fishery products into the EU are subject to official certification, which is based on the recognition of the competent authority of the non-EU country by the European Commission. This formal recognition of the reliability of the competent authority is a pre-requisite for the country to be eligible and authorised to export to the EU. Public authorities with the necessary legal powers and resources must ensure credible inspection and controls throughout the production chain, which cover all relevant aspects of hygiene, public health and, in the case of aquaculture products, also animal health. The European Commission has established a list of countries from which imports of bivalves, molluscs, echinoderms, tunicates, marine gastropods and fishery products are permitted (Notice reference: 2006/766/EC). Currently, South Africa is only a listed country for imports of fishery products. An operator would need to ensure the correct certification for aquaculture products of finfish in order to be able to export to the EU – an activity not yet achieved in southern Africa for aquaculture products.

In Europe, the branding of fresh, farmed fish as a marketing strategy is becoming more prevalent. European seabass and gilthead seabream, as well as Atlantic salmon, are often distributed with the retailers' quality brand. The scope for growth of dusky kob may allow the farmer to produce various products depending on demand and price. These may include small 500-850g whole plate size fish sold as "baby kob", or larger fish of 1.2 kg or above for the whole fresh fish market, or which can be filleted (skinned or skin on) and specially packed (as demonstrated in Table 25). The fillet dress out weight is around 50% for kob (C.McLennan, Fresh Fish Market, Port Alfred, pers. comm.). Waste products such as heads, skeletons, wings and trimmings can be sold to traders, pet food manufacturers, or fertilizer companies.

TABLE 25: PRODUCT OPTIONS FOR DUSKY KOB.

Product range	Size range	
Whole (fresh/chilled, frozen)	➢ 500-850g ➢ 1.2 kg or above for the whole fresh fish market	
Filleted (fresh/chilled, frozen)	➢ 50% of weight	

6.2. Atlantic salmon

6.2.1. The salmonid industry segment

Total salmonid production

The salmonid sector is relatively small within the context of total global aquaculture production (only 4.2% of the total by tonnes harvested (Figure 39)). Nevertheless, it represents what is considered the most industrialised aquaculture segment and boasts a highly efficient production and marketing system that, to a large extent, mitigates many of the risks commonly associated with the aquaculture industry. Equally, these characteristics make for a mature and highly competitive sector where only the most efficient production units and marketing systems survive.

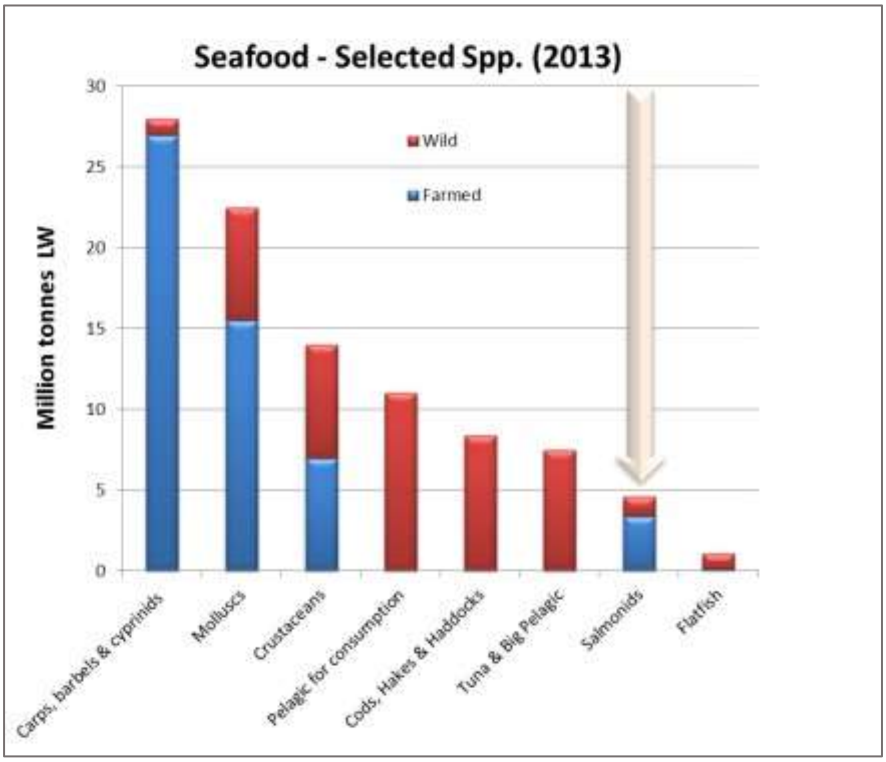


FIGURE 39: ANNUAL FARMED AND WILD-HARVEST PRODUCTION PER SPECIES GROUP (KONTALI ANALYSE, 2015).

Three species are primarily farmed in salmonid aquaculture: Atlantic salmon, large rainbow trout and Coho salmon (*Oncorhynchus kisutch*). Atlantic salmon is the largest contributor to total production (2 million tonnes (2013), with trout and Coho representing smaller, niche volumes particularly when viewed in the context of the major fin-fish species harvest volumes (Figure 40).

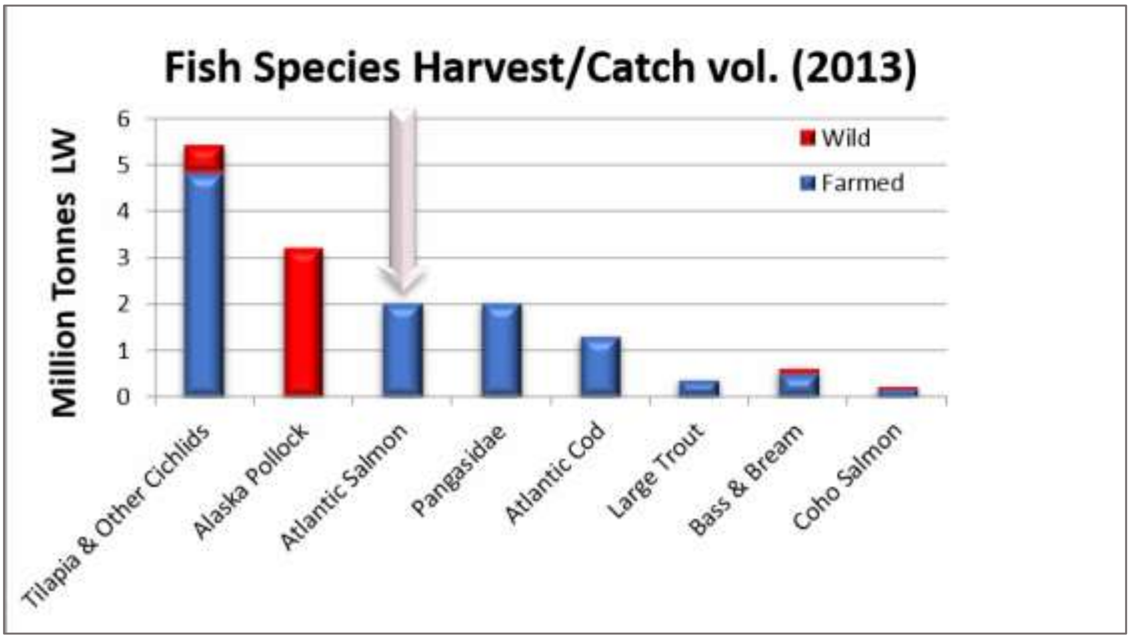


FIGURE 40: ANNUAL FARMED AND WILD-HARVEST PRODUCTION PER FINFISH SPECIES (KONTALI ANALYSE, 2015).

The quality characteristics, product forms and target markets for each of the species are discussed briefly below.

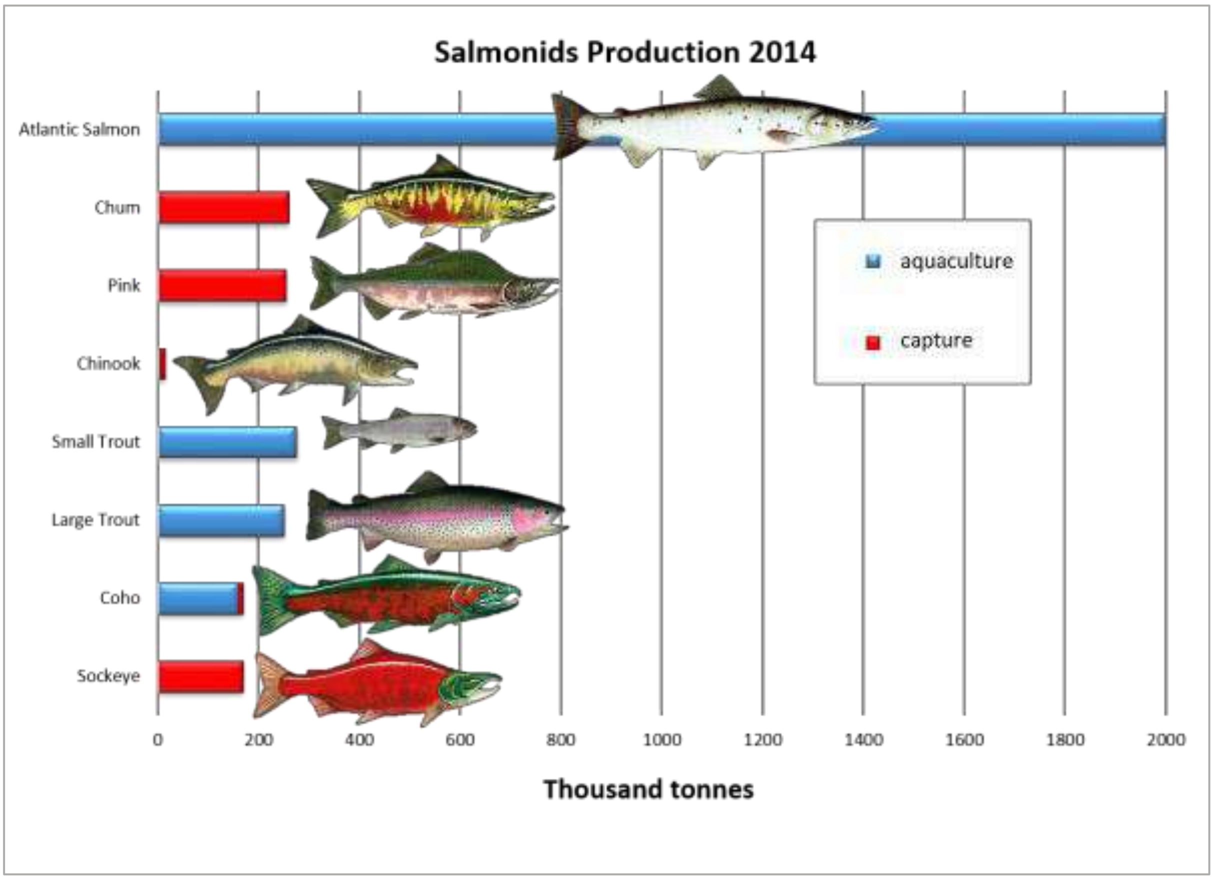


FIGURE 41: SALMONIDS HARVEST 2014, ADAPTED FROM KONTALI ANALYSE (2015).

- ***Atlantic salmon***

Atlantic salmon is the largest contributor to total salmonid production. Annual production is comprised almost entirely of aquaculture product. Major global producers are Norway, Chile, North America, UK and Ireland, New Zealand and the Faroe Islands. Atlantic salmon is a versatile product that is consumed in multiple product forms. Fish are typically traded at the wholesale level in a head-on-gutted fresh on ice form and producers have access to both fixed price and spot price contracts.

- ***Pink salmon (Oncorhynchus gorbuscha*)**

Pink salmon are wild harvested in North America and Russia and are considered a lower quality salmonid species. Harvest is seasonal and fish are generally small (<2kg) and, as such, sales prices are comparatively low. Pink salmon are often processed and sold in a canned product form.

- ***Chum salmon (Oncorhynchus keta*)**

Chum salmon is wild-harvested in Alaska and Japan, predominantly from fish stocked into the wild by commercial hatcheries. Chum salmon are both consumed locally in Japan and exported to China for consumption and secondary processing and re-export.

- ***Large trout***

Large trout (rainbow trout) are often referred to in the marketplace as salmon trout. Large trout are farmed in Norway, Chile and the Faroe Islands in sea-based operations. The primary markets are Japan and Russia. Trout, together with Coho and Chinook, form the 'red-fleshed salmon' category – these species can be characterised by high levels of flesh pigmentation (+30 salmofan colour) which is particularly sought after in the sashimi market.

- ***Small trout***

Small trout (primarily rainbow trout) are grown to a 'plate-size' product of 400-600g. These fish are often cultured in freshwater streams and are sold locally as fresh and smoked product.

- ***Coho salmon***

As a red-fleshed salmon, Coho salmon offer the closest substitute product for large trout. Coho salmon are farmed in Chile for Japanese market and, more recently, are also sold to Russia. Coho salmon are recognised as a lower quality product to large trout and generally receive a slightly lower price.

- ***Sockeye salmon (Oncorhynchus nerka)***

Sockeye salmon is wild-harvested in Russia and Alaska. It is mostly sold into the Japanese market where it receives a premium price and is used for sashimi and salted products.

- ***Chinook salmon (Oncorhynchus tshawytscha)***

Chinook is wild-harvested in small quantities in Alaska and Canada where it is valued as a high quality product.

Supply of farmed and wild harvest salmonids

Catches of salmonids from wild fisheries have remained stable over the past decade with harvest volumes fluctuating within a range of 750 000 – 1 000 000 tpa. Production from aquaculture has, on the other hand, sustained substantial growth over the past decade and currently supplies ± 2 000 000 tpa into the global marketplace (Figure 42).

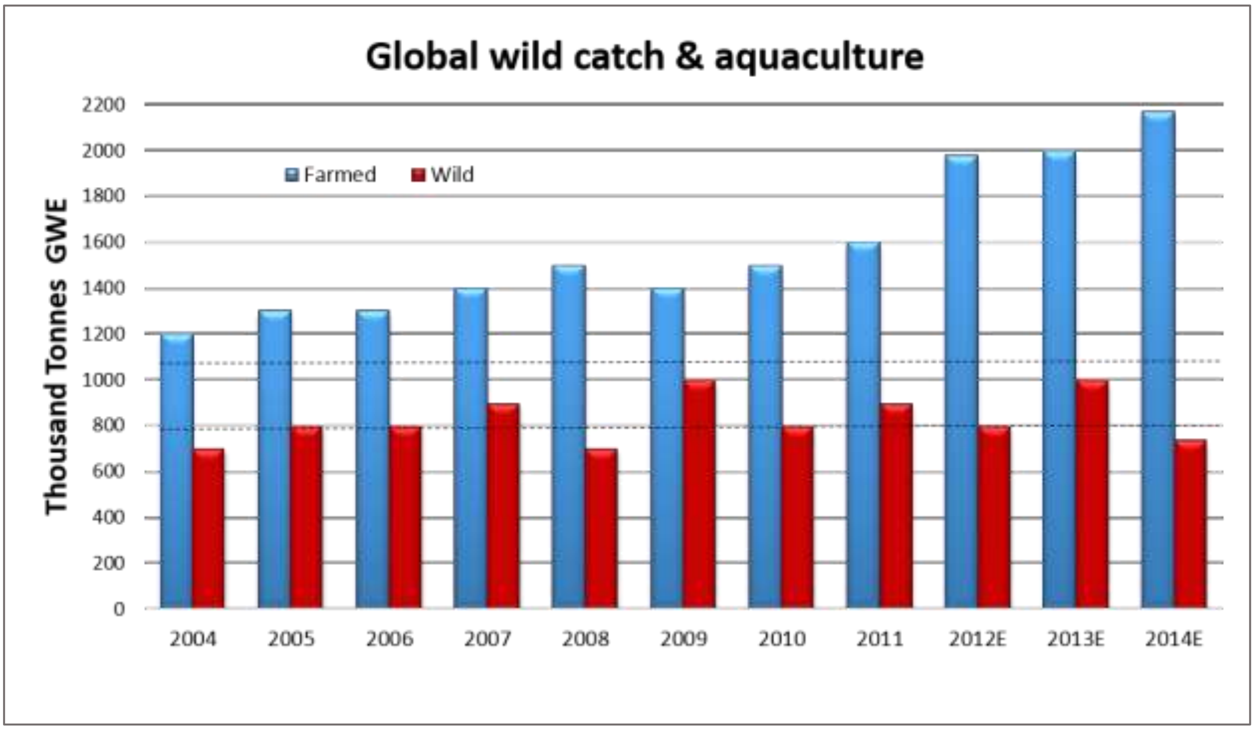


FIGURE 42: SALMONID WILD CATCH AND AQUACULTURE PRODUCTION OVER TIME (KONTALI ANALYSE, 2015).

Due to the very specific environmental requirements of commercial salmonid production, limited viable production sites exist globally and, with a few exceptions, known licensed sites are fully utilised. The expansion of salmonid producing companies has of late been limited primarily to the acquisition of existing farms or licenses and the industry as a whole is expected to achieve only limited growth moving forward (estimated 3% per annum). In the mature industry locations, production growth is expected to come from biological and technological improvements within existing operations rather than the development of new projects. It should be noted however that several large salmon farming companies in Norway are in the process of developing offshore technologies that could enable production to move to offshore sites – if successful this will substantially increase the salmon aquaculture potential in the country.

Salmonid industry structure

The salmonid industry has been through a period of consolidation in the main production locations over the past 10 years and this trend is expected to continue. The industry as it stands is capital intensive and cost efficiencies through increased economies of scale have become essential to a competitive operation.

In Norway, 80% of the ± 1,3 million tonnes of annual production is produced by 23 companies. Similarly in Chile, 80% of the production is produced by 13 companies. As such the industry is increasingly consolidated, vertically integrated and subject to escalating barriers to entry.

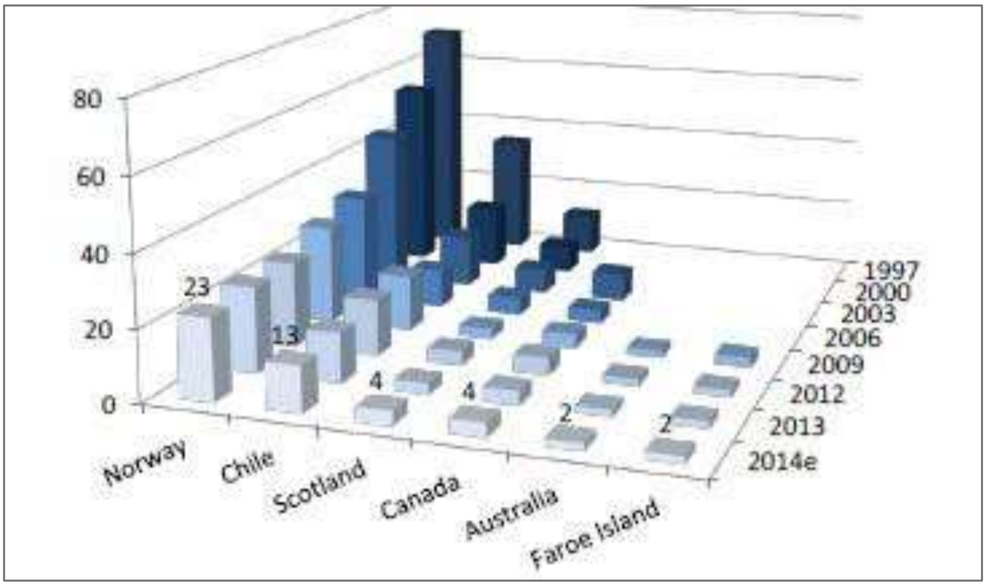


Figure 43: Number of firms operating in the Salmonid Industry by country over time (Kontali Analyse, 2015).

6.2.2. The salmonid market

Global salmonid market overview

In its base product form, salmon has become a commodity and, as such, prices are subject to cyclical trends and fluctuations. Figure 44 below compares the relative prices of the main protein commodities over the past 10 years.

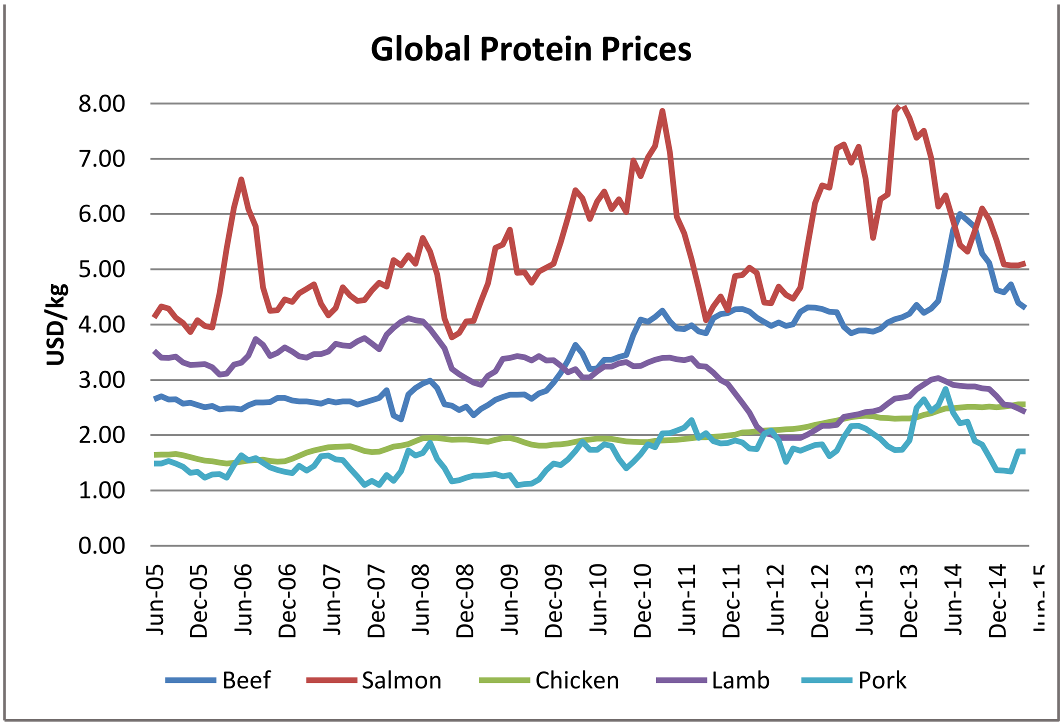


Figure 44: Global protein prices over time (adapted from Index Mundi, 2015).

Salmon remains an expensive source of protein. However, when considering the relative price changes, salmon has become more affordable through improved scale of industry, more efficient production methods, cheaper feed prices, and improved accessibility to the global marketplace.

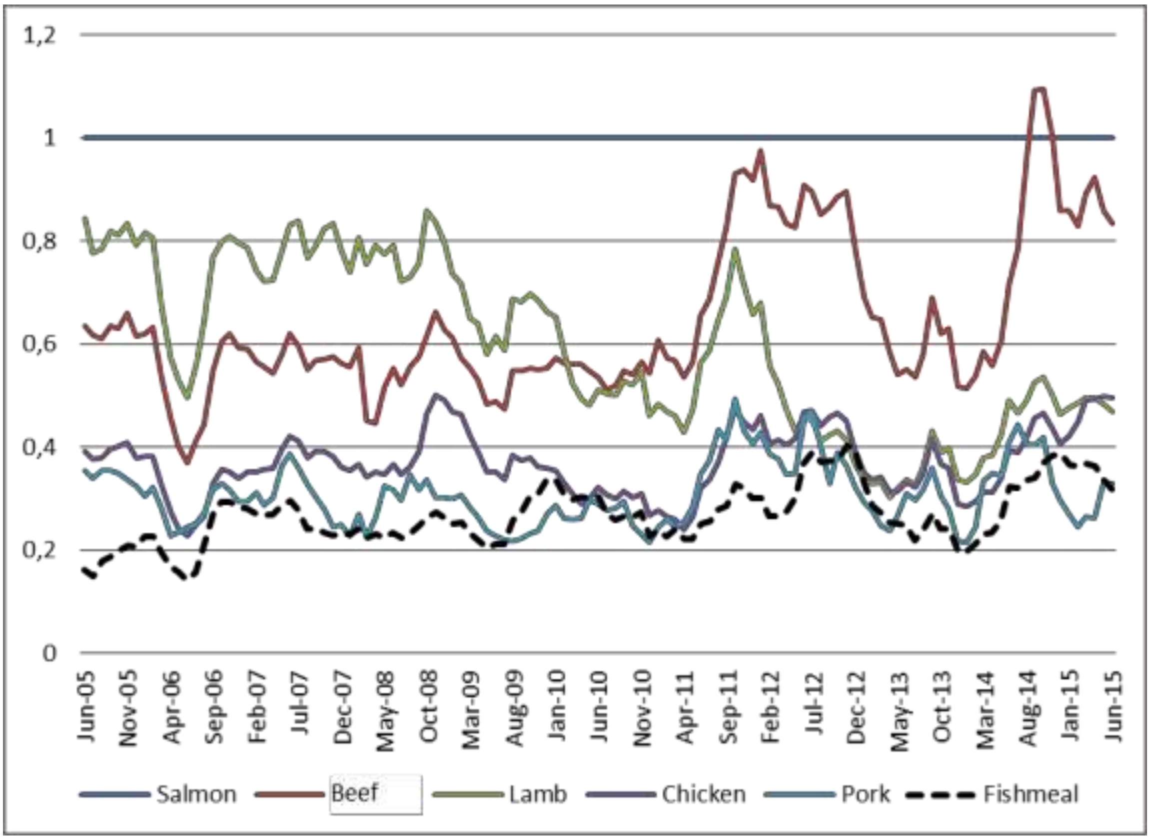


FIGURE 45: PRICES OF PROTEINS INDEXED TO SALMON PRICE (INDEX MUNDI, 2015).

Global production

Global salmonid production is dominated by Atlantic salmon produced primarily in Norway and Chile. Norwegian production is stable at 1.2 - 1.4 million tpa while Chilean production has only recently recovered from the impact of the devastating 2007 - 2010 ISA outbreak and recently peaked at ± 500 000 tpa. A widespread algal bloom episode in March 2016 has, however, set the Chilean industry back once more with an expected loss of + 100 000 tonnes estimated. Increased production of Atlantic salmon in these countries will come from expansion into offshore areas with improved cage and closed-containment technologies capable of withstanding highly dynamic and extreme offshore environmental conditions.

The production of Coho salmon takes place almost exclusively in Chile for supply to the Japanese market. Coho harvest is seasonal and the product is traded in a frozen format to accommodate smoothed delivery volumes. Coho production in Chile increased during the ISA outbreak due to its natural resistance against the disease but has now returned to prior harvest volumes as growers return to the more profitable production of Atlantic salmon.

Trout can be grown out in seawater or freshwater but most large trout are cultured in the sea. Chile is the leading producer of large trout although production in that country has decreased significantly over the past 3 years (-46%) and this trend appears set to continue with a further decrease forecast in 2015 (-26% YTD). As with Coho, some Chilean farms discontinued Atlantic salmon production in favour of the Coho and trout species during the ISA outbreak and the current trend of decreasing trout production can be seen as a reversal back to Atlantic salmon as the preferred culture species for Chile. Norwegian trout production remains stable.

The annual wild harvest of salmon species is considered sustainable at current levels which fluctuate between 750 000 and 1.1 million tpa. The harvest is made up of catch from the USA, Russia, Japan and Canada.

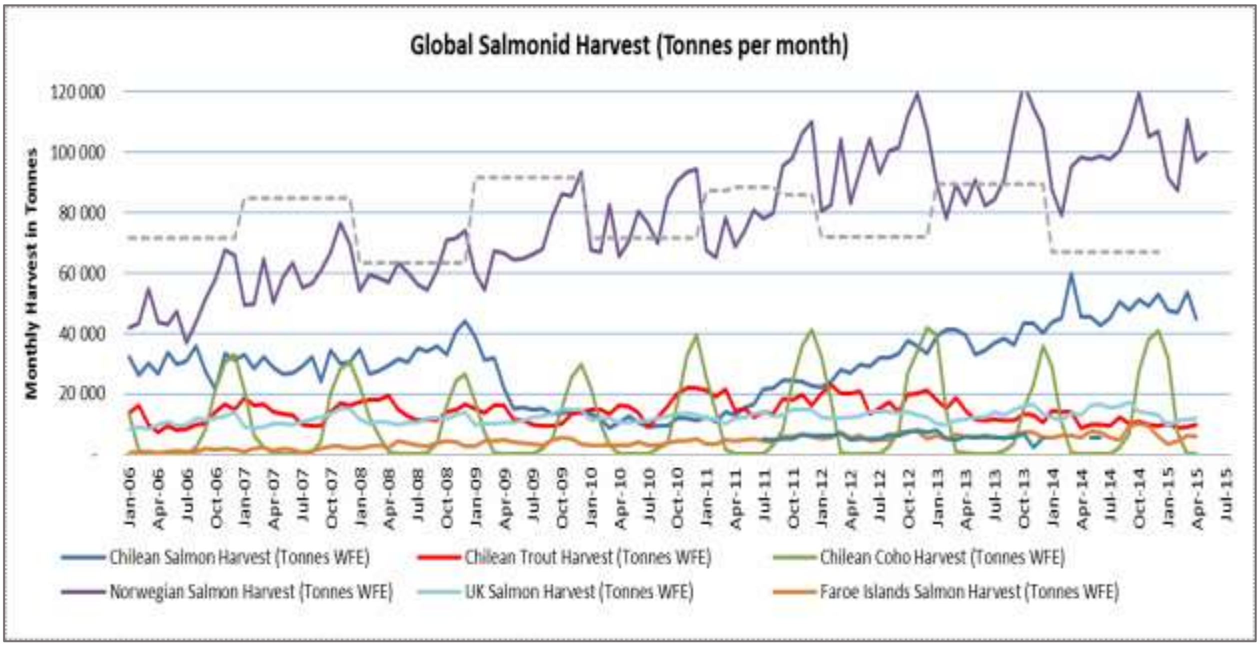


FIGURE 46: GLOBAL SALMONID HARVEST OVER TIME (KONTALI ANALYSE, 2015).

Global market prices

A declining salmonid price off of the peaks attained at the beginning of 2014 was experienced through 2014/15 with numerous factors influencing the trend.

- Market demand: the underlying market demand for salmonid products is increasing globally, driven by recognition of the health benefits of fish and salmonids in particular. Conveniently packaged products and appropriately sized product portions have improved both affordability and accessibility across a wide range of markets.
- The Russian market: the ban on seafood products imported from the EU and Norway into Russia has resulted in a significant decrease in the supply of Atlantic salmon from Norway to Russia. To some extent, producers from the Faroe Islands and Chile have begun to fill the gap but a large quantity of Norwegian salmon has been redirected into Europe as a result and this has negatively impacted sales prices globally.
- The continued use of antibiotics in Chile as a response to sustained disease pressure has resulted in a negative market perception in the North American marketplace and this has translated into reduced prices ex-Miami.

- The weakening value of the Japanese Yen (JPY) has placed pressure on supply denominated in USD and overall salmonid imports into Japan have decreased.
- The market in Brazil has come under pressure due to the slowing of their economy placing further pressure on Chilean producers.

This trend has been sharply reversed in the first quarter of 2016 following Chilean losses associated with the previously mentioned algal bloom and reduced harvest forecasts for the coming 2 years.

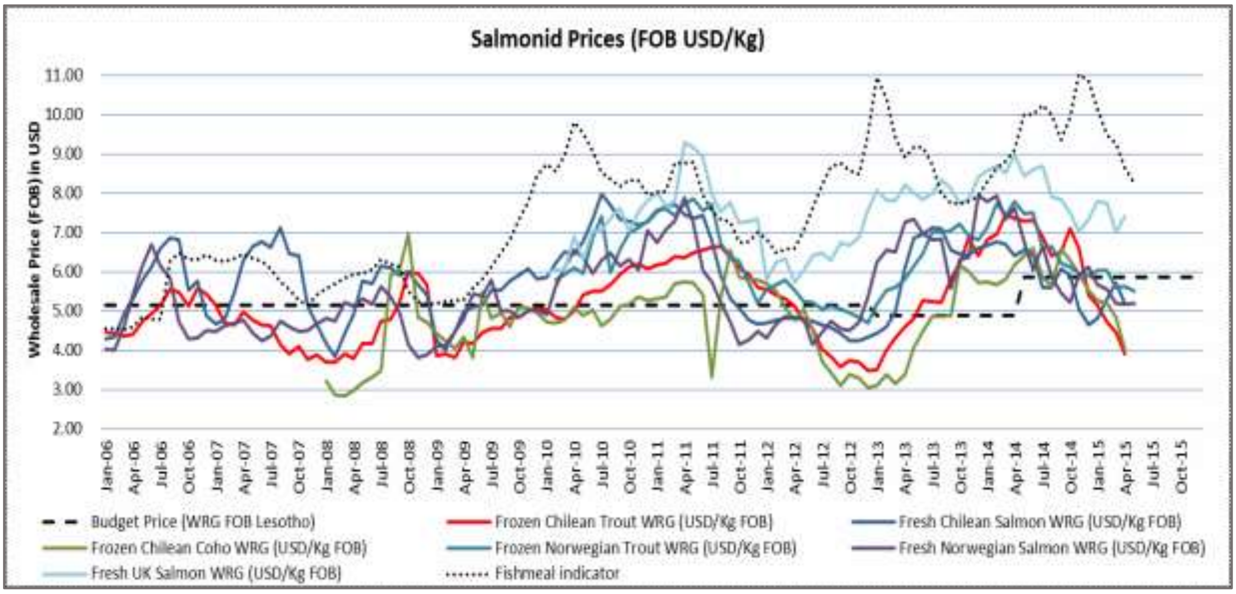


FIGURE 47: GLOBAL SALMONID PRICES (KONTALI ANALYSE, 2015).

Price dynamics

The underlying demand for salmonid products is supported by the fact that year on year increase in demand (estimated at 6% per annum for last 10 years) has exceeded the increase in global production. This is demonstrated by the fact that while the total value of salmonid product sold has tripled since 2004, production has only increased by 85%. It is nevertheless estimated that beyond 2014, demand will equal supply and price fluctuations will be driven by other factors.

Decreasing costs associated with the farming of salmonid species have been supported through increased scale along with key technical advances, including genetic improvements, cost effective feed formulations and accurate monitoring and feeding systems; further improvements however are expected to be marginal and changes in the base cost structure are unlikely to become a driver of future price fluctuations. It is typical in a salmonid farming operation that feed costs will equal + 50% of total costs and as such the cost of the base feed components is likely to remain the main determinant of cost.

South African salmon demand

Salmon, in particular sushi and sashimi, is becoming increasingly popular in South Africa and this has resulted in increased demand for high quality salmon. The majority of salmon products imported into South Africa are fresh or chilled salmon products (Figure 48) (ITC, 2016). The three leading countries of origin for South Africa's salmon imports are Norway, the UK and the USA (NAMC, 2012).

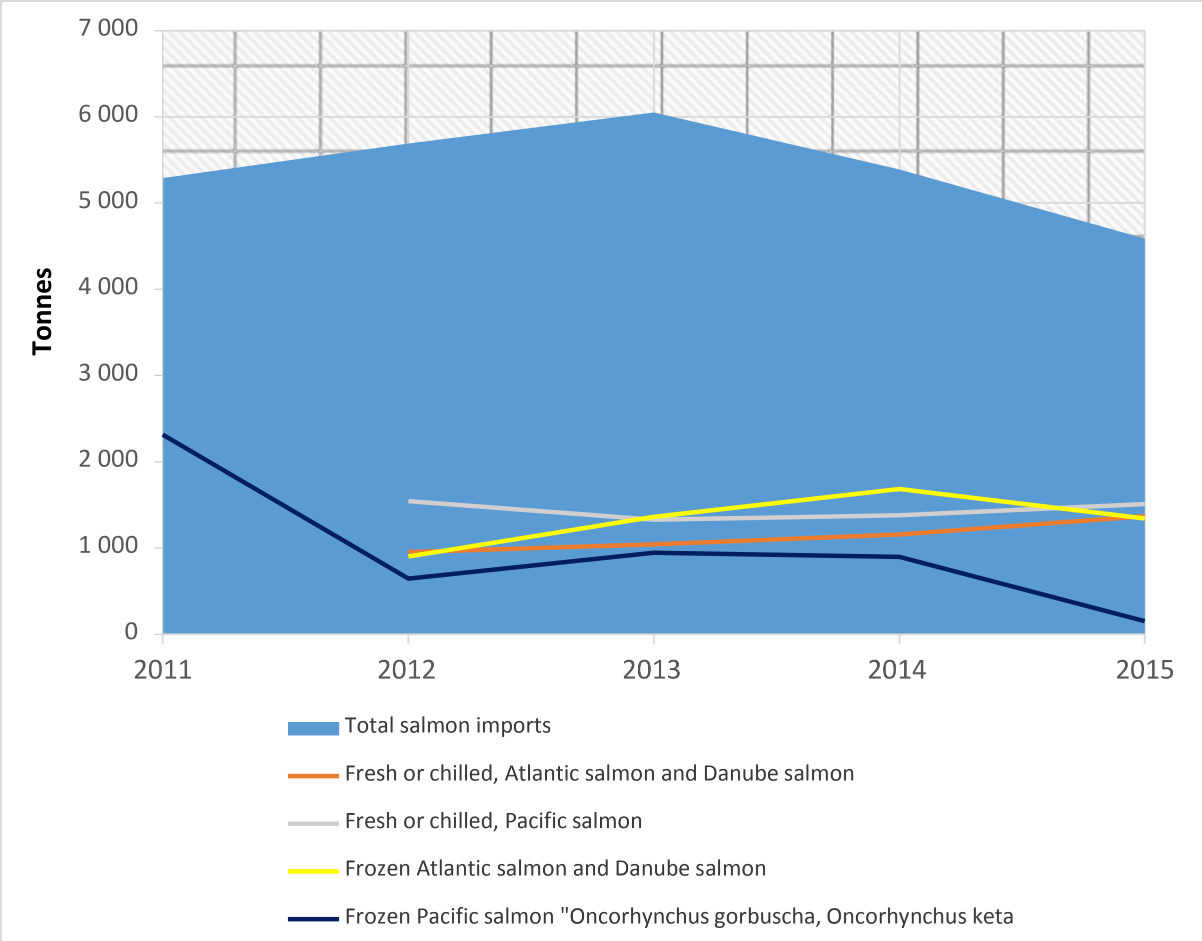


FIGURE 48: SOUTH AFRICAN IMPORTS OF SALMON AND TOP SALMON PRODUCTS (ITC, 2016).

7. CONCEPTUAL PRODUCTION SYSTEM DESIGN AND SPECIFICATIONS

NOTE: As is canvassed in the background study of the feasibility study, there are different production systems for both dusky kob and Atlantic salmon. In order to avoid repetition, the following section will provide a conceptual outline for one potential production system for each species. Full production plans, technical specifications and CAPEX, are provided in the Excel models.

7.1. Dusky kob – 500 tpa RAS hatchery and grow-out facility

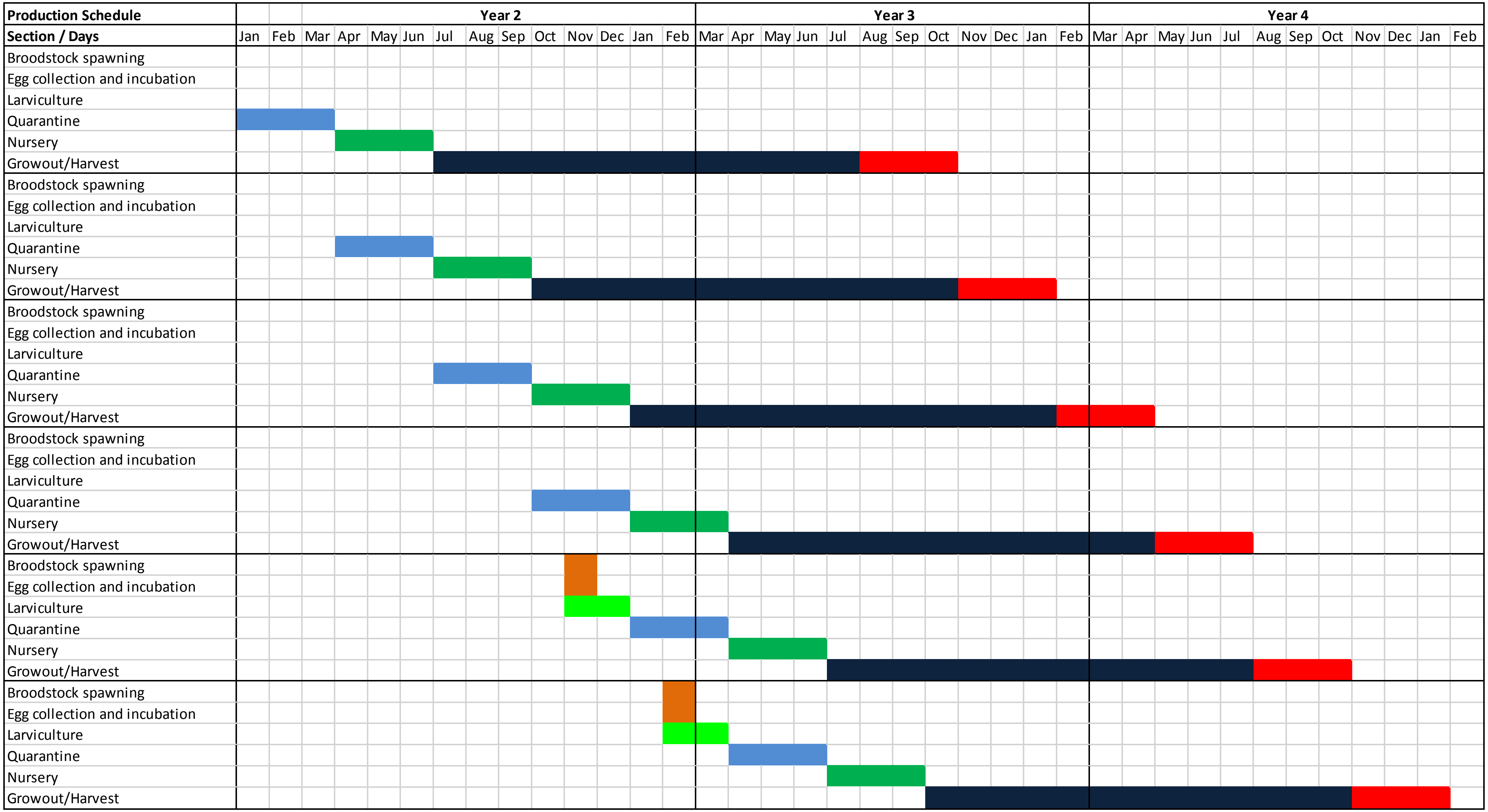
A 500 tpa facility was modelled as this was considered to be a realistic production target based on existing dusky kob aquaculture production statistics and the size of the South African market. The land-based dusky kob facility is a RAS with external and internal water treatment units as well as post-treatment before discharge from the hatchery.

7.1.1. Production plan

The production plan is as follows:

1. The hatchery will produce 2-4g fingerlings in 4 cohort batches for stocking into nursery and grow-out tanks.
2. Production facilities will therefore cater for four production cycles a year (every 12 months). The duration of each fingerling production cycle is approximately 3 months. After the production of a batch, the larval rearing area of the hatchery will be briefly closed to allow for disinfection in order to reduce the chance of disease in the next production cycle (Table 26).
3. Fish will be harvested at 1.8 – 2.7 kg every month, corresponding to a total harvest of approximately 125 tonnes per batch, and 500 tpa.

TABLE 26: PRODUCTION PLAN FOR A CONCEPTUAL 500T DUSKY KOB RAS FACILITY.



7.1.2. Hatchery

The hatchery is to be housed inside a greenhouse structure. Water will be pumped through a drum filter, where it will be filtered to 40 microns before being disinfected using ozone and fed into a reservoir tank. The reservoir tank will act as a sedimentation tank, and will supply both the broodstock systems and the larval rearing systems. From the reservoir the water is pumped separately into the larval rearing and broodstock systems. The hatchery and broodstock systems are all capable of being temperature controlled using heat pumps. Aeration will be by means of a blower, and airlines throughout the building (with oxygen available as backup), feeding both broodstock and larval system tanks and biological filters. A backup generator will supply electricity in the event of a power failure. The building is designed in such a way as to minimise disturbances to both the broodstock and larval systems.

COMPONENT: Broodstock quarantine and acclimation area	
FUNCTION:	
Provide quarantine controls and acclimation treatments for fish entering the hatchery from the external environment.	
TANKS	
Two $10m^3$ tanks	
WATER SUPPLY	
Water exchange: 100% per hour Total water volume: $10m^3$ x 2 = $20m^3$ Raw seawater flow required: $20m^3/h$	
EQUIPMENT	See CAPEX Summary Sheet in Model
CONSIDERATIONS	Located in receipt/dispatch services area Access to freshwater for proper cleaning of equipment Drainage design may to treat effluent prior to disposal Allow for walkways large enough for small equipment – nets, brooms, hose-pipes etc.
COMMENTS	
This area should be located away from the biosecure areas in the hatchery so as to reduce the potential for introduction of pathogens.	
COMPONENT: Broodstock holding and spawning area	
FUNCTION:	
The function of this unit is the proper maintenance of adequate stocks of parent fish to ensure a timely supply of fertilized eggs of the best quality to the larval rearing sector. Three broodstock tanks house two males and four females respectively.	
TANKS	
5 x $50m^3$ volume circular tanks for broodstock holding with walkways and drainage. D-ended tanks promote better water circulation and save space.	
WATER SUPPLY	
Water exchange: 65% per hour Total water volume: $50m^3$ x 5 = $250m^3$ Raw seawater flow required: $162.3m^3/h$	
EQUIPMENT	See Capex Summary in Model
CONSIDERATIONS	Must be adjoined to water storage tanks Must have adjoining area for cleaning equipment Allow for walkways large enough for small equipment – nets, brooms, hose-pipes etc.
Comments	
COMPONENT: Egg incubation area	
FUNCTION:	
Egg incubation tanks house the eggs after collection and prior to stocking in larval rearing tanks. Eggs are	

graded and treated with ozone to reduce the possibility of disease.	
TANKS	
11 x 0.5m^3 diameter cylindro-conical incubation tanks on a flow-through system with walkways and drainage.	
WATER SUPPLY	
Water exchange: 100% per hour Total water volume: 0.5m^3 x 11 = 5.3m^3 Water flow required: 5.3m^3/h	
EQUIPMENT	See CAPEX Summary in Model
CONSIDERATIONS	Must be adjoined to water storage tanks Must have adjoining area for cleaning equipment Must have adjoining area for microscopic analysis of eggs.
Comments	

COMPONENT: Larval rearing area	
FUNCTION:	
Eggs are hatched in the larval rearing tanks which house the larvae for approximately 12 days after which they are transferred to the quarantine tanks.	
TANKS	
4 x 11.5m^3 tanks, enclosed in a building and maintained as a separate quarantined facility.	
WATER SUPPLY	
Water exchange: 200-400% per hour Total water volume: 11.5m^3 x 4 = 46m^3 Water flow required: 184m^3/h	
EQUIPMENT	See CAPEX Summary
CONSIDERATIONS	Must be adjoined to water storage tanks Bio-secure area – allow for decontamination footbaths and hand washing facilities Must have adjoining area for cleaning and disinfection equipment. Allow for walkways large enough for small equipment and trolleys – nets, brooms, hose-pipes etc.
Comments	

COMPONENT: Pure strain and upscale culture room	
FUNCTION:	
Acts as a stock of pure strain algae, rotifers and copepods, as well as upscale cultures for production of large volumes of algae and rotifers.	
SIZE	
Air-conditioned 15m^2 room.	
EQUIPMENT	Glassware including test tubes, pipettes, petri dishes, beakers, flasks, carboys. Freshwater lines CO2 enriched air supply system Aeration Drainage system UV lamp Fluorescent tubes for lighting Glass shelves for placing cultures in glassware Air-conditioning Footbath at entry and exit Hand washing basins
CONSIDERATIONS	Air conditioned room under sterile conditions. Bio-secure area – allow for decontamination entry and exit room
Comments	

COMPONENT: Microalgae duplication room	
FUNCTION:	
Reserved for microalgae duplication and storage of consumables.	
SIZE	
5m^2 room	
EQUIPMENT	Glassware – flasks and carboys for duplicating cultures Air conditioner UV lamps Aeration Glass shelves for placing cultures in glassware Bunsen burner
CONSIDERATIONS	Air conditioned room under sterile conditions. Bio-secure area – allow for decontamination entry and exit room
Comments	

COMPONENT: Intermediate algae, rotifer and copepod culture unit	
FUNCTION:	
Algae and rotifers are cultured in large quantities in polyethylene (PE) bags and/or tanks. They are used directly to feed fish tanks (algae), or as inoculum for duplication and for larger volumes (algae and rotifers)	
SIZE	
26m^2 room.	
EQUIPMENT	PE bags (0.3mm) Wire-mesh cylinders or stands for holding PE bags Seawater lines Tap water CO2 enriched air supply system Air conditioner Aeration – two hoses/PE bag Drainage system UV Sterilizers Fluorescent tube lighting Plastic containers – funnels, cylinders, buckets Glassware to monitor cultures – pipettes, petri dishes, microscope slides
CONSIDERATIONS	Adjacent to the pure strain and starter culture unit. Air conditioned room under sterile conditions Bio-secure area – allow for decontamination entry and exit room
Comments	

COMPONENT: Algal mass culture area	
FUNCTION:	
Algae are cultured in large quantities in tanks.	
SIZE	
Tanks: 8 x 6m^3	
WATER SUPPLY	
Water exchange: 20% per hour Total water volume: 8 x 6 = 48m^3 Water flow required: 9.6m^3/h	
EQUIPMENT	8 x 6m^3 tanks with a conical bottom Drain with valve at cone tip for harvesting Seawater lines Tap water Large plastic filters to harvest rotifers Aeration – 4-5 airstones per tank Drainage system

	Service lighting Plastic containers – funnels, cylinders, buckets Glassware to monitor cultures – pipettes, petri dishes, microscope slides
CONSIDERATIONS	Adjacent to the intermediate algae and rotifer culture unit. Bio-secure area – allow for decontamination entry and exit room
Comments	

COMPONENT: Rotifer and copepod mass culture and enrichment	
FUNCTION:	
Rotifers and copepods are cultured in large quantities in tanks of larger capacity than the PE bags and are then enriched before being fed to fish larvae.	
SIZE	
$26m^2$ room. Tanks: 4 x 1m tanks	
WATER SUPPLY	
Water exchange: 20% per hour Total water volume: $3.8m^3$ x 4 = $15.2m^3$ Water flow required: $3.04m^3/h$	
EQUIPMENT	2 x $1m^3$ tanks with a conical bottom for rotifers 2 x $1m^3$ tanks with a conical bottom for copepods Drain with valve at cone tip for harvesting Seawater lines Tap water Large plastic filters to harvest rotifers Aeration – 4-5 airstones per tank Drainage system Service lighting Plastic containers – funnels, cylinders, buckets Glassware to monitor cultures – pipettes, petri dishes, microscope slides
CONSIDERATIONS	Adjacent to the intermediate algae and rotifer culture unit. Bio-secure area – allow for decontamination entry and exit room
Comments	

COMPONENT: *Artemia* production and enrichment	
FUNCTION:	
The production and enrichment of brine shrimp (*Artemia*) nauplii for larval fish diets.	
SIZE	
One dark room and an adjacent cyst decapsulation area (total area $26m^2$) Tanks: 2 x $1m^3$; 8 x $0.1m^3$	
WATER SUPPLY	
Water exchange: 30% per hour Total water volume: $1m^3$ x 2 + $0.1m^3$ x 8 = $2.8m^3$ Water flow required: $0.84m^3/h$	
EQUIPMENT	Dark room - 2 x $1m^3$ tanks with a conical bottom Decapsulation area – 8 x 100L conical tanks. Tank inner surface gel-coated (white). Drain with valve at cone tip for harvesting Transparent window near cone tip to attract nauplii at harvest time (light source) Seawater lines Tap water Plastic filters for harvesting Strong aeration – open-ended PVC pipes with ball valve Drainage system Lamp (two fluorescent tubes) for each tank with transparent waterproof cover

	Plastic containers – funnels, cylinders, buckets Glassware to monitor cultures – pipettes, petri dishes, microscope slides Wash basin for cleaning implements
CONSIDERATIONS	No windows or transparent walls – total darkness. Tanks against the walls to allow space at centre of the room for harvesting. Adjacent to the rotifer mass culture unit. Bio-secure area – allow for decontamination entry and exit room
Comments	

COMPONENT: Nursery quarantine area	
FUNCTION:	
The nursery quarantine tanks house the fish from 50DAH until they reach a weight of approximately 2-3g.	
TANKS	
12 x 15m^3 tanks with walkways and drainage. Provision may be made for extra tanks for grading purposes.	
WATER SUPPLY	
Water exchange: 100% per hour Total water volume: 15m^3 x 12 = 180m^3 Water flow required: 180m^3/h	
EQUIPMENT	See CAPEX summary in Model
CONSIDERATIONS	Must be adjoined to water storage tanks Must have area for cleaning equipment Allow for walkways large enough for small equipment – nets, brooms, hose-pipes etc.
Comments	

7.1.3. Grow-out

The grow-out production system is contained within a greenhouse structure which allows for a degree of control over ambient temperatures.

COMPONENT: Nursery area	
FUNCTION:	
The nursery tanks house the fish from 2g until they reach a weight of approximately 160g.	
TANKS	
6 x 65m^3 tanks with walkways and drainage. Provision may be made for extra tanks for grading purposes.	
WATER SUPPLY	
Water exchange: 100% per hour Total water volume: 65m^3 x 6 = 390m^3 Water flow required: 390m^3/h	
EQUIPMENT	See CAPEX Summary in Model
CONSIDERATIONS	Must be adjoined to water storage tanks Must have area for cleaning equipment Allow for walkways large enough for small equipment – nets, brooms, hose-pipes etc.
Comments	

COMPONENT: Grow-out area
FUNCTION:
The nursery tanks house the fish from 160g until they reach a weight of approximately 1.9-2.7kg.
TANKS
59 x 65m^3 tanks with walkways and drainage. Provision may be made for extra tanks for grading purposes.
WATER SUPPLY

Water exchange: 65% per hour Total water volume: $65m^3$ x 101 = $6565m^3$ Water flow required: $4268m^3/h$	
EQUIPMENT	See CAPEX Summary in Model
CONSIDERATIONS	Must be adjoined to water storage tanks Must have area for cleaning equipment Allow for walkways large enough for small equipment – nets, brooms, hose-pipes etc.
Comments	

7.1.4. Water treatment units

COMPONENT: Hatchery	
FUNCTION:	
For the treatment of incoming seawater prior to entering the broodstock, egg incubation, larval rearing, and quarantine tanks.	
EQUIPMENT	Drum filters 40micron, 350litres/hr Drum crating HPRS (drum filter) Carbon dioxide stripper Carbon dioxide stripper pumps Protein skimmer Biomedia Biofilter outlet screens Oxygen cones Main system return pumps Oxygen cone system return pumps Oxygen solenoid control panel MCP #1 Motor control for drum filter Low head oxygenator Larvae/quarantine UV water treatment systems
CONSIDERATIONS	
Comments	
COMPONENT: Nursery and grow-out	
FUNCTION:	
For the treatment of incoming seawater prior to entering the nursery and grow-out tanks.	
EQUIPMENT	Drum filter Drum crating HPRS Pump CO_2 Stripper CO_2 Stripper pumps Protein skimmer Biomedia Air grids Blower(s) Blower(s) Accessories Internal walls Biofilter outlet screens O_2 cone Low head oxygenator Main system return pump(s) Oxygen cone system return pumps Oxygen solenoid control panel

	MCP #1 MCP #2
CONSIDERATIONS	
Comments	

7.1.5. Seawater supply

Options available for seawater supply are entirely dependent on the site, proximity to the sea and the nature of the shoreline. If the site is on a rocky shore it may be possible to construct a tidal sump and to then build the pump house over or adjacent to the sump. Construction of a sump would entail digging (and possibly blasting) a sump and reducing wave turbulence by excavating a canal below the low-water springtide mark and laying an oval pipe 1.5m wide by 1m high into the canal and this covered with rock. Alternatively, the sump can be protected by rocks. Secondly, if the site adjoins a sandy beach then a well point system can be constructed. Alternative options may be available if the site is located within an Industrial Development Zone (IDZ) e.g. East London where a common reservoir is used to supply a number of facilities (PureOcean, 2016).

Ideally, water should be abstracted over a low head into a large storage reservoir or header tanks from where it can be gravity-fed through water treatment units into the different farm production areas. The storage reservoir/header tanks provide a safety against any pump failures that are likely to occur at some stage. Gravity-fed seawater supply from a centralised and elevated reservoir is also a cost effective pumping solution in comparison to direct abstraction and supply.

Raw seawater requirements for the different component areas in the facility based on volumes and accepted water exchange rates are shown in Table 27. Assuming a 90% recirculation efficiency with seawater replacement (make-up water) at 10%, the facility will require approximately 8.73 litres per second. Including a contingency water budget of approximately 0.5l/s, the minimum water flow required for the facility is approximately 9.23l/s.

TABLE 27: SUMMARY OF SEAWATER REQUIREMENTS FOR A 500 TPA DUSKY KOB FACILITY OPERATING ON A 90% RAS BASIS.

Production unit	Volume (m^3)	Seawater replacement (10%/day) (l/s)
Broodstock quarantine/acclimation	20	0.023
Broodstock holding/spawning	250	0.28
Egg incubation	5.5	0.006
Larval rearing	46	0.053
Live feed	54.3	0.06
Quarantine	180	0.21
Nursery	390	0.45
Grow-out	6 565	7.6
Biofilters	90	0.1
TOTAL	**7 600**	**8.73**

7.1.6. Wastewater discharge

Waste or used seawater from the farms should be passed through a discharge filtration system. Discharge system options will depend on the location of the site. If the site is located such that it may access a sewerage system (as is the case in an IDZ), then wastewater may be passed through sediment filter bags to remove particulate waste before it is discharged into the sewerage system. In more remote areas, discharge systems may include a drum filter and settling pond equipped with biofilters to ensure adequate mechanical and biofiltration, respectively, prior to the water being discharged back into the sea.

7.1.7. Power supply

In areas with access to public electricity, facilities are supplied with power from ESKOM. In the case of ESKOM shutdowns and/or power failures, standby electricity may be generated by a diesel powered genset. Standby electricity is only provided for life support systems and for cold rooms.

7.1.8. Human resources

When fully operational, the farm would employ a total of 58 people as shown in Table 28.

TABLE 28: HUMAN RESOURCES FOR A 500 TPA DUSKY KOB OPERATION.

Resource	Quantity
Directors	
Managing Director	1
Financial Director	1
Sales and Marketing Director	-
Processing	
Processing Manager	1
Quality Controller	1
Food Safety Officer	-
Technician	-
Team Leaders	1
Processing workers	3
Packaging and storage workers	3
Grow-out	
Production Manager	1
GO Supervisor	1
Workshop Supervisor	2
Drivers/Technicians	3
Team Leaders	3
General Workers	15
Hatchery	
Supervisor	1
Team Leaders	1
General Workers	4
Nursery	
Supervisor	1
Team Leaders	1

General Workers	2
Live feed production	
Supervisor	1
Team Leaders	1
General Workers	3
Laboratories and Environmental	
Environmental Officer	-
Lab Technicians	1
General Workers	1
Administration including sales	
Financial Manager	-
Sales Manager	1
Stakeholder Relations Manager	-
Admin Officers	1
Receptionist/other	1
Cleaners	2
Total	**58**

7.2. Atlantic salmon – 2 000 tpa RAS hatchery and offshore cage culture grow-out operation

The 2 000 tpa conceptual Atlantic salmon operation comprises a land-based RAS hatchery and smolt production facility with external and internal water treatment units as well as post-treatment before discharge from the hatchery. The offshore-based component comprises grow-out cages. The choice of scale is based on the typical production scales by a farm in other production regions from a global context. Furthermore, the production plan accounts for a hatchery and smolt production facility and therefore a larger scale is required in order to achieve the capacity to cover the capital expenditure associated with infrastructure costs.

7.2.1. Production plan

The production plan for the operation is shown in Table 29. In summary:

1. Atlantic salmon eggs will be imported in April/May every year and incubated at the hatchery.
2. The hatchery will produce two batches of S0 (under-yearling) smolts (approx. 70-80g) and one batch of S1 smolts (approx... 130g) smolts for stocking into the grow-out cages.
3. S0 smolts will be stocked in March and June, while S1 smolts will be stocked in the spring (October)
4. Fish will be harvested from 3—6kg. Harvesting may take place year round although this will depend on suitable measures to reduce the proportion of early maturing grilse (approx. 1.5kg). These fish will mature prior to their second calendar winter and will have to be harvested as mature fish are less desirable for market.
5. Precocious parr will be culled.

Please refer to “Atlantic Salmon model.xls” file for the detailed bioplan.

TABLE 29: PRODUCTION PLAN FOR A CONCEPTUAL 2 000 TPA ATLANTIC SALMON FACILITY.

Production Schedule			Year 2												Year 3												Year 4												Year 5											
Section/Days	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Egg incubation/Alevins																																																		
Fry-Parr																																																		
Parr-Smolt																																																			
S0 Smolt Growout																																																		
S0 Smolt Growout																												GRILSE																						
S1 Smolt Growout																																																		
Egg incubation/Alevins																																																		
Fry-Parr																																																		
Parr-Smolt																																																		
S0 Smolt Growout																																																		
S0 Smolt Growout																																								GRILSE										
S1 Smolt Growout																																																		
Egg incubation/Alevins																																																		
Fry-Parr																																																		
Parr-Smolt																																																		
S0 Smolt Growout																																																		
S0 Smolt Growout																																																		
S1 Smolt Growout																																																		
Egg incubation/Alevins																																																		
Fry-Parr																																																		
Parr-Smolt																																																		
S0 Smolt Growout																																																		
S0 Smolt Growout																																																		
S1 Smolt Growout																																																		

7.2.2. Hatchery

The hatchery is housed inside a greenhouse structure. Water will be pumped through a drum filter, where it will be filtered to 40 microns before being disinfected using ozone and fed into a reservoir tank. The reservoir tank will act as a sedimentation tank, and will supply both the smolt production facility. From the reservoir the water is pumped into the hatchery. The egg incubation, first-feeding fry, parr, and smolt systems are all capable of being temperature controlled using heat pumps and chiller units. Aeration will be by means of a blower, and airlines throughout the building (with oxygen available as backup. A backup generator will supply electricity in the event of a power failure. The building is designed in such a way as to minimise disturbances. (Note: For a detailed list of equipment for both the hatchery and cage grow-out facilities, please refer to the "Atlantic Salmon Model/Aquaculture Systems – Hatchery" and "Atlantic Salmon Model/Aquaculture systems – Cages" excel sheets.

COMPONENT: Egg incubation/alevin rearing area	
FUNCTION:	
Egg incubation trays house the eggs after receipt from overseas. Eggs are incubated and hatched in the trays. The alevins are housed in the trays until they are ready to be transferred to first-feeding fry tanks.	
TANKS	
100 x Egg Trays	
WATER SUPPLY	
Water exchange: Industry standard 20l/s Total water volume: 1L trays x 100 = $0.1m^3$ Water flow required: $1,2m^3/h$	
EQUIPMENT	Egg trays are incorporated into vertical incubation stacks. The trays are supplied with water at the uppermost tray before circulating through the egg trays.
CONSIDERATIONS	Must be adjoined to water storage tanks Must have adjoining area for cleaning equipment Must have adjoining area for microscopic analysis of eggs. Preferably located adjacent to fry rearing area for rapid transferral to first-feeding fry tanks.
Comments	

COMPONENT: First-feeding fry and parr rearing	
FUNCTION:	
Alevins (0.01-0.05g) are transferred to the first-feeding fry tanks. Feed is introduced and the fry are reared to a size of approximately 2g after which they have developed parr markings and are ready for transfer to the smolt tanks.	
TANKS	
15 x $15m^3$ tanks.	
WATER SUPPLY	
Water exchange: 200% per hour Total water volume: $15m^3$ x 15 = $255m^3$ Water flow required: $112.5m^3/h$	
EQUIPMENT	Circular fibreglass or plastic, black-walled tanks with sloping bottom to aid waste removal White bottomed tanks for easier detection of fry and debris removal Drainage channels Water supply pipes Airstones Halogen lamps Dimmers Water quality measuring equipment

	Footbaths and hand washing basins at entry and exit Lockable door
CONSIDERATIONS	Must be adjoined to water storage tanks Bio-secure area – allow for decontamination footbaths and hand washing facilities Must have adjoining area for cleaning and disinfection equipment. Allow for walkways large enough for small equipment and trolleys – nets, brooms, hose-pipes etc.
Comments	

COMPONENT: Parr-smolt rearing tanks	
FUNCTION:	
The smolt tanks house the parr from a size of approximately 2g- 70-130g at which stage they have undergone smoltification and are ready for transfer to grow-out cages.	
TANKS	
6 x 200m^3 tanks with walkways and drainage. Provision may be made for extra tanks for grading purposes.	
WATER SUPPLY	
Water exchange: 100% per hour Total water volume: 200m^3 x 6 = 1200m^3 Water flow required: 1800m^3/h	
EQUIPMENT	Circular/D-ended fish tanks with white bottoms Drainage channels Seawater supply pipes Oxygen supply pipes Airstones Plastic buckets and handling nets Halogen lamps Dimmers
CONSIDERATIONS	Must be adjoined to water storage tanks Must have area for cleaning equipment Allow for walkways large enough for small equipment – nets, brooms, hose-pipes etc.
Comments	

7.2.3. Grow-out

Once the fish have undergone seawater challenge tests, the smolts will be transferred to seawater grow-out cages.

COMPONENT: Grow-out cages	
FUNCTION:	
The cages will house the salmon from a weight of approximately 80-110g until harvest (3-6kg).	
CAGES	
34 x Ø15.9m x 15m depth floating HDPE cages	
EQUIPMENT	Circular HDPE floating cages Mooring blocks Buoys Anchor chains and rope Predator nets Walkways Plastic buckets and handling nets
CONSIDERATIONS	Allow for walkways large enough for small equipment – nets, brooms, hose-pipes etc.

Comments

7.2.4. Water treatment units

COMPONENT: Hatchery	
FUNCTION:	
For the treatment of incoming freshwater prior to entering the egg incubation, fry-parr, and parr-smolt tanks.	
EQUIPMENT	Drum filters 40Micron, 350litres/hr Drum crating HPRS (drum filter) Carbon dioxide stripper Carbon dioxide stripper pumps Water chiller units Biomedia Biofilter outlet screens Oxygen cones Main system return pumps Oxygen cone system return pumps Oxygen solenoid control panel MCP #1 Motor control for drum filter Low head oxygenator UV water treatment systems
CONSIDERATIONS	
Comments	

7.2.5. Freshwater supply

Options available for freshwater supply are entirely dependent on the site, proximity to the water source and the topography of the area.

Ideally, water should be abstracted over a low head into a large storage reservoir or header tanks from where it can be gravity-fed through water treatment units into the different farm production areas. The storage reservoir/header tanks provide a safety against any pump failures that are likely to occur at some stage. Gravity-fed freshwater supply from a centralised and elevated reservoir is also a cost effective pumping solution in comparison to direct abstraction and supply.

Raw freshwater requirements for the different component areas in the facility based on volumes and accepted water exchange rates are shown in Table 30. Assuming a 90% recirculation efficiency with freshwater replacement (make-up water) at 10%, the facility will require approximately 4.46 litres per second. Including a contingency water budget of approximately 0.5l/s, the minimum water flow required for the facility is approximately 5.03l/s.

TABLE 30: SUMMARY OF RAW FRESHWATER REQUIREMENTS FOR A 2 000 TPA ATLANTIC SALMON FACILITY OPERATING ON A 90% RAS BASIS.

Production unit	Total water volume (m^3)	Freshwater replacement (10%/day) (l/s)
Egg incubation/alevins	0.1	0.00005
First-feeding fry/parr rearing	225	0.26
Parr-smolt rearing tanks	1 200	1.38
Biofilters	35	0.04
TOTAL	**1 460**	**1.72**

7.2.6. Wastewater discharge

Waste or used freshwater from the farms should be passed through a discharge filtration system. Discharge system options will depend on the location of the site. If the site is located such that it may access a sewerage system (as is the case in an IDZ), then wastewater may be passed through sediment filter bags to remove particulate waste before it is discharged into the sewerage system. In more remote areas, discharge systems may include a drum filter and settling pond equipped with biofilters to ensure adequate mechanical and biofiltration, respectively, prior to the water being discharged back into the environment.

7.2.7. Power supply

In areas with access to public electricity, facilities are supplied with power from ESKOM. In case of ESKOM shutdowns and/or power failures, standby electricity may be generated by a diesel powered genset. Standby electricity is only provided for life support systems and for cold rooms.

7.2.8. Human resources

When fully operational the farm would employ a total of 130 people as shown in Table 31.

TABLE 31: HUMAN RESOURCES REQUIRED FOR A SALMON RAS FACILITY.

Resource	Quantity
Directors	
Managing Director	1
Financial Director	1
Sales Director	1
Legal Director	1
Processing	
Processing Manager	1
Quality Controller	1
Food Safety Officer	1
Technician	1
Team Leaders	3
Processing	14
Packaging	8
Grow-out	
Production Manager	1
GO Supervisor	2

Workshop Supervisor	2
Skippers /drivers/technician	12
Team Leaders	5
General Workers	34
Hatchery and Smolt Production	
Production Manager	1
Hatchery supervisor	1
Team Leaders	3
General Workers	21
Laboratories and Environmental	
Environmental Officer	1
Lab Technicians	3
General Workers	3
Administration including sales	
Financial Manager	-
Junior Sales Manager	1
Stakeholder Relations Manager	-
Admin Officers	1
Admin Officers	2
Receptionist/other	1
Cleaners	3
Total	**130**

8. FINANCIAL STUDY

8.1. Introduction

The financial models were constructed on the back of four primary determinants (Figure 49). These were: market intelligence; the scientific understanding of growth, mortality, EFCR, optimal stocking densities for the candidate species and the interdependence between them; the required infrastructure for the production system and the associated cost; and, finally, the incorporation of operational costs.

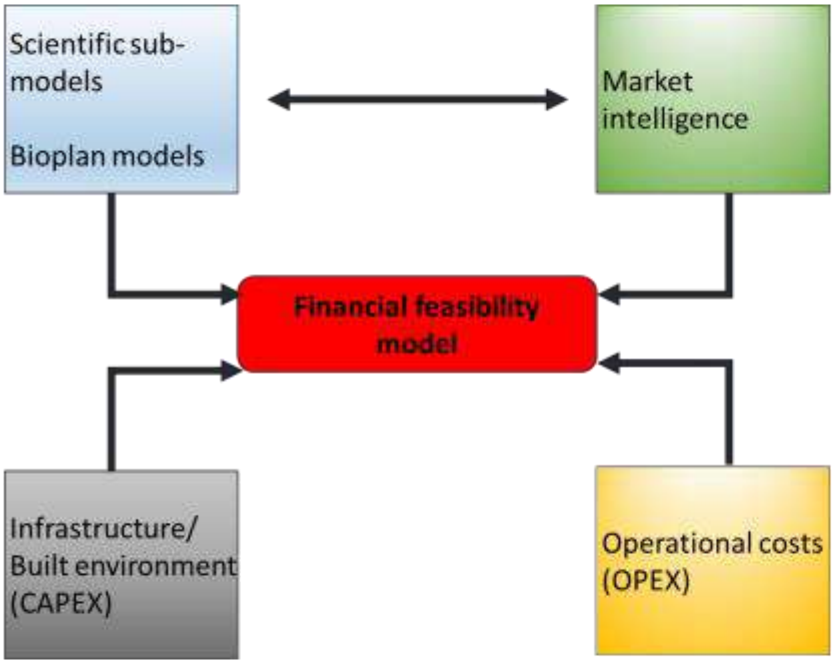


FIGURE 49: FINANCIAL MODEL DETERMINANTS.

8.1.1. Scientific sub-models

The scientific "engine room" sub-models are based on the biological performance of the candidate species under culture conditions. This information is used to derive the "bioplan model" which provides the basis for the development of the financial models.

Key data requirements for the formulation of the bioplan are:

- Growth at length/weight
- Mortality at length/weight
- EFCR at length/weight

Ideally, growth, mortality, and EFCR data at different temperatures will allow the bioplan to more accurately track the biomass of a cohort batch over time under different environmental conditions.

Data limitations

The feasibility studies are based on the high-level, non-site specific viability of farming marine finfish in South Africa. Environmental conditions, and specifically water temperature, will have a significant impact on the growth, mortality and EFCR of a batch of fish. Water temperature varies widely in South Africa, with lower temperatures associated with the Benguela Current on the west coast of South Africa and higher temperatures associated with the Agulhas Current experienced on the east coast. With a wide range in water temperature, it was considered unrealistic to develop bioplans that covered such an extensive geographic area. Furthermore, particularly in the case of dusky kob, there is little growth data available at different temperatures and length/weights. Therefore, it was decided to use biological performance data that were available from regions where the species has been, or currently is being, farmed.

Dusky kob

Growth, mortality, EFCR, and stocking density data (where possible) were obtained from industry. This data is not temperature-specific and, therefore, growth at different sizes for dusky kob was modelled based on data that were available from a specific production system (RAS, cages and ponds).

Atlantic salmon

Growth, mortality and EFCR at different water temperatures are well-documented and these data were obtained from industry. Stocking density information was obtained from the literature. As there was no specific geographic location specified for the feasibility studies, it was decided to use water temperature data from Saldanha Bay, Western Cape, in order to model growth of Atlantic salmon.

8.1.2. Infrastructure and built environment (CAPEX)

The bioplan was used to specify and cost infrastructure and equipment requirements for the species and production system based on the biomass in the system during the production cycle. Cost estimates of the technical infrastructure required for each species were based on an intense costing exercise undertaken by the project team.

The major CAPEX categories for the models are as follows:

1. Pre-development – includes typical costs associated with feasibility studies, concept designs, and fund-raising activities.
2. Land – indicative costs associated with the land requirements for different production systems i.e. cage operations will require less land than land-based RAS systems and therefore cost of land is assumed to be lower.
3. Infrastructure – costs of bulk infrastructure including electricity, roads and potable water.
4. Services – costs of pumping equipment and infrastructure, the provision of oxygen and air, and wastewater treatment and drainage from the facility.
5. Buildings – costs of the built environment including hatcheries, grow-out systems, processing facilities, laboratories, canteens, offices and ablutions.
6. Aquaculture systems – Land-based – costs of aquaculture equipment including tanks, filtrations systems, lighting and life-support services.
7. Aquaculture systems – water-based (cages or ponds) – costs associated with cage or pond infrastructure.
8. Vehicles – costs of tractors, boats and cars.
9. Transport and logistics – costs associated with the delivery of equipment and other during the construction phase.

10. Professional fees – design fees for engineers, architects, technicians and project management fees.
11. Contingency – costs at 5% of total project value

Data limitations

In the absence of a specific geographic location, costs of land, bulk infrastructure, buildings and services are difficult to quantify. For example, bulk infrastructure costs may vary widely depending on whether the operation is in an IDZ or remote, rural area. The cost estimates used in the models are therefore indicative.

8.1.3. Market intelligence

Market factors are of crucial importance in determining the viability of an operation. Market factors which were considered for the financial models included:

1. Existing markets
2. Size of markets
3. Domestic and export markets
4. Market maturity
5. Product forms
6. Sales price

Based on these factors, realistic assumptions regarding the markets that could be accessed and sales prices that could be achieved were made.

8.1.4. Operational costs

Operational costs included:

- Feed
- Ova
- Electricity
- Packaging
- Water lease fees

These were obtained from various sources (e.g. ESKOM website, industry sources). Feed costs were obtained directly from the suppliers and packaging and transport costs are based on industry standards. Rental costs are an unknown at this stage and depend on the kind of future business relationship between the company and community. Cost of ova was obtained from potential suppliers. The cost of consumables, administration cost and general repairs and maintenance were obtained from the consultants own database and from industry experience.

In summary, it is essential to note that this is a high-level model. If a project is to go to the business planning phase, then the model will need to be further refined to an accuracy level of 90%. However, diligence has been applied in providing detail to the model in order to increase its accuracy for viability modelling in the future.

8.2. Production alternatives

Alternative scenarios in terms of production system and operational scale have been applied to the financial analysis and the financial upside they would return. These scenarios are not finite and are impacted by other various factors such as sales price, varying costs of production and management practices. However, the analysis of different scenarios allows for simultaneous assessments of key financial aspects of production of dusky kob and Atlantic salmon under varying production assumptions.

It is important to note that comparisons of different production systems and general conclusions of financial desirability are based on assumptions (for example, input data, capital requirements, production costs or the financial results) in the absence of a defined geographic location and, therefore, should be considered indicative. Notwithstanding these limitations, these models are based on known industry standards. Missing parameters and other information (such as costs of pond construction, use of labour etc.) were estimated from other sources or from first principles, as appropriate. These models allow for the estimation of sensitivity to changes in input costs, market price and production parameters.

8.3. Key assumptions to the financial models

The key assumptions used in the financial models are summarised below and are provided in the .xls file. These may be subject to change depending on the objectives of a prospective operator and the circumstances at the time of modelling.

8.3.1. Exchange rates and inflation

The financial model uses South African Rands (ZAR). The model assumes that both income and expenditure will be inflated at an annual fixed rate of 6% for the 10 year duration of the model in line with conservative inflation and devaluation forecasts. The exception to the above is the cost of electricity which is inflated more aggressively in line with Eskom predictions.

8.3.2. Income tax

The model is based on a commercial aquaculture project that will be subject to relevant corporate tax provisions and a corporate tax rate of 28.0% has been applied accordingly. If a potential operator implements such a project in an area marked for industrial development, such as in an SEZ or ADZ, preferential tax rates may be applicable and should be adjusted accordingly.

8.3.3. Biological assumptions

The biological assumptions as they relate to economic feed conversion ratio (EFCR) and product yield are shown in Table 32. These assumptions are conservative. Growth, mortality, and EFCR data at age and temperature (where possible) are provided in the "Input Data" tab on the financial model .xls files.

TABLE 32: BIOLOGICAL ASSUMPTIONS FOR DUSKY KOB AND ATLANTIC SALMON.

Biological assumption	Dusky kob	Atlantic salmon
EFCR – RAS	1.3	1.4
EFCR – cages	1.6	1.6
EFCR – ponds	1.8	NA
Product yield (G&G)	90%	-
Product yield (WRG)	-	90%
Product yield (H&G)	-	78%

Biological assumption	Dusky kob	Atlantic salmon
Product yield (fillets)	-	45%
G&G: Gilled and gutted WRG: Whole, round, gutted H&G: Headed and gutted		

8.3.4. Market and price assumptions

Table 33 provides a summary of the key product and market assumptions used for dusky kob and Atlantic salmon.

TABLE 33: RELEVANT PRODUCT ASSUMPTIONS USED PER CANDIDATE SPECIES.

Market assumptions	Dusky kob	Atlantic salmon
Product mix	100% Fresh, G&G	50% Fresh, Whole round gutted, 50% Frozen, H&G
Percentage product in SA	100%	70%
Percentage product exported outside SA	0%	30%
SA Price/kg (Fresh)	ZAR 80.00 (G&G)	ZAR 85.00 (WRG)
SA Price/kg (Frozen)	ZAR 65.00 (G&G)	ZAR 80.00 (H&G)
Export price/kg (Fresh)	-	ZAR 105.00 WRG)
Export price/kg (Frozen)	-	ZAR 100.00 (H&G)

Dusky kob

- ***Product mix***

The domestic market for farmed dusky kob is based on fresh, gilled and gutted (G&G) product. The models are therefore based on a product mix which is 100% fresh, G&G.

- ***Local and export market***

Large-scale commercial production of dusky kob in South Africa is still in its infancy and an export market for kob is yet to be established. Therefore, for the purposes of the results presented here, it was assumed that all dusky kob production would be directed to the South African market only. This is not to suggest that, given a detailed marketing and advertising exercise, farmed dusky kob could not represent a viable export prospect in future.

It is important to note that the model user can input a percentage of product exported outside South Africa; however, it is essential that this is based on realistic assumptions of price and cost of sales. Any model which includes a component of product to be exported is making a significant assumption that dusky kob could access a competitive market, establish a brand and obtain a preferential price compared to that which is obtained in South Africa while supplying significant volumes of product.

- ***Price***

The model assumed a sales price of ZAR 80.00 /kg for fresh, G&G dusky kob and this may be adjusted accordingly. This price is slightly higher than the current industry standard of ZAR 75.00 /kg. It was assumed that, given a consistent supply of high quality product, an operator may be able to obtain this sales price.

Atlantic salmon

- ***Product mix***

The market for Atlantic salmon is mature with diverse product offerings. The model assumed the product mix would include 50% whole, round, gutted fresh salmon and 50% frozen, head off gutted product.

- ***Local and export market***

The Atlantic salmon global market is well established. It was assumed that a proportion of Atlantic salmon product could be exported. This export market was assumed to be Asian-based. Furthermore, given that South Africa imports significant quantities of Atlantic salmon, it was assumed that a proportion would be sold into the South African market.

- ***Price***

The model assumed a sales price of ZAR 85.00 /kg for Atlantic salmon and this may be adjusted accordingly.

8.3.5. Cost of sales

In the absence of a specific geographic locations of the farms, sales costs of logistics (both in SA and export) are variable and can be adjusted by the model user. The present values are considered to be within reasonable bounds, however.

TABLE 34: ASSUMED SALES COSTS FOR THE FINANCIAL MODELS.

Sales costs	Unit	Dusky kob	Atlantic salmon
Local consignment size	kg	3 000	21 000
International export consignment size	Kg	-	21 000
SA sales costs – logistics	ZAR	10 000.00	25 000.00
SA sales costs – commissions	%	5	5
Export logistics costs	ZAR	-	85 000.00

Dusky kob

Farmed dusky kob is typically sold in consignments ranging from 500 – 3 000 kg. This will depend on agreements with different buyers in different markets as well as the product. Smaller consignments are typical for the restaurant industry. For the purposes of the model, it was assumed that consignment size for dusky kob was 3 000 kg.

Atlantic salmon

Consignment size for Atlantic salmon was assumed to be similar to that of the large rainbow trout industry in Lesotho – typically a container which contains 21 000 kg (21 tonnes) of product.

8.3.6. Operational and other costs

Packaging costs, ova and vaccine costs (Atlantic salmon), fingerling costs (dusky kob) and feed prices were obtained from industry (Skretting, a leading producer of salmon feed).

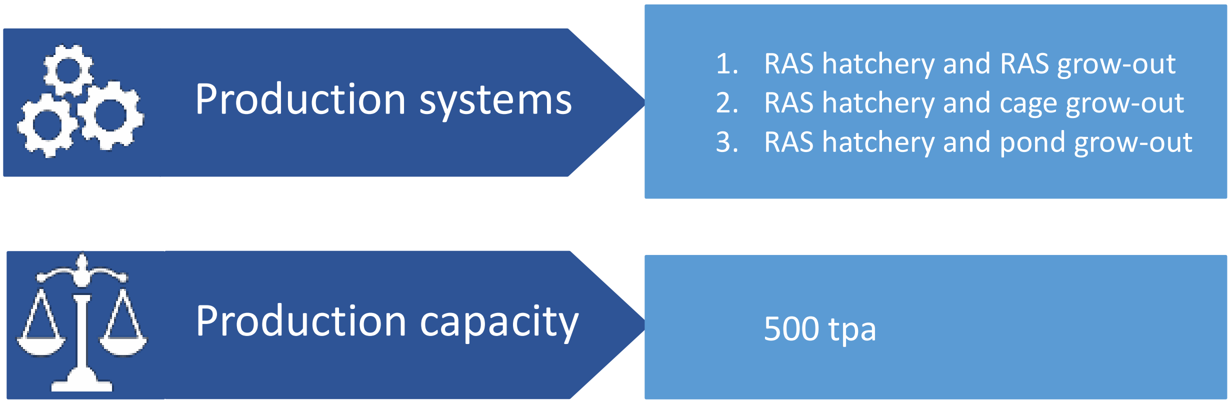
Waste removal costs were determined from industry standard rates for removal of fish waste. The models assume that all fish waste from processing and mortalities will be removed by an established waste removal company. The operator may, however, consider waste treatment and storage strategies in order to reduce these costs.

TABLE 35: SUMMARY OF OPERATIONAL AND OTHER COSTS.

Item	Unit	Dusky kob	Atlantic salmon
SA packaging costs (fresh)	ZAR/kg	4.00	-
SA packaging costs (frozen)	ZAR/ kg	-	2.00
International packaging costs (frozen)	ZAR/ kg	-	2.50
Waste removal	ZAR/ kg	2.50	2.50
Ova costs	ZAR/ 1 000 ova	-	480.00
Fingerling costs	ZAR	2.50	-
Vaccine costs	ZAR/ fingerling	-	0.20
Average feed price (ex-works)	ZAR/ kg	24.50	24.00

8.4. Dusky kob

The modelled scenarios for dusky kob were as follows:



A 500 tpa facility was modelled as this was considered to be a realistic production target based on existing dusky kob aquaculture production statistics and the size of the South African market. These are subject to change depending on the objectives of the prospective operator which will determine production volumes, market, product, CAPEX, OPEX and the feasibility or otherwise of the operation. A detailed breakdown of the financial viability, including CAPEX/OPEX/income, is provided in the financial models as an .xls file.

8.4.1. Capital expenditure

A detailed breakdown of the capital expenditure is provided in the financial models as an .xls file. The total capital costs associated with the development of a dusky kob aquaculture project under the production assumptions are summarised as per Table 36. It is important to note that capital expenses such as land, bulk infrastructure, services, transport and logistics will vary depending on the location of the operation.

TABLE 36: TOTAL CAPITAL COSTS (ZAR) FOR DUSKY KOB.

Production assumption			
Production system	**RAS hatchery & RAS grow-out**	**RAS hatchery & cage grow-out**	**RAS hatchery & pond grow-out**
Production scale	**500**	**500**	**500**
Summary of capital expenses (ZAR)			
Pre-Development	1 509 838	435 854	1 119 607
Land	10 000 000	5 000 000	15 000 000
Bulk infrastructure	4 619 500	2 532 000	4 132 000
Buildings	72 439 800	14 014 800	14 014 800
Services	7 569 750	3 779 750	4 085 500
Aquaculture systems – land based	20 646 295	3 921 470	3 923 072
Aquaculture systems – water based	-	7 340 910	52 617 113
Vehicles	607 500	2 357 500	1 007 500
Transport and logistics	250 000	250 000	250 000
Professional fees	16 446 590	4 560 991	9 534 322
Contingency (5%)	6 704 464	2 209 664	5 284 196
Total (excl. professional fees and contingency)	117 632 682	39 632 283	96 149 592
Total nett of consulting fees	16 446 590	4 560 991	9 534 322
Total % of consulting fees on total project cost	14.09%	11.51%	9.92%
TOTAL	**140 793 736**	**46 402 938**	**110 968 109**

8.4.2. Operational expenditure

A detailed breakdown of the operational expenditure is provided in the financial model as an .xls file.

Costs of production

Costs of production include feed, electricity, human resources, and operation of equipment. The costs of production for dusky kob in different production systems were categorised as follows:

- **Fingerling/juvenile costs** – all costs associated with rearing of juveniles in hatchery operations including live feed but excluding inert, pelletised feed.
- **Grow-out costs** – costs of grow-out of juveniles to harvest size excluding feed.
- **Laboratory costs** – costs of laboratory operations including equipment maintenance and calibration.
- **Feed costs** – total costs of feed including hatchery and grow-out operations.
- **Overhead *and* Fixed costs** – all overhead and fixed costs including accounting, legal, insurance costs
- **Financing costs** – financing of capital investment costs
- **Processing costs** – costs of processing and packaging
- **Yield loss costs** – costs of lost product through processing
- **Sales costs** – cost of sales

The costs of production (ZAR /kg) of dusky kob in the three production systems with a terminal harvest volume of 500 tpa is shown in Table 37. The cost drivers, shown as a percentage contribution to overall cost, are shown in Table 38.

TABLE 37: COSTS OF PRODUCTION OF DUSKY KOB IN THREE PRODUCTION SYSTEMS WITH A TERMINAL HARVEST VOLUME OF 500 TPA

Production assumption			
Production system	**RAS hatchery & RAS grow-out**	**RAS hatchery & cage grow-out**	**RAS hatchery & pond grow-out**
Production scale (approx.)	**500**	**500**	**500**
Cost of production (ZAR /kg)			
Juvenile costs	4.62	2.61	2.63
Grow-out costs (/kg LFE)	6.85	6.56	6.74
Laboratory costs	0.70	0.71	0.71
Total feed costs (/kg LFE)	32.45	36.86	39.98
Overhead costs (/kg LFE)	1.64	1.67	1.66
Fixed costs (/kg LFE)	6.58	6.67	6.66
Financing costs (at 5%) (/kg LFE)	14.08	4.64	11.10
Total costs ex-grow-out system (/kg LFE)	**66.91**	**59.72**	**69.47**
G&G loss @ 90% yield	7.43	6.64	7.72
Total costs ex-grow-out system (/kg G&G)	**74.35**	**66.35**	**77.19**
Processing costs (/kg G&G)	7.52	7.31	7.58
Total costs FOB (/kg G&G)	**81.87**	**73.66**	**84.77**
Sales costs (/kg G&G)	8.13	8.97	8.15
Total costs sold (/kg G&G)	**90.00**	**82.63**	**92.92**
Target price @ 25% margin	120.01	110.17	123.89
Target price @ 33% margin	134.34	123.33	138.69
Through-rate price (ZAR /kg)	79.73	80.10	79.29
Margin @ budget /through-rate price	**-12.89 %**	**-2.87 %**	**-17.20 %**
LFE: Life fish equivalent G&G: Gilled & gutted FOB: Free on board			

TABLE 38: COSTS OF PRODUCTION (%) OF DUSKY KOB IN THREE PRODUCTION SYSTEMS WITH A TERMINAL HARVEST VOLUME OF 500 TPA.

Production system	**RAS hatchery & RAS grow-out**	**RAS hatchery & cage grow-out**	**RAS hatchery & pond grow-out**
Production scale (approx.)	**500**	**500**	**500**
Cost of production (%)			
Juvenile costs	5.13	3.16	2.83
Grow-out costs (/kg LFE)	7.61	7.70	7.25
Laboratory costs	0.77	0.86	0.76
Total feed costs (/kg LFE)	36.05	44.73	43.03
Overhead costs (/kg LFE)	1.82	2.02	1.79
Fixed costs (/kg LFE)	7.31	8,09	7.16
Financing costs (at 5%) (/kg LFE)	15.64	5,63	11.95
Total costs ex-grow-out system (/kg LFE)	**74.33**	**72,22**	**74.76**
G&G loss @ 90% yield	8.25	8,02	8.31
Total costs ex-grow-out system (/kg G&G)	**82.58**	**80,24**	**83.07**

Production system	RAS hatchery & RAS grow-out	RAS hatchery & cage grow-out	RAS hatchery & pond grow-out
Production scale (approx.)	**500**	**500**	**500**
Cost of production (%)			
Processing costs (/kg G&G)	8.35	8,87	8.16
Total costs FOB (/kg G&G)	**90.93**	**89.11**	**91.23**
Sales costs (/kg G&G)	9.07	10.89	8.77
Total costs sold (/kg G&G)	**100**	**100**	**100**

Results in Table 37 indicate that cage grow-out systems have the lowest cost production system for dusky kob. This is further highlighted in the results of the financial projections presented in Section 8.4.3.

The main cost driver was feed, and this was highest in pond systems and lowest in RAS. Other cost drivers included financing costs, which were highest for RAS and ponds, and processing and sales costs.

Juvenile costs are directly related to the size at which they are transferred to grow-out. As RAS operations may hold their juveniles in nursery facilities up to 200 g, the costs are higher than that of cage and pond operations where fish are transferred to grow-out at approximately 15 – 30 g.

Grow-out costs are lowest for cage operations and highest for RAS systems. This is primarily related to the electricity requirements of RAS systems as opposed to cages.

Feed costs are lowest in RAS systems and highest in pond systems in accordance with typically low EFCR's in RAS systems and higher EFCR in more extensive systems like cages and ponds.

Financing costs are an important component of overall cost. For capital intensive systems such as RAS operations, the financing costs are significant compared to lower capital cage operations and, therefore, financing costs per kilo are higher in RAS and pond operations.

Production costs exceed the through-rate price for each production system and, therefore, profit margins are negative. This suggests that a 500 tpa dusky kob operation will not achieve a positive profit margin given an assumed market price of ZAR 80.00.

8.4.3. Financial results

This section illustrates the results on the financial model under the given assumptions. The full suite of projected financial results are contained in the Income Statement tab of the financial models for each respective production system. Table 39 and Figure 50 – Figure 52 provide a summary of the key financial results for dusky kob at 500 tpa, under different production systems. In summary, the modelled scenarios for dusky kob at 500 tpa under different production systems does not represent a scale that reaches pay back within a 10 year period. A more detailed discussion on the variables that impact viability is provided for in the sensitivity analysis in Section 8.4.3.

TABLE 39: SUMMARY OF FINANCIAL RESULTS FOR DUSKY KOB AT 500 TPA IN DIFFERENT PRODUCTION SYSTEMS.

Production assumption			
Production system	**RAS hatchery & RAS grow-out**	**RAS hatchery & cage grow-out**	**RAS hatchery & pond grow-out**

Production scale	500	500	500
Financial indicator			
Capex (ZAR '000)	140 794	46 403	110 968
IRR (%)	-27	-22	-36
Max. cash outflow (ZAR '000)	197 044	78 779	152 635
NPV over 10 years (ZAR '000)	-29 027	-31 650	-77 379
Break-even point (yr)	4	4	+10
Pay-back period (yr)	+10	+10	+10
IRR: Internal rate of return NPV: Net-present value			

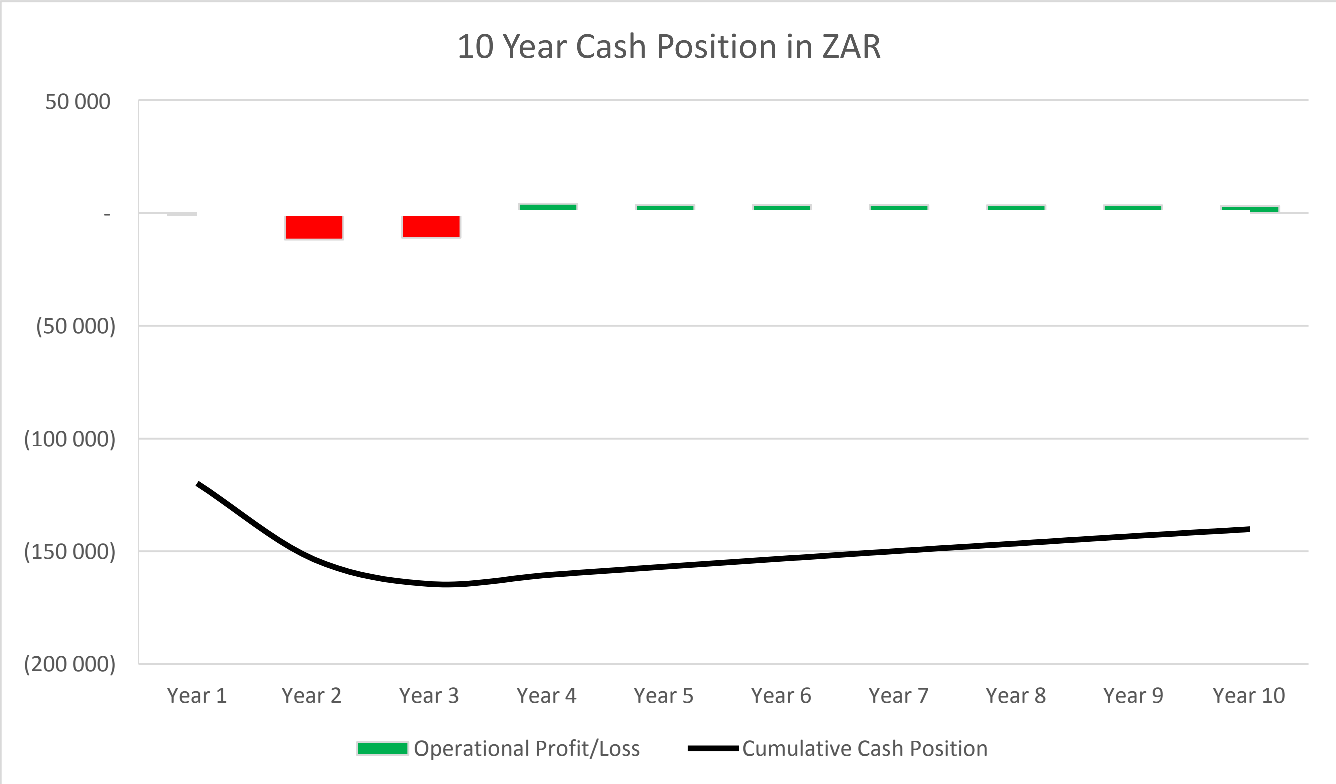


Figure 50: Cashflow requirements for a 500 TPA full RAS production system.

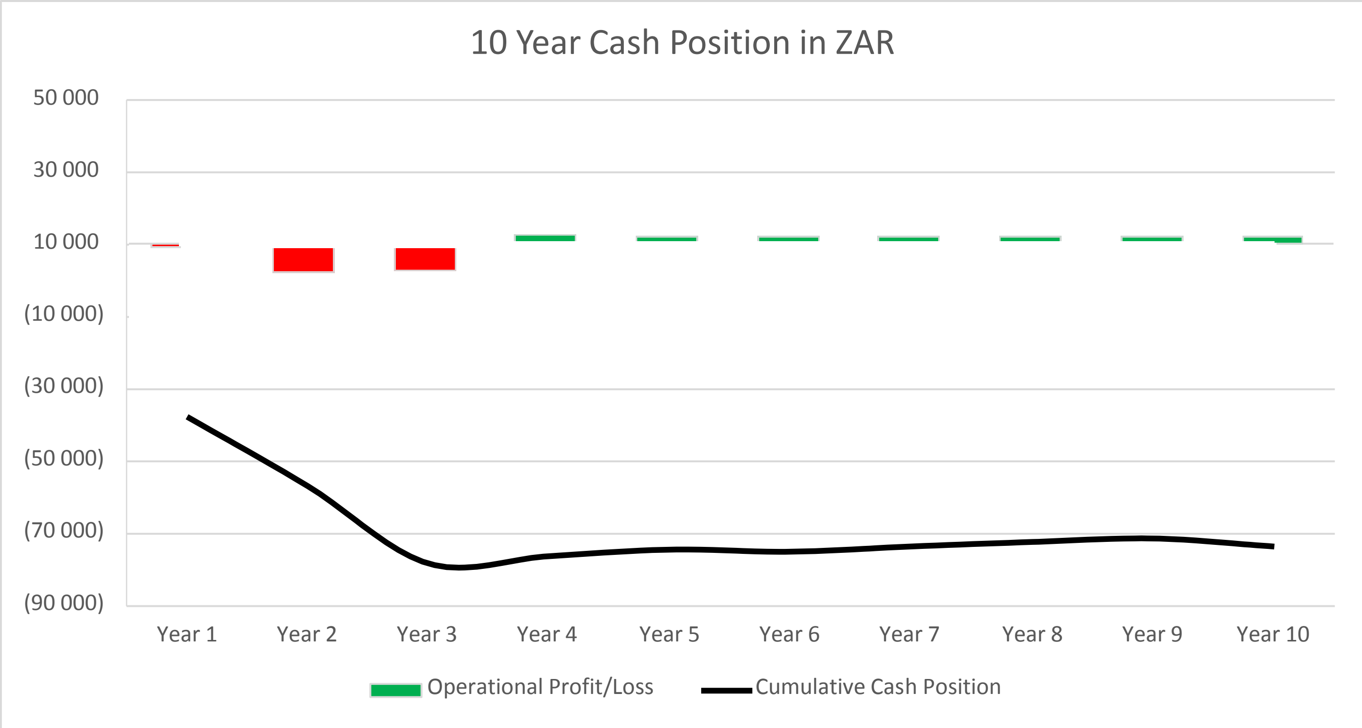


FIGURE 51: CASHFLOW REQUIREMENTS FOR A 500 TPA RAS HATCHERY AND CAGE GROW-OUT DUSKY KOB PRODUCTION SYSTEM.

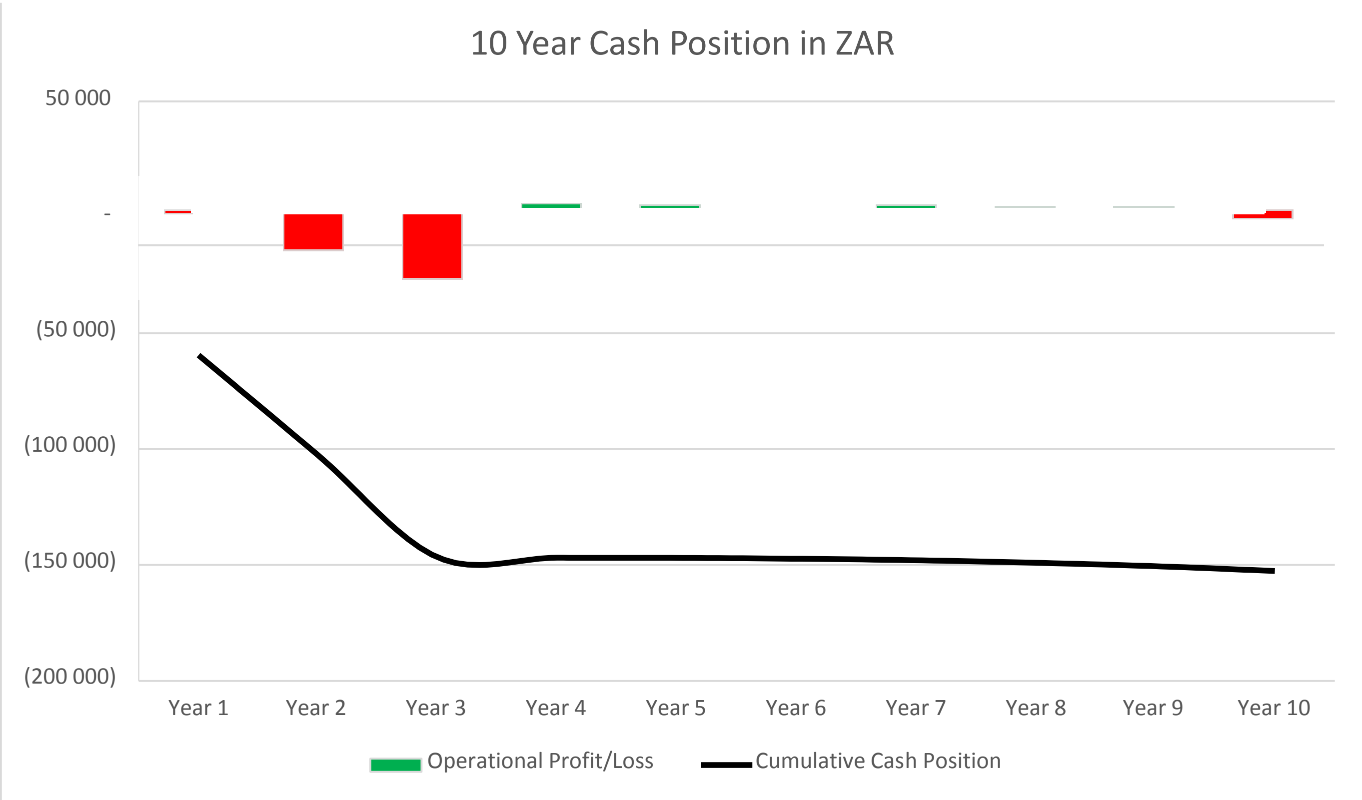


FIGURE 52: CASHFLOW REQUIREMENTS FOR A 500 TPA RAS HATCHERY AND POND GROW-OUT PRODUCTION SYSTEM.

8.4.4. Sensitivity analysis

There are a number of operational and biological performance factors that influence both sales price and production costs which were outlined in Table 37. This section aims to describe how profitability at full production (EBITDA in Year 4) for dusky kob is impacted by high- and low-case scenarios as compared to the base values used for the financial model. The sensitivity analysis predicts the outcome of a decision given a certain range of variables that contribute to production costs and sales price. This allows for the determination of how changes in one variable impact the outcome. High and low range values can be found in the Sensitivity Analysis tab of the financial model spreadsheet for each respective production system. By inputting different upper and lower range values one can visualise marginal costs vs sales price at different production scales and determine an optimum scale for production based on margin.

Production system: RAS hatchery and RAS grow-out

Figure 53 illustrates the marginal cost associated with different production volumes for a full RAS production system.

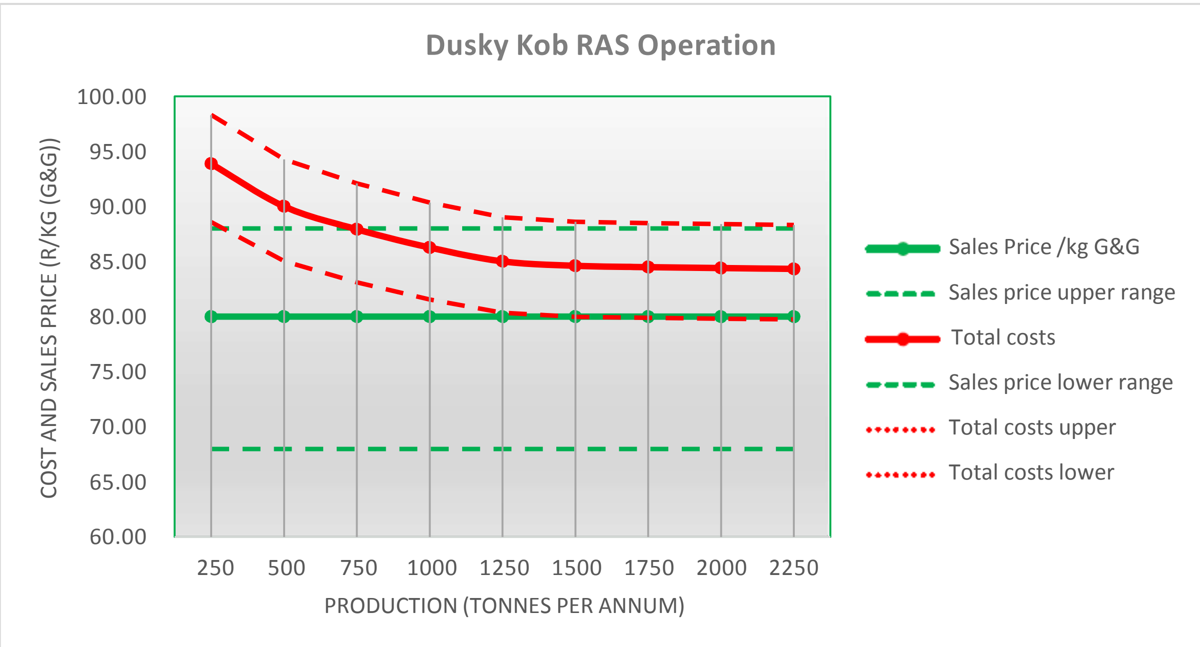


FIGURE 53: ILLUSTRATION OF MARGINAL COSTS WITH INCREASING SCALE FOR A 500 TPA FULL RAS KOB FACILITY.

The results of Figure 53 indicate that, despi te some economies of scale being achieved with increasing production volumes, total costs exceed the assumed sales price of ZAR 80.00. At the upper range of the sales price (ZAR 87.00) and at a production scale of approximately 750 tpa and greater, RAS operations may represent a viable opportunity based on decreased marginal costs.

Production system: RAS hatchery and cage grow-out

Figure 54 illustrates the marginal cost associated with different production volumes for a RAS hatchery and cage grow-out production system.

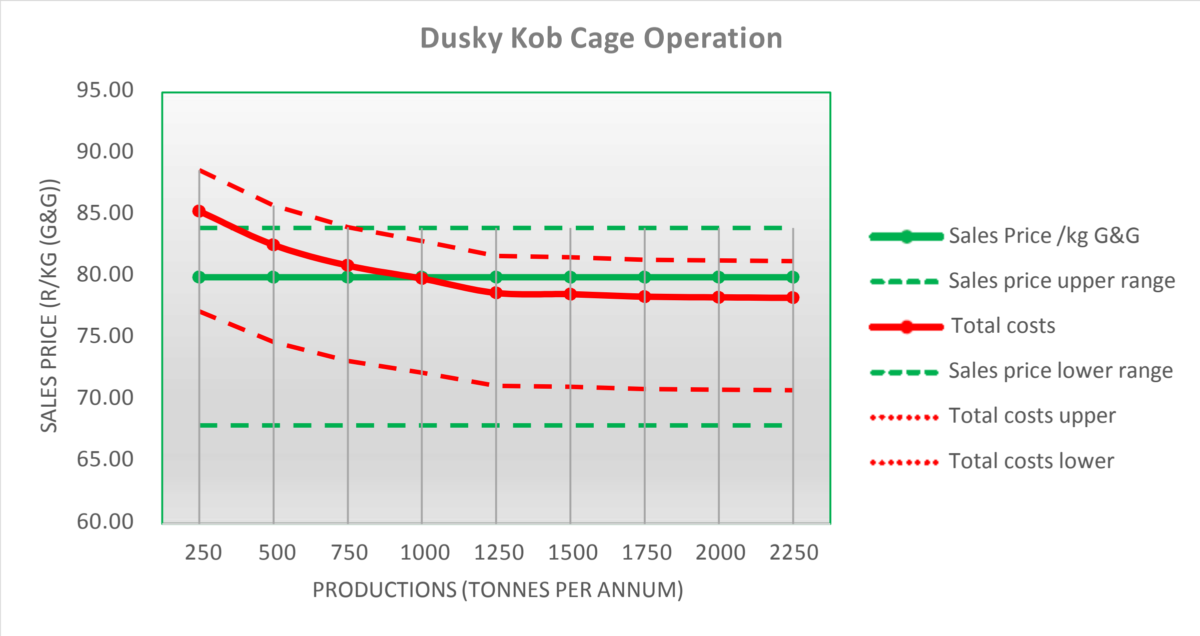


FIGURE 54: ILLUSTRATION OF MARGINAL COSTS WITH INCREASING SCALE FOR A CAGE-BASED KOB PRODUCTION.

At a scale of greater than 750 tpa, sales price exceeds the marginal costs of production in a cage production system. At higher sales price, an operation may be viable at lower production volumes (500 tpa).

Production system: RAS hatchery and pond grow-out

Figure 55 illustrates the marginal cost associated with different production volumes for a RAS hatchery and pond grow-out production system.

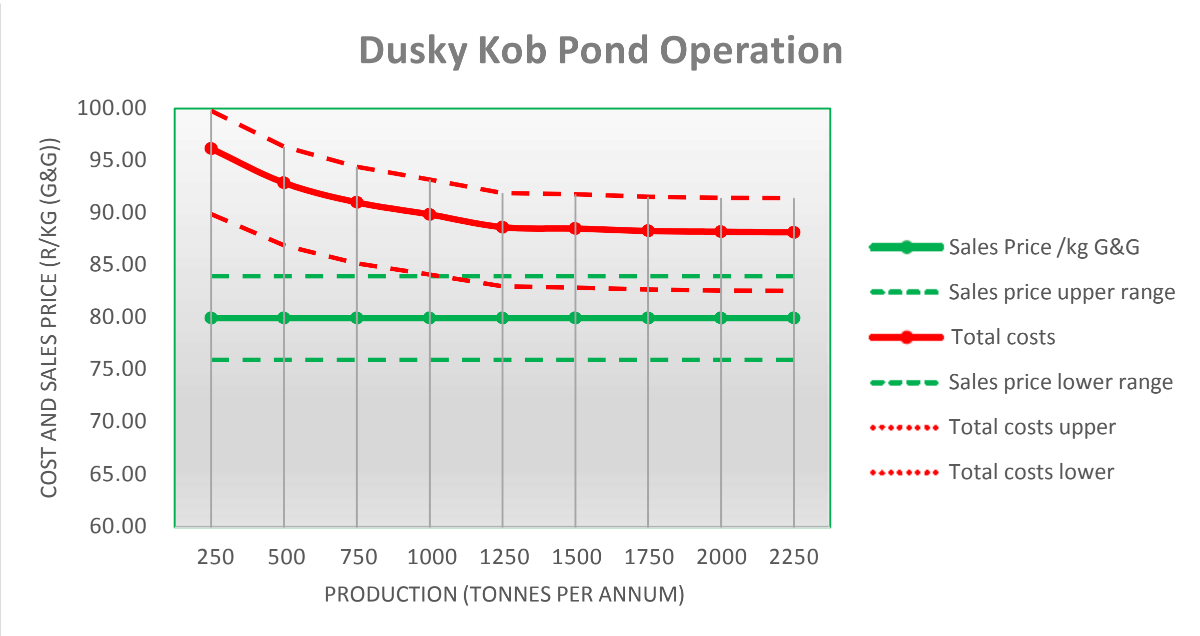


FIGURE 55: ILLUSTRATION OF MARGINAL COSTS WITH INCREASING SCALE FOR A POND-BASED KOB PRODUCTION.

Production cost exceeds sales price at every scale and therefore, under the current model assumptions, pond production does not appear to be a viable business opportunity. Ponds, and the land area they require, are capital intensive and financing costs are high. Furthermore, stocking densities are low in these systems. Under the lower range scenario, marginal costs decrease such that a pond based operation may represent a viable opportunity at scales of 1 500 tpa or greater. This would require a decrease in production costs which may be achieved through improved EFCR, increased mechanisation and optimising the human resources function.

- ***Scale***

The figures above illustrate the importance of economies of scale. The results of the financial projections show that, at 500 tpa and under the fixed model assumptions, dusky kob is not a commercially viable operation for any of the different production systems. As production scale increases, variable costs, various capital requirements such as overhead expenses and certain capital expenditures are diluted, and thus result in lower production costs at higher scales. Table 40 shows a summary of the minimum viable scales for dusky kob under the different production systems, under the model assumptions used in the study.

TABLE 40: MINIMUM OPERATING SCALES FOR FINANCIAL VIABILITY FOR DUSKY KOB UNDER DIFFERENT PRODUCTION SYSTEMS.

Production system	RAS hatchery & RAS grow-out	RAS hatchery & cage grow-out	RAS hatchery & pond grow-out
Minimum viable scale (tpa)	**-**	**1 000**	**-**

Note: It is important to view the results presented in Table 40 while recognising that these are based on certain model assumptions which will vary depending on a range of factors. The model user can adjust these variables in the excel models to determine a minimum viable scale.

Operating at scale is a prerequisite to cost competitiveness in an industry. For example, in the Norwegian and Chilean salmon industries, large companies consolidate product from multiple in-house grow-out operations that they have both independently developed and acquired. Single grow-out operations range in size but a 4 000 tpa unit is widely accepted as representing an industry norm in terms of a single economic grow-out production unit. Scale economies appreciably reduce costs through to a production capacity of approximately 4 000 tpa with moderate efficiencies expected thereafter.

In the case of dusky kob it would appear that, despite economies of scale being achieved at higher production volumes, the production costs are too high given a sales price of ZAR 80.00 /kg.

- ***Sales price***

The figures above illustrate the importance of optimising sales price. This is particularly evident in the case of dusky kob, where a local sales price of ZAR 80.00 /kg, at 500tpa under the model assumptions for the different production systems, is not financially viable.

Ultimately, one would aim to achieve a higher market sales price in order to increase the profitability of an enterprise. In the market assessment of Section 6.1, it is argued that dusky kob may be placed on the international markets with the likes of seabream, seabass and barramundi. Currently, South Africa is not certified to export aquaculture products to Europe and therefore the Asian markets are likely to be the target market. If dusky kob can be seen as a product of similar quality to barramundi, then the FOB price for fresh kob may be targeted at ZAR 85.30/ kg (± USD 6.00/ kg FOB, fresh). Such an increase in sales price would significantly increase the return on investment for such a project. However, it is important to understand that, frequently, a minimum volume for offtake is required by the importing client in order to ensure such a sales price.

Regardless of the end market deal that is negotiated, it is important that an operator create some market diversity in the medium term as a mitigation of market risk. Establishing sales to an international off-take partner would be central to structuring a resilient marketing strategy. The complexities of establishing an international sales off-take are beyond the scope of this report but it is recommended that an investigation be launched that identifies potential markets, details the legal/ phytosanitary/ logistical/ food safety/ market requirements for importing into that market and constructs a roadmap of events leading to the first sales in an agreed period.

- ***Mortality***

It is expected that as part of normal operations, mortalities will be incurred in a cohort batch throughout the life-cycle and monthly losses are planned for. Increased mortalities often occur due to heightened stress caused by negative changes in environmental conditions, increased handling, diseases and parasites. Mortalities incurred exceeding the budgeted loss will result in increased cost on a per kg basis (less biomass is harvested versus the costs incurred).

- ***Growth***

As noted above, biomass can be negatively impacted through increased mortalities. Additionally, biomass can be negatively impacted through slower growth than planned with the same result of increased costs per kg. Growth is subject to numerous variables including temperature, oxygen, density, feed management and fish health. Impaired growth will have the impact of a reducing the average weight per individual in the batch at harvest and increasing cost on a per kg basis.

- ***EFCR***

EFCR is the ratio of harvested biomass to the total quantum of feed used in creating that biomass. The value should not be confused with the Biological FCR (FCR) which is the ratio of total biomass produced (including mortalities) to total feed used. EFCR's are dependent on several variables and change throughout the growth cycle; in general terms weaker EFCR's would be expected for larger fish e.g. a 1kg dusky kob can be grown at an EFCR of 1.1 while the same fish grown to 2.5kg could be expected to achieve an EFCR of 1.4. Apart from harvest size, EFCR will also be negatively impacted by loss of biomass due to increased mortality or slow growth, poor monitoring and feeding practices, and poor feed quality.

The EFCR values inputted in the dusky kob models are conservative. With improved operations, the EFCR values may decrease resulting in a decrease in feed costs.

- ***Financing of capital***

The models assume that capital requirements for the projects are financed at a rate of 10%. These financing costs contribute significantly to the production costs per kilo of dusky kob, particularly in capital intensive RAS and pond systems. The rate at which capital is financed may be subjective and is dependent on a number of factors. If cheaper capital is available e.g. through a funding scheme, this cost will decrease substantially and impact on the viability assessment for the project.

8.5. Atlantic salmon

The following financials are based on the conceptual operations discussed in Section 7. These are subject to change depending on the objectives of the prospective operator which will determine production volumes, market, product, CAPEX, OPEX and the feasibility or otherwise of the operation. A detailed breakdown of the financial viability, including CAPEX/OPEX/income, is provided in the financial models as an .xls file.

The modelled scenarios for Atlantic salmon were as follows:

Production systems

1. RAS hatchery and cage grow-out
2. RAS hatchery and RAS grow-out

Production capacity

2 000 tpa

8.5.1. Capital expenditure

A detailed breakdown of the capital expenditure is provided in the financial model as an .xls file. The total capital costs associated with the development of an Atlantic salmon aquaculture project under the model assumptions are summarised as per Table 41.

TABLE 41: TOTAL CAPITAL COSTS (ZAR) FOR ATLANTIC SALMON.

Production assumption		
Production system	**RAS hatchery & cage grow-out**	**RAS hatchery & RAS grow-out**
Production scale	**2 000**	**2 000**
Summary of capital expenses (ZAR)		
Pre-Development	855 731	2 430 490
Land	10 000 000	20 000 000
Bulk infrastructure	2 532 000	3 849 500
Buildings	32 653 050	89 653 050
Services	4 159 750	7 090 750
Aquaculture systems – hatchery	8 164 191	8 164 191
Aquaculture systems – grow-out	12 071 770	52 642 184
Vehicles	26 982 500	3 482 500
Transport and logistics	1 000 000	1 000 000
Professional fees	8 808 611	18 042 453
Contingency (5%)	5 361 380	10 317 756
Total (excl. professional fees and contingency)	98 418 992	188 312 665
Total nett of consulting fees	8 808 611	18 042 453
Total % of consulting fees on total project cost	8.95	8.58%
TOTAL	**112 588 983**	**216 672 874**

8.5.2. Operational expenditure

A detailed breakdown of the operational expenditure is provided in the financial model as an .xls file.

Costs of production

Costs of production include feed, electricity, human resources, and operation of equipment. The costs of production for Atlantic salmon were categorised as follows:

- **Smolt costs** – all costs associated with rearing of smolt in hatchery operations excluding feed.
- **Grow-out costs** – costs of grow-out of smolts to harvest size excluding feed.
- **Laboratory costs** – costs of laboratory operations including equipment maintenance and calibration.
- **Feed costs** – total costs of feed including hatchery and grow-out operations.
- **Overhead *and* Fixed costs** – all overhead and fixed costs including accounting, legal and insurance costs.
- **Financing costs** – financing of capital investment costs.
- **Processing costs** – costs of processing and packaging.
- **Yield loss costs** – costs of lost product through processing.
- **Sales costs** – cost of sales.

The costs of production (ZAR /kg) for Atlantic salmon with a terminal harvest volume of 2 000 tpa is shown in Table 42. The cost drivers, shown as a percentage contribution to overall cost, are shown in Table 43.

TABLE 42: VARIABLE COSTS OF PRODUCTION OF ATLANTIC SALMON IN TWO PRODUCTION SYSTEMS AT A TERMINAL HARVEST VOLUME OF 2 000 TPA.

Production assumption		
Production system	**RAS hatchery & cage grow-out**	**RAS hatchery & RAS grow-out**
Production scale	**2 000**	**2 000**
Cost of production (ZAR /kg)		
Smolt costs (/kg LFE)	1.61	2.16
Grow-out costs (/kg LFE)	3.32	3.06
Laboratory costs (/kg LFE)	0.51	0.51
Total feed costs (/kg LFE)	34.77	32.24
Overhead costs (/kg LFE)	0.82	0.91
Fixed costs (/kg LFE)	3.30	3.62
Financing costs at 5%	2.81	5.42
Total costs ex-grow-out system (/kg LFE)	**47.14**	**47.92**
Yield loss @ 82% yield	10.35	10.52
Total costs ex-grow-out system (/kg H&G)	**57.49**	**58.44**
Processing costs (/kg H&G)	5.89	5.82
Total costs FOB (/kg H&G)	**63.38**	**64.26**
Sales costs (/kg H&G)	5.54	5.54
Total costs sold (/kg H&G)	**68.92**	**69.80**
Target price @ 25% margin	91.90	93.07
Target price @ 33% margin	102.87	104.18
Through-rate price (ZAR /kg)	84.00	84.00

Production assumption		
Production system	**RAS hatchery & cage grow-out**	**RAS hatchery & RAS grow-out**
Production scale	**2 000**	**2 000**
Cost of production (ZAR /kg)		
Margin @ budget /through-rate price	17.95 %	16.90 %

TABLE 43: VARIABLE COSTS OF PRODUCTION (%) OF ATLANTIC SALMON IN TWO PRODUCTION SYSTEMS AT A TERMINAL HARVEST VOLUME OF 2 000 TPA.

Production system	**RAS hatchery & cage grow-out**	**RAS hatchery & RAS grow-out**
Production scale	**2 000**	**2 000**
Cost of production (ZAR /kg)		
Smolt costs (/kg LFE)	2.34	3.09
Grow-out costs (/kg LFE)	4.53	4.38
Laboratory costs (/kg LFE)	0.74	0.14
Total feed costs (/kg LFE)	50.63	46.19
Overhead costs (/kg LFE)	1.19	1.30
Fixed costs (/kg LFE)	4.81	5.19
Financing costs at 5%	4.09	7.77
Total costs ex-grow-out system (/kg LFE)	**68.34**	**68.65**
Yield loss @ 82% yield	15.00	15.07
Total costs ex-grow-out system (/kg H&G)	**83.36**	**83.72**
Processing costs (/kg H&G)	8.58	8.34
Total costs FOB (/kg H&G)	**91.92**	**92.06**
Sales costs (/kg H&G)	8.07	7.94
Total costs sold (/kg H&G)	**100**	**100**

The major cost driver in the production of Atlantic salmon is feed (Table 43). Yield loss costs were the second major driver however this will fluctuate depending on the product mix of the operation i.e. a product mix incorporating higher volumes of filleted fish will have a higher yield cost.

Based on the cost of production, sales of Atlantic salmon from a 2 000 tpa operation at the budget price achieve a margin ranging between approximately 16.90 – 18.25 % which is far higher than that achieved with dusky kob at 500 tpa. Results in Table 42 indicate that cage grow-out systems have the lowest costs of production for Atlantic salmon. This is further highlighted in the results of the financial projections presented in Section 8.5.3.

8.5.3. Financial results

Financial results under the model assumptions are presented in Table 44 and Figure 56 and Figure 57, under different production systems. The full suite of projected financial results are contained in the Income Statement tab of the financial models for each respective production system.

A more detailed discussion on the variables that impact viability is provided for in the sensitivity analysis in Section 8.5.4.

TABLE 44: SUMMARY OF FINANCIAL RESULTS FOR 2 000 TPA ATLANTIC SALMON PRODUCTION.

Production assumption		
Production system	**RAS hatchery & cage grow-out**	**RAS hatchery & RAS grow-out**
Production scale	**2 000**	**2 000**
Financial indicator		
Capex (ZAR '000)	112 589	216 673
IRR (%)	19	8
Max. cash outflow (ZAR '000)	207 995	325 707
NPV over 10 years (ZAR '000)	7 426	-36 859
Break-even point (yr)	4	5
Pay-back period (yr)	9	9

Production system: RAS hatchery and cage grow-out

Under the model assumptions, a 2 000 tpa Atlantic salmon cage operation represents a commercially viable opportunity, offering a positive NPV over a ten-year period with an IRR of 19% for cage-based operations. Both the NPV and IRR would be significantly improved if the financial analysis was extended beyond the current ten-year horizon.

The cash-flow requirements for a RAS hatchery and cage grow-out project results in a maximum cash outflow of ± ZAR 207 million, peaking in Month 4 of Year 4, thus allowing for both capital development costs and working capital required to reach profitability. Break-even is attained in Year 4 and pay-back period is reached in Year 9.

Production system: RAS hatchery and RAS grow-out

Under the model assumptions, a 2 000 tpa Atlantic salmon full RAS operation represents a marginally viable opportunity, offering a positive NPV over a ten-year period with an IRR of 8%. Both the NPV and IRR would be significantly improved if the financial analysis was extended beyond the current ten-year horizon.

The cash-flow requirements for a RAS hatchery and grow-out project results in a maximum cash outflow of ± ZAR 326 million, peaking in Month 4 of Year 4, thus allowing for both capital development costs and working capital required to reach profitability. This requires a substantially larger capital requirement for full RAS as opposed to cage-based operations. Break-even is attained in Year 5 and pay-back period is reached in Year 9.

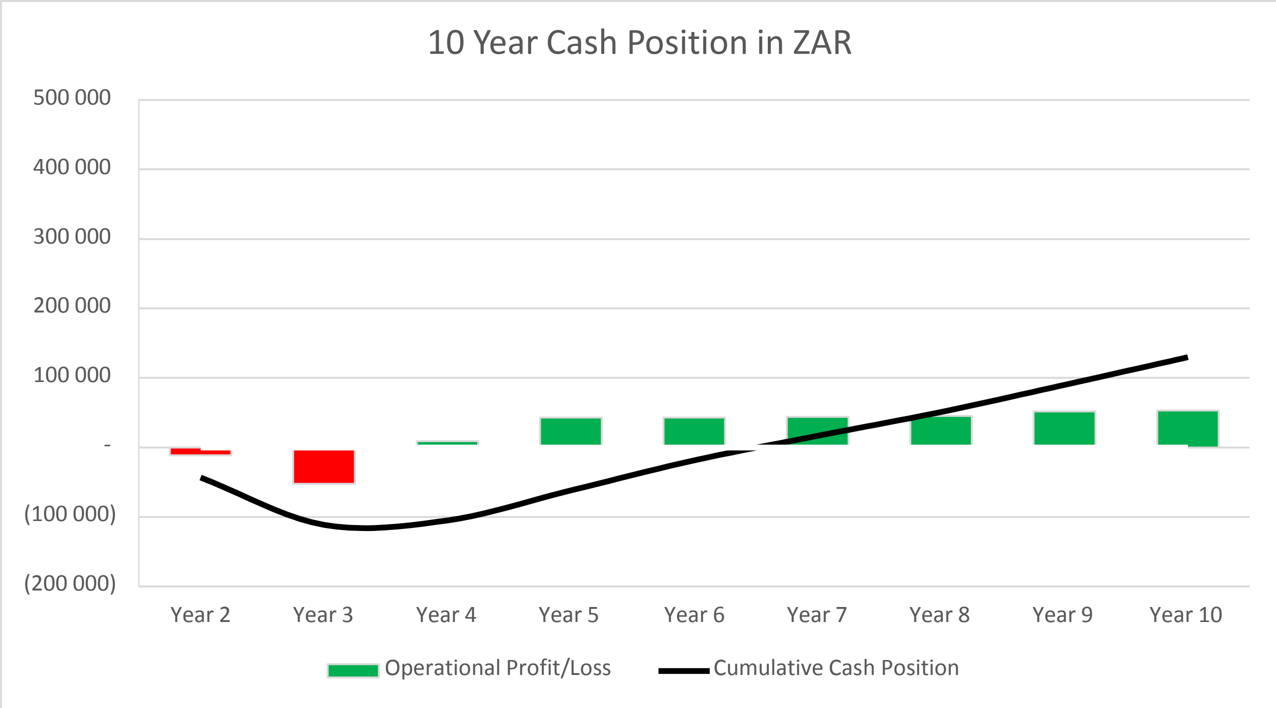


FIGURE 56: CASHFLOW REQUIREMENTS FOR A 2 000 TPA RAS HATCHERY AND CAGE GROW-OUT ATLANTIC SALMON FACILITY.

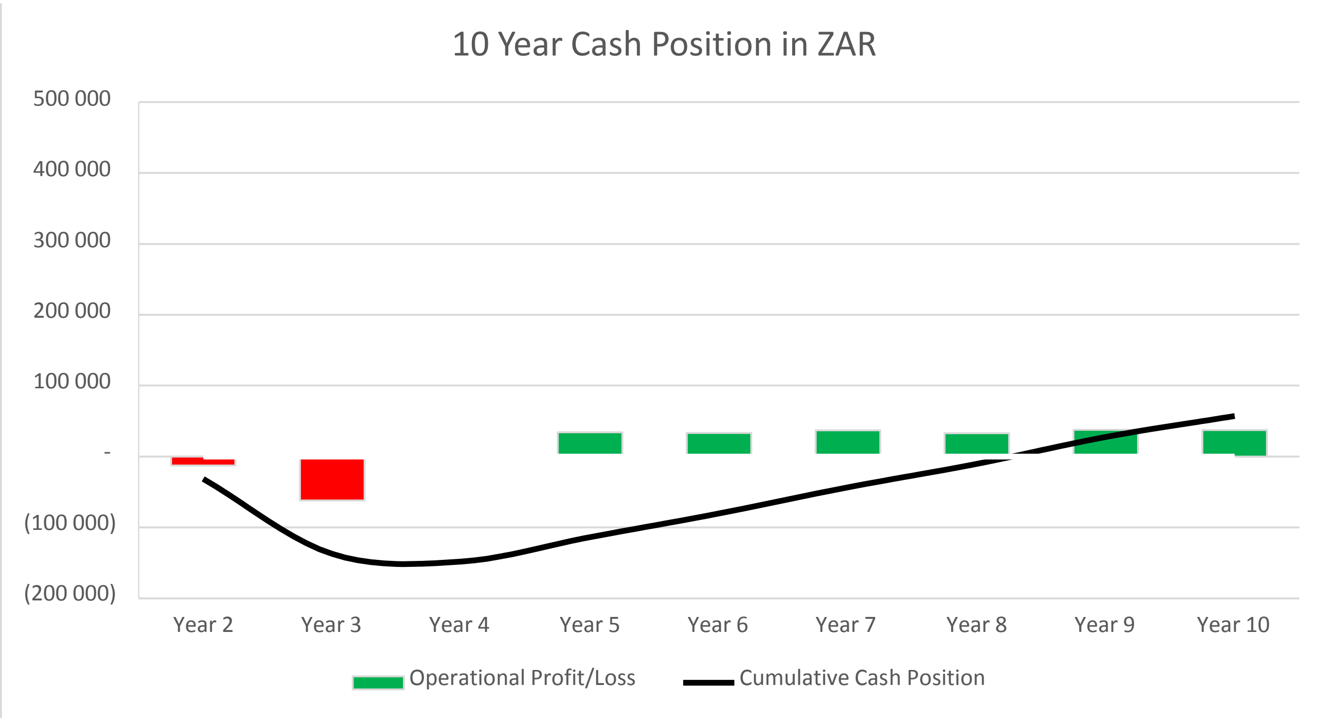


FIGURE 57: CASHFLOW REQUIREMENTS FOR A 2 000 TPA RAS HATCHERY AND GROW-OUT ATLANTIC SALMON FACILITY.

8.5.4. Sensitivity analysis

There are a number of operational and biological performance factors that influence both sales price and production costs which were outlined in Table 35. This section aims to describe how profitability at full production (EBITDA in Year 5) for Atlantic salmon is impacted by high- and low-case scenarios as compared to the base values used for the financial model. The sensitivity analysis predicts the outcome of a decision given a certain range of variables that contribute to production costs and sales price. This allows for the determination of how changes in one variable impact the outcome. High and low range values can be found in the Sensitivity Analysis tab of the financial model spreadsheet for each respective production system. By inputting different upper and lower range values one can visualise marginal costs vs sales price at different production scales and determine an optimum scale for production based on margin.

Production system: RAS hatchery and cage grow-out

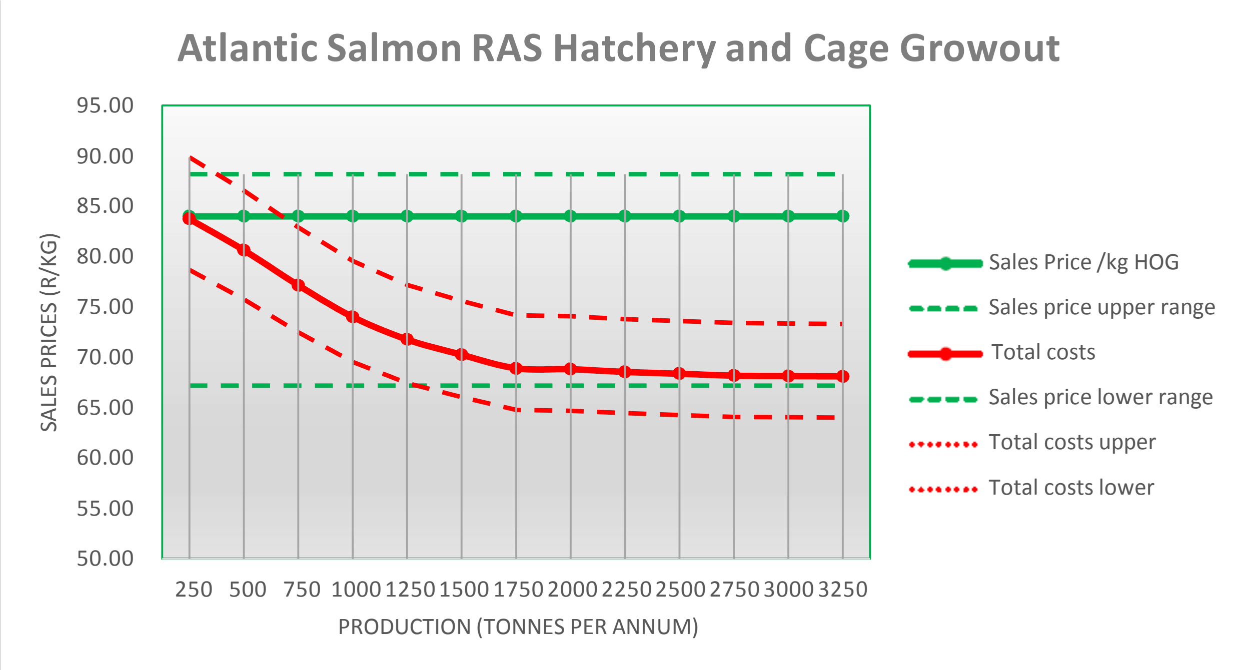


FIGURE 58: MARGINAL COSTS WITH INCREASING SCALE FOR A CAGE-BASED ATLANTIC SALMON PRODUCTION.

Based on the results in Figure 58, and the model assumptions, the base and upper sales price exceeds the production costs of Atlantic salmon farming at smaller and larger scales. The margin between sales price and production cost is maximised from 1 750 tpa and upwards indicating that this represents the optimum scale for production of Atlantic salmon. Under the lower range scenario for sales price, the margin achieved is negative until approximately 2 750 tpa and upwards, where production costs appear to be approximately equal to sales price. This represents a less favourable scenario for revenue generation and, therefore, the viability of the business.

Production system: RAS hatchery and RAS grow-out

Figure 59 illustrates the marginal cost associated with different production volumes for a full RAS production system.

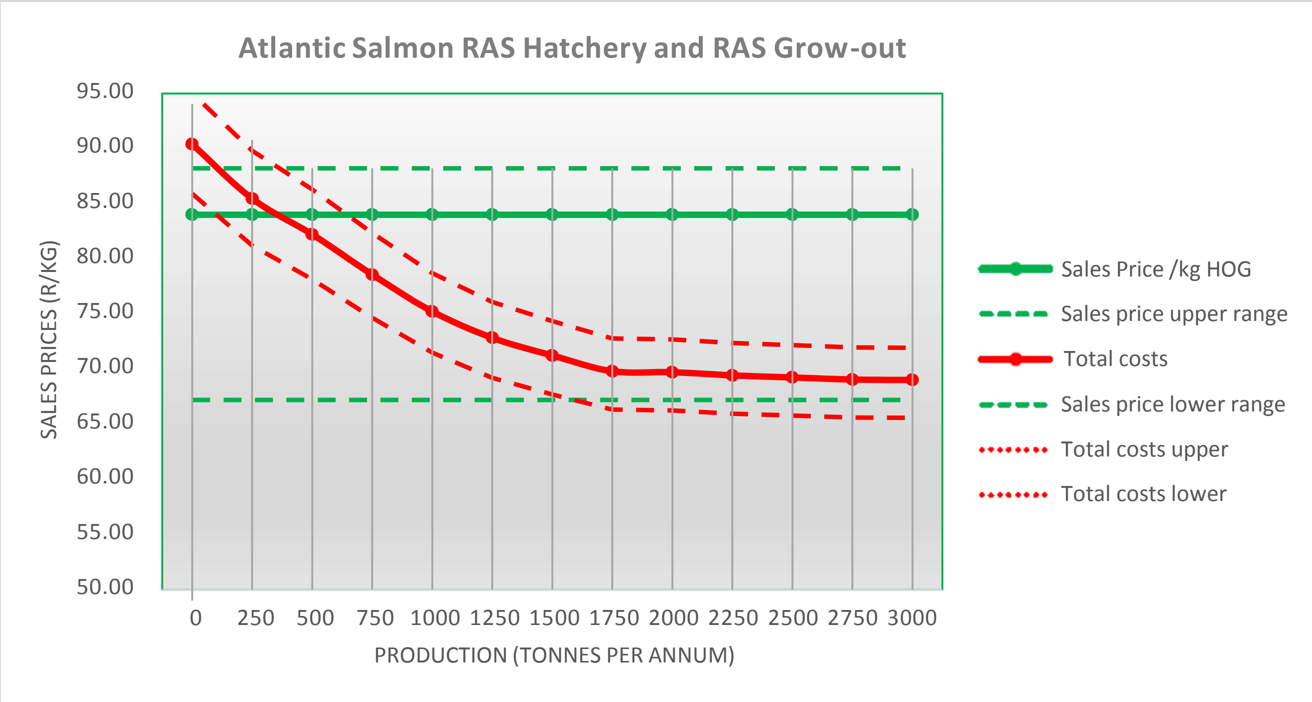


FIGURE 59: MARGINAL COSTS WITH INCREASING SCALE FOR RAS ATLANTIC SALMON PRODUCTION.

At a scale of greater than 500 tpa, sales price exceeds the marginal costs of production in a RAS production system.

- ***Scale***

Operating at scale is a prerequisite to cost competitiveness in an industry. For example, in the Norwegian and Chilean salmon industries, large companies consolidate product from multiple in-house grow-out operations that they have both independently developed and acquired. Single grow-out operations range in size but a 4 000 tpa unit is widely accepted as representing an industry norm in terms of a single economic grow-out production unit. Scale economies appreciably reduce costs through to a production capacity of approximately 4 000 tpa with moderate efficiencies expected thereafter.

The marginal cost and sales price analysis indicates that production capacities of 1 750 tpa and upwards represent the most favourable scale for cage-based Atlantic salmon farming.

- ***Sales price***

Prices of Atlantic salmon may fluctuate widely due to a number of factors (harvest seasons, environmental) primarily related to over- and under-supply on the market. The current sales price of Atlantic salmon (ZAR 85.00) achieves a positive margin ranging between 16.90 – 19 % based on the production cost analyses. Ultimately, one would aim to achieve a higher market sales price in order to increase the profitability of an enterprise. This could be achieved through ensuring a regular supply of quality product.

Regardless of the end market deal that is negotiated, it is important that an operator create some market diversity in the medium term as a mitigation of market risk. Establishing sales to an international off-take partner would be central to structuring a resilient marketing strategy. The complexities of establishing an international sales off-take are beyond the scope of this report but it is recommended that an investigation be launched that identifies potential markets, details the legal/ phytosanitary/ logistical/ food safety/ market requirements for importing into that market and constructs a roadmap of events leading to the first sales in an agreed period.

- ***Mortality***

It is expected that as part of normal operations, mortalities will be incurred in a cohort batch throughout the life-cycle and monthly losses are planned for. Increased mortalities often occur due to heightened stress caused by negative changes in environmental conditions, increased handling, diseases and parasites. Mortalities incurred exceeding the budgeted loss will result in increased cost on a per kg basis (less biomass is harvested versus the costs incurred).

- ***Growth***

As noted above, biomass can be negatively impacted through increased mortalities. Additionally, biomass can be negatively impacted through slower growth than planned with the same result of increased costs per kg. Growth is subject to numerous variables including temperature, oxygen, density, feed management and fish health. Impaired growth will have the impact of a reducing the average weight per individual in the batch at harvest and increasing cost on a per kg basis.

- ***EFCR***

EFCR is the ratio of harvested biomass to the total quantum of feed used in creating that biomass. The value should not be confused with the Biological Feed Conversion Ratio (FCR) which is the ratio of total biomass produced (including mortalities) to total feed used. EFCR's are dependent on several variables and change throughout the growth cycle; in general terms weaker EFCR's would be expected for larger fish e.g. a 1kg salmon can be grown at an EFCR of 1.1 while the same fish grown to 2.5kg could be expected to achieve an EFCR of 1.45. Apart from harvest size, EFCR will also be negatively impacted by loss of biomass due to increased mortality or slow growth, poor monitoring and feeding practices, and poor feed quality.

- ***Financing of capital***

The models assume that capital requirements for the projects are financed at a rate of 5%. These financing costs contribute significantly to the production costs per kilo of Atlantic salmon, particularly in capital intensive RAS systems. The rate at which capital is financed may be subjective and is dependent on a number of factors. If cheaper capital is available e.g. through a funding scheme, this cost will decrease substantially and impact on the viability assessment for the project.

8.6. Investment plan

Should a client decide to proceed with the project then the next logical step would comprise the development of a bankable feasibility study with accompanying business plan.

The components of a bankable business plan would comprise the following:

- Investment approach
- Investment structure

- Security of land tenure
- Approach to community participation and upliftment
- Infrastructure, services and buildings - concept designs and cost
- Approach to dealing with waste streams
- Operational model
- Management Structure
- HR requirement, training and development programmes
- Products
- Markets
- Prices
- Processing and storage facilities - Design and equipment
- Certification
- Logistics - priced alternatives
- Refined CAPEX - 90% accuracy
- Financial / Investment / Funding models
- Risk mitigation measures
- Fatal flaw analysis
- Implementation programme and budget
- Finalisation of business plan

9. RISK ASSESSMENT

Risk is defined as uncertain consequences, usually unfavourable outcomes, due to imperfect knowledge (Kaplan & Garrick, 1981). Risk can be lowered by reducing or removing hazards, i.e. sources of risk. Hazards are tangible threats that can contribute to risk but do not necessarily produce risk. Aquaculture is an inherently risky financial endeavour and it is important to identify the hazards that may result in a risk and attempt to quantify these in order to determine mitigations and assist in decision making as to whether an aquaculture project should proceed.

Based on the assessments done in this study and our experience in the aquaculture industry, key findings are identified below and categorised as items of risk according to the below likelihood/impact matrix.

RISK MATRIX

LIKELIHOOD							
	F 99% Probability	Medium	Medium	High	Very High	Very High	Very High
	E >50% Probability	Low	Medium	High	High	Very High	Very High
	D >20% Probability	Low	Medium	Medium	High	Very High	Very High
	C >10% Probability	Low	Low	Medium	High	High	Very High
	B >1% Probability	Low	Low	Medium	Medium	High	Very High
	A <1% Probability	Low	Low	Low	Medium	High	High
		1	2	3	4	5	6
		IMPACT					

FIGURE 60: RISK MATRIX ACCORDING TO PROBABILITY AND IMPACT.

9.1. Commercial risks

The project is sensitive to several key financial inputs as illustrated briefly below:

RISK: Energy costs		
Energy costs are one of the largest operational costs for an aquaculture project (particularly RAS systems); and as such profitability is impacted by any upward price revisions. A RAS is highly exposed to a loss of power for any extended period. Back-up diesel generators are a means to ensuring water supply is continuous in the event that power from the grid is interrupted. Power supplied from diesel generators is however expensive (4-5 time more that grid power) and the viability would be compromised in an instance that in-house diesel supply is required for any extended period. Given the fragile balance between electricity supply and demand in South Africa and the potential for energy cost increases exceeding inflation are high.		
Consequence		
Diesel generators are required to substitute power in the event of power interruptions, and thus significantly increase operational costs		
Opportunity or Loss	Costs may be higher than forecast	
Impact	**Likelihood**	**Risk Level**
4: Increase in operational costs	E: >50%	**HIGH**
Recommendation		
Solar/ wind energy as a cost reduction mechanism (e.g. new HIK abalone farm).		

RISK: Feed costs		
Feed costs contribute significantly (40-50%) to the operational costs of an operation. In the case of fish feed, there tends to be a close correlation between the sales price of fish and the cost of feed and it is expected that, in the medium term, an improved sales price will counter any increases in feed costs. In terms of imported feed, costs are also dependant on currency exchange rates and is thus a weakening South African Rand (ZAR), will increase operational costs.		
Consequence		
Increasing feed costs result in increased costs of production.		
Impact	**Likelihood**	**Risk Level**
4	**E: >50%**	**HIGH**
Recommendation		

RISK: Currency risks		
Project capital and operational costs are principally denominated in South African Rand (ZAR). Based on the above, the relative strength or weakness of 3 currencies of the USD, ZAR and EUR will impact on profitability. A strengthening of the ZAR against the USD will result in costs increasing versus income; a strengthening of the USD versus the EUR will have the effect of making the product more expensive to the EU consumer. The above is also dependant on the imports of inputs for business operations and whether or not products are exported.		
Consequence		
Transaction exposure Economic (operating) exposure		
Impact	**Likelihood**	**Risk Level**
4	**E: >50%**	**HIGH**
Recommendation		
Currency risk can be mitigated to a large extent through hedging and forward contracting.		

Management and technical skills

RISK: Management and technical skills		
The aquaculture sector in South Africa is entering a state of rapid expansion and if Operation Phakisa's objectives are to be met then there will potentially be a shortage of experienced technical and management personnel in the country to successfully deliver those projects. Technical capacity is available from other countries and could be utilised if necessary. Notwithstanding the optionality of utilising foreign resources, the success of a project will be dependent on obtaining human resources that comprehend the unique socio-economic factors associated with a project and are committed to delivering against multiple objectives.		
Consequence		
Skills shortage leading to wages pressure, project delays, production bottlenecks and delays in expansion plans.		
Impact	**Likelihood**	**Risk Level**
3	**D: >20%**	**MEDIUM**
Recommendation		

Rapid skills transfer forms an important part of mitigating both technical and social risks into the future. Qualified resources from overseas may accelerate training and capacity building in the short-term. Furthermore, research and development should focus on technologies that are well-established in the international aquaculture industry.

Health and safety

RISK: Health and safety		
Aquaculture poses a number of health and safety risks due to the operational nature of the business including the use of heavy machinery and water-related work activities among others. It is also likely that the labour force on a project will be predominantly unskilled and considerable effort will be required to quickly establish a culture of health and safety awareness.		
Consequence		
A hazard in the workplace results in employee(s) illness/injury/death.		
Impact	**Likelihood**	**Risk Level**
4	**B: >1%**	**MEDIUM**
Recommendation		
It is important that health and safety aspects and training are continually incorporated into any aquaculture project. A strong risk management plan must be developed and strict control measures implemented at all times.		

9.2. Environmental

RISK: Environmental management		
If not properly managed, marine aquaculture can impact negatively on the immediate and surrounding environment. This has led to the development of environmental management plans (EMPs) and protocols to ensure that aquaculture operations are managed responsibly. In South Africa, an EMP forms part of an EIA and is designed to ensure environmental impact is managed to minimise the potential for negative events. Failure to adhere to the EMP raises risk for the project in both the environmental and legislative fields.		
Consequence		
Poorly planned and unregulated aquaculture practises may cause negative environmental effects. Operations are suspended as the farm fails an environmental audit. Any offtake agreements with consumers are terminated as the product is associated with a failed environmental audit.		
Impact	**Likelihood**	**Risk Level**
5	**C: >10%**	**HIGH**
Recommendation		
Continual and comprehensive monitoring and evaluation to ensure compliance to the EMP.		

RISK: Harmful algal blooms		
Harmful algal blooms		
Consequence		
HAB event results in significant loss in biomass for cage culture		
Impact	**Likelihood**	**Risk Level**
5	**C: >10%**	**HIGH**
Recommendation		
Continual monitoring of water quality and various other environmental parameters is important for early detection.		

9.3. Social

RISK: Local community impacts		
Social risks in aquaculture include challenges due to real or perceived business impacts on a broad range of issues related to human welfare – for example, working conditions, environmental quality, health, or economic opportunity. The consequences may include brand and reputation damage, increased regulatory pressure, legal action, consumer boycotts, and operational stoppages – jeopardising short- and long-term shareholder value (Bekefi *et al*., 2006). The remote location of many projects and immediate proximity to local communities place them at considerable risk to social upheavals. Projects are regularly the subject of discussion with the local community and it would be essential to audit expectations raised and ensure that a project is geared to meet these.		
Consequence		
Failure to deliver against social objectives will place the project at considerable risk and as such budgets allow for socio-economic investment throughout the development period that are designed to impact all community members and extending beyond those directly benefiting through employment.		
Impact	**Likelihood**	**Risk Level**
3	**D: >20%**	**MEDIUM**
Recommendation		

Careful planning and stakeholder consultation is required to ensure that all stakeholders are taken into consideration and that projects deliver socio-economic benefits.

9.4. Market

RISK: Kob market price		
The project is sensitive to significant negative movements in sales price and has limited optionality in terms of its ability to counter these changes by cutting costs.		
Consequence		
Inability to sell product at target price		
Impact	**Likelihood**	**Risk Level**
6	**D: >20%**	**VERY HIGH**
Recommendation		
Development of strategies to counter price reductions through market and product diversification and through building customer relationships that delink contract prices from mainstream price trends. Increased awareness which promotes farmed dusky kob as a sustainable alternative to product from wild capture fisheries. This will require a more concerted marketing exercise which places the product in a better price category. There is potential for dusky kob to be sold in international markets, more specifically those in Asia. It should ultimately be aimed to be seen as a product of the same quality such as barramundi to increase the sales target price. This will involve a detailed international market analysis of the candidate species, as well as the securing of an off-take agreement.		

RISK: Salmon market price		
Aquaculture projects are sensitive to significant negative movements in sales price and have limited optionality in terms of its ability to counter these changes by cutting costs. It is assumed that the market is able to absorb the increased harvest, without an adjustment of sales price.		
Consequence		
The positive impact of the expanded production facility would be negated if the additional supply resulted in a decreased price.		
Impact	**Likelihood**	**Risk Level**

3	**D: >20%**	**MEDIUM**
Recommendation		
Development of strategies to counter price reductions through market and product diversification and through building customer relationships that delink contract prices from mainstream price trends.		

RISK: Access to markets		
Exposure to a single market destination is an overwhelming risk and investing the time and money needed to enter second and third markets is considered an important part of the investment.		
Consequence		
Single market shrinks resulting in reduced demand and income		
Opportunity or Loss		
Impact	**Likelihood**	**Risk Level**
4	**E: >50%**	**HIGH**
Recommendation		
It is proposed that projects consider diversifying their market by establishing alternative outlets to supplement sale/ exports to a single source. Fundamental to achieving the above is resolving the legislative requirements related to the export of the cultured candidate species to target countries. Requirements vary per country and some can be resolved on a project level e.g. food safety certification, while others must be addressed at an industry or governmental level.		

9.5. Biological

RISK: Biological performance		
The biological performance of stock is a key determinant to profitability and as such negative deviations from plan will potentially compromise the feasibility of a project through a combination of higher costs, lower sales volumes or lower sales price. Management experience, performance of the aquaculture system, genetic material, quality of starting stock, disease management, feed quality and environmental conditions are all variables that play an important role in achieving target biological performance and must be addressed through the location, infrastructure and human capital of the project.		
Consequence		
Yield does not meet production targets		
Opportunity or Loss		
Impact	**Likelihood**	**Risk Level**

4	E: >50%	HIGH
Recommendation		
Ensure that the operation has access to quality inputs such that production is efficient and highly streamlined.		

10. SWOT ANALYSIS

10.1. Strengths

10.1.1. Technology

- The technology for dusky kob and Atlantic salmon aquaculture is established.
- Dusky kob can be reared in a variety of production systems including tanks, ponds, and cages.

10.1.2. Markets

- Dusky kob is recognised as one of the premier linefish species in South Africa and there is a high demand for this species.
- The market assessment revealed that dusky kob may be marketed alongside established European and Asian market species including meagre, European seabass, gilthead seabream, and barramundi.
- Increasing local demand and increasing imports of Atlantic salmon in South Africa reveal that there is a growing market for this species.
- Established global market for Atlantic salmon.

10.1.3. Seed production

- There are kob hatcheries in the country from which fingerlings can be obtained in the event that operators do not wish to invest in a hatchery.
- Atlantic salmon eggs can be imported from a number of highly reputable hatcheries in Europe.

10.1.4. Feed

- Formulated feeds for dusky kob are available from local and international manufacturers.
- There is ongoing research for feed development and improvement.
- Atlantic salmon feeds are manufactured by a number of different producers.
- Feeds for Atlantic salmon are highly advanced, cater for all life stages of production, and result in good growth rates and FCRs.

10.1.5. Human resources

- There is an adequate human resource base in South Africa to employ highly qualified staff.
- Labour in South Africa is comparatively less expensive than in other developed countries which may proffer a competitive advantage on South African operators.

- Good animal health services are available to the marine finfish farming sector through Amanzi Veterinary Services and DAFF.

10.1.6. Industrial associations

- Finfish farmers are strongly represented to DAFF through the Marine Finfish Farmers Association of South Africa.

10.1.7. Institutional

- South Africa recognised the importance of mariculture and DAFF are actively supporting the development of the sector. Various government initiatives and funding schemes which create an enabling environment.

10.2. Weaknesses

10.2.1. Technology

- Dusky kob larval rearing and fingerling production can be highly variable and this must be addressed through concerted R&D efforts.
- Atlantic salmon hatcheries are capital intensive and, in South Africa, will have to be RAS as environmental conditions are largely unsuitable for other technologies.

10.2.2. Markets

- The market for farmed marine fish in South Africa is new and needs to be developed further by all farmers.
- There is a preference for wild-caught dusky kob in some domestic markets.
- There is a lack of awareness particularly surrounding the environmental advantages of consuming farmed dusky kob as opposed to wild-caught fish from a declining stock.
- There is no established export market for South African dusky kob.

10.3. Opportunities

10.3.1. Marketing

- As the market for fish products in South Africa matures there will be increasing awareness regarding the sustainability of different products. The availability of a high quality farmed dusky kob product as opposed to that from the declining linefishery presents an opportunity which needs further marketing and promotion.
- There is potential to market dusky kob alongside well established species such as meagre, European seabass, gilthead seabream, and barramundi in European and Asian markets.
- Atlantic salmon from South Africa may be marketed in international markets in a similar fashion to product from other southern hemisphere operators e.g. Tasmania

10.3.2. Depleted linefish stocks

- All of South Africa's premier linefish species have been overfished.
- This provides an excellent opportunity for aquaculture of dusky kob.

10.3.3. Power

- All new (and existing) farms must stay abreast of new electricity-saving and production technologies of relevance to their operations and be prepared to invest in such technologies.

10.4. Threats

10.4.1. Security

- The capital investment for aquaculture developments is substantial and security against vandalism and theft is a risk.
- Theft of stock is a risk that must be mitigated against through various security means.

10.4.2. Human resources

- Aquaculture requires highly qualified manpower.
- Staff must be highly incentivised and motivated.
- Reliable services and supplies must be used.

10.4.3. Production

- Unforeseen problems, e.g. parasite infections, disease or off-shore oil spills may have an adverse effect on production if management protocols are not strictly adhered to.
- Very little is presently known about diseases and parasites in dusky kob under farming conditions and these will no doubt manifest themselves with increased intensification.
- Continuous innovation is required to reduce production and overhead costs.

10.4.4. Marketing

- Undeveloped local market for farmed finfish in South Africa.
- New markets should be assessed and developed in Europe and Asia for dusky kob products.
- Highly competitive global Atlantic salmon markets.
- Continuous innovation is required to develop new markets and products.

10.4.5. Electricity supply

- The uncertainty surrounding electricity supply in South Africa is a threat.
- Substantial increases in the cost of electricity may jeopardise onshore marine aquaculture.

10.4.6. Force majeur

- Floods
- Oil spills
- Storms

11. CONCLUSIONS AND RECOMMENDATIONS

The results of the marine finfish feasibility studies indicate the following:

11.1. Dusky kob

Despite limited growth data for dusky kob at different temperatures, the following base conclusions have been drawn regarding the future development of aquaculture for this species

11.1.1. Production systems and geographic suitability

Hatcheries

It is strongly advised that hatchery production systems for dusky kob operate on a RAS. Highly inconsistent larval survival rates can be improved through the application of RAS technologies which provide favourable/optimal rearing conditions for larvae and juveniles. Flow-through hatcheries are subject to ambient water temperature conditions that may negatively affect larval and juvenile survival and growth rates.

Hatcheries should be located close to the grow-out systems in order to reduce transport and other costs associated with delivery of juveniles from the hatchery to the grow-out systems.

Grow-out

In conjunction with a RAS hatchery, grow-out systems for dusky kob can be land-based tanks (operating on a RAS or flow-through basis), land-based ponds, or offshore-based cages. The suitability of the grow-out system will depend on the geographic location.

a. Ponds

Pond systems (with a RAS hatchery) are recommended for coastal regions from East London northwards. The relative success of the dusky kob pond operation at Mtunzini suggests that coastal sub-tropical regions e.g. Kwazulu-Natal would provide the best water temperature profiles for growth of dusky kob in pond systems in South Africa.

b. Tanks

Land-based grow-out of dusky kob in tank systems (with a RAS hatchery) can be achieved using RAS or flow-through systems. RAS technology, while more expensive to implement, allows for greater control over rearing conditions and therefore survival and growth. As RAS are equipped with heating/cooling capabilities, these systems can be located along the entirety of the eastern coast of South Africa. It is certainly more cost effective to be located within favourable water temperature profiles in order to reduce heating costs, however. Flow-through technology is reliant on ambient water temperatures and for this reason these systems should, preferably, be located from East London northwards to sub-tropical areas in order to take advantage of warmer temperatures in these regions.

c. Cages

The dynamic nature of South Africa's offshore coastline currently inhibits offshore-based cage aquaculture to those areas which are sheltered and located in bays. However, given developments in Norway which have seen a shift to farming in exposed offshore areas with extreme wind and wave conditions, it is foreseen that these technologies may well have application in the similarly dynamic conditions experienced in South Africa. Currently, and given the infancy of cage farming development in South Africa, it is recommended that cage culture of dusky kob (with a land-based RAS hatchery) is located from Algoa Bay northwards to Richards Bay which has very favourable water temperatures. The suitability of specific sites will depend on conflicts with resource users as well as environmental parameters.

11.1.2. Market

The South African market for farmed dusky kob is small, production costs are high and local sales prices are relatively low. This is not to say that the market could not be developed with marketing and promotions. However, the availability of wild-caught fish at cheaper prices, as well as a preference for this product in some areas, is a major disadvantage. In order to counter this, producers need to ensure a consistent supply of high quality product is available. Awareness around the sustainability of farmed vs wild-caught fish needs to be developed further such that this product can be placed in a higher price category based on positive customer perceptions

The market assessment revealed that dusky kob can be marketed alongside established European and Asian species such as barramundi, seabass, seabream and meagre. Export agreements for these competitive markets rely on a consistent supply of high quality product and, typically, at high volumes. It is recommended that any prospective dusky kob aquaculture operator conduct a detailed market assessment in order to secure an export arrangement or offtake agreement into the future which would counter the limited local market opportunity.

11.1.3. Financial model

Results from the financial model suggest that, based on the model assumptions and at a production scale of 500 tpa, aquaculture of dusky kob does not represent a viable business opportunity. The results of the financial model indicate a negative IRR, and is therefore unfavourable from an investment perspective. Costs of production are high in comparison to the sales price which can be achieved for the product. However; as production volume increases, the margin is improved. The sensitivity analyses indicate that the minimum viable scale is 750 tpa or greater for full RAS and cage production and 1 500 tpa or greater for pond-based production. Depending on the specific circumstances of the investor, some of the model assumptions may be adjusted within reasonable bounds and a different outcome may be realised.

Risks include a low sales price, power supply, feed costs, the limited local market, and high capital investment and capital financing costs, particularly with RAS and pond systems.

Any further development from this feasibility study should include a detailed, site-specific feasibility study and bankable business plan.

11.2. Atlantic salmon

The following base conclusions have been drawn regarding the future development of aquaculture for this species:

11.2.1. Production systems and geographic suitability

Hatcheries

It is strongly advised that hatchery production systems for Atlantic salmon operate on a RAS. Rivers in South Africa with suitable water temperature and water quality profiles, typically mountain streams, do not provide suitably consistent flows for commercial production of Atlantic salmon smolts. Furthermore, these streams are commonly subject to flooding and turbidity episodes which would negatively impact survival and growth in an Atlantic salmon hatchery. RAS production systems allow managers to provide favourable/optimal conditions (within limits) for the sensitive early life stages prior to grow-out.

Suitable geographic regions for an Atlantic salmon RAS hatchery may include the Cape Fold Mountains and Eastern escarpment (Mpumalanga and Kwazulu-Natal). Suitable areas would require access to a perennial source of high quality water provided either by a mountain stream or spring.

Grow-out

In conjunction with a RAS hatchery, grow-out systems for Atlantic salmon can be either land-based tanks (operating on a RAS or flow-through basis) or offshore-based cages. The suitability of the grow-out system will depend on the geographic location.

It is theoretically feasible to grow-out Atlantic salmon in land-based production systems. However, this technology is still in its infancy and is associated with very high capital and operational costs. Conversely, cage culture production systems are well-established, comprise the backbone of the Norwegian and Chilean salmon industries, and have comparatively low capital and operational costs. It is therefore strongly recommended that development of Atlantic salmon aquaculture in South Africa is geared towards implementing cage culture technologies in suitable areas. These areas include sheltered bays along the west coast such as Saldanha Bay, with potentially limited application along the east coast in areas such as Mossel Bay.

Other grow-out technologies may be explored once the industry has established itself and achieves reliable production quantities. The risk associated with developing land-based grow-out systems is too high given that there is currently no established Atlantic salmon aquaculture industry in South Africa. Other offshore-based technologies that are currently being trialled in Norway including advanced closed containment systems may well have application in South Africa. However, these technologies are still in their infancy and it is recommended that, in the absence of an established Atlantic salmon aquaculture industry, prospective entrants consider established technologies first.

11.2.2. Market

Given South Africa's imports of Atlantic salmon and a growing market for salmonid products including trout, there is a local market opportunity of at least 4 000 tonnes of farmed salmon. The export of South African salmon will require a comprehensive market study in order to determine where the product could be sold and, importantly, if it could compete with exports from established producers in Norway, Chile and other producer countries.

11.2.3. Financial model

Results from the financial model indicate that a RAS hatchery with cage grow-out system for Atlantic salmon is feasible under the given model assumptions. A full RAS production facility for Atlantic salmon shows only to be marginally feasible, with a low IRR (of 8%) and numerous risks especially considering the high capital outlay required as well as the infant nature of RAS for Atlantic salmon from a global perspective. From an investment perspective, an IRR of at least 20% would improve the commercial interests of such an operation. Risks include freshwater availability, power supply, feed costs, fluctuations in exchange rate, a competitive export market, and high operational costs associated with a RAS system.

In terms of the pursuit of a RAS system, it is important to note that there are very few profitable cases of RAS at a global context, and these typically use high value species (such as eels) or species that can be maintained at high stocking densities.

Any further development from this feasibility study should include a detailed, site-specific feasibility study and bankable business plan.

Useful financial appraisal requires relatively simple forms of analysis coupled with a thorough knowledge of the technologies and the (often changing) development context. It should therefore be undertaken by technical staff trained in the basics of financial analysis appropriate to a desired scale of an aquaculture enterprise. Financial analysis should be undertaken throughout the project or programme cycle to inform resource allocation decisions, and to guide and refine interventions and extension recommendations.

11.3. Government interventions for dusky kob and Atlantic salmon aquaculture production

This feasibility study has holistically studies the broad-based feasibility of aquaculture production of dusky kob and Atlantic salmon in South Africa. The study has highlighted the key risks and opportunities towards the sustainable and successful establishment of the aquaculture species. Essentially, the aquaculture industry in South Africa is still in its infancy and there is still much work to be done in order to mature the industry such that it can be competitive at a global scale. This section broadens on the interventions that government can implement to assist with the establishment of candidate species.

It is important for one to remember that "History shows that business, not government, develops a nation economically. Governments create the frameworks that encourage – or hinder – that development; but it is the private sector that generates entrepreneurship, creates employment, and builds wealth" (page 12, World Business Council for Sustainable Development, 2004). Governments' major roles are to regulate, to promote and to support private sector investments. Governments should invest in research and development activities, capital infrastructure, and public services and utilities. Furthermore, governments should develop or strengthen the technical capacities of private farms and firms, avoiding subsidies that distort the markets and weaken the competitiveness of the aquaculture sector in the long term.

11.3.1. Market

The DAFF should invest in undertaking dedicated international market assessments of specific aquaculture species, in particular dusky kob. Despite the growing local demand for fish foods, there is a mismatch in the market prices between wild-caught and farmed dusky kob, where wild-caught kob lands a lower price than that of farmed kob due to the high operational costs associated with production. For a local farmed kob market to be successful, there is a reliance on the seafood distributor and end consumer to favour an aquaculture product and be willing to pay an increased price for such a farmed product, which is still lacking (undeveloped) in South Africa. It is on this premise that the South African mariculture industry focuses efforts on farmed kob to become an export product on international markets. In order to ascertain this, an international market assessment is needed to test the product and potential price that may be achieved. On the premise that a feasible price may be achieved, the potential to culture at scale also needs to be achieved in order to secure an off-take agreement.

11.3.2. State-owned or state-supported hatchery and processing facilities

Challenges in securing land and water rights at suitable location as well as raising capital are still significant barriers to entry. A government owned hatchery and/or processing facility would promote entry and meaningful development of sector. This would reduce cost of entry into the sector, the initial capital investment cost and high skill requirement as well as foster opportunity for multiple >1000 ton farms to improve vertical bargaining power and reduce cost of inputs.

11.3.3. Input supplies

Currently, there are few (if any) large-scale producers of good quality fish feed in South Africa. Unfortunately, the technology and nutritional quality required for good quality feed is still lacking due to the infancy of the South African aquaculture industry. Feed that has the potential to optimise FCR in industry is imported from international feed producers (e.g. Skretting) which, in turn, incur high operational costs for producers. Local producers could be assisted with cost reduction if there is access to quality local feed. It is therefore recommended that this is pursued as a focal point by government. It is also highly recommended that the pursuit of this is done with the aim of involving the international "main players" of aquaculture feed that already have the required established knowledge and technology.

11.3.4. Aligned institutional support for aquaculture development

There is a large need for increased collaboration between governmental institutions in terms of support for the aquaculture industry in South Africa. Whilst aquaculture has been given large focus as a mechanism for economic growth and development in South Africa, there still exists a mismatch between departments that result in high operational costs and are a hindrance to the sector. The South African Revenue Service (SARS) is the responsible institution for overseeing the imports of goods into South Africa. However, the tariff costs associated with importing various inputs into the country result in high costs to producers and indicate a lack of correlation in support for the industry. As an example, fish feed from France was re-categorised by SARS to soluble fish feed in early 2016, against professional assessment, such that a 20% import duty could be applied. This indicates that government departments are not aligned with one another, and therefore should be focused on as a priority point to assist with the establishment of the aquaculture sector.

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APPENDIX 1: COMMENTS BY INDUSTRY ON FEASIBILITY STUDY OF MARINE FINFISH

Growth rate of dusky kob:

Growth rate of dusky kob was considered conservative by some members. Some indicated that they have achieved growth rate from egg to 1kg in 12 months at commercial stocking densities while this model predicts a growth rate of 2g (2 month old fish) to 688g in 12 months for Dusky Kob in RAS systems. This will have a significant impact on commercial viability.

DAFF Response: *This feasibility used growth rate of Australian dusky kob. Growth rate in South African dusky kob still needs to be independently tested and verified. Improved growth rates would significantly improve financial model and could be edited in the excel business plan according to specific projects.*

Marine fish hatchery:

What the study does not model is the cost advantage of a marine fish hatchery that services the industry as a whole i.e. one large hatchery operating at scale that services the entire industry. This type of hatchery will reduce juvenile fish supply costs and will also ensure a focus on juvenile quality and genetic improvement as the industry develops.

DAFF Response: *This was identified as a potential government intervention to explore to improve financial viability of both dusky kob and salmon in the execute summary and is being explored.*

Incentives:

Incentives that should be further explored include incentives for services such as electrical costs and sea water charge (in Industrial Development Zones) in order to support the growth and scale of the sector. Aquaculture is a necessary industry and must be seen as “farming” industry and distinctly different to fishing and needs government support and buy-in at all levels. From a future and environmental side it is apparent that with the growing world population aquaculture must be pursued.

Pertaining to the comments on Special Economic Zones (SEZ), page 21, the tax incentives are to be detailed. For example, EL-IDZ incentives and benefits are being talked about but do not seem defined and need more detail. As far as I am aware for the EL-IDZ they are not yet implemented due to the differences between an SEZ and IDZ. I would personally like to see special incentives for services such as reduced electrical costs, sea water charges for aquaculture

DAFF Response: *Agreed, these avenues must be explored but needs to be within the realms of sustainable and feasible solution which does not result in the costs being transferred to government. Current incentives in IDZ's appear to be focused on manufacturing (e.g. 12l Tax Allowable Incentives). This matter needs to be explored further.*