SOCIO-ECONOMIC REPORT

COMPARATIVE ASSESSMENTS FOR THE DEVELOPMENT OF THE PROPOSED SEA-BASED AQUACULTURE DEVELOPMENT ZONE LOCATED WITHIN ALGOA BAY IN THE EASTERN CAPE IN SOUTH AFRICA.

PREPARED BY

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FOR

Department of Agriculture, Forestry and Fisheries

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Front cover: Fish cages in Velfjorden, Brønnøy, Norway-Thomas Bjørk

MARINE SOCIO-ECONOMIC REPORT: MARINE AQUACULTURE DEVELOPMENT ZONES FOR FINFISH CAGE CULTURE

EXECUTIVE SUMMARY

The purpose of the present 'Socio-economic Report' is, together with the 'Ecological Report', to provide the required inputs into the 'Detailed Feasibility Study' comparing the economic, social and ecological feasibility of the two proposed Algoa Bay Aquaculture Development Zone (ADZ) sites, Algoa 1 and Algoa 5 located in Algoa Bay in the Eastern Cape. The present 'Socio-economic Report' is made up of inputs by economic and aquaculture industry specialists. An economist reviewed the Final Environmental Impact Report (EIR) Socio-economic Impact Assessment, which was undertaken in the previous Environmental Impact Assessment process, and the social and economic aspects of the 28 appeals against the Environmental Authorisation. This was followed by a survey of public perception of the social trade-offs associated with the ADZ. Aquaculture industry specialists provided an analysis of the economic viability of a cage aquaculture operation in Algoa Bay based on industry benchmarks. This included a market perspective, operational considerations, cost estimates, revenue, employment and a high level financial model.

The review of the Final EIR socio-economic impact assessment found that the revenue, cost and job projections for the Algoa 1 and Algoa 5 ADZs were speculative. In the absence of certainty over the external costs (including displacement of income costs) it was premature to calculate aggregate (macro) effects for either income or jobs. Thus it was not justifiable to draw any conclusion, positive or negative on the economic feasibility of the ADZs. The estimated job creation numbers greatly exceeded aquaculture industry benchmark figures for fish cage culture.

The review of the 28 appeals to the Environmental Authorisation addressed the concern (shared by most appellants) that tourism could, or will, be negatively affected as a result of the Algoa ADZ development. The weakness of the appellant's argument in this regard is that they speculate on the scale of this negative impact. Nonetheless, the reviewer's finding was that the logic of the various appellant's was reasonable, and there was thus a need for some marketing analysis and a more inclusive social cost benefit analysis. These analyses would enable a better informed financial (investment attractiveness) perspective.

A detailed costing of the socio-economic impact of the ADZ was not possible within the time and budget limitations, and thus a social choice trade-off survey was undertaken. The survey attempted to gauge whether the external costs (negative social and economic impacts on the tourism and conservation value and others) outweigh the income and employment benefits that could be gained as socially attractive elements. A total of 154 people were surveyed on the Humewood Beach front between 23 June and 1 July 2016. The majority (58%) of the respondents surveyed chose the Algoa

Bay fish farm option over the status quo (no fish farm). Consistent with this choice analysis, in a referendum type situation, 50.3% would have voted for the introduction of fish farming into Algoa Bay, 39.4% would have voted against it and 10% would have abstained from voting. The main reason for a majority voting for an ADZ is the prospect of additional income and job creation. Many respondents found the choices offered difficult to choose between. Most of those surveyed had a concern over the adverse impact on recreational activity in Algoa Bay of introducing an ADZ into Algoa 1. These aspects were not as relevant to an ADZ in Algoa 5, as this site is located further away from these activities. The primary detracting feature to society of an ADZ in Algoa 5 is its ecological and ecosystem conservation impact. The option of the development of a fish farm with a low potential impact on both recreational use and the marine ecology would conceivably have improved the support for introducing caged fish farming within both Algoa 1 and Algoa 5 zones.

The economic analysis of cage aquaculture in Algoa Bay provided a market perspective on kob and yellowtail, considered the site and operational feasibility of cage culture at Algoa 1 and Algoa 5, and provided a generic financial model for a 1000t and 3000t farm. Kob and yellowtail enjoy generally strong local demand and are in short supply and thus there is a potential opportunity for farmed fish to penetrate the local market. A further price and market access advantage is enjoyed by aquaculture products which are certified as 'sustainable'. The South African Sustainable Seafood Initiative (SASSI) 'green' listing of kob has thus been a key strategy for pilot scale producers to penetrate the South African retail market. An assessment of the South African market potential for kob and yellowtail is constrained by the lack of hard market data, however the supply of 'linefish' (excluding snoek) declined by 1000t between 2000 and 2012 highlighting the potential supply shortfall. Demand for fish has grown considerably in South Africa over the last decade with the advent of seafood franchises and greater awareness of seafood products (Britz, 2014). Pilot marketing of farmed kob has shown that there is a ready demand for 5-10t of kob per week by the existing seafood value chain at an ex-farm price of R75/kg gutted and gilled. Prices are however vulnerable seasonal periods of abundance of wild fish. The limited information available thus indicates that the current South African market for kob is currently very small – of the order of hundreds of tons, and that well designed marketing strategies will be required to grow the demand for farmed kob based on the characteristics of consistent supply and quality of a known product. This will however take time and therefore a realistic initial aquaculture production volume of 500-1000t/annum is probably realistic to supply the existing South African premium fresh market demand without depressing prices. The international market prospects for kob and yellowtail were not positive, as kob is an unknown species and yellowtail is produced very cheaply in Asia and widely exported. Furthermore, South African capacity for certifying the health of farmed fish products for export is not yet in place.

The area of water required for an ADZ was estimated based on market size and biosecurity considerations. The market demand perspective above indicates that any cage culture production in Algoa Bay would have to begin from a pilot scale of hundreds of tons and grow organically with market demand to a realistically viable 3000t over 5-10 years. There is no market-based evidence to justify planning for 30,000t production on Algoa 1 and 75,000t on Algoa 5. The present environmental authorization for 1000t pilot on 70ha on Algoa 1, with likely expansion to 3000t, is thus a realistic initial goal. Even allowing space for market driven production expansion, the size of the proposed aquaculture footprint within ADZ areas could be reduced without compromising their commercial development potential. To minimize the risk of disease transfer between farms, a minimum farm spacing of 2.4 km was applied in planning the farm spacing within ADZs. Taking into account the required operating area for a 3000t/annum production unit (70ha occupied with space for expansion to 210ha), Algoa 1 (Option 1 North) could theoretically sustain a single farm with a maximum production potential of 9000t/annum. The Algoa 1 – Option 2 (South, 455ha) would thus fall away due to biosecurity farm spacing requirements. Algoa 5 (1000ha) could potentially house more than one farm, assuming a separation distance of 2.4km. In the event that a buffer zone (2.4km) is applied, two operating areas of 210ha could be accommodated. Using the same reasoning as above, this potentially allows for two commercial farms with each a maximum future production potential of 9000t/annum (total production of 18,000t/annum).

The site characteristics of the proposed ADZ's were considered in terms their implications for the economic viability of cage aquaculture. The proposed sites (Algoa 1 and Algoa 5) share similar environmental conditions, with Algoa 5 subject more exposed to SW swells. The primary determinant of the difference in the economic viability of the two sites is their location relative to port service infrastructure with Algoa 1 is situated 4km from Port Elizabeth harbor, and Algoa 5 15km from the Coega container port. Algoa 1 can be serviced with smaller craft and be cost effective due to the short travel distance. The vessels required for servicing Algoa 5 would need to be larger to withstand more exposed sea conditions, require more initial capital and would more suited for operating larger farms**.** The 15 km distance from Nqura Port is however deemed marginal by industry experts for efficient operations. A possible alternative small vessel access for Algoa 5 could be the development of a small vessel harbour at Sundays River. While the larger work vessels required to service the cages would need to operate out of the Nqura Port, personnel could be transported to the site from Sundays River when sea conditions permit launching through the surf zone. Thus the operational feasibility for Algoa 5 is considered very low in terms of distance from port*.*

Algoa Bay is significantly highly exposed to wind which, in combination with swell, severely limits the number of operational days at sea. The high percentage (ca. 50%) of 'poor' and 'caution' sea days characterized by windspeeds of >14knots thus places a severe operational constraint on servicing cage farms in the Algoa 1 and Algoa 5 ADZs. As fish require daily feeding, and staff have to have safe operating conditions, larger and more capital intensive vessels and automated feeding systems would be required to operate effectively. As the Algoa 1 site is in close proximity of Port Elizabeth, it is possible to take advantage of shorter weather windows using smaller vessels to service cages, however the further distance to Algoa 5 imposes a higher vessel specification for safe operations. The operational feasibility of both Algoa 1 and Algoa 5 is considered low in terms of wind and swell exposure.

Red tides are a potential threat to the viability of cage aquaculture in Algoa Bay. A recent intense bloom of the dinoflagellate *Lingulodinium polyedrum* during a warm water event (>20°C), accompanied by calm wind conditions, persisted for 3 months from December 2013 to March 2014. A red tide algal bloom on kob in cage culture will have potentially severe sub-lethal and lethal effects related to low night-time oxygen levels and possible turnover of deoxygenated bottom water. The effect of exceptionally high cell density (29,000/ml) on the gills of the target species in not known, however, in other species red tide cells have been known to cause clogging, irritation and mucous production. The severe red tide bloom persisted for longer off the Sundays and Swartkops estuaries due to the nutrient inputs into the Bay. The location of Algoa 5 off the Sundays estuary thus increases likelihood of this sites long-term exposure red tide events. From an investment perspective, the production risk and uncertainty associated with red tide events renders the suitability of the both Algoa 1 and Algoa 5 sites for cage aquaculture as moderately feasible.

A generic financial model cage culture for 1000t and 3000t production units is presented with realistic cost inputs, prices, and Feed Conversation rates. The approximate capital required was R70.5m for a 1000t unit and R154.5m for a 3000t unit. A 1000 to farm would employ 100 people and a 3000t farm 320 people directly and indirectly.

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1. INTRODUCTION

1.1 PURPOSE OF REPORT

The purpose of the present '**Socio-economic Report'** is, together with the '**Ecological Report'**, to provide the required inputs into the '**Detailed Feasibility Study**' comparing the economic, social and ecological feasibility of the two proposed Algoa Bay Aquaculture Development Zone sites, Algoa 1 and Algoa 5 respectively.

1.2 BACKGROUND

In order to promote the development of the aquaculture sector, the South African government has promulgated a National Aquaculture Strategic Framework Policy (DAFF, 2013) which identifies the establishment of Aquaculture Development Zones (ADZ's) as a key sector development strategy.

An ADZ is an area that has been earmarked specifically for aquaculture activities. The purpose of which is to create an enabling environment for the Marine Finfish Aquaculture Sector to develop and expand in a sustainable manner. The benefits of ADZ's are to encourage investor confidence, create incentives for industry development, provide aquaculture services, manage the risks associated with aquaculture, job creation, skills development, empowerment of rural communities and most importantly benefit from the Special Economic Zones incentives.

In 2009 a Strategic Environmental Assessment (SEA) was undertaken for the South African coastline; as a whole to identify suitable aquaculture sites. This assessment highlighted the Eastern Cape as an area with potential for the development of ADZs. In 2010 the Department of Agriculture, Forestry and Fisheries (DAFF), Branch: Fisheries (then the Department of Environmental Affairs & Tourism) outsourced a project to conduct an Environmental Impact Assessment (EIA) for the development of an Aquaculture Development Zone in the Eastern Cape for the farming of marine finfish. A further updated SEA undertaken in 2011 identified a number of potential in-shore sites through selective criteria mainly identified in collaboration with associated industry as well as known environmental constraints. The sites identified were subjected to a public participation process, as well as to specialist review. In the process a number of sites were eliminated due to the identification of potential fatal flaws. Two possible ADZ sites; i.e. Algoa 1 and Algoa 5 remained and a detailed EIA needed to be undertaken for these sites.

The EIA for the two Algoa sites was undertaken by an independent Environmental Assessment Practitioner and the process commenced in 2010, resulting in the issuing of a positive Environmental Authorisation (EA) dated 9 July 2014 for the proposed development at Algoa 1. It is important to note that although Algoa 5 was considered as an alternative site during the EIA process, DAFF did not consider Algoa 5 as the preferred site and hence a detailed public participation process was not undertaken for this site.

During the appeals process, which followed on the issuing of the decision; a total of twenty eight (28) substantive appeals were lodged against the decision. Based on the grounds of appeal lodged, DAFF as the holder of the environmental authorisation requested that the Minister grant them the opportunity to further explore the feasibility of Algoa 5 through a comparative assessment of the potential impacts associated with Algoa 1 and 5. Based on the latter, the Minister of Environmental Affairs deemed it unnecessary to make a particulate ruling on the grounds of appeal.

Based on the information provided above, DAFF appointed an independent Environmental Assessment Practitioner (EAP) to conduct a comparative assessment of the environmental and socio-economic impacts (positive and negative) at both the Algoa 1 and Algoa 5 sites; with specific reference to the proposed sea-based ADZ in Algoa Bay.

The service provider was required to:

1) Conduct an impact assessment of the potential ecological interactions between the proposed expansion of the Addo Marine Protected Area (MPA) and the proposed ADZ (specifically at Algoa 5) relative to its location within the proposed expansion area of the MPA. This is reported on separately in the '**Ecological Report'.**

2) Conduct a Socio-economic assessment that should include a detailed analysis of the projected revenue and employment opportunities likely to be created by the proposed project, measured against the perceived loss in revenue and employment opportunities as a result of concerns of the proposed project at Algoa 1 North option. This is the brief for the present **'Socio-economic Report'**.

3) Conduct a **Feasibility Study** of social, economic and environmental costs involved to operate a mariculture facility with indigenous species as proposed in the EIA at both Algoa 1 and Algoa 5. The 'Ecological Report' and 'Socio-economic Report' are designed to provide the main inputs and analyses required for the **Feasibility Study Report**.

1.3 SPECIALIST STUDIES

The present 'Socio-economic Report' is made up of inputs by economic and aquaculture industry specialists.

An economist, Professor Stephen Hosking 1) reviewed the Final Environmental Impact Report Socio-economic Impact Assessment (Bloom, 2013), 2) reviewed the social and economic aspects of the 28 appeals against the Environmental Authorisation approving the Algoa 1 ADZ and 3) carried out a survey of public perception of the social trade-offs associated with the ADZ (Section 2 below).

Aquaculture industry specialists, Messrs Willem Schoonbee and Gavin Johnson, provided a perspective on the economic viability of a cage aquaculture operation in Algoa Bay based on industry benchmarks. This included a market perspective, operational considerations, cost estimates, revenue, employment and a high level financial model (Section 3 below).

2. SOCIO-ECONOMIC IMPACT REVIEW AND SOCIAL CHOICE MODELLING EXPERIMENT FOR THE PROPOSED ALGOA BAY SEA-BASED AQUACULTURE DEVELOPMENT ZONES, PORT ELIZABETH

By

Stephen Hosking[1]

31 July 2016

2.1 TERMS OF REFERENCE

The author was required to provide expert input into the socio-economic impact report on the proposed Algoa Bay sea-based Aquaculture Development Zones, Port Elizabeth.

The terms of reference necessarily required this assessment to be made against the backdrop of high levels of uncertainty over the market potential and project definition, and imprecision over the project economic viability and external impacts of the projects and a Department of Agriculture, Forestry and Fisheries (DAFF) proposal to initiate use of part of one of the zones through a single small scale exploratory type project.

In order to provide guidance for social decision making on the DAFF proposal, the author was required to 1) review the Final Environmental Impact Report Socioeconomic Assessment by Bloom (2013), 2) review appeals submitted in response to the Environmental Authorisation approving of the Algoa 1 Aquaculture Development Zones (ADZ), and 3) undertake a survey of public perception on the social and economic trade-offs relating to the fish farm project in Algoa Bay

2.2. INTRODUCTION AND CONTEXT

The Department of Agriculture, Forestry and Fisheries (DAFF) have expressed the intention to proclaim Aquaculture Development Zones (ADZs) for finfish cage farming in Algoa Bay.[2] There are three finfish species that have been identified as suitable for cage culture, namely, yellowtail, dusky kob and silver kob (Bloom, 2013: 18). A pilot study/experiment with dusky kob and yellowtail conducted by the Department of Science and Technology in partnership with Irvin and Johnson Ltd yielded promising results in terms of

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[2] The decision of relevance is the positive one (authorised) on 13 August 2014 by the Department of Agriculture Forestry and Fisheries of a project described as '*The Development of Seabased Aquaculture Development Zones In Algoa Bay Near Port Elizabeth, Eastern Cape. Infrastructure: A plant not exceeding 1000 ton /annum and seafloor footprint of 30ha and a surface envelope of 2.5ha (Exclusive Of Safety Equipment)*'.

fish growth. These results were obtained '*on a site in the Nelson Mandela Bay harbour, sheltered from wind and one kilometer into the ocean'* (Bloom, 2013: 20).

Initially five zones were considered in Algoa Bay by the DAFF for investigation for cage fish farming feasibility. Of these two were short-listed as having such potential in an Environmental Strategic Review (Anchor Environmental, 2011; Anchor Environmental, 2013). The two sites are (a) 665 ha in total (48 ha in sea cage area) approximately 3 kilometres directly offshore from Summerstrand, Hobbie and Humewood beaches, known as Algoa 1 and (b) 1759 ha in total approximately 4.2 km offshore of the Sundays River Mouth, approximately 15 km to the east of the Coega Harbour, known as Algoa 5 (Bloom, 2013: 17).

Even at the initial stage, it was realised that external costs would be increased the closer the cage farming took place to the Summerstrand swimming beaches. For this reason, for the purpose of the analysis, the Algoa 1 zone was divided into two alternative options (either or), rather than considered as one whole zone. The Algoa 1 – Option 1 zone covers an area of 210 ha, of which up to 15 ha could be caged to the surface. This zone lies approximately 4 km from Summerstrand and Humewood beaches and if the whole zone is farmed, it is forecast to impose medium significant negative external costs, even after mitigation measures are implemented[3] (Bloom, 2013, p.56). It was estimated that if the whole of Algoa 1- Option 1 zone were farmed, it could yield approximately 9 000 tons of saleable fish per annum (Yellowtail and or Dusky Kob) (Bloom, 2013).

The Algoa 1 – Option 2 zone covers an area of 455 ha, of which up to 33 ha could be caged to the surface. This zone lies approximately 3 km from Summerstrand and Humewood beaches and if the whole zone is farmed, it is forecast to impose medium significant negative external costs, even after mitigation measures are implemented[4] (Bloom, 2013, p.56). It was estimated that if the whole zone was farmed it would yield approximately 27 000 tons of saleable fish per annum (Bloom, 2013).

The Algoa 5 zone covers an area of 1 750 ha. The zone lies off the Sundays River mouth and the following external impacts are forecast as possible.

(i) Interference with diving and yachting activities off the Sundays River mouth.

(ii) A high negative visual impact.

(iii) A significant ecological functionality and (non-use) cost due to unconsumed feed, faeces, urine and drugs introduced to the fish act as polluting vectors potentially interfere and cause changes to habitats below and adjacent to the cages and to and wild fish populations in the area.

(iv) A negative impact on conservation and ecotourism activities linked to an MPA proposed for the area (Bloom, 2013, p.58).

It is estimated that if the whole Algoa 5 zone were farmed it could yield approximately 75 000 tons of saleable fish per annum (Bloom, 2013).

Fish farming projects within the Algoa 1 and Algoa 5 zones were not framed as mutually exclusive, so;-

[3] Excluding areas in which 'more than 15% activity of any documented recreational activity is undertaken', whatever this may mean (p.58).

[4] Excluding areas in which 'more than 15% activity of any documented recreational activity is undertaken' (Bloom, 2013, p.58).

(a) the socio-economic merit of a cage fish farming project within option 1 of Algoa was required to be weighed up against the alternative of one within option 2 of Algoa 1, and

(b) the socio-economic merit of a cage fish farming project within Algoa 5 was required as a separate (stand alone) assessment.

The purpose of this Feedback Report was not to present the overall socio-economic merit assessment, but to contribute to it in the following ways, viz.:

- review the Bloom (2013) assessment and objections lodged to the approval of the ADZs, and

- survey public choice on the creation of ADZs within Algoa Bay and estimate choice models for ADZs in Algoa Bay, where these models incorporated sensitivity to key characteristics of the different caged fish farming zones proposed of Algoa 1 and Algoa 5.

2.3 A REVIEW OF THE FINAL EIR SOCIO-ECONOMIC IMPACT ASSESSMENT AND OBJECTIONS LODGED ON THE SOCIAL DESIRABILITY OF FISH FARMING IN ALGOA BAY

2.3.1 OVERVIEW OF THE SOCIO-ECONOMIC IMPACT ASSESSMENT

The Socio-economic Assessment by Bloom (2013) assessment roughly (speculatively) forecast the main production costs and revenues and jobs created.[5] The revenue forecast was not informed by any marketing or market demand analysis. The underlying source for the cost forecasts could not be traced or verified. No estimate was reported for the external costs (social, economic and ecological costs). Instead, potential external costs were identified as impacts of various degrees of seriousness (significance), with and without mitigation.

Those external costs relating to the zone Algoa 1 options were as listed below; Option 1 being of a lower degree of seriousness than Option 2, because it is the further one from the Port Elizabeth Summerstrand beaches of the two alternatives and smaller in area.

(i) **Tourism and Recreation**. The first type of external costs are displacement costs of reduced travel cost expenditure incurred to visiting Port Elizabeth (tourism income generation)[6] (Bloom, 2013, p.58) and or decreased recreational value (appeal) in the use of the area for leisure (the two are related but not identical). These effects may be partly reflected in reduced real estate values along or near Marine Drive, Port Elizabeth. These two costs (displaced income and reduced recreational appeal) are caused by:

(a) a high visual impact along Marine Drive, as well as while engaging in diving and yachting activities (Bloom, 2013, p.58),

(b) Reduced appeal of swimming and surfing activity in the area due to perceived or real increased probability of a shark attack (Bloom, 2013, p.58) and

(c) Reduced recreational appeal from diving due to damaged reefs from sea bed anchors of the cages and litter and pollution affecting the dive site appeal (Bloom, 2013, p.58).

[5] The source for jobs created is a quote of an un-named source in the Eastern Cape Herald (13 October, 2011) in which the government estimates that through a 1 000 ton (dusky kob and yellow tail) per annum farm at Qolora on the Wild Coast (one of 10 such aquaculture development zones) an estimated (hoped for) 700 to 1000 jobs would be created (Bloom,2013, p.71) or an average of 850 jobs. This average translates into about 0.85 jobs per ton. Bloom (2013) further assumes that 22% of these jobs would be direct (p.71). In terms of the Bloom's (2013) formula of the average job creation for the project Algoa 1: Option 1 to be an average of 7 650 (of which 1 683 would be direct), while for project Algoa 1: Option 2 it would be 22 950 (of which 5 049 would be direct) and for project Algoa 5 it would be 63 750 (of which 14 025 would be direct). These numbers of jobs created greatly exceed the numbers employed in the wild fish industry. There are 1 200 fishermen working 243 registered boats in Algoa Bay to catch 21 875 tons of wild finfish in 2011 (Bloom,2013,p.26). About 0.05 fishers are 'employed' to generate a ton of wild finfish (about 6.5% of the direct job creation of aquaculture).

[6] A figure of 5% is reported speculated decrease in tourism revenue.

(ii) **Fisheries.** Displacement costs in the form of reduced revenue from squid fish catch, due to reduced area for such fishing to take place in or other negative spinoffs, this area being an historic squid fishing ground.

(iii) **Vessel movement** interference costs in the form of:

(a) Reduced area available for squid boats to seek refuge from stormy seas.

(b) Increased probability of (scope for) collisions with ships, not on a directly navigation route to the port, all be the cages marked according to navigational standards

(iv) **Ecological functionality** and non-use cost

(a) Unconsumed feed, faeces, urine and drugs introduced to the fish act as polluting vectors potentially interfering and causing changes to habitats below and adjacent to the cages and to and wild fish populations in the area.

(b) The mitigation[7] measures related to this cost provide a foundation for the concerns of swimmers and surfers at Port Elizabeth's Summerstrand beaches over increased probabilities of shark attack.

The external costs associated with Algoa 5 project were those resulting from the following:

(i) **Interference with diving and yachting** activities off the Sundays River mouth,

(ii) **A high negative visual impact** off the Sundays River mouth

(iii) **A significant interference with ecological functionality** (non-use) cost related to unconsumed feed, faeces, urine and drugs introduced to the fish act as polluting vectors potentially interfere and cause changes to habitats below and adjacent to the cages and to and wild fish populations in the area.

(iv) **Reduced conservation and ecotourism value**. A significant cost on reduced use appeal of conservation and ecotourism activities linked to an MPA proposed for the area (Bloom, 2013, p.58).

2.3.2 REVIEW COMMENTS ON THE BLOOM ASSESSMENT

(1) The projects within the zones Bloom assessed are not technically mutually exclusive. For this reason, technically they all could be deemed socio-economically attractive, if the relevant economic indicators (net benefits) are positive. Bloom (2013, p.41) shows all three zones yielding a profit before taxation, so it indicates that they all could be proceeded with.

1.1. For project Algoa 1-Option 1, the 'profit' is reported in the first year is about 35% on the total capital outlay, increasing thereafter. It is 118% on the equity outlay in year 1 alone.

[7] Dispersal by winds and currents, efficient feeding, monitoring and correction, astute animal husbandry and adaptive management strategy (p.63)

1.2. For project Algoa 1-Option 2, the 'profit' is reported in the first year is also about 35% on the total capital outlay, increasing thereafter. It is 118% on equity outlay in year 1 alone.

1.3. For project Algoa 5, the 'profit' is reported in the first year is also about 6% on the capital outlay, increasing thereafter. It is 18% on equity outlay in year 1 alone.

(2) At the rates of profit return are high:

- there is a strong case for charging potential operators (and investors) a substantial licence fee, and

- it could be expected that there will be a healthy competition for the right to operate.

(3) There are three good reasons why Bloom's (2013) profit numbers should not be used to guide decision making.

3.1. The revenue benefits are unsupported by a marketing analysis and are speculative (conjecture).

3.2. The cost estimates are speculative and lack evidence support.

3.3. The method by which the social decision criteria are generated (profit before taxation) is unsuited to the purpose required.

3.3.1. The external costs need to be valued and incorporated (as explicitly acknowledged on p82).

3.3.2. The project time horizon needs definition.

3.3.3. The relevant discount rate needs to be determined.

(4) To be fair, the objectives of the Bloom (2013) assessment did not specify guiding social decision making (pp. 13-14) and the Bloom (2013) analysis does make an honest attempt to identify the underlying drivers of the external costs.

(5) Reflecting the speculative basis of the analysis and uncertainty over the real costs and benefits, Bloom (2013):

5.1. prefers the smallest project, Algoa 1 – Option 1 and

5.2. makes provision for a 'fourth' project option, namely:

5.2.1. a 1 000 ton p.a. output in the first year for project Algoa 1: Option 1, with output increasing to the 9 000 ton pa target over 4 years 'providing environmental quality objectives are maintained' (p. 81)

5.2.2. 'grant funding to demonstrate the viability of the project' and 'progression' to a 'public-private partnership' (p.82).

(6) The Bloom's (2013) analysis does not provide a credible basis for accepting or rejecting any of the projects, nor preferring Algoa 1- Option 1 to Algoa 1 Option 2, because it is based on figures that are conjecture (guesses) rather than informed.

(7) In the absence of certainty over the external costs (including displacement of income costs) it was premature for Bloom (2013) to calculate aggregate (macro) effects (pp.69-75) for either income or jobs.

(8) The job creation numbers provided by Bloom (2013) are based on an un-named source and greatly exceed the benchmark figures provided (see Section 3.6) for cage aquaculture. They are speculative.

2.4 A REVIEW OF APPEALS LODGED AGAINST THE APPROVAL OF ADZS IN ALGOA BAY

A synthesis of appeals against the approval of ADZs in Algoa Bay that have economic impact and responses to these objections is provided in Annexure A. The following review comments relate to the appeals (objections) and responses offered to them.

(1) The perceptions and concerns that tourism could, or will, be negatively affected as a result of the Algoa 1 project(s) is shared by most appellants.

> 1.1. The weakness of the appellant's argument in this regard is they speculate on the scale of this negative impact.
>
> 1.2. The DAFF concedes there will be a negative impact on tourism, but speculates it will not be overwhelming: 'the fish farm impact on tourism was assessed in the EIR and was found to have a medium, negative significance rating at Algoa 1 with mitigation' (Response 1d).
>
> 1.3. Bloom's (2013) analysis of the net benefit is claimed to be 'indicative', but this reviewer finds the Bloom (2013) numbers speculative.

1.4. Accordingly, as the matter stands, a review of the tourism impact arguments is reduced to comparing alternative speculations.

1.5. The reviewer's finding is that the logic of the various appellant's is reasonable. There will be a negative external cost imposed through reduced swimming and surfing appeal, altered scope to generate recreational value and a less 'natural' ocean view. It is not currently known what the scale of this cost will be.

(2) The appellant's argue the deductive (reasoning) basis for the EIA preferring the Algoa 1 site to the Algoa 5 is fatally flawed. The argument is that the Algoa 1 site is just as prone to conflict with cetaceans as the Algoa 5 site.

> 2.1. The reviewer's finding is that in both locations there is potential for negative impacts on the wild fish, but this potential does not constitute a fatal flaw[8]. The negative impact will be greater in Algoa 5 because it is a much bigger project and the negative impact of the Algoa 5 project is inconsistent with a DEA plan (intent) for the area in which it falls to be declared a MPA.
>
> 2.2. As against the greater negative impact on wild fish in the Algoa 5 project, the job creation potential (attractiveness) of the Algoa 5 project is greater.

[8] '*Algoa 5 is rejected as a location for fish farm is the concern of the impact of the accidental entanglement of cetaceans in the nets and the moorings, and of alternation in cetacean habitat use or migration patterns*' but it is not explained why this criterion was not equally applied to the Algoa 1 site (Appeal 20ttt).

(3) The Appeal that the aquaculture projects will increase the probability of damage to or even episodes of decimation of wild fish populations is not strictly contested by DAFF. What is contested by DAFF is the magnitude of the increased probability (Response 4d and Response 20jj).

3.1. The reviewer's finding is that there is a prima facie case for determining a probability of damage to wild fish range and linking these probabilities to damage projections.

3.2. The expected value of losses from wild fishing should be incorporated in the benefit and cost calculations.

(4) The Appellant's criticism of the lack of a marketing analysis, a social cost benefit analysis and a proper financial analysis, has to be seen against the DAFF purpose of merely providing figures that are 'indicative'.

4.1. The reviewer's finding is that the numbers are not appropriately 'indicative', that is credible enough to inform the Minister's decision, as they stand. There is a need for some marketing analysis and a more inclusive social cost benefit analysis. These analyses would enable a better informed financial (investment attractiveness) perspective.

4.2. The DAFF numbers 'indicate' overwhelming profitability. If the numbers turn out to be credible there will need to be an economic discussion should be about the cost of the license for an investor to operate. This is a different discussion from the one of providing of grants to cross-subsidise (reluctant) investors and will need to include compensation for external costs imposed.

(5) Two 'social' benefits claimed by DAFF for the projects are improved food security and local job creation.

5.1. The reviewer finds limited support for the aquaculture projects claim to improve food security. The principle food for the finfish is pellets made from wild fish. It seems that a greater mass of wild fish have to be harvested than can be delivered as finfish product. The finfish farming projects do not offer a substitute to wild fish harvesting if the latter is required as a production input for the former. The project is more accurately described as one to convert low (market) value wild fish into high (market) value finfish. There is economic merit in such production, but it cannot be claimed as a sustainable alternative to wild fish harvesting, if wild fish are a necessary production input.

5.2. The reviewer finds it plausible that:

- there will be a significant net job creating benefit resulting from the projects, especially the Algoa 5 one (although not of the scale estimated by Bloom (2013)) and

- such employment opportunities would/will be socially welcomed in the Nelson Mandela Bay region.

2.5 PUBLIC PERCEPTION SURVEY ON SOCIAL TRADE-OFFS ASSOCIATED WITH THE PROPOSED ADZ

2.5.1 MOTIVATION FOR THE USE OF ESTIMATES OF CHOICE MODELS TO AID SOCIAL DECISION MAKING ON THE ADZS

The Bloom (2013) assessment and objections submitted to the proposed ADZ approval in Algoa Bay identify many possible external costs that should be incorporated with a feasibility analysis, but within the timeframe and budget provided, such costing is not feasible, and given the speculative estimates of the revenue production costs, precision in the calculation of external costs is not warranted.

It is against this background that a social choice trade-off analysis was advocated by the author as a guide. The social issue is not about whether the real numbers are attractive for investors. The investors will make their own calculations and decisions. The social issue is first and foremost about whether the external costs as social detracting elements outweigh the income and employment benefits that could be gained as socially attractive elements. Seen in this way, the estimation of choice across vectors of relevant attributes, is a highly appropriate form of analysis.

The theory of choice underlying this type of methodology was first advanced as a characteristics based model of economic choice (Lancaster 1966; Louviere et al, 2009), while the statistical estimation of the relevant random utility models was first articulated by Mc Fadden (1974). The methodology proposed to be applied in this research project is not new. It is outlined in Hensher, Rose and Greene (2005), and has been applied to South African estuaries (Hosking 2013) and water service tariff setting (Hosking 2014).

There are several steps to applying choice modeling methodology. These include the design of the choice model and associated choice experiment, sample design, administration of the survey, data capture and analysis for integrity, model estimation and model analysis and interpretation (Hosking 2013).

The survey description is reported in Section 4 and the estimation of choice models is reported in Section 5 below.

2.5.2 SURVEY - DESCRIPTIVE ANALYSIS

A total of 154 people were surveyed following the intercept sampling method between 23 June and 1 July 2016. Of the 154 surveyed 4 returned complete 'protest responses' and 3 partial 'protest responses'. These respondents declined to make any of the choices between jobs/income vs. the environment or expressed no faith in government (DAFF) to take heed of their choices or enforce the required mitigation measures. Those deemed partial protest responses declined to make some of the choices presented to them.

The socio-demographic profile of these 154 respondents is presented in Table 1.

Table 1: Socio-demographic information of respondents

Characteristic	Number	% of total
Male	88	57%
Age in years: below 20	5	3%
Age in years: 20-39	100	65%
Age in years: 40-60	36	23%
Age in years: above 60	13	8%
Permanent Resident - Port Elizabeth	129	84%
Permanent Resident - outside of Port Elizabeth	9	6%
South African Visitor	5	3%
Foreign visitor	10	6%
Employed	99	64%
Less than matriculation	6	4%
University Qualification	87	56%
Black	38	25%
Coloured	12	8%
White	90	58%
Other	14	9%
Total	154	

The survey was mostly administered along the Summerstrand beachfront. Most of the respondents interviewed were male, under the age of 40 years old, permanently resident in Port Elizabeth, employed, university educated and White (Table 1).

The respondents mostly agreed that South Africa should do more to encourage fish farming and can jointly promote tourism and fish farming (Table 2). They also strongly agreed South Africa should do more to encourage tourism and conservation of its natural resources (Table 2).

Table 2: Attitudes towards fish farming in South Africa of all 154 respondents

Attitude	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree	Don't know	Total
SA should do more fish farming	20	13	3	66	42	11	154
SA should promote tourism conservation more	9	2	0	49	93	2	154
SA can jointly promote tourism fish farming in NMBM	16	12	6	65	46	10	154

The respondents perceived the most important benefit of introducing fish farming into Algoa Bay to be income and job generation (Table 3) and they perceived the most disturbing aspects to be the negative ecological impact and the attraction of large sharks closer towards the Summerstrand swimming beaches (Table 4).

Table 3: Benefits of introducing fish farming into Algoa Bay

Benefit	Very Important	Of some importance	Unimportant	Total
Income generation	99	41	13	153
New Jobs	101	41	11	153
Cheaper fish supply	71	52	29	152
Increasing interesting things to see	43	46	64	153
Other	5	3	0	8

Table 4: Most disturbing aspects of fish farming in Algoa Bay

Disturbing Aspect	Very Important	Of some importance	Unimportant	Total
Spoils natural sea view	60	61	33	154
Takes away area otherwise for recreational boat use	37	65	52	154
Reduces the appeal of diving	47	64	43	154
Attracts large sharks closer to PE swimming beaches	100	38	16	154
Negative ecological impacts	108	34	12	154
Other	21	0	1	22

Most of the respondents surveyed had frequently swum in Algoa Bay, while 23% had dived at an Algoa Bay dive site during the last two years and 30% had been out on recreational craft as far as the area where the fish farm was proposed to be located (Table 5). A significant proportion of respondents (26%) directly associated Algoa Bay with their employment and livelihoods (Table 6).

Table 5: Respondent use of Algoa Bay

Use type	Never	Once	Many times	Total
Swimming and surfing	32	25	98	154
Diving	118	11	26	154
Recreational Craft	108	-	46	154

Table 6: Dependence for Employment on Algoa Bay

Employment type	Number
Employment - from fishing	9
Employment - from tourism	9
Employment - other reason	22
Not employment dependent	114
Total	154

2.5.3. THE SOCIAL CHOICE ANALYSIS OF THOSE SURVEYED

The majority (58%) of the respondents surveyed chose an Algoa Bay fish farm option over the status quo (no fish farm) (Table 7). Consistent with this choice analysis, in a referendum type situation, 50.3% would have voted for the introduction of fish farming into Algoa Bay, 39.4% would have voted against it and 10% would have abstained from voting (Table 8).

Table 7: Respondent choice of status quo over other options with aquaculture*.

Choice presented	Status quo chosen	Total	% of total
Choice card 1	49	150	33
Choice card 2	96	150	64
Choice card 3	54	151	36
Choice card 4	51	151	34
Total	250	602	42

* Each Choice card presented a choice between a) two 'fish farm' options with a differing environmental, social and economic benefits and trade-offs and b) a 'status quo' option (fish farm 'no go')

Table 8: Sample (referendum) vote on introducing fish farming into Algoa Bay

The Vote	Number	% of total
Votes against introduction	61	39.4
Votes in favour of its introduction	78	50.3
Abstain	16	10.3
Total votes	154	100

In addition to the above descriptive analysis of preference, hypothetical choices were modeled and analysed in terms of what focus groups had identified as the most important explanatory characteristics for social choice on the introduction of fish farming into Algoa Bay.

The choice model used for this purpose was one where individual choice is random and explained in terms of utility yielded from characteristics imposed on Algoa Bay users through the introduction of fish farming. The underlying explanatory characteristics of choice, as identified through focus groups, were:

(i) increased visibility of the cages by the users of Algoa Bay impact (VIS),

(ii) increased Ecological and Area Loss to Recreation impact (CONSERV),

(iii) reduced visibility for Diving impact (DIV),

(iv) increased presence of large sharks near swimming beaches impact (SHARK) and

(v) increased Income and Job creation impact (INCOME).

The estimation method applied was the maximum likelihood one. It was applied to two type models: multinomial logit and random parameters logit. The statistical programme used to estimate was NLogit 4.0.1. The multinomial logit function estimation results are shown in Table 9.

Table 9: Explaining Choice (Perceived Utility Maximisation) in a Multinomial Logit Model

Characteristic	Coefficient (b)	Std error	b/std error	P[Abs(Z)>z]	Expected sign
VIS	0.02	0.15	0.13	0.898	-
CONSERV	-0.46	0.21	-2.22	0.027	-
DIV	-1.17	0.37	-3.18	0.002	-
SHARK	-0.05	0.35	-0.15	0.878	-
INCOME	0.002	0.0004	4.67	0	+

Adj R^2 = 0.11

The overall explanatory value (adj R2) was 0.11, slightly less than that found for the random parameters logit model (Table 11). Both fits are acceptable in this type of analysis. Three explanatory variables of choice were found to be significant. Income generation was a highly significant explanatory variable inducing choice for fish farming, while decreased visibility for diving of the sea water column and increased ecological impact were significant explanatory variables for why people would choose to oppose fish farming in Algoa Bay.

The attributes of increased negative ecological impact (CONSERV) and reduced visibility (DIV) of the water column on diving significantly discouraged the choice for fish farming while the generation of income and jobs significantly encouraged this choice. The attributes of increased visibility and increased presence of large sharks scarcely influenced the choice for introducing a fish farm. Both coefficients are not significantly different from zero. The increased presence of sharks is a deterrent but the visibility of the fish cages 3-4 km off shore is not.

The result for choice of the presence of sharks is inconsistent with the finding reported in Table 4. One possible explanation for this contradictory result on the disturbing effect of increased shark presence near beaches (Tables 4 and 9) is that the respondents found the choices they were being asked to make unclear or too difficult.

There were 85 respondents out of 154 (55%) that found the choices difficult (Table 10). The main reason for the difficulty they experienced was that it was difficult to weigh up the important factors against each other (50 of the 85).

Another possible explanation is that many of those surveyed did not believe in the making of choices that increased presence would really translate into greater risk to the beach swimmers.

Table 10: Respondent reason for difficulty in making the choice

Reason difficult	Number	% of total
Too much information	22	14
Did not understand the choice	9	6
Choice was unrealistic	15	10
Difficult to weigh up important factors against each other	50	32
Other	5	3
Number Respondents that found the choice difficult	85	55

In order to test for robustness a random parameters logit (RPL) model was also fitted to the data (Table 11).

Table 11: Explaining Choice (Perceived Utility Maximisation) in a Random Parameters Logit Model

Characteristic	Coefficient (b)	Std error	b/std error	P[Abs(Z)>z]	Expected sign
VIS (b1)	0.02	0.16	0.11	0.911	-
CONSERV (b2)	-0.46	0.21	-2.2	0.028	-
DIV (b3)	-1.19	0.4	-3	0.003	-
SHARK (b4)	-0.06	0.36	-0.16	0.877	-
INCOME (b5)	0.002	0.0004	4.48	0	+

McFadden Psuedo R^2 = 0.12

This RPL model treats the surface visibility impact (VIS) and ecological impact (CONSERV) as normally distributed and treats underwater visibility (DIV) and possible large shark presence impact (SHARK) beach as uniformly distributed (binary).

The coefficient signs and the significance of them in the RPL model is similar to those found for the multinomial logit model, suggesting the results are robust with respect to the estimation model selected.

The homogeneity of the sample was explored by testing the standard deviations of the coefficients for significance. None of the derived standard deviations of the parameter distributions were significant, suggesting that the sample was fairly homogenous.

2.5.4 TRADE-OFF IMPLICATIONS

The ratio of two coefficients in a utility function describes the trade-off or marginal rate of substitution of these two variables to realise a given level of utility (Ben-Akiva and Lerman 1985). The significant coefficients of the utility function are CONSERV, DIV and INCOME.

Two trade-offs of interest are between CONSERV and INCOME and between DIV and INCOME. They are calculated in equations 1 and 2 below.

$$b2/b5 = -0.46/0.002 = -230 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$b3/b5 = -1.19/0.002 = -595 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

The approximate welfare implication of equation 1 is that a R230 million social income gain is required to compensate for a social category worsening of ecological impact in Algoa Bay due to the caged fish farming.

The approximate welfare implication of equation 2 is that a R595 million social income gain is required to compensate for a social category worsening of the visibility of the column of water of Algoa Bay where people seek to dive to see marine life and other things under the water.

2.5.5 CONCLUSIONS FROM THE SURVEY ANALYSIS OF RELEVANCE TO SOCIAL DECISION MAKING ON APPROVING ADZS IN ALGOA 1 OR ALGOA 5 ZONES

2.5.5.1 General observations.

1. A difficult social choice but one to be partly guided by social preference. The respondents found the social choice issue on the introduction of a caged fish farm zone into either Algoa 1 zone or Algoa 5 zone to be a difficult one, but not an overwhelmingly difficult one (Table 10). Given that the degree of difficulty is not overwhelming, it is entirely appropriate that the social choice be partly informed by social preference, and not only with reference to expert opinion.

2. The survey outcome is true for a given level of knowledge of the respondents. If the level of knowledge improves, so too may the outcomes.

3. A preference over the external effects is all that the survey captured. The choice captured was with respect to the perceived external social cost and benefit, given the current levels of knowledge. Whether the investor would obtain a satisfactory return was not relevant. For this reason the relative attractiveness to investors of initiating and operating projects within the Algoa 1 and Algoa 5 zones is not information captured within the survey. (This is dealt with in the following Section 3 below "Economic Perspective on Offshore Fish Farming in Algoa Bay)

2.5.5.2 Sample Bias.

The survey was of a sample of person intercepted largely in the Summerstand area during a period of relatively low outside visitation.

1. Those communities of the Nelson Mandela Bay Municipality (NMBM) beset by low income earning and job opportunities could be expected to weight higher socially improved income earning and job opportunities than the residents of Summerstrand do. Were those communities sampled the leader of this survey investigation would have expected a stronger social preference to have been revealed for approval of ADZs in both Algoa 1 and Algoa 5.

2. During periods of high visitation to swim (i.e., in summer) a sample of social choice along the Summerstrand beach front could be expected to attach greater weight to recreational services and lower large shark presence. Under these circumstances, the

leader of this survey investigation would have expected a stronger social preference for attributes for an Algoa 5 ADZ than an Algoa 1 zone.

3. Most of those surveyed have a concern over the adverse impact on recreational activity in Algoa Bay of introducing an ADZ into Algoa 1. The disturbing aspects identified in focus groups were ranked very important by most of the respondents. These aspects were not as relevant to an ADZ in Algoa 5. The primary detracting feature to society of an ADZ in Algoa 5 is the impact on the ecology.

4. About 40% would vote against introducing fish farming in Algoa Bay, while about 50% would vote in favour of introducing it. The main reason for a majority voting for it is the prospect of additional income and job creation. The option of the development of a fish farm with a low potential impact on both recreational use and the marine ecology would conceivably have improved the support for introducing caged fish farming within both Algoa 1 and Algoa 5 zones.

5. A portion of the respondents (7 of 154) do not believe that it is appropriate to present the public with a choice between coastal environment degradation (through fish farming) and job creation because of the presence of uncertainty over consequences (the precautionary principle) or that the government could be relied upon to enforce the necessary mitigation measures. This challenge is arguably more relevant to the Algoa 5 zone than it is to the Algoa 1 zone because, the potential level of ecological disturbance is greater in the Algoa 5 zone (because it is much larger than either of the two zones proposed for Algoa 1).

6. The choice modeling analysis found a negative impact on the visibility of the water column in which people dive in Algoa Bay to significantly detract from the appeal of and ADZ in Algoa 1. For this reason, the location of a caged fish farm with low diving impact is socially preferable.

7. The choice modeling analysis found a negative impact on the marine ecology of Algoa Bay within and around the Algoa 1 and Algoa 5 zones to significantly detract from the appeal of ADZs in either or both Algoa 1 and Algoa 5 zones. For this reason, the location of a caged fish farm with low ecological and area impact is socially preferable.

8. The relatively homogenous residents surveyed in the Summerstrand area thought jobs and income generation associated with introducing caged fish farming in the Algoa 1 and Algoa 5 zones to be very important and most were willing to trade off the disturbing impacts of a fish farming industry with increased income and job opportunities. There was an approximate social willingness to sacrifice a significant worsening of ecological impact within a zone of Algoa Bay due to the caged fish farming for a R230 million social income gain and the job creation associated with this gain. Similarly, was an approximate social willingness to sacrifice a significant worsening of the visibility of the column of water of Algoa Bay in zones where people currently seek to dive to see marine life and other things under the water for a R595 million social income and the job creation associated with this gain.

ANNEXURE A: A SYNTHESIS OF OBJECTIONS TO THE APPROVAL OF ADZS IN ALGOA BAY THAT HAVE ECONOMIC IMPACT AND RESPONSES TO THESE OBJECTIONS

(1) A common appeal against the decision is that the aquaculture projects will:

(a) increase the probability of shark attacks on swimmers and surfers (many),

(b) reduce navigation options of yachts and other craft (Appeal 1b and Appeal 20b),

(c) reduce the quality of the sea water used by swimmers and surfers (many),

(d) reduce the suitability of the wave for surfing (Appeal 10b), and

(e) reduce the reef appeal to divers (Appeal 14e), thereby making Algoa Bay beaches less attractive to recreational use, ('The mere presence of the fish farm in its final envisaged form no more than 2km will affect the perception of the area negatively' (Appeal uuu), and additionally or consequently

(f) threaten the blue flag status of Port Elizabeth's beaches (Appeal 19d),

(g) conflict with a quest to secure Algoa Bay as a 'hope spot' (Appeal 20x), and

(h) threaten the choice of Port Elizabeth's beachfront as the venue for the Africa Ironman competition, with the resultant economic impacts of there being:

(i) less spent by visitors in this region than would otherwise have been (and less tourism events, like the Iron Man one), and

(j) less jobs created in Algoa Bay's beach tourism industry (see Appeal 9a-e; 10a).

The appellant's complaints in this connection are that the decision was made:

(i) without assessing and comparing (offsetting) these potential losses of tourism revenue and jobs with (against) the alleged gains in aquaculture revenue and jobs (Appeals 20r and 20rr)

(ii) on the basis of claimed 'high' contributions to GDP:

'without supporting data other than extrapolations and estimates' and

excluding potential losses, e.g., in the tourism industry (Appeal 20tt).

The DAFF responses, in effect, are to:

(a) challenge the evidence basis for an increased probability of shark bites on people using the sea and call for more research (Response 1a),

(b) point out there is minimal navigational risk because the cages are not on navigational routes, will be clearly shown on navigational charts and physically indicated (marked) on site (Response 1b),

(c) point out that 'the currents should convey wastes away from the fish cages out of the bay and away from the popular bathing and surfing beaches' (Response 16m)

(d) point out that the 'wave heights were less than 2m for 90% of the time, suggesting that most types of plastic circle cages will be suitable in the water depth at the proposed ADZ (20-50m)' and 'the cage-wave shadow will be of limited size as wave energy will refract horizontally from regions not influenced from the farm. For Algoa Bay the proposed farm is several kilometers from the beach and the dampening effect is unlikely to extend this far.' (Response 3i)

(e) forecast that 'Smothering of reef life is not anticipated as settleable wastes are not expected to settle more than 200-300m from the cages and the nearest dive reefs are some 500m inshore of the proposed' (Response 4b)

(f-j) deny the allegations that it proposes to sacrifice other sectors of the economy, such as tourism: the 'DAFF has no intention to implement an activity at the cost of another' (Response 1c). The DAFF argues 'A financial feasibility assessment was not available for assessment as part of the socio-economic study. As a consequence an indicative assessment was conducted based on several assumptions' (Response 20 r). The 'GDP contribution is an estimate based on an indicative model using various assumptions' (Response 20tt).

(2) On account of the perceived high negative impact on tourism of the Algoa 1 projects, the appellant's have requested other locations be considered, including Algoa 5 and land based aquaculture options (which were not considered in the Bloom (2013) analysis).

The DAFF responses are that:

a) 'Of the two alternatives, Algoa 5 was considered to be the least preferred alternative due to the proposed marine protected area, with Algoa 1 as the preferred alternative.' (Response 1n).

b) 'the majority of marine finfish is produced in cage culture due to the reduced production costs. It must be noted that land based finfish operations have associated high start-up costs for infrastructure, , and high operational costs in pumping water, and the labour intensity' and the Department aims to create an 'enabling environment' for cage aquaculture (Response 3h)

(3) Another economic orientated appeal (which could not be linked to direct support from the fishing industry by the reviewer) was, in effect, that net revenue generation from fishing for wild stock would be reduced because of:

(a) increased costs due to interference with and need for fishing effort and

(b) lower catches due habitat interference (pollution), the increased introduction of disease vectors within the wild fish population, genetic change introduced into the wild fish populations and increased incidence of algal blooms (Appeal 13c and Appeal 20jj).

The DAFF respond (concede) that 'the currents should convey wastes …..towards an identified dive site and squid fishing ground' (Response 16m).

The DAFF argue that:

(a) 'Discussions with the local fishing industry suggest that fish farms have no perceived negative impact on the current fishing industry' (Response 1h) and

(b) the negative impact on wild fish populations is speculative and mitigated (minimised) through management and locating the fish farms in deep enough water, and (Response 1i and 1j).

(4) Another appeal is that the revenue figures are over-optimistic and there is no market or financial feasibility assessment supporting them (Appeal 2h, 20mmm and 20nnn), so by implication:

(a) these figures are not a credible basis on which to make a social decision, and additionally

(b) there is reason for following the precautionary principle (because there is risk of substantial environmental damage).

The DAFF responds that doing the required analysis is a job that remains to be done (Response 20r) and the task they did was merely to provide rough indications.

(5) Another appeal is over the sustainability of the production (as currently conceived) and the plausibility of claims made for non-pecuniary benefits, e.g. improved food security. Many appellant's argue that more than 2 kg of wild fish need to be captured and processed in order to produce 1 kg of fin fish (Appeal 16q). They also argue that, in order to make aquaculture sustainable, the finfish product may be modified (perhaps with adverse health consequences for consumers of the product).

The DAFF response is that a primary objective of the projects to meet the rising demand for certain fish products that cannot be met from catching wild fish.

3. ECONOMIC PERSPECTIVE ON OFFSHORE FISH FARMING IN ALGOA BAY

3.2 ASSESSMENT TEAM

The offshore marine fish farm modeling was done by W.L. Schoonbee and G. Johnston of *Aquaculture Consulting and Management Services (PTY) LTD*. Schoonbee and Johnston previously developed and implemented a commercial pilot scale farming of kob in offshore cages in Mozambique. During the six-year project, kob were successfully raised under commercial conditions to a harvest size of 3kg. Schoonbee was previously involved with the early development of kob (dusky and silver) and yellowtail at Irvin & Johnson's facility at Danger Point, Gansbaai. Schoonbee holds a M.Sc. (Agric) in Aquaculture from Stellenbosch University and Johnston Holds an M.Sc. in Fisheries Science from Rhodes University. The parameters and opinions provided in the development of the generic model are based on actual figures, as well as personal communication with role-players in the marine fish farming industry.

Professor Peter Britz of Rhodes University provided additional market and aquaculture feasibility perspectives.

3.3 MARKET PERSPECTIVE

The development of an offshore fish farming industry should be market driven and not be based primarily on the production potential of a particular area or site. Similarly, in planning an Aquaculture Development Zone, a realistic market prognosis should be included to inform the scale of water, land, infrastructure and other support required to attract investment.

A brief overview of local and international market considerations is provided below which will determine the investment case for marine aquaculture in South Africa and the ADZ planning process. This analysis feeds into the discussion on the production potential of the proposed ADZ at Port Elizabeth.

3.3.1 THE SOUTH AFRICAN MARKET

In this section, a South African market perspective is provided on the prospects for farmed fish in the Algoa Bay ADZ to inform a realistic economic feasibility model.

A constraint to demand for cultured fish is that wild fish remains in relatively plentiful supply, mainly due to the well-managed hake fishery. The South African market for fish is benchmarked around wild Hake, which is of high quality, consistently available and well-priced. Offshore marine fish aquaculture cannot compete with hake on price, and thus the nascent South African aquaculture industry has primarily focused the development of higher value niche species such as kob and yellowtail. Pilot commercial scale production has been undertaken both in shore based and sea cage facilities. The present discussion therefore considers the market prospects for cultured kob, with some comments on yellowtail. It is possible that other species could be proposed by investors for the Algoa ADZ, but based on current information, the most realistic prospects are for these species.

3.3.2 AQUACULTURE'S COMPETITIVE ADVANTAGE: CONSISTENT SUPPLY AND QUALITY

One of the most significant pricing leverages is the ability of a fish farm to supply the market consistently in terms of volume, product size and quality. By contrast, wild catch availability is linked to seasonality, quotas, weather and other variables. Consistent supply has underpinned the strong development of aquaculture species such as farmed salmon around the world. Since the product is available all year round, more people consume it, thus driving an escalating demand and growing production. Aquaculture products are generally able to command a price premium and penetrate new markets due to their consistent supply and quality. Kob and yellowtail are species that enjoy generally strong local demand and are in short supply, so it is logical that consistent supply is a great advantage for farmed kob to penetrate the market.

A further price and market access advantage is conferred on aquaculture products which are certified as 'sustainable'. Retailers in South Africa and internationally are increasingly demanding that the seafood products they buy are sustainably produced or harvested which has given rise to certification schemes such as the *Aquaculture Stewardship Council* and consumer information on the sustainability of seafood products such as the WWF's *South African Sustainable Seafood Initiative (SASSI).* This provides the aquaculture industry with a potential competitive advantage as aquaculture sustainability certification or SASSI "green" status is relatively easy to achieve, whereas many fisheries are heavily over-exploited and not deemed sustainable. Farmed kob has been classified as "green" by SASSI, whereas wild fishery caught silver kob are classed as 'orange' (caution) and dusky kob are classed 'red' (avoid). The SASSI green listing of kob has thus been a key strategy for pilot scale producers to penetrate the South African retail market.

Both kob and yellowtail are mainly sold as fresh 'linefish', along with a suite of other species (Table 1), by artisanal fishers and small buyers. All linefish species are small niche market products, with no commoditized branding, distribution and marketing strategies. These competing species are sold gutted, ex-boat for approximately R45/kg in the Cape area (pers. comm. Whale Coast Seafoods, 2016), which is considered to be a benchmark price to aim for by aquaculture producers.

The supply of 'linefish' (excluding snoek[9]) declined by 38% (by approximately 1000t) between 2000 and 2012 highlighting the potential supply shortfall. Demand for fish has grown considerably in South Africa over the last decade with the advent of seafood franchises and greater awareness of seafood products (Britz, 2014).

An assessment of the South African market potential for kob and yellowtail is constrained by the lack of hard market data, as accurate catch returns are lacking and there is no market data on sales and price trends. In the sections below, a market synopsis is provided based on existing information to provide an insight into the current volume, price and market trends.

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[9] Although 'snoek' are reported as linefish in fishery statistics, they sell into different markets to the other linefish species. Fishmongers, retail seafood counters and restaurants who deal in fresh fish do not trade snoek because it perishes rapidly and does not freeze well.

3.3.3 KOB MARKET SIZE

Kob[10] is one of the best-known and preferred linefish species in the South African market. The supply of kob has decreased from historical levels wild as kob stocks (of both silver and dusky kob) have been heavily over-fished (Griffiths 1996, 1997). This has created an opportunity for aquaculture to enter the South African market with a known product that is sustainably produced and in short supply.

The size of the existing local market for kob can be inferred from catch data and information from local buyers. Formally reported landings for kob declined from around 1,200 tons in the early 1990s, to 221 tons in 2012 (Figure 1, Table 1). The reported fishery yield does not include recreational angler catches which are not reported. Therefore local consumption of kob is considerably higher than the reported linefish catch. Estimates from local traders suggest that the potential local market for kob could be as high as 4 000 tons per annum if the fish was more commonly available (W. Schoonbee, Aquaculture Consulting Management Services, pers. obs., 2016).

Despite the growing supply shortfall in linefish, the primary constraint to marine fish aquaculture development is the small size of the local market for kob. A minimum sized pilot farm is considered to be 1000t annual production, with an 'economically viable' unit deemed to be 3000t per annum which is of the order of 10 times the current supply. The question is thus whether the market will absorb a volume of kob of this magnitude at a profitable price point? Indications are that in the short run, the current market would not at the reigning prices.

Evidence of this is that the benchmark price of R45/kg for kob and yellowtail fluctuates strongly with seasonal periods of abundance. For example, in January 2014, the dock price of Yellowtail fell below R10/kg for several weeks. Similarly, during a 'run' of kob at Struisbaai in March 2014, the ex-boat price was R25-30/kg for fish between 2 and 10 kg, with this price prevailing for several weeks. The pilot marketing (5-8t/month) of large farmed kob from Mozambique by *Aquapemba Lda* in March 2014 was disrupted when this run of seasonal wild Kob flooded the market. The Pemba Kob were being marketed at a R75/kg and the competition from the wild supply led to declining demand. This was a sobering experience for *Aquapemba Lda* since the volume of wild kob caught during the "run" was estimated at 30 - 40 tons over the course of a month.

Pilot marketing of farmed kob has shown that there is a ready demand for 5-10t of kob per week by the existing seafood value chain at an ex-farm price of R75/kg gutted and gilled (Schoonbee, personal observation).

The limited information available thus indicates that the South African market for wild caught kob is currently very small – of the order of hundreds of tons, and that well designed marketing strategies will be required to grow the demand for farmed kob based on the characteristics of

[10] 'Kob' includes two closely related species, the dusky kob (*Argyrosomus japonicus*) and the silver kob *(Argyrosomus inodorous)*. The market does not distinguish between the two species. Most kob caught in the line fishery is silver kob, whereas most kob caught in the rock, surf and estuarine recreational fisheries are dusky kob. The dusky kob is the preferred aquaculture species, the production of which has been taken to a pilot commercial scale.

consistent supply and quality of a known product. This will however take time and therefore a realistic initial aquaculture production volume of 500-1000t/annum is probably realistic to supply the existing South African premium fresh market demand without depressing prices.

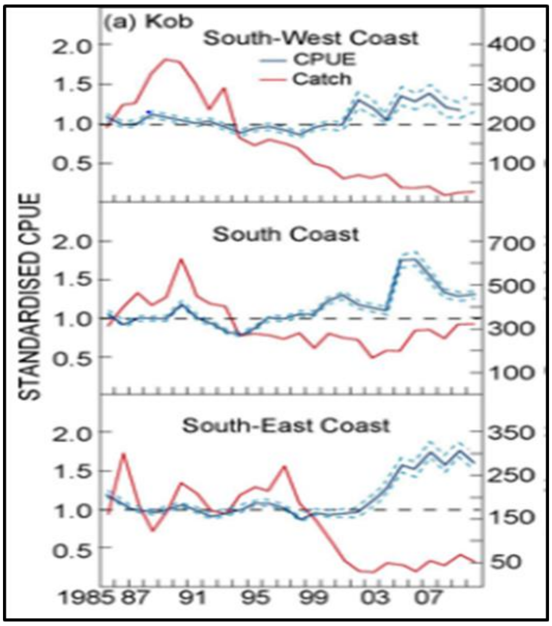

Figure 1. Formally reported catches of Kob between 1985 and 2010. The Red line is the catch in tons, while CPUE is the catch-per-unit-effort, a metric of fishing productivity not relevant to the present discussion (Status of the South African Marine Fishery Resources 2012, Department of Agriculture, Forestry and Fisheries).

Table 3.1. South African Linefish Catch (DAFF, 2014)

Species/ Year	**2000**	**2012**
Snoek	6543	6809
Yellowtail	320	382
Kob	547	221
Carpenter	441	300
Slinger	186	240
Hottentot	234	160
Geelbek	894	337
Roman	23	34
Rock cods	46	30
Elf	15	11
Red steenbras	26	2
Total	**9275**	**8526**
Total excl. Snoek	**2732**	**1717**

3.3.4 INTERNATIONAL MARKETS

Given the very limited market for farmed 'line fish' equivalent fresh fish in South Africa, the international market is a potential option for absorbing a larger volume of farmed fish from Algoa Bay. In this section the opportunities and constraints for exporting farmed South African fish are considered.

Globally aquaculture has boomed over the last four decades against a background of falling wild catch rates. Species such as salmon, tilapia and Vietnamese catfish (basa) have become international commodities substituting the supply from wild fisheries. The strong global growth is aquaculture production has stimulated wide investor interest in fish farms. While the macro-economic picture is very positive, specific aquaculture developments targeting international markets need to be grounded in a realistic context:

- For high value species which are traded successfully internationally in volume, there is generally an existing market. For species that are well known, such as salmon, prawns and sea bass, existing demand supports prices which allows for international supply chains to be developed effectively.
- The bulk of aquaculture production that is filling the gap between wild caught white fish production supply and demand, is based on low cost production of tilapia and Vietnamese catfish.

Kob and yellowtail do not fit into either of these existing successful aquaculture marketing models as they are high production cost, niche species, which do not have the attributes to become a low price, large volume staple in regional markets. The only possibility is thus for the development of international niche markets for high quality cultured South African species, where a sustainably-produced product can have competitive advantage. Kob are however an unknown entity in international markets, while yellowtail are farmed on a large scale at a low cost in Asia.

An in depth market feasibility study would need to be undertaken to establish whether there is a potential export market for kob, and whether it is worth investing in local aquaculture production. To penetrate the high-end international markets with a new species such a dusky kob requires considerable market education, committed marketing partnerships, and a production volume to justify the investment in developing a value chain. Bringing new species to market is thus not a venture to be embarked on lightly and requires the business and financial capacity of a large corporate entity. For example, Cobia (a tropical marine species white fish species with excellent growth characteristics) has been tried in various markets by large companies and has had relatively low success. Based on current information, the export prospects for kob are not positive and hence the current risk too high to justify investment in large scale aquaculture production for export.

Yellowtail by contrast is an internationally known species that is supplied from both fishery and farmed sources. The question is thus whether South Africa enjoys any international comparative advantage for farming yellowtail? Yellowtail are farmed on a large scale in Asia at a relatively low cost due to the efficient value chains that have been established. Farmed yellowtail (frozen whole) imported from Indonesia have been trading in retail in South Africa recently at R45/Kg round weight (Whale Coast Seafoods, pers. comm. 2016). Assuming a retail margin of 30%, the fish are being landed at R34.61/Kg. This is substantially below the expected South African production cost in the model presented below and indicates that farmed yellowtail would not be competitiveness as an export from South Africa.

South Africa's competitiveness as a potential aquaculture exporter is reduced by its geographical location as it is situated far from most high-end markets. All fresh supply would need to be airlifted to these markets at a considerable cost premium (ca. R15/kg). Furthermore, there are fish farming competitors closer to the international markets, often with substantial grant or subsidized production costs. A good example is the sea bass industry in the Mediterranean, which has an additional advantage of being within the EU and so is not subject to the complex European Union hygiene controls for imports. South Africa has additional limitations in that Government implementation capacity for monitoring programs and other necessary requirements from the relevant local competent authorities are not yet in fully place. Residue testing for drugs has proved to be very challenging in terms of government veterinary capacity and too costly for smaller producers attempting to obtain product export certification.

Given the real constraints of opening up an international market, it would seem prudent to remain focused on the local market for the medium term and grow aquaculture production organically in response to increasing demand. This includes marketing to regional markets as there are cities in neighbouring countries with significant demand for high value seafood products.

3.4 ECONOMIC FEASIBILITY ASSESSMENT

3.4.1 APPROACH

The projected maximum Algoa Bay ADZ production and economic figures cited in the Final EIR (CapeEPrac, 2013) are misleading and in need of revision based on industry realities. The review of the Algoa Bay ADZ Final EIR socio-economic report (Bloom, 2013) by Prof Stephen Hosking (Section 2.3.2 above) indicated that the production, financials and jobs figures used were speculative. The revenue forecast was not informed by any marketing or market demand analysis. The underlying source for the cost forecasts could not be traced or verified. No estimate was reported for the external costs. A hypothetical scenario was projected where Algoa 1 and Algoa 5 could produce up to 25,000 and 75,000t/annum respectively based on the size of the sites. It was further assumed that profitable production would occur in year one with a gross profit of 35%. No allowance was made for a 2-3 year lead-time to establish a commercial operation. The production, jobs and cost figures used were thus entirely speculative and misleading as they did not take into account operational and market realities.

In the present analysis, an attempt is made to provide a realistic approximation of a generic commercial offshore cage aquaculture operation. The analysis takes into account the likely development trajectory given existing knowledge and experience with cage aquaculture in South Africa, market demand, known costs, industry best practices and operational realities. A generic high-level financial model for 1000t pilot and 3000t commercial operations is presented that illustrates the relationships between the key economic drivers associated with offshore fish farming.

The financial models are not 'business plans' upon which to base an investment, but rather realistically optimistic scenarios to inform ADZ planning in terms of likely production scale and hence the size of area required. The costs inputs are based on the *AquaPemba Lda* cage culture operation for kob in Mozambique, which achieved pilot scale production of 200 tons before closure due to export marketing problems. The capital costs of developing cage culture in the Algoa Bay ADZ could be considerably higher due to the higher exposure to wind and swell and distance from Port. As the Final EIR Socio-economic report stated, it is "important to note that mariculture is a complicated business and extensive research is required to plan, develop, establish and sustain a mariculture plant. It requires a large investment of time and money over a period of years. By understanding the viability and conducting a feasibility study before starting a farming venture, a clear indication should be obtained of how much it will cost to operate a mariculture facility and if the right conditions for growing a particular species are available in or at the proposed location" (Bloom, 2013).

3.4.2 SITE SIZE AND CAPACITY

In this section, the size of water area required for commercially viable production is motivated, and the spacing of farms is considered based on biosecurity considerations.

Although it would appear that the proposed sites are relatively large expanses of open water that could house multiple farms (Table 3.2), it is important that any planning for farming units be based on international biosecurity best practice to minimize production risk and ensure sustainable production.

Table 3.2. Proposed Algoa ADZ sites characteristics.

Area Name	Size (hectares)	Distance from port (km)
Algoa 1 – Option 1	210	4
Algoa 1 – Option 2	455	4
Algoa 5	1750	15 from Nqura Port 30 from PE harbour 5 from Sundays River estuary (possible small vessel access)

It is generally accepted that to achieve an economy of scale to justify the large capital investment in work vessels and high-seas cages, a commercial offshore farm requires a production volume of 3000t/annum or more to justify the overheads associated with such an operation. The Final EIR suggests a possible maximum capacity of nine commercial size farms on Algoa 1 (30,000t/annum production) and 25 farms on Algoa 5 (75,000t/annum production). The number of economic units was derived by simply dividing the total surface area of each site by the minimum viable size farm of 3000t/annum. Limited market demand, investment risk and biosecurity considerations however dictate that the likely number of farms and hence required ADZ water area will be much lower.

3.4.2.1 BIOSECURITY SPACING

Biosecurity considerations and international best practice are key determinants of reducing risk by means of spacing between farms. The Chilean salmon industry was a leading aquaculture industry until a disease (ISA virus) emerged in 2007 and decimated 2/3 of the farming operations. (Alvial et al, 2012). This led to an industry crisis and the loss of 25 000 direct jobs. Although there were several contributory issues that brought about the crisis, the main issue was considered close clustering of many farms the production areas. A 2.4km separation between farms in Chile proved insufficient for preventing disease transfer between operations. Disease risk which a farm cannot control is now a highly significant consideration for any investor, and highlights the inherent risk locating multiple operations on a single site. The overall biosecurity is only as good as the weakest operator since diseases are spread in water and current movements are not reliably consistent. If a minimum farm spacing of 2.4 km is applied, Algoa 1 could house a single farm and Algoa 5 possibly two.

3.4.2.2 CAGE SIZE AND SPACE REQUIRED

The species specific cage configuration will determine the space required for a farm unit. Kob, currently the preferred species for marine aquaculture in South Africa, is a fish that avoids surface waters and forms a dense shoal at the bottom of the cage as part of its predator avoidance behavior. The use of modern salmon technology (large cages with diameters in excess of 30m and depths in excess of 20M) does not suit the natural behavior of kob which can form shoals that are so dense that the fish in the center of the shoal risk asphyxiation. Kob production is therefore better in smaller cages (20m diameter maximum, 10-12M deep) to limit the size of the shoal that can be formed. This in turn will equate to a larger farm footprint (smaller cages utilize space less efficient than larger cages). It can be assumed that a 3000t/annum production unit will require a minimum of fifty (50) circular cages with a diameter of 20m. These would occupy (including mooring) an area of roughly 70 hectares.

3.4.2.3 SPACE REQUIRED TO MEET KNOWN MARKET DEMAND

The market demand perspective above indicates that the known South African market potential for kob is currently 250-500t, with expansion potential to approximately 4000t. There is no known export market demand. Therefore, any cage culture production in Algoa Bay would have to begin from a pilot scale of hundreds of tons and grow organically with market demand to a realistically viable 3000t over 5-10 years. There is no market based evidence to justify planning for 30,000t production on Algoa 1 and 75,000t on Algoa 5. The present environmental authorization for 1000t pilot on 70ha on Algoa 1, with likely expansion to 3000t, is thus a realistic initial goal. Even allowing space for market driven production expansion, the size of the proposed ADZ areas could be reduced without compromising their commercial development potential.

2.4.2.4 RECOMMENDED ADZ WATER REQUIREMENT

Algoa 1 (combined 665ha): The size of the surface area would in all likelihood present too high an investment risk to house accommodate more than one farming operation as there will not be sufficient distance (2.4km as currently the prescribed distance in Chile) separating multiple farms to ensure a bio-secure operating environment. Taking into account the required operating area for a 3000t/annum production unit (70ha), Algoa 1 (Option 1 North, 210Ha) could theoretically sustain a single farm with an initial production potential of 3000t/annum with space for future expansion to 9000t/annum on the full 210ha. The Algoa 1 – Option 2 (South, 455ha) would thus fall away due to biosecurity farm spacing requirements.

Algoa 5 (1000ha): The size of Algoa 5 creates potential to house more than one farm, assuming a separation distance of 2.4km (see above). In the event that a buffer zone (2.4km) is applied, two operating areas of 210ha could be accommodated. Using the same reasoning as above, this potentially allows for two commercial farms with each a production potential of 3000t/annum on 70ha with future expansion potential to 9000t/annum on each of the 210ha sites (total production potential of 18,000t/annum). The two sites could be located at opposite corners of the ADZ.

The potential production volumes stated above are theoretical from an operational perspective and based purely on available surface area without taking into account the other dynamics such as current speed, water depth and other site specific factors.

3.4.3 ADZ SITE CHARACTERISTICS AND COMPARISON

The proposed aquaculture sites (Algoa 1 and Algoa 5) share similar environmental conditions, with Algoa 5 subject more exposed to SW swells. In this section, the site characteristics of the proposed ADZ's are considered in terms their implications for the economic viability of cage aquaculture.

3.4.3.1 DISTANCE FROM NEAREST PORT INFRASTRUCTURE

The primary determinant of the difference in the economic viability of the two sites is their location relative to port service infrastructure. Algoa 1 is situated 4km from Port Elizabeth harbor, whilst Algoa 5 is situated 30km from Port Elizabeth, 15km from the Coega container port and 5 km from a possible small craft harbour on the Sundays River estuary. The distance from the service port will affect the type of craft used to service the operations.

> **Algoa 1**: Algoa 1 can be serviced with small craft and yet remain cost effective due to the short travel distance. This is ideal for a pilot scale start-up industry as the initial capital requirement for boats would be less. It also allows for the operations to grow organically by adding additional small units (boats and cages) as required.
>
> **Algoa 5:** The distance from the port (even 15km from Nqura Port, which currently does not allow for small craft) would require the use of larger vessels to service the cage area. The average workboat return travel time from Port Elizabeth harbour to Algoa 5 and back would be 3h, and from Nqura 1.5h. The vessels required for servicing Algoa 5 would need to be larger to withstand more exposed sea conditions, require more initial capital and would more suited for operating larger farms. While larger cage service vessels would need to utilize Nqura or Port Elizabeth, it may be possible to transport personnel to site in smaller vessels from the proposed Sundays River small craft harbour. The area off the Sunday River mouth is however an exposed surf zone and thus only small 'ski-

boat' type craft would be able to launch during favourable sea conditions. The Sundays River could not accommodate the larger service vessels required for servicing cages during the strong wind (>14kn) and swell conditions (>2m swell height) which prevail for approximately 50% of the year in Algoa Bay.

The requirement for large service vessels requiring port facilities potentially restricts the development of the Algoa 5 site until the concept of offshore farming in South Africa has been proven and the associated risks are known. A salmon Scottish farming company representative reported that distance from port was a significant factor determining site feasibility and that their furthest site was 10.8km from port which was described as 'extremely challenging' logistically (N. Joy, pers. comm., Loch Duart Aquaculture, September 2016). Thus given the 15km distance of Algoa 5 from the Nqura Port and high swell exposure of the site, the operational feasibility of Algoa 5 is low.

3.4.3.2 SWELL EXPOSURE

The Algoa 1 site is more sheltered from the prevailing SW swell than Algoa 5, with lower average significant wave heights being recorded during the one year ADCP monitoring that was undertaken during the environmental impact assessment (Anchor Environmental 2013; Roberts, 2016). Maximum significant wave heights of 5m were however recorded at both sites, and wave heights of up to 6.5m have been recorded in Algoa Bay (Anchor Environmental 2013; Roberts, 2016). Both sites are equally exposed to Easterly swells. Thus, while Algoa 1 is more conducive for aquaculture operations in terms of average swell, both sites will require similarly specified cage and mooring systems to withstand the maximum significant swells. In comparative terms, Algoa Bay is thus much more exposed to swell than other aquaculture industries based on cage aquaculture, for example, the sea bass culture in the Mediterranean, and salmon in fjords in Chile and Norway. The high swell exposure places Algoa Bay in the commercially experimental "offshore cage aquaculture" category requiring a much higher (and more expensive) equipment specification.

3.4.3.3 WIND EXPOSURE

The high wind exposure of Algoa Bay severely limits the number of operational days at sea. A guide to sea conditions for operating small research vessels in Algoa was compiled by the South African Environmental Observation Network (SAEON) based on five years of wind and swell data (Figure 1, Table 3).

Small research vessels performing day trips from Port Elizabeth harbour do not work under 'poor' and 'caution' conditions. Similar size vessels would be used for pilot aquaculture operations, however larger vessels would be required for commercial operations. The high percentage (ca. 50%) of 'poor' and 'caution' sea days characterized by windspeeds of >14knots thus places a severe operational constraint on servicing cage farms in the Algoa 1 and Algoa 5 ADZs. This is confirmed by the experience at the Irvin and Johnson pilot cage culture operation adjacent to the Port Elizabeth harbour in Algoa Bay, where 95 sea days were missed in a 12 month period due to unsuitable weather (G. Le Roux, 2016 unpublished data). Unscheduled breaks in cage servicing schedules increase the risk of fish escapes, bird predation through torn top nets, mass fish escapes from unmaintained cages, predator attraction and health problems as a result of not removing mortalities. As fish require daily feeding, and staff has to have safe operating conditions, larger and more capital-intensive vessels and automated feeding systems would be required to operate effectively and economically. Cage nets need to be changed one a month, and thus on a farm consisting of 50 cages, vessel capacity to change 3-4 nets would need to be changed on each operational sea day.

Both Algoa 1 and Algoa 5 are similarly exposed to wind, however the further distance to Algoa 5 imposes a higher vessel specification for safe operations. As the Algoa 1 site is on close proximity of Port Elizabeth, it is possible to take advantage of smaller weather windows using smaller vessels. For example, the wind often comes up in the late morning allowing 3-4h of operational time if the port is in close proximity. However, the high wind and swell conditions prevalent in Algoa Bay remain a severe operational constraint as illustrated the high number of sea days missed during the I&J pilot cage culture project.

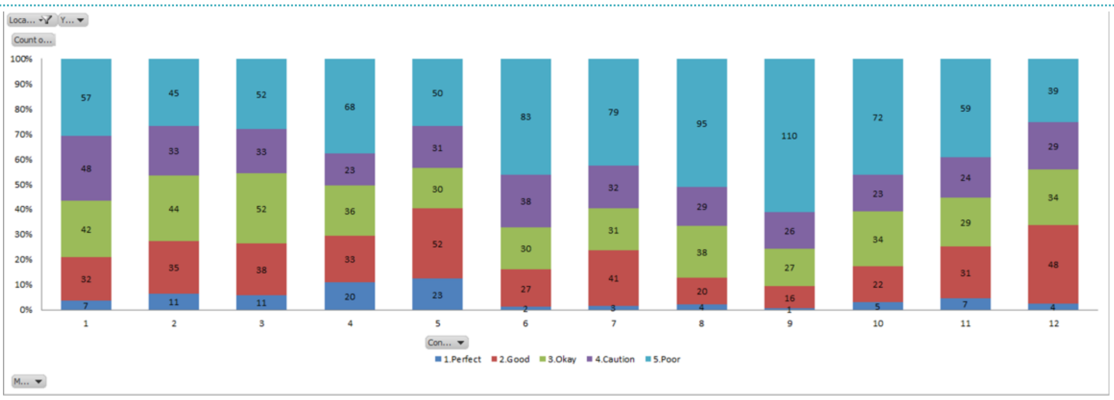

Figure 1. Ranking of sea conditions for small research vessel operations in Port Elizabeth. The sea condition ranking categories are outlined in Tables 3a and 3b below. Figure and tables courtesy of Dr Tommy Bornman, SAEON Elwandle Node.

Table 3.3a. Swell and winding sea ranking categories.

SWELL RANKING	SWELL HEIGHT	WIND RANKING	WIND SPEED
A	<1.9M	I	<7 KN
B	1.9-2.4M	II	8-11 KN
C	2.5-2.9M	III	12-14KN
C	>2.9M	IV	>14KN

Table 3.3b. Ranking of sea conditions for small research vessel operations.

OPERATIONAL CONDITION RATING	SWELL AND WIND RANKING
PERFECT	A-I
GOOD	A-II, B-I
OKAY	A-III, B-II, C-I
CAUTION	B-III, C-II, A-IV
POOR	B-IV, C-III, C-IV, D-I, DI-I, D-III, D-IV

3.4.3.4. WEATHER IMPLICATIONS FOR CAGE FARM EQUIPMENT SPECIFICATIONS

The high exposure of Algoa Bay to wind and swell has important implications for an operating a cage farm at both ADZ sites.

Kob requires daily feeding to achieve economic growth and skipping one or two days has been found to significantly reduce growth rates and food conversion ratios (Guy and Smith, 2016). As small craft cannot operate safely 50% of the time in Algoa Bay, this means that the only alternative to effect daily feeding is the use of larger ships out of Nqura Port on which crew can live aboard (Figure 2). The capital cost of such vessels would only be justified by very large economies of scale.

The prevailing high wind and swell conditions place a severe operational constraint on servicing fish cages. To operate effectively,

- Vessels must be safe and usable under harsh conditions.
- There must be safe operating conditions on board for handling aquaculture equipment e.g. feeding and changing nets.
- It should be possible to lift, clean and install cages under harsh conditions

Cage aquaculture with salmon has only proven commercially successful in relatively sheltered swell conditions for these reasons (Vielma and Kankainen, 2013). When exposed to high wind and swell conditions, it may be possible to feed but operations such as inspecting cages, treating ectoparasites and changing nets are not safe or practical. In addition, cages mooring to move when subject to constant high swell and wind (N. Joy, Loch Duart Aquaculture, September 2016).

FIGURE 2. REMOTE FARMS AT EXPOSED SITES MAY BE MAINTAINED BY VESSELS UP TO 40M LONG. (SOURCE: VIELMA AND KANKAINEN, 2013)

3.4.3.4 RED TIDE

Periodic red tides caused by dinoflagellate are a potential threat to the viability of cage aquaculture in Algoa Bay. The now defunct Marine Growers Abalone farm next to the present Nqura Harbour suffered heavy stock losses during two dinoflagellate (species not unidentified) blooms in January 2000 and again in January 2001 (Muller, 2001). The recent extended (December 2013-March 2014) red tide event of the dinoflagellate *Lingulodinium polyedrum* along the East coast and in Algoa Bay is of particular concern for the viability of cage aquaculture.

L. polyedrum blooms are associated with periods of warm water (>20°C) and calm wind conditions, which are likely to become more prevalent in Algoa Bay as marine warm water events are on the increase globally and in South Africa. Warm water events are of particular concern within the bay as they appears to persist for longer than outside the bay due to the bay circulation pattern (Bornman and Goshen, 2016).

During the severe red tide of the dinoflagellate *Lingulodinium polyedrum* event in early 2014, the South African Environmental Observation Network performed invaluable monitoring of oxygen, chlorophyll and cell density and temperature (Botha and Goschen, 2016 - Appendix 1). The red tide bloom conditions resulted in extremely altered water quality which is considered a high risk to aquaculture production. The cell density of the dinoflagellates reached 29,000 cells per ml producing 200% oxygen supersaturation (12mg/l) in the surface waters as a result of photosynthetic activity. The night-time oxygen levels were not measured, but a severe drop in oxygen level would be expected due to cellular respiration. A red tide bloom in Mexico during which 200% oxygen saturation (12mg/l) was recorded in the daytime had a night-time minimum of 4mg/l (Gocke et al, 1990). The decaying Algoa Bay bloom resulted in low oxygen conditions (<2mg/l) towards 20m and deeper.

Lingulodinium polyedrum is a thecate dinoflagellate that produces yessotoxins. The effect of these toxins on fish is unknown but they have been shown to bioaccumulate in shellfish and have a toxic effect on mice. Thecate dinoflagellates are known to leak toxins when decomposing and the possibility of a toxic plume being produced under or around the sea cages should not be overlooked. Whilst there may not be a proven toxic effect on fish, salmon subjected to a 3 week sitting bloom of *Neoceratium spp* showed histological cell damage to the liver indicative of hypoxia and exposure to toxic phytoplankton. This population of fish struggled to return to normal feeding post the event and as such rapidly lost condition (A. Irish, Senior Biologist, The Scottish Salmon Company, pers. comm., September 2016).

The effects of a red tide bloom on kob in cage culture have not been observed, but could have potentially severe sub-lethal and lethal effects. It is unlikely that the daytime oxygen super-saturation will result in negative effects on the fish[11], however, the low oxygen levels (of the order 4 mg/l) at night would be stressful affecting feeding, growth and making the fish more vulnerable to disease. Wild fish would actively seek water with higher oxygen levels and farmed fish show the same instinct and can display "burrowing" behavior causing extensive physical

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[11] Gas bubble disease in fish results from nitrogen super-saturation and not oxygen super-saturation.

damage to the face which can lead to osmoregulatory failure or secondary infection. While the low oxygen (<2mg/l) at 20m depth would be below the fish cages (10-15m depth), if the the water column turned over moving the deoxygenated bottom water up to the cages, mass fish mortalities could occur. It is not practical to oxygenate water in sea cages and thus there is no mitigation measure for low oxygen in fish cages. The effect of exceptionally high cell density on the gills of the target species in not known, however, in other species red tide cells have been known to cause clogging, irritation and mucous production. Whilst not spined like many other thecate dinoflagellates, the armoured plates of *Lingulodinium polyedrum* will cause a degree of abrasion on gill tissue. This would lead to significant proliferation and hyperplasia of the gill tissue, compromising the respiratory process. Prolonged exposure to this challenge would exacerbate the damage (A. Irish, Senior Biologist, The Scottish Salmon Company, pers. comm., September 2016).

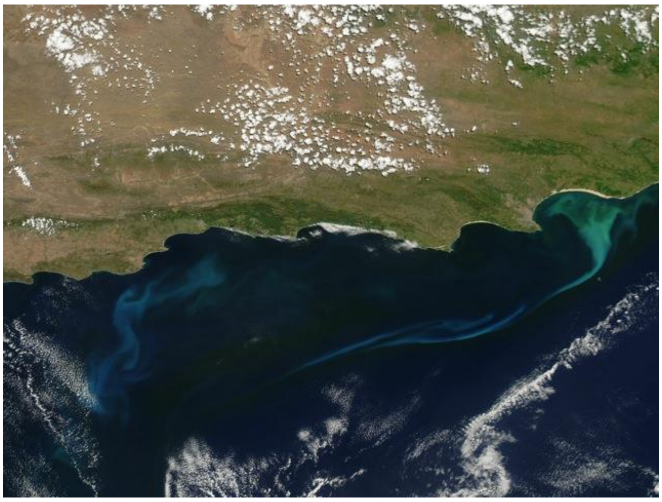

Figure 3. Red tide bloom in Port Elizabeth during January 2014. Humewood Beach (Above) and satellite image of the bloom (Courtesy Dr G Pitcher, DAFF)

Bornman and Goschen's (2016) 2014 survey revealed that the dinoflagellate bloom tended to persist for longer off the Sundays and Swartkops estuaries due to their nutrient input into the bay. The location of Algoa 5 off the Sundays estuary thus increases possibility of the Algoa 5 site experiencing longer exposure to future red tide events.

From an investment perspective, the production risk and uncertainty associated with red tide events renders suitability of the both Algoa 1 and Algoa 5 for cage aquaculture as very low.

3.4.3.5 TEMPERATURE

The Final EIR Marine Specialist Report (Anchor Environmental, 2013) and the present study's Algoa Bay Marine Ecological Impact Assessment report (Roberts, 2016) revealed that the average temperatures in Algoa Bay are sub-optimal for kob, with both Algoa 1 and Algoa 5 subject to rapid temperature drops during upwelling events.

The optimum temperature for juvenile kob aquaculture has experimentally been determined to be 21.3-25.3C° Collett (2007), with pilot fish farms confirming that they obtain their best growth and feed conversion performance in this temperature range (N. Stallard, Mtunzini Aquaculture pers. comm. 2016). Commercial farms have reported report maximum growth to be between 25-28C° (N. Stallard, Mtunzini Aquaculture pers. comm. 2016; W. Schoonbee, Pemba Aquaculture farm, unpublished data). Collett (2007) observed that juvenile kob growth was 40% reduced at 17°C compared to 25C° and pilot kob farms report that growth is uneconomic below 18C° with reduced feed consumption (N. Stallard, Mtunzini Aquaculture pers. comm. 2016; G. Le Roux, pers. comm., 2016; L. Ryan, Oceanwise Aquaculture, Pers. comm, September 2016). Pilot plant performance data of kob in cages indicate that a market size of 1.5kg can be attained within 15months at 28°C, declining to 28 months at 18 °C (G. Le Roux, pers. comm., 2016). The average temperature of both the Algoa 1 and Algoa 5 sites is below 18°C for much of the year (Anchor Environmental, 2013; Roberts, 2016) and well below the optimal range for kob. Kob grown in the Irvin and Johnson cage culture experiment at Port Elizabeth performed poorly, reaching only 276g over 12 months (Jan-Dec). During this period summer water temperatures (Nov-March) ranged between 19.5-22°C and the winter temperature range (April-October) was 15-17.7°C (G. Le Roux, unpublished data, 2016)

A further temperature effect affecting the viability of kob aquaculture in Algoa Bay is the occurrence of upwelling events in Algoa Bay, which can result in rapid drops in water temperature of the order of 7°C within a matter of hours during East wind conditions prevalent in summer (Roberts, 2016). This is highly stressful for kob and was identified as a problem affecting their performance in the I&J-DST pilot cage culture project undertaken near Port Elizabeth harbour (G. Le Roux, pers comm., 2016). A kob mortality rate of 45% occurred over the one-year trial.

The sub-optimal temperature regime in Algoa Bay and observed poor performance of kob in pilot cage culture is thus a fatal flaw in the economic potential of Algoa 1 and Algoa 5 for kob aquaculture. Investment interest in kob is focused on areas with warmer ambient temperatures further north.

Yellowtail yielded better growth performance than kob in the I&J-DST pilot cage culture project with fish attaining an average of 1.2kg over 12 months under the Algoa Bay temperature regime (G. Le Roux, pers. comm., 2016). Yellowtail were thus deemed the better commercial aquaculture candidate for Algoa Bay.

3.5 HIGH LEVEL FINANCIAL MODEL

The assessment of the economic impact requires a basic model to identify and indicate the economic determinants of offshore aquaculture in Algoa Bay. A high level generic financial model was created for marine cage culture using the economic parameters and assumptions applicable to kob (Ar*gyrosomus japonicus*) and yellowtail (*Seriola llandii*). The model provides sufficient detail to indicate the interaction between the economic drivers. Future investments should however be based on a detailed investor-generated business model.

Two models were created: 1000t Commercial Pilot and 3000t Commercial Unit. Both models assume a 'farm only' scenario where juvenile supply and value adding are outsourced from land based hatcheries.

3.5.1 KEY ECONOMIC PARAMETERS AND ASSUMPTIONS

Table 3.4.The economic parameters were used in compiling the financial model is listed below

Parameter	**Value**
Sales Price G&G (Rand)	60
FCR	1.60
Feed Price (Rand)	23
Harvest size G&G (kg)	1.00
Mortality per annum (%)	10%
Juvenile cost (Rand)	1.50
Yield	90%

The key economic parameters are discussed below:

3.5.1.1 SELLING PRICE

The selling prices used in the financial analyses were R60/kg (gilled and gutted) for the 1000t/annum scenario and R54/kg (gilled and gutted) for the 3000t/annum. These are considered to be realistic prices for kob leaning towards 'optimistic' in the current market (2016) due to the premium that can be obtained for an aquaculture product. A premium price for aquaculture product is mainly due to the regularity of supply, consistent size and high quality. The fresh fish market is sensitive to volume and although no one in South Africa has produced these numbers of fish before, price sensitivities were noted by previous producers at volumes as low as 10t/month in the South African market.

The expected selling price and market size are however the biggest unknowns in the planning of commercial size marine finfish farms. A thorough market assessment is advised for any potential business proposals.

3.5.1.2 FEED CONVERSION RATIO

Fish feed is the largest single running cost and the business model is therefore highly sensitive to the amount of feed required to produce a unit of fish. Feed conversion ratio (FCR) is a measure of efficiency with which a particular species convert feed into fish, i.e. how many kilograms of feed required to produce one (1) kilogram of fish. This is normally expressed as the FCR ratio and is affected by environmental conditions, culture system and stock management practices.

A 'commercial' FCR value was used in the financial model. Commercial FCR includes losses due to mortality and culling and is a true economic reflection of feed converted to fish. Commercial FCR is therefore affected by the mortality rate, escape events and growth period (the longer the growth period, the larger the effect of the annual mortality rate).

A commercial FCR of 1.6:1 was used in the calculations based on commercial benchmarks. This is a conservative figure since better FCR's have been achieved in experimental and pilot scale operations (the AquaPemba kob project achieved FCR rates between 1.4:1 and 1.5:1 under optimal growth conditions 25-30°C). However, the environmental conditions in Algoa Bay are sub-optimal (notably temperature) for both kob and yellowtail and will significantly negatively affect performance. A commercial FCR of 1.6:1 would still be considered to be a positive scenario since the marine conditions in and around Algoa bay have historically shown large fluctuations (temperature and oxygen) over relatively short time periods. Fluctuations are the real problem for fish, which normally move within pockets of water to avoid quick change. Cages do not allow the fish to move out of an area that is fluctuating which leads to stress and mortality. These factors then have a direct resonance on the output ability of the farm to be a competitive business.

3.5.1.3 FEED PRICE

The feed price used in the model was at R23/kg based on the current prices (50%local;50% import)(2016).

3.5.1.4 MORTALITY RATE

A 10%/annum mortality rate was used in the model. Based on actual mortality rates for kob (pers. obs. at AquaPemba fish farm and personal communication with Andre Bok at Pure Ocean Aquaculture), this estimate should be seen as fair to optimistic, given the fluctuating nature of the water conditions within Algoa Bay.

The mortality rate was only used to calculate the number of juveniles required. The commercial FCR previously discussed takes into account the expected mortality during the grow-out phase.

3.5.2 FINANCIAL MODELS

The economic model is based on the proposed pilot scale operation of 1000t/annum with the expansion to minimum viable commercial units of 3000t/annum. Whether the unit expands beyond the anticipated size, or whether an additional competitive unit is established, will be governed by market and current economic appetite. The financial models should be taken as high-level indicators and an extensive economic assessment should be completed by potential investors.

The models for the 1000t/annum commercial pilot scale and 3000t/annum commercial units are presented below. From these the following are noted:

Parameter/Farm size	**1000t/annum**	**3000t/annum**
Cost/kg at maturity	R50.62	R45.01
Gross Profit %	21.3%	15.9%
Capex Requirement	R18.5m	R38.5m
Operational Requirement	R52m	R117m
Total Investment Requirement	R70.5m	R154.5m

Pilot Scale 1000t/annum

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Standing Stock (t)	**300**	**700**	**900**	**900**	**900**	**900**
Average size standing stock (kg)	**0.30**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**
Whole weight harvested (t)	**-**	**556**	**889**	**1,111**	**1,111**	**1,111**
Number of fish harvested (n)	**-**	**555,556**	**888,889**	**1,111,111**	**1,111,111**	**1,111,111**
Income	**-**	**30,000,000**	**48,000,000**	**60,000,000**	**60,000,000**	**60,000,000**
Farm gate G&G sold (kg)	-	500	800	1,000	1,000	1,000
Farm gate G&G (Rand)	-	30,000,000	48,000,000	60,000,000	60,000,000	60,000,000
Operational costs	**24,306,667**	**49,801,481**	**55,608,148**	**56,240,741**	**56,240,741**	**56,240,741**
Cost of Sales	15,306,667	40,801,481	46,608,148	47,240,741	47,240,741	47,240,741
Feed	11,040,000	35,164,444	40,071,111	40,888,889	40,888,889	40,888,889
Juveniles	1,666,667	2,037,037	2,037,037	1,851,852	1,851,852	1,851,852
Wages	2,100,000	2,800,000	3,500,000	3,500,000	3,500,000	3,500,000
Other	500,000	800,000	1,000,000	1,000,000	1,000,000	1,000,000
Gross Profit	(15,306,667)	(10,801,481)	1,391,852	12,759,259	12,759,259	12,759,259
GP%	0.0%	-36.0%	2.9%	21.3%	21.3%	21.3%
Overheads	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000
Admin	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Salaries	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000
On-farm logistics	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000
Other	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
EBITDA	(24,306,667)	(19,801,481)	(7,608,148)	3,759,259	3,759,259	3,759,259
EBITDA %	0.0%	-66.0%	-15.9%	6.3%	6.3%	6.3%

Cash requirement	**(37,306,667)**	**(62,608,148)**	**(70,216,296)**	**(66,457,037)**	**(62,697,778)**	**(58,938,519)**
Operations	(24,306,667)	(19,801,481)	(7,608,148)	3,759,259	3,759,259	3,759,259
Capex	(13,000,000)	(5,500,000)	-	-	-	-

Cost/kg Whole Weight (Rand)	81.02	52.12	51.07	50.62	50.62	50.62

Commercial Unit 3000t/annum

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Standing Stock	**900**	**2,100**	**2,700**	**2,700**	**2,700**	**2,700**
Average size standing stock (kg)	**0.30**	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**
Whole weight harvested (t)	**-**	**1,667**	**2,667**	**3,333**	**3,333**	**3,333**
Number of fish harvested (n)	**-**	**1,666,667**	**2,666,667**	**3,333,333**	**3,333,333**	**3,333,333**
Income	**-**	**81,000,000**	**129,600,000**	**162,000,000**	**162,000,000**	**162,000,000**
Farm gate G&G sold (kg)	-	1,500	2,400	3,000	3,000	3,000
Farm gate G&G (Rand)	-	81,000,000	129,600,000	162,000,000	162,000,000	162,000,000
Operational costs	**51,420,000**	**128,004,444**	**148,124,444**	**150,022,222**	**150,022,222**	**150,022,222**
Cost of Sales	41,720,000	117,304,444	134,424,444	136,322,222	136,322,222	136,322,222
Feed	33,120,000	105,493,333	120,213,333	122,666,667	122,666,667	122,666,667
Juveniles	5,000,000	6,111,111	6,111,111	5,555,556	5,555,556	5,555,556
Wages	2,800,000	4,200,000	5,600,000	5,600,000	5,600,000	5,600,000
Other	800,000	1,500,000	2,500,000	2,500,000	2,500,000	2,500,000
Gross Profit	(41,720,000)	(36,304,444)	(4,824,444)	25,677,778	25,677,778	25,677,778
GP%	0.0%	-44.8%	-3.7%	15.9%	15.9%	15.9%
Overheads	9,700,000	10,700,000	13,700,000	13,700,000	13,700,000	13,700,000
Admin	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Salaries	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000
On-farm logistics	4,000,000	4,000,000	6,000,000	6,000,000	6,000,000	6,000,000
Other	2,000,000	3,000,000	4,000,000	4,000,000	4,000,000	4,000,000
EBITDA	(51,420,000)	(47,004,444)	(18,524,444)	11,977,778	11,977,778	11,977,778
EBITDA %	0.0%	-58.0%	-14.3%	7.4%	7.4%	7.4%

Cash requirement	**(68,920,000)**	**(136,924,444)**	**(154,448,889)**	**(143,471,111)**	**(131,493,333)**	**(119,515,556)**
Operations	(51,420,000)	(47,004,444)	(18,524,444)	11,977,778	11,977,778	11,977,778
Capex	(17,500,000)	(21,000,000)	-	-	-	-
Cost/kg Whole Weight (Rand)	57.13	44.65	45.34	45.01	45.01	45.01

3.5.3 CAPITAL EXPENDITURE

The following table provides a rough indication of the expected capital expenditure required:

	1000t	**3000t**
Capex	**18,500,000**	**38,500,000**
Number of Cages	30	70
Cages	9,000,000	21,000,000
Workboat	3,000,000	8,000,000
Service boats	2,000,000	2,000,000
General Equipment	1,500,000	2,500,000
Land base	3,000,000	5,000,000

3.6 EMPLOYMENT

The present review (Section 2.3 above) of the Final EIR Socio-economic report (Bloom, 2013) revealed that the projected number of jobs projected was speculative and unrealistically high. Direct employment in the production component of an offshore farm in Algoa Bay is expected to roughly 50 employees for a 1000t/annum pilot scale operation (1 employee per 20 ton) and 80 employees for a 3000t/annum commercial unit (1 employee per 37.5 tons).

Further employment opportunities could present themselves in services and value adding, with the most significant the increase in processing workers within Fish Processing Establishments to absorb the extra fish production for the region. The actual number of employment opportunities is difficult to estimate as the existing industries in the region will most likely be able to meet the demand for services in an initial marine aquaculture development phase. Service industries will scale with the development of the sector and success from the first commercial operator will signal whether the industry has a viable future. Services could include boat maintenance, net manufacturing and repairs and commercial diving. Initially however, most services required for a pilot scale operation could be supplied by existing businesses. A figure of one direct on farm employee to one service sector employee has been suggested as an approximation of indirect jobs (Britz, 2014). Thus 100 total jobs for a 1000t production unit and 160 for a 3000t unit are projected.

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