Abalone Feasibility Study

Final Report

2018

agriculture,
forestry & fisheries

Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

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Executive Summary

The Department of Agriculture, Forestry and Fisheries (DAFF) Chief Directorate: Aquaculture and Economic Development aims to "*develop a sustainable and competitive sector that will contribute meaningfully to job creation, economic development, sustainable livelihoods, food security, rural development and transformation"* in South Africa. In line with this mandate, research and development has been done on several freshwater and marine species which are important and valuable to the South African aquaculture sector.

Haliotis midae are one of five abalone species that are endemic to South Africa and is the only farmed abalone species in South Africa. Globally, abalone are one of the most luxurious and expensive seafood products, with high demand specifically in the Asian countries because of the cultural, traditional, and medicinal qualities associated with abalone. In South Africa, the abalone industry has experienced rapid growth and development, and today is considered one of the most important and valuable species to the South African aquaculture industry. Abalone production in South Africa is found along the Eastern Cape, Western Cape and Northern Cape coastline as the ocean temperatures offer optimal production conditions for the abalone.

The abalone market is dominated by China and Korea, followed by South Africa, who is the third largest abalone producer in the world. On the international market, South African abalone are well known for their high quality, good taste, textures, and colours. These characteristics have resulted in South African abalone becoming premium products that command high prices on the international market. The South African local market faces challenges from the illegal abalone industry, which compromises abalone prices and the well-established farmed abalone reputation. In recent years, global abalone demand has increased, specifically in Asia (China, Hong Kong, and Japan). This increased demand has triggered an increase in global abalone production however, despite the increased production the abalone prices and demand are expected to remain stable.

The following production guidelines provided in the table below gives a brief overview of a few important factors that should be considered when looking at abalone production in South Africa.

Abalone Production Guidelines

Optimal Temperature Range	16-18°C (Ollerman, 2005)
Water Conditions	Optimal pH: 6.5 – 8.5 Salinity: 30 -35 ppt
Average Feed Cost	• R 27.00 /kg Manufactured feed • R 3.50 / kg Kelp
Typical Survival rate	• **RAS/Flow-through/Cage:** 86% over 45 months • **Ranching:** 30% (After seeding)
Maximum Marketable size catered for in the Generic Economic Model	• **RAS/Cage & Flow-through:** 100 grams (45 months) • **Ranching:** 500 grams (76 months)

The generic economic model for abalone was developed through inputs from technical experts, industry stakeholders and peer-review workshops. Key assumptions used in the model are mentioned above, as well as several other production and system related assumptions were

incorporated into the model**. An example** of the generic economic model results is illustrated in the table below.

Example: Financial Analysis: Abalone in Flow-through System

Production and Financial Assumptions	
Province	Western Cape
System	Flow-through
Minimum viable production	113 tons
Selling price	R 420/kg
Selected selling weight	45 months (100 grams)
Target market	International Market
Applicant details	Start-up farmer with no land, no infrastructure, or facilities
Education level	Formal Education (certificate, diploma, degree)
Finance option	Debt/Equity (20%)
Interest Rate	8.25%
Generic Economic Model Results	
Total Capital Expenditure	R 156 814 255.76
Loan Amount – Working Capital	R 105 215 404.04
Loan Amount - Infrastructure	R 51 598 851.72
Profitability Index (PI)	1.00
Internal Rate Return (IRR)	7%
Net Present Value over 10 years	R 156 884 174.44
Minimum Farm Size Required	4.31 hectares
Number of employees (Year 1)	82

Based on the table above, it is evident that abalone production in the Western Cape is profitable in a flow-through system when producing a minimum of 113 tons per annum, with a selling price of R 420/kg. A positive PI of 1.00 was achieved with an IRR of 7%. The capital expenditure for a flow-through is high due to the required infrastructure, technology, operational costs, and feed costs. A total capital expenditure of R 156 814 255 is required. This amount is the result of the working capital costs which are an estimated R 105 215 404, and the infrastructure costs of R 51 598 851. The working capital costs are calculated for a period of 45 months, as the first abalone sales are expected to occur at the end of month 45.

It is estimated that at 113 tons per annum it will cost R 1 387 736 to produce one ton of abalone.

As previously mentioned, abalone production is limited to the Eastern, Western and Northern Cape coastlines. From the generic economic model, the Western Cape and Eastern Cape are slightly more profitable for abalone production than the Northern Cape. Four (4) production systems were included in the generic economic model, which included recirculating aquaculture systems (RAS), ranching, cage culture and flow-through systems. Although all systems were profitable, out of the four (4) systems, cage culture and ranching are the most profitable systems, with RAS and flow-through, although profitable and more common than the other two production systems, offering a lower return on investment.

Disclaimer: *Production information and assumptions in this report may be subject to change over time as certain production variables can be expected to fluctuate. Technical assumptions were utilised from various industry experts and stakeholders. Due to the sensitive nature of information shared by stakeholders, personal details of stakeholders will not be included in the report. Certain stakeholders will be referenced as "Personal Communication" in the document, and reference list.*

Table of Contents

Table of Figures

List of Tables

1. Introduction

1.1. Project Background

In South Africa, aquaculture has been identified as a key economic sector and employment cluster. Various policies, programmes and initiatives have been developed and implemented to assist with the development of the aquaculture sector. In support of aquaculture development, key initiatives such as the National Aquaculture Strategic Framework (NASF), the Aquaculture Development and Enhancement Programme (ADEP), and Operation Phakisa were established. The primary goal of the various policies, programmes and initiatives is to accelerate the growth of the aquaculture industry in order to assume a critical role of supplying fish products both locally and internationally; improving job creation, and contributing to the national economy, among other aspects. The sector has also been identified as a key industry that can impact the development and reindustrialisation of the rural communities and townships in South Africa.

Aquaculture is one of the fastest growing food sectors in the world, yet in South Africa, the sector remains small and underdeveloped despite the high-growth potential offered by the sector. In recent years, South Africa has seen improved access to aquaculture technology, increasing amounts of research and development, as well as support from various government departments. The South African abalone industry has experienced rapid growth and development which is linked to continued research and development, local and international support, a well-developed local value-chain, and high demand for the South African abalone.

This report focuses specifically on abalone production in South Africa, and considers the following potential production systems:

I. Recirculating Aquaculture Systems (RAS),
II. Flow-through systems,
III. Cage culture, and
IV. Ranching.

1.2. Purpose of the Feasibility Study

This feasibility study will be focusing specifically on abalone, and the potential culture systems identified. The study will cover the following aspects:

I. Abalone background
II. Geographical location best suited for production,
III. Global, regional, and local market assessment,
IV. Potential barriers to entry,
V. SWOT Analysis for abalone in South Africa,
VI. Technical Assessment,
VII. Financial Analysis, and
VIII. Conclusions and recommendations.

In addition to the feasibility study conducted, a generic economic model was developed for abalone. The generic economic model is aimed at assisting DAFF, industry stakeholders, role-players, and new entrants to the abalone industry to determine the financial viability of abalone projects in South Africa

1.3. Feasibility Study Overview

The feasibility study is made up of nine (9) sections. Each section is discussed in more detail below to provide an overview of the report.

- **Section 1:** This section provides a project background and provides the main aspects that are will covered within the feasibility study.
- **Section 2:** This section focuses on providing a species background, and the key biological and physical characteristics for abalone. An overview and introduction to abalone production in South Africa is also covered in this section.
- **Section 3:** A detailed explanation of the potential production systems that can be used for abalone in South Africa is provided. These production systems are included in the generic economic model to determine the financial viability of each system.
- **Section 4:** This section looks at the geographical distribution of abalone in South Africa, and provides a high-level suitability assessment, and identifies key requirements for profitability.
- **Section 5:** This section provides a detailed global, regional, and local market analysis for abalone. Marketing, pricing, demand and supply, and the barriers to entry are key factors to be considered before implementing an aquaculture operation.
- **Section 6:** A SWOT Analysis gives a high-level overview of the abalone industry in South Africa. Mitigation measures are discussed to address key weaknesses and threats identified.
- **Section 7:** A technical assessment provides a brief overview of key production assumptions and guidelines that can be used for abalone production. These assumptions were used in the development of the generic economic model.
- **Section 8:** This section provides a financial analysis for the potential production systems based on the results obtained from the generic economic model. A high-level cost-benefit analysis is discussed to compare the feasibility of the potential production systems. A best-case scenario is provided to highlight the minimum viable tonnage, recommended selling price and investment potential offered by the potential production systems in the Western Cape, Eastern Cape and Northern Cape.
- **Section 9:** The last section provides the conclusion on the feasibility study and provides recommendations for the growth and development of the abalone industry in South Africa.

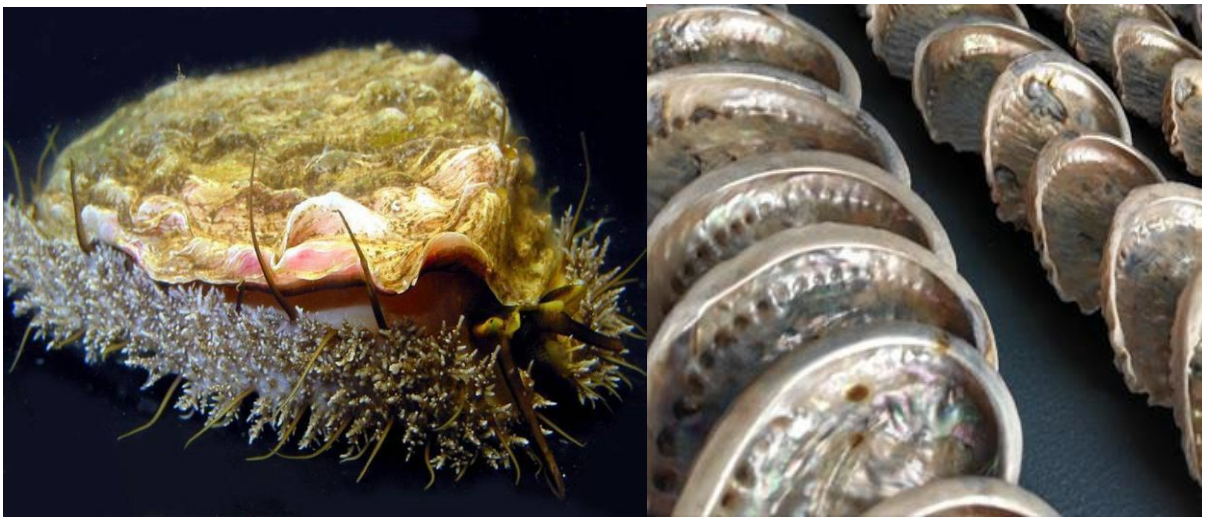
2. Abalone

2.1. Species background

Abalone belong to the family *Haliotidae,* which essentially is a group of small to large edible sea snails and marine gastropod molluscs. There are over a 100-abalone species, belonging to the genus of *Haliotis.* Abalone are a slow-growing and maturing species, that live attached to rocks in intertidal and subtidal sea zones, however, records indicate the first captive spawning of abalone started in 1983, with the abalone industry being established in South Africa in the early 1990's. Since the 1990's, the abalone industry has been successfully producing farmed abalone for consumption. *Haliotis midae* is one of five abalone species that are endemic to South Africa and is commonly known as the "perlemoen". In South Africa, the only farmed abalone species is the *Haliotis midae* which has a flattened, ear-shaped shell with a wide opening at the base- unlike their terrestrial snail cousins that have spiral shells. The South African abalone industry has developed at rapid rate in recent years, specifically in response to the demand and premium prices received for abalone, and the decreasing numbers of wild abalone stocks due to poaching. In South Africa, the rapid development of the industry can be linked to the favourable coastal conditions, labour costs, infrastructure availability and the well-known reputation of South African abalone on the global markets (Troell, et al., 2006). Abalone is considered one of the most luxurious, and expensive seafood products, and is in high demand specifically in Asia due to the cultural, traditional, and medicinal qualities associated with abalone.

In South Africa, the abalone industry has experienced rapid growth and development, and is now considered one of the most important, and valuable species in the South African aquaculture industry. The development of the industry can be attributed to the intense research, development, and support at a local level, as well as the large international demand for the high-quality South African abalone. The South African abalone industry has gone to great efforts to develop itself, which can be seen in the well-developed value chain, which includes specifically developed abalone feed, good breeding, and spawning practices right through to well established marketing channels.

Figure 2-1: Haliotis midae in South Africa



Source: Two Oceans Aquarium (2018)

2.1. Biological characteristics

Abalone can be produced in tanks and ponds; however, consideration for their natural environment should be given as abalone require surfaces to cling to or hide under. Typically, abalone are found in large groups, and are generally inactive with little movement occurring, even in their natural environments. Abalone can be found in various colours, which is thought to be influenced by the type of feed that they consume.

The sex can be determined by the colour of the reproductive organs, which differs between male and female abalone. Male abalone have cream-coloured gonads and female abalone have green-coloured gonads (Visser-Roux,2011). This method of sexing the abalone is common practice on South African abalone farms.

Usually the breeding season and the duration of the season varies according to type of abalone species as well as the environmental conditions. In South Africa however, studies showed that the breeding period for abalone is between March and October, while spawning increases during the period of April and June (Wood& Buxton 1996). During spawning, the abalones release reproductive cells through their small breathing holes. Usually abalone spawn early in the evening or at dawn, where in most cases, the males will release sperm first, which causes the female abalone to spawn. When one abalone, either male or female releases eggs or sperm it can trigger all nearby abalone to spawn.

In South African abalone farming operations, the “hatchery phase” describes the development of the abalone from when the eggs are fertilised, to when a 10-millimetre spat has grown. This phase lasts an average of six (6) months, which highlights the slow-growth rates of the abalone. In commercial abalone operations, broodstock abalone are specifically selected for breeding purposes to offer superior characteristics and ensure the production of high-quality abalone. The broodstock are kept in highly regulated environments to ensure optimal production conditions and health of the abalone. By controlling the broodstock, the eggs produced, and fertilized are bound to be of the highest quality, thus maintaining the quality of farmed abalone which allows for producers to sell the abalone for premium prices on the international markets.

Once the abalone have spawned, the eggs are fertilised by the male sperm, and within a few hours the larvae will emerge from the eggs. The larvae are housed in tanks of filtered and in some cases, UV treated water to remove any contaminants. Larvae are maintained in these tanks until they metamorphose from veliger larvae to trochophore larvae, which can take up to five (5) days. Larvae are lecithotrophic, meaning they can survive on their yolk sacs, once these sacs have been absorbed, the larvae will begin swimming in search of food which indicates they are ready to settle. The larvae are transferred to settlement tanks, which are normally rectangular tanks fitted with plastic corrugated sheets, coated in diatoms. These sheets are placed vertically in the tanks. The settlement tanks are initially operated as closed systems for a short period, after which water is allowed to flow through them at a controlled flow-rate. The larvae at this point undergo a metamorphic phase, which can last between five (5) and seven (7) days depending on the temperature within the settlement tanks. Once the larvae have undergone this phase, they will attach themselves to the diatom plates and begin to feed. These settled larvae are now referred to as spat (Figure 2-2 below) (Fourie, 2014).

Over the next three to four months the spat will feed on the micro-algae until it has been depleted. Before moving the spat to new conditions, they are normally anaesthetised, sorted into size groups and transferred to the next production phase. In the next phase of production, the spat will be weaned off their natural diet of microalgae and introduced to a manufactured feed diet. Under optimal conditions, once the spat have grown are 10 millimetres or larger, they are considered robust enough to handle the grow-out systems. The size of the spat being moved into grow-out units varies from farm to farm, with some farms moving the spat to grow-out units when they reach a size of two (2) centimetres.

Figure 2-2: Abalone Spat

The grow out phase for abalone can last from 36 to 52 months, depending on where the abalone farm is located along the Cape coastlines. Abalone farms along the West Coast have an average growth rate close to 1.5 millimetres (mm) per month, thus the grow-out period can reach 52 months. The Western Cape coast offers the best growth rates for abalone with approximately 1.7 mm per month, thus the grow-out period is estimated to be 45 months. Most South Africa producers utilise land-based flow through systems and suspend the abalone in baskets in specifically designed tanks, and feed an artificial diet of manufactured feed, which has been specifically formulated for abalone production. Continuous monitoring, water quality testing and control of the grow-out systems are required for good quality abalone to be produced (HIK Abalone, 2018).

2.2. Physical requirements

The physical requirements section discusses the feeding patterns and requirements, temperature, and water conditions which play an important role in the successful production of abalone. The physical requirements, specifically feed, water quality and temperature factors are some of the key production assumptions used in the generic economic model, and impact on the infrastructure requirements and operational expenditure of a production system.

2.2.1. Feeding

In South Africa, research and development has, and still does play a crucial role in the development of manufactured abalone feed and understanding the impact feeding (manufactured feed vs kelp) has on growth rates, meat yields and food conversion ratio (FCR). According to research and development conducted for Marifeed, growth rates, meat yields and FCR of abalone are superior when feeding manufactured feed (in this case, Abfeed), as opposed to a strictly kelp (*Ecklonia maxima)* diet or a mixed diet of kelp and Abfeed.

It was also noted that a mixed diet recorded better results than a strictly kelp diet, indicating the importance of manufactured feed for growth rates and meat yields (Marifeed, 2018). Marifeed has developed Abfeed, specifically formulated for South African conditions and abalone production. The formulations of Abfeed are discussed in Table 2-1 below.

Table 2-1: Marifeed: Abfeed Overview

Formulations	Overview

Formulations	Overview
Abfeed S34 Standard & Prime	• Selling Price: R 27 per kilogram (Standard) • Selling Price: R 29 per kilogram (Prime) • 34% protein content • Original Abfeed formulation • Weaning stage to marketable size • Not recommended where temperatures exceed 20°C • Requires good water exchange rates – can be problematic in some recirculation systems
Abfeed ES26 Standard & Prime	• Selling Price: R 27 per kilogram (Standard) • Selling Price: R 29 per kilogram (Prime) • 26% protein • Suitable for Abalone from 15 mm to market size • More suited to higher temperatures, but effective from at least 14°C • Developed to allow farms sustainability certification • Lower protein levels improve water quality through reduced ammonia production • Can be used in recirculation systems

Adapted from (Marifeed, 2018)

From the table above, it can be seen that manufactured feed is only suitable and effective for specific temperatures ranges. According to Green (2009), artificial abalone feed provides challenges for producers, as it is designed to promote the growth of abalone within the optimal temperature range of 18 -20°C, however as most abalone farms make use of flow-through tank based production systems, the abalone are exposed to temperatures outside of this range.

According to Marifeed (2018), while manufactured feed is more expensive than a seaweed-based diet, the following benefits should be noted:

- On well managed abalone farms, FCR' s of 1:1.2 to 1:1.5 can be achieved,
- Increased processing yields (specifically for canning purposes),
- Feeding times can be reduced, thus reduced labour costs,
- Availability of manufactured feed,
- Superior growth rates have been recorded compared to seaweed diets, and
- Reduced risk of imported parasites and pests from the wild (Marifeed, 2018).

2.2.2. Temperature

Abalone can be found in water temperatures between 9°C and 24°C. However, the preferred temperature range for abalone is between 16°C and 18°C. These cool temperatures are conducive to the growth of the abalone through all the development stages of its lifecycle. Water temperature plays a key role in the rate of development and growth of abalone, specifically in the earlier stages of the life cycle. Mortality rates have been reported at temperatures above 25°C. If the temperatures are too high, it will hinder the success of larval or prevent their development. When the temperatures are too low, it may result in slower growth, and a longer than usual larval growth stage. According to Ollerman (2005), the optimal water temperature should be between 16 and 18°C, which will allow for abalone growth rates of approximately 1.6 to 1.8 mm per month to be achieved (Ollerman, 2005).

2.2.3. Water Requirements

In the South Africa, the suitable pH levels for abalone production range from 6 – 9. However, the preferred range for abalone production, is 6.5 to 8.5 which ensures optimal water conditions can be achieved. In terms of salinity, 30 – 35 ppt is recommended for abalone, however this is normally dependant on the location of the abalone culture system, and the natural oceanic conditions. The water quality should be adequate, and free from contaminants (pollutants, chemicals, excess minerals etc), and monitored in terms of temperature, pH, oxygen, and ammonia levels. Juvenile abalone should be raised in filtered, or UV treated water as they are very sensitive to water quality issues that could result from pollution, chemicals, or pollutants.

2.3. Abalone Production in South Africa

Domestic abalone production started in the 1990's and by 2001 was the most important and valuable aquaculture sub-sector in South Africa. According to DAFF (2016), 18 abalone farms were identified in 2015, twelve (12) of which are land abased facilities with independent hatcheries and four (4) operated grow-out facilities only. The remaining two (2) abalone farms include sea cage culture. Three (3) farms were registered as ranching operations. The abalone farms are distributed along the Cape coastline from the Northern Cape and Western Cape to the Eastern Cape. The farms are distributed as follows:

- **Northern Cape:** Four (4) farms,
- **Western Cape:** Twelve (12) farms, and
- **Eastern Cape:** Two (2) farms (DAFF, 2016).

Together these operations produced total of 1300 tons in 2014, with an estimated farm gate value of US$ 42.3 million. According to Agrifusion (2017), land-based abalone production activities in South Africa are expected to increase by up to 60% by 2021, with the five largest producers currently expanding their operations, which will increase the production volumes, and further highlighting the importance and value of abalone sub-sector to the South African aquaculture industry (Agrifusion, 2017). The distribution and location of the abalone the farms along the Cape coastline indicates that the cooler sea temperatures and associated climates are suited for abalone production. The Kwa-Zulu Natal coastline is not suitable for abalone production due to high temperatures resulting from the warm Indian oceans.

2.3.1. Wild Abalone Fishery

Commercial diving abalone has been around since the late 1940's where high volumes of up to 3000 tonnes were recorded as the harvesting of abalone was unregulated. Due to the depletion of wild abalone stocks, commercial quotas were introduced in the late 1980's. Over time, illegal harvesting, declining stocks, and changing eco-system conditions resulted in drastic reductions in the quotas allocated for abalone. Between 2008, and 2010, commercial abalone fishery was banned, however in 2010 it was reopened with an annual quota of 150 tonnes per annum. Recreational harvesting of abalone was suspended in South Africa in 2003 and remains suspended to date.

2.3.2. Abalone Poaching

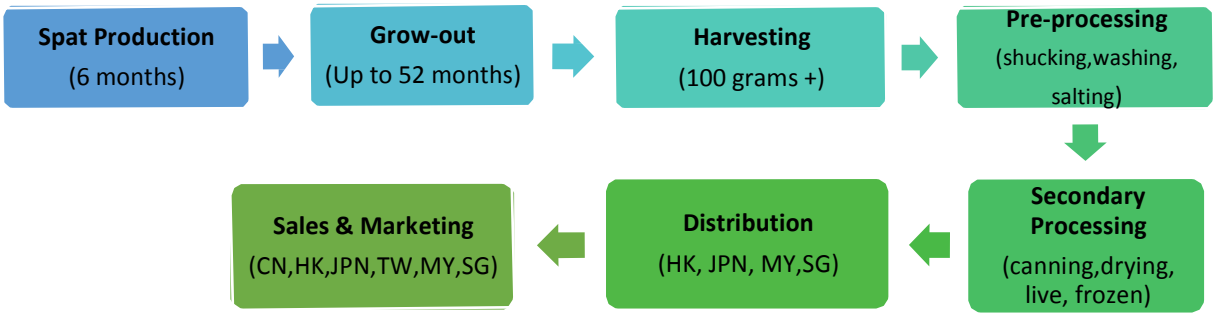
Abalone poaching places major pressure on the abalone industry and is threatening the commercial producers. Generally, poached abalone is of lower quality, and compromises the perceptions of South African farmed abalone, which are normally known as high quality, and premium products on

the international markets. As a direct result of poaching, natural stocks have rapidly declined, and numbers remain exceptionally low with little chance of recovery.

2.3.3. Abalone Value Chain

As land-based production is the primary production method in South Africa, the value chain has been well developed over the years. Today, abalone production is considered as closed life-cycle aquaculture. Land-based production covers the whole life cycle of abalone, from spawning, to harvesting and selling of abalone. Typically, the abalone production cycle runs for approximately 45 to 48 months, and abalone are sold at 100 grams. 100-gram abalone are known as cocktail abalone and are the most commonly produced size of abalone with very few producers targeting bigger abalone. The length of the production cycle is based on the Western Cape abalone industry which records an estimated 1.8 mm shell length growth per month. Figure 2-3 provides an overview of the seven steps involved with the abalone production.

Figure 2-3: Abalone Production Cycle in South Africa[1]



Adapted from (Agrifusion, 2017)

Inbound Logistics (Raw Materials)

- 12 farms have hatcheries and produce their own spat to support their operations,
- A combination of wild abalone stock, and F1 brood stock is normally used, however the larger operations are incorporating genetic selection programmes,
- Kelp, and artificial feed (either exclusively or combined). Some operations are investigating the production of seaweeds (Ulva and Gracilaria sp) to assist with feed production, and
- Two farms have their own abalone feed manufacturing plants, who supply other producers. In addition, there is one independent producer of abalone feed in South Africa.

Grow-out operations

- The largest abalone operation in South Africa currently produces 400 tonnes per annum, however abalone farms are currently expanding their operations,
- Typically, intensive pump ashore flow-through systems are used, as well as sea cage culture and ranching operations (which are currently being piloted),
- South Africa is at the forefront on a global scale when it comes to land-based abalone farming techniques and management systems,

[1] *Distribution: Hong Kong, Japan, Malaysia, Singapore*
Marketing: China, Hong Kong, Japan, Taiwan, Malaysia, Singapore

- The average abalone harvest size is 100 grams; however, they can be harvested from 35 grams upwards. Some farms focus on larger abalones of up to 300 grams in size.

Outbound Logistics (Processing & Distribution)

- Abalone output in South Africa is exported, predominantly to the Far East,
- Several value-add options, namely canned, dried, frozen, or live,
- Pre-processing activities normally conducted at the farms,
- secondary processing is outsourced to four establishments, owned by the largest abalone farms.

Marketing & Sales

- Significant investment has been made in areas of product development, consumer, and buyer market intelligence, branding and promotion, distribution, and the development of sales organisations

2.3.4. Legislation and regulations for Abalone Production

In South Africa, several legislative and regulatory frameworks have been implemented to regulate and monitor abalone operations in South Africa. Typically, an abalone producer or farm in South Africa is required to have the following authorisations in place:

I. **Marine Aquaculture Right:** This must be obtained to engage in marine aquaculture activities in accordance with Section 18 of the Marine Living Resources Act (MLRA,1998), from the DAFF. A right to engage in marine aquaculture is valid for 15 years, and all marine aquaculture permits except for import permits are renewable on an annual basis and remain valid for a period of 12 months. The marine aquaculture permits required include permission to engage in marine aquaculture activities, and additional permission is required to operate a hatchery and collect broodstock, export products produced under marine aquaculture conditions, or operate a marine aquaculture fish processing establishment (FPE).

II. **Abalone Traceability Protocol (2018):** This protocol has been developed to establish a basis for the local marketing of undersized cultured abalone that will assist DAFF to promote marine aquaculture, promote consumer awareness, and prevent the illegal trade of undersized, wild caught abalone on the local market. In addition to this, the traceability protocols are important for food safety to ensure no contaminated food products are sold onto the market, and they provide a mechanism to recall products that are unsuitable for human consumption. In line with the MRLA (No 18 of 1998), a permit is required in circumstances that involve the possession and sale of undersized abalone in terms of regulation 37 promulgated in the MLRA (DAFF, 2018).

IX. **Standard Marine Aquaculture: Specific Conditions Abalone 2018** provides specific conditions for abalone production in South Africa and highlights key aspects that need to be adhered to. Key aspects include broodstock collection, animal movement and diseases, abalone hatchery, abalone grow-out: land based, and sea based, harvesting and processing to name a few. In addition to these specific conditions, ranching operations require specific conditions to be met which differ from the land-based operations (DAFF, 2018).

III. **Environmental Authorisation:** Obtaining this authorisation is dependent on the province and type of activity being engaged in. In the Western Cape, sea-based facilities require authorisation from the Department of Environmental Affairs (DEA) at a provincial level. It is important to note that abalone ranching requires provincial DAFF approvals.

Based on the Environmental Impact Assessment (EIA) regulations (2014), environmental authorisation may be required before establishing an aquaculture operation as certain activities listed under the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998), EIA regulations (GN R982) and accompanying listing notices R983; R984 and R984. Permits for aquaculture projects are based on production capacity and require a basic assessment unless activities which are listed under Notice 2 or 3 of NEMA are triggered.

IV. **Coastal water discharge permit:** An application must be prepared and submitted in accordance with the Integrated Coastal Management Act (ICMA) (Act No. 24 of 2008) and its amendments to obtain permits from the DEA to allow for coastal water discharge (Republic of South Africa, 2008).

V. **Land Use Planning and Access:** The land assigned for the proposed aquaculture activity must be rightfully owned by the applicant, or consent must be obtained for the use of the land from the applicable local/district or metropolitan municipality. The land use planning for the proposed abalone production activity must be in place. The following aspects must be considered:

a. Zoning for the land should specify agricultural use; aquaculture activities or industrial activities. If the zoning is not suitable, a rezoning application must be lodged with the relevant authority.
b. Intended agricultural/aquaculture activities must comply with the Conservation of Agricultural Resources Act,1983 (Act No.43 of 1983).
c. Relevant legislation or documents such as the local municipality town planning schemes, Spatial Planning and Land Use Management Act, relevant Integrated Development Plans (IDP's) and Spatial Development Frameworks (SDF's).

VI. **Lease Agreement or Title Deed**: Depending on the land ownership of the identified site, a valid lease agreement or title deed is required, and will have to be obtained by the abalone producers or company. The Department of Public Works (DPW), Department of Rural Development and Land Reform (DRDLR), or municipality is the responsible authority for allocating land on the admiralty reserve. If the proposed abalone activity requires the lease of sea space (outside of Transnet Port authority), pipelines should be below the High-Water Mark (HWM) and coastal public property (CPP) should be lodged with the DEA. The DEA at a provincial level is the lead agency for coastal leases and concessions, and all applications should be submitted to the relevant department.

3. Potential Culture Systems for Abalone

The following describes the relevant culture systems that could be considered for Abalone production. During the life cycle stages of the abalone, various culture systems can be used to meet the requirements of each growth phase.

- **During larvae phase** a hatchery is used, which operates based on a recirculating aquaculture system (RAS) to allow for the monitoring and control of water temperatures and water quality parameters.

- **Juvenile abalone (2 months old)** are reared in flow-through tanks, where environmental conditions can be regulated to an extent. This phase may not be applicable for every abalone farm and will be dependent on the location of the farms, and the availability of a hatchery/nursery to ensure a favourable temperature can be maintained.

- **Intermediate/Weaning abalone (4 – 6 months)** are transferred to intermediate culture systems, normally tanks with floating plastic mesh baskets structures for the abalone to crawl on. This is also known as the diatom stages, where abalone are attached to microalgae plates, and slowly weaned onto an artificial feed diet.

- **Grow out systems** can be land based, partial re-circulation flow-through tank systems, ranching, RAS, or cage culture systems.

3.1. Recirculating Aquaculture Systems

The Recirculating Aquaculture System (RAS) offers a dual objective of sustainable aquaculture, (i.e. to produce food while sustaining natural resources) which is achieved through the minimum impact the system has on its surrounding environment and the eco-system in general. The RAS is sometimes referred to as indoor or urban aquaculture, reflecting its independency of surface water to produce abalone.

The larval stages of the abalone life cycle are typically conducted in a hatchery, which operates a RAS, as it allows for the monitoring and management of water temperatures and water quality parameters required for larval development and growth. Water recirculating methods of aquaculture production is ideally suitable for areas with scarce water resources. The benefits of using recirculation technology include the possibility of more regulated rearing temperature, and securing high and constant water quality, which can lead to better growth potential and fish health. The capital investment for farm construction is normally much higher for RAS systems, when compared to that of conventional aquaculture systems. As such, the system should be designed and constructed in a way that it would be managed at less running costs, to compensate for the initial capital investment.

Advantages of using the recirculating aquaculture systems

I. Partial RAS generally requires water and pumping than a flow-through system,
II. The system allows for intensive aquaculture production to be undertaken on a smaller footprint,
III. A Partial RAS uses seaweed bio filters, which are in turn fed to back to the abalone thus recirculating nutrients.

IV. RAS provides opportunities to reduce water usage, improve waste management and increase nutrient recycling, and
V. RAS allows for biological pollution control and reduction of visual impact of the farm.

Disadvantages of using the recirculating aquaculture systems

I. Managing disease outbreaks may pose specific challenges in RAS, in which a healthy microbial community contributes to water purification and water quality, Highly technical systems, and not always user-friendly,
II. There are many different bio filtration systems involved in operating the systems. These would need to be screened with the best adapted to local conditions,
III. The discharge of effluent water may require a permit, with required periodic testing and oversight,
IV. Large capital investment is required for building and starting up facilities, and
V. Minerals, drug residues, hazardous feed compounds and metabolites may accumulate in the system and affect the health, quality, and safety of the abalone.

For abalone culturing, while traditional recirculating aquaculture system may not be ideal for abalone production, producers can make use of partial recirculating aquaculture systems which can be less disease prone and risky in comparison to the traditional RAS. Partial recirculation can be used at both 50% and 75% recirculation. According to DAFF (2018), findings on 50% partial recirculation systems showed that abalone growth rates can be maintained, as well as water quality and control. Although RAS has been tested and previously used in South Africa, it carries a higher disease risk than other production systems, and thus careful consideration should be made before selecting a RAS as the primary production system for abalone.

3.2. Flow Through Systems

Currently, land-based flow-through systems are the most commonly used production systems in the South African abalone industry, predominantly due to the success, as well as available resources, data and knowledge surrounding the system. Within an abalone flow-through system, grow-out tanks are continuously refreshed with large quantities of sea water, often pumped directly from the ocean, thus abalone land-based operations should be located in close proximity to the ocean. The most essential features of flow-through aquaculture systems include the rapid removal of waste, the continuous replenishment of the system with highly oxygenated sea water, as well as a sloping topography. Flow-through aquaculture systems require water exchange to maintain suitable water quality for abalone production and rely on water flow for the collection and removal of metabolic wastes. Water for flow-through facilities is usually sourced directly from the ocean, and as a result may require an application for a coastal water discharge permit as well as compliance with certain regulations. The discharge of a high-volume, dilute effluent from flow-through aquaculture facilities greatly limits the treatment options available to producers from both technological and economic perspectives.

Advantages of using the flow through system

I. Good infrastructure and technology available in South Africa,
II. Abalone are currently being successfully produced in land-based operations, thus good information and knowledge on flow-through systems exists within the abalone industry, and

III. The Western Cape, selected areas along the Eastern Cape coastline, and Northern Cape coastlines provide ideal temperatures and high-quality water required for abalone production

Disadvantages of using the flow through system

I. Flow-through systems have been associated with slow-growth rates due to temperature fluctuations,
II. The success of operating a flow-through system depends on natural conditions and environmental events. For example, a cold winter or a hot summer can limit the production,
III. The system could become polluted or contaminated if the pumping site in the ocean is affected by external factors, or issues such as the Red tide,
IV. The system is high-tech driven, thus requires a lot of energy which is not cost effective,
V. Water discharged from flow-through tank systems may pollute receiving waters with nutrients and organic matter,
VI. The discharge of effluent water may require a permit, with required periodic testing and oversight.

3.3. Abalone Ranching

According to the Department of Environmental Affairs (DEA),2008, marine ranching is defined as "identifiable stock released with the intention of being harvested by the releasing agency (Department of Environmental Affairs, 2008)." Troell et al. (2006) describes abalone ranching as process where "hatchery produced abalone seed are stocked into kelp beds outside the natural distribution of abalone." Ranching involves the grow-out of juvenile abalone in the sea, until they reach market size, which essentially provides a "wild" product, and in turn offers substantially lower production costs than traditional land-based, intensive abalone culture systems. Active pilot projects have harvested abalone that far exceed the 100-gram sized abalone commonly produced in South African land-based facilities; these larger abalone are expected to fetch much higher market prices (in the region of R 500 per kilogram) due to their size, quality and "wild" caught status.

Currently in South Africa, it has been identified that rights for abalone ranching must be applied for through the Department of Agriculture, Forestry & Fisheries (DAFF), these rights will be valid for a period of 15 years, with no production limits. Seven companies have been awarded rights for abalone ranching in South Africa, however in 2016, it was noted that abalone ranching may only start producing significant quantities from 2023 due to lengthy process from establishment, seeding, up to harvesting age. Recent records from 2017, indicate that ranching operations with the capacity to produce 28 tonnes per annum are operational and actively seeding and harvesting in line with the permit requirements and conditions. Currently production information, specifically related to growth rates, feeding, stocking density and mortality rates is limited and limited to previous and current pilot projects.

Advantages of using the Ranching system

- Develop the "wild" abalone production in South Africa,

- Lower production and infrastructure costs,
- Permits/licenses are valid for a long time period,
- Ranched abalone will contribute to the natural populations by spawning in the natural environment contributing to the population increase,
- Higher prices are received for "wild caught" abalone, and
- Selected regions along the coast lines of the Western Cape, Eastern Cape and Northern Cape provided optimal ocean temperatures and conditions for abalone ranching.

Disadvantages of using the Ranching system

- Considered as a pilot initiative in South Africa, limited data on viability and success as yet,
- Identification of a suitable ranching site may be challenging,
- Required to meet stringent criteria and comply with DAFF regulations,
- Licensing and permit process is lengthy,
- High security costs as permanent, well trained security is required,
- High mortality rates and low harvest rates,
- Harvesting and seeding times are limited to optimal sea conditions to ensure diver and boat safety,
- Highly skilled divers are required for seeding and harvesting which can increase costs and project related risks,
- Potential loss of abalone into natural environment and stock theft, and
- Difficult to maintain or control production conditions (temperature etc).

3.4. Cage Culture

Cage culture uses existing surface water resources, and in the case of abalone would make use of open ocean water. The abalone would be confined in a mesh enclosure, which allows for feeding, harvesting, and monitoring. The design of the cage systems allows for the movement of water through the 'cages' ensuring the water quality is maintained within the production system (AACI Central, 2005). Rectangular cages have proved to be more effective for handling abalone and have recorded higher survival rates than barrel shaped cages. Normally cages are constructed from PVC type frames covered with heavy duty plastic mesh, which are then suspended from longline systems or floating docks. Abalone are provided with plastic or fibreglass plates in the water for them to attach to (McBride & Conte, 2000). Cage culture relies on seaweed and/or kelp for feeding, with the feed being presented to the abalone on feeding plates and replaced every few days. Artificial feed is not used for cage culture due to high loss of feed that would occur, and the ability of abalone to eat only kelp and/or seaweed. Growth rates may differ in comparison to controlled production systems where artificial and natural feed sources are used, however cage culture abalone, like ranched abalone may attract higher prices, and offer producers the benefits of lower operational costs.

To make use of cage culture systems, careful consideration is required specifically with regards to site selection, feeding programmes, water quality, legal requirements, and the costs associated with developing the cage infrastructure and facilities.

Site Selection: A good site for abalone cage culture should:

- Be protected from strong currents, and wave activity,
- Have an effective water current,

- Water quality should be high, and not in the proximity to potential sites of pollution or contamination,
- Clear water conditions, with a sandy or rocky bottom,
- Minimum water depth of four (4) metres at low tide. Approximately one (1) metre must be maintained between the seabed and cage floor,
- Cages should be near a source of food (kelp forests), and
- Accessibility to transport networks is important.

Advantages of using Cage Culture systems

- Comparably low capital cost in comparison to other productions systems,
- Simplified animal husbandry practices,
- Simplified harvesting methods can be utilised,
- Multi-use of water resources, and
- No provision for disposal and/or treatment of waste water is required.

Disadvantages of using Cage Culture systems

- Feeding programmes and maintenance are essential for the survival of the abalone,
- No control of the water conditions (temperature, quality, pollutants, etc),
- Vandalism and stock theft,
- Predation from marine life (turtles, rock lobster, etc), and
- Limited use and data for cage culture production in South Africa.

3.5. Culture System Summary

Having presented the advantages and disadvantages of various culture systems for abalone production in South Africa based on local and international literature, Table 3-1 below provides a summary for each production system and gives an indication of whether the system is viable or non-viable for abalone production. Based on the system status, the generic economic model was developed to provide additional insight into the financial viability of the potential systems, which is discussed in the Financial Analysis.

Table 3-1: Abalone Production Systems Summary

System	System Overview	System Status
Pond Culture	N/A	N/A
Cages	I. Tested system II. Typically grow out systems for abalone III. Good growth performance IV. Harvesting process simplified V. Feeding programmes are essential VI. No control over water conditions VII. Vandalism & poaching VIII. Limited use in South Africa	Viable
Aquaponics	N/A	N/A
RAS	I. Tested system II. Major disease risk & threat III. Requires high start-up cost IV. Partial RAS recommended V. High pumping and operation costs	Potentially viable (Partial RAS)

System	System Overview	System Status
Flow-through systems	VI. Feeding programmes are essential	
	I. Most typically used farming method in South Africa II. Predominantly land-based flow-through systems III. Typically used for larvae and juvenile abalone IV. Risk is minimal in comparison to ranching and cage culture V. High operational costs (feed & electricity)	Viable
Raceways	N/A	N/A
Ranching	I. Currently being tested/piloted in South Africa II. Offers "wild caught" abalone opportunity III. Reduced operating costs IV. Growth rates etc are not yet published data, thus over time, the pilot projects will provide the required information V. Estimated that 400 to 600-gram abalone will be produced and harvested VI. Opportunity to assist with restocking the depleted natural occurring abalone stocks VII. Poaching and theft is a major challenge experienced with ranching	Viable

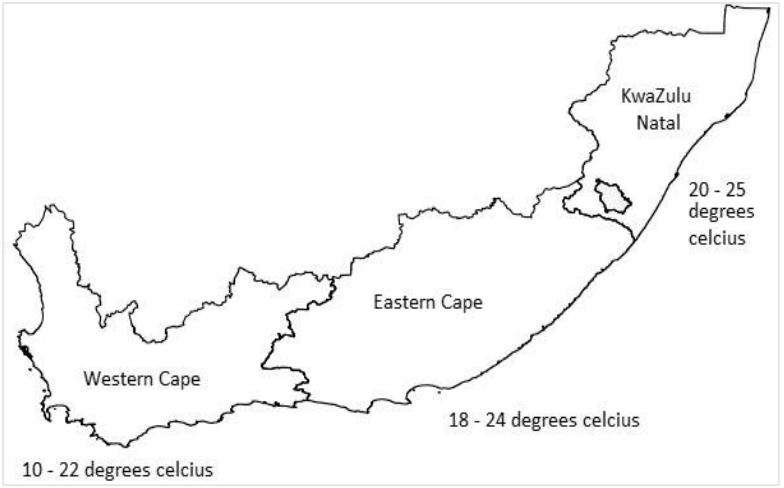
4. Geographical Distribution of Abalone in South Africa

As the climate and geographic conditions differ across South Africa, it is important to understand the suitability of the coastal provinces for abalone production. In terms of the aquaculture operations, it is important to understand what locality conditions are required, and what the key requirements for profitability are. Temperature is a key influencing factor for aquaculture as it determines and impacts on the type of production systems that can be used, as well as has financial implications relating to water heating and infrastructure costs, which can be seen in the abalone generic economic model.

4.1. Suitability Assessment

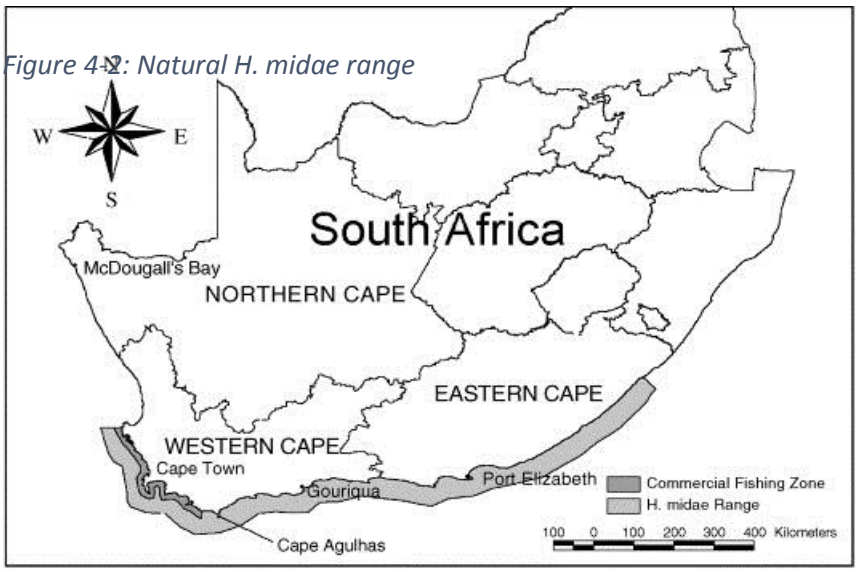
When considering the distribution, and potential for abalone production in South Africa, a key factor is the proximity of the operation to the coastline, as well as water and air temperature conditions. The South Africa coastline experiences temperatures ranging from an average of 10 ˚C to 25 ˚C as seen in Figure 4-1. Seasonal fluctuations may occur, however unlike air temperature, the variations within the ocean are much smaller.

Figure 4-1: Average Ocean Temperatures for the South African Coastline



Abalone can survive in temperatures of 9°C to 24°C, however the optimal temperature for production is 16°C to 18°C, thus the Western Cape and Eastern Cape coastline provides optimal conditions, in comparison to the warmer KwaZulu Natal coastline. Successful abalone operations are also found along the Northern Cape coastline, particularly due to water temperatures and the use of land-based flow-through systems. The natural range for the abalone in South Africa is seen in Figure 4-2 below.

Figure 4-2: Natural H. midae range



Source (de Waal, et al., 2009)

4.2. Key Location and Site Requirements

Location and site requirements will depend on the production system being used for abalone. The following recommendations should be considered

Cage Culture	Flow-Through & Other Systems
• Be protected from strong currents, and wave activity, • High water quality. Not located near potential sites of pollution/contaminants, • Clear water conditions (sandy or rocky bottom), • Minimum water depth of 4 metres at low tide. Approximately 1 metre must be maintained between the seabed and cage floor, • Close proximity to natural food sources (kelp forests) or receive artificial feed, • Access to transport networks, and • Relevant permits and permissions must be obtained.	• Close vicinity to sea water (coastal based), • Close proximity to inputs (spat & feed), • Suitable climatic conditions, • Slope & topography, • Market proximity & access, • Access to transport networks, • Relevant permits and permissions must be obtained, and • High water quality. Not located near potential sites of pollution/contaminants.

4.3. Key requirements for profitability

In addition to the financial results obtained from the generic economic model, the following factors should be considered as they could impact on the profitability of an abalone operation:

I. Proximity to ocean/seawater supply,
II. Hatchery or supply agreements with abalone hatcheries,
III. Access to feed – artificial & kelp,
IV. Consistent quality, colouring and size for export,
V. Access to market,
VI. Some value addition (if possible),
VII. Good farm management skills,
VIII. Skilled labour specifically for hatcheries and diving operations,
IX. Permits and required assessments in place,
X. Compliance with relevant legislation and regulatory guidelines for abalone production,
XI. Technical knowledge and experience is advisable,

XII. Pest and disease management, and

XIII. Topography, specifically the height above sea level as the higher a farm is, the higher the header costs will be.

5. Abalone Market assessment

In this section of the report, the abalone industry, and its role in the market, will be assessed. The section will cover the production and consumption trends of abalone-both globally and locally; the marketing channels, and the market requirements of the industry.

5.1. Production and Consumption Analysis

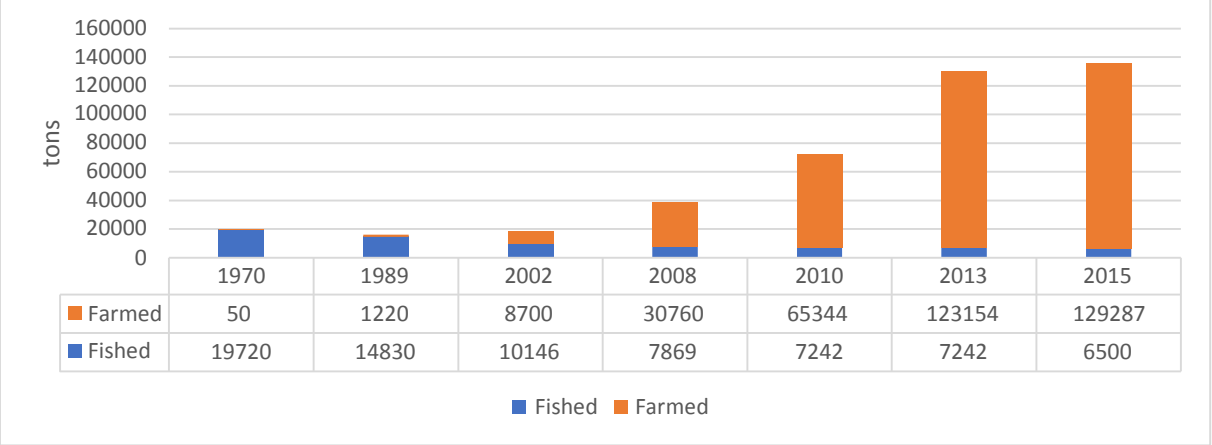
The production and consumption analysis provides insight into the global and local supply, demand and consumption trends and patterns for abalone.

5.1.1. Global Production Analysis

Since ancient times, abalone have been considered the "elixir of life" and as the "emperor of shellfish", and even today abalone is positioned as one of the most expensive and luxurious seafood products worldwide (GlobalFish, 2016). Globally, there are over 100 abalone species (*Haliotis*) however, ten of these species are considered to have a commercial value, which are mostly found in China, Korea, Japan, South Africa, Southern Australia, New Zealand, United States of America, and Mexico (Frost and Sullivan, 2015; Cook, 2016). Each of these countries typically has its own local species for production, however the most valuable species is generally the Japanese abalone (*Haliotis discus hanni*). This species commands the highest market price, particularly if it is wild caught in Japan (Frost and Sullivan, 2015). Abalone worldwide could be either cultured on shore, off shore cages or through ranching systems.

Since the early 1970's, the total global quantity of abalone produced on farms has increased significantly while the volume of abalone from natural fisheries has declined. A total of nearly 20 000 tons were reported to be harvested by the fishing industry during 1970, which was about 100% of total supply. During 2002, records shown that the fishing industry has declined, with harvest volumes nearly matching that of the farmed abalone industry. Since 2015, farmed abalone has dominated the markets, and contributes approximately 95% of the total supply as seen in Figure 5-1 below (Cook, 2016). Any comparison of the fishery vs the farmed abalone suppliers must consider the dynamic between the legal and illegal abalone fisheries industry. In the 1970's abalone fishing was virtually unregulated (and hence, illegal fishery did not exist then), and only post early 2000's, once the regulation of abalone harvesting began did the illegal fishery start to become an issue.

Figure 5-1: Total global production of abalone from legal fisheries and farms

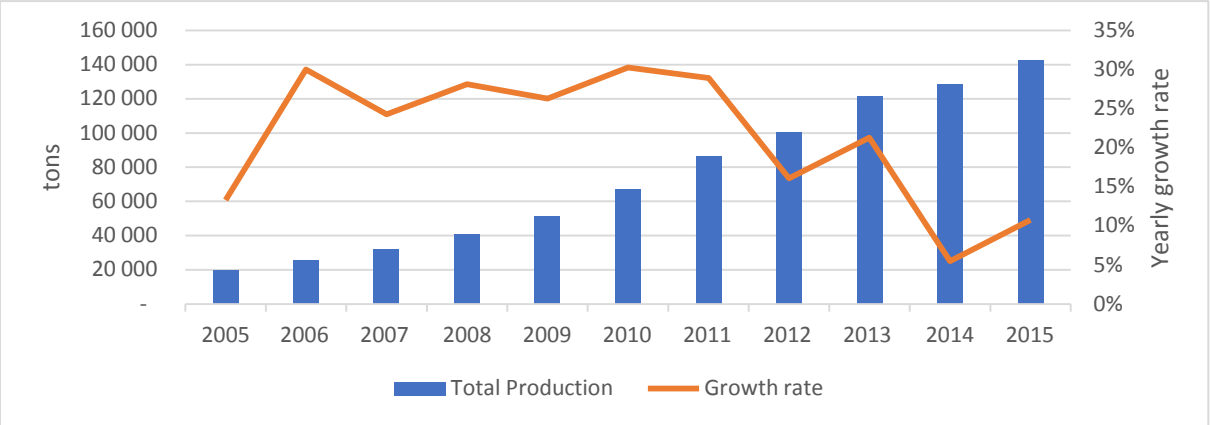


(Cook, 2016).

Source: Cook, 2016

It is evident that the abalone farming industry has gone through a major transformation since the early 2000's. According to the FAO records, total abalone production started picking up around 2006 and expanded rapidly until 2011 with an average yearly growth of 28% as seen in Figure 5-2 below (FAO, 2017).

Figure 5-2: Global abalone production (2005 -2015)



Source: *(FAO, 2017)*

The increase in production was triggered by the decline in fishing industry and resulted in the establishment of the farmed abalone industry during early 2000's in China and Korea (Cook, 2016). A massive increase in production of 172% was noted in China from 2010 (42,737 tons) to 2015 (115,397 tons), which resulted in the Chinese production contributing nearly 90% to the total global production during 2015 (Cook, 2016). Together with Korea whose industry has also expanded rapidly since 2010 (by 88%), both China and Korea control the global supply of abalone, as seen in Table 5-1 below (Cook, 2016).

The rapid production increase in China and Korea is mainly due to the improvement of production techniques, which have shifted from suspended baskets on land-based farms to off-shore cage culture systems. The shift improves the production capacity and the profit margins, making the operations more profitable (Cook, 2016). The second factor that lead to the rapid increase in production is the fast growth rate of the 'Chinese High Net Worth Individual (HNWI) class', which increased the demand for the abalone products (Frost and Sullivan, 2015).

The Chinese production area is located in the southern regions of the country (Fujian and Guangdong Provinces) and focuses mainly on the production of the lower value abalone species (*Haliotis diversicolor supertexta*) however, during 2015, production was reported to be focusing on the *Haliotis. discus hannai* which is the preferred species for export into Japan (Cook, 2016).

Table 5-1: Comparative analysis of Key Abalone Producing Countries (2010 vs 2015)

Countrv	2010	2015	Change between 2010 and 2015 (%)	% of total production in 2015
China	42 373	115 397	172%	89.75%
Korea	5 000	9 400	88%	7.31%
South Africa	1 015	1 488	47%	1.16%
Australia	500	900	80%	0.70%
Chile	1 500	700	-53%	0.54%

Country	2010	2015	Change between 2010 and 2015 (%)	% of total production in 2015
USA	200	362	81%	0.28%
Taiwan	300	171	-43%	0.13%
New Zealand	90	100	11%	0.08%
Mexico	33	30	-9%	0.02%
Europe	10	15	50%	0.01%
Thailand	10	8	-20%	0.01%
Philippines	4	4	0%	0.00%

Source: (Cook, 2016; DAFF, 2017)

The Korean production of abalone (mostly in the remote Wando County in South Jeolla Province) in contrast to the Chinese abalone production focuses more on the production of *Haliotis discus hannai*, for both local and export markets, primarily due to demand, and the higher market value of this species.

Production of abalone in China and Korea has been subjected to disease outbreaks and is of a major concern to the local abalone industry as the common production practices in these countries is the use of net cage systems, which increases the potential spread of disease dramatically due to the density and proximity of farmers to one another. In addition to China and Korea, other key producing countries of farmed abalone are Australia, South Africa, Chile, USA, Taiwan, and New Zealand (Cook, 2016).

In Australia, three types of abalone are produced, namely: the Greenlip abalone (mostly in Western and South Australia), the Blacklip abalone (in Victoria region) and the hybrid Tiger abalone, which generally receives the highest market price because of its attractive shell (Frost and Sullivan, 2015). Australia is considered as the major supplier of wild abalone from its established fisheries industry (Savage, 2016). The farmed abalone industry is also expanding; however, both the fishery and the farmed abalone industries were affected by a disease outbreak in recent years, which reduced Australia's total supply (Cook, 2016; GlobeFish, 2017). The fisheries industry was most affected by the disease outbreak and recorded a reduction in catches from 744 tons in 2014 to 625 tons in 2015 (the lowest level for the past 15-year period) (EconSearch, 2017).

Chile has invested heavily to develop the abalone industry since 1980's and has focused on the production of the Red abalone (*Haliotis rufescens*) and the Green abalone (*H. discus hannai*) (Wurmann & Routledge, 2017). The Red abalone has successfully been adapted to sea cages, using technology from the USA, while *H. discus hannai* yielded limited results in sea cage systems (Wurmann & Routledge, 2017). During 2015, the Chilean abalone farmed industry produce about 700 tons of Red abalone which was a decline from about 1500 tons in 2010 mainly due to the impact of disease on farmed stock. Similar to Chile, the Taiwanese abalone industry also suffered from diseases problems and experienced a decline of 43% in production from 300 tonnes at 2010 to 171 tons during 2015 (Cook, 2016).

Total production of farmed abalone in the USA, positioned along the Californian coastline, was estimated at 362 tons during 2015, indicating an expansion of about 81% since 2010. However, due to the location of the abalone industry, it is unlikely to expand much in the future because of the

very high land values along the Californian coastline and the compliance costs associated with coastal development (Cook, 2016).

In Europe, abalone farming is a very small industry, and is growing slow. The farms, which are mostly in their experimental stages of culturing *H. discus hanni*, are based in the United Kingdom, the Channel Islands, Ireland, France, and Spain. Abalone production could potentially expand into France in Spain in years to come, depending on the success of the current experimental stages (Cook, 2016).

5.1.2. Global Demand Analysis

The key international markets for abalone are China mainland and Hong Kong, Japan, Korea, and Singapore.

China mainland and Hong Kong

China is by far the largest market globally for abalone (GlobeFish, 2017). The total domestic market size of China is extraordinary considering that most of Chinese production (over 115,000 tons in 2015) is consumed by its local market, which seems to be continually growing. Despite the growth of the industry, the local consumption rate of abalone has reduced the Chinese export volumes to Japan to accommodate the domestic demand (GlobeFish, 2017).

Abalone is considered as a delicacy in Chinese cuisine as it is highly valued for its medicinal and nutritional value. Furthermore, the shell of abalone is used as a treatment for various health ailments in Traditional Chinese Medicine (TCM). Abalone is customarily served at special occasions such as weddings, family gathering, and formal banquets, as it is regarded as a symbol for status and wealth. Over recent years, the significant growth in domestic production of abalone in China has broadened the consumer base for abalone in China (Frost and Sullivan, 2015). Consumption in China is combined of both the lower-end *Haliotis diversicolor upertexta* and the upper-end *Haliotis discus hannai* markets (Cook, 2016).The shift in production is aimed at increasing the supply of *Haliotis discus hannai* driven by the rapidly growing class of the High Net Worth Individual (HNWI) (Frost and Sullivan, 2015).

Korea

Similar to China, the Korean consumption of abalone is also linked to the country's traditional cuisine. The Koreans perceived abalone as an attractive product due to its digestive and immunity enhancement, anti-tumour properties, as well as being a good source of protein, Vitamin K, pantothenic acid (Vitamin B5) and Selenium (Frost and Sullivan, 2015). However, unlike China and Japan, abalone is no longer considered a luxury food in Korea, but more a premium food product. This is a result of Korea being the second largest producer of abalone and therefore, the supply is abundant (Frost and Sullivan, 2015). Hence, the Korean domestic market is globally, the second biggest market (by quantities), which absorbs most of its local production. A case in point is that during 2014 1115 tons were exported, while about 9000 tonnes were produced in total (Cook, 2016), (FAO, 2017). This implies that about 87% of total production (i.e.: 7885 tons) were consumed by the local Korean market.

Japan

Japan is one of the most attractive global markets for abalone products as they receive the highest prices. It is also known as the oldest market for abalone, which comes from a strong cultural preferences of eating abalone. In Japan, abalone is considered as a luxury product due to its flavour, medicinal properties, and strong cultural history. The native Japanese abalone *H. discus hanni* is particularly favoured in Japan. The declining numbers of traditional abalone fishery operations and decreasing population of wild abalone contributes to the rarity of wild abalone, which lead to its premium price reaching up to USD 1700 for a piece of wild caught Japanese abalone (Frost and Sullivan, 2015).

The local Japanese consumption of abalone is highly dependent on imports, with a focus on high quality, fresh abalone products. During 2016, Japan was reported to have imported 1531 tons of fresh abalone as well as 656 tons of prepared abalone, valued at an estimated USD 67 million (Trade Map, 2016). This positioned Japan as the second largest market by value (after China) (GlobeFish, 2017).

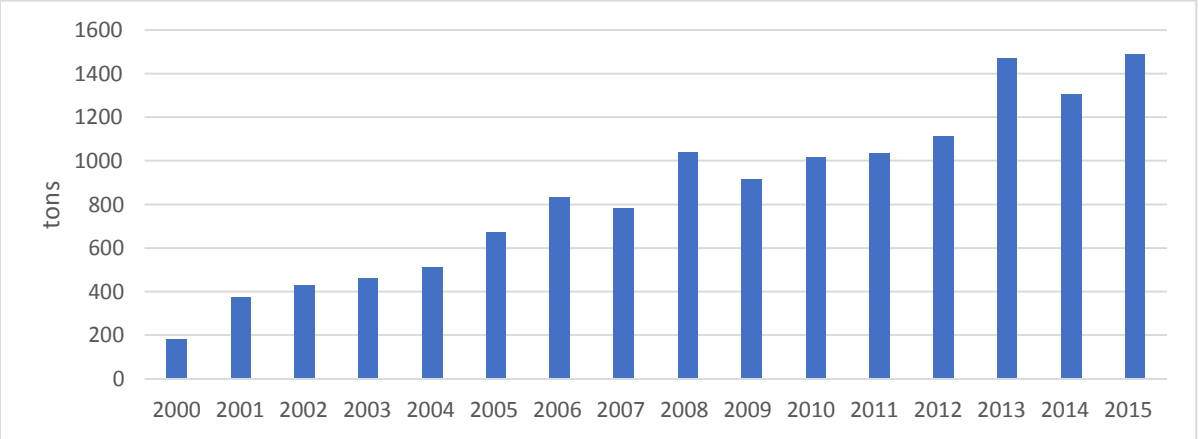
Singapore

Singapore market consumption is dependent on imported goods as well, which was recorded during 2013 at 1432 tons and was similar in size to the Japanese market (FAO, 2017). The abalone market is driven by its young age consumers, with specific lifestyle choices and preferences for "ready to eat" products (Australian Wild Abalone, 2015).

5.1.3. South African Abalone Production Analysis

The South African farmed abalone industry is well established and positioned as third biggest industry after China and Korea (Cook, 2016). The industry is solely based on farmed abalone *Haliotis midae* (also known locally as perlemoen), which is positioned as a premium product on the international market, mainly in Japan and China (HKTDC Research, 2017), and was recorded to supply 1488 tons during 2016 (DAFF, 2017). The industry had experienced major expansion of over 700% since 2000 where production was 181 tons in comparison to 1489 tons in 2015 (Figure 5-3) (DAFF, 2017). The expansion can be attributed to the maturity of the on-shore technology and the highly invested marketing efforts in Asia (Britz & Venter, 2016; HKTDC Research, 2017; Australian Wild Abalone, 2015).

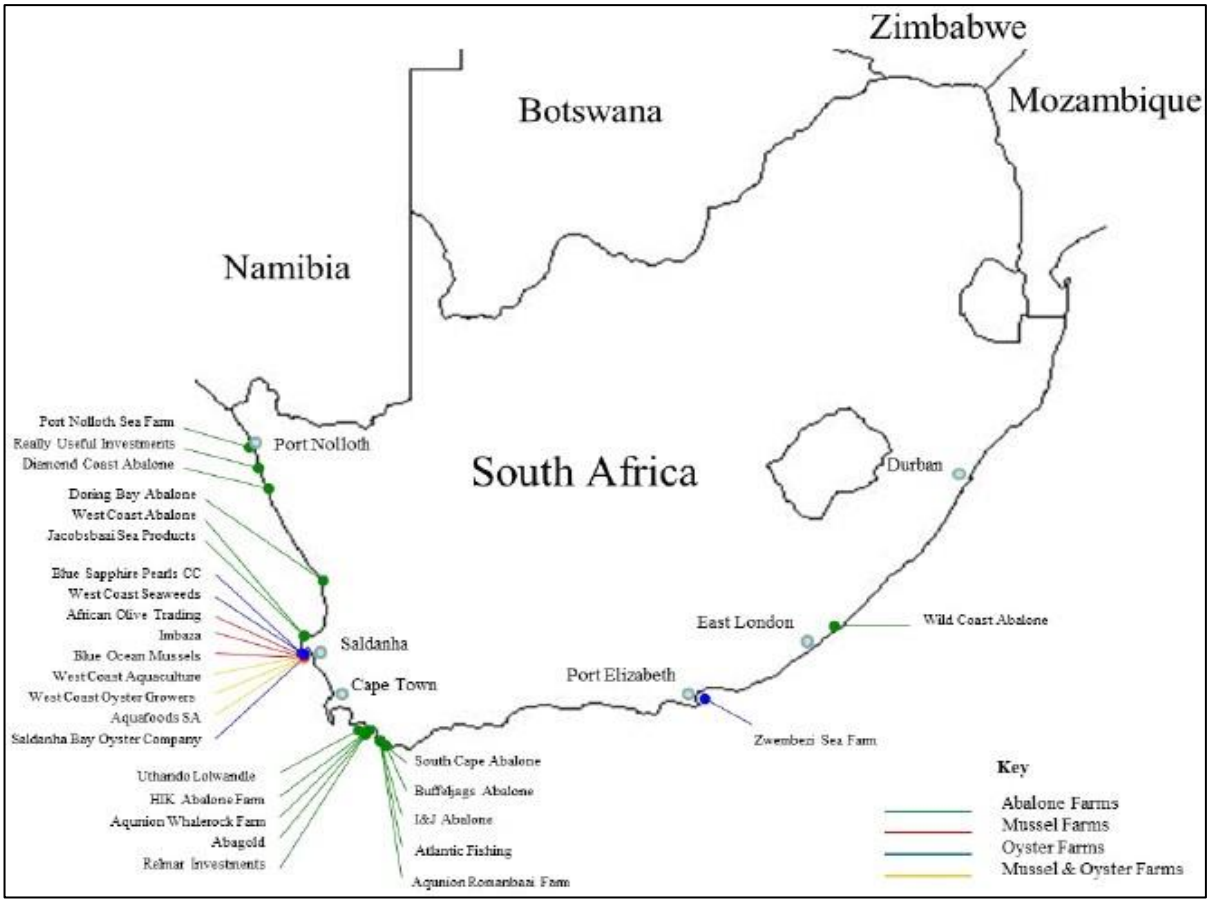
Figure 5-3: Farmed abalone production in South Africa (2000-2015)



Source: (DAFF, 2017)

During 2015, the South African farmed abalone industry comprised of eighteen (18) farms distributed along the coastline of the country ranging from the Northern Cape and Western Cape to the Eastern Cape, as seen Figure 5-5 below (DAFF, 2017). Of the eighteen (18) abalone farms operated in 2015, twelve (12) used land-based facilities with independent hatcheries and four (4) operated grow-out facilities only. The other two (2) abalone farms included sea cage culture. An additional three (3) experimental farms were registered as ranching operations where abalone is seeded into their natural environment (FAO, 2017).

Figure 5-4: Distribution of shellfish farms along the South African coastline



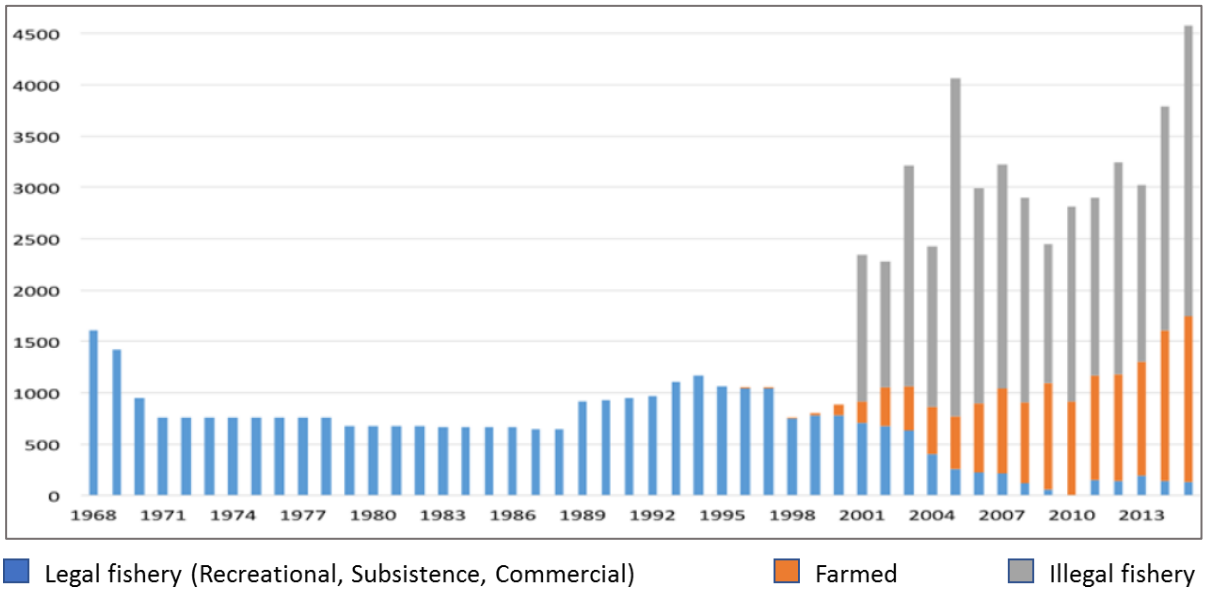
Source: (DAFF, 2017)

The abalone farmed industry in South Africa is part of the site surveillance program of the marine aquaculture sector, introduced in 2008, and named the South African Molluscan Shellfish Monitoring and Control Programme (SAMSM&CP) (DAFF, 2017). The SAMSM&CP aims to provide the necessary guarantees to local and international markets that food safety risks associated with the production of molluscan shellfish are adequately managed and minimized (DAFF, 2017). The abalone farms are monitored by the SAMSM&CP for human health hazards such as bio-toxins, microbiological organisms, heavy metals, pesticides, polychlorinated biphenyls (PCBs), drug residues, dioxins, dyes, and radionuclides during the entire production phase. This programme ensures the compliance of the farms with DAFF's marine aquaculture permitting frameworks and regulations promulgated under the MLRA (DAFF, 2017). The result of the strict programme is good regulation of the abalone quality and has resulted in minimal disease events (i.e.: during 2015, only one case of Abalone Tubercle Mycosis (ATM) disease was reported) (DAFF, 2017).

Abalone farming (on-shore, ranching, and cages) is a potentially high-growth industry as it embodies the scope to become increase its contributions to the social upliftment, revenue, and sustainability

of rural communities along the coastline of South Africa. Specifically, the use of ranching could become a substitute for the recovering, depleted natural abalone resources in South Africa, which have diminished and, as a result, until recently all abalone fishery activities were banned. The recent revival of the South Africa abalone fishery industry and the new abalone ranching operations could provide economic upliftment for these areas suffering from high levels of unemployment and poverty within the fishing communities, provided the introduction of such activities would include a strong buy-in from the local communities (Krohn, et al., 2016). The farmed abalone industry in South Africa still faces a significant supply of abalone from the illegal fisheries, which accounts for more than the total of the farmed and the legal fishery abalone supply in the country (Figure 5-5 below). This massive illegal abalone fishery supplies a much lower quality of products into the international market and, which has a major impact on the South African farmed abalone branding (Personal Communication Piek, 2018).

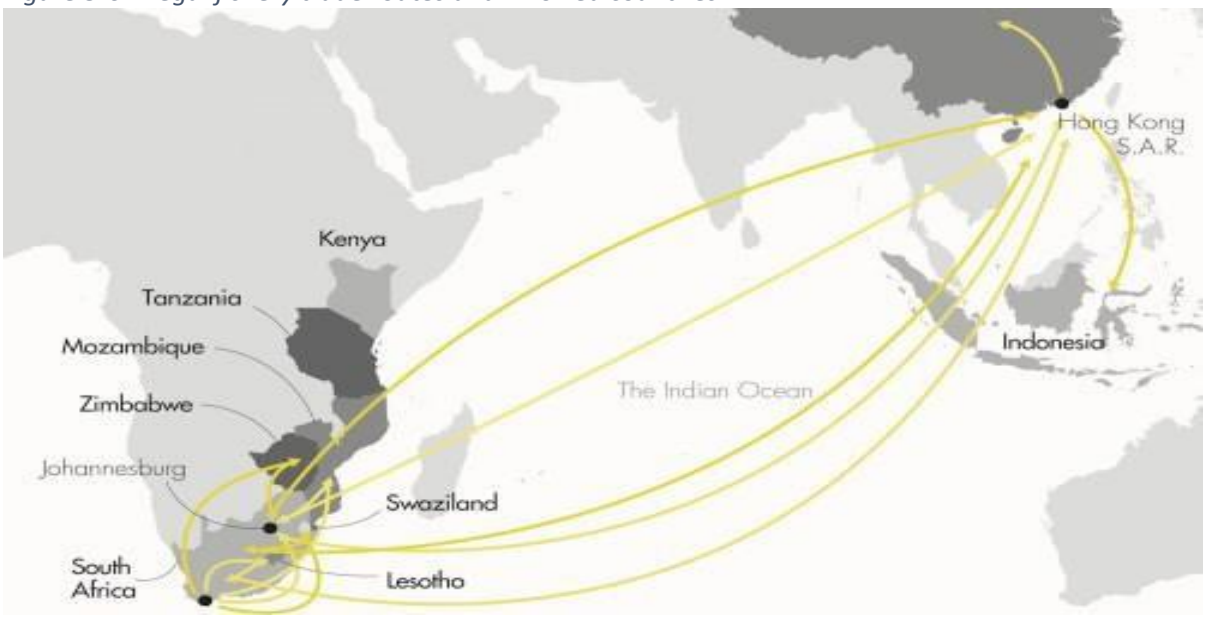
Figure 5-5: Abalone production in South Africa (1968-2015)



Source: (Krohn, et al., 2016)

The South African authorities have aimed to reduce the illegal abalone fishery in various ways including, the introduction of the quota system and criminal penalties during the 1970's to ensure that the populations of wild abalone remained stable. Nevertheless, during the apartheid regime the system only benefited the white minority. Furthermore, during the 1980's, the organized crime groups led by Chinese and Asians evolved to develop an illegal smuggling captured abalone industry with international markets directly mostly at China (Figure 5-6), which is thriving today (Krohn, et al., 2016).

Figure 5-6: Illegal fishery trade routes and involved countries



Source: (Krohn, et al., 2016)

Today, the illegal South African abalone fisheries is considered to be a major social-economic challenge, which is expected to continue. The total value is unknown but estimated to be over 2000 tonnes with a value of about R1 billion during 2015 (Krohn, et al., 2016). Due to the current scale of the illegal abalone fishery problem, it is evident that the government is still struggling to monitor and enforce the regulations of the illegal abalone fishery. The impact of this on the abalone farmed industry is substantial in terms of impact on the reputation of the South African abalone industry quality and the associated high prices. This will be discussed further below.

5.1.4. Local Demand Analysis

Limited and fragmented information exists on the local consumption of abalone. In the local consumption context, both South Africa and surrounding countries are considered. Based on information published in Trade Probe it is noticed that estimated local consumption was equal in South Africa to the level of production between 2005 and 2011 with an average of about 1000 tons a year. However, the local consumption in South Africa has since dropped and was estimated to be around 500 tons during 2014 (Phaleng & Ntshangase, 2017). From records published by DAFF on South Africa exports of abalone, it is evident that a few countries in the region are also consuming abalone at a low quantities including: Namibia with 1,11 tons, and Swaziland with 7,8 tons (DAFF, 2017).

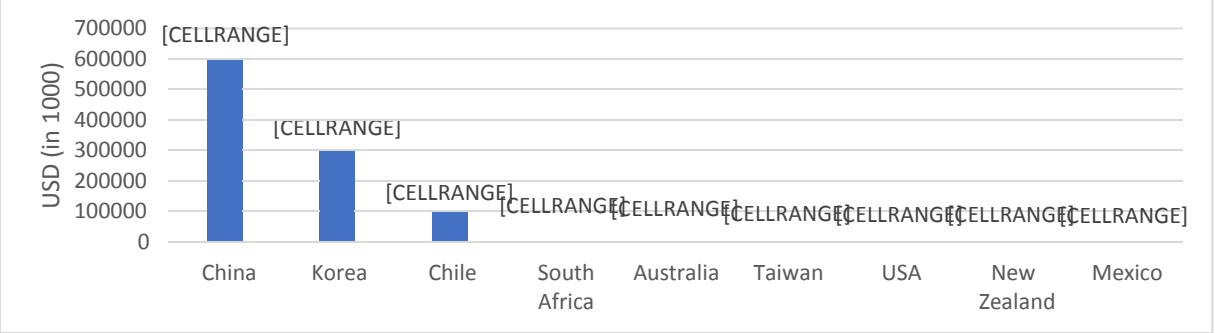
5.2. Marketing channels

Market channels identify the key global, regional, and local marketing channels for abalone that are important to understand in terms of trade, major producers, and the flow of products between countries. The generic economic model takes both local and international markets into consideration and offers flexible pricing options which are dependent on the size of the abalone being produced and the target market identified. The pricing of the abalone, and the target market impact on the financial results obtained when using the generic economic model, as these two factors play a key role in determining the profitability of an operation. Understanding the markets, pricing and preferred products for the market is essential.

5.2.1. Global Abalone Trade

The total global estimated value of the abalone industry in 2015 was estimated to be exceed USD 1 billion, of which Chinese abalone production contributed 57.91 % to the total production volumes (FAO, 2017). After China, considerable contributions were noted from Korea (27.96 %), Chile (7.22 %), South Africa (3.6%) and Australia (2.1%) as seen in Figure 5-7 below. Other producers such as Taiwan, USA, New Zealand, and Mexico were much less in value (with total contribution of 1.38%).

Figure 5-7: Global abalone production by value (USD) during 2015



Source: *(FAO, 2017)*

Abalone, as consumable meat product, is mainly traded in three main product lines: live, fresh, or chilled (LFC); prepared or preserved (PP), in airtight cans and vacuum bags; or traded frozen, dried, or smoked. In addition, abalone shells could be trade as a decorative item (ash trays, soap holders) and jewellery (Krohn, et al., 2016). Due to the wide range of products, farmed abalone can be sold worldwide at any size throughout the year (Krohn, et al., 2016).

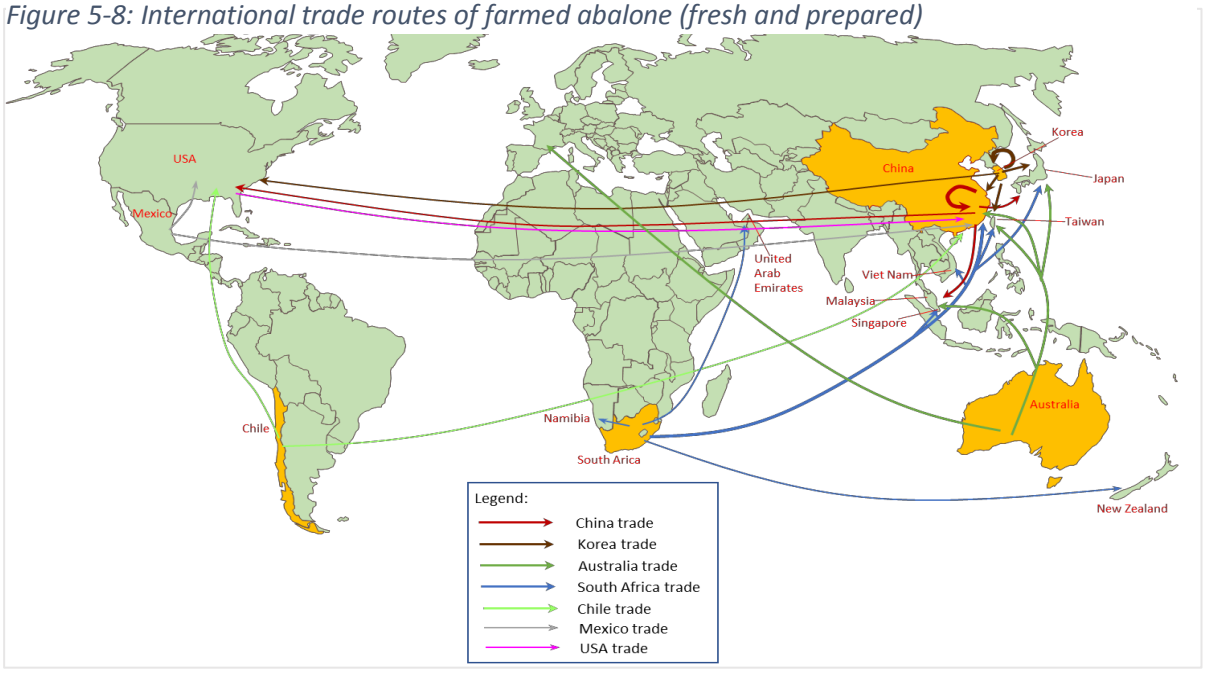
In terms of trade, during 2016, China, Korea, Chile, South Africa, and Australia were the leading exporters while, Japan, Hong Kong and Singapore were the leading importers (GlobalFish, 2016). Further to that, some countries also act as key hubs of distributions to other locations such as Hong Kong, Singapore, and Vietnam (Personal Communication Piek, 2018). The Chinese market (mainland and Hong Kong) is a major destination for imported goods from Korea, South Africa, Australia, and Chile. The growing domestic demand is likely to drive further exports into China specifically since Chinese quality is often considered to be of lower standards than the imported products (Frost and Sullivan, 2015). Chinese abalone exports are currently limited and focused on several markets including the Singaporean markets and the lucrative Japanese market however, it is unlikely to grow significantly due to challenges such as product quality and the Chinese domestic high demand driven by the growing High Net Worth Individuals group (i.e.: upper-middle class) (Frost and Sullivan, 2015).

In contrast to China, Korea is much more active as an exporter in the international market. Korea increased its exports into Japan, China, the United States, and Taiwan from about 70 tons in 2004 to 1115 tonnes in 2014. One key driver for the increase is the demand from China for seed and juvenile abalone (GlobeFish, 2017). Other drivers include the new demand from other Asian populations outside of the Asian region (such as within the USA and specifically San Francisco with 33% of total population being Asians) (Cook, 2016).The exports from Korea is in spite of the fact that the majority of its local production services the Korean domestic market. Furthermore, Korean exports had an important influence on the world market because the majority of Korean production is *Haliotis discus hannai*. (Cook, 2016).

Australia is one of the leading abalone exporters, with the majority of its abalone originating from its fisheries and wild harvest stocks, followed by its growing farmed abalone industry. Australia is strongly targeting the Asian markets (including Japan, Singapore, Taiwan, and China) with the intention to differentiate itself with the supreme quality of its wild stock (branded as "Australian Wild Abalone", known as AWA™) (Australian Wild Abalone, 2015; Savage, 2016). Australia is a leading supplier of abalone to Hong Kong, China, and Singapore, which was reported to be 309 tons during 2014-2015 (Savage, 2016).

Lastly, Chile, Mexico and the USA have established a niche market within Asia, mainly China, with premium quality products due to their cultured Japanese species *Haliotis discus hannai* and the Red California abalone species. Additional trade has been noticed between the exporters Chile and Mexico and the USA (Alaska Mariculture Task Force, 2017).

Figure 5-8: International trade routes of farmed abalone (fresh and prepared)



Source: Urban-Econ, 2017

5.2.2. Regional and Local Trade of Abalone

South Africa is the largest non-Asian exporter of abalone to China (in quantities) and the world's third-largest producer overall (HKTDC Research, 2017). South Africa is a net exporter of farmed abalone with the total value of the industry estimated to be USD 35 million during 2015 (FAO, 2017; DAFF, 2017). This excludes the fishery supply, mostly illegal, which has an estimated value of an additional USD 35 million which was reported by the South African government during 2016 (GlobeFish, 2017). This implies that the illegal abalone fishery accounts for about 50% of total abalone trade from South Africa in value, which is a major concern to the local authorities due to loss of revenue and opportunities for social upliftment (Personal Communication Piek, 2018). South Africa mainly exports abalone, live, fresh, or chilled, prepared, or preserved abalone in canned or dried form with demand typically increasing around the time of the Chinese Spring Festival (HKTDC Research, 2017). Countries that reportedly import abalone from South Africa during 2015 include: Hong Kong, China mainland, Taiwan, Japan, Singapore, Malaysia, Vietnam, New Zealand, United Arab Emirates, Namibia, Swaziland, Botswana, and Tanzania as seen in Table 5-2 below (DAFF, 2017; Krohn, et al., 2016).

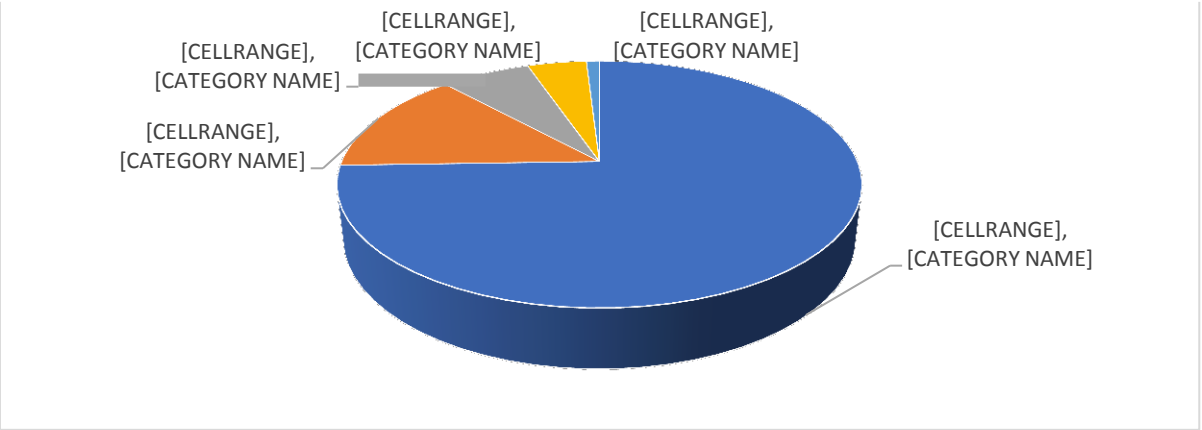
Table 5-2: Importing countries of abalone from South Africa by tons and value (2015)

Country	Tons	Value (USD)	%of total export in Value
Hong Kong	540.55	27 732 189	74.105%
Taiwan	144.97	5 075 440	13.562%
Japan	19.05	2 439 673	6.519%
Singapore	23.806	1 617 665	4.323%
Malaysia	3.787	357 343	0.955%
Viet Nam	1.789	77 360	0.207%
China mainland	1.947	61 729	0.165%
United Arab Emirates	5.881	38 794	0.104%
Namibia	1.115	10 283	0.027%
Swaziland	7.879	9 781	0.026%
New Zealand	0.012	1 387	0.004%
Botswana	0.01	808	0.002%
Tanzania	0.12	290	0.001%

Source: (DAFF, 2017)

The main export markets (by value) for the South African farmed abalone industry were: Hong Kong, Taiwan, Japan, Singapore, and Malaysia as seen in Figure 5-9 below (DAFF, 2017).

Figure 5-9: The main import countries (by value) of the South African abalone during 2015



Source: (DAFF, 2017)

The importation of South African products into China (Hong Kong and Mainland) is projected to grow to an estimated USD 135 million by 2020. One of the key reasons for this is the rising demand for *Haliotis midae* (the abalone species that is exclusive to South Africa's cold coastal waters), which is particularly prized for its flavour, texture, and size (HKTDC Research, 2017). It can be seen that the USA, and the EU markets do not trade or import abalone products from South Africa due to compliance issues and EU market regulations (Personal Communication Piek, 2018).

5.3. Market requirements

In this section market preferences will be discussed, with focus on the largest global meat abalone market in the East Asian countries (i.e.: Hong Kong, China mainland, Korea, Japan, and Singapore). Market preferences and abalone prices are affected by several factors including: the size of the animal, the abalone species, the country of origin, and the type of product (fresh Vs. prepared).

5.3.1. Abalone size

Abalone demand in Asia can generally be divided into two main products size segments:

I. Smaller abalone mainly produced in farms in China and Korea and typically priced at about USD 15/kg farm gate price.

II. Larger abalone, mainly imported, and typically costing over USD 50/kg at wholesale prices in Asia, with a retail price ranging from USD 150-175/Kg.

5.3.2. Country, origin (farmed/wild) and cultured species

Abalone from Japan, Mexico, and USA are the most expensive varieties, while products from South Africa, Australia & New Zealand are mid-priced. Chinese abalone is the cheapest (Frost and Sullivan, 2015).

Japan – the Japanese are very particular with regards to the quality, flavour, and texture. Their preferences are for the local *Haliotis discus hanni* species. *Haliotis discus hannai* is the most valuable species and, in general, larger size animals command higher prices per kilogram, which could reach as much as USD 1700 a piece for wild caught abalone in Japan[2] (Frost and Sullivan, 2015).

South Africa – The South African native species *Haliotis midae* is an established top-quality product in the Asian market due to its unique flavour, texture, and size (HKTDC Research, 2017). The abalone are considered to be free from preservatives and bleaches and is farmed or fished in safe waters (Krohn, et al., 2016). A case in point is the high preferences in local restaurants in Hong Kong and the retail outlets in Singapore for the South African products (Australian Wild Abalone, 2015).

Australia – Wild, large abalone such as the Australian wild caught abalone are perceived as a luxury product in both China and Japan. However, as mentioned, the Japanese market much prefer their own wild caught abalone species (*H. discus hanni*) (Australian Wild Abalone, 2015).

China – The focus of farmed abalone has shifted to focus on the production of *Haliotis discus hanni* in order for China to offer additional products to the Japanese markets, however it is likely to be second to the wild caught in Japan. Local Chinese markets demand for the high quality (i.e.: *H. discus hanni*)) is increasing rapidly.

5.3.3. Product type (Fresh Vs Prepared)

Abalone are typically sold as live, fresh animals, however prepared (dried or tinned), and value-added abalone products are becoming more popular on the market. Typical abalone products are discussed in more detail below.

- **Fresh** – Fresh/chilled/live products are always considered to be of a higher quality in comparison to prepared abalone products for example. Fresh South African abalone are always the first choice in Cantonese restaurants in Hong Kong due to their quality and the high survival rate of the live abalone in transit. It is estimated that one fresh abalone can cost up to USD 250 (Oxpeckers Reporters, 2017).

[2] *It is per a piece. Unfortunately, the Wild piece size is unknown. But using the SA figure for maximum market size – Wild should be more than 200-gram farmed animal*

- **Canned or Dried** – Canned abalone is often used for home preparation primarily as it is cheaper and easier to prepare. However, canned abalone from Taiwan, New Zealand, and South Africa retail at approximately USD 40-50 per 425-gram can in Singapore (equivalent to about USD 150-175 per kg). Dried abalone have their own market niche, typically used for Traditional Chinese Medicine (TCM) (Frost and Sullivan, 2015).

- **Other Value-added products** – Although within the pre-cooked market niche there is a strong preference for can/dried products, there is a new trend to emerging, specifically with the "younger" generation in Singapore who are seeking more "ready to eat" flavoured cuisine options, which could be a potential market for abalone producing countries to target (Australian Wild Abalone, 2015).

Figure 5-10: Live Japanese Abalone, Tokyo

Source: (Australian Wild Abalone, 2015)

Figure 5-11: Canned Abalone, Singapore

Source: (Australian Wild Abalone, 2015)

Figure 5-12: Dried South African Abalone, Hong Kong

Source: (Oxpeckers Reporters, 2017)

Figure 5-13: Pre-prepared Abalone in soup

Source: (Cook, 2016)

Figure 5-14: Ready-made flavoured value-added abalone products

Source: (Cook, 2014)

5.3.4. Seasonality of demand

An additional factor which effects the market in East Asia is the increased demand during the holiday periods. Such the case is with the rapid increase in consumption of all abalone products in Singapore around the Chinese New Year (Australian Wild Abalone, 2015).

5.3.5. Prices indicators

Based on published information by DAFF during 2017, South African average FOB (Free on Board) prices were calculated in Table 5-3 below. From the records, it is clear that the top prices for abalone are found in Japan, New Zealand, and Malaysia markets ranging around the USD 100/kg mark.

However, from interviews with stakeholders involved in the South African abalone industry, the going farm gate prices in South Africa are lower and dependent on the abalone sizes, regardless of the product type (i.e.: live, canned, or dried). For instance, the prices for 40-gram animal is estimated at USD 25/Kg, for 100-gram abalone, and a 200-gram size abalone could reach up to USD 45/Kg. (Personal Communication Krohn, 2017; Personal Communication Piek, 2018). Frozen abalone prices, on the other hand, are slightly lower and can range between USD 20/Kg for 40 grams to USD 35/Kg for a larger animal around 200 grams (Personal Communication Piek, 2018). According to DAFF (2018), prices of $29 to $45 are being achieved by local producers.

Table 5-3: Average FOB prices for South African abalone to various destinations

Market	(USD/Kg)
Hong Kong	51
Taiwan	35
Japan	**128**
Singapore	68
Malaysia	**94**
Viet Nam	43
China	32
United Arab Emirates	7
Namibia	9
Swaziland	1
New Zealand	**116**
Botswana	81
Tanzania	2

Source: (DAFF, 2017)

5.4. Barriers to entry and limitations of the market

Barriers to entry, and market limitations are an important consideration when looking at the feasibility of a product. Various aspects such as market saturation, trade barriers, market competition and potential market restrictions are important for this market assessment.

5.4.1. Market Saturation

The total supply of abalone to the world market in 2015 was more than five times the supply recorded in the 1970's, which is mostly due to the expansion of production in China and Korea. This was expected to have a major impact on the international abalone trade and see the reduction in abalone prices. However, that was not the case, mostly due to the fact that majority of the Chinese and Korea production was and still is aiming at their rapidly growing domestic markets. Nevertheless, continued growth of production could represent a risk to the global industry as it may lead to an over-supply on the world market. Alternatively, to avoid such scenarios, the Chinese production is expected to slow down to match the local demand (Cook, 2016). A further increase of abalone demand is present in other Asian markets, such Singapore and Malaysia, which suggests

that the market is far from being saturated. This may specifically impact on the demand for the higher-end quality products of which South Africa production is typically associated with.

5.4.2. Competition

The significant growth in farmed abalone production in China and Korea did not initiate any significant global competition. This can be linked to China and Korea focusing on meeting the domestic markets requirements (lower quality and prices), which generally is different from the imported goods destined for luxury markets. Chinese and Korean consumers are mainly viewed as lower-end abalone products buyers, while imported products (mostly in the Hong Kong and China markets) are aimed at the upper class-markets and consumers as it associated with higher quality (Frost and Sullivan, 2015). Hence, there is a limited level of competitiveness between the South African and Chinese abalone products, and it is not foreseen as an issue, except for possible competition from other imported products (such as from Australia and Korea) into China from other countries.

A case in point is Korea, which is a major supplier of abalone to the world market of both live and canned products to Japan, Singapore, and Taiwan. This could create some competition specifically with regards to the canned products exported from South Africa. Similar to that, Australia presents some level of competition to the South African industry (with live and canned products), simply because of its high quality that matches the South African abalone products. Due the large scale of the Australian production and supply (from farmed and fishery) they can afford to offer reduced prices, which would then impact on South Africa's abalone trade (Personal Communication Piek, 2018).

5.4.3. Supply Chain Challenges

The Asian abalone supply chain has developed rapidly to support the fast-expanding production, the diversified locations and product types (e.g.: live, can, dried, and frozen) to ensure access to the markets. The supply chains were evolved in each region and country to accommodate its specific requirements. For example, Hong Kong is a major hub of distribution for abalone trade. Key distributing firms are based in Hong Kong and ensure further trade into mainland China, Korea, and even distribution to USA and Canada takes place from there. Other distribution hubs include Viet Nam and Singapore. The latter act as a gateway to the South-East part of Asia (Personal Communication Piek, 2018).

The supply chain is specialised and able to manage both live abalone and added-value products (e.g.: canned). For live abalone, special "Tank to Tank" capabilities are required, which ensure that transportation of live animal from the farm tank to the restaurant tank is done within less than 48 hours (Personal Communication Piek, 2018). Despite the availability of the "Tank to Tank" capabilities specifically to cater for the Hong Kong restaurant trade, the live trade is always considered to be a high-risk trade (due to mortality rate).

Canned products on the other hand, are strongly associated with well-known brand suppliers. For example, in Singapore, an established branding like Calmex for products from Mexico is associated with quality and can be marked-up as far as 40% from other similar products (e.g.: average price for abalone can in Singapore is USD 40-50, while Calmex can sold for USD 150) (Frost and Sullivan, 2015).

Any abalone producer would therefore, need to consider the branding of their product, the brand market share, and to consider a possibly collaborating with well established brands (Personal Communication Piek, 2018). Logistics services for dried and canned abalone are not a substantial expensive, with trade from South Africa to a Hong Kong port estimated to be in a range of 0.6-0.8% of invoice price per a sea freight container (which can take approximately 2000 cans of abalone (Kaiser EDP and Enviro-fish africa, 2011).

5.4.4. Trade and other business Restrictions

In terms of the local (domestic) market in South Africa, strict regulations to combat the massive illegal abalone fishery industry have been put in place. Currently, DAFF is issuing permits to local abalone producers to sell undersized, farmed abalone to the local market, however, the quantities of abalone being sold locally remain very low due to the high international demand and prices. The enabling factor to open the local market for the entire value-chain stakeholders (i.e.: each abalone farm, processing, distributor, retail, and restaurants) is to comply with domestic trade regulations (Personal Communication Piek, 2018).

With regards to the international market access, the lack of access to the EU market presents an additional loss of trading opportunities for the South African industry, whereas other competitors such as Australia are actively trading on these markets. This constraint is a result of South Africa not being listed as an EU compliant supplier of farmed seafood. The currently health, NRCS, and SABS certifications used in the South African abalone industry provide assured quality and can be used to track source of origin of each abalone to the farm level, however this is still not sufficient for the EU market regulations (Personal Communication Piek, 2018).

5.5. Market Recommendations and Conclusions

Sparked by the shift to viable production techniques and the rapid Chinese middle-class growth rate, the abalone industry is today a significant sub-sector in the aquaculture sector. Due to the rapid growth, the entire international abalone value-chain industry is going through a transformation in many aspects including: production, value-addition, processing capabilities, changes in the current market costumer-based, the opening of new niche markets, and lastly the increased capacities of the supply chains to access international markets.

Current leading international markets include China (Hong Kong and mainland), Korea, Japan, Taiwan, and Singapore, who are driving the industry with a focus on both affordable smaller size products (mostly in China and Korea markets) as well as the high quality and larger size products (mainly in Hong Kong, Japan, and Singapore).Production is currently controlled by China and Korea, mostly for the lower-end products, while Mexico, USA, Chile, Australia and South Africa, and some Chinese products are dominating the higher-end of products (live and canned). Value-chain maturity of the abalone industry implies that more advanced marketing strategies are required for the South African farmed abalone industry to maintain its position or even expand its market share. South African abalone are highly valued by importers because it is a robust animal that travels well and can survive well in the restaurant tanks, which is the preferred style in Hong Kong. South African canned abalone is also highly favoured as no preservatives or bleaches are added to the brine as is done with Australian abalone (Krohn, et al., 2016).

Possible South African abalone industry strategies should address the growth potential that exists within the Hong Kong market and major mainland China cities (e.g. Shanghai) in the short and medium term. The short-term focus on canned products is also required, with the emphasis being on establishing and developing the South African brands. Currently, the farmed abalone South African industry is unfortunately slightly fragmented in terms of marketing efforts with two main local South African brands dominating the market in terms of canned abalone products (Personal Communication Piek, 2018).

Collective efforts by South African producers is required to deal with the current competition from Korea and Australia who have the capacity to put pressure on lowering the abalone prices (Krohn, et al., 2016; Personal Communication Piek, 2018). As suggested by industry stakeholders, such collective efforts by the abalone farmers could be achieved by investing in developing a direct link with trade and marketing companies who are well established in the traditional export market space rather than through an intermediary agents (Krohn, et al., 2016). Alternatively, the industry would also need to invest further in its own local branding label so South Africa could retain its current market position. Shifting into the live products market niche could also present an opportunity in the medium to long term for South Africa, provided that the logistics services of “Tank to Tank “could support greater volumes.

Additional international markets such as the USA and EU should be targeted in the long-term. Discussion should be conducted with the relevant regulatory bodies and the local industry to resolve outstanding issues considering the SAMSM&CP performances so far. Additional international markets could be the explored include major metropolitan cities with high Asian populations such as Vancouver, San Francisco, London, Toronto, and Calgary.

Further to the international market, the South African industry could capitalize on the local domestic market provided both producers and off-takers comply with the necessary regulations by applying for permits to sell undersized, farmed abalone which allows for the monitoring and management farmed abalone (from origin to the restaurant). The local domestic market has the potential to be developed jointly with the tourism sector, which is well developed in the country. This could include the West Coast, the Winelands, and the Cape Town restaurants that are frequently visited by business travellers from the Far East (Kaiser EDP and Enviro-fish africa, 2011).

Lastly, further substantial investment is required in South African towards the experimental abalone ranching initiatives, by developing additional dedicated hatcheries which will provide spat for the abalone ranching operations. This would require a strong “buy-in” from coastal communities who could be given long-term ranching or fishing rights to incentivise the natural stock and rehabilitation of abalone local fishery (and by that combat the illegal activities) (Krohn, et al., 2016).

6. SWOT analysis and Mitigation measures

6.1. Abalone SWOT Analysis

The table below presents the strength, weaknesses, opportunities, and the threats faced by the abalone industry in South Africa.

Table 6-1: Abalone Swot Analysis

Strengths	Weaknesses
• High demand for Abalone • Strong government support • Quality, flavour & texture of SA abalone • Unique species to South Africa • Well established export markets • Well established value chain	• Limited local market access • Wild caught abalone stocks limited • Slow growth of abalone • Technology costs & accessibility • Industry dominated by few key players • Limited extension support, skills & knowledge • High production costs • High food safety testing costs
Opportunities	**Threats**
• Existing abalone industry is expanding • Government support (Operation Phakisa) • Technical developments (feed, production etc) • Potential to explore wild abalone & ranching	• Poaching • Increasing production costs (feed & electricity) • Increasing level of competitiveness • Reliant on the Asia export market • Currency appreciation & fluctuations affect profits for South Africa producers • Disease outbreak & Harmful Algal Blooms (HAB's) • Under developed laboratory capacity for drug residue testing

The generic economic model considered some key weaknesses and threats that would impact on profitability of abalone production. The model assists with developing a risk profile for producers which is used to determine interest rates and loan repayments based on education levels and skills, and access to land, infrastructure, and facilities. Factors such as permit, and veterinary costs are built into the model to mitigate the risk of disease outbreak and cover permit costs required. In systems such as ranching and cage culture, provision was made for extra labour and security to mitigate the risk of theft and poaching.

6.2. Mitigation Measures

The mitigation measures identified in the table below aim to address the threats and weaknesses identified in the SWOT analysis discussed above. It is essential for abalone producers to take note of the potential risks and weaknesses identified to ensure they can implement mitigation measures and understand the challenges they may face.

Table 6-2: Abalone Mitigation Measures

Risks Identified	Mitigation Measures
1. Local Market Access	• Encourage local restaurants to purchase farmed abalone • Identify local market barriers and restrictions
2. Wild abalone stocks low	• Encourage stock enhancement programmes
3. Slow-growth of abalone	• Continue research & development to establish if growth rates can be increased through feeding or breeding/genetic programmes
4. Industry dominated by large commercial operations	• Involve commercial producers in mentorship platforms and pilot projects for coastal communities
5. Limited extension, support & knowledge	• Encourage engagements between industry experts & local producers • Equip extension officers to assist abalone producers • Develop mentorship programmes and workshops
6. High production costs	• Investment in local feed production • Promote development of spat breeding to ensure genetic diversity & access to spat for producers
7. Increasing level of competitiveness	• Research and development on value-added and niche market products for abalone
8. Reliance on Asia export market	• Investigate certification & alignment with EU and USA markets
9. Disease outbreak & Algal Blooms	• Research and development • Abalone disease control, treatment & biosecurity • Early warning systems for Harmful Algal blooms (HAB's)
10. Poaching	• Coastline patrols • Permits & restrictions for harvesting & sales • Community education & awareness
11. Under developed laboratory capacity for drug residue testing	• Develop national laboratory capacity to undertake drug residue testing

7. Abalone Technical Assessment

The technical assessment below provides a summary of the assumptions used within the economic model for abalone as well as data presented in the species overview and biological characteristics. The technical assessment covers the following information:

- Water conditions,
- Broodstock/Breeding,
- Genetic selection,
- Hatchery/spat production,
- Production performance, and
- Additional information.

Industry experts, stakeholders and relevant literature sources provided the technical information below. This information may be subject to change.

Table 7-1: Abalone Technical Assessment

Latin name	Haliotis midae
Common name	*Perlemoen* or South African abalone
Natural range	From Port St. Johns in the Eastern Cape, along the Western Cape coastline and extending towards the Northern Cape coastline.
Biological requirements	
Temperature	Ranges from 9 -24°C Optimal temperature range is 16 – 18°C
pH requirements	Tolerable range from 6 -9 Optimal range is 6.5 to 8.5
Salinity	30 -35 ppt is the optimal salinity for abalone production
Broodstock/breeding	
Spawning	The breeding season for South African abalone is between March and October, and spawning will peak between April and June. The preferred water temperature during spawning is around 18°C. Abalone have a single gonad, either ovary or testis. The South African abalone will reach sexual maturity around four to seven years of age. Depending on the size of the abalone, it can span 10 000 to 15 million or more eggs.
(Natural/induced)	It can be induced to spawn by treatment with hydrogen peroxide when exposed to seawater at a pH of between 9.0 and 9.9.
Egg size	The development process from fertilisation to settlement takes 4-10 days. The developed, ripe eggs of 150-244 µm in size can be produced by abalone.
Genetic selection	Superior characteristic selection is also achieved by selection, increasing growth rates, and resistance to disease.
Hatchery/spat production	
Hatchery system	Once the females have spawned, the eggs will hatch within the next 18 hours. The larvae are ready to settle within five days. Settlement takes place on plastic plates seeded with diatoms. The juvenile abalone are then put into **settlement tanks** for three months where they will continue to feed on the diatoms (from 7 to 10 mm). After three months, the juveniles are transferred to **weaning tanks** where they now will live under cones. They are weaned onto a more substantial diet of formulated artificial feed. When they reach eight months, they are transferred to the **grow-out section** where they are grown for approximately 45 months before they are harvested at 100 grams
First feed requirement	The first feed for larvae and spat is generally diatoms and micro-algae until they are transferred to the weaning tanks, where they are introduced to an artificial diet supplemented with kelp.

Latin name	Haliotis midae
Production performance	
Typical FCR	• **Manufactured Feed:** 1:1.3 to 1:1.5 • **Kelp:** 1:12 FCR is heavily influenced by type of feed and water temperatures
Feed requirement	• Abalone are herbivorous gastropods. They gain their energy mainly from kelp, which is ingested from late afternoon to early mornings. • Abalone can digest high levels of dietary protein; however, their ability to utilise fat is limited. • Higher growth rates have been seen by abalone that is primarily fed fishmeal and Spirulina, than the Abalone that was fed soya oil cake, torula yeast and casein.
Feed Costs	• Estimated cost of manufactured feed is R 27/kg. This depends on the brand and dietary composition of the feed. • Kelp (if bought locally) ranges from R 1.20/kg to R 3.50/kg depending where the abalone farm is located
Typical survival	• 80 - 85% during the grow out period.
Typical growth rate	• The growth rate of abalone is depending on the temperature of the water as well as the different diets. • Abalone in general has a very slow growth rate, typically 2 to 3 centimetres per annum • A minimum of 45 months is required for abalone to reach 100 grams in size.
Stocking densities	• Broodstock males and females are kept in separate tanks at a lower stocking density rate. • According to Mgaya and Mercer; Hunt *et al*, (1995), there is a negative correlation between growth rate and stocking density. • The size of the abalone will play a role in the different stocking densities.
Disease	• There have been no viral diseases in abalone documented in South Africa; however, bacterial diseases are common in abalone. • The fungal disease tubercule mycosis has been troublesome in South Africa abalone culture and is primarily associated with RAS.
Abalone Production	
Production systems considered	• Cage culture • RAS • Land based flow-through tank systems • Ranching
South African Abalone industry	• Well-developed value chain that is often vertically integrated. • Good availability of spat, feed & equipment • existing abalone processing industry.
Processing and markets	
Product form	• **Processed:** Canned or dried • **Live** abalone
Ideal Market Size	• 100-gram abalone are the most common. • Larger abalone are increasing in popularity, specifically wild caught abalone which can be produced in sea cages or through ranching.
Additional Information	

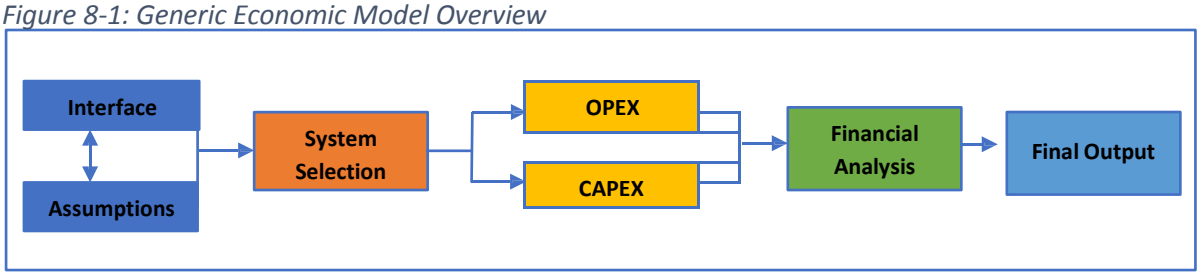
Latin name	Haliotis midae
Research and development	• Pilot projects to test the use of ranching systems are currently underway, • Continued research on optimal feeding for maximum growth, • Continued research on reducing the growth period would assist abalone producers.

8. Abalone Financial Analysis

8.1. Introduction

The generic economic model provides users with the opportunity to individual producer data, proposed production volumes and scales and financial data. Through the model, the users will receive financial outputs which include capital and operational costs and financial indicators which will guide the user in determining whether the proposed aquaculture project is feasible, and a viable investment opportunity. A high-level overview of the model process can be seen in the figure below.

Figure 8-1: Generic Economic Model Overview



Source: Urban-Econ,2018

The generic economic model can be customised to provide results for individual producers based on selections made with regard to the location of the aquaculture operation (at a provincial level), type of operation (start-up or existing), the scale of operation, type of production system, size and pricing of the abalone, education level and type of financing that will be used (equity or debt/equity).

8.2. Key Economic Model Assumptions

The generic economic model for abalone was developed using data from various information sources, consultations with various stakeholders and industry experts, and through inputs gathered at two peer-review workshops conducted.

8.2.1. Production Assumptions

To develop the generic economic model, specific production assumptions for abalone were identified and utilised. Some key assumptions used can be seen in Table 8-1 below.

Table 8-1: Abalone Production Assumptions

	Overview
Abalone spat	• **RAS & Flow-through**: R 1.80 per spat • **Ranching & Cage (bigger spat):** R 2.80 per spat
Production cycle length	• **RAS/Flow-through/Cage**: 45 months • **Ranching**: 76 months
Harvest weight	• **RAS/Flow-through/Cage**: 100 grams • **Ranching**: 500 grams
Survival Rate per production cycle	• **RAS/Flow-through/Cage**: 90% • **Ranching:** 30%
Mortality Rate per production cycle	• **RAS/Flow-through/Cage**: 14% • **Ranching:** 50% at seeding & 10% per cycle • **Freight Mortality:** 5% • **Drip loss:** 7%
Average feed price	• R 27 per kg (Manufactured feed)

Prices and assumptions will differ from farm to farm, specifically with regard to feed ratios and the type of feed used. Manufactured abalone feed caters for different production regions, as the feed has been specifically designed (protein content & nutritional make-up) for either for warm water conditions (Eastern Cape) or cold-water conditions (Western/Northern Cape), Prices are based on 2017/2018 prices and are subject to change over time.

8.2.2. Capital Expenditure

The capital expenditure costs for abalone production focused on the establishment of different production systems suited for abalone production in South Africa. The capital expenditure is determined by the scale of production, and the selected production cycle length. Some of the key factors to note include the following:

a. **Pre-development costs** for construction phase, concept design, specialist consultations, town planning alignment (zoning, rezoning etc.), and development of bulk infrastructure (roads, installation of electricity to the site, bulk water services etc.) were excluded from the model as this is site specific and not suitable to model at a provincial level,

b. **Land costs** were included should an individual/business not have an existing farm. A value of R 246 346 per hectare was used as an average price for land along the Western Cape/Eastern Cape/Northern Cape coastline however this will be site specific,

c. **Services** such as the costs of water and electricity were included in the model, and vary between the provinces,

d. **Buildings** such as storerooms, offices, cold storage, dive huts (ranching) and a feed room were considered,

e. **Aquaculture system** costs focused on the development of infrastructure for the systems (RAS, flow-through, cage culture and ranching), and additional equipment required.

f. **Infrastructure costs** are calculated as a once-off, lump sum amount to be spent in year one, however a producer can choose to phase in production which would spilt the costs up depending on how the production is phased in.

8.2.3. Infrastructure Assumptions

With regard to the four systems that were considered, the design, layout and type of equipment selected by the abalone farm will vary from farm to farm based on industry expertise, preference and type of operation that is being developed. From technical assessments and research, the following equipment assumptions were used in the generic economic model.

Table 8-2: Production Equipment/Infrastructure Assumptions

	RAS	Flow-Through	Cage	Ranching
Tanks & baskets (holding/splitting/grading)	Yes	Yes	Yes – *small-scale shore-based facilities*	Yes – *small-scale shore-based facilities*
Baskets with racks	Yes	Yes	No	Yes – *holding facility*
Cages with racks	No	No	Yes	No

	RAS	Flow-Through	Cage	Ranching
Grow-out tanks	Yes	Yes	No	No
Water Pumps	Yes	Yes	Yes	Yes
Header Water Storage	Yes	Yes	Yes	Yes
Drum Filter	Yes	Yes	Yes	No
Piping	Yes	Yes	Yes	Yes
Aeration	Yes	Yes	Yes	No
Biofilter Tanks & Media	Yes	No	No	No
UV Filtration	Yes	No	No	No
Water Meter/Testing Equipment	Yes	Yes	Yes	Yes
Water Test Kits	Yes	Yes	Yes	Yes

From the table above, it should be noted that a hatchery operation and processing facilities and/or equipment has been excluded from the infrastructure costing. These additional facilities would be site and farm specific based primarily on the scale of production, financial status of an operation, as well as the size of the abalone farm. A seaweed facility has been included for RAS, Flow-through and Cage culture when production volumes exceed 200 tons, however this can be tailored to suit individual abalone farms. General infrastructure such as office space, cold storage, feed storage has been included in the generic economic model, in addition to other equipment that is assumed to be required for a successful abalone farm.

8.2.4. Operational Expenditure

Operational expenditure, or working capital was determined by looking at the variable costs of production, and fixed costs. Costs considered include, but are not limited to the following:

Variable costs

1. Abalone spat,
2. Feed – based on the price of locally manufactured abalone feed, and
3. Transport costs.

Fixed Costs

1. Salaries,
2. Insurance,
3. General expenses (telephone, electricity, health and safety apparel, stationery etc.),
4. Legal/ licensing costs,
5. Vet services,
6. Water test kits, and
7. Reserve and unforeseen costs (calculated at 2% of the variable cost total).

8.2.5. Scale of Production

From the generic economic model, two production volumes were identified. Firstly, the minimum production volume which indicates at what tonnage a producer would first be profitable. Secondly, the optimal production tonnage was identified, which indicates where the optimal return on investment and profitability is achieved.

8.2.6. Market Information

Abalone market information was based on industry experts and research conducted. Prices for abalone range from R 400 to R 700 per kilogram, depending on the size and quality of the abalone. The selling price of R 420 per kilogram (kg) was used for 100-gram abalone produced in RAS, Flow-through and cage culture systems. Prices for larger abalone harvested from ranching operations are estimated to be R 500 per kilogram for 500-gram abalone, which was used when analysing the ranching system. The model assumes the abalone are sold live (in shells), and not as processed goods.

8.3. Abalone Production Financial Overview

Table 8-3 below provides the financial and production assumptions used to conduct the financial analysis on each of the potential production systems. As the generic economic model is based at a provincial level, for this analysis, the Western Cape was selected as most abalone farms in South Africa are located within the province.

Table 8-3: Abalone Financial and Production Assumptions

Province	Western Cape
Market	International
Selling Price	R 420/kg (RAS/Cage/ Flow-through) R 500/kg (Ranching)
Operational Status	Start-up farmer with no existing farm, facilities, or infrastructure
Skills Level	Formal education (certificate/diploma)
Financing Option	Debt/Equity
Debt Percentage	25%
Production Cycle	• **RAS/Flow-through/Cage**: 100 grams • **Ranching**: 500 grams
Additional Information	• The models exclude the construction and development phase. The models consider from when production starts. • Consulting, or specialist fees are not included in the model • Based on spat being purchased for every production cycle. • No hatchery or processing facilities were included. A seaweed facility was included in the infrastructure costs; however, it is assumed that seaweed production will be phased in over time and not start immediately.

Based on the assumptions above, the results obtained from the generic economic model are presented below for abalone.

8.3.1. Recirculating Aquaculture System

Based on the assumptions identified in Table 8-3 above, the following results were obtained from the generic economic model when looking at the use of RAS for abalone production in the Western Cape.

8.3.1.1. Capital Expenditure

Table 8-4 below provides a summary of the infrastructure and built environment costs required to establish a RAS abalone production.

Table 8-4: Total Infrastructure Costs for a RAS

Production Scale	Min Profitable 308 tons	Optimal Scale 860 tons
Purchasing of Land	R 971 465	R 6 370 803
Infrastructure (Buildings)	R 11 649 100	R 25 688 192
RAS Infrastructure	R 31 542 620	R 218 648 994
Additional equipment	R 2 890 134	R 23 574 079
Total Capital Expenditure	**R 47 443 319**	**R 275 576 069**

8.3.1.2. Operational Expenditure

Table 8-5 below provides a summary of the operational costs required for abalone production. The operational expenditure is shown for the first year of operation.

Table 8-5: Total Operational Expenditure for a RAS (Year 1)

Production Scale	Min Profitable 308 tons	Optimal Scale 860 tons
Variable costs	**R 10 819 523**	**R 30 210 355**
Spat	*R 7 000 000*	*R 19 545 455*
Manufactured Feed	*R 77 322*	*R 215 900*
Consumables – water quality	*R 46 200*	*R 129 000*
Fixed Costs	**R 64 352 060**	**R 173 944 641**
Total Operational Costs	**R 75 195 703**	**R 204 154 996**

8.3.1.3. RAS System Financial Overview

Table 8-6 below provides an overview of the capital expenditure required, as well as financial indicators and a high-level overview of the production requirements including land size, estimated number of spat required in month one (1), and the estimated number of employees required in the first year of production.

Table 8-6: RAS Financial Overview

	Min Profitable 308 tons	Optimal Scale 860 tons
Financial Overview		
Total Capital Expenditure	R 441 090 374.66	R 1 163 098 415.76
Loan Amount – Working Capital	R 326 094 162.77	R 887 522 346.93
Loam Amount - Infrastructure	R 114 996 211.89	R 275 576 068.84
Interest Rate	8.25%	8.25%
Profitability Index (PI)	1.00	1.17
Internal Rate Return (IRR)	7%	13%
Net Present Value over 10 years	R 440 033 516.68	R 1 355 316 669.13
Payback Period (years)	20	20
Year until profitable	5	5
Production Overview		
Minimum Farm Size Required	9.95 hectares	25.56 hectares
Number of spat required (Month 1)	324 074	904 882

	Min Profitable 308 tons	Optimal Scale 860 tons
Number of employees (Year 1)	215	593

As previously mentioned, the costs associated with establishing and operating a RAS for abalone production are high, specifically when looking at the working capital, which is required for the first 44 months of operation, as the first abalone sales will take place at the end of month 45. Feed, transport, abalone spat and fixed costs (insurance, electricity, and salaries) are the main costs incurred.

It is estimated that a 308-ton facility (without a hatchery and processing facility) would require a total capital expenditure of R 441 090 374 in year one (1) if no development phasing is used, and to produce 860 tons of abalone, it is estimated that R 1 163 098 415 will be required in year one (1). The area of land required for abalone production is fairly low in comparison to extensive aquaculture production operations for finfish which is noted above. As mentioned salaries are a major cost for producers, which is evident when considering the number of employees required; a 308-ton abalone farm requires approximately 215 employees (high, medium, and low skilled), while an 860-ton abalone farm could employ up to 593 employees.

It is estimated that at 308 tons per annum it will cost R 1 432 111 to produce one ton of abalone. At larger production volumes, (860 tons), it will cost approximately R 1 352 440 to produce one ton of abalone.

8.3.2. Flow-through systems

The tables below provide a financial overview for flow-through systems when used to produce abalone in the Western Cape. The minimum profitable scale was identified at 113 tons per annum, and the optimal return on investment was achieved when producing 746 tons per annum.

8.3.2.1. Capital Expenditure

Table 8-7 below provides a summary of the infrastructure and built environment costs required to establish a flow-through system for abalone production.

Table 8-7: Total Capital Costs for a Flow-through System

Production Scale	Min Scale 113 tons	Optimal 746 tons
Purchasing of Land	R 1 061 652	R 5 533 466
Infrastructure (Buildings)	R 12 662 300	R 24 357 742
Flow-through Infrastructure	R 36 860 360	R 205 319 140
Additional equipment	R 542 539	R 1 520 999
Total Capital Expenditure	**R 51 598 852**	**R 237 888 348**

8.3.2.2. Operational Expenditure

Table 8-8 below provides a summary of the operational costs required for abalone production. The operational expenditure is shown for the first year of operation.

Table 8-8: Total Operational Expenditure for a Flow-through (Year 1)

Production Scale	Min Scale 113 tons	Optimal 746 tons
Variable costs	**R 3 955 550**	**R 26 205 727**
Spat	*R 2 568 182*	*R 16 954 545*

Production Scale	Min Scale 113 tons	Optimal 746 tons
Feed (Artificial & Kelp)	*R 28 368*	*R 187 281*
Consumables – water quality	*R 3 000*	*R 111 900*
Fixed Costs	**R 20 124 729**	**R 119 196 480**
Total Operational Costs	**R 24 080 278**	**R 145 402 206**

8.3.2.3. Flow-through System Financial Overview

Table 8-9 below provides an overview of the capital expenditure required, as well as financial indicators and a high-level overview of the production requirements including land size, estimated number of spat required in month one (1), and the estimated number of employees required in the first year of production.

Table 8-9: Flow-through Financial Overview

Production Scale	Min Scale 113 tons	Optimal 746 tons
Financial Overview		
Total Capital Expenditure	R 156 814 255.76	R 861 575 049.62
Loan Amount – Working Capital	R 105 215 404.04	R 623 686 701.97
Loam Amount - Infrastructure	R 51 598 851.72	R 237 888 347.64
Interest Rate	8.25%	8.25%
Profitability Index (PI)	1.00	1.68
Internal Rate Return (IRR)	7%	21%
Net Present Value over 10 years	R 156 884 174.44	R 1 447 667 264.10
Payback Period (years)	20	20
Year until profitable	4	4
Production Overview		
Minimum Farm Size Required	4.31 hectares	22.46 hectares
Number of spat required (Month 1)	118 897	784 933
Number of employees (Year 1)	82	515

As previously mentioned, the costs associated with establishing and operating a flow-through system for abalone production are high, specifically when looking at the working capital, which is required for the first 44 months of operation, as the first abalone sales will take place at the end of month 45. Feed, transport, abalone spat and fixed costs (insurance, electricity, and salaries) are the main costs incurred.

It is estimated that a 113-ton facility (without a hatchery and processing facility) would require a total capital expenditure of R 156 814 255 in year one (1) if no development phasing is used, and to produce 745 tons of abalone, it is estimated that R 861 575 049 will be required in year one (1). The area of land required for abalone production is fairly low in comparison to extensive aquaculture production operations for finfish which is noted above.

As mentioned salaries are a major cost for producers, which is evident when considering the number of employees required; a 113-ton abalone farm requires approximately 82 employees (high, medium, and low skilled), while a 746-ton abalone farm could employ up to 515 employees. The flow-through system above was developed using similar information as the RAS, thus the employee numbers are similar, however the total capital required is higher for RAS, which can be attributed to additional infrastructure requirements associated with a RAS.

It is estimated that at 113 tons per annum it will cost R 1 387 736 to produce one ton of abalone. At larger production volumes, (746 tons), it will cost approximately R 1 154 926 to produce one ton of abalone.

8.3.3. Cage culture

Cage culture differs when comparing it to the other production systems as it is not land based, and thus factors such as coastal leases, access to suitable sites for the cages to be established, as well as the need to check the cages and maintain them. Cage culture is not commonly used in South Africa, mainly due to the need for very specific cage culture suited production sites, as well as the risks associated with cage culture, as the system allows minimal control of environmental conditions. The minimal profitable scale was identified at 41 tons per annum, and the optimal return on investment was achieved at 686 tons per annum.

8.3.3.1. Capital Expenditure

Table 8-10 below provides a summary of the infrastructure and built environment costs required to establish a cage culture system for abalone production.

Table 8-10: Total Capital Costs for Cage Culture

Production Scale	Minimum 41 tons	Optimal 686 tons
Land Required	R 276 954	R 530 616
Infrastructure (Buildings)	R 11 578 000	R 16 397 500
Cage culture system	R 32 258 129	R 444 585 089
Additional equipment	R 375 922	R 1 276 270
Total Capital Expenditure	**R 44 839 006**	**R 463 829 475**

8.3.3.2. Operational Expenditure

Table 8-11 below provides a summary of the operational costs required for abalone production. The operational expenditure is shown for the first year of operation.

Table 8-11: Total Operational Expenditure for Cage culture (Year 1)

Production Scale	Minimum 41 tons	Optimal 686 tons
Variable costs	**R 1 431 302**	**R 23 948 134**
Spat	*R 931 818*	*R 15 590 909*
Feed	*R 1 334*	*R 22 235*
Consumables – water quality	*R 6 150*	*R 102 900*
Fixed Costs	**R 6 269 993**	**R 64 237 077**
Total Operational Costs	**R 7 701 296**	**R 88 185 211**

8.3.3.3. Cage Culture Financial Overview

Table 8-12 below provides an overview of the capital expenditure required, as well as financial indicators and a high-level overview of the production requirements including land size, estimated number of spat required in month one (1), and the estimated number of employees required in the first year of production.

Table 8-12: Cage Culture Financial Overview

Production Scale	Minimum 41 tons	Optimal 686 tons

Production Scale	Minimum 41 tons	Optimal 686 tons
Financial Overview		
Total Capital Expenditure	R 75 089 192.62	R 816 168 830.05
Loan Amount – Working Capital	R 30 250 186.33	R 352 335 354.08
Loam Amount - Infrastructure	R 44 839 006.29	R 463 829 475.97
Interest Rate	8.25%	8.25%
Profitability Index (PI)	1.05	3.40
Internal Rate Return (IRR)	8%	30%
Net Present Value over 10 years	R 78 527 065.78	R 2 778 383 216.17
Payback Period (years)	20	20
Year until profitable	5	5
Production Overview		
Minimum Farm Size Required	1.12 hectares	2.15 hectares
Number of spat required (Month 1)	43 140	721 801
Number of employees (Year 1)	28	474

As previously mentioned, the costs associated with establishing and operating a cage culture system are considerably lower when comparing more intensive production methods such as the RAS and flow-through systems. When looking at the working capital, which is required for the first 44 months of operation, as the first abalone sales will take place at the end of month 45.

It is estimated that a 41-ton facility (without a hatchery and processing facility) would require a total capital expenditure of R 75 089 192 in year one (1) if no development phasing is used, and to produce 686 tons of abalone, it is estimated that R 816 168 830 will be required in year one (1). The area of land required for cage culture is minimal as the land will primarily be for buildings and small-scale abalone holding facilities. As mentioned salaries are a major cost for producers, which is evident when considering the number of employees required; a 41-ton abalone farm requires approximately 28 employees (high, medium, and low skilled), while a 686-ton abalone farm could employ up to 474 employees.

It is estimated that at 41 tons per annum it will cost R 1 831 443 to produce one ton of abalone. At larger production volumes, (686 tons), it will cost approximately R 1 189 744 to produce one ton of abalone.

8.3.4. Ranching

The use of ranching for abalone production in South Africa is still in its infant stages, with several pilot projects currently underway. The tables below provide a financial analysis for the use of ranching for abalone production.

Abalone produced from ranching operations are sold on the market as 'wild caught' abalone, thus fetching much higher prices than abalone produced in land based, intensive systems. Stakeholders identified an estimated selling price of R 500 per kilogram being received for 500-gram abalone.

8.3.4.1. Capital Expenditure

The table below provides a summary of the infrastructure and built environment costs required to establish a cage culture system for abalone production.

Table 8-13: Total Capital Costs for Ranching

Production Scale	Minimum 28 tons	Optimal 638 tons
Land Required	R 272 945	R 420 943
Infrastructure (Buildings)	R 12 044 392	R 16 948 812
Ranching infrastructure	R 5 633 758	R 10 397 319
Additional equipment	R 397 742	R 1 192 708
Total Capital Expenditure	**R 18 783 838**	**R 29 925 783**

8.3.4.2. Operational Expenditure

The table below provides a summary of the operational costs required for abalone production. The operational expenditure is shown for the first year of operation.

Table 8-14: Total Operational Expenditure for Ranching (Year 1)

Production Scale	Minimum 28 tons	Optimal 638 tons
Variable costs	**R 1 244 354**	**R 28 346 955**
Spat	*R 929 644*	*R 21 182 609*
Kelp (for holding facility)	*R 2 210*	*R 50 346*
Consumables – water quality	*R 4 200*	*R 95 700*
Fixed Costs	**R 7 862 051**	**R 61 638 509**
Total Operational Costs	**R 9 106 405**	**R 89 985 463**

8.3.4.3. Cage Culture Financial Overview

The table below provides an overview of the capital expenditure required, as well as financial indicators and a high-level overview of the production requirements including land size, estimated number of spat required in month one (1), and the estimated number of employees required in the first year of production.

Table 8-15: Ranching Financial Overview

Production Scale	Minimum 28 tons	Optimal 638 tons
Financial Overview		
Total Capital Expenditure	R 84 842 608.64	R 695 709 256.85
Loan Amount – Working Capital	R 66 058 770.70	R 665 783 474.18
Loam Amount - Infrastructure	R 18 783 837.94	R 29 925 782.67
Interest Rate	8.25%	8.25%
Profitability Index (PI)	1.10	2.83
Internal Rate Return (IRR)	25%	55%
Net Present Value over 10 years	R 93 276 545.17	R 1 965 685 682.53
Payback Period (years)	20	20
Year until profitable	10	10
Production Overview		
Minimum Farm Size Required	1.1 hectares	1,7 hectares
Number of spat required (Month 1)	29 461	671 296
Number of employees (Year 1)	31	381

Similar to cage culture the costs associated with ranching abalone are considerably lower when comparing more intensive production methods such as the RAS and flow-through systems. When looking at the working capital, which is required for the first 38 months of operation, as the first abalone sales will take place at the end of month 39, the main costs incurred result from the abalone spat and transport costs as feed costs are minimal with ranching, where the primary feed source is kelp, and is only used in the holding facilities when the abalone are acclimatising before the seeding process. It is estimated that a 12-ton facility (without a hatchery and processing facility) would require a total capital expenditure of R 20 223 093 in year one (1) if no development phasing is used, and to produce 200 tons of abalone, it is estimated that R 101 763 891 will be required in year one (1). The area of land required for ranching operations is minimal as the land will primarily be for buildings and small-scale abalone holding facilities. As mentioned salaries are a major cost for producers, which is evident when considering the number of employees required; a 12-ton abalone farm requires approximately 25 employees (high, medium, and low skilled), while a 200-ton abalone farm could employ up to 43 employees, some of which need to be trained and skilled commercial divers to assist with the seeding and harvesting of abalone, as well as the regular checking of abalone.

It is estimated that at 28 tons per annum it will cost R 3 029 863 to produce one ton of abalone. At larger production volumes, (628 tons), it will cost approximately R 1 090 453 to produce one ton of abalone.

8.3.5. Production System Financial Analysis Summary

Using the generic economic model, each of the four (4) potential production systems identified for abalone production in the Western Cape were analysed to determine the average selling price, minimum profitable tonnage, working capital costs and infrastructure development costs. Table 8-16 below provides a summary of the results obtained when looking at the minimum profitable tonnage identified for each system.

Table 8-16: Abalone Financial Analysis Summary

	RAS	Cage	Flow-Through	Ranching
Min Profitable Tonnage/annum	308	41	113	28
Average Selling Price	R 420/kg	R 420/kg	R 420/kg	R 500/kg
Capital Expenditure	R 441 090 374	R 75 089 192	R 156 814 255	R 84 842 608
IRR	7%	8%	7%	25%
Estimated cost per ton	R 1 432 111	R 1 831 443	R 1 387 736	R 3 029 863

From the table above, it can be seen that cage culture and ranching are more profitable from much lower tonnages (41 tons and 28 tons respectively), which can be linked to the costs of establishing the abalone farm, as well as the operational costs. RAS and flow-through systems require a minimum production of 308 tons and 113 tons per annum when selling at the average price of R 420/kg. Despite their differences, each of the four systems is profitable, and can be successfully used for abalone production in South Africa. Ranching and cage culture offer more favourable returns

however the risks associated with these systems, as well as limited, suitable production areas must be taken into consideration.

8.4. Cost Benefit Analysis

Table 8-17 below shows a high-level cost benefit analysis for abalone produced in the Western Cape, based on the profitability index (PI) which is used as the cost benefit ratio. The analysis considers the potential production systems, at both the minimum viable tonnage, and recommended, optimal tonnage respectively when using the average selling price, and minimum profitable selling price identified.

Table 8-17: Abalone Cost Benefit Analysis

	RAS	Flow-through	Cage	Ranching
Minimum Profitable Tonnage				
Market price	R 420/kg	R 420/kg	R 420/kg	R 500/kg
Tons produced/annum	308	113	41	28
Profitability Index (PI)	1.00	1.00	1.05	1.10
Internal Rate of Return (IRR)	7%	7%	8%	25%
Employees required (Year 1)	215	82	28	31
Optimal Tonnage				
Market price	R 420/kg	R 420/kg	R 420/kg	R 500/kg
Tons produced/annum	860	746	686	638
Profitability Index (PI)	1.17	1.68	3.40	2.83
Internal Rate of Return (IRR)	13%	21%	30%	55%
Employees required (Year 1)	593	515	474	381

From the table above, it can be seen that all four (4) production systems are profitable and feasible for abalone production in the Western Cape. However, although each of the systems is profitable, each one offers unique challenges and advantages for producers which should be carefully considered when selecting a production system.

Out of the four (4) production systems above, it can be seen that cage culture and ranching are the most profitable systems, specifically at the higher tonnages when considering the internal rate of return (IRR) achieved by each of the systems. From the results presented above, RAS and flow-through systems are less profitable than the other two (2) systems which is directly linked to the size of the abalone produced, selling prices, operational costs and infrastructure costs required for the land-based systems. Although RAS and flow-through are less profitable, they do show positive results and are commonly used in South Africa, specifically the flow-through systems.

Each system offers a number of employment, specifically at the higher tonnages, where more specialised and skilled employees can be used as the operation will be able to cover their salaries. At the lower tonnages, the number of jobs created ranges from 28 to 215 (system dependent) in year one of operation. The most labour-intensive systems at the higher tonnages, as seen in the table above, include RAS and Flow-through systems which are more intensive culture systems, while cage culture requires the lowest number of permanent employees in year one (1).

8.5. Best Case Scenario

By making use of the generic economic model for abalone, it is possible to look at "Best Case Scenarios" for each of the potential production systems at a provincial level. To do this, the following categories and criteria were used to assess the economic models.

I. **Selling weight:** The generic economic model accounts for abalone being sold at 100 grams (live, with shell on) at 45 months old when looking at RAS, flow-through and cage culture. Ranched abalone are sold at 76 months old at a weight of 500 grams.

II. **Minimum Tonnage required for each production cycle:** The minimum tonnage was identified to determine the amount that an abalone producer needs to produce in order to be profitable.

III. **Price:** The farm gate price received for abalone has a major impact on the profitability and sustainability of the aquaculture operation. The minimum recommended selling price differs for each production system and is affected by the annual production volume selected.

IV. **Finance Type:** The generic economic model provides three financing options for producers, however for this analysis the debt/equity finance option was selected with a 20% debt ratio. This assumes that a producer contributes 20% of their assets and receives funding for the remaining 80%.

It should be noted that the figures and analysis discussed below are based at a provincial level and were obtained with the general assumptions used in the economic model. While at a provincial level a system and tonnage may show a positive or negative return on investment or profitability index, this may differ at a site-specific level depending on the site temperatures and conditions, water quality and temperature, and access to markets.

As previously mentioned all four (4) production systems have proven to be profitable for abalone when using the general assumptions in the generic economic model. The table below provides an overview of the 'best-case scenarios' for each of the production systems based on the average selling price identified in the model, as well as the minimum profitable tonnage required per annum and the estimated cost to produce one ton of abalone based on the capital expenditure for each system.

Table 8-18: Best Case Scenario Summary

	RAS	Flow-through	Cage	Ranching
Selling Price	R 420/kg	R 420/kg	R 420/kg	R 500/kg
Eastern Cape	308 tons	113 tons	41 tons	28 tons
	R 1 432 111/ton	R 1 387 736/ton	R 1 831 443/ton	R 3 029 863/ton
Western Cape	308 tons	113 tons	41 tons	28 tons
	R 1 432 111/ton	R 1 387 736/ton	R 1 831 443/ton	R 3 029 863/ton
Selling Price	**R 435/kg**	**R 420/kg**	**R 420/kg**	**R 500/kg**
Northern	500 tons	207 tons	41 tons	29 tons

	RAS	Flow-through	Cage	Ranching
Cape	R 1 458 756/ton	R 1 366 130/ton	R 1 831 443/ton	R 3 074 091/ton

From the table above, it is clearly illustrated that the Eastern and Western Cape offer the most profitable abalone producing conditions, with the Northern Cape, although profitable having to contend with further travel distance to export the abalone, as well as obtain inputs (feed and spat). Despite the financial analysis, a key factor that will differ between the provinces is the abalone growth rates which is affected by water temperatures.

If a producer has a hatchery and feed production operation, the results will be almost identical to that of the Eastern Cape and Western Cape. Ranching and cage culture are the two most profitable systems for abalone production, predominantly due to the low operational and infrastructure costs associated with the systems, however, a key factor to consider is the limited resources and knowledge on the use of these systems as in South Africa they are currently being done as pilot studies. When looking at the cost of producing one ton of abalone when selecting ranching (R 3 029 683 per ton) in the Eastern and Western Cape, it is important to note this cost is higher due to the extend production cycle for ranched abalone which is approximately 76 months, in comparison to 45 months for the other three systems.

Flow-through offers producers and investors a good return on investment as well as the comfort in using system that is commonly used and successful in South Africa. RAS showed similar results to the flow-through system, however it is not as widely used due to disease risks, thus partial RAS or flow-through systems are more commonly used for abalone production.

9. Conclusion and recommendations

This section provides conclusions and recommendations based specifically on the production aspect, including systems for abalone. In addition, recommendations based on the market assessment, production systems, and status of abalone production in South Africa are included.

9.1. Conclusions

The South African abalone industry is one of the most valuable, and well-established sectors within the South African aquaculture sector. The study has identified an advanced abalone value-chain that has been developed, which includes specialised feed producers, breeding and hatchery programmes, and advanced production systems, right through to processing and marketing. Abalone producers in South Africa have done well to establish an industry that is known for its quality product, both locally and globally. As a result of the rapid growth in the global abalone industry, the entire international abalone value-chain is going through a transformation in many aspects including: production and value-addition processing capabilities, changes in current market costumer-base and the opening of new niche market, and lastly the increased capacities of the supply chains to access these various international markets. Currently, leading international markets include China (Hong Kong and mainland), Korea, Japan, Taiwan, and Singapore, who are driving the industry with a focus on both affordable smaller size products (mostly in China and Korea markets) as well as the high quality and larger size products (mainly in Hong Kong, Japan, and Singapore).

Currently Chine and Korea dominate the abalone industry, with mostly for the lower-end products, while Mexico, USA, Chile, Australia, and South Africa are dominating the higher-end products (live and canned). International trade-hubs of abalone including Hong Kong (into China and other regions), Singapore (focused on Southern of East Asia), and Viet Nam, are becoming dominant in the global trade of canned and value-added products. Live abalone require a specialised supply chain which is driven by direct marketing such as with the Australian live wild abalone that is aimed at the Japanese, Singaporean, and Chinese markets, while the South African live farmed abalone are directed to Hong Kong market. More advanced marketing strategies are required for the South African farmed abalone industry to maintain its market position or to expand its market share as a premium abalone producer. South African abalone are highly prized in the markets due its flavour, texture, form, and size. It is also highly valued by importers as the South African abalone travel well and can survive in the restaurant tanks as live products, which is the preferred style in Hong Kong.

Poaching and illegal abalone trade is a major threat to the local abalone industry and requires the continued involvement and attention of government and the industry as the continued supply of low-quality abalone is a major risk to the farmed abalone industry (Personal Communication Piek, 2018).

Out of the four (4) production systems above, it can be seen that cage culture and ranching are the most profitable systems, specifically at the higher tonnages when considering the internal rate of return (IRR) achieved by each of the systems. From the results presented above, RAS and flow-through systems are less profitable than the other two (2) systems which is directly linked to the size of the abalone produced, selling prices, operational costs and infrastructure costs required for the land-based systems. Although RAS and flow-through are less profitable, they do show positive results and are commonly used in South Africa, specifically the flow-through systems.

9.2. Recommendations

From the study conducted, the following recommendations have been made:

1. Continued research and development on improving the growth rate of abalone to reduce the production cycle would increase productivity and assist with restocking efforts of wild abalone stocks,
2. Research and development on the potential production systems for abalone is required, specifically looking at how to reduce the operational and infrastructure expenditure, as well as how the systems can be adapted to South African conditions to ensure abalone farms can function with maximum efficiency,
3. Continued research and development on cage culture and ranching systems will assist with the development and success of these systems,
4. The abalone generic economic model should be updated annually to ensure the most recent data and assumptions are used, specifically for ranching systems as data becomes available,
5. Substantial investment is required in the South Africa towards the experimental abalone ranching initiatives, by developing additional dedicated hatcheries which will provide seeds for the ranching abalone operations. This would require a strong "buy-in" from the disadvantaged local coastal communities who would be given long-term ranching or fishing rights to incentivise the natural stock and rehabilitation of abalone local fishery (and by that combat the illegal activities) (Krohn, et al., 2016),
6. Develop national laboratory capacity to undertake drug residue testing on abalone,
7. Efforts to control and eradicate abalone poaching should receive continued support. Community awareness campaigns should be conducted specifically in local communities in abalone producing areas,
8. Address the growth potential identified in Hong Kong market and major mainland China cities (e.g. Shanghai) in the short and medium term, based on their demand for larger and higher-end abalone products,
9. Short term focus on canned products is required with emphasis on the South African higher quality brands. Currently, the farmed abalone South African industry is unfortunately slightly fragmented in terms of marketing efforts with two main local South African brands namely: Overgold and Diamond, which are used to market canned products (Personal Communication Piek, 2018),
10. Collective efforts by South African producers is required to deal with the current competition from Korea and Australia who have the capacity to put pressure on lowering the abalone prices received by South African producers (Krohn, et al., 2016; Personal Communication Piek, 2018),
11. Investing in trading and marketing companies who are well established in the export market would assist South African abalone producers rather than trading through an intermediary's agents (Krohn, et al., 2016),
12. Investing in a local branding label to ensure South Africa retains its status associated with the premium quality abalone produced locally, with superior product characteristics, and the higher pricing compared to the Chinese, Korean and Australian farmed abalone,
13. Shifting into live products market niche could also present an opportunity in the medium to longer term for South Africa, provided that the logistics services of "Tank to Tank" could support greater volumes,

14. Investigate the requirements for South Africa to supply the EU markets. Discussions should be conducted with the regulator and the industry to resolve outstanding issues considering the SAMSM&CP performances so far. Additional international markets could be explored in some of the major metro cosmopolitan cities with high Asian populations such as in Vancouver (43%) San Francisco (33%), London (21%), Toronto (35%), and Calgary (23%), and
15. The South African industry could capitalize on the local domestic market provided regulation by the authorities would be able to accommodate both the control of illegal fisheries and a govern the trade of farmed abalone (from origin to the restaurants).

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