agriculture, forestry & fisheries

Department: Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

ALGOA BAY SEA-BASED AQUACULTURE DEVELOPMENT ZONE

BASIC ASSESSMENT PROCESS IN TERMS OF THE NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998 (ACT NO. 107 OF 1998)

PRE-APPLICATION BASIC ASSESSMENT REPORT
APPENDIX D: MARINE SPECIALIST IMPACT ASSESSMENT

ANCHOR research & monitoring

Anchor Research and Monitoring Report No. 1808/2

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MARINE SPECIALIST IMPACT ASSESSMENT

February 2019

Report Prepared for:
Department of Agriculture, Forestry & Fisheries

agriculture, forestry & fisheries
Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

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PROJECT DETAILS

Objective	Application for Environmental Authorisation in terms of the National Environmental Management Act, 1998 (Act No 107 of 1998)
Applicant	Department of Agriculture, Forestry & Fisheries
Environmental Assessment Practitioner (EAP)	Vera Massie and Dr Barry Clark from Anchor Research & Monitoring (Pty) Ltd
Anchor Project Name	Algoa Bay Sea-Based Aquaculture Development Zone Marine Impact Assessment Report - Draft
Anchor Project Number	1808
Deliverable	2
Status	Pre-application
Application submission date	Not submitted
Competent Authority Reference	Not currently assigned
Case Officer	Not currently assigned

OVERVIEW OF PROJECT OUTPUTS
BASIC ASSESSMENT REPORT AND APPENDICES

Basic Assessment Report (BAR)	**Pre-Application BAR**, Draft BAR, Final BAR
Appendix A	Details of EAP, Expertise and Declaration
Appendix B	Details of Specialists, Expertise and Declaration
Appendix C	Background Information Document
Appendix D	Specialist studies: 1. Benthic Mapping Assessment for the Proposed Algoa Bay Sea-Based Aquaculture Development Zone (Dawson *et al.* 2019) 2. Dispersion Modelling Study for the Proposed Algoa Bay Sea-Based Aquaculture Development Zone (Wright *et al.* 2019) **3. Marine Specialist Study 2019 (Hutchings *et al.* 2019)** 4. Maritime Underwater Heritage Specialist Study (Gribble 2019) 5. Comparative Assessments for the Development of the Proposed Sea Based Aquaculture Development Zone Located within Algoa Bay in the Eastern Cape in South Africa (Rhodes University August 2016) a. Socio-economic Report b. Ecological Report c. Feasibility study
Appendix E	Stakeholder Consultation Report
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GLOSSARY

Alien	An organism occurring outside its natural past or present range and dispersal potential including any parts of the organism that might survive and subsequently reproduce (organisms whose dispersal is caused by human action).
Aquaculture	The propagation, improvement, trade or rearing of aquatic organisms (plant and animal) in controlled or selected aquatic environments (fresh, sea or brackish waters, on land or at sea) for any commercial, subsistence, recreational or other public or private purposes.
Bathymetry	The measured depth of water in oceans, seas, or lakes.
Bioaccumulation	The process where the chemical concentration in an aquatic organism achieves a level that exceeds that in the water as a result of chemical uptake through all routes of chemical exposure (e.g. dietary absorption, transport across the respiratory surface, dermal absorption).
Biosecurity	A set of preventive measures designed to reduce the risk of transmission of infectious diseases, quarantined pests, invasive alien species, and living modified organisms.
Chemical oxygen demand	A measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as Ammonia and nitrite.
Fingerlings	Juvenile fish that have developed scales and working fins.
Fry	Juvenile fish that have developed to the point where they are capable of feeding themselves.
Gametogenesis	The production of sperm and eggs.
Invasive	Alien organisms that have naturalised in a new area and expanding their range.
Mariculture	Marine aquaculture is the process of cultivating and harvesting sea based aquatic organisms.
Mixing zone	A mixing zone is an administrative construct which defines a limited area or volume of the receiving water where the initial dilution of a discharge is allowed to occur, until the water quality standards are met. In practice, it may occur within the near-field or far-field of a hydrodynamic mixing process and therefore depends on source, ambient, and regulatory constraints.
Solid waste	All solid waste, including construction debris, chemical waste, excess cement/concrete, wrapping materials, timber, tins and cans, drums, wire, nails, food and domestic waste (e.g. plastic packets and wrappers).
Species	Defined in terms of the National Environmental Management: Biodiversity Act (Act No 10 of 2004), which means a kind of animal, plant or other organism that does not normally interbreed with individuals of another kind, and includes any subspecies, cultivar, variety, geographic race, strain, hybrid or geographically separate population.
Turbidity	The cloudiness or haziness of a fluid caused by large numbers of individual organic and/or inorganic particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality.
Upwelling	A process that is induced by offshore winds transporting coastal surface water offshore, which is replaced by rising deep, cold and nutrient-rich water.

ABBREVIATIONS

ADZ	Aquaculture Development Zone
Anchor	Anchor Environmental Consultants (Pty) Ltd
AIS	Alien and Invasive Species
BA	Basic Assessment
BAR	Basic Assessment Report
CDC	Coega Development Corporation
COD	Chemical Oxygen Demand
CSIR	Council for Scientific and Industrial Research
CWDP	Coastal Waters Discharge Permit
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DEA:O&C	Department of Environmental Affairs Branch: Oceans & Coasts
DEDEA	Department of Economic Development and Environmental Affairs
DST	Department of Science and Technology
DO	Dissolved oxygen
EA	Environmental Authorisation
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
HDPE	High Density Poly-Ethylene
ICMA	National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008)
IDZ	Industrial Development Zone
I&J	Irvin and Johnson Limited
MIAR	Marine Impact Assessment Report
MPA	Marine Protected Area
NEMBA	National Environmental Management: Biodiversity Act (Act No 10 of 2004)
PE	Port Elizabeth
ppt	Parts per thousand also abbreviated as ‰
PVC	Polyvinyl chloride
RMZ	Recommended Mixing Zone
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SoE	State-owned Enterprise
TSS	Total Suspended Solids

EXECUTIVE SUMMARY

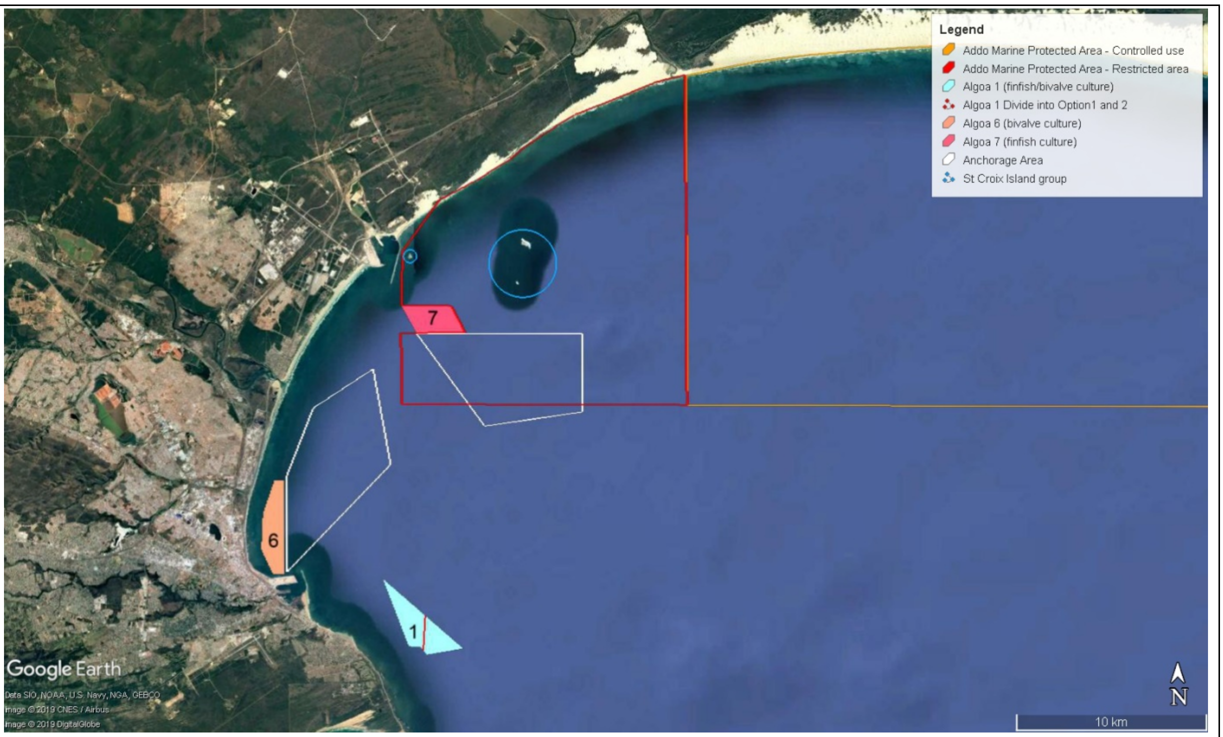
The Department of Agriculture, Forestry and Fisheries (DAFF), as the lead agent for aquaculture management and development in South Africa, has been mandated to establish and manage a sea-based Aquaculture Development Zone (ADZ) in Algoa Bay located in the Eastern Cape. The sea-based ADZ will consist of a selection of designated precincts, which will provide opportunities for existing aquaculture operations to expand and new ones to be established without the need for lengthy, expensive approval processes. The 2009 Strategic Environmental Assessment (SEA) highlighted the Eastern Cape as an area with potential to support an ADZ.

As part of a finer-scale SEA undertaken by DAFF in 2011, two precincts, namely Algoa 1 (off Humewood, Port Elizabeth) and 5 (north-east of the Coega Harbour) were identified as the most promising options for establishment of an ADZ in this area. Environmental Authorisation (EA) was granted for Algoa 1 on 9 July 2014 following a lengthy Environmental Impact Assessment (EIA) process, which was initiated in 2010. During the appeals process that followed the positive decision, a total of twenty eight (28) substantive appeals were lodged against the decision. In response, the Minister of Environmental Affairs issued a decision on the Appeal suspending the EA to allow for further studies to be undertaken.

In mid-2016, DAFF commissioned three comparative assessments, which assessed the potential impacts associated with Algoa 1 and 5 and commissioned three comparative assessments in 2016 including; a detailed feasibility study, a socio-economic assessment, and a marine ecological assessment (these studies are included as stand-alone reports in Appendix D of this BAR). The economic feasibility study (Britz and Sauer 2016b) found that conditions at Algoa 5 were sub-optimal for economic aquaculture and mitigation measures would be impractical or uneconomic to implement, which renders the proposed site not economically competitive. Furthermore, Algoa 5 is located in the middle of the Addo Marine Protected Area (MPA), which was recently approved by cabinet. For the reasons described above, Algoa 5 was screened out and has not taken forward as a potential precinct in the current Basic Assessment process.

DAFF has since withdrawn the original application for environmental authorisation and intends to submit a new application for the development of the ADZ for which a Basic Assessment process is required in terms of the 2017 EIA Regulations of the National Environmental Management Act (Act 107 of 1998) (this application). DAFF intends for the ADZ to accommodate finfish as well as bivalve culture (oysters/mussels) within a combination of precincts.

The precincts considered in this application include one precinct from the previous process (Algoa 1), and two new precincts, designated as Algoa 6 and 7 (See figure below). Algoa 6, situated near the Port Elizabeth Harbour, was identified but screened out in the strategic environmental assessment (SEA) phase of the original EIA (2010-2014) which focussed only on finfish culture, and is now been put forward as a suitable site for bivalve production in this new (2019) application process. Algoa 7 is a new precinct located directly in front of the Ngqura harbour that has been identified as a potential site for finfish culture. This site has undergone an internal feasibility assessment in which it was found to be suitable in terms water depth, shipping traffic, and accessibility (i.e. financial considerations). This site falls within with the recently approved Addo Marine Protected Area (MPA) but the Department of Environmental Affairs Branch Oceans and Coasts and the DAFF are in discussions regarding this precinct. Thus, in this application process, two sites, Algoa 1 and 7, are being put forward for finfish culture , while one of these, Algoa 1, along with a third site, Algoa 6, is being put forward for bivalve culture (See figure below).



Precincts considered during the 2019 application for environmental authorisation for a sea-based Aquaculture Development Zone in Algoa Bay, Eastern Cape. Precincts 1, 6 and 7 constitute feasible precincts and have been considered during the present Basic Assessment process.

DAFF is seeking to promote farming of both bivalves and finfish in Algoa Bay. Rather than considering each of the three sites (Algoa 1, 6 and 7) in isolation, three alternative configurations of precincts, Options A, B and C, as outlined in the table below, are being considered in this Basic Assessment process. These three options allow for varying degrees of farming intensities by excluding finfish farming at Algoa 1 (Option B) or excluding Algoa 1 as a whole (Option C). Potential environmental impacts associated with each of these options have been assessed in this marine specialist study.

Option	Algoa 1	Algoa 7	Algoa 6
A	Finfish & Bivalve	Finfish	Bivalve
B	Bivalve	Finfish	Bivalve
C	X	Finfish	Bivalve
D	X	X	X

DAFF appointed Anchor Research & Monitoring (Pty) Ltd (Anchor) to undertake the Basic Assessment (BA) process for the proposed Aquaculture Development Zone in Algoa Bay. The proposed sea-based ADZ has a wide range of potential impacts on the marine environment. Anchor therefore conducted a marine specialist study to assess the impacts on the marine environment and recommend mitigation measures. This marine specialist study is included in Appendix D of the Basic Assessment Report.

Information and data collected and analysed by the marine specialists during the previous and current EIA processes (Hutchings et al. 2013a/b, Dawson *et al.* 2019 and Wright *et al.* 2019) and the findings of the comparative socio-economic feasibility study compiled by the Rhodes University in 2016 (Britz *et al*. 2016a/b and Britz and Sauer 2016) informed this marine ecological impact assessment. Existing information was reviewed and updated using available desktop information pertaining to the nature of the marine environment, the aquaculture industry and potential impact and mitigation measures where required. The Terms of Reference for the marine ecological specialist study are as follows:

1. A summary description of the receiving environment highlighting sensitive and significant habitats, fauna and flora including maps with locations of sensitive/significant features and habitats;
2. A summary of the findings of the dispersion modelling study and the benthic habitat mapping study;
3. A recommendation of species to consider for the ADZ;
4. Description and assessment of potential impacts associated with the operation of the ADZ;
5. A site recommendation considering the preferred as well as the alternative sites from an ecological perspective; and
6. Recommendations on measures to be adopted/implemented that are expected to mitigate negative impacts on the ecology of the area.

This **marine specialist study** describes and assesses potential environmental impacts associated with each of the three precincts (Algoa 1, 6, and 7) individually first, and subsequently in combination in the form of alternate options as they have been configured for this EIA process (i.e. Option A, B and C, see table above) together with the No-Go option (Alternative D).

The tables below summarise the impacts that may be experienced during the construction and operational phases of the project for finfish mariculture in Algoa 1 and 7, and bivalve mariculture in Algoa 1 and 6, before and after mitigation. The installation of the finfish cages and bivalve longlines and rafts is very swift and the only impact identified for this phase was the disturbance of subtidal habitat, which was rated **low** and **very low** without and with mitigation measures respectively. Fourteen impact types were identified during the operational phase.

Two impacts either did not require mitigation due to low significance, or because there was no feasible mitigation possible. Six impacts were rated **very high** or **high** before mitigation, but only one impact was rated **high** post mitigation (rated **very high** before mitigation). Eight impacts were rated **medium** before mitigation but all of these were rated **low** post mitigation. Four impacts were rated **low** or before mitigation, most of which were rated **very low** post mitigation. Overall post mitigation, one **high,** four **medium** and 13 **low** impacts remained.

Table 1 **Summary of potential marine ecology impacts for the construction of the proposed ADZ mariculture development (finfish and shellfish) in Algoa Bay.**

	Impact identified	Consequence	Probability	Significance	Status	Confidence
CP-ME 1	Disturbance of subtidal habitat	Low	Definite	**LOW**	-ve	High
	With mitigation	Very Low	Definite	**VERY LOW**	-ve	High

Table 2 **Summary of potential marine ecology impacts for the operation of *finfish farms* in the proposed Aquaculture Development Zone development in Algoa Bay.**

Impact identified		Consequence	Probability	Significance	Status	Confidence
OP-ME 1	Disease and parasite transmission to wild fish stocks (ongoing, may be reversible).	Very High	Definite	**VERY HIGH**	-ve	High
	With mitigation	High	Probable	**HIGH**	-ve	Medium
OP-ME 2	Organic waste discharge impacting on the water column and benthic environment arising from mariculture operations (ongoing but reversible).	High	Definite	**HIGH**	-ve	High
	With mitigation	Medium	Definite	**MEDIUM**	-ve	Medium
OP-ME 3	Genetic contamination of wild stocks with escapees from finfish cage culture at Algoa 1 & 7 (ongoing and irreversible).	Very High	Possible	**HIGH**	-ve	Low
	With mitigation	Medium	Improbable	**LOW**	-ve	Low
OP-ME 4	Use of chemical therapeutants and antifoulants in finfish cage culture at Algoa 1 (ongoing but reversible).	Medium	Probable	**MEDIUM**	-ve	Medium
	With mitigation	Low	Probable	**LOW**	-ve	Low
	Use of chemical therapeutants and antifoulants in finfish cage culture at Algoa 7 (ongoing but reversible).	High	Probable	**HIGH**	-ve	Medium
	With mitigation	Low	Probable	**MEDIUM**	-ve	Low
OP-ME 5a	Accidental entanglement of cetaceans in mariculture infrastructure (ongoing but reversible).	Medium	Probable	**MEDIUM**	-ve	Medium
	With mitigation	Medium	Possible	**LOW**	-ve	Low
OP-ME 5b	Possible impacts on cetaceans resulting from alterations in habitat use or migration patterns (ongoing but reversible).	Low	Probable	**LOW**	-ve	Medium
	With mitigation	Low	Probable	**LOW**	-ve	Low

Impact identified		Consequence	Probability	Significance	Status	Confidence
OP-ME6	Piscivorous marine animals interfering with finfish cage culture operations at Algoa 1 (ongoing but reversible).	Medium	Probable	**MEDIUM**	-ve	Medium
	With mitigation	Low	Probable	**LOW**	-ve	Low
	Piscivorous marine animals interfering with finfish cage culture operations at Algoa 7 (ongoing but reversible).	High	Probable	**HIGH**	-ve	Medium
	With mitigation	Medium	Probable	**MEDIUM**	-ve	Low
OP-ME7	Possible impacts on the proposed Addo Elephant MPA, Algoa 7 (irreversible).	Medium	Definite	**MEDIUM**	-ve	High

Table 3 **Summary of potential marine ecology impacts for the operation of _bivalve farms_ in the proposed Aquaculture Development Zone development in Algoa Bay.**

Impact identified		Consequence	Probability	Significance	Status	Confidence
OP-ME 8a	Introduction of alien bivalve species (Mediterranean mussel *Mytilus galloprovincialis*) to the wild.	Low	Improbable	**VERY LOW**	-ve	Medium
	No mitigation required	N/A	N/A	N/A	N/A	N/A
OP-ME 8b	Introduction of alien bivalve species (Pacific oyster *Crassostrea gigas*) to the wild	High	Possible	**MEDIUM**	-ve	Medium
	With mitigation	Medium	Possible	**LOW**	-ve	Medium
OP-ME 9	Introduction of alien fouling species to the wild and provision of habitat to alien fouling species	Medium	Definite	**MEDIUM**	-ve	Medium
	With mitigation	Low	Probable	**LOW**	-ve	Medium
OP-ME 10	Disease and parasite transmission to wild bivalve stocks (ongoing, may be reversible).	Very High	Definite	**HIGH**	-ve	High
	With mitigation	Medium	Possible	**LOW**	-ve	Medium
OP-ME 11	Organic pollution and habitat modification (ongoing but reversible).	High	Possible	**MEDIUM**	-ve	High
	With mitigation	Medium	Possible	**LOW**	-ve	Medium
OP-ME 12	Genetic contamination of wild stocks from bivalve mariculture at Algoa 1 and 6 (ongoing and irreversible).	Low	Improbable	**VERY LOW**	-ve	Medium

	Impact identified	Consequence	Probability	Significance	Status	Confidence
OP-ME 13a	Accidental entanglement of cetaceans in bivalve mariculture infrastructure (ongoing but reversible).	Medium	Probable	**MEDIUM**	-ve	Medium
	With mitigation	Medium	Possible	**LOW**	-ve	Low
OP-ME 13b	Possible impacts on cetaceans resulting from alterations in habitat use or migration patterns (ongoing but reversible).	Low	Probable	**LOW**	-ve	Medium
	With mitigation	Low	Probable	**LOW**	-ve	Low

Due to the presence of sea bird and seal colonies and the anticipated increase in abundance of wild fish and other biota in the Addo MPA, the use of chemical therapeutants and antifoulants, genetic contamination of wild stocks and interactions with piscivorous marine animals (cetaceans sharks, seabirds) with finfish cage culture operations are ranked as having a higher negative impacts on the marine environment at Algoa 7 compared to Algoa 1.

Assessing the four proposed development alternatives (A, B, C and D as shown above) in terms of the number of medium and high significance impacts, favours alternatives B and C over alternative A (see table below). This is simply a result of more mariculture development having more impacts (i.e. having two fish farming sites with a greater total number of cages and higher biomass of farmed fish versus only one). Decision making authorities must, however, be cognisant of the fact that this development is likely to result in a number of moderately significant impacts after mitigation even for the smaller scale of development in options B and C.

The Status Quo Alternative (i.e. Option D) proposes that the Algoa Bay ADZ does not go ahead. This would mean that the negative impacts on biodiversity and conservation efforts in Algoa Bay will not be realised. Impact levels as currently observed will be continued.

Alternative	**A**	**B**	**C**	**D**
Activities	**Algoa 1: finfish and bivalves Algoa 6: bivalves Algoa 7: finfish**	**Algoa 1: bivalves Algoa 6: bivalves Algoa 7: finfish**	**Algoa 6: bivalves Algoa 7: finfish**	**No Go**
Low	23	18	10	0
Medium	6	5	5	0
High	2	1	1	0

Due to the impact level observed even after mitigation and the inclusion of Algoa 7 (MPA site) in options A, B and C, it is recommended that no more than three fin fish operators should be approved for an initial pilot phase, with a total annual production for the ADZ not exceeding 1 000 tonnes in the first year. Should monitoring reveal acceptable impacts as defined by the environmental quality objectives, indicators and performance measures, operators should be permitted to increase production from pilot phase to full commercial scale (not exceeding the carrying capacity at each site for *Seriola lalandi* and *Argyrosomus sp.* as recommended in Wright et al. 2019) over at least a three year period, provided that resource quality objectives are maintained.

Furthermore, the specialist study recommends the following mitigation measures:

- Cages should not be moored over long lived biogenic habitats (i.e. potential reef area identified within Algoa 1 should be excluded) and ensuring minimal movement of moorings during operation or maintenance to keep impact footprint to a minimum;
- A biosecurity management plan should provide mitigation measures to (1) reduce the likelihood of escape occurring; (2) ensure comprehensive training of staff; (3) monitor stock comprehensively for disease and/parasites as part of a formalised stock health monitoring programme and take necessary action to eliminate pathogens through the use of therapeutic chemicals or improved farm management (lowest effective dose); (4) locate cages stocked with different cohorts of the same species as far apart as possible (no less than 100 m).
- If possible, different species should be stocked in cages successively, and stocking option and cage set up recommendations as outlined in the dispersion modelling report should be implemented. Site selection should be influenced by dispersion potential (i.e. well-flushed, deep and productive areas). A comprehensive sediment and water quality monitoring program to determine intensity of impacts should be developed and implemented prior to the operational phase.
- Genetic compatibility between wild and cultured stock by implementing the "Genetic Best Practice Management Guidelines for Marine Finfish Hatcheries" developed by DAFF and ensure adequate genetic monitoring.
- Suitable predator nets and visual deterrents should be installed and maintained. A protocol for dealing with problem piscivores in conjunction with experts and officials should be developed.
- South African oyster hatcheries should be developed to reduce the reliance on spat import, and hence the risk of non -intentional introduction of associated alien species. The cleaning of biofouled infrastructure (ropes etc.) must be conducted in such a way as to minimise deposition to the seafloor beneath the farms (i.e. biofouling must be collected as deposited of at a suitable onshore disposal facility). Routine surveillance on and around marine farm structures, associated vessels and infrastructure must be undertaken for indications of non-native fouling species. If spat import cannot be avoided, culture facilities should only be permitted to use spat sourced from biosecure certified hatcheries and/or quarantine facilities.

In conclusion, the impact assessment of the alternative options provided by the applicant show that Option C has the lowest overall impact on marine ecology. However, the competent authority must consider that there are a number of moderately significant impacts and at least one highly significant negative impact after mitigation for all options. The impact significance of the proposed development on conservation objectives (protection of biota and ecosystem functioning), has been ranked as medium and there are no feasible mitigation measures that could reduce this impact. A comprehensive, site specific Environmental Management Programme (EMPr), which includes the conditions of the overarching ADZ EMPr must be developed and implemented for each aquaculture farm within the ADZ. This EMPr must require independent monitoring of sufficient indicators in order to detect and quantify any of the environmental impacts described in this Basic Assessment Report, and must specify thresholds of concern which require remedial action. The development of the ADZ should be phased in so that cumulative impacts can be detected as they arise, and rigorous adaptive management implemented.

1 INTRODUCTION

The Department of Agriculture, Forestry and Fisheries (DAFF), as the lead agent for aquaculture management and development in South Africa, has been mandated to establish and manage a sea-based Aquaculture Development Zone (ADZ) in Algoa Bay located in the Eastern Cape. The ADZ will consist of a selection of designated precincts that will provide opportunities for existing aquaculture operations to expand and new ones to be established. ADZs provide economic benefits to the local community through job creation and regional economic diversification and allow commercial aquaculture operations to be set up without the need for lengthy, expensive approval processes. Aquaculture is one of the sectors that form part of Operation Phakisa - an initiative of the South African Government launched in 2014 which aims to implement priority marine based economic and social programmes faster and more effectively. The proposed Algoa Bay ADZ will offer significant potential for rural development and will provide employment opportunities for local and regional communities. The 2009 Strategic Environmental Assessment (SEA) highlighted the Eastern Cape as an area with potential to support an ADZ.

As part of a finer-scale SEA undertaken by DAFF in 2011, two precincts, namely Algoa 1 (off Humewood, Port Elizabeth) and 5 (north-east of the Coega Harbour) were identified as the most promising options for establishment of an ADZ in this area. Environmental Authorisation (EA) was granted for Algoa 1 on 9 July 2014 following a lengthy Environmental Impact Assessment (EIA) process, which was initiated in 2010. During the appeals process that followed the positive decision, a total of twenty eight (28) substantive appeals were lodged against the decision. In response, the Minister of Environmental Affairs issued a decision on the Appeal suspending the EA to allow for further studies to be undertaken.

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DAFF has since withdrawn the original application for environmental authorisation and intends to submit a new application for the development of the ADZ for which a Basic Assessment process is required in terms of the 2017 EIA Regulations of the National Environmental Management Act (Act 107 of 1998) (this application). DAFF intends for the ADZ to accommodate finfish as well as bivalve culture (oysters/mussels) within a combination of precincts.

The precincts considered in this application include one precinct from the previous process (Algoa 1), and two new precincts, designated as Algoa 6 and 7 (See figure below). Algoa 6, situated near the Port Elizabeth Harbour, was identified but screened out in the strategic environmental assessment (SEA) phase of the original EIA (2010-2014) which focussed only on finfish culture, and is now been put forward as a suitable site for bivalve production in this new (2019) application process. Algoa 7 is a new precinct located directly in front of the Ngqura harbour that has been identified as a potential site for finfish culture. This site has undergone an internal feasibility assessment in which it was found to be suitable in terms water depth, shipping traffic, and accessibility (i.e. financial considerations). This site falls within with the recently approved Addo Marine Protected Area (MPA) but the Department of Environmental Affairs Branch Oceans and Coasts and the DAFF are in discussions regarding this precinct. Thus, in this application process, two sites, Algoa 1 and 7, are being put forward for finfish culture , while one of these, Algoa 1, along with a third site, Algoa6, is being put forward for bivalve culture (Figure 1).

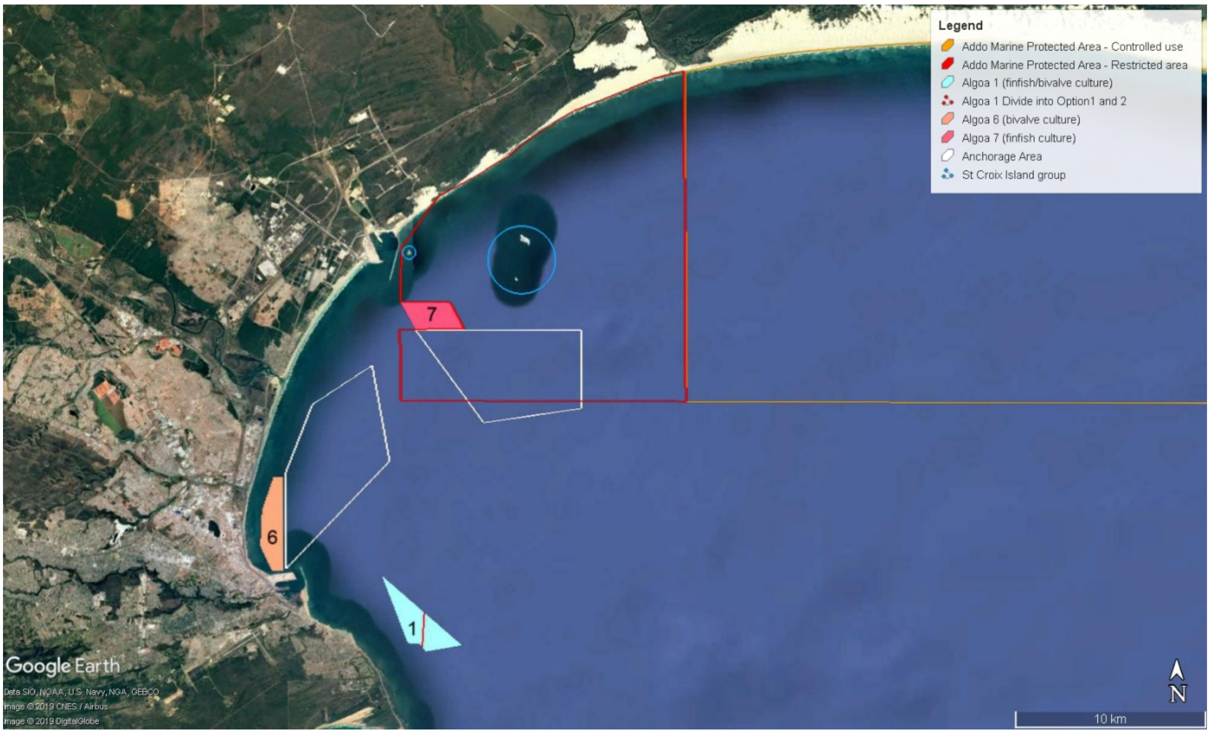

Figure 1 **Precincts considered during the 2019 application for environmental authorisation for a sea-based Aquaculture Development Zone in Algoa Bay, Eastern Cape. Precincts 1, 6 and 7 constitute feasible precincts and have been considered during the present Basic Assessment process.**

DAFF is seeking to promote farming of both bivalves and finfish in Algoa Bay. Rather than considering each of the three sites (Algoa 1, 6 and 7) in isolation, three alternative configurations of precincts, Options A, B and C, as outlined in the Table 4 are being considered in this Basic Assessment process. These three options allow for varying degrees of farming intensities by excluding finfish farming at Algoa 1 (Option B) or excluding Algoa 1 as a whole (Option C). Potential environmental impacts associated with each of these options have been assessed in this marine specialist study.

Table 4 Alternative ADZ development scenarios on the three precincts within Algoa Bay.

Option	Algoa 1	Algoa 7	Algoa 6
A	Finfish & Bivalve	Finfish	Bivalve
B	Bivalve	Finfish	Bivalve
C	X	Finfish	Bivalve
D	X	X	X

The Algoa 5 site was screened out of this EIA process due to the very low economic feasibility ascribed to this site by Britz et al. (2016a/b) and Britz and Sauer (2016). Algoa 6, situated near the Port Elizabeth (PE) Harbour, was identified in the 2012 SEA (Cape EAPrac 2013) and has been put forward as a site for oyster production (Figure 1). As Algoa 7 is located directly in front of the Coega Harbour (Figure 1), this site underwent a detailed internal (DAFF) feasibility assessment which considered suitable water depth, shipping traffic, accessibility (i.e. financial implications for farmers), and distance from bird breeding islands. Shortcomings of the Algoa 7 site include its location within the Addo Marine Protected Area (MPA), as well as its close proximity to the Coega Industrial Development Zone (IDZ) and ADZ, which could compromise sea-water quality for aquaculture operations.

The purpose of this **Marine Specialist Impact Assessment Report (MIAR)** is to provide a summary of the existing descriptions of the marine environment in Algoa Bay, to summarise the farming methods that were discussed in detail in the previous MIAR, and most importantly to consider the potential impacts of ADZ operations at three potential aquaculture precincts on the habitat and biota in Algoa Bay. The previous MIAR discussed the affected user groups that will potentially be affected by mariculture operations (Anchor 2013) and an updated assessment of user group impacts can be found in the 2019 Basic Assessment Report (BAR). In this marine specialist report, possible mariculture species are listed and the potential marine environmental impacts associated with Algoa 1, Algoa 6 and Algoa 7 are discussed. This report draws on information provided by the benthic mapping and habitat analysis for Algoa 7 (Dawson *et al.* 2019), and the dispersion modelling report (Wright *et al.* 2019) that determined probable footprint of waste plumes from the potential mariculture operations and made recommendations on the ADZ specific carrying capacity for fin fish. The updated MIAR will inform the 2019 BAR that will be submitted to the National Department of Environmental Affairs for a decision.

1.1 Site location

Algoa Bay, located on the south-eastern coast of South Africa, is home to the coastal city of Port Elizabeth, which is the commercial capital of the Eastern Cape. Port Elizabeth is a major seaport that provides ore loading facilities, although industrial activities have started shifting to the Port of Ngqura (Coega) where an IDZ or Special Economic Zone (SEZ) was established in 1999. The Coega Development Corporation (CDC), a state-owned enterprise (SoE), is mandated to develop and operate the 9 003 hectares of land within the SEZ.

1.2 Terms of Reference

The marine specialist impact assessment focused on the marine ecology of this area, but also considered the wider marine biogeographical context. Information and data collected and analysed by the marine specialists during the previous and current EIA processes (Hutchings et al. 2013a/b, Dawson *et al.* 2019 and Wright *et al.* 2019) and the findings of the comparative socio-economic feasibility study compiled by the Rhodes University in 2016 (Britz *et al*. 2016a/b and Britz and Sauer 2016) formed the foundation of the marine ecological impact assessment. Existing information was reviewed and updated using available desktop information pertaining to the nature of the marine environment, the aquaculture industry and potential impact and mitigation measures where required. The Terms of Reference for the marine ecological specialist study are as follows:

1. A summary description of the receiving environment highlighting sensitive and significant habitats, fauna and flora including maps with locations of sensitive/significant features and habitats;
2. A summary of the findings of the dispersion modelling study and the benthic habitat mapping study;
3. A recommendation of species to consider for the ADZ;
4. Description and assessment of potential impacts associated with the operation of the ADZ;
5. A site recommendation considering the preferred as well as the alternative sites from an ecological perspective; and
6. Recommendations on measures to be adopted/implemented that are expected to mitigate negative impacts on the ecology of the area.

2 PROJECT DESCRIPTION

Aquaculture is defined as the propagation, improvement, rearing, regular stocking, feeding or protection from predators and harvesting of aquatic organisms (plant and animal) in controlled or selected aquatic environments (fresh, sea or brackish waters, on land or at sea) for any commercial, subsistence, recreational or other public or private purposes (DEA&T 2007, South African Aquaculture Development Bill 2018).

Marine aquaculture, or mariculture, is the process of cultivating and harvesting sea based aquatic organisms. Marine aquaculture includes the commercial farming of all marine organisms such as finfish, shellfish (i.e. abalone, mussels, prawns) and seaweed. Operations generally involve some form of intervention in the rearing process to enhance production (i.e. regular stocking, feeding, and protection from predators).

Aquaculture is the fastest growing form of food production in the world and provides a significant source of protein for people in many countries. Over the past decade, the surging demand for fish and fishery products has been met by aquaculture production, as capture fisheries have been declining in some countries (United Nations 2010). Globally, nearly half of the fish consumed by humans is produced by fish farms. Taking into account population forecasts, an additional 27 million tonnes of production will be required in 2030 to maintain the present level of per capita consumption (United Nations 2010).

In response to a growing interest in aquaculture, the Provincial Department of Economic Development, Environmental Affairs and Tourism (DEDEAT) published an 'Introduction to Aquaculture in the Eastern Cape' which states that the global harvest of natural aquatic resources has reached capacity and has already caused a collapse in the stocks of various species, and has resulted in habitat loss and pollution (Hinrichsen 2008). While the demand for these aquatic resources is increasing, controlled aquaculture production has the potential to meet this demand in a responsible manner.

In response to the appeals against EA granted on the 9th of July 2014, Algoa 6 and Algoa 7 were added as mariculture sites for bivalves (oysters, mussels etc.) and finfish farming respectively. The Sections 2.1 and 2.2 discuss feasible design options for the Algoa Bay ADZ based on results of the dispersion modelling study (Wright *et al.* 2019). The previous MIAR only focused on the farming of indigenous finfish species, such as yellowtail, silver and dusky kob, white stumpnose, white steenbras, yellowfin tuna etc. (Anchor 2013), while this updated report will include considerations for alien shellfish (oysters and other species). Potential impacts of the proposed operations are discussed in Section 4 .

2.1 Finfish farming

2.1.1 Farming technology

The 2011 SEA described design criteria, available fish cage types and the suitable oceanographic conditions for their use (Clark *et al.* 2011). Given the research and development stage of sea-based finfish cage culture in South Africa and the prevailing environmental conditions, it is suggested that circular floating net cages approximately 20-30 m in diameter, 70-100 m in circumference, and 15-20 m deep will be used for the Algoa Bay ADZ (Schoonbee and Bok 2006, CCA Environmental 2008, Hutchings *et al.* 2013b). The nylon net mesh is typically treated with an anti-fouling compound, usually a copper based product, and must be routinely rotated to decrease the amount of bioufouling (marine growth) on the structures. As antifouling coatings have limited lifespans, regular net changes will be required as necessary.

The nets will be suspended between two poly-vinyl chloride (PVC), High Density Poly-Ethylene (HDPE) or flexible rubber hose rings supported by plastic or galvanised steel stanchions which are moored to the sea bed using steel anchors and chains or mooring blocks. Cages are usually moored in a grid pattern with the moorings and anchor lines extending outwards from the cage perimeter. This will result in the seafloor footprint being ~5-10 times greater than the sea surface footprint. The fish cage structure (rings, stanchions and cover nets) would extend approximately 1-2 m above, and 15 m below the sea surface. Following installation, at least 5 m of water depth must remain below the net bottom to allow for the adequate dispersion of wastes (uneaten food and faeces). However, the sluggish currents that predominate in Algoa Bay (see Hutchings *et al.* 2013a) indicate a need for greater depth below the cage floors or more frequent fallowing, especially as farms approach full production capacity.

Polyester or nylon net sizes will vary based on the size of fish stocked and stage of outgrowing. A large mesh size is advisable for the underwater sides of the primary cage mesh to reduce incidents of large marine piscivores predating on cultured stock, although this should not exceed 16 cm (to minimize entanglements). A predator net with a smaller mesh size will be required over the top of the cages to prevent both stock escape and sea bird predation. Copper alloy mesh cages are an alternative approach to nylon mesh, although the initial capital outlay is much greater (Prof. Tom Hecht, Advance Africa Management Services, *personal communication*). In order to minimize risks to shipping, all cages will need to be marked with cardinal marker buoys, radar reflectors and navigational lights to indicate their position.

Water depth is expected to be between 20 and 50 m and significant wave heights of up to 5 m are likely (Clark *et al.* 2011, Hutchings *et al.* 2013b). Similar fish cages have been used in a pilot study within Algoa Bay and proved suitable for the local conditions, albeit in a more sheltered location than that of the proposed ADZ (Nel & Winter 2008). Although the project description is based on the floating circular cages that are most likely to be used, future finfish farm operators must assess the risk, costs and returns, and feasibility of this and other designs.

2.1.2 Potential culture species

The development of modern sea cage finfish farming in the 1970s occurred largely due to the growth of the salmon farming industry in countries with glaciated coastlines such as Scotland, Norway, British Columbia and Chile (Hutchings *et al.* 2013a). The number of finfish species used in marine cage culture has increased substantially over the last three decades with salmon, tuna, flatfish, kingfish, bream, Sciaenids (white sea bass, red drum) and a host of other species grown in a variety of cage culture systems (Staniford 2002). Although some sea cage farming operations rely on wild caught stock (e.g. southern and northern bluefin tuna farms located in Australia and the Mediterranean, respectively), most farms use finfish fingerlings that are obtained from land based hatcheries, where brood stock, egg, and larvae husbandry can be carried out under controlled conditions. Fingerlings are stocked into sea cages at optimal sizes and densities, fed with commercially available protein and lipid rich dry food, treated for diseases and parasites, graded, and harvested at a size that results in the maximum economic return. Several species of the genus *Seriola* are used in aquaculture internationally, mostly Japanese amberjack (*S. quinqueradiata*) that is farmed in Japan and Korea (Hutchings *et al.* 2013b). *Seriola lalandii* has been farmed in sea cages in Australia since 2001 with a production of ~ 3300 tons in 2007/8, and has been trialled in Chile and New Zealand (Poortenaar *et al.* 2003, Frenandes and Tanner 2008, Moran *et al.* 2009). Dusky kob (*Argyrosomus japonicus*) has been farmed in Australia where it is locally known as Mulloway, while the congeneric, *A. regius* is extensively farmed in the Mediterranean, with an estimated production of 15 000 tons recorded in 2010 (FAO 2012).

Around 250 species of fish are landed by South African line fisheries, although only about a dozen account for more than 90% of the catch (Mann 2000). Given that a domestic market already exists for popular linefish species, these are preferable for cage culture in a pioneering industry. Dusky kob are large, predatory teleost fishes of the family Sciaenidae that are widely distributed in estuaries and nearshore subtropical and temperate coastal waters less than 100 m water depth in the Pacific and Indian Oceans. In South Africa, the species occurs from the Cape of Good Hope to northern KwaZulu-Natal where they are targeted by commercial and recreational fishers. Sciaenids worldwide have been demonstrated to be prone to overfishing and dusky kob are overfished in South Africa and Australia. This species has many attributes that make them suitable for aquaculture: they are euryhaline (able to tolerate a wide range of salinities), eurythermal (able to tolerate a wide range of temperatures) and hypoxia tolerant (able to tolerate oxygen deficiencies). Their life histories also make them favourable as they are a gregarious, relatively fast growing, highly fecund, and are easily reproduced in captivity.

Yellowtail (*Seriola lalandi*) has a non-equatorial distribution and is found around Australia, New Zealand, India, and from British Columbia to Chile. In South Africa, this species occurs from the west coast to southern KwaZulu-Natal and frequents both shoreline habitats as well as deep pelagic waters. Yellowtail appear to be well suited to marine aquaculture, as it grows fast, has a good yield, are particularly robust, and thrives in sea cage production systems. Commercial culture of *S. lalandi* commenced in Australia in 1998 and the farming industry has since undergone rapid expansion. Grow-out to market size (3 – 5+ kg) is conducted in sea cages with a total culture production of currently estimated at 1 000 tonnes.

Research and development into the suitability of three species for sea cage culture has already occurred within Algoa Bay; namely yellowtail (*Seriola lalandi*), dusky kob (*Argyrosomus japonicus*) and silver kob (*Argyrosomus inodorus*) (Nel and Winter 2008 & 2009). The Department of Science and Technology (DST) Eastern Cape Sea Cage Finfish Farming Pilot Project was initiated in 2007 by the DST, the Stellenbosch University Aquaculture Division, and Irvin and Johnson Limited (I&J) to determine the technical, environmental and financial feasibility of farming indigenous marine finfish species in South Africa. The project commenced in November 2007 with the installation of four HDPE surface gravity type fish cages moored in an anchor based grid in the lee of PE Harbour. Dusky kob, silver kob and yellowtail were grown over a 30 month period. The project achieved promising yellowtail growth results with some fish reaching 1.5 kilograms in 14 months. The results obtained for both kob species were disappointing, with dusky kob only reaching an average size of 549 grams in 19 months and silver kob reaching an average size of 550 grams in 22 months (Nel and Winter 2008 & 2009). The unavailability of yellowtail fingerlings prevented the successful implementation of the continuation phase of the DST Eastern Cape Sea Cage Finfish Farming Pilot Project which was abandoned in 2011. The production system equipment used by the project were sold to Viking Aquaculture in October 2016 and has subsequently been installed in Saldanha Bay for a sea trout pilot project. The initial phase of the project (2007 – 2010) showed that HDPE surface gravity type cages can be deployed and utilised for sea cage aquaculture at selected nearshore sites along the South African coastline. From a species perspective, the initial phase of the project showed that yellowtail has significant potential for commercial aquaculture in the country. The fish produced by the pilot project was sold to South Africa's premier retailer, indicating a high level of market potential for yellowtail.

The DST Eastern Cape Sea Cage Finfish Farming Project led to the implementation of a dusky kob sea cage project in Richards Bay in August 2015 and the development of a similar project in Mozambique. The DST and Stellenbosch University KZN Aquaculture Development Project was a collaborative undertaking between DST, DAFF and the University to determine the technical, environmental and financial feasibility of farming dusky kob in sea cages in Richards Bay, KwaZulu-Natal. Production commenced in August 2015 with the stocking of 25 000 dusky kob fingerlings and had a standing stock of about 25 tonnes in 2017. Of the two species, yellowtail appears to be the more suitable for aquaculture as it grows significantly faster than dusky kob, has a lower optimum culture temperature and will potentially obtain higher prices in export markets (Stellenbosch University 2017).

Several other indigenous fish species are also under consideration; yellowfin tuna (*Thunnus albacares*), sole (species not given), geelbek (*Atractoscion aequidens*), spotted grunter (*Pomadasys commersonnii*) and several sparids including white steenbras (*Lithognathus lithognathus*), white stumpnose (*Rhabdosargus globiceps*) and red roman (*Chrysoblephus laticeps*) (DEA 2013, Government Gazette No. 36145).

Algoa Bay falls within the distributions of all of the above mentioned indigenous species, indicating that the environmental conditions are, at times, suitable (Hutchings *et al.* 2013a). The presence of local wild populations does not, however, confirm suitability of a species for sea cage culture as cages restrict the natural movement of the stocked species, restricting behavioural responses to variable oceanographic conditions. For example, Sciaenids stocked in the Algoa Bay sea cage trials experienced low growth rates and became susceptible to parasites, presumably partly in response to sudden drops in water temperature (G Le Roux, Stellenbosch University, *personal communication*). Telemetry studies on dusky kob within Algoa Bay have revealed population specific movement responses to changes in water temperature with individual fish displaying site fidelity to estuaries that are used as refugia during periods of low sea water temperature (P Cowley, SAIAB, *personal communication*).

Research and development into the suitability of different species for cage culture in South Africa is ongoing, which may identify additional candidate species. Diversification of species for use in local sea cage culture will depend on research and development around stock husbandry (including viable hatchery techniques), suitability of species to caged conditions, suitability of cages for local sea conditions, and the development of receptive markets. High value species for which sea cage culture techniques have been established and an international market demand already exists (e.g. yellowtail, yellowfin tuna), could prove to be the most economically viable.

The sustainable aquaculture policy does not rule out the use of alien species (Government gazette No 30263, pg. 13). The Alien and Invasive Species Regulations, 2014 (AIS Regulations) published in terms of the National Environmental Management: Biodiversity Act (Act No 10 of 2004) (NEMBA) are concerned with the responsible introduction of new alien species and the management of existing alien and invasive species in South Africa. For new introductions, the AIS Regulations prescribe when and how risk assessments must be conducted.

Atlantic salmon *Salmo salar* is exempt in term of the AIS Regulations as this species had already been introduced into South Africa at the time when the Regulations were promulgated. Experimental salmon farming has taken place historically at Gansbaai and sea trout are is currently undergoing trials by Molapong Aquaculture (Pty) Ltd in Saldanha Bay. The warm temperate waters of Algoa Bay however, are not suitable for many cooler water species (e.g. salmon, trout, flounder and plaice) that were initially the mainstay of finfish sea cage culture internationally, nor consistently warm enough for more recently researched tropical species (such as cobia). Risks of disease and parasite introduction, or the establishment of an invasive alien fish species, are generally considered lower if indigenous species are cultured, although disease transmission between local wild stocks and farmed fish is more likely when local species are farmed. This Basic Assessment (BA) process therefore only considers potential impacts of farming indigenous fin fish species. Should future fish farm operators wish to farm alien fish species, a separate risk and impact assessment will need to be conducted.

2.1.3 Stocking density

A commercially viable, finfish cage farm, producing in the region of 3 000 tons per year, would require about 35 cages of this size, holding approximately 85 tons of fish each (these figures are based on the I&J proposal to farm yellowtail and kabeljou and will vary depending on the species farmed) (CCA Environmental 2008). The sea floor footprint of a farm this size would be about 20-50 ha depending on the mooring system, but to allow for boat access between cages and fallowing of sites, an area of around 70 ha per operator would be required. This suggests that should the site be fully developed for fin fish alone (i.e. no bivalve culture), Algoa 1 could theoretically accommodate nine commercial scale finfish farms with a total production of ~30 000 tons per annum. This exceeds the average annual total South African line fish catch by 2-5 times (Griffiths 2000), and full development of these sites would therefore be reliant on producers accessing new markets for farmed finfish. It is uncertain that this scale of development will be sustainable both from an environmental impact perspective and from industry functionality/economic perspective. The previous EIA (Hutchings et al 2013) therefore adopted a precautionary approach and recommended a much lower initial scale development with no more than three fish cage farms authorized to scale production up from pilot phase (maximum 1000 tons/ precinct) to full commercial viability (three farms producing a total of 9 000 tons per precinct) over a four year period, providing that environmental quality objectives were maintained. Increased global demand for seafood and market changes however, may well have reduced the volume required for commercial viability e.g. the recent development of an export market for South African yellowtail suggests that this figure of commercial viability (3000t per farm) is probably now an overestimate.

In this current BA process a dispersion modelling study was undertaken to estimate carrying capacity and inform the assessment of potential impacts (Wright et al 2019). Two species specific models were developed for the two potential fin fish sites (Algoa 1 and 7) - yellowtail (*Seriola lalandi*), and meagre (*Argyrosomus regius*). Both of these species are widely studied and widely farmed mariculture species around the world, and good baseline and life history data are therefore available in the existing literature for these species. Meagre is a species similar to South African kob (e.g. *Argyrosomus japonicas* and *A. inodorus*), and represents a good proxy for the farming of indigenous kob species in Algoa Bay. In line with the precautionary approach recommended by Cape EAPrac (2013), three scenarios (i.e. various stocking options) were investigated, ranging from a lower initial scale development of 1000 t to maximum estimated commercial viability (9 000 t). These scenarios were modelled in the absence of any bivalve farming on these sites.

Model results indicate that both Algoa 1 and Algoa 7 have acceptable dispersion potential and water quality standards are predicted to be met within the ADZ boundaries (Wright et al 2019). However, the carrying capacity of a site is intrinsically linked to its size – a larger ADZ will inherently present more space for mariculture. Therefore, it is perhaps more useful to consider the production capacity of a site, including the number of farms that can be accommodated and the annual production of those farms, while also taking into consideration strategies to minimise environmental impact.

Carrying capacity was estimated on the premise that:

1. the benthic fauna beneath the farm site must not be allowed to disappear due to accumulation of organic material;
2. the water quality in the net pens must be kept high; and,
3. the water quality in the areas surrounding the farm must not deteriorate.

The estimated maximum carrying capacity for finfish (in the absence of bivalve farming) each of the two proposed sites are summarized in Table 5 below:

Table 5 Summary of dispersion modelling results as per Wright *et al.* (2019) showing carrying capacities for Algoa 1 and 7 for two species, namely *Seriola lalandi* and *Argyrosomus regius.* Note that for each site carrying capacity is shown per species, which means that for example either 3 farms of *S. lalandii* OR 12 farms of *A. regius* can be maintained at Algoa 1 (in the absence of bivalve culture at Algoa 1).

Site	Species	Number of farms	Total annual production per farm (t)
Algoa 1	*S. lalandi*	3	**3 252**
	A. regius	12	**4 911**
Algoa 7	*S. lalandi*	2	**3 555**
	A. regius	7	**4 947**

These results do not account for disease control. Alvial *et al.* (2012) recommended a minimum 2.5 km buffers zone be implemented to prevent disease transferral between farms. Should this buffer zone be implemented, Algoa 1 and 7 each have the capacity for one farm of either *S. lalandi* or *A. regius* (or a similar indigenous *Argyrosomus* species).

2.2 Shellfish farming

The exotic Pacific oyster (*Crassostrea gigas*) and the native Cape Rock Oyster (*Striostrea margaritacea*) are currently cultivated in South Africa. The Pacific oyster *C. gigas* (also accepted as *Magallana gigas*) is an estuarine oyster native to Japan and South East Asia, although it has been shown to survive on rocky shores in sheltered waters of up to 40 m depth and may attach to the shells of other animals. The optimum salinity for these oysters is between 20 and 25 parts per thousand (ppt or ‰), although the species can occur (but not breed) at salinities below 10 ppt and will survive salinities in excess of 35 ppt. Gametogenesis (the production of sperm and eggs) occurs at around 10°C and salinities of between 15 and 32‰. Spawning generally follows at temperatures above 20°C. The Pacific Oyster was introduced to the Knysna Estuary for farming in the 1950s and since then has been farmed in the Kowie and Swartkops estuaries as well as at three offshore sites; Algoa Bay, Saldanha Bay and Alexander Bay (Robinson *et al.* 2005).

Initially, *C. gigas* was not considered an invasive threat as the oysters seemed unable to reproduce and settle successfully under the local environmental conditions; however, farmed populations have been reported to have spread from the site of introduction to nearby estuaries (Robinson *et al.* 2005). Through the use of DNA sequencing, Robinson *et al.* (2005) confirmed the presence of three naturalised populations of in the Breede, Knysna and Goukou estuaries. The highest densities of approximately 184 000 individuals were found in the Breede Estuary (Robinson *et al.* 2005).

C. gigas is classified as a category 2 invasive marine invertebrate species in terms of the 2016 Alien and Invasive Species (AIS) Regulations promulgated under the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEMBA). For this category of invasive species, a permit is generally required to undertake any of the activities listed in terms of NEMBA. However, the AIS regulations exempt the operators from requiring a permit for *C. gigas* in Algoa Bay as shown in Figure 2 (landwards of a straight boundary line with endpoints at the GPS coordinates 33°51'24.82''S 25°38'11.01''E and 33°59'20.68''S 25°40'26.31''E). All activities, except for the introduction of live specimens into the country, involving *C. gigas* in the area shown in Figure 2 are exempt, provided the operator has a valid Permit from the DAFF. Note that *C. gigas* and alien mussel farming would require an AIS permit in terms of NEMBA at Algoa 1.

Figure 2 **Existing Oyster farms in Algoa Bay and area that is exempted for the farming of *Crassostrea gigas* in terms of the 2016 Alien and Invasive Species (AIS) Regulations promulgated under the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEMBA). The area extends landward of the red line.**

In 2015, eight bivalve farms were in operation reporting a total production of 276.85 tons (DAFF 2016). One farm is situated in the Northern Cape, five in the Western Cape, and two in the Eastern Cape (Port Elizabeth/Algoa Bay and Jeffrey's Bay respectively). Algoa Bay is currently being used as a production area for oysters, although the area is only marginally suitable for oyster production due to high summer water temperatures and highly variable phytoplankton levels that can result in very poor growth rates and even mortalities (Pieterse *et al.* 2012). The area is however, suitable as a nursery area and grow out to market size can potentially be undertaken at Algoa 1.

The global production of bivalves has grown from around 1 million tonnes in 1950 to 16.1 million tonnes in 2015 (FOA 2018), with just over half of the volume derived from aquaculture production (McKindsey *et al.* 2011). Bivalve aquaculture accounts for roughly 27 % of global aquaculture production and provided approximately 13 % of the total fish produced for human consumption worldwide in 2006 (FOA 2009). The rapid growth of the industry has raised concerns about the ecological and physico-chemical impacts of aquaculture on local environment (Black 2001) and numerous studies have been conducted to help better understand the ecological role played by culturing activities (Davenport *et al.* 2003; Holmer *et al.* 2008, National Research Council 2010). Ecological studies of bivalve aquaculture recognise three primary methods that culturing of bivalves can impact the ecosystem: 1) material processes – the consumption of food and production of waste, 2) physical structure – the introduction of artificial substrate in the form of structures and anchoring and the introduction of the aquaculture species itself, and 3) pulse disturbances as result of harvesting efforts (Dumbauld *et al.* 2009). Suspended cages or longlines, the method commonly used for bivalve mariculture in South African, reduces the impacts of pulse disturbance because harvesting and maintenance is conducted from on board a boat during which there is no additional physical contact with the benthos.

This off-bottom method is however more susceptible to biofouling (Shumway & Whitlatch 2011) but the impacts of this can be mitigated by appropriate planning and management, which if conducted with enough regularity can prevent biofouling species from significantly altering the benthic community (Forrest et al 2009). Many studies have focused on the role of bivalve biodeposition in changes to the benthos. These largely report that impacts are localised and negligible by comparison to other aquaculture activities, such as finfish cages (Forrest *et al.* 2009). Known as extractive species, the filter feeding habits of bivalves actually remove organic matter from the water column and generally have a positive influence of the water quality of the surrounding system (National Research Council 2010, FOA 2018).

The species under consideration for mariculture in Algoa 1 and Algoa 6 include the Pacific oyster (*C. gigas*), the Mediterranean mussel (*M. galloprovincialis*) and indigenous mussels such as brown mussel *Perna perna* and black mussel *Choromytilus meridionalis*. The Mediterranean mussel is already established in Algoa Bay (see Dawson *et al.* 2019), and therefore the specific risks of alien invasive introduction of the species to the Bay is negligible. However, wild populations of the Pacific oyster *C. gigas* outside of the existing culture area have not yet been detected in Algoa Bay, although it is a known invasive in South Africa, introduced to the Knysna Estuary in the 1950's.

3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 Oceanography

3.1.1 Regional oceanography

The waters off the Eastern Cape coast are warm-temperate with average sea surface temperatures of 17-22°C (Figure 3) (Goschen and Schumann 1988, Schumann *et al.* 2005). The south-flowing Agulhas Current is the dominant oceanic-scale feature and typically flows along the coast at approximately 1 m/s on average (Grundlingh and Lutjeharms 1979, Ross 1988). Several hundred kilometres to the north east of Port Elizabeth near East London, the current moves away from the shore as the continental shelf begins to widen (see Figure 3) (Dingle *et al.* 1987). This generally results in the inshore waters being markedly cooler, by a few degrees compared with the Agulhas Current water further offshore (Goschen and Schumann 1988).

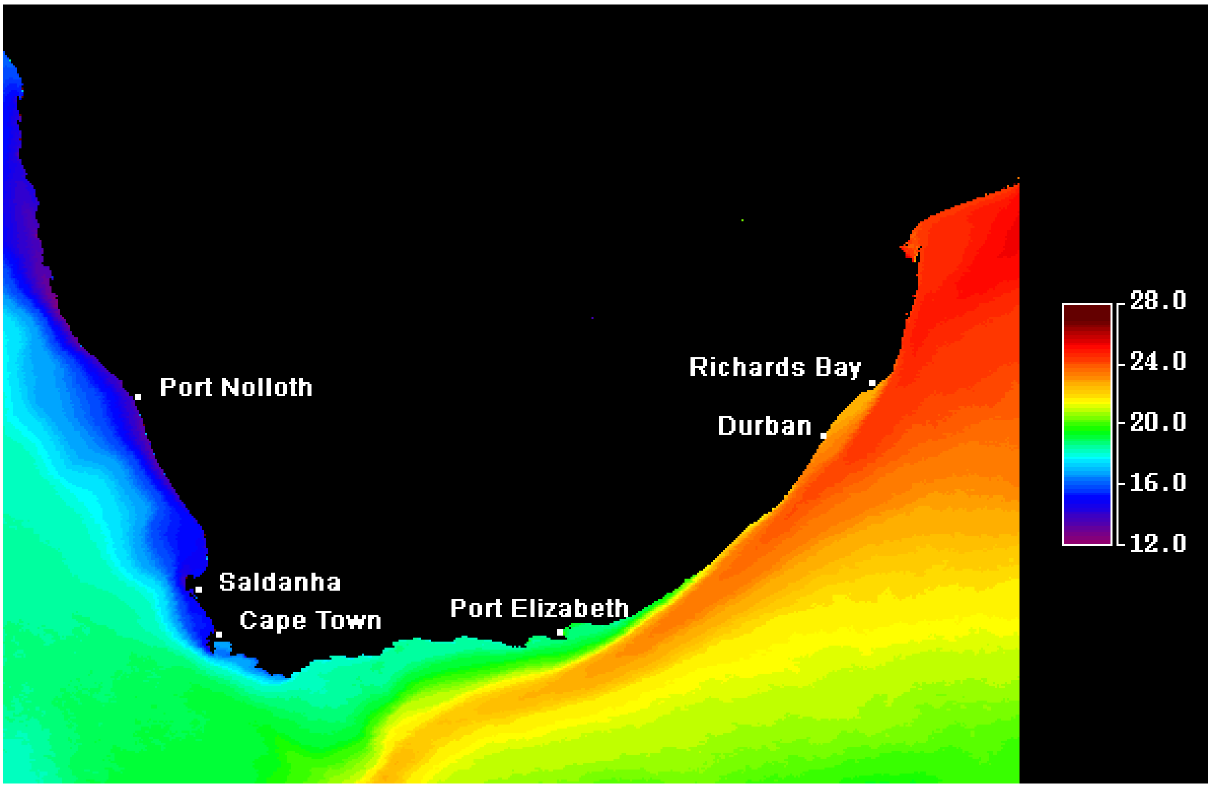

Figure 3 **Average sea surface temperature (°C) showing the warm-water Agulhas Current moving south westerly along the coast (AquaMODIS 4km-resolution, nine-year time composite image).**

The movement offshore of the Agulhas current in the vicinity of East London creates shear edge features such as eddies which may periodically circulate warm water inshore near Port Elizabeth (Stone, 1988). As a result of these Agulhas shear edge features, water temperature can vary over short temporal scales along the Eastern Cape Coast, particularly in the vicinity of St Francis and Port Elizabeth.

Another source of temperature variability and a characteristic of the Eastern Cape coast are upwelling events (Beckley 1983, Schumann 1999, Schumann *et al.* 1988, Churchill 1995, Goschen & Schumann 1995). This phenomenon is caused by wind driven currents particularly during easterly winds (Churchill 1995). Upwelling cells are prominent adjacent to many of the rocky headlands, particularly off Cape Recife and Cape Padrone and may move into Algoa Bay (Schumann *et al.* 1982, Beckley 1983, Churchill 1995, Goschen and Schumann 1995, Goschen *et al.* 2012). Although not as frequent or as severe as those upwelling events on the west coast, wind-driven upwelling has been responsible for fish kills, and water as cold as 6 °C has been recorded in the area (Ross 1988).

Recent research has revealed that several aspects of the Agulhas Current hydrodynamics bring cold, deeper water onto the shelf that may then be bought to the surface by offshore or alongshore winds; and that upwelling events are associated with increased frequency of coastal trapped waves (CTWs), although the links between upwelling and CTWs are unknown (Goschen et al 2012).

Historically, the upwelling events were generally relatively weak and short lived the proliferation of harmful algal blooms was, until recently, not known to occur. Between December 2013 and March 2014; however, a large and persistent harmful algal bloom of *Lingulodinium polyedra* did form within Algoa Bay and spread along the east coast as far as Wilderness (Bornman 2014; Morrissey 2015). The intensity of the bloom was such that waters turned a dramatic red colour with spectacular phosphorescence at night (Figure 4). *Lingulodinium polyedra* produces yessotoxins that are toxic to mice and may accumulate in bivalves (although human toxicity is not known) (Bornman 2014). It does irritate the gills of fish interfering with respiration and the bloom led to fish kills in several places (Bornman 2014). This species had been documented as cysts in marine sediments collected from the area, suggesting that it was not a recent introduction, and the bloom was likely triggered by a combination of favourable environmental conditions. This algal species was again documented in Algoa Bay during December 2015, although it did not develop to the same extent as the 2014 bloom presumably due to the fact that environmental conditions were not conducive. A recent publication by Lemley et al (2019) attribute the increased observation of eutrophic symptoms in Algoa Bay, including harmful algal blooms (e.g. *Heterosigma akashiwo* and *Lingulodinium polyedra*) and hypoxia (<2mgl^{-1}) at least in part to anthropogenic nutrient loading from land based sources (e.g. waste water treatment works, storm water outfalls).

Figure 4 **Harmful Algal bloom in Algoa Bay caused *by Lingulodinium polyedra* during summer 2013-2014.**

Temperature, salinity, nutrients and ocean current dynamics have been studied in Algoa Bay by Goschen and Schumann (1988, 2011) and Schumann *et al.* (2007). The Agulhas Current plays an intermittent role in determining the current and temperature structure in Algoa Bay, while prevailing winds are important on the wider shelf areas inshore (Goschen and Schumann 2011). Current speeds of less than 10 $cm.s^{-1}$ have been measured most frequently within the bay (Roberts, 1990; Schumann *et al.* 2005), although currents exceeding 20 $cm.s^{-1}$ are not uncommon (Schumann *et al.* 2005; Goschen *et al.* 2012). However, currents in the bay are known to be highly variable in both direction and magnitude and show considerable variation depending on where in the bay they are measured (see Harris, 1978, Goschen and Schumann 1988, Roberts 1990, Schumann *et al.* 2005).

Two types of water masses have been documented to move into Algoa Bay, namely warm Agulhas Current water and cold upwelled water originating from upwelling at Cape Recife and Cape Padrone (Figure 5),(Goschen *et al.* 2012). Warm water from the Agulhas Current is associated with occasional large meanders shorewards as the current moves southward. On the other hand, cold upwelled water originating from Cape Recife during relatively short-lived easterly winds, particularly during summer, is known to move into the bay when the wind switches to a westerly direction shortly after upwelling has occurred (Schumann *et al.* 1982, Goschen and Schumann 1995). Upwelling also occurs off Cape Padrone and cool waters can move into Algoa Bay causing rapid temperature decreases (Goschen *et al.* 2012). Upwelling occurs along this stretch of coast because the orientation is such that the easterly wind has an offshore component, which combined with Ekman transport and the steep and prominent bathymetry, readily draws cold bottom water to the surface within the inertial period of 21 h (for this latitude) (Roberts 2005). Upwelled water moving into the bay has been known to cause sharp changes in temperature by approximately 8 °C within a 24 hour period (Goschen and Schumann 1995).

Yearly-average minimum temperatures are found in winter of 14-15°C and maximum average temperatures in summer of 20-22 °C (Beckley 1983 & 1988, Schumann *et al.* 2005). Temperature variation in Algoa Bay is high and typically ranges between 11 °C in winter and 27 °C in summer (Beckley 1983 & 1988). A strong thermocline is evident in summer in water deeper than 15 m characterised by fairly intense gradients of up to 3 °C/m, whereas in winter conditions are homogenous (Schumann *et al.* 2005).

Salinity remains relatively constant within Algoa Bay and close to natural oceanic water for the region of 35.2 ‰ (Schumann *et al.* 1988). However, close to the mouth of the Swartkops River and at the New Brighton Pier outfall, salinity as low as 34.7 ‰ has been measured, although it remains only in the top 5 m of water and does not penetrate deeper (Schumann *et al.* 2005).

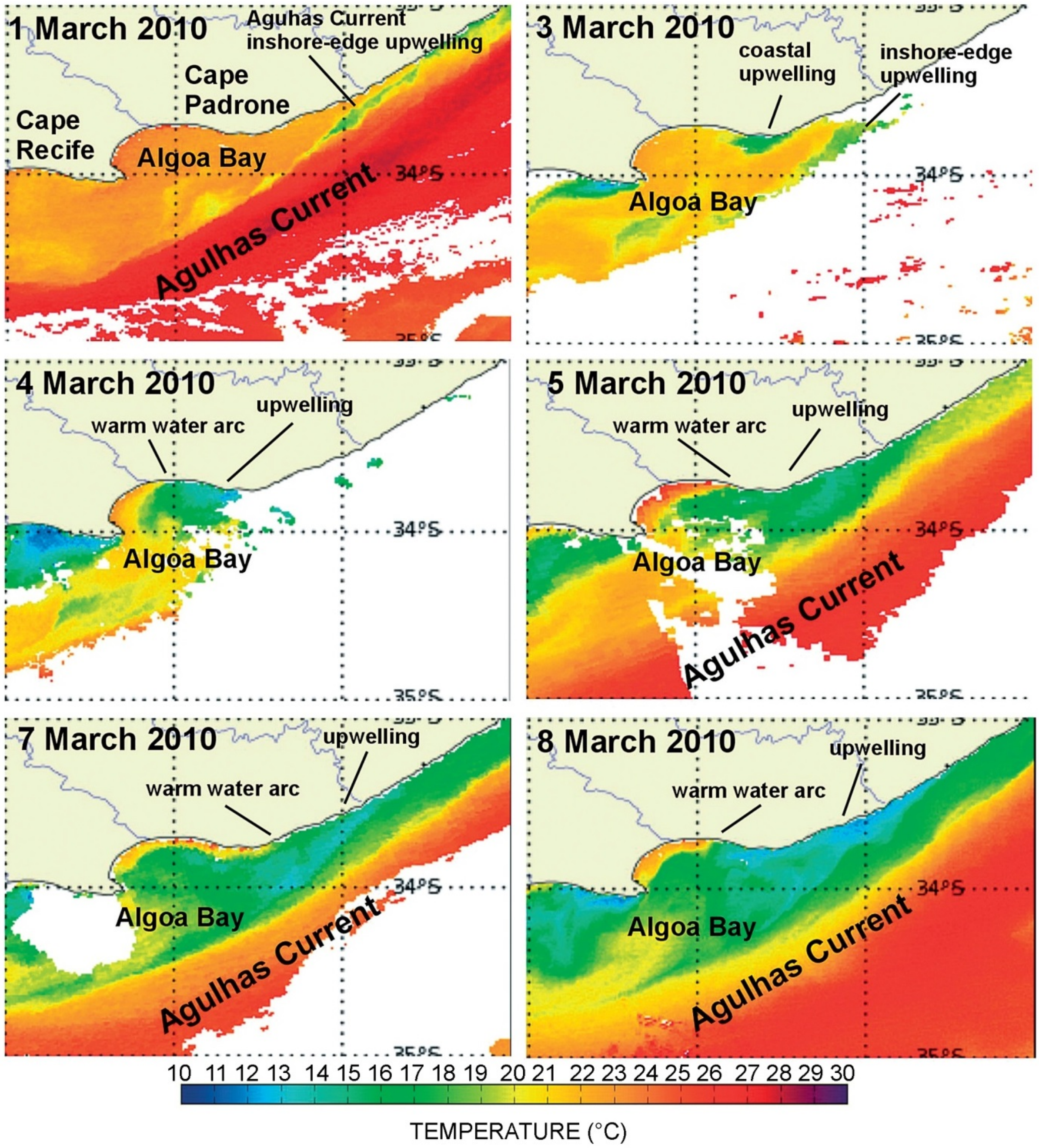

Figure 5 **Satellite imagery of sea surface temperature between 1 and 8 March 2010 showing an upwelling event. Cool water first emerges at Woody Cape/ Cape Padrone and expands into Algoa Bay.**

Schumann *et al.* (1991) found the wind to vary across Algoa Bay, and that prevailing wind directions in Algoa Bay are parallel to the large-scale orientation of the coastline, namely west-south westerly and east-north easterly. Schuman & Martin (1991) reported that the westerly-component of wind dominated in speed and frequency throughout the year, while the easterly component of wind varies considerably between seasons (Figure 6). Both north easterly and south westerly winds reached a maximum in speed and frequency during October and November and a minimum during May, June and July. The maximum average wind speed was 4 m/s for NE winds and 4.7 m/s for south westerly winds during October (Figure 6)

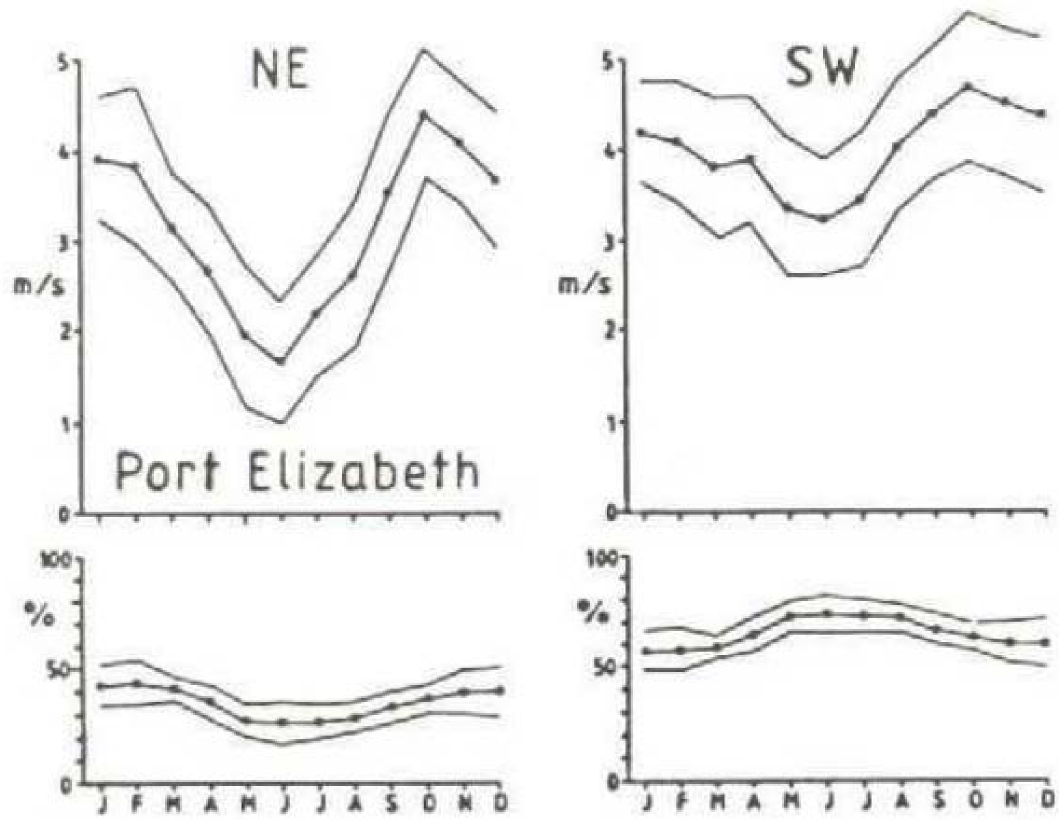

Figure 6 **Monthly variation of the mean major wind speed components at Port Elizabeth Airport (left) north easterly (NE) winds; (right) south westerly wind (SW). Standard deviations about the mean are indicated by the envelope lines. The bottom plot shows the percentage occurrence of the two wind components through the year (from Schumann and Martin 1991).**

Wave climate is predominantly from the south west with swells of less than 2 m being most common and occurring approximately 80% of the time (MacLachlan 1983) (see Figure 7). However, an important percentage of waves in excess of 3 m emanate from the south west generated by storms in the Southern Ocean. Most of Algoa Bay is protected from these swells by the rocky headland at Cape Recife, despite some degree of refraction (Ross 1988, Goschen and Schumann 2011). Nevertheless, maximum wave heights of 6 m have been recorded along the surf zone of Algoa Bay by MacLachlan (1983), possibly from easterly swell, and Council for Scientific and Industrial Research (CSIR, 1987) buoy-data have recorded wave heights of between 0.5-5.0 m (87% of waves between 1-3 m) in summer and between 1.0-6.5 m in winter approaching the Bay at Cape Recife.

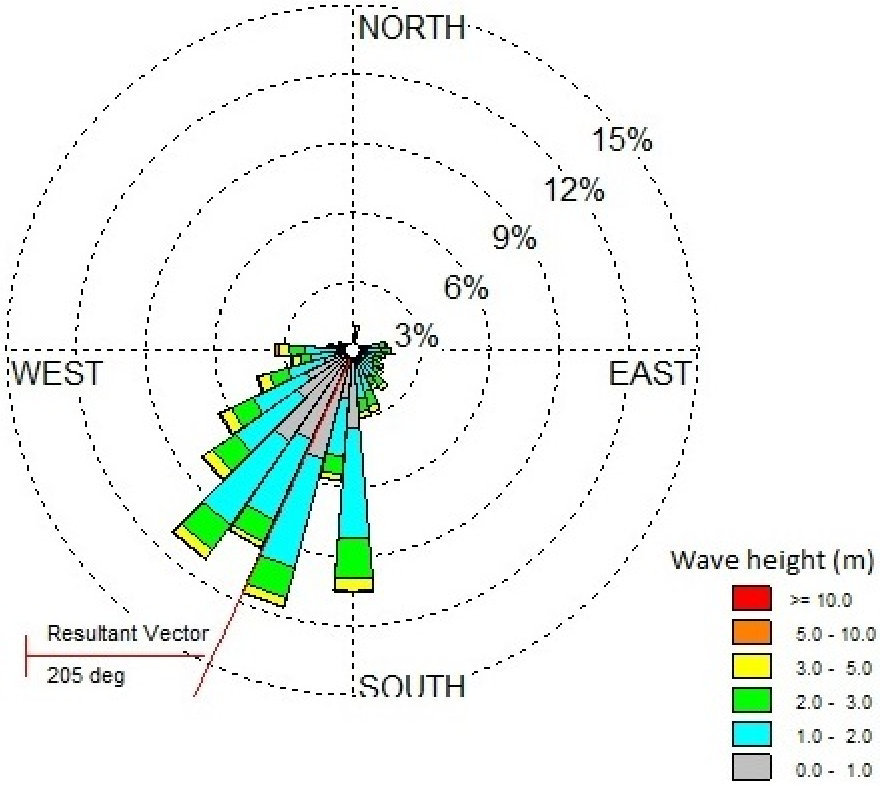

Figure 7 **Wave rose showing the direction from, proportion and magnitude of waves experienced offshore of the St Francis-Algoa Bay region. Data from SADCO Voluntary Observing Ships for a 30-year period.**

3.2 Biogeography

Numerous attempts have been made to understand and map marine biogeographic patterns around the coast of South Africa with the most recent being Sink *et al.* (2012). Algoa Bay falls within the Agulhas ecoregion, between the coast and the South Western Indian Ecoregion (Figure 8). At a finer scale, Algoa Bay falls within the Agulhas inner shelf which ranges from Cape Point to about 100 km north of East London (Figure 8). Although Algoa Bay is smaller and not as deeply recessed as False Bay, it likely shares a number of common species from that region as well as from the warmer water ecozones to the North.

For most groups, marine species diversity increases from west to east, whilst biomass decreases. This combined with the combination of cool water, warm Agulhas eddies, periodic upwelling events and the partial shelter created by the Bay, results in the area will have high diversity and abundance of marine fauna and flora.

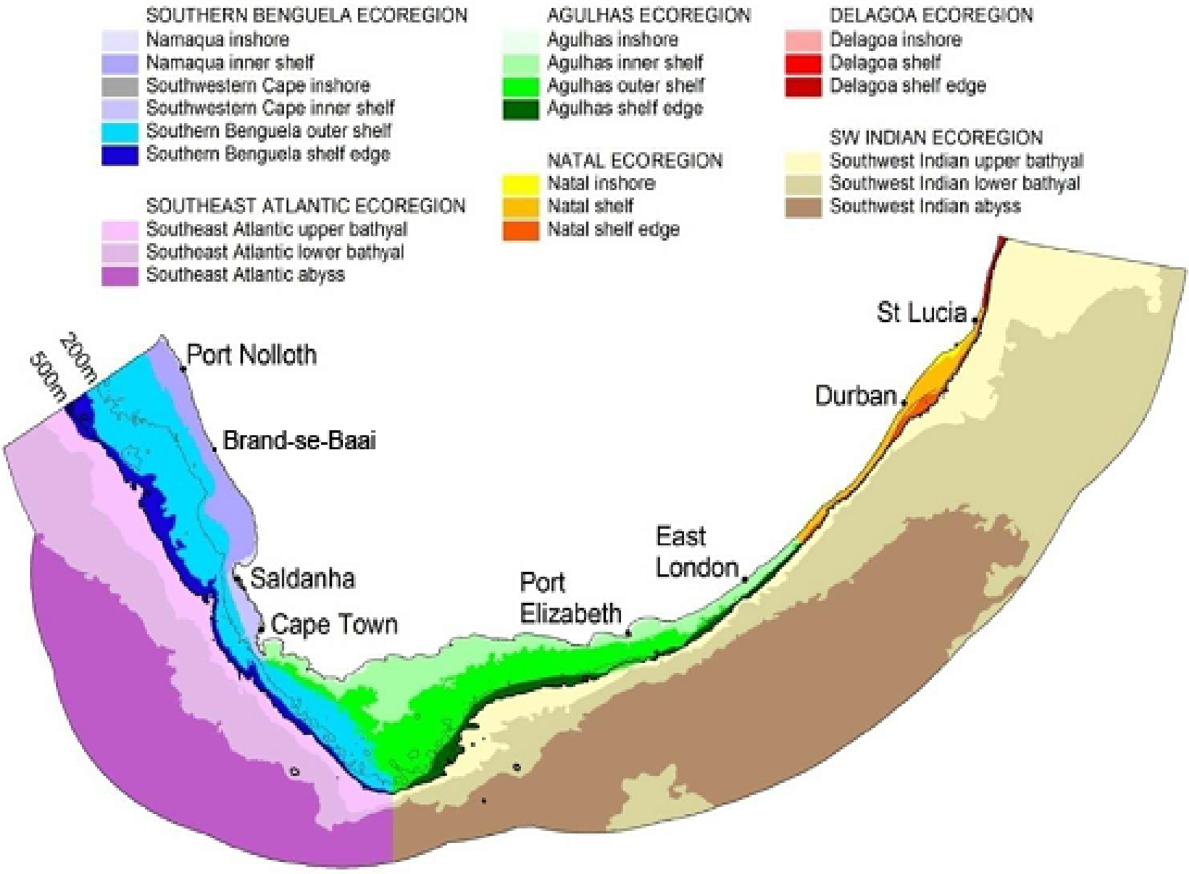

Figure 8 **Six marine ecoregions with 22 ecozones incorporating biogeographic and depth divisions in the South African marine environment as defined by Sink *et al.* (2012).**

3.3 Ecology

3.3.1 Rocky shores

Zonation patterns of marine organisms on rocky shores result from the variation in environmental variables across the shore (e.g. the amount of time each zone is exposed to the air), which in turn influences the organisms which inhabit each section of the shore (Branch & Branch 1981, Beckley 1988). Species that are more tolerant to desiccation (drying out) are found near the high-water mark, while those that cannot stand long periods of water recession are found near the low-water mark. Five distinct zones are typically found on rocky shores South Africa's coast, most of which are present on the Eastern Cape Coastline. These zones (moving in a landward direction) are named the Infratidal zone, the Cochlear zone, the Lower Balanoid zone, the Upper Balanoid zone and the Littorina zone.

On intertidal reefs, red algae dominate particularly *Plocamium corallorhiza*, *P. Cornutum, Pterosiphonia cloiophylla, Hypnea spicifera, Chondrococcus hornemannii, Gigartina paxillata, Laurencia flexuosa and articulated corallines Amphiroa bowerbankii, A. ephedraea, Arthrocardia duthiae, Cheilosporum cultratum, Corallina sp*. and *Jania sp*. (Seagrief 1988; Lubke & Seagrief 1998). Brown algae are also an important component, particularly species of *Dictyota* and *Dictyopteris*, *Zonaria subarticulata, Ecklonia biruncinata* and *Lyengaria stellata*. Green algae such as *Caulerpa filiformis, C. racemosa, Bryopsis sp*. and *Codium spp*. play a subordinate role to intertidal community composition (Seagrief 1988).

Grazers and filter feeders are the most prolific fauna. In the Littorina zone, species of the very abundant periwinkle Nodilittorina sp. are the dominant animal (Wooldridge & Coetzee 1998). The balanoid zone is dominated by three species of barnacle (*Cthalamus dentatus, Tetraclita serrata* & *Octomeris angulosa*), three species of topshell (*Oxystele sinensis, O. tigrina & O. variegate*), beds of brown mussel (*Perna perna),* limpets (especially *Helcion pectunculus, H. pruinosus, Scutellastra granularis, S. longicosta* and *Cymbula oculus*) and false limpets (*Siphonaria capensis, S. oculus, S. aspera & S. concinna*). Predatory whelks (*Burnupena cincta* & *B. lagenaria, Thais capensis, T. castanea, Nucella dubia & N. Squamosa*), echinoderms (particularly *Patiriella exigue, Henricia ornata, Patiria granifera, Parechinus angulosa*) and various sea anemones (*Pseudactinia flagellifer, Actinia equine & Anthothoe stimpsoni*) are also common, especially in rock pools. Lower down the shore, the Cochlear zone is characterised by a dominance of the limpet *Scutellastra cochlear*, however this zone may be absent on very sheltered shores (Beckley 1988). Below the Cochlear zone, and the beginning of the subtidal zone, the red bait ascidian *Pyura stoloinfera* is usually dominant (Beckley, 1988).

3.3.2 Sandy beaches

A description of typical marine communities found in the sandy beach and surf zone habitat types that occur off the Eastern Cape coasts as described in the literature is provided below.

Intertidal sandy beaches are very dynamic environments. The faunal community composition is largely dependent on the interaction of wave energy, beach slope and sand particle size (beach morphodynamics). Three morphodynamic beach types are described: dissipative, reflective and intermediate beaches (McLachlan *et al* 1993). Dissipative beaches are wide and flat with fine sands and high wave energy. Waves start to break far from the shore in a series of spilling breakers that 'dissipate' their energy along a broad surf zone. This generates slow swashes with long periods, resulting in less turbulent conditions on the gently sloping beach face. These beaches usually harbour the richest intertidal faunal communities. Reflective beaches have low wave energy, and are coarse grained (>500 µm sand) which have narrow and steep intertidal beach faces. The relative absence of a surf-zone causes the waves to break directly on the shore causing a high turnover of sand. The result is depauperate faunal communities. Intermediate beach conditions exist between these extremes and have a very variable species composition (McLachlan *et al.* 1993; Jaramillo *et al.* 1995; Soares 2003). This variability is mainly attributable to the amount and quality of food available.

Beaches typically comprise three functional zones, namely the surf zone, the beach (intertidal and backshore zones) and the dunes. They are continually changing; strong waves scour and erode beaches while gentle waves deposit sand. Sand is typically deposited with offshore winds, and eroded with onshore winds. Sand erosion will also increase during the high seas and stormy weather that is relatively common along the Eastern Cape coast. Relatively few species occur on sandy beaches due to their unstable and harsh nature, but those that do occur are hardy, and well adapted to life in these environments (Branch & Branch 1981). Animals living here are, however, offered some degree of protection by being able to burrow into the layers of sand to escape desiccation, overheating and strong waves (Branch & Branch 1981).

Sandy beaches have no hard substratum onto which animals and plants can attach. Organisms living here rely on seaweeds deposited sporadically on the beach and organic rich froth, or spume, which provides a more consistent source of nutrients (Branch & Branch 1981). Five groups of organisms are typically found on sandy beaches: aquatic scavengers, aquatic particle feeders, air breathing scavengers, meiofauna (smaller than 1 mm in size), and higher predators (Branch & Branch 1981).

Aquatic scavengers feed on dead or dying animals that wash up on the beach and their activity is largely regulated by tides. This group includes species such as *Bullia* (the plough snail), that emerge from the sand as the tide rises and are deposited in the same area in which the wave drops the debris and decaying matter. Later they follow the tide down the shore as it recedes to avoid being eaten by terrestrial predators. Three species of plough shells occur on Eastern Cape beaches, *Bullia rhodostoma, B. digitalis and B. pura* (Beckley 1988, Wooldridge and Coetzee 1998). Other important aquatic scavengers in the region include the three spotted swimming crab (*Ovalipe punctatus)* and the subtropical mole crab (*Emerita austroafricana,* Beckley 1988). Several species of burrowing polychaete worms that are either scavengers or carnivores are also found intertidally on sandy beaches. These include *Nephtys capensis, Lumbrineris tetraura, Glycera tridactlya* (previously *G. convolute*) and *Arabella iricolor* (Beckley 1988, Wooldridge and Coetzee 1998).

The dominant aquatic filter feeders on Eastern Cape beaches are the sand mussels (*Donax serra* and *D. sordidus)*, that occur mostly buried on the low and mid-shore and feed on small organic particles they suck in through siphons that protrude above the sand. *D. sordidus* migrates up and down the beach with each tidal cycle, whilst *D. serra* remains in the mid-shore (Beckley 1988). A small crustacean, the surf mysid (*Gastrosaccus psammodytes)* is also very abundant on sandy beaches in the area (Beckely 1988, Wooldridge and Coetzee 1998). This species burrows in the sand during the day and emerges into the water column at night (Branch *et al* 2010). Mysids are an important component in the diet of many surfzone fish.

Air breathing scavengers live high on the shore and feed on kelp and other seaweeds that have been washed up, as well as dead and decaying animal matter. These species complete their life cycles out of water, emerge from the sand during low tide when there is less risk of being washed away, and are almost strictly nocturnal to avoid desiccation and predation. The dominant species in this group are amphipods (e.g. *Talorchestia capensis* and *Talorchestia quadrispinosa*) and isopods (e.g. *Tylos capensis, Euridice longicornis* and *Pontogeloides latipes*). These species are important for the breakdown of sea weeds, and are also a major food source for shore birds and fish that feed on sandy beaches. Another high shore scavenger is the ghost crab (*Ocypode ryderi)*, which is found on some Eastern Cape beaches, predominately during the summer months. Both ghost crabs and mole crabs are rare south of East London (Wooldridge and Coetzee 1998).

Meiofauna (organisms < 1 mm in size) are by far the most abundant of the animals found on sandy beaches, as their small size enables them to live between sand grains. The two most common groups are nematode worms and harpacticoid copepods (Wooldridge and Coetzee 1998).

Sandy beaches are also important for the filtering and decomposition of organic matter in sea water. As water percolates down through the sand the organic particles are trapped and decomposed by bacteria, which in turn release nitrates and phosphates that are returned to the sea. Continual flow of water through the sand maintains oxygen levels and aids bacterial decomposition, and thus sandy beaches act as water purifiers (Branch & Branch 1981).

3.3.3 Subtidal

Relative to sandy habitats, reefs are scarce in Algoa Bay (Figure 9). On shallow subtidal reefs (<10 m), algae, grazers and filter feeders are the most prolific fauna. Dominant algae consist mainly of red foliose species, especially *Plocamium s*pp. The ascidian *Pyura stolonifera* is also abundant (Beckley, 1988). Cape oysters, particularly in areas prone to periodic sanding are prevalent. Abalone *Haliotis midae* are an important species occurring on shallow subtidal reefs, particularly on algae dominated reefs. The large predatory whelk *Charonia lampas* is also frequently encountered, particularly on deeper reefs.

Deeper reefs below 10 m are characterised by exceptionally high levels of diversity and dominated by many species of filter feeders, particularly colonial ascidians, sponges, sea fans, soft corals, hydroids and bryozoans (Wooldridge & Coetzee 1998) (Figure 10). Sponges and ascidians are especially diverse on subtidal reefs in the region and are particularly poorly studied. Sea fans (*Leptogorgia palma, Eunicella albicans, E. papillosa* and *E. tricoronata*) are common in the area as is the purple soft coral *Alcyonium fauri*. Bryozoans become more abundant with depth due to their fragile structure as do feather stars, two species of which, namely *Comanthus wahlbergi* and *Tropiometra carinata* occur in the area.

3.3.4 Benthic macrofauna

Research within Algoa Bay has focused on physical oceanography and large faunal species such as birds, top-predators and commercially important fish species, as well as on the effects of global change on fisheries. However, less is known about the benthic macrofauna communities (Dorrington *et al.* 2018). Studies on subtidal macrofauna tend to include sporadic, observational data collected by SCUBA divers, focused research on a specific species, or more recently, a survey of the subtidal reef conducted by a remotely operated vehicle (Dorrington *et al.* 2018) with limited knowledge available on the distribution and diversity of intertidal soft-bottom macrofaunal communities.

A study conducted on nearshore subtidal macrobenthic communities, at a depth of 10 m along the western shore of the bay, reported a diversity of 174 and 187 species, during summer sampling seasons in 2008 and 2009 respectively (Masikane 2011). In addition, it has recently been suggested that the invertebrate diversity within the Bay may be extraordinarily high and include several previously undescribed taxa (Dorrington 2018). For examples of macrofaunal species found in Algoa Bay, see Figure 11.

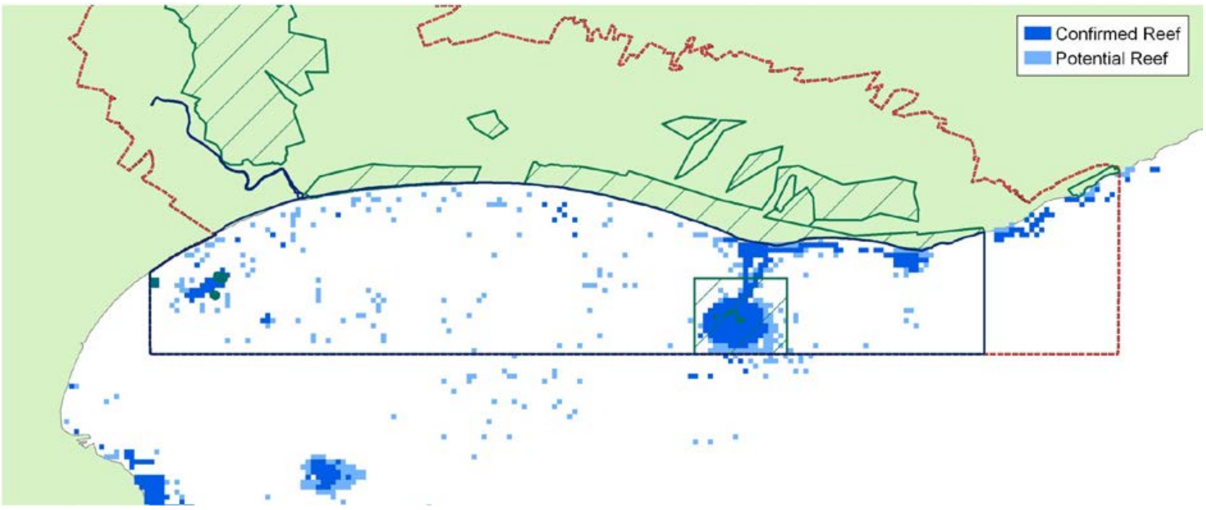

Figure 9 **Reefs areas within the Algoa Bay. The area to the left of the dotted red line is included in the proposed sanctuary zone of the Addo MPA. (Source: A. Oostehuizen, SANParks).**

Figure 10 A typical subtidal reef found in the Algoa Bay area of the Agulhas Bioregion.

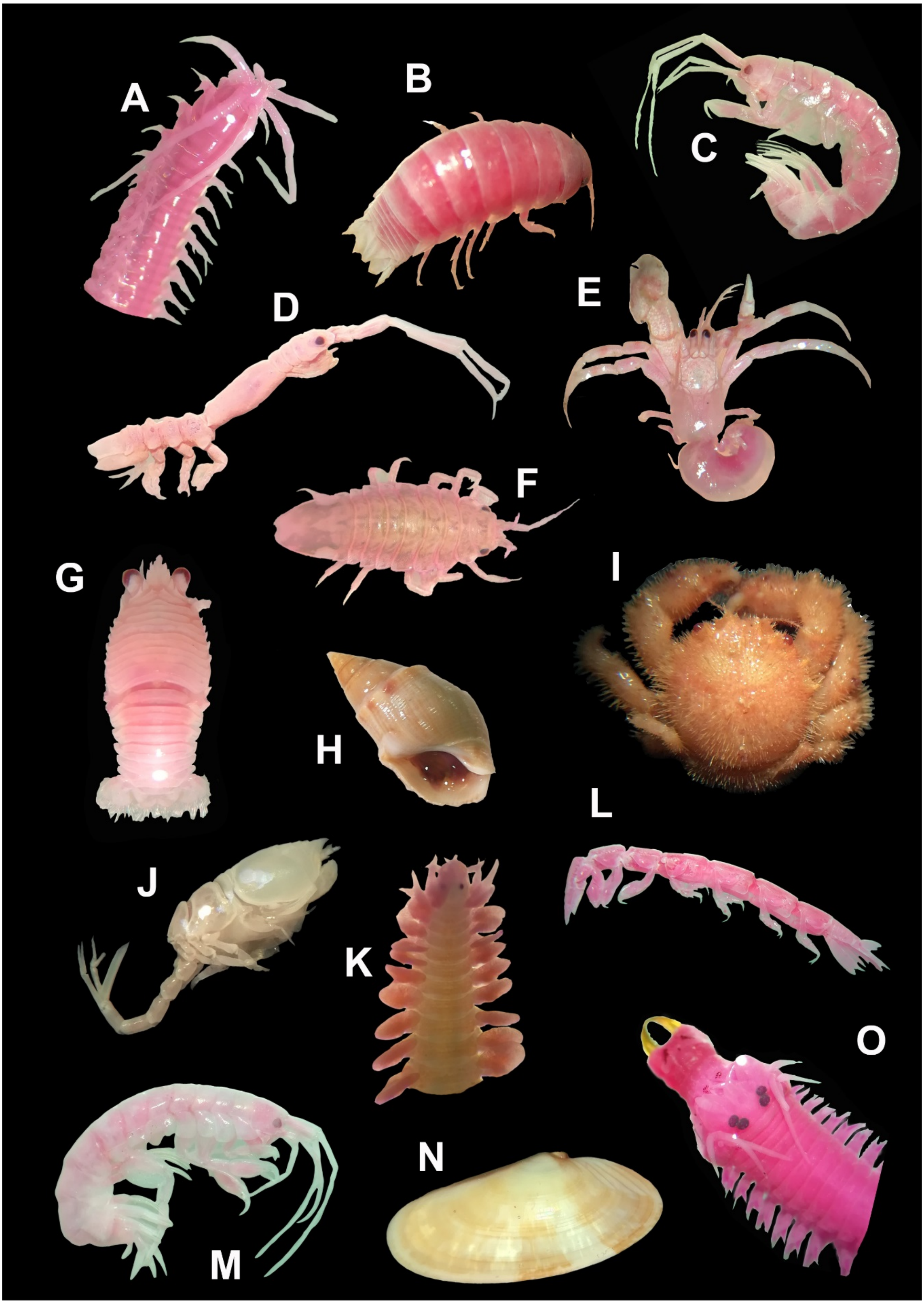

Figure 11 **Examples of benthic macrofaunal species found in Algoa Bay: A – *Onuphis geophiliformis* (Polychaeta); B – *Cirolana sulcate* (Isopoda); C – *Ceradocus rubromaculatu* (Amphipoda); D – *Neastacilla mediterranea* (Isopoda); E – *Diogenes costatus* (Decapoda); F: *Synidotea hirtipes* (Isopoda), G – *Galathea intermedia* (Decapoda); H – *Bullia annulata* (Gastropoda); I – *Dromidae* sp (Decapoda); J – *Ostracoda* sp (Ostracoda); K - *Protomystides capensis* (Polychaeta); L: *Leptanthura laevigata* (Isopoda) M – *Austromaera bruzelii* (Amphipoda); N – *Donax burnupi* (Bivalvia); *Nereis sp* (Polychaeta)**

3.3.5 Birds

Algoa Bay and the associated islands provide shelter, feeding and breeding habitats for numerous bird species, including important conservation species listed on the IUCN red list as endangered, such as the African penguin (*Spheniscus demersus*), Cape cormorant (*Phalacrocorax capensis*) and Cape gannet (*Morus capensis*). Species that utilise the intertidal rocky shores as important foraging areas; include African black oystercatcher (*Haematopus moquini*), pied kingfisher (*Ceryle rudis*), Kelp and Grey-headed gulls (*Larus dominicanus*, *Chroicocephalus cirrocephalus*), swift and common tern (*Sterna bergii,* and *S. hirundo*). In addition, sandy beaches provide food resources for birds such as Kelp and Grey-headed gulls, Swift, Common and Caspian tern (*Hydroprogne caspia*) and numerous species of waders, such as White fronted, Grey and Ringed plovers (*Charadrius marginatus*, *Pluvialis squatarola* and *Charadrius hiaticula*), Curlew sandpiper (*Calidris ferruginea*), as well as Sanderlings (*Calidris alba*) in the summer (Craig 1998).

There are two groups of three islands each, within Algoa Bay that support not only colonies of birds but Cape fur seals (*Arctocephalus pusillus*) too (Figure 12). One island group comprises the large St Croix Island with smaller stacks of Jahleel and Brenton Rocks. St Croix Island lies 4 km from the coast and is situated between the Coega and Sundays river mouths. This rocky 12 ha island rises to 58 m and has very little vegetation. The second island group consists of Bird, Seal and Stag Islands, and lies near Cape Padrone, 7 km from the coastal Woody Cape Nature Reserve. Bird Island (19 ha) is the largest of the Algoa Bay islands and is relatively flat rising by only 9 m. Seal Island is much smaller (0.6 ha) lying 360 m north of Bird Island, and Stag Island is even smaller (0.1 ha), lying 320 m north-west of Bird Island (BirdLife International, 2012).

The islands of Algoa Bay are home to many endangered, vulnerable and near-threatened birds including breeding colonies of African penguins (Crawford *et al.* 1990; Barnes 1998), Cape gannet (Crawford, 1997b; Barnes, 1998), African black oystercatchers (Martin 1997), Roseate tern (*Sterna dougallii*, Randall *et al.* 1991; Crawford, 1997a), Cape Cormorant (Cooper *et al.* 1982) and winter visiting Antarctic terns (Williams, 1997). The African penguin colony at St Croix Island is the largest in the world (Pichegru *et al.* 2010).

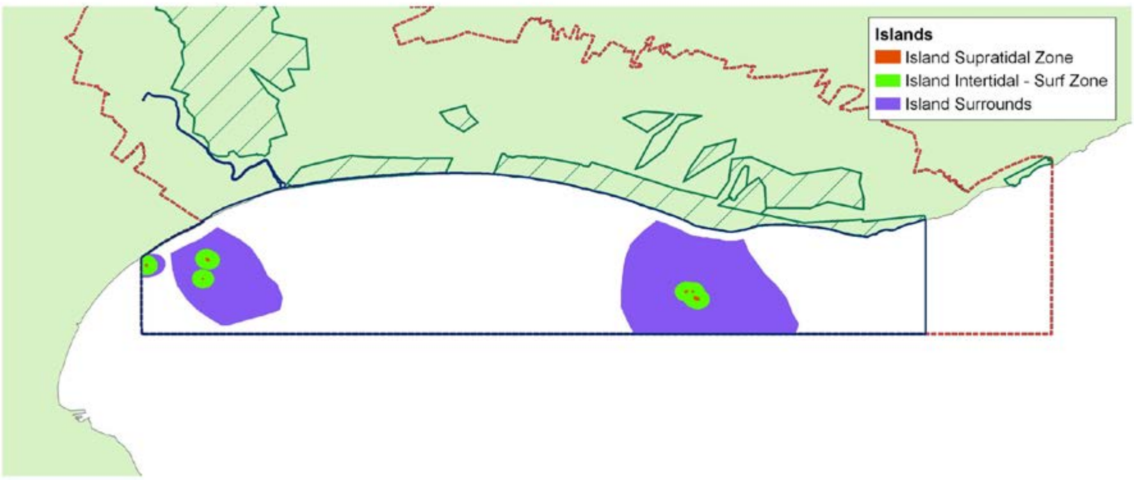

Figure 12 **Demarcated island habitats within Algoa Bay. Red dots indicate the positions of the Ports of Port Elizabeth (left) and Ngqura (right), respectively. (Source: A. Oostehuizen, SANParks).**

3.3.6 Fish, marine mammals and sharks

Algoa bay has high diversity of fish species, the distribution of which depends on the habitats they favour. Species which utilize the intertidal rock pools to prey on invertebrates and algae found on the rocky shore include clinids (especially *Clinus cottoides* and *C. superciliosus*), the gobies (*Caffrogobius spp.*), juvenile sparids, particularly blacktail (*Diplodus capensis*) and fransmadam (*Boopsoidea inornata*) as well as mullet (Mugilidae). While those that feed on sandy beach organisms include species such as galjoen (*Dichistius capensis*) and white steenbras (*Lithognathus lithognathus*) which swim over submerged beaches at high tide and feed on small crabs and the like (Branch & Branch 1981). Elf (*Pomatomus saltatrix*), leervis (*Lichia amia*), sand shark (*Rhinobatos annulatus*) and white sea catfish (*Galeichthys feliceps*), are some of the characteristic species which favour the sandy surf zone.

Characteristic fishes found on the deeper reefs include Panga (*Pterogymnus laniarius*), Piggy grunter (*Pomadasys olivaceum)*, Santer (*Cheimerius nufar)*, Carpenter (*Argyrozona argyrozona*), Fransmadam (*Boopsoidea inornata)*, Roman (*Chrysoblephus laticeps)*, Dageraad (*Chrysoblephus cristiceps)*, Yellowbelly rockcod *(Epinephelus marginatus)*, Steentjie (*Spondyliosoma emarginatum)* and white musselcracker (*Sparadon durbanensis*) (Smale & Buxton 1998; Chalmers 2012).

Wallace *et al.* (1984) also sampled the inshore ichthyofauna using otter-nets, blanket nets, try nets, scoop-nets and dredges in an effort to gain an understanding of the fish community composition and their dependence on estuaries and inshore areas as nursery grounds. Table 6 summarizes those species comprising the catch (according to their relative frequencies) in the vicinity of the Swartkops River which lies between Algoa 6 and Algoa 7. Table 7 lists those species comprising the catch off the Sundays River mouth to the east of the proposed Algoa 7 precinct.

Table 6 **Proportion that each species (%) caught in inshore trawls contributes according to the frequency of that species relative to that of the total catch in the vicinity of the proposed ADZ precincts offshore of the Swartkops River mouth.**

Species name	Common name	Habitat	Percentage of catch
Dasyatis pastinacus	Blue stingray	Benthic on sand or mud, prefers surf zone but found down to 110m	0.43
Myliobatus aquila	Eagle ray	Shallow water to 95m	0.82
Squalus megalops	Spiny dogfish	Shore down to 500m, usually close to bottom, juveniles pelagic over continental shelf	1.37
Argyrosomus inodorus	Silver kob	Important nursery areas are sandy and muddy substrata of the nearshore, sandy reef edges and estuaries	13.91
Cynoglossus capensis	Sand tonguefish	Sandy or silty bottom, from 10m to well below 100m	1.65
Galeichthys feliceps	White sea-catfish	Sheltered reefs or muddy bottom down to 100m	31.25
Merluccius capensis	shallow water hake	In water between 50-400m deep. Closer to surface at night	1.04
Pagellus natalensis	Red tjor tjor	Deep water species brought closer inshore by upwelled water over sandy bottoms	6.74
Pomadasys olivaceum	Piggy grunter	Juveniles and adults in coastal waters. Often over offshore reefs and soft substrate banks	24.42
Pomatomus saltatrix	Shad	Predatory over sandy bottoms and reef edges	12.07
Trachurus trachurus	Maasbanker	Pelagic, surface to 400m	2.83

Table 7 **Proportion that each species (%) caught in inshore trawls contributes according to the frequency of that species relative to that of the total catch in the vicinity of the proposed ADZ precincts offshore of Sundays River mouth.**

Species name	Common name	Habitat	Percentage of catch
Dasyatis pastinacus	Blue stingray	Benthic on sand or mud, prefers surf zone but found down to 110m	0.75
Myliobatus aquila	Eagle ray	Shallow water to 95m	0.6
Narke capensis	One-fin electric ray	No data	0.49
Raja miraletus	Twin-eye skate	shallow water down to 50m	0.44
Squalus megalops	Spiny dogfish	Shore down to 500m, usually close to bottom, juveniles pelagic over continental shelf	1.25
Argyrosomus inodorus	Silver kob	Important nursery areas are sandy and muddy substrata of the nearshore, sandy reef edges and estuaries	26.64
Engraulis encrasicolus	Anchovy	Coastal pelagic down to 400m	11.27
Galeichthys feliceps	White sea-catfish	Sheltered reefs or muddy bottom down to 100m	14.56
Pomadasys olivaceum	Piggy grunter	Juveniles and adults in coastal waters. Often over offshore reefs and soft substrate banks	20.85
Pomatomus saltatrix	Shad	Predatory over sandy bottoms and reef edges	4.75
Trachurus trachurus	Maasbanker	Pelagic, surface to 400m	5.53
Umbrina canariensis	Baardman	Benthic, 40-100m, feed over soft substrata	1.95

Species composition among the three areas is relatively similar, as one would expect, although there are some differences in the rank contribution of species to the overall catch, probably due to local scale determinants.

Inshore fish larvae sampled at depths of 5 and 15 m offshore of the Sundays River mouth (Algoa 5) and further eastwards near Woody Cape revealed the presence of 78 species (Pattrick & Strydom 2008). The larvae of 10 fish families dominated these samples. The gobies (Gobiidae) was the dominant family and made up half (49 %) of the contribution to the total catch. The tonguefish (Cynoglossidae), anchovy (Engraulidae) and herring (Clupeidae) each contributed 8 % and the sea breams (Sparidae) 7 % to the total catch. The blennies (Blenniidae) and sole (Soleidae) contributed 5 % and 4 %, respectively. Croakers (Sciaenidae) contributed 3 % to the catch while the triple-fin blennies (Tripterygiidae) and sea chub (Kyphosidae) contributed 2 % and 1 %, respectively.

The pilchard (*Sardinops sagax)*, anchovy (*Engraulis encrasicolus)* east coast roundherring (*Etrumeus teres)* and saury (*Scomberesox saurus)* are probably the most abundant pelagic species in the region of Algoa Bay and the pilchard, anchovy and round herring in particular are both prolific schooling species occurring in huge shoals (Smale & Buxton 1998, van der Elst 1993). These provide an important food source for many other pelagic species (Batchelor & Ross 1984, Randall & Randall 1986, van der Elst 1993), including other predatory pelagic fish, especially yellowtail (*Seriola lalandi*), skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), leervis (*Lichia amia*), horse mackerel (*Trachurus trachurus*), bronze whaler (*Carcharhinus brachyurus*), dusky sharks (*Carcharhinus obscurus*) and hammerhead sharks (Sphyrna, Smale 1986, Smale 1991, Heemstra & Heemstra 2004).

The small pelagic fish also support important birds and marine mammals. For example more than 90 % of the numerical dietary composition of the Cape gannet (listed as Vulnerable) off Bird Island consisted of three species of small pelagic, mainly Pilchard (*Sardinops ocellata*), Anchovy (*Engraulis capensis)* and Saury (*Scomberesox saurus,* Batchelor & Ross 1984, Klages *et al.* 1992) and the diet of African penguins (*Spheniscus demersus*) from St Croix Island comprised 19 species of fish (Randall & Randall 1986). Pelagic shoaling fish being the dominant prey items, specifically anchovy, pilchard and round herring, in that order (Randall & Randall 1986).

Six species of cetaceans are regularly seen in Algoa Bay; these include southern right whales (*Eubalaena australis*), humpback whales (*Megaptera novaeangliae*), Bryde's whales (*Balaenoptera brydei*), Indian Ocean bottlenose dolphins (*Tursiops aduncus*), Indo-Pacific humpback dolphins (*Sousa chinensis*), and longbeaked common dolphins (*Delphinus capensis*) (Saayman *et al.* 1972, Karczmarski *et al.* 2000, Reisinger & Karczmarski 2009, Melly 2011). The zoogeography of these species has been the focus of a recent comprehensive study that analysed distribution patterns collected from over a year's worth of boat-based observations in relation to various physical and behavioural variables e.g. distance from shore, bottom depth and type, season, sea state, foraging, travelling, resting etc. (see Melly 2011). This study identified key habitats for each species and highlighted the importance of Algoa Bay as a breeding and nursery area for southern right whales and as a potentially important nursery area and migration route for humpback whales. The distribution patterns of the other four cetacean species were thought to be linked primarily to prey distributions.

A key habitat area for southern right whales, humpback dolphins and bottlenose dolphins was identified between PE Port and Cape Recife adjacent to, but mostly inshore of the proposed Algoa 1 precinct (humpback dolphins in particular inhabit very shallow coastal waters, an average of 6.6 m, and most of the Algoa 1 precinct is deeper than 25m). A long coastal strip from just east of the Sundays River estuary mouth to Woody Cape was identified as a key habitat for southern right and humpback whales and bottlenose dolphins. This area also lies inshore and to the east of the Algoa 7 precinct, although humpback whales (along with Brydes whales and common dolphins) were associated with deeper water i.e. a more offshore group whose distributions may more frequently overlap with the proposed precincts.

Algoa Bay is the eastern most distribution of the Cape fur seal and breeding takes place on Black Rocks (Mills & Hes, 1997). The presence of this breeding colony may act as an important factor for the aggregation of Great white sharks (*Carcharodon carcharias*), which are known to target seal breeding colonies as feeding grounds (Kock *et al.* 2013, Hewitt *et al.* 2018). While a range of sizes of white sharks can be found around Seal Island, the inshore areas of Algoa Bay are home to the greatest proportion of young-of-year sharks (Dicken & Booth 2013).

3.3.7 Alien and invasive species

Alien species are plants, animals and microorganisms that are transported beyond their natural range and become established in a new area. They are sometimes called exotic, introduced, non-native or non-indigenous species but are not necessarily invasive. Invasive species are introduced species that have a tendency to spread to a degree believed to cause damage to the environment, to the economy or to human health. At least 92 marine alien species have been recorded in South African waters and an additional 39 species are currently regarded as cryptogenic, which means they are of unknown origin but are likely introduced to South Africa (Anchor 2017).

Most of the introduced species in South Africa have been found in sheltered areas such as harbours, and are believed to have been introduced through ballast water discharge or hull fouling. As ballast water tends to be loaded in sheltered harbours, the species that are transported originate from these habitats and have trouble adapting to South Africa's exposed coast (Griffiths *et al.* 2008). Therefore, although Algoa Bay may host a number of alien species, they are unlikely to spread outside of the bay or be able to established populations further along the coast The exception being that of the invasive Mediterranean mussel (*Mytilus galloprovincialis*, Griffiths *et al.* 1992, Robinson *et al.* 2005) which is found along the west coast of South Africa and along the east coast as far as East London.

3.4 Biodiversity Importance and Conservation Status

Due to the high diversity of habitats, marine organisms and seabirds in Algoa Bay (several of which are of conservation concern), significant biodiversity importance is attributed to many areas in the Bay (Chalmers 2012) (Figure 13). The St Croix Reserve and Bird Island MPA off Woody Cape make a significant contribution to biodiversity conservation, particularly for birds and offshore island habitat (Barnes 1998, Chalmers 2012). However, large areas with high biodiversity conservation importance are afforded no protection. The National Protected Areas Expansion Plan (SANBI 2009) proposed an MPA in Algoa Bay, which would adjoin the Greater Addo Elephant National Park (GAENP) and improve biodiversity conservation considerably. The proposed GAENP MPA was approved by cabinet in 2018 and is the first MPA in South Africa to incorporate a bay environment, exposed rocky headlands and offshore islands.

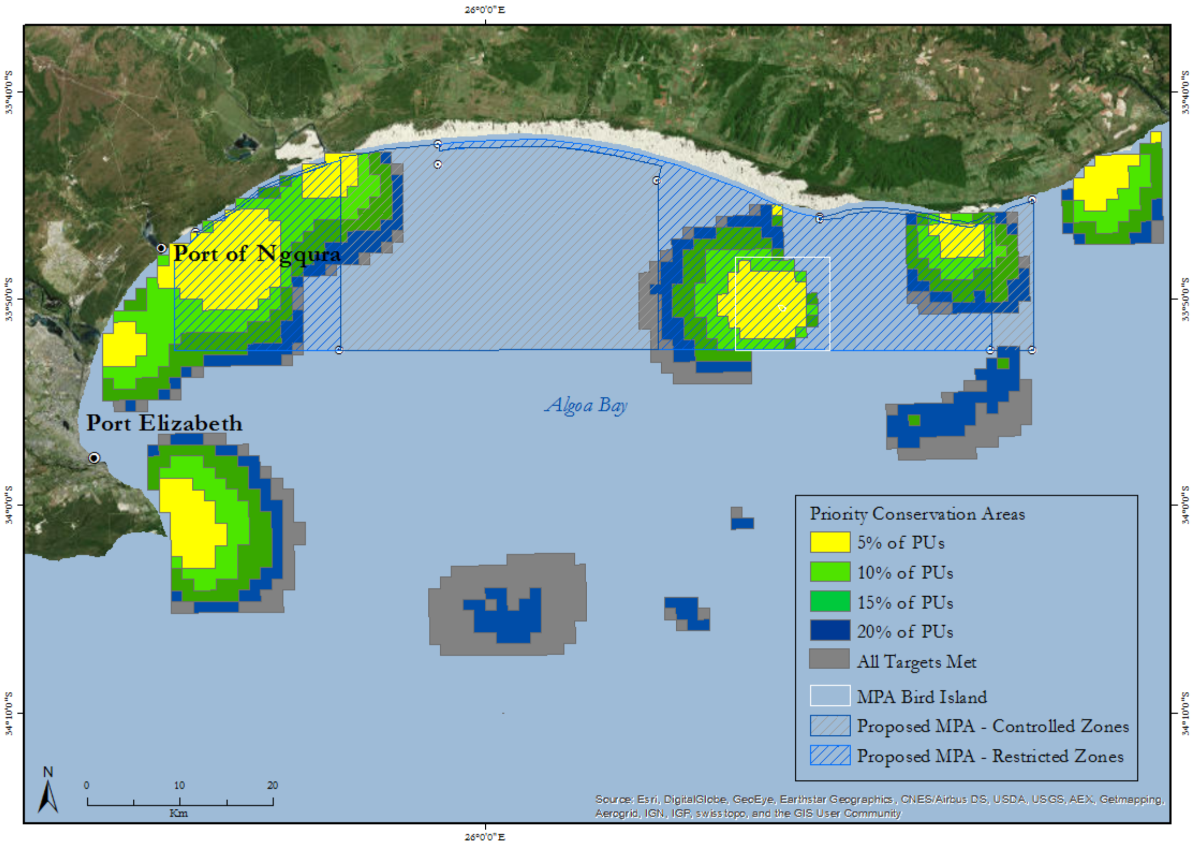

Figure 13 Priority conservation areas within Algoa Bay (Data source: Chalmers, 2012).

3.5 In-situ monitoring of potential sites

Site specific oceanographic and biological investigations were conducted both during the previous 2010-2013 and current BA processes. Comparative analyses of the data arising from these surveys are contained within the Benthic Mapping Report (Dawson et al 2019), and are summarised briefly below.

The proposed Algoa Bay ADZ precincts occur in an area where two large current systems (the Agulhas and Benguela), with different temperatures, undergo mixing. In addition, during easterly winds periodic upwelling may occur near the rocky headlands of the bays that can cause sharp drops in temperature. Temperature and current dynamics are therefore complex and vary over small spatial scales within Algoa Bay. In situ monitoring of the physical oceanography of Algoa Bay was carried out over periods of 4 - 11 months at previously assessed ADZ precincts (Algoa 1, Algoa 2, Algoa 5) using Acoustic-Doppler Current Profilers (ADCPs), thermister strings and single beam echo-sounding for accurate bottom type characterisation and depth profiling. Data collected at Algoa 2, which lies approximately 3 km to the southwest of Algoa 7 provide a reasonable proxy of the oceanographic conditions that are likely to be experienced at Algoa 7.

Results from in situ monitoring at Algoa 2 over an 11 month period suggest that upward movement of the thermocline is a potential concern, with rapid changes in temperatures of more than 7°C over a 12hr period detected as shallow as 13m water depth on occasions during summer, spring and autumn months. Less extreme decreases of up to 2.5^{o}C in 12 hours were recorded at 9m and 5m water depth. On Algoa 1 and Algoa 5, data collected for the four month period between January and June 2013 showed similar temperature variability during the summer and autumn period, with increasing variation in temperature at greater depths. During 2013 monitoring at Algoa 1 and Algoa 5, vertical movement of the thermocline was common below 9 m and nearly reached the surface (5 m depth), where drops of ~ 4°C over a 12 hr period were recorded at both sites, at least once during the four months.

Commercial scale fish cages will be ~15m deep and stock will certainly be exposed to some rapid temperature declines. Stock response to these temperature fluctuations and the impacts on potential maximum stocking density and fish health will be species specific and are not fully understood at this stage, but impacts are likely to be negative. At all three sites during winter, temperatures averaged approximately 17-18°C and were far more stable with little movement of the thermocline detected.

Wave climate at Algoa 2 was characterised by average significant wave heights of less than 2 m 95 % of the time and wave period was most commonly one wave every 12 seconds. However, the maximum significant wave height recorded reached 5 m with a wave period of 13 seconds, which is of concern as this exceeds the specifications for most common floating fish cage designs (significant wave height < 3.5 m). Wave data collected for Algoa 5 confirm that this site is more exposed (being further east and out of the lee of Cape Recife), with wave heights exceeding 2 m, 6.5% of the time and a maximum wave height of 3.4 m. Over the same season during 2012, significant waves heights recorded on Algoa 2 only exceeded 2 m for 1 % of the time. This indicates that Algoa 5 is the least suitable potential site for the floating circular cage types that are most likely to be used in South Africa's pioneering sea cage industry and is one of the reasons Algoa 5 was screened out of this EIA (the other main reasons being travel distance from port and its location in the centre of an approved MPA).

Wave data are not available for Algoa 1 (the ADCP instrument deployed here was not equipped to measure waves), but due to its position in the lee of Cape Recife this site is expected to have the lowest average and maximum significant wave heights of all the fin fish sites assessed.

Dominant currents at Algoa 1 moved mainly in a southerly direction throughout the water column but an increased frequency of northerly current was evident in near bottom waters (although flows were still predominantly southerly). Prevailing flows further in the Bay, at Algoa 2 and Algoa 5 were coast parallel, i.e. easterly or westerly, particularly in the upper water column, becoming orientated on a northwest- southeast axis in the near bottom water. However, currents at all levels of the water column were also found to flow in all possible directions but with relatively low velocities at times.

On average, during the period January – June 2013, currents on Algoa 1 flowed at a higher velocity than the other two monitored sites and in a predominately southerly direction i.e. out of the Bay and away from the popular bathing and surfing beaches, but towards identified dive sites and an identified squid fishing area. This confirmed that any waste material from fish cages is less likely to affect the beach/inland areas, but more likely to affect some of the identified recreational dive sites and a specific squid area favoured by the industry during periods of rough seas. Bivalve mariculture is expected to have much lower organic waste impacts compared to finfish and should this site only be used for bivalve grow-out, impacts on dive sites and squid fishing grounds are expected to be low to insignificant.

Depth at Algoa 1 was found to range from 21 m at the inshore areas to 40 m further offshore; although this depth is deeper than the optimum depth for mussel and oyster production this can be overcome by the use of long lines. Depth gradients over the entire precinct appear consistent and uniform, indicative of an area lacking in any reef. No reef was detected according to bottom type analysis of the sediment at Algoa 1 either. Sediments at Algoa 1 ranged from mean particle sizes per sample of 385 to 1362 µm and can be described as consisting of medium and very course sands. The percentage of total organic content comprising the sediments ranged from 2.27 to 5.04 %.

Depth within Algoa 6 ranged from shallow (5 m) in the south-western corner to a maximum depth of only 13 m along the eastern boundary of the site. For the most part depth increased from the shoreline in the west to the eastern boundary of the site. There was no reef recorded in the Algoa 6 substrate. Mean particle size (averaged from repeated samples collected during 2009) ranged from 203 - 220 µm across all sampling stations, therefore falling within the range of very fine sand.

Depth at Algoa 7 was found to range from 18 m at the inshore, north-western corner of the area to 31 m further offshore, in the south-eastern corner of the area. Depth gradients over the entire precinct appear consistent and uniform, indicative of an area lacking in any reef. This was supported by sediment data which showed an absence of any rock or reef within samples. Sediments ranges from mean particle sizes per sample of 189 to 324 µm and can be described as consisting of fine sand throughout all sampled sites (reflecting the weaker currents found here compared to Algoa 1). The percentage of total organic content comprising the sediments ranged from 2.18 to 3.64 %.

Total macrofaunal abundance and biomass did not differ significantly among the two proposed sites, whilst indices of the macrofaunal community diversity, evenness and taxonomic richness among the two finfish sites (1 & 7) were similar but diversity (based on historical data) was significantly lower at the proposed bivalve site (Algoa 6). Multivariate analyses of community structure of macrofaunal assemblages however, based on species abundance data, showed statistically significant differences among sites. Multivariate dispersion tests showed that community abundance at Algoa 6 and Algoa 7 was less variable, than the variability of abundance at Algoa 1.

At a higher taxonomic level (class and order) all three sites differed. At Algoa 1 taxonomic compositions highlighted both Amphipoda and Polychaeta as the most important groups in terms of abundance; while the most abundant groups at Algoa 6 were the Echinodermata followed by Polychaeta and Decapods in almost equal proportions. Unique to Algoa 7 is the complete dominance of Polychaeta, contributing 69 % to the overall abundance.

Cumulative abundance-biomass plots of macrobenthic communities, also called k-dominance curves, were plotted to visually assess patterns of abundance and biomass in the proposed finfish sites (Algoa 1 and Algoa 7). Algoa 1 exhibited responses indicative of stable conditions, where the frequency or intensity of disturbance is low. In this site k-selected (larger, long-lived species) make an important contribution to community structure. The abundance-biomass curve produced for Algoa 7 however, suggests that abundance is becoming patchier, with many species contributing to overall biomass and is indicative of some level of disturbance. The reduced within site macrofaunal community and sediment variability of Algoa 7 relative to Algoa 1 suggests that Algoa 7 may already be slightly disturbed form nearby dredge disposal activities.

4 ENVIRONMENTAL IMPACT ASSESSMENT

Environmental impacts of finfish cage farming have been well documented and reported in international literature (e.g. see: Stickney & McVey 2002, Staniford 2002). A brief description of the potential environmental impacts of finfish cage culture follows. In the early period of finfish farming internationally, particularly salmon farming in the pioneering countries, a lack of good environmental management and poor farming practices led to significant, negative environmental impacts occurring. This resulted in negative attitudes and opinions amongst the public and conservation organizations towards the industry. This negative sentiment towards sea cage fish farming persists to this day, despite an increasing focus on sustainability by both governments and industry. In a proactive move, the South African Marine Finfish Farmers Association of South Africa (MFFASA) has compiled their own Marine Fish farming Environmental Impact Information document (MFFASA 2010) that includes a code of conduct and identifies most of the known environmental impacts of finfish farming. Unfortunately many of the environmental impacts of cage farming are expensive and difficult to mitigate and the opposition to industrial scale fish cage culture remains strong. Nonetheless, some of the potential impacts of finfish sea cage farming may be mitigated by selection of appropriate sites only (Clark *et al.* 2011). Mitigation for other impacts can only be addressed when operational specific data are available, and should be implemented via an approved Environmental Management Programme (EMPr). The impacts of mariculture depend on the species, culture method, stocking densities, feed type, hydrography of the site and husbandry practices (Wu 1995). Recommended marine monitoring components of an EMPr for the Algoa ADZ are given in Section 5.

In the marine environment a disturbance can be relatively short-lived but the effect of such a disturbance may have a much longer lifetime. The assessment and rating procedure described in Appendix 1 addresses the effects and consequences (i.e. the impact) on the environment rather than the cause or initial disturbance alone. The assessment of impacts was based on specialist expertise, field observations, and desk-top analysis. The significance of all potential impacts is determined in order to assist decision-makers. The significance of an impact is defined as a combination of the consequence of the impact occurring and the probability that the impact will occur. To reduce negative impacts, precautions referred to as 'mitigation measures' are set and attainable mitigation actions are recommended. In this report, the 'construction footprint' is defined as the total area of new infrastructure as determined by design engineers. Each of the impacts is likely to affect the associated biota in different ways and at varying intensities depending on the nature of the affected habitat and the sensitivity of the biota. The degree of each impact depends on the construction methods used. Results of each assessment are presented in Table 9 to Table 25 and are summarised in Table 27.

The Department of Agriculture, Forestry and Fisheries (DAFF) intends to develop an ADZ in Algoa Bay, Eastern Cape. Three potential sites have been identified and will be considered in this impact assessment; Algoa 1, 6 and 7. The specialist impact assessment for Algoa 1, 6 and 7 was compiled based on:

1. The marine baseline study (Porter *et al.* 2012) and impact assessment (Hutchings *et al.* 2013) conducted by Anchor as part of the previous EIA process;
2. The comparative review of Algoa 1 and 5 (Britz and Sauer 2016a); and
3. Benthic habitat mapping and dispersion modelling studies that Anchor completed for DAFF in November 2018 (Dawson *et al.* 2019 and Wright *et al.* 2019).

Potential impacts are denoted by first listing the phase of the development (i.e. CP = Construction Phase; OP = Operational phase) followed by ME indicating the Marine Ecology impact category. Impacts are numbered consecutively and separately for the construction and operational phases.

4.1 Description of alternatives

The precincts considered in this application include Algoa 1 and 7 for finfish culture and Algoa 1 and 6 for bivalve culture. The process by which precincts Algoa 2, 3, 4, and 5 were screened out is described in more detail in the Basic Assessment Report (Massie *et al.* 2019). Each of the precincts taken forward into the impact assessment process is described in more detail below and shown in Sections 4.1.1-4.1.3 below. It is important to note that DAFF proposes to farm both bivalves and finfish in Algoa Bay and therefore the approach to choosing alternatives has changed from considering individual precincts as alternatives to each other (i.e. the previous process chose Algoa 5 as an alternative to Algoa 1) to considering combinations of precincts as alternative options.

The environmental impacts of various farming intensity levels in Algoa Bay are assessed by way of three options (Table 8). Option A includes both finfish and bivalve culture at Algoa 1. This option would allow for finfish farming at two sites. Furthermore, this option would offer a protected environment as a nursery site for bivalves (Algoa 6) as well as a clean, comparatively unpolluted environment as a bivalve grow-out site (Algoa 1). Option B includes only one site for finfish farming (Algoa 7) but provides the same opportunities to bivalve farmers as Option A. Option C excludes Algoa 1 altogether and limits bivalve culture to Algoa 6.

Table 8 **Alternative options of precinct combinations involving Algoa 1, 6 and 7 considered in the Basic Assessment process for the proposed Algoa Bay Aquaculture Development Zone.**

Option	Algoa 1	Algoa 7	Algoa 6
A	Finfish & Bivalve	Finfish	Bivalve
B	Bivalve	Finfish	Bivalve
C	X	Finfish	Bivalve
D	X	X	X

The Status Quo Alternative proposes that the Algoa Bay ADZ does not go ahead. Algoa Bay is one of the few areas along the South African coastline considered suitable for marine based aquaculture. Therefore the 'No-go/Status Quo' alternative will eliminate the potential associated with the area as a whole, which will result in the loss of potential benefits associated with the aquaculture industry, as well as the opportunity to meet growing seafood demand. Not establishing an ADZ will leave only current fishing production methods to supply the growing demand for seafood products. The sustainability of these methods is questionable in the long term, and the negative impact on wild stocks has been flagged by DAFF as a critical concern. Irrespective of the potential positive impacts, a number of negative impacts are associated with developing an ADZ and as such, the No-Go option must be considered as the status quo against which the alternative options must be measured.

4.1.1 Algoa 1

Proposed finfish and bivalve e.g. mussels, oysters etc. culture site. The site measures 665 ha and lies approximately 2 km off shore of the popular beach area that makes up Summerstrand and Humewood. In the past EIA and current BA processes, both the visual and marine specialists have identified criteria that will most likely result in potentially negative impacts on the environment as well as conflict with other users. Monitoring protocols and recommended mitigation measures may however reduce the significance of such impacts. The socio-economic assessment found the Algoa 1 site to be the better than (the now screened out) site 5 in terms of economic viability due to its proximity to land which improves operational and maintenance requirements. It also improves response times in case of emergencies (i.e. entanglements, escape situations). Algoa 1 is however, considered very similar to the new Algoa 7 in terms of economic viability.

4.1.2 Algoa 6

Proposed bivalve culture site. The site measures approximately 800 ha in water ranging in depth from 5 – 12 m. This site is suitable for bivalve culture only. The proposed inshore bivalve culturing site is situated adjacent to the Port Elizabeth harbour wall and extends north parallel to the shoreline for approximately 4.8 km. The immediate coastal area is characterised by urban industrial development and a mostly modified shoreline fringed by railway tracks and the Settlers Highway (M4).

4.1.3 Algoa 7

Proposed finfish culture site. This site measures 355 ha in size and is positioned approximately 3 km offshore from the Ngqura harbour. Despite its proximity to the port entrance and anchorage areas, Algoa 7 is not expected to impact significantly on shipping traffic. This site overlaps slightly with the recently approved Addo Marine Protected Area (MPA) but the Department of Environmental Affairs Branch Oceans and Coasts has indicated that the affected portion of this site could potentially be excised should Environmental Authorisation be granted for this precinct.

4.1.4 Assessment of impacts: construction phase

4.1.4.1 Potential impact CP-ME1: Disturbance of benthic habitat

Construction phase impacts on the marine environment are limited to those caused by the placement of cages and mooring infrastructure on the sites. The mooring anchors, chains and ropes will have a negative impact (mortalities, loss of habitat) on benthic communities directly within the footprint of anchors or mooring blocks and the movements of mooring chains and ropes may cause further mortalities and or disturbance to benthic communities. Seabed acoustic surveys reveal that all three of the proposed ADZ sites are largely sandy substratum (Hutchings *et al.* 2013, Dawson et al 2019). The impact is localized and of low intensity, and is assessed as having **low** overall significance (Table 9). Potential impacts of cage infrastructure on marine vertebrates due to entanglement start as soon as infrastructure is installed, but this is assessed under “operational phase” impacts below.

Table 9 CP-ME 1 - Disturbance of subtidal habitat (ongoing but reversible).

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Local (1)</td><td>Low (1)</td><td>Long-term (3)</td><td>Low (5)</td><td>Definite</td><td>LOW</td><td>-ve</td><td>High</td></tr>
<tr><td colspan="9">Essential mitigation measures:
• Do not moor cages over long lived biogenic habitats (e.g reefs)
Optional mitigation measures:
• Ensure mooring system is well designed to prevent/limit movement of anchors and chains over the sea floor.
• Do not move mooring anchors or blocks when undertaking cage net maintenance or fallowing sites, as replacement of moorings when site is used again will increase impact footprint.</td></tr>
<tr><td>With mitigation</td><td>Local (1)</td><td>Low (1)</td><td>Short – term (1)</td><td>Very Low (3)</td><td>Definite</td><td>VERY LOW</td><td>-ve</td><td>High</td></tr>
</table>

4.1.5 Assessment of impacts: operational phase

Operational phase environmental impacts of finfish cage culture include:

- Incubation and transmission of fish diseases and parasites from captive to wild populations and vice versa.
- Pollution of coastal waters due to the discharge of organic wastes.
- Escape of genetically distinct fish that compete and interbreed with wild stocks that are often already depleted.
- Chemical pollution of marine food chains (& potential risk to human health) due to the use of therapeutic chemicals in the treatment of cultured stock and antifouling treatment of infrastructure.
- Physical hazard to cetaceans and other marine species that may become entangled in ropes and nets.
- Piscivorous marine animals (including mammals, sharks, bony fish and birds) attempt to remove fish from the cages and may become tangled in nets, damage nets leading to escapes and stress or harm the cultured stock. Piscivorous marine animals may also be attracted to the cages that act as Fish Attractant Devices (FADs) and in so doing natural foraging behaviors and food webs may be altered. Internationally fish farmers tend to kill problem predators or use acoustic deterrents (Stickney and McVey 2002).

The significance of these various impacts and possible mitigation measures with respect to the proposed Algoa Bay ADZ are assessed in more detail below.

4.1.5.1 Finfish mariculture

4.1.5.1.1 Potential impact OP-ME1: Disease and parasites affecting finfish

In fish cage aquaculture, high stocking densities (typically 15-20 fish per m^3) serve as a breeding ground for disease and parasite infections (including blood, intestinal and ecto-parasites). Infectious diseases and parasites are regarded as the single biggest threat to aquaculture, with the estimated losses from sea lice (genus *Caligus*) infections of salmon stock alone amounting to hundreds of millions of dollars annually (Staniford 2002, Heuch *et al.* 2005). The cultured stock is often prevented from exercising natural parasite shedding behaviours and the high number of concentrated hosts facilitates parasite and disease reproduction and transmission. This is not only a concern for the productivity of the cultured stock, but also threatens wild stocks due to enhanced transmission of parasites and diseases (Heuch *et al.* 2005, Krosek *et al.* 2007, Ford and Myers 2008). Transmission to wild stocks may take place by direct contact between wild fish and farmed stock as wild fish are often attracted to the cages, or simply as a result of the much higher concentration of pelagic parasite life history stages arising from fish farms.

Wild salmon in particular have suffered increased parasite infection rates due to contact with cage cultured stock (Carr and Whoriskey 2004, Heuch *et al.* 2005). Documented effects of high parasite loads on wild salmonids include increased mortality rates, reduced fecundity and delayed maturity, all of which reduce the fitness of individuals and the productivity of the wild stock as a whole (Bjorn *et al.* 2002, Carr and Whoriskey 2004, Heuch *et al.* 2005, Ford and Myers 2008). Intensive sea bass and sea bream culture in the Mediterranean has also resulted in severe disease problems in fish farms; problem diseases include *Pasteurellosis* and *Nodavirosis*, and parasitic infections include *Ichtyobodo* sp., *Ceratomyxa* sp., *Amyloodinium ocellatum, Trichodina* sp., *Myxidium leei, and Diplectanum aequans* (Agius and Tanti 1997 cited in Staniford 2002). In Australia, experiments have revealed that Monogenean parasites, infected yellowtail up to 18 km downstream of the cages (Chambers and Ernst 2005).

Gill and skin flukes were identified as one of the major factors holding back Australian yellowtail production (Moses *et al.* 2009). Indigenous species currently under consideration for sea cage mariculture in South Africa include silver and dusky kob (*Argyrosomus inodrus* and *A. japonicus*) and yellowtail S*eriola lalandii*. The parasites and diseases infecting these (and other finfish) species in South African waters are not well studied, although both kob species are known to be infected by sea lice of the same genus (*Caligus*) that caused serious problems amongst salmonids, as well as other copepod, trematode, Acanthocephalan (parasitic worm) monogean (specifically the gill fluke *Diplectanum oliverii),* dinoflagellates (*Amyloodinium ocellatum*) and myxozoan species (DEAT undated Grobler *et al.* 2002, Christison & Vaughan 2009, Joubert *et al.* 2009). Sciaenids farmed elsewhere, namely dusky kob in Australia and meagre *A. regius* in the Mediterranean have also proved susceptible to monogean gill parasites that caused disease and mortality (Hayward *et al.* 2007, Merella *et al.* 2009).

Dusky kob are migratory and yellowtail are regarded as nomadic, whilst silver kob within the vicinity (10-100 km) of future sea cages will also likely come into contact with farmed stock (Mann 2000). All three of these species (and any others with nomadic or migratory movement patterns) will therefore be at an increased risk of contracting diseases and or parasites from stocked fish and spreading them through wild populations. Potential negative effects on wild stocks are particularly concerning as all three of these species are important in the commercial and recreational line fisheries and furthermore, the stocks of both South African, wild kob species are assessed as collapsed (Grifitths 2000). Dusky kob has recently been assessed using IUCN criteria and is considered Vulnerable in South Africa (Sink *et al.* in prep). Although treatment of cultured stock to control disease and parasite outbreaks is possible (unlike wild stocks), chemical treatment is not without further environmental impacts, whilst build-up of antibiotic and chemical resistance is becoming increasingly problematic (Staniford 2002).

"Fallowing" as a parasite and disease mitigation measure refers to leaving all cages within a precinct area (or bay) un-stocked for a period of at least two months. "Pseudo-fallowing" in this respect can be achieved by stocking all cages with a different species therefore lowering the environmental load of species specific pathogens (this obviously is not mitigation for benthic impacts and does not help with pathogens/parasites that infect a broader number of species). The economic practicality of implementing effective fallowing (cages un-stocked) in a pioneering industry with only one available site is not known, but this should be considered until better information on parasite and disease risk of cage culture with locals species is available.

Potential disease and parasite transmission to wild stocks could have negative impacts throughout the natural distributional range of the species, the intensity of the potential impact will be high as it could alter wider natural (ecosystem impacts) and social functions (fisheries), and the impact will be ongoing. Mitigation measures are not entirely effective, and the overall significance of the impact is estimated as very high without and high with mitigation (Table 10). This is consistent with the 2013 impact assessment process but is contrary to low significance assigned to this impact by Britz and Sauer (2016) in their Ecological Report. These authors argue that if only indigenous fish species are used, no novel pathogens will be introduced and, as any diseases or parasites would have originated in the wild population wild stocks will have a level of natural resistance. Anchor rejects this assessment and maintains a high significance rating for this impact based on the fact that the probability of transfer of disease and parasites between cultured and wild stock is much higher when indigenous species are farmed. Furthermore the high stocking densities in aquaculture could potentially result in the evolution of native pathogens (especially viral and bacterial agents) to which wild fish do not have resistance. Lastly where disease and parasite transfer between farmed and wild fish have had significant negative impacts internationally, it is where indigenous species are farmed (see examples above) and wild stock have a substantially increased probability of encounter with disease causing pathogens, often at a younger age, than in the absence of fin fish cage culture.

Table 10 OP-ME 1 - Disease and parasite transmission to wild fish stocks (ongoing, may be reversible).

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Regional (2)</td><td>High (3)</td><td>Long-term (3)</td><td>Very High (8)</td><td>Definite</td><td>VERY HIGH</td><td>-ve</td><td>High</td></tr>
<tr><td colspan="9">Essential mitigation measures:
• Ensure that a high level of biosecurity management and planning is in place to limit the introduction of pests and diseases and to be able to respond quickly and effectively should biosecurity risks be identified. Comply with procedures prescribed by the DAFF Aquatic Animal Health Plans.
• Measures to be covered in the biosecurity plan, include, but are not limited to:
o Maintain strict bio-security measures within hatchery, holding tanks and sea cages.
o Ensure all fry undergoes a health examination prior to stocking in sea cages.
o Regularly inspect stock for disease and/parasites as part of a formalised stock health monitoring programme and take necessary action to eliminate pathogens through the use of therapeutic chemicals or improved farm management. This will require focussed research effort into the identification, pathology and treatment of diseases and parasites infecting farmed species, both within culture and wild stocks.
o Maintain comprehensive records of all pathogens and parasites detected as well as logs detailing the efficacy of treatments applied. These records should be made publically available to facilitate rapid responses by other operators to future outbreaks.
o Locate cages stocked with different cohorts of the same species as far apart as possible (no less than 100 m), if possible stock different species in cages successively.
o Treat adjacent cages simultaneously even if infections have not yet been detected.
o Keep nets clean and allow sufficient fallowing time* on sites to ensure low environmental levels of intermediates hosts and or pathogens.</td></tr>
<tr><td>With mitigation</td><td>Regional (2)</td><td>Medium (2)</td><td>Long-term (3)</td><td>High (7)</td><td>Probable</td><td>HIGH</td><td>-ve</td><td>Medium</td></tr>
</table>

4.1.5.1.2 Potential impact OP-ME2: Organic pollution from finfish sea cages

The impacts of fish farming on the marine environment globally have been well studied. One of the primary impacts of cage farming is that untreated wastes resulting mainly from uneaten food and faeces from fish in sea cages are discharged directly into the sea, and represent a potentially significant source of nutrients (Brooks *et al.* 2002, Staniford 2002a). Studies have documented elevated dissolved nutrients and particular components (POC and PON) both below, and in plumes downstream, of fish cages (Pitta *et al.* 2005). These wastes can impact both on the benthic environment and on the water column. Sediments and benthic invertebrate communities under fish farms often show chemical, physical and biological changes attributable to nutrient loading. Elevations in carbon, ammonia and hydrogen sulphide concentrations are frequently observed (Carroll *et al.* 2003). Nutrient enrichment and resulting eutrophication of sediments under fish cages is regarded as a serious issue in some areas (Staniford 2002b).

Impacts on benthic habitats below fish cages does, however, tend to be localized to the area under the cages, but recovery has been observed to take up to fifteen months after the closure. Most studies indicate that the effect is usually contained within a few hundred meters (i.e. Porrello *et al.* 2005), but one Mediterranean study was able to detect changes up to 1000 m away (Sara *et al.* 2004). The extent of contamination of the sediments under fish cages is obviously highly site and project specific. Nearshore marine environments with low flushing rates and/or sediments susceptible to organic loading, should be avoided when selecting sites for finfish cages. Cages should also be placed in water of sufficient depth to allow flushing and to reduce the build-up of wastes directly below cages. Fallowing is the standard mitigation method used to allow recovery of sediments below fish farms in Scotland (Black *et al.* 2004). Feeding by wild fish on the wastes and uneaten food below cages has also been shown to mitigate the impacts of waste on benthic environments. Some studies have reported that 40-80% of the uneaten food and waste falling out of cages was eaten by wild fish (Vita *et al.* 2004, Felsing *et al.* 2005). This in turn, however, may increase the risk of parasite and disease transmission to wild stocks and may also attract piscivores to cages with the associated problems. Feeding fish is however, one of the largest operating costs for farmers who seek to reduce wastage by selecting species with favourable food conversion ratios and using formulated feeds that maximise consumption. Nutrient loading of the water column along with the reduction of dissolved O_2 concentrations as a result of fish cages can also stimulate harmful algal blooms, which pose a threat human health and shellfish mariculture operations (Gowen & Ezzi 1992, Navarro 2000, Ruiz 2001, all cited in Staniford 2002a).

A modelling study of nutrient discharges from yellowtail (*S. lalandi*) farms in Australia indicates that this species may have a significantly higher eutrophication impact than other cultured finfish species (Fernandes & Tanner 2008). This species is amongst the most likely to be utilized in the Algoa Bay ADZ and in combination with the relatively sluggish currents within the bay, the probability of negative benthic and water quality impacts is high. The amount of settable faecal solids, total nitrogen and total phosphorus, however, appears highly dependent on the type (brand, size, floating/sinking) and quality of pellet feed used (Moran et al 2009). Modelling of waste (nutrient and chemical) dispersal from a single proposed commercial scale fish farm at Mossel Bay (an area with similar current speeds to Algoa Bay) has been conducted (Mead *et al.* 2009). Settable waste was expected to sink to the sea floor within 200 m of the cages (Mead *et al.* 2009). However, this study did indicate that elevated levels of dissolved nutrients would likely occur up to 2 km from the fish cages, with nitrate levels expected to be above background concentrations 8-12 km from the site under certain oceanographic conditions and a very efficient assumed Food Conversion Ratio (FCR) of 1.2 (Mead *et al.* 2009).

Untreated wastes resulting mainly from uneaten food and faeces of fish in sea cages are discharged directly into the sea and are not an insignificant source of nutrients (Brooks *et al.* 2002, Staniford 2002). Finfish farms also typically dispose of all fouling material debris into the sea, which results in deposition of fouling material on the benthos within the vicinity of the farm. Current technology on maintenance vessels does not allow for cleaning of the infrastructure on board the vessel. Prevention of fouling currently represents the most effective mitigation measure at the moment and investment into technology that allows the cleaning of infrastructure on deck would contribute towards more effectively mitigating these impacts (*pers. comm.* Michelle Pretorius DAFF).

Hydrodynamic model (*Modelling–Ongrowing fish farm–Monitoring System* - MOM) results do however suggest that both Algoa 1 and Algoa 7 have acceptable dispersion potential and water quality standards are predicted to be met within the precinct boundaries (Wright et al 2019). However, the carrying capacity of a site is intrinsically linked to its size – a larger ADZ will inherently present more space for mariculture. Therefore, it is perhaps more useful to consider the production capacity of a site while also taking into consideration strategies to minimise environmental impact.

Carrying capacity was estimated on the premise that:

1. the benthic fauna beneath the farm site must not be allowed to disappear due to accumulation of organic material;
2. the water quality in the net pens must be kept high; and,
3. the water quality in the areas surrounding the farm must not deteriorate.

Should stocking options recommended by Wright *et al.* (2019) be implemented, in addition to other mitigation measures, the significance of impacts of organic waste discharge are rated **medium** (Table 11). The benthic mapping report (Dawson et al 2019) identified possible existing disturbance of the benthic macrofauna communities at Algoa 7 and therefore recommended this as a preferred site for finfish culture. Algoa 7 however, is within the Adddo MPA sanctuary zone and is closer than Algoa 1 to the sensitive bird and seal islands and although benthic macrofauna on the site may already be disturbed, the significance of potential impacts of organic waste discharge is therefore not assessed as lower for Algoa 7.

The 2016 comparative ecological assessment (Britz and Sauer 2016) considered organic waste discharge impacts to be low significance based on the outputs of MOM modelling that predicted no significant impact on the benthic environment in terms of bottom dissolved oxygen concentration and deposition of particulates. The 2019 dispersion modelling report used the same MOM software, but two species specific models and varying annual production volumes were run (Wright et al 2019). These outputs also predicted negligible benthic impacts from particulate settlement and compliance with water quality standards for dissolved, total ammoniac nitrogen concentration at the specified carrying capacities. However, the estimated volume of organic waste production is substantial at about 40% of nitrogenous waste by mass of the fish (species dependent) production volume. The favourable MOM model predictions are also entirely dependent on water current variability exceeding a specified threshold. During periods with sluggish currents (<5cm.s^{-1}), that occur about 25 % of the time in Algoa Bay according to in situ monitoring data, these model predictions may not be true. Furthermore, fish species different to those modelled by Britz and Sauer (2016) or Wright et al (2019) may well be farmed in the ADZ in the future. Different fish species have very different food conversion ratios (FCR: the ratio of the food input to weight gain by cultured stock) and this significantly alters the amount of organic pollution entering the sea. For the study by Wright et al (2019) yellowtail and meagre were assigned FCRs of 2.5 and 1.4 respectively. Tuna for example have notoriously poor FCRs, especially during the fattening period when fish are typically fed whole bait fish, (although artificial foods are apparently in development, bait fish remains the primary food source for tuna ranching https://thefishsite.com/articles/aquaculture-2016-advances-in-tuna-aquaculture). For example, Vitas et al (2007) report typical FCRs for Bluefin tuna of 15-20:1 and significant negative benthic impacts below tuna cages with altered benthic communities up to 220 m from cages. MOM modelling results predict dissolved inorganic nitrogen (DIN) inputs for farming 3 000 t of yellowtail in Algoa Bay to be in the order of 10% of the total current anthropogenic input of DIN (Wright et al 2019). Recent research suggests that Algoa Bay is already stressed from anthropogenic nutrient loading and additional nutrient inputs from fin fish cage farming would therefore constitute a cumulative impact (Lemeley et al 2019). For these reasons we disagree with the low significance rating by Britz and Sauer (2016) and we maintain a significance rating of medium after mitigation for organic waste impacts (Table 11). Mitigation (as outlined by Anchor & CapeEAPrac 2013) includes the use of species and system-specific feeds designed to maximize food conversion ratios (and minimize waste), rotation of cages within a site to allow recovery of benthos, and sensible site selection (sufficient depth, current speeds and suitable sediment type).

Table 11 OP-ME 2 - Organic waste discharge impacting on the water column and benthic environment arising from mariculture operations (ongoing but reversible).

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local (1)	High (3)	Long-term (3)	High (7)	Definite	**HIGH**	-ve	High
Essential mitigation measures: • Implement a phased approach, starting with <1000 t/ ADZ and do not exceed recommended stocking options as per Wright *et al.* (2019). • Use species and system-specific feeds in order to maximize food conversion ratios (and minimize waste) • Monitor fish feeding behaviour and particulate matter deposition, adapt the feeding strategy to maximise feeding efficiency and minimise particulate matter fallout. • Rotation of cages within a site (fallowing) to allow recovery of benthos (not recommended over long lived habitats (e.g. reefs). • Sensible site selection, namely sufficient depth, current speeds and suitable sediment type (largely achieved in site selection process). • Undertake ongoing, detailed water quality and benthic monitoring, including baseline surveys at control and impact sites (as described in Hutchings *et al.* 2013), and decrease the ADZ carrying capacity should the environmental quality indicators be exceeded outside of the accepted sacrificial footprint. • Minimise biofouling as much as possible. • Cleaning of biofouled infrastructure (ropes etc.) must be conducted in such a way as to minimise deposition to the seafloor beneath the farms (i.e. investment into infrastructure that allows for biofouling material to be collected on board the maintenance vessel, allowing disposal at a suitable onshore disposal facility).								
With mitigation	Local (1)	Medium (2)	Long-term (3)	Medium (6)	Definite	**MEDIUM**	-ve	Medium

4.1.5.1.3 Potential impact OP-ME3: Genetic impacts on wild stocks

Escape of fish from sea cages that may be established in South African is inevitable given that escape from fish farms is a common event globally. Even in countries with advanced sea cage farming industries and calm sheltered waters such as Norway, is it a regular occurrence with an estimated 1.5 million escaped salmon present in Norwegian fjords at any one time (Heuch *et al.* 2005). Given the exposed nature of the South African coast and the abundance of large piscivores, regular escapes, possibly of large numbers of stock as a result of cage failure or breach, is highly likely. Farmed fish that are typically spawned from a limited number of brood stock, have reduced genetic diversity compared to wild stocks, and will have undergone different selective pressures (will also have likely been artificially selected for traits such as rapid growth). Genetically distinct escapees may interbreed or even out-compete wild stocks, resulting in overall reductions on genetic diversity with resultant reductions in the fitness of wild populations (Hershberger 2002, Naylor *et al.* 2005 Ford and Myers 2008).

The significance of genetic impacts of escaped farm fish on wild stocks is largely determined by the extent of genetic differentiation between farmed and wild stocks, the quantity of escapees compared to the size of the wild stock, and the survival and reproductive success of escaped fish (Falconer and Mackay 1996). The risk of genetic contamination is therefore accentuated by the collapsed status of many South African linefish species (that will likely be used in cage farming). The relatively small wild population sizes of exploited South African linefish species such as kob, geelbek and white steenbras, means that these native populations could be swamped by fish farm escapees resulting in potential further loss of genetic diversity (fishing mortality has probably already decreased the genetic variation present in wild populations). Algoa Bay, with its long sandy beaches, productive surf zones and two large estuaries, appears to be important habitat for the overexploited dusky kob (P. Cowley, SAIAB, personal communication, see Hutchings *et al.* 2013). The same is true for other potential culture species with overexploited native populations in Algoa Bay such as the silver kob and white steenbras (*Lithognathus lithognathus*). DAFF has developed "Genetic Best Practice Management Guidelines for Marine Finfish Hatcheries in South Africa" that recommend maintaining an effective broodstock population size of 30-150 individuals sourced from the area in which grow-out will take place, and also that broodstock are rotated between hatcheries and regularly replaced to ensure an effective population size of >100 (DAFF undated). The Marine Finfish Farmers Association of South Africa Environmental Impact Information Document includes similar recommendations, but also recommends reproductive sterility as the future key to eliminating the genetic impact of escaped fish on wild stock (MFFASA 2010).

Recent population genetic research on both yellowtail and dusky kob has revealed little or no spatial structure within the South African stocks of these two mobile (nomadic and migratory) fish species (Miriman et al 2016. Swart et al 2016). This low genetic structuring suggests that escapes of wild caught brood stock or F1 generation offspring will pose negligible risk to the genetic integrity of wild dusky kob or yellowtail stocks at present. Selective breeding by fish farmers in the future may however result in brood stock that are genetically distinct from wild populations. Other, more resident fish species e.g. many SA sparids (where genetic structure within the wild stock may exist) could also be farmed on the ADZ in the future. These considerations suggest that a precautionary approach to genetic management should be implemented. Until reproductively sterile fingerlings are available for fish cage farming in South Africa, the potential genetic impacts of escapees remains a threat to wild stocks. The impact would be across the natural range of the affected species, the intensity of the impact would be high and irreversible (within the foreseeable future but not over evolutionary timescales), resulting in an overall high significance and negative impact in the absence of mitigation (Table 12). Maintaining a large effective population size and genetic homogeneity between cultured and wild stock is potentially a very effective mitigation measure and the overall significance is assessed as low with the successful implementation of mitigation.

Independent monitoring of brood stock rotation, breeding programmes and cultured stock genetic diversity may, however, be required to ensure that mitigation is effective, as future farmers would face a conflict of interest in that they would be tempted to selectively breed for traits that enhance stock productivity (stock improvement). Confidence in this assessment is low as monitoring would be required to determine any changes in genetic diversity in wild stocks due to the influence of escaped culture stock. Furthermore, negative impacts of reduced genetic diversity will only be reflected in the demographics of wild stocks should the population face a threat and reduced environmental fitness is exposed.

Table 12 **OP-ME 3 - Genetic contamination of wild stocks with escapees from finfish cage culture at Algoa 1 and 7 (ongoing and irreversible).**

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Algoa 1 & 7</td><td>Regional (2)</td><td>High (3)</td><td>Long-term (3)</td><td>Very High (8)</td><td>Possible</td><td>HIGH</td><td>-ve</td><td>Low</td></tr>
<tr><td colspan="9">Essential mitigation measures:
• Maintain genetic compatibility (similar levels of variation) between wild and cultured stock by implementing the “Genetic Best Practice Management Guidelines for Marine Finfish Hatcheries” developed by DAFF and ensure adequate genetic monitoring of brood stock rotation.
• Reduce the number of escapees by maintain cage integrity through regular maintenance and replacement and training of staff.
• Develop and implement recovery procedures should escapes occur.
• Implement annual genetic monitoring between indigenous wild caught indigenous and farmed fish to monitor for any significant differences
Optional mitigation measures:
• Develop the technology to create sterile fry for stocking of cages.</td></tr>
<tr><td>Algoa 1 & 7</td><td>Local (1)</td><td>Medium (2)</td><td>Long-term (3)</td><td>Medium (6)</td><td>Improbable</td><td>LOW</td><td>-ve</td><td>Low</td></tr>
</table>

4.1.5.1.4 Potential impact OP-ME4: Chemical pollution arising from finfish cages

Disinfectants, antifoulants and therapeutic chemicals (medicines) are typically used in sea cage fish culture and their use is regulated by the DAFF permit conditions. These chemicals are often directly toxic to non-target organisms and may remain active in the environment for extended periods (Kerry *et al.* 1995, Costello *et al.* 2001). Inappropriate use of medicines may lead to resistance in pathogenic organisms. Some antifoulants contain trace metals (usually copper) that can elevate environmental concentrations, can accumulate in sediments and, can bio-accumulate in susceptible organisms (Costello *et al.* 2001). Some of the chemicals used historically on fish farms to combat sea lice infestations were carcinogenic, whilst others are known to adversely affect reproduction in salmonids (Staniford 2002, More & Waring 2001). Global bodies, (e.g. the World Health Organisation and GESAMP), have highlighted the environmental and public health threats of chemical use on fish farms (GESAMP: 1997, WHO: 1999 cited in Staniford 2002). Due to these concerns, the salmon farming industry is moving away from the use of antibiotics and organophosphates, but numerous other potentially hazardous chemicals such as synthetic pyrethroids, artificial colorants, antifoulants, and antiparasitics are still a serious concern (Staniford 2002). Future South African finfish cage farms will almost certainly need to use chemicals to protect infrastructure and treat stock; the MFFASA code of conduct recommends avoiding hazardous chemical use, minimizing the use of agricultural, veterinary and industrial chemicals and adherence to legal requirements when these are required (MFFASA 2010).

The effects of chemical pollution arising from fish cages on Algoa 1 and Algoa 7 are anticipated to be local, that is confined to Algoa Bay. The Mead *et al.* (2008) study assumed similar dispersal distances for antibiotics as for dissolved nutrients (i.e. tens of km). Without mitigation however, the intensity and overall significance of the impacts is regarded as medium in the case of Algoa 1 and high in the case of Algoa 7 (Table 13), taking the sensitivity of the receiving environment into account) (see Section 3.4). Wider natural processes are anticipated to be altered e.g. breeding success of sea birds on Algoa Bay Islands (and other high trophic level species like sharks, seals and dolphins) may be impacted, should chemicals used in fish cage operations bio accumulate up food chains. Populations of several of the higher trophic level species that occur and or breed within Algoa Bay are considered vulnerable or endangered in terms of their IUCN conservation status. These include Humpback whales, three species of sharks (White, Ragged tooth and Soupfin), Cape gannets and African penguins (important breeding colonies are found on the Algoa Bay Islands), four species of Albatross (Wandering, Black-browed, Indian and Atlantic yellow-nosed) and White-chinned petrels. The tendency for bioaccumulation of many chemicals used in used in fish cage culture is not well researched, and in any case the biological availability and ecotoxicity of these in the environment would be site, species and even population specific, hence the level of confidence in the assessments is low-medium.

With mitigation, the impact of chemical pollution arising from finfish farming were rated as **low** for Algoa 1 and as **medium** for Algoa 7 taking into account the conservation sensitivity of the sites.

Table 13 OP-ME 4 - Use of chemical therapeutants and antifoulants in finfish cage culture at Algoa 1 and Algoa 7 (ongoing but reversible).

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Algoa 1	Local (1)	Medium (2)	Long-term (3)	Medium (6)	Probable	**MEDIUM**	-ve	Medium
Algoa 7	Local (1)	High (3)	Long-term (3)	High (7)	Probable	**HIGH**	-ve	Medium
Essential mitigation measures: • Use only approved veterinary chemicals and antifoulants. • Where effective, use biodegradable alternatives. • Use the most efficient drug delivery mechanisms that minimise the concentrations of biologically active ingredients entering the environment. • Use the lowest effective dose of therapeutants. • Malachite Green as a bactericide or fungicide is prohibited. • Do not apply antifoulants on site (at sea). • Monitoring to determine the intensity of impact.								
Algoa 1	Local (1)	Low (1)	Long-term (3)	Low (5)	Probable	**LOW**	-ve	Low
Algoa 7	Local (1)	Low (1)	Long-term (3)	Low (5)	Probable	**MEDIUM**	-ve	Low

4.1.5.1.5 Potential impact OP-ME5: Impact on marine mammals, turtles and birds (entanglement and habitat modification)

Sporadic entanglement of marine mammals and occasionally other species such as turtles and birds in fish cage infrastructure has been reported internationally (Kemper & Gibbs 2001, Wuersig 2001, Wuersig & Gailey 2002). Entanglement of cetaceans in fishing gear is a common occurrence with an estimated 300 000 mortalities annually (Read and Fernades 2003). Off the South African coast, a large and growing populations of southern right and humback whales occur, these species along with Brydes whales and large pods of common, bottlenose and Indo-Pacific humpback dolphin species inhabit the inshore waters along the Cape coast. Southern right whales frequently become entangled in static fishing gear such as west coast rock lobster traps off the SW Cape and it appears that accidental entanglement is a real risk with future extensive fish cage developments anywhere along the South African coast.

Six species of cetaceans are regularly seen in Algoa Bay; these include southern right whales (*Eubalaena australis*), humpback whales (*Megaptera novaeangliae*), Bryde's whales (*Balaenoptera brydei*), Indian Ocean bottlenose dolphins (*Tursiops aduncus*), Indo-Pacific humpback dolphins (*Sousa chinensis*), and longbeaked common dolphins (*Delphinus capensis*). The zoogeography of these species has been the focus of a comprehensive study that analysed distribution patterns collected from over a year's worth of boat-based observations in relation to various physical and behavioural variables e.g. distance from shore, bottom depth and type, season, sea state, foraging, travelling, resting etc (Melly 2011).

This study identified key habitats for each species and highlighted the importance of Algoa Bay as a breeding and nursery area for southern right whales and as a potentially important nursery area and migration route for humpback whales. The distribution patterns of the other four cetacean species were thought to be linked primarily to prey distributions.

A key habitat area for southern right whales, humpback dolphins and bottlenose dolphins was identified between PE Port and Cape Recife adjacent to, but mostly inshore of the proposed Algoa 1 site (humpback dolphins in particular inhabit very shallow coastal waters, an average of 6.6m depth, and most of the Algoa 1 ADZ is deeper than 25m). A long coastal strip from just east of the Sundays River estuary mouth to Woody Cape was identified as a key habitat for southern right and humpback whales and bottlenose dolphins. This area also lies inshore and to the east of the proposed Algoa 7 site, although humpback whales (along with Brydes whales and common dolphins) were associated with deeper water i.e. a more offshore group whose distributions may more frequently overlap with the proposed ADZ sites.

The proposed Algoa ADZ sites therefore, do not appear to extensively overlap with important cetacean habitats within Algoa Bay as identified in the Melly (2011) study, but it must be acknowledged that Algoa Bay as a whole appears to be an important cetacean habitat, and that these are highly mobile animals whose distributions may well show extensive temporal variation (that leads to overlap with the proposed ADZ sites). Given the rarity of accidental entanglements in mariculture operations internationally and the encouraging statistic of zero cetacean entanglements during the pilot sea cage project undertaken in Algoa Bay, accidental entanglement in sea cage infrastructure is assessed as low to **medium** overall significance (Table 14). Essential mitigation measures do, however, include the establishment of a rapid response protocol to deal with entanglements. Acoustic and other deterrent devices have been shown to be ineffective in the long term due to behavioural conditioning, and are not recommended mitigation (Petras, 2003 in McCord *et al.* 2008).

Cetaceans and other marine animals may be able to avoid lethal effects associated with entanglement in fish cage infrastructure, but the mere presence of sea cages may well adversely affect habitat use and may have chronic negative effects on populations (as well as ecotourism activities) (Wuersig and Gailey 2002). Work boats travelling between PE or Coega Port and the proposed ADZ sites will need to travel through important whale areas daily, possibly leading to disturbance, particularly of mother-calf pairs (also increasing the risk of a boat strike). As fish cage development on the proposed ADZ increases (i.e. as more cages are moored) so does the potential interference with natural cetacean movements and feeding. Due to the expected relatively small increase in boat traffic due to future ADZ development, and the relatively small sea area that would be occupied by the Algoa ADZ, the overall significance of these impacts is assessed as low overall significance (Table 15). The probability of entanglement is inferred from reported studies elsewhere, and monitoring is required to confirm potential impacts on cetacean habitat use.

Table 14 OP-ME 5a- Accidental entanglement of cetaceans in mariculture infrastructure (ongoing but reversible).

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local (1)	Medium (2)	Long-term (3)	Medium (6)	Probable	**MEDIUM**	-ve	Medium
Essential mitigation measures: • Do not locate ADZ sites in important cetacean habitats (fortuitously this is the case). • Ensure all mooring lines and nets are highly visible (use thick lines and bright antifoulant coatings). • Keep all lines and nets tight through regular inspections and maintenance. • Ensure that mesh size on primary and secondary nets does not exceed 16 cm stretched mesh, use square mesh. • Establish a rapid response unit to deal with cetacean entanglements (collaboration with the South African Whale Disentanglement Network).								
With mitigation	Local (1)	Medium (2)	Long-term (3)	Medium (6)	Possible	**LOW**	-ve	Low

Table 15 OP-ME 5b - Possible impacts on cetaceans resulting from alterations in habitat use or migration patterns (ongoing but reversible).

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local (1)	Low (1)	Long-term (3)	Low (5)	Probable	**LOW**	-ve	Medium
Essential mitigation measures: • Do not locate ADZ sites in important cetacean habitats (fortuitously this is the case). • Ensure all mooring lines and nets are highly visible (use thick lines and bright antifoulant coatings). • Keep all lines and nets tight through regular inspections and maintenance. • Ensure that mesh size on primary and secondary nets does not exceed 16 cm stretched mesh, use square mesh. • Establish a rapid response unit to deal with cetacean entanglements (collaboration with the South African Whale Disentanglement Network).								
With mitigation	Local (1)	Low (1)	Long-term (3)	Low (5)	Probable	**LOW**	-ve	Low

4.1.5.1.6 Potential impact OP-ME6: Interactions with piscivorous marine animals

Piscivorous seals, dolphins, sharks, fish and birds are frequently attracted to the large concentrations of fish and or food in sea cages (Wuersig and Gailey 2002, Vita *et al.* 2004, Kloskowski 2005). Their attempts to get at the stock induce a stress response (and consequent decreased growth rates and resistance to disease) in the cultured fish and can damage nets, allowing fish to escape. The predators themselves may also become entangled in sea cage nets with potentially fatal consequences. The most effective and common response by farmers is to install top and curtain anti predator nets, although farmers will also shoot problem animals (which is usually illegal), or use acoustic deterrents (Pemberton & Shaughnessy 1993, Wickens 1995, Beveridge 1996, Wuersig & Gailey 2002). In the case of top predators, which are frequently relatively rare, lethal reactions by farmers to predation attempts may prove unsustainable, whilst acoustic deterrent devices may damage marine mammal’s hearing and interfere with navigation (Wuersig and Gailey 2002).

Seals, sharks and predatory sea birds are abundant within Algoa Bay and interactions with finfish sea cages are likely. During the pilot project undertaken in Algoa Bay, the cages were seen to act as FADS and an incident did occur when two small ragged tooth sharks managed to enter a cage (Nell & Winter 2009). Due to the extensive foraging range of most large marine predators, however, interactions cannot be completely mitigated by site selection away from colonies and the overall significance of the impact is assessed as Medium at the Algoa 1 site and Low after mitigation (Table 16). The proximity of Algoa 7 to the seal and bird Islands and within known feeding areas for some piscivores (e.g penguins, gannets, dolphins - see Hutchings *et al.* 2013), suggests that potential impacts will be more significant at this site than at the Algoa 1 site and are assessed as **medium** after effective mitigation (Table 16). Monitoring is required to confirm frequency of interactions, and to assess the effectiveness of mitigation.

Table 16 **OP-ME 6 - Piscivorous marine animals interfering with finfish cage culture operations at Algoa 1 and 7 (ongoing but reversible).**

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Algoa 1	Local (1)	Medium (2)	Long-term (3)	Medium(6)	Probable	**MEDIUM**	-ve	Medium
Algoa 7	Local (1)	High (3)	Long-term (3)	High (7)	Probable	**HIGH**	-ve	Medium
Essential mitigation measures: • Install and maintain suitable predator nets (sufficient strength, visibility and mesh size, above and below water line). • Install visual deterrents (e.g. tori line type deterrents for birds). • Store feed so piscivores cannot access it, and implement efficient feeding strategy. • Remove any injured or dead fish from cages promptly. • During harvesting of stock, ensure that minimal blood or offal enters the water. • Implement mitigation measures as for entanglement impacts (Table 14). • Develop a protocol for dealing with problem piscivores in conjunction with experts and officials (DAFF, DEA etc). • Maintain a record of all interactions with piscivores as per recommended EMPr. Optional mitigation measures: • Risk-averse site selection and avoidance of Algoa 7.								
Algoa 1	Local (1)	Low (1)	Long-term (3)	Low (5)	Probable	**LOW**	-ve	Low
Algoa 7	Local (1)	Medium (2)	Long-term (3)	Medium (7)	Probable	**MEDIUM**	-ve	Low

4.1.5.1.7 Potential impact OP-ME7: Impacts on the recently approved Addo Marine Protected Area

The description of the affected environment report (Hutchings *et al.* 2013) identified potential conflict resulting from the development of the Algoa ADZ with four types of recreational marine activities, namely non-motorised water sports, recreational SCUBA divers, yacht sailing and recreational boat anglers. The overall significance of direct impacts on these user groups is assessed in the socio-economic impacts assessment of the Basic Assessment Report.

A further user group conflict is identified for Algoa 7. This site overlaps with the recently approved Addo Marine Protected Area (MPA). During the previous EIA process, SANParks, the main proponents of this MPA, indicated that they would not support the concept of commercial mariculture within MPAs and that the declaration of Algoa 5 would not align with the conservation objectives of MPAs. This lack of support was especially directed at the large size of the Algoa 5 site and its position in the centre of the proposed MPA, which would compromise a significant proportion in the middle of the MPA.

DAFF engaged with the DEA early on in the process when Algoa 7 was selected as an additional site to be put forward during the current application process. Algoa 7 measures roughly one quarter in size when compared to Algoa 5 and is positioned on the western border of the Addo MPA just north of an anchorage site that is currently used by the TNPA for ship to ship bunkering and disposal of dredge spoil (refer to Chapter 6 of the BAR – Massie *et al.* 2019). Despite its position within the restricted zone, the proposed finfish farm would therefore be situated within an area that is likely to be disturbed even after the proclamation of the Addo MPA. The Department of Environmental Affairs Branch Oceans and Coasts has indicated that the affected portion of this site could potentially be excised should Environmental Authorisation be granted for this precinct and discussions with DAFF are ongoing.

Algoa 7 was rated to have a medium impact on the MPA (Table 17). The site potentially compromises the functioning and management of the proposed MPA and sets a negative precedent for MPAs elsewhere in South Africa. The impact is rated as irreversible due to the fact the site would be excised from the MPA boundaries. There are no effective mitigation measures for this, other than the No-go option

Table 17 OP-ME 7 - Possible impacts on the proposed Addo Elephant MPA, Algoa 7 (irreversible).

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Algoa 7	Local (1)	Medium (2)	Long-term (3)	Medium (6)	Definite	**MEDIUM**		
Optional mitigation measures: • No go option								

4.1.5.2 Bivalve mariculture

Both rafts and longlines are commonly used for the farming of bivalves worldwide (Heinecken *et al.* 2016). Rafts comprise a floating processing platform from which ropes are vertically suspended. As bivalves are densely packed on the culture ropes, sediments from faecal deposition and processing waste accumulate below the raft. The recommended density or optimal production is approximately one raft per hectare, producing approximately 20 to 30 tonnes of marketable mussels per ha (Pulfrich 2017). In contrast, longlines are surface structures constructed from horizontal floating ropes attached to buoys that are moored to the seafloor. Production ropes are attached to the structure, allowing the mussels or oyster racks to float on the surface. This aquaculture method can be used in water depths of up to 100 m. The lower density of bivalves attached to longlines promotes better current flow and limits the localised impact of sedimentation from mussel faecal deposition. The recommended spacing of longlines is 10 m, while farms should be spaced 40 m apart to allow for vessel movements (Pulfrich 2017).

This section assesses the impacts of bivalve mariculture at Algoa 1 and Algoa 6.

4.1.5.2.1 Potential impact OP-ME8: Introduction of alien bivalve species to the wild

The introduction of alien species into new environments through aquaculture operations is well established and well-studied. Pulfrich (2017) notes that, “The introduction, proliferation and spread of risk organisms on the southern African West Coast could lead to significant effects on marine habitats and their associated values”. Further work can be found at Perez *et al.* (1991), Bourdouresque *et al.* (1985), Wasson *et al.* (2001), Leppäkoski *et al.* (2002) and Hewitt *et al.* (2004).

Mariculture species are often selected based on their tolerance of novel environments, the exact characterises that impose of a high risk of the species becoming invasive (Branch and Steffani 2004). Bivalve mariculture (notably suspended cultivation methods) has been implicated in the introduction of multiple alien species in coastal waters around the world (see Carlton 1992, Ruiz and Carlton 2003, as cited in Pulfrich 2017). The Mediterranean mussel *Mytilus galloprovincialis* is one such species, introduced to Saldanha Bay in the 1970’s for mariculture that has become the most successful marine alien invasive species in South Africa (Picker and Griffiths 2011).

The impacts of such an invasion are permanent, and the scale of the invasion renders the costs of management prohibitive. Despite this, Mead *et al.* (2011) showed that, as a vector pathway for the introduction of non-native marine species, mariculture contributes 6%, compared with the 86% introduced through ship fouling and ballast water.

In addition to the target mariculture species themselves, fouling organisms on the culture stock or on the associated structures and materials (e.g. ropes, floats, pontoons) represent a further source of potential alien introductions (Clapin & Evans 1995, Floc'h *et al.* 1996, Carver *et al.* 2003, Lane and Willemsen 2004, Coutts and Forrest 2007, McKindsey *et al.* 2007; as cited in Pulfrich 2017).

Of particular risk is the establishment of new bivalve mariculture operations in previously unfarmed regions, or in areas where the cultured species is not yet established (Pulfrich 2017). The alien species under consideration for mariculture in Algoa 6 are the Pacific oyster (*Crassostrea gigas*), and the Mediterranean mussel (*M. galloprovincialis*). The Mediterranean mussel is already established in Algoa Bay (see Dawson *et al.* 2019), and therefore the introduction risk of the species to the Bay is negligible (Table 18). However, despite at least a decade of oyster mariculture in the vicinity of Algoa 6, wild populations of the Pacific oyster *C. gigas* has not yet been detected in Algoa Bay and associated estuaries suggesting that conditions are not ideal for the establishment of this species in the wild in this area. The species is however, a known invasive in South Africa, introduced to the Knysna Estuary in the 1950's and naturalised populations are now found in the Breede, Knysna and Goukou estuaries (Robinson et al 2005). Heinecken *et al.* (2016) note that all *C. gigas* spat are currently imported. A permit in terms of NEMBA is required for the importation of this category 2 alien invasive species. However, the farming of this species in Algoa 6 would be exempt in terms of the AIS Regulations (refer to Section 2.2 for more details). The potential impact of introducing *M. galloprovincialis* and *C. gigas* to the wild in Algoa Bay is assessed as very low and low respectively (Table 18,Table 19).

NEMBA (DEA 2014) report also notes that four previously unrecorded species were found to be associated with *C. gigas* oyster spat introduced into South Africa - the black sea urchin, *Tetrapygus niger*; the European flat oyster, *Ostrea edulis*, Montagu's crab, *Xantho incisus*, and the brachiopod *Discinisca tenuis*. As such, the Biodiversity Risk and Benefit Assessment (BRBA) report (DAFF 2015) recommends the development of a South African *C. gigas* hatchery to reduce the reliance on imported spat. Mitigation measures (Table 18) are adapted from Pulfrich (2017). The impact of alien fouling species imported via oyster spat has been assessed separately in Section 4.1.5.2.2.

Table 18 OP-ME 8a - Introduction of alien bivalve species (Mediterranean mussel *Mytilus galloprovincialis*) to the wild.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local (1)	Low (1)	Long-term (3)	Low (5)	Improbable	**VERY LOW**	-ve	Medium
Essential mitigation measures: • Not necessary due to low significance								

Table 19 OP-ME 8b - Introduction of alien bivalve species (Pacific oyster *Crassostrea gigas*) to the wild.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Regional (2)	Medium (2)	Long-term (3)	High (7)	Possible	**MEDIUM**	-ve	Medium
Essential mitigation measures: • Ensure a high level of biosecurity management and planning is in place to limit the introduction of new invasive species and to be able to respond quickly and effectively should biosecurity risks be identified. • Routine surveillance on and around marine farm structures, associated vessels and infrastructure must be undertaken for indications of non-native species.								
Without mitigation	Regional (2)	Low (1)	Long-term (3)	Medium (6)	Improbable	**LOW**	-ve	Medium

4.1.5.2.2 Potential impact OP-ME9: Introduction of alien fouling species to the wild and provision of habitat to alien fouling species

Bivalves will potentially be grown on long-lines suspended in the water at the Algoa 1 and Algoa 6 sites. Oyster longlines provide settling habitat for alien fouling species already present in Algoa Bay. Regular maintenance and monitoring constitute effective mitigation measures.

It has been shown that translocated oysters act as vectors of marine alien species all over the world. Oysters attach to rocks, walls and other surfaces and are exposed to colonisation by fouling organisms, which can be exported into other countries on the oysters. Marine alien species imported on oyster shells may have significant ecological impacts in areas where they establish. Haupt *et al.* (2010) surveyed three oyster farms in South Africa, namely Alexander Bay, Saldanha Bay and Knysna. Alexander Bay is a land-based oyster fam and is situated 147 km north of Kleinzee where the Diamond Coast Aquaculture facility is situated and was surveyed in 2007. Six alien species (excluding the farmed Pacific oyster *Crassostrea gigas*) were found to be growing on the shells of oysters farmed in the Knysna Estuary. These include the crustacean *Jassa slatteryi*, the bryozoan *Bugula neritina*, the mollusc *Littorina saxarilis*, and two ascidians *Diplosoma listerianum* and *Microcosmos squamiger*. Although none of the above-listed species are directly associated with oyster spat introduction, oyster rafts are likely to provide suitable habitat and may therefore be associated with a suite of other alien and potentially invasive species.

On the west coast a breeding population of hundreds of urchins, *Tetrapygus niger,* which occurs along the temperate Pacific coast of South America, was found on the Alexander Bay farm. Both juveniles and adults were recorded. *T. niger* is the most abundant sea urchin in its area of origin along the central Chilean coast (Rodriguez & Ojeda 1993). Due to its isolated position (i.e. from harbours), the most likely vector of this species into Alexander Bay oyster farm is the introduction of juveniles along with spat of *C. gigas* imported from Chile.

The European flat oyster *Ostrea edulis* originates from Europe and has a global distribution from Norway to Morocco, extending into the Mediterranean. In South Africa it was first recorded in the Knysna Estuary in 1946 and was subsequently introduced in Saldanha Bay and St Helena Bay in 1980s and 90s, but were declared locally extinct in 2005 (Robinson *et al.* 2005). Established populations were, however, discovered in Alexander Bay oyster dams in 2007.

DAFF will encourage operators to produce oyster spat from their own stock, but when conditions are not suitable on the farm for spawning and settlement, spat may occasionally have to be imported from Chile (Chile is the only allowable country for import of oyster spat at present). Larger spat has more time to accumulate biofouling on their shells, which means that the smaller the size of the spat imported from Chile, the lower the risk of introducing alien species.

Oysters are cleaned before they are sold or transferred to processing facilities. This involves the removal of fouling organisms from the shells. The cleaning of the oyster shells should take place on land and the debris should be discarded at a landfill and should not be disposed of in the ocean.

The risk of providing suitable habitat for other alien species, as well as the risk of releasing alien fouling species due to oyster shell cleaning has been assessed in Table 20. Mitigation measures to be implemented by DAFF and operators to minimise the risk of importing and releasing alien species have been provided.

Table 20 OP-ME 9 - Introduction of alien fouling species to the wild.

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Local (1)</td><td>Medium (2)</td><td>Long-term (3)</td><td>Medium (6)</td><td>Definite</td><td>MEDIUM</td><td>-ve</td><td>Medium</td></tr>
<tr><td colspan="9"><u>Essential mitigation measures:</u>
• Produce oysters from own stock as far as possible and minimise importing of spat.
• If spat is imported, spat should be the smallest size category, which is less than 5 mm.
• Spat must undergo a freshwater dip prior to transfer into quarantine tanks.
• Spat must be quarantined prior to release into the grow out tanks
• Spat must be accompanied by health and veterinary certificates and guarantees from the supplier country's delegated authority. (this mitigation measure is primarily important for release of alien pathogens and parasites, not marine species)
• Do not discard fouling organisms and debris removed from farming structures, oysters or mussels into the marine environment (molluscs may have alien fouling organisms growing on their shells). Dispose biological waste at a registered Waste Management Facility.
• Undertake routine surveillance for indications of non-native fouling species on and around marine farm structures and associated vessels and infrastructure.
• Maintain effective antifouling coatings and monitor for fouling.
• Clean structures and hulls regularly to ensure eradication of pests before they become established.</td></tr>
<tr><td>Without mitigation</td><td>Local (1)</td><td>Low (1)</td><td>Long-term (3)</td><td>Low (5)</td><td>Probable</td><td>LOW</td><td>-ve</td><td>Medium</td></tr>
</table>

4.1.5.2.3 Potential impact OP-ME10: Disease and parasite transmission to wild bivalve populations

In addition to the introduction of alien/invasive species, mariculture operations have the potential to introduce pests and diseases both to surrounding farms and the broader marine environment. However, Pulfrich (2017) notes that the prevalence of disease and pests in South Africa's aquaculture industry is relatively low compared to other countries. However, the impact of an outbreak of disease or pests can have significant negative impacts on the industry as a whole, (Pulfrich 2017). The risk of transmission of indigenous pathogens or parasites from cultured stock to wild populations and to other species can be considered minimal, given that alien species will liley be cultured and the low likelihood that appropriate intermediate hosts (if required) are available (Pulfrich 2017). Disease transmission to established populations of alien species such as *M. galloprovincialis* is considered to be of negligible impact.

The Biodiversity Risk and Benefit Assessment (BRBA) report (DAFF 2015) provides a list of some of the diseases which commonly infect mariculture species in South Africa, and as with the introduction of alien species into the wild, the potential effects of the spread of diseases from suspended shellfish culture are deemed of high intensity, would potentially persist beyond the duration of the aquaculture activities themselves and are thus considered to be of high significance without mitigation. However, suitable management such as routine monitoring should be sufficient to ensure a **low** impact rating (Table 21). The use of chemicals in disease management is discouraged due to negative impacts on the aquatic environment, consumer reluctance, and because the frequent use of traditional therapeutics may trigger the emergence of disease-resistant strains of pathogens (MPI 2013).

Table 21 OP-ME 10 - Disease and parasite transmission to wild bivalve stocks (ongoing, may be reversible).

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Regional (2)</td><td>High (3)</td><td>Long-term (3)</td><td>Very High (8)</td><td>Definite</td><td>HIGH</td><td>-ve</td><td>High</td></tr>
<tr><td colspan="9">Essential mitigation measures:
• Ensure a high level of biosecurity management and planning is in place to limit the introduction of new invasives and to be able to respond quickly and effectively should biosecurity risks be identified.
• Oyster stacks must be brought ashore for cleaning, and biofouling organisms must not be returned to the water.
• Routine surveillance on and around marine farm structures, associated vessels and infrastructure must be undertaken for indications of non-native fouling species.
• If spat import cannot be avoided, culture facilities should only be permitted to use spat sourced from biosecure certified hatcheries and/or quarantine facilities.
• Use only prescribed veterinary chemicals.
Optional mitigation measures:
• Develop South African bivalve hatcheries to reduce the reliance on spat import, and hence the risk of non - intentional introduction of associated alien species.</td></tr>
<tr><td>With mitigation</td><td>Regional (2)</td><td>Low (1)</td><td>Long-term (3)</td><td>Medium (6)</td><td>Possible</td><td>LOW</td><td>-ve</td><td>Medium</td></tr>
</table>

4.1.5.2.4 Potential impact OP-ME11: Organic pollution and habitat modification due to bivalve culture

The global production of bivalves has grown from around 1 million tonnes in 1950 to 16.1 million tonnes in 2015 (FAO 2018), with just over half of the volume derived from aquaculture production (McKindsey *et al.* 2011). Bivalve aquaculture accounts for roughly 27% of global aquaculture production and provided approximately 13 % of the total fish produced for human consumption worldwide in 2006 (FAO 2009). The rapid growth of the industry has raised concerns about the ecological and physico-chemical impacts of aquaculture on local environment (Black 2001) and numerous studies have been conducted to help better understand the ecological role played by culturing activities (Davenport *et al.* 2003; Holmer *et al.* 2008, National Research Council 2010).

Ecological studies of bivalve aquaculture recognise three primary methods that culturing of bivalves can impact the ecosystem: 1) material processes – the consumption of food and production of waste, 2) physical structure – the introduction of artificial substrate in the form of structures and anchoring and the introduction of the aquaculture species itself, and 3) pulse disturbances as result of harvesting efforts (Dumbauld *et al.* 2009). Suspended cages or longlines, the method commonly used for bivalve mariculture in South African, reduces the impacts of pulse disturbance because harvesting and maintenance is conducted from on board a boat during which there is no additional physical contact with the benthos. This off-bottom method is however, more susceptible to biofouling (Shumway & Whitlatch 2011). Mussel farms currently dispose of all fouling material debris into the sea, which results in deposition of fouling material on the benthos within the vicinity of the farm. Current technology on maintenance vessels does not allow for cleaning of the infrastructure on board the vessel. Prevention of fouling currently represents the most effective mitigation measure at the moment and investment into technology that allows the cleaning of infrastructure on deck would contribute towards more effectively mitigating these impacts (*pers. comm.* Michelle Pretorius DAFF).

Many studies have focused on the role of bivalve biodeposition in changes to the benthos. These largely report that impacts are localised and negligible by comparison to other aquaculture activities, such as finfish cages (Forrest *et al.* 2009). Known as extractive species, the feeding habits of bivalves actually remove waste materials from the water column and generally have a positive influence of the water quality of the surrounding system (National Research Council 2010, FAO 2018).

However, Pulfrich (2017) does note that bivalve mariculture may alter the marine environment in a number of ways:

1. the filter-feeding action of bivalves may result in the benthic sedimentation of organic-rich waste products and the deposition of shells and other fouling biota beneath the mariculture structures during cleaning of rafts;
2. accumulation of organic matter and associated changes in physico-chemical properties can create suboptimal conditions within the sediment matrix that can result in changes in the abundance and diversity of benthic micro- and macrobiota (Danovaro *et al.* 2004 and references therein);
3. direct effects on the seabed from shellfish farms could, under certain conditions, arise through shading from farm structures, potentially reducing the amount of light reaching the seafloor, with implications for the growth, productivity, survival and depth distribution of ecologically important primary producers (Everett *et al.* 1995; Crawford 2003; Huxham *et al.* 2006);
4. changes in phytoplankton community structure due to selective bivalve feeding (mussels are unable to efficiently filter out picoplankton (phytoplankton cells <2 μm) (Saffi and Gibbs 2003) and therefore the water passing through a farm might be expected to contain a higher proportion of picoplankton compared to the larger size classes that are preferentially removed);
5. shellfish mariculture infrastructure creates a heterogeneous, hard substrate habitat for colonisation by sessile organisms, often in open water with few such hard substrate habitats available; and
6. shellfish farm infrastructure could alter hydrodynamics and reduce flow rates and alter current velocities at the farm level.

However, it is likely that any negative impacts would be tempered by the positive impact on water quality the surrounding system generated by the filter feeding bivalves, and therefore, after mitigation, this impact is rated **low** (Table 22).

Table 22 OP-ME 11 - Organic pollution and habitat modification (ongoing but reversible).

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Local (1)</td><td>High (3)</td><td>Long-term (3)</td><td>High (7)</td><td>Possible</td><td>MEDIUM</td><td>-ve</td><td>High</td></tr>
<tr><td colspan="9">Essential mitigation measures:
• Select sites favouring well-flushed, deep and productive areas.
• Implement monitoring of the immediate water column around the precincts or specific farms for key plankton (Chl a, phytoplankton abundance and species composition) parameters.
• Implement monitoring of biodeposition and physico-chemical changes in seabed properties at the farmed site relative to undisturbed control sites and compile annual monitoring reports.
• Minimise biofouling as much as possible.
• Cleaning of biofouled infrastructure (ropes etc.) must be conducted in such a way as to minimise deposition to the seafloor beneath the farms (i.e. investment into infrastructure that allows for biofouling material to be collected on board the maintenance vessel, allowing disposal at a suitable onshore disposal facility).
• Avoid high density culture (overcrowding).</td></tr>
<tr><td>With mitigation</td><td>Local (1)</td><td>Medium (2)</td><td>Long-term (3)</td><td>Medium (6)</td><td>Possible</td><td>LOW</td><td>-ve</td><td>Medium</td></tr>
</table>

4.1.5.2.5 Potential impact OP-ME12: Genetic interactions with wild bivalve populations

Mytilus galloprovincialis is widespread on rocky shores along most of the southern African South and West Coast, suggesting a successful adaptation to the local system, with the result that hybridisation with cultured stocks is unlikely to reduce genetic variation in the population (Table 23). There are no local populations of the Pacific oyster (*C. gigas*) there is no risk of genetic interactions of the cultured stock with wild populations.

Table 23 OP-ME 12 - Genetic contamination of wild stocks from bivalve mariculture at Algoa 1 and 7 (ongoing and irreversible).

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local (1)	Low (1)	Long-term (3)	Low (5)	Improbable	**VERY LOW**	-ve	Medium
Essential mitigation measures: • Neither feasible, nor necessary.								

4.1.5.2.6 Potential impact OP-ME13: Impact of bivalve culture on marine mammals (entanglement and habitat modification)

See Section 4.1.5.1.5. Cetaceans are common in Algoa Bay and as cetaceans are highly mobile animals whose distributions may well show extensive temporal variation (that leads to overlap with the proposed ADZ sites). However, given the rarity of accidental entanglements in mariculture operations internationally and the encouraging statistic of zero cetacean entanglements in the existing oyster mariculture infrastructure on Algoa 6 and during the pilot sea cage project undertaken in Algoa Bay, accidental entanglement in shellfish mariculture infrastructure is assessed as **low** overall significance (Table 24, Table 25). Essential mitigation measures do, however, include the establishment of a rapid response protocol to deal with entanglements.

Acoustic and other deterrent devices have been shown to be ineffective in the long term due to behavioural conditioning, and are not recommended mitigation (Petras 2003 in McCord *et al.* 2008).

Table 24 **OP-ME 13a - Accidental entanglement of cetaceans in Algoa 1 and 6 mariculture infrastructure (ongoing but reversible).**

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Local (1)</td><td>Medium (2)</td><td>Long-term (3)</td><td>Medium (6)</td><td>Probable</td><td>MEDIUM</td><td>-ve</td><td>Medium</td></tr>
<tr><td colspan="9">Essential mitigation measures:
Do not locate ADZ precincts in important cetacean habitats.
Ensure all mooring lines are highly visible (use thick lines and brightly coloured mooring lines).
Keep all lines tight through regular inspections and maintenance.
Establish a rapid response unit to deal with cetacean entanglements (collaboration with the South African Whale Disentanglement Network).</td></tr>
<tr><td>With mitigation</td><td>Local (1)</td><td>Medium (2)</td><td>Long-term (3)</td><td>Medium (6)</td><td>Possible</td><td>LOW</td><td>-ve</td><td>Low</td></tr>
</table>

Table 25 **OP-ME 13b - Possible impacts on cetaceans resulting from alterations in habitat use or migration patterns (ongoing but reversible).**

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Local (1)</td><td>Low (1)</td><td>Long-term (3)</td><td>Low (5)</td><td>Probable</td><td>LOW</td><td>-ve</td><td>Medium</td></tr>
<tr><td colspan="9">Essential mitigation measures:
Do not locate ADZ precincts in important cetacean habitats (fortuitously this is the case).
Ensure all mooring lines and nets are highly visible (use thick lines and bright antifoulant coatings).
Keep all lines tight through regular inspections and maintenance.
Establish a rapid response unit to deal with cetacean entanglements (collaboration with the South African Whale Disentanglement Network).</td></tr>
<tr><td>With mitigation</td><td>Local (1)</td><td>Low (1)</td><td>Long-term (3)</td><td>Low (5)</td><td>Probable</td><td>LOW</td><td>-ve</td><td>Low</td></tr>
</table>

5 RECOMMENDATIONS

5.1 Impact assessment

DAFF proposes to farm both bivalves and finfish in Algoa Bay. This **marine specialist study** describes and assesses potential environmental impacts associated with each of the three precincts (Algoa 1, 6, and 7) individually first, and subsequently in combination in the form of alternate options as they have been configured for this EIA process (i.e. Option A, B and C) together with the No-Go option (Alternative D) (See Section 5.2).

Table 27 below summarises the impacts that may be experienced during the construction and operational phases of the project for finfish mariculture in Algoa 1 and 7, and bivalve mariculture in Algoa 1 and 6, before and after mitigation. A total of eighteen potential marine ecological impacts were assessed for this report with three assessed independently for Algoa 1 and Algoa 7 (Table 27).

Two impacts either did not require mitigation due to low significance, or because there was no feasible mitigation possible. Six impacts were rated **very high** or **high** before mitigation, but only one impact was rated **high** post mitigation (rated **very high** before mitigation). Eight impacts were rated **medium** before mitigation but all of these were rated **low** post mitigation. Four impacts were rated **low** or before mitigation, most of which were rated **very low** post mitigation. Overall post mitigation, one **high,** four **medium** and 13 **low** impacts remained.

Table 26 **Potential impacts on marine ecology during the construction phase of the proposed Aquaculture Development Zone in Algoa Bay without and with mitigation.**

	Impact identified	Consequence	Probability	Significance	Status	Confidence
CP-ME 1	Disturbance of subtidal habitat	Low	Definite	LOW	-ve	High
	With mitigation	Very Low	Definite	VERY LOW	-ve	High

Table 27 **Summary of potential marine ecology impacts of finfish farming for the operation of the proposed ADZ mariculture development in Algoa Bay.**

Impact identified		Consequence	Probability	Significance	Status	Confidence
OP-ME 1	Disease and parasite transmission to wild fish stocks (ongoing, may be reversible).	Very High	Definite	VERY HIGH	-ve	High
	With mitigation	High	Probable	HIGH	-ve	Medium
OP-ME 2	Organic waste discharge impacting on the water column and benthic environment arising from mariculture operations (ongoing but reversible).	High	Definite	HIGH	-ve	High
	With mitigation	Medium	Definite	MEDIUM	-ve	Medium

Impact identified		Consequence	Probability	Significance	Status	Confidence
OP-ME 3	Genetic contamination of wild stocks with escapees from finfish cage culture at Algoa 1 & 7 (ongoing and irreversible).	Very High	Possible	**HIGH**	-ve	Low
	With mitigation	Medium	Improbable	**LOW**	-ve	Low
OP-ME 4	Use of chemical therapeutants and antifoulants in finfish cage culture at Algoa 1 (ongoing but reversible).	Medium	Probable	**MEDIUM**	-ve	Medium
	With mitigation	Low	Probable	**LOW**	-ve	Low
	Use of chemical therapeutants and antifoulants in finfish cage culture at Algoa 7 (ongoing but reversible).	High	Probable	**HIGH**	-ve	Medium
	With mitigation	Low	Probable	**MEDIUM**	-ve	Low
OP-ME 5a	Accidental entanglement of cetaceans in mariculture infrastructure (ongoing but reversible).	Medium	Probable	**MEDIUM**	-ve	Medium
	With mitigation	Medium	Possible	**LOW**	-ve	Low
OP-ME 5b	Possible impacts on cetaceans resulting from alterations in habitat use or migration patterns (ongoing but reversible).	Low	Probable	**LOW**	-ve	Medium
	With mitigation	Low	Probable	**LOW**	-ve	Low
OP-ME6	Piscivorous marine animals interfering with finfish cage culture operations at Algoa 1 (ongoing but reversible).	Medium	Probable	**MEDIUM**	-ve	Medium
	With mitigation	Low	Probable	**LOW**	-ve	Low
	Piscivorous marine animals interfering with finfish cage culture operations at Algoa 7 (ongoing but reversible).	High	Probable	**HIGH**	-ve	Medium
	With mitigation	Medium	Probable	**MEDIUM**	-ve	Low
OP-ME7	Possible impacts on the proposed Addo Elephant MPA, Algoa 7 (irreversible).	Medium	Definite	**MEDIUM**	-ve	High

Table 28 **Summary of potential marine ecology impacts of bivalve farming for the operation of the proposed ADZ mariculture development in Algoa Bay.**

Impact identified		Consequence	Probability	Significance	Status	Confidence
OP-ME 8a	Introduction of alien bivalve species (Mediterranean mussel *Mytilus galloprovincialis*) to the wild.	Low	Improbable	**VERY LOW**	-ve	Medium
	No mitigation required	N/A	N/A	N/A	N/A	N/A
OP-ME 8b	Introduction of alien bivalve species (Pacific oyster *Crassostrea gigas*) to the wild	High	Possible	**MEDIUM**	-ve	Medium
	With mitigation	Medium	Possible	**LOW**	-ve	Medium
OP-ME 9	Introduction of alien fouling species to the wild and provision of habitat to alien fouling species	Medium	Definite	**MEDIUM**	-ve	Medium
	With mitigation	Low	Probable	**LOW**	-ve	Medium
OP-ME 10	Disease and parasite transmission to wild bivalve stocks (ongoing, may be reversible).	Very High	Definite	**HIGH**	-ve	High
	With mitigation	Medium	Possible	**LOW**	-ve	Medium
OP-ME 11	Organic pollution and habitat modification (ongoing but reversible).	High	Possible	**MEDIUM**	-ve	High
	With mitigation	Medium	Possible	**LOW**	-ve	Medium
OP-ME 12	Genetic contamination of wild stocks from bivalve mariculture at Algoa 1 and 6 (ongoing and irreversible).	Low	Improbable	**VERY LOW**	-ve	Medium
OP-ME 13a	Accidental entanglement of cetaceans in bivalve mariculture infrastructure (ongoing but reversible).	Medium	Probable	**MEDIUM**	-ve	Medium
	With mitigation	Medium	Possible	**LOW**	-ve	Low
OP-ME 13b	Possible impacts on cetaceans resulting from alterations in habitat use or migration patterns (ongoing but reversible).	Low	Probable	**LOW**	-ve	Medium
	With mitigation	Low	Probable	**LOW**	-ve	Low

Mitigation measures, both essential and best practise for Algoa Bay finfish mariculture ADZ development include:

- Structural impacts:
  - Do not moor cages over long lived biogenic habitats (i.e. reef area that may be identified);
  - Ensure mooring system is well designed to prevent/limit movement of anchors and chains over the sea floor;
  - Do not move mooring anchors or blocks when undertaking cage net maintenance or fallowing sites, as replacement of moorings when site is used again will increase impact footprint;
- Biosecurity impacts:
  - Develop a biosecurity management plan which provides mitigation measures to reduce the likelihood of escape occurring, and ensure comprehensive training of staff;
  - Develop and implement recovery procedures should escapes occur;
  - Barriers must be checked frequently to remove escaped fish that may be trapped between screens;
  - Develop the technology to create sterile fry for stocking;
  - Maintain strict bio-security measures within hatchery, holding tanks and sea cages;
  - Ensure all fry undergoes a health examination prior to stocking in sea cages;
  - Regularly inspect stock for disease and/parasites as part of a formalised stock health monitoring programme and take necessary action to eliminate pathogens through the use of therapeutic chemicals or improved farm management. This will require focussed research effort into the identification, pathology and treatment of diseases and parasites infecting farmed species, both within culture and wild stocks;
  - Maintain comprehensive records of all pathogens and parasites detected as well as logs detailing the efficacy of treatments applied. These records should be made publically available to facilitate rapid responses by other operators to future outbreaks;
  - Locate cages stocked with different cohorts of the same species as far apart as possible (no less than 100 m), if possible stock different species in cages successively;
  - Treat adjacent cages simultaneously even if infections have not yet been detected;
  - Keep nets clean and allow sufficient fallowing time on sites to ensure low environmental levels of intermediates hosts and or pathogens;
- Pollution impacts:
  - Do not exceed recommended stocking capacity and implement a phased approach as per Hutchings et al (2013) and Wright *et al.* (2019);
  - Use species and system-specific feeds in order to maximize food conversion ratios (and minimize waste);

  - Monitor fish feeding behaviour and particulate matter deposition, adapt the feeding strategy to maximise feeding efficiency and minimise particulate matter fallout;
  - Rotation of cages within a site (fallowing) to allow recovery of benthos (not recommended over long lived habitats (e.g. reefs);
  - Sensible site selection, namely sufficient depth, current speeds and suitable sediment type (partly achieved in site selection);
  - Undertake ongoing, detailed water quality and benthic monitoring, including baseline surveys at control and impact sites (as described in Hutchings *et al.* 2013), and decrease the ADZ carrying capacity should the environmental quality indicator be exceeded outside of the accepted sacrificial footprint;
  - Use only approved veterinary chemicals and antifoulants;
  - Do not apply antifoulants on site (at sea);
  - Where effective, use environmentally friendly alternatives;
  - Use the most efficient drug delivery mechanisms that minimise the concentrations of biologically active ingredients entering the environment;
  - Use the lowest effective dose of therapeutants;
  - Monitoring to determine the intensity of impact;
- Genetic cross contamination impacts
  - Maintain genetic compatibility (similar levels of variation) between wild and cultured stock by implementing the "Genetic Best Practice Management Guidelines for Marine Finfish Hatcheries" developed by DAFF and ensure adequate genetic monitoring;
  - Reduce the number of escapees by maintain cage integrity through regular maintenance and replacement and training of staff;
  - Develop and implement recovery procedures should escapes occur;
- Impacts on cetaceans, seals and seabirds:
  - Do not locate ADZ precinct in important cetacean habitats;
  - Ensure all mooring lines and nets are highly visible (use thick lines and bright antifoulant coatings);
  - Keep all lines and nets tight through regular inspections and maintenance;
  - Ensure that mesh size on primary and secondary nets does not exceed 16 cm stretched mesh, use square mesh;
  - Establish a rapid response unit to deal with cetacean entanglements (collaboration with the South African Whale Disentanglement Network);
  - Install and maintain suitable predator nets (sufficient strength, visibility and mesh size, above and below water line);
  - Install visual deterrents (e.g. tori line type deterrents for birds);
  - Store feed so piscivores cannot access it, and implement efficient feeding strategy;
  - Remove any injured or dead fish from cages promptly;
  - During harvesting of stock, ensure that minimal blood or offal enters the water;
  - Develop a protocol for dealing with problem piscivores in conjunction with experts and officials (DAFF, DEA etc.);
  - Maintain a record of all interactions with piscivores as per recommended EMPr;

Mitigation measures, both essential and best practise for Algoa Bay bivalve mariculture ADZ development include:

- Structural impacts:
    - As above;
- Biosecurity impacts:
    - Develop South African bivalve hatcheries to reduce the reliance on spat import, and hence the risk of non -intentional introduction of associated alien species;
    - Ensure a high level of biosecurity management and planning is in place to limit the introduction of new invasives and to be able to respond quickly and effectively should biosecurity risks be identified;
    - Oyster stacks must be brought ashore for cleaning, and biofouling organisms thus not returned to the water;
    - Routine surveillance on and around marine farm structures, associated vessels and infrastructure must be undertaken for indications of non-native fouling species;
    - If spat import cannot be avoided, culture facilities should only be permitted to use spat sourced from biosecure certified hatcheries and/or quarantine facilities;
    - Use only prescribed veterinary chemicals;
- Organic pollution and habitat modification impacts:
    - Select sites favouring well-flushed, deep and productive areas;
    - Implement monitoring of the immediate water column around the precincts or specific farms for key plankton parameters (chl a, phytoplankton abundance and species composition);
    - Implement monitoring of biodeposition and physico-chemical changes in seabed properties at the farmed site relative to undisturbed control sites and compile annual monitoring reports;
    - Cleaning of biofouled infrastructure (ropes etc.) must be conducted in such a way as to minimise deposition to the seafloor beneath the farms (i.e. biofouling must be collected as deposited of at a suitable onshore disposal facility);
    - Avoid high density culture (overcrowding);
- Impacts on cetaceans, seals and seabirds:
    - As above.

The impacts of the use of chemical therapeutants and antifoulants in finfish cage culture, the impacts of genetic contamination of wild stocks with escapees from finfish cage culture and the impacts of piscivorous marine animals (cetaceans sharks, seabirds) interfering with finfish cage culture operations are ranked as having a higher impact on the marine environment at Algoa 7 than at Algoa 1.

5.2 Comparison of alternative options and recommendations

This marine specialist study identifies several constraints to mariculture activities in Algoa Bay, including shelter from prevailing wind and sea conditions at sites with suitable water depth and proximity to port, the presence of marine predators (sharks, seals, birds) and large cetaceans that may damage infrastructure; and the recent occurrence of Harmful Algal Blooms in Algoa Bay. These constraints have been identified during earlier strategic environmental assessment processes (Jooste 2009, Clark et al 2013) and the impact thereof on the economic feasibility of sea-based fish farming has been assessed in subsequent reports (Britz et al 2016, Britz and Sauer 2016 a,b, Advance Africa 2017). DAFF is well aware of these (and other) constraints and the current low feasibility of sea cage farming of indigenous finfish farming. The Advance Africa (2017) study calls for government interventions including: "detailed international market assessments, state-owned or state-supported hatchery and processing facilities, engagements with global feed producers with the aim of reducing feed prices and improving access to high-quality feed, and increased institutional support from governmental departments" to overcome the barriers to the development of the South African fish farming industry. This marine specialist impact assessment study therefore does not further consider the constraints on aquaculture development, nor the economic viability thereof, as these have been reported on elsewhere. The DAFF has taken cognisance of these studies and with its mandate to promote development of the sector, (with further impetus from Operation Phakisa), has made the decision to apply for environmental authorization for an ADZ in Algoa Bay. The marine specialist study focusses on the potential impacts of future, mariculture activities (finfish and bivalve farming) within the ADZ on the receiving environment.

The marine specialist assessment has identified potential medium and high significance impacts on marine vertebrates, particularly on sea birds, seals, sharks and cetaceans associated with the St Croix Island group, as well as the issue of Algoa 7 lying within the approved Addo MPA (thus contrary to conservation objectives). The marine specialist assessment therefore finds that the development of Algoa 7 as a site for finfish is less favourable than Algoa 1. The impacts of the use of chemical therapeutants and antifoulants in finfish cage culture, the impacts of genetic contamination of wild stocks with escapees from finfish cage culture and the impacts of piscivorous marine animals (cetaceans shakers, seabirds) interfering with finfish cage culture operations are ranked as having a lower potential impact at Algoa 1 than at Algoa 7.

There is a high degree of uncertainty as to many of the potential environmental impacts of finfish cage culture on these sites (as assessed above). Certainly the ability of the environment to assimilate wastes produced by commercial scale farms is unknown and difficult to predict or model. Even with the available current profiling data (which doesn't include surface water movement due to wind that may carry buoyant wastes such as oils) for these sites, much more explicit planning data would be needed on species to be farmed, future farm developments and operating procedures, in order to accurately model cumulative nutrient loading and waste plume dimensions. Potential impacts on marine vertebrates, including wild fish populations, bird and mammal piscivores and cetaceans are also very difficult to predict.

Environmental authorization for the proclamation of an Algoa ADZ for finfish and bivalve culture will require a comprehensive Environmental Management Programme (EMPr). This EMPr must require independent monitoring of sufficient indicators in order to detect and quantify any of the environmental impacts described above, and must specify thresholds of concern which require remedial action. The development of the ADZ should be phased in so that cumulative impacts can be detected as they arise, and adaptive management implemented.

It is recommended that no more than three finfish operators should be approved for an initial pilot phase, with a total annual production for the ADZ not exceeding 1 000 tonnes in the first year. Should monitoring reveal acceptable impacts as defined by the environmental quality objectives, indicators and performance measures, operators should be permitted to increase production from pilot phase to full commercial scale (carrying capacity at each site for *Seriola lalandii* and *Argyrosomus sp.* as recommended in Wright et al. (2019) over at least a three year period, provided resource quality objectives are maintained). Further development and expansion (addition of more operators and/ increase in production for established farms) should be dependent on acceptable environmental quality objectives as revealed by ongoing monitoring.

Assessing the four proposed development alternatives in terms of the number of medium and high significance impacts favours alternatives B and C (finfish at Algoa 7 and bivalves at Algoa 1 and/or 6) over alternative A (finfish at both Algoa 1 and 7, bivalves at both Algoa 1 and Algoa 6) (Table 29). This is simply a result of more mariculture development (i.e. having two bivalve and fish farming sites versus only two sites) having more impacts. The marine ecological impact assessment however resulted in more high and medium significance impacts for finfish cage culture at Algoa 7 than Algoa 1. The Status Quo Alternative (i.e. Option D) proposes that the Algoa Bay ADZ does not go ahead. This would mean that the negative potential impacts on marine biodiversity and conservation efforts in Algoa Bay will not occur.

Table 29. Comparison of the sum of impact significance of alternative options A, B, C and D for the proposed sea-based Algoa Bay Aquaculture Development Zone on marine ecology (negative impact after mitigation).

Alternative	**A**	**B**	**C**	**D**
Activities	**Algoa 1: finfish and bivalves Algoa 6: bivalves Algoa 7: finfish**	**Algoa 1: bivalves Algoa 6: bivalves Algoa 7: finfish**	**Algoa 6: bivalves Algoa 7: finfish**	**No Go**
Low	23	18	10	0
Medium	6	5	5	0
High	2	1	1	0

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APPENDICES

7 APPENDIX 1

The significance of each identified impact was rated according to the methodology set out below:

Step 1 – Determine the consequence rating for the impact by determining the score for each of the three criteria (A-C) listed below and then adding them. The rationale for assigning a specific rating, and comments on the degree to which the impact may cause irreplaceable loss of resources and be irreversible, must be included in the narrative accompanying the impact rating:

Rating	Definition of Rating	Score
A. *Extent – the area over which the impact will be experienced*		
Local	Confined to project or study area or part thereof (e.g. limits of the concession area)	1
Regional	The region (e.g. the whole of Namaqualand coast)	2
(Inter) national	South African land and waters and beyond	3
B. *Intensity – the magnitude of the impact in relation to the sensitivity of the receiving environment, taking into account the degree to which the impact may cause irreplaceable loss of resources*		
Low	Site-specific and wider natural and/or social functions and processes are negligibly altered	1
Medium	Site-specific and wider natural and/or social functions and processes continue albeit in a modified way	2
High	Site-specific and wider natural and/or social functions or processes are severely altered	3
C. *Duration – the time frame for which the impact will be experienced and its reversibility*		
Short-term	Up to 2 years	1
Medium-term	2 to 15 years	2
Long-term	More than 15 years (state whether impact is irreversible)	3

The combined score of these three criteria corresponds to a **Consequence Rating**, as follows:

Combined Score (A+B+C)	3 – 4	5	6	7	8 – 9
Consequence Rating	Very low	Low	Medium	High	Very high

Example 1:

Extent	Intensity	Duration	Consequence
Regional 2	Medium 2	Long-term 3	High 7

Step 2 – Assess the **probability** of the impact occurring according to the following definitions:

Probability– the likelihood of the impact occurring	
Improbable	< 40% chance of occurring
Possible	40% - 70% chance of occurring
Probable	> 70% - 90% chance of occurring
Definite	> 90% chance of occurring

Example 2:

Extent	Intensity	Duration	Consequence	Probability
Regional 2	Medium 2	Long-term 3	High 7	Probable

Step 3 – Determine the overall **significance** of the impact as a combination of the **consequence** and **probability** ratings, as set out below:

		Probability			
		Improbable	Possible	Probable	Definite
Consequence	Very Low	**INSIGNIFICANT**	**INSIGNIFICANT**	**VERY LOW**	**VERY LOW**
	Low	**VERY LOW**	**VERY LOW**	**LOW**	**LOW**
	Medium	**LOW**	**LOW**	**MEDIUM**	**MEDIUM**
	High	**MEDIUM**	**MEDIUM**	**HIGH**	**HIGH**
	Very High	**HIGH**	**HIGH**	**VERY HIGH**	**VERY HIGH**

Example 3:

Extent	Intensity	Duration	Consequence	Probability	Significance
Regional 2	Medium 2	Long-term 3	High 7	Probable	HIGH

Step 4 – Note the **status** of the impact (i.e. will the effect of the impact be negative or positive?)

Example 4:

Extent	Intensity	Duration	Consequence	Probability	Significance	Status
Regional 2	Medium 2	Long-term 3	High 7	Probable	HIGH	– ve

Step 5 – State the level of **confidence** in the assessment of the impact (high, medium or low).

Impacts are also considered in terms of their status (positive or negative impact) and the confidence in the ascribed impact significance rating. The prescribed system for considering impacts status and confidence (in assessment) is laid out in the table below. Depending on the data available, a higher level of confidence may be attached to the assessment of some impacts than others. For example, if the assessment is based on extrapolated data, this may reduce the confidence level to low, noting that further ground-truthing is required to improve this.

Confidence rating	
Status of impact	+ ve (beneficial) or – ve (cost)
Confidence of assessment	Low, Medium or High

Example 5:

Extent	**Intensity**	**Duration**	**Consequence**	**Probability**	**Significance**	**Status**	**Confidence**
Regional 2	Medium 2	Long-term 3	High 7	Probable	HIGH	– ve	High

The significance rating of impacts is considered by decision-makers, as shown below. Note, this method does not apply to minor impacts which can be logically grouped into a single assessment.

INSIGNIFICANT: the potential impact is negligible and **will not** have an influence on the decision regarding the proposed activity.

VERY LOW: the potential impact is very small and **should not** have any meaningful influence on the decision regarding the proposed activity.

LOW: the potential impact **may not** have any meaningful influence on the decision regarding the proposed activity.

MEDIUM: the potential impact **should** influence the decision regarding the proposed activity.

HIGH: the potential impact **will** affect a decision regarding the proposed activity.

VERY HIGH: The proposed activity should only be approved under special circumstances.

Step 6 – Identify and describe practical **mitigation** and **optimisation** measures that can be implemented effectively to reduce or enhance the significance of the impact. Mitigation and optimisation measures must be described as either:

- **Essential**: must be implemented and are non-negotiable; and
- **Best Practice**: must be shown to have been considered and sound reasons provided by the proponent if not implemented.

Essential mitigation and optimisation measures must be inserted into the completed impact assessment table. The impact should be re-assessed with mitigation, by following Steps 1-5 again to demonstrate how the extent, intensity, duration and/or probability change after implementation of the proposed mitigation measures.

Example 6: A completed impact assessment table

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Regional **2**	Medium **2**	Long-term **3**	**High** **7**	Probable	**HIGH**	**– ve**	High
Essential mitigation measures: xxxxx xxxxx								
With mitigation	Local 1	Low 1	Long-term 3	**Low** **5**	Improbable	**VERY LOW**	**– ve**	High

Step 7 – Prepare a summary table of all impact significance ratings as follows:

Impact	***Consequence***	***Probability***	**Significance**	***Status***	***Confidence***
Impact 1: XXXX	Medium	Improbable	LOW	–ve	High
With Mitigation	Low	Improbable	VERY LOW		High
Impact 2: XXXX	Very Low	Definite	VERY LOW	–ve	Medium
With Mitigation:	*Not applicable*				

Indicate whether the proposed development alternatives are environmentally suitable or unsuitable in terms of the respective impacts assessed by the relevant specialist and the environmentally preferred alternative.

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