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FEASIBILITY STUDY

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

**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 Bjørkan

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FEASIBILITY STUDY: MARINE AQUACULTURE DEVELOPMENT ZONES FOR FINFISH CAGE CULTURE

1. PURPOSE

The present Feasibility Study forms part of the 'Comparative Assessment of Development of the Proposed Sea-Based Aquaculture Development Zone (ADZ) Located Within Algoa Bay, Eastern Cape Province'. It integrates the diagnostic outputs of the preceding Ecological Report and Socioeconomic Report, which were specialist studies analysing the key issues determining the feasibility of the proposed Algoa 1 and Algoa 5 ADZ sites. The feasibility study evaluates the economic, social and ecological feasibility of the two sites.

2. BACKGROUND

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

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 (Anchor Environmental, 2011). 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 Environmental Impact Assessment (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 (CapeEAPrac, 2013), 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 service provider (Rhodes University) 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 reported on separately in the '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' provide the main inputs and analyses for the Feasibility Study Report which integrates all relevant issues.

3. FEASIBILITY STUDY APPROACH

The feasibility study draws on the key diagnostic conclusions from the Ecological and Socio-economic which determine the feasibility of the two Algoa Bay ADZ sites. The Final Environmental Impact Assessment (EIR) Socio-economic impact report noted that:

"...it is essential to consider the viability and feasibility of the project in the context of the broader economic trade-off between other activities such as tourism. If the project proves to be viable and projections suggest that the project indicates signs of being commercially feasible in the future, a broader perspective related to macro-economic and industry specific (i.e. tourism, etc.) risk are also considered to reach an informed decision" (Bloom, 2013).

The positive Environmental Authorisation for a pilot project at the Algoa 1 (Option 1) site triggered a public outcry and wave of appeals against the decision highlighting the need to consider the 1) the economic feasibility and socio-economic benefits of the ADZ more rigorously and 2) the likely external social and economic costs to other sectors. These primary studies were carried out and reported on in the Ecological and Socio-economic Reports.

In the Feasibility Study, a summary of the key findings from the Ecological and Socio-economic Reports are integrated to evaluate the feasibility of the Algoa 1 and Algoa 5 ADZ's.

- 1) **Algoa ADZ Economic Feasibility**, which evaluates the ADZ business case.
- 2) **Algoa ADZ socio-economic Feasibility**, which evaluates the external socio-economic costs and benefits.
- 3) **Algoa ADZ Ecological Feasibility** which evaluates the ecological impacts and social costs and tradeoffs.

Table 1. Aquaculture Economic Feasibility Ranking Criteria. A score between 1 and 5 was assigned to each key parameter determining the aquaculture economic feasibility for Algoa 1 and Algoa 5 ADZs.

Aquaculture Economic Feasibility Ranking Criteria	High Feasibility	Good Feasibility	Moderate Feasibility	Low Feasibility	Very Low Feasibility
Score	5	4	3	2	1
Ranking Criteria	Ideal condition for aquaculture. Economic competitive advantage	Generally ideal condition mitigation measures highly feasible. Economically competitive	Condition below ideal for aquaculture but still economically viable with mitigation measures. Not economically competitive advantage.	Condition marginal for economic aquaculture limited mitigation possible. Not economically competitive	Sub-optimal condition for aquaculture mitigation measures impractical or uneconomic, not economically feasible under current economic and technological
Aquaculture Site Feasibility Criteria					
Distance from Port	≤3km	3-5km	5-8km	8-10km	>10km
Wind and swell (Workable Sea Days%)	90-100	80-90	70-80	60-70	<60
Temperature (Kob aquaculture)	Ideal growth range (21-26°C) all year round. No upwelling temperatures	Ideal 21-26°C growth range over 75% of year, no upwelling temperatures	Ideal growth 21-28°C range over 50% of year, no upwelling temperatures	Ideal 21-26°C range under 15% of year, low growth, regular upwelling temperatures	Ideal 21-26°C range under 15% of year, minimal growth, regular upwelling temperatures
Temperature (Yellowtail aquaculture)	Ideal growth range (21-26°C) all year round. No upwelling temperatures	Ideal 21-26°C growth range over 75% of year, no upwelling temperatures	Ideal growth 21-28°C range over 50% of year, no upwelling temperatures	Ideal 21-26°C range under 30% of year, low growth, occasional upwelling temperatures	Ideal 21-26°C range under 15% of year, minimal growth, frequent upwelling temperatures
Red Tide Risk	No red tides recorded	Red tide has occurred in the past (10 year scale) but no pathological symptoms associated with toxins and/or low	Red tides do occur occasionally (3-5 year frequency). No toxic effects recorded. Dense blooms have reduced oxygen concentrations	Red tides occur regularly (1-3 years). Pathological effects due to low oxygen or toxicity have been observed in fish	Red tides occur annually. Pathological effects due to low oxygen or toxicity have been observed in fish
Aquaculture Business Case Feasibility Criteria (1000t and 3000t farm scale)					
Market	Established product. Quality advantage. Price competitive.	Established product. Quality advantage. Price higher than competition. Supply deficit	Established product. Price higher than competition. Supply deficit < 500t	Unknown product. Price higher than competition. No supply deficit	Unknown product. Price higher than competition. No supply deficit
Value chain	Established aquaculture value chain. Excellent service infrastructure	Developing aquaculture value chain. Most services locally obtainable. Good service infrastructure	Developing aquaculture value chain. Some services require insourcing. Infrastructure gaps.	Rudimentary aquaculture value chain. Most services require insourcing or importation. Infrastructure building required	No aquaculture value chain. Most services require insourcing or importation. Infrastructure building required
Margin (BITDA (Earnings before Interest, Taxation, Deductions and	≥20%	16-20%	11-15%	6-10%	<5%

Table 2. Ecological Feasibility ranking criteria.

Ecological Feasibility Ranking Criteria	High	Feasible	Moderately Feasible	Low Feasibility	Very Low Feasibility
Score	5	4	3	2	1
Ranking Criteria	Very low ecological impact. No mitigation required.	Low ecological impact. Minimal and ineffective mitigation possible	Moderate ecological impact. Ineffective mitigation possible	Significant ecological impact. Limited mitigation possible	High ecological impact. Little/no mitigation possible.

Table 3. Socio-economic Feasibility Ranking Criteria

Socio-economic Feasibility Ranking Criteria	High Feasibility	Feasible	Moderately Feasible	Low Feasibility	Very Low Feasibility
Score	5	4	3	2	1
Ranking criteria	Very High positive socio-economic	Moderate positive socio-economic	Neutral socio-economic impact	Negative socio-economic impact	Highly negative socio-economic impact

The feasibility analyses are presented in tabular form in the section below.

This is followed by a discussion and conclusions.

4. FEASIBILITY ANALYSIS

A comparative analysis of the economic business case (Table 1), socio-economic costs and benefits (Table 2) and ecological costs (Table 3) and is presented below.

This is followed by a scored ranking comparison of the Algoa 1 and Algoa 5 sites (Table 4).

Table 4. ALGOA ADZ ECONOMIC FEASIBILITY

1. Key Site Characteristics				
<p>Distance from Port.</p> <p><i>Distance from port infrastructure is a key determinant of the economic feasibility of cage aquaculture. Algoa 1 is 4km from Port Elizabeth harbour and Algoa 5 is 15km from Nqura Port.</i></p>	<p>Feasibility</p>			
	<p>Algoa 1. The 4 km distance from port is not an operational constraint. The short distance allows for servicing of cages during short weather windows e.g. before the wind comes up late morning.</p> <p>Algoa 5. The 15km from Nqura Port is a severe operational constraint to servicing cages. In salmon farming, 10km from port is regarded as a maximum feasible travel distance from port for daily feeding. This, combined with the severe wind and swell exposure of the site will require larger, safer vessels to be able to service the cages for daily feeding and maintenance. The possibility of a small harbour development at Sundays River may provide for personnel access on small vessels during calm sea conditions, but the larger vessels required cage servicing will not be able to operate out of the Sunday’s estuary. The requirement for larger vessels will add dramatically to the capital costs for Algoa 5 rendering the return on investment unattractive.</p>			
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Algoa 1	Algoa 5			
Highly feasible distance from port	Very low feasibility for distance from port			
<p>Wind and swell</p> <p><i>Both Algoa 1 and Algoa 5 are significantly exposed to wind (>14kn) and swell (>3m). This limits the number of sea days for servicing fish cages.</i></p>	<p>Feasibility</p>			
	<p>Algoa Bay is highly exposed to wind and swell compared to the more sheltered locations of established aquaculture industries based on cage culture (e.g. Norway, Chile, and the Mediterranean). Both Algoa 1 and Algoa 5 are subject to a similar wind regime with only 50% of annual days (<14kn windspeed) good for small craft operations. Both sites are significantly exposed to swells of 3-5m during storms. Algoa 1 is more sheltered from the prevailing SW swell, while both are fully exposed to Easterly swells. The high exposure of wind and swell severely limits the number of workable sea days using small vessels. As the economics of aquaculture require daily feeding, the only solution is to invest in larger, more seaworthy and safer vessels. This high capital cost would only be justifiable for very large operations. Even if daily feeding is achieved using larger vessels, the high swell and wind combination will limit the days available for cage inspection, net changing, fish handling and other operations. While technically possible to operate, the high capital cost of the equipment required reduces the investment case for both sites.</p>			
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<p>Temperature</p> <p><i>The ambient water temperature is a key determinant of fish growth. The average temperature of the Algoa 1 and Algoa 5 sites is 18°C. The Bay is</i></p>	<p>Feasibility</p>			
<p>The average water of both Algoa 1 and Algoa 5 (18 °C) is well below the optimum for kob and yellowtail growth and feed conversion. The optimum temperature for kob growth is 25 °C and yellowtail 26.5. Growth of kob is deemed uneconomic, however reasonable growth of yellowtail (1.2kg in 12 months) was obtained during the I&J pilot cage culture trial. The periodic upwelling of cold water will have serious negative effects on fish growth rate and</p>				

<p>subject to periodic upwelling of cold water which may rapidly reduce the temperature in fish cages (ca. 5°C over 12h at 9m depth at Algoa 1).</p>	<p>health.</p> <table border="1" style="width: 100%; text-align: center;"> <tr> <td style="background-color: #ffffcc;">Algoa 1</td> <td style="background-color: #ffffcc;">Algoa 5</td> </tr> <tr> <td>Low feasibility</td> <td>Low feasibility</td> </tr> </table>		Algoa 1	Algoa 5	Low feasibility	Low feasibility				
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<p>Red Tide</p> <p><i>Algoa Bay is susceptible to red tide dinflagellate blooms during warm water (>20°C) events.</i></p>	<table border="1" style="width: 100%; text-align: center;"> <tr> <td colspan="2" style="background-color: #ffffcc;">Feasibility</td> </tr> <tr> <td colspan="2"> <p>The dense red tide blooms, with recorded cell counts of up to 29,000 cells/ml of <i>Lingulodinium polyedrum</i>, may seriously affect water quality and fish health at both Algoa 1 and Algoa 5. The 2014 <i>L. polyedrum</i> bloom persisted 3 months in Algoa Bay with varying intensity. Low dissolved oxygen in the water from the red tide may produce both sub-lethal (reduced feeding, FCR and health problems) and lethal effects (suffocation from anoxia). The high cell density may result in gill clogging and irritation, mucous production, and toxicity to the fish. There are no mitigation measures to protect fish in cages from these effects. A limitation is the lack of information on the risk of red tide in respect of frequency and toxicity for cage cultured fish. 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.</p> </td> </tr> <tr> <td style="background-color: #e0f2f7;">Algoa 1</td> <td style="background-color: #e0f2f7;">Algoa 5</td> </tr> <tr> <td>Moderate feasibility due to red tide production risk</td> <td>Moderate feasibility due to red tide production risk</td> </tr> </table>		Feasibility		<p>The dense red tide blooms, with recorded cell counts of up to 29,000 cells/ml of <i>Lingulodinium polyedrum</i>, may seriously affect water quality and fish health at both Algoa 1 and Algoa 5. The 2014 <i>L. polyedrum</i> bloom persisted 3 months in Algoa Bay with varying intensity. Low dissolved oxygen in the water from the red tide may produce both sub-lethal (reduced feeding, FCR and health problems) and lethal effects (suffocation from anoxia). The high cell density may result in gill clogging and irritation, mucous production, and toxicity to the fish. There are no mitigation measures to protect fish in cages from these effects. A limitation is the lack of information on the risk of red tide in respect of frequency and toxicity for cage cultured fish. 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.</p>		Algoa 1	Algoa 5	Moderate feasibility due to red tide production risk	Moderate feasibility due to red tide production risk
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for fishery products. However, the South African aquaculture sector is not established and there is no evidence for any comparative advantage that would confer a competitive advantage on indigenous marine fish produced in Algoa Bay.

international markets and widely farmed. However, the cost of aquaculture production in South Africa is not competitive with Asian producers who are landing culture yellowtail in South Africa for around R34/kg. The investment case for the aquaculture of South African kob and yellowtail for export is thus not positive.

Algoa 1	Algoa 5
Low feasibility	Low feasibility

3. Overall Investment Case

Feasibility					
<p>Algoa ADZs</p> <p><i>The environmental characteristics of Algoa Bay and market potential for kob and yellowtail are the key determinants of the investment case for aquaculture in the ADZs.</i></p>	<p>The present Socio-economic Report analysis (Appendix 1) indicates that the case for investment in either Algoa 1 or Algoa 5 is not attractive because:</p> <ul style="list-style-type: none"> • The value chain for marine fish cage culture of indigenous fish is not established. Thus, transaction and unit production costs will be comparatively high, reducing the competitiveness and profitability of aquaculture operations in the ADZs. • A high level financial model indicates marginal economic viability at 1000t and 3000t production. • The ADZ sites are not suitable for economic culture of kob and yellowtail due the average water temperature (18°C) being well below the optimum for kob (25°C) and yellowtail (26°C). Upwelling events where water temperatures can drop by 7°C within hours are stressful and will negatively affect cultured fish growth and health. • The high wind and swell exposure of Algoa Bay limits the number of sea days possible from small vessels making it not possible to feed and service cages daily. The high swell and wind will also affect the stability of conventional cage moorings. Using larger vessels and experimental 'high seas' cage systems increase the capital and economy of scale investment dramatically. • The occurrence red tides of the dinoflagellate (<i>Lingulodinium polyedrum</i> and other species) increases the risk to cage culture of marine fish. There are no mitigation measures for their potential sub-lethal (reduced feeding, growth and health) and lethal (suffocation from low oxygen or absorption of red tide toxins) effects. • The known market demand (500 tons on the South African market) is too small to justify investment in a cage culture operation of an economic scale (ca. 3000 tons and higher). New markets would need to be developed to justify investment on the scale required. 				
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Table 5. ALGOA ADZ SOCIO-ECONOMIC FEASIBILITY

1. Socio-economic costs.				
<p>Recreation and Tourism.</p> <p><i>The economy of the the beachfront area of Port Elizabeth is based on Recreation and Tourism. The Greater Addo National Park with the proposed MPA is a major tourist drawcard.</i></p>	<p style="text-align: center;">Feasibility</p> <p>The Algoa 1 final Environmental Impact Report (EIR), widespread public concern and 28 appeals to the Environmental Authorisation indicated a significant negative impact on Port Elizabeth’s recreation and tourism economy. Concerns included perceived impacts on diving, yachting, ski-boating, property values, increased risk of shark attacks, and job losses. While this potential cost was not quantified in terms of economic value, a high proportion of people surveyed (39%) found the perceived social cost to be unacceptable (Hosking, 2016). The final EIR (CapeEAPrac, 2013) rated the impacts the major negative socio-economic impacts (tourism and recreation, real estate and vessel navigation routes) as ‘medium’ for Algoa 1 and ‘low’ for Algoa 5. While a majority (50%) of those surveyed were in favour of the positive socio-economic benefits of an ADZ, the location of a cage fish farm in an area with lower socio-economic and ecological impact was deemed preferable. Location of the ADZ at Algoa 5 would mitigate most of the recreational and tourism economy impacts, but would have an impact on the development of the tourism potential of the Addo MPA.</p>			
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<p>Fisheries</p> <p><i>Possible ADZ impacts on fisheries included spatial reduction of fishing grounds, disease transfer to wild stocks, and genetic contamination from escapees.</i></p>	<p style="text-align: center;">Feasibility</p> <p>Based on the present recommended reduction in size of the fish farm footprint within the ADZs, the present Ecological Report and revised the impacts identified in the Final EIR (CapeEAPrac, 2013) on the squid, shark longline, pelagic, and linefish fisheries to <u>low</u> to <u>very low</u>. The negative social and economic impacts of the proposed ADZs on fisheries would thus be negligible.</p>			
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Algoa 1	Algoa 1			
Feasible in terms of low impact on fisheries	Feasible in terms of low impact on fisheries			
<p>Vessel Navigation Routes</p> <p><i>The ADZs will exclude vessel passage and anchorage and pose a potential vessel collision hazard.</i></p>	<p style="text-align: center;">Feasibility</p> <p>Negative economic impacts on vessel navigation for the Algoa 1 ADZ include restriction of the anchorage available to squid vessels during storms, restricted transit by skiboats, yachts, fishing and other vessels, and a potential collision hazard. Based on the present recommended reduction in size of the ADZs, the impact identified in the Final EIR (CapeEAPrac, 2013) on vessel navigation is revised from <u>medium</u> to <u>low</u>. No negative impact on vessel navigation was identified for Algoa 5 due to its remote location from Port</p>			

Elizabeth harbour.					
	<table border="1"> <tr> <th>Algoa 1</th> <th>Algoa 5</th> </tr> <tr> <td>Feasible in terms of low impact on vessel navigation</td> <td>Feasible in terms of low impact on vessel navigation</td> </tr> </table>	Algoa 1	Algoa 5	Feasible in terms of low impact on vessel navigation	Feasible in terms of low impact on vessel navigation
Algoa 1	Algoa 5				
Feasible in terms of low impact on vessel navigation	Feasible in terms of low impact on vessel navigation				
Conservation Value of Algoa Bay <i>The Algoa Bay marine ecosystem and habitats have a significant value to society in respect of fulfilling national marine protected area (MPA) objectives (non-use value) and its eco-tourism linked asset value.</i>	<p style="text-align: center;">Feasibility</p> <p>The present socio-economic report (Appendix 1) recognised the stakeholder concerns related to possible devaluation of the Algoa Bay ecosystem services resulting from both the Algoa 1 and Algoa 5 ADZs. The appeals to the Environmental Authorisation for a 1000ton/y fish farm at Algoa 1 and the socio-economic report indicated that the proposed mitigation measures were not sufficient to address these concerns. The survey further showed that while the socio-economic benefits of an ADZ were desirable, a significant number of respondents rated the conservation value of the bay as very important. The present ecological report rated the negative impact on the conservation objective of the Addo National Park MPA as medium significance.</p>				
	<table border="1"> <tr> <th>Algoa 1</th> <th>Algoa 5</th> </tr> <tr> <td>Feasible in respect of conservation value of Algoa Bay.</td> <td>Moderate feasibility in respect of the Addo National Park MPA objectives.</td> </tr> </table>	Algoa 1	Algoa 5	Feasible in respect of conservation value of Algoa Bay.	Moderate feasibility in respect of the Addo National Park MPA objectives.
Algoa 1	Algoa 5				
Feasible in respect of conservation value of Algoa Bay.	Moderate feasibility in respect of the Addo National Park MPA objectives.				
2. Socio-economic benefits					
Employment <i>The Algoa Bay ADZ will potentially create jobs, but the negative impacts of the ADZ on other sectors may result in job losses.</i>	<p style="text-align: center;">Feasibility</p> <p>The present Socio-economic report (Appendix 1) projects the realistic number of direct ADZ jobs would to be 100 people for a 1000t/annum and 320 people for a 3000t farm. The Ecological Report concluded that the possible loss of jobs from fisheries would be minimal if the ADZ areas were reduced in size as recommended. The socio-economic report indicates that the potential loss of tourism and recreation related jobs remains an (unquantified) concern if the Algoa 1 ADZ is approved.</p>				
	<table border="1"> <tr> <th>Algoa 1</th> <th>Algoa 5</th> </tr> <tr> <td>Moderate feasibility in respect of net jobs benefit</td> <td>Moderate feasibility in respect of net jobs benefit</td> </tr> </table>	Algoa 1	Algoa 5	Moderate feasibility in respect of net jobs benefit	Moderate feasibility in respect of net jobs benefit
Algoa 1	Algoa 5				
Moderate feasibility in respect of net jobs benefit	Moderate feasibility in respect of net jobs benefit				
Economic Impact <i>The economic impact of the Algoa Bay ADZs is determined by the net gain in income generated by the development after accounting for possible external costs to other</i>	<p style="text-align: center;">Feasibility</p> <p>The present socioeconomic report (Appendix 1) concluded that the economic benefits of the proposed ADZs were much lower than indicated in the Final EIR (CapeEAPrac, 2013). The existing South African market demand for linefish was limited and thus a 1000ton fish farm was a realistic production goal with possible organic growth to 3000t. A 1000t farm would require an investment of R70 million and generate a turnover of R60 million per annum, while a 3000t farm would require an investment of R199million and generate turnover of R612 million. Any economic benefit of an ADZ development would need to be</p>				

sectors.

balanced against the external costs to other sectors.

Algoa 1	Algoa 5
Moderate feasible	Moderate feasibility

Table 6. ECOLOGICAL FEASIBILITY

1. Ecological Costs

	Feasibility	
<p>Interactions with piscivorous marine animals (general)</p> <p><i>Piscivores are frequently attracted to the large concentrations of fish and food in sea cages, as well as attracted to other concentrations of fish also drawn by the cages or waste food settled on the substratum. Attempts to get to the caged fish not only lead to a stress response in cultured fish, but can also result in damaged nets and even entanglement of piscivores.</i></p>	<p>Due to the extensive foraging range of most large marine predators, interactions cannot be completely mitigated by site selection away from prey colonies. The Ecological Report (Appendix 2) assessed the significance of the impact as Low for Algoa 1. For Algoa 5, the proximity to the seal and bird Islands and proximity of known feeding areas for penguins, gannets, dolphins, and sharks suggests that potential impacts will be more significant and were assessed as High without mitigation and Medium with mitigation.</p>	
	<p>Algoa 1 ADZ</p> <p>Feasible with mitigation measures for large piscivorous marine mammals</p>	<p>Algoa 5 ADZ</p> <p>Medium feasibility due to medium ranked impact of interaction with marine piscivores.</p>
<p>Cetaceans-entanglement and habitat use</p> <p><i>The entanglement of marine mammals and occasionally other species such as turtles and birds in fish cage infrastructure are rare but do occur.</i></p>	<p>Feasibility</p> <p>Algoa Bay is an important cetacean habitat. Cetaceans may be able to avoid entanglement in fish cage infrastructure, but the mere presence of sea cages, as well as work boats continually travelling between land and the farm, may adversely affect habitat use and may have chronic negative effects on populations (as well as ecotourism activities). The ecological report ranked the impact on cetaceans as low.</p>	
	<p>Algoa 1 ADZ</p> <p>ADZ feasible with mitigation against cetacean entanglement</p>	<p>Algoa 5 ADZ</p> <p>ADZ feasible with mitigation against cetacean entanglement</p>
<p>Disease</p> <p><i>The high stocking densities in fish aquaculture may to the spread of infectious diseases and parasites to wild stocks.</i></p>	<p>Feasibility</p> <p>The Ecological Report (Appendix 2) ranked to likelihood of disease impact on wild populations as <u>low</u> with recommended mitigation measures.</p>	
	<p>Algoa 1 ADZ</p> <p>ADZ feasible with mitigation</p>	<p>Algoa 5 ADZ</p> <p>ADZ feasible with mitigation</p>

	against disease transmission	against disease transmission
<p>Genetic impacts on wild stocks</p> <p><i>Escape of fish from sea cages is inevitable and may affect the genetic integrity of wild stocks.</i></p>	Feasibility	
	<p>The Ecological Report ranked the likelihood of escaped cultured fish impacting the genetic integrity of wild stocks as <u>Very low</u> for Algoa 1 and <u>Low</u> for Algoa 5</p>	
	Algoa 1 ADZ	Algoa 5 ADZ
	ADZ feasible with mitigation against disease transmission	ADZ feasible with mitigation against disease transmission
<p>Benthic fauna and flora (reef)</p> <p><i>Fish farm cages should be located away from benthic reef habitats due to possible negative ecological impacts.</i></p>	Feasibility	
	<p>The Final EIR for the Algoa 1 ADZ provided for at least a 1km buffer around diving reefs (CapeEAPrac). The proposed Algoa 5 has very little reef habitat. The Ecological Report (Appendix 2) recommended that cages in the Algoa 5 ADZ be located away from any reef habitat.</p>	
	Algoa 1	Algoa 5
	Moderately Feasible in respect of benthic fauna and flora.	Feasible in respect of benthic fauna and flora.
<p>Organic pollutants: Waste</p> <p><i>Untreated wastes from uneaten food and faeces of fish in sea cages are a significant source of nutrients which may affect benthic sediments and contribute to algal blooms.</i></p>	Feasibility	
	<p>The Ecological Report (Appendix 2) modelled the organic waste dispersal and assimilation and demonstrated that the effects would not cause any measurable negative pollution effects in respect of nutrients and benthic sediments. Nonetheless, the proximity of Algoa 1 to popular diving reefs and water based recreation means that suspended particulate matter and floating oil from fish feeds could be detectable and affect the human experience of the environment. The dissolved nutrient input from the proposed ADZs into Algoa Bay would be minute compared to other sources and not cause harmful red tide blooms. The impact was rates as Low with mitigation</p>	
	Algoa 1	Algoa 5
	Moderately Feasible in respect of impact of organic waste nutrients.	Feasible in respect of impact of organic waste nutrients.
<p>Chemical pollution</p> <p><i>Disinfectants, antifoulants and therapeutic chemicals (medicines) are typically used in sea cage fish culture. These may be toxic to non target organisms and may remain active</i></p>	Feasibility	
	<p>Modern best practise farming techniques have minimised the use of chemicals which are harmful to the environment (for example, hydrogen peroxide is now used to treat ectoparasites). The Ecological Report rated the impact as <u>Low</u> with mitigation.</p>	
	Algoa 1	Algoa 5

in the environment for extended periods.

Feasible in respect of impact of organic waste nutrients

Feasible in respect of impact of organic waste nutrients

Table 7. Ranked Feasibility Comparison of Algoa 1 and Algoa 5 ADZs	Algoa 1	Algoa 5
Aquaculture Economic Feasibility	Score out of 5	Score out of 5
Aquaculture Site Feasibility		
Distance from Port	4	1
Wind and Swell	2	1
Temperature (kob)	1	1
Temperature (yellowtail)	2	2
Red Tide risk	2	2
Overall Site Suitability (Distance+Wind and Swell+Temperature+Red tide/5)	2,2	1,4
Aquaculture Business Feasibility 1000t and 3000t farm scale		
Market	3	3
Value chain	3	3
Margin EBITDA (Earnings before Interest, Taxation, Deductions and Amortisation)	2	2
Overall Investment Case (Market+Value Chain+margin)	2,7	2,7
Overall Aquaculture Feasibility (Site Feasibility + Aquaculture Business Feasibility)	2,4	1,9
Socio-economic Feasibility		
Recreation and Tourism	1	4
Fisheries	4	4
Vessel Navigation Routes	4	4
Conservation Value of Algoa Bay	4	3
Employment	4	4
Economic Impact	4	4
Overall Socioeconomic Feasibility	3,5	3,8
Ecological Feasibility		
Interactions with piscivorous marine animals	4	3
Cetaceans-entanglement and habitat use	4	4
Disease	4	4
Genetic impacts on wild stocks	4	4
Benthic fauna and flora (reef)	3	4
Organic pollutants: Waste	3	4
Chemical pollution	4	4
Overall Ecological Feasibility	3,7	3,9
Overall Feasibility score (Economic+Socio-economic+Ecological/15)	9,6	9,6

5. DISCUSSION

The present feasibility analysis complements the environmental impact assessment of the Algoa 1 and Algoa 5 sites which focused primarily on the impacts on the ecology of Algoa Bay and its users (CapeEAPrac, 2013). Shortcomings identified in the 28 appeals to the Environmental Authorisation, which were addressed in the present ADZ comparative analysis, were 1) the lack of a feasibility study on the economic viability of the proposed ADZ's, 2) a cost-benefit analysis of the expected socio-economic gains of fish farming versus potential costs to other sectors and 3) a re-assessment of the final EIR ecological impacts, based on a reduced ADZ footprint and oceanographic modeling the dispersal fish farmed organic (faeces and uneaten food) waste.

The Ecological Report re-assessment of the impacts identified for the Algoa 1 and Algoa 5 ADZs indicated that most could be effectively mitigated, such that fish cage aquaculture operations would have a 'low' to 'very low' ecological impact. These included identified impacts on benthic fauna and flora, organic and chemical pollutants, genetic contamination and disease transfer to wild fish populations, and entanglement of cetaceans. The feasibility ranking for Algoa 1 was slightly lower (moderately feasible) than Algoa 5 (feasible) for benthic fauna and flora and organic pollution due to possible effects on diving and other recreational activity. However, for Algoa 5, the ADZ's impact on large piscivorous animals was assessed as 'moderately feasible' due to its proximity to the seal and bird islands and known feeding areas for penguins, gannets, dolphins, and sharks. The overall ecological feasibility scores were similar for both Algoa 1 and Algoa 5, and with aquaculture deemed 'feasible' due to the generally low ecological impacts (Table 7).

The socio-economic feasibility analysis yielded similar ranking for all criteria, except for the highly negative socio-economic impact indicated for the Algoa 1 ADZ. The major public outcry and 28 substantive appeals by stakeholders indicate that the Algoa 1 ADZ has a low social (and hence political) acceptability. The Final EIR, review 28 appeals, and public perception survey (Hosking, 2016) confirmed that the socio-economic cost to the tourism and recreation sectors of developing the Algoa 1 ADZ was a real, but unquantified concern. While a majority of survey respondents were in favour of the positive socio-economic benefits of aquaculture, they were also concerned about the conservation value of Algoa Bay. The socio-economic feasibility analysis revealed that the socio-economic benefits (as jobs and income) indicated in the Final EIR were unrealistically high, when the South African market demand and farm biosecurity considerations were taken into account. Realistically, the South African market could currently absorb 500-1000t of a linefish substitute such as kob, with possible organic growth in demand to expand production to 3000t. This equates to 100 and 320 direct respectively. The impact of the Algoa ADZ on fisheries income and jobs was however over-estimated in the original EIR and ranked as a negligible impact. Although SANParks objected to the Algoa 5 ADZ in the 28 appeals, the Department of Environmental Affairs has nonetheless made provision for an aquaculture area of 1000ha within the proposed MPA (DEA, 2016). The overall socio-economic feasibility score was thus slightly higher for Algoa 5 compared to Algoa 1 due to the perceived negative impact on the recreation and tourism economy of the Port Elizabeth beachfront (Table 7).

The present Algoa Bay ADZ Economic Feasibility analysis indicates an overall low to very low economic viability for both the Algoa 1 and Algoa 5 ADZs under present technological and market conditions (Tables 4, 7). The Algoa Bay temperature regime is unsuitable for kob aquaculture as its growth rate is uneconomic at the average bay temperature of 18°C, and the regular upwelling events will compromise fish growth and health. Yellowtail growth is better under the Algoa Bay temperature regime with 1.2kg attainable within 12 months. The high wind and swell exposure at both sites limits the number of sea days using small work vessels and conventional cages, requiring an 'offshore aquaculture' equipment specification which would increase capital costs substantially. 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. Although Algoa 1 is more sheltered from SW swells and closer to port than Algoa 5, it is none the less highly exposed to wind and swell precluding daily servicing with conventional equipment. This could be mitigated to some extent by using more highly specified 'offshore aquaculture' technology which is currently in a development phase. The high-level financial model presented for 1000

ton/y and 3000 ton/y fish farm units, which was based on conventional cage culture specifications and industry benchmarks, indicates marginal economic viability for both the Algoa 1 and Algoa 5 sites. The susceptibility of Algoa Bay to red tide blooms presents an investment uncertainty and risk and was ranked as moderately feasible. The cumulative combination of unsuitable environmental conditions, difficult sea-based logistics, uneconomic growth rates, limited current market demand, high capital costs and marginal returns renders the overall economic feasibility of the Algoa 1 as 'low' and Algoa 5 ADZ's as 'very low' for cage culture of indigenous marine species (Table 7).

6. CONCLUSIONS

6.1 ECOLOGICAL FEASIBILITY

6.1.1 The Algoa 1 ADZ is rated as ecologically feasible (low to very low impact) with appropriate mitigation measures.

6.1.2 The Algoa 5 ADZ is ecologically feasible (low to very low impact with mitigation) with appropriate mitigation measures.

6.2 SOCIO-ECONOMIC FEASIBILITY

6.2.1 For Algoa 1, the socio-economic feasibility was ranked 'moderately feasible' for most indicators (Table 7). The unquantified socio-economic costs and trade-offs associated with the 'tourism and recreation' economy were however ranked as a 'very low feasibility'.

6.2.2 For Algoa 5, the socio-economic feasibility was ranked 'moderately feasible' for most indicators (Table 7).

6.3 ECONOMIC FEASIBILITY

6.3.1 The known market for indigenous South African marine fish such as kob and yellowtail is of the order of 500-1000 tons per annum. The international market export prospects for these species are not positive.

6.3.2 The economic feasibility of Algoa 1 is ranked 'low' and Algoa 5 'very low', due to the unsuitable environmental conditions, susceptibility to red tide events, limited market demand, and exposure to high wind and swell conditions. The lower economic feasibility ranking of Algoa 5 compared to Algoa 1 is due to the greater distance of the ADZ from port.

6.3.3 Based on the limited market potential and farm biosecurity considerations, which require a buffer zone between farms to reduce the risk of disease transmission between farms, the Algoa 1 ADZ could accommodate one 3000t farm on a 210ha footprint with expansion potential to 9000t. The Algoa 5 ADZ could accommodate two 3000t farms each on 210ha (with expansion potential to 9000t each), separated by a 2.4km biosecurity buffer.

7. RECOMMENDATIONS

7.1 Aquaculture is ecologically feasible at both the Algoa 1 and Algoa 5 sites with appropriate mitigation.

7.2 Aquaculture is socio-economically 'moderately feasible' at both Algoa 1 and Algoa 5 ADZs for most indicators, however the 'very low' feasibility ranking in respect of the negative impact on the recreation and tourism economy mitigates against recommending the Algoa 1 ADZ.

7.3 The economic feasibility of aquaculture is 'low' for the Algoa 1 ADZ and 'very low' for the Algoa 5 ADZ under the current species technology and market conditions. It is thus an option not to zone either ADZ for aquaculture.

7.4 The economic feasibility of aquaculture at the Algoa 1 and 5 ADZs might improve in the future if alternative species are developed and/or 'offshore aquaculture' technology advances to become economically viable. Given the negative impact on the Algoa 1 ADZ on the Port Elizabeth recreation and tourist economy, it is thus an option to zone the Algoa 5 ADZ for possible future aquaculture development.

7. REFERENCES

- Abbink W, Garcia AB, Roques JAC, Partridge GJ, Kloet K, and Schneider O (2012) The effect of temperature and pH on the growth and physiological response of juvenile yellowtail kingfish *Seriola lalandi* in recirculating aquaculture systems. *Aquaculture* DOI: 10.1016/j.aquaculture.2011.11.043.
- Anchor Environmental (2011) '*Strategic Environmental Assessment: Identification of potential aquaculture development zones for finfish cage culture.*' Draft for Public Comment. Report prepared for Department of Agriculture, Forestry and Fisheries, Cape Town.
- Bloom J. (2013) '*Socio-Economic Impact Assessment for the proposed Algoa Bay sea-based Aquaculture Development Zones, Port Elizabeth*', Appendix B3, Final Environmental Impact Report.
- CapeEAPrac (2013) *Final Impact Assessment Report and Environmental Management Programme. Algoa Bay Sea-Based Aquaculture Development Zones Port Elizabeth.* Cape Environmental Assessment Practitioners (Cape EAPrac). Prepared for the Applicant: Department of Agriculture, Forestry and Fisheries (DAFF).
- DAFF (2013). *National Aquaculture Policy Framework for South Africa.* Department of Agriculture, Forestry and Fisheries, Government Notice 763. Government Gazette Volume 580, No. 36920.
- Department of Environmental Affairs (2016). *Draft Notice Declaring The Addo Elephant Marine Protected Area Under Section 22a Of The National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003).* Government Gazette Notice: No. R. 116 by Department Of Environmental Affairs: National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003). 3 February 2016.
- Hosking, S (2016) Socio-Economic Impact Review and Social Choice Modelling Experiment for the Proposed Algoa Bay Sea-Based Aquaculture Development Zones, Port Elizabeth. In: Britz PJ, Hosking S, Schoonbee W and Johnson G. *Comparative Assessments For The Development of the Proposed Sea-Based Aquaculture Development Zone Located Within Algoa Bay, Eastern Cape Province.* A report for the Department of Agriculture, Forestry and Fisheries by Rhodes University, August 2016.