APPLICATION FOR ALLUVIAL DIAMONDS PROSPECTING WITH BULK SAMPLING ON PORTION 4 OF THE FARM RIETFONTEIN EXTENSION NO. 151 AND PORTION 4 OF THE FARM GRAAUW DUINEN NO. 152, VANRHYNSDORP

Marine Ecology Assessment

Prepared for:

Enviro Africa

On behalf of:

Fish by the Sea (Pty) Ltd

February 2024

BASIC ASSESSMENT AS PART OF THE PROSPECTING RIGHT APPLICATION WITH BULK SAMPLING FOR DIAMONDS AT BRAND SE BAAI, NORTHERN CAPE

MARINE ECOLOGY ASSESSMENT

Prepared for

Enviro Africa

On behalf of:

Fish by the Sea (Pty) Ltd

Prepared by

Andrea Pulfrich
Pisces Environmental Services (Pty) Ltd

February 2024

PISCES Environmental Services (Pty) Ltd

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Contact Details:

Andrea Pulfrich
Pisces Environmental Services
PO Box 302, McGregor 6708, South Africa,
Tel: +27 21 782 9553
E-mail: apulfrich@pisces.co.za
Website: www.pisces.co.za

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ABBREVIATIONS and UNITS

BCC	Benguela Current Commission
BCLME	Benguela Current Large Marine Ecosystem
cm	centimetres
cm/s	centimetres per second
CBA	Critical Biodiversity Area
CBD	Convention of Biological Diversity
CITES	Convention on International Trade in Endangered Species
CMS	Centre for Marine Studies
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
E	East
EBSA	Ecologically or Biologically Significant Area
ECOP	Environmental Code of Practice
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
ESA	Ecological Support Area
FAO	Food and Agricultural Organisation
g C/m^2/day	grams Carbon per square metre per day
GIS	Global Information System
ha	hectares
HABs	Harmful Algal Blooms
HWS	High Water Spring
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
km	kilometre
km^2	square kilometre
km/h	kilometres per hour
kts	knots
MPA	Marine Protected Area
MSP	Marine Spatial Planning
m	metres
m^2	square metres
m^3	cubic metre
m^3/h	cubic metre per hour
mm	millimetres
mg/ℓ	milligrams per litre
N	north
NE	Northeast
NDP	Namibian Dolphin Project
NEMA	National Environmental Management Act
NNW	north-northwest
NW	north-west
PIM	Particulate Inorganic Matter

POM	Particulate Organic Matter
S	south
SACW	South Atlantic Central Water
SADCO	Southern Africa Data Centre for Oceanography
SANBI	South African National Biodiversity Institute
SLR	SLR Consulting (South Africa) (Pty) Ltd
SST	Sea Surface Temperature
SSW	South-southwest
SW	south-west
tons/h	tons per hour
tons/km^2	tons per square kilometre
TAC	Total Allowable Catch
TSPM	Total Suspended Particlate Matter
UNEP	United Nations Environmental Programme
VMEs	Vulnerable Marine Ecosystems
VOS	Voluntary Observing Ships
WCP	Wet Concentrator Plant
WSP	WSP Coastal and Port Engineers
wt%	percentage weight
µm	micrometre/micron
µM	microMol
˚C	degrees Centigrade
%	percent
‰	parts per thousand
~	approximately
<	less than
>	greater than
± SD	plus/minus one Standard Deviation

GLOSSARY

Anti-cyclonic	An extensive system of winds spiralling outward anti-clockwise (in Southern Hemisphere) from a high-pressure centre.
Benthic	Referring to organisms living in or on the sediments of aquatic habitats (lakes, rivers, ponds, etc.).
Benthos	The sum total of organisms living in, or on, the sediments of aquatic habitats.
Benthic organisms	Organisms living in or on sediments of aquatic habitats.
Biodiversity	The variety of life forms, including the plants, animals and micro-organisms, the genes they contain and the ecosystems and ecological processes of which they are a part.
Biomass	The living weight of a plant or animal population, usually expressed on a unit area basis.
Biota	The sum total of the living organisms of any designated area.
Bivalve	A mollusk with a hinged double shell.
Community structure	All the types of taxa present in a community and their relative abundance.
Community	An assemblage of organisms characterized by a distinctive combination of species occupying a common environment and interacting with one another.
Cyclonic	An atmospheric system characterized by the rapid inward circulation of air masses about a low-pressure centre; circulating clockwise in the Southern Hemisphere
Dissolved oxygen (DO)	Oxygen dissolved in a liquid, the solubility depending upon temperature, partial pressure and salinity, expressed in milligrams/litre or millilitres/litre.
Epifauna	Organisms, which live at or on the sediment surface being either attached (sessile) or capable of movement.
Ecosystem	A community of plants, animals and organisms interacting with each other and with the non-living (physical and chemical) components of their environment.
Euphotic/photic zone	the zone in the ocean that extends from the surface down to a depth where light intensity falls to one percent of that at the surface; i.e. there is to sufficient sunlight for photosynthesis to occur.
Habitat	The place where a population (e.g. animal, plant, micro-organism) lives and its surroundings, both living and non-living.
Hypoxic	Deficiency in oxygen.
Infauna	Animals of any size living within the sediment. They move freely through interstitial spaces between sedimentary particles or they build burrows or tubes.
Intertidal	The area of seashore which is covered at high tide and uncovered at low tide.
Macrofauna	Animals >1 mm.
Macrophyte	A member of the macroscopic plant life of an area, especially of a body of water; large aquatic plant.
Meiofauna	Animals <1 mm.
Mariculture	Cultivation of marine plants and animals in natural and artificial environments.
Marine environment	Marine environment includes estuaries, coastal marine and near-shore zones, and open-ocean-deep-sea regions.
Pelagic	of or pertaining to the open seas or oceans; living at or near the surface of ocean.
Population	Population is defined as the total number of individuals of the species or taxon.

Recruitment	The replenishment or addition of individuals of an animal or plant population through reproduction, dispersion and migration.
Sediment	Unconsolidated mineral and organic particulate material that settles to the bottom of aquatic environment.
Species	A group of organisms that resemble each other to a greater degree than members of other groups and that form a reproductively isolated group that will not produce viable offspring if bred with members of another group.
Subtidal	The zone below the low-tide level, *i.e.* it is never exposed at low tide.
Supratidal	The zone above the high-tide level.
Surf-zone	Also referred to as the 'breaker zone' where water depths are less than half the wavelength of the incoming waves with the result that the orbital pattern of the waves collapses and breakers are formed.
Suspended material	Total mass of material suspended in a given volume of water, measured in mg/ℓ.
Suspended sediment	Unconsolidated mineral and organic particulate material that is suspended in a given volume of water, measured in mg/ℓ.
Taxon (Taxa)	Any group of organisms considered to be sufficiently distinct from other such groups to be treated as a separate unit (e.g. species, genera, families).
Turbidity	Measure of the light-scattering properties of a volume of water, usually measured in nephelometric turbidity units.
Vulnerable	A taxon is vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

EXPERTISE AND DECLARATION OF INDEPENDENCE

This report was prepared by Dr Andrea Pulfrich of Pisces Environmental Services (Pty) Ltd. Andrea has a PhD in Fisheries Biology from the Institute for Marine Science at the Christian-Albrechts University, Kiel, Germany.

As Director of Pisces since 1998, Andrea has considerable experience in undertaking specialist environmental impact assessments, baseline and monitoring studies, and Environmental Management Programmes relating to marine diamond mining and dredging, hydrocarbon exploration and thermal/hypersaline effluents. She is a member of the South African Council for Natural Scientific Professions, South African Institute of Ecologists and Environmental Scientists, and International Association of Impact Assessment (South Africa).

This Specialist Report was compiled for EnviroAfrica on behalf of Fish by the Sea (Pty) Ltd for their use in preparing a Scoping and Environmental Impact Assessment (SEIA) Report as part of the application for a prospecting permit for diamonds in the Brand-se-Baai area. I do hereby declare that Pisces Environmental Services (Pty) Ltd is financially and otherwise independent of the Applicant and NJ van Zyl.

Andrea Pulfrich

Dr Andrea Pulfrich

1. GENERAL INTRODUCTION

EnviroAfrica has been appointed by Fish by the Sea (Pty) Ltd as the Environmental Assessment Practitioner, to prepare an application for a prospecting with bulk sampling permit for alluvial diamonds on a Portion 4 of the Farm Rietfontein Extension No. 151 and Portion 4 of the Farm Graauw Duinen No. 152 situated in the Matzikama Local Authority of the Van Rhynsdorp Registration division in the Western Cape Province. The prospecting area is 121 Ha in size, stretches along a ~5 km stretch of coastline just north of Brand-se-Baai and includes the adjacent Surf Zone up to the low water mark but excludes the area 31.49 meters below the low water mark.

To meet the requirements of the Mineral and Petroleum Resources Development Act and the National Environmental Management Act (NEMA), a Scoping and Environmental Impact Assessment (SEIA) Report is required to obtain environmental authorisation for the proposed prospecting with bulk sampling activities. EnviroAfrica is undertaking the required application for environmental authorisation and in turn has approached Pisces Environmental Services (Pty) Ltd to provide the marine specialist inputs as part of the submission.

1.1. Scope of Work

The Terms of Reference for the marine ecology specialist study, are:

- Using a desktop approach, provide a marine ecological baseline of the intertidal and subtidal macrofaunal and floral communities in the project area.
- Based on information provided in the baseline description, identify and map key environmental constraints (e.g. sensitive marine receptors) that may impact the project design and/or site selection.
- Undertake an evaluation and assessment of the impacts of the proposed prospecting operations on the marine ecology in the project area. All identified marine and coastal impacts (direct, indirect and cumulative) will be summarised, categorised and ranked in appropriate impact assessment tables, to be incorporated in the overall Environmental Impact Report. The significance of the impacts would be rated according to the impact assessment methodology specified by the lead consultant and as required by the NEMA, and would include an assessment of the no-go alternative.
- Propose mitigatory measures and management actions to avoid impacts or reduce their severity.

1.2. Approach to the Study

As specified in the Scope of Work, this marine specialist assessment has adopted a desktop approach. The assessment includes information on marine ecosystems and fisheries in the project area and is based on a review and expert interpretation of all relevant, available local and international publications and information sources on the disturbances and risks associated with prospecting operations in the shallow subtidal habitat.

This specialist assessment only covers potential impacts from operations that affect the environment below the high water mark. All identified marine impacts are summarised, categorised and ranked in appropriate impact assessment tables, to be incorporated in the overall Basic Assessment Report.

1.2.1 Assumptions, Limitations and Information Gaps

As determined by the terms of reference, this study has adopted a 'desktop' approach. Consequently, the description of the natural baseline environment in the study area is based on the descriptions provided in various Marine and Coastal Ecology Assesments compiled as part of other marine-related projects undertaken in the area. Information has been updated where appropriate. The information for the identification of potential impacts of mining activities on the coastal and marine environment was drawn from various scientific publications, the Generic EMPr for Diamond Mining on the South African West Coast (Lane & Carter 1999) and the Benguela Current Large Marine Ecosystem (BCLME) Thematic Report (Clark *et al.* 1999) and the assessment of cumulative effects of marine diamond mining activities on the BCLME Region (Penney *et al.* 2008) and information sourced from the Internet. The sources consulted are listed in the Reference chapter.

The study is based on the project description made available to the specialist at the time of the commencement of the study.

Information gaps relevant to this application include:

- information specific to the marine communities of intertidal rocky shores, and nearshore reefs; and
- information specific to the marine communities of intertidal beaches in the project area in particular.

1.2.2 Impact Assessment Methodology

This assessment methodology enables the assessment of biophysical, cultural, and socio-economic impacts including cumulative impacts and impact significance through the consideration of intensity, extent, duration, and the probability of the impact occurring. Consideration is also given to the degree to which impacts may cause irreplaceable loss of resources, be avoided, reversibility of impacts and the degree to which the impacts can be mitigated.

Part A provides the definition for determining impact consequence (combining intensity, extent, and duration) and impact significance (the overall rating of the impact). Impact consequence and significance are determined from Part B and C. The interpretation of the impact significance is given in Part D. This methodology is utilised to assess both the incremental and cumulative project related impacts.

<table>
<tr><th colspan="3">PART A: DEFINITIONS AND CRITERIA</th></tr>
<tr><td colspan="2">Definition of SIGNIFICANCE</td><td>Significance = consequence x probability</td></tr>
<tr><td colspan="2">Definition of CONSEQUENCE</td><td>Consequence is a function of intensity, extent, and duration</td></tr>
<tr><td rowspan="5">Criteria for ranking of the INTENSITY of environmental impacts</td><td>VL</td><td>• Negligible change, disturbance, or nuisance with very minor consequences or deterioration.
• Targets, limits, and thresholds of concern never exceeded.
• Species or habitats with negligible importance.
• No interventions or clean-up actions required.
• No complaints anticipated.</td></tr>
<tr><td>L</td><td>• Minor (Slight) change, disturbance, or nuisance with minor consequences or deterioration.
• Targets, limits, and thresholds of concern rarely exceeded.
• Habitats and ecosystems which are degraded and modified.
• Require only minor interventions or clean-up actions.
• Sporadic complaints could be expected.</td></tr>
<tr><td>M</td><td>• Moderate change, disturbance, or discomfort with real but not substantial consequences.
• Targets, limits, and thresholds of concern may occasionally be exceeded.
• Habitats or ecosystems with important functional value in maintaining biotic integrity.
• Occasional complaints can be expected.</td></tr>
<tr><td>H</td><td>• Prominent change, disturbance, or degradation with real and substantial consequences.
• May result in illness or injury.
• Targets, limits, and thresholds of concern regularly exceeded.
• Habitats or ecosystems which are important for meeting national/provincial conservation targets.
• Will require intervention.
• Threats of community action.
• Regular complaints can be expected when the impact takes place.</td></tr>
<tr><td>VH</td><td>• Severe change, disturbance, or degradation with severe consequences.
• May result in severe illness, injury, or death.
• Targets, limits, and thresholds of concern continually exceeded.
• Habitats or ecosystems of high importance for maintaining the persistence of species or habitats that meet critical habitat thresholds.
• Substantial intervention will be required.
• Vigorous/widespread community mobilization against project can be expected.
• May result in legal action if impact occurs.</td></tr>
<tr><td rowspan="4">Criteria for ranking the DURATION of impacts</td><td>Very Short term</td><td>Very short, always less than a year or may be intermittent (less than 1 year). Quickly reversible.</td></tr>
<tr><td>Short term</td><td>Short-term, occurs for more than 1 but less than 5 years. Reversible over time.</td></tr>
<tr><td>Medium term</td><td>Medium-term, 5 to 10 years.</td></tr>
<tr><td>Long term</td><td>Long term, between 10 and 20 years. Likely to cease at the end of the operational life of the activity or because of natural processes or by human intervention.</td></tr>
</table>

PART A: DEFINITIONS AND CRITERIA		
	Permanent	Very long, permanent, +20 years. Irreversible. Beyond closure or where recovery is not possible either by natural processes or by human intervention.
Criteria for ranking the EXTENT of impacts (alternative)	**Within / near site**	Impact is limited to the immediate footprint of the activity and the nearby vicinity.
	Local	Impact goes beyond site footprint but is confined to a localised area / project surroundings / remains within a habitat or vegetation type or local (municipal) administrative boundary.
	Regional	Impact goes well beyond site footprint and is regional, but remains within an ecosystem or regional (district / province) administrative boundary.
	Inter-regional	Impact affects several regions, e.g. several ecosystems or regional administrative units.
	National / International	Impact extends to a national scale and/or beyond.

PART B: DETERMINING CONSEQUENCE - APPLIES TO POTENTIAL POSITIVE OR ADVERSE IMPACTS						
		EXTENT				
		Within / near site	**Local**	**Regional**	**Inter-regional**	**National / International**
	INTENSITY = VL					
DURATION	**Very short term**	Very Low	Very Low	Very Low	Low	Low
	Short term	Very Low	Very Low	Low	Low	Medium
	Medium term	Very Low	Low	Low	Medium	Medium
	Long term	Low	Low	Medium	Medium	Medium
	Very long term/permanent	Low	Medium	Medium	Medium	High
	INTENSITY = L					
DURATION	**Very short term**	Very Low	Very Low	Low	Low	Medium
	Short term	Very Low	Low	Low	Medium	Medium
	Medium term	Low	Low	Medium	Medium	Medium
	Long term	Low	Medium	Medium	Medium	High
	Very long term/permanent	Medium	Medium	Medium	High	High
	INTENSITY = M					
DURATION	**Very short term**	Very Low	Low	Low	Medium	Medium
	Short term	Low	Low	Medium	Medium	Medium
	Medium term	Low	Medium	Medium	Medium	High
	Long term	Medium	Medium	Medium	High	High
	Very long term/permanent	Medium	Medium	High	High	High
	INTENSITY = H					
DURATION	**Very short term**	Low	Low	Medium	Medium	Medium
	Short term	Low	Medium	Medium	Medium	High
	Medium term	Medium	Medium	Medium	High	High
	Long term	Medium	Medium	High	High	High
	Very long term/permanent	Medium	High	High	High	Very High

PART B: DETERMINING CONSEQUENCE - APPLIES TO POTENTIAL POSITIVE OR ADVERSE IMPACTS						
	INTENSITY = VH					
DURATION	**Very short term**	Low	Medium	Medium	Medium	High
	Short term	Medium	Medium	Medium	High	High
	Medium term	Medium	Medium	High	High	High
	Long term	Medium	High	High	High	Very High
	Very long term/permanent	High	High	High	Very High	Very High

PART C: DETERMINING SIGNIFICANCE - APPLIES TO POSITIVE OR ADVERSE IMPACTS						
		CONSEQUENCE				
		Very Low	**Low**	**Medium**	**High**	**Very High**
PROBABILITY (of exposure to impacts)	**Unlikely**	Insignificant	Insignificant	Very Low	Low	Medium
	Conceivable	Insignificant	Very Low	Low	Medium	High
	Possible	Insignificant	Very Low	Low	Medium	High
	Probable	Very Low	Low	Medium	High	Very High
	Very Likely	Very Low	Low	Medium	High	Very High

PART D: INTERPRETATION OF SIGNIFICANCE		
Significance		**Decision guideline**
Insignificant		Inconsequential, not requiring any consideration.
Very Low	Very Low +	These beneficial or adverse impacts will not have an influence on the decision. In the case of adverse impacts, mitigation is not required.
Low	Low +	These beneficial or adverse impacts are unlikely to have a real influence on the decision. In the case of adverse impacts, limited mitigation is likely to be required.
Medium	Medium +	These beneficial or adverse impacts may be important but are not likely to be key decision-making factors. In the case of adverse impacts, mitigation will be required.
High	High +	These beneficial or adverse impacts are considered to be very important considerations and must have an influence on the decision. In the case of adverse impacts, substantial mitigation will be required.
Very High	Very High +	Represents a key factor in decision-making. Adverse impact would be considered a potential fatal flaw unless mitigated to lower significance.

Additional assessment criteria

Additional criteria that are taken into consideration in the impact assessment process to further describe the impact and support the interpretation of significance in the impact assessment process include:

- the degree to which impacts may cause irreplaceable loss of resources;
- the degree to which impacts can be avoided;
- the degree to which impacts can be reversed;

- the degree to which the impacts can be mitigated; and
- the extent to which cumulative impacts may arise from interaction or combination from other planned activities or projects is tabulated below.

ADDITIONAL ASSESSMENT CRITERIA		
Criteria for DEGREE TO WHICH AN IMPACT CAN BE REVERSED	IRREVERSIBLE	Where the impact cannot be reversed and is permanent.
	PARTIALLY REVERSIBLE	Where the impact can be partially reversed and is temporary.
	FULLY REVERSIBLE	Where the impact can be completely reversed.
Criteria for DEGREE OF IRREPLACEABLE RESOURCE LOSS	NONE	Will not cause irreplaceable loss.
	LOW	Where the activity results in a marginal effect on an irreplaceable resource.
	MEDIUM	Where an impact results in a moderate loss, fragmentation or damage to an irreplaceable receptor or resource.
	HIGH	Where the activity results in an extensive or high proportion of loss, fragmentation or damage to an irreplaceable receptor or resource.
Criteria for DEGREE TO WHICH IMPACT CAN BE AVOIDED	NONE	Impact cannot be avoided and consideration should be given to compensation and offsets.
	LOW	Impact cannot be avoided but can be mitigated to acceptable levels through rehabilitation and restoration.
	MEDIUM	Impact cannot be avoided, but the significance can be reduced through mitigation measures.
	HIGH	Impact can be avoided through the implementation of preventative mitigation measures.
Criteria for the DEGREE TO WHICH IMPACT CAN BE MITIGATED	NONE	No mitigation is possible or mitigation even if applied would not change the impact.
	LOW	Some mitigation is possible but will have marginal effect in reducing the impact significance rating.
	MEDIUM	Mitigation is feasible and will may reduce the impact significance rating.
	HIGH	Mitigation can be easily applied or is considered standard operating practice for the activity and will reduce the impact significance rating.
Criteria for POTENTIAL FOR CUMULATIVE IMPACTS	UNLIKELY	Low likelihood of cumulative impacts arising.
	POSSIBLE	Cumulative impacts with other activities or projects may arise.
	LIKELY	Cumulative impacts with other activities or projects either through interaction or in combination can be expected.

2. DESCRIPTION OF THE PROPOSED PROJECT

2.1. Introduction

De Beers conducted exploration over this area in the past providing opportunity for a preliminary evaluation phase and redefinition of the area prior to the commencement of prospecting operations, so that the pre-bulk sampling work (geophysics and exploration pits) can be done on selected target. Information obtained during previous exploration results describes the emerged (as opposed to submerged) marine gravel terraces as the Lower Terrace (0-9 mamsl), the Middle Terrace (10-30 mamsl), the Upper Terrace (30-55 mamsl). The current application only covers portions of the Lower Terrace. The trenching done in this area as part of the De Beers exploration were primary trenches, which means that the trenches were placed across zones where marine gravels were delineated by drilling. No secondary trenches, which are used to delineate zones of enrichment found by primary trenching, have been done in the area. The prospecting with bulk sampling right application area has been identified as a potential future mining target and was included as part of the Mining Works Plan submitted as part of a prospecting right application.

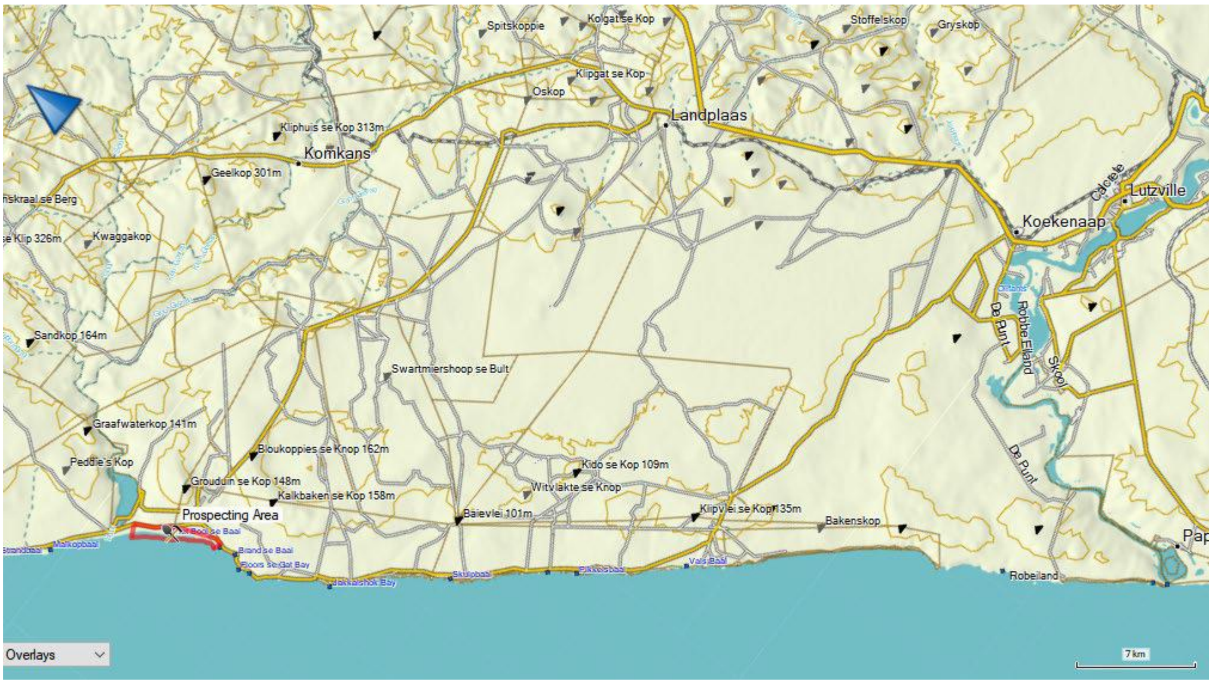

Figure 2-1: The Brand-se-Baai prospecting target in relation to major routes and towns in the region.

2.2. Proposed Prospecting Approach

The prospecting operations will adopt a phased approach.

Phase 1: Non-invasive prospecting covering the entire prospecting lease area will include a literature study, imagery analysis, geological mapping and geophysical survey. During this phase the desktop studies and studying of available information on surrounding exploration work that are already done will be supplemented by field observations. Ground Resistivity measurements will also be used to "home in" on target areas.

PHASE 2: Invasive prospecting: Preliminary evaluation by means of prospecting pits to determine a ballpark estimate of grade and size and thus possible in-situ value of the deposit. This is normally established by collecting mini samples by the most cost-effective method available. Due to the relative shallow overburden, the excavation of prospecting pits is the most common technique and will be employed during this exploration program to allow for geological samples. It is anticipated that no more than 20 pits will be excavated. After results are logged the pit will be back-filled immediately for security and safety reasons before the moving to the next pit position.

The following volumes requiring earthmoving during pit sampling are estimated:

- Pit floor to inspect and log the gravel: 5.0 m long and 2.0 m wide (10 m^2)
- Depth of Topsoil: 0.5 m to be stockpiled separate from overburden
- Depth of Overburden: 5 m to be stockpiled separate from topsoil
- Depth of Gravel: 1 m to be logged and photographed
- Total Depth of Prospecting Pit: 6.5 m
- Footprint including 3 m bench: 11 m long x 8 m wide (88 m^2)
- Volume topsoil: 88 m^2 x 0.5 m = 44 m^3
- Volume overburden: 50 m^2 (average 88 m^2 top & 10 m^2 bottom) x 5 m = 250 m^3
- Volume gravel: 10 m^2 x 1 m = 10 m^3

Total volumes excavated from 20 Prospecting pits: (44 m^3+250 m^3) x 20 = 5 880 m^3.

The gravel from the pits is not removed and treated but left intact and closed after logging of results. In the case of positive results, the pit excavation will be extended for the purpose of a bulk sample.

PHASE 3 Bulk sampling (Trenches)

The bulk sample will consist of a trench excavated perpendicularly to the low-water mark or paleo beach. There will only ever be one trench open at any given time and it is anticipated that only four such sample sites will be developed in the prospecting area (Figure 2-2).

The bulk sampling or trial mining needs to continue until ~1 000 carats have been recovered for the feasibility of the mine to be concluded and for it to be determined whether a mining right application is required. The information from this trial mining is also essential to determine the most efficient final recovery method. The following are pertinent with regard to the prospecting trench development.

The trench width will be determined by:

- Overburden depth: the thicker the overburden, the wider the trench will be at the surface.
- The angle of repose and safety of the sidewalk in terms of slumping: the operator on site must determine these, as they are in situ safety considerations.

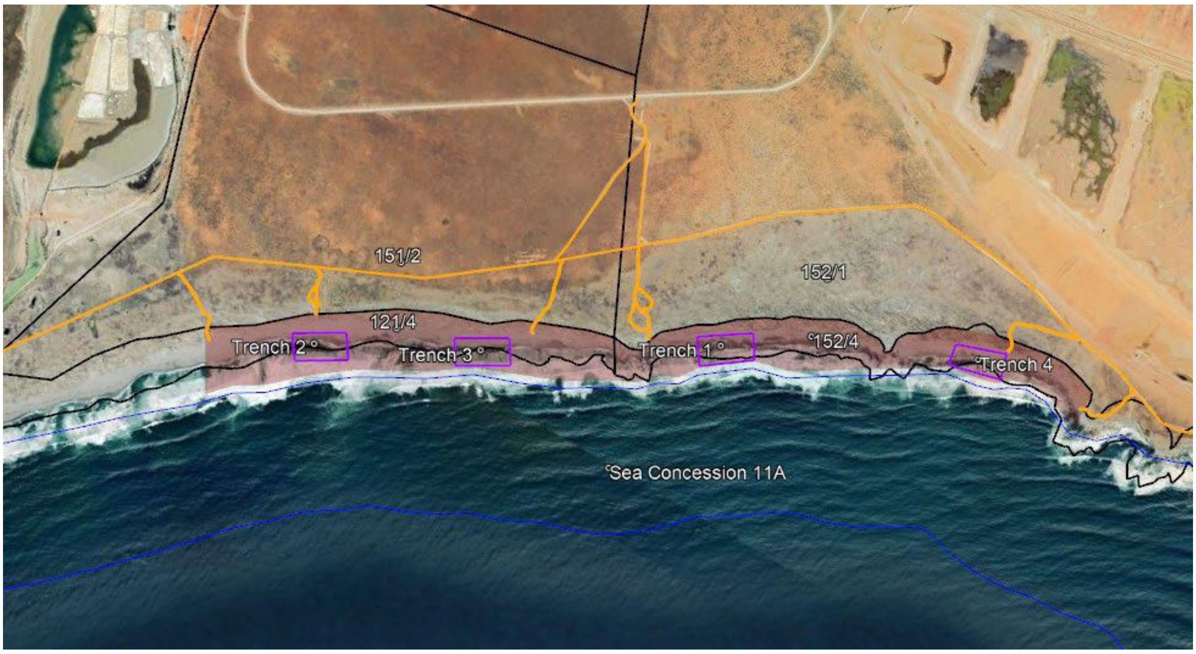

Figure 2-2: Prospecting area showing locality of proposed trenches and existing access roads, the parking area for equipment when not in use, as well as the containerised processing plant.

Prospecting trenching development will consist of the following procedures:

- Remove the overburden (beach sand of 5 m -10 m thick) to create a berm on average 4 m high around the excavation to prevent seawater and waves entering the excavation (Figure 2-3).
- Extract alluvial material (2 - 5 m thick layer) and use infield screening to remove fines (-2 mm) and oversize (+21 mm). Of the excavated material ±99% will be return to the trench for immediate backfill (Figure 2-4).
- The remaining 1% (concentrate) will be bagged and trucked to the containerised processing plant (Bourevestnik autosorter) (Figure 2-5).
- Concentrate from the trommel screen are processed by the flow sort X-ray Media Separator and the final concentrate for recovery is deposit in safe boxes.

The following volumes requiring earthmoving during bulk sampling are estimated:

- Total Depth of Prospecting Trench: 10 – 15 m
- Footprint of trench: 300 m long x 150 m wide (45 000 m^2)
- Volume overburden: 45 000 m^2 x 10 m deep = 450 000 m^3
- ROM 45 000 m^2 x 5 m = 225 000 m^3
- Concentrate 225 000 m^3 x 1% = 2 250m^3 x 2 (specific gravity) = 4 500 tonnes

At least 5 000 tonnes of concentrate are required for processing to obtain a representative sample for sufficient statistical analysis to complete a resource statement and to determine a grade of carats per 100 tonnes.

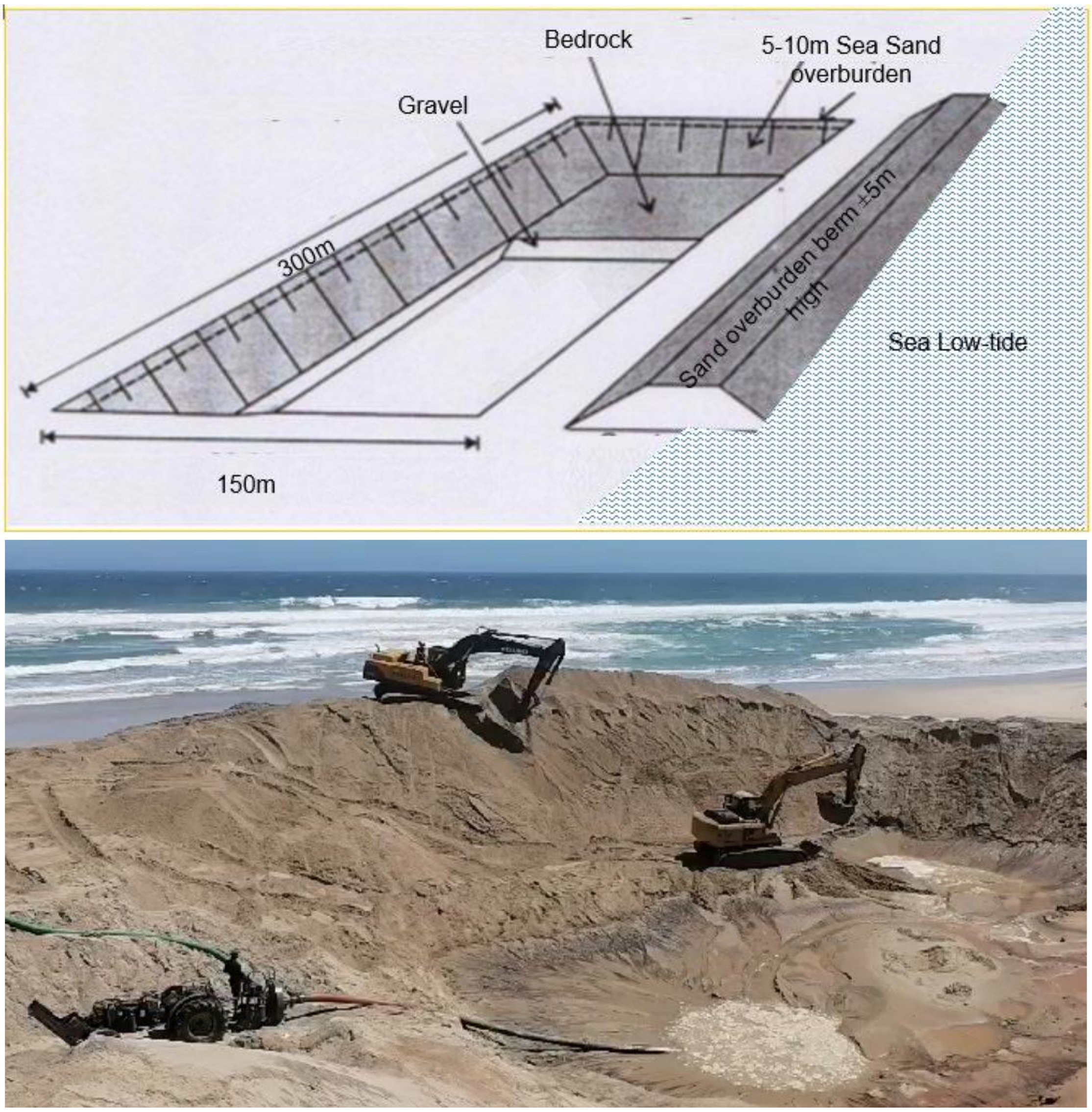

Figure 2-3: Top: schematic of trench excavation and Bottom: removal of overburden to create beach berm to protect the mining area.

Figure 2-4: Infield trommel screen used to process the mined sediments.

Figure 2-5: Mobile containerised processing plant.

3. DESCRIPTION OF THE BASELINE MARINE ENVIRONMENT

The descriptions of the physical and biological environments along the South African West Coast focus primarily on the broader study area between the Orange River mouth and Lamberts Bay. The purpose of this environmental description is to provide the marine baseline environmental context within which the proposed heavy mineral mining would take place. The summaries presented below are primarily based on information gleaned from Lane & Carter (1999) and Penney *et al.* (2007) and supplemented by updated references where appropriate. These were presented in the marine ecology specialist report as part of the Alexkor EMPr Amendment (Pulfrich 2018) and have been updated here as necessary.

3.1. Geophysical Characteristics

3.1.1 Bathymetry and Coastal Topography

The continental shelf along the West Coast is generally wide and deep, although large variations in both depth and width occur. The shelf maintains a general NNW trend, widening north of Cape Columbine and reaching its widest off the Orange River (180 km). Between Cape Columbine and the Orange River, there is usually a double shelf break, with the distinct inner and outer slopes, separated by a gently sloping ledge. The immediate nearshore area consists mainly of a narrow (about 8 km wide) rugged rocky zone, sloping steeply seawards to a depth of around 80 m. The middle and outer shelf typically lacks relief, sloping gently seawards before reaching the shelf break at a depth of ~300 m.

The topography on the coastal plains of the project area is homogeneous. The coastline is dominated by exposed rocky headlands alternating with fine grained sandy beaches often backed by a rocky and/or sandy escarpment. Wavecut platforms and pebble beaches are absent along this stretch of the coastline.

3.1.2 Coastal Geology

Prevailing soils are yellow-red-brown silty sands of Pleistocene origin, often overlain by a calcrete layer varying in depth and compaction. Windblown sands overly the calcrete layer. The unconsolidated nature of the sediment leads to high potential for erosion by runoff and wind where it is disturbed by excavation or vehicles.

Exploration of marine alluvial diamonds shows that there are preferential localities in which marine sedimentary deposits have higher probabilities of containing diamonds. These include gullies, potholes, and bedrock depressions, all of which are associated with marine wave-cut terraces. Such bedrock features are key concentration factors, and control all major aspects of sediment deposition in the marine environment. Diamonds are generally found close to the bedrock and are deposited in high-energy environment sediments containing pebbles, cobbles, and boulders. These sediments commonly owe their existence to storm beach deposits along the base lines of low cliffs and wave-cut terraces. Also, it is upon these surfaces that diamondiferous gravels have been concentrated and redistributed northward by wave and current action during sea-level still stands. Due to numerous sea-level fluctuations, particularly in the Quaternary, multiple terrace development during sequential periods of transgression and regression has resulted in modification of existing terraces and the disruption of the depositional pattern of marine diamonds.

3.2. Biophysical Characteristics

3.2.1 Wind Patterns

Winds are one of the main physical drivers of the nearshore Benguela region, both on an oceanic scale, generating the heavy and consistent south-westerly swells that impact this coast, and locally, contributing to the northward-flowing longshore currents, and being the prime mover of sediments in the terrestrial environment. Physical processes are characterised by the average seasonal wind patterns, and substantial episodic changes in these wind patterns have strong effects on the entire Benguela region.

The prevailing winds in the Benguela region are controlled by the perennial South Atlantic subtropical anticyclone, the eastward moving mid-latitude cyclones south of southern Africa, and the seasonal atmospheric pressure field over the subcontinent. The south Atlantic anticyclone undergoes seasonal variations, being strongest in the austral summer, when it also attains its southernmost extension, lying south west and south of the subcontinent. In winter, the south Atlantic anticyclone weakens and migrates north-westwards.

These seasonal changes result in substantial differences between the typical summer and winter wind patterns in the region, as the southern hemisphere anti-cyclonic high-pressures system, and the associated series of cold fronts, moves northwards in winter, and southwards in summer. The strongest winds occur in summer, during which winds blow 99 % of the time Virtually all winds in summer come from the southeast to south-west (**Error! Reference source not found.**; supplied by CSIR), strongly dominated by southerlies which occur over 40% of the time, averaging 20-30 kts and reaching speeds in excess of 100 km/h (60 kts). South-easterlies are almost as common, blowing about one-third of the time, and also averaging 20 - 30 kts. The combination of these southerly/south-easterly winds drives the offshore movements of surface water, and the resultant strong upwelling of nutrient-rich bottom waters, which characterise this region.

Winter remains dominated by southerly to south-easterly winds, but the closer proximity of the winter cold-front systems results in a significant south-westerly to north-westerly component (**Error! Reference source not found.**). This ‘reversal’ from the summer condition results in cessation of upwelling, movement of warmer mid-Atlantic water shorewards and breakdown of the strong thermoclines which develop in summer. There are more calms in winter, occurring about 3 % of the time, and wind speeds generally do not reach the maximum speeds of summer. However, the westerlies blow in synchrony with the prevailing south-westerly swell direction, resulting in heavier swell conditions in winter.

During autumn and winter, catabatic, or easterly ‘berg’ winds can also occur. These powerful offshore winds can exceed 50 km/h, producing sandstorms that considerably reduce visibility at sea and on land. Although they occur intermittently for about a week at a time, they have a strong effect on the coastal temperatures, which often exceed 30°C during ‘berg’ wind periods (Shannon & O’Toole 1998). The winds also play a significant role in sediment input into the coastal marine environment with transport of the sediments up to 150 km offshore.

3.2.2 Large-Scale Circulation and Coastal Currents

The West Coast is strongly influenced by the Benguela Current, with current velocities in continental shelf areas ranging between 10–30 cm/s (Boyd & Oberholster 1994). On its western side, flow is more transient and characterised by large eddies shed from the retroflection of the

Agulhas Current. The Benguela current widens northwards to 750 km, with flows being predominantly wind-forced, barotropic and fluctuating between poleward and equatorward flow (Shillington *et al*. 1990; Nelson & Hutchings 1983). Fluctuation periods of these flows are 3 - 10 days, although the long-term mean current residual is in an approximate northwest (alongshore) direction. Near-bottom shelf flow is mainly poleward (Nelson 1989) with low velocities of typically 5 cm/s.

The major feature of the Benguela Current Coastal is upwelling and the consequent high nutrient supply to surface waters leads to high biological production and large fish stocks. The prevailing longshore, equatorward winds move nearshore surface water northwards and offshore. To balance the displaced water, cold, deeper water wells up inshore. Although the rate and intensity of upwelling fluctuates with seasonal variations in wind patterns, the most intense upwelling tends to occur where the shelf is narrowest and the wind strongest. There are three upwelling centres in the southern Benguela, namely the Namaqua (30°S), Cape Columbine (33°S) and Cape Point (34°S) upwelling cells (Taunton-Clark 1985) (Figure 3-1; bottom left). The project area falls between the Cape Columbine and Namaqua cell. Upwelling in these cells is seasonal, with maximum upwelling occurring between September and March. An example of one such strong upwelling event in December 1996, followed by relaxation of upwelling and intrusion of warm Agulhas waters from the south, is shown in the satellite images in Figure 3-1.

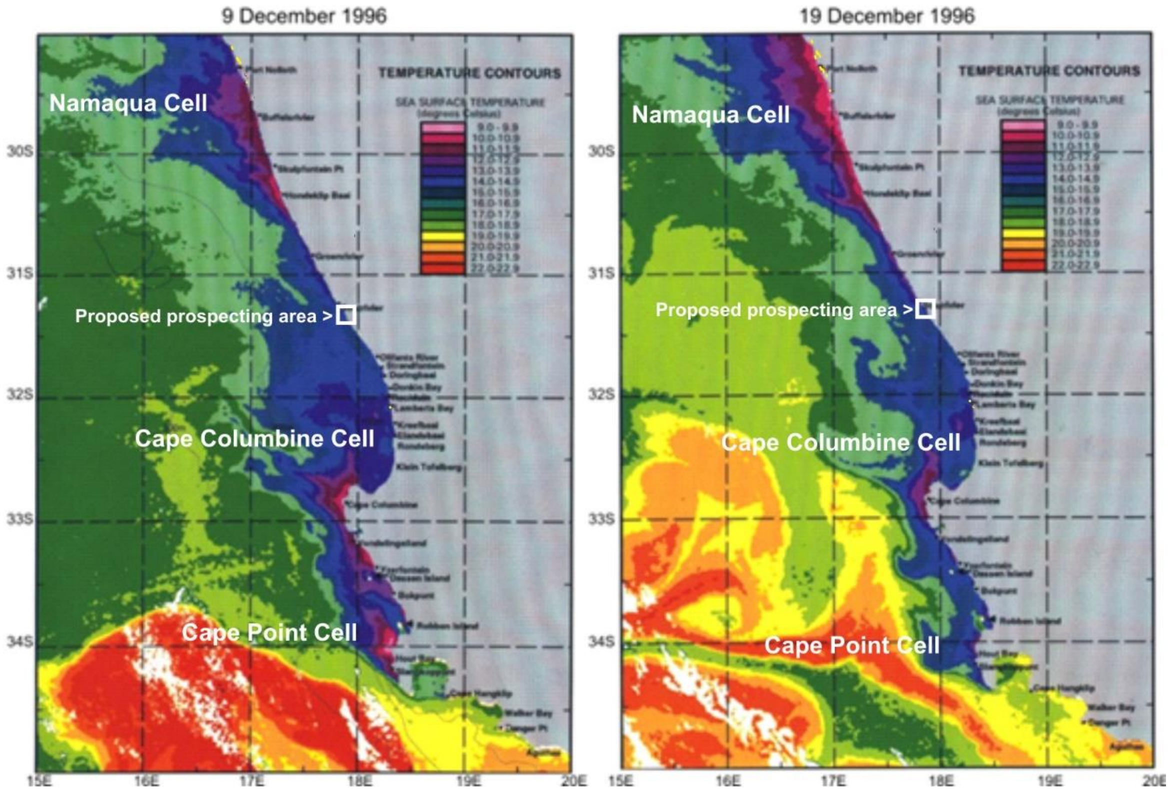

Figure 3-1: Satellite sea-surface temperature images showing upwelling intensity in the three upwelling cells along the South African west coast on two days in December 1996 (from Lane & Carter 1999). The location of the proposed project area (white square) is indicted.

3.2.3 Waves and Tides

Most of the west coast of southern Africa is classified as exposed, experiencing strong wave action, rating between 13-17 on the 20 point exposure scale (McLachlan 1980). Much of the coastline is therefore impacted by heavy south-westerly swells generated in the roaring forties, as well as significant sea waves generated locally by the prevailing southerly winds. The peak wave energy periods fall in the range 9.7 – 15.5 seconds.

The wave regime along the southern African west coast shows only moderate seasonal variation in direction, with virtually all swells throughout the year coming from the SW - S direction (Figure 3-2). Winter swells are strongly dominated by those from the SW - SSW, which occur almost 80% of the time, and typically exceed 2 m in height, averaging about 3 m, and often attaining over 5 m. With wind speeds capable of reaching 100 km/h during heavy winter south-westerly storms, winter swell heights can exceed 10 m. Typical seasonal swell-height rose-plots, compiled from Voluntary Observing Ship (VOS) data off Oranjemund, are shown in Figure 3-2 (supplied by CSIR).

Summer swells tend to be smaller on average (~2 m), with a more pronounced southerly component. These southerly swells tend to be wind-induced, with shorter wave periods (~8 seconds), and are generally steeper than swell waves (CSIR 1996). These wind-induced southerly waves are relatively local and, although less powerful, tend to work together with the strong southerly winds of summer to cause the northward-flowing nearshore surface currents, and result in substantial nearshore sediment mobilisation, and northwards transport, by the combined action of currents, wind and waves.

In common with the rest of the southern African coast, tides are semi-diurnal, with a total range of some 1.5 m at spring tide, but only 0.6 m during neap tide periods.

3.2.4 Water

South Atlantic Central Water (SACW) comprises the bulk of the seawater in the project area, either in its pure form in the deeper regions, or mixed with previously upwelled water of the same origin on the continental shelf (Nelson & Hutchings 1983). Salinities range between 34.5 ‰ and 35.5 ‰ (Shannon 1985).

Seawater temperatures on the continental shelf typically vary between 6°C and 16°C. Well-developed thermal fronts exist, demarcating the seaward boundary of the upwelled water. Upwelling filaments are characteristic of these offshore thermal fronts, occurring as surface streamers of cold water, typically 50 km wide and extending beyond the normal offshore extent of the upwelling cell. Such fronts typically have a lifespan of a few days to a few weeks, with the filamentous mixing area extending up to 625 km offshore.

The continental shelf waters of the Benguela system are characterised by low oxygen concentrations, especially on the bottom. SACW itself has depressed oxygen concentrations (oligoxic: ~80% saturation value), but lower oxygen concentrations (<40% saturation) and hypoxia (<20% saturation) frequently occur (Bailey *et al.* 1985; Chapman & Shannon 1985; Montiero & van der Plas 2006; Montiero *et al.* 2006).

Nutrient concentrations of upwelled water attain 20 µm nitrate-nitrogen, 1.5 µM phosphate and 15-20 µM silicate, indicating nutrient enrichment (Chapman & Shannon 1985). This is mediated by nutrient regeneration from biogenic material in the sediments (Bailey *et al.* 1985).

Modification of these peak concentrations depends upon phytoplankton uptake which varies according to phytoplankton biomass and production rate. The range of nutrient concentrations can thus be large but, in general, concentrations are high.

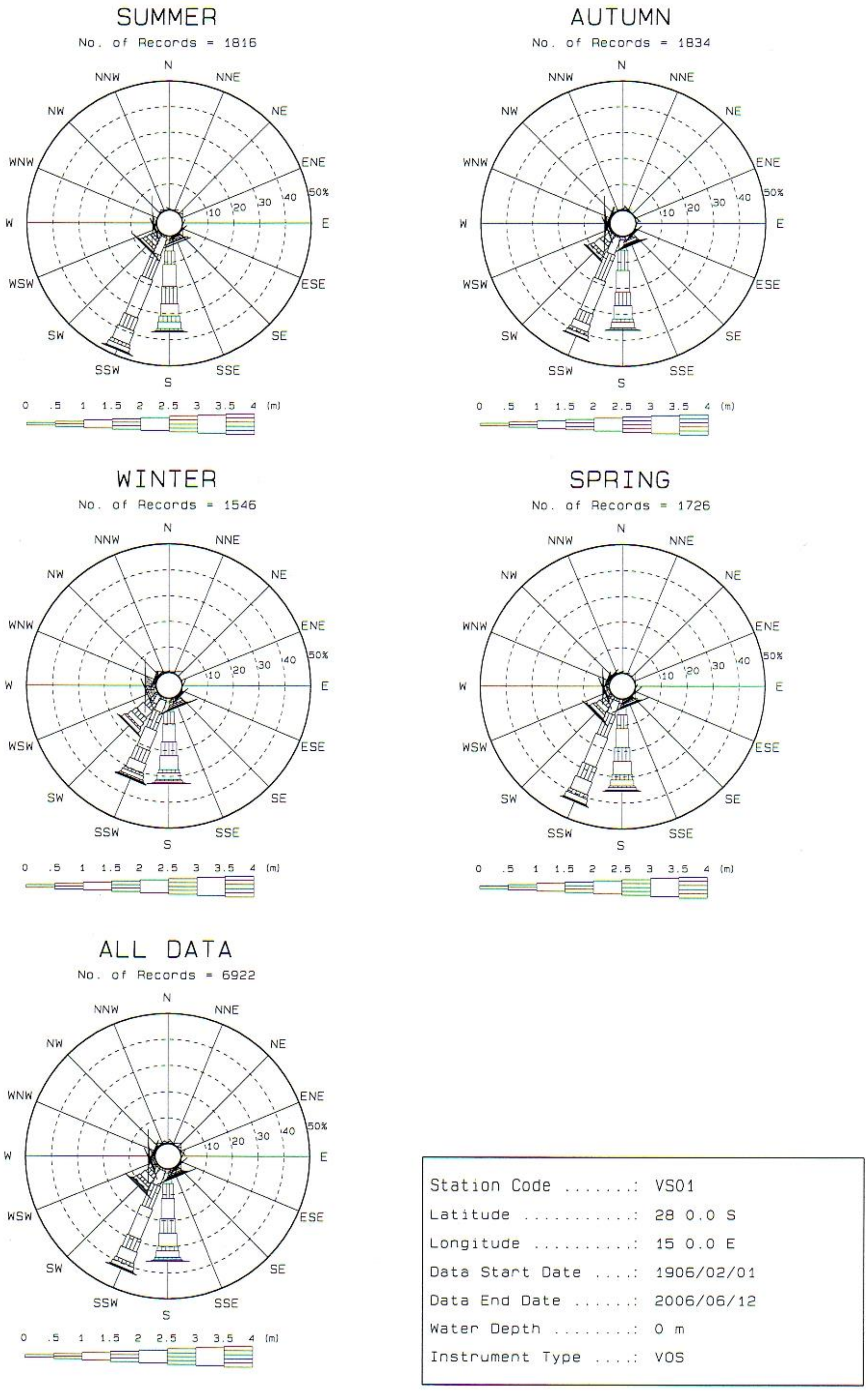

Figure 3-2: VOS Wave Height vs Wave Direction data for the offshore area (28°-29°S; 15°-16°E recorded during the period 1 February 1906 and 12 June 2006)) (Source: Voluntary Observing Ship (VOS) data from the Southern African Data Centre for Oceanography (SADCO)).

3.2.5 Upwelling & Plankton Production

The cold, upwelled water is rich in inorganic nutrients, the major contributors being various forms of nitrates, phosphates and silicates (Chapman & Shannon 1985). During upwelling the comparatively nutrient-poor surface waters are displaced by enriched deep water, supporting substantial seasonal primary phytoplankton production. This, in turn, serves as the basis for a rich food chain up through zooplankton, pelagic baitfish (anchovy, pilchard, round-herring and others), to predatory fish (hake and snoek), mammals (primarily seals and dolphins) and seabirds (jackass penguins, cormorants, pelicans, terns and others). High phytoplankton productivity in the upper layers again depletes the nutrients in these surface waters. This results in a wind-related cycle of plankton production, mortality, sinking of plankton detritus and eventual nutrient re-enrichment occurring below the thermocline as the phytoplankton decays.

3.2.6 Organic Inputs

The Benguela upwelling region is an area of particularly high natural productivity, with extremely high seasonal production of phytoplankton and zooplankton. These plankton blooms in turn serve as the basis for a rich food chain up through pelagic baitfish (anchovy, pilchard, round-herring and others), to predatory fish (snoek), mammals (primarily seals and dolphins) and seabirds (jackass penguins, cormorants, pelicans, terns and others). All of these species are subject to natural mortality, and a proportion of the annual production of all these trophic levels, particularly the plankton communities, die naturally and sink to the seabed.

Balanced multispecies ecosystem models have estimated that during the 1990s the Benguela region supported biomasses of 76.9 tons/km^2 of phytoplankton and 31.5 tons/km^2 of zooplankton alone (Shannon *et al.* 2003). Thirty six percent of the phytoplankton and 5% of the zooplankton are estimated to be lost to the seabed annually. This natural annual input of millions of tons of organic material onto the seabed off the southern African West Coast has a substantial effect on the ecosystems of the Benguela region. It provides most of the food requirements of the particulate and filter-feeding benthic communities that inhabit the sandy-muds of this area, and results in the high organic content of the muds in the region. As most of the organic detritus is not directly consumed, it enters the seabed decomposition cycle, resulting in subsequent depletion of oxygen in deeper waters.

An associated phenomenon ubiquitous to the Benguela system are red tides (dinoflagellate and/or ciliate blooms) (see Shannon & Pillar 1985; Pitcher 1998). Also referred to as Harmful Algal Blooms (HABs), these red tides can reach very large proportions, extending over several square kilometres of ocean (

Figure 3-3, left). Toxic dinoflagellate species can cause extensive mortalities of fish and shellfish through direct poisoning, while degradation of organic-rich material derived from both toxic and non-toxic blooms results in oxygen depletion of subsurface water (

Figure 3-3, right).

3.2.7 Low Oxygen Events

The continental shelf waters of the Benguela system are characterised by low oxygen concentrations with <40% saturation occurring frequently (e.g. Visser 1969; Bailey *et al*. 1985). The low oxygen concentrations are attributed to nutrient remineralisation in the bottom waters of the system (Chapman & Shannon 1985). The absolute rate of this is dependent upon the net organic material build-up in the sediments, with the carbon rich mud deposits playing an important role. As the mud on the shelf is distributed in discrete patches, there are corresponding preferential areas for the formation of oxygen-poor water. The two main areas of low-oxygen water formation in the southern Benguela region are in the Orange River Bight and St Helena Bay (Chapman & Shannon 1985; Bailey 1991; Shannon & O'Toole 1998; Bailey 1999; Fossing *et al*. 2000). The spatial distribution of oxygen-poor water in each of the areas is subject to short- and medium-term variability in the volume of hypoxic water that develops. De Decker (1970) showed that the occurrence of low oxygen water off Lambert's Bay is seasonal, with highest development in summer/autumn. Bailey & Chapman (1991), on the other hand, demonstrated that in the St Helena Bay area daily variability exists as a result of downward flux of oxygen through thermoclines and short-term variations in upwelling intensity. Subsequent upwelling processes can move this low-oxygen water up onto the inner shelf, and into nearshore waters, often with devastating effects on marine communities.

Figure 3-3: Red tides can reach very large proportions (Left, Photo: www.e-education.psu.edu) and can lead to mass stranding, or 'walk-out' of rock lobsters, such as occurred at Elands Bay in March 2022 (Right, Photo: Henk Kruger/African News Agency).

Periodic low oxygen events in the nearshore region can have catastrophic effects on the marine communities leading to large-scale stranding of rock lobsters, and mass mortalities of marine biota and fish (Newman & Pollock 1974; Matthews & Pitcher 1996; Pitcher 1998; Cockcroft *et al.* 2000) (see

Figure 3-3, right). The development of anoxic conditions as a result of the decomposition of huge amounts of organic matter generated by algal blooms is the main cause for these mortalities and walkouts. The blooms develop over a period of unusually calm wind conditions when sea surface temperatures where high. Algal blooms usually occur during summer-autumn (February to April) but can also develop in winter during the 'berg' wind periods, when similar warm windless conditions occur for extended periods.

3.2.8 Turbidity

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulate matter. Total Suspended Particulate Matter (TSPM) can be divided into Particulate Organic Matter (POM) and Particulate Inorganic Matter (PIM), the ratios between them varying considerably. The POM usually consists of detritus, bacteria, phytoplankton and zooplankton, and serves as a source of food for filter-feeders. Seasonal microphyte production associated with upwelling events will play an important role in determining the concentrations of POM in coastal waters. PIM, on the other hand, is primarily of geological origin consisting of fine sands, silts and clays. Off Namaqualand, the PIM loading in nearshore waters is strongly related to natural inputs from the Orange River or from 'berg' wind events. 'Berg' wind events can potentially contribute the same order of magnitude of sediment input as the annual estimated input of sediment by the Orange River (Shannon & Anderson 1982; Zoutendyk 1992, 1995; Shannon & O'Toole 1998; Lane & Carter 1999). For example, a 'berg' wind event in May 1979 described by Shannon and Anderson (1982) was estimated to have transported in the order of 50 million tons of sand out to sea, affecting an area of 20,000 km^2.

Concentrations of suspended particulate matter in shallow coastal waters can vary both spatially and temporally, typically ranging from a few mg/ℓ to several tens of mg/ℓ (Bricelj & Malouf 1984; Berg & Newell 1986; Fegley *et al.* 1992). Field measurements of TSPM and PIM concentrations in the Benguela current system have indicated that outside of major flood events, background concentrations of coastal and continental shelf suspended sediments are generally <12 mg/ℓ, showing significant long-shore variation (Zoutendyk 1995). Considerably higher concentrations of PIM have, however, been reported from southern African West Coast waters under stronger wave conditions associated with high tides and storms, or under flood conditions. During storm events, concentrations near the seabed may even reach up to 10,000 mg/ℓ (Miller & Sternberg 1988). In the vicinity of the Orange River mouth, where river outflow strongly influences the turbidity of coastal waters, measured concentrations ranged from 14.3 mg/ℓ at Alexander Bay just south of the mouth (Zoutendyk 1995) to peak values of 7,400 mg/ℓ immediately upstream of the river mouth during the 1988 Orange River flood (Bremner *et al.* 1990).

The major source of turbidity in the swell-influenced nearshore areas off the West Coast is the redistribution of fine inner shelf sediments by long-period Southern Ocean swells. The current velocities typical of the Benguela (10-30 cm/s) are capable of resuspending and transporting considerable quantities of sediment equatorwards. Under relatively calm wind conditions, however, much of the suspended fraction (silt and clay) that remains in suspension for longer periods becomes entrained in the slow poleward undercurrent (Shillington *et al.* 1990; Rogers & Bremner 1991).

Superimposed on the suspended fine fraction, is the northward littoral drift of coarser bedload sediments, parallel to the coastline. This northward, nearshore transport is generated by the predominantly south-westerly swell and wind-induced waves. Longshore sediment transport varies considerably in the shore-perpendicular dimension, being substantially higher in the surf zone than at depth, due to high turbulence and convective flows associated with breaking waves, which suspend and mobilise sediment (Smith & Mocke 2002).

On the inner and middle continental shelf, the ambient currents are insufficient to transport coarse sediments typical of those depths, and re-suspension and shoreward movement of these by wave-induced currents occur primarily under storm conditions (see also Drake *et al.* 1985; Ward 1985). Data from a Waverider buoy at Port Nolloth have indicated that 2-m waves are capable of re-suspending medium sands (200 µm diameter) at ~10 m depth, whilst 6-m waves achieve this at ~42 m depth. Low-amplitude, long-period waves will, however, penetrate even deeper. Most of the sediment shallower than 90 m can therefore be subject to re-suspension and transport by heavy swells (Lane & Carter 1999).

Mean sediment deposition is naturally higher near the seafloor due to constant re-suspension of coarse and fine PIM by tides and wind-induced waves. Aggregation or flocculation of small particles into larger aggregates occurs as a result of cohesive properties of some fine sediments in saline waters. The combination of re-suspension of seabed sediments by heavy swells, and the faster settling rates of larger inorganic particles, typically causes higher sediment concentrations near the seabed. Significant re-suspension of sediments can also occur up into the water column under stronger wave conditions associated with high tides and storms. Re-suspension can result in dramatic increases in PIM concentrations within a few hours (Sheng *et al.* 1994). Wind speed and direction have also been found to influence the amount of material re-suspended (Ward 1985).

Although natural turbidity of seawater is a global phenomenon, there has been a worldwide increase of water turbidity and sediment load in coastal areas as a consequence of anthropogenic activities. These include dredging associated with the construction of harbours and coastal installations, beach replenishment, accelerated runoff of eroded soils as a result of deforestation or poor agricultural practices, and discharges from terrestrial, coastal and marine mining operations (Airoldi 2003). Such increase of sediment loads has been recognised as a major threat to marine biodiversity at a global scale (UNEP 1995).

3.3. The Biological Environment

Biogeographically, the study area falls within the cold temperate Namaqua Bioregion (Emanuel *et al.* 1992; Lombard *et al.* 2004), which in the 2018 National Biodiversity Assessment (Sink *et al.* 2019) is referred to as as a subregion of the Southern Benguela Shelf ecoregion (Figure 3-4). The coastal, wind-induced upwelling characterising the western Cape coastline, is the principle physical process which shapes the marine ecology of the southern Benguela region. The Benguela system is characterised by the presence of cold surface water, high biological productivity, and highly variable physical, chemical and biological conditions. The West Coast is, however, characterized by low marine species richness and low endemicity (Awad *et al.* 2002).

Communities within marine habitats are largely ubiquitous throughout the southern African West Coast region, being particular only to substrate type (i.e. hard vs. soft bottom), exposure to wave action, or water depth. These biological communities consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales). The mining target area extends from the high water mark on the coast to the low water mark. The benthic and coastal habitats of South Africa have been mapped by Sink *et al.* (2019). Those specific to the study area can be broadly grouped into:

- Sandy intertidal and unconsolidated subtidal substrates,
- Intertidal rocky shores and subtidal reefs,
- Mixed shores, and
- The water body.

The biological communities 'typical' of these benthic habitats and the overlying water body are described briefly below, focussing both on dominant, commercially important and conspicuous species, as well as potentially threatened or sensitive species, which may be affected by the mining activities. No rare or endangered species have been recorded (Awad *et al.* 2002).

Figure 3-4: Proposed project area (red square) in relation to the ecoregions on the South African West Coast (adapted from Sink *et al.* 2019).

3.3.1 Sandy and Unconsolidated Habitats and Biota

The benthic biota of unconsolidated marine sediments constitute invertebrates that live on (epifauna) or burrow within (infauna) the sediments, and are generally divided into macrofauna (animals >1 mm) and meiofauna (<1 mm).

The coastline from the Orange River mouth to Kleinzee is dominated by rocky shores, interspersed by isolated short stretches of sandy shores. Sandy beaches are one of the most dynamic coastal environments. With the exception of a few beaches in large bay systems (such as St Helena Bay, Saldanha Bay, Table Bay), the beaches along the South African west coast are typically highly exposed. Exposed sandy shores consist of coupled surf zone, beach and dune systems, which together form the active littoral sand transport zone (Short & Hesp 1985). The composition of their faunal communities is largely dependent on the interaction of wave energy, beach slope and sand particle size, which is termed beach morphodynamics. Three morphodynamic beach types are described: dissipative, reflective and intermediate beaches (McLachlan *et al.* 1993). Generally, dissipative beaches are relatively wide and flat with fine sands and low 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 in contrast, have high wave energy, and are coarse grained (>500 µm sand) with 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 with a high input of e.g. kelp wrack have a rich and diverse drift-line fauna, which is sparse or absent on beaches lacking a drift-line (Branch & Griffiths 1988). As a result of the combination of typical beach characteristics, and the special adaptations of beach fauna to these, beaches act as filters and energy recyclers in the nearshore environment (Brown & McLachlan 2002).

Numerous methods of classifying beach zonation have been proposed, based either on physical or biological criteria. The general scheme proposed by Branch & Griffiths (1988) is used below (Figure 3-5), supplemented by data from various publications on West Coast sandy beach biota (e.g. Bally 1987; Brown *et al.* 1989; Soares *et al.* 1996, 1997; Nel 2001; Nel *et al.* 2003; Soares 2003; Branch *et al.* 2010; Harris 2012). The macrofaunal communities of sandy beaches are generally ubiquitous throughout the southern African West Coast region, being particular only to substratum type, wave exposure and/or depth zone. Due to the exposed nature of the coastline in the study area, most beaches are of the intermediate to reflective type. The upper beach dry zone (supralittoral) is situated above the high water spring (HWS) tide level, and receives water input only from large waves at spring high tides or through sea spray. This zone is characterised by a mixture of air breathing terrestrial and semi-terrestrial fauna, often associated with and feeding on kelp deposited near or on the driftline. Terrestrial species include a diverse array of beetles and arachnids and some oligochaetes, while semi-terrestrial fauna include the oniscid isopod *Tylos granulatus*, and amphipods of the genus *Talorchestia*. The mid-beach retention zone and low-beach saturation zone (intertidal zone or mid-littoral zone) have a vertical range of about 2 m. This mid-shore region is characterised by the cirolanid isopods *Pontogeloides latipes*, *Eurydice* (*longicornis*=) *kensleyi*, and *Excirolana natalensis*, the polychaetes *Scolelepis squamata*, *Orbinia angrapequensis*, *Nepthys hombergii* and *Lumbrineris tetraura*, and amphipods of the families Haustoridae and Phoxocephalidae (Figure 3-6). In some areas, juvenile and adult sand mussels *Donax serra* may also be present in considerable numbers.

The surf zone (inner turbulent and transition zones) extends from the Low Water Spring mark to about -2 m depth. The mysid *Gastrosaccus psammodytes* (Mysidacea, Crustacea), the ribbon worm *Cerebratulus fuscus* (Nemertea), the cumacean *Cumopsis robusta* (Cumacea) and a variety of polychaetes including *Scolelepis squamata* and *Lumbrineris tetraura*, are typical of this zone, although they generally extend partially into the midlittoral above. In areas where a suitable swash climate exists, the gastropod *Bullia digitalis* (Gastropoda, Mollusca) may also be present in considerable numbers, surfing up and down the beach in search of carrion.

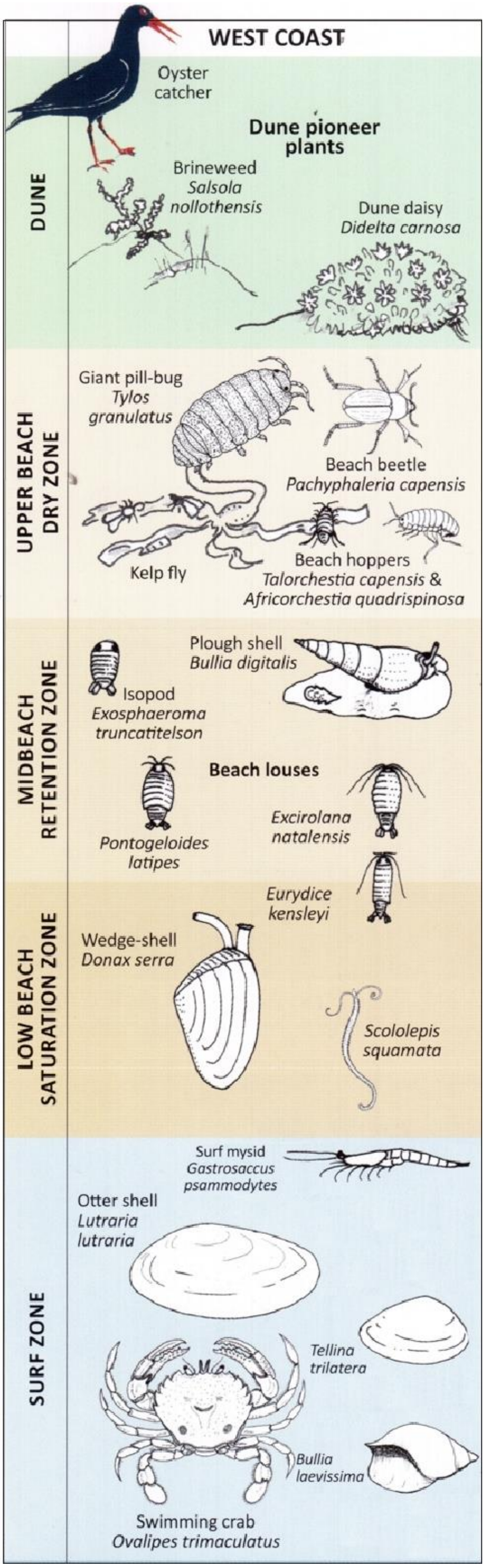

Figure 3-5: Schematic representation of the West Coast intertidal beach zonation (adapted from Branch & Branch 2018). Species commonly occurring on the Namaqualand beaches are listed.

The transition zone spans approximately 2 - 5 m depth beyond the inner turbulent zone. Extreme turbulence is experienced in this zone, and as a consequence this zone typically harbours the lowest diversity on sandy beaches. Typical fauna include amphipods such as *Cunicus profundus* and burrowing polychaetes such as *Cirriformia tentaculata* and *Lumbrineris tetraura.*

The outer turbulent zone extends below 5 m depth, where turbulence is significantly decreased and species diversity is again much higher. In addition to the polychaetes found in the transition zone, other polychaetes in this zone include *Pectinaria capensis*, and *Sabellides ludertizii*. The sea pen V*irgularia schultzi* (Pennatulacea, Cnidaria) is also common as is a host of amphipod species and the three spot swimming crab *Ovalipes punctatus* (Brachyura, Crustacea).

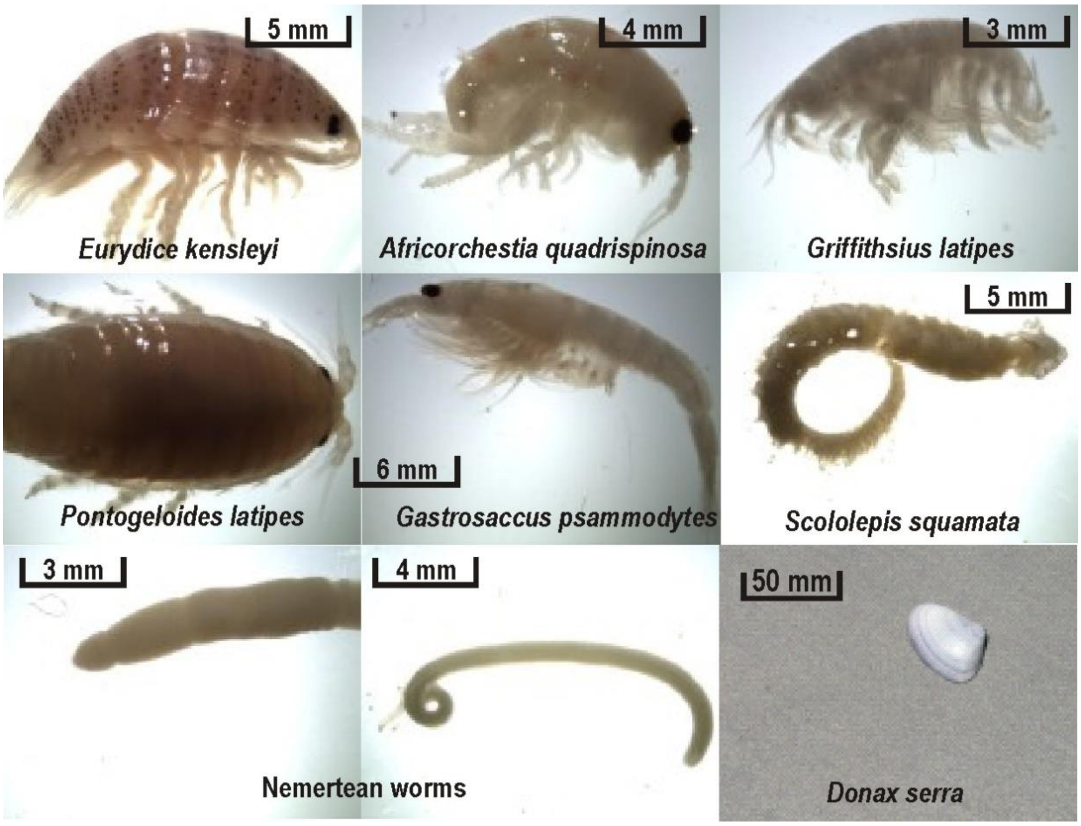

Figure 3-6: Common beach macrofaunal species occurring on exposed West Coast beaches.

The marine component of the 2018 National Biodiversity Assessment (NBA) (Sink *et al*. 2019), identified a diversity of coastal and offshore ecosystem types within South Africa's exclusive economic zone (EEZ). Those ecosystem types within the general project area are illustrated in Figure 3-7. The prospecting area comprises Namaqua exposed rocky shores, Namaqua mixed shores and Southern Benguela disspiative-intermediate sandy shores. Due to the lack of Marine Protected Areas (MPAs) offering protection to the Namaqua biozones (sub-photic, deep-photic, shallow-photic, intertidal and supratidal zones) substantial portions of the coastal and shelf-edge ecosystem types in the area have been assigned a threat status of 'Critically endangered', 'Endangered' or 'Vulnerable'. The proposed prospecting area overlaps with portions of sections of the coastline in the proposed prospecting area are rated as either 'vulnerable' or of 'least concern' (Figure 3-7) (see **Error! Reference source not found.**).

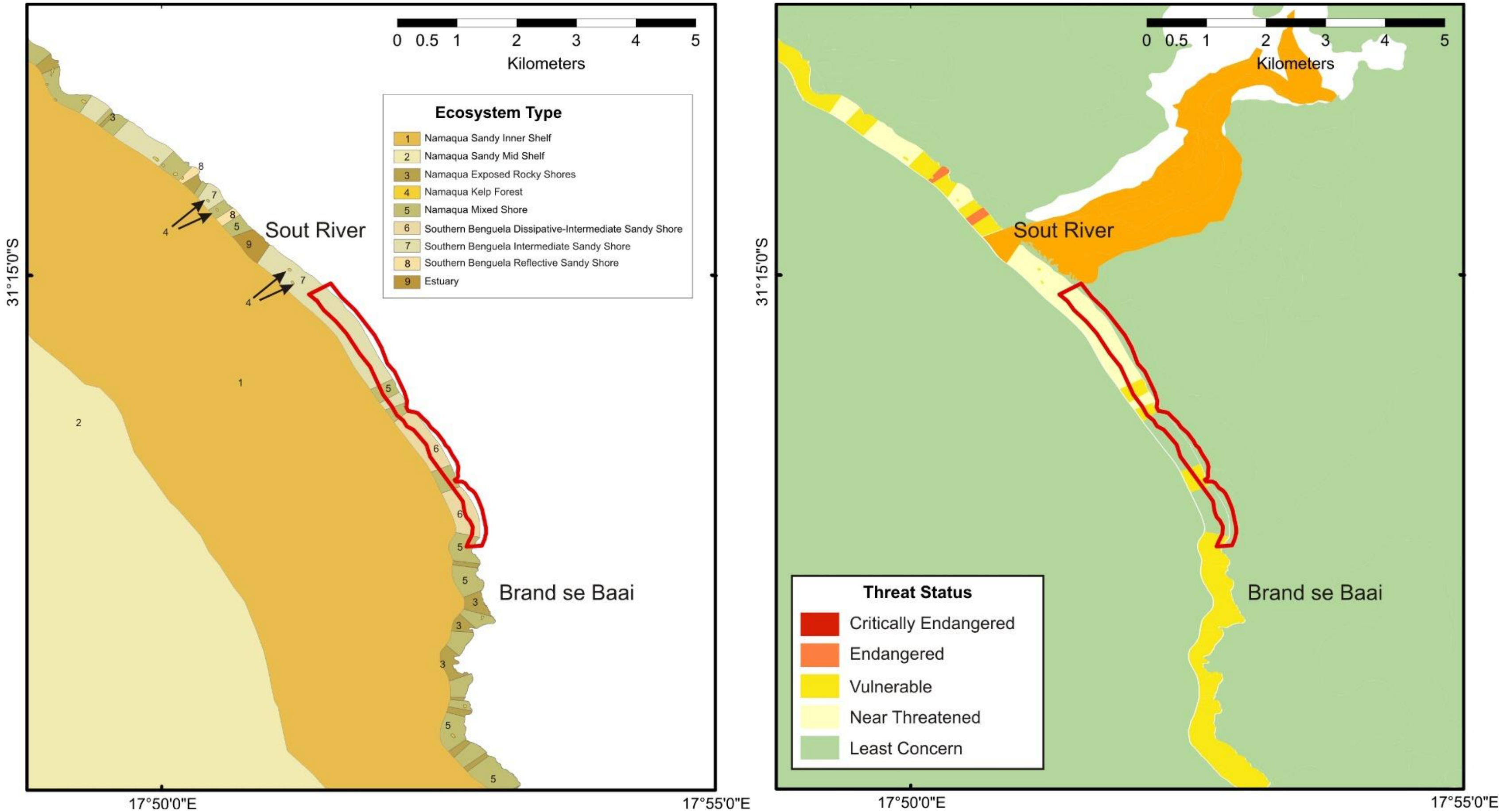

Figure 3-7: Proposed prospecting area (red polygon) in relation to the marine ecosystem types (left) and the ecosystem threat status (right) for coastal and offshore ecosystem types in the broader project area (adapted from Sink *et al*. 2019).

3.3.2 Rocky Substrate Habitats and Biota

The following general description of the intertidal and subtidal habitats for the West Coast is based on Field *et al.* (1980), Branch & Griffiths (1988), Field & Griffiths (1991) and Branch & Branch (2018).

3.3.2.1 Intertidal Rocky Shores

Several studies on the west coast of southern Africa have documented the important effects of wave action on the intertidal rocky-shore community. Specifically, wave action enhances filter-feeders by increasing the concentration and turnover of particulate food, leading to an elevation of overall biomass despite a low species diversity (McQuaid & Branch 1985, Bustamante & Branch 1995a, 1996a, Bustamante *et al.* 1997). Conversely, sheltered shores are diverse with a relatively low biomass, and only in relatively sheltered embayments does drift kelp accumulate and provide a vital support for very high densities of kelp trapping limpets, such as *Cymbula granatina* that occur exclusively there (Bustamante *et al.* 1995). In the subtidal, these differences diminish as wave exposure is moderated with depth.

West Coast rocky intertidal shores can be divided into five zones on the basis of their characteristic biological communities: The Littorina, Upper Balanoid, Lower Balanoid, Cochlear/Argenvillei and the Infratidal Zones. These biological zones correspond roughly to zones based on tidal heights (Figure 3-8 and Figure 3-9). Tolerance to the physical stresses associated with life on the intertidal, as well as biological interactions such as herbivory, competition and predation interact to produce these five zones.

The uppermost part of the shore is the supralittoral fringe, which is the part of the shore that is most exposed to air, perhaps having more in common with the terrestrial environment. The supralittoral is characterised by low species diversity, with the tiny periwinkle *Afrolittorina knysnaensis*, and the red alga *Porphyra capensis* constituting the most common macroscopic life.

The upper mid-littoral is characterised by the limpet *Scutellastra granularis*, which is present on all shores. The gastropods *Oxystele variegata*, *Nucella dubia*, and *Helcion pectunculus* are variably present, as are low densities of the barnacles *Tetraclita serrata*, *Octomeris angulosa* and *Chthalamus dentatus*. Flora is best represented by the green algae *Ulva* spp.

Toward the lower Mid-littoral or Lower Balanoid zone, biological communities are determined by exposure to wave action. On sheltered and moderately exposed shores, a diversity of algae abounds with a variable representation of: green algae – *Ulva* spp, *Codium* spp.; brown algae – *Splachnidium rugosum*; and red algae – *Aeodes orbitosa*, *Mazzaella (=Iridaea) capensis*, *Gigartina polycarpa* (=*radula*), *Sarcothalia* (=*Gigartina*) *stiriata*, and with increasing wave exposure *Plocamium rigidum* and *P. cornutum*, and *Champia lumbricalis*. The gastropods *Cymbula granatina* and *Burnupena* spp. are also common, as is the reef building polychaete *Gunnarea capensis*, and the small cushion starfish *Patiriella exigua*. On more exposed shores, almost all of the primary space can be occupied by the dominant alien invasive mussel *Mytilus galloprovincialis*. First recorded in 1979 (although it is likely to have arrived in the late 1960s), it is now the most abundant and widespread invasive marine species spreading along the entire West Coast and parts of the South Coast (Robinson *et al.* 2005). *M. galloprovincialis* has partially displaced the local mussels *Choromytilus meridionalis* and *Aulacomya ater* (Hockey & Van Erkom Schurink 1992), and competes with several indigenous limpet species (Griffiths *et al.* 1992; Steffani & Branch 2003a, b).

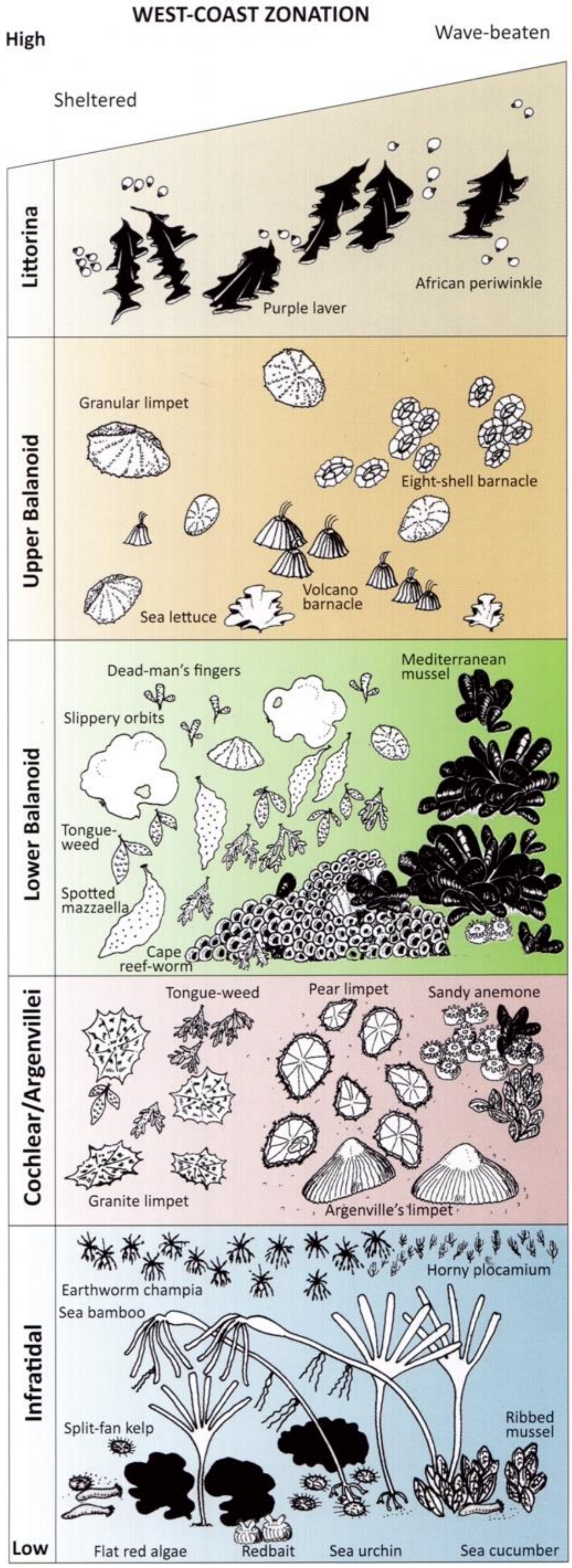

Figure 3-8: Schematic representation of the West Coast intertidal zonation (adapted from Branch & Branch 2018).

Another alien invasive recorded in the past decade is the acorn barnacle *Balanus glandula*, which is native to the west coast of North America where it is the most common intertidal barnacle (Simon-Blecher *et al*. 2008). There is, however, evidence that it has been in South Africa since at least 1992 (Laird & Griffith 2008). At the time of its discovery, the barnacle was recorded from 400 km of coastline from Misty Cliffs near Cape Point to Elands Bay (Laird & Griffith 2008). It has been reported on rocky shores as far north as Lüderitz in Namibia (Pulfrich 2016), and was identified in the Alexkor mining licence area 554MRC during a site visit in July 2017. When present, the barnacle is typically abundant at the mid zones of semi-exposed shores.

Figure 3-9: Typical rocky intertidal zonation on the southern African west coast.

Along the sublittoral fringe, the large kelp-trapping limpet *Scutellastra argenvillei* dominates forming dense, almost monospecific stands achieving densities of up to 200/m^2 (Bustamante *et al*. 1995). Similarly, *C. granatina* is the dominant grazer on more sheltered shores, also reaching extremely high densities (Bustamante *et al*. 1995). On more exposed shores *M. galloprovincialis* dominates. There is evidence that the arrival of the alien *M. galloprovincialis* has led to strong competitive interaction with *S. argenvillei* (Steffani & Branch 2003a, 2003b, 2005). The abundance of the mussel changes with wave exposure, and at wave-exposed locations, the mussel can cover almost the entire primary substratum, whereas in semi-exposed situations it is never abundant. As the cover of *M. galloprovincialis* increases, the abundance and size of *S. argenvillei* on rock declines and it becomes confined to patches within a matrix of mussel bed. As a result exposed sites, once dominated by dense populations of the limpet, are now largely covered by the alien mussel. Semi-exposed shores do, however, offer a refuge preventing global extinction of the limpet. In addition to the mussel and limpets, there is variable representation of the flora and fauna described for the lower mid-littoral above, as well as the anemone *Aulactinia reynaudi*, numerous whelk species and the sea urchin *Parechinus angulosus*. Some of these species extend into the subtidal below.

More recently, the invasion of west coast rocky shores by another mytilid, the hermaphroditic Chilean *Semimytilus algosus*, was noted (de Greef *et al.* 2013). It is hypothesized that this species was introduced either by shipping traffic from Namibia (Walvis Bay and Swakopmund) or through the importing of oyster spat from Chile for mariculture purposes. First reported in 2009 from Elands Bay, its distribution spread rapidly to cover 500 km of coastline within a few years (de Greef *et al.* 2013). Its current range extends from Lüderitz (pers. obs) to Bloubergstrand in the south. Where present, it occupies the lower intertidal zone completely dominating primary rock space, while *M. galloprovincialis* dominates higher up the shore. Many shores on the West Coast have thus now been effectively partitioned by the three introduced species, with *B. glandula* colonizing the upper intertidal, *M. galloprovincialis* dominating the mid-shore, and now *S. algosus* smothering the low-shore (de Greef *et al.* 2013). The shells of *S. algosus* are, however, typically thin and weak, and have a low attachment strength to the substrate, thereby making the species vulnerable to predators, interference competition, desiccation and the effects of wave action (Zeeman 2016). The competitive ability of *S. algosus* is strongly related to shore height. Due to intolerance to desiccation, it cannot survive on the high shore, but on the low shore its high recruitment rate offsets the low growth rate, and high mortality rate as a result of wave action and predation.

Most of the rocky shores in the southern portion of 554MRC and in the Perdevlei project area will be similar to 'typical' shores as described above, although those in the centre of the target beach are expected to show evidence of sand scouring and periodic sand inundation. Such shores will harbour more sand-tolerant and opportunistic foliose algal genera (e.g. *Ulva* spp., *Grateloupiabelangeri, Nothogenia erinacea)* many of which have mechanisms of growth, reproduction and perennation that contribute to their persistence on sand-influenced shores (Daly & Matheison 1977; Airoldi *et al.* 1995; Anderson *et al.* 2008). Of the benthic fauna, the sand-tolerant anemone *Bunodactis reynaudi*, the Cape reef worm *Gunnarea gaimardi*, and the siphonarid *Siphonaria capensis* were prevalent, with the anemone in particular occupying much of the intertidal space.

3.3.2.2 Mixed Shores

In common with most semi-exposed to exposed coastlines on the southern African west coast, the rocky shores that occur in the region are strongly influenced by sediments, and include considerable amounts of sand intermixed with the benthic biota. This intertidal mixture of rock and sand is referred to as a mixed shore, and constitutes 31% of the South African coast between the Orange River and Kosi Bay (Bally *et al.* 1984). Substantial fluctuations in the degree of sand coverage are common (often in response to seasonal cycles in wave energy). Although the fauna and flora of mixed shores can be impoverished compared to more homogenous shores, these shores can provide important habitat for opportunistic species capable of sequestering within sand, but susceptible to elimination by competition in more uniform rocky intertidal environments.

The species present may also be different from those on pure rocky shores , with the biota being characterised by species that can tolerate substantial changes in the relative proportions of sand and exposed rock. In particular, rocky shore macrobenthos is characterised by sand-tolerant species whose lower limits on the shore are determined by their abilities to withstand periodic physical smothering by sand (Daly & Mathieson 1977; Dethier 1984; van Tamelen 1996). Rock-associated communities in mixed shores can therefore undergo dramatic changes in composition as a result of longer-term (decadal) cycles in sand deposition or removal.

On the southern African West Coast, semi-exposed to exposed shores influenced by sand are inhabited by the sand tolerant *Choromytilus meridionalis* (Brown *et al*. 1991; Marshall & McQuaid 1993). The scavenging gastropod *Burnupena* spp., common on rocky shores, is also found on mixed shores due to its adaptive ability to move over sand, as well as burrowing into it. Various species of sea cucumbers (*Roweia frauenfeldii* and *Thyone aurea*) common in rock crevices and between mussels can also tolerate sand burial (Branch *et al*. 2010; Brown 1996). In contrast, few of the limpets are sand tolerant and, of the west coast intertidal limpets, only *Siphonaria capensis* extends its distribution into regions where sand deposition is a regular occurrence (Marshall & McQuaid 1989).

The composition of intertidal and subtidal macrophytes on mixed shores is dominated by psammophytic (sand-tolerant) and opportunistic foliose genera, such as *Cladophora*, *Ulva*, *Chaetomorpha*, *Jania* and *Chondria* spp. Many of the psammophytic algal species have mechanisms of growth, reproduction and perennation that contribute to their persistence on sand-influenced shores. Specific adaptations include peak growth and reproduction just prior to seasonal burial, abbreviated life cycles, the ability to regenerate fronds from remnant basal parts, or rhizomatous growth (Daly & Matheison 1977; Airoldi *et al*. 1995).

3.3.2.3 Rocky Subtidal Habitat and Kelp Beds

Biological communities of the rocky sublittoral can be broadly grouped into an inshore zone from the sublittoral fringe to a depth of about 10 m dominated by flora, and an offshore zone below 10 m depth dominated by fauna. This shift in communities is not knife-edge, and rather represents a continuum of species distributions, merely with changing abundances.

From the sublittoral fringe to a depth of between 5 and 10 m, the benthos is largely dominated by algae, in particular two species of kelp. The canopy forming kelp *Ecklonia maxima* extends seawards to a depth of about 10 m. The smaller *Laminaria pallida* forms a sub-canopy to a height of about 2 m underneath *Ecklonia*, but continues its seaward extent to about 30 m depth, although in the northern regions of the west coast, and in the coastal mining licence areas, increasing turbidity limits growth to shallower waters (10-20 m) (Velimirov *et al*. 1977; Jarman & Carter 1981; Branch 2008). *Ecklonia maxima* is the dominant species in the south forming extensive beds from west of Cape Agulhas to north of Cape Columbine, but decreasing in abundance northwards. *Laminaria* becomes the dominant kelp north of Cape Columbine and thus in the project area, extending from Danger Point east of Cape Agulhas to Rocky Point in northern Namibia (Stegenga *et al*. 1997; Rand 2006).

Kelp beds absorb and dissipate much of the typically high wave energy reaching the shore, thereby providing important partially-sheltered habitats for a high diversity of marine flora and fauna, resulting in diverse and typical kelp-forest communities being established (Figure 3-10). Through a combination of shelter and provision of food, kelp beds support recruitment and complex trophic food webs of numerous species, including commercially important rock lobster stocks (Branch 2008).

Figure 3-10: The canopy-forming kelp *Ecklonia maxima* provides an important habitat for a diversity of marine biota (Photos: West Coast Abalone).

Growing beneath the kelp canopy, and epiphytically on the kelps themselves, are a diversity of understorey algae, which provide both food and shelter for predators, grazers and filter-feeders associated with the kelp bed ecosystem. Representative under-storey algae include *Botryocarpa prolifera*, *Neuroglossum binderianum*, *Botryoglossum platycarpum*, *Hymenena venosa* and *Rhodymenia* (=*Epymenia*) *obtusa*, various coralline algae, as well as subtidal extensions of some algae occurring primarily in the intertidal zones (Bolton 1986). Epiphytic species include *Polysiphonia virgata*, *Gelidium vittatum (=Suhria vittata)* and *Carpoblepharis flaccida*. In particular, encrusting coralline algae are important in the under-storey flora as they are known as settlement attractors for a diversity of invertebrate species. The presence of coralline crusts is thought to be a key factor in supporting a rich shallow-water community by providing substrate, refuge, and food to a wide variety of infaunal and epifaunal invertebrates (Chenelot *et al*. 2008).

The sublittoral invertebrate fauna is dominated by suspension and filter-feeders, such as the mussels *Aulacomya ater* and *Choromytilus meriodonalis*, and the Cape reef worm *Gunnarea gaimardi*, and a variety of sponges and sea cucumbers. Grazers are less common, with most herbivory being restricted to grazing of juvenile algae or debris-feeding on detached macrophytes. The dominant herbivore is the sea urchin *Parechinus angulosus*, with lesser grazing pressure from limpets, the isopod *Paridotea reticulata* and the amphipod *Ampithoe humeralis*. The abalone *Haliotis midae*, an important commercial species present in kelp beds south of Cape Columbine is naturally absent north of Cape Columbine, although attempts at ranching this species along the Namaqualand coast are currently underway. Key predators in the sub-littoral include the commercially important West Coast rock lobster *Jasus lalandii* and the octopus *Octopus vulgaris*. The rock lobster acts as a keystone species as it influences community structure *via* predation on a wide range of benthic organisms (Mayfield *et al*. 2000). Relatively abundant rock lobsters can lead to a reduction in density, or even elimination, of black mussel *Choromytilus meriodonalis*, the preferred prey of the species, and alter the size structure of populations of ribbed mussels *Aulacomya ater*, reducing the proportion of selected size-classes (Griffiths & Seiderer 1980). Their role as predator can thus reshape benthic communities, resulting in large reductions in taxa such as black mussels, urchins, whelks and barnacles, and in the dominance of algae (Barkai & Branch 1988; Mayfield 1998).

Of lesser importance as predators, although numerically significant, are various starfish, feather and brittle stars, and gastropods, including the whelks *Nucella* spp. and *Burnupena* spp. Fish species commonly found in kelp beds off the West Coast include hottentot *Pachymetopon blochii*, two tone finger fin *Chirodactylus brachydactylus*, red fingers *Cheilodactylus fasciatus*, galjoen *Dichistius capensis*, rock suckers *Chorisochismus dentex* and the catshark *Haploblepharus pictus* (Branch *et al*. 2010).

There is substantial spatial and temporal variability in the density and biomass of kelp beds, as storms can remove large numbers of plants and recruitment appears to be stochastic and unpredictable (Levitt *et al*. 2002; Rothman *et al*. 2006). Some kelp beds are dense, whilst others are less so due to differences in seabed topography, and the presence or absence of sand and grazers. The 2018 NBA identified isolated kelp beds along the northern shoreline of the proposed prospecting area (see Figure 3-7), suggesting the presence of shallow subtidal reefs.

3.3.3 The Water Body

In contrast benthic biota which are associated with the seabed, pelagic species live and feed in the open water column. The pelagic communities are typically divided into plankton and fish, and their main predators, marine mammals (seals, dolphins and whales), seabirds and turtles.

3.3.3.1 Plankton

Plankton is particularly abundant in the shelf waters off the West Coast, being associated with the upwelling characteristic of the area. Plankton range from single-celled bacteria to jellyfish of 2-m diameter, and include bacterio-plankton, phytoplankton, zooplankton, and ichthyoplankton (Figure 3-11).

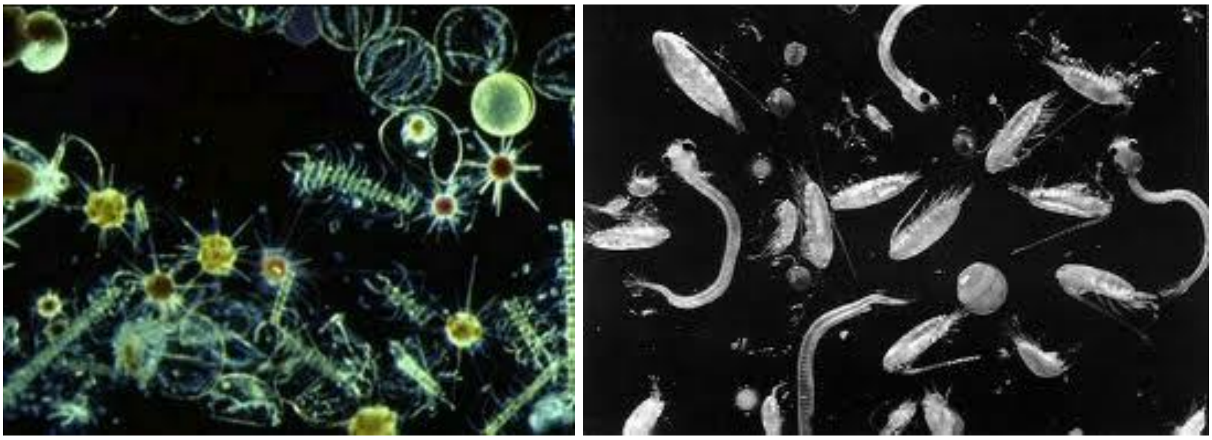

Figure 3-11: Phytoplankton (left, photo: hymagazine.com) and zooplankton (right, photo: mysciencebox.org) is associated with upwelling cells.

Phytoplankton are the principle primary producers with mean productivity ranging from 2.5 - 3.5 g C/m^2/day for the midshelf region and decreasing to 1 g C/m^2/day inshore of 130 m (Shannon & Field 1985; Mitchell-Innes & Walker 1991; Walker & Peterson 1991). The phytoplankton is dominated by large-celled organisms, which are adapted to the turbulent sea conditions. The most common diatom genera are *Chaetoceros*, *Nitschia*, *Thalassiosira*, *Skeletonema*, *Rhizosolenia*, *Coscinodiscus* and *Asterionella* (Shannon & Pillar 1985). Diatom blooms occur after upwelling events, whereas dinoflagellates (e.g. *Prorocentrum*, *Ceratium* and *Peridinium*) are more common in blooms that occur during quiescent periods, since they can grow rapidly at low nutrient concentrations. In the surf zone, diatoms and dinoflagellates are nearly equally important members of the phytoplankton, and some silicoflagellates are also present.

Red-tides are ubiquitous features of the Benguela system (see Shannon & Pillar 1986). The most common species associated with red tides (dinoflagellate and/or ciliate blooms) are *Noctiluca scintillans*, *Gonyaulax tamarensis*, *G. polygramma* and the ciliate *Mesodinium rubrum*. *Gonyaulax* and *Mesodinium* have been linked with toxic red tides. Most of these red-tide events occur quite close inshore although Hutchings *et al.* (1983) have recorded red-tides 30 km offshore.

The mesozooplankton (≥200 µm) is dominated by copepods, which are overall the most dominant and diverse group in southern African zooplankton. Important species are *Centropages brachiatus*, *Calanoides carinatus*, *Metridia lucens*, *Nannocalanus minor*, *Clausocalanus arcuicornis*, *Paracalanus parvus*, *P. crassirostris* and *Ctenocalanus vanus*. All of the above species typically occur in the phytoplankton rich upper mixed layer of the water column, with the exception of *M. lucens* which undertakes considerable vertical migration.

The macrozooplankton (≥1,600 µm) are dominated by euphausiids of which 18 species occur in the area. The dominant species occurring in the nearshore are *Euphausia lucens* and *Nyctiphanes capensis*, although neither species appears to survive well in waters seaward of oceanic fronts over the continental shelf (Pillar *et al.* 1991).

Standing stock estimates of mesozooplankton for the southern Benguela area range from 0.2 - 2.0 g C/m^2, with maximum values recorded during upwelling periods. Macrozooplankton biomass ranges from 0.1-1.0 g C/m^2, with production increasing north of Cape Columbine (Pillar 1986). Although it shows no appreciable onshore-offshore gradients, standing stock is highest over the shelf, with accumulation of some mobile zooplanktors (euphausiids) known to occur at oceanographic fronts. Beyond the continental slope biomass decreases markedly.

Zooplankton biomass varies with phytoplankton abundance and, accordingly, seasonal minima will exist during non-upwelling periods when primary production is lower (Brown 1984; Brown & Henry 1985), and during winter when predation by recruiting anchovy is high. More intense variation will occur in relation to the upwelling cycle; newly upwelled water supporting low zooplankton biomass due to paucity of food, whilst high biomasses develop in aged upwelled water subsequent to significant development of phytoplankton. Irregular pulsing of the upwelling system, combined with seasonal recruitment of pelagic fish species into West Coast shelf waters during winter, thus results in a highly variable and dynamic balance between plankton replenishment and food availability for pelagic fish species.

The project area lies within the influence of the Namaqua upwelling cell, and seasonally high phytoplankton abundance can be expected, providing favourable feeding conditions for micro-, meso- and macrozooplankton, and for ichthyoplankton. Although ichthyoplankton (fish eggs and larvae) comprise a minor component of the overall plankton, it remains significant due to the commercial importance of the overall fishery in the region. Various pelagic and demersal fish species are known to spawn in the inshore regions of the southern Benguela (Crawford *et al.* 1987), and their eggs and larvae form an important contribution to the ichthyoplankton in the region. However, in the Orange River Cone area immediately to the north of the upwelling cell, high turbulence and deep mixing in the water column result in diminished phytoplankton biomass and consequently the area is considered to be an environmental barrier to the transport of ichthyoplankton from the southern to the northern Benguela upwelling ecosystems. Important pelagic fish species, including anchovy, redeye round herring, horse mackerel and shallow-water hake, are reported as spawning on either side of the Orange River Cone area, but not within it. Ichthyoplankton abundances in the project area are thus expected to be comparatively low.

3.3.3.2 Pelagic Fish

The structure of the nearshore and surf zone fish community varies greatly with the degree of wave exposure. Species richness and abundance is generally high in sheltered and semi-exposed areas but typically very low off the more exposed beaches (Clark 1997a, 1997b). The surf zone and outer turbulent zone habitats of sandy beaches are considered to be important nursery habitats for marine fishes (Modde 1980; Lasiak 1981; Kinoshita & Fujita 1988; Clark *et al*. 1994). However, the composition and abundance of the individual assemblages seems to be heavily dependent on wave exposure (Blaber & Blaber 1980, Potter *et al*. 1990, Clark 1997a, 1997b). Surf zone fish communities off the South African West Coast have relatively high biomass, but low species diversity. Typical surf zone fish include harders (*Liza richardsonii*), white stumpnose (*Rhabdosargus globiceps*) (Figure 3-12), Cape sole (*Heteromycteris capensis*), Cape gurnard (*Chelidonichthys capensis*), False Bay klipfish (*Clinus latipennis*), sandsharks (*Rhinobatos annulatus*), eagle ray (*Myliobatis aquila*), and smooth-hound (*Mustelus mustelus*) (Clark 1997b).

Figure 3-12: Common surf zone fish include the harder (left, photo: aquariophil.org) and the white stumpnose (right, photo: easterncapescubadiving.co.za).

Fish species commonly found in kelp beds off the West Coast include hottentot *Pachymetopon blochii* (Figure 3-13, left), twotone fingerfin *Chirodactylus brachydactylus* (Figure 3-13, right), red fingers *Cheilodactylus fasciatus*, galjoen *Dichistius capensis*, rock suckers *Chorisochismus dentex,* maned blennies *Scartella emarginata* and the catshark *Haploblepharus pictus* (Sauer *et al*. 1997; Brouwer *et al*. 1997; Branch *et al*. 2010).

Small pelagic species occurring beyond the surf zone and generally within the 200 m contour include the sardine/pilchard (*Sadinops ocellatus*) (Figure 3-14, left), anchovy (*Engraulis capensis*), chub mackerel (*Scomber japonicus*), horse mackerel (*Trachurus capensis*) (Figure 3-14, right) and round herring (*Etrumeus whiteheadi*). These species typically occur in mixed shoals of various sizes (Crawford *et al*. 1987), and exhibit similar life history patterns involving seasonal migrations between the west and south coasts. The spawning areas of the major pelagic species are distributed on the continental shelf and along the shelf edge from south of St Helena Bay to Mossel Bay on the South Coast (Shannon & Pillar 1986). They spawn downstream of major upwelling centres in spring and summer, and their eggs and larvae are subsequently carried around Cape Point and up the coast in northward flowing surface waters.

Figure 3-13: Common fish found in kelp beds include the Hottentot fish (left, photo: commons. wikimedia.org) and the twotone fingerfin (right, photo: www.parrphotographic.com).

Figure 3-14: Cape fur seal preying on a shoal of pilchards (left). School of horse mackerel (right) (photos: www.underwatervideo.co.za; www.delivery.superstock.com).

At the start of winter every year, juveniles of most small pelagic shoaling species recruit into coastal waters in large numbers between the Orange River and Cape Columbine. They recruit in the pelagic stage, across broad stretches of the shelf, to utilise the shallow shelf region as nursery grounds before gradually moving southwards in the inshore southerly flowing surface current, towards the major spawning grounds east of Cape Point. Recruitment success relies on the interaction of oceanographic events, and is thus subject to spatial and temporal variability. Consequently, the abundance of adults and juveniles of these small, short-lived (1-3 years) pelagic fish is highly variable both within and between species.

Two species that migrate along the West Coast following the shoals of anchovy and pilchards are snoek *Thyrsites atun* and chub mackerel *Scomber japonicas*. Both these species have been rated as 'Least concern' on the national assessment (Sink *et al*. 2019). While the appearance of chub mackerel along the West and South-West coasts is highly seasonal, adult snoek are found throughout their distribution range and longshore movement are random and without a seasonal basis (Griffiths 2002). Initially postulated to be a single stock that undergoes a seasonal longshore migration from southern Angola through Namibia to the South African West Coast (Crawford & De Villiers 1985; Crawford *et al.* 1987), Benguela snoek are now recognised as two separate sub-populations separated by the Lüderitz upwelling cell (Griffiths 2003). On the West Coast, snoek move offshore to spawn and there is some southward dispersion as the spawning season progresses, with females on the West Coast moving inshore to feed between spawning events as spawning progresses. In contrast, those found further south along the western Agulhas Bank remain on the spawning grounds throughout the spawning season (Griffiths 2002) (**Error! Reference source not found.**). They are voracious predators occurring throughout the water column, feeding on both demersal and pelagic invertebrates and fish. Chub mackerel similarly migrate along the southern African West Coast reaching South-Western Cape waters between April and August. They move inshore in June and July to spawn before starting the return northwards offshore migration later in the year. Their abundance and seasonal migrations are thought to be related to the availability of their shoaling prey species (Payne & Crawford 1989).

The fish most likely to be encountered on the shelf, beyond the shelf break and offshore of the concession area are the large migratory pelagic species, including various tunas, billfish and sharks, many of which are considered threatened by the International Union for the Conservation of Nature (IUCN), primarily due to overfishing. Tuna and swordfish are targeted by high seas fishing fleets and illegal overfishing has severely damaged the stocks of many of these species. Similarly, pelagic sharks, are either caught as bycatch in the pelagic tuna longline fisheries, or are specifically targeted for their fins, where the fins are removed and the remainder of the body discarded.

These large pelagic species migrate throughout the southern oceans, between surface and deep waters (>300 m) and have a highly seasonal abundance in the Benguela. Species occurring off western southern Africa include the albacore/longfin tuna *Thunnus alalunga*, yellowfin *T. albacares*, bigeye *T. obesus*, and skipjack *Katsuwonus pelamis* tunas, as well as the Atlantic blue marlin *Makaira nigricans*, the white marlin *Tetrapturus albidus* and the broadbill swordfish *Xiphias gladius* (Payne & Crawford 1989). The distributions of these species are dependent on food availability in the mixed boundary layer between the Benguela and warm central Atlantic waters. Concentrations of large pelagic species are also known to occur associated with underwater feature such as canyons and seamounts as well as meteorologically induced oceanic fronts (Shannon et al. 1989; Penney et al. 1992). Seasonal association with Child's Bank (off Namaqualand) and Tripp Seamount (off southern Namibia) occurs between October and June, with commercial catches often peaking in March and April (www.fao.org/fi/fcp/en/NAM/body.htm; see CapMarine 2018 – Fisheries Specialist Study).

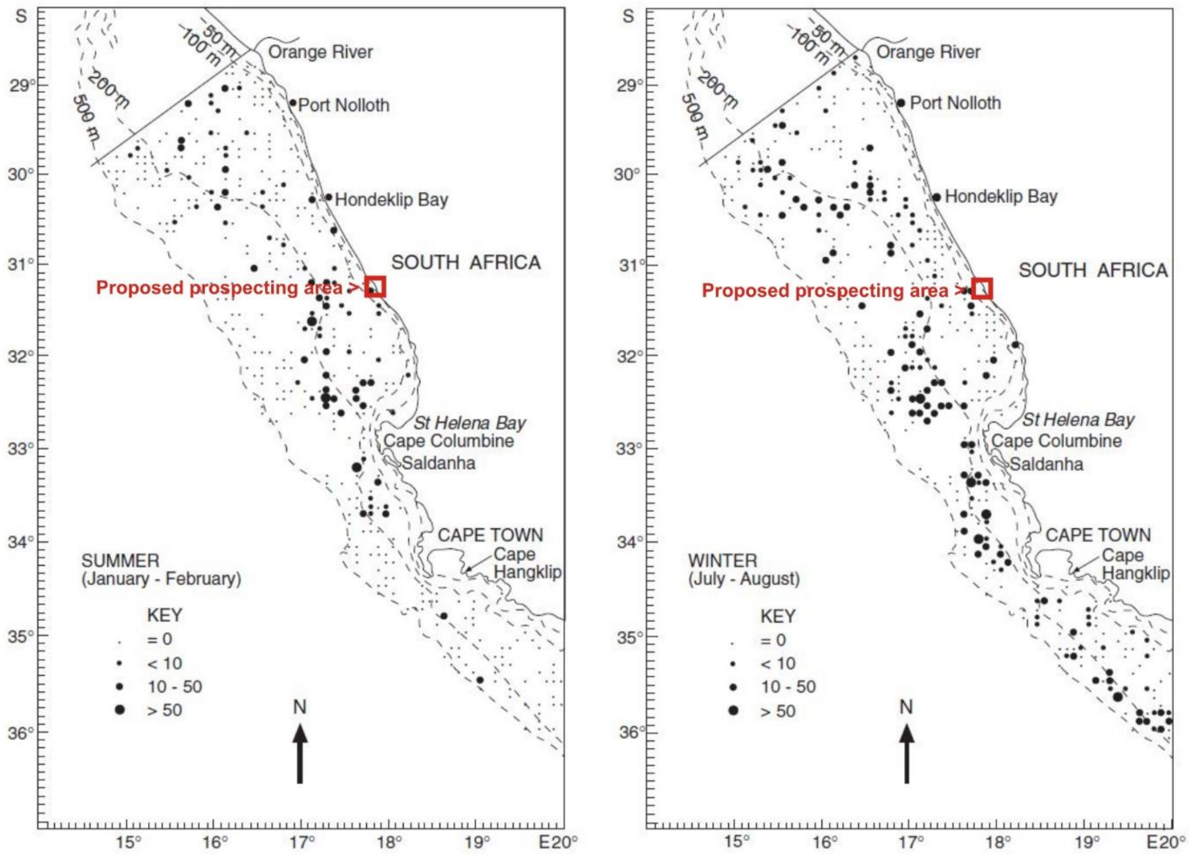

Figure 3-15: Mean number of snoek per demersal trawl per grid block (5 × 5 Nm) by season for (A) the west coast (July 1985–Jan 1991) and (B) the south coast in relation to the proposed prospecting area (red square) (adapted from Griffiths 2002).

3.3.3.3 Turtles

Three species of turtle occur along the West Coast, namely the Leatherback (*Dermochelys coriacea*) (Figure 3-16, left), and occasionally the Loggerhead (*Caretta caretta*) (Figure 3-16, right) and the Green (*Chelonia mydas*) turtle. Loggerhead and Green turtles are expected to occur only as occasional visitors along the West Coast. The most recent conservation status, which assessed the species on a sub-regional scale, is provided in Leatherback turtles inhabit deeper waters and are considered a pelagic species, travelling the ocean currents in search of their prey (primarily jellyfish). While hunting they may dive to over 600 m and remain submerged for up to 54 minutes (Hays et al. 2004). Their abundance in the study area is unknown but expected to be low. Leatherbacks feed on jellyfish and are known to have mistaken plastic marine debris for their natural food. Ingesting this can obstruct the gut, lead to absorption of toxins and reduce the absorption of nutrients from their real food. Leatherback Turtles are listed as 'Critically endangered' worldwide by the IUCN and are in the highest categories in terms of need for conservation in CITES (Convention on International Trade in Endangered Species), and CMS (Convention on Migratory Species). The 2017 South African list of Threatened and Endangered Species (TOPS) similarly lists the species as 'Critically endangered', whereas on the National Assessment (Hughes & Nel 2014) Leatherbacks were listed as 'Endangered', whereas Loggerhead and green turtles are listed globally as 'Vulnerable' and 'Endangered', respectively, whereas on TOPS both species are listed as 'Endangered'. As a signatory of CMS, South Africa has endorsed and signed a CMS International Memorandum of Understanding specific to the conservation of marine turtles. South Africa is thus committed to conserve these species at an international level.

Table 3-1.

The Leatherback is the only turtle likely to be encountered in the offshore waters of west South Africa. The Benguela ecosystem, especially the northern Benguela where jelly fish numbers are high, is increasingly being recognized as a potentially important feeding area for leatherback turtles from several globally significant nesting populations in the south Atlantic (Gabon, Brazil) and south east Indian Ocean (South Africa) (Lambardi *et al*. 2008, Elwen & Leeney 2011). Leatherback turtles from the east South Africa population have been satellite tracked swimming around the west coast of South Africa and remaining in the warmer waters west of the Benguela ecosystem (Lambardi *et al*. 2008).

Figure 3-16: Leatherback (left) and loggerhead turtles (right) occur along the West Coast of Southern Africa (Photos: Ketos Ecology 2009; www.aquaworld-crete.com).

Leatherback turtles inhabit deeper waters and are considered a pelagic species, travelling the ocean currents in search of their prey (primarily jellyfish). While hunting they may dive to over 600 m and remain submerged for up to 54 minutes (Hays et al. 2004). Their abundance in the study area is unknown but expected to be low. Leatherbacks feed on jellyfish and are known to have mistaken plastic marine debris for their natural food. Ingesting this can obstruct the gut, lead to absorption of toxins and reduce the absorption of nutrients from their real food. Leatherback Turtles are listed as 'Critically endangered' worldwide by the IUCN and are in the highest categories in terms of need for conservation in CITES (Convention on International Trade in Endangered Species), and CMS (Convention on Migratory Species). The 2017 South African list of Threatened and Endangered Species (TOPS) similarly lists the species as 'Critically endangered', whereas on the National Assessment (Hughes & Nel 2014) Leatherbacks were listed as 'Endangered', whereas Loggerhead and green turtles are listed globally as 'Vulnerable' and 'Endangered', respectively, whereas on TOPS both species are listed as 'Endangered'. As a signatory of CMS, South Africa has endorsed and signed a CMS International Memorandum of Understanding specific to the conservation of marine turtles. South Africa is thus committed to conserve these species at an international level.

Table 3-1: Global and Regional Conservation Status of the turtles occurring off the South Coast showing variation depending on the listing used.

Listing	Leatherback	Loggerhead	Green
IUCN Red List:			
Species (date)	V (2013)	V (2017)	E (2004)
Population (RMU)	CR (2013)	NT (2017)	*
Sub-Regional/National			
NEMBA TOPS (2017)	CR	E	E
Sink & Lawrence (2008)	CR	E	E
Hughes & Nel (2014)	E	V	NT

NT – Near Threatened V – Vulnerable E – Endangered CR – Critically Endangered
DD – Data Deficient UR – Under Review * - not yet assessed

3.3.3.4 Seabirds

Fifteen species of seabirds breed in southern Africa, including Cape Gannet, African Penguin, African Black Oystercatcher (Figure 3-17, left), four species of Cormorant (Figure 3-17, right),, White Pelican, three Gull and four Tern species (Table 5). The breeding areas are distributed around the coast with islands being especially important. The closest breeding islands to the proposed prospecting area are Bird Island in Lambert's Bay and the Saldanha Bay Islands approximately 95 km and 200 km to the south, respectively. There are breeding colonies of African Penguins at Bird Island (Lambert's Bay), and further south at Dassen Island and Robben Island. In the Western Cape, African Penguins breed mainly from February to October (peak during March to May) when their prey species (anchovy and sardine) are typically most abundant in the area (Crawford et al. 1995). The number of successfully breeding birds at the particular breeding sites varies with food abundance. Most of the breeding seabird species forage at sea with most birds being found relatively close inshore (10 - 30 km). Cape Gannets, which breed at only three locations in South Africa (Bird Island Lambert's Bay, Malgas Island and Bird Island Algoa Bay) are known to forage within 200 km offshore (Dundee 2006; Ludynia 2007; Grémillet et al. 2008; Crawford et al. 2011), and African Penguins have also been recorded as far as 60 km offshore. The proposed prospecting area lies within the aggregate core home ranges of African Penguins but to the north of aggregate core home ranges of Cape Cormorant and Cape Gannet (Figure 3-18). There is, however, overlap of the concession with the foraging areas for Cape Cormorant and the core use area for African Penguins from Bird Island (Figure 3-18).

Figure 3-17: The African Black Oystercatcher (Left, photo: patrickspilsbury.blogspot.com) and Crowned Cormorant (right, photo: savoels.za.net) occur in the project area.

Interactions with commercial fishing operations, either through incidental bycatch or competition for food resources, is the greatest threat to southern African seabirds, impacting 56% of seabirds of special concern. Crawford *et al.* (2014) reported that four of the seabirds assessed as Endangered compete with South Africa's fisheries for food: African Penguins, Cape Gannets and Cape Cormorants for sardines and anchovies, and Bank Cormorants for rock lobsters (Crawford *et al.* 2015). Populations of seabirds off the West Coast have recently shown significant decreases, with the population numbers of African Penguins currently only 2.5% of what the population was 80 years ago; declining from 1 million breeding pairs in the 1920s, 25,000 pairs in 2009 and 15,000 in 2018 (Sink *et al.* 2019). Poor prey availability (Crawford *et al.* 2006), and a shift in prey biomass eastwards in response to climatic changes has lead to high adult mortality and continued population declines in African Penguins (Sherley *et al*. 2017). For Cape Gannets, the global population decreased from about 250,000 pairs in the 1950s and 1960s to approximately 130,000 in 2018, primarily as a result of a >90% decrease in Namibia's population in response to the collapse of Namibia's sardine resource. In South Africa, numbers of Cape Gannets have increased since 1956 and South Africa now holds >90% of the global population. However, numbers have recently decreased in the Western Cape but increased in Algoa Bay mirroring the southward and eastward shift sardine and anchovy. Algoa Bay currently holds approximately 75% of the South African Gannet population.

Table 3-2: Breeding resident seabirds present along the South-West Coast (adapted from CCA & CMS 2001). IUCN Red List and National Assessment status are provided (Sink *et al*. 2019). * denotes endemicity.

Common Name	Species Name	Global IUCN	National
African Penguin*	*Spheniscus demersus*	Endangered	Endangered
African Black Oystercatcher*	*Haematopus moquini*	Near Threatened	Least Concern
White-breasted Cormorant	*Phalacrocorax carbo*	Least Concern	Least Concern
Cape Cormorant*	*Phalacrocorax capensis*	Endangered	Endangered
Bank Cormorant*	*Phalacrocorax neglectus*	Endangered	Endangered
Crowned Cormorant*	*Phalacrocorax coronatus*	Near Threatened	Near Threatened
White Pelican	*Pelecanus onocrotalus*	Least Concern	Vulnerable
Cape Gannet*	*Morus capensis*	Endangered	Endangered
Kelp Gull	*Larus dominicanus*	Least Concern	Least Concern
Greyheaded Gull	*Larus cirrocephalus*	Least Concern	Least Concern
Hartlaub's Gull*	*Larus hartlaubii*	Least Concern	Least Concern
Caspian Tern	*Hydroprogne caspia*	Least Concern	Vulnerable
Swift Tern	*Sterna bergii*	Least Concern	Least Concern
Roseate Tern	*Sterna dougallii*	Least Concern	Endangered
Damara Tern*	*Sterna balaenarum*	Vulnerable	Vulnerable

Cape cormorants and Bank cormorants showed a substantial decline from the late 1970s/early 1980s to the late 2000s/early 2010s, with numbers of Cape cormorants dropping from 106,500 to 65,800 breeding pairs, and Bank cormorants from 1,500 to only 800 breeding pairs over that period (Crawford *et al*. 2015).

Large numbers of pelagic seabirds exploit the pelagic fish stocks of the Benguela system. Of the 49 species of seabirds that occur in the Benguela region, 15 are defined as resident, 10 are visitors from the northern hemisphere and 25 are migrants from the southern Ocean. The species classified as being common in the southern Benguela are listed in

Table 3-3. The area between Cape Point and the Orange River supports 38% and 33% of the overall population of pelagic seabirds in winter and summer, respectively. Most of the pelagic species in the region reach highest densities offshore of the shelf break (200 – 500 m depth), with highest population levels during their non-breeding season (winter). Pintado petrels and Prion spp. show the most marked variation here. The abundance of pelagic seabirds in the Brand-se-Baai area is expected to be low, as their foraging areas all lie well offshore of the coast (see maps in Harris *et al*. 2022).

Demersal and pelagic longlining are key contributors to the mortality of albatrosses (Browed albatross 7%, Indian and Atlantic Yellow-Nosed Albatross 3%), petrels (white-chinned petrel 66%), shearwaters and Cape Gannets (2%) through accidental capture (bycatch and/or entanglement in fishing gear), with an estimated annual mortality of 450 individuals of 14 species for the period 2006 to 2013 (Rollinson *et al*. 2017). Other threats include predation by mice on petrel and albatross chicks on sub-Antarctic islands, predation of chicks of Cape, Crowned and Bank Cormorants by Great White Pelicans, and predation of eggs and chicks of African Penguins, Bank, Cape and Crowned Cormorants by Kelp gulls. Disease (avian flu), climate change (heat stress and environmental variability) and oil spills are also considered major contributors to seabird declines (Sink *et al*. 2019).

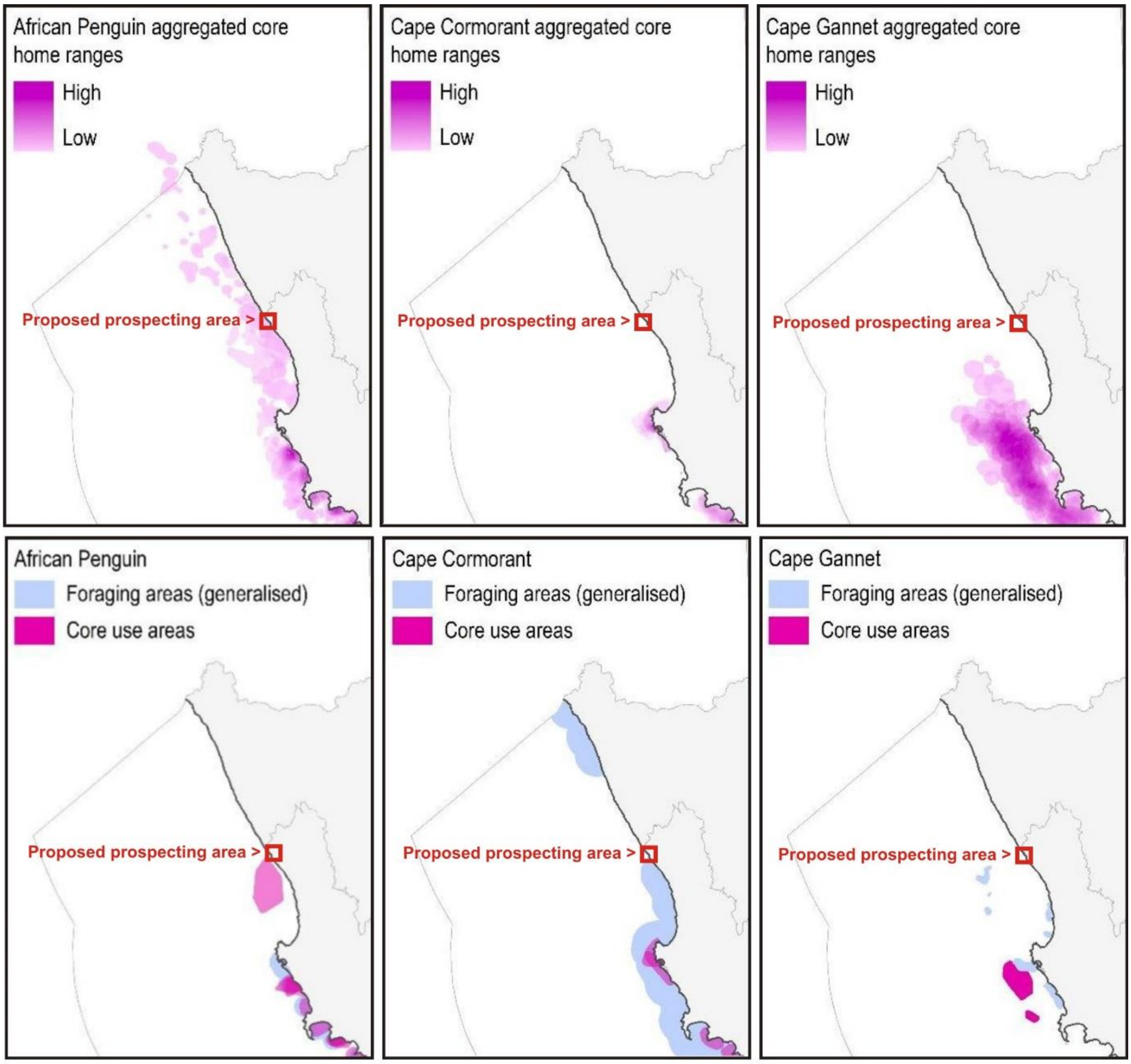

Figure 3-18: The proposed prospecting area (red square) in relation to aggregate core home ranges (top) and generalised foraging areas and core usage areas (bottom) of African Penguins (left), Cape Cormorant (middle) and Cape Gannet (right) (adapted from Harris *et al*. 2022).

Table 3-3: Pelagic seabirds common in the southern Benguela region (Crawford *et al*. 1991). IUCN Red List and Regional Assessment status are provided (Sink *et al*. 2019).

Common Name	Species name	Global IUCN	Regional Assessment
Shy Albatross	*Thalassarche cauta*	Near Threatened	Near Threatened
Black-browed Albatross	*Thalassarche melanophrys*	Least concern	Endangered
Atlantic Yellow-nosed	*Thalassarche chlororhynchos*	Endangered	Endangered
Indian Yellow-nosed Albatross	*Thalassarche carteri*	Endangered	Endangered
Wandering Albatross	*Diomedea exulans*	Vulnerable	Vulnerable
Southern Royal Albatross	*Diomedea epomophora*	Vulnerable	Vulnerable
Northern Royal Albatross	*Diomedea sanfordi*	Endangered	Endangered
Sooty Albatross	*Phoebetria fusca*	Endangered	Endangered
Light-mantled Albatross	*Phoebetria palpebrata*	Near Threatened	Near Threatened
Tristan Albatross	*Diomedea dabbenena*	Critically Endangered	Critically Endangered
Grey-headed Albatross	*Thalassarche chrysostoma*	Endangered	Endangered
Giant Petrel sp.	*Macronectes halli/giganteus*	Least concern	Near Threatened
Southern Fulmar	*Fulmarus glacialoides*	Least concern	Least concern
Pintado Petrel	*Daption capense*	Least concern	Least concern
Blue Petrel	*Halobaena caerulea*	Least concern	Near Threatened
Salvin's Prion	*Pachyptila salvini*	Least concern	Near Threatened
Arctic Prion	*Pachyptila desolata*	Least concern	Least concern
Slender-billed Prion	*Pachyptila belcheri*	Least concern	Least concern
Broad-billed Prion	*Pachyptila vittata*	Least concern	Least concern
Kerguelen Petrel	*Aphrodroma brevirostris*	Least concern	Near Threatened
Greatwinged Petrel	*Pterodroma macroptera*	Least concern	Near Threatened
Soft-plumaged Petrel	*Pterodroma mollis*	Least concern	Near Threatened
White-chinned Petrel	*Procellaria aequinoctialis*	Vulnerable	Vulnerable
Spectacled Petrel	*Procellaria conspicillata*	Vulnerable	Vulnerable
Cory's Shearwater	*Calonectris diomedea*	Least concern	Least concern
Sooty Shearwater	*Puffinus griseus*	Near Threatened	Near Threatened
Flesh-footed Shearwater	*Ardenna carneipes*	Near Threatened	Least concern
Great Shearwater	*Puffinus gravis*	Least concern	Least concern
Manx Shearwater	*Puffinus puffinus*	Least concern	Least concern
Little Shearwater	*Puffinus assimilis*	Least concern	Least concern
European Storm Petrel	*Hydrobates pelagicus*	Least concern	Least concern
Leach's Storm Petrel	*Oceanodroma leucorhoa*	Vulnerable	Critically Endangered
Wilson's Storm Petrel	*Oceanites oceanicus*	Least concern	Least concern
Black-bellied Storm Petrel	*Fregetta tropica*	Least concern	Near Threatened
White-bellied Storm Petrel	*Fregetta grallaria*	Least concern	Least concern
Pomarine Jaeger	*Stercorarius pomarinus*	Least concern	Least concern
Subantarctic Skua	*Catharacta antarctica*	Least concern	Endangered
Parasitic Jaeger	*Stercorarius parasiticus*	Least concern	Least concern
Long-tailed Jaeger	*Stercorarius longicaudus*	Least concern	Least concern
Sabine's Gull	*Larus sabini*	Least concern	Least concern
Lesser Crested Tern	*Thalasseus bengalensis*	Least concern	Least concern
Sandwich Tern	*Thalasseus sandvicensis*	Least concern	Least concern
Little Tern	*Sternula albifrons*	Least concern	Least concern
Common Tern	*Sterna hirundo*	Least concern	Least concern
Arctic Tern	*Sterna paradisaea*	Least concern	Least concern
Antarctic Tern	*Sterna vittata*	Least concern	Endangered

3.3.3.5 Marine Mammals

The marine mammal fauna occurring off the southern African coast includes several species of whales and dolphins and one resident seal species.

Cetaceans (whales and dolphins)

Thirty four species of whales and dolphins are known (based on historic sightings or strandings records) or likely (based on habitat projections of known species parameters) to occur in these waters (Table 3-4). Current information on the distribution, population sizes and trends of most cetacean species occurring on the west coast of southern Africa is lacking and the precautionary principal must be used when considering possible encounters with cetaceans in this area.

Records from stranded specimens show that the area between St Helena Bay (~32° S, 18° E) and Cape Agulhas (~34° S, 20° E) is an area of transition between Atlantic and Indian Ocean species, as well as those more commonly associated with colder waters of the west coast (e.g. dusky dolphins and long finned pilot whales) and those of the warmer east coast (e.g. striped and Risso's dolphins) (Findlay *et al.* 1992). The project area lies north of this transition zone and can be considered to be truly on the 'west coast'.

The distribution of cetaceans can largely be split into those associated with the continental shelf and those that occur in deep, oceanic water. Cetacean density on the continental shelf is usually higher than in pelagic waters as species associated with the pelagic environment tend to be wide ranging across 1,000s of km. As the project area is located on the coast, cetacean diversity in likely to be lower than further offshore on the shelf.

Cetaceans are comprised of two taxonomic groups, the mysticetes (filter feeders with baleen) and the odontocetes (predatory whales and dolphins with teeth). Due to differences in sociality, communication abilities, ranging behavior and acoustic behavior, these two groups are considered separately. A review of the distribution and seasonality of the key cetacean species likely to be found within the project area is provided below.

Table 3-4 lists the cetaceans likely to be found within the project area, based on data sourced from: Findlay *et al.* (1992), Best (2007), Weir (2011) and unpublished records held by the Namibian Dolphin Project. Of the 16 species listed, two are endangered (IUCN Red Data list Categories). The majority of data available on the seasonality and distribution of large whales in the project area is the result of commercial whaling activities mostly dating from the 1960s. Changes in the timing and distribution of migration may have occurred since these data were collected due to extirpation of populations or behaviours (e.g. migration routes may be learnt behaviours). The large whale species for which there are current data available from the continental shelf waters are the humpback and southern right whale.

Mysticete (Baleen) whales

The majority of mysticetes whales fall into the family Balaenopeteridae. Those occurring in the area include the fin, sei, Antarctic minke, dwarf minke, humpback and Bryde's whales. The southern right whale (Family Balaenidae) and pygmy right whale (Family Neobalaenidae) are from taxonomically separate groups. The majority of mysticete species occur in pelagic waters with only occasional visits to shelf waters. Most of these species show some degree of migration either to or through the latitudes encompassed by the broader project area when *en route* between higher latitude (Antarctic or Subantarctic) feeding grounds and lower latitude breeding grounds. Depending on the ultimate location of these feeding and breeding grounds, seasonality may be either unimodal, usually in winter months, or bimodal (e.g. May to July and October to November), reflecting a northward and southward migration through the area. Northward and southward migrations may take place at different distances from the coast due to whales following geographic or oceanographic features, thereby influencing the seasonality of occurrence at different locations. Because of the complexities of the migration patterns, each species is discussed separately below.

Two genetically and morphologically distinct populations of Bryde's whales (Figure 3-19, left) live off the coast of southern Africa (Best 2001; Penry 2010). The "offshore population" lives beyond the shelf (>200 m depth) off west Africa and is unlikely to be seen in the project area. The "inshore population" of Bryde's, which lives on the continental shelf and Agulhas Bank, is unique amongst baleen whales in the region by being non-migratory. It may move further north into the Benguela current areas of the west of coast of South Africa and Namibia, especially in the winter months (Best 2007).

Sei whales migrate through South African waters, where they were historically hunted in relatively high numbers, to unknown breeding grounds further north. Their migration pattern thus shows a bimodal peak with numbers west of Cape Columbine highest in May and June, and again in August, September and October. All whales were caught in waters deeper than 200 m with most caught deeper than 1,000 m (Best & Lockyer 2002). There is no current information on abundance or distribution patterns in the region. Sei whales are unlikely to be sighted near the project area due to their distribution further offshore.

Table 3-4: Cetaceans occurrence off the West Coast of South Africa, their seasonality and South African (Child *et al*. 2016) conservation status.

Common Name	Species	Seasonality	RSA Regional Assessment	IUCN Global Assessment
Delphinids				
Dusky dolphin	*Lagenorhynchus obscurus*	Year round	Least Concern	Least Concern
Heaviside's dolphin	*Cephalorhynchus heavisidii*	Year round	Least Concern	Near Threatened
Common bottlenose dolphin	*Tursiops truncatus*	Year round	Least Concern	Least Concern
Common dolphin	*Delphinus delphis*	Year round	Least Concern	Least Concern
Southern right whale dolphin	*Lissodelphis peronii*	Year round	Least Concern	Least Concern
Killer whale	*Orcinus orca*	Year round	Least Concern	Data deficient
False killer whale	*Pseudorca crassidens*	Year round	Least Concern	Near Threatened
Baleen whales				
Antarctic Minke	*Balaenoptera bonaerensis*	>Winter	Least Concern	Near Threatened
Dwarf minke	*B. acutorostrata*	Year round	Least Concern	Least Concern
Fin whale	*B. physalus*	MJJ & ON	Endangered	Vulnerable
Blue whale (Antarctic)	*B. musculus intermedia*	Winter peak	Critically Endangered	Critically Endangered
Sei whale	*B. borealis*	MJ & ASO	Endangered	Endangered
Bryde's (inshore)	*B brydei (subspp)*	Year round	Vulnerable	Least Concern
Bryde's (offshore)	*B. brydei*	Summer (JFM)	Data Deficient	Least Concern
Pygmy right	*Caperea marginata*	Year round	Least Concern	Least Concern
Humpback sp.	*Megaptera novaeangliae*	Year round, SONDJF	Least Concern	Least Concern
Humpback B2 population	*Megaptera novaeangliae*	Spring/Summer peak ONDJF	Vulnerable	Not Assessed
Southern Right	*Eubalaena australis*	Year round, ONDJFMA	Least Concern	Least Concern

Figure 3-19: The Bryde's whale *Balaenoptera brydei* (left) and the Minke whale *Balaenoptera bonaerensis* (right) (Photos: www.dailymail.co.uk; www.marinebio.org).

Fin whales were historically caught off the West Coast of South Africa, with a bimodal peak in the catch data suggesting animals were migrating further north during May-June to breed, before returning during August-October *en route* to Antarctic feeding grounds. Some juvenile animals may feed year round in deeper waters off the shelf (Best 2007). There are no recent data on abundance or distribution of fin whales off western South Africa. There are no recent data on the abundance or distribution of fin whales off the west coast, although a sighting in St Helena Bay in 2011 (Mammal Research Institute, unpubl. data) and several sightings in southern Namibia in 2014 and 2015 as well as a number of strandings and acoustic detections (Thomisch *et al.* 2016) in Namibia, confirm their contemporary occurrence in the region.

Two forms of minke whale (Figure 3-19, right) occur in the southern Hemisphere, the Antarctic minke whale (*Balaenoptera bonaerensis*) and the dwarf minke whale (*B. acutorostrata* subsp.); both species occur in the Benguela (Best 2007). Antarctic minke whales range from the pack ice of Antarctica to tropical waters and are usually seen more than ~50 km offshore. Although adults migrate from the Southern Ocean (summer) to tropical/temperate waters (winter) to breed, some animals, especially juveniles, are known to stay in tropical/temperate waters year round. The dwarf minke whale has a more temperate distribution than the Antarctic minke and they do not range further south than 60-65°S. Dwarf minkes have a similar migration pattern to Antarctic minkes with at least some animals migrating to the Southern Ocean during summer. Dwarf minke whales occur closer to shore than Antarctic minkes. Both species are generally solitary and densities are likely to be low in the project area.

The most abundant baleen whales in the Benguela are southern right whales and humpback whales (Figure 3-20). In the last decade, both species have been increasingly observed to remain on the west coast of South Africa well after the 'traditional' South African whale season (June – November) into spring and early summer (October – February) where they have been observed feeding in upwelling zones, especially off Saldanha and St Helena Bay (Barendse *et al.* 2011; Mate *et al.* 2011).

The majority of humpback whales passing through the Benguela are migrating to breeding grounds off tropical west Africa, between Angola and the Gulf of Guinea (Rosenbaum *et al.* 2009; Barendse *et al.* 2010). Those breeding in this area are defined as Breeding Stock B1 (BSB1) by the International Whaling Commission (IWC), and were estimated at 9,000 individuals in 2005 (IWC 2012). Animals feeding in the southern Benguela are defined as population BSB2 by the IWC and are genetically distinct from BSB1, although there are resightings of individuals between the areas and it remains unclear exactly how animals in BSB1 and BSB2 relate to each other. BSB2 was estimated as only 500 individuals in 2001-2002 (Barendse *et al.* 2011) and both populations have increased since this time at least 5 % per annum (IWC 2012). Humpback whales in the SE Atlantic migrate north during early winter (June), meet and then follow the coast at varying places, so there is no clear migration 'corridor' on the west coast of South Africa. On the southward migration, returning from tropical West Africa, many humpbacks follow the Walvis Ridge offshore after leaving Angola then head directly to high latitude feeding grounds, while others follow a more coastal route (including the majority of mother-calf pairs), lingering in the feeding grounds off west South Africa in summer (Elwen *et al.* 2014; Rosenbaum *et al.* in 2014, Findlay *et al.* 2017). The number of humpback whales feeding in the southern Benguela has increased substantially since estimates made in the early 2000s (Barendse *et al.* 2011). Since ~2011, 'supergroups' of up to 200 individual whales have been observed feeding within 10 km from shore (Findlay *et al.* 2017) with many hundred more passing through and whales are now seen in all months of the year around Cape Town. In the first half of 2017 (when numbers are expected to be at their lowest) more than 10 humpback whales were reported stranded along the Namibian and west South African coasts. The cause of these deaths is not known, but a similar event off Brazil in 2010 was linked to possible infectious disease or malnutrition (Siciliano *et al.* 2013), which suggests the West African population may be undergoing similar stresses and caution should be taken in increasing stress through human activities. Humpback whales are thus likely to be the most frequently encountered baleen whale in the offshore portions of the concession areas with year-round presence but numbers peaking in July for the northwards migration and October to February during the southward migration and when animals from the BSB2 population are feeding in the Benguela Ecosystem.

Figure 3-20: The Humpback whale *Megaptera novaeangliae* (left) and the Southern Right whale *Eubalaena australis* (right) are the most abundant large cetaceans occurring along the southern African West Coast (Photos: www.divephotoguide.com; www.aad.gov.au).

The southern African population of southern right whales historically extended from southern Mozambique (Maputo Bay) to southern Angola (Baie dos Tigres) and is considered to be a single population within this range (Roux *et al.* 2011). While in southern African waters, the vast majority of whales remain with a few kilometers of shore, predominantly in sheltered bays. The most recent abundance estimate for this population (2017), estimated the population at ~6,116 individuals including all age and sex classes, which is thought to be at least 30% of the original population size with the population growing at ~6.5% per year since monitoring began (Brandaõ *et al.* 2018). Although the population is likely to have continued growing at this rate overall, there have been observations of major changes in the numbers of different classes of right whales seen; notably there has been a significant decrease in the number of adults without calves seen in near-shore waters since 2009 (Roux *et al.* 2015; Vinding *et al.* 2015). A large resurgence in numbers of right whales along the SA coast in 2018 and analysis of calving intervals suggests that these 'missing whales' are largely a result of many animals shifting from a 3 year to 4 year calving intervals (Brandaõ *et al.* 2018). The reasons for this are not yet clear but may be related to broadscale shifts in prey availability in the Southern Ocean, as there has been a large El Nino during some of this period. Importantly, many right whales also feed in summer months in the Southern Benguela, notably St Helena Bay (Mate *et al.* 2011). Several animals fitted with satellite tags which fed in St Helena Bay took an almost directly south-west path from there when leaving the coast. There are no current data available on the numbers of right whales feeding in the St Helena Bay area but mark-recapture data from 2003-2007 estimated roughly one third of the South African right whale population at that time were using St Helena Bay for feeding (Peters *et al.* 2005). Pelagic concentrations of right whales were recorded in historic whaling records, in a band between 30°S and 40°S between Cape Town and Tristan da Cunha (Best 2007), well offshore of the project area. These aggregations may be a result of animals feeding in this band, or those migrating south west from the Cape. Given this high proportion of the population known to feed in the southern Benguela, and the historical records, it is highly likely that large numbers of right whales may pass through the project area between November and January.

Odontocetes (toothed) whales

The Odontoceti are a varied group of animals including the dolphins, porpoises, beaked whales and sperm whales.

Killer whales have a circum-global distribution being found in all oceans from the equator to the ice edge (Best 2007). Killer whales occur year round in low densities off western South Africa (Best *et al.* 2010), Namibia (Elwen & Leeney 2011) and in the Eastern Tropical Atlantic (Weir *et al.* 2010). Killer whales are found in all depths from the coast to deep open ocean environments and may thus be encountered in the project area at low levels.

The false killer whale has a tropical to temperate distribution and most sightings off southern Africa have occurred in water deeper than 1,000 m, but with a few recorded close to shore (Findlay *et al.* 1992). They usually occur in groups ranging in size from 1 - 100 animals (Best 2007). The strong bonds and matrilineal social structure of this species makes it vulnerable to mass stranding (8 instances of 4 or more animals stranding together have occurred in the western Cape, all between St Helena Bay and Cape Agulhas). There is no information on population numbers or conservation status and no evidence of seasonality in the region (Best 2007).

The common dolphin is known to occur offshore in West Coast waters (Findlay *et al.* 1992; Best 2007), although the extent to which they occur in the project area is unknown, but likely to be low. Group sizes of common dolphins can be large, averaging 267 (±*SD* 287) for the South Africa region (Findlay *et al.* 1992). They are more frequently seen in the warmer waters offshore and to the north of the country, seasonality is not known.

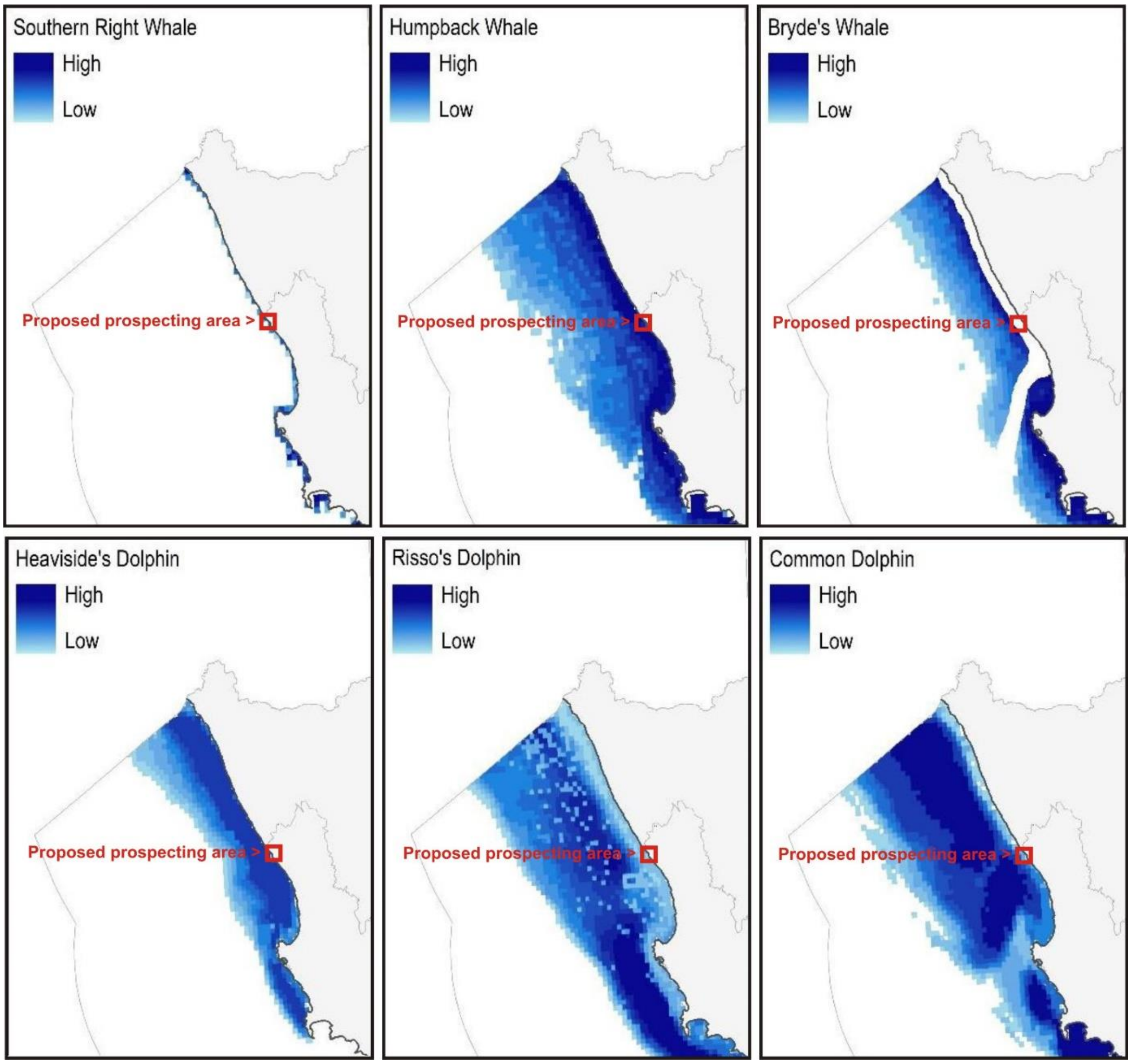

Figure 3-21: The proposed prospecting area (red square) in relation to the predicted distribution of southern right whale (top left), humpback whale (top middle), Bryde's whale (top right), Heaviside's dolphin (bottom left), Risso's dolphin (bottom middle) and common dolphin (bottom right) with darker shades of blue indicating highest likelihood of occurrence (adapted from Harris *et al.* 2022).

In water <500 m deep, dusky dolphins (Figure 3-22, right) are likely to be the most frequently encountered small cetacean as they are very "boat friendly" and often approach vessels to bowride. The species is resident year round throughout the Benguela ecosystem in waters from the coast to at least 2,000 m deep (Findlay *et al.* 1992). Although no information is available on the size of the population, they are regularly encountered in near shore waters between Cape Town and Lamberts Bay (Elwen *et al.* 2010a; NDP unpubl. data) with group sizes of up to 800 having been reported (Findlay *et al.* 1992). A hiatus in sightings (or low density area) is reported between ~27°S and 30°S, associated with the Lüderitz upwelling cell (Findlay *et al.* 1992). Dusky dolphins are resident year round in the Benguela.

Heaviside's dolphins (Figure 3-22, left) are relatively abundant in the Benguela ecosystem region with 10,000 animals estimated to live in the 400 km of coast between Cape Town and Lamberts Bay (Elwen *et al.* 2009). This species occupies waters from the coast to at least 200 m depth, (Elwen *et al.* 2006; Best 2007), and may show a diurnal onshore-offshore movement pattern (Elwen *et al.* 2010b), but this varies throughout the species range. Heaviside's dolphins are resident year round and likely to be frequently encountered off the project area.

Figure 3-22: The endemic Heaviside's Dolphin *Cephalorhynchus heavisidii* (left) (Photo: De Beers Marine Namibia), and Dusky dolphin *Lagenorhynchus obscurus* (right) (Photo: scottelowitzphotography.com).

All whales and dolphins are given protection under the South African Law. The Marine Living Resources Act, 1998 (No. 18 of 1998) states that no whales or dolphins may be harassed, killed or fished. No vessel or aircraft may, without a permit or exemption, approach closer than 300 m to any whale and a vessel should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m from a vessel or aircraft.

Seals

The Cape fur seal (*Arctocephalus pusillus pusillus*) (Figure 3-23) is the only species of seal resident along the west coast of Africa, occurring at numerous breeding and non-breeding sites on the mainland and on nearshore islands and reefs (see **Error! Reference source not found.**). Vagrant records from four other species of seal more usually associated with the subantarctic environment have also been recorded: southern elephant (*Mirounga leoninas),* subantarctic fur (*Arctocephalus tropicalis),* crabeater *(Lobodon carcinophagus)* and leopard seals (*Hydrurga leptonyx)* (David 1989).

There are a number of Cape fur seal colonies within the broader study area: at Bucchu Twins and Cliff Point near Alexander Bay, at Kleinzee (incorporating Robeiland), and at Strandfontein Point (south of Hondeklipbaai). The colony at Kleinzee has the highest seal population and produces the highest seal pup numbers on the South African Coast (Wickens 1994). The colony at Buchu Twins, formerly a non-breeding colony, has also attained breeding status (M. Meyer, DAFF, pers. comm.). Non-breeding colonies occur south of Hondeklip Bay at Strandfontein Point and on Bird Island at Lamberts Bay, with the McDougall's Bay islands and Wedge Point being haul-out sites only and not permanently occupied by seals. The closest colony to the proposed prospecting area is located at Cliff Point, ~5 km south of the southern boundary if the proposed licence area.

All have important conservation value since they are largely undisturbed at present. Seals are highly mobile animals with a general foraging area covering the continental shelf up to 120 nautical miles offshore (Shaughnessy 1979), with bulls ranging further out to sea than females. The timing of the annual breeding cycle is very regular, occurring between November and January. Breeding success is highly dependent on the local abundance of food, territorial bulls and lactating females being most vulnerable to local fluctuations as they feed in the vicinity of the colonies prior to and after the pupping season (Oosthuizen 1991).

Figure 3-23: Colony of Cape fur seals *Arctocephalus pusillus pusillus* (Photo: Dirk Heinrich).

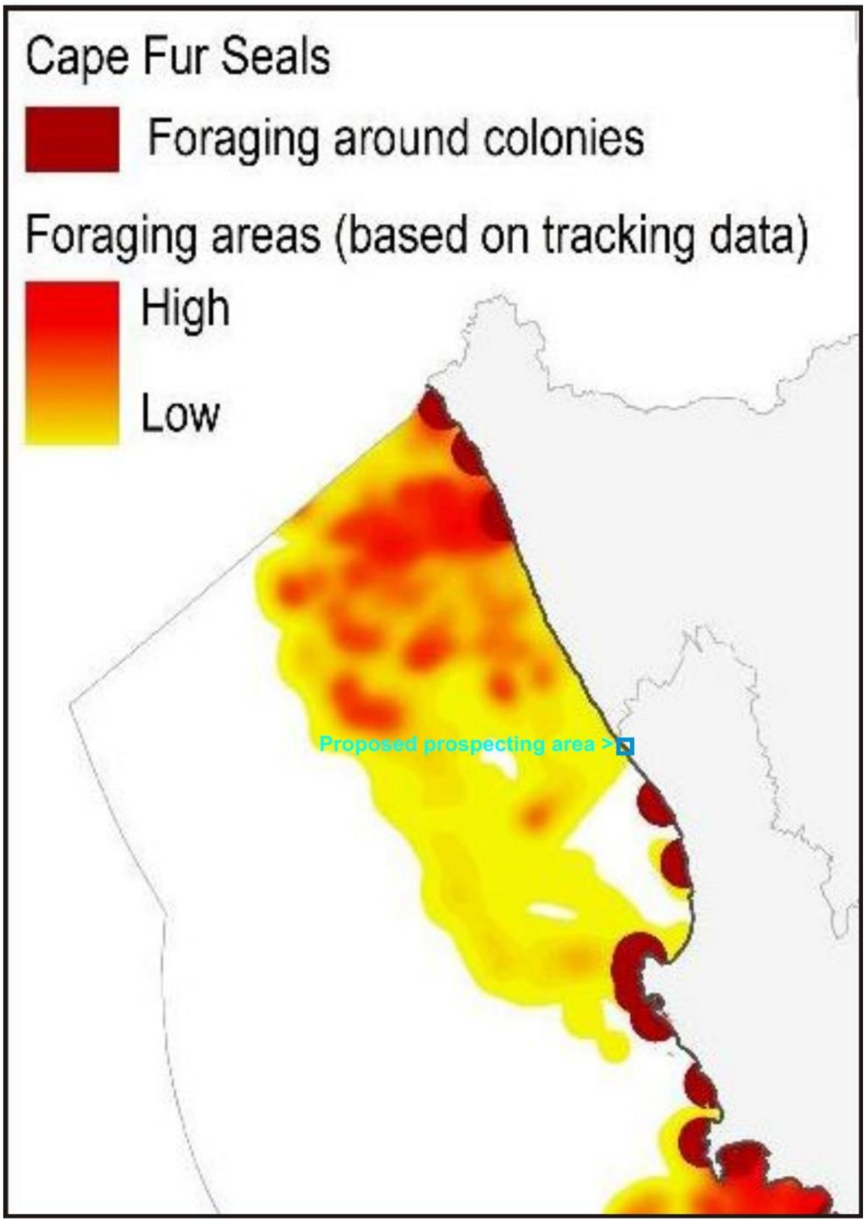

Figure 3-24: The proposed prospecting area (cyan square) in relation to seal foraging areas on the West and South Coasts. Brown areas are generalised foraging areas around colonies, and areas in shades of red are foraging areas based on tracking data. Darker shades of red indicate areas of higher use (Adapted from Harris *et al*. 2022).

3.4. Other Uses of the Area

3.4.1 Beneficial Uses

The proposed prospecting area extends from the high water mark to the edge of the surf zone at approximately -5 m depth. Other users of these areas include marine diamond mining contractors, the commercial and recreational fishing industries and a kelp collection concession.

3.4.1.1 Diamond Mining

The marine diamond mining concession areas are split into four or five zones (Surf zone and (a) to (c) or (d)-concessions), which together extend from the high water mark out to approximately 500 m depth (Figure 3-25). On the Namaqualand coast marine diamond mining activity is primarily restricted to the surf-zone and (a)-concessions, which extend to 1,000 m offshore of the high water mark. Nearshore shallow-water mining is typically conducted by divers using small-scale suction hoses operating either directly from the shore in small bays or from converted fishing vessels out to ~30 m depth. However, over the past few years there has been a substantial decline in small-scale diamond mining operations due to the global recession and depressed diamond prices. Some vessels still operate out of Alexander Bay and Port Nolloth, but activity out of Hondeklip Bay and Lambert's Bay has all but ceased. More recently (since 2020) there has been a renewed interest in some of the concessions around the Olifants River mouth, with numerous applications for geophysical surveys, sampling and bulk sampling being submitted. Interference with vessel-based mining or prospecting activities in adjacent concessions during the proposed prospecting and sampling operations is highly unlikely.

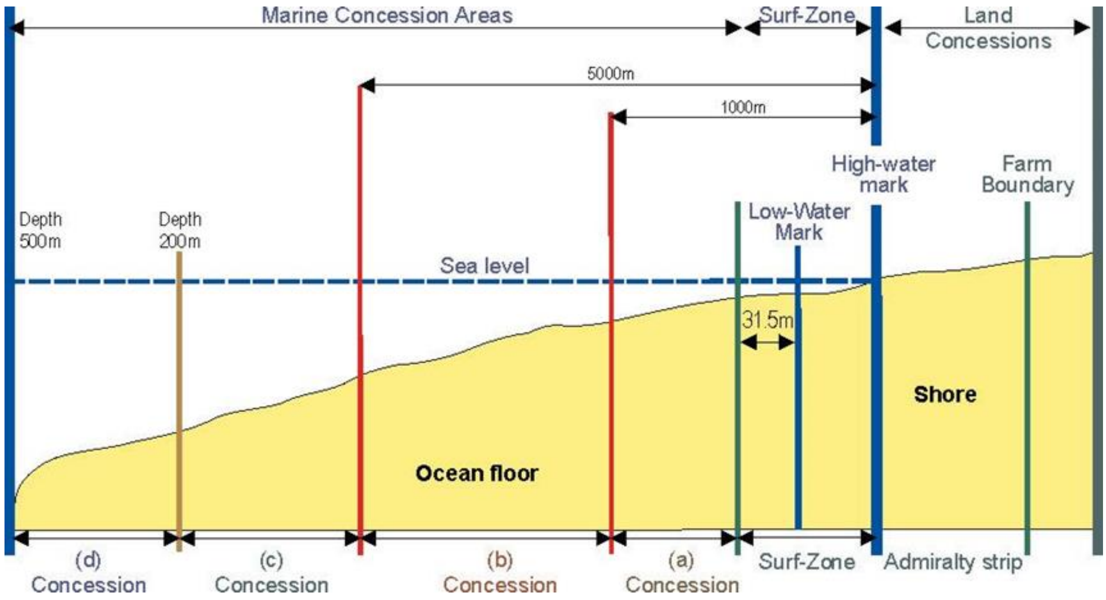

Figure 3-25: Diagram of the onshore and offshore boundaries of the South African (a) to (d) marine diamond mining concession areas.

3.4.1.2 Kelp Collecting

The West Coast is divided into numerous seaweed concession areas. The proposed prospecting area area falls within seaweed concession 14 held by Eckloweed Industries, which extends from Hartbeesklip to the Groen River mouth. Access to a seaweed concession is granted by means of a permit from the Fisheries Branch of the DFFE to a single party for a period of five years. The seaweed industry was initially based on sun dried beach-cast seaweed, with harvesting of fresh seaweed occurring in small quantities only (Anderson *et al*. 1989). The actual level of beach-cast kelp collection varies substantially through the year, being dependent on storm action to loosen kelp from subtidal reefs (Table 3-5). Permit holders collect beach casts of both *Ecklonia maxima* and *Laminaria pallida* from the driftline of beaches. The kelp is initially dried just above the high water mark before being transported to drying beds in the foreland dune area. The dried product is ground before being exported for production of alginic acid (alginate). In the areas around abalone hatcheries fresh beach-cast kelp is also collected as food for cultured abalone, although quantities have not been reported to the DFFE. Beach cast collections in concession 14 are provided in Table 3-5.

Table 3-5: Beach-cast collections (in kg dry weight) for kelp concessions north of Lamberts Bay (Data source: Seaweed Section, DFFE).

	Concession Number					
	13	14	15	16	18	19
2005	65,898	165,179	10,300	35,920	0	0
2006	94,914	145,670	19,550	28,600	0	0
2007	122,095	79,771	0	84,445	0	0
2008	61,949	204,365	23,646	16,804	0	0
2009	102,925	117,136	0	0	0	0
2010	53,927	166,106	0	0	0	0
2011	40,511	72,829	0	0	0	0
2012	43,297	151,561	160,500	156,000	0	0
2013	20,485	97,283	36,380	24,000	0	0
2014	19,335	136,266	74,300	75,743	0	0
2015	52,827	158,184	0	0	0	0
2016	69,363	154,010	0	0	0	0
2017	0	168,268	0	0	43,700	0
2018	3,000	148,560	0	0	34,053	216,900
2019	93,514	91,906	0	0	29,510	132,955
2020	22,758	29,747	0	0	0	90,885
2021	4,633	109,080	0	0	0	37,600
2022	7,164	0	0	0	0	0
2023	0	0	0	0	0	128,820

3.4.1.3 Rock Lobster Fishery

The West Coast rock lobster *Jasus lalandii* is a valuable resource of the South African West Coast and consequently an important income source for West Coast fishermen. Following the collapse of the rock-lobster resource in the early 1990s, fishing has been controlled by a Total Allowable Catch (TAC), a minimum size, restricted gear, a closed season and closed areas (Crawford *et al.* 1987, Melville-Smith *et al.* 1995). The fishery is divided into the offshore fishery (30 m to 100 m depth) and the near-shore fishery (< 30 m depth). Management of the resource is geographically specific, with the TAC annually allocated by Area. The Whale Head Minerals prospecting area falls within Management Area 1 of the commercial rock lobster fishing zones, which extends from the Orange River Mouth to Kleinzee. The fishery operates seasonally, with closed seasons applicable to different zones; Management Areas 1 and 2 operate from 1 October to 30 April.

Commercial catches of rock lobster in Zone A and Zone B are primarily confined to shallower water (<30 m) with almost all the catch being taken in <15 m depth. Actual rock-lobster fishing takes place only at discrete suitable reef areas along the shore within this broad depth zone.

Lobster fishing is conducted from a fleet of small dinghies/bakkies. The majority of these work directly from the shore within a few nautical miles of the harbours, with only 30% of the total numbers of bakkies partaking in the fishery being deployed from larger deck boats. As a result, lobster fishing tends to be concentrated close to the shore within a few nautical miles of Port Nolloth, Hondeklip Bay, Doring Bay and Lambert's Bay.

The proposed prospecting area falls within Area 3 of Zone B. Rock lobster landings from Zones A (Orange River to Brak River) and B (Brak River to ~20 km south of Elands Bay) for the years 2006 to 2022 are provided in

Table 3-6.

Table 3-6: Total Allowable Catch (TAC) and Actual landed catch (tons) for the nearshore sector in Zone A and Zone B in the Northern and Western Cape during the 2005/06 to 2021/2022 fishing seasons (Data source: Rock Lobster Section, DAFF). Data for the interim relief and small-scale sectors are also provided.

	Commercial Nearshore Sector			Interim relief and small-scale Sector		
Year	TAC (t)	Zone A (Area 1 & 2)	Zone B (Area 3 & 4)	TAC ZA + ZB (t)	Zone A (Area 1 & 2)	Zone B (Area 3 & 4)
2006	30	16	86			
2007	30	21	23			
2008	30	19	79			
2009	24.2	19	58			
2010	24.2	18	66			
2011	24.2	15	47			
2012	24.2	10	68			
2013	24.2	3	62			
2014	24.2	7	68	16 + 49		
2015	20	12	74	16 + 44.1		
2016	20	4	44	16 + 44.1		
2017	20	7	55	55 + 44.1	2.5	44.3
2018	20	1.1	31	16 + 44	4	34
2019	13	5	21	12.5 + 23.4	4	36
2020	13	5	20	12.5 + 23.4	9	34
2021	10.1	4	16	10.1 + 17.9	10	16
2022	9.07	2	9	9.07 + 16.3	9	11

3.4.1.4 Recreational Fisheries

Recreational and subsistence fishing on the West Coast is small in scale when compared with the south and east coasts of South Africa. The population density in Namaqualand is low, and poor road infrastructure and ownership of much of the land by diamond companies in the northern parts of the West Coast has historically restricted coastal access to the towns and recreational areas of Port Nolloth, McDougall's Bay, Hondeklipbaai and the Groenrivier mouth.

Recreational line-fishing is confined largely to rock and surf angling in places such as Brand-se-Baai, well to the south of the proposed prospecting area, and the more accessible coastal stretches in the regions. Boat angling is not common along this section of the coast due to the lack of suitable launch sites and the exposed nature of the coastline. Fishing effort has been estimated at 0.12 angler/km north of Doringbaai. These fishers expended effort of approximately 200,000 angler days/year with a catch-per-unit-effort of 0.94 fish/angler/day (Brouwer *et al*. 1997; Sauer & Erasmus 1997). Traget species consist mostly of hottentot, white stumpnose, kob, steenbras and galjoen, with catches being used for domestic consumption, or are sold.

Recreational rock lobster catches are made primarily by diving or shore-based fishing using baitbags. Hoop-netting for rock lobster from either outboard or rowing boats is not common along this section of the coast (Cockcroft & McKenzie 1997). Most of the recreational catch is made early in the season, with 60% of the annual catch landed by the end of January. The majority of the recreational take of rock lobster (~68%) is made by locals resident in areas close to the resource. Due to the remoteness of the area and the lack of policing, poaching of rock lobsters by the locals, seasonal visitors as well as the shore-based mining units is becoming an increasing problem. Large numbers of rock lobsters are harvested in sheltered bays along the Namaqualand coastline by recreational divers who disregard bag-limits, size-limits or closed seasons. This potentially has serious consequences for the sustainability of the stock in the area.

3.4.1.5 Mariculture

Although the Northern Cape coast lies beyond the northern-most distribution limit of abalone (*Haliotis midae*) on the West Coast, ranching experiments have been undertaken in the region since 1995 (Sweijd *et al*. 1998, de Waal & Cook 2001, de Waal 2004). As some sites have shown high survival of seeded juveniles, the Department of Agriculture, Forestry and Fisheries (DAFF) published criteria for allocating rights to engage in abalone ranching or stock enhancement (Government Gazette No. 33470, Schedule 2, 20 August 2010) in four areas along the Namaqualand Coast (

Table 3-7). Ranching in these areas is currently being investigated at the pilot phase.

Table 3-7: Allocated abalone ranching areas on the West Coast.

Area	Description	Latitude	Longitude	Rights Holder
NC1	Boegoeberg North	28°45′41.35″S	16°33′41.93″E	Turnover Trading
	Beach north of North Point	29°14′07.65″S	16°51′14.08″E	
NC2	South-end of McDougall Bay	29°17′34.23″S	16°52′32.08″E	Really Useful Investments No 72
	Rob Island	29°40′07.12″S	16°59′50.45″E	
NC3	Beach at Kleinzee	29°43′43.09″S	17°03′03.50″E	Port Nolloth Sea Farms
	Swartduine	30°02′52.04″S	17°10′39.69″E	
NC4	Skulpfontein	30°06′08.15″S	17°11′08.03″E	Diamond Coast Abalone
	2 rocks 200 m from shore	30°25′56.26″S	17°20′05.43″E	
WC1	Doring Bay	31°45′26.34″S	18°13′25.35″E	Doring Bay Abalone
	Strandfontein Bay	31°49′14.43″S	18°13′54.44″E	

Associated with the ranching projects are land-based abalone hatcheries located at North Point near Port Nolloth, at Kleinzee and at Hondeklipbaai. These hatcheries operate on a semirecirculation system using seawater pumped from the shallow subtidal zone to top-up the holding tanks (Anchor Environmental Consultants 2010).

These operations all lie well to the north of the proposed prospecting area and should in no ways be impacted by sampling operations.

3.4.2 Conservation Areas and Marine Protected Areas

Numerous conservation areas and marine protected areas (MPAs) exist along the West Coast, although these are all located to the north or south of Brand-se-Baai. For the sake of completeness, they are briefly described below.

3.4.2.1 Sanctuaries

Sanctuaries are considered a type of management area within South Africa's multi-purpose expanded MPA network in which access and/or resource use is prohibited. Sanctuaries in the vicinity of the project area in which restrictions apply are the McDougall's Bay, Stompneusbaai and Saldanha Bay rock lobster sanctuaries, which are closed to commercial exploitation of rock lobsters. These sanctuaries were originally proclaimed early in the 20th century under the Sea Fisheries Act of 1988 as a management tool for the protection of the West Coast rock lobster (Mayfield et al. 2005). There is no overlap of the proposed prospecting area with any of these sanctuaries.

3.4.2.2 Marine Protected Areas

'No-take' MPAs offering protection of the Namaqua biozones (sub-photic, deep-photic, shallow-photic, intertidal and supratidal zones) are absent northwards from Cape Columbine (Emanuel et al. 1992; Lombard et al. 2004). This resulted in substantial portions of the coastal and shelf-edge marine biodiversity in the area being assigned a threat status of 'Critically endangered', 'Endangered' or 'Vulnerable' in the 2011 NBA (Lombard et al. 2004; Sink et al. 2012). Using biodiversity data mapped for the 2004 and 2011 NBAs a systematic biodiversity plan was developed for the West Coast (Majiedt et al. 2013) with the objective of identifying both coastal and offshore priority areas for MPA expansion. Potentially vulnerable marine ecosystems (VMEs) that were explicitly considered during the planning included the shelf break, seamounts, submarine canyons, hard grounds, submarine banks, deep reefs and cold water coral reefs. To this end, nine focus areas were identified for protection on the West Coast between Cape Agulhas and the South African – Namibian border. These focus areas were carried forward during Operation Phakisa, which identified potential offshore MPAs. A network of 20 MPAs was gazetted on 23 May 2019, thereby increasing the ocean protection within the South African EEZ to 5%. The approved MPAs within the broader project area are described briefly below.

The **Namaqua National Park MPA**, located ~45 km north of the proposed prospecting area, provides the first protection to habitats in the Namaqua bioregion, including several 'critically endangered' coastal ecosystem types. The area is a nursery area for Cape hakes, and the coastal areas support kelp forests and deep mussel beds, which serve as important habitats for the West Coast rock lobster. This 500 km2 MPA was proclaimed in 2019, both to boost tourism to this remote area and to provide an important baseline from which to understand ecological changes (e.g. introduction of invasive alien marine species, climate change) and human impacts (harvesting, mining) along the West Coast. Protecting this stretch of coastline is part of South Africa's climate adaptation strategy.

The **Rocher Pan MPA**, located ~120 km south of the proposed prospecting area, stretches 500 m offshore of the high water mark of the adjacent Rocher Pan Nature Reserve, was declared in 1966. The MPA primarily protects a stretch of beach important as a breeding area to numerous waders.

Other offshore MPAs along the West Coast (e.g. Benguela Muds MPA and Cape Canyon MPA) are all located over 110 km offshore and south of the proposed prospecting area, with the Child's Bank MPA located ~140 km to the northwest.

3.4.2.3 Sensitive Areas

Despite the development of the offshore MPA network a number of 'Endangered' and 'Vulnerable' ecosystem types are currently 'not well protected' and further effort is needed to improve protection of these threatened ecosystem types (Sink et al. 2019) (Figure 3-26, right). Ideally, all highly threatened ('Critically Endangered' and 'Endangered') ecosystem types should be well protected. Currently, however, most of the Namaqua Sandy Mid Shelf and Namaqua Muddy Mid Shelf Mosaic are poorly protected receiving only 0.2-10% protection (Sink et al. 2019). Within concession 12B, the ecosystem types are all considered 'poorly protected'.

3.4.2.4 Ecologically or Biologically Significant Areas

As part of a regional Marine Spatial Management and Governance Programme (MARISMA 2014-2020), the Benguela Current Commission (BCC) and its member states have identified a number of Ecologically or Biologically Significant Areas (EBSAs) both spanning the border between Namibia and South Africa and along the South African West, South and East Coasts, with the intention of implementing improved conservation and protection measures within these sites. South Africa currently has 12 EBSAs solely within its national jurisdiction with a further three having recently been proposed. It also shares eight trans-boundary EBSAs with Namibia (3), Mozambique (2) and the high seas (3). The principal objective of these EBSAs is identification of features of higher ecological value that may require enhanced conservation and management measures. They currently carry no legal status. The impact management and conservation zones within the EBSAs are under review and currently constitute a subset of the biodiversity priority areas map (see next section); EBSA conservation zones equate to Critical Biodiversity Areas (CBAs), whereas impact management zones equate to Ecological Support Area (ESAs). The relevant sea-use guidelines accompanying the CBA areas would apply.

The following summaries of the EBSAs in the broader project area are adapted from http://cmr.mandela.ac.za/EBSA-Portal/Namibia/. The proposed prospecting area falls within the transboundary Benguela Upwelling System EBSA and lies south of the southern portion of the Namaqua Coastal Area EBSA (Figure 3-26, left). The text and figures below are based on the EBSA status as of October 2020 (MARISMA EBSA Workstream 2020).

Figure 3-26: The proposed prospecting area (red polygon) in relation to the location of Ecologically and Biologically Significant Areas (EBSAs) (left) and to the protection levels of 150 marine ecosystem types as assessed by Sink *et al.* (2019).

The **Benguela Upwelling System** EBSA is a transboundary EBSA and is globally unique as the only cold-water upwelling system to be bounded in the north and south by warm-water current systems, and is characterized by very high primary production (>1,000 mg $C.m^{-2}.day^{-1}$). It includes important spawning and nursery areas for fish as well as foraging areas for threatened vertebrates, such as sea- and shorebirds, turtles, sharks, and marine mammals. Another key characteristic feature is the diatomaceous mud-belt in the Northern Benguela, which supports regionally unique low-oxygen benthic communities that depend on sulphide oxidising bacteria.

The **Namaqua Coastal Area** EBSA encompasses the Namaqua Coastal Area MPA and is characterized by high productivity and community biomass along its shores. The area is important for several threatened ecosystem types represented there, including two 'Endangered' and four 'Vulnerable' ecosystem types, and is important for conservation of estuarine areas and coastal fish species. There is no overlap of the proposed prospecting area with this EBSA (see Figure 3-26).

3.4.2.5 Biodiversity Priority Areas

The National Coastal and Marine Spatial Biodiversity Plan[1] comprises a map of Critical Biodiversity Areas (CBAs), Ecological Support Area (ESAs) and accompanying sea-use guidelines. The CBA Map

[1] The latest version of the National Coastal and Marine Spatial Biodiversity Plan (v1.2 was released in April 2022) (Harris *et al.* 2022). The Plan is intended to be used by managers and decision-makers in those national government departments whose activities occur in the coastal and marine space, e.g., environment, fishing, transport (shipping), petroleum, mining, and others. It is relevant for the Marine Spatial Planning Working Group where many of these departments are participating in developing South Africa's emerging marine spatial plans. It is also intended for use by relevant managers and decision-makers in the coastal provinces and coastal

presents a spatial plan for the marine environment, designed to inform planning and decision-making in support of sustainable development. The sea-use guidelines enhance the use of the CBA Map in a range of planning and decision-making processes by indicating the compatibility of various activities with the different biodiversity priority areas so that the broad management objective of each can be maintained. The intention is that the CBA Map (CBAs and ESAs) and sea-use guidelines inform the MSP Conservation Zones and management regulations, respectively.

The proposed prospecting area overlaps with areas mapped as Critical Biodiversity Area 1 Natural (CBA 1N), Critical Biodiversity Area 1 Restore (CBA 1R), Critical Biodiversity Area 2 Natural (CBA 2N) and Critical Biodiversity Area 2 Restore (CBA 2R). CBA 1 indicates irreplaceable or near-irreplaceable sites that are required to meet biodiversity targets with limited, if any, option to meet targets elsewhere, whereas CBA 2 are "best design sites" and there are often alternative areas where feature targets can be met; however, these will be of higher cost to other sectors and/or will be larger areas.

Regardless of how CBAs are split, CBAs are generally areas of low use and with low levels of human impact on the marine environment but can also include some moderately to heavily used areas with higher levels of human impact. Given that some CBAs are not in natural or near-natural ecological condition, but still have very high biodiversity importance and are needed to meet biodiversity feature targets, CBA 1 and CBA 2 were split into two types based on their ecological condition. CBA Natural sites have natural / near-natural ecological condition, with the management objective of maintaining the sites in that natural / near natural state; and CBA Restore sites have moderately modified or poorer ecological condition, with the management objective to improve ecological condition and, in the long-term, restore these sites to a natural/near-natural state, or as close to that state as possible. ESAs include all portions of EBSAs that are not already within MPAs or CBAs, and a 5-km buffer area around all MPAs (where these areas are not already CBAs or ESAs), with the exception of the eastern edge of Robben Island MPA in Table Bay where a 1.5-km buffer area was applied (Harris *et al.* 2022).

Activities within these management zones are classified into those that are "compatible", those that are "not compatible", and those that have "restricted compatibility" subject to certain conditions. Non-destructive prospecting activities are classified as having "restricted compatibility", subject to certain conditions, in CBAs and ESAs. **Destructive prospecting activities with localised impact, e.g. bulk sampling, are considered "not compatible" in CBA Natural and CBA Restore areas** and as having "restricted compatibility" within ESAs. Mining construction and operations are similarly classified as being "not compatible" in CBA Natural and CBA Restore areas but as having "restricted compatibility" within ESAs (Harris *et.al.* 2022). These zones have been incorporated into the most recent iteration of the national Coastal and Marine CBA Map (v1.2 released April 2022) (Harris *et al.* 2020) (Figure 3-27).

Overlap with CBA 1: Natural and CBA 2: Natural accounts for 21.5% and 0.77% of the proposed prospecting area, respectively (Figure 3-27), whereas overlap with CBA 1: Restore and CBA 2: Restore accounts for 53.3% and 2.63%, respectively.

municipalities, EIA practitioners, organisations working in the coast and ocean, civil society, and the private sector.

3.4.2.6 Important Bird Areas (IBAs) and RAMSAR Sites

There are a number of coastal Important Bird Areas (IBAs) in the general project area (Table 3-8) (https://maps.birdlife.org/marineIBAs), but none overlap with the proposed prospecting area.

Various marine IBAs have also been proposed in South African territorial waters, with a candidate marine IBA suggested off the Orange River mouth and a further candidate marine IBA suggested in international waters west of the Cape Peninsula (Figure 3-28). The proposed prospecting area falls within the proposed Bird Island / Dassen Island / Heuningnes river and estuary system / Lower Berg river wetlands marine IBA.

Table 3-8: List of confirmed coastal Important Bird Areas (IBAs) and their criteria listings. (www.BirdLife.org.za). Those incorporating or listed as RAMSAR sites are shaded.

Site Name	IBA Criteria
Orange River Mouth Wetlands (ZA023)	A1, A3, A4i, A4iii
Olifants River Estuary (ZA078)	A3, A4i
Verlorenvlei Estuary (ZA082)	A4i
Berg River Estuary (ZA083)	A4i
West Coast National Park and Saldanha Bay Islands (ZA 084) (incorporating Langebaan RAMSAR site)	A1, A4i, A4ii, A4iii

A1. Globally threatened species
A2. Restricted-range species
A3. Biome-restricted species
A4. Congregations
- **i.** applies to 'waterbird' species
- **ii.** This includes those seabird species not covered under i.
- **iii.** modelled on criterion 5 of the Ramsar Convention for identifying wetlands of international importance. The use of this criterion is discouraged where quantitative data are good enough to permit the application of A4i and A4ii.

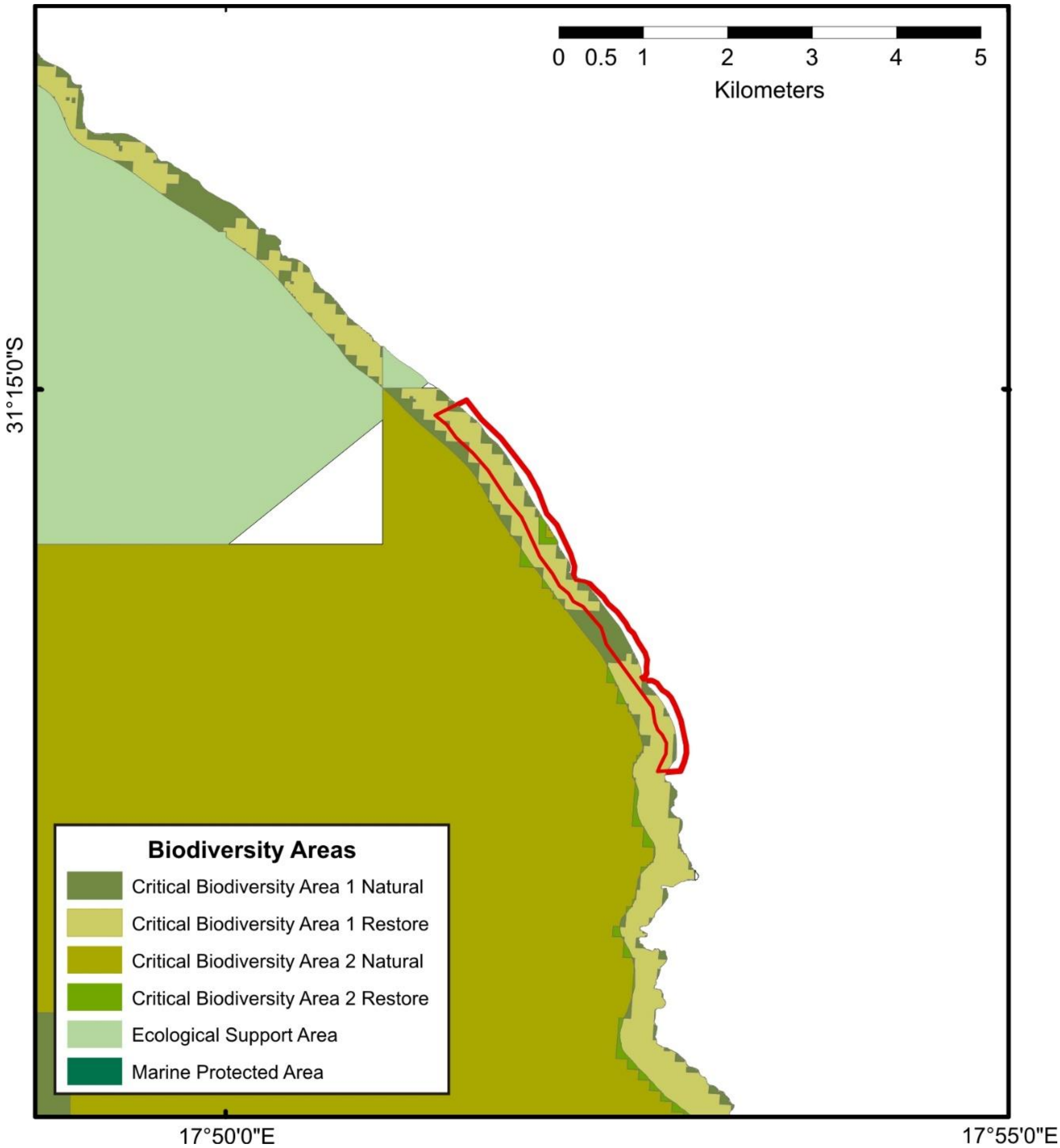

Figure 3-27: The proposed prospecting area (red polygon) in relation to Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) (Version 1.2) (Harris *et al*. 2022).

A Ramsar site is considered wetland designated to be of international importance under the Ramsar Convention, also known as "The Convention on Wetlands", an intergovernmental environmental treaty established by UNESCO in 1971. The convention entered into force in South Africa on 21 December 1975. It provides for national action and international cooperation regarding the conservation of wetlands, and wise sustainable use of their resources. South Africa currently has 27 sites designated as Ramsar Sites, with a surface area of 571,089 hectares.

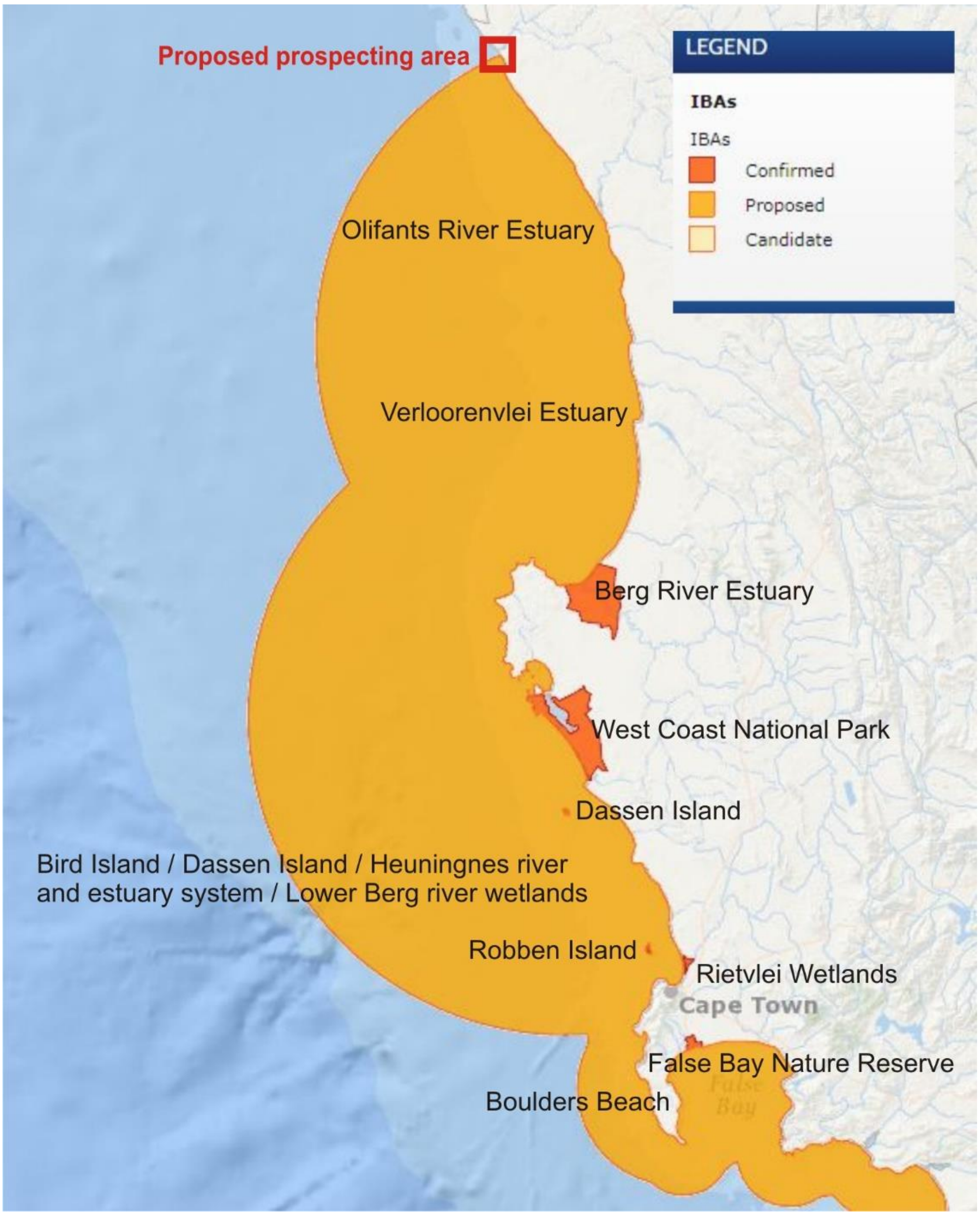

Figure 3-28: The proposed prospecting area (red polygon) in relation to coastal and marine IBAs (Source: https://maps.birdlife.org/marineIBAs).

2.4.2.7 Important Marine Mammal Areas (IMMAs)

Important Marine Mammal Areas (IMMAs) were introduced in 2016 by the IUCN Marine Mammal Protected Areas Task Force to support marine mammal and marine biodiversity conservation. Complementing other marine spatial assessment tools, including the EBSAs and Key Biodiversity Areas (KBAs), IMMAs are identified on the basis of four main scientific criteria, namely species or population vulnerability, distribution and abundance, key life cycle activities and special attributes. Designed to capture critical aspects of marine mammal biology, ecology and population structure, they are devised through a biocentric expert process that is independent of any political and socio-economic pressure or concern. IMMAs are not prescriptive but comprise an advisory, expert-based classification of areas that merit monitoring and place-based protection for marine mammals and broader biodiversity.

Modelled on the BirdLife International process for determining IBAs, IMMAs are assessed against a number of criteria and sub-criteria, which are designed to capture critical aspects of marine mammal biology, ecology and population structure. These criteria are:

Criterion A - Species or Population Vulnerability

Areas containing habitat important for the survival and recovery of threatened and declining species.

Criterion B - Distribution and Abundance

<u>Sub-criterion B1</u> – Small and Resident Populations: Areas supporting at least one resident population, containing an important proportion of that species or population, that are occupied consistently.

<u>Sub-criterion B2</u> – Aggregations: Areas with underlying qualities that support important concentrations of a species or population.

Criterion C - Key Life Cycle Activities

<u>Sub-criterion C1</u> – Reproductive Areas: Areas that are important for a species or population to mate, give birth, and/or care for young until weaning.

<u>Sub-criterion C2</u> – Feeding Areas: Areas and conditions that provide an important nutritional base on which a species or population depends.

<u>Sub-criterion C3</u> – Migration Routes: Areas used for important migration or other movements, often connecting distinct life-cycle areas or the different parts of the year-round range of a non-migratory population.

Criterion D - Special Attributes

<u>Sub-criterion D1</u> – Distinctiveness: Areas which sustain populations with important genetic, behavioural or ecologically distinctive characteristics.

<u>Sub-criterion D2</u> – Diversity: Areas containing habitat that supports an important diversity of marine mammal species

Although much of the West Coast of South Africa has not yet been assessed with respect to its relevance as an IMMA, the coastline from the Olifants River mouth on the West Coast to the Mozambiquan border overlaps with three declared IMMAs (Figure 3-29) namely the

- Southern Coastal and Shelf Waters of South Africa IMMA (166,700 km^2),

- Cape Coastal Waters IMMA (6,359 km^2), and
- South East African Coastal Migration Corridor IMMA (47,060 km^2).

These are described briefly below based on information provided in IUCN-Marine Mammal Protected Areas Task Force (2021) (www.marinemammalhabitat.org).

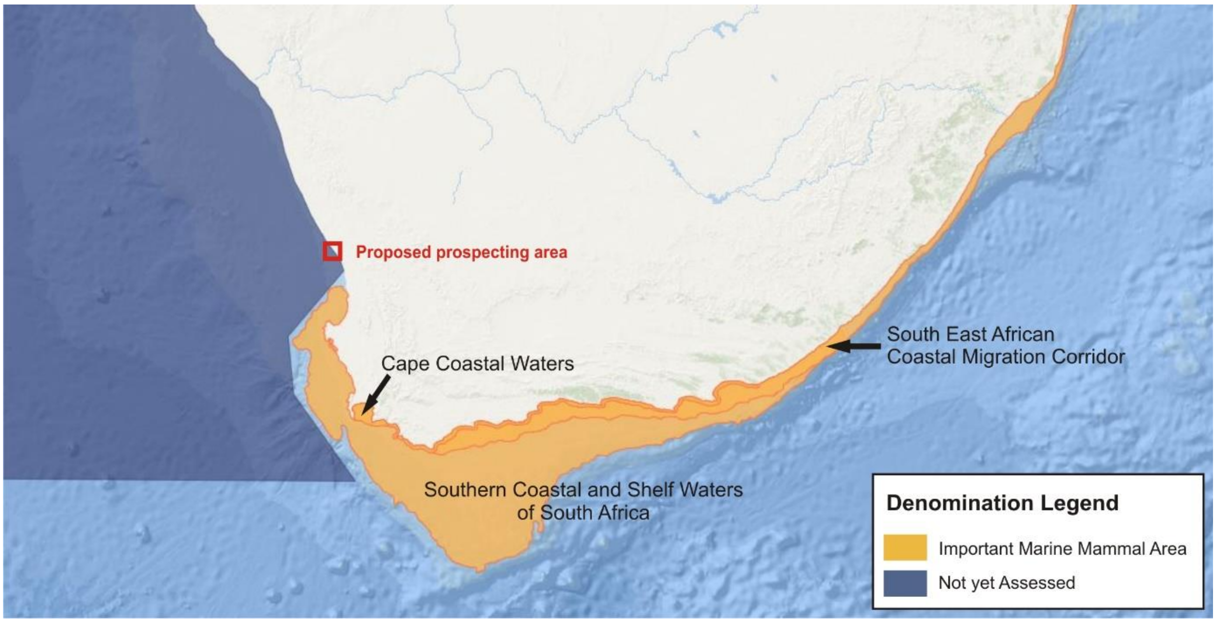

Figure 3-29: Concession 12B (red polygon) in relation to coastal and marine IMMAs (Source: www.marinemammalhabitat.org/imma-eatlas/).

The 166,700 km^2 Southern Coastal and Shelf Waters of South Africa IMMA extends from the Olifants River mouth to the mouth of the Cintsa River on the Wild Coast. Qualifying species are the Indian Ocean Humpback dolphin (Criterion A, B1), Bryde's whale (Criterion C2), Indo-Pacific bottlenose dolphin (Criterion B1, C3, D1), Common dolphin (Criterion C2) and Cape fur seal (criterion C2). The IMMA covers the area supporting the important 'sardine run' and the marine predators that follow and feed on the migrating schools (Criterion C2) as well as containing habitat that supports an important diversity of marine mammal species (Criterion D2) including the Indian Ocean humpback dolphin, the inshore form of Bryde's whale, Indo-Pacific bottlenose dolphin, common dolphin, Cape fur seal, humpback whales, killer whales and southern right whales.

The Cape Coastal Waters IMMA extends from Cape Point to Woody Cape at Algoa Bay and extends over some 6,359 km^2. It serves as one of the world's three most important calving and nursery grounds for southern right whales, which occur in the extreme nearshore waters (within 3 km of the coast) from Cape Agulhas to St. Sebastian Bay between June and November (Criterion B2, C1). Highest densities of cow-calf pairs occur between Cape Agulhas and the Duivenhoks River mouth (Struisbaai, De Hoop, St Sebastian Bay), while unaccompanied adult densities peak in Walker Bay and False Bay. The IMMA also contains habitat that supports an important diversity of marine mammal species including the Indian Ocean humpback dolphin and Indo-Pacific bottlenose dolphin.

The South East African Coastal Migration Corridor IMMA extends some 47,060 km^2 from Cape Agulhas to the Mozambiquan border and serves as the primary migration route for C1 substock of Southern Hemisphere humpback whales (Criterion C3). On their northward migration between June and August, they are driven closer to shore due to the orientation of the coast with the Agulhas Current, whereas during the southward migration from September to November, they remain further offshore (but generally within 15 km of the coast) utilising the southward flowing Agulhas Current as far west as Knysna. The IMMA also contains habitat that supports an important diversity of marine mammal species including the Indian Ocean humpback dolphin, Common dolphin, Indo-Pacific bottlenose dolphin, Spinner dolphin, Southern Right whale, and killer whale.

There is no overlap of the project area with the IMMAs.

4. IDENTIFICATION AND ASSESSMENT OF IMPACTS OF PROSPECTING FOR ALLUVIAL DIAMONDS WITH BULK SAMPLING ON MARINE FAUNA

This chapter describes and assesses the significance of potential direct and indirect impacts related to the proposed diamond prospecting activities with bulk sampling in the Brand-se-Baai area. All impacts are assessed according to the rating scale defined in Section 1.2.2. Where appropriate, mitigation measures are proposed, which could ameliorate the negative impacts or enhance potential benefits, respectively. The significance of impacts with and without mitigation is assessed.

4.1. Identification of Impacts

Beaches are highly suitable for a wide variety of human uses, ranging from recreational pedestrian traffic, through large-scale beachfront developments to intensive seawall mining as practiced in southern Namibia. All of these activities, as well as storm events and other natural processes, can alter the physical characteristics of the beaches resulting in temporary or permanent alterations in faunal communities inhabiting them (McLachlan *et al.* 1994; Defeo & Alava 1995; Alonso *et al.* 2002; Borges *et al.* 2002; Brown & McLachlan 2002; Gomez-Pina *et al.* 2002). Such changes may alter the manner in which beaches function as an interface between the marine and terrestrial environments, either in terms of their physical behaviour or their role in nutrient cycling. The magnitude of the impact depends on an interactive balance between the relative sensitivity of particular beaches to physical disturbance and the degree of anthropogenic disturbance imposed.

The most sensitive part of the littoral active zone is the fore-dune area, which is the beach/dune interface (Brown & McLachlan 2002). Fore or primary dunes (the small sparsely vegetated dunes just above the drift line), as well as the stabilised, large secondary dunes, are a transition zone between the physically and biologically different terrestrial habitats, and surf-zone processes. As this specialist report focuses on the intertidal beach area below the high water mark, the dune/cliff area falls outside of the scope of this study.

Certain beaches are comparatively sheltered and naturally undisturbed, and their faunal communities are typically sensitive to anthropogenic physical disturbance. In contrast, other beaches are exposed to substantial natural environmental disturbance (wind, wave and tidal impacts), and they and their faunal communities are robust to such disturbance (Brown & McLachlan 2002). Sandy beaches facing open oceans are highly dynamic and their associated faunal communities naturally variable, particularly over short to medium time frames (tidal cycles, storm events, seasons or inter-annual weather changes) (McLachlan 1980; Souza & Gianuca 1994; Calliari *et al.* 1996). On such dynamic beaches, it is often difficult to identify trends in beach faunal community structure over and above natural variation, particularly those due to anthropogenic disturbance.

Although this assessment relates to prospecting and bulk sampling only, it must be kept in mind that a number of environmental issues of concern have been raised around cofferdam and beach mining, particularly when non-native material is used to construct the protective seawalls/berms.

The proposed prospecting for diamonds with bulk sampling may potentially result in a number of direct and indirect impacts on the marine biota of the beach itself and of the shallow subtidal habitats opposite the cliffed coast, as well as those in adjacent marine habitats. More specifically, these include:

- Crushing of invertebrate beach macrofauna through heavy vehicle traffic, plant infrastructure and pipelines;
- Disturbance or loss of invertebrate beach macrofauna through excavation and processing of sands;
- Changes in the sediment particle size distribution on the beach, in the surf zone and the shallow subtidal with concomitant changes in beach profile and morphodynamic state;
- Changes in invertebrate macrofaunal community composition in response to physical changes in the beach;
- Smothering of invertebrate beach macrofauna as a consequence of tailings discharges;
- Increased turbidity in the surf-zone opposite the prospecting site through suspension of sediments with potential effects on phytoplankton production and foraging efficiency of higher order consumers;
- Potential indirect impacts on adjacent rocky shores through mobilisation and re-deposition of sediments;
- Habitat deterioration through littering, pollution and accidental spills; and
- Effects on other users of the marine environment as a result of prospecting operations on the beach, in the surf zone and in the shallow subtidal area.

Although the proposed destructive prospecting operations will occur at a much smaller scale, impacts remain similar to those resulting from mining and will thus be evaluated in the light of information from studies on beach mining conducted in southern Namibia, and on the Namaqualand and Western Cape coasts, and from the scientific literature, and in the context of the short-and long-term natural disturbances characterising the nearshore marine environment in the Benguela region.

Interaction of these activities with the receiving environment gives rise to a number of environmental aspects, which in turn may result in potential impacts. The identified aspects and their potential impacts are summarised below:

- Physical disturbance and alteration of the supratidal, intertidal, shallow subtidal sandy and rocky habitats, and offshore unconsolidated sediments

  Supratidal:

  – Disturbance and alteration of supratidal habitats and loss of associated dune and coastal vegetation and biota through:

    > crushing and compacting by vehicles and heavy equipment,

    > trampling by personnel, and

    > loss of terrestrial resources through illegal plant collection.

  Intertidal and shallow sub-tidal:

  – Disturbance and alteration of intertidal and shallow subtidal habitats and loss of associated benthic biota through:

    > construction of berms using overburden materials,

> removal of sediments and changes in the sediment particle size distribution on the beach,
> smothering by discarded coarse tailings,
> crushing by tractors and machinery,
> trampling by mining personnel,
> loss of terrestrial and marine living resources through illegal plant collection, fishing, and gathering of intertidal organisms.

Nearshore

- Disturbance and loss of benthic biota and alteration of the seabed in coastal waters through removal of sediments during prospecting and sampling,
- Disturbance and alteration of nearshore habitats and the associated communities through smothering by discarded tailings,
- Crushing of benthic biota during removal of sediments.

- Accumulation of coarse tailings in the intertidal zone
  - Smothering of beach and shallow seabed habitat and associated benthic fauna,
  - Reduced physiological functioning of marine organisms due to the biochemical effects on the water column and seabed sediments.
- Discharge of fine tailings from classifiers
  - Increased water turbidity and reduced light penetration,
  - Reduced physiological functioning of marine organisms due to the biochemical effects on the water column and seabed sediments.
- Increase in atmospheric noise levels by mining machinery
  - Disturbance / behavioural changes of coastal and marine fauna,
  - Avoidance of key feeding areas ,
  - Effects on key breeding areas (e.g. coastal birds and cetaceans),
  - Abandonment of nests (birds) and young (birds and seals).
- Discharge of wastes to sea from prospecting operations, and local reduction in water quality
  - Reduced physiological functioning of marine organisms due to the biochemical effects on the water column and seabed sediments,
  - Increased food source for marine fauna,
  - Fish aggregation and increased predator-prey interactions.
- Localised reduction in water quality due to accidental release of fuel into the sea, discharge of fuel during bunkering and discharge of hydraulic fluid due to pipe rupture
  - Toxic effects on marine biota and reduced faunal health.

4.2. Assessment of Impacts

The impacts of marine diamond mining activities on marine benthic communities have been comprehensively investigated over the past 20 years thereby providing a good understanding of the potential impacts that might be expected from beach mining activities. The identified environmental aspects and the related potential impacts are discussed and assessed below using information from the available literature.

4.2.1 IMPACT 1: Physical disturbance of habitats

By its very nature, prospecting for and bulk sampling of diamonds results in the physical disturbance of the shoreline and seabed. As the magnitude and extent of the disturbance is dependent both on the location of the target ores and the sampling/mining approach, these will be discussed separately below.

These activities and their associated aspects are described below:

- Shore-based contractors operational in the intertidal areas and surf zones typically establish tracks in the coastal zone to permit access to their prospecting areas by vehicles, tractors and heavy equipment.
- Poaching of marine resources and illegal collecting of succulents by mining personnel.
- Mining infrastructure and equipment may be left on site following completion of sampling operations, or if the equipment becomes derelict.

IMPACT 1A: ***Disturbance and loss of supratidal[1] habitats and associated biota***

Impact assessment

The impacts associated with prospecting or mining activities in the coastal zone all result in severe scarring of the landscape, compaction of surface soils, destabilisation of dunes, disturbance and/or destruction of plant communities, and degradation of faunal communities dependant on the affected vegetation. Any biota present in the footprint of the parking area(s) and high-shore processing area is likely to be crushed and trampled by vehicle activities and personnel.

The degree of impact associated with access tracks and mining camps depends on the scale of the prospecting/mining activity and the type of terrain disturbed. Construction of camps, infrastructure and access routes results in localised removal of vegetation, which can potentially lead to soil erosion and removal of topsoil and its associated plant seed bank depending on where the camps, infrastructure and access routes are located. While actively forming soils tend to support rugged pioneer plant communities, which are typically dynamic and resilient to disturbances, older, more stable soils harbour established terrestrial plant communities more sensitive to disturbance of the soil equilibrium. Such plant communities and their dependent fauna usually only recover over the long term following disturbance of the soil equilibrium. The indiscriminate storage of mining equipment and vehicles, the location of camps and vehicle parking areas, and proliferation of informal tracks can also damage vegetation and lead to compaction of soil and uncontained erosion of access roads, thus hampering the re-establishment

[1] The supratidal zone lies above the mean high water spring tide mark and is only occasionally inundated by water during exceptional tides or by tides augmented by storm surges.

of vegetation. Where access roads to sampling/mining sites traverse dunes, the crushing and destruction of dune vegetation can affect dune stability and dynamics, potentially leading to wind erosion and the creation of blow-outs. The fore-dune area (the small sparsely vegetated dunes just above the drift line) in particular, is the most sensitive part of the littoral active zone as it serves as a transition zone between the physically and biologically different terrestrial habitats, and surf zone processes (Brown & McLachlan 2002). As such, individual beaches may develop specific characteristics, resulting from local physical conditions, and the resultant faunal and floral communities are adapted to these specific characteristics.

Poaching of wildlife and marine resources, and illegal succulent collecting by mining personnel have also been identified as major threats to the coastal flora and fauna (Newton & Chan 1998; Burke & Raimondo 2002). Mining infrastructure and discarded equipment left on site also hinders recovery of the arid terrestrial ecosystems, as well as resulting in severe aesthetic impacts.

Impacts associated with the disturbance of supratidal habitats would be of high intensity, but remain localised around the contractor site. Due to the sensitivity of the coastal habitats to disturbance, impacts would persist over the medium- to long term and be only partially reversible. The likelihood of impacts to coastal vegetation and biota is highly probable and any adverse effects on coastal biota are considered of **MEDIUM** significance without mitigation and LOW significance with mitigation.

Destruction and loss of coastal vegetation and biota		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Construction and Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change (High)	Moderate change (Medium)
Duration	Long-term (10 to 20 years)	Medium-term (5 to 10 years)
Extent	Whole site and nearby surroundings	Within / near site
Consequence	Medium	Low
Probability	Probable (High)	Probable (High)
Significance	Medium	**Low**
Additional Assessment Criteria		
Degree to which impact can be reversed	*Partially Reversible*	
Degree to which impact may cause irreplaceable loss of resources	*Medium as some sensitive habitats may be permanently lost*	
Degree to which impact can be avoided	*Medium as coastal zone also impacted by other users*	
Degree to which impact can be mitigated	*Medium as coastal zone also impacted by other users*	
Cumulative Impact		
Extent to which a cumulative impact may arise	*Likely*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Very high	**Medium**

Residual Impact Assessment

With the implementation of the mitigation measures, the residual impact of potential destruction and loss of coastal vegetation and biota would reduce to LOW.

Management objectives, mitigation actions/measures and monitoring

<table>
<tr><th>Management objective</th><td>Minimise impact to coastal vegetation and biota</td></tr>
<tr><th colspan="2">Mitigation actions/measures</th></tr>
<tr><td colspan="2">Prepare site-specific Environmental Code of Practice (ECOP) for each contractor. The ECOP should include specific details for the following aspects:
– Environmental considerations (i.e. identification of sensitive receptors) and establishment of no-go areas
– Access route(s) to the allocated prospecting area
– Extent of prospecting area and demarcation of the campsite and processing area(s), and refuelling / maintenance areas
– Housing keeping:
> Use of drip trays under stationary plant and for refuelling and maintenance activities
> Use and maintenance of toilet facilities
> Bunding of fuel stores
> Demarcation of refuelling and maintenance areas
– Waste management, including the removal of all facilities, waste and other features established during prospecting activities
– Rehabilitation specification (if necessary), e.g. topsoil management, reshaping, netting, etc.
– Establishment of a rehabilitation fund
– Monitoring</td></tr>
<tr><td colspan="2">Use only established tracks and roads, as far as possible, to access allocated prospecting sites to avoid the creation of new tracks. When prospecting moves along the coast within a prospecting right area and no tracks or roads exist parallel to the coast, access should be undertaken below the HWM when on sandy / beach areas.</td></tr>
<tr><td colspan="2">Identify and map the required existing tracks and develop a maintenance and rehabilitation program that ensures that necessary tracks are maintained. Permitted tracks are to be marked as such and all duplicate tracks leading to prospecting sites should be closed and rehabilitated.</td></tr>
<tr><td colspan="2">Avoid the establishment of processing areas or camps within 100 m of the edge of a river channel or estuary mouth.</td></tr>
<tr><td colspan="2">Locate processing areas or camps, as far as possible in previously disturbed areas or areas of least sensitivity.</td></tr>
<tr><td colspan="2">Limit the processing area and campsite to the minimum reasonably required and to that which will cause least disturbance to the vegetation and natural environment. The extent of the sites should be clearly demarcated (e.g. with droppers).</td></tr>
<tr><td colspan="2">Do not collect any plants within the prospecting area</td></tr>
</table>

Undertake Environmental Awareness Training to ensure personnel are appropriately informed of the purpose and requirements of the Environmental Management Progamme Report (EMPr) and Environmental Code of Operational Practice (ECOP).
Before the commencement of any work on site, the contractor's site staff must attend an environmental awareness-training course presented by the Environmental Manager/Officer. The contractor must keep records of all environmental training sessions, including names of attendees, dates of their attendance and the information presented to them.
Prior to the contractor leaving the site and/or moving to a new site, the area must be audited by the Environmental Manager/Officer. Only once the Environmental Manager/Officer is satisfied that the area has been suitably cleaned and rehabilitated should the rehabilitations funds be paid back to the contractor.

IMPACT 1B: ***Disturbance and loss of intertidal and shallow subtidal habitats and associated biota***

Prospecting and bulk sampling targets for beach mining operations in the intertidal and surf zones are located in bedrock features underlying modern beach sands, extending through the intertidal zone into the immediate nearshore subtidal areas. The diamondiferous deposits would be bulk sampled within the confines of a berm constructed from overburden stripped from the beach. The berm is constantly maintained while the impounded area is pumped dry and the target gravels are extracted by bucket-shovel, and stockpiled before being fed into a feed-hopper/classifier. Once bulk sampling at a specific site is completed, the berm is actively or naturally breached by wave action. As the use of non-native material for the construction of berms on beach or rocky shorelines significantly changes the nature of the original shoreline, this practice will not be undertaken but potential impacts are included in the assessments below.

Impact assessment

The excavators used as the prospecting tool would primarily be implemented below the high water mark and into the surf zone of the target beach, which is classified primarily as Southern Benguela Intermediate Sandy Shore, with some representation of Namaqua Mixed Shore and has been identified as 'near threatened' and 'vulnerable', respectively (Sink *et al*. 2019). The building of berms on either sandy or mixed shores would effectively disturb, damage or likely completely eliminate any supratidal, intertidal and subtidal biota in the footprint of the excavators tracks and berm and in the target sampling area. Tailings discarded back onto the beach from the plant would smother invertebrate epifauna and infauna in the intertidal and surf zone sediments (see Impact 2A). Although not directly targeted by the prospecting, the biota associated with the rocky outcrops on the southern and northern extremes of the beach, may be indirectly affected through sediment scouring and smothering following mobilisation and re-deposition of sediments eroded from the berms.

By disrupting and turning over the natural sediment structure in the intertidal zone, the nature of the intertidal area is altered thereby potentially resulting in shifts in benthic community structure, with potential knock-on effects on higher order consumers who rely on the intertidal organisms as a food source. Further indirect impacts may include localised changes in long-shore wave patterns resulting in increased erosion of the beaches down current (to the north) of the berms. Assuming that berms are actively breached at the end of operations and the beach returned to close to its original profile, this effect is likely to persist only for as long as the berms are left in place and for some time afterwards, until the beach profiles and shorelines regain equilibrium. If large foundation rocks are left in place, residual impacts are likely to remain. Although the impacts of beach mining remain localised by definition, impacts can extend 100s of metres along-shore and offshore. The impacts of a single beach mining operation is therefore more extensive than that of a diver-assisted shore unit.

On sandy beaches, the physical characteristics of the beach, namely the sand particle size, wave energy and beach slope, play an important role in determining the composition of the biological communities inhabiting the beach (McLachlan *et al.* 1993; McLachlan 1996). On a high-energy coastline the recovery of the physical characteristics of intertidal and shallow subtidal unconsolidated sediments to their pre-disturbance state following *localised* beach mining operations, can occur within a few tidal cycles under heavy swell conditions, and will typically result in subsequent rapid recovery of the invertebrate epifaunal and infaunal communities to their previous state, provided no severe changes to the sediment structure have occurred. Previous studies on the impact of sea and larger-scale seawall mining on macrofaunal beach communities identified that the physical state of beaches on the West Coast is entirely driven by natural conditions, and is not affected (except during actual mining) by beach mining operations in the medium- to long-term (Pulfrich *et al.* 2004; Pulfrich *et al.* 2015; Pulfrich & Hutchings 2019). The intertidal area of sandy beaches is characterised by a relatively rich fauna, with species abundance typically declining substantially in the surf zone and reaching a minimum at the breakpoint of the waves (McLachlan and Brown 2006). Removal of beach sands and subsequent extraction of target gravels results in a significant, yet localised and short-term decrease in macrofaunal abundance, biomass, community structure and species richness and are evident at all taxonomic levels of the sandy beach infaunal communities (see also Defeo & Lecari 2003). Intertidal beach macrofauna inhabiting the naturally highly dynamic intertidal environment are inherently robust and habituated to natural disturbances, and re-colonization of disturbed areas is rapid (van der Merwe & van der Merwe 1991; Brown & Odendaal 1994; Peterson *et al.* 2000; Schoeman *et al.* 2000; Seiderer & Newell 2000; Nel *et al.* 2003). Impacted areas are initially colonized by small, abundant and opportunistic pioneer species with fast breeding responses to tolerable conditions (e.g. crustaceans and polychaetes).

If the surface sediment is similar to the original surface material when prospecting and bulk sampling operations cease, and if the final long-term beach profile has similar contours to the original profile, the addition or removal of layers of sand and gravel does not have enduring adverse effects on the sandy beach benthos (Hurme & Pullen 1988; Nel & Pulfrich 2002; Nel *et al.* 2003; Pulfrich *et al.* 2004; Pulfrich & Branch 2014). Recolonisation of disturbed beaches takes place by passive translocation of animals from adjacent areas during successive tidal cycles or storms, active immigration of mobile species, and immigration and settlement of pelagic larvae and juveniles (Hall 1994; Kenny & Rees 1994, 1996; Herrmann *et al.* 1999; Ellis 2000; Menn 2002). Usually, undisturbed sediments adjacent to the impacted site provide an important source of colonising species, enabling faster recovery (van Moorsel 1993, 1994; Cheshire & Miller 1999).

The removal of subsamples would not result in detectable changes in the physical characteristics of the impacted beaches, or to changes in community structure of invertebrate macrofauna in response to such physical changes. Such changes are considered to be of very low intensity, regardless of the SANBI benthic habitat classification, and limited to each sampling location.

Impacts would persist over the very short-term (days) as immigration from neighbouring undisturbed beach areas will be rapid and are thus considered to be of **VERY LOW** significance without mitigation. In the case of bulk sampling, impacts would be of high intensity and extend over a larger area (but still remain localised around the sampling target) and persist over a few tidal cycles, with recovery of impacted macrofaunal communities following such localised disturbance is expected within the short-term and are thus considered to be of **LOW** significance without mitigation. In both cases impacts are fully reversible. However, should large volumes of non-native rock be used during berm construction, this is likely to result in the physical alteration of the shoreline to an extent that cannot be remediated by swell action. While the rock material may become covered with sand over time as it settles into the beach sediments, the sediment profile may be permanently altered, with potential effects on the associated macrofaunal communities. In extreme cases, where the berm material is not completely removed, stretches of sandy beach could be permanently transformed into mixed and rocky shore habitats, with concomitant changes in the associated benthic biota. In such cases the impact would be of **MEDIUM** significance without mitigation.

If the berm is constructed in rocky intertidal or mixed shore habitats, impacts to the biota originally present on the shoreline would persist over the short term and be fully reversible only if original overburden sands from adjacent beaches were used. Establishment of alternative mixed shore communities in the altered habitat would, however, occur over the short-term.

Destruction and loss of intertidal and shallow subtidal biota by bulk sampling operations		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	High (Prominent)	High (Prominent)
Duration	Short-term (1 to 5 years)	Very Short-term (< 1 year)
Extent	Within / near site	Within / near site
Consequence	Low	Low
Probability	Highly Likely / Definite	Highly Likely / Definite
Significance	**Low**	**Very Low**
Additional Assessment Criteria		
Degree to which impact can be reversed	*Fully reversible over the short term*	
Degree to which impact may cause irreplaceable loss of resources	*High: The giant pill bug Tylos granulatus, which is considered severely threatened on the West Coast may be extirpated from the beach*	
Degree to which impact can be avoided	*Low*	
Degree to which impact can be mitigated	*Low*	
Cumulative Impact		
Extent to which a cumulative impact may arise	*Possible*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	Low	**Very low**

Residual Impact Assessment

With the implementation of the mitigation measures below, the residual impact of potential destruction and loss of intertidal and shallow subtidal habitats and biota would reduce to VERY LOW.

Management objectives, mitigation actions/measures and monitoring

Management objective	Minimise destruction and loss of intertidal and shallow subtidal biota
Mitigation actions/measures	
General	
– Prospecting/Mining of any nature should not be permitted in intertidal and shallow subtidal habitats identified as endangered (Southern Benguela Reflective Sandy Shore) or vulnerable (Namaqua Mixed Shore) by the SANBI's National Biodiversity Assessment (Sink et al. 2011). If, however, prospecting / mining is proposed within these areas an independent assessment of the habitats and associated biota should be undertaken by a suitably qualified ecologist to verify the habitat status. Should it be confirmed that the habitats are indeed ecologically unique, these areas should be declared 'no-go' areas and any future prospecting / mining there should be prohibited. – An Environmental Code of Practice (ECOP) must be prepared for each contractor. – Minimise disturbance of beach habitat adjacent to the sampling location through stringent environmental management and good house-keeping practices. – Do not collect any shellfish (including abalone, rock lobster, mussels) or undertake recreational or subsistence fishing within the mining area. – Prior to a contractor leaving a site and/or moving to a new site, the area must be audited by the Environmental Manager/Officer. Only once the Environmental Manager/Officer is satisfied that the area has been suitably cleaned and rehabilitated, equipment, tailings dumps and berms have been removed, and area reshaped back to natural topography should the rehabilitations funds be paid back to the contractor.	
The Environmental Manager/Officer must meet with the contractor on-site prior to sampling in order to obtain an understanding of the sampling approach and the local environmental sensitivities; after which a project-specific ECOP should be compiled for the prospecting operations.	
Use only stripped overburden sands for berm construction and do not use non-native or quarried material.	
Active rehabilitation involving backfilling of sampling holes in the high- and mid-shore areas with tailings should be undertaken concurrently with sampling operations. Back-filling in the low-shore and subtidally will occur naturally through wave action.	

IMPACT 2: Discharge of tailings from classifiers and treatment plants and redistribution of berm sediments

Beach sampling/mining operations in the intertidal and surf zones require the constant maintenance of the berm with overburden sediments. Finer materials are constantly eroded from the berms as the tide rises and redistributed down-current by wave action.

IMPACT 2A: Smothering of benthic biota by mobilised sediments and re-depositing tailings

Impact assessment

During the bulk sampling process, overburden sediments are used to construct and constantly maintain the berm. If overburden sediments are deposited onto a portion of the beach as yet undisturbed, the immediate impact would be the localised, short-term burial of the intertidal and subtidal macrofauna beneath a layer of sand. Depending on their size fraction, the sediments discharged in the intertidal zone would spread to a greater or lesser degree down the shore and into the surf zone where they would ultimately be redistributed by wave action, rip currents and eddies.

In the case of large volume sediment discards, the indirect effects manifest themselves as the inundation of adjacent intertidal and shallow subtidal reefs by sand, and corresponding responses by the benthic faunal and floral communities. In South Carolina, the effects of increased siltation and smothering from sand movement following beach replenishment were considered to have a greater impact on hard substratum habitats than on the replenished sandy shoreline. Smothering of nearshore reef habitats resulted in the loss of productive fishing grounds and declines in the nearshore fish communities (Van Dolah *et al.* 1994). Monitoring in southern Namibia has shown that mobilisation and re-deposition of sediments from mining sites can have severe impacts on intertidal and shallow subtidal rocky shore habitats bordering the sampled/mined beaches and at some distance away, with both temporary and permanent loss of rocky intertidal habitats being reported as a result of shoreline accretion (Clark *et al.* 2004, 2005, 2006; Pulfrich & Atkinson 2007; Pulfrich *et al.* 2007, 2008; Pulfrich *et al.* 2010, 2011; Pulfrich & Branch 2014a, 2014b; Pulfrich et al 2015, 2016, 2017, 2018, 2019).

There are three possible avenues for depositing sediments to influence rocky-shore communities: (1) smothering that depletes all or some groups thereby affecting community diversity (Littler *et al.* 1983; McQuaid & Dower 1990); (2) alteration of supply of particulate materials with potential enhancement of suspension-feeders (Menge 1992); (3) ripple effects by which depletion of taxa in higher trophic levels influences the abundance of those in lower trophic levels (Littler & Murray 1975; Hawkins & Hartnoll 1983, Littler *et al.* 1983; Hockey & Bosman 1986; Branch *et al.* 1990; Eekhout *et al.* 1992). These predicted effects have all, to a greater of lesser extent, been observed in rocky shore communities in the vicinity of coastal mining operations in southern Namibia, and would, to some extent, be expected in the Brand-se-Baai area, especially on the exposed rocky shore outcrops to the north and south of the beach. However, considering the small scale of the proposed prospecting, the erosion and mobilisation of sediments during sampling is not expected to be detectable above natural long-shore littoral drift, and natural cyclical sedimentation processes.

The impacts associated with the mobilisation and redistribution of sediments during sampling are considered to be of very low intensity and as they would remain localised and not persist beyond the very short term (one tidal cycle), they are considered to be of **INSIGNIFICANT**. Impacts are possible and would be fully reversible.

The target gravels are pumped to a classifier located on the shore and discharged onto sorting screens, which separate the large gravel, cobbles and boulders and fine silts from the 'plantfeed'. Coarse tailings accumulate around the classifier smothering and crushing underlying biota, while fines are either used to backfill sampled voids or released to the sea across the beach. If the classifiers are located in the intertidal zone, tailings will be redistributed by wave action over the very short term, and during this redistribution process scouring and smothering of adjacent rocky shore communities may occur. If coarse tailings are deposited above the high water mark, redistribution would not occur and the sterile tailings heaps would persist permanently.

Smothering involves physical crushing or smothering, a reduction in nutrients and oxygen, clogging of feeding apparatus, as well as affecting choice of settlement site, and post-settlement survival. In general terms, the rapid deposition of the coarser fraction from the water column is likely to have more of an impact on the benthic community than gradual sedimentation of fine sediments to which benthic organisms are adapted and able to respond. The significance of such discharges will depend not only on the nature and volume of tailings being discarded, but also the nature of the receiving environment. For example, benthic communities near river mouths would be naturally adapted to higher sediment loads compared to communities occurring further offshore beyond the wave-base regime.

Factors known to determine the effect of burial on species are 1) the depth of burial; 2) the nature of depositing sediments; 3) burial time; 4) tolerance of species (life habitats, escape potential, tolerance to hypoxia etc.); 5) presence of contaminants in the depositing sediments, and 6) season (mortality rate by burial higher in summer than winter) (Kranz 1974; Maurer *et al.* 1981a, 1981b, 1982, 1986; Bijkerk 1988; Hall 1994; Baan *et al.* 1998; Harvey *et al.* 1998; Essink 1999; Schratzberger *et al.* 2000b; Baptist *et al.* 2009; Janssen *et al.* 2011).

Any effects are however extremely localised and ephemeral, as tailings are rapidly redistributed by swell action and any resultant impacts would be negligible when seen in context with the high levels of natural disturbance in the nearshore environment (Barkai & Bergh 1992; Parkins & Branch 1995, 1996, 1997; Pulfrich 1998b; Pulfrich & Penney 2001). Excessive and repetitive dumping on the same area may, however, preclude dispersion and thus induce persistent change by reducing biodiversity, changing community structure, potentially altering preferred rock lobster habitat and smothering of benthic organisms, thereby reducing food availability for lobsters. The abundance of lobsters within a habitat depends on the availability and suitability of food (Parrish & Polovina 1994; Hudon 1987; Branch & Griffiths 1988; Wahle & Steneck 1991, 1992). Off the West Coast, rock lobsters feed primarily on ribbed mussels, barnacles, urchins and algae (Mayfield *et al.* 2000). Smothering of reef areas and their associated benthic communities adjacent to sampling targets through the discharge of oversize tailings may therefore indirectly affect rock lobster abundance in an area as well as reducing growth and reproductive rates of the animals.

Studies have shown that some mobile benthic animals are capable of actively migrating vertically through overlying sediment thereby significantly affecting the recolonization of impacted areas and the subsequent recovery of disturbed areas of seabed (Maurer *et al.* 1979, 1981a, 1981b, 1982, 1986; Ellis 2000; Schratzberger *et al.* 2000; but see Harvey *et al.* 1998; Blanchard & Feder 2003). Many benthic invertebrates inhabiting unconsolidated sediments are able to burrow or move through the sediment matrix, and numerous studies have shown that some infaunal species are able to actively migrate vertically through overlying deposited sediment thereby significantly affecting the recolonisation and subsequent recovery of impacted areas (Maurer *et al.* 1979, 1981a, 1981b, 1982, 1986; Lynch 1994; Ellis 2000; Schratzberger *et al.* 2000a; but see Harvey *et al.* 1998; Blanchard & Feder 2003). Lynch (1994) conducted vertical migration experiments with beach macrofauna to determine their tolerance to sand overburdens, and found that several species were capable of burrowing through sediments between 60 and 90 cm, and Maurer *et al.* (1979) reported that some animals are capable of migrating upwards through 30 cm of deposited sediment. In contrast, consistent faunal declines were noted during deposition of mine tailings from a copper mine in British Columbia when the thickness of tailings exceeded 15-20 cm (Burd 2002), and Schaffner (1993) recorded a major reduction in benthic macrofaunal densities, biomass, and species richness in shallow areas in lower Chesapeake Bay subjected to heavy disposal (>15 cm) of dredged sediments. Similarly, Roberts *et al.* (1998) and Smith & Rule (2001) found difference in species composition detectable only if the layer of instantaneous applied overburden exceeded 15 cm. In general, mortality tends to increase with increasing depth of deposited sediments, and with speed and frequency of burial.

The survival potential of benthic infauna, however, depends not only on their ability to migrate upwards through the deposited sediment, but also on the nature of the deposited sediments (Turk & Risk 1981; Chandrasekara & Frid 1998; Schratzberger *et al.* 2000a; Speybroeck *et al.* 2004). Although there is considerable variability in species response to specific sediment characteristics (Smit *et al.* 2006), higher mortalities were typically recorded when the deposited sediments have a different grain size composition from that of the receiving environment (Maurer *et al.* 1981a, 1981b, 1982, 1986; Smit *et al.* 2006; Smit *et al.* 2008), migration ability and survival rates generally being lower in silty sediments than in coarser sediments (Hylleberg *et al.* 1985; Ellis & Heim 1985; Maurer *et al.* 1986; Romey & Leiseboer 1989, cited in Schratzberger *et al.* 2000a; Schratzberger *et al.* 2000a). Some studies indicate that changes to the geomorphology and sediment characteristics may in fact have a greater influence on the recovery rate of invertebrates than direct burial or mortality (USDOI/FWS 2000). The availability of food in the depositional sediment is, however, also influential. In the case of the Whale Head Minerals prospecting operation, most of the fine sand fraction (75 – 180 µm) will have been removed by the trammel and the particle size distribution of the discharged sands will be skewed towards the medium, coarse and very coarse sand fractions and thus no longer resemble the native beach sediments. This effect would be highly localised, however, and is unlikely to affect community structure in the greater prospecting area.

The burial time, or duration of burial, will also determine the effect on benthos. Here a distinction must be made between incidental deposition, where species are buried by deposited material within a short period of time (temporary stockpiling of excess sands), and continuous deposition, where species are exposed to an elevated sedimentation rate over a longer period of time (as would occur around the walpomp units). Whereas the volumes deposited per unit time will likely be lower under conditions of continuous deposition, such deposition can nonetheless have negative effects when the sedimentation rate is higher than the velocity at which the organisms can move or grow upwards. The sensitivity to long-term continuous deposition is species dependent and also dependent on the sediment type, with continuous deposition of silt being more lethal than a deposition of sand.

The nature of the receiving community is also of importance. In areas where sedimentation is naturally high (e.g. wave-disturbed shallow waters) the ability of taxa to migrate through layers of deposited sediment is likely to be well developed (Roberts *et al.* 1998). The life-strategies of organisms is a further aspect influencing the susceptibility of the fauna to mortality. Kranz (1972, cited in Hall 1994) studied the burrowing habits of 30 species of bivalves and showed that mucous-tube feeders and labial palp deposit-feeders were most susceptible to sediment deposition, followed by epifaunal suspension feeders, boring species and deep-burrowing siphonate suspension-feeders, none of which could cope with more than 1 cm of sediment overburden. Infaunal non-siphonate suspension feeders were able to escape 5 cm of burial by their native sediment, but normally no more than 10 cm. The most resistant species were deep-burrowing siphonate suspension-feeders, which could escape from up to 50 cm of overburden. Menn (2002) reported that meiofaunal species appeared less susceptible to burial than macrofauna, and Carey (2005) was unable to detect any effects of beach replenishment on benthic microalgae.

The exact depth of sand through which beach biota can successfully migrate ('fatal depth') thus depends on the species involved (reviewed by Essink 1993). Although numerous studies have investigated the burrowing efficiency of local species under different swash conditions or grain size composition (e.g. Brown & Trueman 1991, 1995; Nel *et al.* 2001), information on successful upward migration and survival following heavy deposition of sediments is largely lacking (but see Trueman & Ansell 1969). However, benthic organisms living in nearshore wave influenced areas in the Benguela region are likely to be adapted to relatively high sedimentation rates. Nonetheless, it is safe to assume that most beach infauna in the stockpile footprint (RC drill) or in the immediate vicinity of the walpomp would be smothered.

The localised impacts of smothering, burial and loss of intertidal and shallow subtidal benthic communities through the discard of excess sediments is considered to be of low intensity in the immediate vicinity of the drill site or walpomp area. Impacts are likely to persist over the short-term only as sediments would either be used to backfill sampling excavations or be rapidly redistributed by wave action. Smothering of beach macrofauna by discarded sediments is thus considered to be of **VERY LOW** significance without mitigation and would be fully reversible. This would reduce to **INSIGNIFICANT** if excess sediments are returned to the excavations or discarded into the swash zone.

In contrast, sedentary communities may be adversely affected by both rapid and gradual deposition of sediment. Filter-feeders are generally more sensitive to suspended solids than deposit-feeders, since heavy sedimentation may clog the gills. Impacts on highly mobile invertebrates and fish are likely to be negligible since they can move away from areas subject to redeposition.

<u>Supratidal (High Shore)</u>

The discharge of tailings around classifiers located in the high shore would be of medium intensity, but would be permanent if not actively removed. If tailings discards occur in vulnerable (Namaqua Mixed Shore) habitats, the intensity would be high. Impacts would be highly localised and limited to a scale of a few 10s of metres around each individual operation. Impacts are definite and would be irreversible if not actively mitigated. The significance of the impact of discarding tailings in the high shore is thus considered **MEDIUM** without mitigation, reducing to **INSIGNIFICANT** with the implementation of mitigation measures.

<u>Intertidal and Shallow Subtidal</u>

Impacts associated with the contruction of berms using overburden sands and the discard of tailings from classifiers located in the intertidal would be of medium intensity, persisting over the very short term only as they would be rapidly redistributed by wave action. If tailings discards occur in vulnerable (Namaqua Exposed Rocky Shore, Namaqua Kelp Forest, Namaqua

Mixed Shore) habitats, the intensity would be high. As impacts would be limited to a scale of a few 10s of metres around each individual operation the extent of the impact is highly localise to within the site. Impacts are highly likely and would be fully reversible. The impact of sediment redistribution and tailings discarged in the intertidal zone and in nearshore waters is considered to be of **LOW** significance without mitigation, reducing to **VERY LOW** significance with mitigation.

Smothering of highshore communities and alteration of habitat by discarded tailings and overburden sediments		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	High (Prominent)	Low (Minor)
Duration	Permanent (> 20 years)	Very Short-term (< 1 year)
Extent	Within / near site	Within / near site
Consequence	Medium	Very Low
Probability	Probable	Possible
Significance	**Medium**	**Insignificant**
Additional Assessment Criteria		
Degree to which impact can be reversed	*Irreversible unless tailings are actively removed*	
Degree to which impact may cause irreplaceable loss of resources	*High as some supratidal vegetation and biota are considered endangered*	
Degree to which impact can be avoided	*High*	
Degree to which impact can be mitigated	*High*	
Cumulative Impact		
Extent to which a cumulative impact may arise	*Likely*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	High	**Low**

Smothering of intertidal and nearshore reef communities and alteration of habitat by discharged tailings and eroded berm sediments		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	High (Prominent)	Medium (Moderate)
Duration	Very Short-term (< 1 year)	Very Short-term (< 1 year)
Extent	Within / near site	Within / near site
Consequence	Low	Very Low
Probability	Highly Likely / Definite	Probable
Significance	**Low**	**Very Low**
Additional Assessment Criteria		
Degree to which impact can be reversed	*Fully reversible as tailings and eroded berm sediments would be rapidly redistributed by wave action*	

Degree to which impact may cause irreplaceable loss of resources	*Low as biota are ubiquitous throughout the West Coast*	
Degree to which impact can be avoided	*Low*	
Degree to which impact can be mitigated	*Low*	
Cumulative Impact		
Extent to which a cumulative impact may arise	*Possible*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	Low -	**Very low -**

Residual Impact Assessment

With the implementation of the mitigation measures below, the residual impact of potential smothering of supratidal and intertidal habitats and biota by discarded tailings and eroded berm sediments would reduce to **LOW** and **VERY LOW**, respectively

Management objective, mitigation actions/measures and monitoring

Management objective	Minimise the smothering effects on biota of discarded tailings
Mitigation actions/measures	
General	
No mitigation measures other than the 'no go' option are possible for the indirect impacts of smothering and alteration of habitats through berm construction, discharge of tailings and redistribution of sediments eroded from berms. However, the following best practice management measures are proposed:	
An Environmental Code of Practice (ECOP) must be prepared for each contractor (refer to Section 5.2.1.1 and 5.2.1.3 for the contents of onshore and offshore ECOPs, respectively).	
Prospecting/Mining of any nature should not be permitted in intertidal and shallow subtidal habitats (with restricted representation) identified as endangered (Southern Benguela Reflective Sandy Shore, Namaqua Kelp Forest) or vulnerable (Namaqua Mixed Shore) by the SANBI's National Biodiversity Assessment (Sink et al. 2011). If, however, prospecting / mining is proposed within these areas an independent assessment of the habitats and associated biota should be undertaken by a suitably qualified ecologist to verify the habitat status. Should it be confirmed that the habitats are indeed ecologically unique, these areas should be declared 'no-go' areas and any future prospecting / mining there should be prohibited.	
Monitoring	Integrated environmental management measures implemented as part of the prospecting/mining activities should include a well-structured monitoring programme the principal objective of which is to demonstrate natural recovery processes by means of pre- and post-mining seabed and benthic faunal community surveys. Pre-mining baseline data should be collected in areas where mining activities are planned and changes in the benthic community structures in impacted areas should be regularly assessed. Details are provided in the monitoring plan (see Section 7).

IMPACT 2B: Increased water turbidity and reduced light penetration

Impact assessment

Suspended sediment plumes are generated by all sampling/mining operations, regardless of the prospecting approach. These occur on the beach and in the surf zone through re-suspension of fine sediments by excavtors, by the discharge of fine sediments from classifiers and processing plants into the sea, and by the constant erosion of finer materials from berms by wave action.

The finer components of surface discharges generate a plume in the upper water column, which is dispersed away from the point of discharge by prevailing currents, diluting rapidly to background levels at increasing distances from the mining vessel. Distribution and re-deposition of suspended sediments are the result of a complex interaction between oceanographic processes, sediment characteristics and engineering variables that ultimately dictate the distribution and dissipation of the plumes in the water column. Ocean currents, both as part of the meso-scale circulation and due to local wind forcing, are important in distribution of suspended sediments. Turbulence generated by surface waves can also increase plume dispersion by maintaining the suspended sediments in the upper water column.

One of the more apparent effects of increased concentrations of suspended sediments and consequent increase in turbidity, is a reduction in light penetration through the water column with potential adverse effects on the photosynthetic capability of phytoplankton (Poopetch 1982; Kirk 1985; Parsons *et al.* 1986a, 1986b; Monteiro 1998; O'Toole 1997) and the foraging efficiency of visual predators (e.g. pelagic fish, seabirds and marine mammals) (Simmons 2005; Braby 2009; Peterson *et al.* 2001). However, due to the rapid dilution and widespread dispersion of settling particles, any adverse effects in the water column would be ephemeral and highly localised. Any biological effects on nectonic and planktonic communities would be negligible (Aldredge *et al.* 1986). Turbid water is a natural occurrence along the southern African west coast, resulting from aeolian and riverine inputs, resuspension of seabed sediments in the wave-influenced nearshore areas and seasonal phytoplankton production in the upwelling zones. The development of invertebrate and fish eggs and/or larvae may be impaired through high sediment loading, but as the major spawning areas are all located on the continental shelf, south of the concession areas, any potential effects of turbid water plumes generated during tailings disposal on phytoplankton and ichthyoplankton production, fish migration routes and spawning areas, or on benthic and demersal species in the area would thus be negligible. Increased turbidity of near-bottom waters through resuspension of fine sediments by mining tools, may place transient stress on sessile and mobile benthic organisms, by negatively affecting filter-feeding efficiency of suspension feeders or through disorientation due to reduced visibility (reviewed by Clarke & Wilber 2000). However, in most cases sub-lethal or lethal responses occur only at concentrations well in excess of those anticipated at the seabed and in the water column. Benthic species that may be impacted by near-bottom plumes include bivalves and crustaceans. Suspended sediment effects on juvenile and adult bivalves occur mainly at the sublethal level with the predominant response being reduced filter-feeding efficiencies at concentrations above about 100 mg/ℓ. Lethal effects are seen at much higher concentrations (>7 000 mg/ℓ) and at exposures of several weeks. Furthermore, as marine communities in the Benguela are frequently exposed to naturally elevated suspended-sediment levels, they can be expected to have behavioural and physiological mechanisms for coping with this feature of their habitat.

Poor visibility may also inhibit pelagic visual predators. A wide range of birds forage in or just behind the surf zone. Seabirds are visual predators that forage by sight and therefore need clear water to locate their prey. Most pelagic fish species, which form the major component of seabird diets, however, tend to avoid turbid waters. This is likely to affect local feeding efficiency of seabirds either by obscuring their vision or by potentially reducing prey availability through avoidance responses of prey species to turbid water areas. The significance of the potential impacts of sampling-induced turbidity on seabird populations, would largely depend on the extent and duration of the sediment plumes. If the plumes are highly localised and disperse quickly, as would be expected in this case, then the consequences are likely to be negligible. Turbid water is a natural occurrence along the southern African west coast, resulting from aeolian and riverine inputs, resuspension of seabed sediments in the wave-influenced nearshore areas and seasonal phytoplankton production in the upwelling zones.

Due to the naturally turbid nearshore waters, kelp is restricted to the immediate subtidal regions to a maximum depth of ~10 m. Those fringing kelp beds along the coastline of the proposed prospecting area are unlikely to be affected by the turbidity plumes generated as a result of tailings discharges or sediments eroded from berms. Similarly, no shading of these canopy forming macrophytes by sampling-related turbidity plumes is expected.

It is anticipated that the sediments in the sampling target area have a negligible clay and silt fraction, so the generation of suspended sediment plumes above natural background levels are expected to be insignificant. Turbidity offshore of the sampling site(s) is thus unlikely to exceed levels attained naturally during turn-over of nearshore sediments by wave action or seasonal inputs from river discharges. As turbid water is a natural occurrence along the southern African west coast, any turbidity-related effects in the near-shore environment as a direct result of mining operations are likely to be insignificant.

As suspended sediment plumes will be ephemeral, any possible adverse effects on sessile benthos, or on the feeding, spawning and recruitment of mobile predators, will be fully reversible as biota would be well adapted to naturally high suspended sediment concentrations. Even the highest concentrations in the immediate discharge of fine tailings onto the beach are unlikely to reach concentrations that would have lethal or sub-lethal effects on marine fauna or inhibit primary productivity of phytoplankton or nearshore algae. Similarly, due to their highly localised and ephemeral nature, any suspended sediment plumes generated during sampling operations in proximity to the mouth of the Sout River, are highly unlikely to penetrate the river mouth on those occasions when the mouth is open. The biochemical impact of reduced water quality through increased turbidity can confidently be rated as being **INSIGNIFICANT** without mitigation.

Residual Impact Assessment

As no mitigation measures are possible for the erosion of sediments from berms or discharge of tailings from infield processing equipment, residual impacts will be no different to realised impacts.

Impacts of tailings discharges and eroded sediments on surf zone water biochemistry (turbidity and light)		
Type of Impact	Indirect	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Very Low (Negligible)	Very Low (Negligible)
Duration	Very Short-term (< 1 year)	Very Short-term (< 1 year)
Extent	Part of site/property	Part of site/property
Consequence	Very low	Very low
Probability	Unlikely	Unlikely
Significance	Insignificant	Insignificant
Additional Assessment Criteria		
Degree to which impact can be reversed	*Fully reversible as concentrations would be sublethal*	
Degree to which impact may cause irreplaceable loss of resources	*None*	
Degree to which impact can be avoided	*Low*	
Degree to which impact can be mitigated	*None*	
Cumulative Impact		
Extent to which a cumulative impact may arise	*Unlikely*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Insignificant	Insignificant

Management objectives, mitigation actions/measures and monitoring

Management objective	Minimise effects of increased turbidity
Mitigation actions/measures	
General	
No mitigation measures are possible for the indirect impacts of the discharge of tailings from infield plants or the erosion of sea materials by wave action.	

IMPACT 2C: Impacts on higher-order consumers

Although recovery of invertebrate macrofaunal communities following disturbance of beach habitats generally occurs within 3 – 5 years after cessation of the disturbance, the species inhabiting beaches are all important components of the sandy-beach food chain. Most are scavengers, particulate- and filter-feeders that depend on inputs of detritus or beach-cast seaweeds (Brown & Odendaal 1994). As such, they assimilate food sources available from the detrital accumulations typical of this coast and, in turn, become prey for surf-zone fishes and shorebirds that feed on the beach slope and in the swash and surf zones. By providing energy input to higher trophic levels, they are important in nearshore nutrient cycling. The reduction or loss of these assemblages in the medium to long-term may thus have cascade effects through the coastal ecosystem (Dugan *et al*. 2003). Similarly, recovery of rocky intertidal habitats following smothering occurs over the short-term, but these also serve as important feeding habitats for shore birds. The negative effects on higher order consumers (surf-zone fish and shorebirds) of changes in abundance of macrofaunal prey items as a consequence of beach nourishment operations in North Carolina have been demonstrated (Peterson *et al*. 2000; Lindquist & Manning 2001). However, considering the extremely localised nature of the proposed sampling operations in comparison to the available coastal feeding-ground habitat for the fish and shorebirds, and the relatively quick recovery of benthic communities following disturbance, the effects of these higher order consumers can be considered negligible (see also Essink 1997; Baptist *et al*. 2009).

Due to recovery over the short-term of the invertebrate communities that serve as a food source for higher-order consumers, the potential impacts are considered to be of very low intensity and are thus considered to be **INSIGNIFICANT**.

Impacts of prospecting operations on higher order consumers		
Type of Impact	Indirect	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Very Low (Negligible)	Very Low (Negligible)
Duration	Very Short-term (< 1 year)	Very Short-term (< 1 year)
Extent	Part of site/property	Part of site/property
Consequence	Very low	Very low
Probability	Unlikely	Unlikely
Significance	Insignificant	Insignificant
Additional Assessment Criteria		
Degree to which impact can be reversed	*Fully reversible as any effects would be ephemeral*	
Degree to which impact may cause irreplaceable loss of resources	*None*	
Degree to which impact can be avoided	*Low*	
Degree to which impact can be mitigated	*None*	
Cumulative Impact		
Extent to which a cumulative impact may arise	*Unlikely*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Insignificant	Insignificant

Management objectives, mitigation actions/measures and monitoring

Management objective	Minimise effects of increased turbidity
Mitigation actions/measures	
General	
No mitigation measures other than the 'no-go' option are possible for the indirect impacts of the prospecting operations on higher order consumers.	

IMPACT 2D: Disturbance of coastal biota by noise

During prospecting operations, noise and vibrations from heavy earth-moving machinery and infield processing plants may have an impact on surf zone biota, marine mammals and shore birds in the area. Noise levels would, however, be at a frequency much lower than that used by marine mammals for communication (Findlay 1996), and these are therefore unlikely to be affected. Additionally, the maximum radius over which the noise may influence is very small compared to the population distribution ranges of surf zone fish species, resident cetacean species and the Cape fur seal. Both fish and marine mammals are highly mobile and should move out of the noise-affected area (Findlay 1996). Similarly, shorebirds and terrestrial biota are typically highly mobile and would be able to move out of the noise-affected area.

Disturbance and injury to marine biota due to operational noise is thus deemed of very low intensity within the immediate vicinity of the sampling/processing sites, with impacts persisting over the very short-term only (hours). Whereas noise impacts on shorebirds is possible, fish and marine mammals in the area are unlikely to be affected. The impact of noise is therefore considered **INSIGNIFICANT**.

Mitigation

As the noise associated with construction is unavoidable, no direct mitigation measures, other than the no-project alternative, are possible.

Disturbance of coastal biota by noise		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Very Low (Negligible)	Very Low (Negligible)
Duration	Very Short-term (< 1 year)	Very Short-term (< 1 year)
Extent	Part of site/property	Part of site/property
Consequence	Very low	Very low
Probability	Unlikely	Unlikely
Significance	Insignificant	Insignificant
Additional Assessment Criteria		
Degree to which impact can be reversed	*Fully reversible as any effects would be ephemeral*	
Degree to which impact may cause irreplaceable loss of resources	*None*	
Degree to which impact can be avoided	*Low*	
Degree to which impact can be mitigated	*None*	
Cumulative Impact		
Extent to which a cumulative impact may arise	*Unlikely due to the remoteness of the area*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Insignificant	Insignificant

Management objectives, mitigation actions/measures and monitoring

Management objective	Minimise effects of operational noise
Mitigation actions/measures	
General	
As the noise associated with sampling operations is unavoidable, no mitigation measures other than the 'no-go' option are possible.	

IMPACT 3: Discharge of waste to sea and local reduction in water quality

During beach prospecting operations all equipment and vehicles are left in specially designated parking / storage areas near the mining site. Litter generated during operational times can be distributed by the wind into intertidal areas and the nearshore marine environment.

Inputs can be either direct by discarding garbage into the sea, or indirectly from the land when litter is blown into the water by wind. Marine litter is a cosmopolitan problem, with significant implications for the environment and human activity all over the world. Marine litter travels over long distances with ocean currents and winds. It originates from many sources and has a wide spectrum of environmental, economic, safety, health and cultural impacts. It is not only unsightly, but can cause serious harm to marine organisms, such as turtles, birds, fish and marine mammals. Considering the very slow rate of decomposition of most marine litter, a continuous input of large quantities will result in a gradual increase in litter in coastal and marine environment. Although volumes generated and discardedinto the coastal and marine environment would be low, associated impacts could be of medium intensity and depending on the type of litter persist over the medium-term, potentially spreading regionally. Unless suitable waste management practices are implemented to ensure that littering is avoided, dispersal of litter would definitely occur as a result of the coastal mining operations. Impacts are only partially reversible. The significance of the potential impacts is therefore considered to be **HIGH** without mitigation.

Impacts of litter in the coastal and marine environment from prospecting operations		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	All	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	Medium (Moderate)	Low (Minor)
Duration	Medium-term (5 to 10 years)	Short-term (1 to 5 years)
Extent	Regional/National	Within / near site
Consequence	High	Very Low
Probability	Probable	Probable
Significance	High	Very Low

Additional Assessment Criteria		
Degree to which impact can be reversed	*Partially reversible due to slow decomposition rate*	
Degree to which impact may cause irreplaceable loss of resources	*Medium*	
Degree to which impact can be avoided	*Low*	
Degree to which impact can be mitigated	*Low*	
Cumulative Impact		
Extent to which a cumulative impact may arise	*Likely*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	High	Very Low

Management objectives, mitigation actions/measures and monitoring

Management objective	Minimise waste discharges and litter in the coastal and marine environment
Mitigation actions/measures	
General	
Develop and implement a waste management system for all prospecting operations that addresses all wastes generated. This should include: – Separation of wastes at source; – Recycling and re-use of wastes where possible.	
All wastes (including galley wastes) generated by the prospecting operations must be disposed of at a licenced waste disposal site.	
Ensure that chemical toilets are available at the prospecting site.	
All hazardous wastes must be disposed of at a licenced hazardous waste site.	
Conduct a comprehensive environmental awareness programme amongst contracted personnel.	
Provide waste skips at each operational site.	
Ensure regular collection and removal of refuse and litter from intertidal areas.	

Residual Impact Assessment

With appropriate waste management controls in place, residual impacts would reduce to very low.

Potential Impacts related to Unplanned Events

IMPACT 4: Accidental Loss and discard of Equipment

Contractors operational in the admiralty strips and surf zones typically establish storage areas for vehicles, tractors and heavy equipment. Mining infrastructure and equipment are often left on site following completion of prospecting/mining operations in an area, or if the equipment becomes derelict.

Impact assessment

Equipment abandoned in the coastal zone primarily causes an aesthetic impact.

The impact is highly localised but would be permanent if the equipment is abandoned. The impact is considered to be of **VERY LOW** significance without mitigation and **INSIGNIFICANT** with mitigation.

Residual Impact Assessment

With the implementation of the project controls and mitigation measures, the residual impact will remain of **VERY LOW** significance

Impacts of abandoned equipment		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Negligible change (Very low)	Negligible change (Very low)
Duration	Permanent (> 20 years)	Permanent (> 20 years)
Extent	Within / near site	Within / near site
Consequence	Low	Very Low
Probability	Possible (Medium)	Unlikely
Significance	**Very Low**	**Insignificant**
Additional Assessment Criteria		
Degree to which impact can be reversed	*Partially reversible*	
Degree to which impact may cause irreplaceable loss of resources	*Low*	
Degree to which impact can be avoided	*High*	
Degree to which impact can be mitigated	*High*	
Cumulative Impact		
Extent to which a cumulative impact may arise	*Possible*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Very Low	**Very Low**

Management objective, mitigation actions/measures and monitoring

Management objective	Reduce accidental loss and discard of equipment
Mitigation actions/measures	
General	
Remove all derelict and abandoned equipment in the coastal zone and dispose of at a licenced landfill site and/or recycle.	
Maintain an inventory of all equipment and undertake frequent checks to ensure these items are stored and secured safely at the prospecting site.	

IMPACT 5: Loss of Fuel and/or Hydraulic Oils to Sea

Instantaneous spills of marine diesel and/or hydraulic fluid in the intertidal zone or at the surface of the sea can potentially occur during all project activity phases. Such spills are usually of a low volume and occur accidentally during refueling or as a result of hydraulic pipe leaks.

Mining infrastructure and equipment is stored and parked above the high water mark where accidental spills may occur during refuelling, or leaks may develop as a consequence of poor maintenance and neglect.

Impact assessment

Onshore spills are likely to be of a low volume and occurring accidentally during refuelling of machinery or as a result of hydraulic pipe leaks or ruptures as a consequence of poor maintenance and neglect. As diesel tends to penetrate porous sediments quickly, spills in the supratidal and intertidal area would result in soil contamination. However, if spilled in the rocky intertidal, it would be washed off quickly by waves and tidal flushing as it is not very sticky or viscous. Although degraded by naturally occurring microbes within one to two months diesel oil is considered to be acutely toxic to marine organisms. Consequently, intertidal invertebrates and seaweed that come in direct contact with a diesel spill may be killed.

A highly localised operational spill in the supratidal and intertidal would thus be of medium intensity in the very short term. Small operational spills onshore are considered highly likely, but in most cases the impacts on biota can be considered of **VERY LOW** significance before mitigation, reducing to **INSIGNIFICANT** with mitigation. Should they occur, impacts would be fully reversible.

Residual Impact Assessment

With the implementation of the project controls and mitigation measures, the residual impact will reduce to INSIGNIFICANT

Operational Spills		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Medium (Moderate)	Very low (Negligible)
Duration	Very Short-term (< 1 year)	Very Short-term (< 1 year)
Extent	Within / near site	Within / near site
Consequence	Very Low	Very Low
Probability	Highly Likely / Definite	Unlikely
Significance	**Very Low**	Insignificant
Additional Assessment Criteria		
Degree to which impact can be reversed	*Partially reversible*	
Degree to which impact may cause irreplaceable loss of resources	*Medium*	
Degree to which impact can be avoided	*Medium*	
Degree to which impact can be mitigated	*High*	
Cumulative Impact		
Extent to which a cumulative impact may arise	*Unlikely*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Insignificant	Insignificant

Management objective, mitigation actions/measures and monitoring

Management objective	Minimise the risk of hydrocarbon spills from mining operations
Mitigation actions/measures	
Seek to reduce the probabilities of accidental and/or operational spills through enforcement of stringent oil spill management systems. These should incorporate plans for emergencies and Environmental Awareness and Spill Training to ensure the contractors and their staff are appropriately informed of how to deal with spills.	
Ensure good housekeeping practices are in place at all shore-based operations. This should include : – Place drip trays under all stationary machinery, – Bunding of all fuel storage areas, – Restrict vehicle maintenance to the maintenance yard area, except in emergencies when the beach area may be used if absolutely necessary – Maintain equipment to ensure that no oils, diesel, fuel or hydraulic fluids are spilled	

- **Cumulative Impacts**

The primary impacts associated with prospecting forand mining of marine diamonds on the West Coast of South Africa, relate to physical disturbance of the seabed, discharges of tailings to the benthic environment, and associated contractor presence.

Although the areas of seabed targeted for prospecting amounts to only a fraction of the total surf zone and admiralty strip concessions the cumulative impact of years of mining by an increasing number or contractors applying progressively modern techniques to locate and access diamond deposits must be kept in mind. Considering the prevalence of endangered and vulnerable habitat types in the coastal zone of the broader project area and the decades of uncontrolled and environmentally irresponsible operations these cumulative impacts are considered to be of **MEDIUM** significance. Detailed records of annual and cumulative areas sampled and mined should be maintained, and submitted to the authorities should future informed decisions need to be made regarding disturbance limits to benthic habitat types in the Namaqua Bioregion.

There are currently numerous diamond mining applications pending for (a)-concessions as well as for concessions further offshore. How many of these will be approved and mining actually realised is unknown at this stage, but some cumulative impacs can be expected.

Conclusions

The impacts on marine habitats and communities associated with the proposed prospecting for marine diamonds in the Brand-se-Baai area are summarised in the Table below (Note: * indicates that no mitigation is possible, thus significance rating remains).

Impact	Significance (before mitigation)	Significance (after mitigation)
Disturbance and loss of supratidal habitats and associated biota	Medium	Low
Destruction and loss of intertidal and shallow subtidal biota by beach mining operations	Low	Very Low
Smothering of highshore communities and alteration of habitat by discarded tailings and overburden seddiments	Medium	Insignificant
Smothering of intertidal and nearshore reef communities and alteration of habitat by discharged tailings and eroded berm sediments	Low	Very Low
Impacts of tailings discharge and eroded sediments on surf zone water biochemistry (turbidity and light)	Insignificant	Insignificant*
Impacts on higher order consumers	Insignificant	Insignificant*
Disturbance of coastal biota by noise	Insignificant	Insignificant*
Impacts of litter in the coastal and marine environment from prospecting operations	High	Very Low
Impacts of abandoned equipment	Very Low	Insignificant*
Impacts of an operational spill and vessel accidents	Very Low	Insignificant

4.3. No-development Alternative

The "no-development" alternative implies that the proposed prospecting with bulk sampling operation does not go ahead. From a marine ecological perspective this is undeniably the preferred alternative, as all impacts associated with beach disturbance, shoreline changes, loss of biota, unplanned pollution events and indirect sedimentation will not be realised. This must, however, be seen in context with existing mining and exploration rights and sustainability of the associated mines, and thus needs to be weighed up against the potential socio-economic benefits undoubtedly associated with accessing the potentially rich placer deposits present in the surf zone.

4.4. Cumulative Impacts

In the context of diamond prospecting operations, a cumulative impact on the beach habitat and its associated macrofaunal communities would be an impact:

- which occurs on a beach that is experiencing, has experienced, or may foreseeably experience similar impacts in the future (e.g. either further diamond prospecting/mining or heavy mineral sands prospecting/mining in the same area),
- where there is the potential for synergistic interaction between impacts (*i.e.* diamond mining and heavy mineral sands prospecting impacts interact with each other to produce a total effect greater than the sum of the component impacts), and/or
- where ecological thresholds may be breached by a number of consecutive or simultaneous impacts, which individually may not have resulted in impacts.

The project area is located along the coast of Concession 11a, which is held by TransHex Operations and for which an updated EMPr is currently (January 2024) being prepared for beach mining, shore-based and vessel-based diver operations. The beaches and shallow subtidal areas have in the past been prospected and mined for diamonds by De Beers contractors. As the TransHex contractors are currently active in Concession 11a and along the coast further south in the Weskus admiralty strip concession, any further prospecting or mining ventures in the area during the next 5 years will at the very least result in additive cumulative impacts to the invertebrate macrofaunal communities inhabiting the beach sediments, potentially with synergistic and both space- and time-crowding effects as well.

However, the significance of this needs to be seen in the context of the short-and long-term natural disturbances characterising the nearshore marine environment in the Benguela region and the robustness of the marine biota in coping with, and recovering from, these. From the monitoring studies of the large-scale and long-term beach mining operations in southern Namibia, it is apparent that despite the substantial cumulative impacts of decades of seawall mining operations and large-volume sediment discharges, the macrofaunal communities respond rapidly to the cessation of the mining disturbance. Evidence therefore suggests that provided there are no significant changes to the physical characteristics of the beach in the short-term, the likely cumulative impacts of prospecting for diamonds in the Brand-se-Baai area is not expected to have detectable effects on the benthos of intertidal and subtidal sandy habitats. In the case of highly localised sampling as proposed for this prospecting operation, no cumulative impacts would thus be expected.

Cumulative impacts have been considered in each of the assessment tables. Although the area of Namaqua exposed rocky shore, Namaqua Mixed Shore and Namaqua Kelp Forest overlapping with the proposed prospecting rights area amounts to only a fraction of the total area of those habitat types in the region, the cumulative impact of years of prospecting and mining by an increasing number or contractors applying progressively modern techniques to locate and access deposits must be kept in mind. Considering the vulnerability of the habitat types in the mining licence area and the decades of uncontrolled and environmentally irresponsible operations, the cumulative impacts associated with the proposed diamond prospecting and bulk sampling are considered to be of **LOW** significance. This would increase though should beach mining go ahead in future. Detailed records of annual and cumulative areas prospected and mined should be maintained by the applicant, and submitted to the authorities should future informed decisions need to be made regarding disturbance limits to benthic habitat types in the Namaqua Bioregion.

4.5. Project Controls

A generic Environmental Code of Practice (ECOP) was developed for beach mining operations in the surf zone and shallow portions of the TransHex concessions. Contractors undertaking diamond prospecting and/or mining would be required to comply with the environmental specifications in an ECOP pertaining to:

- housekeeping;
- fuel and lubricant storage and management;
- refuelling;
- hydrocarbon contamination and oil spill procedure and reporting;
- solid waste management; and
- weekly monitoring.

5. CONCLUSIONS

5.1. Environmental Acceptability and Impact Statement

The main marine impacts associated with the proposed prospecting for diamonds with bulk sampling at Brand-se-Baai are related to disturbance and loss of sandy habitats and their associated benthic fauna in the sampling/processing footprint. However, as removal and treatment of sediments are an unavoidable consequence of the proposed prospecting with bulk sampling, there can be no direct mitigation for their impacts on marine biological communities. Other than the 'no go' option, the impacts to the intertidal and shallow subtidal marine biota are thus unavoidable should prospecting go ahead. These impacts are, however, highly localised and effects would be transient with all impacts being fully revesible over the short-term. Furthermore, as diamond mining operations have been ongoing along this section of the coast for decades, the proposed sampling area cannot be considered particularly 'pristine'. Nonetheless, from a marine perspective the 'no go' option is undeniably the preferred alternative, as all impacts associated with the disturbance of beach and rocky habitats would no longer be an issue.

Provided the impacts are meticulously managed and pro-active infilling of sampling excavations is undertaken as far as is feasible in the coastal environment, there is no reason why the proposed prospecting for diamonds should not go ahead.

5.2. Mitigation Measures and Management Actions

Environmental management actions for implementation in the Environmental Management Plan should focus on the following aspects to be considered prior to, during and on cessation of prospecting activities in an area:

- Develop the prospecting plan to ensure that sampling proceeds systematically and efficiently from one end of the target area to the next.
- To prevent degradation of the sensitive high-shore beach areas, all activities must be managed according to a strictly enforced Environmental Management Plan. High safety standards and good house-keeping must form an integral part of any operations on the shore from start-up, including, but not limited to:
  - drip trays and bunding under all vehicles and equipment on the shore where losses are likely to occur;
  - no vehicle maintenance or refuelling on shore;
  - accidental diesel and hydrocarbon spills to be cleaned up accordingly; and
  - collect and dispose polluted soil at appropriate bio-remediation sites.
- To avoid unnecessary disturbance of communities and destruction of habitats, heavy vehicle traffic in the high- and mid-shore must be limited to the minimum required, and must be restricted to clearly demarcated access routes and operational areas only. The operational footprint of the intertidal sampling sites site should be minimised as far as practicable.
- Initiate infilling of individual sampling holes on completion of sampling at that site. This should involve back-filling excavations using excess sediments and discards and restoring the beach profile to that resembling the pre-sampling situation.
- On cessation of operations, all sampling equipment, artificial constructions or beach modifications created during prospecting must be removed from above and within the intertidal zone.

6. MITIGATION AND MANAGEMENT PLAN

This chapter lists the project controls and mitigation measures that shall be implemented to avoid or minimise impacts on the environment from the proposed prospecting with bulk sampling activities.

6.1. Scope and Objectives

The significance of residual impacts are contingent on the applicant's (and any third parties) commitment to fully implement the measures in the Mitigation and Management Plan. This Mitigation and Management Plan has the following objectives:

- Promoting compliance with South African legislation, international law and standards and the applicant's own standards.
- Impact prevention and, where they cannot be prevented, minimisation.
- Providing an implementation mechanism for mitigation measures and commitments identified in the EMPR process.
- Establishing a monitoring programme and record-keeping protocols against which the applicant's and its contractor's/sub-contractor's performance can be measured and to allow for corrective actions or improvements to be implemented when needed.
- Protocols for dealing with unforeseen circumstances such as unplanned events or ineffective mitigation measures.

6.2. Organisation Roles and Responsibilities

6.2.1 The Applicant

Although the applicant would likely outsource the majority of the prospecting with bulk sampling operations to contractors, it is accountable for the management of the environmental and social commitments. The applicant will ensure that:

- commitments are implemented in all material respects;
- prospecting with bulk sampling environmental and social performance complies in all material respects with applicable legal, regulatory and policy standards;
- adequate plans and sufficient resources are in place for rehabilitation, restoration and reclamation activities **to run concurrently with** prospecting with bulk sampling activities;
- pertinent environmental and social information will be freely shared with interested stakeholders;
- all work will be carried out by a third party is in a manner satisfactory to the applicant.

The Environmental Manager and Environmental Officer(s) shall act as the applicant's on-site implementing agent(s). They will be responsible for:

- preparing a site-specific Environmental Code of Operational Practice (ECOP) for each contractor and each allocated prospecting with bulk sampling area;

- ensuring that contractors are informed and understand environmental requirements before the commencement of activities on site (Environmental Awareness Training);
- environmental matters and for seeing that prospecting with bulk sampling activities are carried out safely and in accordance with the requirements of the EMPR and ECOP;
- verifying that environmental requirements are implemented in full, both by the applicant and its contractors;
- verifying that there are adequate plans and sufficient resources in place for worker health care and contingency plans to respond to workplace accidents;
- ensuring that all operations permissions (including relevant permits, licences and necessary approvals from the relevant authorities) are valid prior to commencing activities on site;
- monitoring the contractor's compliance with the EMPR and ECOP during weekly site inspections, including the preparation of weekly environmental checklists;
- advising the contractor on environmental issues within defined prospecting with bulk sampling areas;
- recommending additional environmental protection measures should this be necessary;
- preparing monthly reports and providing feedback at Executive Committee meetings; and
- undertaking final site audit before the contractor leaves site and preparing the Final Audit Report.

6.2.2 Contractors

Contractor(s) entity refers to any company or individual that is allocated a prospecting with bulk sampling area or contracted by the applicant to undertake any prospecting with bulk sampling on the proposed site. The EMPR shall be the overarching contractual document for all environmental and social management requirements to which all contractor (and any subcontractor) plans and documents must be aligned. The EMPR (or relevant section depending on the mining method used) shall be provided to all contractors, who shall be required to include the following provisions to ensure that the EMP is effective:

- clearly define roles, responsibilities and reporting lines for the execution of the EMPR;
- ensure that all staff are familiar with the EMPR and the measures with it and they sign off that they have read and understood the document;
- appropriate reporting and remedial action procedures to ensure that any incidents are reported promptly and dealt with effectively; and
- approximate monitoring and auditing actions.

The Environmental Representative, appointed by the Contractor, shall be responsible for monitoring, reviewing and verifying the Contractor's compliance with the EMPR. Duties shall include:

- monitoring and verifying that the EMPR and ECOP are adhered to at all times and taking action if specifications are not followed;
- monitoring and verifying that environmental impacts are kept to a minimum;
- inspecting the site on a daily basis with regard to compliance with the EMPR and ECOP;
- completing weekly checklists of these inspections;
- assisting the applicant's Environmental Manager/Officer in finding environmentally responsible solutions to problems;
- keeping a record of on-site incidents and accidents and how these were dealt with; and
- reporting any incidents of non-compliance with the EMPR to the Environmental Manager/Officer.

6.3. Training, Awareness and Competency

The applicant recognises that it is important that contractors, including staff at all levels, are aware of it's environmental and social policy; potential impacts of their activities; and roles and responsibilities in achieving conformance with the policy and procedures.

The applicant (Environmental Manager and Environmental Officer) will subject all the contractor's site staff to regular environmental awareness training to ensure effective implementation of the EMPR and procedures for which they have responsibilities. This training would include awareness and competency with respect to:

- General awareness relating to prospecting activities, including environmental and social impacts that could potentially arise from these activities.
- Legal requirements in relation to environmental performance.
- Necessity of conforming to the requirements of the EMP and ECOP, including reporting and monitoring requirements (i.e. such as incident reporting).
- Activity-specific training (i.e. waste management practices).
- Roles and responsibilities to achieve compliance, including change management and emergency response.

Training will take cognisance of the level of education, designation and language preferences of the personnel.

6.4. Compliance Verification and Corrective Actions

Inspections, monitoring and auditing will be undertaken to confirm appropriate implementation of the EMPR and ECOP, as well as the effectiveness of mitigation measures. Corrective actions include those intended to improve performance, non-compliances and non-conformances.

6.4.1 Inspection

Contractors will be required to conduct inspections on a weekly basis, on an ad hoc basis (internally) and formally once every month in an effort to monitor compliance and implement conditions stipulated in this EMPR and ECOP. The results of the inspection and monitoring activities shall be documented and reported to the applicant (Environmental Manager or Environmental Officer) on a weekly basis or more frequently if requested.

6.4.2 Monitoring

Monitoring will be conducted to:

- ensure compliance with regulatory and EMPR requirements;
- evaluate the effectiveness of operational controls and mitigation measures and provide a basis for recommending additional or alternative measures;
- verify predictions made in the EMPR amendment process by obtaining real time measurements;
- identify changes in existing physical, biological and social characteristics of the environment, compared to the baseline;
- verify that all project management plans are appropriate and relevant to their respective project activities and phases;
- quantify the direct impacts of prospecting on various marine benthic habitats (if required);
- quantify the indirect impacts of prospecting (use of tracks, establishment of parking and mineral processing areas etc) on various terrestrial habitats (if required), and
- Provide accountability and a sense of ownership through the project lifecycle.

6.4.3 Auditing

An external, independent Environmental Auditor should be appointed to conduct an evaluation of implementation of all requirements of this EMP. Findings will be documented in a Audit Report, which shall be submitted to the applicant for action and follow-up.

A final audit will be performed by the Environmental Manager/Officer to ensure the site has been rehabilitated and is in a satisfactory state before the contractor leaves site or moves to a new mining area. Findings will be documented in a Final Audit Report, which shall be submitted to the contractor for action and follow-up.

6.4.4. Corrective Actions

The applicant will implement a formal non-compliance and corrective action tracking procedure for investigating cause and identifying corrective actions in response to accidents, environmental and/or social non-compliances.

Where corrective actions are deemed necessary, specific measures will be developed, with designated responsibility and timing, and implemented. In this way, continuous improvement in performance would be achieved.

The Environmental Manager/Officer will be responsible for keeping records of corrective actions and for overseeing the modification of environmental or social protection procedures and/or training programmes to avoid repetition of non-conformances and non-compliances.

6.5. Management of Change

The development and implementation of the EMPR is an ongoing process that is iterative in nature. This document must thus be seen as a 'living' document and amendments may need to be implemented during the course of the project. Typical changes that can affect the EMPR include:

- A material design change that occurs after the EMPR has been compiled and approved.
- Changes in the feasibility/availability of specific mitigation measures sometimes following a period of monitoring.
- Material personnel changes on the project.

The following scenarios may apply:

- Minor changes to the EMPR that are not considered to be materially significant departures or material to the findings of the EMPR amendment process can be implemented by the applicant.
- Any significant revisions to the EMPR that are considered to be materially significant departures from the mitigation measures listed in the EMPR must be approved by DMR before the amended EMPR is implemented.
- Any changes to the prospecting methods or areas that are considered to be material to the findings of the EMPR revision process may require further approval from DMR (namely EMPR amendment process, including further possible public consultation).

A register of changes to the EMPR shall be kept with an approval sign off sheet.

6.6. Communication

Channels of communication will be established and upheld between the applicant, the contractor(s) and external stakeholders.

Where feasible, comply with the local development objectives, spatial development framework and integrated development planning of the municipality, and promote co-operative governance and integrated decision making.

A grievance procedure will be established and maintained to record any complaints or comments received from the contractors and public. The grievance procedure will be underpinned by the following principles and commitments:

- Disseminate key information to directly interested and impacted stakeholders.
- Seek to resolve all grievances timeously.
- Maintain full written records of each grievance case and the associated process of resolution and outcome.

The responsibility for resolution of grievances will lie with the applicant.

6.7. Document Control and Reporting

6.7.1 Documentation

The applicant will control all environmental related documentation, including project licences, approvals, permits, ECOPs, checklists, forms and reports, through a formal procedure.

Contractors will be required to develop a system for maintaining and controlling its own documentation.

6.7.2 Reporting

Following any environmental incidents, the applicant will conduct an incident investigation and prepare a report detailing the events and corrective and preventative measures implemented as a result. Significant incidents will be reported to the competent authority (e.g. DME, DEA, Department of Water and Sanitation, etc.).

6.7.3 Performance Assessments

In compliance with Section 55 of MPRDA, the applicant (or an independent consultant) will undertake a Performance Assessment at the end of propecting with bulk sampling operations (or as specified by DMR) for submission to DMR.

Performance Assessments will focus on:

- evaluating compliance with the EMPR and the requirements of the relevant legislation;
- assessing the continued appropriateness and adequacy of the EMPR (including the effectiveness of rehabilitation measures);
- identifying additional mitigation measures to address any non-compliances or deficiencies;
- presenting the results of the habitat monitoring programme (if required); and
- evaluating whether the closure objective are being met.

6.7.4 Mine Closure

When closure of a prospecting licence is intended, the applicant will conduct a final EMP Performance Assessment and submit a report to DME the Department of Minerals and Energy ensuring the following:

- Compliance with relevant legislation;
- Closure Objectives described in the EMP have been met;
- Residual Environmental Impacts and Risks of Latent impacts from prospecting operations have been identified, quantified and arrangements for management thereof have been assessed.

6.8. Mitigation and Management Plan

This section details the specific management commitments that should be implemented to prevent, minimise or manage significant negative impacts.

Ref. No.	Activity	Environmental and social objective	Mitigation and Management actions	Responsibility	Timing / Frequency	Monitoring and record keeping requirements
6.8.1 PLANNING / ESTABLISHMENT PHASE						
6.8.1.1	Finalisation of contractor prospecting with bulk sampling areas	Minimise disturbance to sensitive coastal habitats	• Prohibit prospecting with bulk sampling in the endangered Southern Benguela Reflective Sandy Shore habitats and in endangered estuarine habitats (Sout River). > If, however, prospecting with bulk sampling is proposed within these areas an independent assessment of the habitats and associated biota should be undertaken by a suitably qualified ecologist to verify the habitat status. > Should it be confirmed that the habitats are indeed ecologically unique, these areas should be declared 'no-go' areas and any future prospecting or mining there should be prohibited. • Establish a 5 metre wide "no-go" zone, measured from the base of the primary dunes or sea cliffs onto the beach, from the point of access to the beach to the area of operations. No prospecting or related operations are permitted in this zone. • Restrict prospecting to the use of current technologies applied in beach mining operations.	Applicant and independent ecologist	Prior to commencement of operation	Incorporate the SANBI benthic habitat map into the Applicant's GIS database Ecological assessment (if applicable)
6.8.1.2	Protection of heritage and cultural features	Reduce risk to cultural heritage material	• Exclude any shipwrecks identified during prospecting with bulk sampling from the operation area. • Exclude any shell middens or caves from the parking and equipment storage areas. • Train mining staff to recognise potential archaeological and palaeontological sites in the area, especially shell middens.	Applicant	Prior to commencement of operation	
6.8.1.3	Establishment of campsite and processing areas	Minimise disturbance to sensitive coastal habitats	The establishment of campsites by contractors on the coast is not permitted	Applicant	During establishment of mineral processing area	Final processing area location and extent to be specified in ECOP
			• Avoid the establishment of processing areas within 100 m of the edge of a river channel or estuary mouth. • No trenching on the beach, or construction of berms and raised processing areas closer than 5 m from the base of the primary dunes or sea cliffs.	Contractor		
6.8.1.4			Locate processing areas, as far as possible, in previously disturbed areas or areas of least sensitivity (palaeontological and environmental).	Contractor		

Ref. No.	Activity	Environmental and social objective	Mitigation and Management actions	Responsibility	Timing / Frequency	Monitoring and record keeping requirements
6.8.1.5			• Limit the processing area to the minimum reasonably required and that which will cause least disturbance to the beach environment. • Clearly demarcate the extent of the processing area (e.g. with droppers). • Confine operations such as stockpiling of gravel, jigging or classifying to below the HWM. • Confine ore stockpiles to mineral processing areas and limit the separation process to a specific controlled area.	Contractor		
	Establishment of vehicle and equipment storage areas	Minimise disturbance to sensitive coastal habitats	• Parking and storage areas should be kept to the absolute minimum required for the planned prospecting operation, in number and in surface area. • Parking and storage areas must be clearly demarcated. Their location must be documented and adhered to during prospecting operations. • Parking and storage areas should be sited in previously disturbed, unvegetated areas. No vegetation should be removed or damaged to establish storage and parking areas without prior evaluation of the sensitivity of the area, and preparation of adequate rehabilitation plans for the area to be disturbed. Sensitive areas should be avoided. • Should proposed parking and/or equipment storage areas fall within vegetation communities or ecological zones identified as being sensitive to disturbance, the advice of a vegetation community specialist should be sought before the establishment of such areas. No gravel is to be stockpiled in these areas.			
6.8.1.6	Preparation of site-specific Environmental Code of Operational Practice (ECOP)	Minimise disturbance to sensitive coastal habitats	Prepare site-specific ECOP for each contractor and each allocated prospecting area. The ECOP should include specific details for the following aspects: • Environmental considerations (i.e. identification of sensitive receptors) and establishment of no-go areas. • Access route(s) to allocated prospecting areas. • Extent of prospecting area and demarcation of the processing area(s), and refuelling/maintenance areas. • Housing keeping: > Use of drip trays under stationary plant and for refuelling/maintenance activities. > Adequate provision and maintenance of toilet facilities (chemical toilets).	Environmental Manager/Officer	Prior to commencement of operation	Copy of ECOP

Ref. No.	Activity	Environmental and social objective	Mitigation and Management actions	Responsibility	Timing / Frequency	Monitoring and record keeping requirements
			> Bunding of fuel stores. • Waste management plan. • Rehabilitation specification (if necessary), e.g. backfiling of sampling void, levelling of berms, removal of rocks etc. • Establishment of a rehabilitation fund. • Monitoring.			
6.8.1.7			Appoint an Environmental Representative to ensure that all environmental specifications in the EMPR and ECOP are met at all times.	Contractor	Prior to commencement of operation	Weekly audit reports/ checklists
6.8.1.8	Compliance with EMPR and ECOP	Operator and contractor to commit to adherence to EMPR and ECOP	Ensure that a copy of the approved EMPR (or part thereof) and ECOP are supplied to the contractor and is on site during the operation.	Applicant	Prior to commencement of operation	Signed acknowledgment of receipt
6.8.1.9	Disposal of waste	Minimise pollution and maximise recycling by implementing and maintain pollution control and waste management procedures at all times	Establish a solid waste control and removal system that is acceptable to the Applicant in order to prevent the spread of waste in, and beyond, the mining area.	Contractor	Prior to commencement of operation	
6.8.2 OPERATION PHASE						
6.8.2.1	Environmental awareness training	Ensure personnel are appropriated trained	• Undertake Environmental Awareness Training to ensure mining personnel are appropriately informed of the purpose and requirements of the EMPR and ECOP, including emergency procedures, spill management, etc. • Ensure that responsibilities are allocated to personnel. • Establish training and exercise programmes to ensure that the response activities can be effectively executed.	Environmental Manager/Officer	At commencement of operation	Copy of attendance register and training records
6.8.2.2	Site access	Minimise disturbance to sensitive coastal habitats	Demarcate and use only established and stabilised roads to access allocated prospecting areas.	Contractor	At commencement of operation	Weekly audit reports/ checklists
			Abide by all requirements of landowners relating to the care of, closing and/or locking of access gates in the area	Contractor	During operation	
			Where prospecting moves along the coast within a prospecting right area and no tracks or roads exit parallel to the coast, access should be undertaken below the high water mark when on sandy/beach areas.	Contractor	During operation	

Ref. No.	Activity	Environmental and social objective	Mitigation and Management actions	Responsibility	Timing / Frequency	Monitoring and record keeping requirements
			• Do not drive vehicles in ecologically sensitive areas (e.g. salt marsh or mudflats, rocky outcrops, white sand habitats). • Remain away from the foot of the coastal primary dunes or sea cliffs, and do not damage these in any away.	Contractor	During operation	
6.8.2.3	Berm construction and phasing	Minimise disturbance to sensitive coastal habitats	• Restrict berms to locations where there are sufficient available sources of beach sand or non-contaminated tailings for berm construction and road access. • Use materials sourced locally from old tailings dumps and existing sea walls for coffer dam construction. • Use only boulders sourced from below the HWM on the target beach to stabilize the bases of sea embankments. • Do not undercut or use material from cliffs, middens or vegetated dunes for sea wall construction. • No construction materials sourced from terrestrial areas or quarries above the HWM may be introduced to the beach environment.	Contractor	During construction	
6.8.2.4		Minimise disturbance to sensitive coastal habitats	• Limit the number of prospecting trenches operational concurrently. • Sample each trench sequentially to completion.	Contractor	During construction	Weekly audit reports/ checklists
6.8.2.5			Backfill all coastal excavations with the excavated material as prospecting progresses in such a way as to maintain the original beach profile as far as possible.	Contractor	During construction and operation	
6.8.2.6	Mineral Processing and tailings discharge	Facilitate natural recovery	• Confine stockpiles and processing of ore to mineral processing areas and limit the separation process to a specific controlled area. • Deposit tailings from gravel processing below the HWM and as far down the beach as possible to ensure their rapid removal by wave action. • No permanent structures of any kind may be erected above the HWM.	Contractor	During operation	
6.8.2.7			Backfill all tailings generated in prospecting trenches.	Contractor	During operation	
6.8.2.8	Storage of hazardous substances	Reduce risk of spillages and associated impacts	Store all fuel and oil in suitable containers in adequately bunded areas within the parking and storage area.	Contractor	During operation	Weekly audit reports/ checklists
6.8.2.9			Provide suitable fire-fighting equipment in the hazardous substances storage area.	Contractor	During operation	
6.8.2.10	Storage of equipment	Reduce area of disturbance and risk of spillages	Store all plant, vehicles or other items within the parking and storage area.	Contractor	During operation	Weekly audit reports/ checklists
6.8.2.11			Provide drip trays for stationary plant (such as compressors, pumps, generators, etc.) and for "parked" plant (e.g. mechanised equipment).	Contractor	During operation	

Ref. No.	Activity	Environmental and social objective	Mitigation and Management actions	Responsibility	Timing / Frequency	Monitoring and record keeping requirements
6.8.2.12	Refuelling	Minimise the risk of biophysical impacts	Inspect and maintain all fuel containers.	Contractor	During operation	Weekly audit reports/ checklists
6.8.2.13			Use drip trays when refuelling plant and/or vehicles.	Contractor	During refuelling	
6.8.2.14			• Ensure there is always a supply of absorbent material readily available to absorb/breakdown spills and where possible is designed to encapsulate minor hydrocarbon spillage. • The quantity of such materials shall be able to handle the total volume of the hydrocarbon/hazardous substance stored on site.	Contractor	During refuelling	
6.8.2.15			Refueling is to take place above the high water mark > and/or 30 m of any watercourse.	Contractor	During refuelling	
6.8.2.16	Maintenance	Minimise the risk of pollution and associated biophysical impacts	Keep all vehicles and equipment in good working order and serviced regularly.	Contractor	During maintenance	
6.8.2.17			Repair leaking equipment immediately or removed from the site.	Contractor	During maintenance	
6.8.2.18			Restrict vehicle maintenance to the maintenance yard area, except in emergencies when the beach area may be used if absolutely necessary.	Contractor	During maintenance	
6.8.2.19			Use drip trays when servicing equipment for the collection of waste oil and other lubricants.	Contractor	During maintenance	
6.8.2.20	Disposal of general waste	Minimise pollution and maximise recycling by implementing and maintain pollution control and waste management procedures at all times	Implement Waste Management Plan in ECOP.	Contractor	During operation	Record types and volumes of general wastes Waste receipts
6.8.2.21			Provide waste storage containers (bins) that are covered, tip-proof, weatherproof and scavenger proof.	Contractor	During operation	
6.8.2.22			Empty bins on a weekly basis.	Contractor	During operation	
6.8.2.23			Ensure that the site is kept free of litter.	Contractor	During operation	
6.8.2.24			No waste material or litter shall be burnt or buried on site.	Contractor	During operation	
6.8.2.25			Dispose of all solid waste offsite at an approved landfill site.	Contractor	During operation	
6.8.2.26	Disposal of hazardous waste	Minimise pollution and maximise recycling by implementing and maintain pollution control and waste management procedures at all times`	Segregate, classify and store all hazardous waste in suitable receptacles on board in order to ensure the safe containment and transportation of waste.	Contractor	During operation	Record types and volumes of hazardous wastes Waste receipts
6.8.2.27			Provide a specific waste management storage and segregation area at the onshore logistics base.	Contractor	During operation	
6.8.2.28			Dispose of hazardous waste at a facility that is appropriately licensed and accredited.	Contractor	During operation	
6.8.2.29			No hydrocarbon and hazardous waste shall be burnt or buried on site.	Contractor	During operation	
6.8.2.30	Accidental spills and leaks	Minimise the risk of spills and leaks and associated biophysical impacts	Ensure site staff are aware of the procedure to be followed for dealing with spills and leaks.	Contractor	In event of spill	Copy of attendance register and training records
6.8.2.31			Use absorbent material to absorb / breakdown spills.	Contractor	In event of spill	

Ref. No.	Activity	Environmental and social objective	Mitigation and Management actions	Responsibility	Timing / Frequency	Monitoring and record keeping requirements
6.8.2.32			Report any accidental spill and/or leak to the Applicant's Environmental Manager/Officer so that the best remediation method can be quickly implemented.	Contractor	In event of spill	Record of all spills (Spill Record Book), including spill reports; emergency exercise reports. Weekly audit reports/ checklists
6.8.2.33	Protection of natural features, flora and fauna	Minimise biophysical impacts	Refrain from collecting any plants (succulents) within the mining concession or adjacent areas.	Contractor	During operation	
6.8.2.34			Refrain from collecting any shellfish (including abalone, rock lobster, mussels) or undertaking recreational or subsistence fishing within the allocated mining concession or adjacent areas.	Contractor	During operation	
6.8.2.35			Restrict fires/braais to properly constructed facilities and provide firewood.	Contractor	During operation	
			Any area not surveyed and mapped as designated vehicle tracks, parking or equipment storage areas will also be considered as "no-go" areas.	Contractor	At all times	
6.8.2.36	Protection of heritage and cultural features	Reduce risk to cultural heritage material	If palaeontological or shipwreck material is encountered during the course of mining, the following should apply: • Work in the directly affected area should cease until the South African Heritage Resources Agency (SAHRA) has been notified and the contractor/THO has complied with any additional mitigation as specified by SAHRA. • Recover, where possible, any artefacts and take photographs of them, noting the date, time, location and types of artefacts found. • Retain permits and copies of correspondence from SAHRA. • Train mining staff to recognise potential archaeological and palaeontological sites in the area, especially shell middens.	Contractor	During operation	Copies of all correspondence
6.8.2.37	Monitor sand accumulation or erosion from the southern and northern limits of individual coffer dams	To determine the extent of sand accumulation or erosion to the north and south of individual coffer dams	Refer to Section **Error! Reference source not found.**.	Applicant	Monthly, at spring low tide	Monitoring results to be included in Performance Assessments in order to confirm the significance of the residual impact and, depending on the results, inform future mining planning and methods

Ref. No.	Activity	Environmental and social objective	Mitigation and Management actions	Responsibility	Timing / Frequency	Monitoring and record keeping requirements
6.8.3 DEMOBILISATION PHASE						
6.8.3.1	Final waste disposal	Minimise pollution and ensure correct disposal of waste	Dispose all waste (including derelict equipment) at a licensed waste site.	Contractor	Prior to leaving site	Waste receipts
6.8.3.2	Rehabilitation	Maximise rate of habitat recovery	• Remove berm material to below the low tide level, as far as wave action will allow, as soon as a trench has been excavated.	Contractor	Prior to leaving site	
6.8.3.3	Rehabilitation	Maximise rate of habitat recovery	Reshape beach and supratidal area back as close to the original profile as possible.	Contractor	Prior to leaving site	Final audit report
6.8.3.4			Remove all artificial constructions or beach modifications (e.g. tracks, berms, stockpiles, etc.), structures, equipment (including derelict), materials, waste, debris, rubble, etc. from site.	Contractor	Prior to leaving site	
6.8.3.5			Scarify parking areas and processing areas to a depth of 100 mm to break up any compacted soil. This may, however, not be necessary in very sandy areas or where hard calcrete is found at the surface.	Contractor	Prior to leaving site	
6.8.3.6			Close (with rock barrier or fence) and rehabilitate all non-essential tracks leading to allocated prospecting areas.	Contractor	Prior to leaving site	
6.8.3.7			Protect areas susceptible to erosion by installing necessary temporary erosion control measures (e.g. netting) to the satisfaction of the Environmental Manager/Officer.	Contractor	Prior to leaving site	
6.8.3.8	Final site audit	Ensure corrective action and compliance and contribute towards improvement of EMPr implementation	Audit allocated mining area in terms of compliance with EMPR and ECOP.	Environmental Manager/Officer	Prior to contractor leaving and/or moving to a new site	Final audit report
6.8.3.9			Return the rehabilitations funds to the contractor once the Environmental Manager/Officer is satisfied that the area has been suitably cleaned and rehabilitated.	Environmental Manager/Officer	Prior to contractor leaving and/or moving to a new site	
6.8.3.10	Monitoring of supratidal zone	Ensure corrective action and compliance and contribute towards improvement of EMPr implementation	• Monitoring of the success of passive3 rehabilitation. • If rehabilitation is not seen to be successful, implement additional rehabilitation measures to improve the restoration process (e.g. netting, seeding, etc.).	Applicant	Annual, for at least three years	
6.8.3.11	Reporting	Assessment of cumulative impacts	Report areas mined in terms of location and volume of gravel removed to DME annually.	Contractor	Annually	

[3] Passive restoration' is where minimal activities are undertaken and the disturbed area is allowed to re-establish on its own. This would involve the reshaping of the disturbed area and the replacement of topsoil (and associated seedbank).

Rehabilitation Plan

MONITORING AND REHABILITATION PLAN						
Ref. No.	**Activity**	**Habitat**	**Monitoring/Rehabilitation objective**	**Monitoring/Rehabilitation details**	**Responsibility**	**Timing / Frequency**
REHABILITATION						
	Rehabilitation after prospecting operations	Shallow subtidal, intertidal and coastal zone	Maximise rate of vegetation and habitat recovery	• Provide data, maps and calculations of soil volumes excavated during propsecting and bulk sampling to DME, to allow the annual calculation of areas worked on. • Remove all tailings stockpiles that have been created on the high shore and reshape back as close to the original profile as possible. • Close (with rock barrier or fence) and rehabilitate all tracks leading to allocated mining concession areas. • Remove all artificial constructions or beach modifications (e.g. tracks, berms, stockpiles, etc.), structures, equipment (including derelict), materials, waste, debris, rubble, etc. from site. • Scarify access tracks and storage/processing areas to a depth of 100 mm to break up any compacted soil. This may, however, not be necessary in very sandy areas or where hard calcrete is found at the surface. • Rehabilitation areas must be protected from future damage.	Contractor	Prior to leaving site
			Maximise rate of vegetation and habitat recovery	• Protect areas susceptible to erosion by installing necessary temporary erosion control measures (e.g. netting) to the satisfaction of the Environmental Manager/Officer. • Monitoring of the success of passive rehabilitation. • If rehabilitation is not seen to be successful, implement additional rehabilitation measures to improve the restoration process (e.g. netting, seeding, etc.).	Contractor	Prior to leaving site
		Intertidal and coastal zone	Maximise rate of habitat recovery	• Backfill all beach excavations above mean sea level with the excavated material as mining progresses, in such a way as to maintain the original beach sediment profile as far as possible (i.e. place heavier gravels and boulders at the bottom of excavations, followed by the less coarse/ sandy fraction). • Remove berm material to below the low tide level, as far as wave action will allow, as soon as a block has been mined out.	Contractor	Prior to leaving site
				• Reshape beach and supratidal area back as close to the original profile as possible. • Remove all artificial constructions or beach modifications (e.g. tracks, berms, stockpiles, etc.), structures, equipment (including derelict), materials, waste, debris, rubble, etc. from site.	Contractor	Prior to leaving site

MONITORING AND REHABILITATION PLAN						
Ref. No.	**Activity**	**Habitat**	**Monitoring/Rehabilitation objective**	**Monitoring/Rehabilitation details**	**Responsibility**	**Timing / Frequency**
				• Scarify parking areas and mineral processing areas to a depth of 100 mm to break up any compacted soil. This may, however, not be necessary in very sandy areas or where hard calcrete is found at the surface. • Close (with rock barrier or fence) and rehabilitate all non-essential tracks leading to allocated mining areas. • Protect areas susceptible to erosion by installing necessary temporary erosion control measures (e.g. netting) to the satisfaction of the Environmental Manager/Officer. • Rehabilitation areas must be protected from future damage.		
				• Monitoring of the success of passive4 rehabilitation. • If rehabilitation is not seen to be successful, implement additional rehabilitation measures to improve the restoration process (e.g. netting, seeding, etc.).	Contractor	Prior to leaving site

[4] Passive restoration' is where minimal activities are undertaken and the disturbed area is allowed to re-establish on its own. This would involve the reshaping of the disturbed area and the replacement of topsoil (and associated seedbank).

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APPENDIX A

Curriculum Vitae Dr Andrea Pulfrich

Personal Details

Born:	Pretoria, South Africa on 11 August 1961
Nationality and Citizenship:	South African and German
Languages:	English, German, Afrikaans
ID No:	610811 0179 087

Address:	20 Plein Street, McGregor, 6708, South Africa PO Box 302, McGregor, 6708, South Africa
Tel:	+27 21 782 9553
Cell :	082 781 8152
E-mail:	apulfrich@pisces.co.za

Academic Qualifications

BSc (Zoology and Botany), University of Natal, Pietermaritzburg, 1982
BSc (Hons) (Zoology), University of Cape Town, 1983
MSc (Zoology), University of Cape Town, 1987
PhD, Department of Fisheries Biology of the Institute for Marine Science at the Christian-Albrechts University, Kiel, Germany, 1995

Membership in Professional Societies

South African Council for Natural Scientific Professions (Pr.Sci.Nat. No: 400327/06)
South African Institute of Ecologists and Environmental Scientists
International Association of Impact Assessment (South Africa)

Employment History and Professional Experience

1998-present: Director: Pisces Environmental Services (Pty) Ltd. Specifically responsible for environmental impact assessments, baseline and monitoring studies, marine specialist studies, and environmental management plan reports.

1999: Senior researcher on contract to Namdeb Diamond Corporation and De Beers Marine South Africa, at the University of Cape Town; investigating and monitoring the impact of diamond mining on the marine environment and fisheries resources; experimental design and implementation of dive surveys; collaboration with fishermen and diamond divers; deep water benthic sampling, sample analysis and macrobenthos identification.

1996-1999: Senior researcher at the University of Cape Town, on contract to the Chief Director: Marine and Coastal Management (South African Department of Environment Affairs and Tourism); investigating and monitoring the experimental fishery for periwinkles on the Cape south coast; experimental design and implementation of dive surveys for stock assessments; collaboration with fishermen; supervision of Honours and Masters students.

1989-1994: Institute for Marine Science at the Christian-Albrechts University of Kiel, Germany; research assistant in a 5 year project to investigate the population dynamics of mussels and cockles in the Schleswig-Holstein Wadden Sea National Park (employment for Doctoral degree); extensive and intensive dredge sampling for stock assessments, collaboration with and mediation between, commercial fishermen and National Park authorities, co-operative interaction with colleagues working in the Dutch and Danish Wadden Sea, supervision of Honours and Masters projects and student assistants, diving and underwater scientific photography. Scope of doctoral study: experimental design and implementation of a regular sampling program including: (i) plankton sampling and identification of lamellibranch larvae, (ii) reproductive biology and condition indices of mussel populations, (iii) collection of mussel spat on artificial collectors and natural substrates, (iv) sampling of recruits to the established populations, (v) determination of small-scale recruitment patterns, and (vi) data analysis and modelling. Courses and practicals attended as partial fulfilment of the degree: Aquaculture, Stock Assessment and Fisheries Biology, Marine Chemistry, and Physical and Regional Oceanography.

1988-1989: Australian Institute of Marine Science; volunteer research assistant and diver; implementation and maintenance of field experiments, underwater scientific photography, digitizing and analysis of stereo-photoquadrats, larval culture, analysis of gut contents of fishes and invertebrates, carbon analysis.

1985-1987: Sea Fisheries Research Institute of the South African Department of Environment Affairs and Tourism: scientific diver on deep diving surveys off Cape Agulhas; censusing fish populations, collection of benthic species for reef characterization.

South African National Research Institute of Oceanography and Port Elizabeth Museum: technical assistant and research diver; quantitative sampling of benthos in Mossel Bay, and census of fish populations in the Tsitsikamma National Park.

University of Cape Town, Department of Zoology and Percy Fitzpatrick Institute of African Ornithology; research assistant; supervisor of diving survey and collection of marine invertebrates, Prince Edward Islands.

1984-1986: University of Cape Town, Department of Zoology; research assistant (employment for MSc Degree) and demonstrator of first year Biological Science courses. Scope of MSc study: the biology, ecology and fishery of the western Cape linefish species *Pachymetopon blochii*, including (i) socio-economic survey of the fishery and relevant fishing communities, (ii) collection and analysis of data on stomach contents, reproductive biology, age and growth, (iii) analysis of size-frequency and catch statistics, (iv) underwater census, (v) determination of hook size selectivity, (vi) review of historical literature and (vii) recommendations to the Sea Fisheries Research Institute of the South African Department of Environment Affairs and Tourism for the modification of existing management policies for the hottentot fishery.