CHAPTER 2

Marine ecology

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Executive Summary

Introduction

South Africa has ambitions to become a player in the globally emerging green hydrogen market, and a substantial programme of greenfield infrastructure has been proposed in the Northern Cape consisting of three components:

- A new breakwater port at Boegoebaai, dry and liquid bulk berths, and multi-purpose terminals.
- A mixed-use Special Economic Zone (SEZ) located in the region adjacent to the proposed Boegoebaai port.
- An expansive regional renewable energy (wind and solar photovoltaic) generation and transmission infrastructure.

The CSIR was appointed to undertake a Strategic Environmental Assessment (SEA) to address potential concerns around this proposed development by a consortium comprising of the South African National Energy Development Institute (SANEDI), Northern Cape Economic Development Trade and Investment Promotion Agency (NCEDA), and Transnet National Ports Authority (TNPA). The CSIR, in turn, appointed Pisces Environmental Services (Pty) Ltd and Anchor Environmental Consultants (Pty) Ltd to undertake necessary marine ecology specialist studies as part of the SEA.

The purpose of the SEA is *"to develop an integrated decision-making framework to guide the planning of the proposed Boegoebaai port, Special Economic Zone, and wider Namakwa region in a sustainable manner".*

The SEA has been divided into two components, a local-scale SEA concerned with assessing the sensitivities of the receiving environment around the proposed port and Special Economic Zone (Work Package 1) and a regional-scale SEA report covering the main sustainability issues associated with an expansive Northern Cape Green Hydrogen economy covering parts of the Namakwa District, delineated by the Richtersveld, Nama Khoi, Kamiesberg and Khâi Ma Local Municipalities (Work Package 2).

This document represents the marine ecological specialist report compiled as part of Work Package 1. Findings from this study (briefly summarised below) have been designed to inform the planning of the Port and SEZ, as well as provide reference and recommendations for future project-specific Environmental Impact Assessments.

Physical environment

Aspects of the physical environment that are likely to influence the design, layout and implementation of this project are largely dealt with in the prefeasibility study report for the Boegoebaai Port prepared by PRDW (2015) and do not need to be reiterated here. Suffice is to say that the bathymetry of the coastline, or at least proximity of deep water close to the shore, is the primary factor from a physical environment perspective that will likely influence selection of a suitable location for the port. Boegoebaai Point is immensely suitable in this respect (which it why it has been selected for this purpose) but there are a number of important marine ecological considerations that militate against the selection of this site as being suitable for port development (highlighted below). There are many other locations on the shoreline between the Orange River Mouth and Port Nolloth where the bathymetry profile of the shoreline is also likely to be suitable for port development that are not as sensitive from a biophysical perspective, which should be considered for this purpose.

Marine fauna and flora

According to the National Biodiversity Assessment (NBA), the Boegoebaai study area is positioned in the "Namaqua inshore" portion of the Southern Benguela Ecoregion (Harris et al. 2019a). The latter extends all along the western coast of southern Africa between Cape Agulhas and Angola, while the former makes up the inner most portion of this area, extending from the Orange River to Cape Point. Rocky intertidal habitat in this region comprises mainly one habitat type (termed Namaqua Exposed Rocky Shore). A review of available literature on the area and field surveys conducted as part of this study suggests that there is a high overall similarity between communities of this habitat type in the Boegoebaai area and those that have been studied elsewhere in the Southern Benguela Ecoregion. None of the species present on the shore are listed as endangered, threatened or rare (ETP) species, although it must be said that few of these species have been subject to any formal assessment. It is important to note that the proposed development would significantly increase the amount of sheltered rocky shore habitat within the region to several times that of what currently exists within the inlets of Homewood Harbour and Peacock Bay. Such habitats are rare within the region and have been shown to host a completely different community of intertidal fauna and flora (Blamey & Branch 2009).

Three broad morphodynamic sandy-beach types are recognised worldwide: dissipative, intermediate and reflective, distinguished on the basis of interaction of wave energy, beach slope and sand particle size. All three major beach types exist in the Boegoebaai area, along with two intermediate types (e.g. dissipative-intermediate and reflective-intermediate). Macrofaunal communities associated with beaches normally vary strongly in accordance with morphodynamic state but tend to be similar across beaches of similar types within the same ecoregion. Dissipative beaches usually support higher diversity, abundance and biomass of macrofauna than do intermediate beaches, while reflective beaches are normally most depauperate. Beaches in the study area all follow this general pattern but faunal communities were all depauperate relative to other beaches of similar morphodynamic state elsewhere in the Southern Benguela Ecoregion. This is likely a result of disturbance by diamond mining operations in the region, evidence of which can been seen throughout the area, but especially in the north. Little has been done in terms of identifying ETP beach macrofauna species but one species, the giant isopod *Tylos granulatus,* has been singled out as being important. The range of *T. granulatus* once extended across the whole southern African west coast from Swakopmund to Cape Point but has now been reduced to probably less than half that. More than two decades ago it was suggested that *T. granulatus* should be assigned red data status of perhaps 'Vulnerable' or 'Low Risk. Recent genetic research has uncovered high levels of population structure in southern African *T. granulatus* populations with two distinct lineages present on the west coast, to the north and south of a Hondeklip/Kleinzee break (Mbongwa et al. 2019), which are sufficiently different that they may constitute separate species. A recent, preliminary IUCN red list assessment supports the classification of *T. granulatus* as an endangered species under Criterion B due to its small natural habitat (sandy beaches, supratidal to low water mark only), declines in habitat quality, and fragmented populations as shown by the population genetics results (Linda Harris, Nelson Mandela Metropolitan University, pers. comm.). This species is very sensitive to disturbance, appears strongly photophobic and rapidly disappears as development encroaches possibly due to light pollution.

Mixed shore ecosystems, which include any area of the shore that is not pure rock or pure sand, makes up a significant portion (almost one third) of the intertidal shoreline habitats in the Boegoebaai area. These habitats have been poorly studied in general and were not specifically surveyed in this study. Species present in these habitats are mostly also present in the pure sections of each component habitat type, but species richness on mixed shore can be higher due to increased habitat complexity and heterogeneity.

Surf zone habitats are located offshore of sandy beaches, extending from the low water mark out to the back of the breaker zone where they grade into more extensive unconsolidated soft bottom subtidal habitats. Despite their turbulent nature, surf zone habitats are an important nursery and feeding area for a range of marine fish and invertebrate species. Pilot seine net sampling undertaken in surf zone habitats in the Boegoebaai region revealed low species richness (only three species) none of which are listed as ETP species. These habitats are therefore not considered particularly sensitive in the Boegoebaai area.

Fauna that inhabits unconsolidated (soft bottom) subtidal areas include both epifaunal and infaunal organisms. On the west coast of South Africa, benthic infauna assemblages are typically made up of (a) deposit feeders, such as worms (polychaetes), which either ingest sediments to extract organic matter trapped between the grains or actively gather organic detritus, (b) suspension feeders, such as sea pens and some crab species, which consume drifting detritus and plankton from the water column, and (c) filter feeders, including bivalves and certain amphipods and polychaetes, that actively pump and filter water to capture suspended particles. Predators in these soft-bottom habitats either burrow through sediments to hunt prey or ambush prey on the surface. According to the NBA (Sink et al. 2019a), unconsolidated (soft bottom) subtidal habitats around Boegoebaai are listed as “endangered” due to the limited protection afforded to these areas through the formal protected area network, and threats from flow reduction in the Orange River and disturbance from diamond mining. Much of this habitat type in the study area is listed as Critically Biodiversity Area (CBA)-Restore or Ecological Support Area (ESA) and thus should be subject to as little disturbance as possible.

Consolidated (or rocky) subtidal habitat is widespread in the study area. Rocky reefs in shallow waters (less than 20 m depth) support dense kelp forests comprising mostly of *Ecklonia maxima* and *Laminaria pallida.* Other important species that inhabit rocky reefs in the study area include whelks, limpets, sea anemones, black mussel, red algae (*Rhodymenia* sp., *Gigartina* sp., and *Champia* sp.), encrusting coralline algae, crabs, chitons, reticulated starfish, barnacles, and sea cucumbers. Rocky reef habitats near Boegoebaai are classified as “vulnerable” due to limited protection afforded to these areas through the formal protected area network. Much of this habitat is listed as CBA-Restore or Ecological Support Area and thus should be subject to as little disturbance as possible.

A total of 72 water birds has been recorded in the Boegoebaai study area. Many of these birds are classified as threatened by the IUCN, including five species of coastal seabirds (20%) and 15 pelagic seabird species (25%). Many anthropogenic activities and uses of the marine environment (including those likely to be associated with the development of a new port and SEZ at Boegoebaai) pose a serious risk to these already threatened seabirds. At least two species of seabirds (including Endangered the Bank Cormorant *Phalacrocorax neglectus*) are known to breed on the rocky cliffs at Boegoebaai Point, which is the identified site for the port breakwater. Other costal seabird species are known to breed on the rocky and mixed shore (e.g. African Black Oystercatcher *Haematopus moquini)* and sandy beach (White fronted plover *Charadrius marginatus*) habitats in the study area. Care needs to be taken to ensure that these threatened marine and coastal birds are not unduly disturbed by project activities.

At least thirty-six marine mammals are likely to occur in the study area, including numerous cetacean species (whales and dolphins). This also includes a breeding population of Cape fur seal *Arctocephalus pusillus* at the proposed site for the port breakwater. The most sensitive area is around the headland within the proposed port precinct area of the SEZ. The high-profile rocky shore and cliffs not only offer some degree of protection from land-based predators but also provide shaded refugia and pools for seals to thermoregulate. The latter has been shown to be the most important environmental factor for breeding seal haul-outs in the lower latitudes where there is a high risk of overheating (Stevens & Boness 2003).

Seals started breeding at this site in 1991 and the colony remains small (n = 107 pups counted in 2007) but is growing. Despite their IUCN red list status of “Least Concern” and the prevalence of seal colonies along the west coast of southern Africa, seals are protected in South Africa under the Sea Birds and Seals Protection Act 1973. Further to this, any activities that disturb seals are deemed to be illegal according to the NEMBA (National Environmental Management: Biodiversity Act).

Construction of a breakwater and or port at Boegoebaai is likely to seriously disturb and/or displace both the seals and breeding seabirds present at this site and it is strongly recommended that consideration be given to identifying an alternate site for port development for this reason alone. If displaced, it is unlikely that the Cape fur seal colony would re-establish on adjacent low-profile rocky shore areas as these offer no shaded refugia, pools or protection from land-based predators. Female seals are likely to be disturbed by human activities associated with port construction, and may elect to avoid contact with humans to reduce the risk of conflict and are therefore unlikely to return to the breeding colony and their pups. This is supported by research showing that breeding and pupping harbour seals on the west coast of North America have been displaced by shellfish aquaculture activities (Becker et al. 2011). Potential mitigation in the form of an artificial haul-out area that could be constructed as part of the port development may offer a solution, however, there is a risk that such initiatives may fail.

Seals started breeding at this site in 1991, and the colony remains small (n = 107 pups counted in 2007) but is growing. In South Africa, seals are protected under the Sea Birds and Seals Protection Act 1973 which states that it is an offence to pursue, shoot, wilfully disturb, kill or capture any sea bird or seal unless duly authorised by the relevant authority. Construction of a breakwater and or port at Boegoebaai is likely to seriously disturb both the seal colony and breeding seabirds present at this site. It is strongly recommended that consideration be given to identifying an alternate site for port development for this reason alone.

The South African west coast is generally a highly productive area that supports a high biomass of marine biota and several important fisheries. Surprisingly though, few of these fisheries extend into the Boegoebaai area. The Northern Cape is also sparsely populated, which means it is also not heavily utilised by small scale commercial, subsistence or recreational fishers. Demersal trawling, demersal longlining and pelagic longlining, are practiced in the offshore water greater than 200 m depth, but the area is not considered particularly important for any of these fisheries. There is an abalone ranching concession area that extends from just south of Alexander Bay to Port Nolloth, but the owner of this fishing right is not practicing any ranching at present. Neither activity is likely to be negatively affected by the proposed development at Boegoebaai.

Sensitivity Assessment

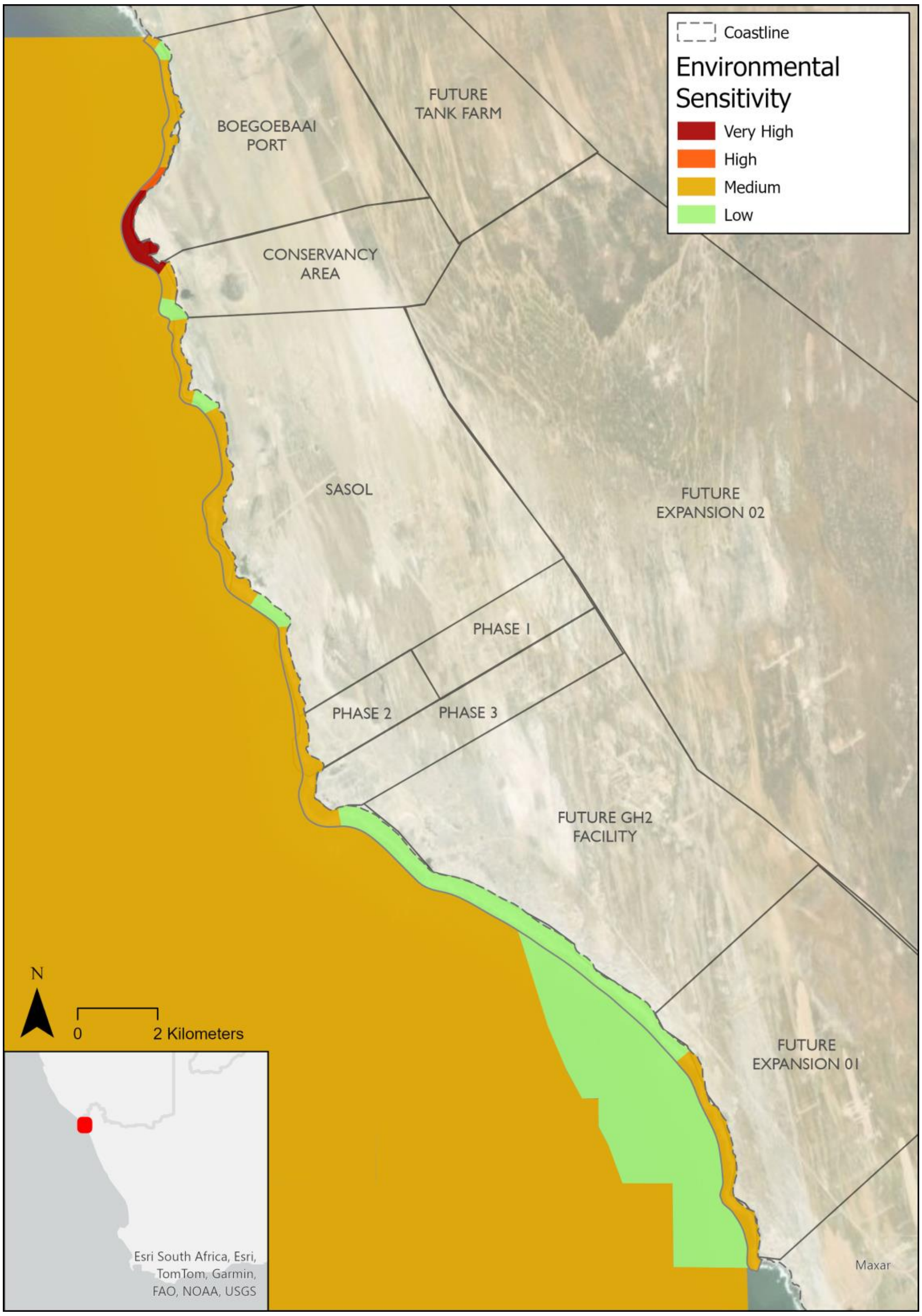
An environmental sensitivity assessment is a critical component when informing future development as it provides a spatially explicit understanding of ecological vulnerability of a defined area to anthropogenic disturbance(s). The assessment of environmental sensitivity is particularly relevant in dynamic and biodiverse coastal and marine ecosystems, where environmental changes and human activities can have significant and lasting impacts. Sensitivity assessments integrate multiple environmental and ecological factors to evaluate both vulnerability and resilience of various habitat types to development pressures. Determining environmental sensitivity was an important component of the WP1 Boegoebaai SEA as this can be used to inform where, from a marine ecology perspective, development might be constrained, and where development might be permissible (subject to future authorisation) as part of future development and conservation planning, as well as informing mitigation strategies to minimize environmental impacts. The sensitivity assessment aims to be intuitive for policy makers, developers and non-technical audiences.

The environmental sensitivity assessment for the Boegoebaai SEZ provides a GIS-based analysis, incorporating conservation, environmental and threatened status, validated by in situ field sampling. The assessment categorized habitats into four sensitivity levels (Low, Medium, High and Very High) (see Figure

S-1 below). A key finding is that mixed rocky shores and subtidal reefs hold medium to high sensitivity due to their biodiversity value, habitat complexity, and limited formal protection. These habitats support diverse marine communities and are classified as Vulnerable, emphasizing the need for conservation measures. In contrast, sandy beaches generally exhibited lower sensitivity, except for reflective and intermediate sandy shores, where relatively high numbers of *Tylos granulatus* were recorded. The assessment also found that surf zone fish communities in the area had low species richness and no recorded Endangered, Threatened, or Protected species, further confirming lower sensitivity in sandy beach areas.

The most sensitive area identified in the assessment is the rocky headland within the proposed port precinct, which serves as a breeding site for Cape fur seals and threatened seabirds, including Bank Cormorants and African Black Oystercatchers. Development in this area, particularly the construction of a port and breakwater, poses a high risk of disturbance to these species and could have irreversible ecological consequences. The assessment strongly recommends considering alternative port locations to avoid significant impacts on these critical habitats. Additionally, much of the intertidal and nearshore environments within the SEZ are listed as Critical Biodiversity Areas (CBA-Restore), reinforcing the need for careful management and mitigation measures. Field surveys also revealed inaccuracies in existing national ecosystem type classifications of reflective and intermediate sandy shore in the SEZ region, which were corrected to ensure a more accurate sensitivity assessment. The findings underscore the importance of integrating ecological sensitivity into spatial planning, ensuring that development aligns with conservation priorities, and minimizing impacts on vulnerable marine and coastal ecosystems.

The options of relocating the breakwater to the north of the current site seem limited given the bathymetry of the area but there appear to be some options to the south of Boegoebaai Point. Potential areas to the south of the current proposed site have been identified as areas to be considered as viable alternative areas based on their ecological sensitivity and their bathymetry profile immediately offshore.



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Glossary

Alien species: Species that occur outside their natural range and dispersal potential. Alien species are spread by human activity, intended or unintended, to new areas. May or may not become 'invasive species'.

Anthropogenic: Relating to or resulting from the influence of human beings on nature.

Avifauna: The birdlife of a particular region or habitat.

Benthic: The benthic zone is the ecological region at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers. Organisms living in this zone are collectively referred to as the "benthos", e.g., the benthic invertebrate community, including crustaceans and polychaetes.

Biogeography: the patterns and processes that have influenced the distribution of species and ecosystems over space and time.

Bioregion: A region defined by characteristics of the natural environment rather than by man-made divisions.

Critical Biodiversity Area: An area in a natural condition that is required to meet biodiversity targets, for species, ecosystems or ecological processes and infrastructure. The management objectives for these areas require that they are to remain in a natural or near-natural state, with no further loss of natural habitat. Defined as "Strict Biodiversity Conservation Zones" in the 2024 Marine Spatial Planning (MSP): Biodiversity Sector Plan.

CBA Natural Area: Sites that have natural/near-natural ecological condition, with the management objective of maintaining the sites in that natural/near-natural state. Defined as "Biodiversity Conservation Areas (Natural)" in the 2024 Marine Spatial Planning (MSP): Biodiversity Sector Plan.

CBA Restore Area: 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. As a minimum in CBA Restore sites, further deterioration in ecological condition must be avoided, and options for future restoration must be maintained. Defined as "Biodiversity Restoration Areas (Modified)" in the 2024 Marine Spatial Planning (MSP): Biodiversity Sector Plan.

Diversity: The number of different species that are represented in a given community.

Detritivore: An organism that feeds on dead and decomposing organic matter (detritus).

Ecological Support Area: An area that is not essential for meeting biodiversity targets but does play an important role in supporting the functioning of Protected Areas or CBAs and are often vital for delivering ecosystem services. Within ESAs, negative impacts of human activities on key biodiversity features are managed and minimised to maintain the features in at least a functional, semi-natural state and/or to allow the area to improve in ecological condition. The 2024 Marine Spatial Planning (MSP): Biodiversity Sector Plan defines these areas as "Biodiversity Impact Management Zones".

Ecologically or Biologically Significant Marine Areas: Defined by the Convention on Biological Diversity (CBD) as "geographically or oceanographically discrete areas that provide important services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics, or otherwise meet the [EBSA] criteria". EBSAs are

Ecosystem Threat Status: Developed by SANBI (2018) is an indicator of how threatened ecosystems are, specifically the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function, or composition (Harris et al. 2018).

Ecosystem: a biological community of interacting organisms and their physical environment – a complex network or interconnected system.

Ecozone/Ecoregion: The 2011 National Biodiversity Assessment used the terms 'ecoregions' and 'ecozones' to replace the similar, but revised 'bioregions' and 'biozones' used previously and to avoid confusion between the different map layers from previous assessments

Environment: The external circumstances, conditions and objects that affect the existence of an individual, organism, or group. These circumstances include biophysical, social, economic, historical, and cultural aspects.

Environmental Authorisation: Permission granted by the competent authority for the applicant to undertake listed activities in terms of the NEMA EIA Regulations, 2014.

Environmental Impact Assessment: A process of evaluating the environmental and socio-economic consequences of a proposed course of action or project.

Epifauna: Organisms residing in the benthos, specifically on surfaces of the seafloor and/or attached to surfaces such as rocks, shells and pilings.

Fauna: General term for all the animals found in a particular location.

Filter feeder: A sub-group of suspension feeding animals that feed by straining suspended matter and food particles from water, typically by passing the water over a specialized filtering structure.

Grazer: Any animal that relies on herbivory (feeds on plants) as its primary food source. Examples of ocean grazers include herbivorous fish, sea urchins and certain sea snails.

Impact: A change to the existing environment, either adverse or beneficial, that is directly or indirectly due to the development of the project and its associated activities.

Infauna: The assemblage of organisms inhabiting the seafloor.

Intertidal zone: The section of the marine environment that lies exposed at low tide and submerged at high tide.

Invasive species: Alien species capable of spreading beyond the initial introduction area and have the potential to cause significant harm to the environment, economy or society.

Invertebrate: Animals that do not have a backbone. Invertebrates either have an exoskeleton (e.g. crabs) or no skeleton at all (worms).

IUCN listed species: Species included and rated by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, a comprehensive inventory of the global conservation status of biological species. It uses a set of precise criteria to evaluate the extinction risk of thousands of species and subspecies.

Macrobenthos/macrofauna: Those animals retained by a 1.0-mm-mesh sieve. Macrobenthic invertebrates are defined as organisms that live on or inside the deposit at the bottom of a water body.

Marine Spatial Planning: The public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that have been specified through a political process.

Nursery habitat: A subset of all habitats where juveniles of a species occur, having a greater level of productivity per unit area than other juvenile habitats.

Offshore: The area seaward of the nearshore environment boundary.

Polychaete: Segmented worms with many bristles (i.e., bristle worms).

Predator: (Marine) Animals that hunt and kill other animals for food. They play a vital role in marine ecosystems, helping to regulate populations and maintain balance.

Sediment: Mud, sand, silt, clay, shell debris, and other particles that settle on the bottom of rivers, lakes, estuaries, and oceans.

Species richness: the number of species within a defined region.

Species: A category of biological classification ranking immediately below the genus, grouping related organisms. A species is identified by a two-part name; the name of the genus followed by a Latin or Latinised un-capitalised noun.

Suspension feeder: An animal that feeds on particles of organic matter that are suspended in water.

Taxon (plural – taxa): Refers to any unit used in the science of biological classification, or taxonomy.

Upwelling: An oceanographic phenomenon that involves wind-driven motion of dense, cooler, and usually nutrient-rich water from deep water towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water.

Vulnerable Marine Ecosystem: Groups of species, communities or habitats characterized by their structural functionality and their vulnerability to physical disturbance. The identification of VMEs includes (i) uniqueness or rarity; (ii) functional significance of the habitat; (iii) fragility; (iv) live-history traits of component species that make recovery difficult; and (iv) structural complexity. Includes seamounts, hydrothermal vents, cold water corals and sponge fields.

Abbreviations and Acronyms

Anchor	Anchor Environmental Consultants
BCC	Benguela Current Commission
CBD	Convention on Biological Diversity
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DFFE	Department of Forestry, Fisheries and the Environment
DHI	Danish Hydraulic Institute
EBSA	Ecologically or Biologically Significant Marine Area
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ESA	Ecological Support Area
ETP	endangered, threatened or rare
FAO	Food and Agricultural Organisation
GH2	Green Hydrogen
ha	hectares
Hm0	Significant wave height calculated from the zeroth moment (M0) of a wavespectrum
ICCAT	the International Commission for the Conservation of Atlantic Tunas
IOTC	Indian Ocean Tuna Commission
IMD-SA	International Mining and Dredging – South Africa
IUCN	International Union for the Conservation of Nature
km	kilometre
KZN	KwaZulu Natal
MARISMA	Marine Spatial Management and Governance Programme
MIBA	Marine Important Bird Areas
MPA	Marine Protected Area
MSL	mean sea level
MSP	Marine Spatial Planning
NASA	National Aeronautics and Space Administration
NBA	National Biodiversity Assessment
NCEDA	Northern Cape Economic Development Trade and Investment Promotion Agency
NCEP	National Centres for Environmental Prediction

NTU	Nephelometric Turbidity unit
PSD	Particle Size Distribution (sediment)
QDGC	Quarter-Degree Grid Cell
RFMOs	Regional Fisheries Management Organisations
RO Plant	Reverse Osmosis (desalination) Plant
SABAP	South African Bird Atlas Project
SANBI	South African National Biodiversity Institute
SANEDI	South African National Energy Development Institute
SAWS	South African Weather Service
s	seconds
Sc0	dynamic baseline scenario
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SW	southwest
TAC	Total Allowable Catch
TAE	Total Allowable Effort
TNPA	Transnet National Ports Authority
TOC	Total Organic Carbon
Tp	Peak wave period
TSS	Total Suspended Solid
WASA	Weather Atlas of South Africa
WCRL	West Coast Rock Lobster
WP1	Work Package 1
WP2	Work Package 2
°C	degrees centigrade
g/m^2	grams per square metre
mg/L	milligrams per litre
%	percent (parts per hundred)

CHAPTER 2. MARINE ECOLOGY

2.1 INTRODUCTION

As part of South Africa's ambition to become a player in the globally emerging green hydrogen market, a substantial programme of greenfield infrastructure has been proposed in the Northern Cape consisting of three components:

- A new breakwater port at Boegoebaai, dry and liquid bulk berths, and multi-purpose terminals (Figure 2-1.1).
- A mixed-use Special Economic Zone (SEZ) located in the region adjacent to the proposed Boegoebaai port (Figure 2-1.2).
- An expansive regional renewable energy (wind and solar photovoltaic) generation and transmission infrastructure.

Figure 2-1.1. Artist's impression of the Port of Boegoebaai. Source: TNPA (2024)

Green hydrogen production, at the scale envisaged for this project, will be a diverse and multifaceted process with many direct and indirect impacts, both positive and negative. All programme components, including their interconnected transport corridors, will require substantial areas of land surface, as well as other resource intensive inputs, all proposed in a sparsely populated but ecologically sensitive region. Existing, and potentially competing, land uses in the region include conservation, agriculture, fishing, tourism, mining, and some subsistence livelihoods.

A Strategic Environmental Assessment (SEA) was therefore initiated through a collaboration between the South African National Energy Development Institute (SANEDI), Northern Cape Economic Development Trade and Investment Promotion Agency (NCEDA), and Transnet National Ports Authority (TNPA).

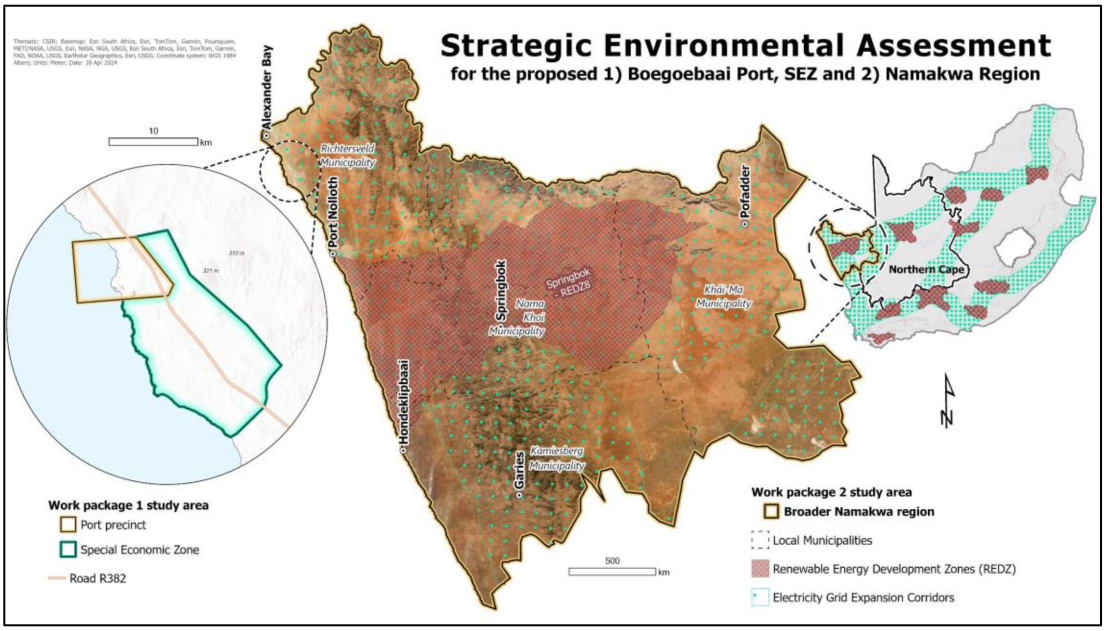


Figure 2-1.2. Boegoebaai Special Economic Zone.

The Council for Scientific and Industrial Research (CSIR) was appointed to undertake the SEA. The CSIR, in turn, appointed Pisces Environmental Services (Pty) Ltd and Anchor Environmental Consultants (Pty) Ltd to undertake necessary marine ecology specialist studies as part of the SEA.

The purpose of the SEA is "*to develop an integrated decision-making framework to guide the planning of the proposed Boegoebaai port, Special Economic Zone, and wider Namakwa region in a sustainable manner*".

The objectives of the SEA are to:

- Assess the social and ecological sensitivity of local and regional receiving environments;
- Classify spatial regions, based on multiple criteria, as being more, or less, suitable for future development;
- Identify strategic-level constraints, opportunities, cumulative impacts, and strategic management actions; and
- Provide an integrated decision-making framework and suite of tools, to guide project developers, practitioners, and policymakers.

The SEA has been divided into two components:

1. **Boegoebaai Port and Special Economic Zone (Work Package 1):** Local-scale SEA report concerned with assessing the sensitivities of the receiving environment around the proposed port and SEZ.
2. **Namakwa Region (Work Package 2):** Regional-scale SEA report covering the main sustainability issues associated with an expansive Northern Cape Green Hydrogen economy covering parts of the Namakwa District, delineated by the Richtersveld, Nama Khoi, Kamiesberg and Khâi Ma Local Municipalities.

This document represents the marine ecological specialist report compiled as part of Work Package 1. It is a local-scale, spatially focused SEA report identifying sensitivities around the proposed port and SEZ development covering ~33 500 ha ("Boegoebaai Port and SEZ SEA"). It includes expert on-site, ground-truthing to produce high resolution spatial data. Findings from this study have been designed to inform the planning of the Port and SEZ, as well as provide reference and recommendations for future project-specific Environmental Impact Assessments.

The Terms of Reference for this study required that the following key tasks be undertaken for this study:

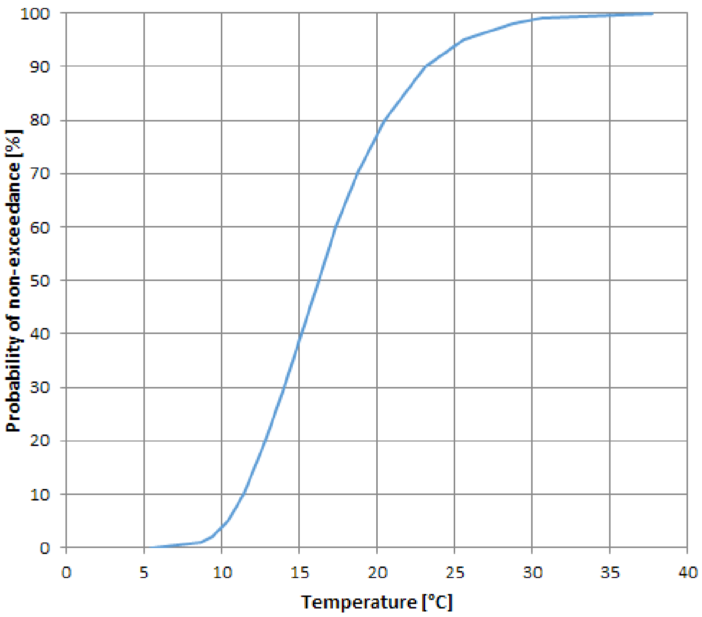
1. Prepare a Plan of Study:
    - Outline the approach, data requirements, assumptions, limitations and timeframe of tasks.
    - Provide report / chapter framework.
2. Description of the receiving environment:
    - Describe the land use dynamics and likely changes in the receiving environment and broader region as it relates to your topic. This will feed into the dynamic baseline scenario (Sc0) used in WP2 "Regional SEA" as needed – "how is the social-ecological system changing even if a GH_2 economy does not realise?".
    - Describe the key characteristics of the receiving environment as it pertains to your area of expertise - *"What, where, why is it important?"*
    - Should be spatially explicit as far as possible.
3. Site visit / ground-truthing:
    - Site visit to augment the receiving environment description, and to map and verify environmental sensitivity, including limited offshore sampling (within the limits of the budget and time available), to validate habitat sensitivity maps.
4. Sensitivity analysis:
    - Spatial layers distinguishing relative sensitivity of the receiving environment (Low, Medium, High, Very High).
    - Verified and refined based on site visit / ground-truthing.
5. Aspects and impacts register:
    - Potential impacts (negative and positive) that may arise from the planned activities and infrastructure (based on a project description provided by CSIR).
6. Recommendations for planning and future Environmental Impact Assessments (EIAs):
    - Practical recommendations to inform the planning and layout of the Port and SEZ.
    - Practical recommendations for future EIA studies.
    - Practical recommendations to enhance positive impacts and reduce negative impacts.

2.2 DESCRIPTION OF THE AFFECTED MARINE ENVIRONMENT

2.2.1 Climate

2.2.1.1 Temperature

No detailed data on air temperature at Boegoebaai are available. However, PRDW (2015) present data from air temperature measurements at 60 m above ground level (taken around 20 km away from the Boegoebaai site) available from the "Weather Atlas of South Africa (WASA) project" (Mabille et al. 2014). These data indicate a moderate climate with air temperatures between 10.4 °C and 25.5 °C for 90% of the time. The highest and lowest temperatures recorded in the three-year dataset were 37.7 °C and 5.4 °C, respectively (Figure 2-2.1).



Probability of non-exceedance [%]	Temperature at 60m above ground level [°C]
0	5.4
1	8.6
2	9.4
5	10.4
10	11.4
20	12.8
30	14.0
40	15.1
50	16.2
60	17.4
70	18.7
80	20.5
90	23.1
95	25.5
98	28.7
99	30.6
100	37.7

Figure 2-2.1. Air temperature measurements taken at 60 m above ground level available from the "Weather Atlas of South Africa (WASA) project". Taken from PRDW (2015).

2.2.1.2 Wind

Four datasets of wind data are available for the study area, as presented in PRDW (2015). The NOAA/NCEP WAVEWATCH III CFSR Reanalysis Hindcast dataset and the data collected through the "Weather Atlas of South Africa (WASA) project" (Mabille et al. 2014) is considered to be the most reliable of these (PRDW 2015). Wind measurements from WASA station (WM01, located at 28.602°S 16.664°E, approximately 20 km NW of Boegoebaai) are available at 10-minute intervals over a range of heights above ground level for the period of October 2010 to March 2014 (Figure 2-2.2). Wind rose and wind speed exceedance plots derived from these measurements averaged over 10-minute intervals at 10 m above the ground and wind directions at the 20-m level are presented in Figure 2-2.3 and Figure 2-2.4.

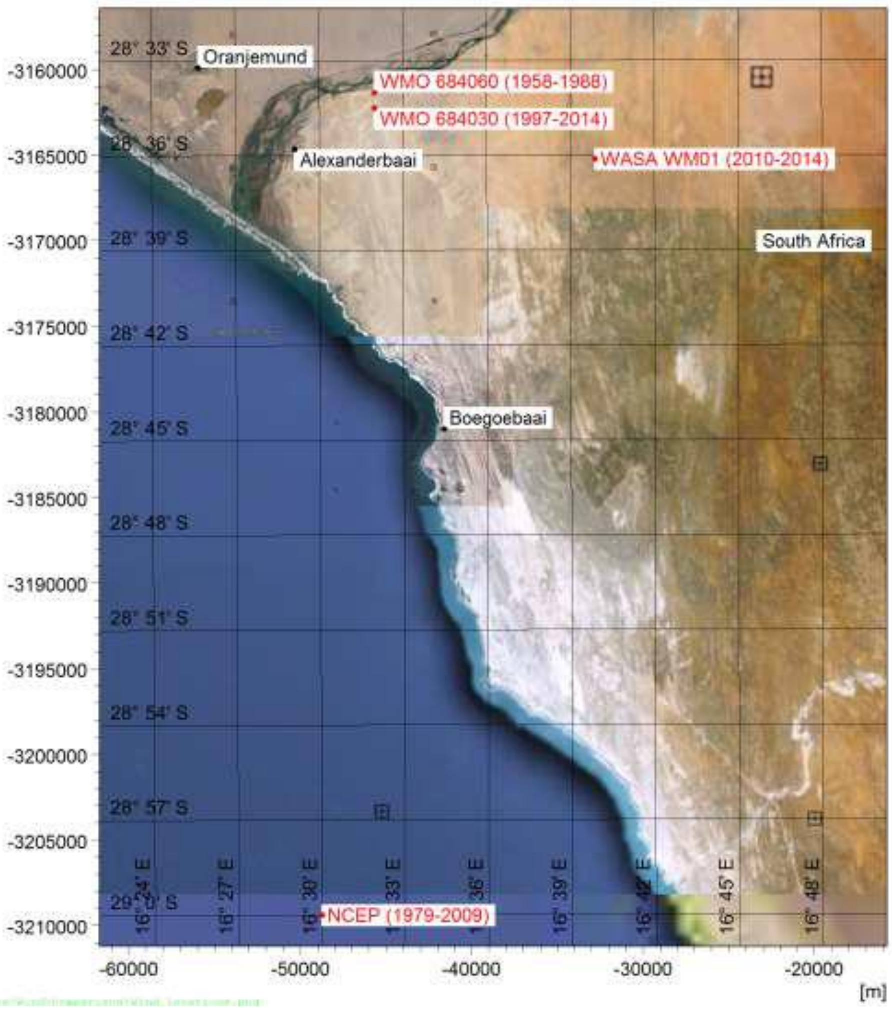


Figure 2-2.2. Locations of available wind datasets for Boegoebaai. Source: PRDW (2015).

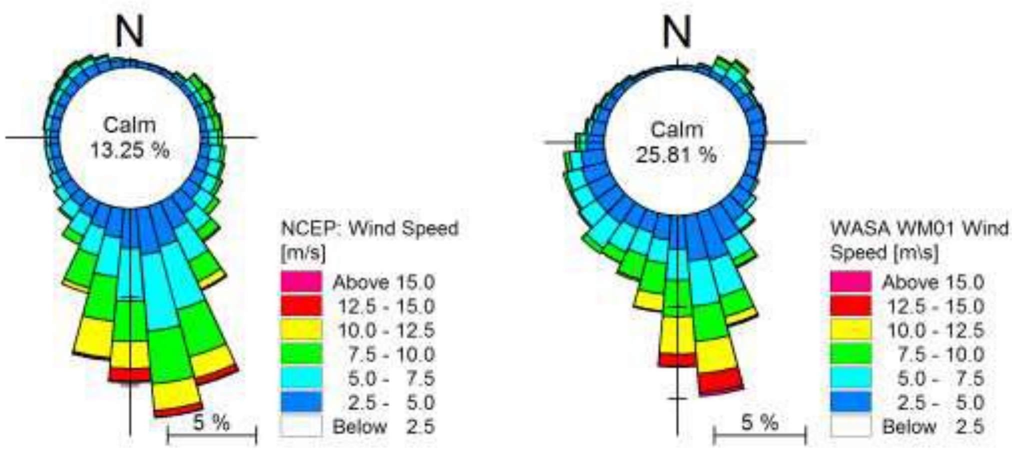
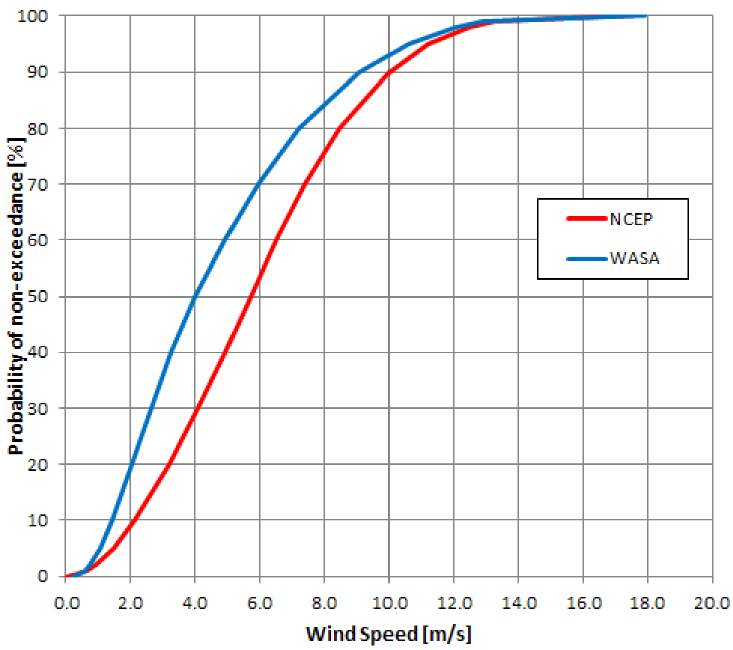


Figure 2-2.3. Wind rose data for Boegoebaai from the NCEP and WASA. Source: PRDW (2015).



Probability of non-exceedance [%]	Wind Speed [m/s] NCEP	Wind Speed [m/s] WASA
0	0.04	0.22
1	0.64	0.58
2	0.91	0.74
5	1.45	1.05
10	2.14	1.43
20	3.19	2.04
30	4.09	2.63
40	4.90	3.26
50	5.70	4.00
60	6.51	4.90
70	7.39	5.96
80	8.48	7.18
90	10.00	9.06
95	11.22	10.58
98	12.45	12.06
99	13.27	12.90
100	17.53	17.93

Note: The NCEP dataset represents 1-hour averaged wind speeds. The WASA data has been converted to 1-hour average wind speeds from the measured 10-minute averages.

Figure 2-2.4. Wind speed exceedance comparison of the NCEP and WASA datasets. Source: PRDW (2015).

2.2.1.3 Rain and fog

Detailed data on rainfall at Boegoebaai are not available at this stage, however, data from a weather station located in Alexander Bay managed by the South African Weather Service (SAWS) as reported by PRDW (2015) indicate that Alexander Bay is the driest station in South Africa with a mean annual rainfall of 46 mm per year (SAWS 2015).

PRDW (2015) presents data on hourly fog occurrence recorded at Port Nolloth, sourced mostly from weather logs provided by De Beers Marine. Months for which no data were available (Apr, Nov, Fe and Mar, filled in green) were filled with data from months with an average similar number of fog days per month sourced from the South African Sailing Directions (1975). Fog is most prevalent during summer and autumn (Jan-May), both in terms of frequency of occurrence and duration (Figure 2-2.5).

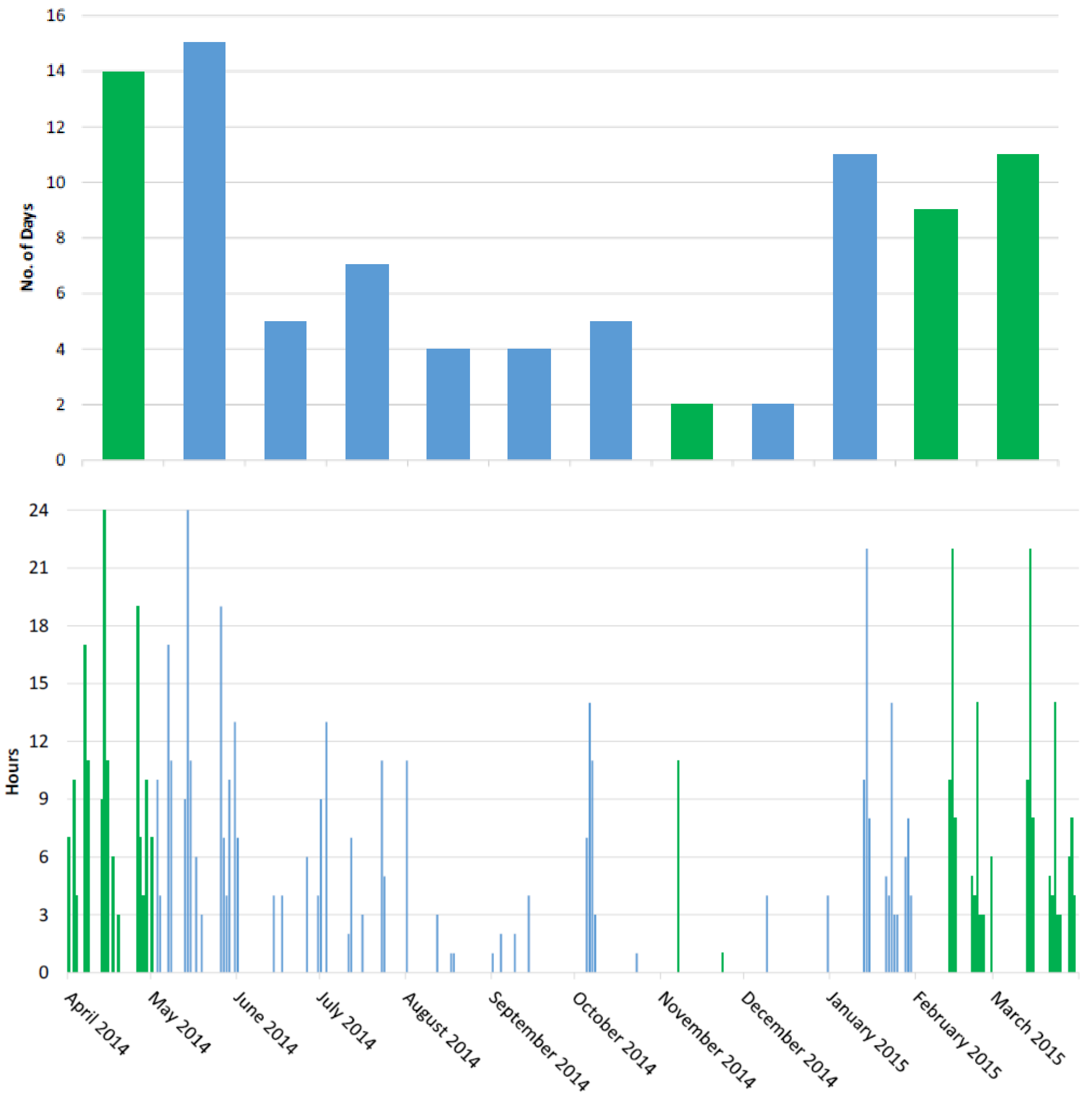


Figure 2-2.5. (Top) Number of fog days per month and (bottom) duration of fog (hours per day) at Port Nolloth. Values in green are interpolated (see text). Source: PRDW (2015).

2.2.2 Oceanography

2.2.2.1 Overview

The Benguela system is influenced predominantly by the wind-driven upwelling of deep nutrient rich water close to the coast. Wind is the primary driver of life in the system, strongly influencing both water temperature and inorganic nutrient levels, and in turn, primary production. The prevailing south-easterly winds displace surface water offshore during the summer, and cause cold, nutrient rich water to rise from deeper water masses to replace this surface water. These upwelling events are the trigger for minimum temperatures and maximum nutrient levels (Branch & Griffiths 1988). The oceanic primary producers, phytoplankton, bloom when upwelled inorganic nutrients become available for photosynthesis in the presence of sunlight. These are consumed by zooplankton, which are in turn consumed by small pelagic fish species such as anchovy and sardine. The Benguela is one of the world's most productive systems, supporting rich fishing grounds and attracting large colonies of sea birds and seals (Branch & Branch 2018b).

2.2.2.2 Tides and waves

The West Coast is subject to semi-diurnal tides, with each successive high (and low) tide separated by about 12.25 hours. Spring tides occur once a fortnight during full and new moons. Tidal activity greatly influences the biological cycles (feeding, breeding and movement) of intertidal marine organisms, and has an influence on when people visit the coastline to partake in various activities such as bathing and the harvesting of marine resources. The tidal variation on the West Coast usually ranges between 0.28 m (relative to the chart datum) at mean low water springs and 1.91 m at mean high water springs, with the highest and lowest astronomical tide being 2.25 m and 0.056 m, respectively.

The west coast of South Africa typically experiences high wave energy and is dominated by south-westerly swells with a long fetch and a period of 10 to 15 seconds (Branch et al. 1988). Southerly and south-westerly waves frequently exceed 2 m (Figure 2-2.6). The predominant SW swell direction in this area results in a northward-flowing littoral current that runs parallel to the coast (MacDonald & Rozendaal 1995). PRDW (2015) undertook a wave refraction modelling study with a view to characterise the operational and extreme wave climates at the proposed Boegoebaai port. Results of this modelling study indicate that peak wave periods fall primarily between 7 s to 18 s with some occurrences of periods exceeding 20 s (Figure 2-2.6). Short period wave energy originating from locally generated seas was also observed from the southerly and westerly to north-westerly sectors.

2.2.2.3 Currents

Currents measured inshore at 10 m depth during late summer are mostly shore parallel (north westerly or south easterly) and 90% of the measured current velocities are low (<10 cm/second). The average water temperature during the summer months is cool due to upwelling (approximately 11 °C) and slightly warmer during downwelling events, which are caused by westerly winds or occasional Benguela Niños when unseasonal westerly winds result in a breakdown of the upwelling front with movement of warm oceanic water towards the coast (Laird & Clark 2018). Average background Total Suspended Solid (TSS) concentration in seawater along the west coast is highly variable and dependent on prevailing weather and sea conditions. For example, TSS was measured off Tormin Mine to the north of Doringbaai as 73.73 mg/L on 14 March 2017, while average turbidity over the period 10 February to 14 March 2017 was calculated at 5.24 NTU (~1.75 mg/L) (Laird & Clark 2018). Turbidity peaks in the vicinity of Doringbaai are expected during large wave events where fine material is resuspended, intense upwelling events when phytoplankton blooms, and during floods from the Olifants Estuary when a considerable input of fine terrestrial sediments can be expected.

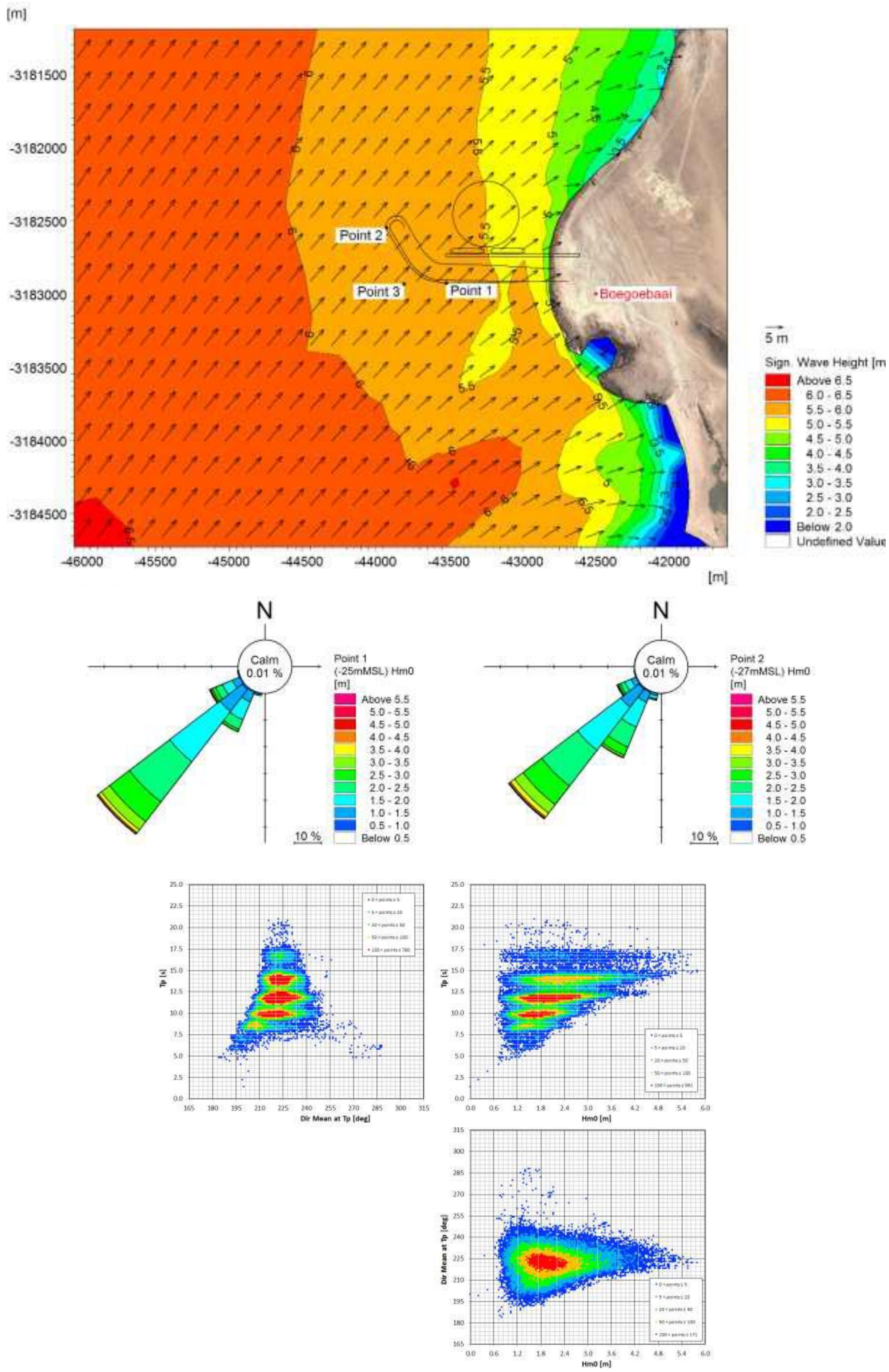


Figure 2-2.6. (Top) Typical wave refraction during a storm event (Offshore condition: Hm0 = 8.5 m, Tp = 15 s, Mean direction at Tp = 215 degrees). (Middle) Wave rose plots for Point 1 and Point 2 along the proposed breakwater. The roses are constructed from 31 years of modelled data. (Bottom) Source: Scatter plot of wave parameters at Point 3. Source: PRDW (2015).

2.2.3 Bathymetry

PRDW (2015) presents data on regional and nearshore bathymetry that were sourced from the 'MIKE by DHI' CMAP Electronic Charts (DHI 2017) and nearshore bathymetry surveys of the Boegoebaai area obtained from IMD-SA (Pty) Ltd. The available data extend from the shore (at -7 m mean sea level) to approximately 7 km west of the Boegoebaai headland (Figure 2-2.7). Of greatest significance here is the way in the bathymetric contours are compressed in the region of Boegoebaai point, indicating the proximity of deep water (>15 m) close to the shoreline, which is the primary reason for the selection of this site for construction of the port breakwater. According to PRDW (2015) this presents an opportunity to reduce initial capital cost by limiting the length of the primary marine structures, i.e. breakwater and access trestle.

A more recent bathymetric survey of the northern portion of the Boegoebaai area presents similar results, confirming the proximity of deep water close to the shoreline at Boegoebaai point (Tritan Survey 2018). These survey results also show scattered subtidal reefs close to the shore along most of the mapped section of coastline and also an extensive reef area offshore of the coast in the range of 3-6 km from the shore in the north that approaches right up to the coast south of Boegoebaai point. These reefs may be important for biodiversity and/or from a fisheries perspective.

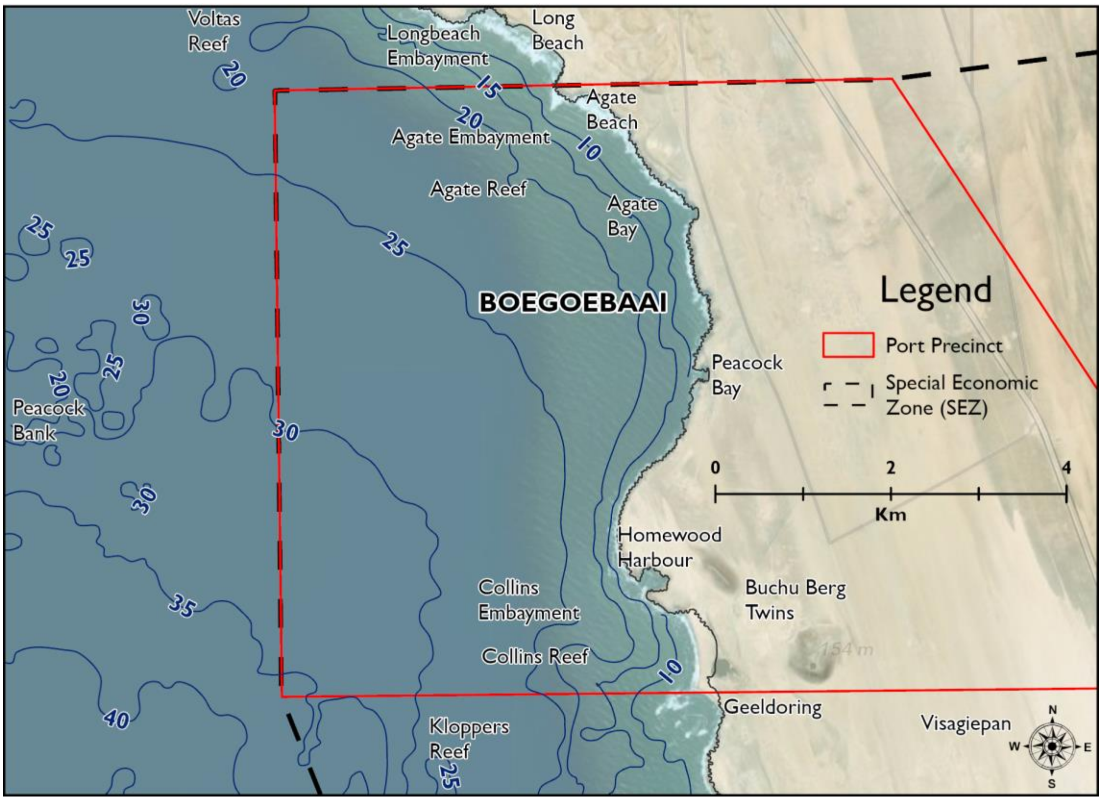


Figure 2-2.7. Nearshore bathymetry at Boegoebaai. Vertical datum is nominally Mean Sea Level, although the presented bathymetric data have not been corrected for tidal variation and the accuracy is thus at best ±1 m. Source: Anchor Environmental Consultants.

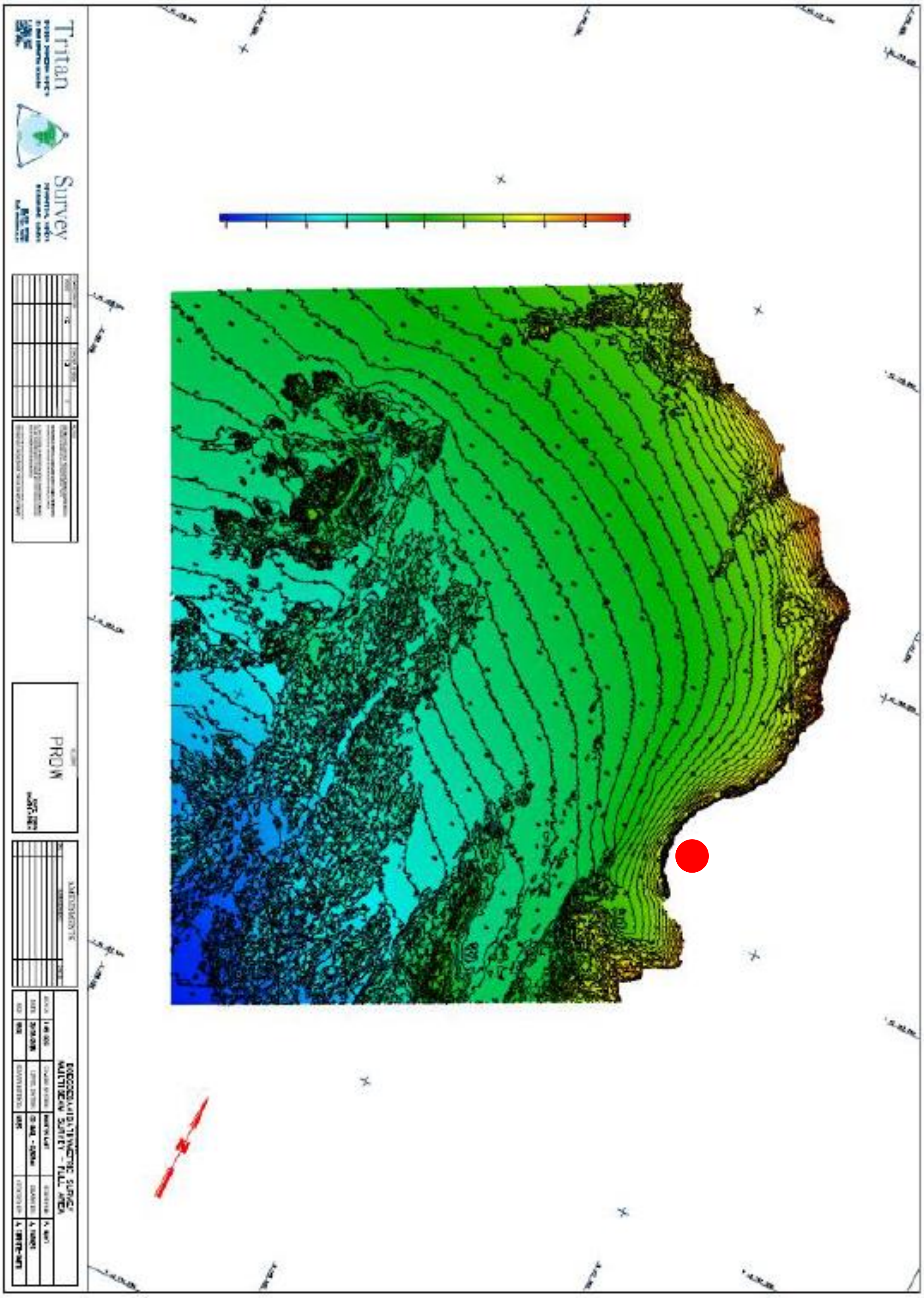


Figure 2-2.8. Bathymetry map of the northern portion of Boegoebaai area. Boegoebaai Point is marked with a red dot. Source: Tritan Survey (2018).

2.2.4 Climate change

Climate change is widely recognised as posing a significant threat to South African ecosystems, economies, and livelihoods. South Africa has reportedly warmed by approximately 0.2°C per decade, which is roughly twice as fast as the global average (Johnston et al. 2024). Increasing temperature is contributing to climate impacts ranging from extreme heat and drought to sea level rise and flooding.

Although less well publicised, significant changes in marine and coastal ecosystems in South Africa have also been reported. Parts of the Agulhas Current have warmed more rapidly than 90% of the world's oceans (Grantham et al. 2011, Hobday and Pecl 2014, Popova et al. 2019), while upwelling on the west and south coasts has increased due to intensified winds, leading to inshore cooling (Rouault et al. 2010). These shifts are accompanied by increases in sea level, changes in ocean currents, wave height, ocean acidification, low oxygen events, increasingly frequent storms and harmful algal blooms (Davis-Reddy and Vincent 2017, Augustyn *et al.* 2018, Young and Ribal 2019).

Increases in sea level and increased storm surges are likely the greatest threats to the Boegoebaai development. Global sea level has reportedly risen 3.3 ± 0.4 mm/year over the last decade (Rahmstorf et al. 2007) and it is virtually certain that these increases will continue into the future, rising by up to 90 cm under a very high emissions scenario (SSP5-8.5, comparing 2081–2100 levels with 1995–2014 levels) or by up to 50 cm in a very low emissions scenario (SSP1-2.6, over the same period) (Ranasinghe et al. 2021). Coupled with an increase in the intensity of sea storms and wave heights (the extent to which remains uncertain at this stage), this poses a significant threat to coastal ecosystems and infrastructure. Fortunately, projected increases in sea level and wave height seem to have been taken into account in the Boegoebaai port prefeasibility assessment at least (PRDW 2015).

2.2.5 Biogeography

The classification and mapping of ecosystem types is foundational to their assessment and management. South Africa's first National Spatial Biodiversity Assessment (Lombard et al. 2004) used a hierarchical habitat classification to map and describe different marine bioregions. This has been further developed through several iterations and the latest National Biodiversity Assessment recognises 150 different marine ecosystem types in the South Africa Exclusive Economic Zone embedded within a hierarchical classification system (Figure 2-2.9) (Sink et al. 2019a).

- At the largest spatial scale of Level 1 (Ecoregion), four shelf ecoregions and two deep ocean ecoregions have been defined. These are the Southern Benguela, the Agulhas, the Natal and the Delagoa, and the Southeast Atlantic Deep Ocean and the Southwest Indian Deep Ocean respectively (Figure 2-2.9).

- At the next level, Level 2 (Bathyregions), ecoregions are subdivided into bathyregions on the basis of depth, with five major bathyregions identified: shore, shelf, slope, plateau and abyss. On this basis, the Southern Benguela ecoregion is split into "shore" and "shelf" regions, while the Southeast Atlantic Deep Ocean ecoregion is split into "slope", "plateau" and "abyss" regions (Figure 2-2.9).

- At Level 3 (Substratum types), ecoregions and bathyregions are further subdivided based on substratum types (sandy, rocky, mixed or mosaic) and geomorphological units (submarine canyons and seamounts). These have been further sub-classified at Level 4 (Ecosystem types) in accordance with local-scale drivers that are known to influence biodiversity pattern. Examples of these sub-classifiers include wave exposure on rocky shores, beach morphodynamic state, fluvial fans, major reef complexes or banks (e.g. Childs, Alphard and Browns Bank), slope features (e.g. Port Elizabeth Ridge), finer scale regional and depth patterns (inner versus mid shelf), and oceanographic features (presence of gyres, eddies and the cold ridge). In some cases, biotopes or distinct biological assemblages have also been used to further sub-classify ecosystem types (Figure 2-2.9).

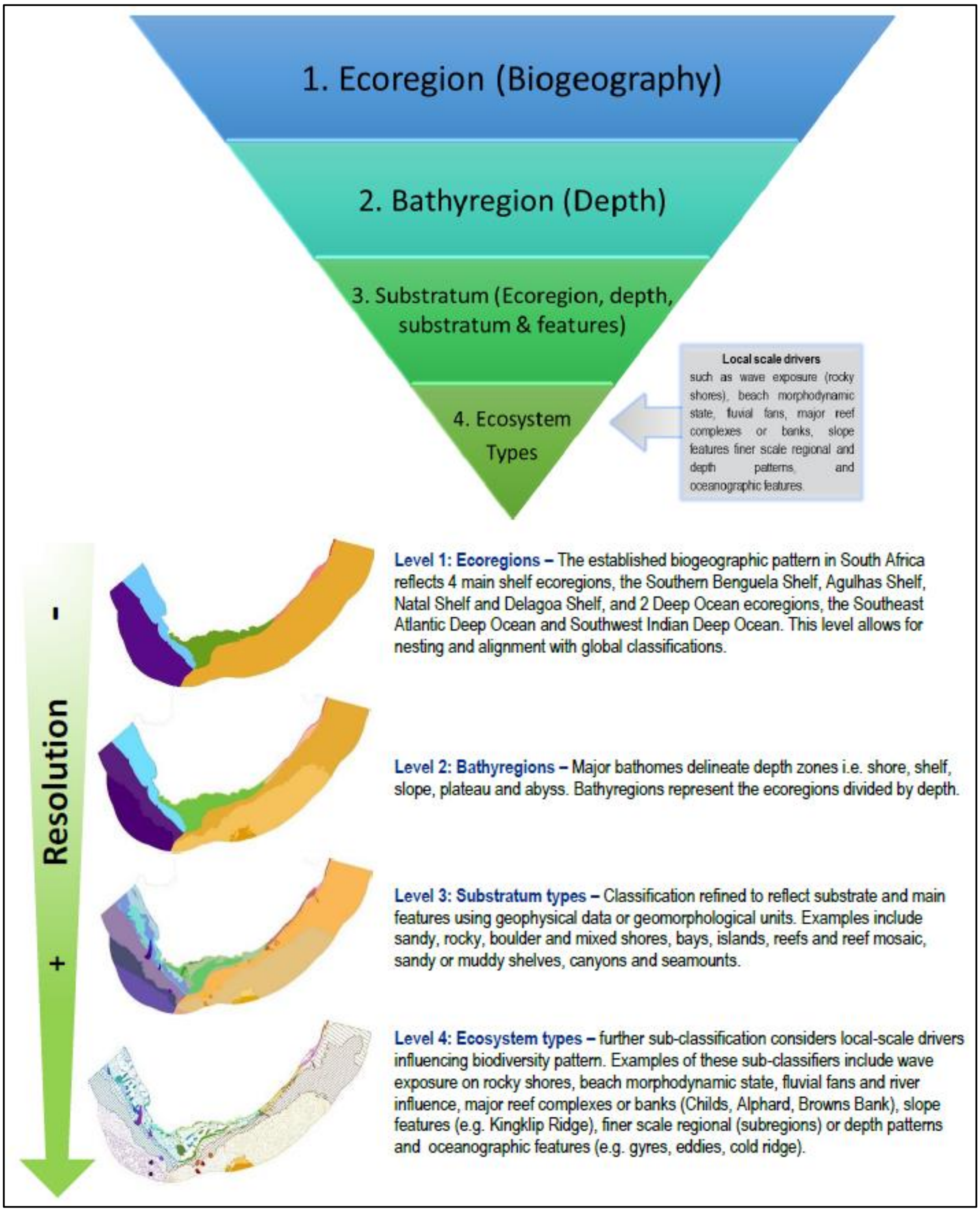


Figure 2-2.9. Hierarchical classification approach used to classify marine ecosystem types around South Africa (Sink et al. 2019a).

Boegoebaai is located in the Southern Benguela ecoregion, with the Southeast Atlantic Deep Ocean ecoregion located offshore the site (Figure 2-2.9 and Figure 2-2.10). The study area is positioned in the "Namaqua inshore" portion of the "Southern Benguela Ecoregion" (Figure 2-2.10). The latter extends all along the western coast of southern Africa between Cape Agulhas and Angola, while the former makes up the inner most portion of this area, extending from the Orange River to Cape Point.

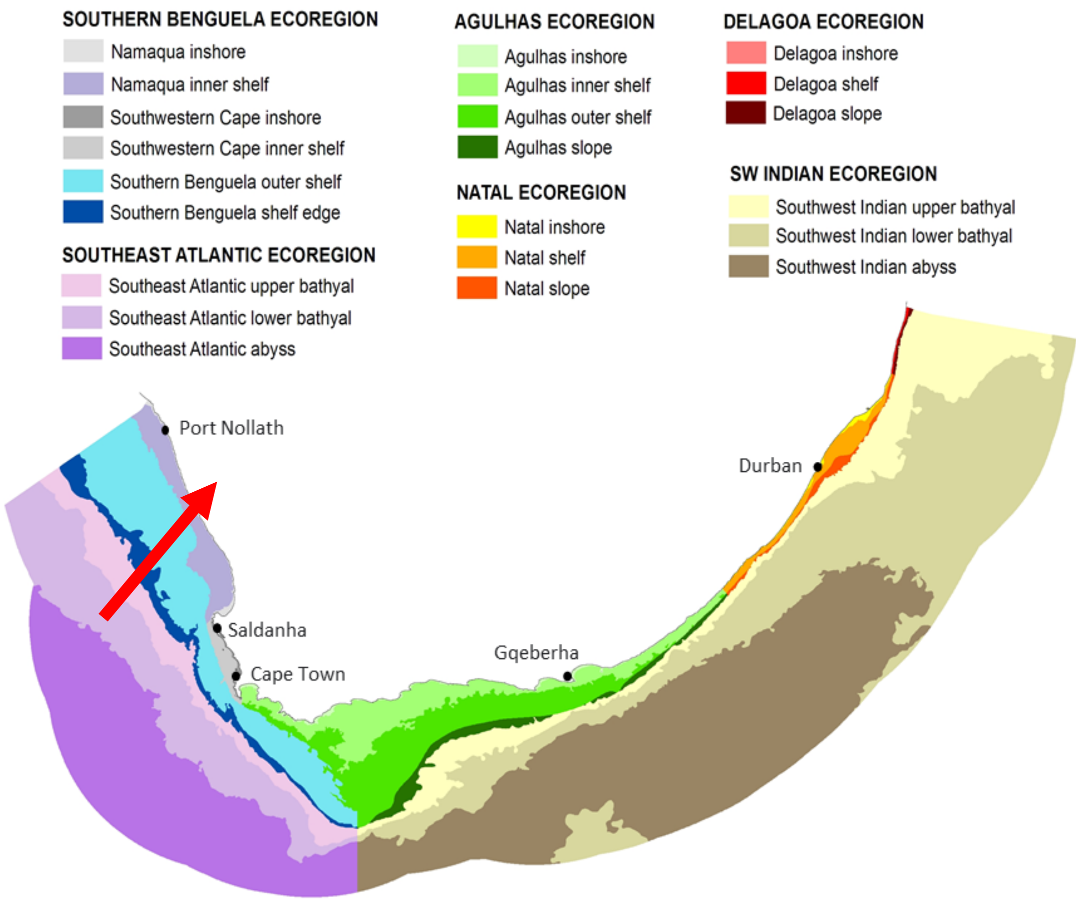


Figure 2-2.10. Six marine ecoregions with 22 ecozones incorporating biogeographic and depth divisions in the South African marine environment as defined by Sink et al. (2019b). The red arrow indicates the location of the project.

The following shoreline (or intertidal) marine habitats exist in the study area (Sink et al. 2019a, Figure 2-2.11):

- Namaqua Exposed Rocky Shore
- Namaqua Mixed Shore
- Southern Benguela Reflective Sandy Shore
- Southern Benguela Intermediate Sandy Shore
- Southern Benguela Intermediate-Dissipative Sandy Shore
- Southern Benguela Dissipative Sandy Shore

In addition, the Namaqua Kelp Forest and Namaqua Cone Inner Shelf are shelf (or subtidal) ecosystem types are present in the study area: (note these are located immediately offshore of the coast and extend out to the edge of the continental shelf at around 100 m depth).

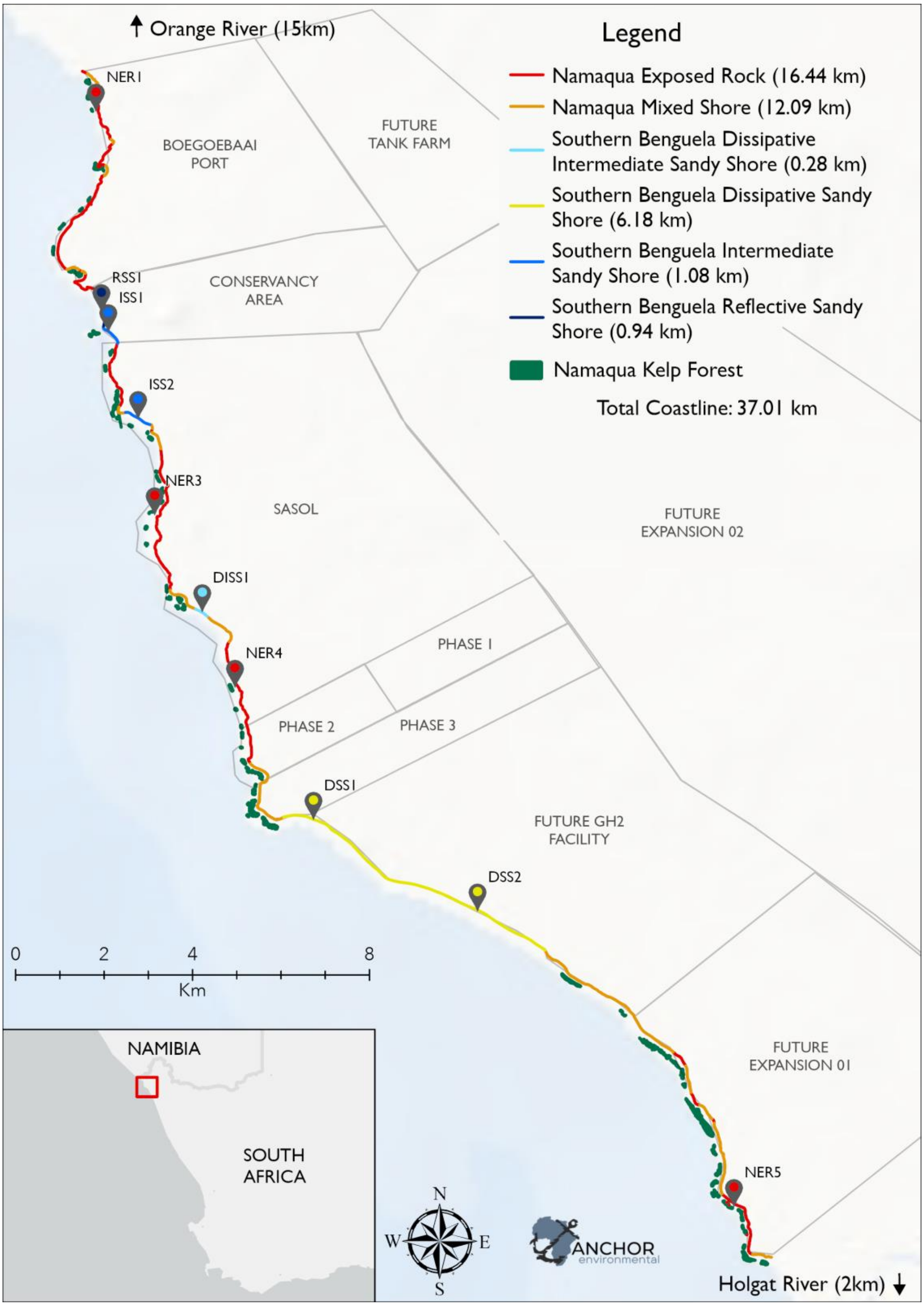


Figure 2-2.11. Intertidal and subtidal habitat types present in the study area as mapped through the National Biodiversity Assessment (Sink et al. 2019a). Red pins indicate rocky-shore sampling sites. Blue and yellow pins indicate sandy beach sampling sites with various degrees of wave-exposure (see Table 2-2.3).

Note that these habitat types are named in accordance with the ecoregion or portion thereof in which they are found (i.e., “Southern Benguela” or “Namaqua”) and are further subdivided into substratum-type and wave exposure categories (in the case of the shoreline habitats) and substratum-type only in the case of the subtidal or shelf habitat types. Wave exposure strongly influences the ecology of all intertidal habitats and is a key determinant of alongshore patterns of biodiversity observed in rocky intertidal (Stephenson & Stephenson 1972, Menge & Branch 2001, Branch & Branch 2018b) and sandy beach habitats (McIntyre 1971, McLachlan 1980, McLachlan et al. 1981). The net result of this is that rocky and sandy shores that are in close proximity to each other but experience different wave exposures, are generally occupied by entirely different organisms, while others that are further apart but have the same wave exposure feature similar biotic communities. The 2018 NBA (Sink et al. 2019a) distinguishes among very exposed, exposed and sheltered rocky intertidal types, which were determined by a group of experts, who assigned wave exposure levels to each rocky shore according to its shoreline orientation and - where known - its community attributes. All rocky intertidal habitats in Boegoebaai area have been classified as “Exposed”.

Table 2-2.1. Various habitat types present in the study area.

Habitat type	Habitats in study area	Shoreline length/ habitat area
Rocky Intertidal	Namaqua Exposed Rocky Shore	16.44 km
Sandy Beach	Southern Benguela Reflective Sandy Shore	0.94 km
	Southern Benguela Intermediate Sandy Shore	1.08 km
	Southern Benguela Dissipative-Intermediate Sandy Shore	0.28 km
	Southern Benguela Dissipative Sandy Shore	6.18 km
Mixed shore	Namaqua Mixed Shore	12.09 km

In the case of sandy beach habitats, the NBA (Sink et al. 2019a) relied on an approach developed by Harris et al. (2011) for distinguishing different beach types within each ecoregion. In terms of this approach, beach types are distinguished based on beach morphodynamic state (a function of breaking wave conditions, grain size and tidal range) (Jackson & Short 2020) which is widely recognised as a strong predictor of macrofauna diversity. Harris et al. (2011) looked at correlations between a range of physical characteristics acquired from Google Earth at sites where measures of beach morphodynamic state have historically been conducted and identified beach width as being the only factor that significantly predicted beach-morphodynamic type, giving four categories (in order of increasing wave exposure): dissipative, dissipative-intermediate, intermediate and reflective. Note that dissipative and reflective beaches mark the two extremes of this morphodynamic continuum (Wright & Short 1984, Short 2006). Dissipative beaches have a flat and wide fine-sand littoral component, with multiple lines of breakers that dissipate the majority of their wave energy in the very wide surf zone. Reflective beaches, in contrast, are narrow and steeply sloping, comprising usually coarser sand. They have a limited surf zone with waves surging directly onto the shore. Intermediate forms are defined by the presence (or absence), nature and form of sand bars and rip currents in the surf (Short 2006). As beach conditions tend towards the dissipative end of the morphodynamic spectrum, species richness and abundance of macrofauna increases (McLachlan & Dorvlo 2005).

Mixed shore communities comprise species from both rocky and sandy shores that are tolerant of sand inundation and rock presence, respectively (Smith et al. 1999, Garner 2013), and can be more, less or equally diverse compared to their adjacent rocky or sandy counterparts. There is limited information on mixed shores in South Africa. Harris et al. (2011) reports that there is no ecologically based classification scheme for mixed shores that is based on national sampling, even though they comprise a third of the coast. In the 2018 NBA (Sink et al. 2019a), no distinction is drawn between mixed shores in the different ecoregions.

Namaqua Exposed Rocky Shore (16.44 km and 44.4% of the total), Namaqua Mixed Shore (9.99 km or 30% of the total) and Southern Benguela Dissipative Sandy Shore (6.18 km, 16.7%) are the dominant shoreline habitats in the study area, while the other habitat types make much smaller contributions (1–3%, Table 2-2.1).

Mapping of subtidal (or shelf) habitats in the Southern Benguela was guided by the presence of kelp floating on the surface (which can be discerned on satellite imagery) owing to limited data available on substratum characteristics in the area. Thus, areas mapped as “Namaqua Kelp Forest” offshore of Boegoebaai include only those areas shallow enough to be colonized by kelp with fronds that extend all the way to the sea surface (specifically *Ecklonia maxima*). All of the remaining subtidal (or shelf) habitat in the study area has been classified as “Namaqua Cone Inner Shelf” habitat and includes both unconsolidated (soft bottom) and consolidated (rocky reef) habitat.

2.2.6 Marine fauna and flora associated with marine habitats in the study area

2.2.6.1 Rocky intertidal

Rocky shores are a common habitat type along the southern African west coast (Jackson & Lipschitz 1984). The abundance and distribution of organisms in this habitat varies across different sites and are influenced primarily by exposure to wave action and to a lesser extent, shoreline topography (Branch & Branch 2018b). Common species found along these rocky shores include various species of algae (seaweeds and kelp), gastropods (limpets and sea snails), bivalves (mussels), echinoderms (sea stars, sea cucumbers and sea urchins), tunicates (ascidians and sea squirts), cnidarians (sea anemones), sea sponges and crustaceans (amphipods, shrimps, prawns, barnacles, and crabs). More tolerant species capable of withstanding desiccation (drying out) are found near the high water mark while those unable to sustain prolonged exposure are found near the low water mark or subtidally. Five distinct zones, linked to tide levels, can be distinguished within this habitat (moving landward), the infratidal zone, the cochlear zone, the lower balanoid zone, the upper balanoid zone, and the Littorina zone.

The infratidal zone, only exposed during spring low tide, is inhabited by species that cannot withstand long periods of exposure (desiccation). These include several species of algae (*Gigartina* sp., *Champia lumbricalis* and corallines), sea urchins *Parechinus angulosus* and the invasive black mussel *Mytilus galloprovincialis*. The cochlear zone, often low shore/shallow subtidal, is on exposed shores home to dense stands of limpets *Scutellastra argenvillei* and *S. cochlear* while more sheltered shores are defined by high densities of *Cymbula granatina*. *Octopus vulgaris*, and various species of fish, particularly those known as ‘klipvis’, are found in rock pools where they prey upon bivalves and other invertebrates. Above the cochlear zone is the lower balanoid, where the limpet *Cymbula oculus*, the gastropods *Oxystele antoni* and *O. impervia*, the Mediterranean invasive mussel *Mytilus galloprovincialis*, and the ribbed mussel *Aulacomya atra* occur (Stephenson et al. 1937, Robinson et al. 2007, Branch & Branch 2018b). Seaweed is sparse in the lower balanoid zone; however, the sea lettuce *Ulva* spp. and encrusting brown algae *Pseudoralfsia verrucosa* are often present in patches. The barnacles *Tetraclita serrata*, *Balanus glandula* and *Octomeris angulosa* densely populate the upper reaches of the balanoid zone along with various other species. The southern periwinkle *Affrolittorina knysnaensis* and the algae *Porphyra* spp. colonise the Littorina zone.

Four rocky intertidal sites were surveyed in the Boegoebaai area (NER1, NER3, NER4, NER5), starting at the high-water mark and extending seaward to the spring low-tide low water mark, to characterise the rocky intertidal community in this area (Figure 2-2.11, red pins labelled as NER1–5, Figure 2-2.16). Sites were all located in the “Namaqua Exposed Rock” habitat type identified by (Sink et al. 2019a) which is considered the dominant rocky intertidal habitat types present in the study area. Sites were selected to span the full geographic range of this habitat type present in the study area.

Each transect was divided into three distinct shore height zones: high, mid and low shore. Within each zone, three standard 0.5 m x 1 m replicate quadrats were randomly placed, and the percentage cover of all sessile species was recorded as either primary (occurring directly on the rock) and/or secondary (occurring on other benthic fauna or flora) cover. Additionally, individual mobile organisms were counted within the quadrat area to calculate densities of 1 m^2. The primary and secondary cover data for both mobile and sessile organisms were subsequently combined and standardised to a total of 100%. Percentage cover represents the area occupied by organisms on the rock surface, while abundance refers to the number of individual organisms present (Table 2-2.2). This survey protocol aligns with those used in similar studies conducted along the South African south and west coasts.

Table 2-2.2. Percentage cover per 1 m^2 of rocky shore sites: NER1, NER3, NER4 and NER5. Assigned taxonomic and functional groupings are included for reference. Where applicable, (p) represents primary attachment and (s) secondary attachment.

Taxon	Taxonomic Group	Functional Group	NER1	NER3	NER4	NER5
Actinia equina	Anemone	Predator	0	0	0	0.01
Afrolittorina knysnaensis	Gastropod	Grazers	0	0.13	0.46	0.05
Ahnfeltiopsis complicata	Red algae	Articulated algae	0	0.04	0	0.02
Ahnfeltiopsis glomerata	Red algae	Articulated algae	0	0	0.07	0
Anthopleura michaelseni	Anemone	Predator	0	0.13	0	0
Aulacomya atra	Bivalve	Filter feeder	0.77	0.17	0.94	2.75
Botryocladia paucivesicaria	Red algae	Articulated algae	0	0	0	0.01
Brown turf	Brown algae	Corticated algae	0	0.03	0	0
Bunodactis reynaudi	Anemone	Predator	0	0	0	0.09
Burnupena spp.	Gastropod	Predator	0	0.2	0.36	0.56
Callithamnion collabens	Red algae	Articulated algae	0	0.05	0	0.04
Caulacanthus ustulatus	Red algae	Articulated algae	0.29	0.15	0	0.19
Centroceras clavulatum	Red algae	Ephemeral algae	0.08	0	0	0
Ceramium spp.	Red algae	Ephemeral algae	0.03	0.01	1.93	0.08
Chaetomorpha robusta	Green algae	Articulated algae	0	0	0.04	0
Champia lumbricalis	Red algae	Articulated algae	1.9	0.21	0.27	4.8
Chiton	Chiton	Grazers	0	0.01	0	0
Chordariopsis capensis	Brown algae	Articulated algae	0.36	0.12	0	0.04
Chthamalus dentatus	Barnacle	Filter feeder	0.12	0	0.04	0.01
Cladophora spp.	Green algae	Ephemeral algae	0.04	0.05	0.24	0.06
Colonial ascidian	Sea squirt	Filter feeder	0	0	0.02	0
Coralline (crustose)	Coral	Corticated algae	7.35	0.07	8.07	1.98
Coralline (upright)	Coral	Corticated algae	0.1	0.11	1.09	0.15
Cymbula granatina	Gastropod	Grazers	0.66	1.53	0.25	0.26
Cymbula oculus	Gastropod	Grazers	0	0	0	0.01
Diatoms	Diatom	Corticated algae	0	0	0	22.5
Dodecaceria pulchra (s)	Marine worm	Detritivore/Scavenger	0	0	0.03	0
Ecklonia maxima	Brown algae	Corticated algae	0	0.16	0	0.47
Fanworm	Marine worm	Filter feeder	3.59	0.96	0.07	0.55
Fissurella mutabilis	Gastropod	Grazers	0	0.04	0	0.02
Gigartina bracteata	Red algae	Articulated algae	1.76	2.02	0.29	0.17
Gigartina polycarpa	Red algae	Articulated algae	0.07	0.06	0.18	0
Green turf	Green algae	Ephemeral algae	0.03	0.01	0	0.01

Taxon	Taxonomic Group	Functional Group	NER1	NER3	NER4	NER5
Gunnarea gaimardi	Marine worm	Filter feeder	3.59	0.96	0.07	0.55
Gymnogongrus dilatatus	Red algae	Articulated algae	0	0.05	0	0
Helcion dunkeri	Gastropod	Grazers	0	0	0.04	0
Helcion pectunculus	Gastropod	Grazers	0.13	0.01	0.07	0.34
Helcion pruinosus	Gastropod	Grazers	0	0.03	0	0
Helcion spp	Gastropod	Grazers	0.02	0	0	0
Hildenbrandia spp.	Red algae	Corticated algae	2.15	0	8.59	0
Isopod	Isopod	Detritivore/Scavenger	0	0	0	0.01
Kelp limpet	Limpet	Grazers	2.04	0	0	0
Laminaria pallida	Brown algae	Corticated algae	2.1	0	0.1	0
Leathesia difformis	Brown algae	Articulated algae	0	0.17	0	0.01
Leathesia marina	Brown algae	Corticated algae	0	0.04	0	0
Mazzaella capensis	Red algae	Articulated algae	0	0.1	0.11	0.03
Mytilus galloprovincialis	Bivalve	Filter feeder	5.63	7.48	6.75	2.43
Neuroglossum binderianum	Red algae	Articulated algae	0	0	0.07	0.04
Nucella dubia	Gastropod	Predator	0.08	0	0.07	0
Nucella squamosa	Gastropod	Predator	0	0.01	0	0.01
Octomeris angulosa	Barnacle	Filter feeder	0.03	0	0.15	0.29
Ophiuroidea	Sea star	Predator	0	0.01	0	0
Oxystele antoni	Gastropod	Grazers	0.17	0.01	0.35	0.23
Oxystele tigrina	Gastropod	Grazers	0.03	0.01	0	0
Pachymenia cornea	Red algae	Ephemeral algae	0	0.23	0	0
Pachymenia orbitosa	Red algae	Ephemeral algae	0.62	0	0.11	0.1
Parechinus angulosus	Sea urchin	Grazers	0	0.03	0	0.18
Parvulastra exigua	Sea star	Grazers	0	0.01	0.46	0.03
Pentacta doliolum	Sea cucumber	Filter feeder	0	0.01	0	0
Plocamium spp.	Red algae	Articulated algae	0	0.05	0.17	0.03
Porphyra capensis	Red algae	Ephemeral algae	0.24	4	0	0.14
Pseudoralfsia verrucosa	Brown algae	Corticated algae	0.53	0.01	0.46	0
Pycnogonida	Sea spider	Predator	0	0.01	0	0
Red turf	Red algae	Articulated algae	0	0	0	0.12
Sarcothalia radula	Red algae	Articulated algae	0.05	0	0	0
Sarcothalia stiriata	Red algae	Articulated algae	0.85	0	0	0
Scutellastra argenvillei	Gastropod	Grazers	0	0.13	0.7	0.19
Scutellastra barbara	Gastropod	Grazers	0.12	0	0	0
Scutellastra granularis	Gastropod	Grazers	3.88	0.65	2.29	0.72
Siphonaria capensis	Gastropod	Grazers	0	0.05	0	0.03
Splachnidium rugosum	Brown algae	Articulated algae	0.05	0.14	0	0

Taxon	Taxonomic Group	Functional Group	NER1	NER3	NER4	NER5
Sponge	Sea sponge	Filter feeder	0	0	0.06	0
Tetraclita serrata	Barnacle	Filter feeder	0	0	0	0.07
Tricolia neritina	Gastropod	Grazers	0	0.01	0	0
Trochia cingulata	Gastropod	Predator	0	0	0	0.1
Ulva spp.	Green algae	Ephemeral algae	0.12	0.83	0.58	0.24

As no biota were removed during sampling, smaller infaunal species (e.g., polychaetes, amphipods, isopods) inhabiting the complex matrix of mussel beds or dense algae stands were not recorded. Algae and invertebrates that could not be easily identified to generic or specific levels in the field were recorded under a higher classification (e.g. crustose and articulate corallines, red turfs, sponge, colonial ascidian) (Table 2-2.2).

Analysis tools used included univariate (i.e., total number of species per site and average species richness per shore height) and multivariate statistics. Multivariate analyses exploring similarities or dissimilarities among communities across rocky shore sites were employed to assess species and/or groups driving community dissimilarities. For some of these analyses, intertidal species were grouped into seven functional groups: articulated algae (*Ahnfeltiopsis complicate, A. glomerata* and *Gigartina bracteata*), corticated algae (encrusting coralline, diatoms, *Ecklonia maxima* and *Pseudoralfsia verrucosa*), ephemeral foliose algae (mainly *Ulva* and *Poryphora* spp.), grazers (mostly limpets and winkles), filter-feeders (including sessile suspension feeders such as mussels and barnacles), predators and detritivore/scavengers (e.g., carnivorous whelks, crabs and anemones).

Average species richness (number of species) was calculated for each shore height zone and was visualised as bar graphs for comparison. Multivariate analyses exploring similarities or dissimilarities among communities across transects were conducted in R (Oksanen et al. 2024, R Core Team 2024). Data were fourth root (square root by square root) transformed to facilitate non-metric multidimensional scaling (nMDS), PERMDISP and PERMANOVA using the Bray-Curtis dissimilarity index (Oksanen et al. 2024). SIMPER (similarity percentages) analyses were subsequently performed to compare specific sites and identify species driving community dissimilarities. Average species richness (number of species) was calculated for each shore height zone and was visualised as a bar graph for comparison. Multivariate analyses exploring similarities or dissimilarities among communities across transects were conducted in R (cite R and vegan). Data were fourth root (square root by square root) transformed to facilitate non-metric multidimensional scaling (nMDS), PERMDISP and PERMANOVA using the Bray-Curtis dissimilarity index (Oksanen et al. 2024). SIMPER (similarity percentages) analyses were subsequently performed to compare specific sites and identify species driving community dissimilarities.

A total of 77 species, all characteristic of rocky shore habitats along the west coast of South Africa (Day 1974, Branch et al. 2022), was recorded across the four sites surveyed in October 2024 (Figure 2-2.11). Marine invertebrate comprised 43 species (56% of the total community composition), while algae accounted for 34 species (44%). These species spanned 19 taxonomic groups, including green algae (Chlorophyta), red algae (Rhodophyta), brown algae (Ochrophyta), gastropods (sea snails and limpets), bivalves (mussels), echinoderms (sea stars), cnidarians (sea anemones) and crustaceans (barnacles and crabs) (Figure 2-2.12 and Figure 2-2.13). To visualize differences in community composition across these sites, a heatmap of taxonomic groups was generated (Figure 2-2.12 and Figure 2-2.13).

Diatoms exhibited a high total percentage cover at site NER5 but were absent at the other three sites (Figure 2-2.13). Of the marine invertebrate animals, bivalves and gastropods were dominant and most consistently present at all sites (Figure 2-2.13). All algal groups were also found at every site, with red algae displaying the highest total percentage cover (Figure 2-2.13). Certain taxonomic groups (e.g., chiton, isopod, limpet, sea cucumber, sea spider, sea sponge and sea squirt) were only recorded at one site (Figure 2-2.13).

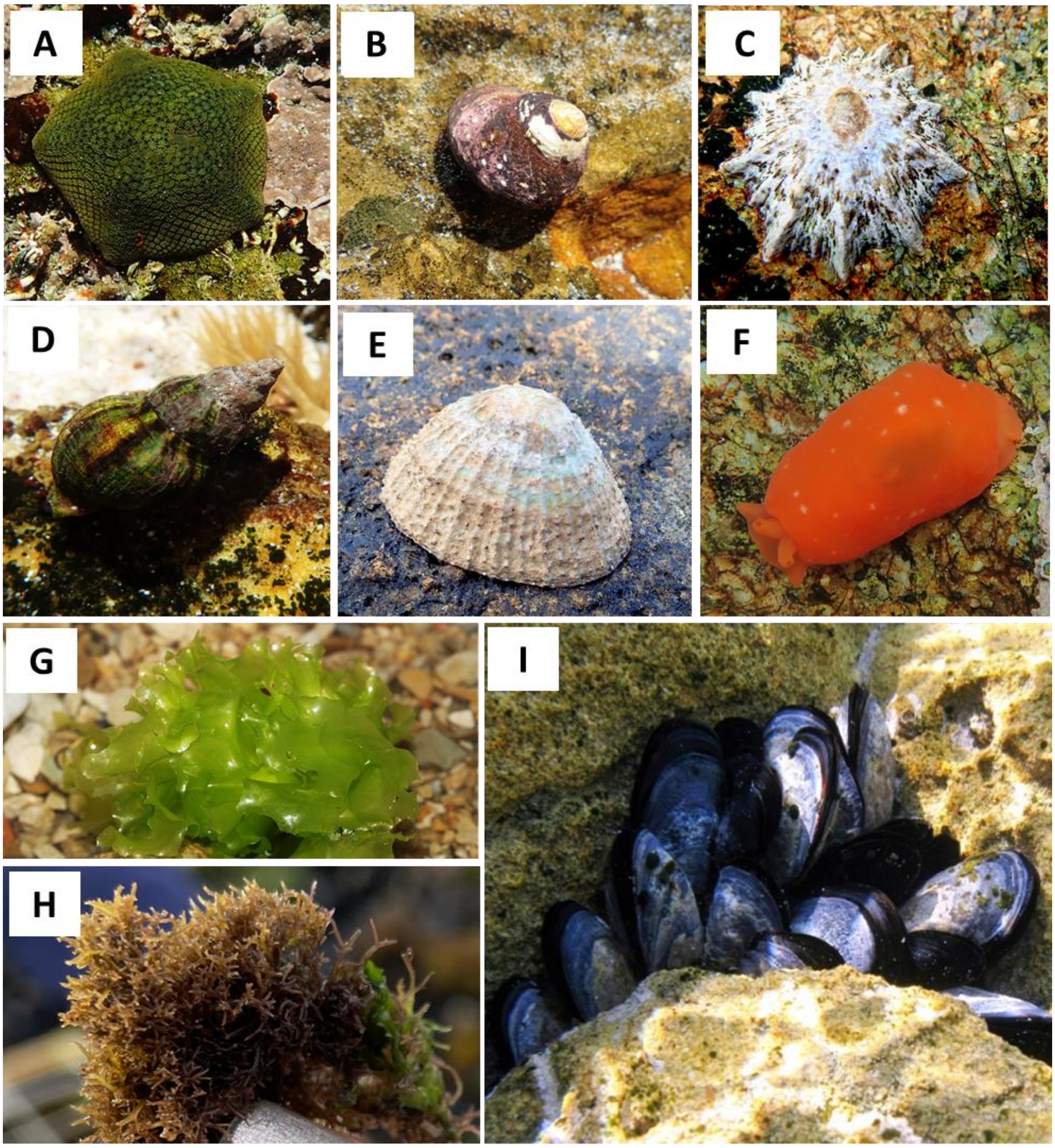


Figure 2-2.12. Examples of species commonly found at the mid shore sites included (A) the dwarf cushion-star *Parvulastra exigua*, (B) the variegated topshell *Oxystele tigrina*, (C) the granite limpet *Cymbula granatina*, (D) burnupena whelks *Burnupena catarrhacta*, (E) the granular limpet *Cymbula granularis*, (F) a nudibranch, (G) the sea lettuce *Ulva* sp., (H) spiky turf weed *Caulacanthus ustulatus* and (I) the invasive Mediterranean mussel *Mytilus galloprovincialis*.

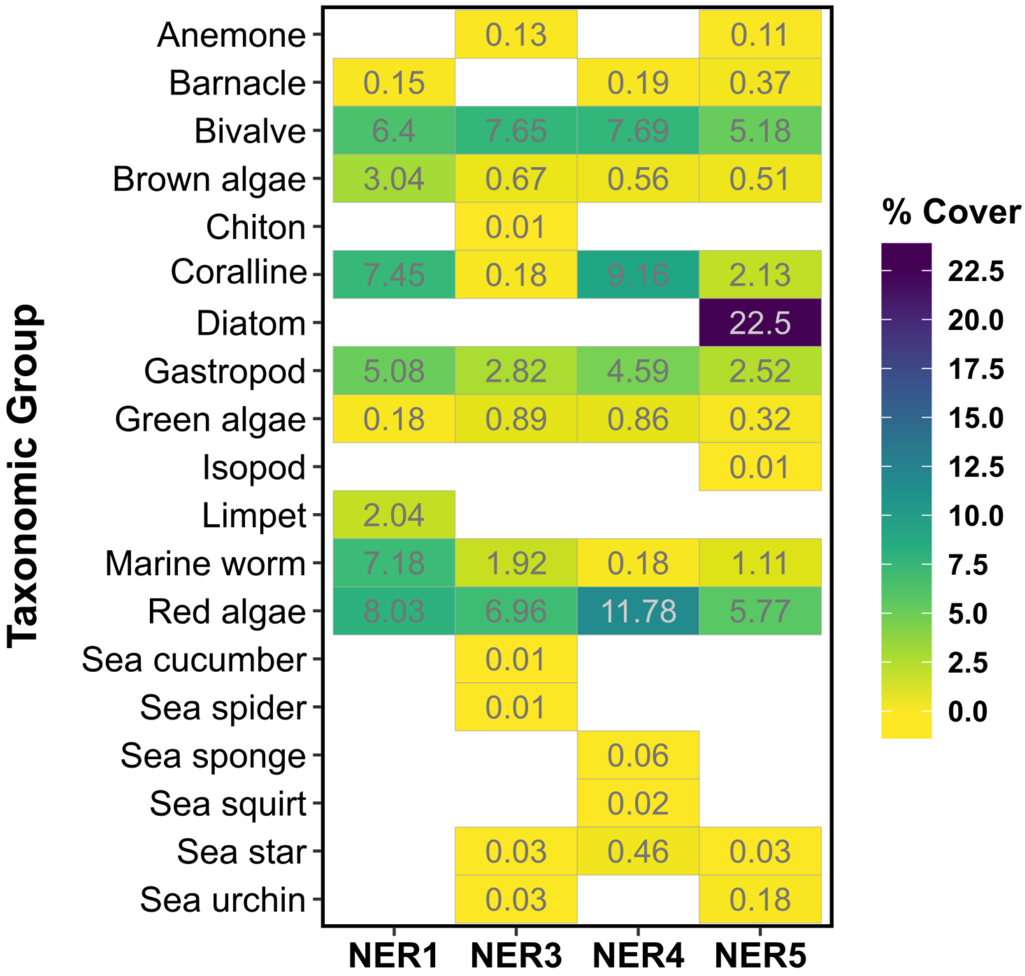


Figure 2-2.13. Total percentage cover of each taxonomic group at each rocky shore site. Percentage cover (rounded to two decimal places) annotate each cell when presence was recorded.

The overall faunal composition included ten species of filter feeders (13%), 19 grazers (25%), ten predators (13%) and two detritivore/scavengers (3%). The algal component consisted of 18 articulated algae (23%), nine corticated algae (12%) and nine ephemeral algae (12%). Similar trends were observed for functional groupings as for taxonomic groups– algae were present at all sites, along with filter feeders, grazers and predators (Figure 2-2.14). Corticated algae were dominant at most sites, particularly at NER5, where they accounted for 25.1% of the cover (Figure 2-2.14). Detritivores/scavengers, such as crabs, were only found at NER4 and NER5, comprising 0.03% and 0.01% of the cover, respectively (Figure 2-2.14).

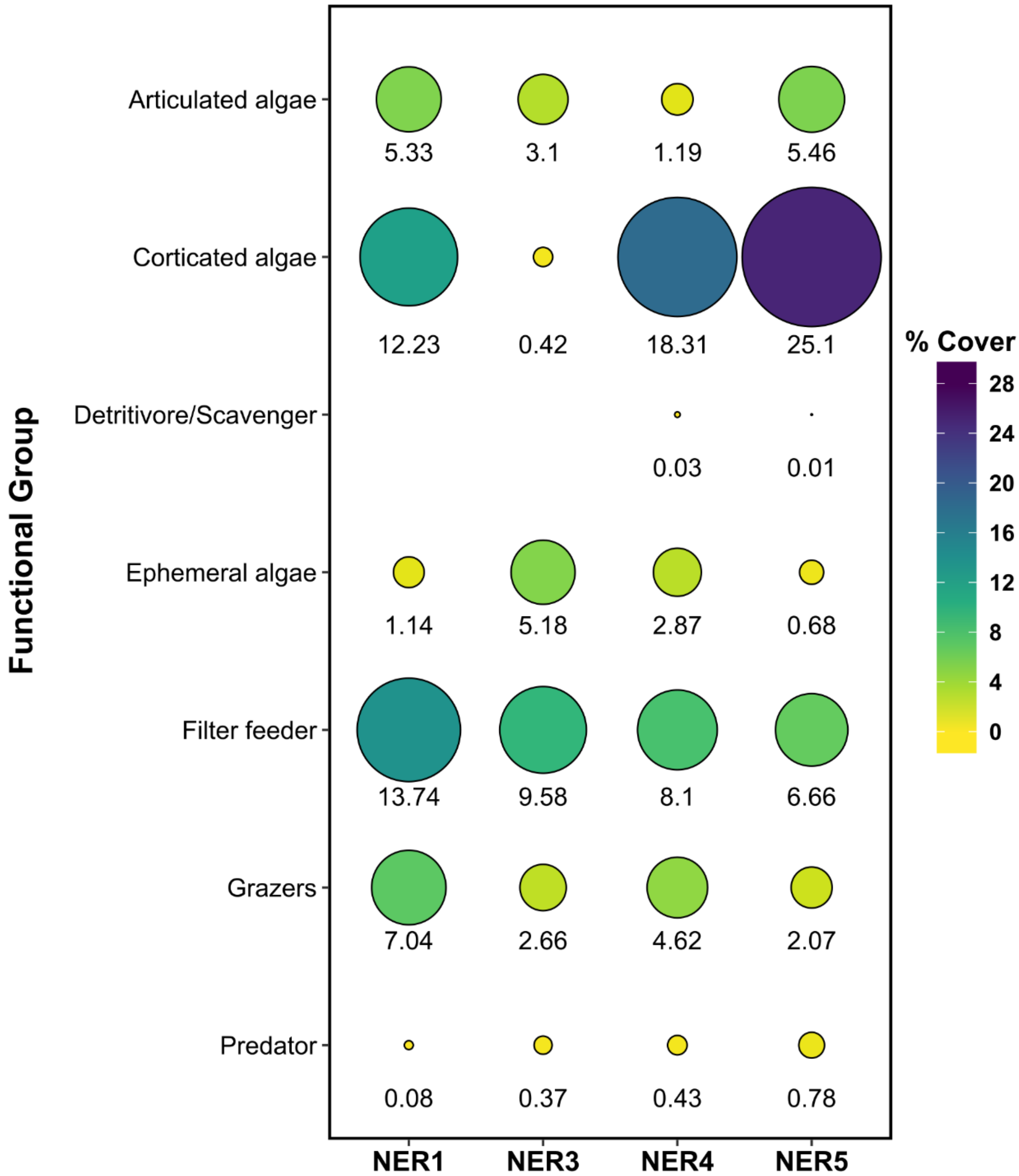


Figure 2-2.14. Total percentage cover of each functional group at each rocky shore site. Percentage cover (rounded to two decimal places) is included beneath each bubble (size corresponds to percentage cover).

The average numbers of species per shore height and site were calculated from four replicates (Figure 2-2.15). Rocky shore habitats are typically characterised by an increase in species richness moving seaward (see Section 2.2.5 and Section 2.2.6.1) (Bustamante et al. 1997). This trend was observed at all surveyed sites with NER3 and NER5 possessing higher numbers of species in the low shore (Figure 2-2.15). NER1 and NER4 showed similar trends, although the high shore of NER1 supported eight species compared to only three species at NER4. Mid-shore species richness was consistent across all sites (Figure 2-2.15).

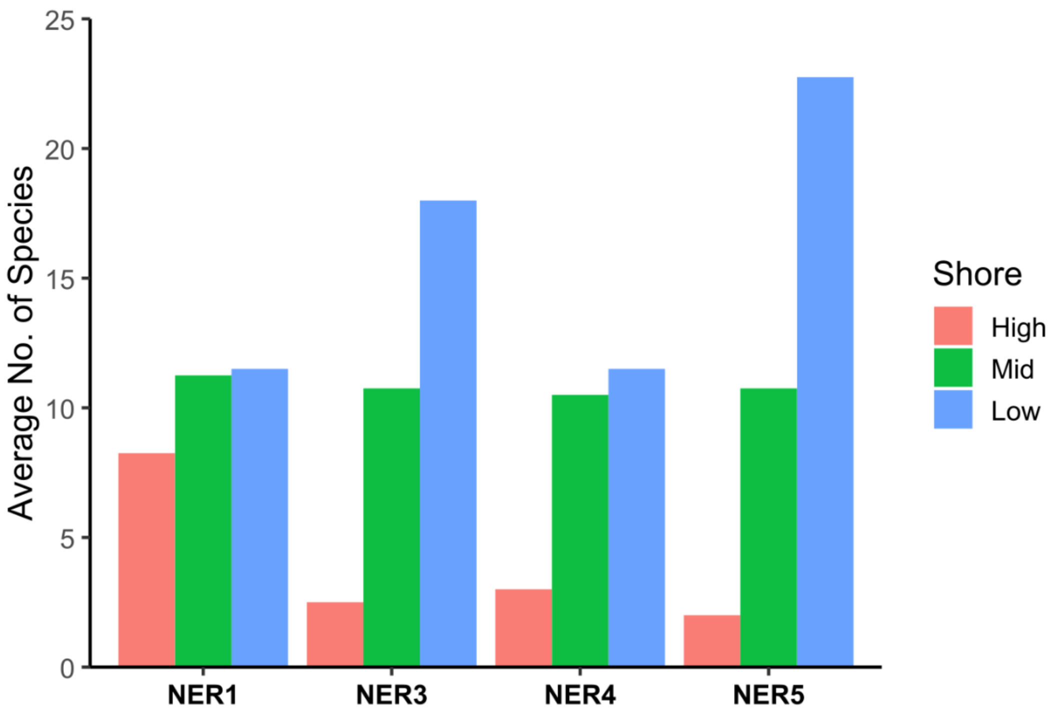


Figure 2-2.15. Average number of species (species richness) for the three shore heights at each rocky shore site. Colours are indicative of shore heights.

The topography of NER1 and NER4 likely explains the lower species richness observed at these locations, particularly at NER1 (Figure 2-2.16). Zonation at these sites was less pronounced, as high shore regions featured rock structures typical of mid and low shores (Figure 2-2.16). Additionally, these sites were highly exposed, leading to strong wave action and decreased desiccation during low tides. The reduced zonation and overlap of mid/low shore habitats in the high shore regions contribute to the minimal differences observed between shore heights.

Figure 2-2.16. Rocky shore habitats found at NER1 (left) and NER4 (right).

Analysis of the spatial distribution using non-metric multidimensional scaling (nMDS) (Figure 2-2.17) revealed that low-shore communities differed from mid- and high-shore communities, though mid- and high-shore communities were more similar to each other (Branch & Branch 2018b). High-shore communities across all sites were relatively consistent, while mid- and low-shore communities displayed more variability. Site NER5 exhibited the greatest dissimilarity among shorelines. These findings reflect the differences in average species richness between shore heights, with low-shore communities showing the greatest spatial dispersion (Figure 2-2.15 and Figure 2-2.17).

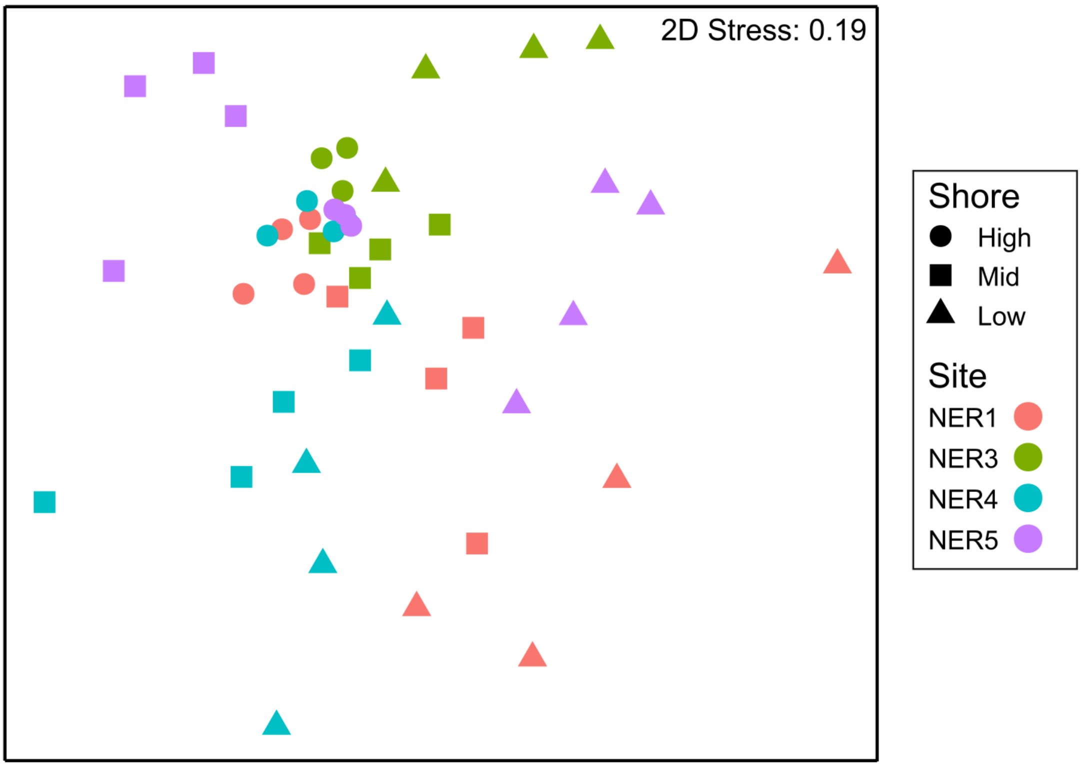


Figure 2-2.17. Spatial distribution of rocky intertidal species composition across varying shore heights (high, mid, and low) at four sites, represented by different colours, based on a non-metric multidimensional scaling (nMDS) ordination plot using Bray-Curtis dissimilarity.

A PERMDISP analysis evaluating group dispersions showed significant differences among shore heights ($F_{(3,\ 2)} = 37.8$, $p < 0.001$), indicative of distinct communities at high, mid and low shores. However, differences among site location along the proposed port development region was not significant. Within-group clustering was further analysed using a PERMANOVA, which found significant effects of both site ($F_{(3,\ 2)} = 4.49$, $p = 0.001$) and shore height ($F_{(3,\ 2)} = 6.95$, $p = 0.001$). These results suggest that community composition is strongly influenced by shore height, wave action and exposure, consistent with descriptions of such environments by Branch & Branch (2018) and in Section 2.2.5.

SIMPER analysis indicated that the average dissimilarity in community composition between sites was 1.1–1.2% and between shore heights ranged from 0.9–1.4%. Despite differences in species richness across sites and shore heights, the Namaqua exposed rock ecosystem along the Boegoebaai Port to Future Expansion 01 region shows high overall similarity.

Other rocky shore surveys undertaken on the west coast were included to provide context for the findings at Boegoebaai (Biccard & Clark 2014b a, Laird et al. 2014, Pulfrich 2018). These communities reflect the characteristic west-coast zonation and species composition described by (Branch & Branch 2018b). Life on highly exposed, wave-beaten shores tends to be more diverse compared to sheltered shores. Our findings across different sites along the west coast align with this trend, although with considerable variation (Figure 2-2.18). Saldanha Bay and Boegoebaai sites exhibited the highest species richness, with 79 and 77 species, respectively while other sites had varying species counts (Figure 2-2.18). Brand-se-Baai 2 displayed the lowest count, with only 24 species despite its ‘exposed’ classification (Figure 2-2.18).

The diversity figure was, however, compromised as sampling effort varied across surveys and, consequently, sites; Saldanha Bay had the most comprehensive sampling (six replicates per shore height), followed by Boegoebaai (four replicates per shore height). Other sites were sampled with three replicates per shore height, except for Brand-se-Baai 1 and 2, and Groenrivier, where only one transect was sampled. It is also important to note that Hondeklip South 1 was incomplete due to weather constraints (low-shore quadrats were not sampled) as described by Pulfrich (2018). These differences in sampling effort likely contributed to the variation in species counts, as fewer replicates result in less habitat coverage (Pulfrich 2018).

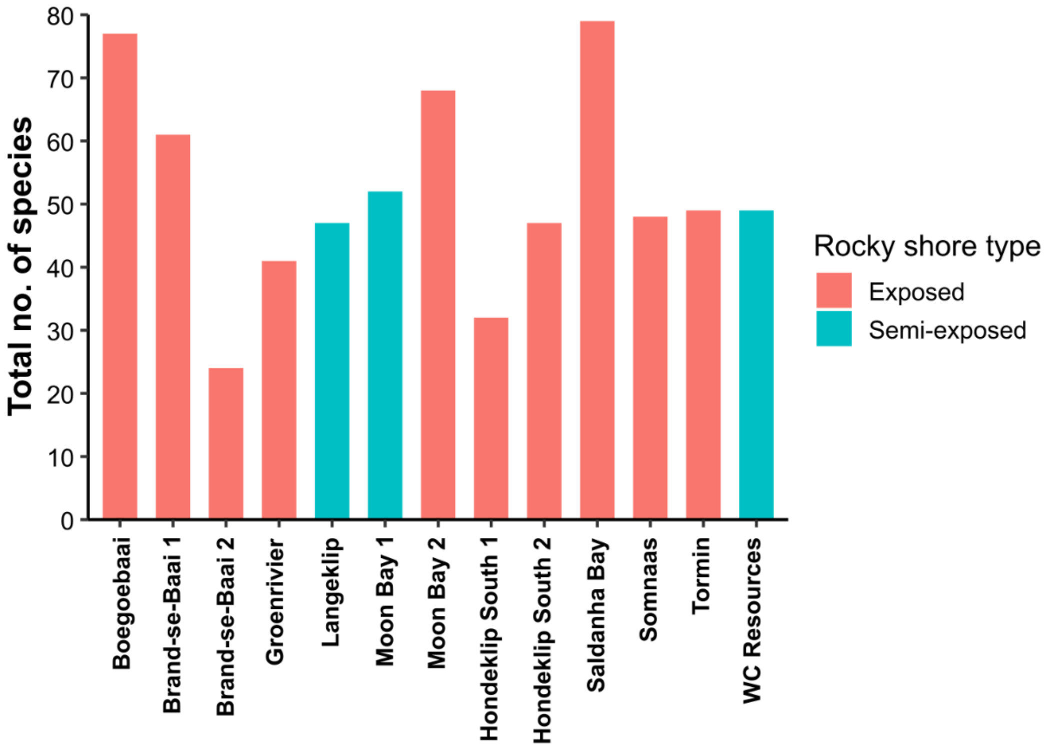


Figure 2-2.18. Total number of species recorded per site along the upper west coast of South Africa.

The presence and absence of taxonomic groups were analysed to better understand the community composition of these rocky shore habitats and assess the representativeness of the diversity (Figure 2-2.19) described at higher taxonomic levels. Community composition across surveyed rocky shore sites was broadly similar, with algae, gastropods, and bivalves consistently represented. Rare or small species, including sea cucumbers, isopods, sea spiders, bryozoans, sea squirts, sea stars, and chitons, were observed at select sites only (Figure 2-2.19). This accounts for differences in species counts across sites (Figure 2-2.18, Figure 2-2.19).

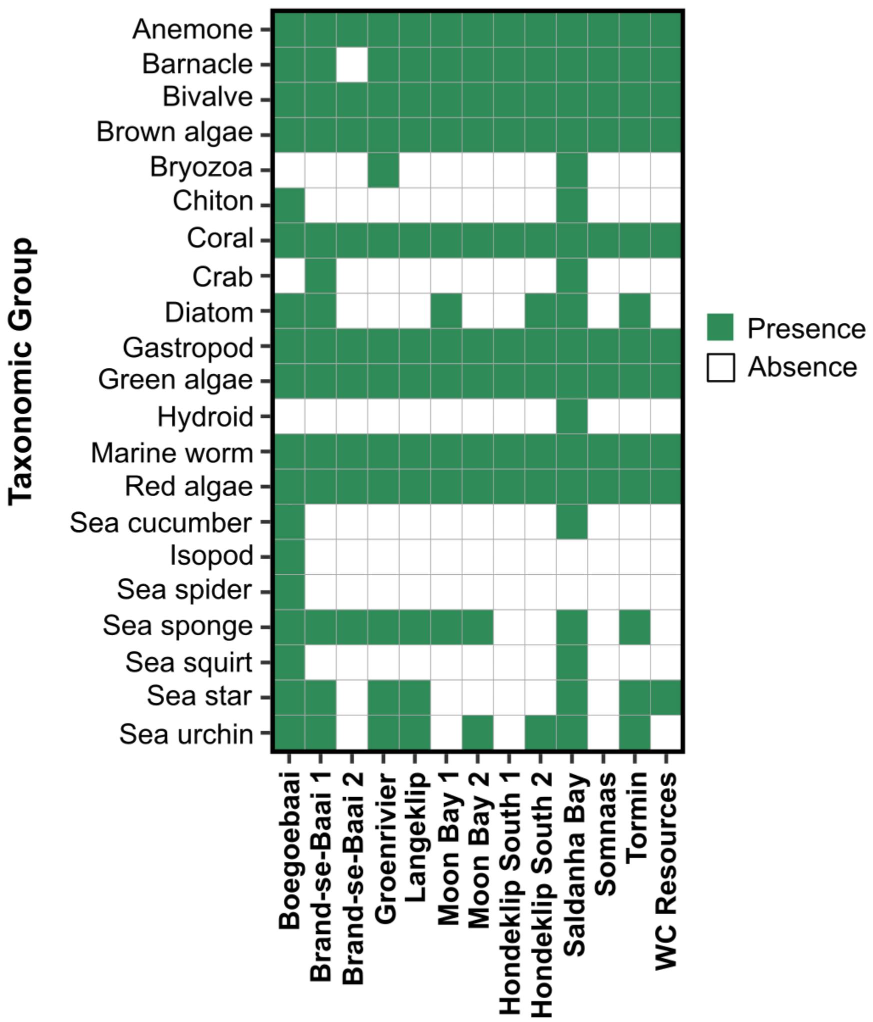


Figure 2-2.19. Presence and/or absence heatmap of taxonomic groups found on rocky shore habitats along the west coast of South Africa.

Greater sampling effort at certain locations, such as Saldanha Bay (~570 km south of Boegoebaai), allowed for broader habitat coverage, providing a more comprehensive representation of these exposed rocky intertidal ecosystems. Nevertheless, the rocky intertidal community observed at Boegoebaai closely aligns with that characteristic of west-coast rocky shores in general, as described by Branch & Branch (2018) and observed in Saldanha Bay as well as other parts of the west coast (Figure 2-2.18, Figure 2-2.19). Sheltered rocky shores are considered a rare occurrence on this exposed coastline

It has been shown that sheltered rocky shore habitat on the west coast of South Africa host a completely different community of intertidal fauna and flora (Blamey & Branch 2009). Such habitat types within this region are rare and exist only within the protected inlets of Homewood Harbour and Peacock Bay (Figure 2-2.7). It is important to note that the proposed development would significantly increase the amount of sheltered rocky shore habitat within the region to several times that of what exists at present.

2.2.6.2 Sandy beaches

2.2.6.2.1 Overview

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 1982). 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 variable species composition (McLachlan et al. 1993, 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 and Griffiths (1988) is used below (Figure 2-2.20), supplemented by data from various publications on West Coast sandy beach biota (Bally 1987, Brown et al. 1989, Soares et al. 1996, 1997, Nel 2000, Nel et al. 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 and/or wave exposure. Due to the exposed nature of the coastline in the study area, most beaches are of the intermediate-dissipative 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 Africorchestia.* The mid-beach retention zone and low-beach saturation zone (intertidal zone or mid-littoral zone) have a vertical range of about 2 m.

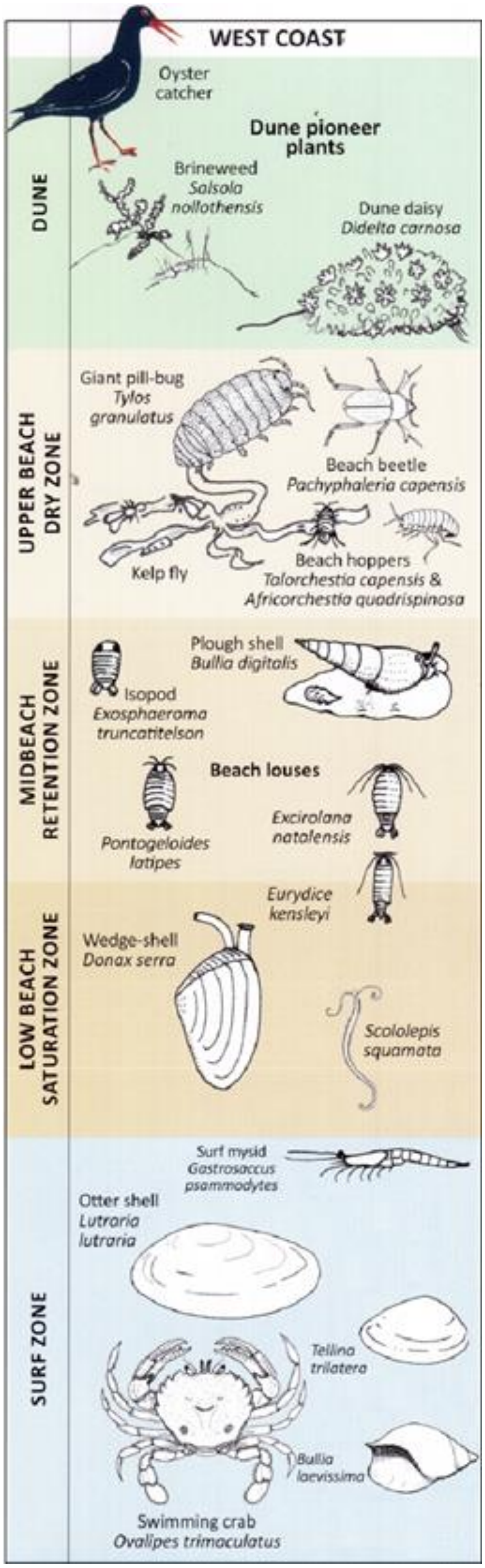


Figure 2-2.20. Schematic representation of the West Coast intertidal beach zonation (adapted from Branch & Branch 2018).

This mid-shore region is characterised by the cirolanid isopods *Excirolana latipes*, *Eurydice kensleyi*, *and Excirolana natalensis*, the polychaetes *Scolelepis capensis* (previously named *S. squamata*), *Orbinia angrapequensis*, *Nepthys hombergii* and *Lumbrineris tetraura*, and amphipods of the families Haustoridae and Phoxocephalidae. In some areas, juvenile and adult sand mussels *Donax serra* may also be present.

The surf zone (inner turbulent and transition zones) extends from the Low Water Spring mark to about 2 m depth. The mysid *Gastrosaccus nambiensis* (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.

A transition zone spans approximately 2-5 m depth beyond the inner turbulent surf 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 *Ampharete ludertizii*. The sea pen *Virgularia schultzei* (Pennatulacea, Cnidaria) is also common as is a host of amphipod species and the three spot swimming crab *Ovalipes trimaculatus* (Brachyura, Crustacea).

There are numerous indices, based on benthic invertebrate fauna information, which can be used to explore conditions and trends in the state of sandy beach ecosystems. These include abundance, biomass, diversity and community composition each of which can be used to evaluate ecosystem conditions and trends over time. Given the complexity inherent in environmental assessment it is recommended that several indices be used (Salas et al. 2006). The community composition, diversity, abundance and biomass of intertidal beach and soft bottom benthic macrofauna samples, collected in Boegoebaai, are considered in this report.

Of particular importance is the presence and abundance of the giant isopod *Tylos granulatus*, found predominantly on the upper portion of sandy beaches, as one of two semi-terrestrial isopod species that occur on sandy beaches in southern Africa (Figure 2-2.21). It is commonly referred to as the ‘Pill bug’ due to its propensity to curl up into a ball when disturbed (Figure 2-2.21). Historically, *T. granulatus* is known to have a natural distribution range extending from Swakopmund in Namibia to Cape Point in South Africa (Kensley 1974), being restricted to the west coast of southern Africa.

Tylos granulatus is strictly nocturnal and exhibits lunar and semi-lunar behavioural rhythmicity (Kensley 1974). *T. granulatus* remains buried up to 40 cm under the sand above the Spring High Water Mark during the day. During periods of burial, its metabolic rate drops dramatically, conserving energy (Marsh & Branch 1979). It emerges *en masse*, at least one hour after sunset, to scavenge on kelp wrack and other organic flotsam on sandy beaches (Figure 2-2.21). *T. granulatus* will infrequently emerge on high (but ebbing) tides during neaps, but most foraging activity takes place in a couple of hours during low tides each night (Kensley 1974). *T. granulatus* appears strongly photophobic — Kensley (1974) noted that *T. granulatus* seldom emerges during full moons, and Odendaal et al. (1999) state that the species is inactive during full moon. The latter authors studied *T. granulatus* populations in Namaqualand and found evidence that *T. granulatus* is preyed on by yellow mongoose *Cynictis pencillata*. Odendaal et al. (1999) postulated that predation may be an important factor regulating activity (resulting in inactivity during daytime and full moon nights).

Figure 2-2.21. Left: *T. granulatus* – one individual rolling into a ball for protection (right of image), after being disturbed (Scale: 20 mm body width). Right: *T. granulatus* burrowing (foreground) and feeding on kelp (upper individual).

The population status of *T. granulatus* remains mostly unknown, but there is evidence suggesting that certain populations may be severely threatened, and others have completely disappeared (Brown 2000). The range of *T. granulatus* once extended across the whole southern African west coast, stretching far north into Namibia, but has now been reduced to probably less than half that. Human-induced disturbance (in the form of pollution, kelp harvesting, vehicles, construction and development) in the coastal zone was hypothesised to be responsible for the reduction in *T. granulatus* abundance and distribution (Brown & Odendaal 1994). Recent genetic research has uncovered high levels of population structure in southern African *T. granulatus* populations with two distinct lineages present on the west coast, to the north and south of a Hondeklip/Kleinzee break (Mbongwa et al. 2019). More than two decades ago it was suggested that *T. granulatus* should be assigned a Red Data Book[1] status of perhaps 'Vulnerable' or 'Low Risk' (Brown & Odendaal 1994, Brown 2000). A preliminary IUCN red list assessment supported the classification of *T. granulatus* as an endangered species under Criterion B due to its small natural habitat (sandy beaches, supratidal to low water mark only), declines in habitat quality, and fragmented populations as shown by the population genetics results (Linda Harris, Nelson Mandela Metropolitan University, pers. comm.).

Diamond mining, the primary coastal activity affecting sandy beaches in the Boegoebaai study area, inevitably alters the morphology of impacted shorelines, a situation that often persists, depending on the rehabilitation undertaken, for some time post-mining. Understanding the effects of beach diamond-mining on *T. granulatus* populations on Namibian sandy beaches (20-100 km north of Boegoebaai) is improving due to the long-term monitoring that is being undertaken. Nearly the entire northern *T. granulatus* lineage exists in areas impacted by coastal diamond mining and given the wide-scale decrease in abundance and distribution of this species (Brown & Odendaal 1994, Brown 2000), the proposed Boegoebaai development may be of concern.

Beach macrofaunal sampling (such as that described in the following section) usually detects some degree of *T. granulatus* abundance, but during the day (when beach macrofauna is generally sampled), the species tends to occupy the upper regions of the beach zone and is buried too deep in the sand for detection though conventional beach sampling methods. To provide a more representative reflection of *T. granulatus* abundance and population status, dedicated sampling using pitfall traps is conducted (see below).

Sediment quality is also important for understanding ecosystem health as it reflects alterations in benthic sediments from its natural state, by measuring factors like Particle Size Distribution (PSD), organic content, and contaminant levels. The proportion of various sediment grain sizes, including gravel, sand, and mud, play a pivotal role in shaping biological communities and determining the potential for organic and contaminant accumulation (Clabaut & Davoult 1989, Martinez-Garcia et al. 2015, Kim et al. 2020). For example, fine sediment particles, like mud and silt, tend to accumulate trace metals and can elevate organic inputs, including Total Organic Carbon (TOC), which can lead to eutrophication, affecting benthic macrofauna through various responses such as increased growth rates, species loss due to oxygen

[1] Species whose continued existence is threatened are classified into different categories of perceived risk and listed in an appropriate Red Data Book.

depletion, and shifts in community composition (Warwick 1993, Hyland et al. 2005, Dewenter et al. 2023). Disturbances such as dredging activities can resuspend mud, releasing pollutants into the water column (Eggleton & Thomas 2004). Although buried metals are typically inert (non-threatening), they can become hazardous once transformed into soluble forms like metal sulphides. Additionally, coastal desalination plants and associated discharges have been found to increase heavy metal concentrations in outfall areas (Alshahri 2017), which can affect the health of the marine species, especially filter feeders like mussels. Understanding sediment PSD is thus necessary for assessing the impact of the proposed development on the Boegoebaai coastal ecosystem.

2.2.6.2.2 Methods

Sampling was conducted at six sites as part of this study, one station at each of the smaller, more wave exposed beaches, and two on the more extensive dissipative beaches in the south (Figure 2-2.11 and Table 2-2.3).

Physical variables were measured at each sampling site within half an hour of low tide. These included grain size, and wave height and frequency, which are used to define beach morphodynamic states. The beach gradient, effluent-line crossings and surf-zone width were also measured to determine exposure rating. These factors were measured and calculated as follows:

- Grain size (in µm): Surface sediment samples (250 ml) were collected from Stations 1, 3, and 5 (i.e. high, mid and low shore) at each site, and dry sieved and weighed to determine sedimentary composition. GRADISTAT Version 8 (Blott & Pye 2001) was used to calculate mean particle diameter, settling velocity, sorting and skewness;

- Wave height (m): A visual estimate of the maximum height difference between the wave trough and the highest point before breaking;

- Wave frequency (no.min^{-1}): Counted as the number of waves passing a fixed point in the surf zone, per minute. Wave period (in seconds) is calculated as 1/Frequency x 60;

- Dean's Parameter/Beach morphodynamic state (Ω): $\Omega = H_b / (T_b \times W_s)$ (where H_b is the wave height in cm, T_b the wave period in seconds, and W_s the sand fall velocity in cm.s^{-1});

- Beach gradient: Measured as the ratio of the height difference between the first and last sampled stations and the beach width between the drift line and water line;

- Effluent line crossings (no. min^{-1}): The number of waves that reaches the beach and swash past the edge of the glassy layer per five minutes;

- Surf-zone Width (m): A visual estimate of the width from the swash line to the seaward edge of the breaker zone; and

- Exposure Index: Calculated according to McLachlan (1980).

Table 2-2.3. Boegoebaai sandy beach sampling sites and (in brackets) Tylos sampling effort.

Habitat type	Site name	Lat	Long	Tylos sampling effort
Intermediate-Dissipative Sandy Shore	DISS1	28.834595° S	16.591579° E	4 transects (5 traps/ transect)
Dissipative Sandy Shore	DSS1	28.875858° S	16.610804° E	7 transects (3 traps/transect, 1 transect with 2 traps – no supratidal habitat present at dune foot)
	DSS2	28.898079° S	16.652923° E	5 transects (5 traps/transect, 1 transect with 4 traps, 1 transect with 2 traps)
Intermediate Sandy Shore	ISS1	28.777684° S	16.572499° E	4 transects (5 traps/transect)
	ISS2	28.795334° S	16.578549° E	4 transects (5 traps/transect)
Reflective Sandy Shore	RSS1	28.773609° S	16.571109° E	4 transects (5 traps/transect)

All visual estimates were made by the same individual during each survey, to keep estimates consistent and comparable.

At each beach site, three transect lines, 5 m apart, were surveyed perpendicular to the shore. Each transect consisted of five equidistant stations across the width of the beach. The three samples at corresponding heights at each station were treated as replicates and were used to measure the level of variability at each site (a total of 15 samples were collected at each beach site). At each sampling station on the three transects, 0.1 m^2 core samples were excavated to a depth of 30 cm and washed through a 1-mm mesh sieve bag to remove fine material. All fauna retained in the sieve bag were then preserved in 96% ethanol (Figure 2-2.22). On beaches where a large fraction of coarser sediment was retained in the sieve bags, sediments were elutriated until three consecutive decants yielded no further macrofauna. Large, heavy organisms (such as large molluscs) were recovered from samples by hand.

Figure 2-2.22. Field survey team surveying beach sites, measuring beach profiles, and elutriating sediment samples to extract macrofauna.

This is less intensive sampling than that outlined by McLachlan (1980), typically involving 30 samples at each beach site. This reduction in sampling intensity was due to the relatively narrow width and reflective nature of the beaches in the study area. The survey team were satisfied that the reduced sampling effort was sufficient to capture the sandy beach macrofaunal community structure and aligned sampling effort with that for the subtidal macrofaunal sites.

In the laboratory, beach macrofauna were identified to species level where possible. The biomass (blotted wet mass in grams to four decimal places) and abundance of each species was recorded for each sample. Molluscs were weighed in their shells. Numbers and biomass of each species were expressed per m^2 at each station, to compare samples. In addition, the species richness (total number of species) per transect was calculated, as well as the total abundance (no./m) and biomass (g/m) of all species combined per running metre[2] of beach down the transect line.

Monitoring ecosystem health of an area also involves identifying stress effects and evaluating recovery post-environmental disturbances. On the west coast of South Africa, monitoring populations of the intertidal isopod, *T. granulatus* populations can offer insights into the overall health of the marine environment, with changes to these populations acting as early-warning signs of environmental impacts like pollution or habitat degradation.

Sampling for *T. granulatus* was conducted at each of the beach sampling sites (Table 2-2.3) during the new moon phase from 30 September to 3 October 2024. Pitfall traps consisted of clear 1 litre plastic jars with an 8 cm diameter opening and a depth of 19 cm. The jars were baited with a teaspoon of peanut butter and dug into the sand so that the opening of the jar lay flush with the surface of the ground. Any *T. granulatus* attracted by the bait fell directly into the trap. Pitfall traps were evenly distributed throughout the available *T. granulatus* habitat (from the dune vegetation to the driftline). For the purposes of this baseline study, traps were distributed evenly along parallel transect lines set perpendicular to the coastline at each beach site (see Table 2-2.3 for the number of transect lines and traps per transect that were set at each site). Traps were set an hour after sunset for a total time of two hours either side of the evening spring low tide.

After the allocated two-hour sampling period, all traps were collected and the captured *T. granulatus* were counted and measured to the nearest 0.5 mm across their maximum body width and then returned to the beach. As *T. granulatus* curls into a ball when disturbed, it was necessary to measure body width rather than length. Body width is proportional to length (Mclachlan & Sieben 1991).

2.2.6.2.3 Sandy beach macrofauna results

The beach widths were all relatively wide (48-72 m), with a gently sloping upper *drift* line, becoming steeper closer to the low-water mark except for intermediate sandy shore site, ISS1 which had a beach width of 31 m and a relatively steep slope (1:7.5) (Figure 2-2.23 and Figure 2-2.24). This is an odd result for an intermediate sandy beach which should be wider and not as steep. Further inspection of the physical beach data revealed that the beach width at the reflective sandy shore site, RSS1, was 48 m and the beach slope was 1:19. It is obvious that the NBA classification of these two beach habitats have been erroneously swapped around. Beach ISS1, which is located on a south-west facing shore (directly opposite the prevailing swell direction), should be classified as a reflective beach and beach RSS1, which faces directly west, should be classified as an intermediate sandy shore. For consistency, we have maintained the original erroneous classification, as it appears in the NBA, in this report. In general, the Boegoebaai beaches that were surveyed in this study can be described as relatively high energy beaches.

Data on key physical and biological (infauna) parameters measured at each site are presented in Table 2-2.4. Overall, sediments were coarsest at beach sites RSS1, DSS1 and ISS1 and were dominated by medium sand. All the sediments were well sorted. The skewness values were mostly symmetrical or fine skewed at DISS1. Apparent wave height across the 6 beaches sampling sites ranged from 1.7-3 m during the survey. Dean's values (Ω, morphodynamic state - a dimensionless number used to classify beach states based on wave energy and sediment characteristics) ranged between 1.78 and 4.45 (Table 2-2.4). When rated on the McLachlan (1980) exposure scale, nearly all of the sites were classified as exposed (12-14), with little difference in exposure rating between sites (Table 2-2.4).

[2] The term 'running meter' of beach is used to designate a 1 m wide strip down the beach, from the spring high tide to spring low tide mark. The area of this will be the length of the transect x 1 m, and estimates from the sampled quadrats were scaled up to this area to provide an estimate of total abundance or numbers along the entire transect, notwithstanding variations in beach width among transects.

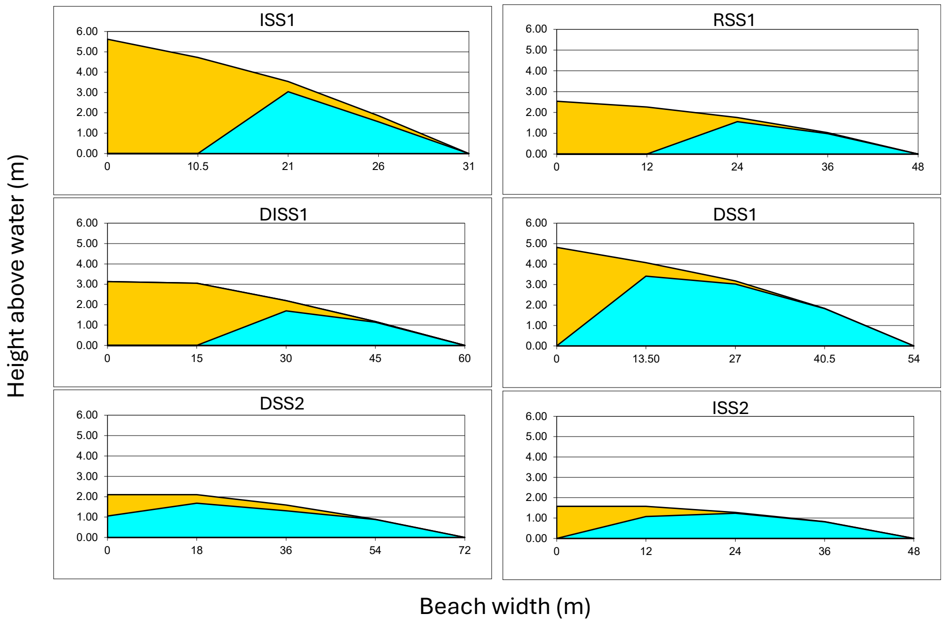


Figure 2-2.23. Measured beach profiles at Boegoebaai sandy beach sampling sites. In each graph the yellow shaded area represents the beach profile (sand) and the blue area represents the water table.

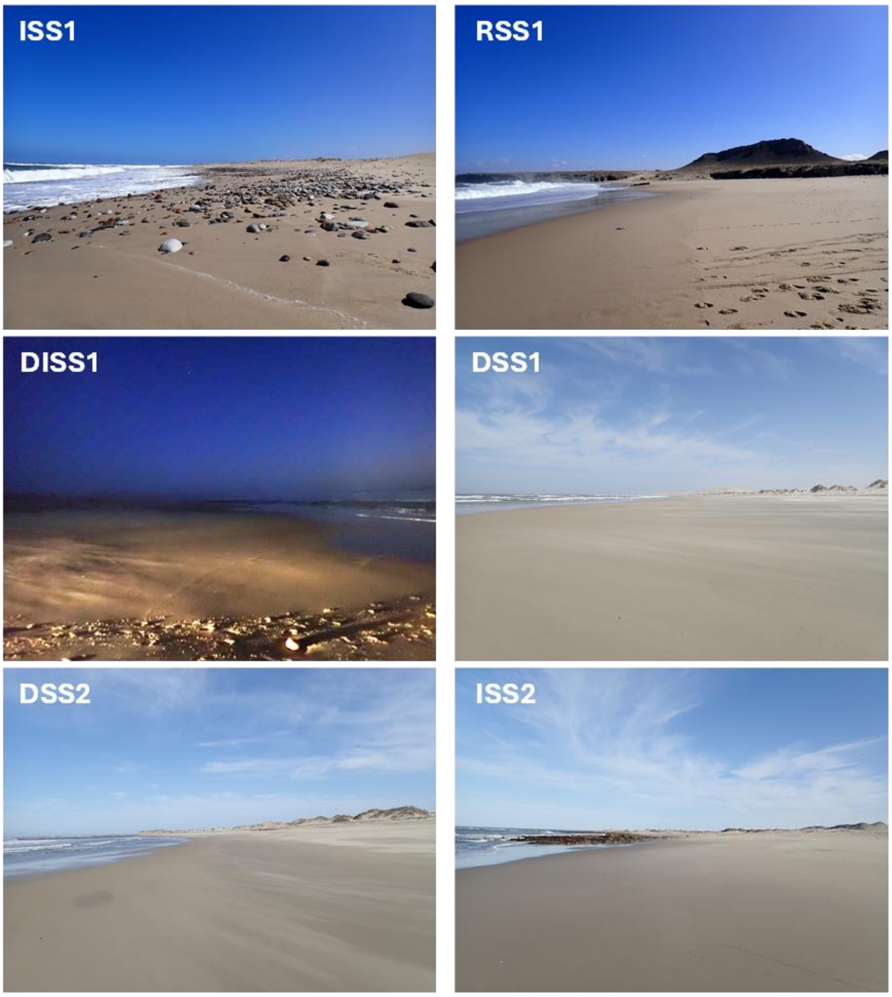


Figure 2-2.24. Boegoebaai sandy beach sampling sites.

Table 2-2.4. Key physical and biological variables recorded at the Boegoebaai beach sites. For species number, abundance and biomass, only supra- and intertidal 'marine' species are included, i.e. insects and arachnids are omitted. Sediment data are presented for station 5 (low shore).

	ISS1	RSS1	DISS1	DSS1	DSS2	ISS2
	Station 3	Station 3	Station 3	Station 3	Station 3	Station 3
Mean particle size (µm)	382.8	384.6	242.2	384.2	293.2	404
Mean particle size (ϕ)	1.471	1.464	2.113	1.46	1.849	1.372
Mean	Medium sand	Medium sand	Fine sand	Medium sand	Medium sand	Medium sand
Sorting	Well sorted	Well sorted	Very well sorted	Very well sorted	Well sorted	Very well sorted
Skewness	Symmetrical	Symmetrical	Fine skewed	Symmetrical	Symmetrical	Symmetrical
Beach width (m)	31	48	60	54	72	48
Wave Height (m)	3	3	3	1.7	2	2
Wave Freq. (no./min)	6	6	10	9	7	8
Wave period (secs)	10	10	6	7	9	8
Effluent Crossings / min.	4	2	1	1	1	2
Slope (1:H)	1:7.5	1:19	1:19	1:11	1:34	1:30.5
Dean's parameter	1.78	2.31	4.45	3.2	2.65	3.02
Beach state	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Exposure	14	14	13	12	14	13
Total no. of Species	7	8	7	10	13	7
Total no. of Species (marine)	4	5	4	8	9	5
Total abundance per m^2	317.33	22.67	52.00	471.33	231.33	38.67
Total abundance per m^2 (marine)	171.33	17.33	42.67	461.33	221.33	32.00
Total abundance per running m	9837	1088	3120	25452	16656	1856
Total abundance per running m (marine)	5311	832	2560	24912	15936	1536
Total biomass per m^2	1.39	0.27	0.17	1.38	0.74	0.44
Total biomass per m^2 (marine)	1.18	0.27	0.09	1.37	0.74	0.35
Total biomass per running metre	43.16	13.04	10.48	74.42	53.60	20.95
Total biomass per running m (marine)	36.65	12.80	5.46	74.04	53.07	16.63

In total, 17 macrofauna taxa (11 of which are marine) were collected across the habitats (see examples in Figure 2-2.25), comprising five broad taxonomic groups, including crustaceans (Amphipoda, Isopoda and Mysida), molluscs (Bivalvia), Nemertea, worms (Polychaeta) and Insecta (Table 2-2.5 and Table 2-2.6). The fauna was dominated by crustaceans (eight taxa), and insects (five taxa), with lesser contributions from worms (two taxa), molluscs (one taxon), and bivalves. The amphipod, *Africorchestia* sp., and isopods, *Excirolana latipes* and *T. granulatus* dominated the intertidal habitats of Boegoebaai. *Africorchestia* sp., *Excirolana natalensis* and *T. granulatus* were present across all habitat types. (Table 2-2.5 and Table 2-2.6).

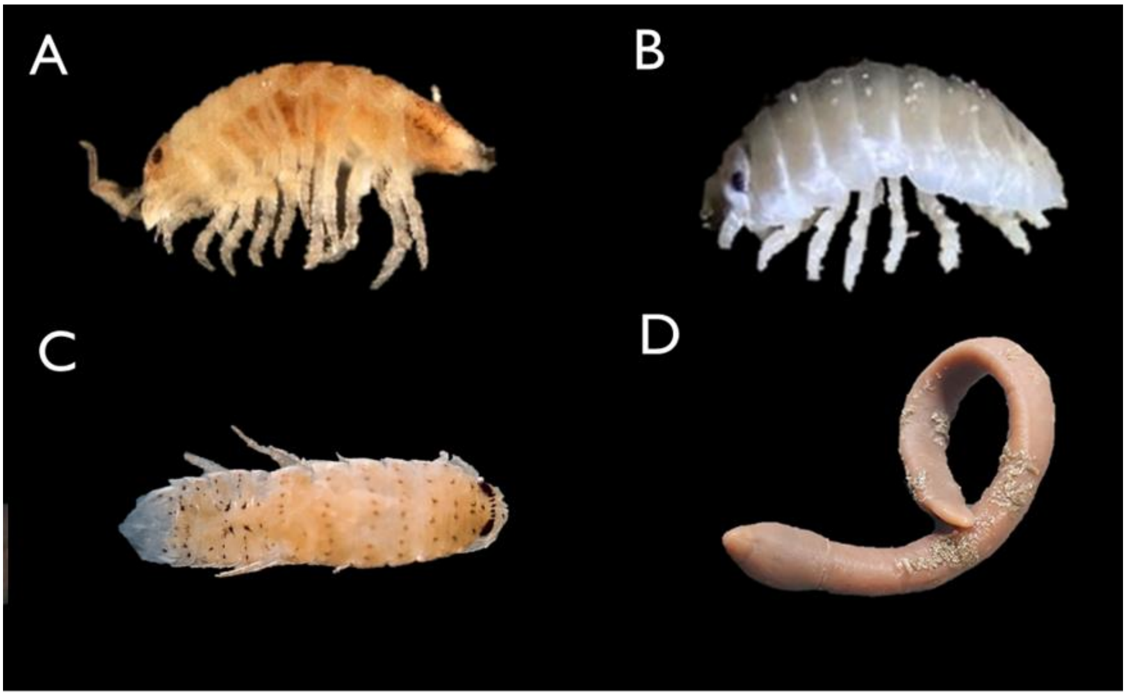


Figure 2-2.25. Selection of intertidal macrofauna species collected during the Boegoebaai baseline survey in 2024. A) Isopoda sp. 1 B) *Tylos granulatus*, C) *Eurydice kensleyi* and D) Nemertea sp.

Dissipative beaches, DSS1 and DSS2, had the highest recorded mean abundance, averaging 461 and 221 ind./m^2, respectively, primarily due to high counts of the amphipod, *Africorchestia* sp., and the isopod, *Excirolana latipes* (Figure 2-2.26 and Table 2-2.5). As expected and according to Table 2-2.5, the lowest abundances were recorded at sites ISS1 (reflective beach) and RSS1 (intermediate beach), averaging 15 and 17 ind./m^2, respectively. In contrast, site DISS1 and ISS2 had moderately high abundances, averaging 43 and 32 ind./m^2, respectively.

Biomass results generally agree with the abundance results except for site ISS1 (reflective beach) where low abundance was recorded: mean recorded biomass was highest at site DSS1 (1.37 g/m^2) due the high abundance of the isopod, *Excirolana latipes*, at this site followed by ISS1 (1.18 g/m^2) due to the presence of the isopod *T. granulatus* (Figure 2-2.27 and Table 2-2.6). Relatively high biomass was also observed at DSS2 (0.74 g/m^2), and ISS2 (0.35 g/m^2). Lowest indices of mean biomass were recorded at sites DISS1 (0.09 g/m^2) and RSS1 (0.09 g/m^2).

Table 2-2.5. Abundance (total number of individuals per running meter) of beach macrofauna sampled at Boegoebaai. Abundance per running meter can be converted to unit area (m^2) by dividing by shore width (Refer to Table 2-2.4 with beach parameters information).

	DISS1	DSS1	DSS2	ISS1	ISS2	RSS1
CRUSTACEA						
Amphipoda						
Africorchestia sp.	1080	8676	12960	280	576	128
Griffithsius latipes	40	1656	288	0	0	64
Isopoda						
Excirolana latipes	0	10980	144	28	256	96
Excirolana natalensis	760	144	912	224	352	416
Isopoda sp. 1	0	36	0	0	288	0
Tylos granulatus	680	864	240	6664	64	128
Eurydice kensleyi	0	2448	816	0	0	0
Mysida						
Gastrosaccus namibiensis	0	0	288	0	0	0
MOLLUSCA						
Bivalvia						
Semimytilus patagonicus	0	0	48	0	0	0
NEMERTEA	0	108	0	0	0	0
POLYCHAETA						
Scolelepis capensis	0	0	240	0	0	0
INSECTA						
Diptera (adult)	0	252	96	0	96	64
Diptera larva sp. 1	280	0	480	4844	0	160
Diptera larva sp. 2	40	0	48	1232	0	32
Insect Beetle sp. 1	240	0	96	56	224	0
Insect Beetle sp. 2	0	288	0	0	0	0
Grand Total	**3120**	**25452**	**16656**	**13328**	**1856**	**1088**

Table 2-2.6. Biomass (total per running metre) of beach macrofauna sampled at the Boegoebaai. Biomass per running metre can be converted to unit area (m^2) by dividing by the shore width (Refer to Table 2-2.4 with beach parameters information).

	DISS1	DSS1	DSS2	ISS1	ISS2	RSS1
CRUSTACEA						
Amphipoda						
Africorchestia sp.	3.32	18.91	34.91	1.33	1.29	0.12
Griffithsius latipes	0.05	1.23	0.13	0.00	0.00	0.04
Isopoda						
Excirolana latipes	0.00	47.21	0.84	0.00	7.05	2.06
Excirolana natalensis	1.80	0.68	13.00	2.00	8.02	9.30
Isopod 1	0.00	0.00	0.00	0.00	0.24	0.00
Tylos granulatus	0.28	0.91	1.92	33.31	0.02	1.29
Eurydice kensleyi	0.00	3.52	1.23	0.00	0.00	0.00
Mysida						
Gastrosaccus namibiensis	0.00	0.00	0.64	0.00	0.00	0.00
MOLLUSCA						
Bivalvia						
Semimytilus patagonicus	0.00	0.00	0.04	0.00	0.00	0.00
NEMERTEA	0.00	1.57	0.00	0.00	0.00	0.00
POLYCHAETA						
Scolelepis capensis	0.00	0.00	0.37	0.00	0.00	0.00
INSECTA						
Diptera (adult)	0.00	0.05	0.01	0.00	0.02	0.05
Diptera larva sp. 1	0.31	0.00	0.46	4.73	0.00	0.18
Diptera larva sp. 2	0.17	0.00	0.02	0.98	0.00	0.00
Insect Beetle sp. 1	4.54	0.00	0.04	0.80	4.31	0.00
Insect Beetle sp. 2	0.00	0.33	0.00	0.00	0.00	0.00
Grand Total	**10.48**	**74.42**	**53.60**	**43.16**	**20.95**	**13.04**

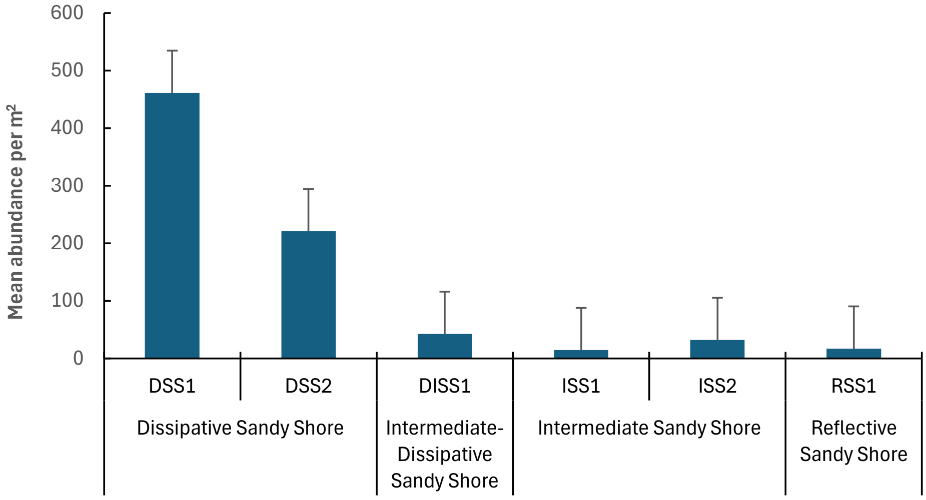


Figure 2-2.26. Mean abundance per m^2 (+ one standard error) of intertidal macrofauna (marine species only) sampled at four habitat types in Boegoebaai. Error bars are one standard error.

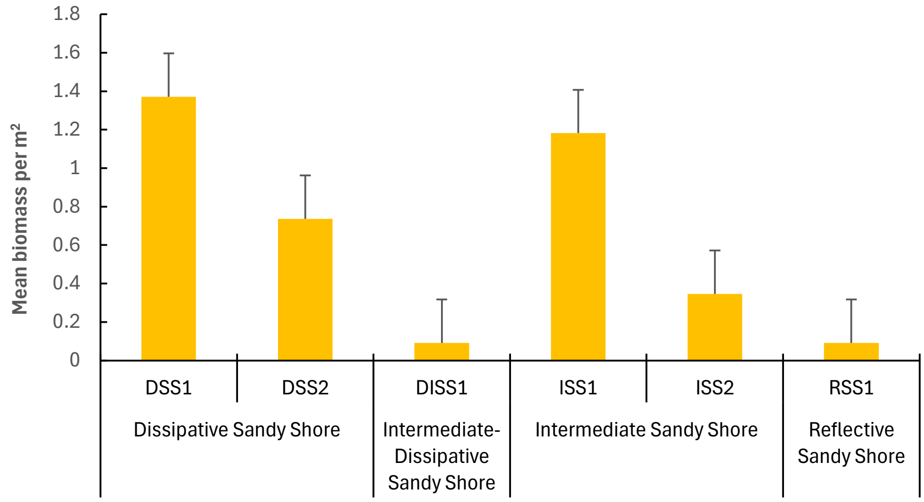


Figure 2-2.27. Mean biomass (grams per m^2 + one standard error) of intertidal macrofauna (marine species only) sampled at four habitat types in Boegoebaai. Error bars are one standard error.

By comparison, mean abundance of intertidal macrofauna for six intermediate dissipative beaches (of similar widths) sampled at Doringbaai, 380 km south of Boegoebaai (also within the Namaqua inshore ecoregion), ranged between 79-163 ind./m^2 while mean biomass ranged between 0.95-15.5 g/m^2 and total diversity of beach macrofauna recorded was 16 taxa (12 of which were marine) (Biccard et al. 2024). Overall, mean biomass across all Boegoebaai beaches sampled during the present study (0.64 g/m^2) is an order of magnitude lower than that recorded at Doringbaai (4.91 g/m^2). The Doringbaai beaches that were surveyed are relatively undisturbed in comparison to the Boegoebaai beaches which are considered highly disturbed as a result of diamond mining activity. Baseline data (prior to mining activities) for the Boegoebaai beaches are not available, however, our survey results, when compared to those from Doringbaai, suggest that coastal diamond mining activities have had a detrimental impact on intertidal sandy beach macrofauna communities in Boegoebaai and that univariate indices of abundance, biomass and diversity observed in this study are not necessarily representative of the habitat types that were surveyed.

Some taxa were restricted to the DSS habitat, including the isopod, *E. kensleyi*, the mysid, *G. namibensis*, the polychaete, *Scolelepis capensis*, an unidentified nemertean and the bivalve, *Semimytilus patagonicus* – the latter likely to have been washed ashore from nearby rocky shore habitats. This restricted distribution could point to the sensitivity of these taxa to high wave action and their preference for more dissipative beaches.

The multidimensional scaling (MDS) ordination plot (a technique for grouping samples with similar macrofaunal communities and separating dissimilar samples – see Section 2.2.6.1) depicts infaunal community structures among Boegoebaai habitat types (Figure 2-2.28). Based on the results, it appears that the samples from the dissipative beaches (DSS1 and DSS2) are grouped together and share greater similarity than samples from the other beach habitat types (Figure 2-2.28). As expected, samples also appear to be clustered according to their height on the shore (Figure 2-2.28) with those from stations one and two (higher on the shore) clustering separately from those collected at stations three four and five (lower on the shore). This result indicates that the environmental conditions present at varying heights across the width of the shore (presence/absence of seawater) appears to be the most important predictor of intertidal macrofaunal community structure, in this case more so than beach habitat type.

2.2.6.2.4 Tylos results

Average *T. granulatus* abundance per trap for the six sites sampled in Boegoebaai are shown in Figure 2-2.29. Surprisingly, of all the beaches sampled, site ISS1 (with a narrow beach width, steep profile and reflective sandy shore), had the highest catches of *T. granulatus* (11.7 individuals per trap). This was followed by the adjacent beach, RSS1 (intermediate sandy shore) with an average abundance of 4.7 individuals per trap. Beaches ISS2, DSS1 and DSS2 had poor average catches ranging from 0.5-1.9 individuals per trap with a zero-catch recorded for DISS1 (Figure 2-2.29). In comparison to the catches made at Doringbaai (27.8 and 23.6 individuals per trap at the two beaches sampled), the abundance of Tylos at the Boegoebaai is extremely low. Size frequency data from each of the beaches paint a similar picture with only the juvenile cohorts present at each of the beaches sampled (Figure 2-2.30) – the complete absence of adult Tylos from the population on Boegoebaai beaches will compromise reproductive success and is likely to result in complete collapse or local extinction of the species (already observed at site DISS1).

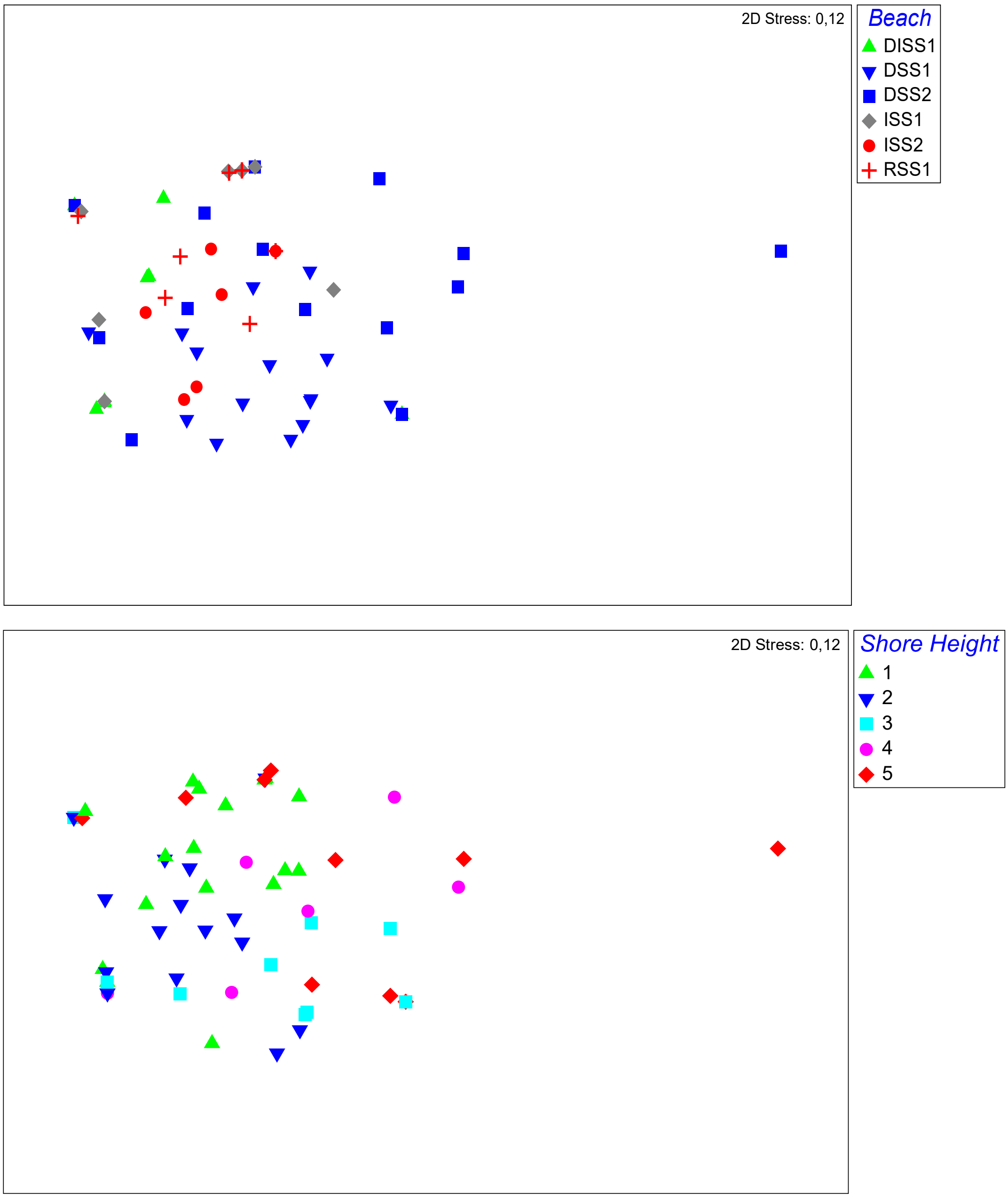


Figure 2-2.28. Non-metric multi-dimensional scaling (nMDS) ordination plot depicting relative similarity between the macrofaunal communities sampled from four beach habitat types (intermediate dissipative sandy shore, dissipative sandy shore, intermediate sandy shore and reflective sandy shore) at Boegoebaai. Samples were plotted according to the habitat types (top graph) and shore height (bottom graph: station 1 at the high-water mark and station 5 at the low-water mark).

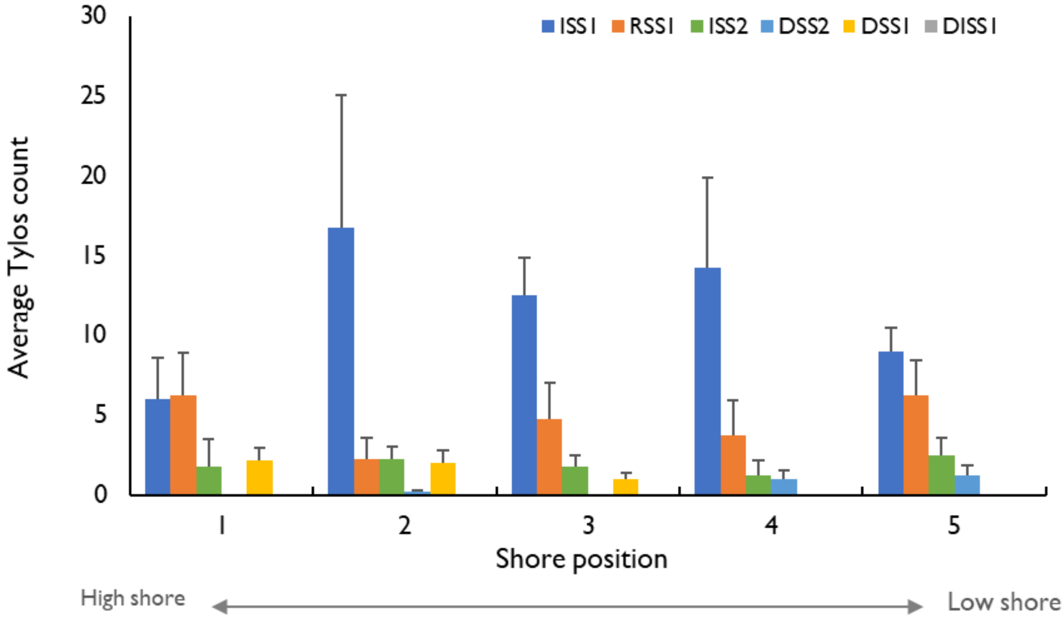


Figure 2-2.29. Average Tylos counts (per trap, moving from high shore to low shore) at Boegoebaai. The error bars denote one standard error.

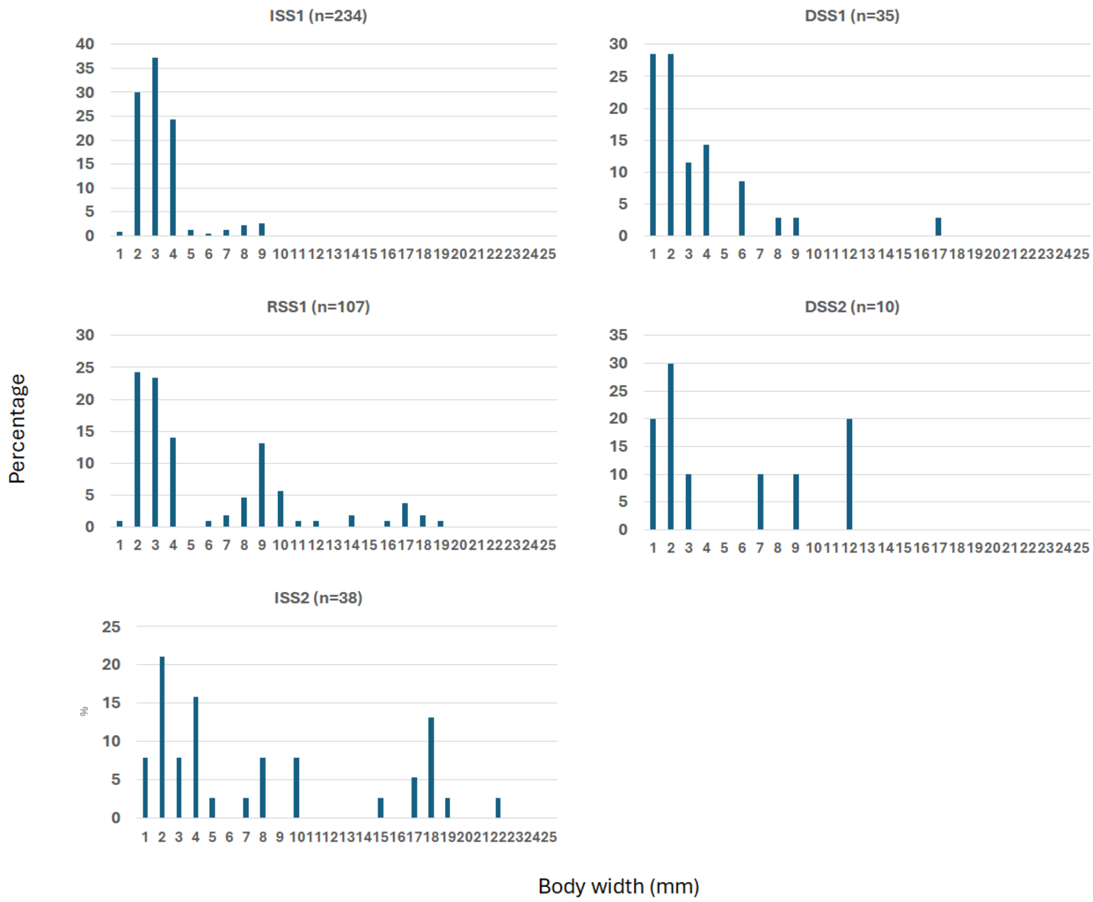


Figure 2-2.30. *T. granulatus* body width frequency distributions at Boegoebaai beach sites sampled during the 2024 field survey. Note that a zero-catch rate was recorded for DISS1.

It is well established that intertidal diamond mining by means of seawall and/or cofferdam construction tends to destroy or remove nearly all of the available inter- and supra-tidal habitat needed by *T. granulatus* and, as a consequence, this species usually disappears from beaches in the immediate vicinity of such activities. This has been observed on beaches just to the north of the Orange River where monitoring of the impacts associated with intertidal diamond mining on sandy beaches has been taking place for more than two decades (Pulfrich & Hutchings 2023) and is almost certainly the case here in Boegoebaai. Other anthropogenic effects such as the presence of vehicles, lights, prospecting (drilling), accretion activities associated with the 'Sand to Sea' project in Southern Coastal Mines just north of the Orange River and natural disturbance events (Orange River discharges of freshwater and sediment and beach erosion from storm events) have also been identified as potential drivers of declines and temporal variation observed in *T. granulatus* populations in southern Namibia (Pulfrich & Hutchings 2023) and are also likely to play a role explaining the low abundance of *T. granulatus* observed on the Boegoebaai beaches in this study. Again, it needs to be acknowledged that there are no baseline data against which current results can be compared, but when compared to results from Doringbaai (Biccard et al. 2024) and control sites just north of the Orange River (Pulfrich & Hutchings 2023) it is clear that the abundances of *T. granulatus* populations on all beaches that were sampled in Boegoebaai are very low and most likely have been heavily impacted and are approaching collapse (with total collapse observed at DISS1).

Based on these findings, and those presented in the previous section (intertidal macrofauna) it is difficult to identify particular sandy beach habitat that are sensitive and should be avoided/conserved during the proposed Boegoebaai Port development. Our results are indicative of depauperate sandy beach infaunal communities across all beach habitat types that were sampled – we suspect this is a direct result of the high amount of anthropogenic disturbance associated with intertidal diamond mining observed throughout the entire study area. In general, more dissipative beaches are known to harbour the richest intertidal faunal communities (in comparison to reflective beaches) and these are habitats that should be avoided. If there is cessation of mining activities, and with adequate rehabilitation, sandy beach faunal communities within the Boegoebaai study area are likely to recover. Such recovery, to a condition comparable to 'natural' populations, has indeed been demonstrated on mined beaches that have been rehabilitated to the north of the Orange River (Pulfrich & Hutchings 2023). It is recommended that a range of sandy beach habitat types within the Boegoebaai area (away from the footprint of the proposed development) are earmarked for rehabilitation and are afforded some form of protection going forward. Priority should be given to rehabilitation and conservation of dissipative beaches as these have the richest faunal communities.

2.2.6.3 Mixed shore

Any area of the shore that is not pure rock or pure sand is classed as "mixed shore", where sections of each kind are small enough to be influenced throughout by the adjacent shore type (Bally et al. 1984). Classifying mixed shores presents a challenge, as they cover the full range between pure sand and pure rock, covering types such as 'sand with isolated rocks', 'sand with many rocks', 'sand in the low shore and rock in the high shore' (and vice versa), 'rock with extensive sand', and 'rock with patches of sand'. They also have the added complexity of shifts among these broad categories temporally, giving them a potential seasonality not found on the pure shore types. All of this gives mixed shores a unique habitat structure that needs consideration. Mixed shores make up between 22 and 52 percent of the southern African shoreline, with 24 percent of the stretch of coast between the Orange River and Cape Point falling into this habitat classification (Bally et al. 1984). Note that in the 2018 NBA mixed shores in the Namaqualand region are all grouped as a single type.

Species richness on mixed shores has been shown to be greater than that on either pure sand or pure rock shores due to increased habitat complexity and heterogeneity (McQuaid & Dower 1990). The species composition found on the rocky and sandy components of the mixed shore are significantly different from their respective pure habitats. The rocky components are differentiated by species with higher tolerance to sand distribution in the forms of inundation, clogging, and abrasion. Mean grain size does not drive the differences in species composition in mixed sand and pure sand habitats; rather, the rocks interfere with migrating sandy beach macrofauna through the swash climate (Brown et al. 1991). Mixed shore communities have a high diversity of detritivores, primary producers and herbivores. Secondary consumers, like small carnivores, are highly opportunistic. Molluscs are the most diverse taxonomic group, followed by algae, then crustaceans, polychaetes and then other groups. Biomass of mixed shore habitats in southern Africa are dominated by filter feeders, mainly mussels (Smith et al. 1999).

Mixed shores in the Boegoebaai area were not sampled directly as part of this study but are expected to support species found on both the sandy beaches and the rocky shores. They are expected to follow the same pattern of dominant groups as that found by Smith et al. (1999) in False Bay.

2.2.6.4 Nearshore surf zone habitats

Surf zone habitats are located offshore of sandy beaches, extending from the low wark mark out to the back of the breaker zone where they grade into more extensive unconsolidated soft bottom subtidal habitats. Despite its turbulent nature, surf zone habitat is an important nursery and feeding area for a range of marine fish and invertebrate species. Pilot seine netting on four of the intertidal beach sites (three hauls per site) was conducted using a beach-seine net, 30 m long, 2 m deep, with a stretched mesh size of 12 mm (Figure 2-2.31). The seine net catch was used to quantify and characterize the fish population in the surf zone at sites RSS1, ISS2, DSS1, and DSS2 (and Figure 2-2.32).

Three species were caught across the combined sampling sites, namely the southern mullet, *Chelon richardsonii*, elongated sand klipfish, *Cancelloxus longior,* and a horned blenny, *Parablennius cornutus* (Table 2-2.7). The variability in the number of mullet caught among sites and their size differences (Figure 2-2.32) is not an unexpected result, given the life history and behaviour of the species. Sites RSS1 and ISS2 had lower catch rates and higher wave action than sites DSS1 and DSS2. This follows the expected trend in a decline in catch abundance and diversity with increasing wave disturbance (Romer 1990, Clark 1997). Seine net sampling could not be conducted at ISS1 as the intertidal profile and wave energy at this site made it too rough to sample. As previously mentioned, it is likely that the NBA classification of sites RSS1 and ISS1 have been erroneously swapped around - beach ISS1 should be classified as a reflective beach and beach RSS1should be classified as an intermediate sandy shore. This trend of lower density of fish in areas with higher wave action is seen clearly in Saldanha Bay and Langebaan Lagoon, 570 km south of Boegoebaai, where mean density of catches in Big Bay are half of what they are in Small Bay, which are in turn lower than those from Langebaan Lagoon (Clark et al. 2024a).

Figure 2-2.31. Trek net sampling in Boegoebaai.

Table 2-2.7. Abundance (number of fish) of each fish species sampled at Boegoebaai fish sampling sites.

Species	Common name	Site			
		DSS1	DSS2	ISS2	RSS1
Chelon richardsonii	Southern mullet	24	313	0	1
Cancelloxus longior	Elongated sand klipvis	0	1	0	0
Parablennius cornutus	Horned blenny	0	0	0	1

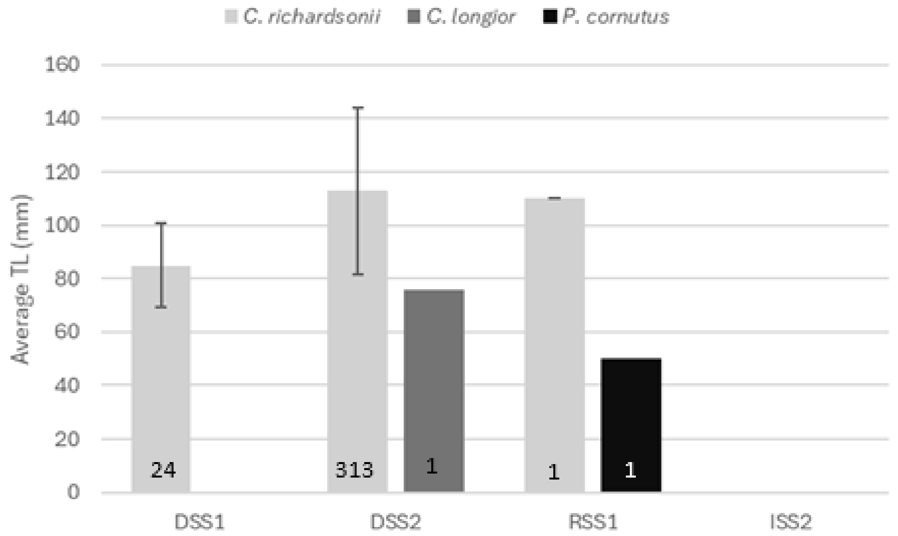


Figure 2-2.32. Average size of fish caught during the October 2024 survey at each of the four surf zone sites (TL = Total Length). Number indicates how many individuals measured at each site. Error bars denote standard deviation.

2.2.6.5 Subtidal unconsolidated substrata

Biological indicators provide an integrated measure of the state/health of the ecosystem across both space and time. Intertidal and subtidal biota are most frequently monitored to detect changes in the health of the marine environment. This is largely because these taxa are relatively short-lived and, as a consequence, their community composition responds rapidly to environmental changes (Warwick 1993). Given that they are also relatively non-mobile (as compared with fish and birds) they tend to be directly affected by development/pollution and they are easy to sample quantitatively (Warwick 1993). Furthermore, they are well-studied compared with other sediment-dwelling components (e.g., meiofauna and microfauna), with taxonomic keys are available for most groups. In addition, intertidal faunal community responses to a number of anthropogenic influences are well documented.

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

Results of a hydrographic survey undertaken by Tritan Survey (Tritan Survey 2018) using an Applied acoustic low frequency "Boomer" suggests that much of the marine subtidal habitat directly offshore of Boegoebaai Point comprises unconsolidated sediments lying on top of bedrock, with a peak thickness of ~6.0 m, an average of 2.5 m and a median of 2.13 m (Figure 2-2.33). This grades into rocky reef around 1 000 m offshore, which is also evident on the bathymetry maps of the same area (Figure 2-2.7).

Fauna that inhabits unconsolidated subtidal areas includes both epifaunal and infaunal organisms. Benthic epifauna refers to fauna that inhabit the surfaces of subtidal sediment, while benthic infauna is those that burrow or dig into the soft sediments (Castro & Huber 1997). The distribution of infauna and the depth at which organisms can live in the substrate is largely dependent on sediment particle size. Coarser, more porous substrates allow for greater water circulation through the sediment, which replenishes oxygen depleted during the decomposition processes.

On the west coast of South Africa, much of the benthic infauna comprises deposit feeders, such as worms, which either ingest sediments to extract organic matter trapped between the grains or actively gather organic detritus (Castro & Huber 1997). Suspension feeders, such as sea pens and some crab species, consume drifting detritus and plankton from the water column, while filter feeders, including bivalves and certain amphipods and polychaetes, actively pump and filter water to capture suspended particles (Castro & Huber 1997). Predators in these soft-bottom habitats either burrow through sediments to hunt prey or ambush prey on the surface (Castro & Huber 1997).

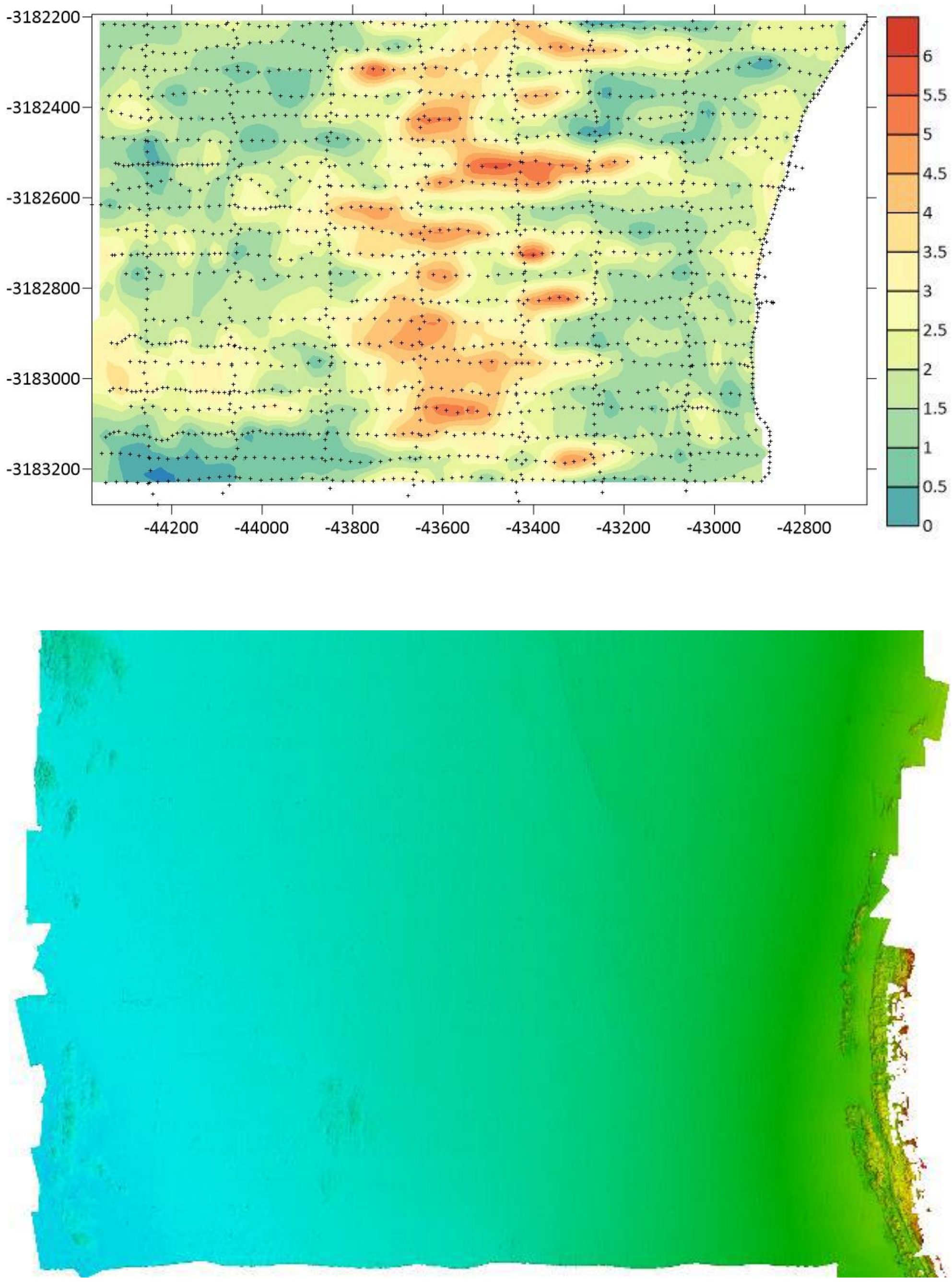


Figure 2-2.33. Sediment thickness (top) and bathymetry (bottom) of the environment offshore of Boegoebaai point. Source: Tritan Survey (2018).

Benthic soft bottom habitats in Boegoebaai, and their associated infauna, remain largely understudied. To provide a comparative context, findings from other offshore benthic studies in the region are considered here (Figure 2-2.34). For example, the benthic macrofaunal communities of St Helena Bay and Saldanha Bay have been intensively studied, with over 150 species recorded (Clark et al. 2023, 2024b). Anchor Environmental Consultants have also collected Van Veen grab samples at greater depths further north and offshore of Boegoebaai, on the continental shelf within the same ecoregion (Duna et al. 2016, Mostert et al. 2016, Tunley 2016) (Figure 2-2.34).

Data from these offshore studies were utilised to infer aspects of subtidal benthic community structure, as no subtidal sampling was undertaken as part of this study. Duna et al. (2016), Mostert et al. (2016), and Tunley (2016) documented a total of 63 benthic macrofauna taxa, with polychaetes dominating the assemblages at 44.4% followed by crustaceans (Class: Malacostraca) at 30.2% (Figure 2-2.35). Numerous species recorded in these offshore studies correspond to those observed in St Helena Bay and Saldanha Bay (Clark et al. 2023, 2024b). Examples of species identified are shown in Figure 2-2.35.

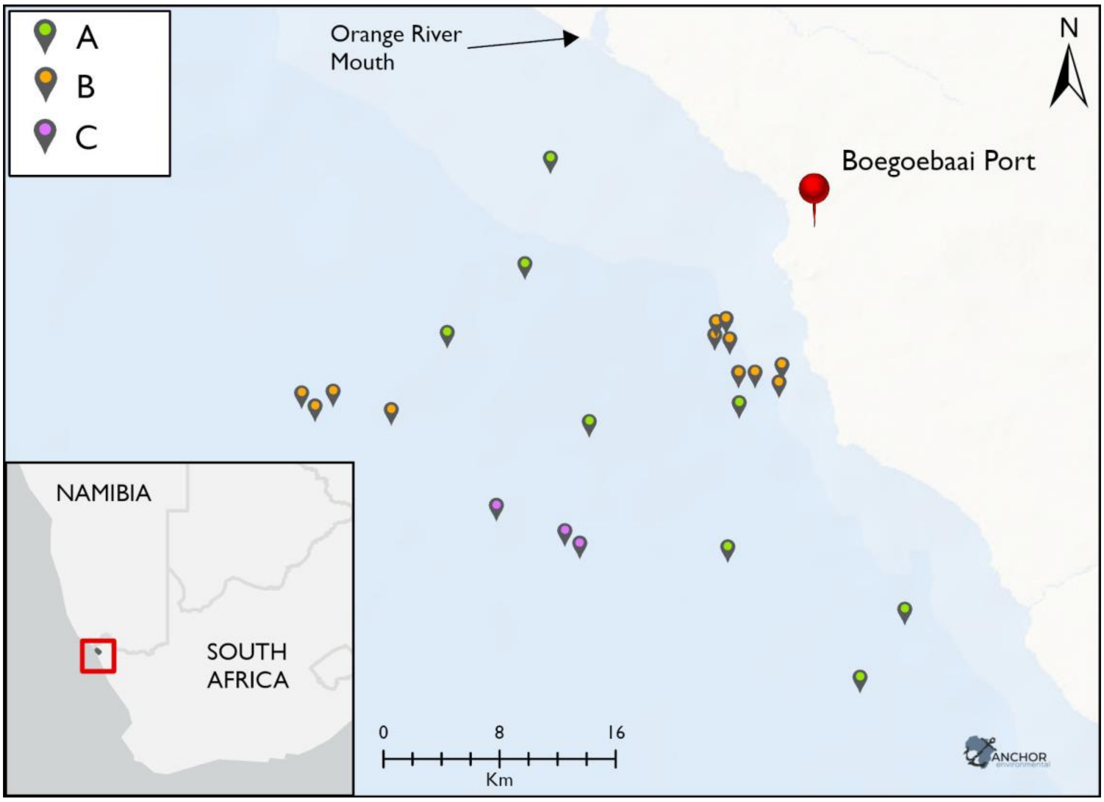


Figure 2-2.34. Sampling locations of subtidal macrofauna surveys offshore along the continental shelf near Boegoebaai. (A) Tunley (2016); (B) Mostert et al. (2016) and C) Duna et al. (2016).

Table 2-2.8. Subtidal macrofauna taxa collected from the Atlantic continental shelf off southern Africa (Duna et al. 2016, Mostert et al. 2016, Tunley 2016).

Class	Order	Family	Taxon	Range
Phylum: Annelida				
Polychaeta	Sipuncula		*Sipunculid* sp.	
	Eunicida	Lumbrineridae	*Lumbrineris heteropoda difficilis*	Southern Africa
			Lumbrineris meteorana	Indo-Atlantic (?)
		Onuphidae	*Diopatra monroi*	Indo-Atlantic (?)
			Diopatra neapolitana	Indo-Atlantic (?)
	Phyllodocida	Glyceridae	*Glycera benguellana*	Indo-Atlantic (?)
			Glycera tridactyla	Cosmopolitan
		Nephtyidae	*Micronephthys sphaerocirrata*	Cosmopolitan
			Nephtys hombergii	Cosmopolitan
		Nereididae	*Nereis*	-
		Pilargidae	*Cabira capensis*	Cosmopolitan (?)
			Sigambra parva	Cosmopolitan (?)
		Polynoidae	*Harmothoe*	-
	Spionida	Spionidae	*Paraprionospio pinnata*	Cosmopolitan
			Prionospio saldanha	Cosmopolitan (?)
			Scolelepis (Parascolelepis) gilchristi	Cosmopolitan
	Terebellida	Ampharetidae	*Ampharete luederitzi*	Indo-Atlantic (?)
			Amphicteis gunneri	Cosmopolitan
		Cirratulidae	*Chaetozone setosa*	Cosmopolitan
			Kirkegaardia dorsobranchialis	Cosmopolitan
		Flabelligeridae	*Brada villosa capensis*	Southern Africa
			Stylarioides swakopianus	Indo-Atlantic (?)
		Pectinariidae	*Amphictene capensis*	Indo-Atlantic (?)
		Trichobranchidae	*Terebellides stroemii*	Cosmopolitan
		Arenicolidae	*Abarenicola affinis africana*	Southern Africa
		Capitellidae	*Mediomastus capensis*	Cosmopolitan
		Cossuridae	*Cossura coasta*	Cosmopolitan
		Magelonidae	*Magelona*	-
		Sabellariidae	Sabellariidae	-
Phylum: Anthozoa				
Octocorallia	Scleralcyonacea	Virgulariidae	*Virgularia schultzei*	Cosmopolitan (?)
Phylum: Arthropoda				
Malacostraca	Amphipoda	Ampeliscidae	*Ampelisca anomala*	Cosmopolitan
Malacostraca	Amphipoda	Ampeliscidae	*Ampelisca spinimana*	Cosmopolitan
		Atylidae	*Nototropis guttatus*	Cosmopolitan
		Liljeborgiidae	*Idunella lindae*	Atlantic (?)
		Oedicerotidae	*Perioculodes pallidus*	Southern Africa
			Westwoodilla manta	Southern Africa
		Photidae	*Latigammaropsis afra*	Cosmopolitan
			Photis longidactyla	Southern Africa

Class	Order	Family	Taxon	Range
		Phoxocephalidae	Phoxocephalidae	-
		Pontogeneiidae	*Paramoera capensis*	Southern Africa
	Cumacea		Cumacea	-
	Decapoda	Axiidae	*Calocaris barnardi*	Atlantic (?)
		Callianassidae	*Callianassa australis*	Atlantic (?)
		Nautilocorystidae	*Nautilocorystes ocellatus*	Atlantic (?)
	Isopoda	Anthuridae	*Amakusanthura africana*	Southern Africa
			Haliophasma	-
		Cirolanidae	*Natatolana hirtipes*	Cosmopolitan
		Idoteidae	*Synidotea hirtipes*	Cosmopolitan
	Stomatopoda	Squillidae	*Pterygosquilla capensis*	Southern Africa (?)
Phylum: Chordata				
Ascidiacea			Ascidian	-
Phylum: Cnidaria				
Hexacorallia	Actiniaria		Actiniaria	-
Phylum: Echinodermata				
Holothuroidea			Holothuroidea	-
Phylum: Mollusca				
Bivalvia	Adapedonta	Pharidae	*Afrophaxas decipiens*	Indo-Atlantic
	Cardiida	Tellinidae	*Macomopsis crawfordi*	Southern Africa
			Moerella tulipa	Indo-Atlantic
	Carditida	Condylocardiidae	*Carditopsis rugosa*	Southern Africa
	Lucinida	Lucinidae	Lucinidae	-
Gastropoda	Cephalaspidea	Philinidae	Philine	-
	Neogastropoda	Volutidae	*Capensisvoluta lutosa*	Atlantic (?)
			Gastropoda	-
Hexacorallia	Actiniaria		Actiniaria	-
Phylum: Nermetea				
			Nemertea	-

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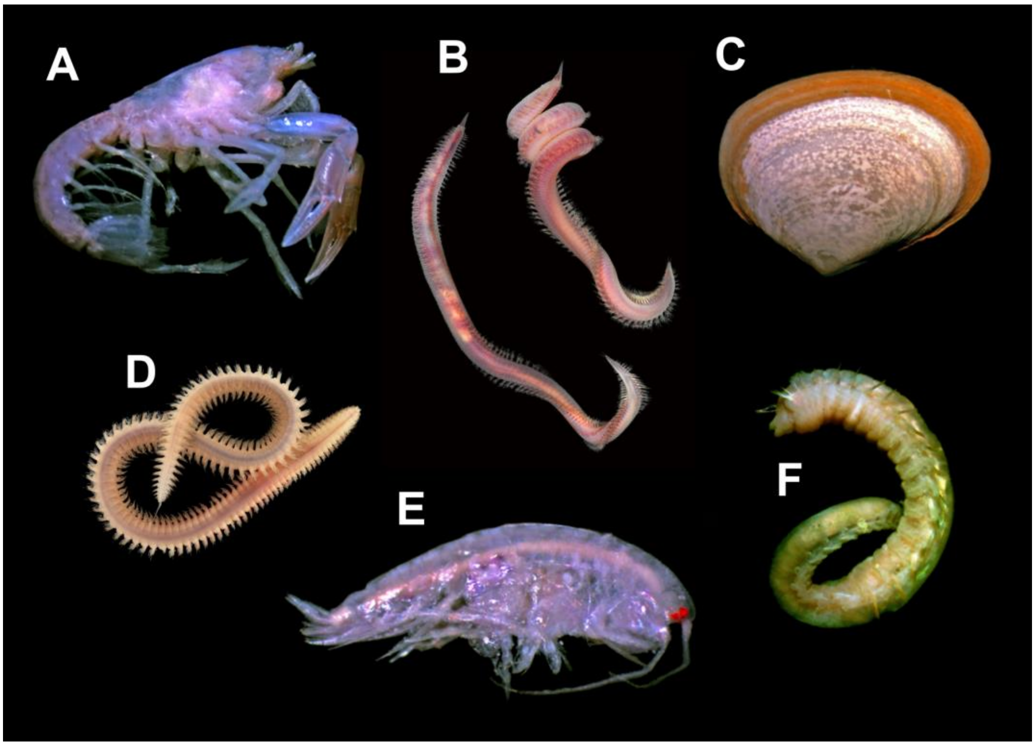

Figure 2-2.35. Examples of subtidal (benthic) infauna found in grab samples from the inner continental shelf off the west coast of South Africa: A – prawn *Calocaris barnardi*; B – glycerine worm *Glycera tridactyla* (Paul Sterry, Nature Photographers); C – bivalve *Macoma* sp.; D – polychaete *Nephtys hombergii* (Fredrik Pleijel); E – amphipod *Ampelisca anomala*; F – cosmopolitan polychaete *Amphicteis gunneri*.

2.2.6.6 Subtidal consolidated substrata

Temperate rocky reefs are found below the low water mark, where they experience disturbances such as wave action and sedimentation from surrounding unconsolidated sediments. Many large predators such as fish and sharks are attracted to rocky reefs and as such represent an important component of these ecosystems (Barros et al. 2001). Reefs also provide a stable substratum for kelp species such as *Ecklonia maxima* and *Laminaria pallida*, which form extensive kelp forests. These forests offer food and shelter to a diverse array of marine organisms. *E. maxima* thrives at depths of up to approximately 12 m, while *L. pallida* extends to depths of about 30 m (Branch et al. 2010). Beneath the kelp canopy, encrusting coralline algae dominate, accompanied by understorey algae species and epiphytic algae growing on the kelp itself (Meyer & Clark, 1999). Filter feeders such as mussels, red bait and sea cucumbers comprise a large part of the faunal community on subtidal rocky reefs (Branch et al. 2010). Grazers include the dominant sea urchin *Parechinus angulosus*, limpets, isopods like. *Paridotea reticulata* and amphipods such as *Ampithoe humeralis* (Branch & Branch 2018b).

Rocky shore and shallow subtidal reef habitats near Boegoebaai are classified as vulnerable by the 2018 NBA (Sink et al. 2019a). While photographic reef surveys using underwater video cameras were not conducted in Boegoebaai, other ecological reef surveys conducted by Anchor Environmental Consultants at study sites further south, within the same ecoregion, (Hutchings et al. 2023, 2024, Biccard et al. 2024, Hutchings & Schmidt 2024) were used to characterise these habitats.

Reef surveys south of Boegoebaai were conducted in the subtidal areas of Kleinsee (~120 km away), Hondeklip Bay (~185 km away), Doringbaai (380 km away) and Saldanha Bay (~570 km away). These habitats primarily consisted of kelp forests interspersed with large boulders and rocky outcrops resting on substrates of fine to gravelly sand (Figure 2-2.36 and Figure 2-2.37). Dominant species observed included whelks, limpets, sea anemones, and the black mussel species *Choromytilus meridionalis*. (Figure 2-2.37). Red algae (*Rhodymenia* sp., *Gigartina* sp., and *Champia* sp.) and encrusting coralline algae (*Mesophyllum engelhartii*) were commonly found among these reefs (Figure 2-2.36 and Figure 2-2.37). Other species recorded included Cape rock crabs, chitons, reticulated starfish, barnacles, and sea cucumbers.

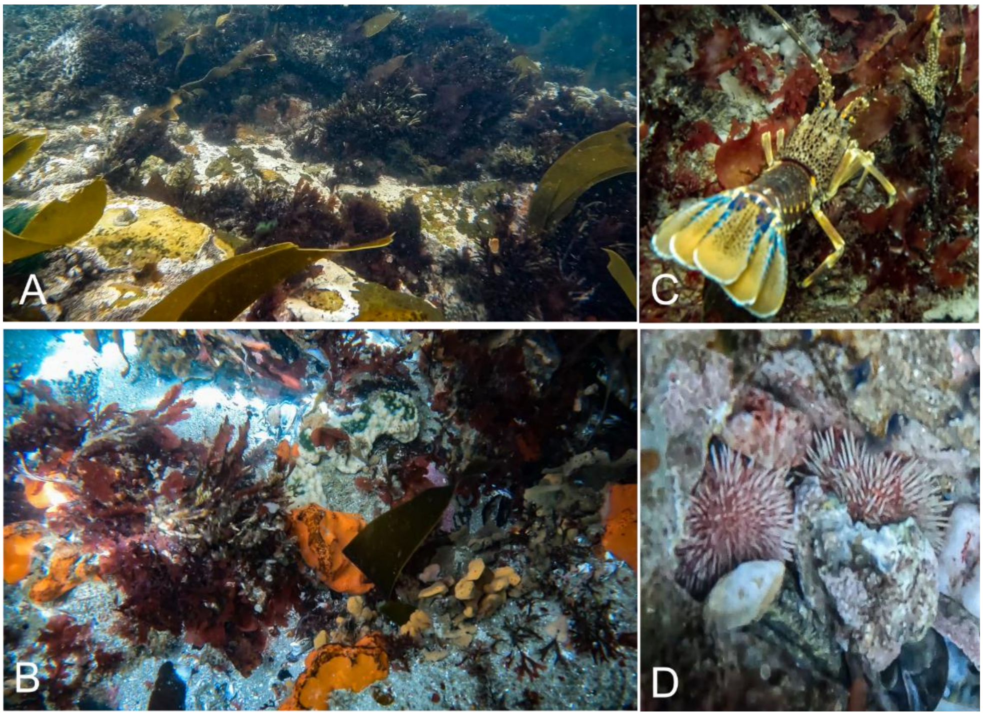

Figure 2-2.36. An overview of: (A) the shallow subtidal reef habitat in Kleinsee, (B) subtidal sediment composition of fine to gravelly sand among large boulders, (C) West Coast rock lobster, *Jasus lalandii*, observed among red algae, and (D) common sea urchin, *Parechinus angulosus.*

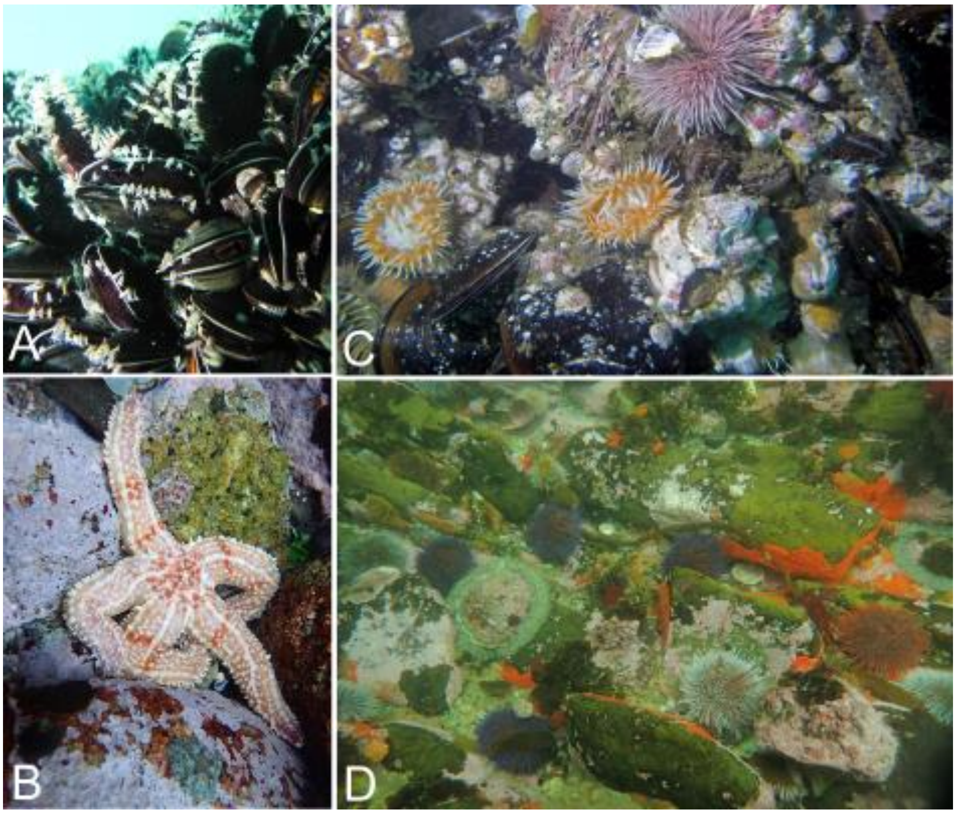

Figure 2-2.37. An example of (A) the invasive Mediterranean mussel *Mytilus galloprovincialis*, (B) a spiny starfish *Marthasterias africanus*; an overview of (C) and (D) the shallow reef habitat hosting the common sea urchin, sea anemones, barnacles and the black mussel *Choromytilus meridionalis* from Robben Island.

2.2.6.7 Sea birds

A total of 72 water birds has been recorded in the Boegoebaai study area according to the South African Bird Atlas Project (SABAP2) database, which is a citizen science project based at the University of Cape Town funded by the FitzPatrick Institute of African Ornithology and the South African National Biodiversity Institute and supported by BirdLife South Africa and BirdLasser. Data are collected by volunteers on a monthly basis across southern Africa (South Africa, eSwatini, Lesotho, Namibia, Zimbabwe, Zambia, Botswana, Mozambique, Malawi).

SABAP2 uses a grid system to divide the region into smaller survey areas. The region is divided into a grid of 5-minute by 5-minute cells of latitude and longitude, known as pentads. Each pentad covers an area of approximately 8 x 7.6 km. Each quarter-degree grid cell (QDGC) is a larger unit that measures 15 minutes by 15 minutes of latitude and longitude. There are nine pentads within each QDGC1. The numbering of pentads is based on their position within the QDGC. The coordinates of the top-left corner of the pentad are used to identify it. For example, if the top-left corner of a pentad is at 25°00'S, 30°00'E, this coordinate is used to name the pentad. When entering data, the latitude and longitude of the pentad's top-left corner are entered into the SABAP2 system, which then calculates the correct pentad and its corresponding QDGC. This system ensures that bird observations are systematically recorded and can be accurately mapped and analyzed.

Counts have been undertaken in a total of four pentads in the study area (Figure 2-2.38), with the most counts (89) undertaken in the northmost pentad (2835_1625) and lower numbers (11-23) in the other three, (Table 2-2.9).

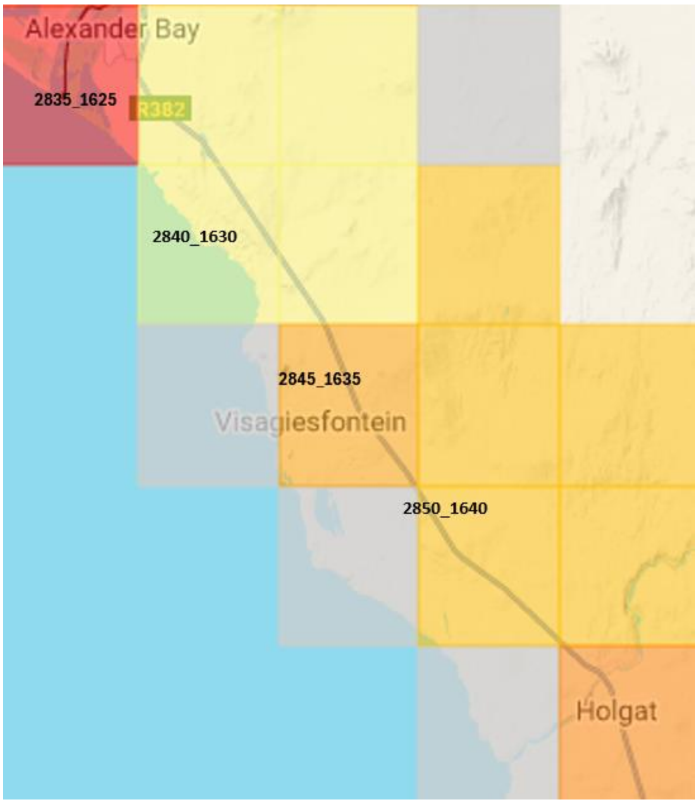

Figure 2-2.38. SABAP pentads in the Boegoebaai study area. Pentads for which count data exist are numbered.

The northmost pentad includes the Orange River estuary which is outside the study area and explains the disproportionately high numbers of birds recorded here (1696) relative to the other pentads (10-115). Pentads with the smallest section of coast (2845-1635 and 2850-1640) support few waterbirds (10 and 29, respectively). Only 20 truly "marine" or "coastal" species have been recorded in the area (species names underlined in Table 2-2.9). The presence of the remaining species can be attributed to the presence of the Orange River estuary and artificial water bodies (such as mining ponds) in and adjacent to the study area. Maritz (2020) lists birds associated with mining ponds in southern Namibia. Seventeen waterbird species were recorded during the site visit that was conducted as part of this study (highlighted in bold in Table 2-2.9). No truly pelagic seabird species were recorded in the SABAP2 counts or those done for this study; but this is not surprising given these birds seldom venture very close in shore and the counts were all done on land.

A significant proportion of South African seabird species are currently classified as threatened by the International Union for the Conservation of Nature (IUCN). This includes five species of coastal seabirds (20%) and 15 pelagic seabird species (25%) (BirdLife South Africa 2024). Many anthropogenic activities and uses of the marine environment (including those likely to be associated with the development of a new port and SEZ at Boegoebaai pose a serious threat to these already threatened seabirds. This includes resource competition between seabirds and fishing fleets for the same prey resources (Sydeman et al. 2017), bycatch of seabirds in fishing gear (Dias et al. 2019), noise and oil pollution (Crawford et al. 2000, Wolfaardt et al. 2009, Pichegru et al. 2017) etc. Brief notes on these species are included below, specifically referencing the importance of the Boegoebaai study area for these species.

Table 2-2.9. Waterbirds species recorded in four SABAP pentads (2835-1625, 2840-1630, 2845-1635 and 2850-1640) in the Boegoebaai area. Species names for the truly "coastal" and "marine" species are underlined while those that were recorded during field surveys undertaken as part of this study are highlighted in bold.

Common name	Species	2835-1625	2840-1630	2845-1635	2850-1640	Total
Black-necked Grebe	***Podiceps nigricollis***	8		1	2	11
Little Grebe	*Tachybaptus ruficollis*	27				27
Great White Pelican	*Pelecanus onocrotalus*	48				48
Cape Gannet	*Morus capensis*	1				1
White-breasted Cormorant	*Phalacrocorax lucidus*	59	2			61
Cape Cormorant	*Phalacrocorax capensis*	40	102			142
Bank Cormorant	*Phalacrocorax neglectus*	2				2
Reed Cormorant	*Microcarbo africanus*	30				30
Crowned Cormorant	*Microcarbo coronatus*	9				9
African Darter	*Anhinga rufa*	18				18
Grey Heron	*Ardea cinerea*	52	1	1		54
Goliath Heron	*Ardea goliath*	2				2
Purple Heron	*Ardea purpurea*	16				16
Great Egret	*Ardea alba*	9			25	34
Little Egret	*Egretta garzetta*	59				59
Intermediate Egret	*Ardea intermedia*	3				3
Western Cattle Egret	*Bubulcus ibis*	27				27
Black Heron	*Egretta ardesiaca*	2				2
Little Bittern	*Ixobrychus minutus*	1				1
Black-crowned Night Heron	*Nycticorax nycticorax*	7				7
Hamerkop	*Scopus umbretta*	2				2
White Stork	*Ciconia ciconia*	2				2
African Sacred Ibis	***Threskiornis aethiopicus***	18				18

Common name	Species	2835-1625	2840-1630	2845-1635	2850-1640	Total
African Spoonbill	*Platalea alba*	45				45
Greater Flamingo	*Phoenicopterus roseus*	65		1		66
Lesser Flamingo	***Phoeniconaias minor***	57				57
Spur-winged Goose	*Plectropterus gambensis*	15				15
Egyptian Goose	***Alopochen aegyptiaca***	40				40
South African Shelduck	*Tadorna cana*	53			1	54
Cape Shoveler	*Anas smithii*	31				31
African Black Duck	*Anas sparsa*	1				1
Yellow-billed Duck	*Anas undulata*	29				29
Red-billed Teal	***Anas erythrorhyncha***	14				14
Cape Teal	*Anas capensis*	65		3		68
African Fish Eagle	*Haliaeetus vocifer*	24				24
Western Osprey	*Pandion haliaetus*	5				5
African Crake	*Crex egregia*	1				1
African Swamphen	*Porphyrio madagascariensis*	8				8
Common Moorhen	*Gallinula chloropus*	23				23
African Jacana	*Actophilornis africanus*	2				2
African Oystercatcher	*Haematopus moquini*	23	3			26
Ruddy Turnstone	*Arenaria interpres*	7				7
Common Ringed Plover	*Charadrius hiaticula*	24				24
White-fronted Plover	***Charadrius marginatus***	44				44
Chestnut-banded Plover	*Charadrius pallidus*	13				13
Kittlitz's Plover	*Charadrius pecuarius*	22				22
Three-banded Plover	*Charadrius tricollaris*	27				27
Grey Plover	*Pluvialis squatarola*	18				18
Blacksmith Lapwing	*Vanellus armatus*	35				35
Curlew Sandpiper	*Calidris ferruginea*	21				21
Little Stint	*Calidris minuta*	29				29
Sanderling	*Calidris alba*	7				7
Ruff	*Calidris pugnax*	22				22
Common Sandpiper	***Actitis hypoleucos***	8				8
Marsh Sandpiper	*Tringa stagnatilis*	4				4
Common Greenshank	*Tringa nebularia*	37				37
Wood Sandpiper	*Tringa glareola*	6				6
Bar-tailed Godwit	*Limosa lapponica*	6				6
Eurasian Curlew	*Numenius arquata*	2				2
Eurasian Whimbrel	*Numenius phaeopus*	10	1			11

Common name	Species	2835-1625	2840-1630	2845-1635	2850-1640	Total
Pied Avocet	*Recurvirostra avosetta*	58		1		59
Black-winged Stilt	***Himantopus himantopus***	31		1		32
Kelp Gull	***Larus dominicanus***	78	3			81
Grey-headed Gull	*Chroicocephalus cirrocephalus*	9				9
Hartlaub's Gull	***Chroicocephalus hartlaubii***	69	2			71
Caspian Tern	*Hydroprogne caspia*	50				50
Common Tern	*Sterna hirundo*	23				23
Sandwich Tern	*Thalasseus sandvicensis*	33		1		34
Greater Crested Tern	***Thalasseus bergii***	37	1	1		39
Little Tern	*Sternula albifrons*	2				2
Damara Tern	*Sternula balaenarum*	20			1	21
White-winged Tern	*Chlidonias leucopterus*	1				1
Total		**1696**	**115**	**10**	**29**	**1850**
No. counts (2007-2024)		**89**	**11**	**21**	**23**	

Cape Gannets, *Morus capensis*, are endemic to southern Africa and breed on only six islands off South Africa and Namibia. This species is included as “Vulnerable” on the IUCN red list. There were an estimated 78 800 breeding pairs present in the late 1970s (Crawford et al. 1983), but this increased to around 106 500 by 2014 (Crawford et al. 2015a). According to the South African Bird Atlas Project (SABAP) data this species Is not commonly found in the study area (Figure 2-2.39).

The Cape Cormorant *Phalacrocorax capensis* is endemic to southern Africa, breeding at 69 localities between Namibia and the Eastern Cape Province (Cooper et al. 1982). This species is listed as “Endangered” on the IUCN red list (IUCN 2025). All of the main breeding colonies lie in the western and eastern Cape Provinces and therefore do not overlap with the study area (Cook 2015b). There were approximately 106 500 breeding pairs in 1982, but this decreased to an estimated 65 800 by 2014 (Crawford et al. 2015b). The Cape Cormorant is generally strictly a marine species, breeding on offshore island and rocks and cliffs and on artificial structures on the coastline. The main breeding season for birds off the west coast is September to February. According to the SABAP data, this species is moderately abundant in the study area (Figure 2-2.39).

The Bank Cormorant *Phalacrocorax neglectus* is a marine species endemic to southern Africa. Its range extends from Walvis Bay to Cape Agulhas, broadly following the beds of *Ecklonia maxima* kelp. This species is considered “Endangered” (IUCN 2025). While these were an estimated 1 500 breeding pairs of birds at 44 breeding localities in the 1980’s this has declined to around 800 pairs (Cooper 1981, Crawford et al. 1999, 2015a). This species is moderately common in the study area (Figure 2-2.39 and Figure 2-2.40).

The White Breasted Cormorant, *Phalacrocorax lucidus*, is found in Europe, eastern North America, northwest Africa, and most of sub-Saharan Africa. The species frequents dams, impoundments, rivers and inshore coastal areas, and breeds colonially at predator free localities such as offshore islands, cliff ledges, rock stacks, and man-made structures (Berruti 1980, Brooke et al. 1982b). The portion of the population breeding along the coast is estimated at around 1700 pairs (up from 1100 in the 1980s) (Brooke et al. 1982a, Crawford et al. 2015b). This species is present in moderate to high numbers in the study area, and is known to breed on the coast in this area (Figure 2-2.39 and Figure 2-2.40). The species is listed as “Least Concern” (IUCN 2025).

The Crowned Cormorant *Phalacrocorax coronatus* is endemic to southern Africa and breeds at 48 localities between Walvis Bay and Cape Agulhas in a variety of habitats, including rocky cliffs, ledges, stacks, caves, boulders, and trees (Crawford et al. 1982b). .It is a coastal species and is seldom found more than 10 km offshore (Siegfried et al. 1975). The size of the breeding population was estimated at 1 700 pairs in the late 1970s and in 2014 had risen to around 1 900 pairs (Crawford et al. 2015b). This species is moderately abundant in the study area and is listed as “Least Concern” (Figure 2-2.39) (IUCN 2025).

Swift Terns (also named Greater Crested Tern) *Thalasseus bergii* are widely distributed across the southern hemisphere in the south-east Atlantic, the Indian and Pacific Oceans. The nominate subspecies S*. b. bergii* is endemic to southern Africa. The southern African population is actually increasing in abundance up from around 4 700 pairs in 1984 to 10 1000 in 2013 (Cooper et al. 1990, Crawford et al. 2014). Swift terns occur in moderate to low numbers in the study area (Figure 2-2.39). The majority of their population breeds at islands between Saldanha Bay and Cape Town and is listed as “Least Concern” (IUCN 2025) (Crawford & Dyer 1995, IUCN 2025).

Kelp Gulls *Larus dominicanus* are widely distributed in the southern hemisphere from South America to New Zealand and is listed as “Least Concern” (Croxall 1984, IUCN 2025). The subspecies *L. d. vetula* is endemic to southern Africa and has been recorded breeding at 79 localities between Angola and the eastern Cape (Brooke & Cooper 1979, Bridgeford 1982, Crawford et al. 1982a). The southern African population numbers around 17 400 individuals (Whittington et al. 2016a). Kelp gulls nest colonially in a wide variety of marine habitats including cliffs, rock stacks, small islets and sand banks in estuaries, salt works and sewage works, and on larger islands in lagoons and offshore (Crawford et al. 1982). There are colonies present on the Orange River estuary and on the islands to the south of Boegoebaai but none in the study area itself (Whittington et al. 2016b).

The African Black Oystercatcher *Haematopus moquini* forages exclusively in the intertidal zone and they can be found on both rocky and sandy shores throughout the year along the Benguela coast. The species is listed as ‘Least Concern” by the IUCN (IUCN 2025). Its favoured breeding habitats including offshore islands and sandy beaches, and on mainland rocky shores (Biccard & Clark 2014b). The birds build their nests just above the high-water mark (usually within 30 m). It is likely that breeding pairs will occur on this stretch of coastline and will likely be present on site between December and February each year (Biccard & Clark 2014b). This species is present in low numbers in the study area (Figure 2-2.39).

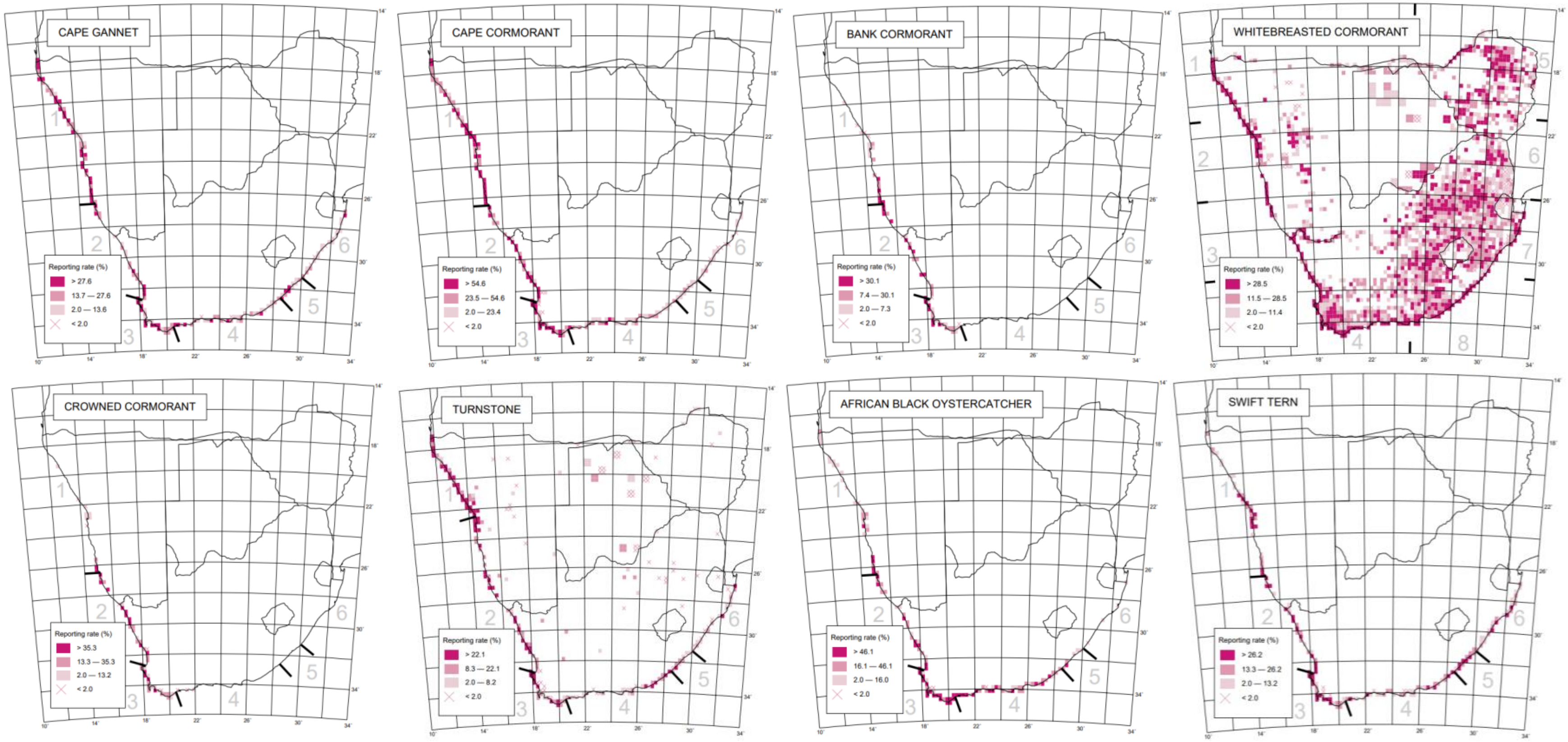

Figure 2-2.39. Distribution maps of Cape gannet, Cape, Bank, White breasted and Crowned cormorants, African black oystercatcher, turnstone and Swift tern. Source: https://sabap2.birdmap.africa/.

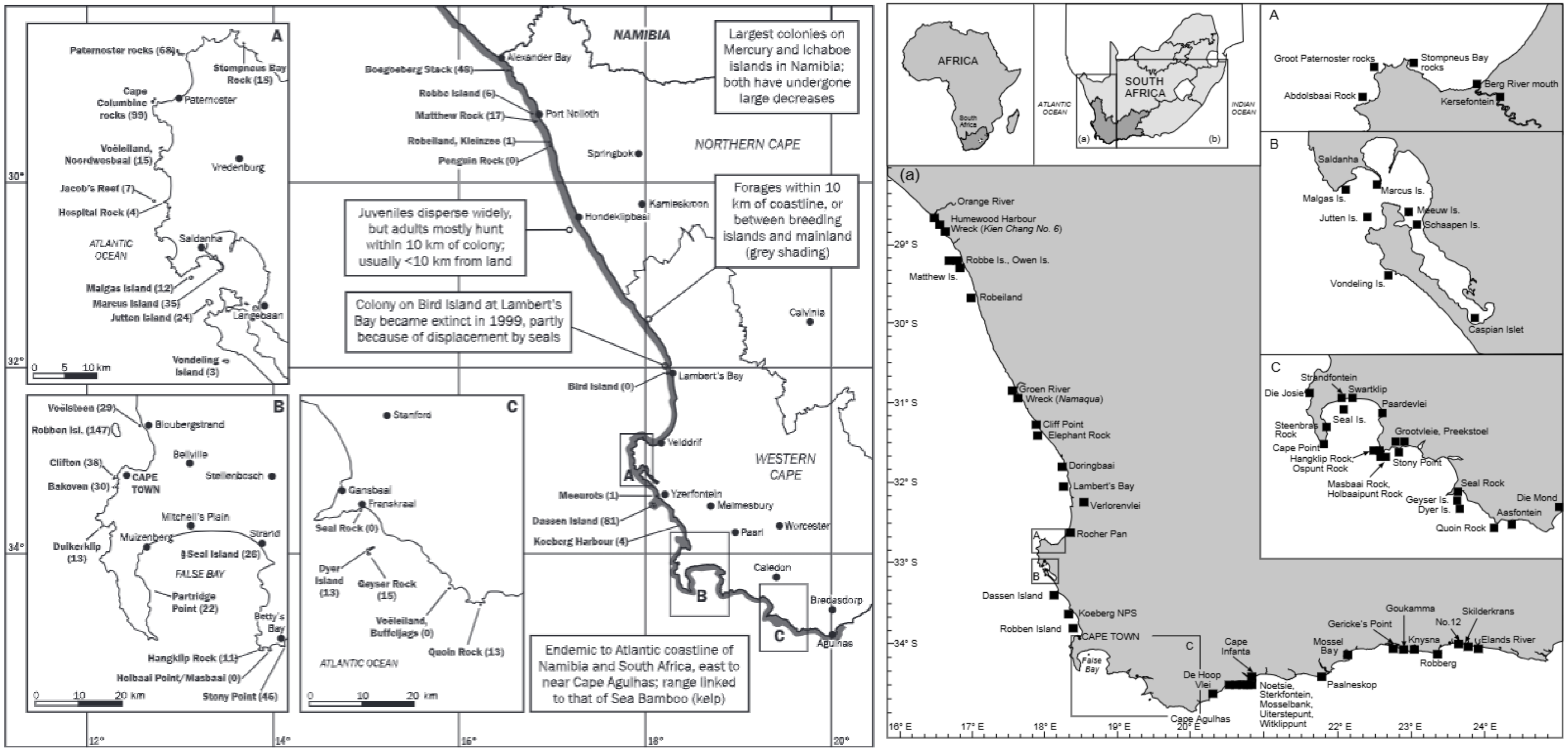

Figure 2-2.40. (Left) Current and historic breeding sites for Bank Cormorant *Phalacrocorax neglectus*. Note that this includes the Boegoeberg Stack at the site of the proposed Boegoebaai port (Cook 2015a). (Right) Locations of known coastal and some adjacent inland breeding localities of white-breasted cormorants in western South Africa (Crawford et al. 2013).

The White fronted plover *Charadrius marginatus* has an extremely large range and global population in excess of 80 000 individuals (Wetlands International 2023). Adults of coastal populations in southern and eastern Africa are sedentary, although they often move from exposed to sheltered shores in the winter, while others are migratory (Urban et al. 1986b, del Hoyo et al. 1996b, Hockey et al. 2005b). This species shows a preference for sandy seashores and coastal dunes but is often found on rocky shores, coastal and inland mudflats, salt-pans, estuaries (Urban et al. 1986a, del Hoyo et al. 1996a). White fronted plovers nest on the shore on dunes, sandbars, and occasionally in quarries, typically more than 70 m above the high-water mark (Urban et al. 1986a, del Hoyo et al. 1996a, Watson et al. 1997, Hockey et al. 2005a). This "Least Concern" species is present in low numbers in the study area (IUCN 2025).

Ruddy turnstone *Arenaria interpres* is a circumpolar breeder in artic tundra. Several nominate races exist, with the central Siberian population migrating through the Mediterranean and Black Sea to southern Africa. This population comprises of around 34 000 individuals (Summers et al. 1977a). While in southern Africa, these birds mostly inhabit sheltered rocky shores and mixed rock and sandy shores (Summers et al. 1977b, Underhill & Whitelaw 1977, Underhill et al. 1980). This species is present in moderate to low numbers in the study area (Figure 2-2.40) and is included as "Least Concern" on the IUCN red list.

Birdlife South Africa (2024) have made an attempt to collate available tracking data for threatened seabirds which occur within the South African Exclusive Economic Zone (EEZ) in an effort to identify areas of the marine environment that are important for these species. They have delineated marine Important Bird Areas and utilization distributions from tracking data for three Endangered coastal seabird species (African Penguin, Cape Gannet and Cape Cormorant) that breed in various colonies in South Africa and a further five pelagic seabird species (Indian Yellow-nosed [Endangered], Atlantic Yellow-nosed [Endangered] and Wandering [Vulnerable] albatrosses and Northern Giant Petrel [Least Concern]) breeding in colonies on islands within the Southern Ocean but that regularly occur within the South African EEZ. For species for which there is no available tracking data, or for which tracking data is only available for a limited number of colonies, buffers of the species' known foraging ranges were created.

Based on the results of this study, no overlap was evident between identified Marine Important Bird Areas (MIBAs) and important distribution areas for certain seabird species. This applies to threatened coastal seabird species breeding in South Africa for which good tracking data was available. However, there is some overlap between buffers of 30 and 20 km (for Cape and Bank Cormorants respectively) placed around each species' known breeding colonies (Figure 2-2.41) and also with raw tracks from non-breeding adult Cape Gannets tracked from Malgas Island (Saldanha Bay) and Bird Island (Algoa Bay), and juvenile Cape Gannets tracked from Bird Island (Figure 2-2.42).

Similarly, there is some overlap between foraging areas for incubating Atlantic Yellow-Nosed Albatrosses from Gough Island and Nightingale in the Southern Ocean (Figure 2-2.43).

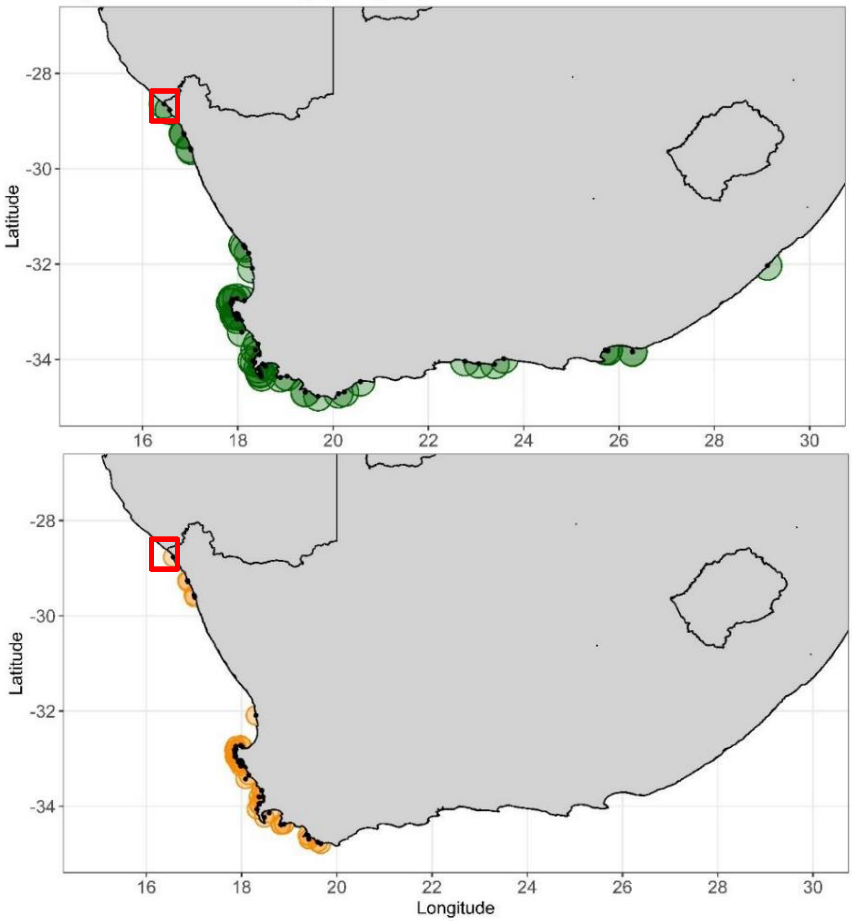

Figure 2-2.41. Buffers of 20 km around known Cape Cormorant (top) and Bank Cormorant (bottom) breeding colonies. The Boegoebaai study area is indicated by a red arrow on the map. Source: Birdlife South Africa (2024).

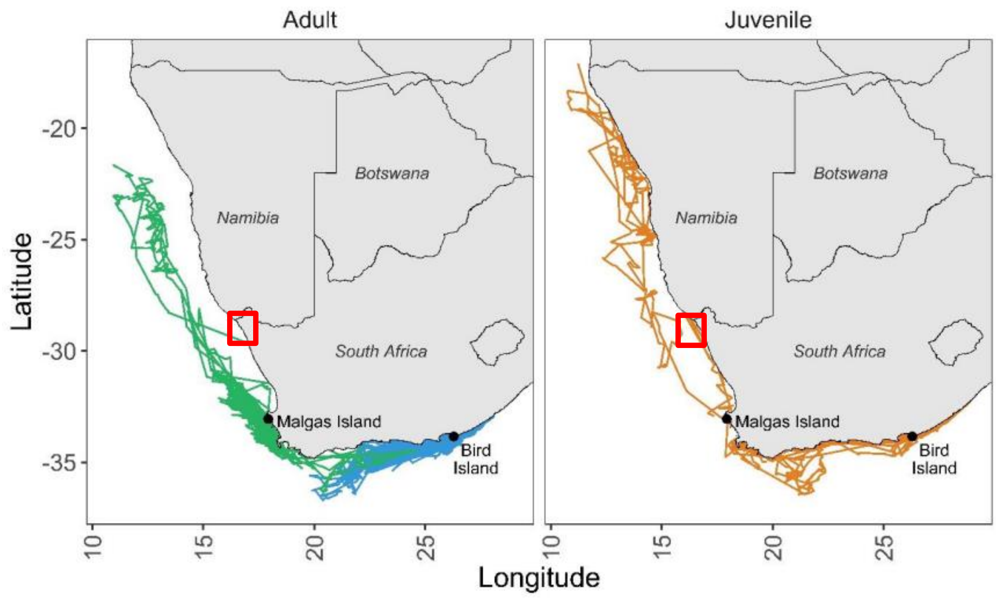

Figure 2-2.42. Raw tracks from non-breeding adult Cape Gannets (left panel) tracked from Malgas Island (Saldanha Bay, green tracks) and Bird Island (Algoa Bay, blue tracks) in South Africa, and juvenile Cape Gannets tracked from Bird Island in Algoa Bay (orange tracks in right panel). Source: Birdlife South Africa (2024).

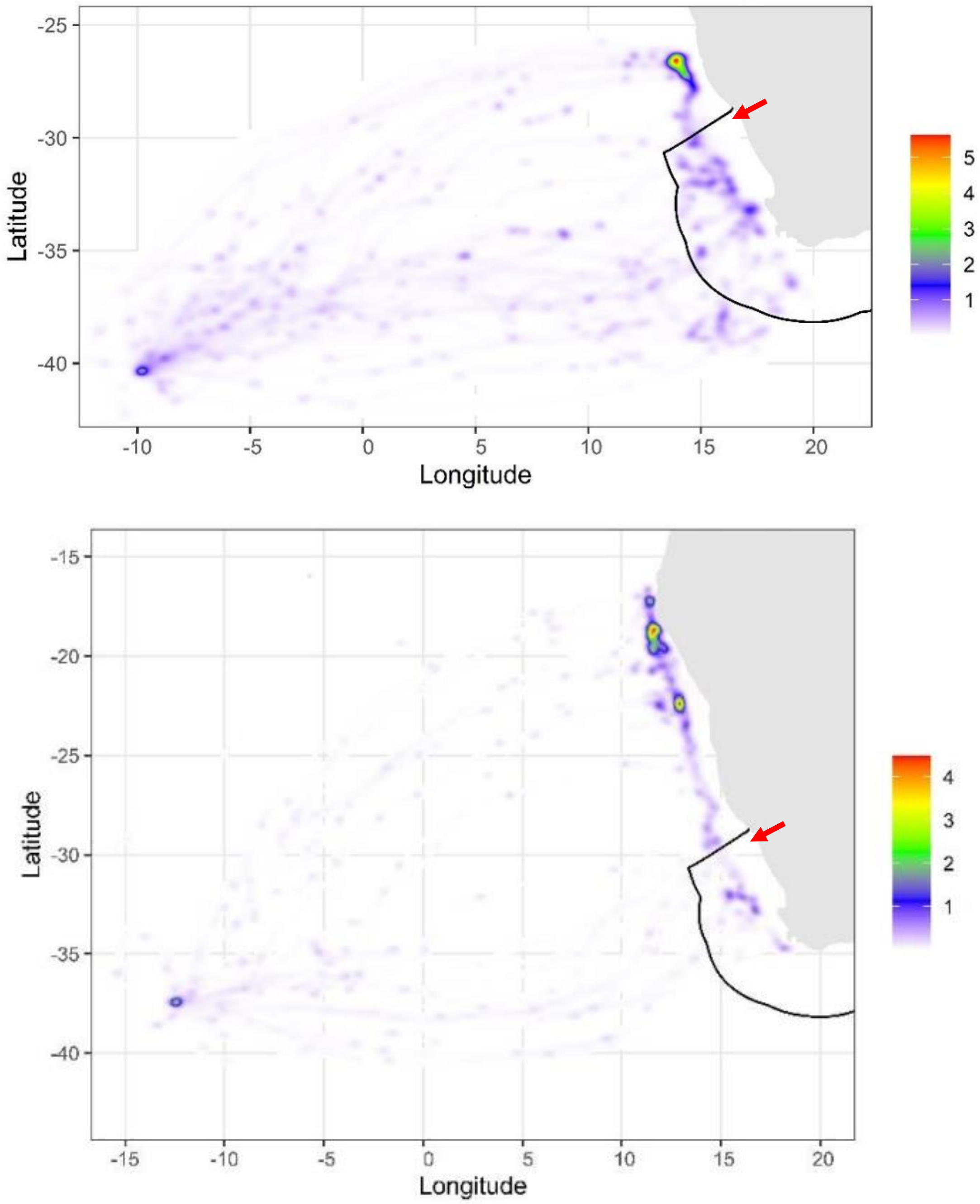

Figure 2-2.43. Utilization distribution of incubating Atlantic Yellow-Nosed Albatrosses from Gough Island (top) and Nightingale Island (bottom), Southern Ocean. The two islands are located in the bottom left corner of each image. The Boegoebaai study area is indicated by a red arrow on the map. Source: Birdlife South Africa (2024).

2.2.6.8 Marine mammals

This remote and relatively undisturbed area is part of the Benguela Current ecosystem supports a rich diversity of marine life, including several species of marine mammals. Thirty-six marine mammals may occur in the study area (Meyer & Clark 1999, Penney et al. 2007, Child et al. 2016, Biccard et al. 2018, Pulfrich 2021, SLR 2021).

The Cape fur seal, *Arctocephalus pusillus* (listed as 'least concern' by the IUCN) is the only pinniped mammal that has established breeding colonies in southern Africa. Its range extends from the centre of Angola to the east coast of South Africa, with breeding colonies extending south from Baia dos Tigres on the southern border of Angola, through Namibia, down the west coast of South Africa and around to Algoa Bay in the Eastern Cape of South Africa (Figure 2-2.45). Historically (before 1900), it is likely that seals were present on most (if not all) islands off South Africa and Namibia, where they prefer to breed as they are protected from mainland predators. However, populations on many of the islands were significantly depleted or disappeared completely as a result of uncontrolled hunting, and human occupation of the islands for the collection of guano and other seabird related products (Kemper et al. 2003). Subsequent to the ban on seal hunting, the Cape fur seal population recovered, showing an almost 20-fold growth in numbers in the 20th century before stabilizing at about two million animals (Kemper et al. 2003). In addition, the number of breeding colonies have increased since 1970 from 23 to 40 colonies (Kirkman et al. 2013). The overall population count has reportedly remained largely unchanged since 1993 and is estimated at 1.5–2.0 million, however, the distribution of these seals has been shown to vary in relation to prey distribution and shortages (Kemper et al. 2003, Kirkman et al. 2013, 2019).

The northern-most colony in South Africa is at Buchu Twins (28°45.57 S, 16°33.78 E), and was formerly a non-breeding colony but has recently attained breeding status (Kirkman 2010, EIMS 2021) with seals utilising a ~1 km stretch of exposed rocky coastline within the proposed port development area (Figure 2-2.45 and Figure 2-2.46). The coastline at Buchu Twins/Boegoebaai Point is unique in comparison to surrounding areas in that it consists of high-profile rocky outcrops/cliffs that offer pools and shaded refugia (Figure 2-2.46) for seals as well as a certain degree of protection from land-based predators. Habitat associated with thermoregulation (e.g. shade or pools) may be more important to fur seals in southern Africa, which breed at lower latitudes and are at greater risk of overheating on land than other populations (Stevens & Boness 2003). These factors may explain why seals have selected this area to establish a breeding colony. The colony numbers at this site are increasing (mean rate of change (± SE) 1991–2008 0.1412 ± 0.1674, see Kirkman 2010), but in comparison with other Cape Fur seal breeding sites around South Africa, seal numbers are relatively low (n = 107, aerial pup counts, (Kirkman et al. 2007).

In South Africa, seals are protected under the Sea Birds and Seals Protection Act 1973. Specifically, the Cape fur seal, which is one of the most common seal species found along the South African coastline, is protected under this legislation. The seals are protected against hunting, harassment, and disturbance in their natural habitats. Additionally, South Africa is a signatory to international agreements and conventions aimed at protecting marine life, including seals. These include agreements such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Convention for the Protection of the Marine Environment and Coastal Area of the South-East Atlantic (the Benguela Current Convention), which further support the protection of seals and other marine species in South Africa's waters.

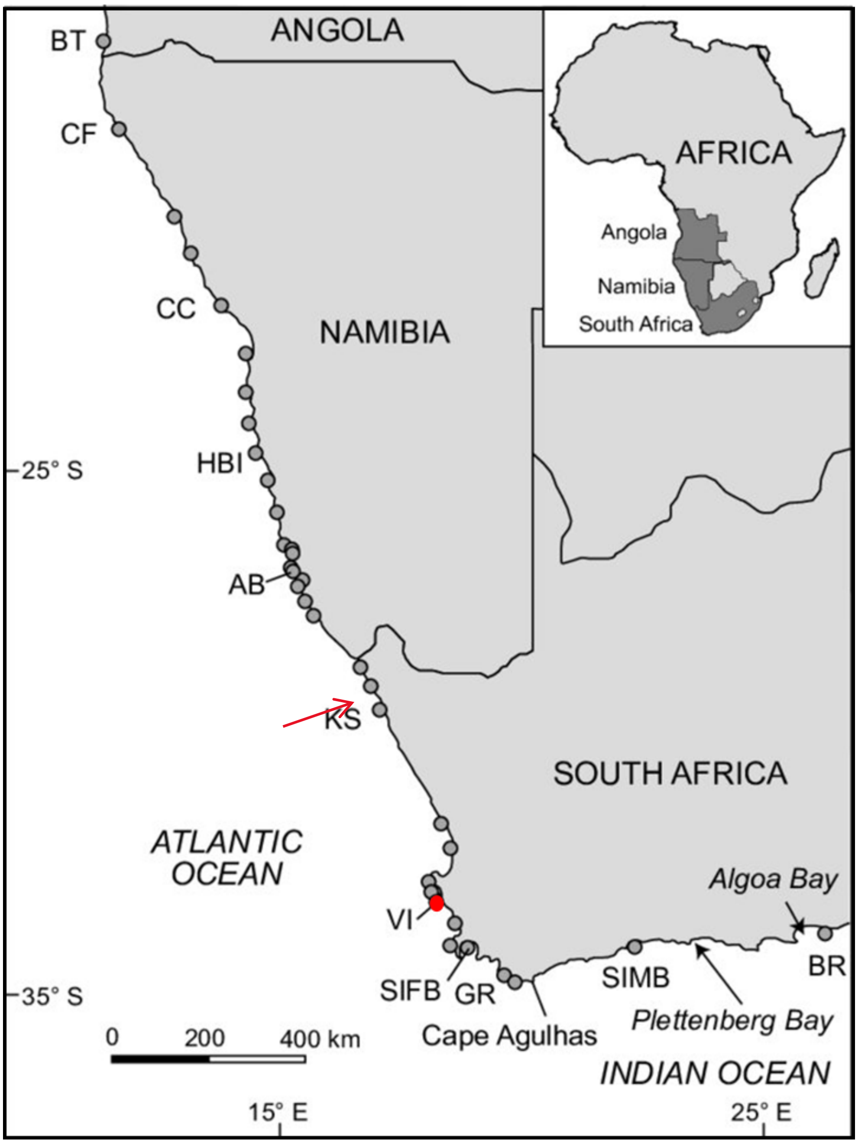

Figure 2-2.44. Distribution of Cape fur seal breeding colonies of Southern Africa from Black Rocks (BR), Algoa Bay to Baia dos Tigres (BT), southern Angola, with selected breeding colonies indicated including Seal Island in Mossel Bay (SIMB), Geyser Rock (GR), Seal Island in False Bay (SIFB), Vondeling Island (VI), Kleinsee (KS), Atlas Bay (AB), Hollam's Bird Island (HBI), Cape Cross (CC) and Cape Frio (CF). The red arrow indicates the location of the Buchu Twins colony within the proposed port development area - adapted from Huisamen et al. (2011).

The marine mammal cetacean fauna occurring off this part of southern African coast includes several species of baleen whales, toothed whales, beaked whales, dolphins. The most abundant baleen whales in the Benguela are humpback whales (*Megaptera novaeangliae*) and southern right whales (*Eubalaena australis*). During the last decade, the prevalence of both species on the West Coast of South Africa outside of the usual June-November whale season has increased with feeding behaviour observed in upwelling zones off Kommetjie, Saldanha and St Helena Bay (Mate et al. 2011, Barendse et al. 2011, Findlay et al. 2017) . Increasing numbers of summer records of both species from the southern half of Namibia suggest that animals may also be feeding in the Lüderitz upwelling cell (NDP unpublished data) and could therefore pass through the area of interest (Pulfrich 2021). Southern Right whales come annually from sub-Antarctic regions to calve off the western coast of Africa during the months of June to November, often very close to shore. Humpback whales may be sighted during the months of October and November as they migrate south from their breeding grounds in tropical West Africa to their feeding grounds in the Antarctic. Over the last decade, large supergroups (20-200 individuals) of feeding humpback whales have frequented the West Coast during spring and summer (Findlay et al. 2017). Schools of over 1 000 common dolphins *Delphinus delphis* and dusky dolphins *Lagenorhynchus obscurus* have been known to occur in the area surrounding the site, as have the endemic Heaviside's dolphins

Cephalorhynchus heavisidii. Impacts of the proposed development on cetaceans that utilise this area are likely to arise from increased vessel traffic i.e., noise and the associated increase in risk of ship-strikes.

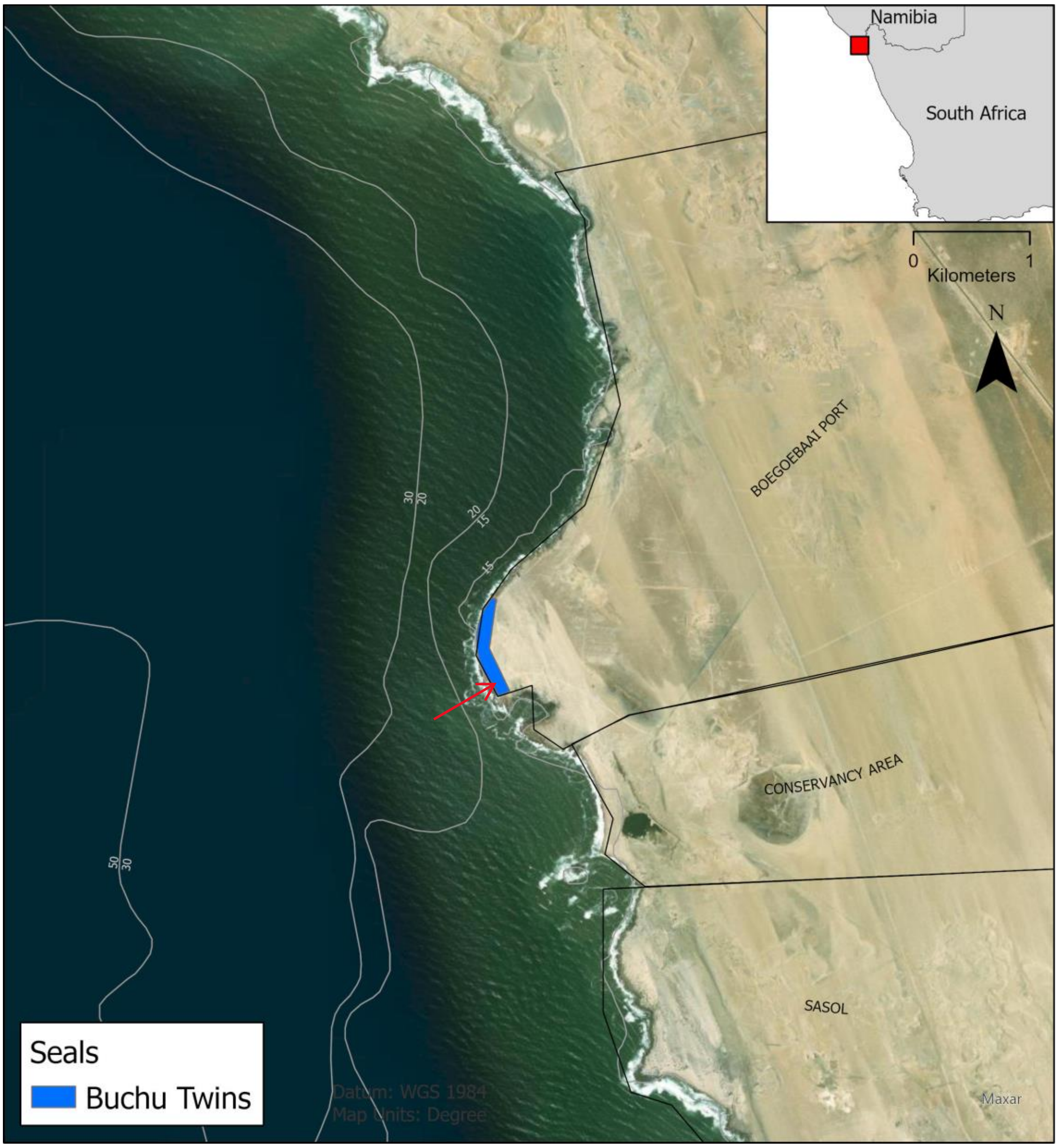

Figure 2-2.45. Known Cape fur seal, *Arctocephalus pusillus*, breeding colony location (Buchu Twins – indicated by red arrow) within the proposed project area (Kirkman et al. 2016).

Figure 2-2.46. This figure demonstrates the ~ 1 km extent of the Cape Fur Seal colony at Buchu Twins and the unique high-profile rocky structure at this site offering shaded refugia for the seals – a rarity on this coast. The figure inset is a zoomed-in view with black arrows indicating groups of seals that have hauled-out. Source: Google Earth.

2.2.7 Fisheries

The Namaqua upwelling cell is characterised by nutrient rich water, as is much of the West Coast of South Africa (Monteiro & Roychoudhury 2005). Due to this enrichment, the western coast is generally a productive system that supports a high biomass of marine biota and several important fisheries. However, the more exposed coast of the Northern Cape is less protected from weather conditions and is more uniform in respect to its coastline, with few protected bays. As a result, this coast is less retentive and generally considered less productive, compared to St Helena Bay, for example. The Northern Cape is also sparsely populated which contributes to large commercial fisheries not being as prevalent in this area.

Brief descriptions of the different types of fishing activity that are practiced in the vicinity of Boegoebaai are provide below, largely drawn from descriptions provided by the 2018 NBA (Sink et al. 2019a).

2.2.7.1 Demersal trawling

Demersal trawling means the trawl is dragged on the seafloor, with the 'ground' gear, consisting of the trawl doors, bridles and net (especially the groundrope) making contact with the sediments and fauna living there. South Africa has both an inshore and an offshore demersal trawl sector targeting hake and other fish species. The inshore trawl fishery operates on the south coast only, not on the west coast. The offshore trawl sector operates predominantly between 230 m and 630 m. Drag durations tend to range from 1 to 6 hours (median=3 hours) and towing speeds from 3 to 4 knots. The effort distribution for these inshore and offshore demersal trawling sectors is shown on Figure 2-2.47 below. Trawling intensity offshore of Boegoebaai is relatively low and mostly practiced more than 50 km offshore and, hence, very unlikely to be affected by the development.

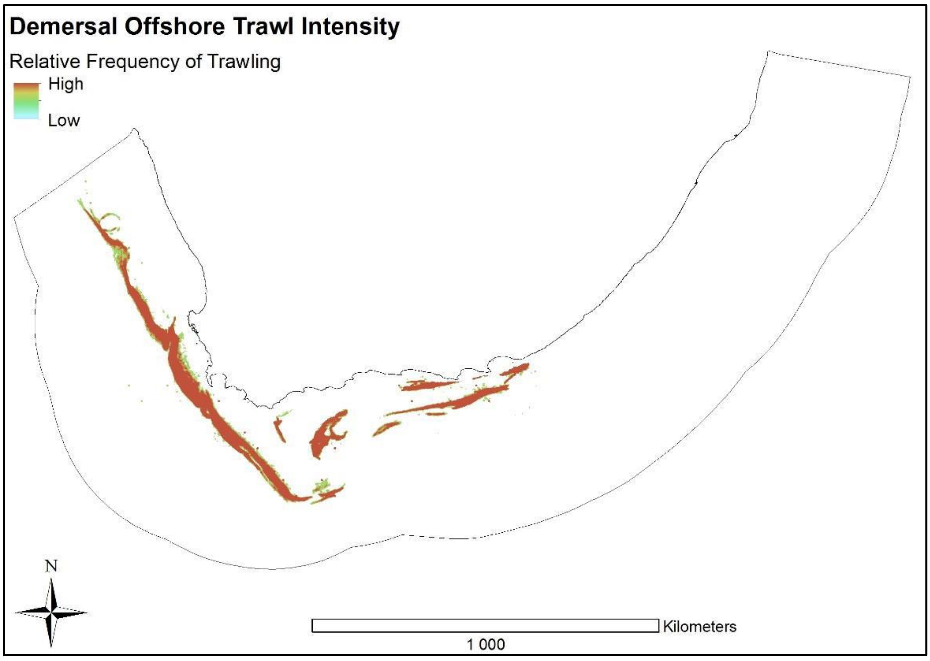

Figure 2-2.47. Demersal trawl fishing intensity off the coast of South Africa (Sink et al. 2019a).

2.2.7.2 Demersal longline

In South Africa, demersal longlines are typically set on rocky substrate, adjacent to demersal trawling grounds (Badenhorst 1988a). The demersal longline gear is composed of a mainline or groundline which forms the branching point of shorter lines called gangions or snoods, to which baited hooks are attached (Stevenson et al. 2004a, Dietrich & Fitzgerald 2010a). Surface floats are attached to the ends of vertical droplines or anchor lines which connect to the mainline (Dietrich & Fitzgerald 2010b). The mainline lies on the seafloor or may be weighed down with anchors at regular intervals in the presence of strong currents, which is the method employed in the South African fishery (Badenhorst 1988b). The mainline is generally long, ranging anywhere from 1 to 40 km (Stevenson et al. 2004b). The South African demersal longline fishery targets deep sea hake and employs the Spanish double-longline system whereby a top and bottom line is set between the anchor lines, and the number of hooks deployed can vary between 6 000-7 000 for smaller vessels and 9 000-14 000 hooks for longer vessels (Japp 1989). Lines are generally 30 km in length and are deployed around depths of 200-400 m (Fairweather et al. 2006, Petersen 2008). Deployment of longlines takes place at night and they are recovered by hauling during the day (Petersen 2008). Demersal longline fishing effort is concentrated off the southwestern Cape and southern Cape coastlines (Figure 2-2.48). Effort in the region of Boegoebaai is relatively low and is almost entirely located more than 50 km offshore and, hence, very unlikely to be affected by the development.

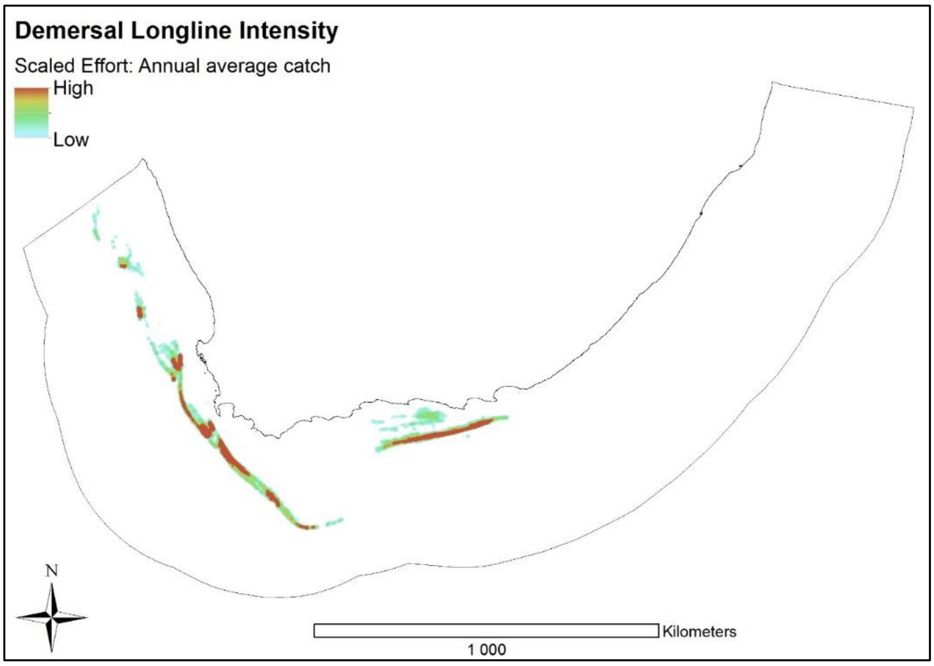

Figure 2-2.48. Demersal longline fishing intensity off the coast of South Africa (Sink et al. 2019a).

2.2.7.3 Pelagic longline

The pelagic longline fishery in South Africa uses gear similar to that of the demersal sector; the main differences being that in the pelagic sector, longlines consist of a double-line system suspended at different depths covered in baited hooks that do not touch the seafloor, as they have small buoys and float lines to suspend the gear below the surface (Watson & Kerstetter 2006). The pelagic longline fishery targets large, highly mobile species including Bigeye Tuna *Thunnus obesus*, Yellowfin Tuna *Thunnus albacares*, Bluefin Tuna *Thunnus thynnus* and Swordfish *Xiphias gladius*. Albacore Tuna *Thunnus alalunga*, Blue Shark *Prionace glauca* and Shortfin Mako Shark *Isurus oxyrinchus* (DAFF 2016). Management of these highly migratory species is the responsibility of Regional Fisheries Management Organisations (RFMOs). South Africa is a member of three tuna directed RFMOs namely the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT). Pelagic longline fishing activity is distributed right around the South African coast with peaks off the Orange River (Boegoebaai), the southwestern Cape and southern Cape coastlines and KwaZulu Natal (Figure 2-2.49). Fishing activity off Boegoebaai is restricted to areas more than 100 km from the coast and will not be affected by the development.

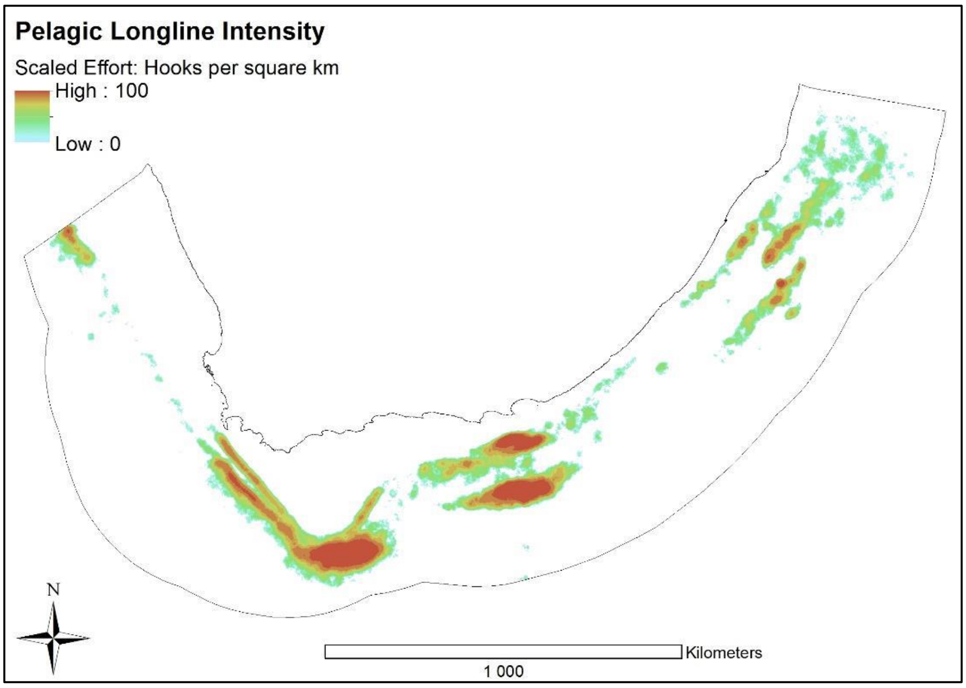

Figure 2-2.49. Pelagic longline fishing intensity off the coast of South Africa (Sink et al. 2019a).

2.2.7.4 Tuna pole

The South African Tuna Pole-Linefishery uses pole fishing gear or rod-and-reel (DAFF 2016); the latter being similar to the fishing gear used by the commercial linefishery. Rod and reel gear is typically used to target yellowfin tuna and pole gear used to target Albacore (Atkinson & Sink 2008, DAFF 2016). Pole fishing gear consists of a hooked line (usually a barbless hook with a feathered jig) attached to a rigid pole of 2-3 m. Boats use bait and/or water-spraying to aggregate fish (spray gives the illusion of activity from a shoal of small fish). Once the target species has aggregated, pole fishing is conducted by casting feathered jigs into the water and hauling them back a few seconds later. Once a tuna lands on the vessel's deck, it releases itself from the barbless hook and the line can be thrown again, leading to several tonnes of tuna being fished in a few hours. Smaller vessels make short trips of 5-7 days and have a specialised crew of 8-10 fishermen equipped with long poles and gaffs (long poles with hooks), while larger vessels with crew of 20 or more are capable of fishing further from port and operate along the entire west coast (Norman et al. 2018). The Tuna Pole-Line fishery operates out of Cape Town and Saldanha Bay and is strongly focussed around the southwestern Cape with boats seldom fishing as far north as Boegoebaai (Figure 2-2.50) and never sufficiently nearshore for the development to influence the fishery.

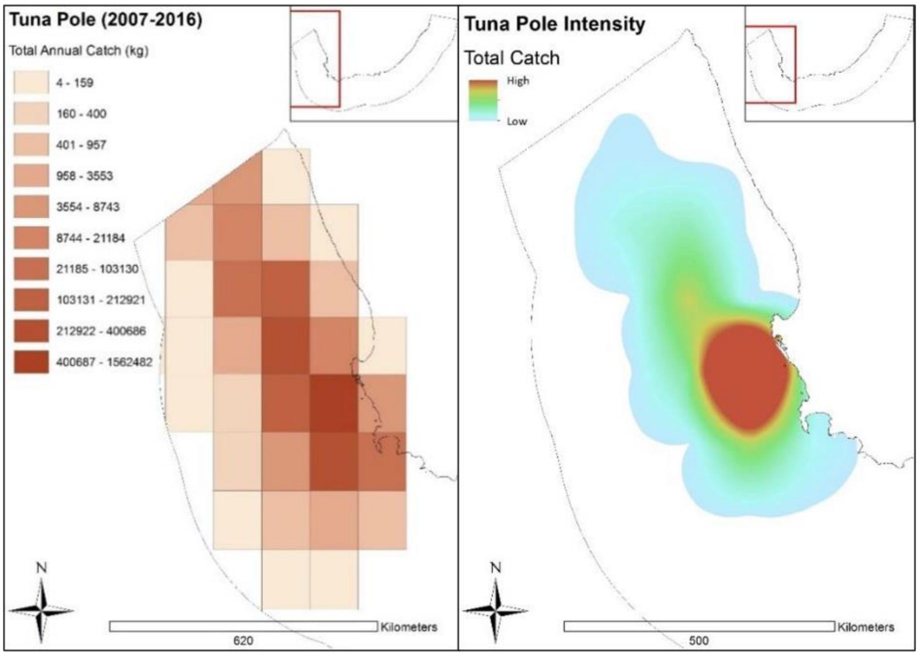

Figure 2-2.50. Tuna pole fishing intensity using annual average catch on a one-degree grid (left), and the scaled tuna pole intensity (right) (Sink et al. 2019a).

2.2.7.5 Small pelagics

South Africa's small pelagic fishery catches the largest catch volume of all of the fishery sectors and constitutes the second largest catch value, second only to the hake trawl fishery (DAFF 2016). This fishery targets adult sardine *Sardinops sagax*, juvenile Anchovy *Engraulis encrasicolus* and adult redeye round herring *Etrumeus whiteheadi* using purse-seine nets. Purse-seine fishing consists of rapidly sinking a wall of netting around a group of fish, then closing the bottom edge with purse strings and finally hauling the catch aboard the vessel (He & Wardle 1986). Purse seine nets are deployed once a shoal of fish has been detected, and a smaller vessel is launched to deploy the net and encircle the shoal. The current fleet operating in this fishery consists of 101 vessels with landings ranging between approximately 200 000 and 600 000 tonnes from 2000 to 2016 (Norman et al. 2018). The small pelagic purse-seine fishery focusses mostly between Lamberts Bay and Gansbaai, with smaller pockets of effort off Mossel Bay and Port Elizabeth (Figure 2-2.52) and East London, mostly in nearshore waters (within 10 km of the coast). There is very little fishing effort offshore of Boegoebaai.

Several west coast nursery grounds that are utilised by small pelagic fish species including sardine, *Sardinops sagax*, horse mackerel, *Trachurus capensis* and anchovy, *Engraulis capensis,* including one near Boegoebaai (centred around Port Nolloth, Northern Cape) (Hutchings et al. 2002) (Figure 2-2.52). The western coast nursery areas extend along much of the West Coast shelf and are bookended by the Cape Columbine upwelling cell in the south and the Lüderitz upwelling cell in the north (Hutchings et al. 2002). Spawning of anchovy and sardines mostly takes place during the spring and summer months with recruits reaching the west coast via general north-westerly drift of Agulhas Bank surface waters and a coastal jet current off Cape Point and Cape Columbine. Models of egg and larval dispersal estimate that most recruits would reach the western coast within 1-3 weeks of spawning i.e., December to May would see the greatest abundance of juvenile small pelagic fish within nursery grounds (Hutchings et al. 2002, Rasehlomi et al. 2024).

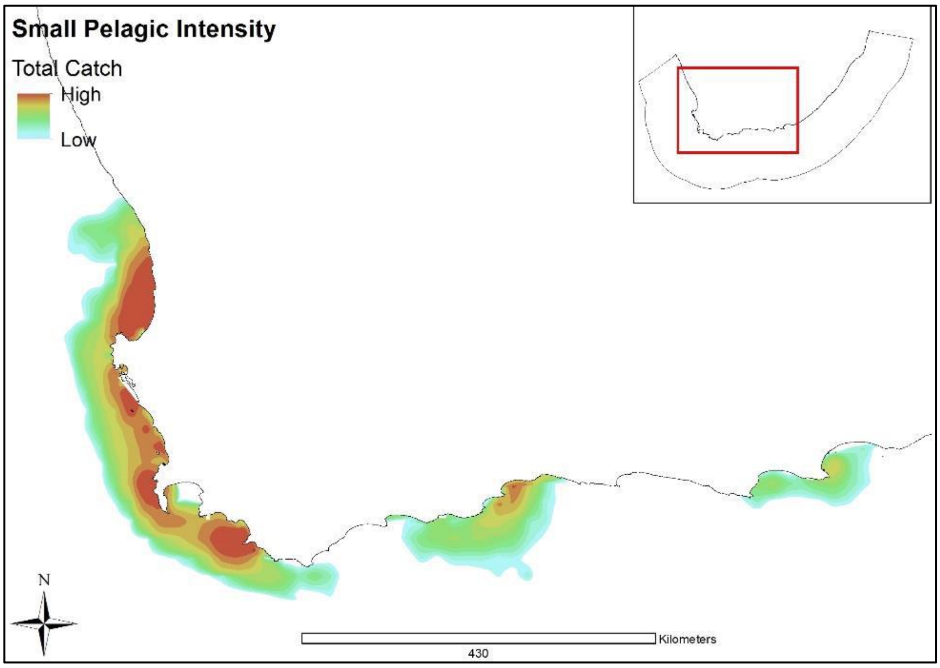

Figure 2-2.51. Small pelagic fishing intensity off the coast of South Africa (Sink et al. 2019a).

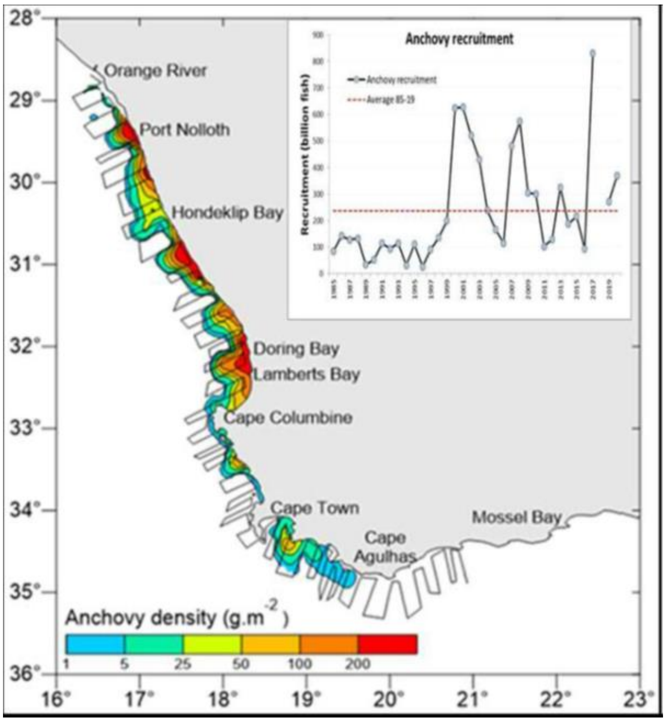

Figure 2-2.52. Recruitment survey results (May 2020) for anchovy and recruitment trend (inset). The red dotted line is the running average level of recruitment since 1985 (information and figure provided by J. Coetzee and D. Merkel of DFFE).

2.2.7.6 West coast rock lobster

The West Coast Rock Lobster (WCRL) fishery targets the temperate or cold-water rock lobster *Jasus lalandii.* It South Africa's most valuable crustacean fishery. This is due to the high market value of the resource (more than R 260 million per year) and provides jobs for more than 4 200 people (DAFF 2016). Two major fishing sectors harvest this resource; the offshore trap vessels operating in waters up to 100 m depth, and the inshore sector that utilises hoop nets to harvest WCRL in shallow water up to 1 nautical mile from the shore (Sink et al. 2019a). Hoop nets (also known as fyke, barrel or fiddler nets) are tubular shaped nets with a series of tapered hoops spaced along the length of the net to keep it open. The net is laid out and the bait is placed in the closed or tail end of the net, relying on lobsters to enter voluntarily and becoming trapped inside. Traps can be shaped as tubes or boxes that are set out and left to soak for a period of time and also rely on lobsters being lured by bait and becoming trapped inside. The near-shore resource is also harvested by recreational fishers and the informal small-scale subsistence fishers (Cockcroft & Mackenzie 1997) (DAFF 2016). The majority of the catch is apportioned to the offshore sector (80%) with a smaller portion (20%) being landed by the inshore sector (DAFF 2016). The fishing grounds extend from Quoin Point in the east up to Hondeklipbaai in the west but do not extend up into the Boegoebaai area, so there is no overlap with the proposed development.

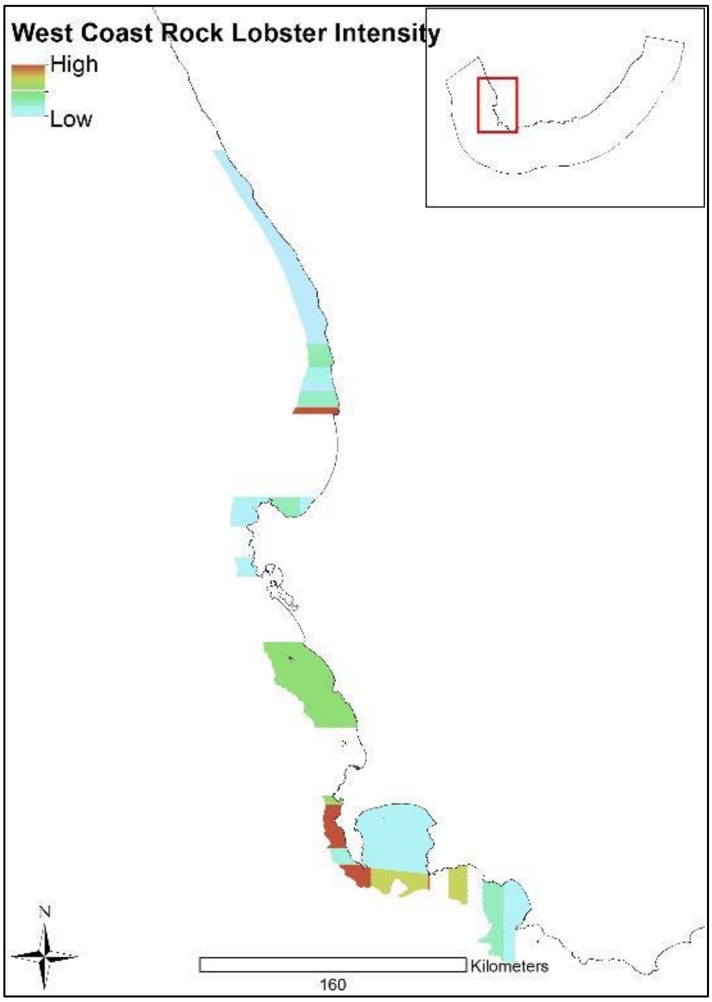

Figure 2-2.53. Fishing intensity for west coast rock lobster (Sink et al. 2019a).

2.2.7.7 Linefish

Linefishing is defined as the capture of fish with hook and line, and has a long history in South Africa dating as far back as the 1500s (DAFF 2016). Approximately 250 species have been reported in catches for this sector, although only 35 species make up the majority of catches. Vessels involved in the linefishery in South Africa range from 6-8 m ski-boats capable of surf-launching, to harbour-based freezer vessels (generally longer than 20 m) that can remain at sea for more than 2 weeks at a time (Mann 2013). The commercial linefishery has the largest fleet but its catches make up only 6% of the total value of all commercial marine fisheries (DAFF 2016). Linefishing effort in South Africa is concentrated between Lamberts Bay on the west coast through to East London on the South coast and also in KZN (Figure 2-2.54). Very little if any commercial linefishing effort is undertaken offshore of Boegoebaai (Figure 2-2.54).

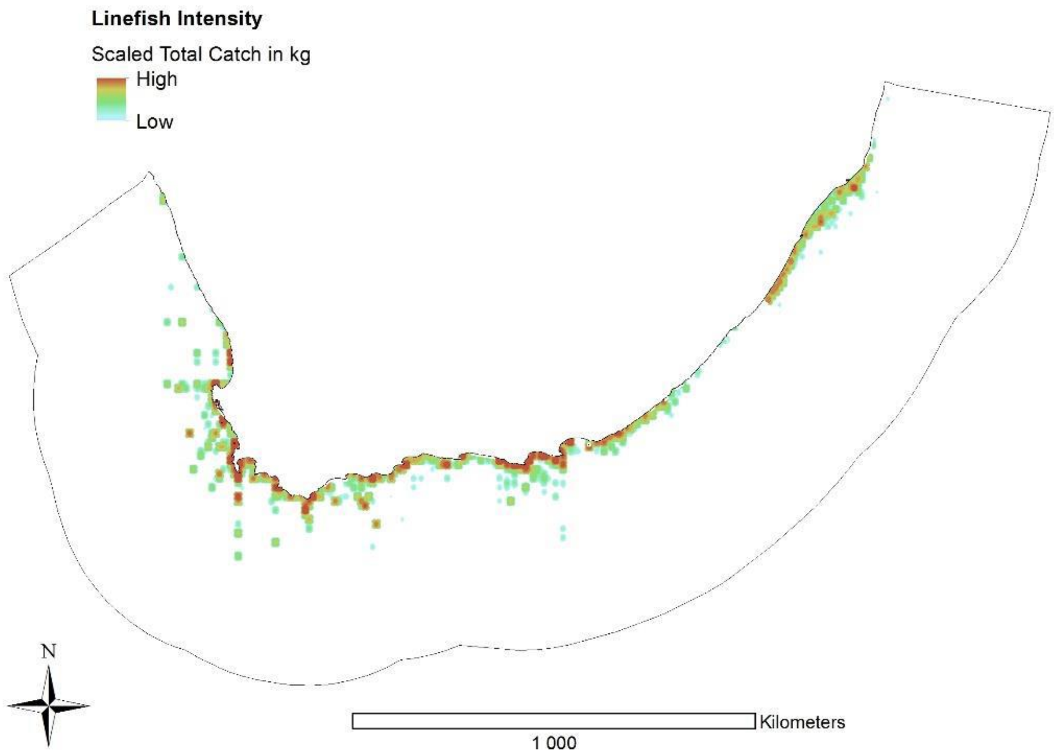

Figure 2-2.54. Commercial linefishing intensity South Africa for period 2000-2016 (Sink et al. 2019a).

2.2.7.8 Abalone

Abalone, *Haliotis midae,* is a slow-growing mollusc and highly prized seafood delicacy both in South Africa and the Far East. Abalone are harvested by divers and pried from rocks using a blade. Abalone harvesting permits strictly forbid the use of scuba gear and no more than 3 bags are permitted on board an abalone boat (DAFF 2016). The commercial (diver) fishery for abalone started in the late 1940s and was dominated by a few large abalone-processing plants. Initially, catches were unregulated, peaked at close to 3 000 tonnes in 1965, but by 1970, catches had declined rapidly, to around 600–700 t. The recreational fishery boomed in the early 1990s, and this, along with a significant increase in illegal fishing activities contributed to further declines in abalone stocks. Subsistence rights were introduced in 1998/1999, and were later replaced by medium-term and long-term rights, which broaden participation in the fishery to some 300 right-holders. The fishery was closed in 2008 after rampant poaching and continued resource declines (DAFF 2016). The commercial fishery was re-opened in 2010, with a Total Allowable Catch (TAC) of 150 t. Commercial fishing effort is concentrated around the southwestern Cape, but illegal fishing is practiced throughout the range of the species, all the way into the Eastern Cape (Figure 2-2.55) and greatly exceed annually allocated legal Total Allowable Catches (Branch & Branch 2018a).

Although the Northern Cape coast lies beyond the northern-most distribution limit of abalone on the West Coast, ranching experiments have been undertaken in the region since 1995 (Sweijd 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 (Figure 2-2.56). Ranching in these areas is currently being investigated at the pilot phase. The Boegoebaai study area falls within Northern Cape Area 1 held by Turnover Trading. No seeding has as yet commenced in the area and DFFE are still awaiting the baseline assessment for the area as required in terms of permit conditions (Zimasa Jika, DAFF, pers. comm.).

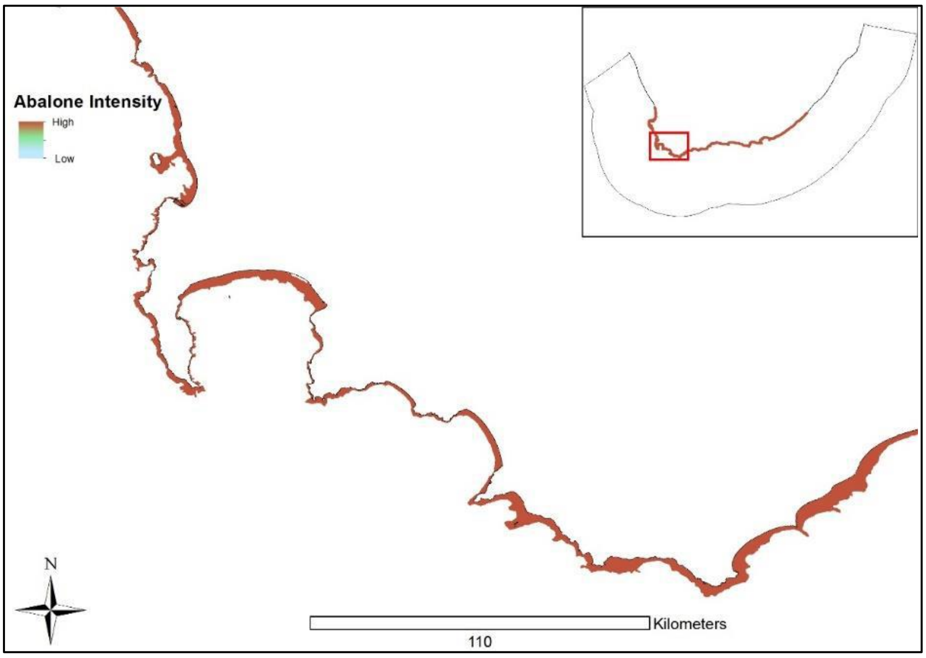

Figure 2-2.55. Fishing effort (legal and illegal) for abalone (Sink et al. 2019a).

2.2.7.9 Seaweed

The South African seaweed harvesting industry is based mainly on the harvesting of the kelp (mainly *Ecklonia maxima* and to a lesser extent *Laminaria pallida*) used by the abalone aquaculture industry as feed and for use in other kelp-based products, while the red seaweeds *Gelidium* and *Gracilaria* are used for agar. There are 23 commercial seaweed harvesting concession areas, arranged along the coast between the Orange River and the Mtamvuna River on the East Coast. The Boegoebaai project area falls within seaweed concession 19 held by Premier Fishing Area, and extends from the border of the proclaimed State Alluvial Diggings just north of Port Nolloth (29°13′56″S, 16°51′15″E) to the southern bank of the Orange River (28°38′18″S, 16°27′42″E). Commercially harvested seaweeds that are present in this concession area include the two kelp species *E. maxima* and *L. pallida, which* are widely distributed between Cape Agulhas and northern Namibia (and hence occur in the study area).

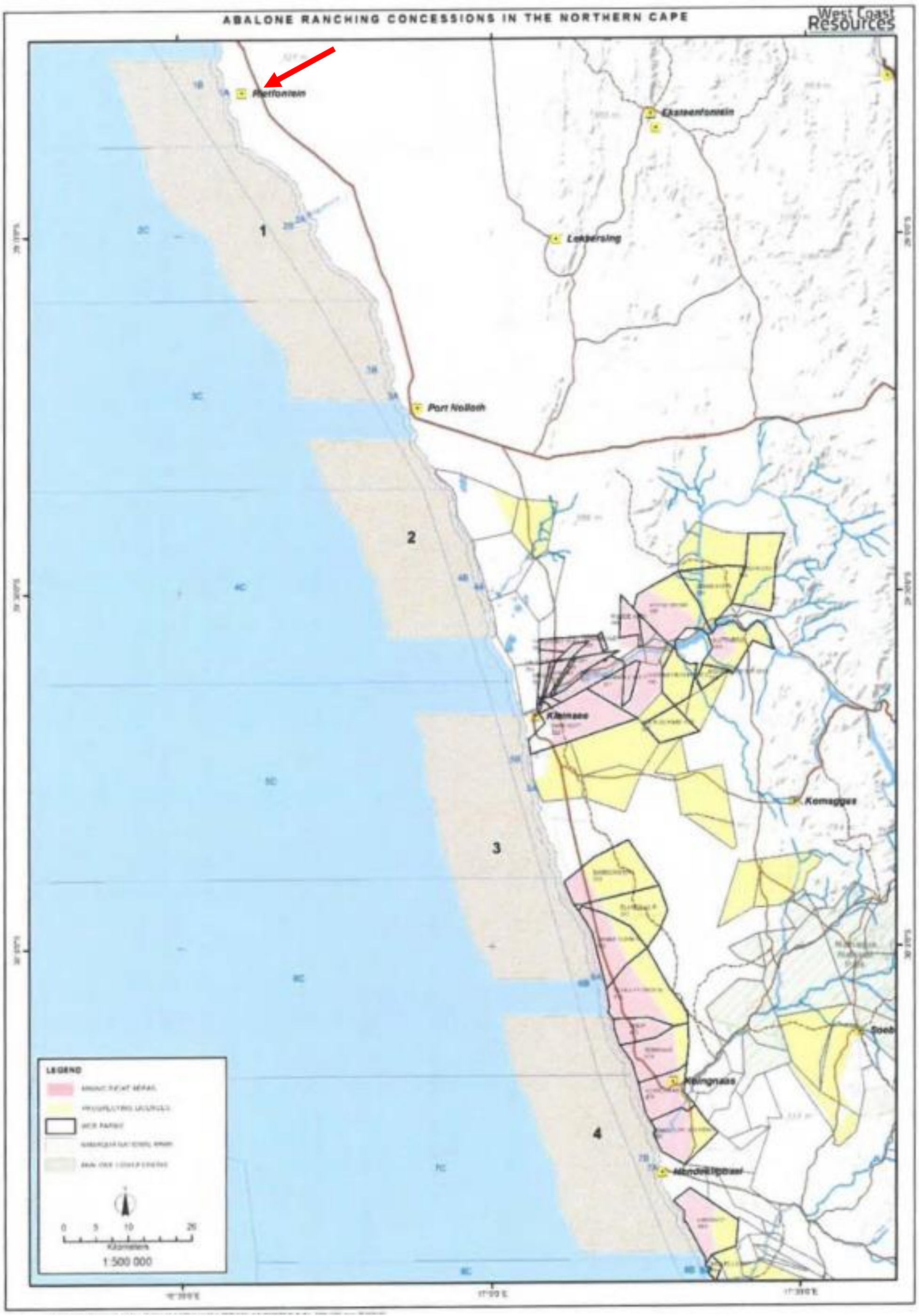

Figure 2-2.56. Abalone ranching concession areas (1-4) in the Northern Cape. Boegoebaai Point is indicated with red arrow.

Kelp harvesting entails harvesting of fresh kelp from live stocks and removal of kelp that has washed up in the surf from beaches, referred to as beach-cast kelp (DAFF 2016). Beach cast kelp is picked up off the beach or rocks by teams of labourers, usually when it is partly or completely dry. Material is removed and spread out in the foreland dune area to dry completely, then milled to various size chips. It is graded, bagged and (mainly) exported for the extraction of alginate, a colloid with many industrial uses. In the areas around abalone hatcheries fresh beach-cast kelp is also collected as food for cultured abalone, although quantities have not been reported. Live kelp harvesting (almost *entirely E. maxima*) is generally done from boats, at low tide, when kelp fronds are accessible from the surface. Workers lean over the side, pull up the kelp head, and either cut the whole head off, or (preferably) cut the fronds off but leave the first

30 cm intact and attached to the head, which allows the plant to re-grow. Fresh kelp fronds are landed and immediately delivered to abalone farms where they are supplied to the abalone as food.

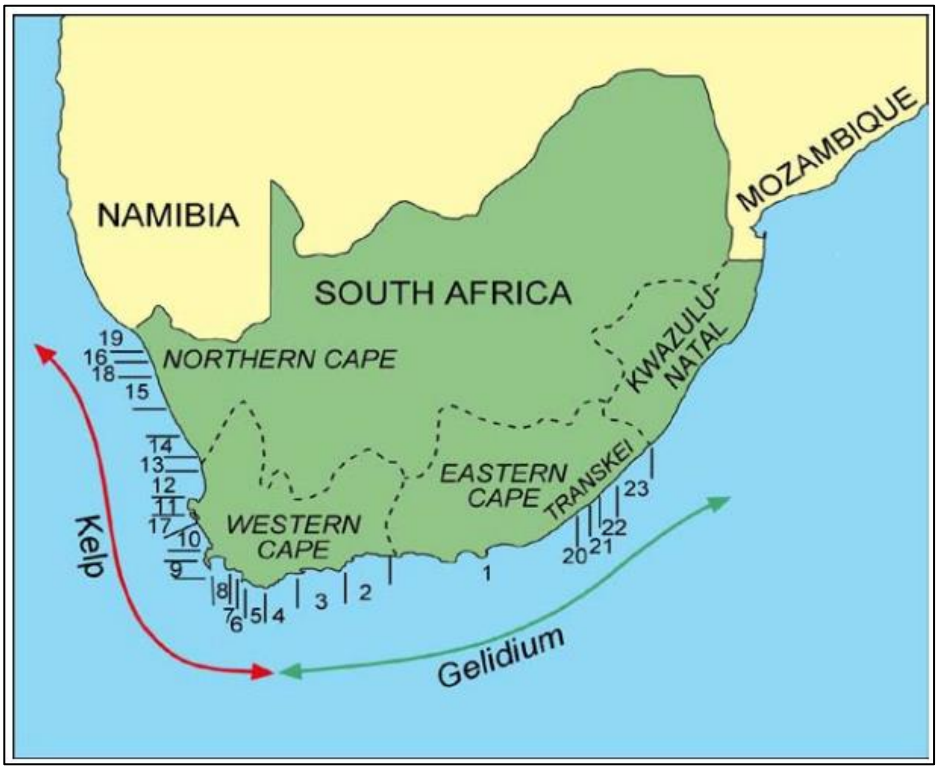

Figure 2-2.57. Seaweed concession areas in South Africa (DFFE 2013).

Access to a seaweed concession is granted by means of a permit from the DFFE to a single party for each concession area 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). Beach-cast kelp harvesting is managed by controlling Total Applied Effort (TAE) while live kelp harvesting is managed by Maximum Sustainable Yields, as set out in annual permits. The level of beach-cast kelp collection varies substantially among years, being dependent on storm action to loosen kelp from subtidal reefs. The harvesting of live kelp has been mapped in South Africa and is focussed around the southwestern Cape, between Cape Agulhas and St Helena Bay (Figure 2-2.58). Information on kelp harvesting in Boegoebaai (Area 19) and the areas south of there is presented in Table 2-2.10.

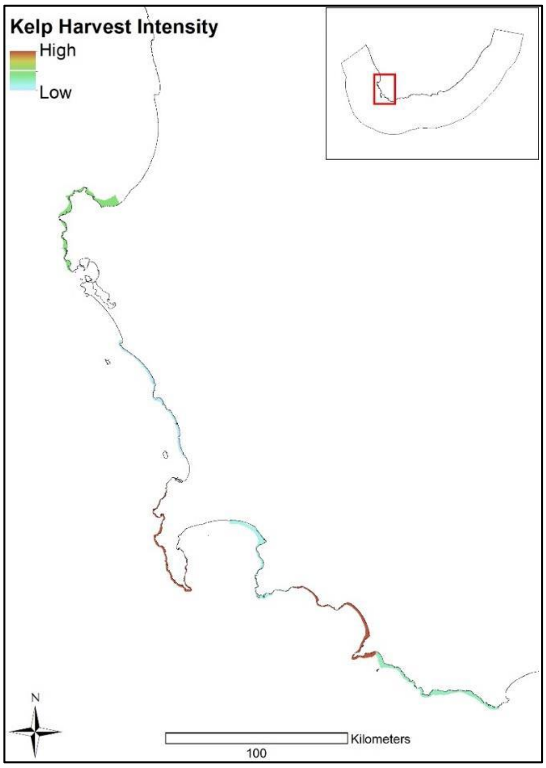

Figure 2-2.58. Kelp harvesting intensity in South Africa (Sink et al. 2019a).

Table 2-2.10. Beach-cast collections (in kg dry weight per annum) for kelp concessions north of Lamberts Bay (Data source: Seaweed Section, DFFE).

Year	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

Year	Concession Number					
	13	14	15	16	18	19
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

2.2.7.10 Recreational/subsistence fishing

Recreational fisheries in South Africa include linefisheries, rock lobster fisheries and harvesting of intertidal resources such as mussels, redbait and oysters (Griffiths et al. 2004, Cooke and Cowx 2006, Winker et al. 2014, Parker et al. 2016, Maggs et al. 2017, Kerwath et al. 2019, Steyn et al. 2019, Lewin et al. 2006). Recreational linefishing is a popular activity in South Africa and takes place across the coast. Between 1994 and 1997, the first nation-wide survey was conducted to evaluate participation in South Africa's recreational shore angling fishery, and its management (Brouwer et al. 1997, Mann et al. 2003).

Recreational fishing in South Africa includes participation from approximately 1.32 million fishers, of which approximately half fish from the ocean, targeting mainly linefish and rock lobster (Saayman et al. 2017). The Marine Living Resources Act (1998) legally recognised subsistence fishers and made provision for the declaration of coastal areas for their exclusive use. Since it is a restricted diamond area, the intensity of recreational fishing around Boegoebaai is extremely low, as is the case with subsistence harvesting harvesters (Figure 2-2.59).

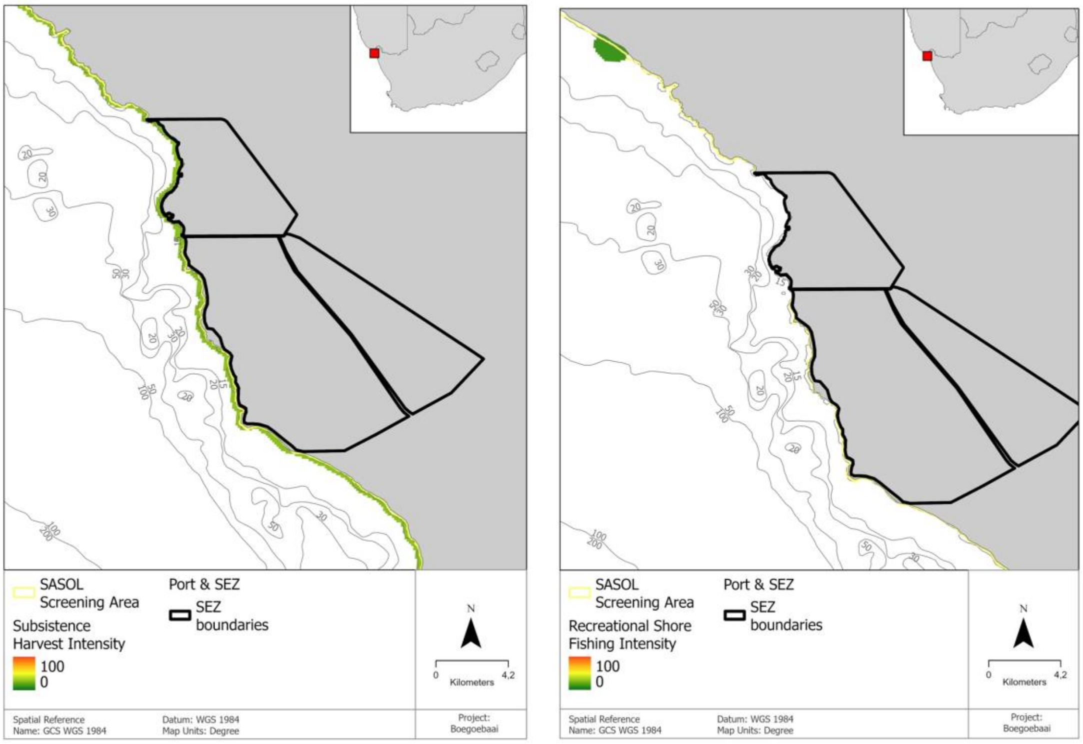

Figure 2-2.59. Map of scaled intensity for subsistence harvesting (left) and the recreational shore fisheries (right) and in the screening area and around the proposed site location for green hydrogen developments (Rees et al. 2022).

2.3 MARINE SPATIAL PLANNING

2.3.1 Overview

Marine Spatial Planning (MSP) is an approach to improving the rational planning, management and governance of ocean space and marine resources. MSP entails a development planning approach for marine areas which organizes the use of space to guide single- and multi-sector decision-making and provides for coherent, comprehensive, integrated and complementary planning and management. It also offers a practical way to address specific challenges and to select appropriate management strategies to maintain good ecosystem health that will, in turn, facilitate sustainable national and regional economic and socio-cultural development. In South Africa, MSP is undertaken under the auspices of the Marine Spatial Planning Act (Act No. 16 of 2018) and the national Marine Spatial Planning Framework (DFFE 2021). A number of draft Marine Sector Plans have been prepared by sector national government departments to support the development of Marine Area Plans as part of the Marine Spatial Planning process. These Marine Sector Plans specify and outline the spatial claims and interests of each sector in the South African marine environment from a national point of view. They specify and outline the spatial claims and interests of each sector in the South African marine environment. The following draft Marine Sector Plans are being released for public comment: 1) Marine Biodiversity Sector Plan; 2) Coastal and Marine Tourism Sector Plan; 3) Marine Transport and Ports Sector Plan; 4) Maritime and Underwater Cultural Heritage Sector Plan; 5) Marine Defence (Navy) Sector Plan; 6) Marine Science and Innovation Sector Plan; 7) Marine Aquaculture Sector Plan; 8) Marine offshore Oil and Gas Sector Plan; 9) Marine Underwater Infrastructure Sector Plan; 10) Wild Fisheries Sector Plan.

The Marine Biodiversity Sector Plan is of greatest relevance to this study. This plan sets out the overall national spatial development objectives and priorities of the sector for the next two decades. It specifies the spatial requirements of the sector for South Africa's mainland EEZ marine area. It includes proposed biodiversity zones and their spatial regulations. As with other Marine Sector Plans, the Biodiversity Sector Plan summarises spatial priority areas and their associated management requirements, for which the sector is making the case to secure in the Marine Area Plans as part of the coming Marine Area Plan development processes. Essential components and spatial layers that have been developed for the Marine Biodiversity Sector Plan are summarised below. Combined, these MSP layers and delineations form a significant component of our marine and coastal sensitivity assessment (see Section 2.4). The location of all MSP features (EBSAs, MPAs, CBAs and ESAs – each of which are expounded upon below) in relation to the proposed SEZ area are shown together on a regional map (Figure 2-3.1).

2.3.2 Ecosystem Threat Status

The Ecosystem Threat Status developed by SANBI (2018) is an indicator of how threatened ecosystems are, specifically the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function, or composition (Harris et al. 2019b). All of the coastal (intertidal) ecosystem types identified through the National Biodiversity Assessment have been categorised into one of five categories: "Critically Endangered", "Endangered", "Vulnerable", "Near Threatened" or "Least Concern", based on the proportion of the original extent of each ecosystem type that remains in good ecological condition relative to a series of biodiversity thresholds.

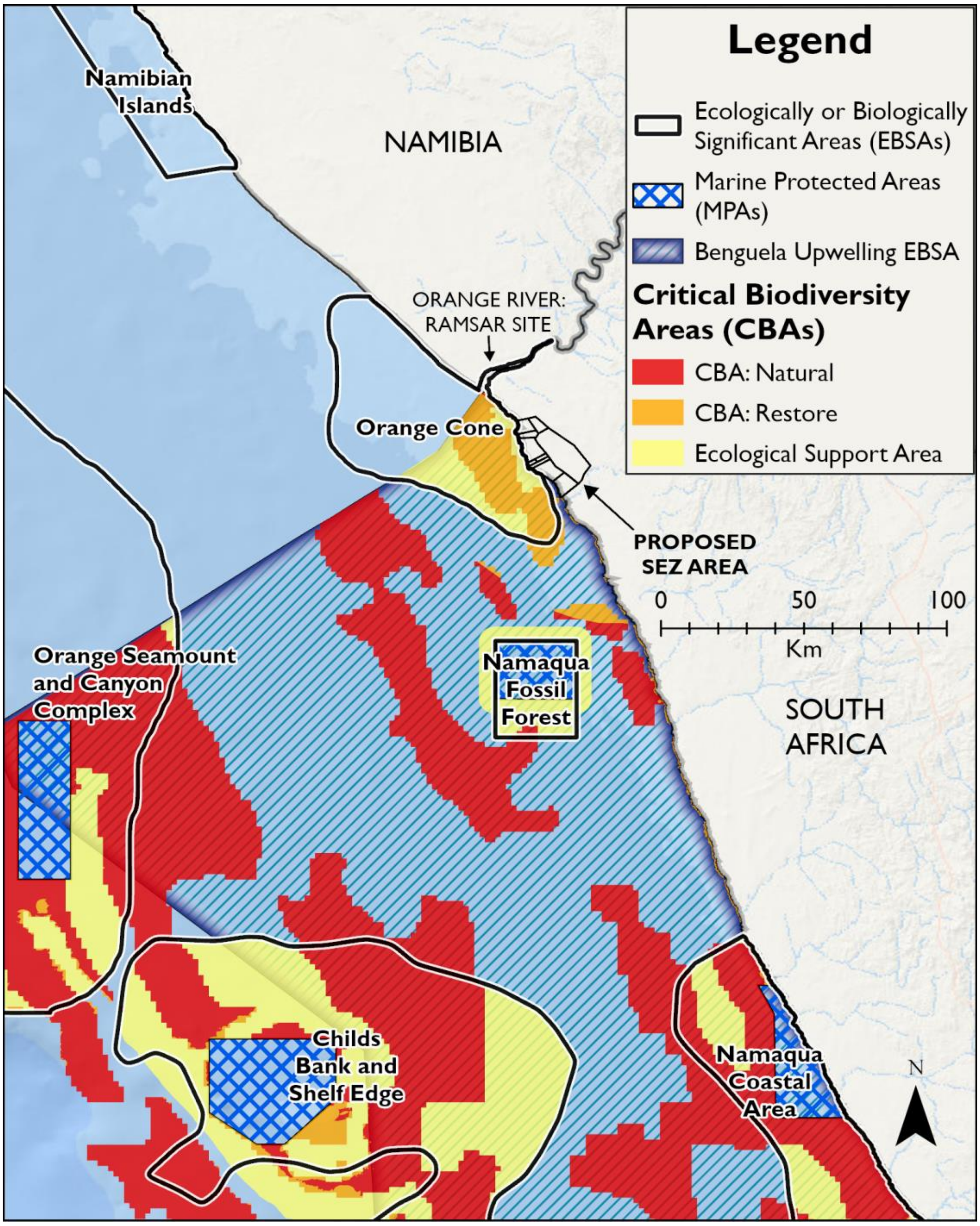

Figure 2-3.1. Regional Marine Spatial Planning map displaying the proximity of the proposed SEZ area to Ecologically or Biologically Significant Areas (EBSAs), Marine Protected Areas (MPAs), and Critical Biodiversity Areas (CBAs).

This threat status is considered to apply to a distance of ~200 m from the coast, with areas further offshore being classified in a similar manner (Figure 2-3.2). The outcome of this is that most of the coastal (intertidal) habitats, in the Boegoebaai study area, including the rock intertidal, mixed shore habitats have been classified as vulnerable, the dissipative and dissipative-intermediate sand shore as least concern, the intermediate sandy shores as near threatened, and the reflective sandy shore and all of the offshore habitats as endangered. The classification of the offshore habitats as endangered is linked to impacts of flow reduction and reduced sediment outputs from the Orange River estuary.

2.3.3 Ecologically or Biologically Significant Marine Areas

Ecologically or Biologically Significant Marine Areas (EBSAs) are defined by the Convention on Biological Diversity (CBD) as “geographically or oceanographically discrete areas that provide important services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics, or otherwise meet the [EBSA] criteria”. In the marine realm, South Africa has a network of EBSAs, based on original focus areas for offshore MPAs, which were adopted by the CBD in 2014 (Sink et al. 2011). The Benguela Current Commission (BCC) and its member states have been working on a regional Marine Spatial Management and Governance Programme (MARISMA EBSA Workstream 2020). The intent is to refine the boundaries of existing EBSAs and identify relevant new ones, assess their status and management requirements, and incorporate these into MSP processes in South Africa to achieve sustainable ocean use in the Benguela Current (Harris et al. 2019b). Through the MARISMA Project (https://cmr.mandela.ac.za/Research-Projects/EBSA-Portal/MARISMA), South Africa has refined the boundaries of its EBSAs and identified new EBSAs.

Note, in South Africa, these older EBSAs are integrated with newer Critical Biodiversity Areas (See Section 2.3.4) and are linked through MSP frameworks that aim to integrate biodiversity conservation with sustainable ocean use. While EBSAs inform broad-scale conservation goals and international reporting, Critical Biodiversity Areas are directly used in decision-making tools like EIAs, permitting, and sectoral planning (e.g., mining, fisheries, offshore energy. This ensures that spatial planning remains dynamic, adapting to new ecological data and pressures.

South Africa has 18 recognised EBSAs excluding those that extend into the high seas area. Of these recognised EBSAs, 16 of these 18 areas have some protection. The Orange Cone is one of two EBSAs entirely within national jurisdiction that currently lack any form of protection from anthropogenic activities.

The proposed site location and the northern part of the screening area falls within the Orange Cone EBSA. Orange Cone is a transboundary EBSA between Namibia and South Africa that spans the mouth of the Orange River. The marine environment in this area experiences slow, but variable currents and weaker winds, making it potentially favourable for reproduction of pelagic species. Furthermore, given the proven importance of river outflow for fish recruitment at the Thukela Banks (a comparable shallow, fine-sediment environment on the South African east coast) (Lamberth et al. 2009), a similar ecological dependence for the inshore Orange Cone has been inferred. Evidence supporting this hypothesis has not yet been consolidated.

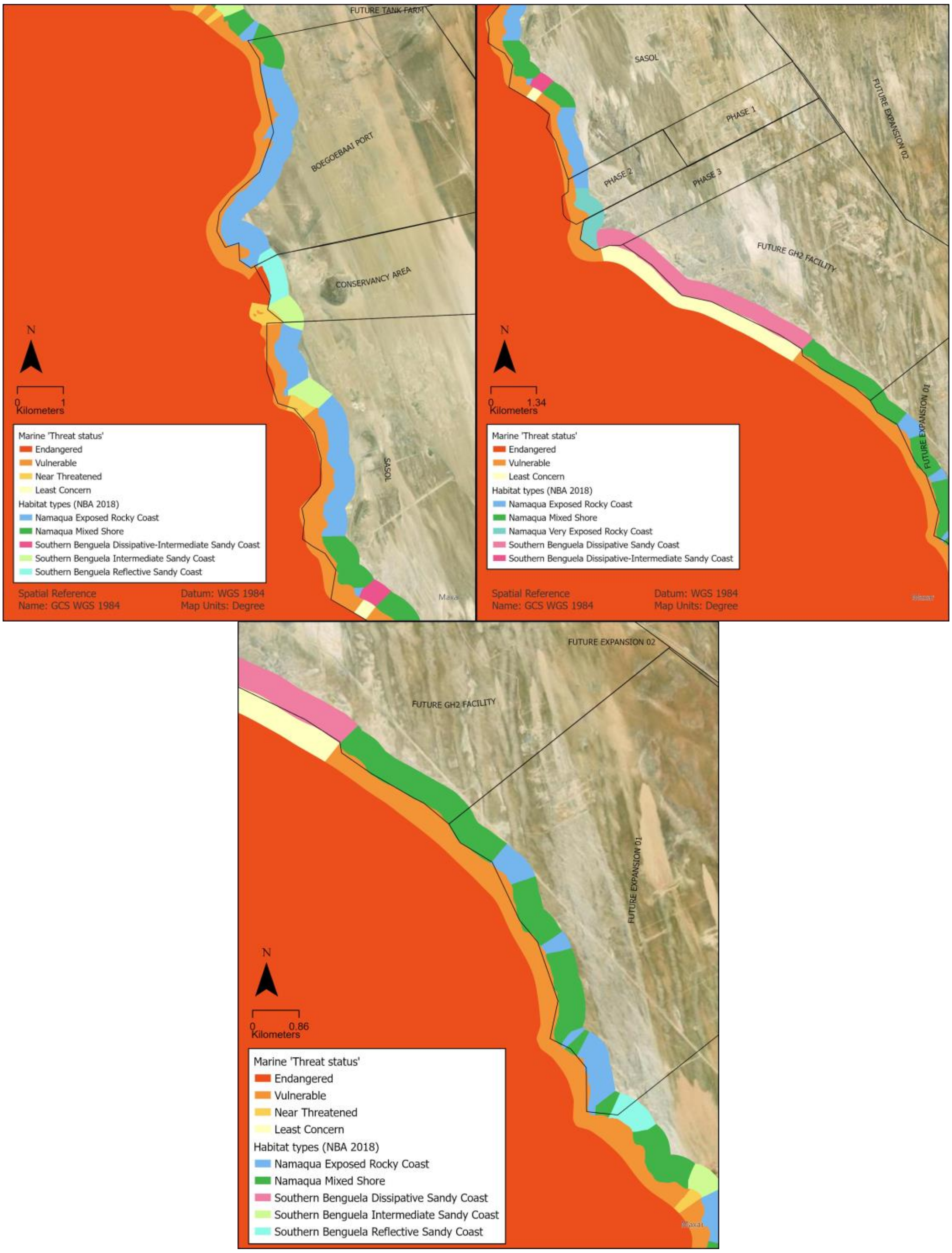

Figure 2-3.2. Ecosystem Threat Status (northern (left), central (left), and southern (bottom left) regions of the SEZ as per the NBA (Sink *et al*. 2019) around Boegoebaai. Coastal Habitat Classification types are also shown (NBA 2018). The three panels overlap but run consecutively southwards.

The proposed site location and the northern part of the screening area falls within the Orange Cone EBSA. Orange Cone is a transboundary EBSA between Namibia and South Africa that spans the mouth of the Orange River. The marine environment in this area experiences slow, but variable currents and weaker winds, making it potentially favourable for reproduction of pelagic species. Furthermore, given the proven importance of river outflow for fish recruitment at the Thukela Banks (a comparable shallow, fine-sediment environment on the South African east coast) (Lamberth et al. 2009), a similar ecological dependence for the inshore Orange Cone has been inferred. Evidence supporting this hypothesis has not yet been consolidated.

The goal of this zoning is to protect biodiversity while also allowing for some human activities. Biodiversity Conservation Zones aim to protect critical biodiversity areas (both natural and those requiring restoration) while Impact Management Zones (equivalent to Ecological Support Areas) aim to manage human impacts to maintain ecological functionality. The division of the Orange Cone EBSA into these Conservation and Impact Management zones, and their relevance to the proposed development, are indicated in Figure 2-3.3. The immediate nearshore around the proposed development site is adjacent to the 'Impact Management' zone of the EBSA.

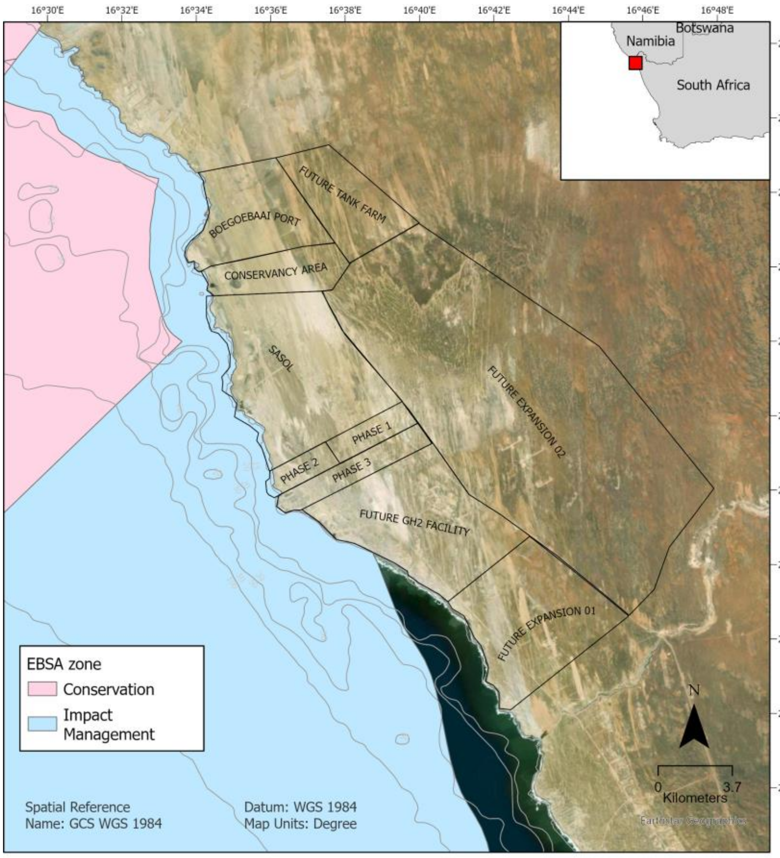

Figure 2-3.3. Ecologically or Biologically Significant Marine Areas (EBSAs) near to the Boegoebaai SEZ. Data from Sink et al. (2019a). The inshore around the proposed development site is adjacent to the Impact Management zone of the Orange Cone EBSA.

2.3.4 Critical Biodiversity Areas

A Critical Biodiversity Area (CBA) assessment presents a newer spatial plan for the natural environment, designed to inform planning and decision-making in support of sustainable development (Van Niekerk et al. 2019). CBA maps are developed using the principles of systematic biodiversity planning. These maps comprise three categories of biodiversity priority areas, namely Protected Areas, CBAs and Ecological Support Areas (ESAs). These are all considered important for the persistence of a viable representative sample of all ecosystem types and species, as well as the long-term ecological functioning and connectivity of the landscape or seascape as a whole.

There are two categories of CBA, namely 'CBA Natural' areas and 'CBA Restore' areas. 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. As a minimum in CBA Restore sites, further deterioration in ecological condition must be avoided, and options for future restoration must be maintained. The 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).

Within ESAs, negative impacts of human activities on key biodiversity features are managed and minimised to maintain the features in at least a functional, semi-natural state and/or to allow the area to improve in ecological condition.

A CBA assessment was completed for the South African marine environment as part of the National Biodiversity Assessment and results are presented on Figure 2-3.4 below. This assessment yielded a very large number of small (many less than 100 m in length) CBA Natural areas scattered along the coast in the Boegoebaai area along with a smaller number of slightly larger (2 km +) sized CBA Restore areas. It is not clear why the analysis yielded this plethora of tiny CBA Natural areas but they are unlikely to offer much in the way of conservation benefits. They do not align with any of the shoreline or offshore habitat types. The slightly larger CBA restore areas presumably align with areas that have been subject to mining in the past. Again, these areas do not align with specific shoreline or offshore (subtidal) habitat types and it is not clear how much value they would add if they were conserved. Much of the remaining coastal and offshore habitat in the study areas has been incorporated into what appears to be a single large ESA. Again, this does not align with any of the shoreline or subtidal habitat types and its value as a conservation area is questionable. It is generally recommended that caution be taken when interpreting the CBA maps. Given the scale of the national assessments, the datasets recording pressures are mapped and analysed at a scale and resolution entirely appropriate for the realm, but not for the very narrow shore and backshore which are barely even visible when viewed on a national map (Harris et al. 2022b). Indeed, the authors of the CBA assessment identify the resolution of the datasets and analyses are probably too coarse for accurate assessment at high resolution such as the current assessment.

This notwithstanding, it must be noted that a set of guidelines, termed “sea-use guidelines” have been developed to inform planning and decision-making around CBAs and ESAs in support of sustainable development (Harris et al. 2022b). These are based on an assessment of activities compatibility with the management objectives of CBAs and ESAs. Because the management objectives relate to the ecological condition of the site, the extent and severity of degradation resulting from an activity is considered in the compatibility assessment to determine whether the management objective could still be maintained if the activity were present.

A compatibility matrix has thus been compiled as part of a conceptual framework for evaluating each activity, indicating which combinations of extent and severity of degradation are compatible, not compatible or have restricted compatibility with the management objectives of the different CBA Map categories. This matrix was informed by the IUCN Red List of Ecosystems and the NBA 2018 Marine assessment of ecological condition (Sink et al. 2019b), which are both based on the same principles. Principals used for assessing compatibility of activities within the CBA Map categories, and recommendations for management of those activities are included in Table 2-3.1 below, while the actual matrix of sea-use guidelines is presented in Table 2-3.2.

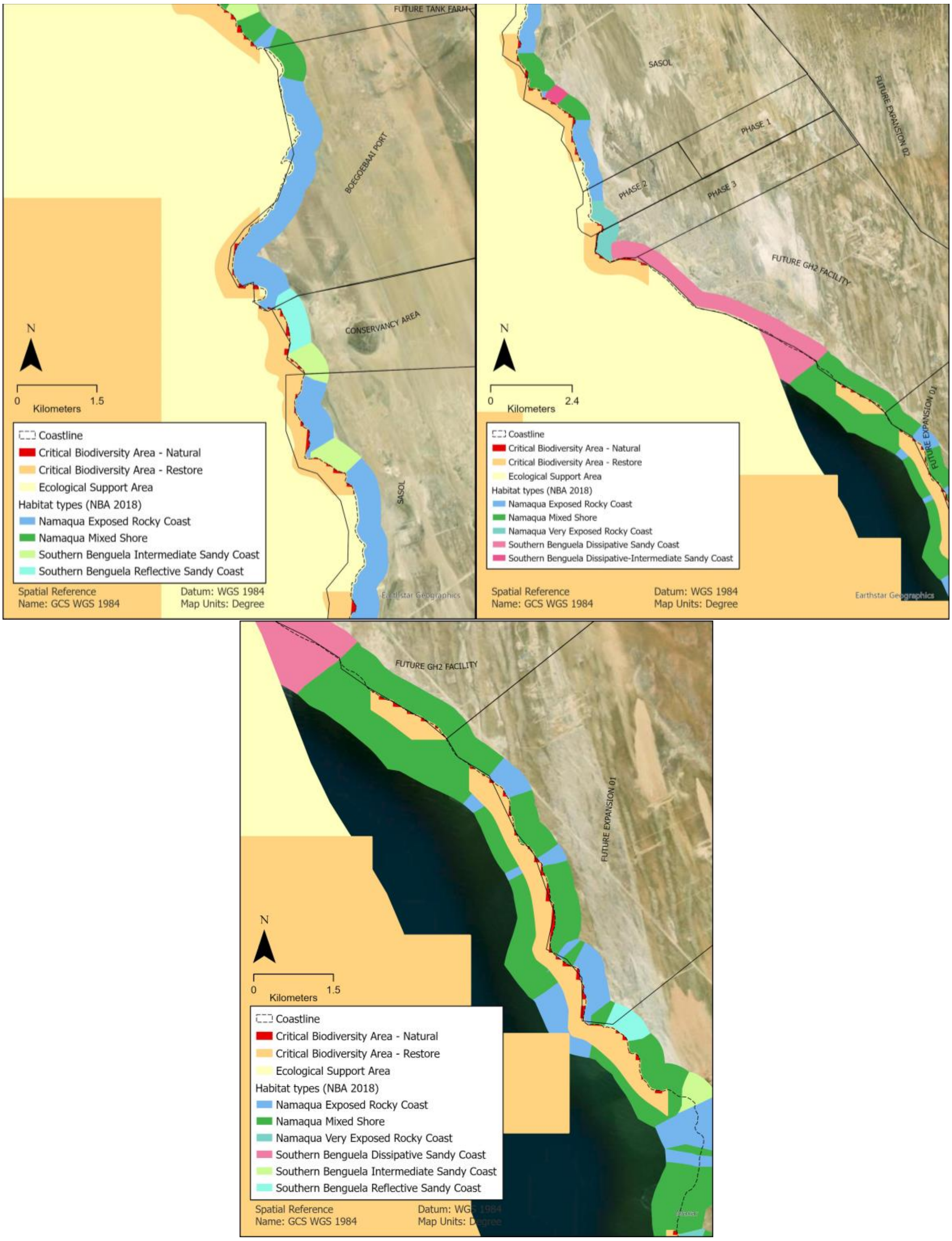

Figure 2-3.4. Critical Biodiversity Areas (CBAs) in area surrounding the northern (top left), central (top right) and southern (bottom left) sections of the study area. Data source: Sink et al. (2019a).

Table 2-3.1. Principals for assessing compatibility of activities within the CBA Map categories, and recommendations for management of those activities. Source: (Harris et al. 2022b).

Type of activity	**Critical Biodiversity Area (Natural)** *Compatibility with the management objective: to keep the area in a natural / near-natural state*	**Critical Biodiversity Area (Restore)** *Compatibility with the management objective: to improve ecological condition and, in the long term, restore to a natural / near-natural state, or as near to that state as possible. As a minimum, avoid further deterioration in ecological condition and maintain options for future restoration.*	**Ecological Support Areas** *Compatibility with the management objective: to avoid further deterioration in ecological condition.*
Activities that could result in **Severe or Very Severe degradation** over **broad areas** (includes activities that have a high disaster risk)	**Not compatible**	**Not compatible**	**Restricted compatibility**
Activities that could result in **Severe or Very Severe degradation** of **localised sites** but do not result in degradation across broad areas	**Not compatible**	**Not compatible**	**Restricted compatibility**
Activities that could result in or contribute to **Moderate degradation** over **broad areas**	**Not compatible**	**Restricted compatibility**	**Compatible**
Activities that could result in or contribute to **Moderate degradation** over **localised sites**	**Restricted compatibility**	**Restricted compatibility**	**Compatible**
Activities that could result in **low to very low degradation** and/or are not managed by biodiversity zones	**Compatible**	**Compatible**	**Compatible**

Management recommendations:

- **Compatible:** Activities should be allowed and regulated by current general rules. Notwithstanding, there should still be duty of care, possibly requiring monitoring and evaluation programmes, to avoid unintended cumulative impacts to the biodiversity features for which this area is recognised.
- **Restricted compatibility:** A robust site-specific, context-specific assessment is required to determine the activity compatibility depending on the biodiversity features for which the site was selected. Particularly careful attention would need to be paid in areas containing irreplaceable to near-irreplaceable features where the activity may be more appropriately evaluated as not permitted. The ecosystem types in which the activities take place may also be a consideration as to whether or not the activity should be permitted, for example. Where it is permitted to take place, strict regulations and controls over and above the current general rules and legislation would be required to be put in place to avoid unacceptable impacts on biodiversity features. Examples of such regulations and controls include: exclusions of activities in portions of the zone; avoiding intensification or expansion of current impact footprints; additional gear restrictions; and temporal closures of activities during sensitive periods for biodiversity features.
- **Not compatible:** The activity should not be permitted to occur in this area because it is not compatible with the management objective. If it is considered to be permitted as part of compromises in MSP negotiations, it would require alternative CBAs and/or offsets to be identified. However, if this is not possible, it is recommended that the activity remains prohibited within the CBA.

Table 2-3.2. List of all sea-use activities, grouped by their broad sea use and Marine Spatial Planning (MSP) Zones, and categorised according to their compatibility with the management objective of Critical Biodiversity Areas (CBA-N = CBA Natural; CBA-R = CBA Restore) and Ecological Support Areas (ESA) described in Table 2-3.1. Activity compatibility is given as Y = yes, compatible, R = restricted compatibility, or N = not compatible. Marine protected areas (MPAs) are managed according to their gazetted regulations. Data sources: (Harris et al. 2022b, DFFE 2023)

Broad sea use	Associated MSP Zones	Associated sea-use activities	MPA	CBA-N	CBA-R	ESA
Conservation	Biodiversity Zones	Expansion of place-based conservation measures (e.g., MPA expansion)	Sea-use activities as per gazetted MPA regulations	Y	Y	Y
Recreation and tourism	Marine Tourism Zone	Beach recreation, non-motorised water sports		Y	Y	Y
		Ecotourism (e.g., shark cage diving, whale watching)		Y	Y	Y
		SCUBA diving		Y	Y	Y
		Motorised water sports (e.g., jet skis)		R	R	Y
		Recreational fishing (e.g., shore-based, boat-based and spearfishing)		N	R	Y
		Shark control: exclusion nets		Y	Y	Y
		Shark control: drumlines and gillnets		N	R	Y
Heritage	Heritage Conservation Zone	Protection of sites of heritage importance, including historical shipwrecks		Y	Y	Y
		Protection of sites of seascape value		Y	Y	Y
Fisheries	Commercial and Small-Scale Fishing Zones	Abalone harvesting		R	R	Y
		Linefishing		N	R	R
		Demersal shark longlining		N	R	Y
		Demersal hake longlining		N	R	R
		Midwater trawling		N	R	Y
		Pelagic longlining		R	R	Y
		Small pelagics fishing		N	R	Y
		South coast rock lobster harvesting		R	R	Y
		Squid harvesting		R	R	Y
		Tuna pole fishing		R	R	Y
		West coast rock lobster harvesting		R	R	Y
		Crustacean trawling		N	N	R
		Demersal hake trawling (inshore and offshore)		N	R	R
		Hake handlining		R	R	Y
		Seaweed harvesting		R	R	Y
		Commercial white mussel harvesting		R	R	Y
		Beach seining		R	R	Y
		Gillnetting		R	R	Y
		Kelp harvesting		R	R	Y
		Oyster harvesting		R	R	Y
		Small-scale fishing		R	R	Y
	Fisheries Resource Protection Zone	Resource protection		Y	Y	Y
Aquaculture	Aquaculture Zone	Sea-based aquaculture		N	R	R
Mining	Mining Zone	Mining: prospecting (non-destructive)		R	R	R
		Mining: prospecting (destructive, e.g., bulk sampling)		N	N	R
		Mining: mining construction and operations[1]		N	N	R
Petroleum	Petroleum Zone	Petroleum: exploration (non-invasive)		R	R	R
		Petroleum: exploration (invasive, e.g., exploration wells)		R	R	R
		Petroleum: production[1,2]		N	N	R
		Petroleum: oil and gas pipelines		N	N	R
Renewable Energy	Renewable Energy Zone	Renewable energy installations		N	R	R
Defence	Military Zone	Military training and practice areas		R	R	Y
		Missile testing grounds		R	R	Y
Transport	Maritime Transport Zone	Designated shipping lanes (including port approach zones)		R	R	Y
		Anchorage areas		R	R	Y
		Bunkering		N	N	R
		Ports and harbours (new)		N	N	R
		Dumping of dredged material		N	N	R
Infrastructure	Underwater Infrastructure Zone	Pipelines (excluding oil and gas)		N	R	Y
		Undersea cables (new installations)		N	R	Y
	Land-based Infrastructure Zone	Coastal development (new installations, including piers, breakwaters, and seawalls)[3]		N	N	R
Abstraction and Disposal	Disposal Zone	Waste-water (new installations)		N	R	Y
	Sea-water abstraction and disposal	Sea-water abstraction and disposal (e.g., desalination)		R	R	Y
		Sea-water abstraction and disposal (e.g., aquaculture disposal)		N	R	Y

[1] The activity should not be permitted to occur in CBAs because it is not compatible with the respective management objectives. However, if significant mineral or petroleum resources are identified during prospecting/exploration, then the selection of the site as a CBA could be re-evaluated as part of compromises negotiations in current or future MSP processes. This would require alternative CBAs and/or biodiversity offsets to be identified. However, if it is not possible to identify alternative CBAs to meet targets for the same biodiversity features that are found at the site, it is recommended that the activity remains prohibited.
[2] The recommended prohibition of the activity in CBAs (because it is not compatible with the management objective) refers to the location of the biodiversity disturbance rather than the location of the petroleum resource. If petroleum production is possible using lateral drilling or other techniques that do not result in any impacts on biodiversity within the CBAs, then production may be treated as an activity with restricted compatibility (i.e., recommended to be a consent activity).
[3] New coastal development should not be permitted in CBA Restore sites unless it is part of rehabilitation and restoration activities to improve ecological condition.

2.3.5 Marine Protected Areas

A Marine Protected Area (MPA) is an area of ocean and/or coastline specifically protected for the benefit of people and the environment, which receives a higher level of protection than the surrounding areas. MPAs may be zoned to permit defined human activities in parts of the MPA while providing complete protection from extractive and harmful activities in other parts. It is stated in the Protected Areas Act (Act No. 57 of 2003) that "no person may conduct commercial prospecting or mining, exploration, production or related activities in a protected environment without the written permission of the Minister and the Cabinet member responsible for minerals and energy affairs". Therefore, these areas provide some refuge from human induced impacts for marine species and ecosystems. Prior to 2019, South Africa had 25 formally declared MPAs which covered a total ocean area of 0.43% of South Africa's mainland ocean territory (not including the Prince Edward Island in the Southern Ocean). In May 2019, the government formally gazetted the addition of 20 new or expanded MPAs (identified through Operation Phakisa), thereby increasing the total number of MPAs to 41 and the protected area of South Africa's EEZ to 5% (Government Gazette 42478, Notice No. 757). These areas provide some protection to 87% of the different marine ecosystem types found in South African waters, ensuring that the MPA network is representative of the country's important diversity. Included in this was the addition of several new offshore MPAs, the purpose of which is to help ensure the sustainability of food and job security provided by fisheries, by securing the spawning grounds of numerous marine species as well as protecting vulnerable and unique habitats. No MPAs have been proclaimed in the study area. The nearest MPA is the Namaqua Fossil Forest MPA located offshore around 60 km south of the development area (Figure 2-3.5).

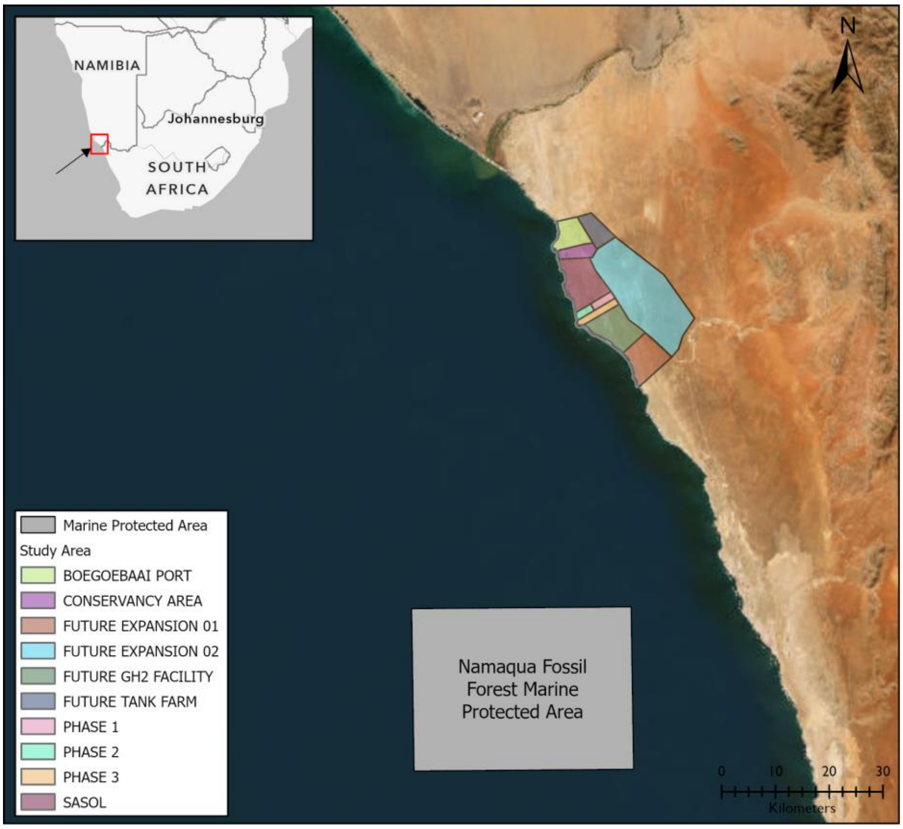

Figure 2-3.5. Location of the proposed project area in relation to the nearest Marine Protected Area.

2.4 SENSITIVITY ASSESSMENT

2.4.1 Introduction

An environmental sensitivity assessment is a critical component of development planning, as it provides a spatially explicit understanding of ecological vulnerability of a defined area to anthropogenic disturbances. The assessment of environmental sensitivity is particularly important in dynamic and biodiverse coastal and marine ecosystems. These systems are known to support a wide range of ecological functions, including biodiversity conservation, fisheries productivity, shoreline protection, and carbon sequestration and as such, environmental changes and human activities can have significant and lasting impacts.

Sensitivity assessments aim to integrate multiple environmental and ecological factors to evaluate both the vulnerability and as well as the resilience of various habitat types to development pressures. In coastal and marine environments, these factors may include species composition, ecological function, exposure to human activities, and regulatory designations (i.e., spatial constraints, such as those defined as part of the MSP process). Determining environmental sensitivity was an important component of the WP1 Boegoebaai SEA to provide intuitive, objective, ground-truthed input on where, from a marine ecology perspective, development might be constrained, permitted, or a clear no-go. This sensitive assessment also serves as the baseline point to inform mitigation planning and performance management to minimize potential environmental impacts.

This sensitivity assessment aims to be intuitive for policy makers, developers and non-technical audiences.

2.4.2 Scoring methods

This assessment was undertaken to identify the key areas of marine coastal and offshore sensitivity associated with the proposed development area of the Boegoebaai SEZ. This GIS-based environmental sensitivity analysis incorporated existing spatial constraints such as habitat vulnerability, marine spatial planning frameworks, and regulatory conservation priorities, and was further refined through targeted field surveys and site verification to ground-truth findings. Objective criteria were applied (detailed below) that incorporated the following inputs to classify areas into four sensitivity categories (Very High, High, Medium, and Low):

- Spatial constraints and marine spatial planning, including Marine Threat Status (Sink et al. 2019c), Critical Biodiversity Areas (Harris et al. 2022a b) and Marine Protected Areas (Sink et al. 2019a).

- Species level information based on a combination of desktop review and in situ validation/field sampling results (see Section 2.2.6). These included the composition (abundance and diversity) of macrofaunal communities; the population structure of *Tylos granulatus* populations; the presence of kelp forest habitat (indicative of subtidal reef systems); the observed presence of seabird and marine mammal populations, especially breeding populations; and surf zone marine fish communities.

The sensitivity assessment was underpinned by the Ecosystem Type layer as described in the NBA 2018 (Sink et al. 2019a), which serves as the foundational framework for evaluating ecological vulnerability. These data delineate distinct habitat types within the study area, providing essential ecological context for assessing sensitivity.

First, these ecosystem types were contextualized at the site (SEZ) level (see Section 2.2.6). To achieve this, the ecosystem types that occur within the study area were compared to those that occur within the Southern Benguela Ecoregion (coarsest scale of habitat biogeography) to determine whether any site-specific habitats were regionally rare. The proportional representation of each ecosystem type (area) within the site was assessed against regional trends to evaluate whether the site's habitat composition was reflective of the broader coastal and marine environment of the region. This proportionality was then weighted as part of the sensitivity assessment i.e. if certain ecosystems were overrepresented within the site compared to their regional distribution, they were assigned higher importance in the sensitivity assessment than those that were relatively underrepresented within the site (see Section 2.4.3). This approach recognizes that even if a habitat is not inherently rare, its local dominance may indicate a key ecological role within the site, warranting greater consideration in environmental planning and impact mitigation.

Secondly, spatial data layers were assessed, including habitat distribution maps, Marine Protected Area boundaries, biodiversity priority areas (including EBSAs), and other environmental constraints to establish a baseline understanding of habitat vulnerability and any spatial restrictions relevant to development (as per Section 2.3). Areas within these delineated sensitive/protected sites were assigned higher importance in the sensitivity assessment than those that that fell outside of these areas (see Section 2.4.3).

Thirdly, a scoring protocol was designed to systematically evaluate the sensitivity and biodiversity status within of different habitat areas. Each spatial constraint/ biodiversity feature was assigned a score, per delineated ecosystem type, based on its ecological importance and susceptibility to disturbance within each delineation. The cumulative scores were then used as part of the sensitivity matrix to classify habitat areas intone of the four sensitivity categories, with higher scores indicating greater sensitivity (see Section 2.4.3). The assessment encompassed both the intertidal and offshore marine environments to provide a comprehensive sensitivity profile across the study area.

Finally, field survey and site verification results were used for validation (Section 2.2.6). This involved in situ observations, habitat condition assessments, and verification of key ecological features identified in the spatial analysis.

2.4.3 Scoring matrix

The proportionality of habitats within the site, along with the biodiversity status scoring, were integrated into a matrix to determine final sensitivity classifications for each delineated area (Table 2-4.1). This matrix cross-references two key factors: the percentage area of each habitat within the site relative to regional expectations and its biodiversity status score based on ecological vulnerability and resilience:

- Ecosystem Proportionality – Each habitat was categorized as being less than expected, equal to expected, or more than expected compared to regional distributions. Overrepresented habitats were assigned greater importance due to their local ecological dominance.

- Biodiversity Status – Ecosystems were given a score based on their conservation importance, threatened status and their sensitive ecological features present, ranging from < 4 (Low) to 8+ (Very High), reflecting their conservation value and resilience.

These scores were added together to give a final Biodiversity Status score (Table 2-4.1).

Table 2-4.1. Scoring method for each spatial constraint/ecological feature within each delineation as part of the Environmental Sensitivity Assessment.

Feature/constraint	Category	Assigned score
Marine Threat Status	Endangered	4
	Vulnerable	3
	Near Threatened	2
	Least Concern	1
Critical Biodiversity Area	Natural	3
	Restore	2
	Ecological Support Area	1
Species importance e.g., marine mammals	High	1
	Medium	0.5
	Low	0

Final Sensitivity Classification – The intersection of these two factors in the matrix determined the final habitat sensitivity category (Table 2-4.2). For example:

- A habitat with a low status score but overrepresented in the site was elevated to a higher sensitivity category.
- A habitat with a high status score but less than expected in the site retained its high sensitivity classification.
- Equal representation followed a baseline scoring approach.

Table 2-4.2. Environmental Sensitivity scoring matrix

		ECOSYSTEM PROPORTIONALITY		
		Less than expected	*Equal*	*More than expected*
BIODIVERSITY STATUS	*< 4*	LOW	LOW	MEDIUM
	4 - 5.9	MEDIUM	MEDIUM	MEDIUM
	6 - 7.9	MEDIUM	HIGH	HIGH
	8+	HIGH	VERY HIGH	VERY HIGH

The final sensitivity assessment produced a sensitivity map delineating habitat sensitivity across the study area (Section 2.4.4). These maps visually represent the spatial distribution of Very High, High, Medium, Low sensitivity zone. The integration of GIS analysis with field verification ensured that the outputs were both data-driven and ecologically robust.

2.4.4 Sensitivity Assessment – spatial output

The mapped sensitivity distributions for the coastal and offshore marine realms of the Boegoebaai proposed SEZ area, highlighting key areas of concern, and implications for environmental management is presented in Figure 2-4.1, and discussed below.

A large proportion of the coastal habitat of the Boegoebaai SEZ area is rated a **medium environmental sensitivity** (Figure 2-4.1). This is largely on account of the exposed and mixed rocky shore contributing to a large proportion of coastal habitat in this region. Mixed shore ecosystems, which include any area of the shore that is not pure rock or pure sand, makes up a significant (almost one third) of the intertidal shoreline habitats in the Boegoebaai area. Species richness on mixed shore can be higher due to increased habitat complexity and heterogeneity. Furthermore, the bathymetry of the SEZ indicates scattered subtidal reefs close to the shore adjacent to most of the rocky and mixed shores within the SEZ. There is also evidence of significant subtidal reefs from the shore (3-6 km offshore) in the north that approaches right up to the coast south of Boegoebaai point. These reefs may be important for biodiversity and or from a fisheries perspective. The rocky and mixed shore habitats near Boegoebaai are classified as Vulnerable due to biodiversity they support and limited protection afforded to these areas through the formal protected area network. Much of these habitats within the SEZ area listed as CBA-Restore, and should be subject to as little disturbance as possible.

In general, the Boegoebaai beaches that were surveyed in this study can be described as relatively high energy beaches. Beaches sampled in the study area showed the general pattern of depauperate macrofauna populations relative to other beaches of similar morphodynamic state elsewhere in the Southern Benguela Ecoregion and so are less environmentally sensitive, except in the case of the reflective and intermediate beach habitats which had relatively higher and numbers of the indicator species *Tylos granulatus* recorded at them during the survey (Section 2.2.6.2), with evidence of multiple cohorts present. Furthermore, experimental seine net sampling undertaken in surf zone habitats of sandy beaches in the Boegoebaai region revealed low species richness and none of the species caught are listed as ETP species. This further confirms generally these habitats are not considered particularly sensitive in the Boegoebaai area (Figure 2-4.1). The large, dissipative sandy shore to the south of the concession area has the lowest level of environmental sensitivity in our assessment, rated as **low environmental sensitivity** (Figure 2-4.1).

The most sensitive area is around the headland within the proposed port precinct area of the SEZ, in combination with the presence of the seal breeding colony. This area is rated as of **very high environmental sensitivity** (Figure 2-4.1) on account of the breeding population of Cape fur seals, *Arctocephalus pusillus,* that exist here (Section 2.2.6.8). The high-profile rocky shore and cliffs not only offer some degree of protection from land-based predators but also provide shaded refugia and pools for seals to thermoregulate. The latter has been shown to be the most important environmental factor for breeding seal haul-outs in the lower latitudes where there is a high risk of overheating (Stevens & Boness 2003).

Seals started breeding at this site in 1991 and the colony remains small (n = 107 pups counted in 2007) but is growing. Despite their IUCN red list status of "Least Concern" and the prevalence of more than 40 seal colonies along the coast of southern Africa, seals are protected in South Africa under the Sea Birds and Seals Protection Act 1973. Further to this, any activities that disturb seals are deemed to be illegal according to the NEMBA (National Environmental Management: Biodiversity Act).

Construction of a breakwater and or port at Boegoebaai is likely to seriously disturb and/or displace both the seals and breeding seabirds present at this site and it is strongly recommended that consideration be given to identifying an alternate site for port development for this reason alone. If displaced, it is unlikely that the Cape fur seal colony would re-establish on adjacent low-profile rocky shore areas as these offer no shaded refugia, pools or protection from land-based predators. Female seals are likely to be disturbed by human activities associated with port construction, and may elect to avoid contact with humans to reduce the risk of conflict and are therefore unlikely to return to the breeding colony and their pups. This is supported by research showing that breeding and pupping harbour seals on the west coast of North America have been displaced by shellfish aquaculture activities (Becker et al. 2011). Potential mitigation in the form of an artificial haul-out area that could be constructed as part of the port development may offer a solution, however, there is a risk that such an initiative may fail.

Many anthropogenic activities and uses of the marine environment (including those likely to be associated with the development of a new port and SEZ at Boegoebaai) pose a serious risk to these already threatened seabirds. At least two species of seabird (Bank Cormorant *Phalacrocorax neglectus* and White breasted cormorants *Phalacrocorax lucidus*) are known to breed on the rocky cliffs at Boegoebaai Point (the identified site for the port breakwater). Other costal seabird species are known to breed on the rocky and mixed shore (e.g. African Black Oystercatcher *Haematopus moquini)* and sandy beach *(*White fronted plover *Charadrius marginatus*) habitats in the study area. Much care needs to be taken to ensure that these threatened marine and coastal birds are not overly disturbed by project activities.

It is important to note, that the two ecosystem types that border the Conservancy Area of the SEZ (see Figure 2-4.1) have been incorrectly labelled in the National Biodiversity Assessment. From our sampling sites, beach ISS1 (Intermediate Sandy Shore), which is located on a south-west facing shore (directly opposite the prevailing swell direction), should be classified as a reflective beach and beach RSS1 (Reflective Sandy Shore), which faces directly west, should be classified as an intermediate sandy shore. Although throughout the report we have maintained the original erroneous classification, as it appears in the NBA, for our Environmental Sensitivity Assessment, to avoid a misleading final sensitivity classification, we have assessed the ecosystems based on the site survey and *in situ* validation i.e., the reflective beach is actually intermediate and the macrofauna and *Tylos* sampling results in particular support this so their relative importance has been accounted for in our final classification.

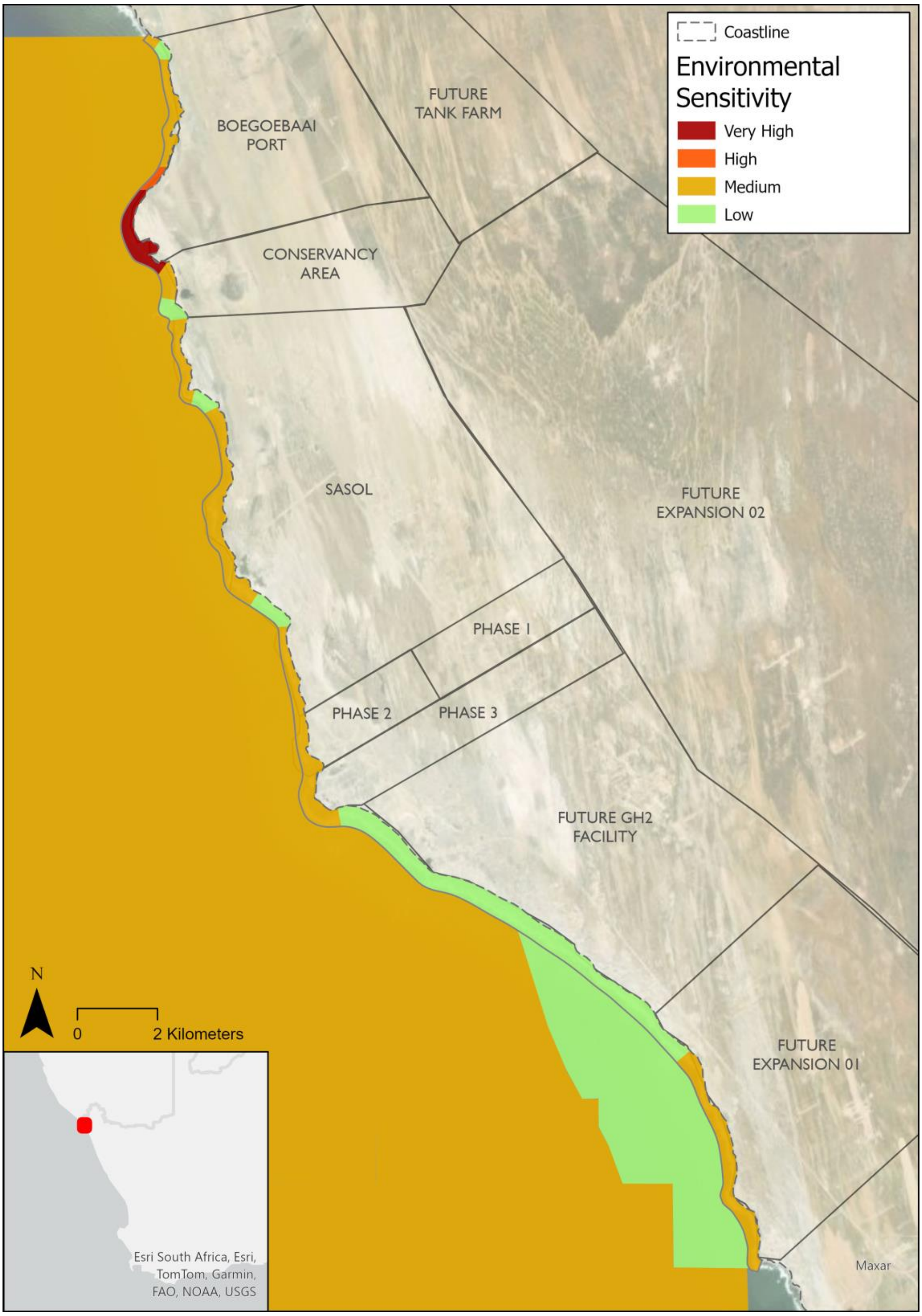

Figure 2-4.1. Marine and coastal Environmental Sensitivity Assessment of the Boegoebaai SEZ region.

2.5 ASPECTS AND IMPACT REGISTER

Consideration has been given to potential impacts the Boegoebaai development may have on the marine environment during the construction and operational phases of the project along with potential impacts from unplanned activities (e.g. increase in shipping traffic). These are summarised in Table 2-5.1 below.

Table 2-5.1. Summary of potential impacts on the marine environment associated with the Boegoebaai Port and SEZ.

Activity Phase	Activity	Aspect	Potential Impact
1. Construction	Building of breakwater, jetties and quays	Increase in underwater noise levels (construction/blasting/pile driving)	Physiological and behavioural effects on marine fauna
		Permanent loss of habitat and associated communities under breakwater and alteration of substrate type and associated communities through introduction of non-native rock	Changes in benthic and associated demersal communities in CBA1restore and ESA areas
			Falls within EBSA Impact Management Zone
			Overlap with coastal habitats assigned a threat status of "vulnerable' and nearshore habitats that are considered 'endangered
		Increased turbidity	Physiological and behavioural effects on marine fauna
		Routine discharges to sea from construction vessels/machinery and local reduction in water quality	Physiological effect on marine fauna
		Hindrance of alongshore movement of juvenile and adult fish in the surf zone	Effects on recruitment
		Changes in wave patterns and/or currents causing sand accumulation or erosion	Changes in longshore currents affecting littoral drift
		Disturbance of seals and destruction of seal colony	Displacement or mortality
	Capital dredging	Increased turbidity	Physiological and behavioural effect on marine fauna
		Remobilisation of contaminants in the sediments	Physiological effect on marine fauna and bioaccumulation risks
		Loss of unconsolidated habitat and associated communities	Disturbance and removal of benthic macrofauna in dredge footprint
			Disturbance and smothering of benthic fauna at spoils dump site
			Cascade effects on higher-order consumers
		Routine discharges to sea from construction vessels/machinery and local reduction in water quality	Physiological effect on marine fauna
	Installation of intake and discharge pipelines for RO Plant	Permanent loss of habitat under submerged intake and discharge pipelines	Loss of endangered Orange Cone Inner Shelf mud reef mosaic and vulnerable Namaqua exposed rocky shores ecosystem types
		Underwater noise levels (blasting)	Physiological and behavioural effects on marine fauna
	General housekeeping during construction	Accidental spills, litter, sewage, run-off	Physiological effect on marine fauna
			Degradation of coastal environment

Activity Phase	Activity	Aspect	Potential Impact
2. Operation Phase	Presence of vessels and operation of port	Increase in underwater noise levels	Physiological and behavioural effects on marine fauna
		Routine discharges to sea (e.g. deck and machinery space drainage, sewage and galley wastes) and local reduction in water quality	Physiological effect on marine fauna
	Lighting from port and vessels	Light emissions in marine environment	Disorientation and mortality of seabirds and marine mammals
			Attraction of plankton and increased risk to fish, turtles and cetaceans
	Increase in vessel traffic	Increase in underwater noise levels	Physiological and behavioural effects on marine fauna
		Increased risk of ship strikes	Injury or mortality of marine mammals/turtles
		Increased risk of vessel accidents and operational spills leading to reduction in water quality	Effects on faunal health (e.g. respiratory damage) or mortality (e.g. suffocation and poisoning)
			Physical damage to and mortality of benthic species / habitats
			Oiling of coastal habitats
	Maintenance dredging	Increased turbidity	Physiological and behavioural effect on marine fauna
		Remobilisation of contaminants in the sediments	Physiological effect on marine fauna and bioaccumulation risks
		Loss of unconsolidated habitat and associated communities	Disturbance and removal of benthic macrofauna in dredge footprint
			Disturbance and smothering of benthic fauna at spoils dump site
	Operation of RO Plant	Seawater intakes	Impingement and Entrainment
		Brine discharges	Physiological effect on marine fauna of RO Plant effluents
			Flow distortion around outlet
3. Unplanned Activities	Increase in vessel traffic	Increased risk of collision with marine fauna	Physiological and behavioural effects on marine fauna
	Accidental hydrocarbon spills / releases (e.g. vessel accident, bunkering and pipe rupture)	Loss of hydrocarbons to sea and reduction in water quality	Effects on faunal health (e.g. respiratory damage) or mortality (e.g. suffocation and poisoning)
			Physical damage to and mortality of benthic species / habitats
			Oiling of coastal habitats

2.6 SUMMARY & RECOMMENDATIONS

2.6.1 Physical environment

Aspects of the physical environment that are likely to influence the design, layout and implementation of this project are largely dealt with in the prefeasibility study report for the Boegoebaai Port prepared by PRDW (2015) and do not need to be reiterated here. Suffice is to say that the bathymetry of the coastline, or at least proximity of deep water close to the shore, is the primary factor from a physical environment perspective that will likely influence selection of a suitable location for the port. Boegoebaai Point is immently suitable in this respect (which it why it has been selected for this purpose) but there are a number of important marine ecological considerations that militate against the selection of this site as being suitable for port development (highlighted below). There are many other locations on the shoreline between the Orange River Mouth and Port Nolloth where the bathymetry profile of the shoreline is also likely to be suitable for port development that are not as sensitive from a biophysical perspective, which should be considered for this purpose.

2.6.2 Marine fauna and flora

According to the National Biodiversity Assessment (NBA), the Boegoebaai study area is positioned in the "Namaqua inshore" portion of the "Southern Benguela Ecoregion" (Sink et al. 2019a). The latter extends all along the western coast of southern Africa between Cape Agulhas and Lüderitz. Rocky intertidal habitat in this region comprises mainly of one habitat type (termed Namaqua Exposed Rocky Shore). A review of available literature on the area and field surveys conducted as part of this study suggests that there is a high overall similarity between communities in the Boegoebaai area and those that have been studied elsewhere on Exposed Rocky Shores in the Southern Benguela Ecoregion. None of the species present on the shore are listed as endangered, threatened or rare (ETP) species, although it must be said that few of these species have been subject to any formal assessment. It is important to note that the proposed development would significantly increase the amount of sheltered rocky shore habitat within the region to several times that of what currently exists within the inlets of Homewood Harbour and Peacock Bay (Figure 2-2.7). Such habitats are rare within the region and have been shown to host a completely different community of intertidal fauna and flora (Blamey & Branch 2009).

Three broad morphodynamic sandy-beach types are recognised worldwide: dissipative, intermediate and reflective, distinguished on the basis of interaction of wave energy, beach slope and sand particle size. All three major beach types exist in the Boegoebaai area, along with two intermediate types (e.g. dissipative-intermediate and reflective intermediate). Macrofaunal communities associated with beaches normally vary strongly in accordance with morphodynamic state but tend to be similar across beaches of similar types within the same ecoregion. Dissipative beaches usually support higher diversity, abundance and biomass of macrofauna than do intermediate beaches, while reflective beaches are generally most depauperate. Beaches in the study area all follow this general pattern but faunal communities were all depauperate relative to other beaches of similar morphodynamic state elsewhere in the Southern Benguela Ecoregion. This is likely a result of disturbance by diamond mining operations in the region, evidence of which can been seen throughout the area, but especially in the north. Little has been done in terms of identifying ETP beach macrofauna species but one species, the giant isopod *Tylos granulatus,* has been singled out as being important. The range of *T. granulatus* once extended across the whole southern African west coast from Swakopmund to Cape Point but has now been reduced to probably less than half that. More than two decades ago it was suggested that *T. granulatus* should be assigned red data status of perhaps 'Vulnerable' or 'Low Risk' (Brown 2000). Recent genetic research has uncovered high levels of population structure in southern African *T. granulatus* populations with two distinct lineages present on the west coast, to the north and south of a Hondeklip/Kleinzee break (Mbongwa et al. 2019). A recent, preliminary IUCN red list assessment supports the classification of *T. granulatus* as an endangered species under Criterion B due to its small natural habitat (sandy beaches, supratidal to low water mark only), declines in habitat quality, and fragmented populations as shown by the population genetics results (Linda Harris, Nelson Mandela Metropolitan University, pers. comm.). This species is very sensitive to disturbance, appears strongly photophobic and rapidly disappears as development encroaches, possibly due to alterations of beach state related to mining or light pollution. It is recommended that a range of sandy beach habitat types within the Boegoebaai area (away from the footprint of the proposed development) are earmarked for rehabilitation and are afforded some form of protection going forward. Priority should be given to rehabilitation and conservation of dissipative beaches as these have the richest faunal communities.

Mixed shore ecosystems, which include any area of the shore that is not pure rock or pure sand, makes up a significant (almost one third) of the intertidal shoreline habitats in the Boegoebaai area. These habitats have been poorly studied in general and were not specifically surveyed in this study. Species present in these habitats are mostly also present in the pure sections of each component habitat type, but species richness on mixed shore can be higher due to increased habitat complexity and heterogeneity.

Surf zone habitats are located offshore of sandy beaches, extending from the low water mark out to the back of the breaker zone where they grade into more extensive unconsolidated soft bottom subtidal habitats. Despite their turbulent nature, surf zone habitats are an important nursery and feeding area for a range of marine fish and invertebrate species. Pilot seine net sampling undertaken in surf zone habitats in the Boegoebaai region revealed low species richness (only three species), none of which are listed as ETP species. These habitats are not considered particularly sensitive in the Boegoebaai area.

Fauna that inhabits nonconsolidated (soft bottom) subtidal areas include both epifaunal and infaunal organisms. On the west coast of South Africa, benthic infaunal assemblages are typically made up of (a) deposit feeders, such as worms, which either ingest sediments to extract organic matter trapped between the grains or actively gather organic detritus; (b) suspension feeders, such as sea pens and some crab species, which consume drifting detritus and plankton from the water column, and (c) filter feeders, including bivalves and certain amphipods and polychaetes, that actively pump and filter water to capture suspended particles (Castro & Huber 1997). Predators in these soft-bottom habitats either burrow through sediments to hunt prey or ambush prey on the surface. According to the NBA (Sink et al. 2019a), nonconsolidated (soft bottom) subtidal around Boegoebaai are listed as “endangered” due to the limited protection afforded to these areas through the formal protected area network, and threats from flow reduction in the Orange River and disturbance from diamond mining. Much of this habitat type in the study area is listed as CBA-Restore or ESA and thus should be subject to as little disturbance as possible.

Consolidated (or rocky) subtidal habitat is widespread in the study area. Rocky reefs in shallow waters (less than 20 m depth) support dense kelp forests comprising mostly *Ecklonia maxima* and *Laminaria pallida*. Other important species that inhabit rocky reefs in the study area include whelks, limpets, sea anemones, black mussel, red algae (*Rhodymenia* sp., *Gigartina* sp., and *Champia* sp.), encrusting coralline algae, crabs, chitons, spiny starfish, reticulated starfish, barnacles, and sea cucumbers. Rocky reef habitats near Boegoebaai are classified as Vulnerable due to limited protection afforded to these areas through the formal protected area network. Much of this habitat is listed as CBA-Restore or Ecological Support Area (ESA) and thus should be subject to as little disturbance as possible.

A total of 72 water birds has been recorded in the Boegoebaai study area. Many of these birds are classified as threatened by the IUCN, including five species of coastal seabirds (20%) and 15 pelagic seabird species (25%). Many anthropogenic activities and uses of the marine environment (including those likely to be associated with the development of a new port and SEZ at Boegoebaai) pose a serious risk to these already threatened seabirds. At least two species of seabird (Bank Cormorant *Phalacrocorax neglectus* and White breasted cormorants *Phalacrocorax lucidus*) are known to breed on the rocky cliffs at Boegoebaai Point (the identified site for the port breakwater). Other costal seabird species are known to breed on the rocky and mixed shores (e.g. African Black Oystercatcher, *Haematopus moquini*) and on sandy beaches (White Fronted Plover, *Charadrius marginatus*) habitats in the study area. Much care needs to be taken to ensure that these threatened marine and coastal birds are not unduly disturbed by project activities.

At least thirty-six marine mammals are likely to occur in the study area, including numerous cetacean species (whales and dolphins). This also includes a breeding population of Cape fur seal *Arctocephalus pusillus* at Boegoebaai Point (the proposed site for the port breakwater). Seals only recently (1991) started breeding at this site and the colony remains small (n = 107 pups counted in 2007) but is growing. In South Africa, seals are protected under the Sea Birds and Seals Protection Act 1973 which states that it is an offence to pursue, shoot, wilfully disturb, kill or capture any sea bird or seal unless duly authorised by the relevant authority. Construction of a breakwater and or port at Boegoebaai is likely to seriously disturb both the seal colony and breeding seabirds present at this site. It is strongly recommended that consideration be given to identifying an alternate site for port development for this reason alone. Impacts of the proposed development on cetaceans that utilise this area are likely to arise from increased vessel traffic i.e., noise and the associated increase in risk of ship-strikes.

The South African west coast is generally a highly productive area that supports a high biomass of marine biota and several important fisheries. Surprisingly though, few of these fisheries extend into the Boegoebaai area. The Northern Cape is also sparsely populated which means it is also not heavily utilised by small scale commercial, subsistence or recreational fishers. Demersal trawling, demersal longline and pelagic longlining, are practiced in the offshore water greater than 200 m depth, but the area is not considered particularly important for any of these fisheries. There is an abalone ranching concession area that extends from the just south of Alexander Bay to Port Nolloth, but the owner of this fishing right is not practicing any ranching at present. Neither activity is likely to be negatively affected by the proposed development at Boegoebaai.

2.6.3 Sensitivity

A large proportion of the coastal habitat of the Boegoebaai SEZ area is rated a **medium environmental sensitivity**, largely on account of the exposed and mixed rocky shore contributing to a large proportion of coastal habitat in this region. The rocky and mixed shore habitats near Boegoebaai are classified as Vulnerable due to biodiversity they support and limited protection afforded to these areas through the formal protected area network. Much of these habitats within the SEZ area listed as CBA-Restore, and should be subject to as little disturbance as possible.

In general, the Boegoebaai beaches that were surveyed in this study can be described as relatively high energy beaches. The large, dissipative sandy shore to the south of the concession area has the lowest level of environmental sensitivity in our assessment, rated as **low environmental sensitivity**.

The most sensitive area is around the headland within the proposed port precinct area of the SEZ on account of the cliffs and rocky headland, with sheltered coves, suitable for seal haul out. This area is also host to the roosting and nesting sites of a number of IUCN listed seabirds. The area is rated as of **very igh environmental sensitivity** (this area includes a 300 m buffer to the north and south of the colony). It is strongly recommended that consideration be given to identifying an alternate site for port development. The options of relocating the breakwater to the north of the current site seem limited given the bathymetry of the area but there appear to be some options to the south of Boegoebaai Point. Potential areas have been identified in Figure 2-6.1 as areas to be considered as viable alternative areas based on their ecological sensitivity and their bathymetry profile immediately offshore which could accommodate the proposed breakwater. The areas identified are only approximate and this map should be used as high level guidance.

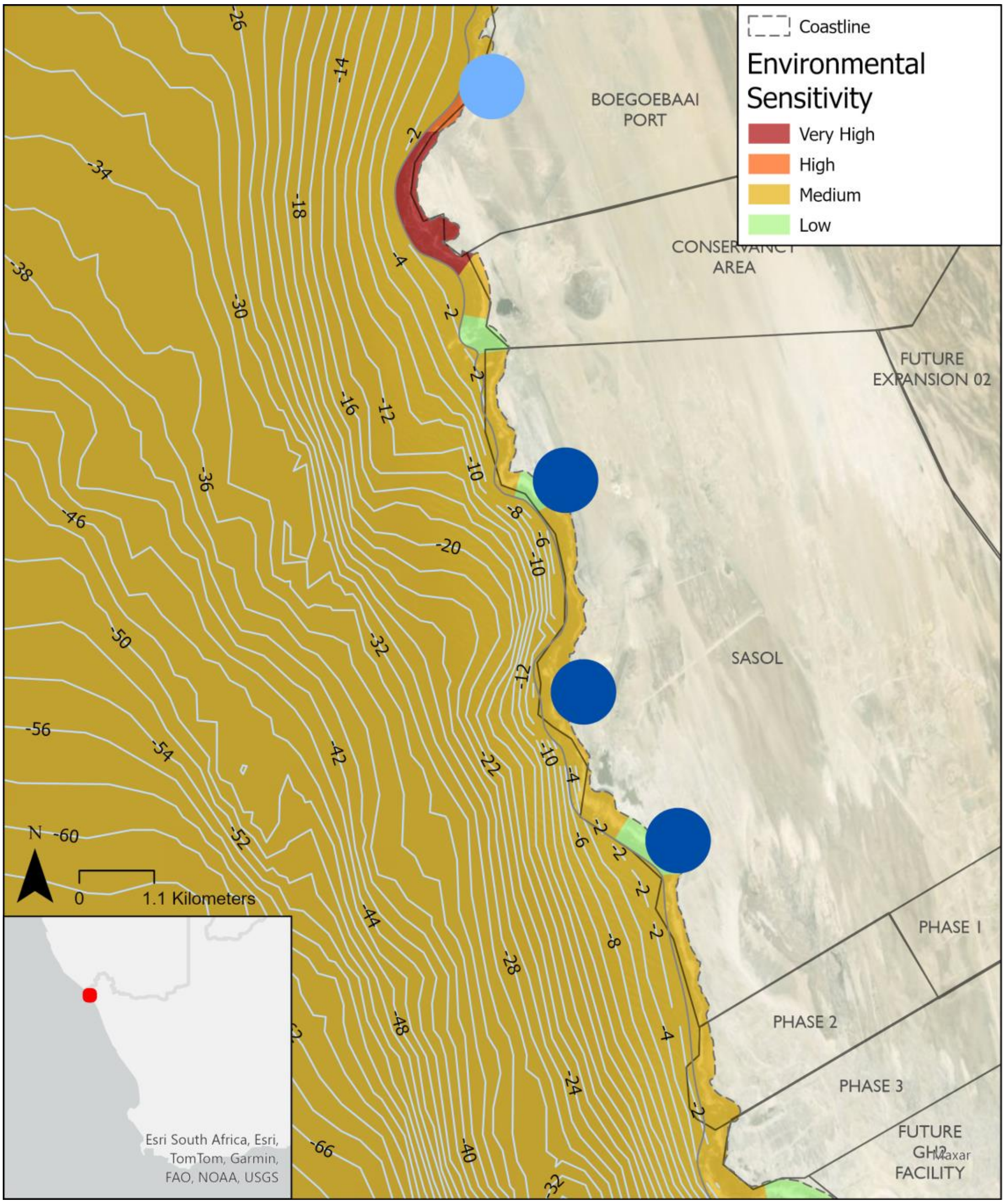

Figure 2-6.1. Potential sites (dark blue dot) and current proposed site (light blue dot) for the Boegoebaai breakwater location. 2 m resolution bathymetry contours and underlying sensitivity assessment is also displayed for guidance.

2.6.4 Offset and/or compensation requirements

As per the Draft Marine Biodiversity Sector Plan (2023), the development of new ports or harbours are considered **non-compatible** with CBA Natural and CBA Restore areas (Table 2-3.2). The environmentally preferable option would be to contrast the Boegoebaai port in an area not classified as CBA Natural or CBA Restore. However, complete avoidance or CBA Natural and/or Restore areas may not be feasible, as there are a plethora of small CBA Natural areas scattered all the way down the coast in the area under consideration in this study, and much of the offshore environment in the study area has been classified as CBA Restore (Figure 2-3.4). There is provision in Harris *et al.* (2022) that, should avoidance of identified CBA areas be deemed impossible, alternative CBAs and/or biodiversity offsets should be identified to meet targets for the same biodiversity features that are found at the site. This provision would be potentially applicable in this instance, however, we do not feel that this should extend to development on Boegoebaai Point, which is an area that has been identified as being of very high sensitivity and is likely irreplaceable.

As per the National Biodiversity Offset Guidelines (2023), a biodiversity offset is defined as a "measurable outcome of compliance with a formal requirement contained in an environmental authorisation to implement an intervention that has the purpose of counterbalancing the residual negative impacts of an activity, or activities, on biodiversity, through increased protection and appropriate management, after every effort has been made to avoid and minimise impacts, and rehabilitate affected". However, the guideline is noted to only be applicable in the terrestrial and freshwater realms and is not applicable in the offshore marine realm and estuarine ecosystems. (No explanation is provided in the gazette notice as to why this is the case. The gazette notice does, however, state that this does not mean that biodiversity offsetting is not required for residual negative impacts on biodiversity in estuarine ecosystems and the marine realm).

Given the foregoing, we consider that deferring to the IFC biodiversity offset requirements have merit. As per the mitigation hierarchy specified in IFC Performance Standard 1, it is required that an "offset" be designated to compensate for direct impacts on delineated "Natural habitat[3]" as a result of the proposed development activities that cannot be abated or reduced at the source. As per IFC Performance Standard 6, *"biodiversity offsets are a set of actions with on-the-ground 'measurable conservation outcomes' that can balance significant residual biodiversity losses caused by the client's project only after appropriate avoidance, minimization and restoration measures have been applied, with equivalent biodiversity gains in terms of ecological characteristics ("like-for-like or better") and size of expected gains"*. In other words, the decision to undertake a biodiversity offset cannot act as a replacement for mitigation and management measures to avoid significant impact.

The IFC Performance Standard 6 GN31 stipulates that two general types of offsets can be used to compensate for significant residual impacts:

- Restoration offsets, which are designed to remediate past damage to biodiversity (due to factors unrelated to the client's project) via rehabilitation or enhancement of biodiversity components (or even re-creation of ecosystems and their associated biodiversity values) at suitable offset sites; and,
- Protection or averted loss offsets protect biodiversity in an area demonstrated to be under threat of imminent or projected loss (due to factors unrelated to the client's project). Projections of the losses of biodiversity that will be averted by an offset require credible analysis of those trends. In some cases, this type of offset may not be appropriate where there is great uncertainty or there is a lack of stakeholder support for the analysis supporting those projections.

The main biodiversity offset design steps include:

1. Scoping, in consultation with relevant stakeholders, of potential conservation activities or offset sites within the landscape that could benefit the biodiversity values potentially impacted by the project (i.e., "like-for-like or better").
2. Assessing if the loss of biodiversity at the project site can be compensated by gains at the offset site.
3. Identifying means for securing offset activities over the long term, including, for example, legal protections.
4. Establishing an effective process for communities affected by the offset to participate in the design and implementation of the biodiversity offset.

[3] According to the IFC standards, "Natural habitats" are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition. This aligns well with the definition of CBA Natural areas which are defined as areas which must be safeguarded in their natural or near-natural state because they are critical for conserving biodiversity and maintaining ecosystem functioning.

5. Defining the specific offset activities and how they will be implemented in a biodiversity offset management plan, including the roles, responsibilities, and budget projections for the involved parties.

6. Establishing a funding mechanism to support the offset for as long as project impacts persist.

7. Designing a system for monitoring, evaluation, and adaptive management.

8. Ensuring that the project meets all applicable laws, regulations, and policies pertaining to biodiversity offsets.

Full consideration of a potential offset is beyond the scope of this study, but we strongly recommend that these steps be followed in identifying any offsets required to mitigate against negative impacts on any habitat identified as being CBA Natural or CBA restore on Figure 2-3.3.

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