PROPOSED INSTALLATION OF THE ASN 2AFRICA (WEST) CABLE SYSTEM, YZERFONTEIN, WEST COAST, SOUTH AFRICA

Marine Ecology Assessment

Prepared for:

ACER (Africa) Environmental Consultants

March 2021

PISCES

ENVIRONMENTAL SERVICES (PTY) LTD

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Prepared by

Andrea Pulfrich
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Contact Details:

Andrea Pulfrich

Pisces Environmental Services (Pty) Ltd

PO Box 302, McGregor 6708, South Africa,

Tel: +27 21 782 9553, E-mail: apulfrich@pisces.co.za

Website: www.pisces.co.za

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ABBREVIATIONS and UNITS

CBA	Critical Biodiversity Area
CBD	Convention of Biological Diversity
CCA	CCA Environmental
CITES	Convention on International Trade in Endangered Species
cm	centimetres
cm/sec	centimetres per second
CMS	Centre for Marine Studies
CMS	Convention on Migratory Species
CSIR	Council for Scientific and Industrial Research
dB	decibell
DEA	Department of Environmental Affairs
E	East
EBSA	Ecologically or Biologically Significant marine Areas
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EMF	Electromagnetic field
EMPr	Environmental Management Programme
ENE	east-northeast
ESA	Ecological Support Area
GIS	Global Information System
gC/m^2	grams Carbon per square metre
ha	hectares
Hz	Herz
IDZ	Industrial Development Zone
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
JNCC	Joint Nature Conservation Committee
kHz	kiloHerz
km	kilometre
km^2	square kilometre
MBES	Multibeam Echo Sounder
MPA	Marine Protected Area
m	metres
m^2	square metres
mg/m^3	milligrams per cubic metre
ml	millilitre
mm	millimetre
m/sec	metres per second
m^3/sec	cubic metres per second
NBA	National Biodiversity Assessment
NE	northeast

NNE	north-northeast
ppt	parts per thousand
PTS	Permenent Threshold Shifts
RIICZ	Robben Island Inner Controlled Zone
RIMCZ	Robben Island Middle Controlled Zone
RIOCZ	Robben Island Outer Controlled Zone
RIRZ	Robben Island Restricted Zone
ROV	Remotely Operated Vehicle
S	south
SANBI	South African National Biodiversity Institute
S&EIR	Scoping and Environmental Impact Report
SSW	south-southwest
SW	southwest
TTS	Temporary Threshold Shift
WSW	west-southwest
µg/l	micrograms per litre
µPa	micro Pascal
°C	degrees Centigrade
percent	percent
~	approximately
<	less than
>	greater than

GLOSSARY

Benthic	Referring to organisms living in, or on, the sediments of aquatic habitats (lakes, rivers, ponds, etc.).
Benthos	The sum total of organisms living in, or on, the sediments of aquatic habitats.
Benthic organisms	Organisms living in, or on, sediments of aquatic habitats.
Biodiversity	The variety of life forms, including the plants, animals and micro-organisms, the genes they contain and the ecosystems and ecological processes of which they are a part.
Biomass	The living weight of a plant or animal population, usually expressed on a unit area basis.
Biota	The sum total of the living organisms of any designated area.
Community structure	All the types of taxa present in a community and their relative abundance.
Community	An assemblage of organisms characterized by a distinctive combination of species occupying a common environment and interacting with one another.
Ecosystem	A community of plants, animals and organisms interacting with each other and with the non-living (physical and chemical) components of their environment
Environmental impact	A positive or negative environmental change (biophysical, social and/or economic) caused by human action.
Epifauna	Organisms, which live at or on the sediment surface being either attached (sessile) or capable of movement.
Habitat	The place where a population (*eg,* animal, plant, micro-organism) lives and its surroundings, both living and non-living.
Infauna	Animals of any size living within the sediment. They move freely through interstitial spaces between sedimentary particles or they build burrows or tubes.
Macrofauna	Animals >1 mm.
Macrophyte	A member of the macroscopic plant life of an area, especially of a body of water; large aquatic plant.
Meiofauna	Animals <1 mm.
Marine environment	Marine environment includes estuaries, coastal marine and nearshore zones, and open-ocean-deep-sea regions.
Pollution	The introduction of unwanted components into waters, air or soil, usually as result of human activity; *eg,* hot water in rivers, sewage in the sea, oil on land.

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

EXPERTISE AND DECLARATION OF INDEPENDENCE

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

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

This specialist report was compiled on behalf of ACER (Africa) Environmental Consultants for their use in preparing a Scoping and Environmental Impact Report (S&EIR) for the proposed installation of the ASN 2AFRICA (West) Cable System, off the West Coast of South Africa. I do hereby declare that Pisces Environmental Services (Pty) Ltd is financially and otherwise independent of the Applicant and ACER.

Dr Andrea Pulfrich

1. GENERAL INTRODUCTION

The Project involves the installation and operation of a fibre optical submarine cable to provide international high-speed connectivity and reliability. Alcatel Submarine Networks (ASN) has been appointed as the supplier and installer of the 2AFRICA (West) Cable System. The system will be installed in phases, with the final phase entailing the installation of a cable landing at Yzerfontein on the Western Cape, with further branches landing in Namibia, Angola and numerous other countries along the West African coastline. The system will connect Africa to Europe and the United Kingdom. The 2AFRICA/GERA (West) Cable would be operated by MTN (Pty) Ltd as the South African landing partner. MTN aims to secure local permits to land the 2AFRICA/GERA (East) cable at Yzerfontein.

Submarine telecommunications cables are important for international telecommunications networks, transporting almost 100% of transoceanic Internet traffic throughout the world (www.iscpc.org). Access to affordable international bandwidth is key to economic development in every country. Improvement in Africa's information technology infrastructure *via* telecommunications cables is expected to remove one of the current key inhibitors to development in Africa and support economic growth and opportunities on the continent.

In an African and local context, the cable will support the objectives set out by the New Partnership for Africa's Development (NEPAD) and provide a means of fulfilling the South African Government's requirements in terms of digital television broadcasting.

The main 2AFRICA (West) cable trunk be located in international waters ~200 to 500 km from the shore. From the main cable, branches will run through exclusive economic zones (EEZs) and territorial waters to the landing sites in each country. The cable route will approach South African coastal waters from Namibia and run parallel to the coastline along the West Coast in waters in excess of 1,000 m deep. The cable will enter South African Territorial Waters ~22 km (12 Nm) from the coast, with the proposed Yzerfontein landing site being the southern-most point of the cable (end station) (Figure 1). The exact position of the final section of the cable will be identified based on a combination of engineering, environmental and economic factors and will require offshore and nearshore surveying of the seabed; however, at Yzerfontein the general alignment for this landing will make landfall at the existing WACS Cable landing point and will take into consideration other existing cable systems within the area. Two landing locations at Yzerfontein are being considered; one at approximately 33°20'23.91˝S; 18°9'38.35˝E (preferred option), and the other ~40 m north at 33°20'23.87˝S; 18°9'38.09˝E (alternative option).

As part of the EIA process, an assessment was undertaken of the impact of the proposed Project on the South African fishing industry (see Japp & Wilkinson 2021).

1.1. Scope of Work

This specialist report was compiled as a desktop study on behalf of ACER Environmental Consultants, for inclusion in the S&EIR and for developing an EMPr for the proposed installation of the subsea cable system off Yzerfontein on the West Coast of South Africa.

The terms of reference for this study are:

- Undertake a desktop assessment of the potential impact that the ASN 2AFRICA (West) Cable System and related infrastructure will have on the Marine Benthic Environment based on the alignment selected. This must include the cable alignment from when it enters South Africa's waters from Namibia up until it lands in Yzerfontein. In this context, the specialist study should identify and discuss the following topics:
    a) An introduction with a brief project overview, study approach, methodology, and assumptions and limitations.
    b) A description of the marine environment of the project area, focusing on the benthic invertebrate communities based on available literature and previous experience.
    c) A description of the potential impacts of the project on the benthic invertebrate fauna, followed by an assessment of the significance of these impacts using the assessment criteria provided (it must be noted that marine telecommunications cables once installed have a legislated 500 m buffer either side of the cable where no fishing/trawling or anchoring of vessels may take place).
- Provide a detailed motivation why site investigations were deemed unnecessary.
- In assessment of impacts take into account the spatial scale, intensity, duration, etc. of the impacts and include recommendations for mitigation of impacts.
- Address specific issues and concerns raised by stakeholders during the public review phase of the EIA process (an Issues and Responses Report will be provided to specialists).
- Discuss any other sensitivities and important issues from a Marine Benthic perspective that are not identified in these terms of reference.

1.2. Approach to the Study

As determined by the terms of reference, this study has adopted a 'desktop' approach. The landing site at Yzerfontein is characterized by a stretch of dissipative sandy beach, no different from other similar beaches in the southern Benguela, and which have been adequately described in the scientific literature. A detailed site investigation was thus not deemed necessary and no new data have been collected.

All identified marine impacts are summarised, categorised and ranked in appropriate impact assessment tables, to be incorporated into the EIA Report.

1.2.1 Assumptions, Limitations and Information Gaps

As determined by the terms of reference, this study has adopted a 'desktop' approach. Consequently, the description of the natural baseline environment in the Marine Study Area is based on a review and collation of existing information and data from the scientific literature, and various internal reports. The information for the identification of potential impacts on benthic communities was drawn from various scientific publications, and information sourced from the Internet. The sources consulted are listed in the Reference chapter.

The assumptions made in this specialist assessment are:

- The study is based on the **project description made available to the specialists at the time of the commencement of the study** (cable routing, cable installation and construction approaches, *etc*.).

- Some important conclusions and associated assessments and recommendations made in this study are based on generic descriptions of cable installation processes sourced in the literature.
- Potential changes in the marine environment such as sea-level rise and/or increases in the severity and frequency of storms related to climate change are not included in the terms of reference and therefore not dealt with in this report.

Information gaps include:

- details of the benthic macrofaunal communities and potentially vulnerable species beyond the shelf break;
- details on demersal fish communities beyond the shelf break;
- information specific to the habitats and associated marine communities of theCape Canyon and Southeast Atlantic Deep Ocean; and
- current information on the distribution, population sizes and trends of most pelagic seabird, turtle and cetacean species occurring in South African waters and the project area in particular.

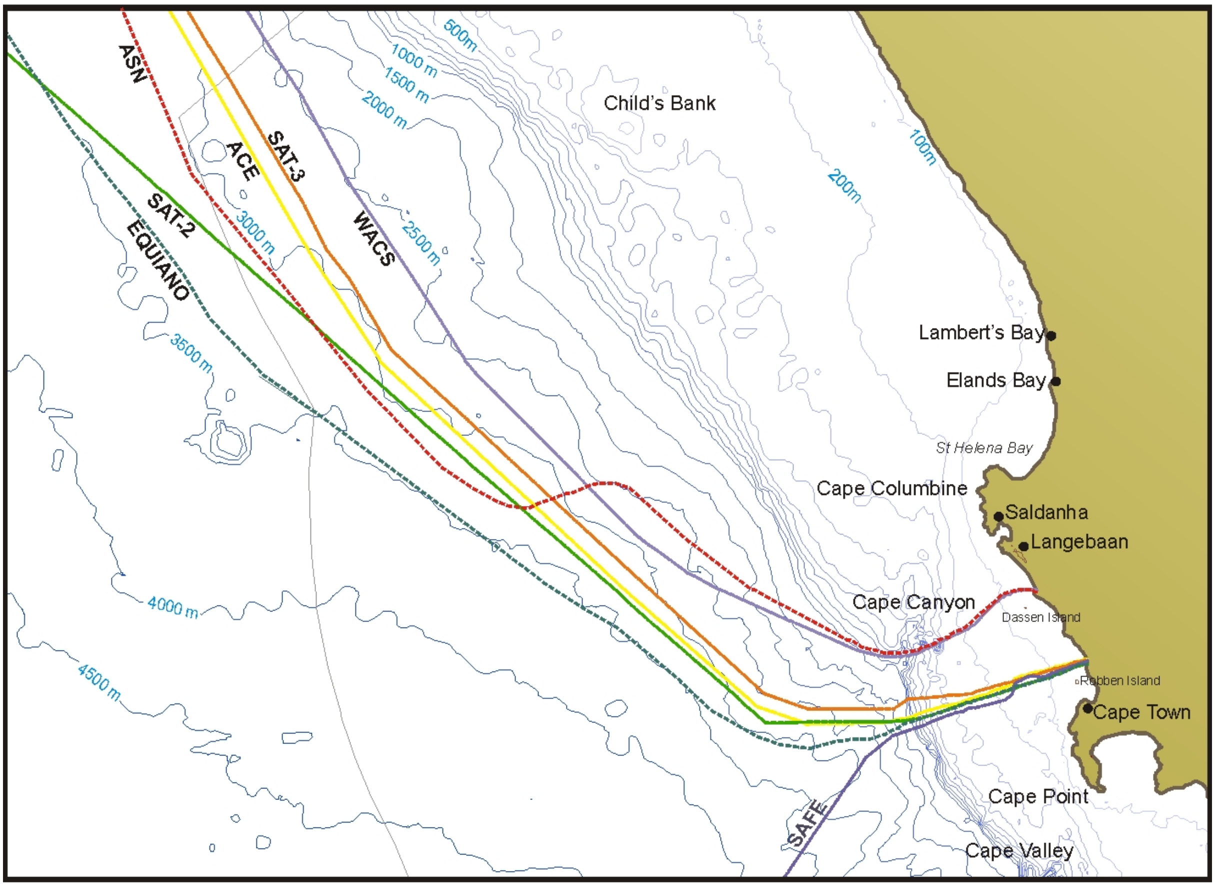

Figure 1: Map indicating proposed route of the ASN 2AFRICA (West) Cable System (red dashed line) in relation to other existing subsea cables and bathymetric features off the Western Cape. Places mentioned in the text and the extent of the Exclusive Economic Zone are also indicated. The routing of the proposed Equiano Cable is also illustrated.

2. DESCRIPTION OF THE PROPOSED PROJECT

2.1. Project Location

The project involves the installation and operation of a 35-mm diameter subsea fibre optic cable system, the main trunk of which will run ~14,000 km from the United Kingdom to South Africa. Branches will split from the main trunk to landing sites located *en route*, including Portugal, Guinea, Côte d'Ivoire, Ghana, Nigeria, Gabon, Congo and the Democratic Republic of Congo (DRC).

The main trunk of the marine cable will be located ~200 to 500 km from the shoreline in international waters, with branch cables running to the shoreline through territorial waters to the landing site in each country. South Africa will be the southern-most point of the cable with the end station located at approximately 33°20'23.91˝S; 18°9'38.35˝E at Yzerfontein on the West Coast (see Figure 1). The general alignment of the ASN 2AFRICA (West) Cable System will follow the alignment of the WACS cable. Nonetheless, a detailed bathymetric and geophysical survey will be undertaken along the cable route to inform the proposed routing along the WACS alignment, particularly up the continental slope and onto the shelf. A further survey will be conducted at the landing site to determine the final alignment of the cable at the shore crossing to access the existing WACS land-based infrastructure.

The landing site at Yzerfontein is characterized by a stretch of sandy beach (Figure 2). At the shore crossing, the buried subsea fibre optics cable will enter an existing WACS beach manhole and be run through existing cable sleeves to the connect to the terrestrial portion of the cable situated in the existing Cable Landing Station.

Figure 2: GoogleEarth image showing the routing of the proposed ASN 2AFRICA (West) Cable System in shallow waters and the shore crossing at the beach in Yzerfontein.

2.2. Installation Phase

The installation of the cable would involve:

- Following a Cable Route Desktop Study, a **cable route survey** is undertaken of the offshore and nearshore seabed to provide the necessary information for detailed engineering, construction, installation and subsequent maintenance of the cable. The main objective of the survey is to define a routing that will maximise cable survivability and avoid seabed features that may pose a hazard to cable integrity or that constitute habitat of conservation interest. In water of depths less than 1,000 m, multibeam swath bathymetry, sub-bottom profiling and side scan sonar surveys are undertaken along a 500-m wide corridor along the cable route. This allows adjustment of the cable position off the centre line if required by seabed hazards. In water of depths greater than 1,000 m, only multibeam bathymetry will be acquired. All the systems are hull-mounted and no towed equipment will be used. Sound levels from the acoustic equipment would range from 190 to 240 dB re 1 μPa at 1 m.
    - swath bathymetry systems (multibeam echo sounders (MBES)) produce a digital terrain model of the seafloor (source levels of 190-220 dB re 1 μPa at 1 m);
    - sub-bottom profiler seismic systems (e.g. boomer, sparker, chirp and sleeve gun), which generate profiles beneath the seafloor to give a cross section view of the sediment layers (source levels of 200-230 dB re 1 μPa at 1 m); and
    - side-scan sonar systems, which produce acoustic intensity images of the seafloor and are used to map the different sediment textures from associated lithology of the seafloor (source levels of 190-242 dB re 1 μPa at 1 m).

  Seabed sampling and *in situ* testing of seabed physical properties, are also usually undertaken to determine the type and thickness of sediment suitable for cable burial thereby assisting in defining the most appropriate mode of burial (e.g. ploughing, jetting, horizontal directional drilling and trenching).
- A **pre-lay grapnel run**, which is conducted immediately in advance of cable installation to remove any obstacles from the path of the final subsea cable route in water depths up to 1,500 m. The operation involves the towing of one or an array of grapnels by the main cable laying vessel, or another designated vessel, along the route where burial is required. The grapnel is towed at a rate that ensures it maintains contact with the seabed and can penetrate up to 40 cm into unconsolidated sediments. As a matter of routine, the grapnel is recovered and inspected at intervals of ~15 km along the route. Usually a single tow is made along the route, although in areas where other marine activity or seabed debris are high, additional runs may be required. Route clearance will be performed at specific locations where decommissioned cables are known to cross the ASN 2AFRICA (West) cable route where burial is planned.
- **Subsea cable installation**, which is undertaken by a specialised cable laying vessel that places the cable on the seabed along the predetermined route. At depths exceeding 1,500 m the cable can be placed directly on the seabed without the need for burial because at these depths it is highly unlikely that the cable could be damaged by contact with bottom tending deep sea fishing gears such as trawls and dredges. At depths shallower than 1,500 m, a trench 1.0 – 1.5 m deep is excavated in the unconsolidated sediments by a specialised subsea cable plough to receive the cable. The foot print of the plough is limited to the area in which the four plough skids and the plough share, which is approximately

0.75 m wide, are in contact with the seabed. Within this width, a spoil heap of unconsolidated material exists to one side of the plough line; but the height of this is normally less than 0.25 m and will be eroded with time due to bottom currents. The plough itself is 5 - 8 m wide, with a submerged weight of 13 tonnes. The plough is designed to backfill the cable burial trench during operation. Heavier armouring around the cable is also used to provide additional protection, particularly in areas of uneaven or rocky seabed. A Remotely Operated Vehicle ROV equipped with jetting tools may be deployed to undertake post lay burial to a depth of 1 m – this is reserved for restricted areas where ploughing is ineffective or impractical.

In the littoral zone (<15 m) to the landing point on the beach, the cable will be installed through 'direct shore end operation'. This involves floating the shore end cable directly from the main cable installation vessel to the beach landing point using buoys and assisted by small boats and divers. The sections of the cable crossing the low water mark and the beach will be buried in the seabed using diver-operated hand-held jets. The expected maximum width of the seabed fluidised by the jet burial is approximately 200 mm with burial to a target depth of 1.0 m. In rocky areas where burial cannot be achieved, or where additional cable protection is required, conduiting or an articulated split-pipe may be used to maximise cable security and protection.

- The **shore-crossing** of the cable segment from the low water mark to the beach man hole will involve trenching of the beach sediments to a target depth of 2 m below the beach level, or until bedrock is reached. The beach excavation will typically be carried out using tracked backhoe diggers and hand tools.

Table 1: Summary of Cable Installation Activities revalent to the marine environment.

Conditions/Environment	Installation Method
Water depth >1,500 m	No burial, cable surface laid without armouring.
Water depth < 1,500 m	Ploughing from the subsea cable lay vessel to a target water depth of 15 m with Post Lay Burial to a depth of 1 m reserved for areas where ploughing is ineffective or impractical.
Littoral zone	Trench excavation using diver-operated hand-held jets. . The subsea cable is generally protected by clamping additional pipe sections around it (articulated pipe or uraduct protection). In areas of hard seabed and high wave energy, the split pipes may be pinned to the seabed to prevent movement. Where possible, Existing anchor sites will be used.
Beach landing	Trenching above the High Water Mark (HWM) to achieve burial to 2 m depth

2.3. Operations

Once installed and operational the subsea cable will not require routine maintenance, although cable repair may be required as a result of physical damage (either anthropogenic or natural) or failure. To effect repairs on deep sea cables, the damaged subsea cable is cut at the seabed and each end separately brought to the surface, whereupon a new section is spliced in. Dedicated repair ships are on standby to respond to any emergency repairs.

2.4. Decommissioning

The subsea cable is expected to be operational for at least 25 years. Options for decommissioning of the system at the end of the Project's lifetime include retirement in place, or removal and salvage. Decommissioning would involve demolition, recovery and removal of terrestrial components (if they are not re-used for new cables or another purpose).

The subsea cable is likely to be left in place, as per current global industry practice. This is done in accordance with a Decommissioning Plan, details of which will be provided in the EIA Report.

3. DESCRIPTION OF THE BASELINE MARINE ENVIRONMENT

The descriptions of the physical and biological environments along the South African West Coast focus primarily on the study area between St Helena Bay and Cape Town. The purpose of this environmental description is to provide the marine baseline environmental context within which the proposed Subsea cable will be installed. The summaries presented below are based on information gleaned from Lane and Carter (1999), CCA and CMS (2001) and Penney *et al.* (2007) and more recent scientific studies undertaken in the general area. The description of benthic macrofaunal communities was provided by Natasha Karenyi of the South African National Biodiversity Institute, and the section on marine mammals was provided by Dr Simon Elwen of the Namibian Dolphin Project and Mammal Research Institute (University of Pretoria).

3.1. Geophysical Characteristics

3.1.1 Bathymetry

The continental shelf along the West Coast is generally wide and deep, although large variations in both depth and width occur. The shelf maintains a general north-northwest trend, widening north of Cape Columbine and reaching its widest (180 km) off the Orange River. Underwater features in the general project area include the Cape Canyon and Cape Valley. The cable route crosses the base of the Cape Canyon, but lies some 100 km north of the Cape Valley.

3.1.2 Coastal and Inner-shelf Geology and Seabed Geomorphology

Figure 3 illustrates the distribution of seabed surface sediment types off the South African north-western coast. The inner shelf is underlain by Precambrian bedrock (Pre-Mesozoic basement), whilst the middle and outer shelf areas are composed of Cretaceous and Tertiary sediments (Dingle 1973; Dingle *et al.* 1987; Birch *et al.* 1976; Rogers 1977; Rogers and Bremner 1991). As a result of erosion on the continental shelf, the unconsolidated sediment cover is generally thin, often less than 1 m. Sediments are finer seawards, changing from sand on the inner and outer shelves to muddy sand and sandy mud in deeper water. However, this general pattern has been modified considerably by biological deposition (large areas of shelf sediments contain high levels of calcium carbonate) and localised river input. A ~500-km long mud belt (up to 40 km wide, and of 15 m average thickness) is situated over the innershelf between the Orange River and St Helena Bay (Birch *et al.* 1976). Further offshore, sediment is dominated by muds and sandy muds. The continental slope, seaward of the shelf break, has a smooth seafloor, underlain by calcareous ooze.

Detailed descriptions of the seabed geomorphology along the cable route are provided in Fugro (2020). This report emphasizes the diversity of seabed sediments and features often over small spatial scales and at great depths.

3.2. Biophysical Characteristics

3.2.1 Wind Patterns

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

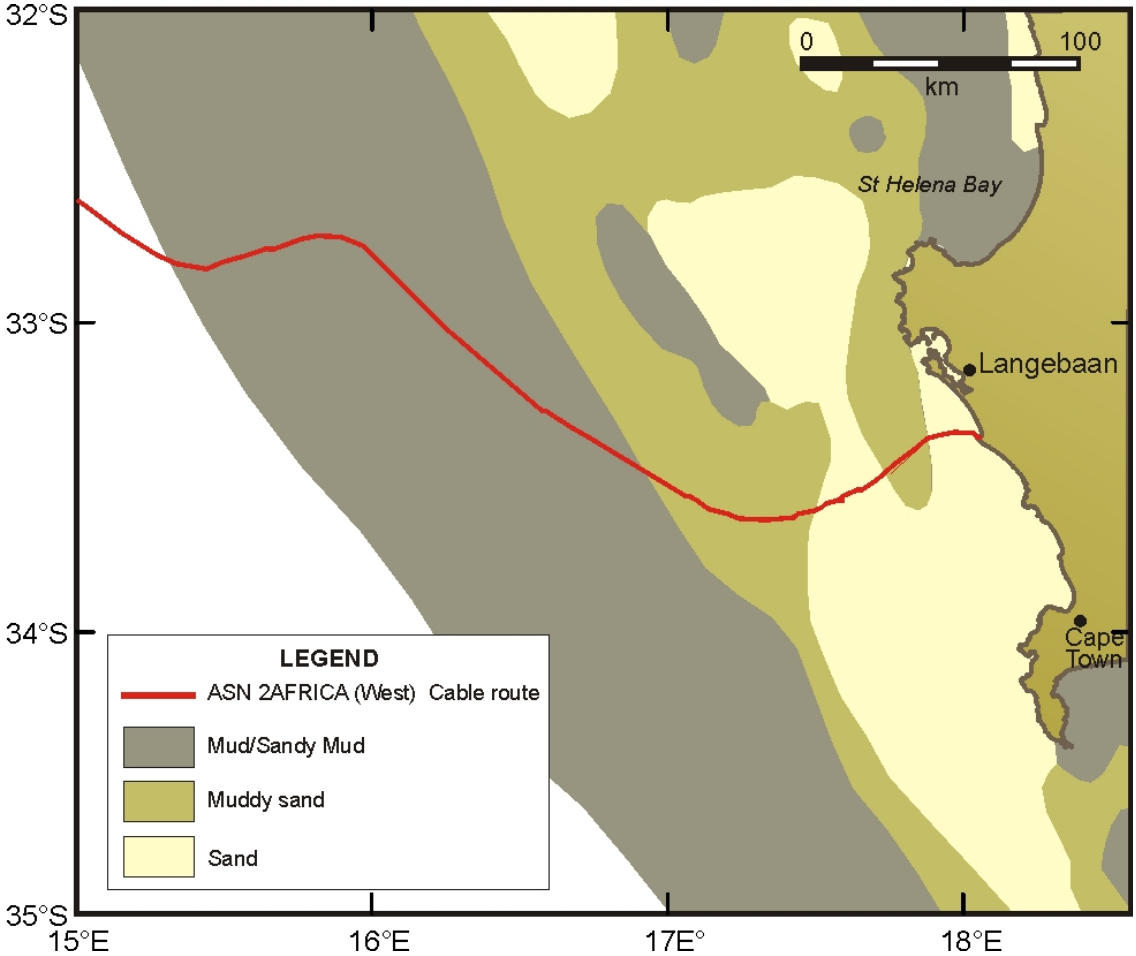

Figure 3: Sediment distribution on the continental shelf of the South African West Coast in relation to the proposed ASN 2AFRICA (West) Cable route (adapted from Rogers 1977).

The prevailing winds in the Benguela region are controlled by the South Atlantic subtropical anticyclone, the eastward moving mid-latitude cyclones south of southern Africa, and the seasonal atmospheric pressure field over the subcontinent. The south Atlantic anticyclone is a perennial feature that forms part of a discontinuous belt of high-pressure systems which encircle the subtropical southern hemisphere. This undergoes seasonal variations, being strongest in the austral summer, when it also attains its southernmost extension, lying south west and south of the subcontinent. In winter, the south Atlantic anticyclone weakens and migrates north-westwards.

These seasonal changes result in substantial differences between the typical summer and winter wind patterns in the region, as the southern hemisphere anti-cyclonic high-pressures system, and the associated series of cold fronts, moves northwards in winter, and southwards in summer. The strongest winds occur in summer (October to March), during which winds blow 98% of the time, and gales (winds exceeding 18 m/s or 35 kts) are frequent (CSIR 2006). Virtually all winds in summer come from the south to south-southeast, , averaging 20 - 30 kts and reaching speeds in excess of 100 km/h (60 kts) (Figure 4). The combination of these southerly/south-easterly winds drives the massive offshore movements of surface water, and the resultant strong upwelling of nutrient-rich bottom waters, which characterise this region in summer.

Winter remains dominated by southerly to south-easterly winds, but the closer proximity of the winter cold-front systems results in a significant south-westerly to north-westerly component (Figure 4). This 'reversal' from the summer condition results in cessation of upwelling, movement of warmer mid-Atlantic water shorewards and breakdown of the strong thermoclines which typically develop in summer. There are also more calms in winter, occurring about 4% of the time, and wind speeds generally do not reach the maximum speeds of summer. However, the westerly winds blow in synchrony with the prevailing south-westerly swell direction, resulting in heavier swell conditions.

3.2.2 Large-Scale Circulation and Coastal Currents

The southern African West Coast is strongly influenced by the Benguela Current. Current velocities in continental shelf areas generally range between 10–30 cm/s (Boyd and Oberholster 1994), although localised flows in excess of 50 cm/s occur associated with eddies (PRDW 2013). On its western side, flow is more transient and characterised by large eddies shed from the retroflection of the Agulhas Current, resulting in considerable variation in current speed and direction over the domain (PRDW 2013). In the south, the Benguela current has a width of 200 km, widening rapidly northwards to 750 km. The surface flows are predominantly wind-forced, barotropic and fluctuate between poleward and equatorward flow (Shillington *et al.* 1990; Nelson and Hutchings 1983). Fluctuation periods of these flows are 3 - 10 days, although the long-term mean current residual is in an approximate northwest (alongshore) direction. Current speeds decrease with depth, while directions rotate from predominantly north-westerly at the surface to south-easterly near the seabed. Near bottom shelf flow is mainly poleward with low velocities of typically <5 cm/s (Nelson 1989; Boyd and Oberholster 1994; Shannon and Nelson 1996; PRDW 2013).

The major feature of the Benguela Current is coastal upwelling and the consequent high nutrient supply to surface waters leads to high biological production and large fish stocks. The prevailing longshore, equatorward winds move nearshore surface water northwards and offshore. To balance the displaced water, cold, deeper water wells up inshore (average sea surface temperature 10 - 14°C). Although the rate and intensity of upwelling fluctuates with seasonal variations in wind patterns, the most intense upwelling tends to occur where the shelf is narrowest and the wind strongest. There are three upwelling centres in the southern Benguela, namely the Cape Point (34°S), Cape Columbine (33°S) and Namaqua (30°S) upwelling cells (Taunton-Clark 1985). Upwelling in these cells is seasonal, with maximum upwelling occurring between September and March. An example of one such strong upwelling event, followed by relaxation of upwelling and intrusion of warm Agulhas waters from the south, is shown in the satellite images in Figure 5.

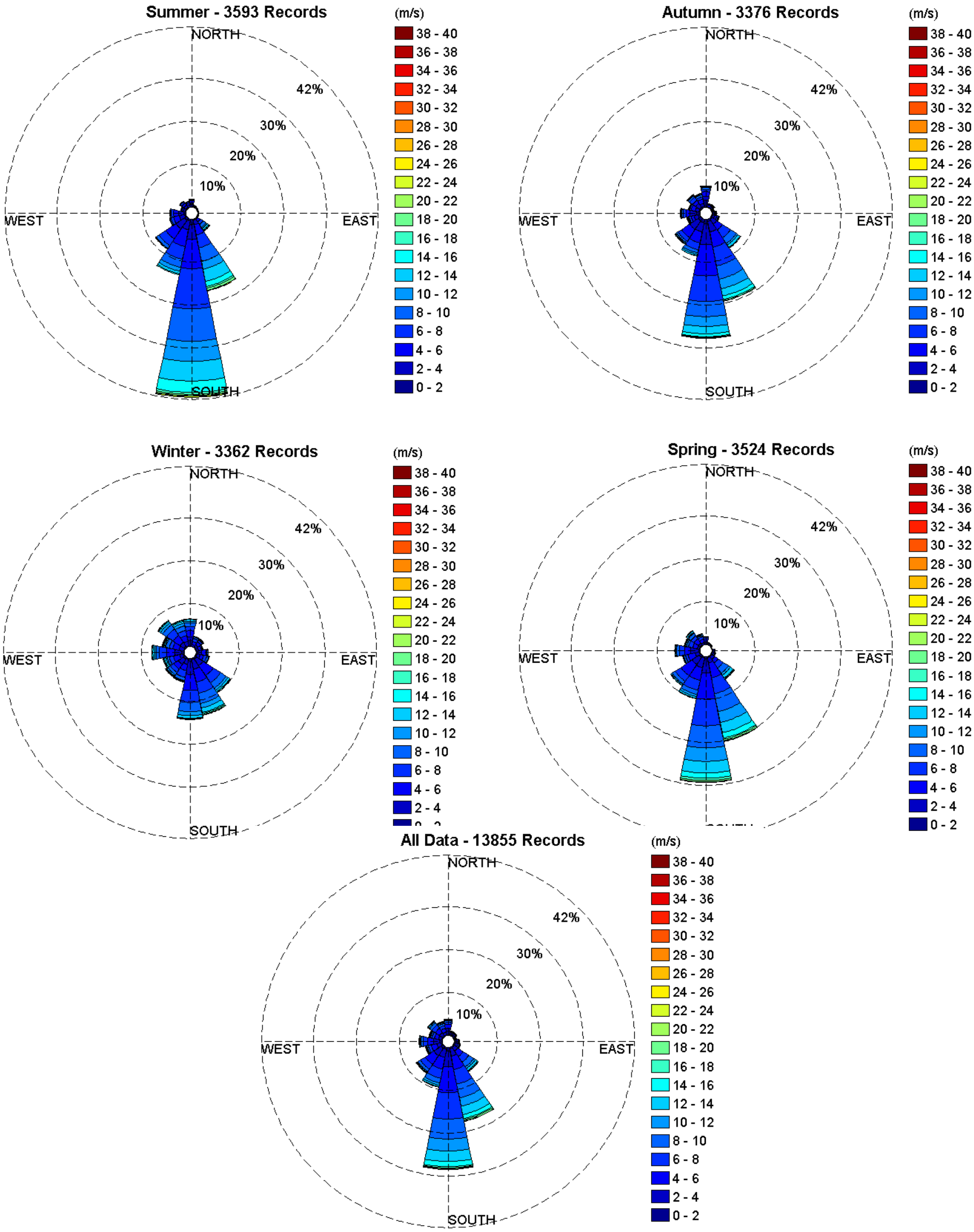

Figure 4: VOS Wind Speed vs Wind Direction data for the Cape Columbine area 32.0 to 32.9 S and 17.0 to 17.9 E (1903-11-01 to 2011-05-24; 13,855 records) (from CSIR).

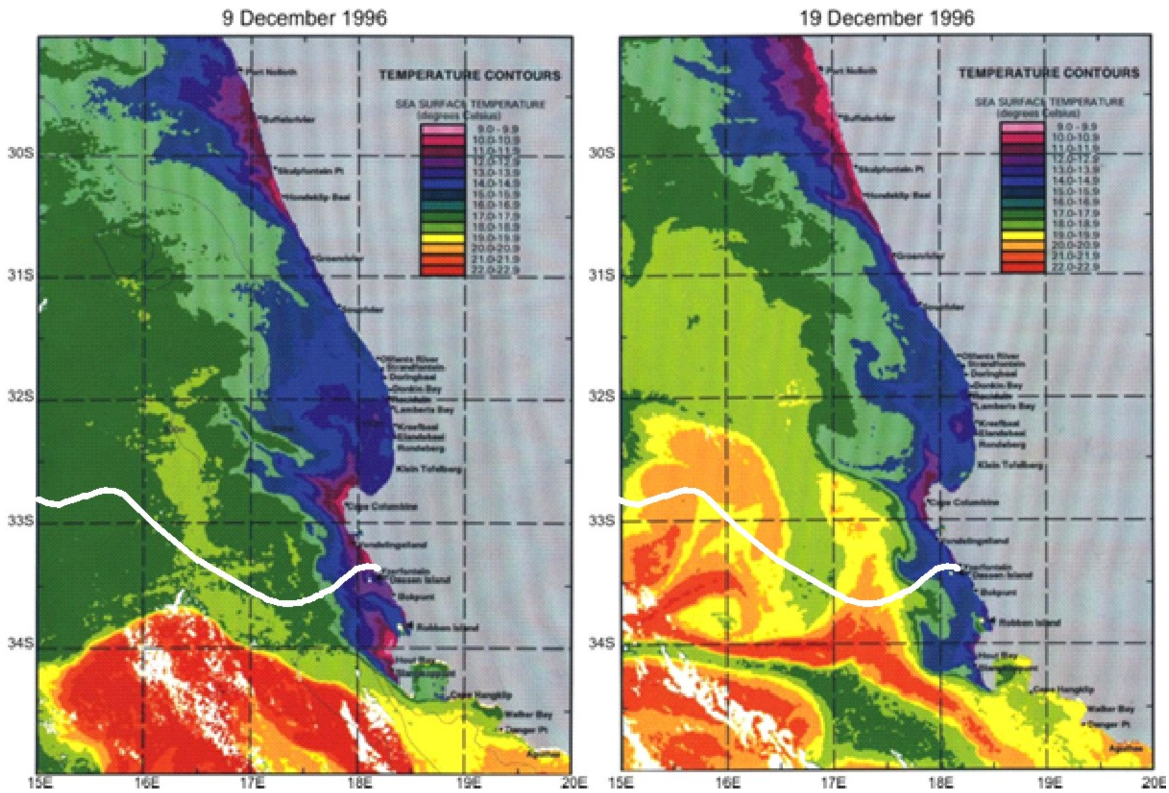

Figure 5: Satellite sea-surface temperature images showing upwelling intensity along the South African west coast on two days in December 1996 and the offshore warm Agulhas Rings (from Lane and Carter 1999), in relation to the proposed ASN 2AFRICA (West) Cable route (white line).

Where the Agulhas Current passes the southern tip of the Agulhas Bank (Agulhas Retroflection area), it may shed a filament of warm surface water that moves north-westward along the shelf edge towards Cape Point, and Agulhas Rings, which similarly move north-westwards into the South Atlantic Ocean (Figure 5, right). These rings may extend to the seafloor and west of Cape Town may split, disperse or join with other rings. The surface water of the Agulhas Current is generally >21 °C, and its influence west of Cape Agulhas results in average sea surface temperatures in the southern Benguela of 16 - 20 °C (Shannon 1985). During the process of ring formation, intrusions of cold sub-Antarctic water moves into the South Atlantic. The contrast in warm (nutrient-poor) and cold (nutrient-rich) water is thought to be reflected in the presence of cetaceans and large migratory pelagic fish species (Best 2007).

3.2.3 Waves and Tides

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

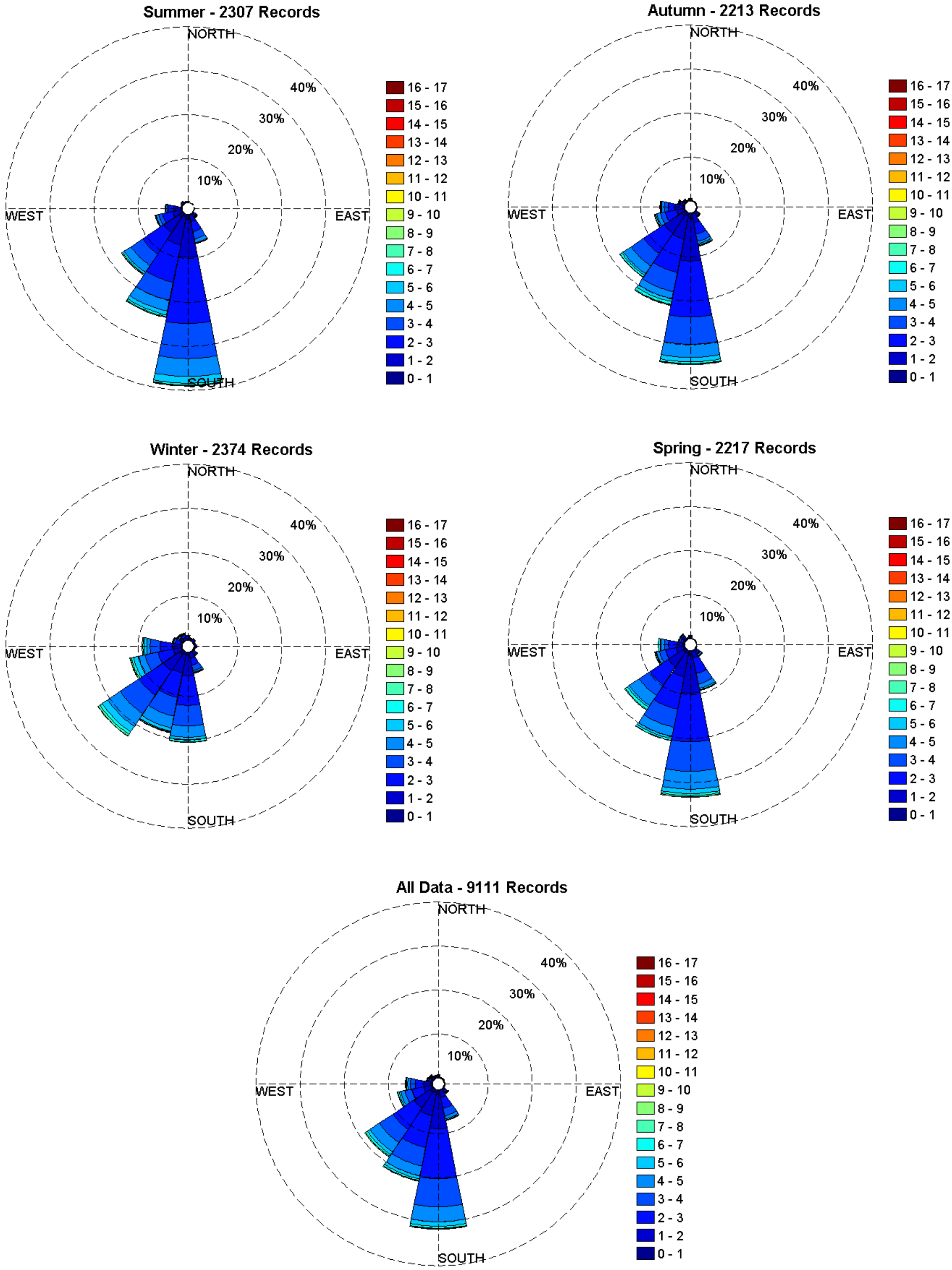

Figure 6: VOS Wave Height vs. Wave Direction data for the Cape Columbine area 32.0 to 32.9 S and 17.0 to 17.9 E (1903-11-01 to 2011-05-24; 9,111 records) (from CSIR).

The wave regime along the southern African west coast shows only moderate seasonal variation in direction, with virtually all swells throughout the year coming from the S and SSW direction (Figure 6). Winter swells are strongly dominated by those from the S and SSW, which occur almost 80% of the time, and typically exceed 2 m in height, averaging about 3 m, and often attaining over 5 m. With wind speeds capable of reaching 100 km/h during heavy winter south-westerly storms, winter swell heights can exceed 10 m.

In comparison, summer swells tend to be smaller on average, typically around 2 m, not reaching the maximum swell heights of winter. There is also a slightly more pronounced southerly swell component in summer. These southerly swells tend to be wind-induced, with shorter wave periods (~8 seconds), and are generally steeper than swell waves (CSIR 1996). These wind-induced southerly waves are relatively local and, although less powerful, tend to work together with the strong southerly winds of summer to cause the northward-flowing nearshore surface currents, and result in substantial nearshore sediment mobilisation, and northwards transport, by the combined action of currents, wind and waves.

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

3.2.4 Water

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

Seawater temperatures on the continental shelf of the southern Benguela typically vary between 6°C and 16°C. Well-developed thermal fronts exist, demarcating the seaward boundary of the upwelled water. Upwelling filaments are characteristic of these offshore thermal fronts, occurring as surface streamers of cold water, typically 50 km wide and extending beyond the normal offshore extent of the upwelling cell. Such fronts typically have a lifespan of a few days to a few weeks, with the filamentous mixing area extending up to 625 km offshore. South and east of Cape Agulhas, the Agulhas retroflection area is a global “hot spot” in terms of temperature variability and water movements.

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

3.2.5 Upwelling and Plankton Production

During upwelling the comparatively nutrient-poor surface waters are displaced by enriched deep water, supporting substantial seasonal primary phytoplankton production. The cold, upwelled water is rich in inorganic nutrients, the major contributors being various forms of nitrates, phosphates and silicates (Chapman and Shannon 1985). Nutrient concentrations of upwelled water of the Benguela system attain 20 µM nitrate-nitrogen, 1.5 µM phosphate and 15-20 µM silicate, indicating nutrient enrichment (Chapman and Shannon 1985). This is mediated by nutrient regeneration from biogenic material in the sediments (Bailey *et al.* 1985). Modification of these peak concentrations depends upon phytoplankton uptake which varies according to phytoplankton biomass and production rate. The range of nutrient concentrations can thus be large but, in general, concentrations are high.

High phytoplankton productivity in the upper layers again depletes the nutrients in these surface waters. This results in a wind-related cycle of plankton production, mortality, sinking of plankton detritus and eventual nutrient re-enrichment occurring below the thermocline as the phytoplankton decays. Biological decay of plankton blooms can in turn lead to “black tide” events, as the available dissolved oxygen is stripped from the water during the decomposition process (see below). Subsequent anoxic decomposition by sulphur reducing bacteria can result in the formation and release of hydrogen sulphide (Pitcher and Calder 2000).

3.2.6 Organic Inputs

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

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

An associated phenomenon ubiquitous to the Benguela system are red tides (dinoflagellate and/or ciliate blooms) (see Shannon and Pillar 1985; Pitcher 1998). Also referred to as Harmful Algal Blooms (HABs), these red tides can reach very large proportions, extending over several square kilometres of ocean (Figure 7, left). Toxic dinoflagellate species can cause extensive mortalities of fish and shellfish through direct poisoning, while degradation of organic-rich material derived from both toxic and non-toxic blooms results in oxygen depletion of subsurface water (Figure 7, right).

3.2.7 Low Oxygen Events

The continental shelf waters of the Benguela system are characterised by low oxygen concentrations with <40% saturation occurring frequently (e.g. Visser 1969; Bailey *et al.* 1985). The low oxygen concentrations are attributed to nutrient remineralisation in the bottom waters of the system (Chapman and Shannon 1985). The absolute rate of this is dependent upon the net organic material build-up in the sediments, with the carbon rich mud deposits playing an important role. As the mud on the shelf is distributed in discrete patches (see Figure 3), there are corresponding preferential areas for the formation of oxygen-poor water. The main area of low-oxygen water formation in the southern Benguela region is in St Helena Bay (Chapman and Shannon 1985; Bailey1991; Shannon and O'Toole 1998; Bailey 1999; Fossing *et al.* 2000). The spatial distribution of oxygen-poor water in this area is subject to short- and medium-term variability in the volume of hypoxic water that develops. De Decker (1970) showed that the occurrence of low oxygen water off Lambert's Bay is seasonal, with highest development in summer/autumn. Bailey and Chapman (1991), on the other hand, demonstrated that in the St Helena Bay area daily variability exists as a result of downward flux of oxygen through thermoclines and short-term variations in upwelling intensity. Subsequent upwelling processes can move this low-oxygen water up onto the inner shelf, and into nearshore waters, often with devastating effects on marine communities.

Figure 7: Red tides can reach very large proportions (left,Photo: www.e-education.psu.edu) and can lead to mass stranding, or 'walk-out' of rock lobsters, such as occurred at Elands Bay in February 2002 (Photo: www.waterencyclopedia.com)

Periodic low oxygen events in the nearshore region can have catastrophic effects on the marine communities leading to large-scale stranding of rock lobsters, and mass mortalities of marine biota and fish (Newman and Pollock 1974; Matthews and Pitcher 1996; Pitcher 1998; Cockcroft *et al.* 2000) (see Figure 7, right). The development of anoxic conditions as a result of the decomposition of huge amounts of organic matter generated by phytoplankton blooms is the main cause for these mortalities and walkouts. The blooms develop over a period of unusually calm wind conditions when sea surface temperatures where high. Algal blooms usually occur during summer-autumn (February to April) but can also develop in winter during the 'berg' wind periods, when similar warm windless conditions occur for extended periods.

3.2.8 Turbidity

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulate matter. Total Suspended Particulate Matter (TSPM) can be divided into

Particulate Organic Matter (POM) and Particulate Inorganic Matter (PIM), the ratios between them varying considerably. The POM usually consists of detritus, bacteria, phytoplankton and zooplankton, and serves as a source of food for filter-feeders. Seasonal microphyte production associated with upwelling events will play an important role in determining the concentrations of POM in coastal waters. PIM, on the other hand, is primarily of geological origin consisting of fine sands, silts and clays.

Concentrations of suspended particulate matter in shallow coastal waters can vary both spatially and temporally, typically ranging from a few mg/ℓ to several tens of mg/ℓ (Bricelj and Malouf 1984; Berg and Newell 1986; Fegley *et al.* 1992). Field measurements of TSPM and PIM concentrations in the Benguela current system have indicated that outside of major flood events, background concentrations of coastal and continental shelf suspended sediments are generally <12 mg/ℓ, showing significant long-shore variation (Zoutendyk 1995). Considerably higher concentrations of PIM have, however, been reported from southern African West Coast waters under stronger wave conditions associated with high tides and storms, or under flood conditions. During storm events, concentrations near the seabed may even reach up to 10,000 mg/ℓ (Miller and Sternberg 1988).

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

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

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

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

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

3.3. The Biological Environment

Biogeographically, the ASN 2AFRICA (West) Cable System will traverse the Southeastern Atlantic Deep Ocean and Southern Benguela Ecoregions (Sink *et al.* 2019) (Figure 8). These were previously referred to as the Southwestern and Atlantic Offshore Cape Bioregions (Emanuel *et al.* 1992; Lombard *et al.* 2004). The coastal, wind-induced upwelling characterising the Western Cape coastline, is the principle physical process which shapes the marine ecology of the southern Benguela region. The Benguela system is characterised by the presence of cold surface water, high biological productivity, and highly variable physical, chemical and biological conditions. The West Coast is, however, characterized by low marine species richness and low endemicity (Awad *et al.* 2002).

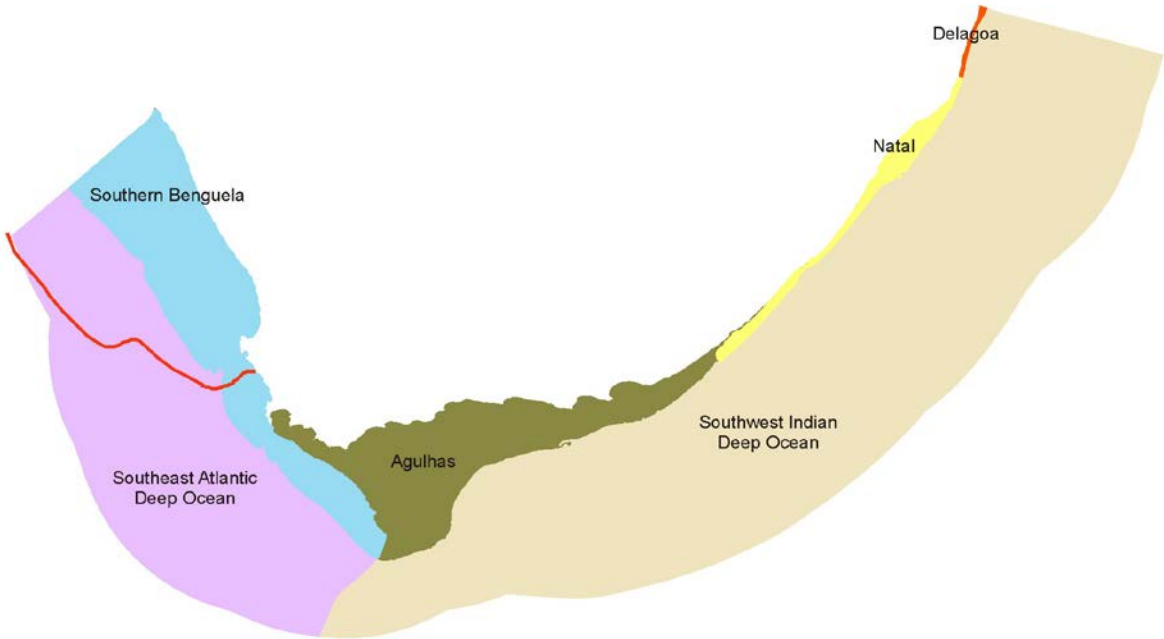

Figure 8: The South African inshore and offshore ecoregions in relation to the proposed ASN 2AFRICA (West) Cable route (red line) (adapted from Sink *et al.* 2019).

The seabed communities in the project area lie within the Namaqua photic, sub-photic and continental slope biozones, which extend from the shore to the shelf edge, and beyond to the lower deepsea slope, respectively. The benthic habitats of South Africa were mapped as part of the 2018 National Biodiversity Assessment (Sink *et al.* 2019) to develop assessments of the ecosystem threat status and ecosystem protection level. The benthic ecosystem types were subsequently mapped (Figure 9) and assigned an ecosystem threat status based on their level of protection (Figure 10).

Although most of the cable route falls within offshore habitats considered by the 2018 National Biodiversity Assessment (Sink *et al.* 2019) as of 'least concern', the cable does pass through portions of the inner and outer continental shelf on the West Coast rated as 'vulnerable' (Cape Rocky Midshelf Mosaic, Cape Sandy Inner Shelf and Cape Lower Canyon) and 'endangered' (Cape Upper Canyon) (Figure 10).

The biota of nearshore and offshore marine habitats on the West Coast are relatively robust, being naturally adapted to an extremely dynamic environment where biophysical disturbances are commonplace. Communities within this region are largely ubiquitous, particular only to substrate type (i.e. hard vs. soft bottom), exposure to wave action, or water depth. Habitats specific to the study area include:

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

The biological communities consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales). No rare or endangered species have been recorded (Awad *et al.* 2002). The biological communities 'typical' of these habitats are described briefly below, focussing both on dominant, commercially important and conspicuous species, as well as potentially threatened or sensitive species, which may be affected by the proposed ASN 2AFRICA (West) Cable System routing.

3.3.1 Sandy Substrate Habitats and Biota

The benthic biota of soft bottom substrates constitutes invertebrates that live on, or burrow within, the sediments, and are generally divided into megafauna (>10 cm), macrofauna (animals >1 mm) and meiofauna (<1 mm).

Intertidal Sandy Beaches

The coastline between Cape Town and Saldanha Bay is dominated by sandy shores, although isolated rocky headlands occur within 500 m to the north and south of the proposed shore crossing at the Yzerfontein beach. 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 and Hesp 1985). The composition of their faunal communities is largely dependent on the interaction of wave energy, beach slope and sand particle size, which is termed beach morphodynamics. Three morphodynamic beach types are described: dissipative, reflective and intermediate beaches (McLachlan *et al.* 1993). Generally, dissipative beaches are relatively wide and flat with fine sands and low wave energy. Waves start to break far from the shore in aseries of spilling breakers that 'dissipate' their energy along a broad surf zone. This generates

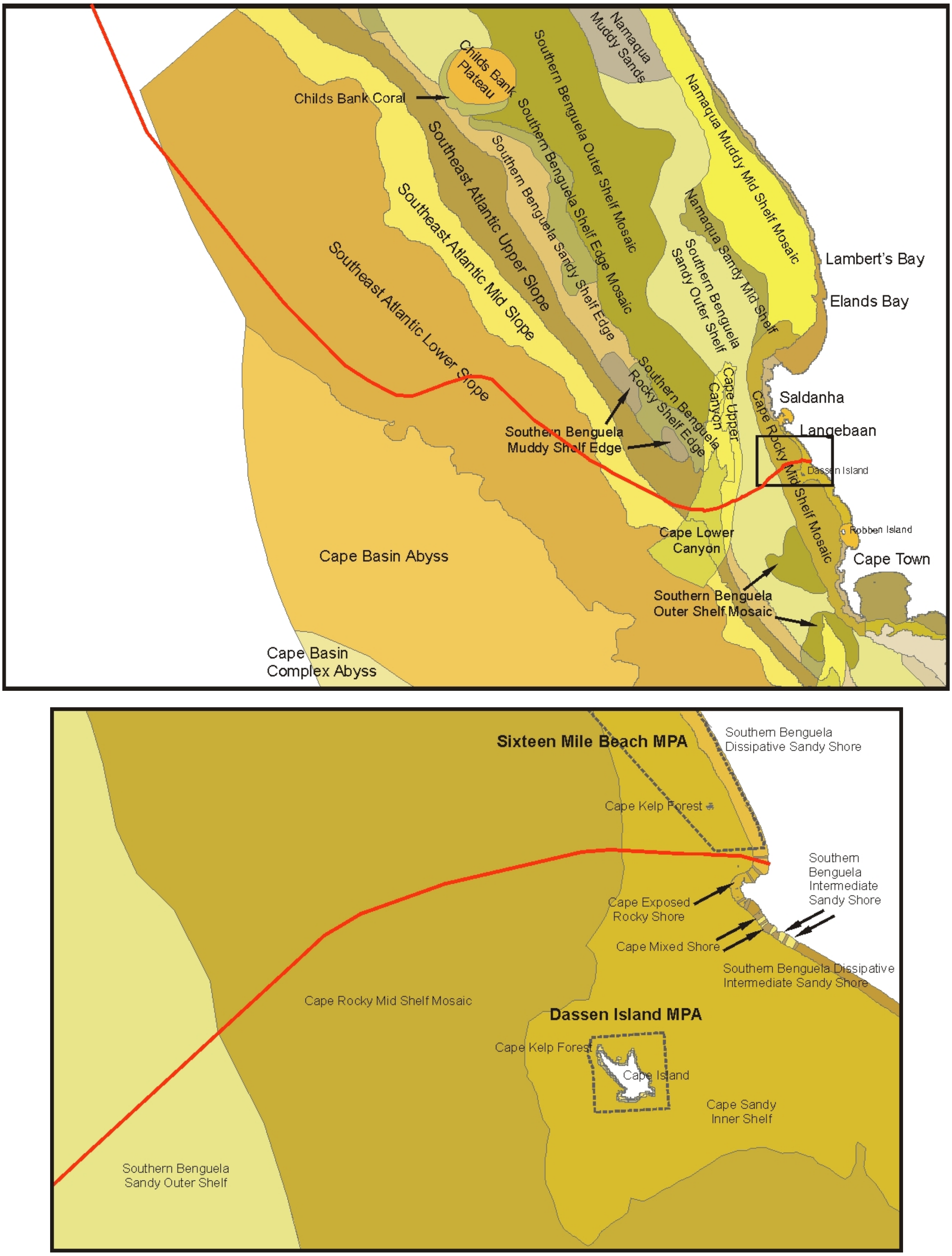

Figure 9: Offshore benthic and coastal ecosystem types along the Southwestern Cape coastline (top), detailing the habitats affected by the proposed ASN 2AFRICA (West) Cable (red line). Those inshore habitats affected by the shore crossing are detailed in the insert (bottom). Marine Protected Areas are also illustrated

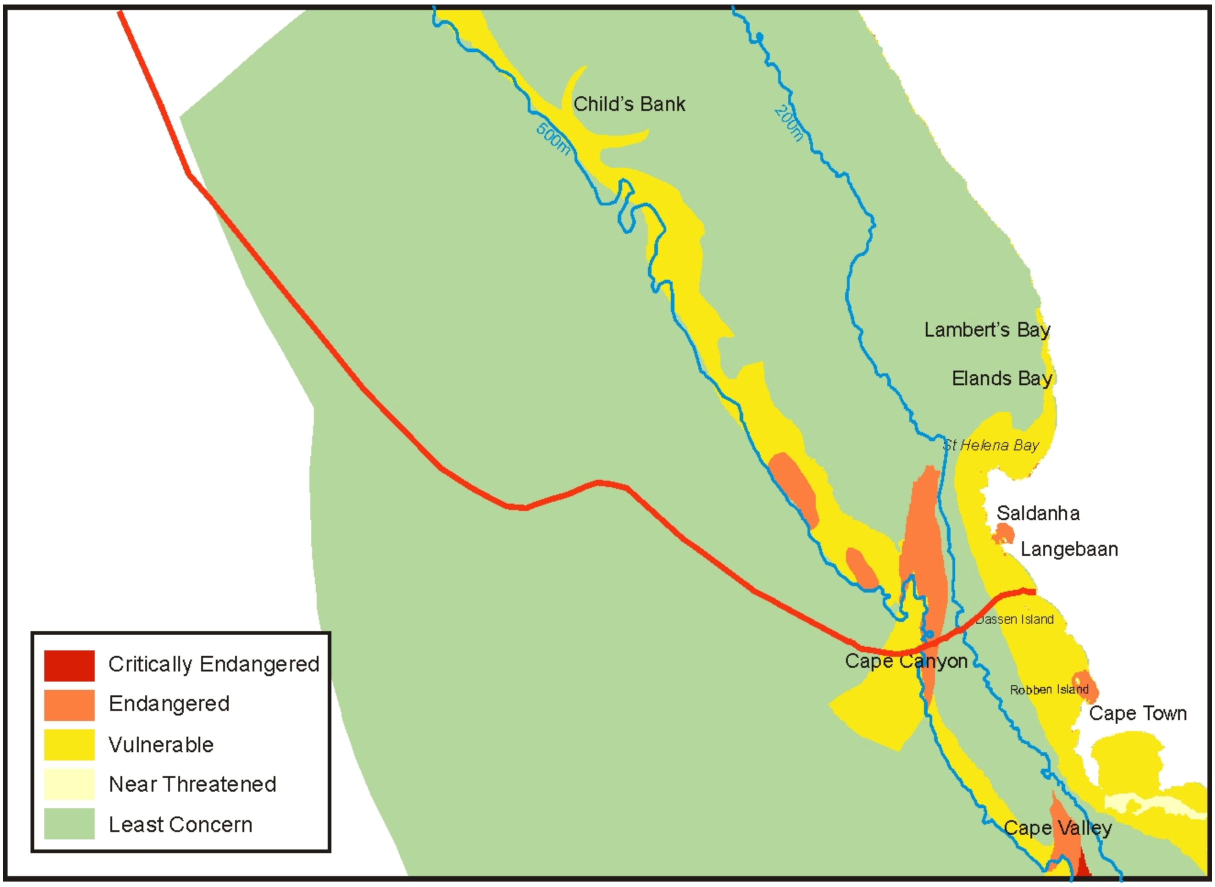

Figure 10: Ecosystem threat status for coastal and offshore benthic habitat types on the South African West Coast in relation to the proposed ASN 2AFRICA (West) Cable route (red line) (adapted from Sink *et al.* 2019).

slow swashes with long periods, resulting in less turbulent conditions on the gently sloping beach face. These beaches usually harbour the richest intertidal faunal communities. Reflective beaches in contrast, have high wave energy, and are coarse grained (>500 µm sand) with narrow and steep intertidal beach faces. The relative absence of a surf-zone causes the waves to break directly on the shore causing a high turnover of sand. The result is depauperate faunal communities. Intermediate beach conditions exist between these extremes and have a very variable species composition (McLachlan *et al.* 1993; Jaramillo *et al.* 1995; Soares 2003). This variability is mainly attributable to the amount and quality of food available. Beaches with a high input of e.g. kelp wrack have a rich and diverse drift-line fauna, which is sparse or absent on beaches lacking a drift-line (Branch and 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 and McLachlan 1990).

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 11), supplemented by data from various publications on West Coast sandy beach biota (e.g. Bally 1987; Brown *et al.* 1989; Soares *et al.* 1996, 1997; Nel 2001; Nel *et al.* 2003; Soares 2003; Branch *et al.* 2010; Harris 2012). The macrofaunal communities of sandy beaches are generally

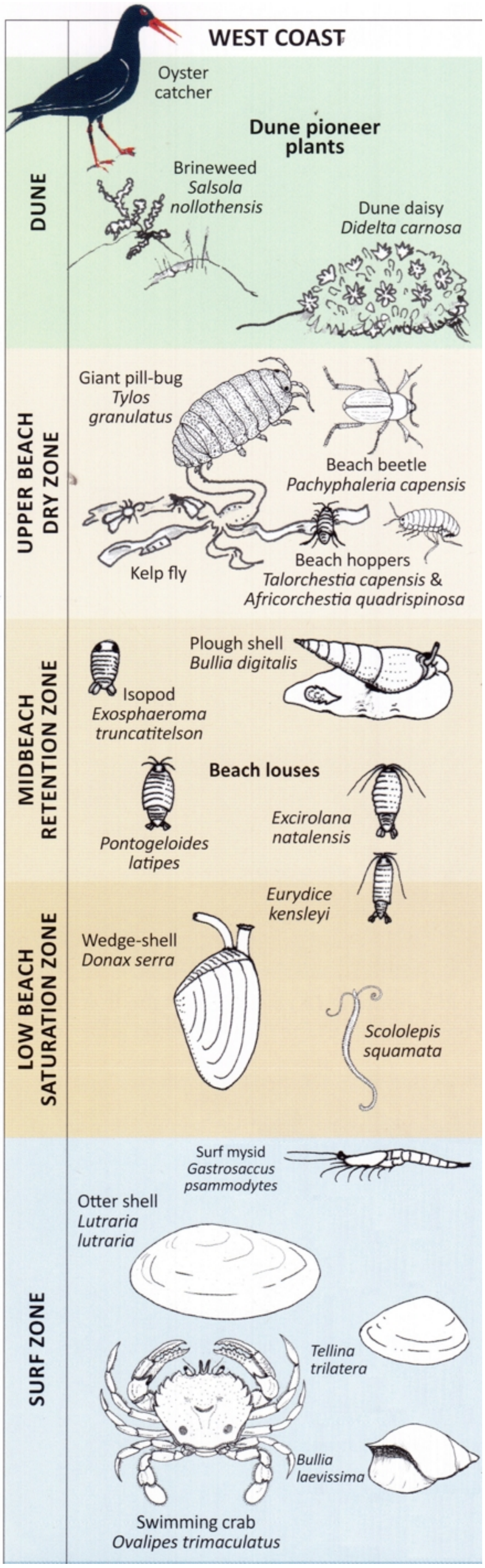

Figure 11: Schematic representation of the West Coast intertidal beach zonation (adapted from Branch and Branch 2018). Species commonly occurring on the Western Cape beaches are listed.

ubiquitous throughout the southern African West Coast region, being particular only to substratum type, wave exposure and/or depth zone. Due to the exposed nature of the coastline in the study area, most beaches are of the intermediate to reflective type. According to the 2018 National Biodiversity Assessment (Sink *et al.* 2019), the beach at Yzerfontein is classified as dissipative (see Figure 9, bottom). The landing site is characterised by a gently sloping beach of ~80 m width (Fugro 2020). The supralittoral zone 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 *Africhorcestia (=Talorchestia)*. The intertidal zone or mid-littoral zone has a vertical range of about 2 m. This mid-shore region is characterised by the cirolanid isopods *Pontogeloides latipes*, *Eurydice* (longicornis=) *kensleyi*, and *Excirolana natalensis*, the polychaetes *Scolelepis squamata, Orbinia angrapequensis, Nepthys hombergii* and *Lumbrineris tetraura*, and amphipods of the families Haustoridae and Phoxocephalidae (Figure 12). In some areas, juvenile and adult sand mussels *Donax serra* may also be present in considerable numbers.

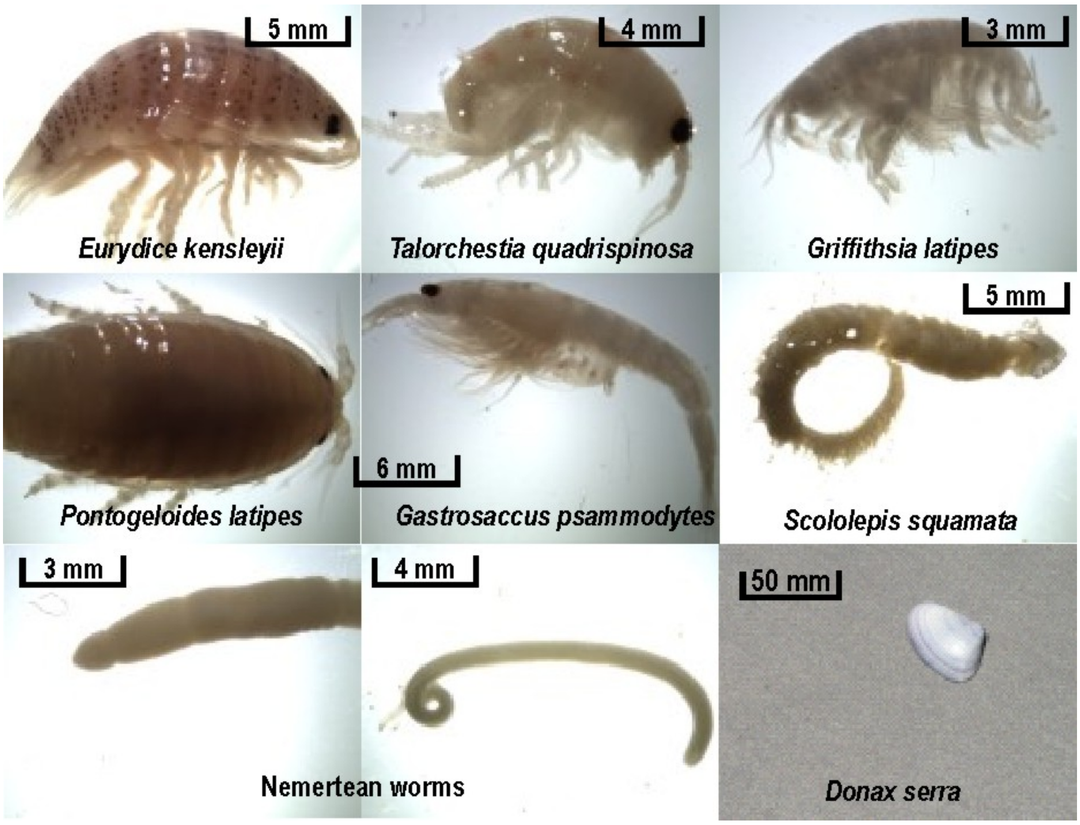

Figure 12: Common beach macrofaunal species occurring on exposed West Coast beaches.

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

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

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

Nearshore and Offshore unconsolidated habitats

Numerous studies have been conducted on southern African West Coast continental shelf benthos, mostly focused on mining, pollution or demersal trawling impacts (Christie and Moldan 1977; Moldan 1978; Jackson and McGibbon 1991; Environmental Evaluation Unit 1996; Field and Parkins 1997; Parkins and Field 1997; 1998; Pulfrich and Penney 1999; Goosen *et al.* 2000; Savage *et al.* 2001; Steffani and Pulfrich 2004a, 2004b; 2007; Steffani 2007a; 2007b; Steffani 2009a, 2009b, 2010a, 2010b, 2010c; Atkinson *et al.* 2011; Steffani 2012a, 2012b, 2014; Karenyi 2014; Steffani *et al.* 2015; Biccard and Clark 2016; Biccard *et al.* 2016; Duna *et al.* 2016; Karenyi *et al.* 2016; Biccard *et al.* 2017, 2018, 2019). These studies, however, concentrated on the continental shelf and nearshore regions, and consequently the benthic fauna of the outer shelf and continental slope (beyond ~450 m depth) are very poorly known. This is primarily due to limited opportunities for sampling as well as the lack of access to Remote Operated Vehicles (ROVs) for visual sampling of hard substrata.

To date very few areas on the continental slope off the West Coast have been biologically surveyed. Although sediment distribution studies (Rogers & Bremner 1991) suggest that the outer shelf is characterised by unconsolidated sediments (see Figure 3), recent surveys conducted between 180 m and 480 m depth revealed high proportions of hard ground rather than unconsolidated sediment. Due to the lack of information on benthic macrofaunal communities beyond the shelf break, no description can be provided for those deepwater habitats. The description below for areas on the continental shelf, is drawn from recent surveys by Karenyi (2014), Duna *et al.* (2016), Mostert *et al.* (2016), and Giwhala *et al.* (2018, 2019).

Three macro-infauna communities have been identified on the inner- (0-30 m depth) and mid-shelf (30-150 m depth, Karenyi unpublished data). The inner-shelf community, which is affected by wave action, is characterised by various mobile predators (e.g. the gastropod *Bullia laevissima* and polychaete *Nereis* sp.), sedentary polychaetes and isopods. The mid-shelf community inhabits the mudbelt and is characterised by the mud prawns *Callianassa* sp. and *Calocaris barnardi*. A second mid-shelf sandy community occurring in sandy sediments, is characterised by various polychaetes including deposit-feeding *Spiophanes soederstromi* and *Paraprionospio pinnata*. Polychaetes, crustaceans and molluscs make up the largest proportion of individuals, biomass and species on the west coast (Figure 11). The distribution of species within these communities are inherently patchy reflecting the high natural spatial and temporal variability associated with macro-infauna of unconsolidated sediments (e.g. Kenny *et al.* 1998; Kendall and Widdicombe 1999; van Dalfsen *et al.*

2000; Zajac *et al.* 2000; Parry *et al.* 2003), with evidence of mass mortalities and substantial recruitments recorded on the South African West Coast (Steffani and Pulfrich 2004). Given the state of our current knowledge of South African macro-infauna it is not possible to determine the threat status or endemicity of macro-infauna species on the West Coast, although such research is currently underway (pers. comm. Ms N. Karenyi, SANBI and NMMU).

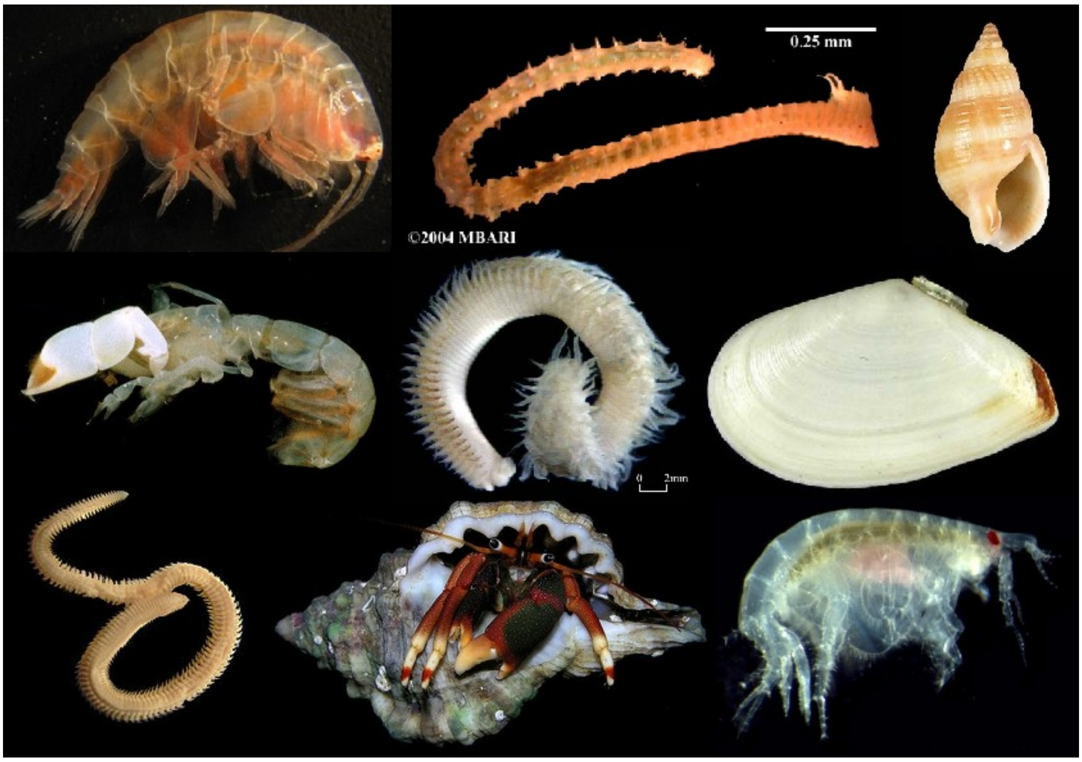

Figure 13: Benthic macrofaunal genera commonly found in nearshore sediments include: (top: left to right) *Ampelisca*, *Prionospio*, *Nassarius*; (middle: left to right) *Callianassa*, *Orbinia*, *Tellina*; (bottom: left to right) *Nephtys*, hermit crab, *Bathyporeia*.

Generally species richness increases from the inner shelf across the mid shelf and is influenced by sediment type (Karenyi unpublished data). The highest total abundance and species diversity was measured in sandy sediments of the mid-shelf. Biomass is highest in the inshore (± 50 g/m^2 wet weight) and decreases across the mid-shelf averaging around 30 g/m^2 wet weight. This is contrary to Christie (1974) who found that biomass was greatest in the mudbelt at 80 m depth off Lamberts Bay, where the sediment characteristics and the impact of environmental stressors (such as low oxygen events) are likely to differ from those further offshore.

Benthic communities are structured by the complex interplay of a large array of environmental factors. Water depth and sediment grain size are considered the two major factors that determine benthic community structure and distribution on the South African west coast (Christie 1974, 1976; Steffani and Pulfrich 2004a, 2004b, 2007; Steffani 2007a, 2007b amongst others) and elsewhere in the world (e.g. Gray 1981; Ellingsen 2002; Bergen *et al.* 2001; Post *et al.* 2006). However, studies have shown that shear bed stress - a measure of the impact of current velocity on sediment – oxygen concentration (Post *et al.* 2006; Currie *et al.* 2009; Zettler *et al.* 2009), productivity

(Escaravage *et al.* 2009), organic carbon and seafloor temperature (Day *et al.* 1971) may also strongly influence the structure of benthic communities. There are clearly other natural processes operating in the deepwater shelf areas of the West Coast that can over-ride the suitability of sediments in determining benthic community structure, and it is likely that periodic intrusion of low oxygen water masses is a major cause of this variability (Monteiro and van der Plas 2006; Pulfrich *et al.* 2006). In areas of frequent oxygen deficiency, benthic communities will be characterised either by species able to survive chronic low oxygen conditions, or colonising and fast-growing species able to rapidly recruit into areas that have suffered oxygen depletion. The combination of local, episodic hydrodynamic conditions and patchy settlement of larvae will tend to generate the observed small-scale variability in benthic community structure.

The invertebrate macrofauna are important in the marine benthic environment as they influence major ecological processes (e.g. remineralisation and flux of organic matter deposited on the sea floor, pollutant metabolism, sediment stability) and serve as important food source for commercially valuable fish species and other higher order consumers. As a result of their comparatively limited mobility and permanence over seasons, these animals provide an indication of historical environmental conditions and provide useful indices with which to measure environmental impacts (Gray 1974; Warwick 1993; Salas *et al.* 2006).

Also associated with soft-bottom substrates are demersal communities that comprise epifauna and bottom-dwelling vertebrate species, many of which are dependent on the invertebrate benthic macrofauna as a food source. According to Lange (2012) the continental shelf on the West Coast between depths of 100 m and 250 m, contained a single epifaunal community characterised by the hermit crabs *Sympagurus dimorphus* and *Parapaguris pilosimanus*, the prawn *Funchalia woodwardi* and the sea urchin *Brisaster capensis*. Atkinson (2009) also reported numerous species of urchins and burrowing anemones beyond 300 m depth off the West Coast.

3.3.2 Rocky Substrate Habitats and Biota

The following general description of the intertidal and subtidal habitats for the West Coast is based on Field *et al.* (1980), Branch and Branch (1981), Branch and Griffiths (1988) and Field and Griffiths (1991). The biological communities of rocky intertidal and subtidal reefs are generally ubiquitous throughout the southern African West Coast region, being particular only to wave exposure, turbulence and/or depth zone.

Intertidal Rocky Shores

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

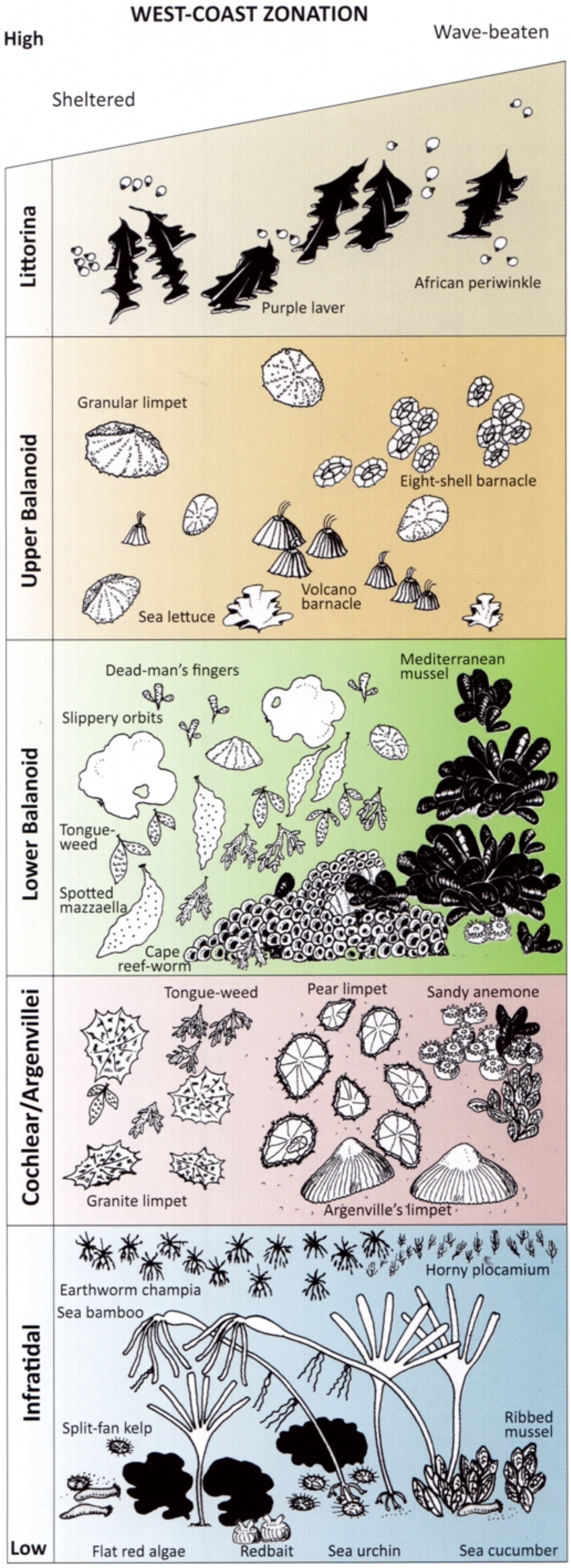

Figure 14: Schematic representation of the West Coast intertidal zonation (adapted from Branch and Branch 2018).

West Coast rocky intertidal shores can be divided into five zones on the basis of their characteristic biological communities: The Littorina, Upper Balanoid, Lower Balanoid, Cochlear/Argenvillei and the Infratidal Zones. These biological zones correspond roughly to zones based on tidal heights (Figure 14 and Figure 15). Tolerance to the physical stresses associated with life on the intertidal, as well as biological interactions such as herbivory, competition and predation interact to produce these five zones.

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

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

Figure 15: Typical rocky intertidal zonation on the southern African west coast.

Toward the lower Mid-littoral or Lower Balanoid zone, biological communities are determined by exposure to wave action. On sheltered and moderately exposed shores, a diversity of algae abounds with a variable representation of: green algae – *Ulva* spp, *Codium* spp.; brown algae – *Splachnidium rugosum*; and red algae – *Aeodes orbitosa*, *Mazzaella (=Iridaea) capensis*, *Gigartina polycarpa* (=*radula*), *Sarcothalia* (=*Gigartina*) *striiata*, and with increasing wave exposure *Plocamium rigidum* and *P. cornutum*, and *Champia lumbricalis*. The gastropods *Cymbula granatina* and *Burnupena* spp. are also common, as is the reef building polychaete *Gunnarea capensis*, and the small cushion starfish *Patiriella exigua*. On more exposed shores, almost all of the primary space can be occupied by the dominant alien invasive mussel *Mytilus galloprovincialis*. First recorded in 1979 (although it is likely to have arrived in the late 1960s), it is now the most abundant and widespread invasive marine species spreading along the entire West Coast and parts of the South Coast (Robinson *et al.* 2005). *M. galloprovincialis* has partially displaced the local mussels *Choromytilus meridionalis* and *Aulacomya ater* (Hockey and Van Erkom Schurink 1992), and competes with several indigenous limpet species (Griffiths *et al.* 1992, Steffani and Branch 2003a, 2003b). Recently, another alien invasive has been recorded, the acorn barnacle *Balanus glandula*, which is native to the west coast of North America where it is the most common intertidal barnacle. The presence of *B. glandula* in South Africa was only noticed a few years ago as it had always been confused with the native barnacle *Cthamalus dentatus* (Simon-Blecher *et al.* 2008). There is, however, evidence that it has been in South Africa since at least 1992 (Laird and Griffith 2008). At the time of its discovery, the barnacle was recorded from 400 km of coastline from Elands Bay to Misty Cliffs near Cape Point (Laird and Griffith 2008). When present, the barnacle is typically abundant at the mid zones of semi-exposed shores.

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

Very recently, the invasion of West Coast rocky shores by another mytilid, the small *Semimytilus algosus*, was noted (de Greef *et al.* 2013). It is hypothesized that this species has established itself fairly recently, probably only in the last ten years. Its current range extends from the Groen River mouth in the north to Bloubergstrand in the south. Where present, it occupies the lower intertidal zone, where they completely dominate primary rock space, while *M. galloprovincialis* dominates higher up the shore. Many shores on the West Coast have thus now been effectively partitioned by the three introduced species, with *B. glandula* colonizing the upper intertidal, *M. galloprovincialis* dominating the mid-shore, and now *S. algosus* smothering the low-shore (de Greef *et al.* 2013).

Rocky Subtidal Habitat and Kelp Beds

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

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

Kelp beds absorb and dissipate much of the typically high wave energy reaching the shore, thereby providing important partially-sheltered habitats for a high diversity of marine flora and fauna, resulting in diverse and typical kelp-forest communities being established (Figure 16). Through a combination of shelter and provision of food, kelp beds support recruitment and complex trophic food webs of numerous species, including commercially important rock lobster stocks (Branch 2008).

Figure 16: The canopy-forming kelp *Ecklonia maxima* provides an important habitat for a diversity of marine biota (Photo: Geoff Spiby).

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

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

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

There is substantial spatial and temporal variability in the density and biomass of kelp beds, as storms can remove large numbers of plants and recruitment appears to be stochastic and unpredictable (Levitt *et al.* 2002; Rothman *et al.* 2006). Some kelp beds are dense, whilst others are less so due to differences in seabed topography, and the presence or absence of sand and grazers.

Deep-water coral communities and Vulnerable Marine Ecosystems

There has been increasing interest in deep-water corals in recent years because of their likely sensitivity to disturbance and their long generation times. These benthic filter-feeders generally occur at depths below 150 m with some species being recorded from as deep as 3,000 m. Some species form reefs while others are smaller and remain solitary. Corals add structural complexity to otherwise uniform seabed habitats thereby creating areas of high biological diversity (Breeze *et al.* 1997; MacIssac *et al.* 2001). Deep water corals establish themselves below the thermocline where there is a continuous and regular supply of concentrated particulate organic matter, caused by the flow of a relatively strong current over special topographical formations which cause eddies to form. Nutrient seepage from the substratum might also promote a location for settlement (Hovland *et al.* 2002). In the productive Benguela region, substantial areas on and off the shelf edge should thus potentially be capable of supporting rich, cold water, benthic, filter-feeding communities. Evidence from video footage taken on hard-substrate habitats in 100 - 120 m depth off southern

Namibia and to the south-east of Child's Bank (De Beers Marine, unpublished data) (Figure 17) suggest that vulnerable communities including gorgonians, octocorals and reef-building sponges do occur on the continental shelf.

The deep water habitats off the West Coast are thought to be characterised by a number of Vulnerable Marine Ecosystem (VME) indicator species such as sponges, soft corals and hard corals. The distribution of 22 potential VME indicator taxa for the South African EEZ were recently mapped, with those from the West Coast listed in Table 2 (Atkinson & Sink 2018).

The concept of a 'Vulnerable Marine Ecosystem' (VME) centres upon the presence of distinct, diverse benthic assemblages that are limited and fragmented in their spatial extent, and dominated (in terms of biomass and/or spatial cover) by rare, endangered or endemic component species that are physically fragile and vulnerable to damage (or structural/biological alteration) by human activities (Parker *et al.* 2009; Auster *et al.* 2011; Hansen *et al.* 2013). As the component species of VMEs typically exhibit traits of slow growth, late maturity, low fecundity, unpredictable recruitment and high longevity, VMEs are characterised by sensitivity to changes in environmental conditions and slow recovery from damage (FAO 2009).

Figure 17: Gorgonians and bryozoans communities recorded on deep-water reefs (100-120 m) off the southern African West Coast (Photos: De Beers Marine).

VMEs are known to be associated with higher biodiversity levels and indicator species that add structural complexity, resulting in greater species abundance, richness, biomass and diversity compared to surrounding uniform seabed habitats (Buhl-Mortensen *et al.* 2010; Hogg *et al.* 2010; Barrio Froján *et al.* 2012; Beazley *et al.* 2013, 2015). Compared to the surrounding deep-sea environment, VMEs typically form biological hotspots with a distinct, abundant and diverse fauna, many species of which remain unidentified. Levels of endemism on VMEs are also relatively high compared to the deep sea. The coral frameworks offer refugia for a great variety of invertebrates and fish (including commercially important species) within, or in association with, the living and dead coral framework thereby creating spatially fragmented areas of high biological diversity. The skeletal remains of Scleractinia coral rubble and Hexactinellid poriferans can also represent another important deep-sea habitat, acting to stabilise seafloor sediments allowing for colonisation by distinct infaunal taxa that show elevated abundance and biomass in such localised habitats (Bett & Rice 1992; Raes & Vanreusel 2005; Beazley *et al.* 2013; Ashford *et al.* 2019).

Table 2: Table of Potential VME species from the continental shelf and shelf edge off the southwestern Cape (Atkinson & Sink 2018)

Phylum	Name	Common Name
Porifera	*Suberites dandelenae*	Amorphous solid sponge
	Rossella cf. antarctica	Glass sponge
Cnidaria	*Melithaea* spp.	Colourful sea fan
	Thouarella spp.	Bottlebrush sea fan
Family: Isididae	?	Bamboo coral
	Anthoptilum grandiflorum	Large sea pen*
	Lophelia pertusa	Reef-building cold water coral
	Stylaster spp.	Fine-branching hydrocoral
Bryozoa	*Adeonella* spp.	Sabre bryozoan
	Phidoloporidae spp.	Honeycomb false lace coral
Hemichordata	*Cephalodiscus gilchristi*	Agar animal

VMEs are also thought to contribute toward the long-term viability of a stock through providing an important source of habitat for commercial species (Pham *et al.* 2015; Ashford *et al.* 2019). They can provide a wide range of ecosystem services ranging from provision of aggregation- and spawning sites to providing shelter from predation and adverse hydrological conditions (Husebø & Nøttestad *et al.* 2002; Krieger & Wing, 2002; Tissot *et al.*, 2006; Baillon *et al.* 2012; Pham *et al.* 2015). Indicator taxa for VMEs are also known to provide increased access to food sources, both directly to associated benthic fauna, and indirectly to other pelagic species such as fish and other predators due to the high abundance and biomass of associated fauna (Krieger & Wing, 2002; Husebø & Nøttestad *et al.* 2002; Buhl-Mortensen *et al*, 2010; Hogg *et al.*, 2010; Auster *et al.* 2011).

VME frameworks are typically elevated from the seabed, increasing turbulence and raising supply of suspended particles to suspension feeders (Krieger & Wing 2002; Buhl-Mortensen & Mortensen 2005; Buhl-Mortensen *et al.* 2010). Poriferans and cold-water corals further shown to provide a strong link between pelagic and benthic food webs (Pile & Young 2006., Cathalot *et al.* 2015). VMEs are increasingly being recognised as providers of important ecosystem services due to associated increased biodiversity and levels of ecosystem functioning (Ashford *et al.* 2019).

3.3.3 The Water Body

Demersal Fish Species

Demersal fish are those species that live and feed on or near the seabed. As many as 110 species of bony and cartilaginous fish have been identified in the demersal communities on the continental shelf of the West Coast (Roel 1987). Changes in fish communities occur with increasing depth (Roel 1987; Smale *et al.* 1993; Macpherson and Gordoa 1992; Bianchi *et al.* 2001; Atkinson 2009), with the most substantial change in species composition occurring in the shelf break region between 300 m and 400 m depth (Roel 1987; Atkinson 2009). The shelf community (<380 m) is dominated by the Cape hake *M. capensis*, and includes jacopever *Helicolenus dactylopterus*, Izak catshark *Holohalaelurus regain*, soupfin shark *Galeorhinus galeus* and whitespotted houndshark *Mustelus* *palumbes*. The more diverse deeper water community is dominated by the deepwater hake *Merluccius paradoxus*, monkfish *Lophius vomerinus*, kingklip *Genypterus capensis*, bronze whiptail *Lucigadus ori* and hairy conger *Bassanago albescens* and various squalid shark species. There is some degree of species overlap between the depth zones.

Roel (1987) showed seasonal variations in the distribution ranges shelf communities, with species such as the pelagic goby *Sufflogobius bibarbatus*, and West Coast sole *Austroglossus microlepis* occurring in shallow water north of Cape Point during summer only. The deep-sea community was found to be homogenous both spatially and temporally. In a more recent study, however, Atkinson (2009) identified two long-term community shifts in demersal fish communities; the first (early to mid-1990s) being associated with an overall increase in density of many species, whilst many species decreased in density during the second shift (mid-2000s). These community shifts correspond temporally with regime shifts detected in environmental forcing variables (Sea Surface Temperatures and upwelling anomalies) (Howard *et al.* 2007) and with the eastward shifts observed in small pelagic fish species and rock lobster populations (Coetzee *et al.* 2008; Cockcroft *et al.* 2008).

The diversity and distribution of demersal cartilagenous fishes on the West Coast is discussed by Compagno *et al.* (1991). The species that may occur on the continental shelf in the general project area, and their approximate depth range, are listed in Table 3.

Pelagic Communities

In contrast to demersal and benthic biota that are associated with the seabed, pelagic species live and feed in the water column. The pelagic communities are typically divided into plankton and fish, and their main predators, marine mammals (seals, dolphins and whales), seabirds and turtles. These are discussed separately below. Noteworthy is that the marine component of the 2011 National Biodiversity Assessment (Sink *et al.* 2012), rated the majority of the offshore pelagic habitat types as 'least threatened' (see Figure 10, right), with only a narrow band along the shelf break of the West Coast being rated as 'vulnerable', primarily due to its importance as a migration pathway for various resource species (e.g. whales, tuna, billfish, turtles).

Plankton

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

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

Table 3: Demersal cartilaginous species found on the continental shelf along the West Coast, with approximate depth range at which the species occurs (Compagno *et al.* 1991).

Common Name	Scientific name	Depth Range (m)
Frilled shark	*Chlamydoselachus anguineus*	200-1,000
Six gill cowshark	*Hexanchus griseus*	150-600
Bramble shark	*Echinorhinus brucus*	55-285
Arrowhead dogfish	*Deania profundorum*	200-500
Longsnout dogfish	*Deania quadrispinosum*	200-650
Spotted spiny dogfish	*Squalus acanthias*	100-400
Shortnose spiny dogfish	*Squalus megalops*	75-460
Shortspine spiny dogfish	*Squalus mitsukurii*	150-600
Sixgill sawshark	*Pliotrema warreni*	60-500
Tigar catshark	*Halaelurus natalensis*	50-100
Izak catshark	*Holohalaelurus regani*	100-500
Yellowspotted catshark	*Scyliorhinus capensis*	150-500
Soupfin shark/Vaalhaai	*Galeorhinus galeus*	<10-300
Houndshark	*Mustelus mustelus*	<100
Whitespotted houndshark	*Mustelus palumbes*	>350
Little guitarfish	*Rhinobatos annulatus*	>100
Atlantic electric ray	*Torpedo nobiliana*	120-450
Roughnose legskate	*Crurirajaparcomaculata*	150-620
Thorny skate	*Raja radiata*	50-600
Slime skate	*Raja pullopunctatus*	15-460
Rough-belly skate	*Raja springeri*	85-500
Yellowspot skate	*Raja wallacei*	70-500
Biscuit skate	*Raja clavata*	25-500
Bigthorn skate	*Raja confundens*	100-800
Spearnose skate	*Raja alba*	75-260
St Joseph	*Callorhinchus capensis*	30-380

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

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

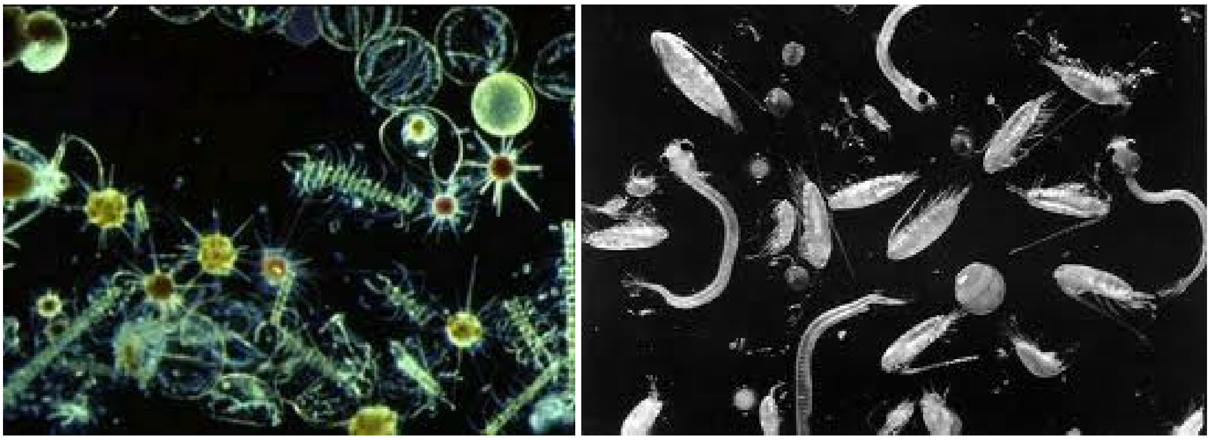

Figure 18: Phytoplankton (left, photo: hymagazine.com) and zooplankton (right, photo: mysciencebox.org) is associated with upwelling cells.

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

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

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

Although ichthyoplankton (fish eggs and larvae) comprise a minor component of the overall plankton, it remains significant due to the commercial importance of the overall fishery in the region. Various pelagic and demersal fish species are known to spawn in the inshore regions of the southern Benguela, (including pilchard, round herring, chub mackerel lanternfish and hakes (Crawford *et al.* 1987) (see Figure 19), and their eggs and larvae form an important contribution to the ichthyoplankton in the region. Ichthyoplankton abundance along the inshore portions of the proposed cable route (*i.e.* on the continental shelf) is thus expected to be high.

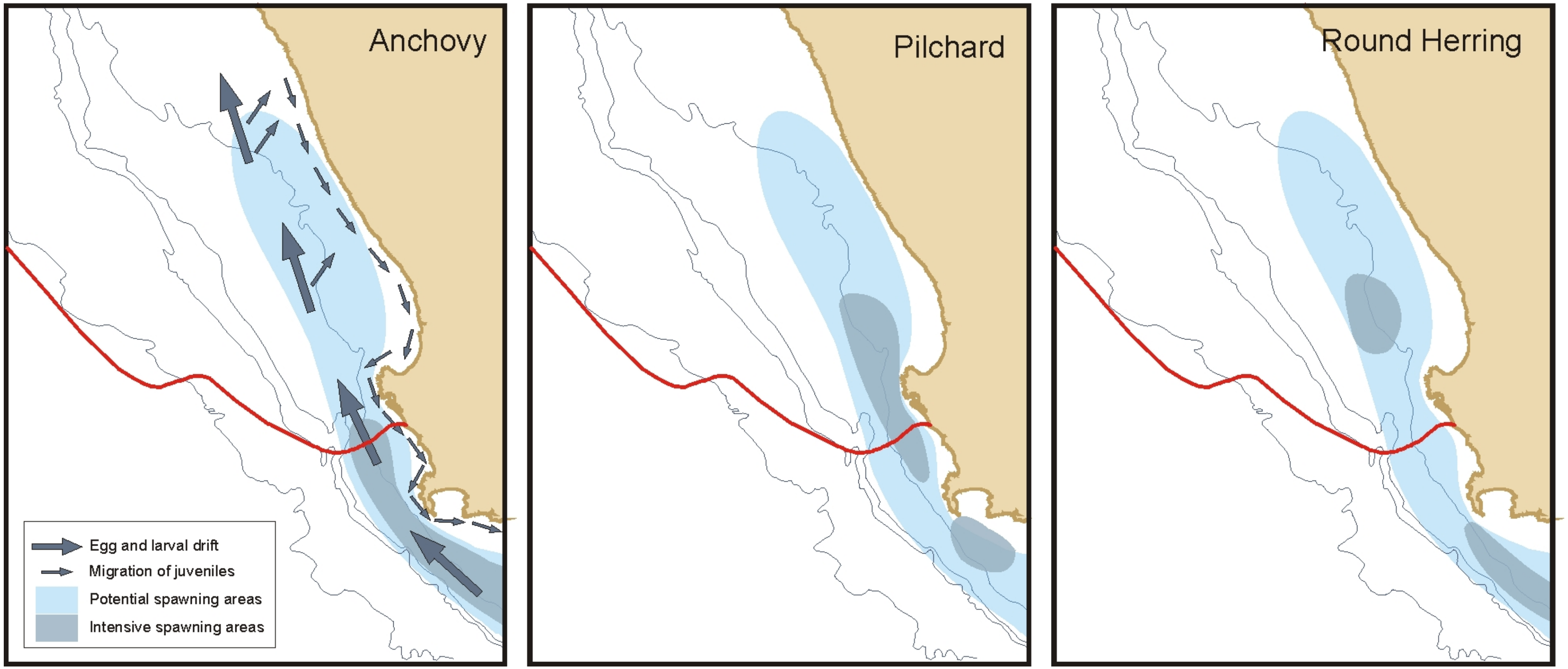

Figure 19: Major spawning areas in the southern Benguela region in relation to the ASN 2AFRICA (West) Cable System route (red line) (adapted from Cruikshank 1990).

Cephalopods

Fourteen species of cephalopods have been recorded in the southern Benguela, the majority of which are sepiods/cuttlefish (Lipinski 1992; Augustyn *et al.* 1995). Most of the cephalopod resource is distributed on the mid-shelf with *Sepia australis* being most abundant at depths between 60-190 m, whereas *S. hieronis* densities were higher at depths between 110-250 m. *Rossia enigmatica* occurs more commonly on the edge of the shelf to depths of 500 m. Biomass of these species was generally higher in the summer than in winter.

Cuttlefish are largely epi-benthic and occur on mud and fine sediments in association with their major prey item; mantis shrimps (Augustyn *et al.* 1995). They form an important food item for demersal fish.

Cephalopods that may be encountered beyond the shelf break along the proposed subsea cable route are the colossal squid *Mesonychoteuthis hamiltoni* and the giant squid *Architeuthis* sp. Both are deep dwelling species, with the colossal squid's distribution confined to the entire circum-

antarctic Southern Ocean (Figure 20, top) while the giant squid is usually found near continental and island slopes all around the world's oceans (Figure 20, bottom). Both species could thus potentially occur in the offshore pelagic habitats along the cable route, although the likelihood ofencounter is extremely low. Growing to in excess of 10 m in length, they are the principal prey of the sperm whale, and are also taken by beaked whaled, pilot whales, elephant seals and sleepersharks. Nothing is known of their vertical distribution, but data from trawled specimens and sperm whale diving behaviour suggest they may span a depth range of 300 – 1,000 m.

Pelagic Fish

The structure of the nearshore and surf zone fish community varies greatly with the degree of wave exposure. Species richness and abundance is generally high in sheltered and semi-exposed areas but typically very low off the more exposed beaches (Clark 1997a, 1997b).

The surf-zone and outer turbulent zone habitats of sandy beaches are considered to be important nursery habitats for marine fishes (Modde 1980; Lasiak 1981; Kinoshita and Fujita 1988; Clark *et al.* 1994). However, the composition and abundance of the individual assemblages seems to be heavily dependent on wave exposure (Blaber and Blaber 1980, Potter *et al.* 1990, Clark 1997a, b). Surf-zone fish communities off the South African West Coast have relatively high biomass, but low species diversity. Typical surf-zone fish include harders (*Chelon richardsonii*), white stumpnose (*Rhabdosargus globiceps*) (Figure 21), Cape sole (*Heteromycteris capensis*), Cape gurnard (*Chelidonichthys capensis*), False Bay klipfish (*Clinus latipennis*), sandsharks (*Rhinobatos annulatus*), eagle ray (*Myliobatis aquila*), and smooth-hound (*Mustelus mustelus*) (Clark 1997b).

Fish species commonly found in kelp beds off the West Coast include hottentot *Pachymetopon blochii* (Figure 22, left), twotone fingerfin *Chirodactylus brachydactylus* (Figure 22, right), red fingers *Cheilodactylus fasciatus*, galjoen *Dichistius capensis*, rock suckers *Chorisochismus dentex,* maned blennies *Scartella emarginata* and the catshark *Haploblepharus pictus* (Sauer *et al.* 1997; Brouwer *et al.* 1997; Branch *et al.* 2010).

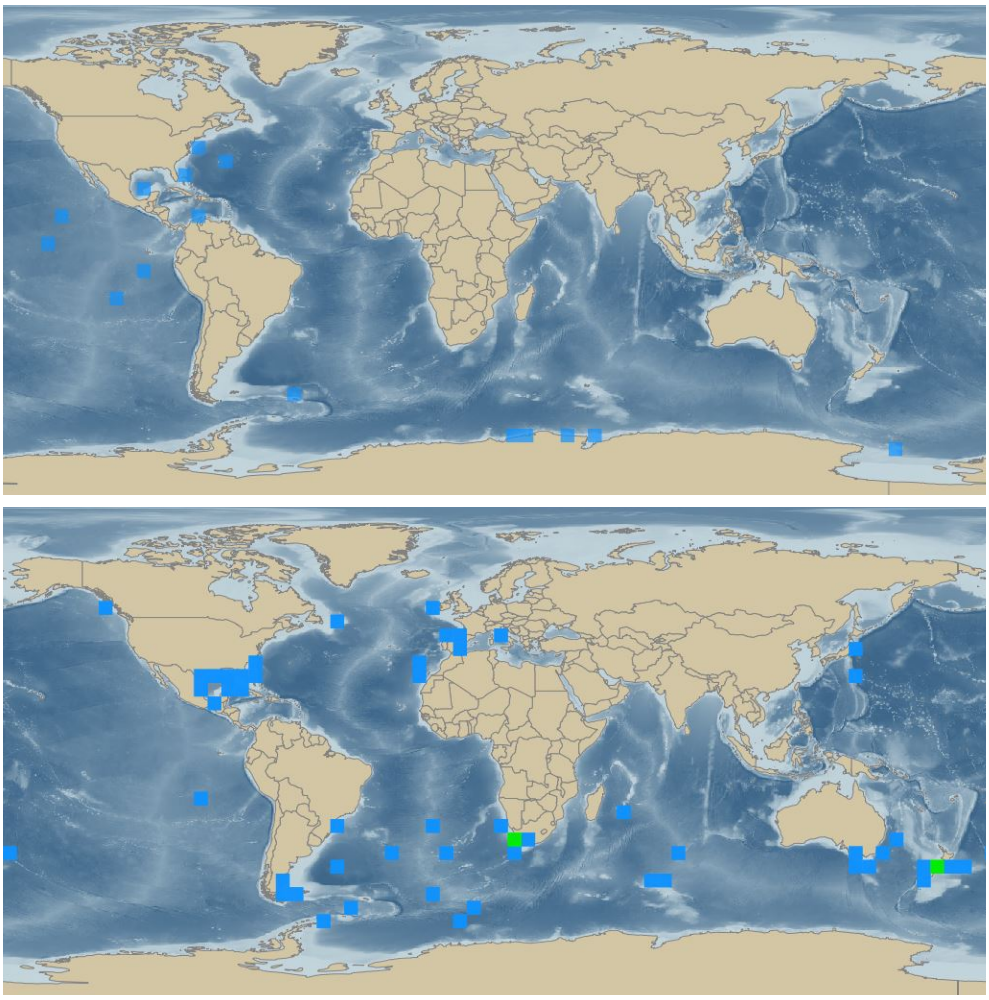

Figure 20: Distribution of the colossal squid (top) and the giant squid (bottom). Blue squares <5 records, green squares 5-10 records (Source: http://iobis.org).


Figure 21: Common surf-zone fish include the harder (left, photo: aquariophil.org) and the white stumpnose (right, photo: easterncapescubadiving.co.za).

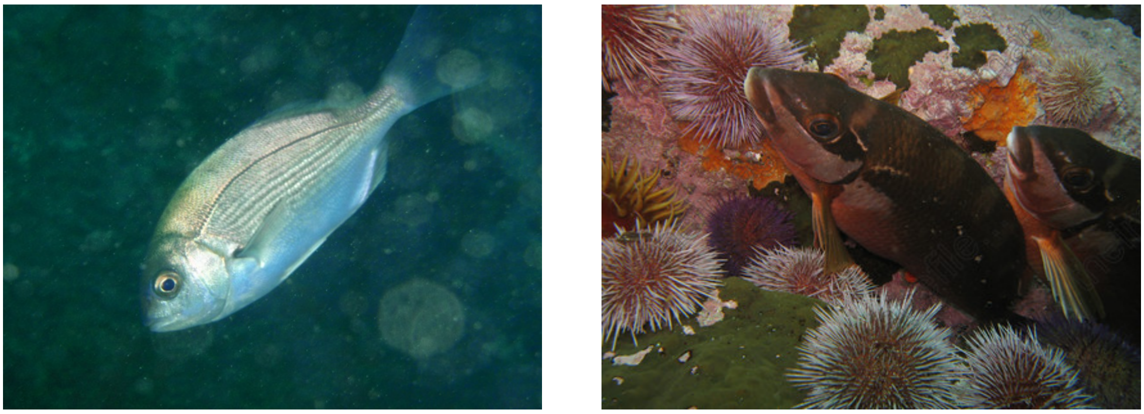

Figure 22: Common fish found in kelp beds include the Hottentot fish (left, photo: commons. wikimedia.org) and the twotone fingerfin (right, photo: www.parrphotographic.com).

Small pelagic species occurring beyond the surfzone and generally within the 200 m contour include the sardine/pilchard (*Sadinops ocellatus*) (Figure 23, left), anchovy (*Engraulis capensis*), chub mackerel (*Scomber japonicus*), horse mackerel (*Trachurus capensis*) (Figure 23, right) and round herring (*Etrumeus whiteheadi*). These species typically occur in mixed shoals of various sizes (Crawford *et al.* 1987), and exhibit similar life history patterns involving seasonal migrations between the west and south coasts. The spawning areas of the major pelagic species are distributed on the continental shelf and along the shelf edge extending from south of St Helena Bay to Mossel Bay on the South Coast (Shannon and Pillar 1986). They spawn downstream of major upwelling centres in spring and summer, and their eggs and larvae are subsequently carried around Cape Point and up the coast in northward flowing surface waters.

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

Figure 23: Cape fur seal preying on a shoal of pilchards (left). School of horse mackerel (right) (photos: www.underwatervideo.co.za; www.delivery.superstock.com).

Two species that migrate along the West Coast following the shoals of anchovy and pilchards are snoek *Thyrsites atun* and chub mackerel *Scomber japonicas*. Their appearance along the West and South-West coasts are highly seasonal. Snoek migrating along the southern African West Coast reach the area between St Helena Bay and the Cape Peninsula between May and August. They spawn in these waters between July and October before moving offshore and commencing their return northward migration (Payne and Crawford 1989). They are voracious predators occurring throughout the water column, feeding on both demersal and pelagic invertebrates and fish. Chub mackerel similarly migrate along the southern African West Coast reaching South-Western Cape waters between April and August. They move inshore in June and July to spawn before starting the return northwards offshore migration later in the year. Their abundance and seasonal migrations are thought to be related to the availability of their shoaling prey species (Payne and Crawford 1989).

Large pelagic species include tunas, billfish and pelagic sharks, which migrate throughout the southern oceans, between surface and deep waters (>300 m) and have a highly seasonal abundance in the Benguela. Species occurring off western southern Africa include the albacore/longfin tuna *Thunnus alalunga* (Figure 24, right), yellowfin *T. albacares*, bigeye *T. obesus*, and skipjack *Katsuwonus pelamis tunas*, as well as the Atlantic blue marlin *Makaira nigricans* (Figure 24, left), the white marlin *Tetrapturus albidus* and the broadbill swordfish *Xiphias gladius* (Payne and Crawford 1989). The distributions of these species is dependent on food availability in the mixed boundary layer between the Benguela and warm central Atlantic waters. Concentrations of large pelagic species are also known to occur associated with underwater feature such as canyons and seamounts as well as meteorologically induced oceanic fronts (Penney *et al.* 1992).

Figure 24: Large migratory pelagic fish such as blue marlin (left) and longfin tuna (right) occur in offshore waters (photos: www.samathatours.com; www.osfimages.com).

A number of species of pelagic sharks are also known to occur on the West Coast, including blue *Prionace glauca*, short-fin mako *Isurus oxyrinchus* and oceanic whitetip sharks *Carcharhinus longimanus*. Occurring throughout the world in warm temperate waters, these species are usually found further offshore on the West Coast. Great whites *Carcharodon carcharias* may also be encountered in coastal and offshore areas. This species is a significant apex predator along the southern African coast, particularly in the vicinity of the seal colonies. Although not necessarily threatened with extinction, great whites are listed in Appendix II (species in which trade must be controlled in order to avoid utilization incompatible with their survival) of CITES (Convention on International Trade in Endangered Species) and is described as "vulnerable" in the International Union for Conservation of Nature (IUCN) Red listing. In response to global declines in abundance, white sharks were legislatively protected in South Africa in 1991.

Many of the large migratory pelagic species are considered threatened by the IUCN, primarily due to overfishing (Table 4). Tuna and swordfish are targeted by high seas fishing fleets and illegal overfishing has severely damaged the stocks of many of these species. Similarly, pelagic sharks, are either caught as bycatch in the pelagic tuna longline fisheries, or are specifically targeted for their fins, where the fins are removed and the remainder of the body discarded.

Table 4: Some of the more important large migratory pelagic fish likely to occur in the offshore regions of the West Coast.

Common Name	Species	IUCN Conservation Status
Tunas		
Southern Bluefin Tuna	*Thunnus maccoyii*	Critically Endangered
Bluefin Tuna	*Thunnus thynnus*	Endangered
Bigeye Tuna	*Thunnus obesus*	Vulnerable
Longfin Tuna/Albacore	*Thunnus alalunga*	Near Threatened
Yellowfin Tuna	*Thunnus albacares*	Near Threatened
Frigate Tuna	*Auxis thazard*	Least concern
Skipjack Tuna	*Katsuwonus pelamis*	Least concern
Billfish		
Blue Marlin	*Makaira nigricans*	Vulnerable
Sailfish	*Istiophorus platypterus*	Least concern
Swordfish	*Xiphias gladius*	Least concern
Black Marlin	*Istiompax indica*	Data deficient
Pelagic Sharks		
Pelagic Thresher Shark	*Alopias pelagicus*	Vulnerable
Common Thresher Shark	*Alopias vulpinus*	Vulnerable
Great White Shark	*Carcharodon carcharias*	Vulnerable
Shortfin Mako	*Isurus oxyrinchus*	Vulnerable
Longfin Mako	*Isurus paucus*	Vulnerable
Blue Shark	*Prionace glauca*	Near Threatened
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Vulnerable

Turtles

Three species of turtle occur along the West Coast, namely the Leatherback (*Dermochelys coriacea*) (Figure 25, left), and occasionally the Loggerhead (*Caretta caretta*) (Figure 25, right) and the Green (*Chelonia mydas*) turtle. Loggerhead and Green turtles are expected to occur only as occasional visitors along the West Coast.

The Leatherback is the only turtle likely to be encountered in the offshore waters of west South Africa. The Benguela ecosystem, especially the northern Benguela where jelly fish numbers are high, is increasingly being recognized as a potentially important feeding area for leatherback turtles from several globally significant nesting populations in the south Atlantic (Gabon, Brazil) and south east Indian Ocean (South Africa) (Lambardi *et al.* 2008, Elwen and Leeney 2011). Leatherback turtles from the east South Africa population have been satellite tracked swimming around the west coast of South Africa and remaining in the warmer waters west of the Benguela ecosystem (Lambardi *et al.* 2008) (Figure 26).

Leatherback turtles inhabit deeper waters and are considered a pelagic species, travelling the ocean currents in search of their prey (primarily jellyfish). While hunting they may dive to over 600 m and remain submerged for up to 54 minutes (Hays *et al.* 2004). Their abundance in the project area is expected to be low. Leatherbacks feed on jellyfish and are known to have mistaken plastic marine debris for their natural food. Ingesting this can obstruct the gut, lead to absorption of toxins and reduce the absorption of nutrients from their real food. Leatherback Turtles are listed as 'Vulnerable' worldwide by the IUCN and are in the highest categories in terms of need for conservation in CITES (Convention on International Trade in Endangered Species), and CMS (Convention on Migratory Species). The conservation status for the Southern African Regional Management Unit population, however, is considered 'Critically Endangered'. The species is also listed as 'Critically Endangered' in the NEMBA list of Threatened or Protected Species (TOPS). Loggerhead turtles are globally listed as 'Vulnerable', whereas Green turtles are globally listed as 'Endangered'. As a signatory of CMS, South Africa has endorsed and signed a CMS International Memorandum of Understanding specific to the conservation of marine turtles. South Africa is thus committed to conserve these species at an international level. The most recent conservation status, which assessed the species on a sub-regional scale, is provided in Table 5.

Figure 25: Leatherback (left) and loggerhead turtles (right) occur along the West Coast of Southern Africa (Photos: Ketos Ecology 2009; www.aquaworld-crete.com).

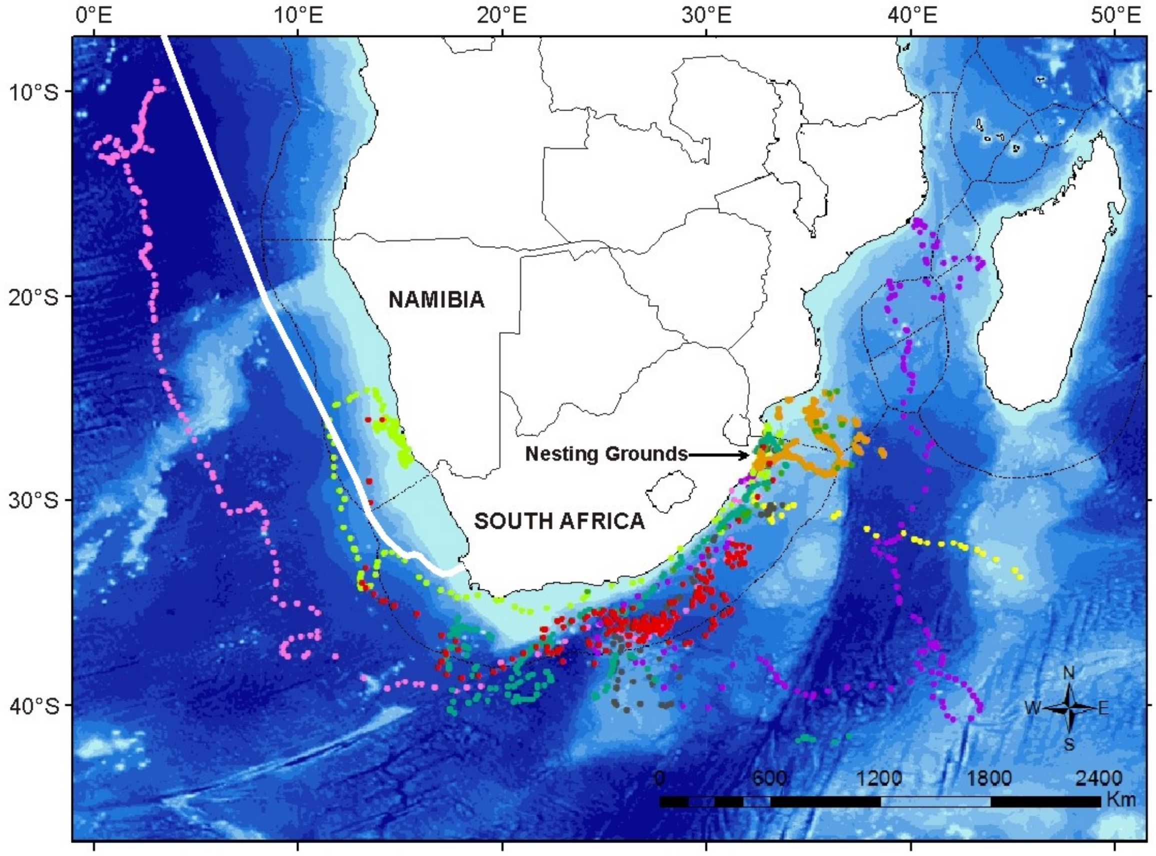

Figure 26: The post-nesting distribution of nine satellite tagged leatherback females (1996 – 2006; Oceans and Coast, unpublished data). The white lines show the proposed cable routing.

Table 5: Global and Regional Conservation Status of the turtles occurring off the South Coast showing variation depending on the listing used.

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

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

Seabirds

Large numbers of coastal and pelagic seabirds exploit the pelagic fish stocks of the Benguela system. Of the 49 species of seabirds that occur in the Benguela region, 14 are defined as resident, 10 are visitors from the northern hemisphere and 25 are migrants from the southern Ocean. The 18 species classified as being common in the southern Benguela are listed in Table 6. The area between Cape Point and the Orange River supports 38% and 33% of the overall population of pelagic seabirds in winter and summer, respectively. Most of the species in the region reach highest densities offshore of the shelf break (200 – 500 m depth), with highest population levels during their non-breeding season (winter). Pintado petrels and Prion spp. show the most marked variation here.

Table 6: Pelagic seabirds common in the southern Benguela region (Crawford *et al.* 1991).

Common Name	Species name	Regional Assessment	Global IUCN
Shy Albatross	*Thalassarche cauta*	Near Threatened	Near Threatened
Black browed Albatross	*Thalassarche melanophrys*	Endangered	Least concern
Indian Yellow-nosed Albatross	*Thalassarche carteri*	Endangered	Endangered
Atlantic Yellow-nosed Albatross	*Thalassarche chlororhynchos*	Endangered	Endangered
Wandering Albatross	*Diomedea exulans*	Vulnerable	Vulnerable
Northern Giant Petrel	*Macronectes halli*	Near Threatened	Least concern
Southern Giant Petrel	*Macronectes giganteus*	Near Threatened	Least concern
Pintado Petrel	*Daption capense*	Least concern	Least concern
Greatwinged Petrel	*Pterodroma macroptera*	Near Threatened	Least concern
Soft-plumaged Petrel	*Pterodroma mollis*	Near Threatened	Least concern
Antarctic Prion	*Pachyptila desolata*	Least concern	Least concern
Salvin's Prion	*Pachyptila salvini*	Near Threatened	Least concern
Broad-billed Prion	*Pachyptila* vittata	Least concern	Least concern
White-chinned Petrel	*Procellaria aequinoctialis*	Vulnerable	Vulnerable
Cory's Shearwater	*Calonectris diomedea*	Least concern	Least concern
Great Shearwater	*Puffinus gravis*	Least concern	Least concern
Sooty Shearwater	*Puffinus griseus*	Near Threatened	Near Threatened
European Storm Petrel	*Hydrobates pelagicus*	Least concern	Least concern
Leach's Storm Petrel	*Oceanodroma leucorhoa*	Critically Endangered	Vulnerable
Wilson's Storm Petrel	*Oceanites oceanicus*	Least concern	Least concern
Spectacled Petrel	*Procellaria conspicillata*	Vulnerable	Vulnerable
Blackbellied Storm Petrel	*Fregetta tropica*	Near Threatened	Least concern
Subantarctic Skua	*Catharacta antarctica*	Endangered	Least concern
Sabine's Gull	*Larus sabini*	Least concern	Least concern

14 species of seabirds breed in southern Africa; Cape Gannet (Figure 27, left), African Penguin (Figure 27, right), four species of Cormorant, White Pelican, three Gull and four Tern species (Table 7). The breeding areas are distributed around the coast with islands being especially important. Breeding islands within the project area are Bird Island at Lambert's Bay, the Saldanha Bay islands, Dassen Island off Yzerfontein and Robben Island in Table Bay. The number of successfully breeding birds at the particular breeding sites varies with food abundance. Most of the breeding seabird species forage at sea with most birds being found relatively close inshore

(10-30 km). Cape Gannets, however, are known to forage up to 140 km offshore (Dundee 2006; Ludynia 2007), and African Penguins have also been recorded as far as 60 km offshore.

Figure 27: Cape Gannets *Morus capensis* (left) (Photo: NACOMA) and African Penguins *Spheniscus demersus* (right) (Photo: Klaus Jost) breed primarily on the offshore Islands.

Table 7: Breeding resident seabirds present along the West Coast (CCA and CMS 2001).

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

Shore birds likely to be encountered in the area of the proposed ASN 2AFRICA (West) Cable shore crossings include the African Black Oystercatcher *Haematopus moquini*. As the southern African population is estimated at only between 5,000 and 6,000 individuals, the species has been listed as 'near threatened' on the IUCN red data list. The breeding success of African Black Oystercatcher is particularly susceptible to disturbance from off-road vehicles and coastal developments as they nest and breed on beaches between the Eastern Cape and southern Namibia.

Marine Mammals

The marine mammal fauna occurring off the southern African coast includes several species of whales and dolphins and one resident seal species. Thirty five species of whales and dolphins are known (based on historic sightings or strandings records) or likely (based on habitat projections of known species parameters) to occur in these waters (Table 8). The offshore areas have been particularly poorly studied with almost all available information from deeper waters (>200 m) arising from historic whaling records prior to 1970. Current information on the distribution, population sizes and trends of most cetacean species occurring on the west coast of southern Africa is lacking. Information on smaller cetaceans in deeper waters is particularly poor and the precautionary principal must be used when considering possible encounters with cetaceans in this area.

Records from stranded specimens and at-sea sightings show that the area between St Helena Bay (~32° S, 18° E) and Cape Agulhas (~34° S, 20° E) is an area of transition between Atlantic and Indian Ocean species, as well as those more commonly associated with colder waters of the west coast (e.g. dusky dolphins and long finned pilot whales) and those of the warmer east coast (e.g. striped and Risso's dolphins) (Findlay *et al.* 1992). The cable route lies within and offshore of this transition zone, and the warmer waters that occur there provide an entirely different habitat, that despite the relatively high latitude may host some species associated with the more tropical and temperate parts of the Atlantic. These include, rough toothed dolphins, Pan-tropical spotted dolphins and short finned pilot whales. Although cetacean mass-stranding events are rare in the Southern African subregion compared to elsewhere in the world, the area between Cape Point and St Helena Bay is recognised as a mass-stranding 'hot-spot' (Kirkman *et al.* 2010), particularly between August and December (Child *et al.* 2016).

The distribution of cetaceans can largely be split into those associated with the continental shelf and those that occur in deep, oceanic water. Importantly, species from both environments may be found on the continental slope (from the shelf break (200 m to ~2,000 m) making this the most species rich area for cetaceans. Cetacean density on the continental shelf is usually higher than in pelagic waters as species associated with the pelagic environment tend to be wide ranging across 1,000s of km. As the cable route crosses the continental shelf into oceanic waters, cetacean diversity can be expected to be relatively high, although densities will be low compared to on the shelf.

Cetaceans are comprised of two taxonomic groups, the mysticetes (filter feeders with baleen) and the odontocetes (predatory whales and dolphins with teeth). The term 'whale' is used to describe species in both groups and is taxonomically meaningless (e.g. the killer whale and pilot whale are members of the Odontoceti, family Delphinidae and are thus dolphins). Due to differences in sociality, communication abilities, ranging behavior and acoustic behavior, these two groups are considered separately.

Table 8 lists the cetaceans likely to be found within the greater project area, based on data sourced from Findlay *et al.* (1992), Best (2007), Weir (2011), and unpublished records held by Sea Search / Namibian Dolphin Project. Of the 35 species listed, the blue whale is listed as 'critically endangered', the fin and sei whales are endangered and the sperm, Bryde's (inshore) and humpback (B2 population) are considered vulnerable (South African Red Data list Categories). Altogether eight species are listed as 'data deficient' underlining how little is known about cetaceans, their

Table 8: Cetaceans occurrence off the West Coast of South Africa, their seasonality, likely encounter frequency with proposed cable installation activities and South African Red List conservation status (Child *et al.* 2016).

Common Name	Species	Shelf	Offshore	Seasonality	IUCN Conservation Status
Delphinids (14 spp)					
Dusky dolphin	*Lagenorhynchus obscurus*	Yes (0- 800 m)	No	Year round	Data Deficient
Heaviside's dolphin	*Cephalorhynchus heavisidii*	Yes (0-200 m)	No	Year round	Least Concern
Common bottlenose dolphin	*Tursiops truncatus*	Yes	Yes	Year round	Least Concern
Common dolphin	*Delphinus delphis*	Yes	Yes	Year round	Least Concern
Southern right whale dolphin	*Lissodelphis peronii*	Yes	Yes	Year round	Least Concern
Striped dolphin	*Stenella coeruleoalba*	No	?	?	Least Concern
Pantropical spotted dolphin	*Stenella attenuata*	Edge	Yes	Year round	Least Concern
Long-finned pilot whale	*Globicephala melas*	Edge	Yes	Year round	Least Concern
Short-finned pilot whale	*Globicephala macrorhynchus*	?	?	?	Least Concern
Rough-toothed dolphin	*Steno bredanensis*	?	?	?	Least Concern
Killer whale	*Orcinus orca*	Occasional	Yes	Year round	Least Concern
False killer whale	*Pseudorca crassidens*	Occasional	Yes	Year round	Least Concern
Pygmy killer whale	*Feresa attenuata*	?	Yes	?	Least Concern
Risso's dolphin	*Grampus griseus*	Yes (edge)	Yes	?	Least Concern
Sperm whales (3 spp)					
Pygmy sperm whale	*Kogia breviceps*	Edge	Yes	Year round	Data Deficient
Dwarf sperm whale	*Kogia sima*	Edge	?	?	Data Deficient
Sperm whale	*Physeter macrocephalus*	Edge	Yes	Year round	Vulnerable

Common Name	Species	Shelf	Offshore	Seasonality	IUCN Conservation Status
Beaked whales (8 spp)					
Cuvier's	*Ziphius cavirostris*	No	Yes	Year round	Least Concern
Arnoux's	*Beradius arnouxii*	No	Yes	Year round	Data Deficient
Shepherd's	*Tasmacetus sheperdi*	No	Yes	Year Round	Not Assessed
Southern bottlenose	*Hyperoodon planifrons*	No	Yes	Year round	Least Concern
Layard's	*Mesoplodon layardii*	No	Yes	Year round	Data Deficient
True's	*M. mirus*	No	Yes	Year round	Data Deficient
Gray's	*M. grayi*	No	Yes	Year round	Data Deficient
Blainville's	*M. densirostris*	No	Yes	Year round	Data Deficient
Baleen whales (10.5 spp)					
Antarctic Minke	*Balaenoptera bonaerensis*	Yes	Yes	>Winter	Least Concern
Dwarf minke	*B. acutorostrata*	Yes	Yes	Year round	Least Concern
Fin whale	*B. physalus*	Yes	Yes	MJJ & ON, rarely in summer	Endangered
Blue whale (Antarctic)	*B. musculus intermedia*	No	Yes	?	Critically Endangered
Sei whale	*B. borealis*	Yes	Yes	MJ & ASO	Endangered
Bryde's (offshore)	*B. brydei*	Yes	Yes	Summer (JF)	Data Deficient
Bryde's (inshore)	*B brydei (subspp)*	Yes	Yes	Year round	Vulnerable
Pygmy right	*Caperea marginata*	Yes	?	Year round	Least Concern
Humpback sp.	*Megaptera novaeangliae*	Yes	Yes	Year round, higher in SONDJF	Least Concern
Humpback B2 population	*Megaptera novaeangliae*	Yes	Yes	Spring Summer peak ONDJF	Vulnerable
Southern right	*Eubalaena australis*	Yes	No	Year round, higher in SONDJF	Least Concern

Table 9: Seasonality of baleen whales in the impact zone based on data from multiple sources, predominantly commercial catches (Best 2007 and other sources) and data from stranding events (NDP unpubl data). Values of high (H), Medium (M) and Low (L) of the particular species within each month are relative within each row (species) and not comparable between species. For abundance / likely encounter rate within the broader region, see Table 8.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bryde's Inshore	L	L	L	L	L	L	L	L	L	L	L	L
Bryde's Offshore	**H**	**H**	**H**	L	L	L	L	L	L	L	L	L
Sei	L	L	L	L	**H**	**H**	L	**H**	**H**	**H**	L	L
Fin	M	M	M	**H**	**H**	**H**	M	**H**	**H**	**H**	M	M
Blue	L	L	L	L	L	**H**	**H**	**H**	L	M	L	L
Minke	M	M	M	**H**	**H**	**H**	M	**H**	**H**	**H**	M	M
Humpback	M	M	L	L	L	**H**	**H**	M	M	L	M	**H**
Southern Right	**H**	M	L	**L**	L	**H**	**H**	**H**	**M**	**M**	**H**	**H**
Pygmy right	**H**	**H**	**H**	M	L	L	L	L	L	L	M	M

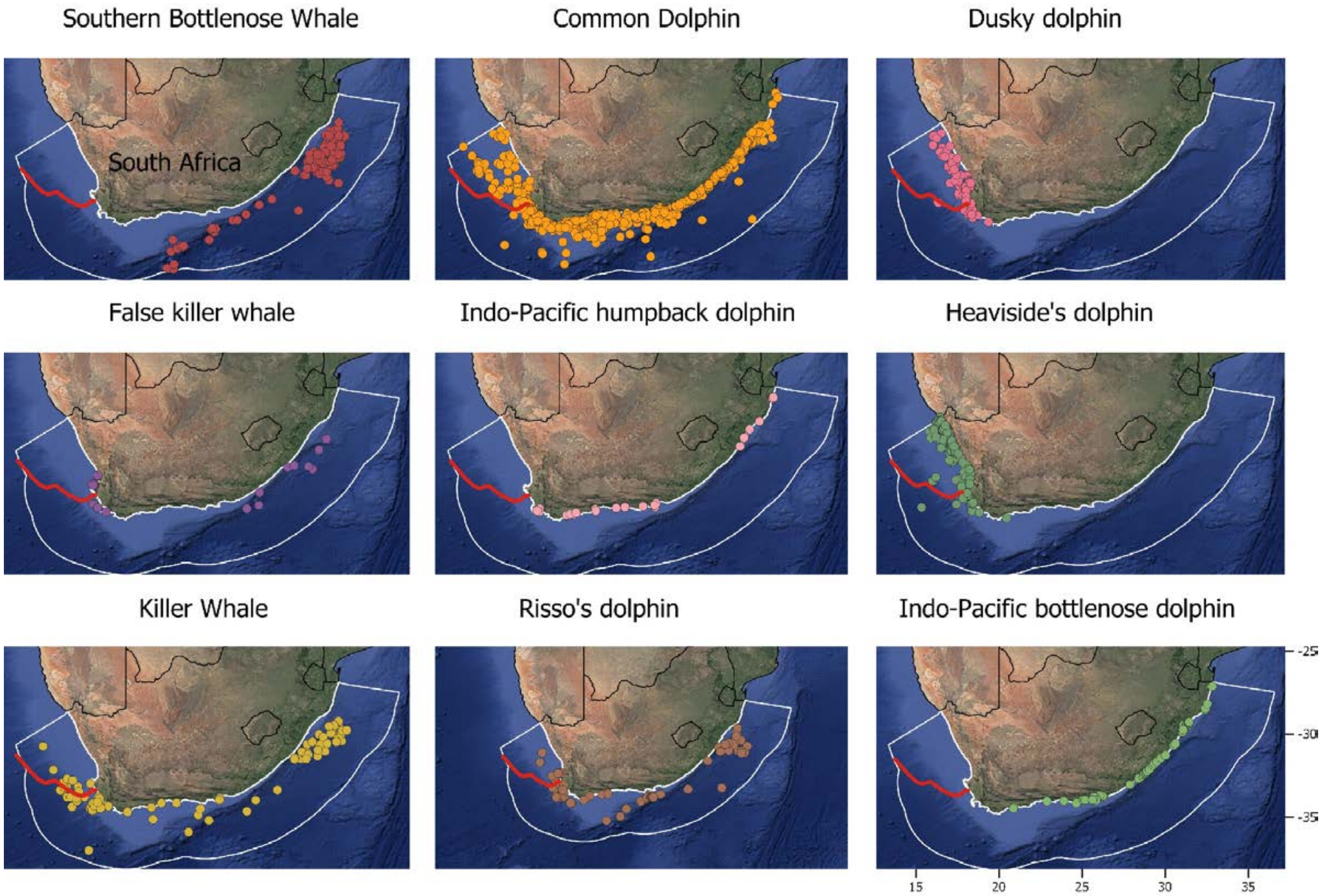

Figure 28: The proposed ASN 2AFRICA (West) cable route in relation to projections of predicted distributions for nine odontocete species off the Coast of South Africa (adapted from: Purdon *et al*. 2020).

distributions and population trends. Even historical data from commercial whaling activities dating from the 1960s, or government run cruises between 1975 and 1986 (Findlay *et al.* 1992), mostly occurred in inshore portions of the continental shelf. Changes in the timing and distribution of migration may have occurred since these data were collected due to extirpation of populations or behaviours (e.g. migration routes may be learnt behaviours). The large whale species for which there are current data available are the humpback and southern right whale, although almost all data is limited to that collected on the continental shelf close to shore.

A review of the distribution and seasonality of the key cetacean species likely to be found within the broader project area and along the cable route is provided below.

Mysticete (Baleen) whales

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

BRYDE'S WHALE (*BALAENOPTER EDENI*) - Two genetically and morphologically distinct populations of Bryde's whales (Figure 29, left) live off the coast of southern Africa (Best 2001; Penry 2010). The "offshore population" lives beyond the shelf (>200 m depth) off west Africa and migrates between wintering grounds off equatorial west Africa (Gabon) and summering grounds off western South Africa. Its seasonality on the west coast is thus opposite to the majority of the balaenopterids with abundance likely to be highest in the broaderProject area in January - March. The "inshore population" of Bryde's, which lives on the continental shelf and Agulhas Bank, is unique amongst baleen whales in the region by being non-migratory. It may move further north into the Benguela current areas of the west of coast of South Africa and Namibia, especially in the winter months (Best 2007). Only the offshore form is likely to be encountered in the project area.

SEI WHALE (*BALAENOPTERA BOREALIS*) - Sei whales migrate through South African waters, where they were historically hunted in relatively high numbers, to unknown breeding grounds further north. Their migration pattern thus shows a bimodal peak with numbers west of Cape Columbine highest in May and June, and again in August, September and October. All whales were caught in waters deeper than 200 m with most deeper than 1,000 m (Best and Lockyer 2002). Almost all information is based on whaling records 1958-1963 and there is no current information on abundance or distribution patterns in the region. Sei whales may be sighted along the offshore portions of the cable route.

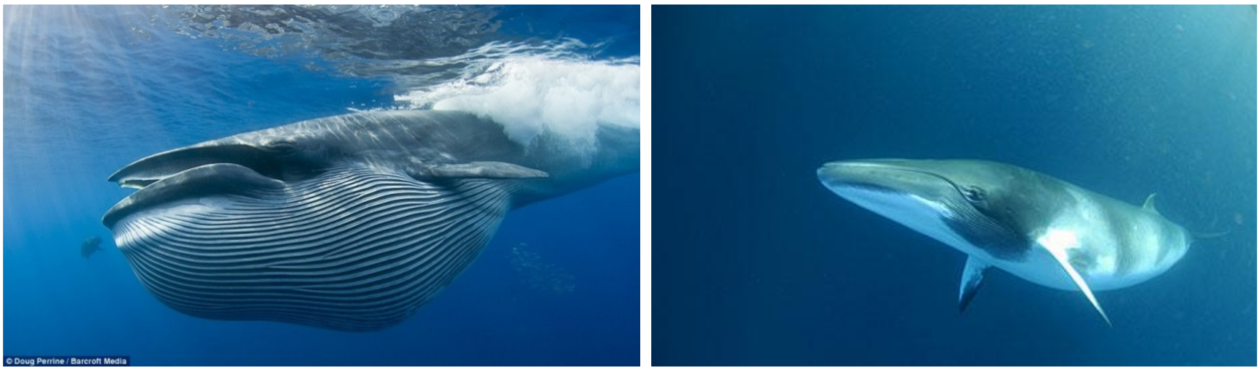

Figure 29: The Bryde's whale Balaenoptera brydei (left) and the Minke whale Balaenoptera bonaerensis (right) (Photos: www.dailymail.co.uk; www.marinebio.org).

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

BLUE WHALE (*BALAENOPTERA MUSCULUS*) - Antarctic and pygmy blue whales were historically caught in high numbers during commercial whaling activities, with a single peak in catch rates during July in Walvis Bay, Namibia and Namibe, Angola suggesting that in the eastern South Atlantic these latitudes are close to the northern migration limit for the species (Best 2007). The two sub-species are difficult to differentiate at sea, so are considered as one species here. Evidence of blue whale presence in the SE Atlantic is rapidly increasing. Recent acoustic detections of blue whales in the Antarctic peak between December and January (Thomisch *et al.* 2016) and in northern Namibia between May and July (Thomisch 2017) supporting observed timing from whaling records. Several recent (2014-2015) sightings of blue whales have occurred during seismic surveys off the southern part of Namibia in water >1,000 m deep confirming their current existence in the area and occurrence in Autumn months.

MINKE WHALE (*BALAENOPTERA BONAERENSIS / ACUTOROSTRATA*) - Two forms of minke whale (Figure 29, right) occur in the southern Hemisphere, the Antarctic minke whale (*Balaenoptera bonaerensis*) and the dwarf minke whale (*B. acutorostrata* subsp.); both species occur in the Benguela (Best 2007). Antarctic minke whales range from the pack ice of Antarctica to tropical waters and are usually seen more than ~50 km offshore. Although adults migrate from the Southern Ocean (summer) to tropical/temperate waters (winter) to breed, some animals, especially juveniles, are known to stay in tropical/temperate waters year round. The dwarf minke whale has a more temperate distribution than the Antarctic minke and they do not range further south than 60-65°S. Dwarf minkes have a similar migration pattern to Antarctic minkes with at least some animals migrating to the Southern Ocean during summer. Dwarf minke whales occur closer to shore than Antarctic minkes. Both species are generally solitary and densities are likely to be low in the project area.

PYGMY RIGHT WHALE (*CAPEREA MARGINATA*) - this is the smallest of the baleen whales reaching only 6 m total length as an adult (Best 2007). The species is typically associated with cool temperate waters between 30°S and 55°S and records in Namibia are the northern most for the species with no confirmed records north of Walvis Bay. Its preference for cooler waters, suggests that it is likely to be restricted to the continental shelf areas within the Benguela system, and is may occur along the deeper portions of the cable route.

The most abundant baleen whales in the Benguela are southern right whales and humpback whales (Figure 30). In the last decade, both species have been increasingly observed to remain on the West Coast of South Africa well after the 'traditional' South African whale season (June – November) into spring and early summer (October – February) where they have been observed feeding in upwelling zones, especially off Saldanha and St Helena Bay (Barendse *et al.* 2011; Mate *et al.* 2011).

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

SOUTHERN RIGHT WHALE (*EUBALAENA AUSTRALIS*) - The southern African population of southern right whales historically extended from southern Mozambique (Maputo Bay) to southern Angola (Baie dos Tigres) and is considered to be a single population within this range (Roux *et al.* 2011). While in southern

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

Figure 30: The Humpback whale Megaptera novaeangliae (left) and the Southern Right whale Eubalaena australis (right) are the most abundant large cetaceans occurring along the southern African West Coast (Photos: www.divephotoguide.com; www.aad.gov.au).

Odontocetes (toothed) whales

The Odontoceti are a varied group of animals including the dolphins, porpoises, beaked whales and sperm whales. Species occurring within the broader project area display a diversity of features, for example their ranging patterns vary from extremely coastal and highly site specific to oceanic and wide ranging. Those in the region can range in size from 1.6-m long (Heaviside's dolphin) to 17 m (bull sperm whale).

SPERM WHALE (*PHYSETER MACROCEPHALUS*) - All information about sperm whales in the southern African sub-region results from data collected during commercial whaling activities prior to 1985 (Best 2007). Sperm whales are the largest of the toothed whales and have a complex, structured social system with adult males behaving differently to younger males and female groups. They live in deep ocean waters, usually greater than 1,000 m depth, although they occasionally come onto the shelf in water 500 - 200 m deep (Best 2007) (Figure 31, left). They are considered to be relatively abundant globally (Whitehead 2002), although no estimates are available for South African waters. Seasonality of catches suggests that medium and large sized males are more abundant in winter months while female groups are more abundant in autumn (March - April), although animals occur year round (Best 2007). Sperm whales are likely to be encountered in relatively high numbers in deeper waters (>500 m), predominantly in the winter months (April - October). Sperm whales feed at great depths during dives in excess of 30 minutes making them difficult to detect visually, however the regular echolocation clicks made by the species when diving make them relatively easy to detect acoustically using monitoring equipment such as Passive Acoustic Monitoring (PAM).

Figure 31: Sperm whales Physeter macrocephalus (left) and killer whales Orcinus orca (right) are toothed whales likely to be encountered in offshore waters (Photos: www.onpoint.wbur.org; www.wikipedia.org).

There are almost no data available on the abundance, distribution or seasonality of the smaller odontocetes (including the beaked whales and dolphins) known to occur in oceanic waters (>200 m) off the shelf of southern Africa. Beaked whales are all considered to be true deep water species usually being seen in waters in excess of 1,000 – 2,000 m deep (see various species accounts in Best 2007).

PYGMY AND DWARF SPERM WHALES (KOGIA SPP) - The genus *Kogia* currently contains two recognised species, the pygmy (*K. breviceps*) and dwarf (*K. sima*) sperm whales, both of which most frequently occur in pelagic and shelf edge waters, although their seasonality is unknown. The majority of what is known about Kogiidae whales in the southern African subregion results from studies of stranded specimens (e.g. Ross 1979; Findlay *et al.* 1992; Plön 2004; Elwen *et al.* 2013). Dwarf sperm whales are associated with the warmer waters south and west of St Helena Bay. They are recorded from both the Benguela and Agulhas ecosystem (Best 2007) in waters deeper than ~1,000 m.

KILLER WHALE (*ORCINUS ORCA*) - Killer whales (Figure 31) have a circum-global distribution being found in all oceans from the equator to the ice edge (Best 2007). Killer whales occur year round in low densities off western South Africa (Best *et al.* 2010), Namibia (Elwen and Leeney 2011) and in the Eastern Tropical Atlantic (Weir *et al.* 2010). Killer whales are found in all depths from the coast to deep open ocean environments and may thus be encountered along the cable route at low levels.

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

LONG-FINNED PILOT WHALES (*GLOBICEPHALA MELAS*) – Long finned pilot whales display a preference for temperate waters and are usually associated with the continental shelf or deep water adjacent to it (Mate *et al.* 2005; Findlay *et al.* 1992; Weir 2011). They are regularly seen associated with the shelf edge by marine mammal observers (MMOs) and fisheries observers and researchers. The distinction between long-finned and short finned pilot whales is difficult to make at sea. As the latter are regarded as more tropical species (Best 2007), it is likely that the vast majority of pilot whales encountered in the project area will be long-finned.

COMMON DOLPHIN (*DELPHINUS* SPP.) – The common dolphin is known to occur offshore in West Coast waters (Findlay *et al.* 1992; Best 2007). Group sizes of common dolphins can be large, averaging 267 (± *SD* 287) for the South Africa region (Findlay *et al.* 1992). They are more frequently seen in the warmer waters offshore and to the north of the country, seasonality is not known.

DUSKY DOLPHINS (*LAGENORHYNCHUS OBSCURUS*) - In water <500 m deep, dusky dolphins (Figure 32, right) are likely to be the most frequently encountered small cetacean as they are very "boat friendly" and often approach vessels to bowride. The species is resident year round throughout the Benguela ecosystem in waters from the coast to at least 2,000 m deep (Findlay *et al.* 1992; Sea Search data). Although no information is available on the size of the population, they are regularly encountered in near shore waters between Cape Town and Lambert's Bay (Elwen *et al.* 2010; Sea Search unpubl. data) with group sizes of up to 800 having been reported (Findlay *et al.* 1992). A hiatus in sightings (or low density area) is reported between ~27°S and 30°S, associated with the Lüderitz upwelling cell (Findlay *et al.* 1992).

HEAVISIDE'S DOLPHINS (*CEPHALORHYNCHUS HEAVISIDII*) – This species (Figure 32, left) is relatively abundant in the Benguela ecosystem region with 10,000 animals estimated to live in the 400 km of coast between Cape Town and Lamberts Bay (Elwen 2008; Elwen *et al.* 2009a, 2009b). The Heaviside's dolphin occupies waters from the coast to at least 200 m depth, (Elwen *et al.* 2006; Best 2007), and may show a diurnal onshore-offshore movement pattern (Elwen *et al.* 2010), but this varies throughout the species range. Heaviside's dolphins are resident year round and likely to be frequently encountered.

OTHER DELPHINIDS – Several other species of dolphins that might occur in deeper waters at low levels include the pygmy killer whale, Risso's dolphin, rough toothed dolphin, pan tropical spotted dolphin and striped dolphin (Findlay *et al.* 1992; Best 2007). Nothing is known about the population size or density of these species in the project area but encounters are likely to be rare.

Figure 32: The endemic Heaviside's Dolphin Cephalorhynchus heavisidii (left) (Photo: De Beers Marine Namibia), and Dusky dolphin Lagenorhynchus obscurus (right) (Photo: scottelowitzphotography.com).

BEAKED WHALES (VARIOUS SPECIES) – Beaked whales were never targeted commercially and their pelagic distribution makes them the most poorly studied group of cetaceans. With recorded dives of well over an hour and in excess of 2 km deep, beaked whales are amongst the most extreme divers of any air breathing animals (Tyack *et al.* 2011). They also appear to be particularly vulnerable to certain types of anthropogenic noise, although reasons are not yet fully understood. All the beaked whales that may be encountered are pelagic species that tend to occur in small groups usually less than five, although larger aggregations of some species are known (MacLeod and D'Amico 2006; Best 2007).

All whales and dolphins are given protection under the South African Law.

Pinnepeds

The Cape fur seal (*Arctocephalus pusillus pusillus*) (Figure 33) is the only species of seal resident along the west coast of Africa, occurring at numerous breeding and non-breeding sites on the mainland and on nearshore islands and reefs (see Figure 35). Vagrant records from four other species of seal more usually associated with the subantarctic environment have also been recorded: southern elephant seal (*Mirounga leoninas),* subantarctic fur seal (*Arctocephalus tropicalis),* crabeater *(Lobodon carcinophagus)* and leopard seals (*Hydrurga leptonyx)* (David 1989).

There are a number of Cape fur seal colonies within the broader study area: Elephant Rocks (north of the Olifants River mouth), Paternoster Rocks and Jacobs Reef at Cape Columbine, and Robbesteen near Koeberg. Non-breeding colonies occur at Strandfontein Point (south of Hondeklipbaai), on Bird Island at Lamberts Bay and at Paternoster Point at Cape Columbine and Duikerklip in Hout Bay. All have important conservation value since they are largely undisturbed at present. Seals are highly mobile animals with a general foraging area covering the continental shelf up to 120 nautical miles offshore (Shaughnessy 1979), with bulls ranging further out to sea than females. The timing of the annual breeding cycle is very regular, occurring between November and

January. Breeding success is highly dependent on the local abundance of food, territorial bulls and lactating females being most vulnerable to local fluctuations as they feed in the vicinity of the colonies prior to and after the pupping season (Oosthuizen 1991).

Figure 33: Colony of Cape fur seals *Arctocephalus pusillus pusillus* (Photo: Dirk Heinrich).

3.4. Other Uses of the Area

3.4.1 Beneficial Uses

Other users of the offshore areas include the commercial fishing, marine diamond mining and petroleum industries (Figure 34). Other industrial uses of the marine environment include the intake of feed-water for mariculture, fish processing or diamond-gravel treatment. Most of these are located well north of the proposed ASN 2AFRICA (West) Cable route and should in no way be affected by installation of the cable system. Recreational use of the offshore areas is negligible.

3.4.2 Conservation Areas and Marine Protected Areas

Marine Protected Areas

Numerous conservation areas and a coastal and offshore marine protected area (MPA) exist along the coastline of the Western Cape. They are illustrated in Figure 35 and briefly summarised below.

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

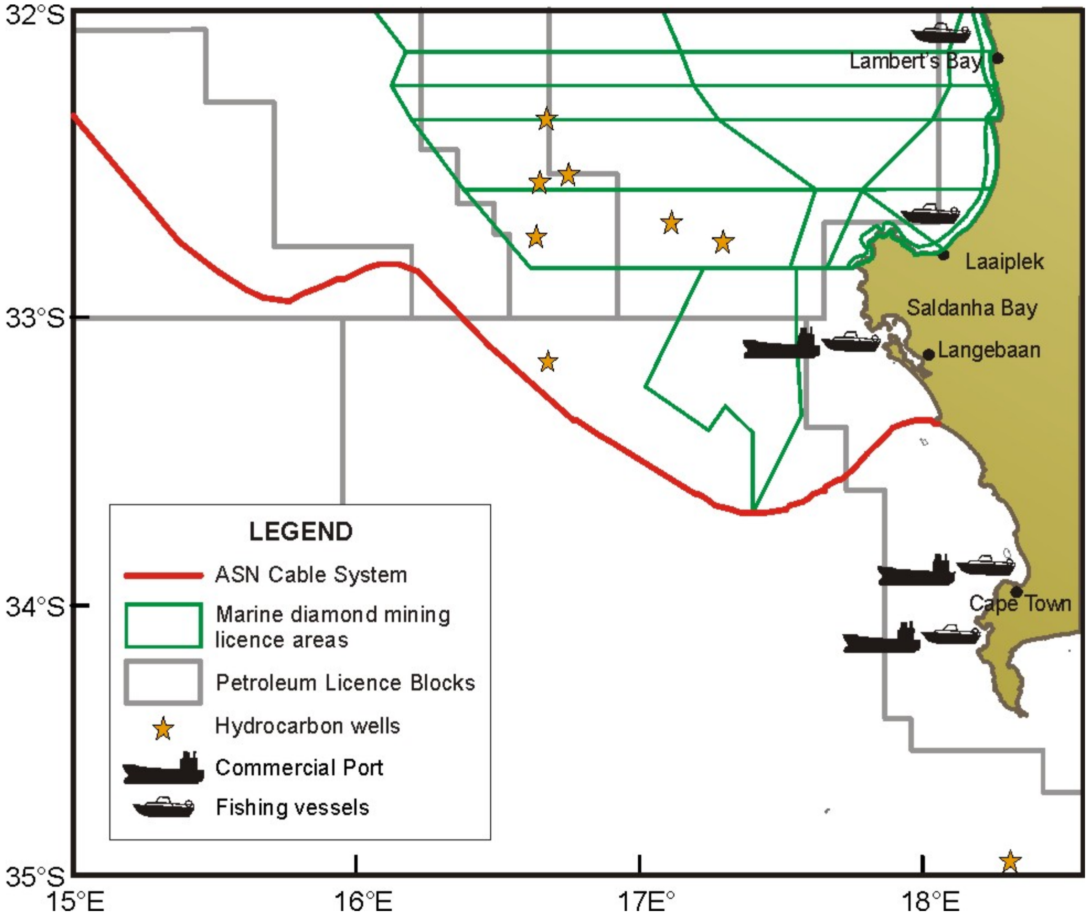

Figure 34: Project - environment interaction points on the West Coast, illustrating the petroleum licence blocks and location of existing hydrocarbon wells, marine diamond mining concessions and ports for commercial and fishing vessels in relation to the proposed ASN 2AFRICA (West) Cable route.

The **West Coast National Park**, which was established in 1985 incorporates the Langebaan Lagoon and Sixteen Mile Beach MPAs, as well the islands Schaapen (29 ha), Marcus (17 ha), Malgas (18 ha) and Jutten (43 ha). Langebaan Lagoon was designated as a Ramsar site in April 1988 under the Convention on Wetlands of International Importance especially as Waterfowl Habitat. The lagoon is divided into three different utilization zones namely: wilderness, limited recreational and multi-purpose recreational areas. The wilderness zone has restricted access and includes the southern end of the lagoon and the inshore islands, which are the key refuge sites of the waders and breeding seabird populations respectively. The limited recreation zone includes the middle reaches of the lagoon, where activities such as sailing and canoeing are permitted. The mouth region is a multi-purpose recreation zone for power boats, yachts, water-skiers and fishermen. However, no collecting or removal of abalone and rock lobster is allowed. The length of the combined shorelines of Langebaan Lagoon MPA and Sixteen Mile Beach is 66 km. The uniqueness of Langebaan lies in its b eing a warm oligotrophic lagoon, along the cold, nutrient-rich and wave exposed West Coast.

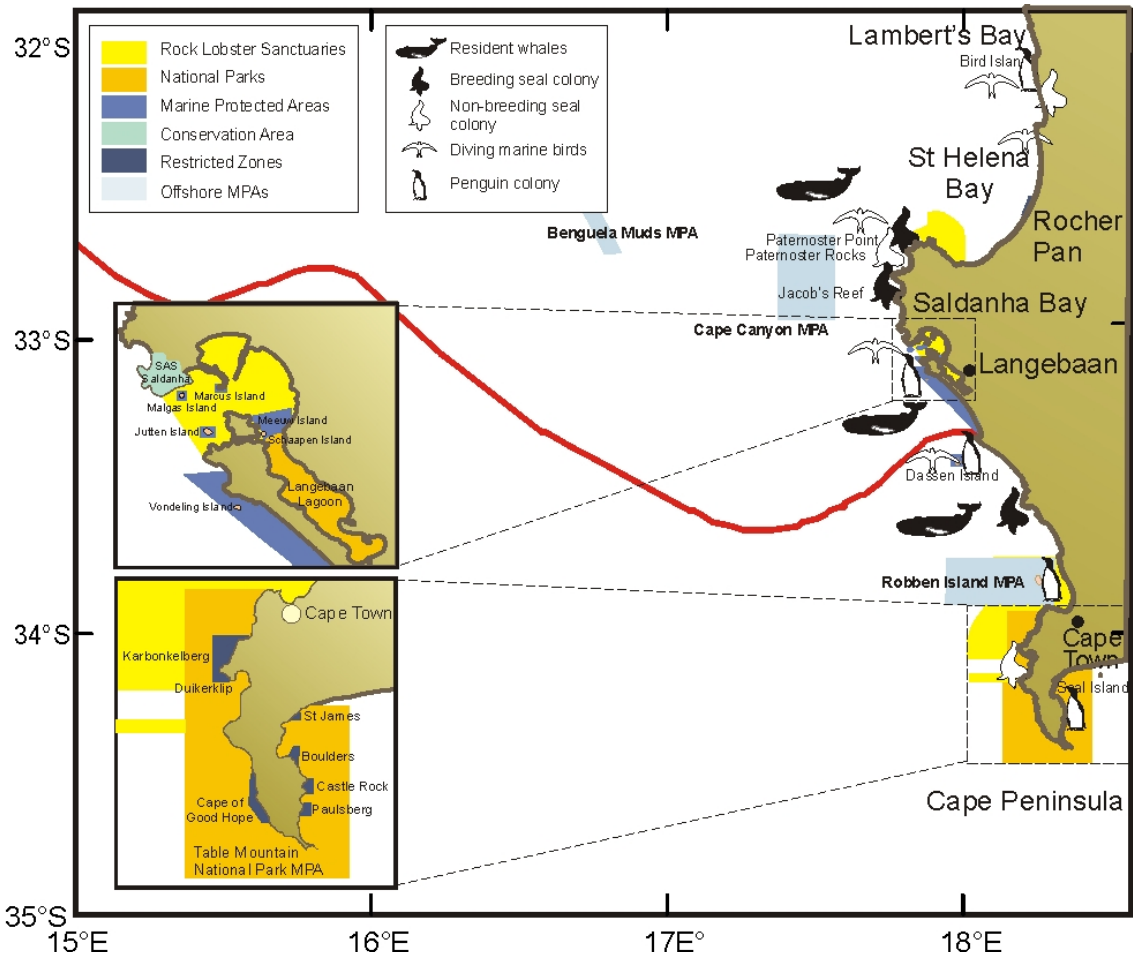

Figure 35: Project - environment interaction points on the West Coast, illustrating the location of seabird and seal colonies and resident whale populations and coastal conservation zones and Marine Protected Areas in relation to the proposed ASN 2AFRICA (West) Cable route.

No rock lobster may be caught in Saldanha Bay eastwards of a line between North Head and South Head. There is also a Rock Lobster Sanctuary in St Helena Bay. Further marine conservation areas in the Saldanha/Cape Columbine region include:

- Paternoster Rocks – Egg and Seal Island reserves for seabirds and seals
- Jacob's Reef - Island reserve for seabirds and seals
- An area within the military base, SAS Saldanha
- Vondeling Island

The **Table Mountain National Park (TMNP) MPA** was declared in 2004, and includes 996 km^2 of the sea area and 137 km of coastline around the Cape Peninsula from Moullie Point in the North to Muizenberg in the south. Although fishing is allowed in the majority of the MPA (subject to Department of Agriculture, Forestry and Fisheries (DAFF) permits, regulations and seasons), the MPA includes six 'no-take' zones where no fishing or extractive activities are allowed. These 'no-take' zones are important breeding and nursery areas for a wide variety of marine species thereby providing threatened species with a chance to recover form over-exploitation.

Until recently, 'No-take' MPAs offering protection of the Namaqua biozones (sub-photic, deep-photic, shallow-photic, intertidal and supratidal zones) were absent northwards from Cape Columbine (Emanuel *et al.* 1992, Lombard *et al.* 2004). This resulted in substantial portions of the coastal and shelf-edge marine biodiversity in the area being assigned a threat status of 'Critically endangered', 'Endangered' or 'Vulnerable' in the 2011 National Biodiversity Assessment (NBA) (Lombard *et al.* 2004; Sink *et al.* 2012). Using biodiversity data mapped for the 2004 and 2011 NBAs a systematic biodiversity plan was developed for the West Coast (Majiedt *et al.* 2013) with the objective of identifying both coastal and offshore priority areas for MPA expansion. Potentially vulnerable marine ecosystems (VMEs) that were explicitly considered during the planning included the shelf break, seamounts, submarine canyons, hard grounds, submarine banks, deep reefs and cold water coral reefs. To this end, nine focus areas were identified for protection on the West Coast between Cape Agulhas and the South African – Namibian border. These focus areas were carried forward during Operation Phakisa, which identified potential offshore MPAs. A network of 20 MPAs was gazetted on 23 May 2019, thereby increasing the ocean protection within the South African Exclusive Economic Zone (EEZ) to 5%. The approved MPAs within the broad project area are shown in Figure 36 and described briefly below (https://www.marineprotectedareas.org.za/).

The 1,335 km^2 **Child's Bank MPA**, located to the east of the Deep Western Orange Basin Block, supports seabed habitats inhabited by a diversity of starfish, brittle stars and basket stars, many of which feed in the currents passing the bank's steep walls. Although trawling has damaged coral in the area, some pristine coral gardens remain on the steepest slopes. The Child's Bank area was first proposed for protection in 2004 but was only proclaimed in 2019, after reducing its size to avoid petroleum wellheads and mining areas. The MPA provides critical protection to these deep sea habitats (180 - 450 m) as they allow for the recovery of important nursery areas for young fish.

The **Namaqua National Park MPA** provides the first protection to habitats in the Namaqua bioregion, including several 'critically endangered' coastal ecosystem types. The area is a nursery area for Cape hakes, and the coastal areas support kelp forests and deep mussel beds, whcih serve as important habitats for the West Coast rock lobster. This 500 km^2 MPA was proclaimed in 2019, both to boost tourism to this remote area and to provide an important baseline from which to understand ecological changes (e.g. introduction of invasive alien marine species, climate change) and human impacts (harvesting, mining) along the West Coast. Protecting this stretch of coastline is part of South Africa's climate adaptation strategy.

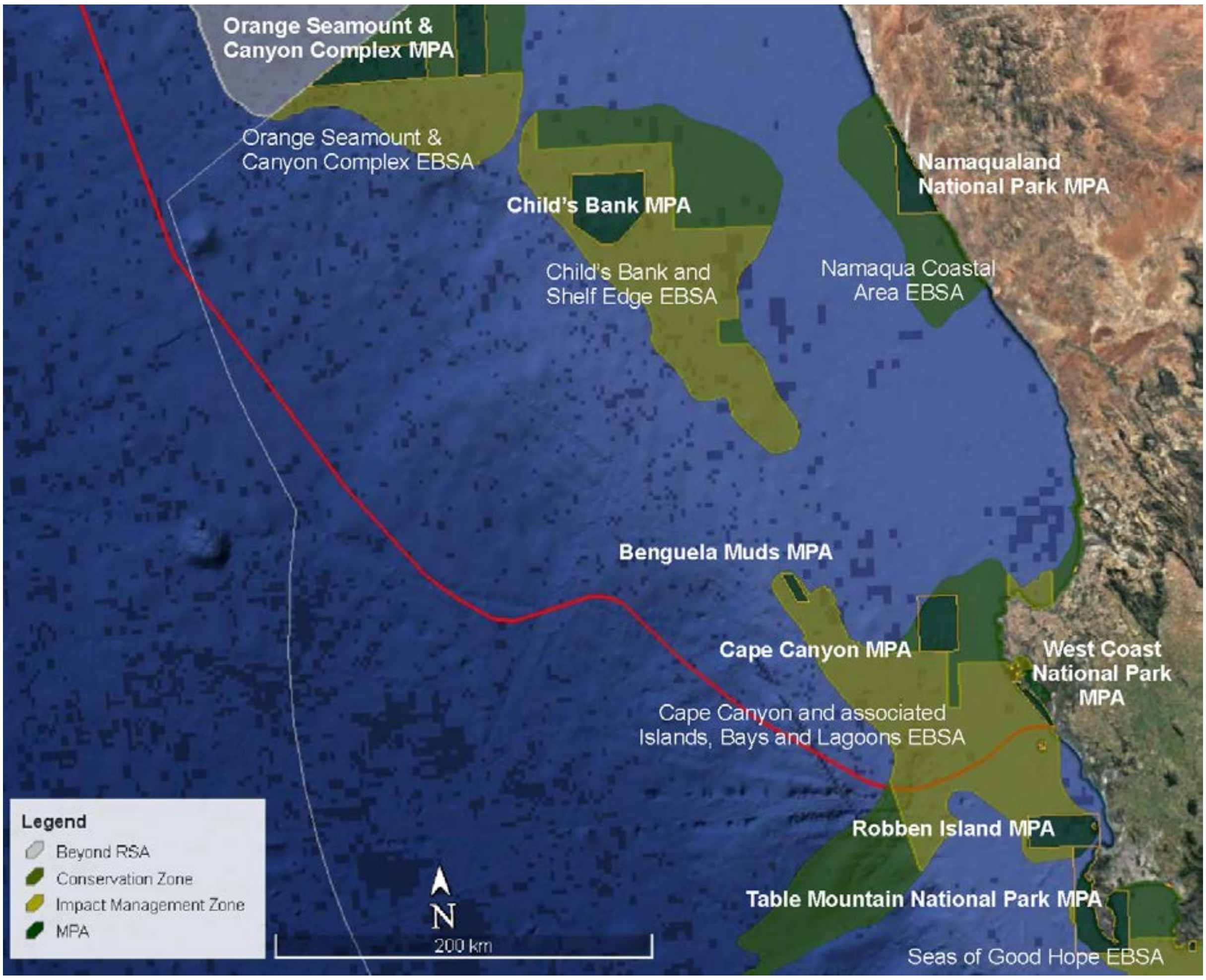

Figure 36: Conservation areas and Marine Protected Areas on the West Coast, in relation to the proposed ASN 2AFRICA (West) Cable route (red line).

The **Benguela Muds MPA** located to the east of the southern portion of the Deep Western Orange Basin Block, is the smallest of the South African offshore MPAs. At only 72 km^2 the muddy habitats located in this area are created by sediment washed down the Orange River and out to sea. These mud habitats are of limited extent and were considered 'critically endangered' on South Africa's deep continental margin of the west coast (Sink *et al.* 2014). The MPA represents the least trawled stretch of muddy seabed on the west coast.

The **Cape Canyon** is a deep and dramatic submarine canyon carved into the continental shelf and extending to a maximum depth of 3,600 m. The 580 km^2 MPA was proclaimed in 2019 and protects the upper part of the canyon where depths range from 180 to 500 m. Underwater footage has revealed a rich diversity of seafans, hermit crabs and mantis shrimps, with hake, monk and john dory resident on the soft canyon floor. Rocky areas in the west of the canyon support fragile rocky habitat, but the area also includes sandy and muddy habitats, which have been trawled in the past. Interaction of nutrient-rich bottom water with a complex seascape results in upwelling, which in turn provides productive surface waters in which seabirds, humpback whales and Cape fur seals feed.

The 612 km^2 **Robben Island MPA** was proclaimed in 2019 to protect the surrounding kelp forests - one of the few areas that still supports viable stocks of abalone. The island harbours the 3rd largest penguin colony, with the breeding population peaking in 2004 at 8,524, but declining since. The island also holds the largest numbers of breeding Bank Cormorant in the Western Cape (120 pairs in 2000) and significant populations of Crowned Cormorant, African Black Oystercatcher (35 breeding pairs in 2000), Hartlaub's Gull and Swift Tern.

Sensitive Areas

Despite the development of the offshore MPA network a number of 'Vulnerable' ecosystem types (i.e. Cape Lower Canyon, Southern Benguela Sandy Shelf Edge) are currently "poorly protected' or 'not protected' and further effort is needed to improve protection of these threatened ecosystem types (Sink *et al.* 2019) (Figure 37). Ideally, all highly threatened ('Critically Endangered' and 'Endangered') ecosystem types should be well protected. Currently, however, most of the Southern Benguela Sandy Shelf Edge and Southeast Atlantic Upper- and Mid-Slope are poorly protected receiving only 0.2-10% protection, whereas the Southeast Atlantic Lower Slope receives no protection at all (Sink *et al.* 2019). Most of the ecosystem types in the proposed ASN 2AFRICA (West) cable route are either poorly protected or not protected, with only the portion inshore of the 100 m depth contour and the upper portions of the Cape Canyon receiving 'moderate protection'.

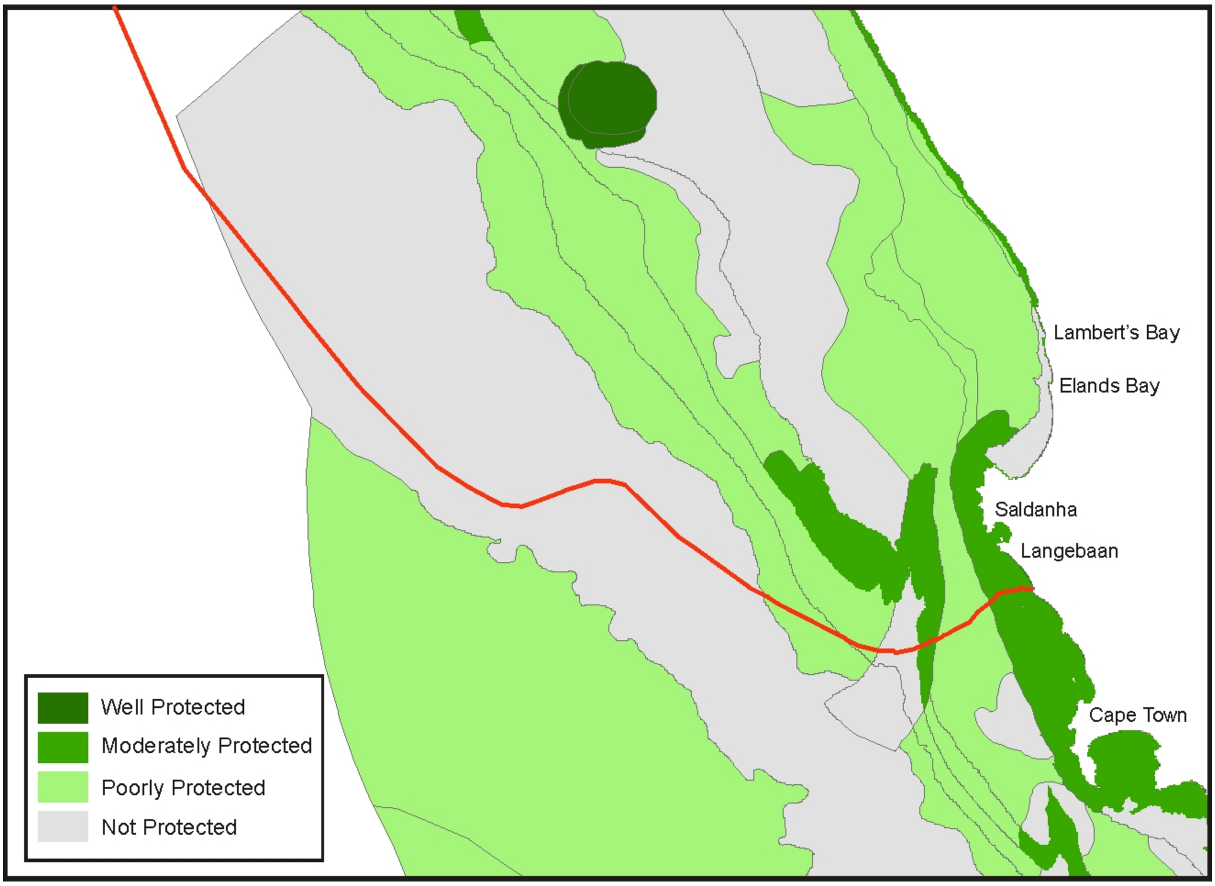

Figure 37: Protection levels of marine ecosystem types as assessed by Sink *et al.* (2019) in relation to the proposed ASN 2AFRICA (West) cable routing.

Ecologically or Biologically Significant Areas (EBSAs)

As part of a regional Marine Spatial Management and Governance Programme (MARISMA 2014-2020) the Benguela Current Commission (BCC) and its member states have identified a number of Ecologically or Biologically Significant Areas (EBSAs) both spanning the border between Namibia and South Africa and along the South African West, South and East Coasts, with the intention of implementing improved conservation and protection measures within these sites. South Africa currently has 12 EBSAs solely within its national jurisdiction with a further three having been proposed. It also shares eight trans-boundary EBSAs with other countries (Namibia (3) and Mozambique (2)) and high seas (3). The principal objective of these EBSAs is identification of features of higher ecological value that may require enhanced conservation and management measures.

Although no specific management actions have as yet been formulated for the EBSAs, two biodiversity zones have recently been defined within each EBSA as part of the marine spatial planning process. The management objective in the zones marked for 'Conservation' is "*strict place-based biodiversity protection aimed at securing key biodiversity features in a natural or semi-natural state, or as near to this state as possible*". The management objective in the zones marked for 'Impact Management' is "*management of impacts on key biodiversity features in a mixed-use area to keep key biodiversity features in at least a functional state*" (https://cmr.mandela.ac.za/EBSA-Portal/South-Africa/SA-EBSA-Status-Assessment-Management). Activities within these two zones can be placed into one of four different Marine Spatial Planning (MSP) categories depending on their compatibility with the EBSA features and management objective of that zone.

Primary	*An activity that supports the maintenance of biodiversity features. This activity should be encouraged in this zone, and should be prioritized when spatial management decisions are being made. These activities are still likely to be subject to reasonable controls and management measures.*
General	*An activity that is allowed and regulated by current general rules and legislation.*
Consent	*An activity which can continue in this zone subject to specific regulation and control. Careful controls are likely to be put in place to avoid unacceptable impacts on biodiversity features, or ideally to avoid intensification or expansion of impact footprints of uses that are already occuring and where there are no realistic prospects of excluding these activities.*
Prohibited	*An activity which is not allowed or should not be allowed because it is incompatible with maintaining the biodiversity objectives of the zone.*

Various future activities such as the dumping of dredge spoils, disused ammunition, mining construction and operations, and the exploration for Oil and Gas may be prohibited in the conservation zone of these EBSAs, but may be consented in the impact management zone (https://cmr.mandela.ac.za/EBSA-Portal/South-Africa/SA-EBSA-Status-Assessment-Management; accessed 30 March 2021). In the Underwater Infrastructure Zone, sea-use activities permitted with consent include undersea cables, seawater inlets and pipelines. It must be noted, however, that the EBSA Zone boundaries are subject to ongoing revision based on discussions with the National

EBSA Working Group. These zones have been incorporated into the most recent iteration of the national Coastal and Marine Critical Biodiverity Area (CBA) Map (v1.0 (Beta 2) released 26th February 2021) (Harris *et al.* 2020) (Figure 39). This indicates that the cable route passes through a number of CBA1 and CBA2 regions. CBA 1 indicates irreplaceable or near-irreplaceable sites that are required to meet biodiversity targets with limited, if any, option to meet targets elsewhere, whereas CBA 2 indicates optimal sites that generally can be adjusted to meet targets in other areas. Ecological Support Areas (ESAs) represent EBSAs outside of MPAs and not already selected as CBAs. Sea-use within the CBAs and ESAs reflect those specified by the EBSA biodiversity conservation and management zones described above.

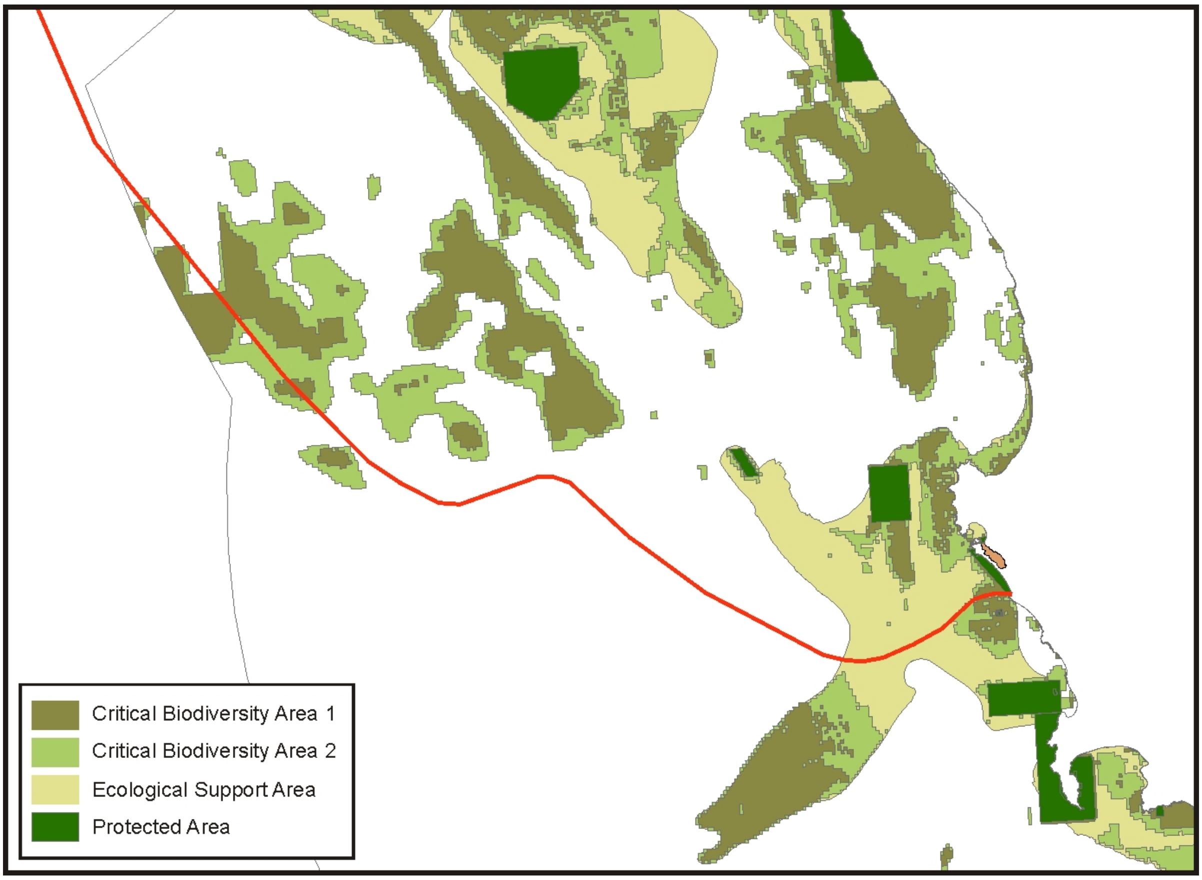

Figure 38: The proposed ASN 2AFRICA (West) cable routing (red line) in relation to the National Coastal and Marine Critical Biodiversity Areas (version 1.0 (Beta 2)) (adapted from Harris *et al.* (2020)).

Those EBSAs in the broader project area are described briefly below (see Figure 36).

The **Childs Bank and Shelf Edge** EBSA, which lies to the east of the cable route, is a unique submarine bank feature rising from 400 m to -180 m on the western continental margin on South Africa. This area includes five benthic habitat types, including the bank itself, the outer shelf and the shelf edge, supporting hard and unconsolidated habitat types. Childs Bank and associated habitats are known to support structurally complex cold-water corals, hydrocorals, gorgonians and glass sponges; species that are particularly fragile, sensitive and vulnerable to disturbance, and recover slowly.

The **Namaqua Coastal Area** EBSA, which lies to the east of the Deep Western Orange Basin block and encompasses the Namaqua Coastal Area MPA, is characterized by high productivity and community biomass along its shores. The area is important for several threatened ecosystem types represented there, including two 'Endangered' and four 'Vulnerable' ecosystem types, and is important for conservation of estuarine areas and coastal fish species.

The **Cape Canyon and Associated Islands** EBSA lies to the southeast of the Deep Western Orange Basin block. The EBSA includes the Benguela Muds MPA and the Cape Canyon, which is thought to hosts fragile habitat-forming species. The area is considered important for pelagic fish, foraging marine mammals and several threatened seabird species and serves to protect nine 'Endangered' and 12 'Vulnerable' ecosystem types, and two that are 'Near Threatened'. There are several small coastal MPAs within the EBSA.

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

The proposed **Seas of Good Hope EBSA** is located at the coastal tip of Africa, wrapping around Cape Point and Cape Agulhas. It extends from the coast to the inner shelf, and includes key islands (Seal Island, Dyer Island And Geyser Rocks), two major bays (False Bay and Walker Bay), and is of key importance for threatened species and habitats. The threatened habitats include coastal, inshore and inner shelf ecosystem types. The important life-history stages supported by the area are breeding and/or foraging grounds for a myriad of top predators, including sharks, whales, and seabirds, some of which are threatened species. This EBSA is also the place where the Benguela and Agulhas Currents meet.

Important Bird Areas (IBAs)

IBAs in the general project area include Lower Berg River wetlands and the West Coast National Park and Saldanha Bay Islands, Dassen and Robben Islands, Rietvlei Wetland and False Bay Nature Reserve. Various marine IBAs have also been proposed in South African territorial waters. The proposed ASN 2AFRICA (West) Route passes through the proposed Bird Island / Dassen Island / Heuningnes river and estuary system / Lower Berg river wetlands – Marine IBA (Figure 39).

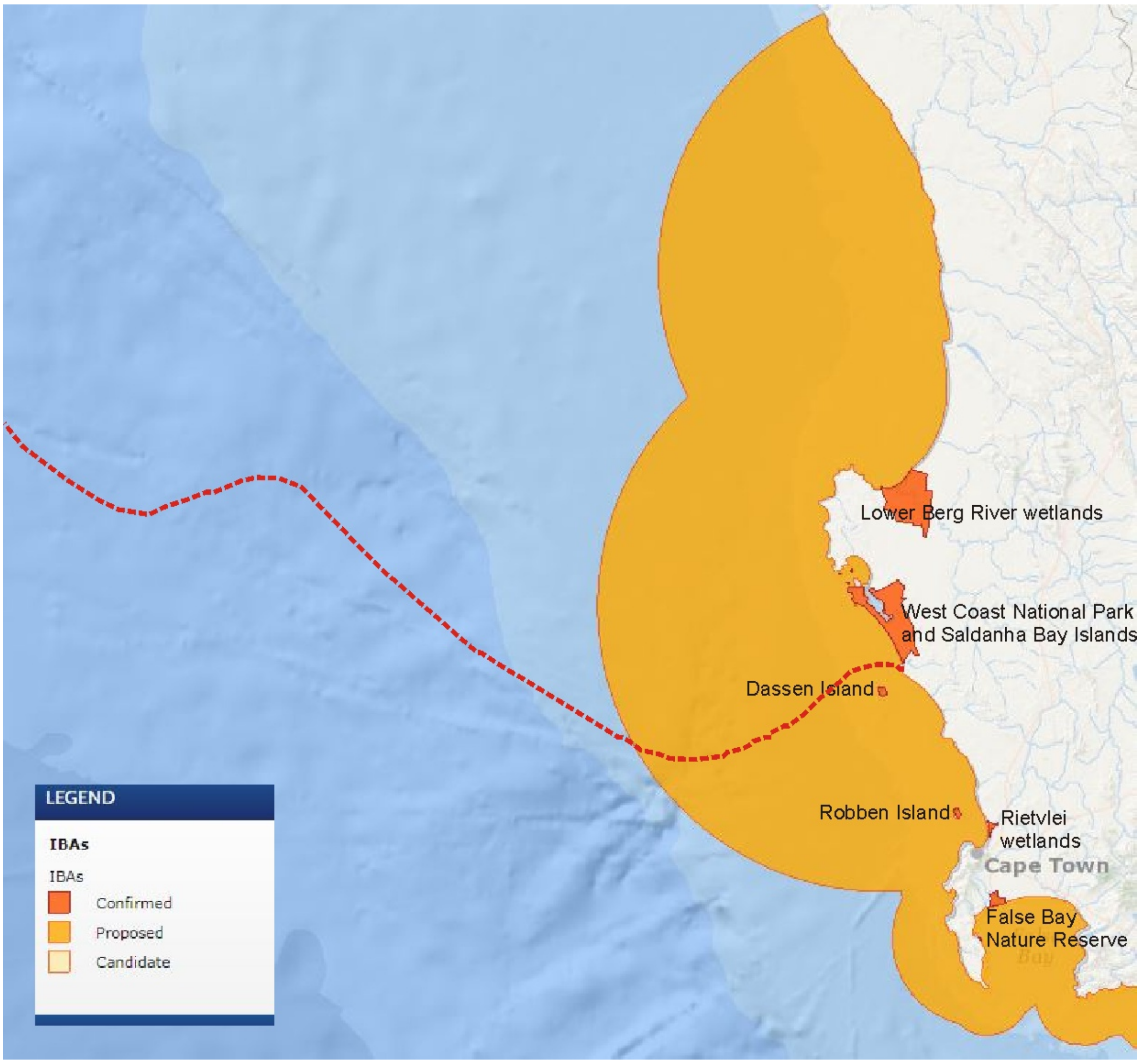

Figure 39: The ASN 2AFRICA (West) cable route in relation to coastal and marine IBAs (Source: https://maps.birdlife.org/marineIBAs).

4. ASSESSMENT OF IMPACTS ON MARINE FAUNA

4.1. Impact Assessment Methodology

An EIA methodology should minimise subjectivity as far as possible and accurately assess the project impacts. In order to achieve this ACER has followed the methodology defined below.

4.1.1 Impact Identification and Characterisation

An 'impact' is any change to a resource or receptor caused by the presence of a project component or by a project-related activity. Impacts can be negative, positive or neutral.

Nature of the Impact *– describes whether the impact would have a negative, positive or zero effect on the affected environment*	
Positive	The impact benefits the environment
Negative	The impact results in a cost to the environment
Neutral	The impact has no effect

Type of impacts assessed:

Type of impacts assessed	
Direct (Primary)	Impacts that are caused directly by the activity and generally occur at the same time and at the place of the activity. These impacts are usually associated with the construction, operation or maintenance of an activity and are generally obvious and quantifiable.
Indirect	Indirect or induced changes that may occur because of the activity. These types of impacts include all the potential impacts that do not manifest immediately when the activity is undertaken, or which occur at a different place because of the activity.
Cumulative	Impacts that result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities. Cumulative impacts can occur from the collective impacts of individual minor actions over time and can include both direct and indirect impacts.

Impacts are described in terms of their characteristics, including the impact type and the impact spatial and temporal features (namely extent, duration, scale and frequency). The following convention was used to determine significance ratings in the assessment:

Rating	Definition of Rating
***Intensity** – establishes whether the magnitude of the impact is destructive or benign in relation to the sensitivity of the receiving environment*	
Negligible	Inconsequential change, disturbance or nuisance. The impact affects the environment in such a way that natural functions and processes are not affected.
Low	Minor (Slight) change, disturbance or nuisance. The impact on the environment is not detectable.
Medium	Moderate change, disturbance or discomfort. Where the affected environment is altered, but natural functions and processes continue, albeit in a modified way.
High	Prominent change, disturbance or degradation. Where natural functions or processes are altered to the extent that they will temporarily or permanently cease.
***Duration** – the time frame over which the impact will be experienced*	
Short-term	<3 years.
Medium-term	3 – 10 years.
Long-term	>10 years, but where the impact will eventually cease either because of natural processes or by human intervention.
Permanent	Where mitigation either by natural processes or by human intervention would not occur in such a way or in such time span that the impact can be considered transient.
***Extent** – defines the physical extent or spatial scale of the impact*	
Site specific	Impacts are limited to the site area only.
Local	Impacts extend only as far as the activity; limited to the site and its immediate surroundings; <2 km.
Regional	Impacts are confined to the region or are experienced within 30 km of the site.
National	Impacts are limited to the coastline of South Africa.
International	Impacts extend beyond the borders of South Africa.
***Loss of resources** - the degree to which a resource is permanently affected by the activity, i.e. the degree to which a resource is irreplaceable*	
Low	Where the activity results in a loss of a particular resource which is easily replaceable.
Medium	Where the loss of a resource occurs, but it can be replaced with effort.
High	Where the activity results in an irreplaceable loss of a resource.
***Reversibility** – defines the potential for recovery to pre-impact conditions*	
Irreversible	Impacts are permanent.
Low	Where the impact can be reversed to only a limited degree.
Medium	Where the impact can be partially reversed.
High	Where the impact can be completely reversed.

***Probability** – the likelihood of the impact occurring*	
Improbable	Where the possibility of the impact to materialise is very low either because of design or historic experience, i.e. ≤ 30% chance of occurring.
Probable	Where there is a distinct possibility that the impact would occur, i.e. > 30 to ≤ 60% chance of occurring.
Highly Probable	Where it is most likely that the impact would occur, i.e. > 60 to ≤ 80% chance of occurring.
Definite	Where the impact would occur regardless of any prevention measures, i.e. > 80% chance of occurring.

Using the core criteria above (namely extent, duration, intensity and loss of resources), the consequence of the impact is determined:

***Consequence** – attempts to evaluate the importance of a particular impact, and in doing so incorporates extent, duration and intensity*	
Low	Impacts could be EITHER: of low intensity, duration, extent and impact on irreplaceable resources; OR of low intensity with up to two of the other criteria rated as medium; OR of medium intensity with all three other criteria rated as low.
Medium	Impacts are of medium intensity with at least two of the other criteria rated as medium.
High	Impacts could be EITHER: of high Intensity and impact on irreplaceable resources, with any combination of extent and duration; OR of high intensity, with all of the other criteria rated medium or high.

The consequence rating is considered together with the probability of occurrence in order to determine the overall significance using the table below.

		PROBABILITY			
		IMPROBABLE	**POSSIBLE**	**PROBABLE**	**DEFINITE**
CONSEQUENCE	**LOW**	VERY LOW	VERY LOW	LOW	LOW
	MEDIUM	LOW	LOW	MEDIUM	MEDIUM
	HIGH	MEDIUM	MEDIUM	HIGH	HIGH

Further criteria assessed are:

Frequency - Description of any repetitive, continuous or time-linked characteristics of the impact	
Once-off	occuring any time during construction.
Intermittent	occuring from time to time, without specific periodicity.
Periodic	occuring at more or less regular intervals.
Continuous	occuring without interruption.
Degree of confidence in predictions *– in terms of basing the assessment on available information and specialist knowledge*	
Low	Less than 35 % sure of impact prediction.
Medium	Between 35 % and 70 % sure of impact prediction.
High	Greater than 70 % sure of impact prediction.

A key objective of an EIA is to identify and define environmentally and technically acceptable and cost effective measures to manage and mitigate potential impacts. Mitigation measures are developed to avoid, reduce, remedy or compensate for potential negative impacts, and to enhance potential environmental benefits.

The priority is to first apply mitigation measures to the source of the impact (i.e. to avoid or reduce the magnitude of the impact from the associated project activity), and then to address the resultant effect to the resource/receptor *via* abatement or compensatory measures or offsets (i.e. to reduce the significance of the effect once all reasonably practicable mitigations have been applied to reduce the impact magnitude).

Once mitigation measures are declared, the next step in the impact assessment process is to assign residual impact significance. This is essentially a repeat of the impact assessment steps discussed above, considering the assumed implementation of the additional declared mitigation measures.

Degree to which impact can be mitigated *- the degree to which an impact can be reduced / enhanced*	
None	No change in impact after mitigation.
Very Low	Where the significance rating stays the same, but where mitigation will reduce the intensity of the impact.
Low	Where the significance rating drops by one level, after mitigation.
Medium	Where the significance rating drops by two to three levels, after mitigation.
High	Where the significance rating drops by more than three levels, after mitigation.

4.2. Identification of Impacts

Potential impacts to the marine environment as a result of the installation and operation of the subsea cable are briefly summarised below, and discussed in more detail in Sections 4.3 and 4.4.

4.2.1 Cable Route Survey

The cable route survey could result in:

- Physiological injury or behavioural disturbance of marine fauna by the sounds emitted by the geophysical survey equipment; and
- Potential injury to marine mammals and turtles through vessel strikes.

4.2.2 Subsea Cable Installation

The installation of the subsea cable would result in:

- Disturbance of sediments and associated fauna during the pre-lay grapnel run;
- Disturbance of sediments and associate fauna during cable installation;
- Elimination of biota in the cable's structural footprint;
- Reduced area of unconsolidated seabed available for colonisation by infaunal communities; and
- Physical presence of the cable providing an alternative substratum for colonising benthic communities, or resulting in faunal attraction to fish and mobile invertebrates.

4.2.3 Shore crossing of the Subsea Cable

Infrastructure crossing the shore will impact on intertidal and shallow subtidal biota during the construction phase in the following ways:

- Temporary loss of benthic habitat and associated sessile communities due to preparation of seabed for buried cable laying and associated activities;
- Possible temporary impacts on adjacent habitat health due to turbidity generated during trenching and installation;
- Temporary disturbance of marine biota, particularly marine mammals and coastal birds, due to construction activities;
- Possible impacts to marine water quality and sediments through hydrocarbon pollution by marine construction infrastructure and machinery, and inappropriate disposal of used lubricating oils from marine machinery maintenance; and
- Potential contamination of marine waters and sediments by inappropriate disposal of spoil from trenching activities or backfilling, and human wastes, which could in turn lead to impacts upon marine flora, fauna and habitat.

4.2.4 Operation of the Subsea Cable System

As no routine maintenance of the subsea cable system is required, impacts associated with the operational phase would consitute temporary disturbance of the seabed if subsea cable sections require replacing. Impacts would be highly localised and sporadic.

4.2.5 Decommissioning

As the subsea cable will most likely be left in place at decommissioning, the potential impacts during the decommissioning phase are expected to be minimal and no key issues related to the marine environment are identified at this stage. As full decommissioning will require a separate EIA process, potential issues related to this phase will not be dealt with further in this report.

4.3. Geophysical Surveying of the Cable Route

Although the geophysical surveying of the cable route has already been undertaken, it is discussed and assessed briefly below for the sake of completeness and in the event that portions of the proposed cable route may need to be re-surveyed for some reason.

Noise propagation represents energy travelling either as a wave or a pressure pulse through a gas or a liquid. Due to the physical differences between air and water (density and the speed at which sound travels), the decibel units used to describe noise underwater are different from those describing noise in air. Furthermore, hearing sensitivities vary between species and taxonomic groups. Underwater noise generated by drilling activities is therefore treated separately from noise generated in the air.

The ocean is a naturally noisy place and marine animals are continually subjected to both physically produced sounds from sources such as wind, rainfall, breaking waves and natural seismic noise, or biologically produced sounds generated during reproductive displays, territorial defence, feeding, or in echolocation (see references in McCauley 1994). Such acoustic cues are thought to be important to many marine animals in the perception of their environment as well as for navigation purposes, predator avoidance, and in mediating social and reproductive behaviour. Anthropogenic sound sources in the ocean can thus be expected to interfere directly or indirectly with such activities thereby affecting the physiology and behaviour of marine organisms (NRC 2003). Natural ambient noise will vary considerably with weather and sea state, ranging from about 80 to 120 dB re 1 µPa (Croft & Li 2017). Of all human-generated sound sources, the most persistent in the ocean is the noise of shipping. Depending on size and speed, the sound levels radiating from vessels range from 160 to 220 dB re 1 µPa at 1 m (NRC 2003). Especially at low frequencies between 5 to 100 Hz, vessel traffic is a major contributor to noise in the world's oceans, and under the right conditions, these sounds can propagate 100s of kilometres thereby affecting very large geographic areas (Coley 1994, 1995; NRC 2003; Pidcock *et al.* 2003). Other forms of anthropogenic noise include 1) multi-beam sonar systems, 2) seismic acquisition, 3) hydrocarbon and mineral exploration and recovery, and 4) noise associated with underwater blasting, pile driving, and construction (Figure 39).

The cumulative impact of increased background anthropogenic noise levels in the marine environment is an ongoing and widespread issue of concern (Koper & Plön 2012), as such sound sources interfere directly or indirectly with the animals' biological activities. Reactions of marine mammals to anthropogenic sounds have been reviewed by McCauley (1994), Richardson *et al.* (1995), Gordon & Moscrop (1996) and Perry (1998) (amongst others), who concluded that anthropogenic sounds could affect marine animals in the surrounding area in the following ways:

- Physiological injury and/or disorientation;
- Behavioural disturbance and subsequent displacement from key habitats;
- Masking of important environmental sounds and communication;

- Indirect effects due to effects on prey.

It is the received level of the sound, however, that has the potential to traumatise or cause physiological injury to marine animals. As sound attenuates with distance, the received level depends on the animal's proximity to the sound source and the attenuation characteristics of the sound.

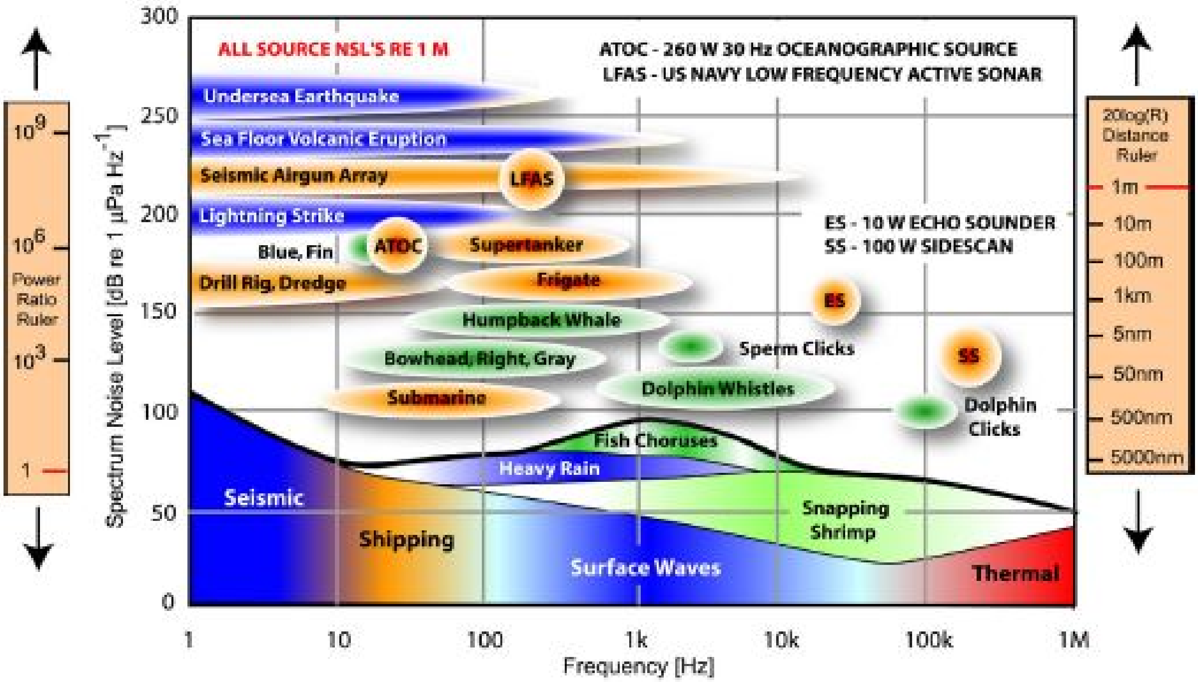

Figure 40: Comparison of noise sources in the ocean (Goold & Coates 2001).

The survey vessel would be equipped with a high to very high resolution multi-beam echo sounder (MBES), sub-bottom profiler and side scan sonar. This equipment emits a fan of acoustic beams from a transducer at frequencies ranging from 12 – 850 kHz[1] and typically produce maximum sound levels in the order of 190 to 240 dB re 1 µPa at 1 m. The operating frequencies falls into the high frequency kHz range, and are thus beyond the low frequency hearing ranges of fish species and sea turtles (from below 100 Hz to up to a few kHz) (Table 10). The high frequency active sonar sources, however, have energy profiles that clearly overlap with cetaceans' hearing sensitivity frequency range, particularly for cetaceans of High Frequency and Very High Frequency hearing groups, and would be audible for considerable distances (in the order of tens of km) before attenuating to below threshold levels. The noise emissions from the geophysical sources are highly directional, spreading as a fan from the sound source, predominantly in a cross-track direction. The noise impact would therefore be highly localised for the majority of marine mammal species. As surveys using the MBES, sub-bottom profiling and side sacan sonar sources have much lower noise emissions compared with seismic airgun sources, no specific considerations have been put in place in developing

1 Low frequency MBES (12-50 kHz) are designed for deep water (4,000 – 6,000 m) and intermediate depths and continental slopes. Medium- (70-150 kHz) and high-frequency (>200 kHz) MBES are designed for shallow to intermediate depths and ultrashallow depths (few metres to tens of metres), respectively (Lurton 2015).

Table 10: Known hearing frequency ranges of various marine taxa (adapted from Koper & Plön 2012; Southall *et al.* 2019).

Taxa	Order	Hearing frequency (kHz)
Shellfish	Crustaceans	0.1 – 3
Fish	Teleosts	
Hearing specialists		0.03 - >3
Hearing generalists		0.03 – 1
Sharks and skates	Elasmobranchs	0.1 – 1.5
African penguins	Sphenisciformes	0.6 - 15
Sea turtles	Chelonia	0.1 – 1
Seals and sea lions	Pinnipeds	0.75 – 75
Low Frequency Cetaceans	Mysticetes	0.007 – 22
High-frequency Cetaceans	Odontocetes	0.15 – 160
Very High-Frequency Cetaceans	Odontocetes	0.2 - 180

assessment criteria for these. Despite being audible by most marine mammals, the emission of underwater noise from geophysical surveying is not considered to be of sufficient amplitude to cause auditory or non-auditory trauma in marine animals (Burkhardt *et al.* 2008; Lurton 2010, 2015). Whereas behavioural effects (e.g. avoidance of the source) have been reported, there has been no evidence of physical damage (i.e. Permanent Threshold Shifts (PTS) and Temportary Threshold Shifts (TTS)) (Childerhouse *et al.* 2016). Recent sound transmission loss modelling studies undertaken for MBES surveys to depths of 3,600 m off the edge of the Agulhas Bank (Li & Lewis 2020) have predicted that marine mammals of all hearing groups except very-high-frequency cetaceans would experience PTS effect within 10 m from the MBES source, whereas for very-high-frequency cetaceans the maximum zones of PTS effect occurs within ~70 m from the MBES source along the cross-track direction. The zones of TTS due to a single pulse exposure for marine mammals of all hearing groups except very-high-frequency cetaceans are predicted to be within approximately 25 m from the MBES source, extending to within 140 m from the MBES source along the cross-track direction for very-high frequency cetaceans. Therefore, only directly below or within the sonar beam would received sound levels be in the 240 dB range where exposure would result in trauma or physiological injury. Furthermore, as the anticipated radius of influence of a multi-beam sonar is significantly less than that for a seismic airgun array, the statistical probability of crossing a cetacean or pinniped with the narrow multi-beam fan several times, or even once, is very small. As most pelagic species likely to be encountered along the cable route are highly mobile, they would be expected to flee and move away from the sound source before trauma could occur.

Due to the extremely strong source directivity characteristics, the sound energy emissions from individual MBES pulses at cross-track directions are expected to dominate cumulative sound energy exposure at receiving locations. Very high-frequency cetaceans were predicted to have the highest zones of impact for cumulative PTS and TTS, being in the order of 400 m and 1,200 m, respectively. However, as these are limited to cross-track directions, the actual impact footprints are significantly smaller than with omnidirectional noise emissions. For cetaceans of other hearing groups and for seals, no PTS impact was predicted. For Low Frequency and High Frequency cetaceans, the cumulative sound exposure impact was predicted to be highly localised around the MBES source location, with the highest impact zone being <100 m from the source.

The underwater noise from the survey systems may, however, induce localised behavioural changes in some marine mammal. The maximum impact distance for behavioural disturbance caused by the immediate exposure to individual sonar MBES pulses was predicted to be within ~2 km from the MBES source for marine mammals of all hearing groups, at cross-track directions. Evidence of significant behavioural changes that may impact on the wider ecosystem is lacking (Perry 2005).

Given the evidence available from the scientific literature and the results of sound transmission loss modelling, the effects of high frequency sonars on marine fauna is considered to be of low intensity, localised along the cable route and short-term (for duration of survey i.e. weeks). Any behavioural or physiological impacts on marine fauna would be fully reversible and consequently the impact is considered of **VERY LOW** significance both without and with mitigation.

Mitigation Measures

Despite the low significance of impacts for geophysical surveys, the Joint Nature Conservation Committee (JNCC) provides a list of guidelines to be followed by anyone planning marine sonar operations that could cause acoustic or physical disturbance to marine mammals (JNCC 2017). These have been revised to be more applicable to the southern African situation.

- Onboard Marine Mammal Observers (MMOs) should conduct visual scans for the presence of cetaceans around the survey vessel prior to the initiation of any acoustic impulses.
- Pre-survey scans should be limited to 15 minutes prior to the start of survey equipment.
- "Soft starts" should be carried out for any equipment of source levels greater than 210 dB re 1 µPa at 1 m over a period of 20 minutes to give adequate time for marine mammals to leave the area.
- Terminate the survey if any marine mammals show affected behaviour within 500 m of the survey vessel or equipment until the mammal has vacated the area.
- Avoid planning geophysical surveys during the movement of migratory cetaceans (particularly baleen whales) from their southern feeding grounds into low latitude waters (beginning of June to end of November), and ensure that migration paths are not blocked by sonar operations. As no seasonal patterns of abundance are known for odontocetes occupying the proposed exploration area, a precautionary approach to avoiding impacts throughout the year is recommended.
- Ensure that PAM (passive acoustic monitoring) is incorporated into any surveying taking place at night or between June and November.
- A dedicated MMO and PAM operator should be appointed to ensure compliance with mitigation measures during seismic geophysical surveying. The MMO can be either an independent MMO or a suitably trained crew member.

The mitigation measures recommended above are considered industry best-practice and have become accepted by the authorities as the norm.

Impacts of multi-beam and sub-bottom profiling sonar on marine fauna		
Characteristic	**Impact**	**Residual Impact**
Intensity	Low	Low
Duration	Short-term; for duration of survey	Short-term
Extent	Local: limited to within the path of the subsea cable route, but with indirect effects on adjacent areas	Local
Frequency	Once-off	Once-off
Loss of resource	Low	Low
Probability	Improbable	Improbable
Reversibility	Fully reversible	Fully reversible
Significance of Impact	**VERY LOW**	**VERY LOW**
Confidence	High	
Mitigation Potential	Very Low	

4.4. Installation of the Subsea Cable

Construction phase impacts associated with the installation of the subsea cable are discussed below.

4.4.1 Disturbance of the Coastal Zone[2]

Installation of the subsea cable through the surf-zone and across the beach would require the subsea cable to be buried to sufficient depth to ensure it is not exposed during seasonal variation of the beach levels. Excavated material would be disposed of onto the beach and into the surf-zone down-current of the construction site. Subtidal trenching would result in the mobilisation and redistribution of sediments in tidal currents and the littoral drift. This would result in localised increased suspended sediment concentrations in the water column. Where burial cannot be achieved and additional cable protection is required, an articulated split-pipe may be used to maximise cable security. The trenching and cable burial process would result in disturbance of high shore, intertidal and shallow subtidal sandy beach habitats and their associated macrobenthic communities through displacement, injury or crushing.

Although the activities on the shore and in the shallow subtidal regions would be localised and confined to within a few 10s of metres of the construction site and cable shore-crossing route, the benthic biota would be damaged or destroyed through moving of equipment and machinery and the general activities of contractors around the construction site. Mobile organisms such as fish and marine mammals, on the other hand, would be capable of avoiding the construction area. Any shorebirds feeding and/or roosting in the area would also be disturbed and displaced for the duration of construction activities.

The invertebrate macrofauna inhabiting these beaches are all important components of the detritus / beach-cast seaweed-based food chains, being mostly scavengers, particulate organic matter and

2 The coastal zone is defined as the coastal strip from 500 m inland of the high water mark to the 30 m depth contour (Sink *et al.* 2012).

filter-feeders (Brown and McLachlan 1994). As such, they assimilate food sources available from the detritus accumulations typical of this coast and, in turn, become prey for surf-zone fishes and migratory shorebirds that feed on the beach slope and in the swash zone. By providing energy input to higher trophic levels, they are all important in nearshore nutrient cycling, and significant reduction or loss of these macrofaunal assemblages may therefore have cascade effects through the coastal ecosystem (Dugan *et al.* 2003).

On a high-energy coastline the recovery of the physical characteristics of intertidal and shallow subtidal unconsolidated sediments to their pre-disturbance state following trenching and cable burial will occur within a few tidal cycles under heavy swell conditions, and will typically result in subsequent rapid recovery of the invertebrate epifaunal and infaunal communities to their previous state. Previous studies on the impact of cofferdam and larger-scale seawall mining on macrofaunal beach communities identified that the physical state of beaches on the West Coast is entirely driven by natural conditions, and is not affected (except during the actual disturbance) in the medium- to long-term (Pulfrich *et al.* 2004; Pulfrich *et al.* 2015). Removal of beach sands results in a significant, yet localised and short-term decrease in macrofaunal abundance and biomass. Intertidal beach macrofauna appear to be relatively tolerant to disturbance, and re-colonization of disturbed areas is rapid (van der Merwe & van der Merwe 1991; Brown & Odendaal 1994; Newell *et al.* 1998; Peterson *et al.* 2000; Schoeman *et al.* 2000; Seiderer & Newell 2000; Nel *et al.* 2003). Impacted areas are initially colonized by small, abundant and opportunistic pioneer species with fast breeding responses to tolerable conditions (e.g. crustaceans and polychaetes). If, following the disturbance, the surface sediment is similar to the original surface material, and if the final long-term beach profile has similar contours to the original profile, the addition or removal of layers of sand does not have enduring adverse effects on the sandy beach benthos (Hurme & Pullen 1988; Nel & Pulfrich 2002; Nel *et al.* 2003).

Provided the construction activities are all conducted concurrently, the duration of the construction disturbance should be limited to a few weeks. Disturbed subtidal communities within the wave base (<40 m water depth) might recover even faster (Newell *et al.* 1998). However, while recovery of the intertidal and subtidal communities is rapid, physical alteration of the shoreline in ways that cannot be remediated by swell action, such as deposition of large piles of pebbles and boulders, can be more or less permanent. Whilst the construction activities associated specifically with the cable installation are unlikely to have a significant effect at the ecosystem level, the cumulative effects of increasing development along this stretch of coast must be kept in mind.

The impacts on benthic communities as a result of cable installation through the littoral zone would be of medium intensity. Impacts would, however, be once-off and highly localised, being restricted to an ~10 m wide strip through the intertidal and surf-zone. Impacts would be expected to endure over the short-term only as communities within the wave-influenced zone are adapted to frequent natural disturbances and recover relatively rapidly. The subsea cable routing passes through inshore benthic habitats identified as 'least concern' (South Benguela Dissipative Sandy Shore). The loss of resources would be low and impacts would be fully reversible. Disturbance of intertidal and shallow subtidal benthic organisms will definitely occur, but the potential impacts of the cable's shoreline crossing on benthic organisms is deemed to be of **LOW** significance without mitigation.

Mitigation Measures

As standard industry practice, the routing of the proposed subsea cable should be planned to as far as practicably possible avoid sensitive benthic habitats in the coastal and nearshore zone.

The following essential mitigation measures should be implemented:

- Obtain a vehicle access permit from DEA (Branch Oceans and Coasts) prior driving in the coastal zone.
- Restrict disturbance of the intertidal and subtidal areas to the smallest area possible. Once the shore crossing is finalised and the associated construction site is determined, the area located outside of the site should be clearly demarcated and regarded as a 'no-go' area.

The following best-practice mitigation measures are recommended:

- As far as practicable, ensure that construction activities required for subsea cable installation occur concurrently thereby minimizing the disturbance duration in the coastal and nearshore zone;
- Restrict traffic in the intertidal area to minimum required;
- Restrict traffic to clearly demarcated access routes and construction areas only. These areas should be defined in consultation with the Environmental Control Officer (ECO);
- Have good house-keeping practices in place during construction, specifically waste management; and
- No accumulations of excavated sediments or rock stockpiles should be left above the high water mark. Any substantial sediment accumulations below the high water mark should be levelled to follow the natural profile.

Disturbance and destruction of sandy beach biota during trench excavation and** subsea **cable installation		
Characteristic	**Impact**	**Residual Impact**
Intensity	Medium	Medium
Duration	Short-term; recovery is expected within 2-5 years	Short-term
Extent	Local: limited to within a few metres of the subsea cable route, but with indirect effects on adjacent areas	Local
Frequency	Once-off	Once-off
Loss of resource	Low	Low
Probability	Definite	Definite
Reversibility	Fully reversible	Fully reversible
Significance of Impact	**LOW**	**LOW**
Confidence	High	
Mitigation Potential	Very Low	

4.4.2 Disturbance of nearshore Benthic Habitats

Trenching of the subsea cable in the littoral zone beyond 10-15 m depth would result in the mobilisation and redistribution of sediments in tidal currents and the littoral drift. This would result in localised increased suspended sediment concentrations in the water column. Where burial cannot be achieved and additional cable protection is required, an articulated split-pipe may be used to maximise cable security. Within the wave-base (0 – 50 m), the subsea cable and/or articulated split-pipes may be held in place with saddle clamps at specific locations. This would require drilling into the bedrock to secure the clamps. The subsea cable burial and/or securing process would result in disturbance of subtidal unconsolidated sediments and their associated macrobenthic communities through displacement, injury or crushing.

Although the activities in the subtidal regions would be localised and confined to within a few metres of the subsea cable route, the benthic biota would be disturbed, damaged or destroyed through displacement of sediments during trenching and subsea cable burial. Mobile organisms such as fish and marine mammals, on the other hand, would be capable of avoiding the construction area. Any seabirds feeding in the area may also be disturbed and displaced for the duration of construction activities.

Once the subsea cable has been buried, the affected seabed areas would, with time, be recolonised by benthic macrofauna. The ecological recovery of the disturbed sea floor is generally defined as the establishment of a successional community of species, which progresses towards a community that is similar in species composition, population density and biomass to that previously present (Ellis 1996; Ellis and Garnett 1996; Ellis 2000). In general, communities of short-lived species and/or species with a high reproduction rate (opportunists) may recover more rapidly than communities of slow growing, long-lived species. Opportunists are usually small, mobile, highly reproductive and fast growing species and are the early colonisers. Sediments in the nearshore wave-base regime, which are subjected to frequent disturbances, are typically inhabited by these opportunistic species (Newell *et al.* 1998). Recolonisation will start rapidly after cessation of trenching, and species diversity and abundance may recover within short periods (weeks) whereas biomass often remains reduced for several years (Kenny and Rees 1994, 1996). Disturbed subtidal communities within the wave base (<40 m water depth) and in areas of substantial longshore sediment drift might recover even faster (Newell *et al.* 1998; Porter-Smith *et al.* 2004; Sherwood *et al.* 2016). Although recovery is site specific and dependent on different modes of cable burial and varied sediment environments, Kraus and Carter (2018) reported that on the inner and middle shelf, recovery of benthic communities following cable burial by plough typically occurs within 1-2 years (see also Grannis 2005; Sherwood *et al.* 2016). From their study they concluded that the physical presence of the cable and the disturbance caused by its burial had little effect on the benthic communities along the cable route.

The impacts of trenching and increased suspended sediments on benthic communities within and beyond the surf-zone as a result of the subsea cable installation would be of medium intensity. Impacts would be once-off and highly localised, being restricted to within a few metres of the cable trench and subsea cable route, possibly extending to immediately adjacent areas. Impacts would be expected to endure over the short-term only as communities within the wave-influenced zone are adapted to frequent natural disturbances and recover relatively rapidly. Although the subsea cable route passes through nearshore benthic habitats identified as 'vulnerable' (Cape Sandy Inner

Shelf), the loss of resources would be low and impacts would be fully reversible. Assuming a worst-case disturbance footprint of 5 m wide, the proportion of vulnerable Cape Sandy Inner-Shelf habitat affected by the subsea cable installation was calculated at 0.026%, which can be considered negligible in relation to the available 526.2 km^2 of habitat area (Sink *et al.* 2019). The potential impacts of cable installation on benthic organisms in the nearshore environments is consequently deemed to be of **LOW** significance without mitigation.

Mitigation Measures

As standard industry practice, the routing of the proposed subsea cable should be planned to as far as practicably possible avoid sensitive benthic habitats in the nearshore zone.

The following best-practice mitigation measures are recommended:

- Align routing of cable as closely as possible to the routes of existing or de-commissioned cables (even when these traverse a Marine Protected Area) thereby avoiding the impact of as yet undisturbed ecoststem types.

Disturbance and destruction of nearshore biota in unconsolidated sediments during trench excavation and cable installation		
Characteristic	**Impact**	**Residual Impact**
Intensity	Medium	Medium
Duration	Short-term; recovery is expected within 2-5 years	Short-term
Extent	Local: limited to within a few metres of the subsea cable route, but with indirect effects on adjacent areas	Local
Frequency	Once-off	Once-off
Loss of resource	Low	Low
Probability	Probable	Probable
Reversibility	Fully reversible	Fully reversible
Significance of Impact	**LOW**	**LOW**
Confidence	High	
Mitigation Potential	Very Low	

4.4.3 Disturbance of Offshore Habitats

The grapnel used during the pre-lay grapnel run, and the subsea cable plough and/or tracked jet-trenching/burial ROV implemented during subsea cable laying would result in the disturbance and turnover of unconsolidated sediments along a swath of seabed. The extent of disturbed seabed depends on the cable laying method used (i.e. ploughing or jetting), which in turn depends on the nature of the sea-floor. Each method results in different spatial and temporal scales of damage (Kraus and Carter 2018; Taormina *et al.* 2018). Ploughs are usually 2–8 m wide, mounted on skids, wheels or caterpillar tracks, and are towed by a cable laying ship. The plough blade disturbes a swath of seabed ≤1 m wide but potentially extending to a depth of 3 m. The excavated sediment is allowed to fall back into the furrow once the cable has been laid (Kraus & Carter 2018; Taormina *et al.* 2018). Any epifauna or infauna associated with the disturbed sediments are likely to be displaced, damaged or destroyed. Similarly, the plough skids would injure or crush benthic invertebrates in their path. Mobilisation and redistribution of sediments in near-bottom currents during cable burial would result in localised increased suspended sediment concentrations near the seabed and in the water column (see Section 4.4.5).

In contrast, during jetting the seabed is liquified to allow the cable to settle in the trench, with burial occuring through the redeposition of sediments out of the slurry. Although the jetted trench is also typically ≤1 m wide, sediment disturbance is extensive and redeposition can spread to 100s of metres from the trench, with plumes of the suspended mud fractions potentially extending to 2 km from the cable route, thereby creating a larger impact footprint (Kraus & Carter 2018).

As the cable is typically only 25 mm[3] – 200 mm[4] in diameter the disturbance associated with laying it on top of the sediment or consolidated substrate is limited to the footprint of the cable itself and any protective encasing material. Impacts associated with placing the cable directly onto the seabed include crushing, damaging or displacement of organisms (Dunham *et al.* 2015; Taormina *et al.* 2018). Unless cables traverse habitats supporting vulnerable slow-growing species (e.g. glass sponges, deep-water corals) (see for example Dunham *et al.* 2015), the loss of substratum would, however, be temporary as the cable itself would provide an alternative substratum for colonising benthic communities or provide shelter for mobile invertebrates (see Section 4.4.6). Where the subsea cable is exposed, colonisation of the cable would commence within a few weeks. Studies from elsewhere have determined that benthic macro- and mega-fauna within 0–100 m of trenched and surface-laid cables showed negligible changes in abundance and distribution following cable installation (Kogan *et al.* 2006; Kuhnz *et al.* 2015).

Once the cable has been laid, the affected seabed areas around the cable would with time be recolonised by benthic macrofauna, with the encrusting epifauna resembling that inhabiting natural reefs in the area. The rate of recovery/re-colonisation depends largely on the type of community that inhabits the affected benthic habitats, the extent to which the community is naturally adapted to high levels of disturbances, the sediment character (grain size) and physical factors such as depth and exposure (waves, currents) (Newell *et al.* 1998; Herrmann *et al.* 1999).

Communities of short-lived species with a high reproduction rate tend to recover more rapidly than communities of slow growing, long-lived species. Recolonisation takes place by passive translocation of animals during storms or sediment influx from nearby unaffected areas, active immigration of mobile species, and immigration and settlement of pelagic larvae and juveniles (Hall 1994; Kenny and Rees 1994, 1996; Herrmann *et al.* 1999; Ellis 2000). More stable deep-water habitats are typified by large, often burrowing, slow growing and long-lived species (Newell *et al.* 1998). As long-lived species need longer to re-establish the normal age and size structure of the population, biomass often remains reduced for several years (Kenny and Rees 1994, 1996; see also Duna *et al.* 2016; Biccard *et al.* 2016, 2017, 2018, 2019).

It must be kept in mind, however, that re-colonisation is a site specific process, with the recovery time and resulting community structure being dependent not only upon sediment characteristics, but also local hydrodynamic conditions (Morton 1977; van der Veer *et al.* 1985) and depth. In deep water benthic community recovery rates are appreciably slower than in shallower areas subject to

[3]un-armoured cable at depths >900 m.

[4]armoured cable in the littoral zone, including articulated split-pipes.

strong swell or current effects. Recovery of benthic macrofaunal communities following diamond mining in 80-150 m depth off the southern African West Coast has been demonstrated to occur within eight years (Duna *et al.* 2016), but at depths excess of 1,000 m, re-colonization of disturbed seabeds to conditions similar to undisturbed areas is thought to take decades (Foell *et al.* 1990, 1992a, 1992b, Thiel and Schriever 1994; Schriever *et al.* 1997; Schratzberger and Warwick 1999). In contrast, recovery of shallow water (<30 m depth) sandy seabed communities can occur within 1 year following disturbance (Saloman *et al.* 1982; Hall and Harding 1997). Provided the sediment characteristics of the areas disturbed along the cable route are not dramatically altered, full recovery of such communities on the continental shelf following disturbance by the grapnel and cable plough would be expected within 5-10 years (Lopez-Jamar *et al.* 1995; Ellis and Garnett 1996; Kaiser *et al.* 1996). Studies on recovery of the seabed and associated benthic communities in deeper water also reported impacts persisting for as long as 15 years (Grannis 2005; Kuhnz *et al.* 2015), with recovery depending upon depositional rates of suspended load and bed load. The impacts assocated with cable burial are, however, a once-off disturbance, with affected communities able to recover naturally following the cable installation. NOAA (2005) noted that a single impact such as a cable burial, is preferred to continuous, multiple or recurring impacts such as those associated with, for example, a demersal trawl.

The potential direct impacts on benthic organisms of crushing and sediment disturbance would be of medium intensity and once off (unless cable repair is necessary). Although the cable will extend along some 14,000 km of seabed, benthic impacts will be highly localised along the length of the subsea cable route. Impacts would be limited to the medium-term only as recolonisation of disturbed sediments from adjacent areas would occur within a year, but full recovery to functional similarlity can take longer (medium- to long-term). The change in habitat from unconsolidated sediments to the hard sustratum of the cable itself would, however, be permenent. Although the subsea cable route passes through offshore benthic habitats identified as 'endangered' (Cape Upper Canyon) and 'vulnerable' (Cape Lower Canyon, Southern Benguela Sandy Shelf Edge, and Cape Rocky Mid-Shelf Mosaic) the loss of resources would be low and impacts would be partially reversible as unconsolidated habitat will be replaced by hard substratum in areas where the cable is not buried. Furthermore, the proportion of vulnerable habitat affected by the subsea cable installation can be considered negligible in relation to the available habitat area[5]. Consequently, the potential impacts on benthic organisms of cable installation across the continental shelf and abyss is deemed to be of **LOW** significance without mitigation. The elimination of marine benthic communities in the structural footprint of the cable is an unavoidable consequence of the installation of subsea cables, and no direct mitigation measures, other than the no-project option, are possible. Impacts will, however, be temporary as recolonisation of disturbed sediments from adjacent areas will occur within a few weeks.

Mitigation Measures

As standard industry practice, the routing of the proposed subsea cable should be planned to as far as practicably possible avoid sensitive deepwater benthic habitats.

5 Assuming a worst-case disturbance footprint of 5 m wide, the proportion of vulnerable habitats disturbed was calculated using the total areas for those habitats provided in Sink *et al.* 2019: 0.004% of Cape Lower Canyon; 0.0007 of the Cape Upper Canyon, 0.006% of Southern Benguela Sandy Shelf Edge; 0.003% of Cape Rocky Mid-Shelf Mosaic.

The following best-practice mitigation measures are recommended:

- Align routing of cable as closely as possible to the routes of existing or de-commissioned cables (even when these traverse a Marine Protected Area) thereby avoiding the impact of as yet undisturbed ecoststem types.

Disturbance and destruction of offshore benthic biota during cable laying		
Characteristic	**Impact**	**Residual Impact**
Intensity	Medium	Medium
Duration	Medium- to Long-term: recovery of deep-water benthos can be expected within 10 years	Medium-term
Extent	Site specific: limited to the subsea cable route	Site specific
Frequency	Once-off	Once-off
Loss of resource	Low	Low
Probability	Definite	Possible
Reversibility	Partially reversible	Fully reversible
Significance of Impact	**LOW**	**LOW**
Confidence	High	
Mitigation Potential	Very Low	

4.4.4 Increase in Noise

During installation of the subsea cable shore-crossing, noise and vibrations from excavation machinery may have an impact on surf-zone biota, marine mammals and shore birds in the area. Noise levels during construction are generally at a frequency much lower than that used by marine mammals for communication (Findlay 1996), and these are therefore unlikely to be significantly affected. Additionally, the maximum radius over which the noise may influence is very small compared to the population distribution ranges of surf-zone fish species, resident cetacean species and shore birds. Both fish and marine mammals are highly mobile and should move out of the noise-affected area (Findlay 1996). Similarly, shorebirds and terrestrial biota are typically highly mobile and would be able to move out of the noise-affected area. However, birds that nest and breed on beaches (e.g. African Black Oystercatcher) would be particularly susceptible to disturbance and noise from pedestrian traffic and construction activities on the beach.

Further offshore, underwater noise generated during subsea cable installation could affect a wide range of fauna; from benthic invertebrates and demersal species residing on the seabed along the subsea cable route, to those invertebrates and vertebrates occurring throughout the water column and in the pelagic habitat near the surface. Due to their hearing frequency ranges, the taxa most vulnerable to noise disturbance are turtles, pelagic seabirds, large migratory pelagic fish, and both migratory and resident cetaceans.

The cumulative impact of increased background anthropogenic noise levels in the marine environment is an ongoing and widespread issue of concern (Koper and Plön 2012). The sound level generated by the subsea cable laying vessel and subsea apparatus would fall within the hearing range of most fish and marine mammals, and would be audible for considerable ranges (in the order of tens of kms) before attenuating to below threshold levels. However, the noise is not considered to be of sufficient amplitude to cause direct physical injury or mortality to marine life, even at close range. The underwater noise may, however, induce localised behavioural changes or masking of biologically relevant sounds in some marine fauna. As much of the cable route is aligned with the main offshore shipping lanes that pass around southern Africa, the vessel noise component of the ambient noise environment is expected to be significant along the cable route. Given the significant local shipping traffic and relatively strong metocean conditions specific to the area, ambient noise levels are expected to be 90 - 130 dB re 1 µPa for the frequency range 10 Hz – 10 kHz (SLR Consulting Australia 2019). The noise generated by the cable laying vessel would be no different from that of other vessel traffic throughout the oceans, and from the point of vessel operations no specific mitigation (e.g. avoidance of marine mammal migration periods) is therefore deemed necessary when the vessel is in high seas waters.

Disturbance and injury to marine biota due to construction noise or noise generated by the vessel and cable plough is thus deemed of low magnitude within the immediate vicinity of the construction site/subsea cable route, with impacts persisting over the short-term only. In both cases impacts are fully reversible once construction and subsea cable installation operations are complete. Without mitigation, the direct impacts of construction and vessel noise are therefore assessed to be of **VERY LOW** significance, respectively. As the noise associated with construction and subsea cable installation is unavoidable, no direct mitigation measures, other than the no-project alternative, are possible. Impacts of construction noise can, however, be kept to a minimum through responsible construction practices.

Mitigation Measures

The following best-practice mitigation measures are recommended:

- If cable installation across the continental shelf is scheduled during the whale migration period (beginning of June to end of November), consideration will be required from the cable-laying vessel to appoint a suitably trained crew member as a dedicated Marine Mammal Observer (MMO) with experience in seabird, turtle and marine mammal identification and observation techniques, to carry out daylight observations of the subsea cable route and record incidence of marine mammals, and their responses to vessel activities. Data collected should include position, distance from the vessel, swimming speed and direction, and obvious changes in behaviour (eg, startle responses or changes in surfacing/diving frequencies, breathing patterns). Both the identification and the behaviour of the animals must be recorded accurately.

Disturbance and avoidance behaviour of surf-zone fish communities, shore birds and marine mammals through coastal construction noise and offshore cable installation noise		
Characteristic	**Impact**	**Residual Impact**
Intensity	Low	Low
Duration	Temorary (Short): for duration of shore-crossing installation and construction	Temporary
Extent	Local: limited to the construction site and around the cable vessel	Local
Frequency	Once-off	Once-off
Loss of resource	Low	Low
Probability	Possible	Possible
Reversibility	Fully reversible	Fully reversible
Significance of Impact	**VERY LOW**	**VERY LOW**
Confidence	High	
Mitigation Potential	Very Low	

Behavioural changes and masking of biologically significant sounds in Marine Fauna due to noise from cable installation operations		
Characteristic	**Impact**	**Residual Impact**
Intensity	Low	Low
Duration	Temorary (Short): for duration of shore-crossing installation and construction	Short-term
Extent	Local: limited to the construction site and around the cable vessel	Local
Frequency	Once-off	Once-off
Loss of resource	Low	Low
Probability	Possible	Possible
Reversibility	Fully reversible	Fully reversible
Significance of Impact	**VERY LOW**	**VERY LOW**
Confidence	High	
Mitigation Potential	Very Low	

4.4.5 Increased Turbidity

The disturbance and turnover of sediments during the pre-lay grapnel run and during trenching will result in increased suspended sediments in the water column and physical smothering of biota by the re-depositing sediments. The effect of sediment plumes generated by cable burial on the resident biota depends upon several variables including (i) the mode of burial (jetting will produce more suspended sediment than ploughing), (ii) sediment type (mud produces longer-lived plumes compared to sand and gravel), (iii) rate of plume dispersal by waves and currents and (iv) the response of the biota to increased turbidity (e.g. Gooding *et al.* 2012; Meißner *et al.* 2006). Generally,plumes tend to be short-lived when mainly sandy deposits of the inner shelf are ploughed as the coarse sediment grain-size will encourage rapid deposition close to the trench (Swanson *et al.* 2006; Gooding *et al.* 2012; Taormina *et al.* 2018). In contrast, cable burial in mid-to outer shelf and upper slope mud deposits will generate sediment plumes that have the potential to last for days due to the fine grain-size, with active shelf currents, especially along the shelf edge, affecting plume stability and dilution and potentially distributing suspended sediments up to 2 km from the trench (Gooding *et al.* 2012).

The effects of elevated levels of particulate inorganic matter and depositions of sediment have been well studied, and are known to have marked, but relatively predictable effects in determining the composition and ecology of intertidal and subtidal benthic communities (e.g. Zoutendyk and Duvenage 1989, Engledow and Bolton 1994, Iglesias *et al.* 1996, Slattery and Bockus 1997). Increased suspended sediments in the surf-zone and nearshore can potentially affect light penetration and thus phytoplankton productivity and algal growth, whereas further offshore it can load the water with inorganic suspended particles, which may affect the feeding and absorption efficiency of filter-feeders. The increase accurrence of turbidity plumes near the surface can also affect the feeding success of visual predators (Simmons 2005; Braby 2009; Peterson *et al.* 2001), For example, the foraging areas of African Penguins and Cape Gannets overlaps with the section of the cable crossing north of Robben Island (Grémillet *et al.* 2008; Campbell 2016) and suspended sediment plumes generated during cable installation could affect foraging success. However, due to the rapid dilution and widespread dispersion of settling particles, any adverse effects in the water column would be ephemeral and highly localised. Any biological effects on nectonic and planktonic communities would be negligible (Aldredge *et al.* 1986). Turbid water is a natural occurrence along the Southern African coast, resulting from aeolian and riverine inputs, resuspension of seabed sediments in the wave-influenced nearshore areas and seasonal phytoplankton production in the upwelling zones.

The impact of the sediment plume is thus expected to be relatively localised and temporary (only for the duration of pre-lay, construction and trenching activities below the low water mark). As the biota of sandy and rocky intertidal and subtidal habitats in the wave-dominated nearshore areas of southern Africa are well adapted to high suspended sediment concentrations, periodic sand deposition and resuspension, impacts are expected to occur at a sublethal level only. Considering the extended ranges over which visual predators such as seabirds feed, localised suspended sediment plumes are not expected to effect their feeding efficiency in any way.

Rapid deposition of material from the water column and direct deposition of excavated sands on adjacent areas of seabed may result in the physical smothering of resident biota by the depositing sediments. Some mobile benthic animals inhabiting soft-sediments are capable of migrating vertically through more than 30 cm of deposited sediment (Maurer *et al.* 1979; Newell *et al.* 1998; Ellis 2000; Schratzberger *et al.* 2000a, 2000b). Sand inundation of shallow-water reef habitats was found to directly affect species diversity, whereby community structure and species richness appears to be controlled by the frequency, nature and scale of disturbance of the system by sedimentation (Seapy and Littler 1982; Littler *et al.* 1983; Schiel and Foster 1986, McQuaid and Dower 1990, Santos 1993, Airoldi and Cinelli 1997 amongst others). For example, frequent sand inundation may lead to the removal of grazers, thereby resulting in the proliferation of algae (Hawkins and Hartnoll 1983; Littler *et al.* 1983; Marshall and McQuaid 1989; Pulfrich *et al.* 2003a, 2003b; Pulfrich and Branch 2014).

Elevated suspended sediment concentrations due to trenching and burial activities associated with the subsea cable installation is deemed of low intensity and would extend locally around the subsea cable route and down-current of the shore-crossing, with impacts persisting only temporarily. Within the wave-base at least, marine biota are typically adapted to periods of elevated turbidity and as suspended sediment concentrations would remain at sub-lethal levels, the loss of resources would be low and impacts would be fully reversible. The impact is therefore assessed to be of **VERY LOW** significance without mitigation. As elevated suspended sediment concentrations are an unavoidable consequence of trenching activities, no direct mitigation measures, other than the no-project alternative, are possible. In the intertidal and shallow subtidal zone, impacts can however be kept to a minimum through responsible construction practices.

Mitigation Measures

No mitigation other than the no-go option is deemed feasible or necessary.

Reduced physiological functioning of marine organisms due to increased turbidity in surf-zone as a result of excavations and mobilising of sediments

Characteristic	Impact	Residual Impact
Intensity	Low	Low
Duration	Temporary; suspended sediment plumes will rapidly dissipate	Temporary
Extent	Local: limited to within a few metres of the subsea cable route, but with indirect effects on adjacent areas	Local
Frequency	Intermittent during trenching	Intermittent
Loss of resource	Low	Low
Probability	Possible	Possible
Reversibility	Fully reversible	Fully reversible
Significance of Impact	**VERY LOW**	**VERY LOW**
Confidence	High	
Mitigation Potential	Very Low	

4.4.6 Physical Presence of Subsea Cable

Although the cable is typically only 25 mm – 200 mm in diameter, its presence and that of any protective steel sleeves or concrete mattresses effectively reduces the area of seabed available for colonisation by macrobenthic infauna in seabed sediments. The subsea cable itself and any protective covering, however, would serve as an alternative substratum for colonising benthic communities or provide shelter for mobile invertebrates and demersal fish (Figure 40). Assuming that the hydrographical conditions around the subsea cable and repeaters would not be significantly different to those on the seabed, a similar community to that typically found on hard substrata in the area can be expected to develop over time. As offshore portions of the subsea cable will be located on unconsolidated sediments, biota developing on the structures would be different from the original soft sediment macrobenthic communities, and the artificial reef' effect is expected to be stronger than where cables are laid on top of or among natural rocky reefs (Taormina *et al.*

2018). The presence of subsea infrastructure (namely cable and repeaters) can therefore alter the community structure in an area, and effectively increase the availability of hard substrate for colonisation by sessile benthic organisms, thereby locally altering and increasing biodiversity and biomass (Grannis 2005; Kogan *et al.* 2006; Bicknell *et al.* 2019), potentially also attracting mobile macro- and megafauna who utilize the biofouling community as a food source. Where cable protections are of a different structure than the surrounding natural reef (e.g. concrete mattresses vs. boulders), different species assemblages and reef effects may result (Sheehan *et al.* 2018).

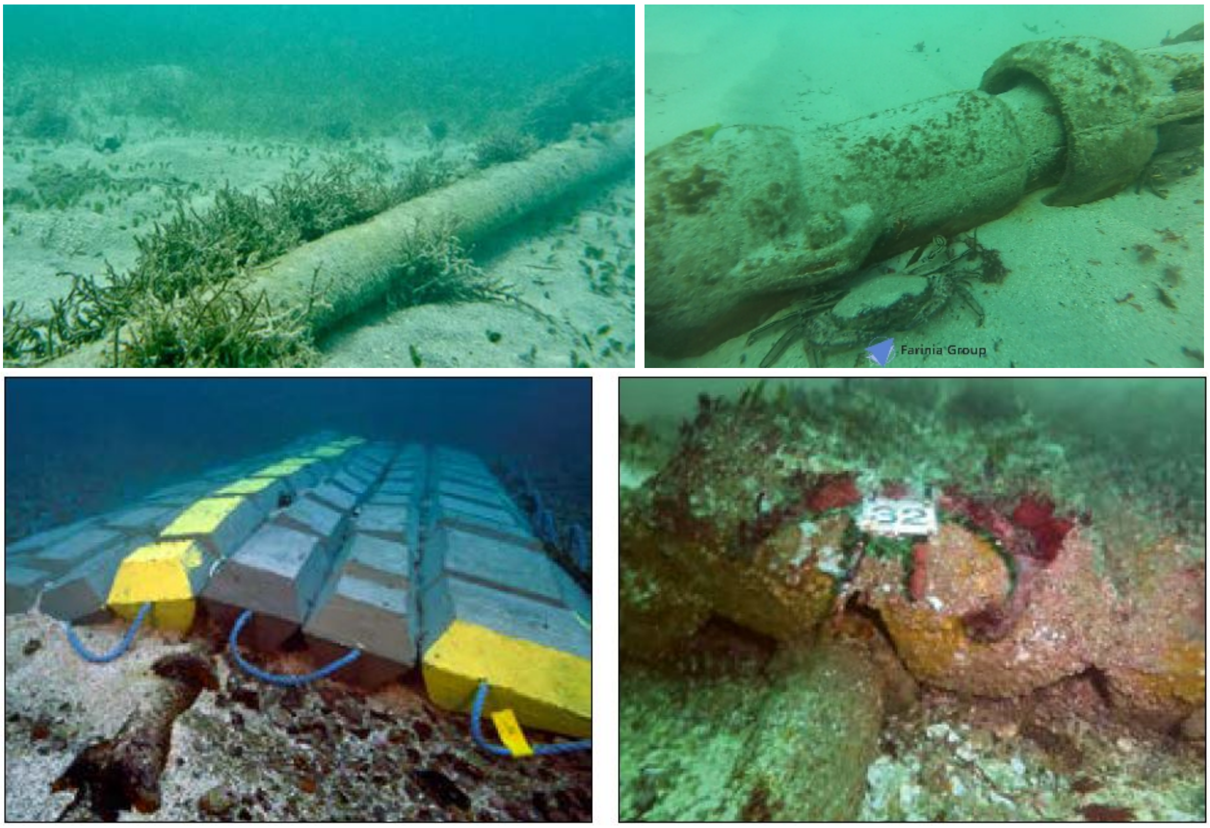

Figure 41: Subsea cables and their protective armouring can provide alternative substratum for colonising benthic biota and shelter for mobile invertebrates (Source: www.digit.in/telecom/reliance-jio-launches-longest-100gbps-subsea-cable-system-aae-1-35827; www.farinia.com; Copping & Hemery 2020).

The composition of the fouling community on artificial structures depends on the age (length of time immersed in water) and the composition of the substratum, and usually differs somewhat from the communities of nearby natural rocky reefs (Connell and Glasby 1999; Connell 2001). In the intertidal and shallow subtidal habitats, colonisation of hard substratum goes through successional stages (Connell & Slayter 1977). Early successional communities are characterized by opportunistic algae (eg, *Ulva* sp., *Enteromorpha* sp.). These are eventually displaced by slower growing, long-lived species such as mussels, sponges and/or coralline algae, and mobile organisms, such as urchins and lobsters, which feed on the fouling community. With time, a consistent increase in biomass, cover and number of species can usually be observed (Bombace *et al.* 1994; Relini *et al.* 1994;

Connell & Glasby 1999). Depending on the supply of larvae and the success of recruitment, the colonization process can take up to several years. For example, a community colonising concrete blocks in the Mediterranean was found to still be changing after five years with large algae and sponges in particular increasing in abundance (Relini *et al.* 1994). Other artificial reef communities, on the other hand, were reported to reach similar numbers of species (but not densities and biomass) to those at nearby natural reefs within eight months (Hueckel *et al.* 1989).

Studies investigating the abundance, diversity and size class structure of macrobenthos associated with oil platforms (Ellis *et al.* 1996) and marine renewable energy devices (Macleod *et al.* 2016; Want *et al.* 2017; Dannheim *et al.* 2019) concluded that differences in community structure of associated fauna were attributable to the physical presence of the subsea infrastructure, and the unique physical environment around each piece of infrastructure. Differences in epifaunal communities near the structures compared to far away were attributed to differences in food availability and predation. Mobile fish and invertebrates would be attracted by the shelter and food (biofouling organisms) provided by the underwater structures (Bull & Kendall 1994; Fechhelm *et al.* 2001; Copping & Hemery 2020 and references therein). Designated cable protection zones with suitable habitats may in fact help to maintain and improve biodiversity and species abundance, and therefore act as *de facto* marine reserves or sanctuaries (Shears & Usmar 2006), although this concept has yet to be proven.

The impacts on marine biodiversity through the physical presence of the subsea cable would be of medium intensity and highly localised along the cable itself. As the subsea cable would likely be left in place on the seabed beyond decommissioning of the project, its impacts would thus be permanent. No direct mitigation measures, other than the no-project alternative, are possible. The potential impacts on marine biota is consequently deemed to be of **LOW** significance without mitigation.

Mitigation Measures

No mitigation other than the no-go option is deemed feasible or necessary.

Physical presence of the subsea cable		
Characteristic	**Impact**	**Residual Impact**
Intensity	Medium	Medium
Duration	Permanent: cable will be left in place	Permanent
Extent	Site-specific: limited to the cable and repeaters	Site-specific
Frequency	Once-off	Once-off
Loss of resource	Low	Low
Probability	Definite	Definite
Reversibility	Partially reversible	Partially reversible
Significance of Impact	**LOW**	**LOW**
Confidence	High	
Mitigation Potential	Very Low	

4.4.7 Other potential Impacts of Subsea Cable

Heat Dissipation

A subsequent effect of burying subsea cables in the sediment is the localized increase in temperature at the cable-sediment interface. While high and medium voltage seabed power transmission cables can emit heat, the voltage associated with telecommunication cables (for powering the repeaters) is very low, and any associated heat emissions are understood to be negligible. Although the potential consequences of this thermal radiation on benthic organisms has not yet been investigated *in situ*, the narrow footprint of the cables and the expected low temperature differences suggest that impacts are likely to be negligible (Heath 2001; Taormina *et al.* 2018 and references therein).

Sound Emmissions

Under normal operations, fibre optics cables do not emit any audible sound. During the laying of the cable it does vibrate as a result of regular vortex shedding as its descends through the water column. At ~10 Hz, this is a low frequency phenomenon and well below the hearing frequencies of marine fauna (see Table 10). Once the cable comes to rest on the seabed the sound ceases (Heath 2001).

In areas of high wave or current action on the continental shelf, cables can be exposed and undermined. Where undermining is significant, the suspended cable can vibrate or strum under the water motions (Carter *et al.* 2009). This sound would likewise be of low frequency and would not be of sufficient amplitude to cause auditory or non-auditory trauma in marine animals. The sound is expected to attenuate rapidly to below ambient levels.

Electric and Electromagnetic fields

Fibreoptics cables carry a constant direct current of 1 - 1.6 Amps to power the underwater repeaters. This current is fed along the inner conductor and depending on the length of the cable span it may require several thousands of volts to maintain it. Typically half of the required voltage is applied at positive polarity to one end of the system and half the voltage at negative polarity to the other end, thereby establishing a zero voltage point midway along the cable span and reducing the level of voltage stress on the cable and repeaters. There is no external electric field associated with the power on the inner conductor as the polyethylene insulation ensures that the electric field remains only within the cable insulation (Heath 2001).

The direct current in the inner conductor does, however, set up a stationary magnetic field in the form of concentric rings emanating from the cable. The magnetizing force produced by this field diminishes with increasing radius from the cable such that at a distance of 1 m from the cable, the electromagnetic field (EMF) would be in the order of 0.32 micro Tesla. This is two orders of magnitude lower than the typical magnetic flux densities of the earth, which range from 30 microTesla at the equator to 60 microTesla at the magnetic poles. Animals with the capacity to detect and use constant geomagnetic fields are thus likely to only detect the signal within close proximity to the source (within centimetres) (Heath 2001; but see also Kraus & Carter 2015).

The marine environment is by no means devoid of electric and magnetic fields. An electrical current is generated (induced) in any conductor moving through a magnetic field (as per Faraday's Law). The geomagnetic field may thus also produce weak electric fields when, for example, an ocean current moves at right angles to it. Furthermore, all marine animals are electrical conductors as they continually generate internal voltage gradients and electrical currents as part of normal functions, sensory and motor mechanisms, reproductive processes, and membrane integrity. Organisms use internal electric potentials and signals for a wide variety of biological functions (e.g orientation or prey detection), and in some cases can perceive very small electric and magnetic fields. Perturbations from external electric and magnetic fields on such physiological systems need not necessarily have detrimental biological effects, as the magnitude of the effect will depend on the field intensities and exposure times to them, their frequency content, modulation, etc. Comprehensive descriptions on electromagnetism and its potential effects on marine organisms are provided in the reviews by Johnsson & Ramstad (2004) and Buchanan *et al.* (2006).

A wide variety of taxa are sensitive to electromagnetic fields and some examples are provided summarised from Johnsson & Ramstad (2004) and Buchanan *et al.* (2006) . Western Atlantic spiny lobsters (*Panulirus argus*), which undertake mass migrations, were found to orientate to the polarity of the Earth's field or to an induced magnetic field. Most species of salmon travel great distances from their natal streams to oceanic feeding grounds, and some (Pacific, Atlantic, Chinook, Sockeye) have been reported to orientate magnetically. While the electroreceptive sensitivity of sharks, skates, and rays is well established, and some studies have shown that these fishes can detect the Earth's geomagnetic field, empirical evidence that elasmobranchs use geotaxis to navigate is still lacking. There is strong evidence that turtle hatchings (at least loggerhead and leatherback sea turtles) and loggerhead juveniles use geomagnetic orientation to navigate long distances although there is little evidence that adults do the same. It has been theorized that cetaceans use geomagnetic information for orientation, with live strandings being attributed to areas where geomagnetic contour lines run perpendicular to shore, generally occurring 1-2 days after major geomagnetic storms.

Elasmobranchs and chimaerids are the taxa most likely to detect the electrical fields produced by fibre-optics cables because their electroreceptive organs are sensitive to stimuli in the very low frequency range from 0.125 Hz to 8.0 Hz. This may explain fibre-optic cable failures as a result of shark attacks in water depths of 1,060 – 1,900 m. Although the reasons for the attacks are uncertain, sharks may be encouraged by the electromagnetic fields, particularly from suspended cables that strum in the currents (Carter *et al.* 2009).

The injection of a low frequency electrical signal from the land station is known as 'toning' and is undertaken to aid in cable location in the event of a fault or when a safe distance needs to be kept from a cable during other marine work. The resultant proportion of current in the seawater, enables electrodes trailed from a ship to detect the cable by locating the maximum level of the tone. The level of the signal injected is usually 160 mA at 25 Hz. The attenuation of the cables at low frequency is such that a tone injected at the terminal should be detectable across most of the continental shelf by the electrodes whose threshold level of detection on electrodes is normally around 20mA. Toning has been used for many years on submarine cables throughout the world, and no adverse affects on marine life has been reported.

Leaching of Contaminants

Modern deep-water fibre-optic cables are composed of hair-like glass fibres, a copper power conductor and steel wire strength member, all of which are sheathed in high-density polyethylene. Where extra protection is required, as for areas of rocky seabed or strong wave and current action, additional steel wire armour is added. No anti-fouling agents are used. The cable-grade polyethylene used for the sheath is essentially inert in seawater. Oxidation, hydrolysis and mineralization processes for polyethylene are extremely slow, with the total conversion to carbon dioxide and water estimated to take centuries. The effects of ultraviolet light, the main cause of degradation in most plastics, are minimized through the use of light-stabilized materials, burial of the cable into the seabed and the natural reduction in light penetration through the photic zone. Where the cable is located on the energetic continental shelf and mechanical abbrasion of the cable's plastic sheathing by fine-grained particles is possible, the cable is either armoured or buried (Carter *et al.* 2009).

A study investigating potential leachates of copper, iron and zinc from the conductors and galvanized steel armour, identified that only zinc passed into the seawater, yielding concentrations of less than 6 mg/l for intact cables and less than 11 mg/l for cut cables with exposed wire armour ends[6]. The amount of leaching declined after ~10 days. Although this is above the recommended BCLME water quality guideline value of 5 µg/l (CSIR 2006), dilution of leachates by the surrounding water would be rapid and any negative effects on marine organisms are likely to be highly localised. Although zinc is an essential food element and occurs as Zn^{II} in dissolved form, it is listed amongst the 129 priority pollutants by the US Environmnetal Protection Agency as it can have lethal and sub-lethal effects at concentrations as low as 170 µg/l, particularly on the egg and larval stages of marine invertebrates.

Based on available information in the literature, the impacts on marine fauna through the generation of heat, sound, EMFs and leachates by the submarine cable would be of negligible intensity and highly localised along the cable itself. As the subsea cable would be in operation for up to 25 years, the impacts would persist over the long-term. No direct mitigation measures, other than the no-project alternative, are possible. The potential impacts on marine biota is consequently deemed to be of **VERY LOW** significance without mitigation.

Mitigation Measures

No mitigation other than the no-go option is deemed feasible or necessary.

6 Tests were carried out in a small, finite volume of seawater (Collins 2007)

Heat, Sound, Electromagnetic fields and leaching of contaminats from thesubsea cable		
Characteristic	**Impact**	**Residual Impact**
Intensity	Negligible	Negligible
Duration	Long-term: for the life time of the cable	Long-term
Extent	Site-specific: limited to the cable and repeaters	Site-specific
Frequency	Intermittent (Leaching) to Continuous (heat, EMF)	Intermittent to Continuous
Loss of resource	Low	Low
Probability	Improbable	Improbable
Reversibility	Fully reversible	Fully reversible
Significance of Impact	**VERY LOW**	**VERY LOW**
Confidence	High	
Mitigation Potential	None	

4.5. Decommissioning Phase

No decommissioning procedures have been developed at this stage. In the case of decommissioning the cable will most likely be left in place. The potential impacts during the decommissioning phase are thus expected to be minimal in comparison to those occurring during the installation phase.

4.6. Unplanned Events

4.6.1 Pollution and Accidental Spills

Trenching during installation of the shore-crossing of the subsea cable will involve excavation and construction activities. There would thus be potential for or accidental spillage or leakage of fuel, chemicals or lubricants, litter, inappropriate disposal of human wastes and general degradation of ecosystem health on the shoreline. Any release of liquid hydrocarbons has the potential for direct, indirect and cumulative effects on the marine environment through contamination of the water and/or sediments. These effects include physical oiling and toxicity impacts to marine fauna and flora, localised mortality of plankton, pelagic eggs and fish larvae, and habitat loss or contamination (CSIR 1998; Perry 2005). Many of the compounds in petroleum products have been known to smother organisms, lower fertility and cause disease in aquatic organisms. Hydrocarbons are incorporated into sediments through attachment to fine-grained particles, sinking and deposition in low turbulence areas. Due to differential uptake and elimination rates, filter-feeders, particularly mussels, can bioaccumulate organic (hydrocarbons) contaminants (Birkeland *et al.* 1976).

During construction, litter can enter the marine environment. Inputs can be either direct by discarding garbage into the sea, or indirectly from the land when litter is blown into the water by wind. Marine litter is a cosmopolitan problem, with significant implications for the environment and human activity all over the world. Marine litter travels over long distances with ocean currents and winds. It originates from many sources and has a wide spectrum of environmental, economic, safety, health and cultural impacts. It is not only unsightly, but can cause serious harm to marine organisms, such as turtles, birds, fish and marine mammals. Considering the very slow rate of decomposition of most marine litter, a continuous input of large quantities will result in a gradual increase in litter in coastal and marine environment. Suitable waste management practices should thus be in place to ensure that littering is avoided.

Potential hydrocarbon spills and pollution in the intertidal and shallow subtidal zone during installation of the subsea cable are deemed of medium intensity within the immediate vicinity of the construction site, with impacts persisting over the short- to medium-term. Impacts of pollution and accidental spills would be direct, indirect and cumulative. As the coastal habitats at the shore-crossing have been identified as 'vulnerable' (Southwestern Cape Mixed Shore) the loss of resources could potentially be medium, with impacts being only partially reversible in the worst-case scenario. Pollution and accidental spills on the shoreline during the construction phase is probable and the impact is therefore assessed to be of **MEDIUM** significance.

Mitigation Measures

The recommended best-practice mitigation measures for the construction phase of the proposed ASN 2AFRICA (West) cable installation are:

- All construction activities in the coastal zone must be managed according to a strictly enforced EMPr.
- Ensure that contracted construction personnel are aware of, and adhere to, the requirements of the EMP.
- Keep heavy vehicle traffic associated with construction in the coastal zone to a minimum.
- Restrict vehicles to clearly demarcated access routes and construction areas only. These should be selected under guidance of the local municipality.
- Maintain vehicles and equipment to ensure that no oils, diesel, fuel or hydraulic fluids are spilled.
- For equipment maintained in the field, oils and lubricants must be contained and correctly disposed of off-site.
- Good housekeeping must form an integral part of any construction operations on the beach from start-up.
- Ensure regular collection and removal of refuse and litter from intertidal areas.

The following essential mitigation measures should be implemented during construction:

- There is to be no vehicle maintenance or refuelling on beach.
- Ensure that all accidental diesel and hydrocarbon spills are cleaned up accordingly.
- No mixing of concrete in the intertidal zone.
- Regularly clean up concrete spilled during construction.
- No dumping of construction materials, excess concrete or mortar in the intertidal and subtidal zones or on the sea bed.

- After completion of construction activities remove all artificial constructions or created shore modifications from above and within the intertidal zone. No accumulations of excavated intertidal sediments should be left above the high water mark, and any substantial sediment accumulations below the high water mark should be levelled.

If these mitigation measures are implemented, all residual impacts are expected to be of low significance.

Accidental spillage or leakage of fuel, chemicals or lubricants, cement and disposal of litter may cause water or sediment contamination and/or disturbance to intertidal and subtidal biota		
Characteristic	**Impact**	**Residual Impact**
Intensity	Medium	Low
Duration	Short- to Medium-term	Short-term
Extent	Site-specific: limited to the cable and repeaters	Site-specific
Frequency	Intermittent	Once-off
Loss of resource	Medium	Low
Probability	Probable	Possible
Reversibility	Partially reversible	Fully reversible
Significance of Impact	**MEDIUM**	**LOW**
Confidence	High	
Mitigation Potential	High	

4.6.2 Collisions with and entanglement by Marine Fauna

Vessel traffic can affect large cartilaginous fish species, turtles and marine mammals by direct collisions or propeller injuries. The potential effects of vessel presence on turtles and cetaceans include behavioural disturbance, physiological injury or mortality.

Collisions between cetaceans and vessels are not limited to survey or cable laying vessels. In areas of heavy ship traffic, whales and dolphins can experience propeller or collision injuries, with most of these injuries caused by fast moving vessels. Injuries and deaths resulting from direct ship collisions represent a significant threat to several whale populations (Laist *et al.* 2001; Jensen & Silber 2003). All types and sizes of vessels hit whales, but most lethal and serious injuries are caused by larger vessels and most vessel strikes occur on the continental shelf and when vessels were doing in excess of 10 knots (Laist *et al.* 2001).

During acquisition of swath bathymetry, the survey vessel typically travels at a speed of around 6 knots. Depending on the onboard equipment and types of ploughs used, prevailing sea conditions as well as the nature of the seabed, subsea cable vessels can lay 100-150 km of cable per day, with modern ships and ploughs achieving up to 200 km of cable laying per day (www.independent.co.uk>science). This equates to a vessel speed of between 2.3 – 4.5 knots. Once the cable has reached the seabed, the ship can increase its speed to 6-8 knots, slowing only to pass repeaters and amplifiers through the machinery that controls cable tension and pay-out speed (Carter *et al.* 2009). The pre-laying grapnel run is typically conducted at 0.5 knots; and vessels will maintain the same speed when plough-burying cable. Given the slow speed of the vessels during surveying, the pre-lay grapnel run and the cable installation, ship strikes with marine mammals and turtles are unlikely, and should the impact occur it would be very infrequent.

Ship strikes have been reported to result in medium-term effects such as evasive behaviour by animals experiencing stress, or longer-term effects such as decreased fitness or habitual avoidance of areas where disturbance is common and in the worst case death (see for example Constantine 2001; Hastie *et al.* 2003; Lusseau 2004, 2005; Bejder *et al.* 2006; Lusseau *et al.* 2009). Ship strikes have been documented from many regions and for numerous species of whales (Panigada *et al.* 2006; Douglas *et al.* 2008; Elvin & Taggart 2008) and dolphins (Bloom & Jager 1994; Elwen & Leeney 2010), with large baleen whales being particularly susceptible to collision.

Entanglement of whales with old telegraph cables occurred during the telegraph era (1850s to 1950s) at sites where cables had been repaired on the edge of the continental shelf or on the adjacent continental slope in water depths down to 1,135 m. With improved design, laying and maintenance techniques,sincedevelopment of the coaxial submarine cables in the 1950s and into the fibre-optic era in the early 1980s, no further entanglements with marine mammals have been recorded (Wood & Carter 2008). As the cable would be under constant tension during installation, entanglements are highly unlikely and once on the seabed, the weight of the cable and torsional balance will prevent coils and loops (Carter *et al.* 2009). Furthermore, as the cable would be buried along much of its length on the continental shelf, entanglements are highly unlikely.

As much of the cable would be installed in the offshore marine environment, the strong operational lighting used to illuminate the survey and cable vessels may disturb and disorientate pelagic seabirds feeding in the area. Operational lights may also result in physiological and behavioural effects of fish and cephalopods as these may be drawn to the lights at night where they may be more easily preyed upon by other fish and seabirds. The response of marine organisms to artificial lights can vary depending on a number of factors such as the species, life stage and the intensity of the light. Considering the extensive distributions and low numbers of pelagic seabirds likely to be encountered in the offshore environment, the olikelihood of collisions would be low.

In the event of a collision or entaglement, the impact is deemed of low intensity and would be site specific to the vessel/cable location. Injury through collision and/or entanglement would persist over the short term and considering the slow vessel speed would likely remain at sub-lethal levels. Although this direct impact could result in a medium loss of resources, the impact is assessed to be of **LOW** significance without mitigation.

Mitigation Measures

The recommended best-practice mitigation measures for the installation phase of the proposed ASN 2AFRICA (West) subsea cable are:

- If cable installation across the continental shelf is scheduled during the whale migration period (beginning of June to end of November), consideration will be required from the cable-laying vessel to appoint a suitably trained crew member as a dedicated Marine Mammal Observer (MMO) with experience in seabird, turtle and marine mammal identification and observation techniques, to carry out daylight observations of the subsea cable route and record incidence of marine mammals, and their responses to vessel activities. Data collected should include position, distance from the vessel, swimming speed and direction, and obvious changes in behaviour (eg, startle responses or changes in surfacing/diving frequencies, breathing patterns). Both the identification and the behaviour of the animals must be recorded accurately.

- Should a cetacean become entangled in towed gear, contact the South African Whale Disentanglement Network (SAWDN) formed under the auspices of DEA to provide specialist assistance in releasing entangled animals.

Collions with and Entanglement by Marine Fauna		
Intensity	Low	Low
Duration	Short-term	Short-term
Extent	Site-specific: limited to around the vessel	Site-specific
Frequency	Once-off	Once-off
Loss of resource	Medium	Low
Probability	Improbable	Improbable
Reversibility	Partially reversible	Fully reversible
Significance of Impact	**LOW**	**LOW**
Confidence	High	
Mitigation Potential	Medium	

4.7. Cumulative Impacts

The primary impacts associated with the installation of subsea cables in the Southern Benguela and Southeast Atlantic Deep Ocean Ecoregions, relate to physical disturbance of the seabed, either through placing the cable on the seabed (>1,500 m depth) or by burying the cable in a trench excavated by a fit-for-purpose cable plough, diver-operated jet-pump or (where it crosses the beach) a tracked backhoe digger. As the ASN 2AFRICA (West) cable routing will largely follow that of the existing WACS, SAT-2 and ACE cables, cumulative impacts need to be considered.

The proposed cable route, where possible, avoids sensitive reef areas and environments such as MPAs, but will pass through the Cape Canyon and Associated Islands EBSA. Consequently impacts will mostly affect communities in unconsolidated habitats, which are less sensitive to disturbance and recover more quickly than those inhabiting hard grounds. Cumulative impacts are therefore less likely. The greatest possibility of cumulative impacts is where the proposed ASN cable route meets those of other existing subsea cables, particularly as it passes through the Cape Canyon and at the Yzerfontein shorecrossing. These cumulative impacts are, however, assessed to be of low to very low significance as in reality the total cumulative impacted area at any one time would be minimal, due to the natural recovery of nearshore benthic communities of unconsolidated habitats over the short- to medium term. In other words, the benthic habitats disturbed during the installation of the existing cables in the 'cable corridor' passing through the Cape Canyon and associated EBSA, are likely to have already fully recovered, and so additional impacts in the same general area through routing of the proposed 2AFRICA (West) subsea cable will unlikely be significant.

5. ENVIRONMENTAL STATEMENT AND CONCLUSIONS

5.1 Environmental Statement

Installation of the cable will potentially result in localised disturbance of the upper beach and intertidal and shallow subtidal sandy habitats, as well as unconsolidated seabed beyond the surf-zone and across the shelf. Most potentially negative impacts were rated as being of low significance, with only pollution and accidental spills during construction rated as medium significance. As recovery of marine communities over the short- to medium-term can be expected, residual impacts were all considered minor.

5.2 Management Recommendations

From the marine ecology assessment in Chapter 4, certain recommendations can be put forward as how best to manage potential impacts to the marine environment of the proposed installation of the subsea cable. Some of these are already part of standard industry practice, but they are documented here for the sake of completeness. These include:

- Plan routing of proposed cable to as far as practicably possible avoid sensitive benthic habitats in the coastal and nearshore zone. This is undertaken following analysis of the geophysical data collected during the cable route survey.
- Align routing of the cable as closely as possible to the routes of existing or de-commissioned cables (even when these traverse a Marine Protected Area) thereby avoiding the impact of as yet undisturbed ecoststem types.
- Ensure that constant monitoring for the presence of marine mammals and turtles is maintained by a ship's staff member designated as a marine mammal observer. The observation post must keep a record of sightings, recording date, time, coordinates and approximate distance. This is particularly important should cable installation across the continental shelf be scheduled during the whale migration period (beginning of June to end of November).
- Should a cetacean become entangled in towed gear, contact the South African Whale Disentanglement Network (SAWDN) formed under the auspices of DEA to provide specialist assistance in releasing entangled animals.

For the construction phase of the proposed cable shore-crossing the recommended best-practice mitigation measures include:

- As far as practicable, ensure that construction activities required for subsea cable installation occur concurrently thereby minimizing the disturbance duration in the coastal and nearshore zone.
- All construction activities in the coastal zone must be managed according to a strictly enforced EMPr.
- Ensure that contracted construction personnel are aware of, and adhere to, the requirements of the EMP.

- Keep heavy vehicle traffic associated with construction in the coastal zone to a minimum.
- Restrict vehicles to clearly demarcated access routes and construction areas only. These should be selected under guidance of the local municipality.
- Maintain vehicles and equipment to ensure that no oils, diesel, fuel or hydraulic fluids are spilled.
- For equipment maintained in the field, oils and lubricants must be contained and correctly disposed of off-site.
- Good housekeeping must form an integral part of any construction operations on the beach from start-up.
- Ensure regular collection and removal of refuse and litter from intertidal areas.

The following essential mitigation measures should be implemented during construction of the shore crossing:

- Obtain a vehicle access permit from DEA (Branch Oceans and Coasts) prior driving in the coastal zone.
- Restrict disturbance of the intertidal and subtidal areas to the smallest area possible. Once the shore crossing is finalised and the associated construction site is determined, the area located outside of the site should be clearly demarcated and regarded as a 'no-go' area.
- There is to be no vehicle maintenance or refuelling on the beach.
- Ensure that all accidental diesel and hydrocarbon spills are cleaned up accordingly.
- No mixing of concrete in the intertidal zone.
- Regularly clean up concrete spilled during construction.
- No dumping of construction materials, excess concrete or mortar in the intertidal and subtidal zones or on the sea bed.
- After completion of construction activities remove all artificial constructions or created shore modifications from above and within the intertidal zone. No accumulations of excavated intertidal sediments should be left above the high water mark, and any substantial sediment accumulations below the high water mark should be levelled.

If these mitigation measures are implemented, all residual impacts are expected to be of low to very low significance. Potential cumulative impacts are likewise expected to be of low to very low significance.

5.3 Conclusions

If all environmental guidelines and appropriate management and monitoring recommendations advanced in this report are implemented, there is no reason why the proposed installation of the ASN 2AFRICA (West) fibre optics cable should not proceed.

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Curriculum Vitae

Dr Andrea Pulfrich

Dr Andrea Pulfrich is the founder, director, sole employee and share holder of Pisces Environmental Services (Pty) Ltd. The company was established in January 1998 to help fill the growing need for an expert interface between users of the coastal and marine environment and the various national and provincial management authorities. Since then, PISCES has been providing a wide range of information, analyses, environmental assessments, advice and management recommendations to these user groups, particularly the South African and Namibian marine diamond mining and hydrocarbon industries.

Personal Details

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

Address:	23 Cockburn Close, Glencairn Heights 7975, South Africa PO Box 31228, Tokai, 7966, South Africa
Tel:	+27 21 782 9553
Cell :	+27 82 781 8152
E-mail:	apulfrich@pisces.co.za

Academic Qualifications

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

Membership in Professional Societies

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

Employment History and Professional Experience

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

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

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

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

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

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

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

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

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

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	
NEAS Reference Number:	
Date Received:	

Application for integrated environmental authorisation and waste management licence in terms of the-

(1) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014; and

(2) National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) and Government Notice 921, 2013

PROJECT TITLE

PROPOSED MARINE TELECOMMUNICATIONS SYSTEM (ASN 2AFRICA (WEST) CABLE SYSTEM) TO BE LANDED AT YZERFONTEIN ON THE WEST COAST OF SOUTH AFRICA

Specialist:	Dr Andrea Pulfrich		
Contact person:	Dr Andrea Pulfrich		
Postal address:	PO Box 302 McGregor		
Postal code:	6708	Cell:	082 7818152
Telephone:	021 7829553	Fax:	
E-mail:	apulfrich@pisces.co.za		
Professional affiliation(s) (if any)	South African Council for Natural Scientific Professions (Pr.Sci.Nat. No: 400327/06) South African Institute of Ecologists and Environmental Scientists International Association of Impact Assessment (South Africa)		

Project Consultant:
Contact person: Postal
address: Postal code:
Telephone:
E-mail:

Giles Churchill			
P.O.Box 503			
Mtunzini			
035 3402715	Cell:	082 9079738	
Giles.churchill@acerafrica.co.za	Fax:	035 3402232	

4.2 The specialist appointed in terms of the Regulations_

I, Andr~~ea Pulfrich, declare that -- General declara~~tion:

I act as the independent specialist in this application;
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, Regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Andrea Pulfrich

Signature of the specialist:

Pisces Environmental Services (Pty) Ltd

Name of company (if applicable):

15 January 2021

Date: