PROPOSED INSTALLATION
OF THE 2AFRICA/GERA (EAST) CABLE SYSTEM, DUYNEFONTEIN, 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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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.

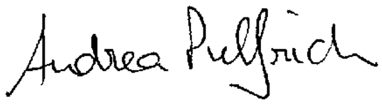
Population	The total number of individuals of the species or taxon.
Recruitment	The replenishment or addition of individuals of an animal or plant population through reproduction, dispersion and migration.
Sediment	Unconsolidated mineral and organic particulate material that settles to the bottom of 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/GERA (East) Cable System, off the South African east and west coasts with the landing at Duynefontein. 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/GERA (East) Cable System. The system will be installed in phases, with the first phase entailing the installation of cable landings at Duynefontein in the Western Cape, with further branches landing at Port Elizabeth in the Eastern Cape and Amamzimtoti on the KwaZulu Natal Coast. The system will connect Africa to Europe and parts of the Middle East. The 2AFRICA/GERA (East) 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 Duynefontein.

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 (East) 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 Mozambique and run parallel to the coastline along the East Coast of Africa in deep water. The cable will enter South African Territorial Waters ~22 km (12 Nm) from the coast, with the proposed Duynefontein 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 Duynefontein the general alignment for this landing will make landfall near the ACE Cable landing point and will take into consideration existing cable systems within the area (SAT2, SAT3, ACE and the future Equiano cable system). Two landing locations at Duynefontein are being considered; one at approximately 33°41.666'S; 18°26.387'E (preferred option), and the other ~300 m south at 33°41.822'S; 18°26.441'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.

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 Duynefontein on the West Coast of South Africa.

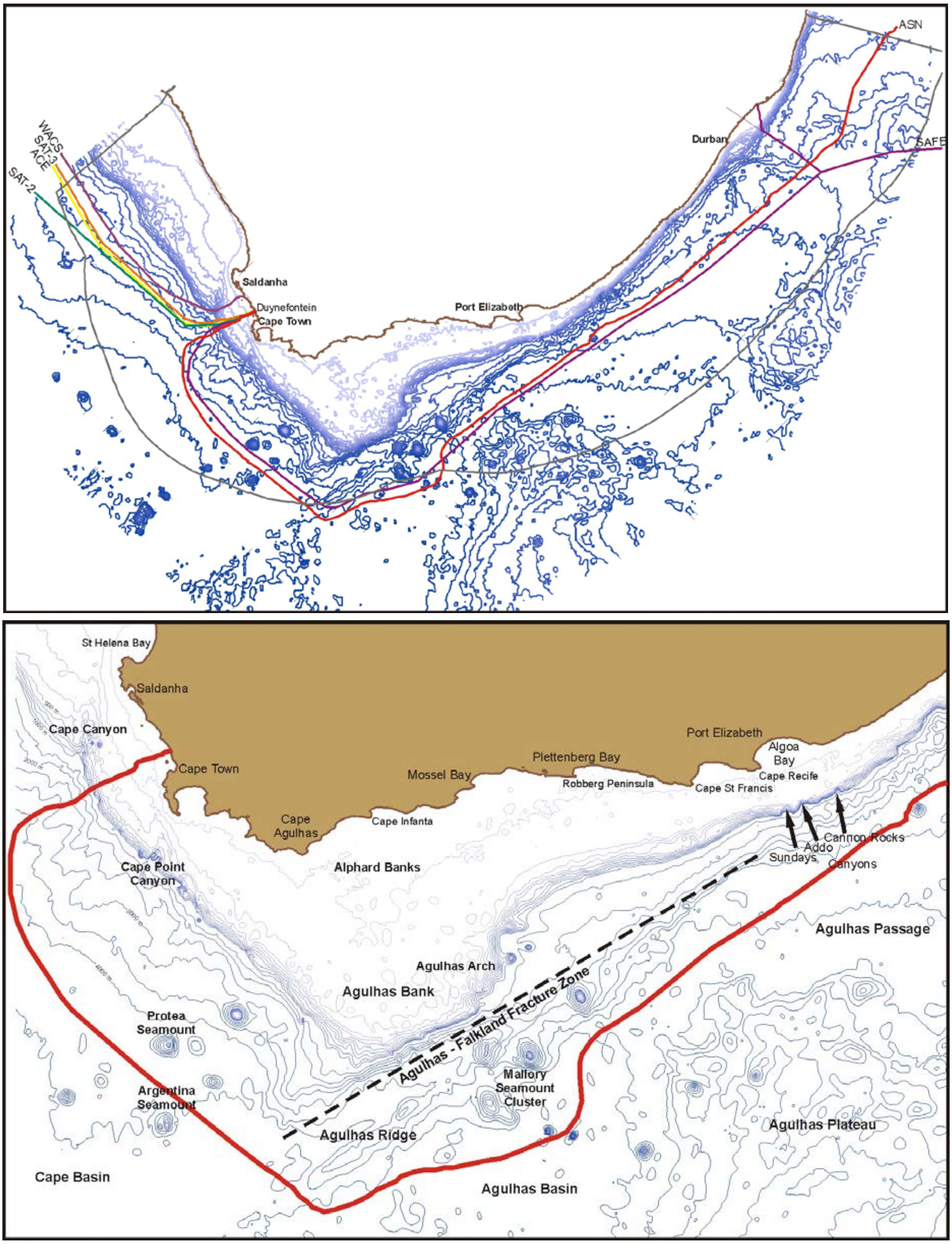


Figure 1: Map indicating proposed route of the 2AFRICA/GERA (East) Cable System in relation to other existing subsea cables and bathymetric features off the South African coast (top). Specific bathymetric features off the south coast in relation to the cable routing are shown (bottom). Places mentioned in the text and the extent of the Exclusive Economic Zone are also indicated.

The terms of reference for this study are:

- Undertake a desktop assessment of the potential impact that the 2AFRICA/GERA (East) 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 Mozambique up until it lands in Duynefontein. 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 Duynefontein 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 the Southeast Atlantic and Southwest Indian 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.

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 along the African east coast from the Middle East to South Africa. Branches will split from the main trunk to landing sites located *en route*, including Somalia, Kenya, Tanzania, Madagascar and Mozambique.

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°41.666'S; 18°26.387'E at Duynefontein on the West Coast (see Figure 1). The general alignment of the 2AFRICA (East) Cable System will follow the alignment of the SAFE cable from the south. Nonetheless, a detailed bathymetric and geophysical survey will be undertaken along the cable route to inform the proposed routing. 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 ACE land-based infrastructure.

The landing site at Duynefontein is characterized by a stretch of sandy beach (Figure 2). At the shore crossing, the buried subsea fibre optics cable will enter an existing SAT-2 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 2AFRICA/GERA (East) Cable System in shallow waters and the shore crossing alternatives at the beach in Duynefontein.

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 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 Coast focus primarily on the area between St Helena Bay and Cape Town, where the cable will cross onto the continental shelf and make landfall. Descriptions of the physical and biological environments along the cable route along the East and South Coasts will be generic only as information on the biotic components of the deep ocean beyond the shelf break is largely unknown. 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 CCA and CMS (2001) and Penney *et al.* (2007) and more recent scientific studies undertaken in the general area.

3.1. Geophysical Characteristics

3.1.1 Bathymetry

The orientation of the coastline along the East Coast is relatively uniform, and north-northeast trending. A significant topographical feature is the Natal Bight, a coastal indentation between Cape Vidal and Durban, which is sheltered from the main force of the southward flowing Agulhas Current. The Tugela Bank is a prominent feature is located on the continental shelf along the KwaZulu-Natal coast between 28° 30' S and 30° 20' S. Here the continental shelf widens to 50 km offshore, the maximum width reached along the East Coast (Lutjeharms *et al.* 1989), and the continental slope is more gentle (Martin & Flemming 1988). To the south, the continental margin descends into the Natal Valley, while to the north-eastwards it develops into the Central Terrace (see Figure 1a).

The northern KwaZulu-Natal coastline boasts a total of 23 submarine canyons, including six mature-phase (large, steep-sided features breaching the continental shelf), 17 youthful-phase (smaller, deepwater features occurring near the continental margin) and numerous incipient (shallow linear depressions on the seafloor) canyons that run approximately perpendicular to the shore. The canyon heads breach the relatively narrow (2-4 km) shelf at depths of 90-120 m, and their thalwegs (bottoms) have depths of several hundred metres. The Tugela Bank is interrupted by two canyons; the large and prominent Tugela Canyon and the smaller Goodlad Canyon (also referred to as 29°25' S). The Tugela Canyon is an example of a large submarine canyon restricted to the mid-lower continental slope. Unlike those off the Greater St Lucia Wetland Park (GSLWP) further north, this canyon lacks connection to the upper continental slope and shelf. The canyon head is located at ~600 m depth with the thalweg ending in the Natal Valley at ~2,800 m (Wiles *et al.* 2013). Information on the Goodlad Canyon is sparse. It is reported to start as a small 20 m deep valley (Martin & Flemming 1988) deepening to 250 m while becoming a 50 km wide, shallow valley at a depth of 1,400 m. It emerges from the Tugela Bank at 2,320 m (Goodlad 1986). Further canyons are located to the south of the Bank where the continental shelf narrows and the continental margin descends into the Natal Valley, and along the continental marin between Port Shepstone and Algoa Bay. The cable route passes down the Central Terrace into the Natal Valley well seawards of the Tugela Bank, shelf edge and the submarine canyons.

Along the East coast, the bathymetry is characterised by a very narrow shelf, which widens in the region of Algoa Bay. Moving westwards, depth increases more gradually to the shelf break, which is located at a depth of 140 m off Port Elizabeth, 130 m off Cape St Francis, and 300 m south of Cape

Agulhas (Birch & Rogers 1973). Between 22° and 23°E, the shelf break indents towards the coast forming the Agulhas 'bight' (Schumann 1998). At the apex of the Agulhas Bank the shelf widens to 250 km. Major bathymetric features on the Agulhas Bank include various banks (Alphard, 6-Mile, 12-Mile, 45-Mile and 72-Mile Banks, and the "Blues" and "Browns" Banks), situated south of Cape Infanta and off Cape Agulhas, the Agulhas Arch and Alphard Rise (Birch & Rogers 1973; CCA & CSIR 1998). Dalgleish Bank and Grue Bank lie due south of Knysna, with Grue Bank extending eastwards as a deep reef complex referred to as Kingklip Koppies and the Agulhas- and Kingklip Ridges. The Kingklip Ridge (situated on the slope between Port Elizabeth and Cape St. Francis) is a unique 40 km long, 500 m wide feature that rises from a depth of more than 700 m to as shallow as 350 m with very strong currents on the outer ridge (Sink *et al.* 2019). Outside the shelf break, depth increases rapidly to more than 1,000 m (Hutchings 1994).

Whereas the East Coast is primarily linear, the coastline of the South Coast is characterised by a number of capes separated by sheltered sandy embayments. Three submarine canyons are known off Algoa Bay with the Sundays and Addo Canyons breaching the shelf and spanning a depth range of approximately -150 m to -2 000 m. The deeper Cannon Rocks Canyon, off the Boesmans Estuary east of Port Elizabeth, is confined to the slope. Two potential canyons off Tsitsikamma that were included in the 2004 National Biodiversity Assessment (NBA) (Lombard *et al.* 2004), could not be located during the Deep Secrets cruise (Sink 2016, cited in Sink *et al.* 2019) (see Figure 1b).

The Agulhas Ridge is a positive relief feature rising more than 3 km above the surrounding seafloor and forms part of the Agulhas-Falkland Fracture Zone (Ben-Avraham *et al.* 1997; Uenzelmann-Neben & Gohl 2004) (see Figure 1b). This approximately 2,500 km long linear feature, located between the southern margin of South Africa and the northern edge of the Falkland Plateau separates the Cape Basin and the Agulhas Basin (Ben-Avraham *et al.* 1997; Schut *et al.* 2002; Uenzelmann-Neben & Gohl 2004). The deep and expansive Agulhas Basin lies to the east of the Agulhas Bank and is generally deemed featureless except for the Southwest Indian Seamount chain. This seamount chain occurs at a depth of more than 3,000 m, and includes the Mallory-, Davie-, Shackleton- and Natal Seamounts (Sink *et al.* 2019). To the west of the Agulhas Ridge lies the Cape Basin and the prominent Southeast Atlantic seamounts (Protea and Argentina Seamounts) that rise up to 700 m deep from a depth of 2,500 m. The cable route passes south of the Mallory Seamount Cluster into the Agulhas Basin, around the southern portion of the Agulhas Ridge and between the Protea and Argentina seamounts (see Figure 1b).

Along the West Coast, the continental shelf 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. The nature of the shelf break varies off the South African West Coast. Between Cape Columbine and the Orange River, there is usually a double shelf break, with the distinct inner and outer slopes, separated by a gently sloping ledge. The immediate nearshore area consists mainly of a narrow (about 8 km wide) rugged rocky zone and slopes steeply seawards to a depth of around 80 m. The middle and outer shelf normally lacks relief and slopes gently seawards reaching the shelf break at a depth of ~300 m. Underwater features in the general project area include the Cape Canyon and Cape Valley (see Figure 1b). The cable route crosses the base of the Cape Canyon, but lies some 100 km north of the Cape Valley.

Banks on the continental shelf along the West Coast include the Orange Bank (Shelf or Cone), a shallow (160 - 190 m) zone that reaches maximal widths (180 km) offshore of the Orange River, and Child's Bank, situated ~150 km offshore at about 31°S. Child's Bank is the only known submarine bank within South Africa's Exclusive Economic Zone (EEZ), rising from a depth of 350 - 400 m water to less than 200 m at its shallowest point. The bank area has been estimated to cover some 1,450 km^2 (Sink *et al.* 2012).

3.1.2 Coastal and Inner-shelf Geology and Seabed Geomorphology

The Tugela Bank is the major sedimentary deposition centre of the KZN continental shelf, being characterised by fluvial deposits of Tugela River and Mgeni River origin. Sediment dispersal in the Bight is controlled by the complex interaction of shelf morphology, the Agulhas Current, wave regime, wind-driven circulation, sediment supply and the presence of the semi-permanent gyre. The seabed is thus sedimentary in nature but varies in the degree to which it is consolidated (CBD 2013; see also Green & MacKay 2016). North of Durban, the shelf region is dominated by terrigenous sand (0.063 – 2 mm), with patches of gravel (>2 mm) occurring throughout the area. Areas on the mid-shelf contain sediments comprising up to 60% terrigenous mud. Two large mud depo-centres are found off the Tugela River mouth, while a smaller one is located off St Lucia. These mud depo-centres are a rare environment along the east coast of South Africa, comprising only about 10% of the shelf area (Demetriades & Forbes 1993). The muds and their associated elevated organic contents provide habitat to a unique fauna dominated by benthic and deposit feeders that favour muddy sediments and turbid waters. Despite being primarily a soft-sediment habitat, low profile beachrock outcrops (Fennessy 1994a, 1994b; Lamberth *et al.* 2009) occur just offshore of the 50 m contour off Durban and around the 200 m contour off Richard's Bay.

South of Durban, sand dominates both the inshore and offshore surficial sediments, although a substantial gravel component is present on the middle and outer shelf to as far as Port St Johns, occurring as coarse lag deposits in areas of erosion or non-deposition. Traces of mud are present on most areas of the shelf, although significant mud depo-centres are absent. The outer shelf is dominated by gravels of shell-fragment and algal-nodule origin (Heydorn *et al.* 1978). These outer shelf sediments are influenced solely by the strong Agulhas Current, forming large-scale subaqueous dunes with a southwesterly transport direction. North and south of the Tugela Bank, the Agulhas Current generates active dune fields at the shelf edge (Flemming & Hay 1988). Subaqueous dunes in the inner and mid shelf are prone to current reversals (Uken & Mkize 2012). In contrast, sediments on the shelf area of the Tugela Bank to a depth of 100 m are affected mostly by wave action (CSIR 1998; Green & MacKay 2016). South of the Ilovo River the inner shelf comprises sand sheets, while sand ribbons and streamers occur on the mid-shelf comprises, with gravel pavements dominating the outer shelf.

The coastline of the South Coast is characterised by a number of capes separated by sheltered sandy embayments. A large expanse of the mid-shelf region (40-100 m depth) of the Agulhas Bank comprises either rock or areas with sparse sediment cover. Inshore on the South Coast the seafloor is rocky. Offshore of this, an inner shelf sediment wedge extends up to 30 km offshore comprising soft liquid muds to the west of Mossel Bay and firm terrigenous sediment to the east (Birch & Rogers 1973; Schumann 1998). Although mud patches occur inshore east of Cape Infanta and south of Cape Agulhas, the majority of unconsolidated sediment is sand to muddy sand (Birch & Rogers 1973).

The seabed in the inshore region of the South Coast is largely dominated by rocky reefs with sparse sediment cover. Westwards of Mossel Bay, an inner shelf sediment wedge extends up to 30 km offshore comprising soft liquid muds, whilst firm terrigenous sediment extends to the east of Mossel Bay. Mud patches also occur inshore to the east of Cape Infanta and south of Cape Agulhas, but most unconsolidated sediments are sand or muddy sand (Birch & Rogers 1973). A large expanse of the Agulhas Bank mid-shelf seafloor comprises both rock and areas with sparse sediment cover (relic sands, Dingle et al 1987). Along the eastern half of the South Coast, the seabed is predominantly rocky reefs (Birch & Rogers 1973).

On the West 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 (2020a, 2020b, 2020c). These reports emphasize the diversity of seabed sediments and features often over small spatial scales and at great depths.

3.2. Biophysical Characteristics

3.2.1 Wind and Swell Patterns

The main wind axis off the KZN coast is parallel to the coastline, with north-north-easterly and south-south-westerly winds predominating for most of the year (Schumann & Martin 1991) and with average wind speeds around 2.5 m/s (Schumann 1998).

In the sea areas off Durban, the majority of swells are from the South and South-southwest, with the largest attaining >7 m. During summer and autumn, some swells also arrive from the east. The less regular weather patterns affecting the East Coast (e.g. low pressure cells present NE of Durban, cut-off low pressure cells and tropical cyclones) strongly influence the wave climate, resulting in swells in excess of 10 m (Hunter 1988; Schumann 1998). The giant waves (>20 m high) that are at times encountered within the Agulhas Current (Heydorn & Tinley 1980), arise from the meeting of the south-westerly swells and the southerly flowing Agulhas Current, and may be a navigation hazard at times.

Along the South Coast, westerly winds predominate in winter, frequently reaching gale force strengths. During summer, easterly wind directions increase markedly resulting in roughly similar strength/frequency of east and west winds during that season (Jury 1994). The strongest winds are observed at capes, including Agulhas, Infanta, Cape Seal, Robberg and Cape Recife (Jury & Diab 1989). Calm periods are most common in autumn (CCA & CSIR 1998).

Along the South Coast, wind-driven upwelling occurs inshore, especially during summer when easterly winds prevail (Schumann *et al.* 1982; Walker 1986; Schumann 1998). Such upwelling usually begins at the prominent capes and progresses westwards (Schumann *et al.* 1982; Schumann 1988), and can result in temperature changes of up to 8° C within a few hours (Hutchings 1994).

Intensive upwelling of Indian Ocean Central Water occurs periodically over the shelf and shelf edge, along the inner boundary of the Agulhas Current (Schumann 1998). This process is primarily due to frictional interactions between the Agulhas Current and bottom topography (Hutchings 1994), and is most intense at the eastern boundary of the South Coast, where the cold bottom layer breaks the surface. Such shelf-edge upwelling largely defines the strong thermocline and halocline topography of the Agulhas Bank region, particularly in summer. A cool ridge of upwelled water that extends in a north-east (NE) – south-west (SW) direction over the mid-shelf regions between the shelf-edge upwelling and inshore waters close to the coast. (Swart & Largier 1987; Boyd & Shillington 1994; Schumann 1998), dividing the waters of the Agulhas Bank into the two-layered structure in the inshore region and a partially mixed structure in the eastern offshore region.

On the South Coast, the majority of waves arrive from the south-west quadrant (Whitefield *et al.* 1983), dominating wave patterns during winter (June – August) and spring (September – November) (Carter & Brownlie 1990). Waves from this direction frequently exceed 6 m (Swart & Serdyn 1981, 1982) and can reach up to 10 m (Heydorn 1989). During summer, easterly wind-generated 'seas' occur (Heydorn & Tinley 1980; Heydorn 1989; Carter & Brownlie 1990).

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.

In the Benguela region, the prevailing winds 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). 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. 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.

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. 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.

Focusing specifically on the wave regime and exposure ratings at the proposed landing site at Duynefontein, like most of the southern African West Coast, the coastline at the shore crossing 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 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.

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.

3.2.2 Large-scale Circulation

The oceanography of the East and South coasts is almost totally dominated by the warm Agulhas Current that flows southwards along the shelf edge (Schumann 1998) (Figure 3). The Agulhas Current forms between 25° and 30° S, its main source coming from recirculation in a South-West Indian Ocean subgyre. Further contributions to the Agulhas Current come from the Mozambique Current and the East Madagascar Current in the form of eddies that act as important perturbations to the flow (Lutjeharms 2006). It flows southwards at a rapid rate following the shelf edge along the East Coast. It is a well-defined and intense jet some 100 km wide and 1,000 m deep (Schumann 1998), flowing in a south-west direction at a rapid rate, and water transport rates of over 60×10^6 m^3/s have being recorded (Pearce *et al.* 1978; Gründlingh 1980).

Where it meets the northern part of the Tugela Bank near Cape St Lucia, the inertia of the Agulhas Current carries it into deep water. This generates instability in the current (Gill & Schumann 1979) resulting in meanders and eddies (Pearce *et al.* 1978; Guastella & Roberts 2016; Roberts *et al.* 2016).

South of Durban, the continental shelf again narrows and the Agulhas Current re-attaches itself as a relatively stable trajectory to the coast, until off Port Edward it is so close inshore that the inshore edge (signified by a temperature front) is rarely discernible (Pearce 1977). At Port St Johns, however, there exists a semi-permanent eddy, which results in a northward-flowing coastal current and the movement of cooler water up the continental slope onto the centre of the very narrow shelf (Roberts *et al.* 2010). On the eastern half of the South Coast, the Agulhas Current flows along the shelf break at speeds of up to 3 m/sec, diverging inshore of the shelf break south of Still Bay (34° 28'S, 21° 26'E) before realigning to the shelf break off Cape Agulhas (Heydorn & Tinley 1980) (Figure 3). The Agulhas Current may produce large meanders with cross shelf dimensions of approximately 130 km, which move downstream at approximately 2 000 m per day (Lutjeharms 2006). Over the inner and mid-shelf (to depths of 160 m), currents are weak and variable, with velocities ranging from 0.25 – 0.75 m/s midshelf and 0.1 – 0.4 m/s closer inshore. Eastward flow may occur close inshore (Boyd *et al.* 1992; Boyd & Shillington 1994), being particularly strong off Port Elizabeth. Bottom water shows a persistent westward movement, although short-term current reversals may occur (Swart & Largier 1987; Boyd & Shillington 1994; CCA & CSIR 1998).

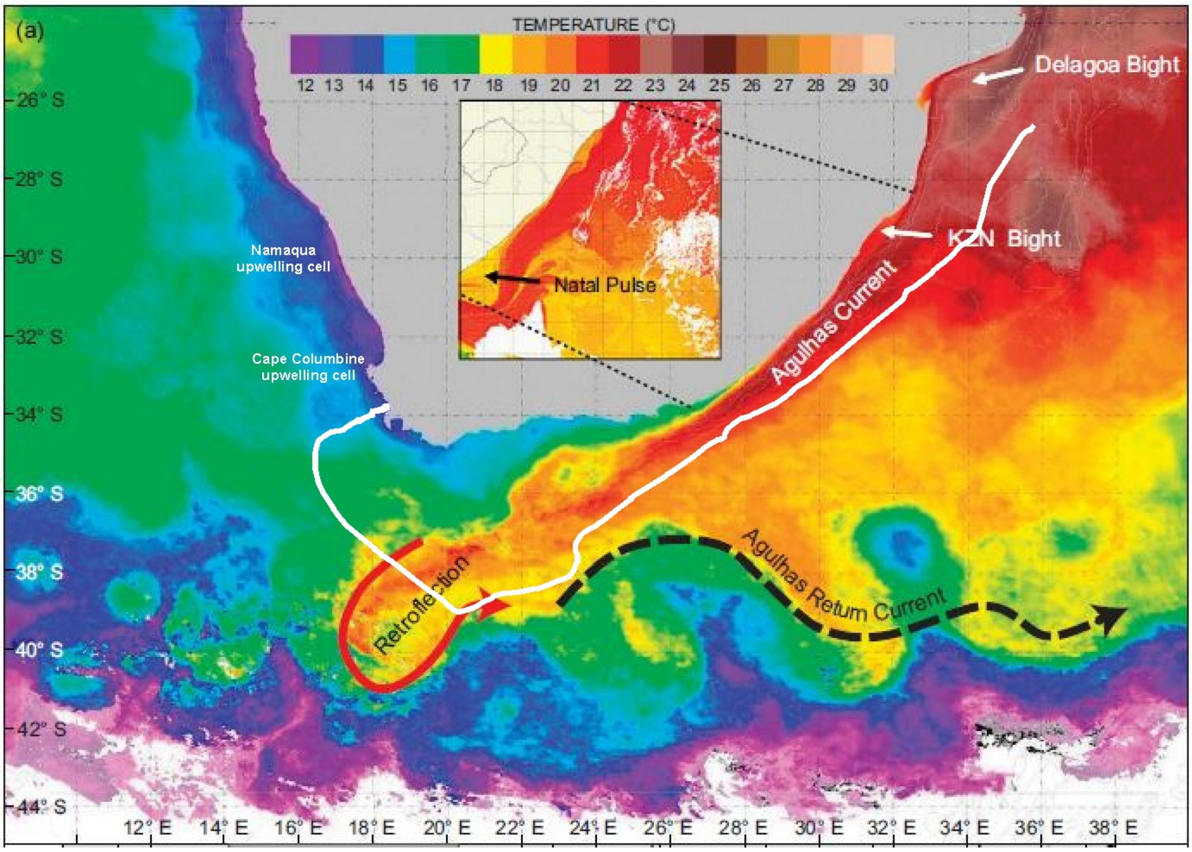


Figure 3: Satellite sea-surface temperature image showing the predominance of the warm Agulhas Current along the South African south coast and the colder upwelled water on the west coast, in relation to the proposed 2AFRICA/GERA (East) Cable route (white line).

Further south, when the Agulhas Current reaches the wider Agulhas Bank, where the continental slopes are weaker, it starts to exhibit meanders, shear edge eddies and plumes of warm surface waters at the shelf edge (Figure 4). These grow downstream and have attendant cyclonic eddies and warm water plumes (Lutjeharms 2006), which can travel at around 0.20 m/s and advect onto the Agulhas Bank (Swart & Largier 1987; Penven *et al.* 2001), where they are thought to influence the waters and the biota in bays on the coastline (Goschen & Schumann 1988, 1994).

Occasionally huge warm-water rings break off from the main current and slowly spin off into the South Atlantic, carrying heat, salt and some pelagic plants and animals characteristic of the Agulhas Current far into the South Atlantic Ocean (Gründlingh 1988; Luschi *et al.* 2003; Lutjeharms 2006). These rings may extend to the seafloor and west of Cape Town may split, disperse or join with other rings (Figure 4). This movement of surface waters from the Indian Ocean to the Atlantic is an important component of the global circulation of water, maintaining the input of heat and salt into the Atlantic Ocean. Long-term variations in this input have been linked to global changes in glacial and inter-glacial periods (Peeters *et al.* 2004; Beal *et al.* 2011).

After detaching from the shelf edge at 15° E, the Agulhas Current retroflects and flows eastwards as the Agulhas Return Current (Schumann 1998). The Return Current navigates through shallower features such as the Agulhas Plateau, which result in wide meanders along the eastern edge of the Agulhas Bank in the direction of the equator (Figure 4).

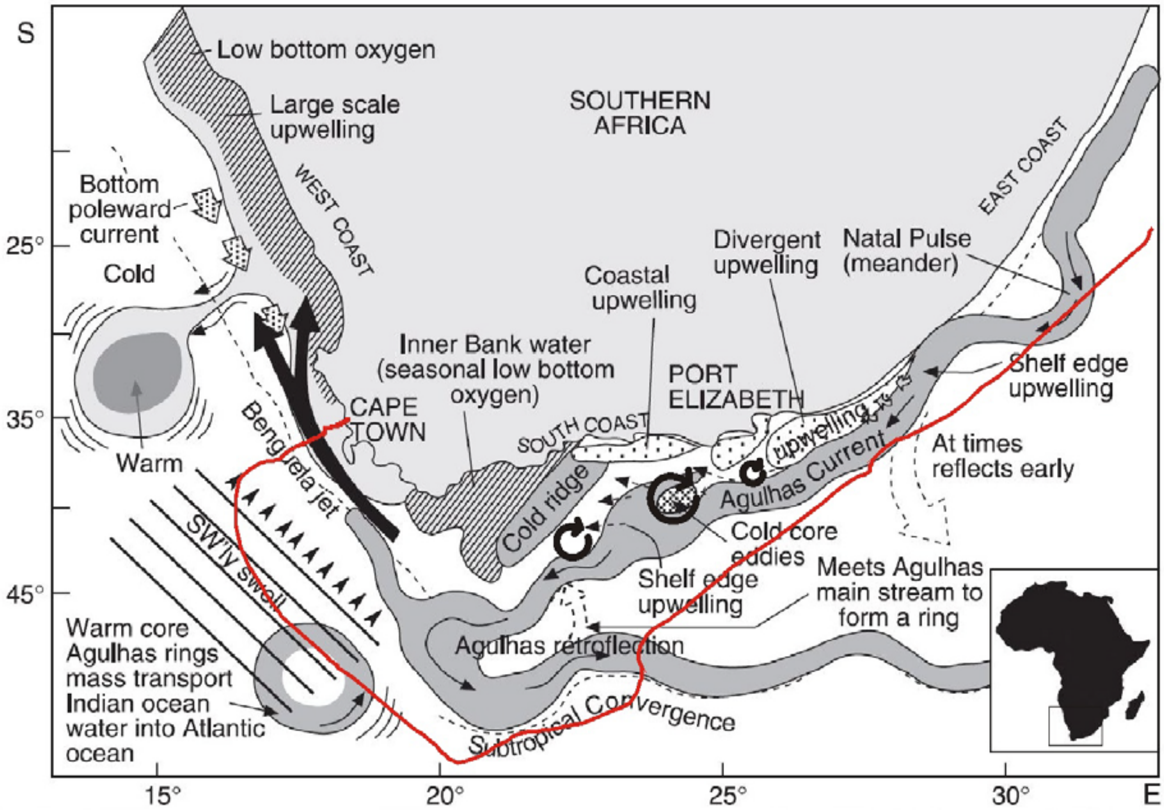


Figure 4: The proposed 2AFRICA/GERA (East) Cable route (red line) in relation to the major circulatory elements along the South Coast (adapted from Lutjeharms 2006).

On the western edge of the Agulhas Bank, the inner- and mid-shelves are characterised by weak and variable currents to depths of -160 m, with wind-driven coastal upwellings occurring over the inner (Largier *et al.* 1992). The upwelling of nutrient-rich sub-photic water creates an intensive, dynamic mixing region on the Agulhas Bank that is intermediate in terms of temperature and productivity between the Benguela and Agulhas regimes (Jackson *et al.* 2012; Goschen *et al.* 2015). Cold water upwelled over the shelf-edge forms a basal layer on the shelf while intrusive plumes of more saline, surface water continually replenish a warm, mixed layer at the surface (Swart & Largier 1987). The circulation and stratification of the Agulhas Bank are therefore the result of an interaction between oceanic forcing and wind-forcing (Largier *et al.* 1992).

The West Coast is strongly influenced by the Benguela Current, which in continental shelf areas has current velocities generally ranging 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).

3.2.3 Water

The surface waters off the East Coast are a mix of Tropical Surface Water (originating in the South Equatorial Current) and Subtropical Surface Water (originating from the mid-latitude Indian Ocean). Surface waters are warmer than 20°C and have a lower salinity than the Equatorial Indian Ocean, South Indian Ocean and Central water masses found below. Surface water characteristics, however, vary due to insolation and mixing (Schumann 1998). Seasonal variation in temperatures is limited to the upper 50 m of the water column (Gründlingh 1987), increasing offshore towards the core waters of the Agulhas Current where temperatures may exceed 25° C in summer (21° C in winter) (Schumann 1998). Further offshore of the core waters, temperatures again decrease.

South Indian Ocean Central Water of 14º C and a salinity of 35.3 ppt occurs below the surface water layers at between 150 - 800 m depth. The deeper waters comprise, from shallowest to deepest, Antarctic Intermediate Water, North Indian Deep Water, North Atlantic Deep Water and Antarctic Bottom Water. Sub-tropical Surface Water of between 15 and 20º C often intrudes into the Agulhas Current at depths of 150 - 200 m from the east (Schumann 1998).

Seasonal variation in temperatures is limited to the upper 50 m of the water column (Gründlingh 1987), increasing offshore towards the core waters of the Agulhas Current. South of Mbashe and East London, a persistent wedge of cooler water is present over the continental shelf during summer (Beckley & Van Ballegooyen 1992), extending northwards to the southern KwaZulu-Natal coast in winter. This wedge is typically cooler than 19° C, but may be cooler than 16° C between East London and Port Alfred, and south of Mbashe. Inshore, waters are warmest during autumn, with warm water tongues found off Cape Recife (near Port Elizabeth) from January to March, and Knysna from October to January and during August. Warm water also tends to bulge towards Knysna between April and July and during September (Christensen 1980).

The thermal structure of Agulhas Bank waters is mediated by the intrusions of Agulhas Current water at surface and subsurface depths, upwelling and surface heating by insolation. At the inner boundary of the Agulhas current, cold bottom water is advected onto the Agulhas Bank *via* shelf-edge upwelling (Schumann 1998). This process is primarily due to frictional interactions between the Agulhas Current and bottom topography (Hutchings 1994), and is most intense at the eastern boundary of the South Coast, where the cold bottom layer breaks the surface. On the central Agulhas bank, a prominent feature of the midshelf is the ridge of cool water that extends in a north-east (NE) – south-west (SW) direction between the shelf-edge upwelling and inshore waters close to the coast (Swart & Largier 1987; Boyd & Shillington 1994; Schumann 1998; Krug *et al.* 2014). The ridge has its 'base' at the coast between Cape Seal and Cape St Francis and appears to be most prominent under SE wind conditions, which cause coastal upwelling in the Knysna region (Walker 1986; Boyd & Shillington 1994; Jury 1994). As easterly winds dominate in the spring-autumn period the cool water ridge is a semi-permanent feature during much of the year. Inshore of the cool water ridge, the thermoclines may be disrupted by coastal upwelling on the lee side of capes under easterly wind conditions (Schumann *et al.* 1982; Walker 1986; Goshen & Schumann 1995; Schumann 1998). Such upwelling usually begins at the prominent capes and progresses westwards (Schumann *et al.* 1982; Schumann *et al.* 1988), and can result in temperature changes of up to 8 °C within a few hours (Hutchings 1994). However, northeastward moving upwelling has also been reported (Goshen *et al.* 2012).

The thermoclines on the central and eastern Agulhas Bank are resistant to breakdown under strong wind conditions due to their strong gradients. These extend inshore during the summer, but breaking down during the cooler and windier winter conditions (Schumann & Beekman 1984; Boyd & Shillington 1994). During strong winds, the isothermal upper mixed layer erodes down into the top of the thermocline, thereby increasing the temperature gradient and thus thermocline stability (Carter *et al.* 1987). Temperature gradients are usually around 5-6 °C/10 m close inshore east of Cape Agulhas but reaching extremes of 10 °C/10 m around the Alphard Banks and eastwards inshore towards Cape St. Francis. At the eastern edge of the South Coast, thermoclines are located at 20-40 m depth, whereas they are deeper at the western edge (40-60 m) (Largier & Swart 1987).

In contrast, on the outer Bank, offshore of the cold water ridge, thermocline development is weak. In winter, when westerly winds dominate, the cold bottom water recedes to the shelf break and the nearer shore water column tends to become isothermal (Schumann & Beekman 1984; Boyd & Shillington 1994).

South Atlantic Central Water (SACW) comprises the bulk of the seawater in the Southern Benguela, 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 ppt and 35.5 ppt (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).

3.2.4 Upwelling and Plankton Production

As the Agulhas Current originates in the equatorial region of the western Indian Ocean its waters are typically blue and clear, with low nutrient levels and a low frequency of chlorophyll fronts. The region is generally oligotrophic, with nutrients (silicates, phosphates and nitrates) occurring in very low concentrations in the upper mixed layer, increased below the pycnocline (Muir *et al.* 2016). On the Tugela Bank, however, nutrient concentrations are higher than in areas where the continental shelf is narrower (Carter & d'Aubrey 1988) and are characterised by temporal and spatial variability. This is attributed in part, to the topographically induced upwelling that occurs in the area as a result of the bathymetric arrangement of the Natal Bight (Gill & Schumann 1979; Schumann 1988; Lutjeharms *et al.* 1989), inputs from the Thukela River and a cyclonic lee eddy off Durban (Barlow *et al.* 2015; de Lecea *et al.* 2015; van der Molen *et al.* 2016). The cyclonic eddy incorporates enrichment, retention and concentration mechanisms, and together with the upwelling and elevated phytoplankton production in the north of the Bight (Lutjeharms *et al.* 2000b), creates the necessary conditions for enhanced survivorship of early larvae and juveniles of pelagic spawners (Beckley & van Ballegooyen 1992; Hutchings *et al.* 2003). Recently, Roberts & Nieuwenhuys (2016) identified that upwelling in the northern KZN Bight is common, and that almost all major and minor cold-water intrusions coincided with upwelling-favourable north-easterly winds that simultaneously force a south-westerly coastal current. Major upwelling events last for 5-10 days, whereas shorter duration events persist for 1-2 days. Wind-driven upwelling also occurs in the inner bight between Richards Bay and Port Durnford. Furthermore, the canyons of northern bight may also play a role in enhancing upwelling. Upwelling has also been reported in the southern bight 'swirl'. The cold nutrient-rich upwelled waters are a source of bottom water for the entire Natal Bight (Lutjeharms *et al.* 2000a, b). However, from all other perspectives, the Bight may be considered a semi-enclosed system (Lutjeharms & Roberts 1988) as the strong Agulhas Current at the shelf edge forms a barrier to exchanges of water and biota with the open ocean.

On the South Coast, where cold bottom water is advected onto the Agulhas Bank *via* shelf-edge upwelling (Schumann 1998), the core of the upwelling lies at Port Alfred but can extend from the eastern edge of Algoa Bay to Mbashe on the Transkei Coast (Lutjeharms *et al.* 2000b). This upwelling has been associated with large meanders in the Agulhas Current (Jackson *et al.* 2012; Goshen *et al.* 2015; Malan *et al.* 2018). Such shelf-edge upwelling largely defines the strong thermocline and halocline topography that typically develops between the cold bottom water and the sun warmed surface layer during spring (September to November), summer (December to February) and autumn (March to May).

Under the SE wind conditions prominent during the spring-autumn period, coastal upwelling occurs in the Knysna region (Walker 1986; Boyd & Shillington 1994; Jury 1994) as well as on the lee side of prominent capes. Such upwelling usually progresses westwards (Schumann *et al.* 1982; Schumann *et al.* 1988), although northeastward moving upwelling has also been reported (Goshen *et al.* 2012).

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 comparatively nutrient-poor nearshore surface water northwards and offshore. To balance the displaced water, cold, nutrient-enriched 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.

The cold, upwelled water is rich in inorganic nutrients, the major contributors being various forms of nitrates, phosphates and silicates (Chapman and Shannon 1985) supporting substantial seasonal primary phytoplankton production.. Nutrient concentrations of upwelled water of the Benguela system attain 20 µM nitrate-nitrogen, 1.5 µM phosphate and 15-20 µM silicate (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. On the West Coast, the 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).

3.2.5 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 5, 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 5, right).

Figure 5: 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)

3.2.6 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 **Error! Reference source not found.**), 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; Bailey 1991; 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.

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 5, 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.

3.2.7 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. The PIM loading in nearshore waters is strongly related to natural riverine inputs and resuspension and bedload transport of seabed sediments. As there are no major rivers entering the South Coast or the West Coast south of Saldanha Bay, PIM loading in the offshore regions would be negligible. Similarly, in the offshore waters of the East Coast, PIM loadings would be negligible, and well offshore of riverine influences onto the Tugela Bank.

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). However, offshore of the continental shelf, and along most of the cable route, the oceanic surface waters are clear and background concentrations are typically <1 mg/ℓ (Emery *et al.* 1973).

A feature of continental shelf waters off the South Coast and inshore of the cable route, is the benthic nepheloid layer (Zoutendyk & Duvenage 1989; Dorfler 2002). This layer can be up to 10 m thick and may have TSPM values of up to 38 mg/ℓ. It is usually located below the thermocline at a depth of between 20 m and 30 m (Zoutendyk & Duvenage 1989). Initially thought to be associated with the mud belts on the inner Agulhas Bank near Mossel Bay, the nepheloid layer has recently been found associated with the Cape St Francis and Cape Infanta areas (Dorfler 2002), as well as at about 150 m depth on the continental slope between Knysna and Cape St Francis (Jackson *et al.* 2012). Although thought to originate from detrital fallout from surface waters, Zoutendyk & Duvenage (1989) reported that POM contributed <10% of the TSPM in the turbid layer. The dynamics of the nepheloid layer are complex, and appear to be driven by a combination of wind, waves and currents. Turbidity events, however, not only occur during upwelling but also in isothermal conditions, with down-welling and turbidity being correlated in deeper waters (Dorfler 2002). The benthic nepheloid layer plays a significant role in the benthic community structure of nearshore reefs (Zoutendyk & Duvenage 1989) and is thought to influence the spawning success of squid in Eastern Cape inshore waters (Dorfler 2002).

Off the West Coast, the major source of turbidity in the swell-influenced nearshore areas 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 2AFRICA/GERA (East) Cable System will traverse the Southern Benguela, Southeastern Atlantic Deep Ocean and Southwest Indian Deep Ocean Ecoregions (Sink *et al.* 2019) (Figure 6). The cable will largely be located beyond the shelf break in over 2,000 m of water. The seabed communities in the project area lie within the Southwestern Cape photic, sub-photic and continental slope bioregion, which extend from the shore to the shelf edge. Where the cable passes from the upper and lower continental slope and abyssal deepsea, it lies within the Atlantic Offshore, Indo-Pacific Offshore, West Indian Offshore and Southwest Indian Offshore bioregions (Lombard *et al.* 2004).

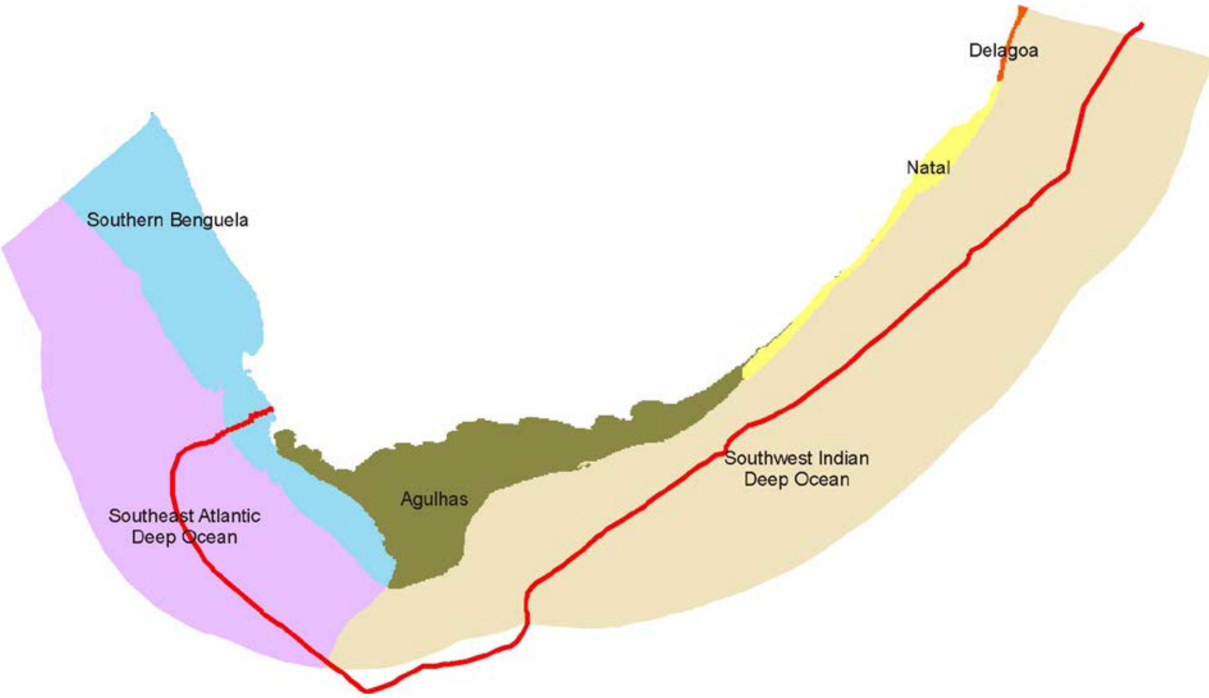


Figure 6: The South African inshore and offshore ecoregions in relation to the proposed 2AFRICA/GERA (East) Cable route (red line) (adapted from Sink *et al.* 2019).

On the Western Cape coastline, the coastal, wind-induced upwelling is the principle physical process that 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).

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 a and 7b) and assigned an ecosystem threat status based on their level of protection (Figure 8).

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' (Figure 8). The proposed routing, however, avoids the 'endangered' habitat types associated with the Cape Upper Canyon and Robben Island.

As the benthic fauna of the outer shelf and continental slope (beyond ~450 m depth) are very poorly known, this description of the biological communities will focus primarily on those in the Southern Benguela ecoregion, where the cable crosses the continental shelf to land at Duynefontein. Where information on the larger pelagic species is available from along the entire cable route, this will be provided.

The biota of nearshore 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

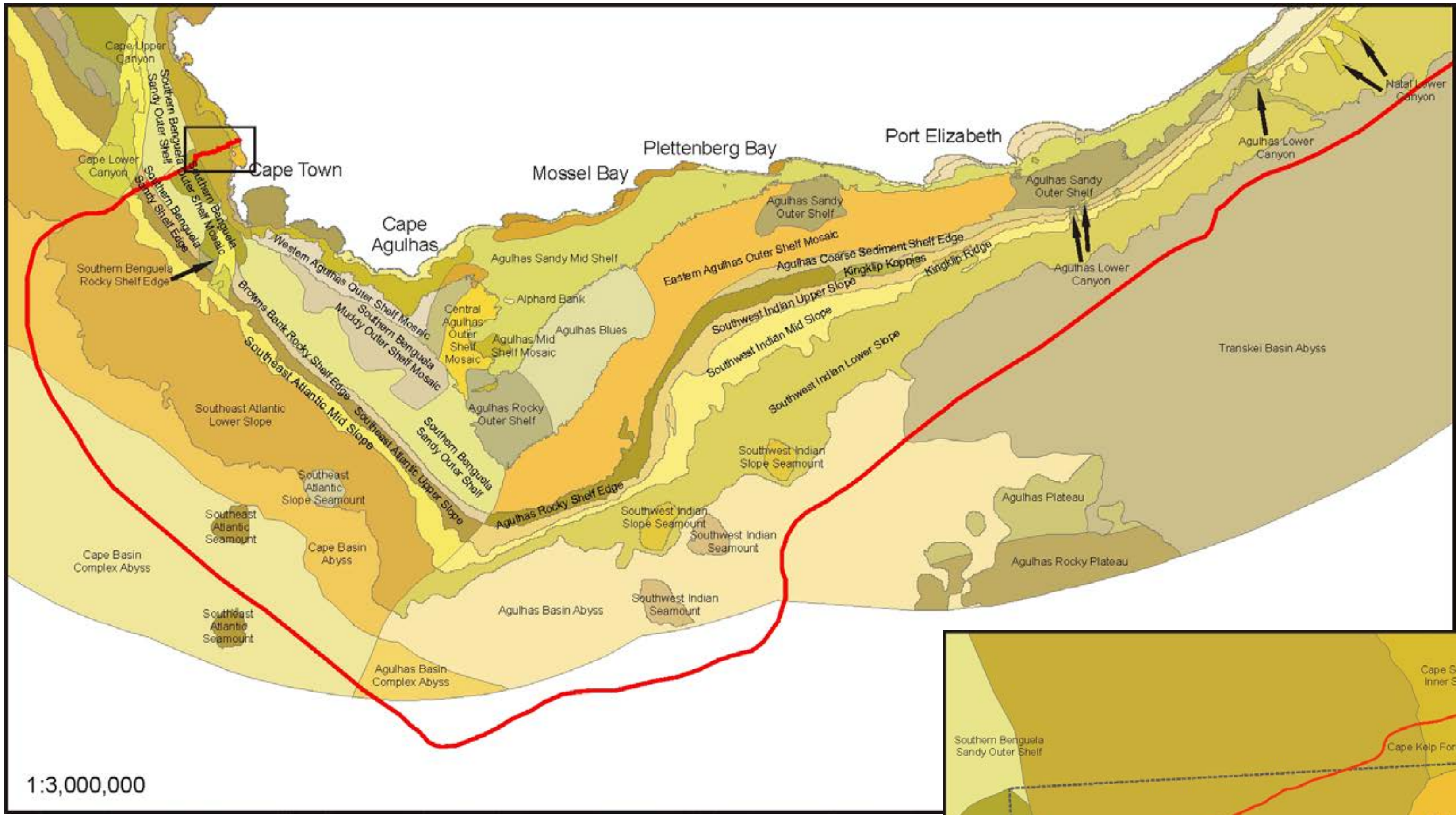
The biological communities consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales). No rare or endangered species have been recorded (Awad *et al.* 2002). The biological communities 'typical' of these habitats are described briefly below, focussing both on dominant, commercially important and conspicuous species, as well as potentially threatened or sensitive species, which may be affected by the proposed 2AFRICA/GERA (East) 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 2,500 m to the south of the proposed shore crossing at Duynefontein, with the breakwater of the Koeberg intake basin located ~2 km to the north. 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



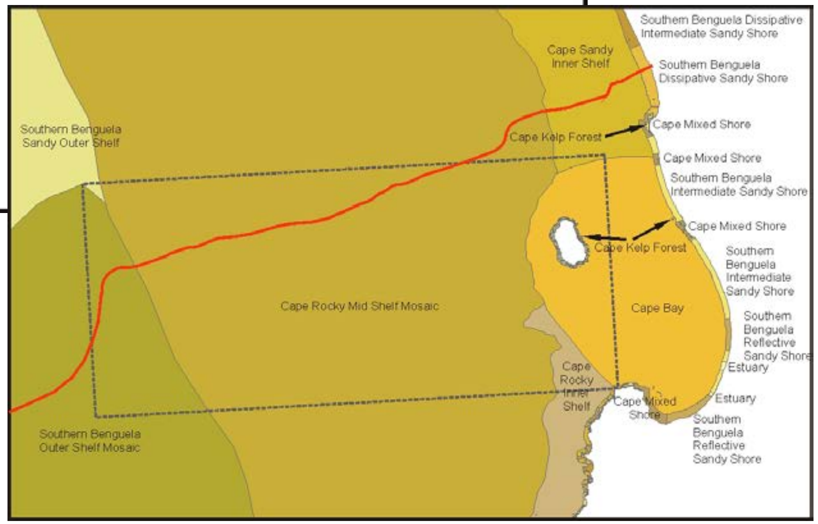


Figure 7a: Offshore and coastal ecoregions along the Southwest and South Coasts in relation to the proposed 2AFRICA/GERA (East) Cable route (red line) (adapted from Sink *et al.* 2019). Note: only offshore ecoregions have been labelled. Those inshore habitats affected by the shore crossing are detailed in the insert (bottom). The Boundary of the Robben Island MPA is also shown.

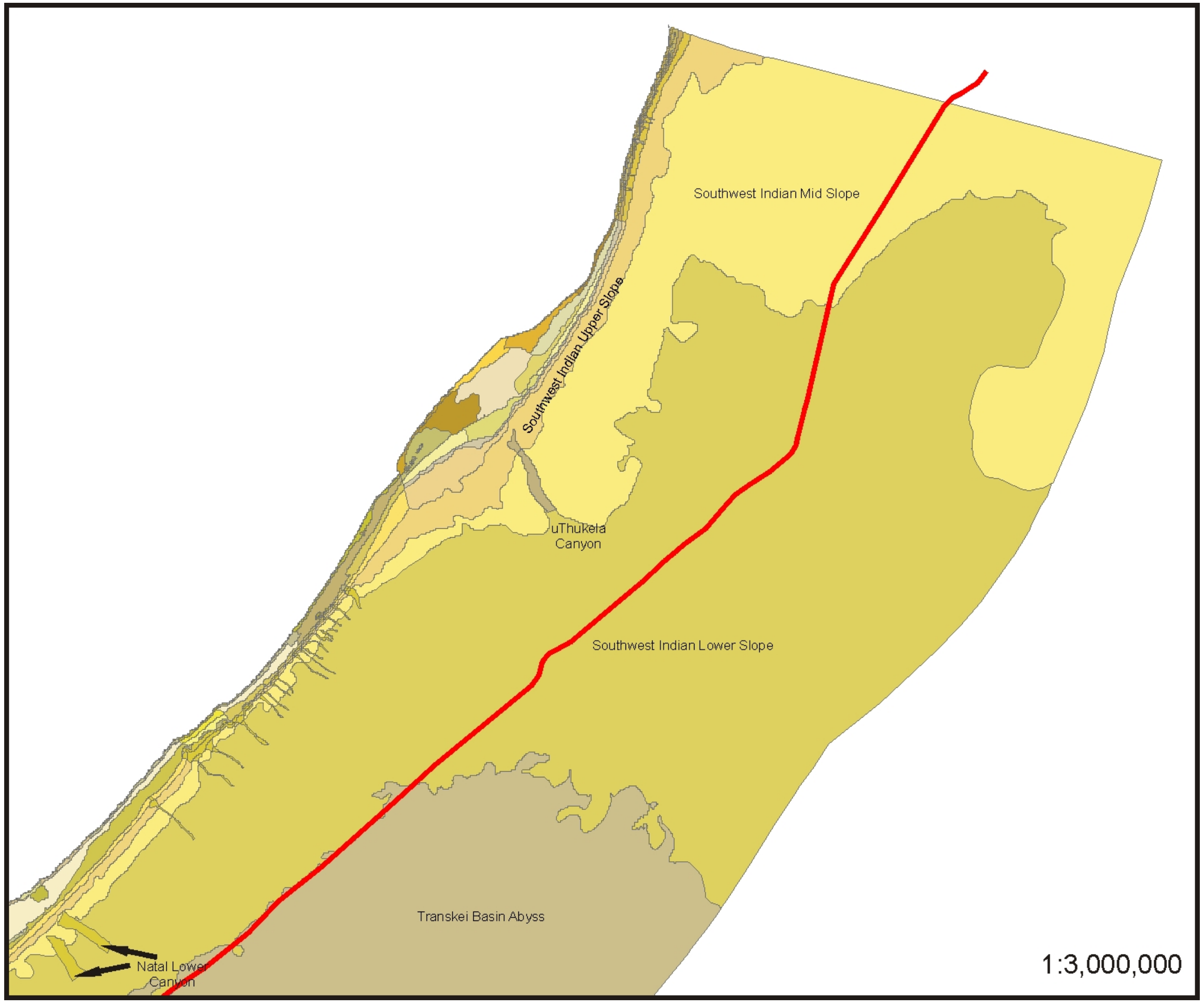


Figure 7b: Offshore and coastal ecoregions along the East Coast in relation to the proposed 2AFRICA/GERA (East) Cable route (red line) (adapted from Sink *et al.* 2019). Note: only offshore ecoregions have been labelled.

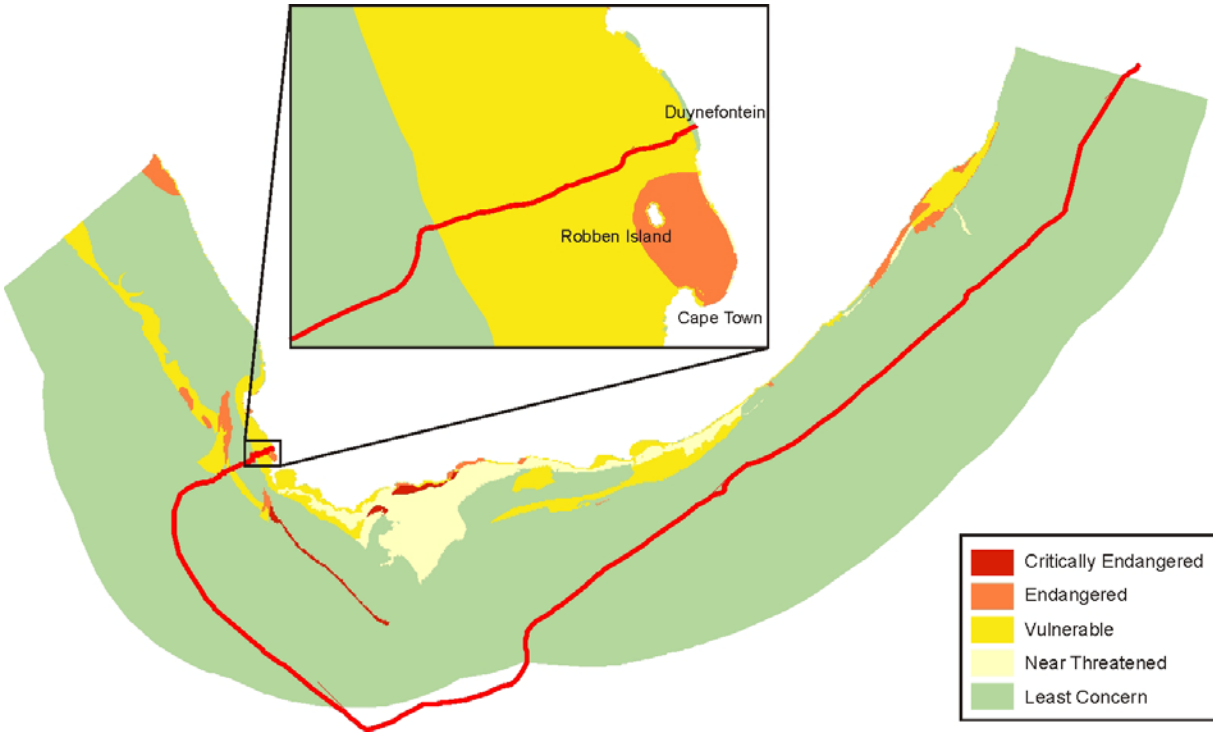


Figure 8: Ecosystem threat status for coastal and offshore benthic habitat types on the South African West Coast in relation to the proposed 2AFRICA/GERA (East) Cable route (red line) (adapted from Sink *et al.* 2019). Insert shows details of the shore crossing.

(McLachlan *et al.* 1993). Generally, dissipative beaches are relatively wide and flat with fine sands and low wave energy. Waves start to break far from the shore in a series of spilling breakers that 'dissipate' their energy along a broad surf zone. This generates slow swashes with long periods, resulting in less turbulent conditions on the gently sloping beach face. These beaches usually harbour the richest intertidal faunal communities. Reflective beaches in contrast, have high wave energy, and are coarse grained (>500 µm sand) with narrow and steep intertidal beach faces. The relative absence of a surf-zone causes the waves to break directly on the shore causing a high turnover of sand. The result is depauperate faunal communities. Intermediate beach conditions exist between these extremes and have a very variable species composition (McLachlan *et al.* 1993; Jaramillo *et al.* 1995; Soares 2003). This variability is mainly attributable to the amount and quality of food available. Beaches with a high input of e.g. kelp wrack have a rich and diverse drift-line fauna, which is sparse or absent on beaches lacking a drift-line (Branch 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 9), supplemented by data from various publications on West Coast sandy beach biota (e.g. Bally 1987; Brown *et al.* 1989; Soares *et al.* 1996, 1997; Nel 2001; Nel *et al.* 2003; Soares 2003; Branch *et al.* 2010; Harris 2012). The macrofaunal communities of sandy beaches are generally ubiquitous throughout the southern African West Coast region, being particular only to substratum

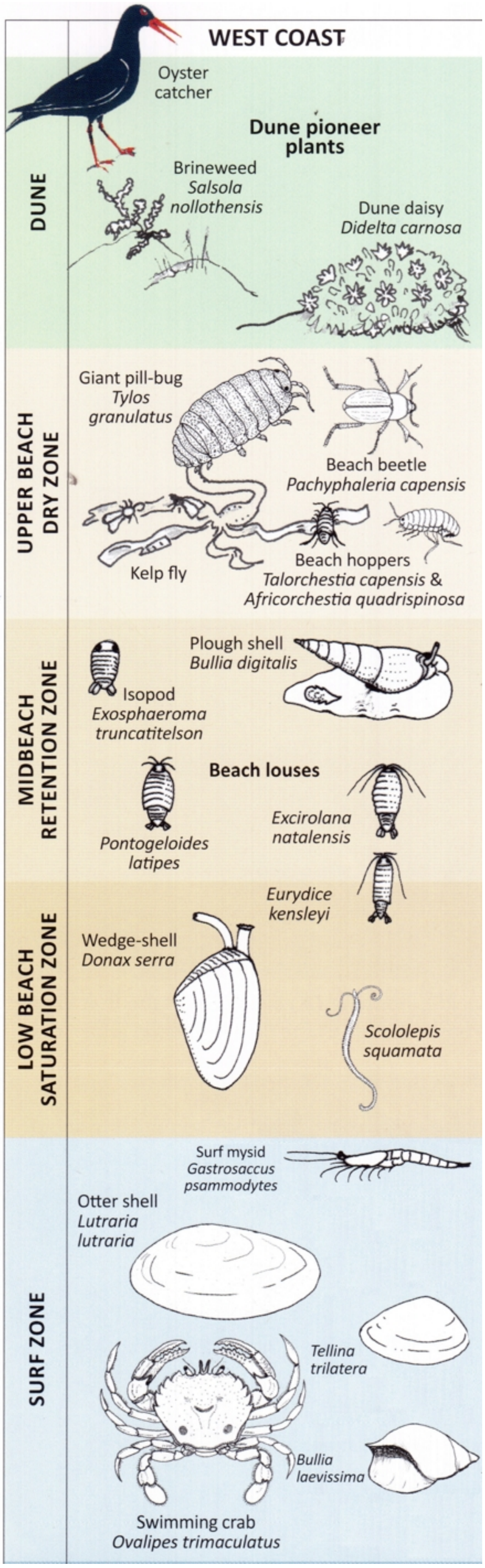


Figure 9: Schematic representation of the West Coast intertidal beach zonation (adapted from Branch and Branch 2018). Species commonly occurring on the Western Cape beaches are listed.

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 Duynefontein is classified as dissipative (see Figure 7a insert). The landing site is characterised by a gently sloping beach of 150 m to 200 m width underlain by rock of the Malmesbury group (Fugro 2020a). 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 10). In some areas, juvenile and adult sand mussels *Donax serra* may also be present in considerable numbers.

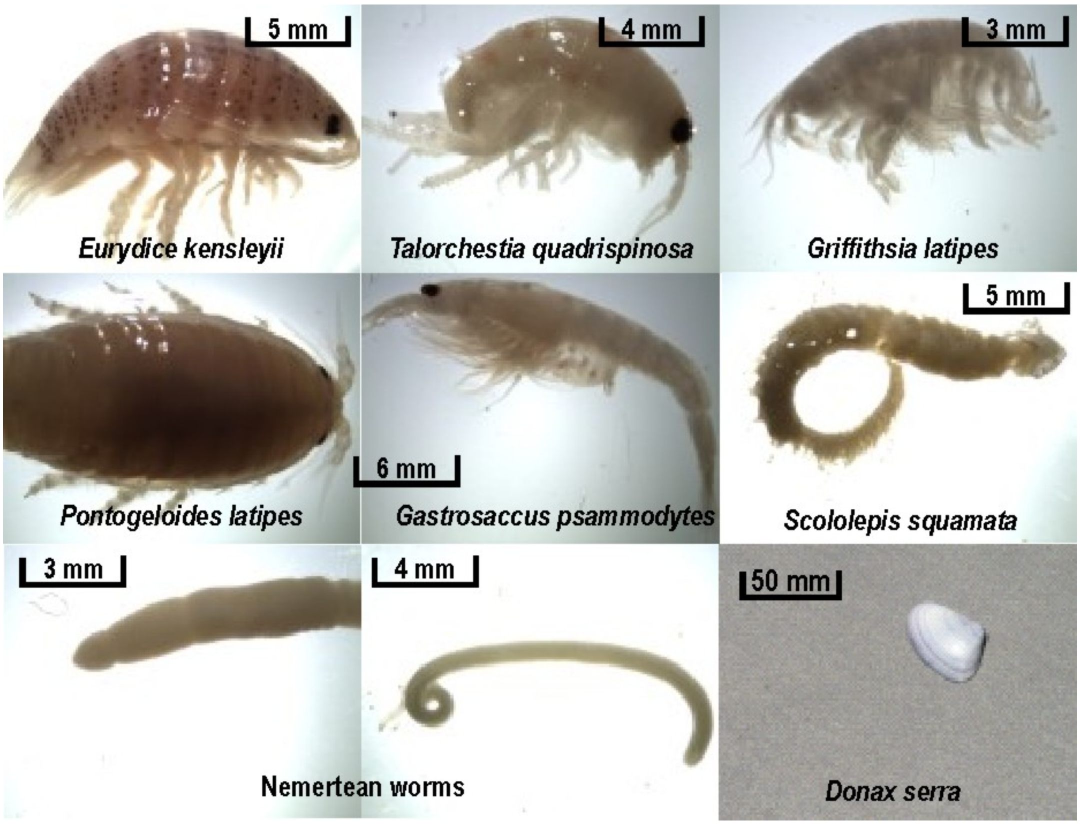


Figure 10: Common beach macrofaunal species occurring on exposed West Coast beaches.

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, 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 to the north of the project area, 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).

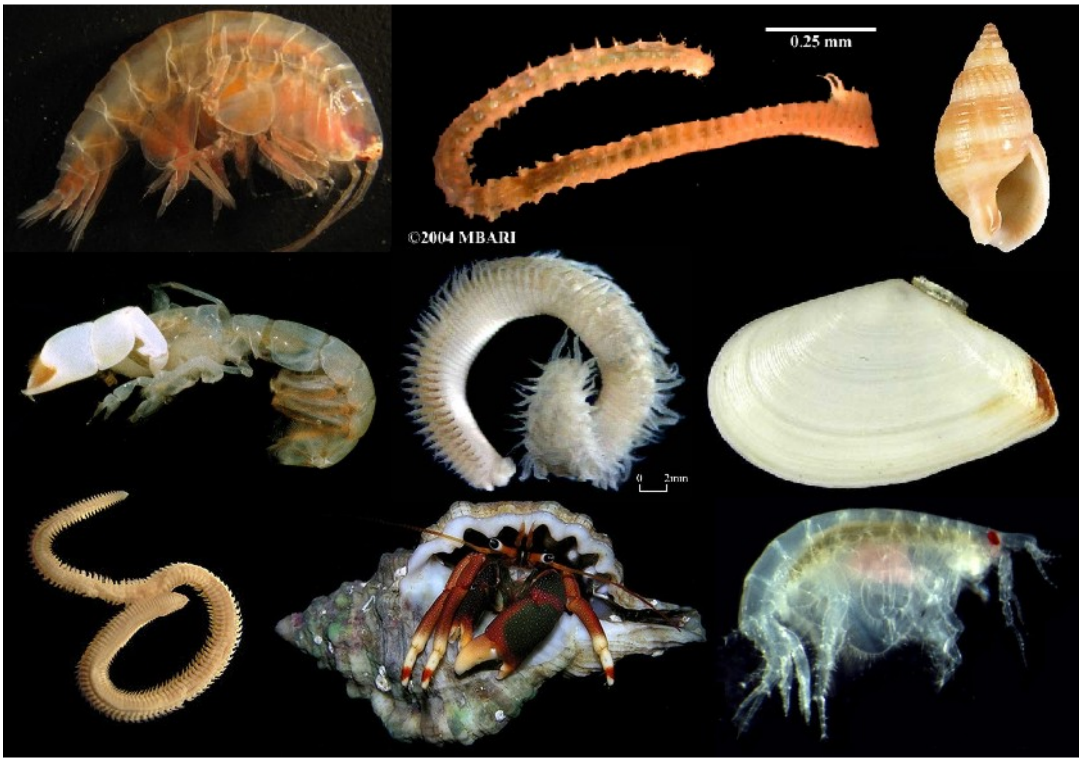


Figure 11: Benthic macrofaunal genera commonly found in nearshore sediments include: (top: left to right) *Ampelisca*, *Prionospio*, *Nassarius*; (middle: left to right) *Callianassa*, *Orbinia*, *Tellina*; (bottom: left to right) *Nephtys*, hermit crab, *Bathyporeia*.

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

Although the cable crosses the shore at a sandy beach, there are rocky shores located ~9 km to the north and 3 km to the south of the proposed cable landing position. A brief description of rocky shore habitats is therefore provided for the sake of completeness. 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.

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 12 and Figure 13). Tolerance to the physical stresses associated with life on the intertidal, as well as biological interactions such as herbivory, competition and predation interact to produce these five zones.

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

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

Toward the lower Mid-littoral or Lower Balanoid zone, biological communities are determined by exposure to wave action. On sheltered and moderately exposed shores, a diversity of algae abounds with a variable representation of: green algae – *Ulva* spp, *Codium* spp.; brown algae – *Splachnidium rugosum*; and red algae – *Aeodes orbitosa*, *Mazzaella (=Iridaea) capensis*, *Gigartina polycarpa* (=*radula*), *Sarcothalia* (=*Gigartina*) *stiriata*, and with increasing wave exposure *Plocamium rigidum* and *P. cornutum*, and *Champia lumbricalis*. The gastropods *Cymbula granatina* and *Burnupena* spp. are also common, as is the reef building polychaete *Gunnarea capensis*, and the small cushion starfish *Patiriella exigua*. On more exposed shores, almost all of the primary space can be occupied by the dominant alien invasive mussel *Mytilus galloprovincialis*. First recorded in 1979 (although it is likely to have arrived in the late 1960s), it is now the most abundant and widespread invasive marine species spreading along the entire West Coast and parts of the South Coast (Robinson *et al.* 2005). *M. galloprovincialis* has partially displaced the local mussels *Choromytilus meridionalis* and *Aulacomya ater* (Hockey 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). As it has been reported on rocky shores south of Lüderitz in Namibia (Pulfrich 2013), it is likely that it occurs in the study area. When present, the barnacle is typically abundant at the mid zones of semi-exposed shores.

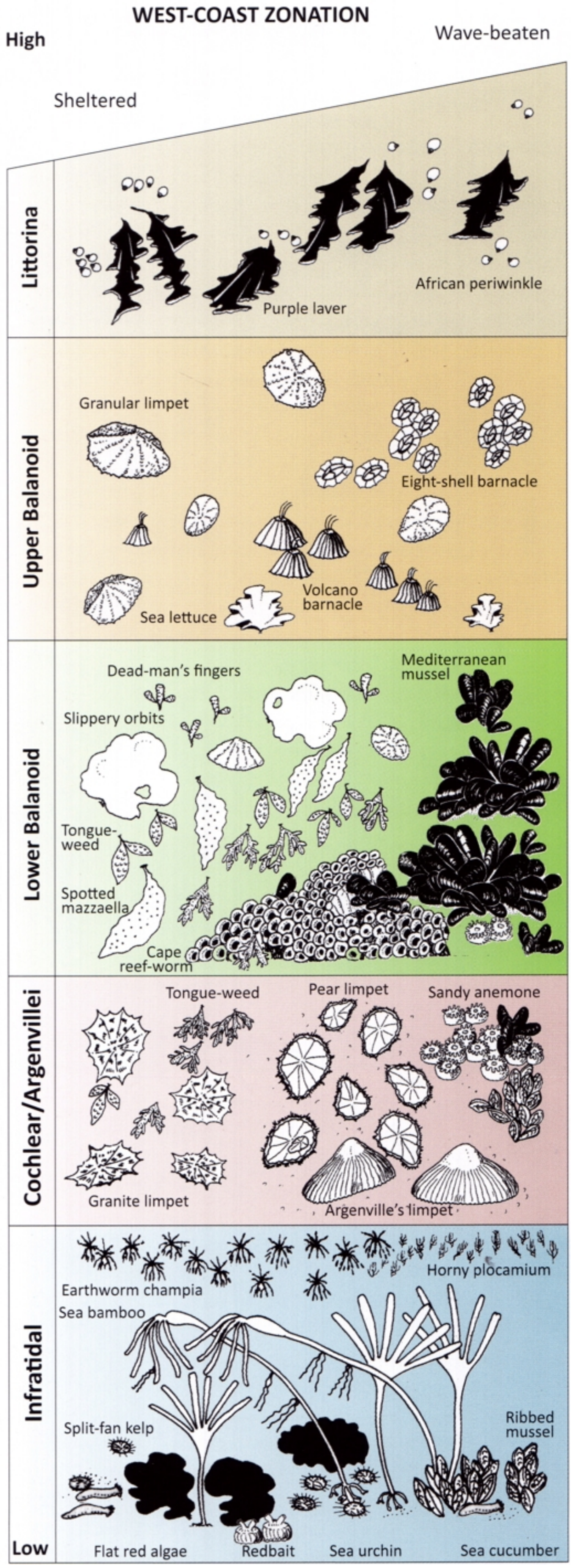


Figure 12: Schematic representation of the West Coast intertidal zonation (adapted from Branch and Branch 2018).

Figure 13: Typical rocky intertidal zonation on the southern African west coast.

Along the sublittoral fringe, the large kelp-trapping limpet *Scutellastra argenvillei* dominates forming dense, almost monospecific stands achieving densities of up to 200/m^2 (Bustamante *et al.* 1995). Similarly, *C. granatina* is the dominant grazer on more sheltered shores, also reaching extremely high densities (Bustamante *et al.* 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 14). 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 14: 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 15) 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 **Error! Reference source not found.** (Atkinson & Sink 2018).

Figure 15: Gorgonians and bryozoans communities recorded on deep-water reefs (100-120 m) off the southern African West Coast (Photos: De Beers Marine).

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).

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 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).

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 along the cable route, and their approximate depth range, are listed in

Table 3.

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

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 8, 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 range from single-celled bacteria to jellyfish of 2-m diameter, and include bacterio-plankton, phytoplankton, zooplankton, and ichthyoplankton.

The nutrient-poor characteristics of the Agulhas Current water are reflected in comparatively low primary productivity inshore on the continental shelf throughout most of the East and South Coasts. Mean *chlorophyll a* concentrations in KwaZulu-Natal inshore areas range between 0.03 and 3.88 µg/l (Carter & Schleyer 1988; see also Coetzee *et al.* 2010), whereas further south concentrations average between 1-2 mg/m^3 over the whole year in the top 30 m of the water column. *Chlorophyll a* concentrations vary seasonally, being minimal in winter and summer (<1 – 2 mg/m^3), and maximal (2 - 4 mg/m^3) in spring and autumn (Brown 1992). On the South Coast, lower concentrations are partly due to nutrient limitation due to the strong summer thermoclines or light limitations due to deep mixing in winter (Probyn *et al.* 1994), but if the thermocline falls within the 1% light depth, phytoplankton biomass can increase dramatically, with sub-surface chlorophyll concentration maxima often being in excess of 10 mg/m^3 (Carter *et al.* 1987; Hutchings 1994). Chlorophyll concentrations can also be high where upwelling occurs at the coast (Probyn *et al.* 1994). Along the eastern half of the South Coast (Knysna to Cape Padrone), phytoplankton concentrations are usually higher than further west (Hutchings 1994). Further offshore and along the majority of the cable route, the pelagic environment is characterised by very low productivity, with the low variability in water-column temperature resulting in very low frequency of chlorophyll fronts.

Zooplankton and ichthyoplankton abundances along the East and South Coasts will reflect localised areas of higher primary productivity (Oliff 1973; Probyn *et al.* 1994). On the East Coast, continental shelf waters support greater and more variable concentrations of zooplankton biomass than offshore waters (Beckley & Van Ballegooyen 1992), with species composition varying seasonally (Carter & Schleyer 1988). Copepods represent the dominant species group (Carter & Schleyer 1988), but chaetognaths are also abundant (Schleyer 1985). On the South Coast, zooplankton communities have comparatively high species diversity (De Decker 1984). Biomass of mesozooplankton increases from west (~0.5-~1.0 gC/m^2) to east (~1.0-~2.0 gC/m^2), mirroring the eastward increase in *chlorophyll a* concentrations, peaking on the central and eastern Agulhas Bank during summer in association with the subsurface ridge of cool upwelled water. Standing stocks of mesozooplankton (>200 µm) along the eastern half of the South Coast ranges from 3 – 6 g C/m^2, and is dominated by the calanoid copepod *Calanus aghulensis*, which associates with shallow thermoclines and the mid-shelf cool water ridge (Verheye *et al.* 1994). This species may contribute up to 85% of copepod biomass in the region, and is an important food source for pelagic fishes (Peterson *et al.* 1992). Macrozooplankton (>1,600 µm) standing stocks are estimated to be 0.079 gC/m^2 between Cape Agulhas and Cape Recife (Verheye, unpublished data). Dense swarms of euphausiids dominate this zooplankton component, and form an important food source for pelagic fishes (Cornew *et al.* 1992; Verheye *et al.* 1994).

Off the West Coast, plankton is particularly abundant in the shelf waters being associated with the upwelling characteristic of the area. Phytoplankton productivity ranges from 2.5 - 3.5 g C/m^2/day for the midshelf region, 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.

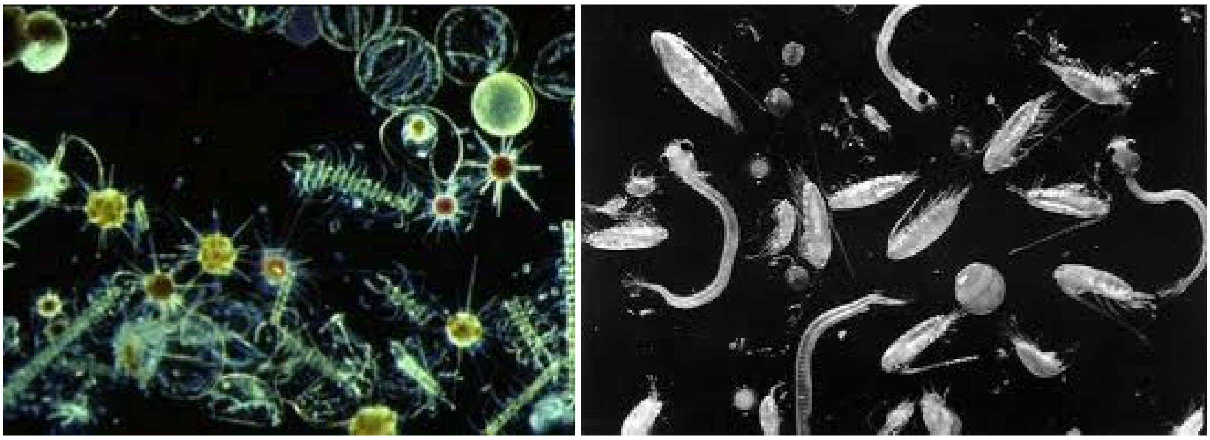


Figure 16: Phytoplankton (left, photo: hymagazine.com) and zooplankton (right, photo: mysciencebox.org) is associated with upwelling cells.

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 these typically occur in the phytoplankton rich upper mixed layer of the water column, with the exception of *M. lucens* which undertakes considerable vertical migration.

The macrozooplankton (≥1,600 µm) are dominated by euphausiids of which the dominant species the 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, and along most of the cable route, biomass decreases markedly.

Zooplankton biomass varies with phytoplankton abundance and, accordingly, seasonal minima exist during non-upwelling periods when primary production is lower (Brown 1984; Brown & Henry 1985), and during winter when predation by recruiting anchovy is high. More intense variation occurs in relation to the upwelling cycle; newly upwelled water supports 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 shelf waters during winter, thus results in a highly variable and dynamic balance between plankton replenishment and food availability for pelagic fish.

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. A variety of pelagic fish species, including anchovy, round herring and horse mackerel, spawn east of Cape Agulhas between the shelf-edge upwelling and the cold-water ridge (Crawford 1980; Hutchings 1994; Roel & Armstrong 1991; Hutchings *et al.* 2003) (Figure 17). The eggs and larvae spawned in this area are thought to largely remain on the Agulhas Bank, although some may be carried to the West Coast or be lost to the Agulhas Current retroflection (Hutchings 1994; Duncombe Rae *et al.* 1992; Hutchings *et al.* 2003). Pilchards also spawn on the Agulhas Bank during spring and summer (Crawford 1980), with adults moving eastwards and northwards after spawning. After the "sardine run" in June and July (see later), pilchard eggs occur in inshore waters along the Eastern Cape and the southern KwaZulu-Natal coast (Anders 1975; Connell 1996). There is also recent evidence for winter (June-July) spawning of sardines on the central Agulhas Bank in patches of high concentrations of phytoplankton (van der Lingen *et al.* 2006). The sardine and other clupeid eggs persist in inshore waters throughout winter – spring, before disappearing in early summer as the shoals break up and move northwards and further offshore (Connell 2010). Recent evidence suggests that the inshore areas of the KZN coast may also function as a nursery area for these small pelagic species during the winter months (Connell 2010; Coetzee *et al.* 2010) as freshwater flows from the large rivers provide cues for spawning and the recruitment of juveniles (Lamberth *et al.* 2009). Anchovy (*Engraulis japonicus*) eggs have also been reported in the water column during December extending from Port Elizabeth eastwards to as far north as St Lucia (Anders 1975). Demersal species that spawn along the South Coast include the cape hakes and kingklip (Crawford *et al.* 1987) (see Figure 17), and their eggs and larvae form an important contribution to the ichthyoplankton in the region.. Spawning of the shallow-water hake occurs primarily over the shelf (<200 m) whereas that by the deep-water hake occurs off the shelf. Similarly, kingklip spawn in an isolated area off the shelf edge to the south of St Francis and Algoa Bays (Shelton 1986; Hutchings 1994) (Figure 17).

The proposed cable route thus lies well offshore of the major fish spawning and migration routes, and although ichthyoplankton abundance over the continental shelf (<200 m) can be seasonally high, no interaction is expected with cable installation and operation activities.

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.

The squid (*Loligo vulgaris reynaudii*) occurs extensively on the Agulhas Bank out to the shelf edge (500 m depth contour) increasing in abundance towards the eastern boundary of the South Coast, especially between Plettenberg Bay and Algoa Bay (Augustyn 1990; Sauer *et al.* 1992; Augustyn *et al.* 1994). Adults are normally distributed in waters >100 m, except along the eastern half of the South Coast where they also occur inshore, forming dense spawning aggregations at depths between 20 - 130 m (Augustyn 1990; Downey 2014). The most important spawning grounds are between Plettenberg Bay and Algoa Bay (Augustyn 1990), these having been linked to specific spawning habitat requirements (Roberts & Sauer 1994; Roberts 2005). Spawning aggregations are a seasonal occurrence, reaching a peak between September and December (Augustyn *et al.* 1992). Spawning is thought to be triggered by upwelling events (Downey *et al.* 2010; Roberts 1998) or possibly a rapid temperature change (Schön *et al.* 2002). Eggs are typically laid on sand and low relief reefs in large and sheltered bays, with environmental conditions playing an important role in the migration of the adults into the spawning areas. Following passive and active planktonic phases, juveniles move offshore, dispersing over the shelf over the full range of their distribution (southern Namibia to East London), eventually returning as adults to their spawning grounds (Augustyn *et al.* 1992). The species is fished commercially along the inshore regions of the southern Cape Coast, with annual catches varying considerably (Roberts & Sauer 1994).

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 18, top) while the giant squid is usually found near continental and island slopes all around the world's oceans (Figure 18, bottom). Both species could thus potentially occur in the offshore pelagic habitats along the cable route, although the likelihood of encounter 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.

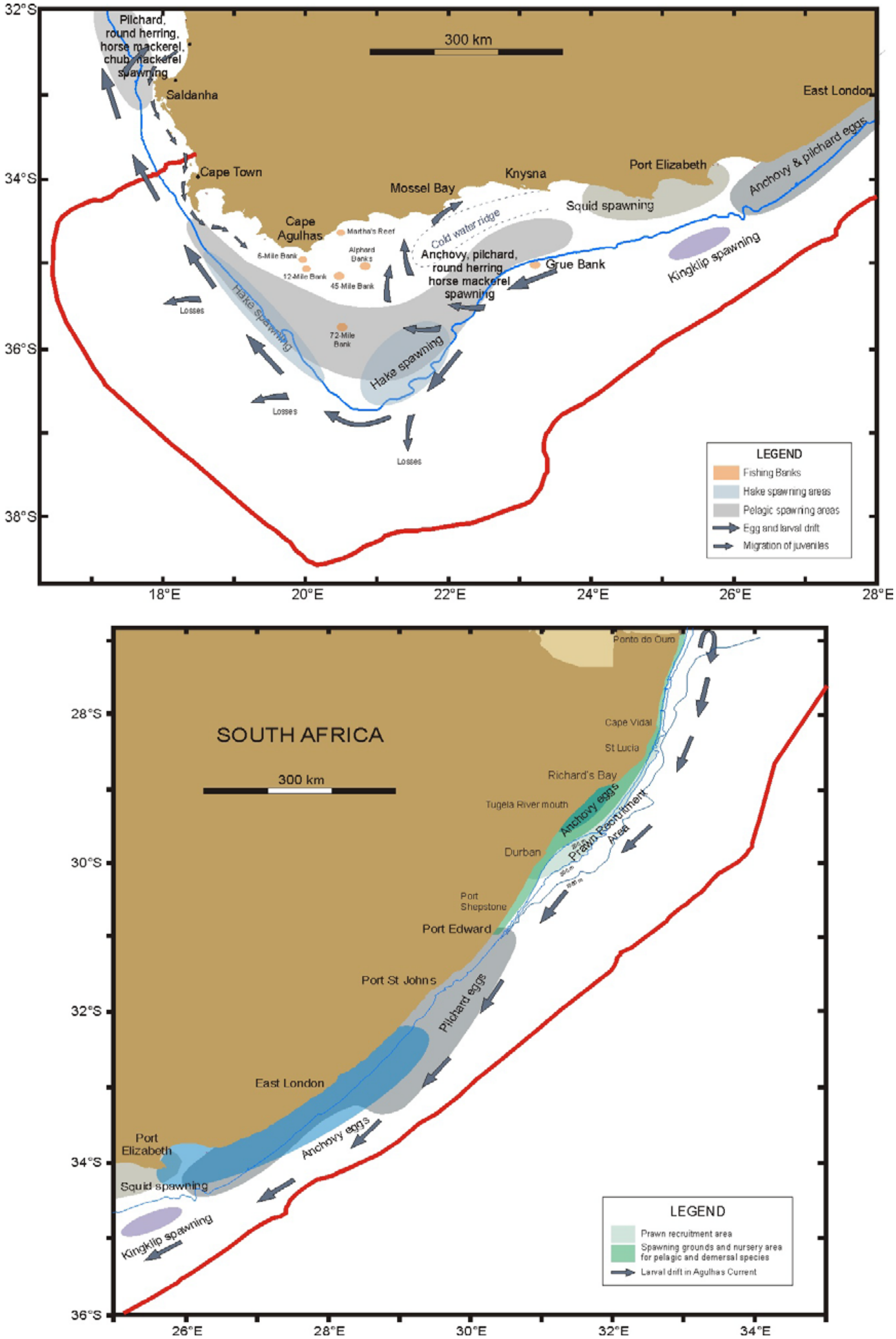


Figure 17: Major spawning areas off the Southwest and South Coasts (top) and the East Coast (bottom) in relation to the 2AFRICA/GERA (East) Cable route (red line) (adapted from Anders 1975; Crawford *et al.* 1987; Cruikshank 1990; Hutchings 1994).

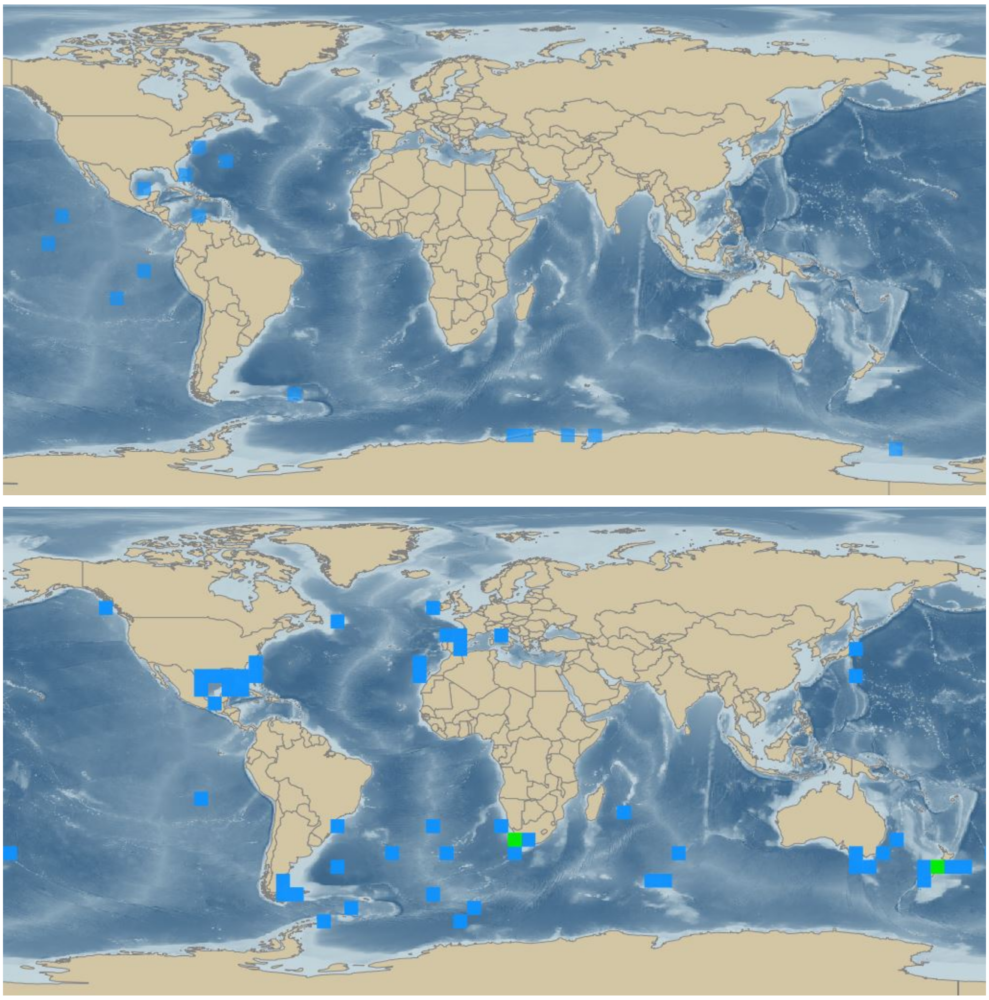


Figure 18: Distribution of the colossal squid (top) and the giant squid (bottom). Blue squares <5 records, green squares 5-10 records (Source: http://iobis.org).

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 (*Liza richardsonii*), white stumpnose (*Rhabdosargus globiceps*) (Figure 19), Cape sole (*Heteromycteris capensis*), Cape gurnard (*Chelidonichthys capensis*), False Bay klipfish (*Clinus latipennis*), sandsharks (*Rhinobatos annulatus*), eagle ray (*Myliobatis aquila*), and smooth-hound (*Mustelus mustelus*) (Clark 1997b).

Figure 19: Common surf-zone fish on the West Coast include the harder (left, photo: aquariophil.org) and the white stumpnose (right, photo: easterncapescubadiving.co.za).

Fish species commonly found in kelp beds off the West Coast include hottentot *Pachymetopon blochii* (Figure 20, left), twotone fingerfin *Chirodactylus brachydactylus* (Figure 20, 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).

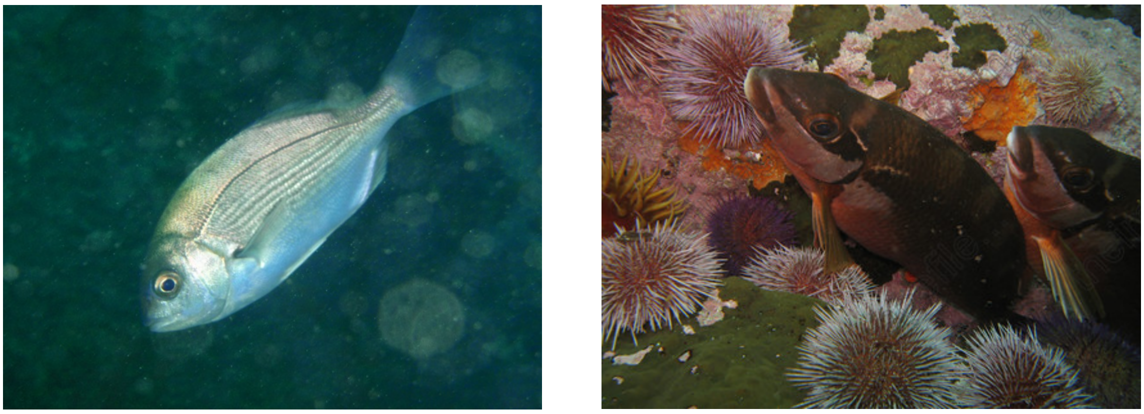


Figure 20: Common fish found in kelp beds include the Hottentot fish (left, photo: commons. wikimedia.org) and the twotone fingerfin (right, photo: www.parrphotographic.com).

Small pelagic species occurring beyond the surfzone and generally within the 200 m contour include the sardine/pilchard (*Sadinops ocellatus*) (Figure 21, left), anchovy (*Engraulis capensis*), chub mackerel (*Scomber japonicus*), horse mackerel (*Trachurus capensis*) (Figure 21, 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.

Figure 21: Cape fur seal preying on a shoal of pilchards (left). School of horse mackerel (right) (photos: www.underwatervideo.co.za; www.delivery.superstock.com).

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

Two species that migrate along the West Coast following the shoals of anchovy and pilchards are snoek *Thyrsites atun* and chub mackerel *Scomber japonicas*. 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).

The varied habitat of rocky reefs and soft-bottom substrates associated with the inshore and shelf waters off the South and East Coasts supports a high diversity of Teleosts (bony fish) and Chondrichthyans (cartilaginous fish), many of which are endemic to Southern Africa (Smale *et al.* 1994) and form an important component of the demersal trawl and long-line fisheries. There is a high diversity of endemic sparid and other teleost species along the South Coast (Smale *et al.* 1994) (**Error! Reference source not found.**), some of which move into inshore protected bays to spawn (Buxton 1990) or undertake spawning migrations eastwards up the coast into KZN waters. The inshore area of the Agulhas Bank, especially between the cool water ridge and the shore, serve as an important nursery area for numerous linefish species (e.g. dusky kob *Argyrosomus japonica*, elf *Pomatomus saltatrix*, seventy-four *Polysteganus undulosus*, steenbras *Petrus rupestrus*, black musselcracker *Cymatoceps nasutus*, leervis *Lichia amia*, white musselcracker *Sparodon durbanensis*, silverbream *Rhabdosargus holubi,* strepie *Sarpa salpa,* geelbek *Atractoscion aequidens,* carpenter *Argyrozona argyrozona* and garrick *Lichia amia*) (Wallace *et al.* 1984; Smale *et al.* 1994). Adults undertake spawning migrations along the South Coast into KZN waters during the winter months (Van der Elst 1976, 1981; Griffiths 1987; Garret 1988; Beckley & van Ballegooyen 1992). Following spawning during spring and summer (November to April), the eggs and larvae are dispersed southwards by the Agulhas Current, with juveniles occurring on the inshore Agulhas Bank (Van der Elst 1976, 1981; Garret 1988; van der Lingen *et al.* 2006).

Off KZN, the Tugela Banks, as well as the many estuaries along the KZN coastline, are similarly used as a nursery area by numerous fish species (e.g. squaretail kob and various sciaenids (snapper, sin croaker, beareded croaker)) due to suitable food sources and protection from predators in the turbid water (Fennesy 1994a, 1994b).

The proposed cable route thus lies well offshore of the major fish migration routes, and no interaction is expected with cable installation and operation activities. Information on other neritic and demersal fish and megabenthic invertebrates beyond the shelf break is lacking and no description of these communities can be can be provided.

The fish most likely to be encountered between surface and deep waters (>300 m) on the shelf, beyond the shelf break and in the offshore waters along the cable route are the large migratory pelagic species, including various tunas (Figure **22**, left), billfish (Figure 22, right) and sharks (Figure 23) (Van der Elst 1988; Smale *et al.* 1994) (see Table 4).

Off the West Coast, 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 22: Large migratory pelagic fish such as longfin tuna (left) and sailfish (right) occur in offshore waters (photos: www.arkive.org; www.osfimages.com).

Figure 23: The great white shark *Carcharodon carcharias* (left) and the dusky shark *Charcharhinus obscurus* (right) (photos: www.flmnh.ufl.edu).

Table 4: Some of the more important large migratory pelagic fish likely to occur in the offshore regions of the Southwest, South and East Coasts.

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
Eastern Little Tuna/Kawakawa	*Euthynnus affinis*	Least concern
Skipjack Tuna	*Katsuwonus pelamis*	Least concern
Billfish		
Blue Marlin	*Makaira nigricans*	Vulnerable
Striped Marlin	*Kajikia audax*	Near Threatened
Sailfish	*Istiophorus platypterus*	Least concern
Swordfish	*Xiphias gladius*	Least concern
Black Marlin	*Istiompax indica*	Data deficient
Pelagic Sharks		
Great Hammerhead Shark	*Sphyrna mokarran*	Endangered
Smooth Hammerhead shark	*Sphyrna zygaena*	Vulnerable
Pelagic Thresher Shark	*Alopias pelagicus*	Vulnerable
Bigeye Thresher Shark	*Alopias superciliosus*	Vulnerable
Common Thresher Shark	*Alopias vulpinus*	Vulnerable
Dusky Shark	*Carcharhinus obscurus*	Vulnerable
Great White Shark	*Carcharodon carcharias*	Vulnerable
Shortfin Mako	*Isurus oxyrinchus*	Vulnerable
Longfin Mako	*Isurus paucus*	Vulnerable
Whale Shark	*Rhincodon typus*	Vulnerable
Blue Shark	*Prionace glauca*	Near Threatened
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Vulnerable

A number of species of pelagic sharks are also known to occur along the Southwest, South and East Coasts (Table 4). Occurring throughout the world in warm temperate waters, these species are usually found further offshore. 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. 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.

White sharks migrate along the entire South African coast, typically being present at seal colonies during the winter months, but moving nearshore during summer (Johnson *et al.* 2009). Recent research at Mossel Bay into the residency patterns of white sharks revealed that male sharks display low site fidelity, often rapidly moving in an out of the area. Females in contrast, display high site fidelity and may remain resident in the area for up to two months (Koch & Johnson 2006). Great white sharks are, however, capable of transoceanic migrations (Pardini *et al.* 2001; Bonfil *et al.* 2005; Koch & Johnson 2006), with recent electronic tag data suggesting links between widely separated populations in South Africa and Australia and possible natal homing behaviour in the species. Although during transoceanic migrations they appear to spend most of the time just below the sea surface, frequent deep dives to a much as 980 m are made whilst *en route*. Long-distance return migrations along the South African coast are also frequently undertaken (Figure 24), particularly by immature individuals (Bonfil *et al.* 2005). These coastal migrations, which are thought to represent feeding-related events, traverse the project area.

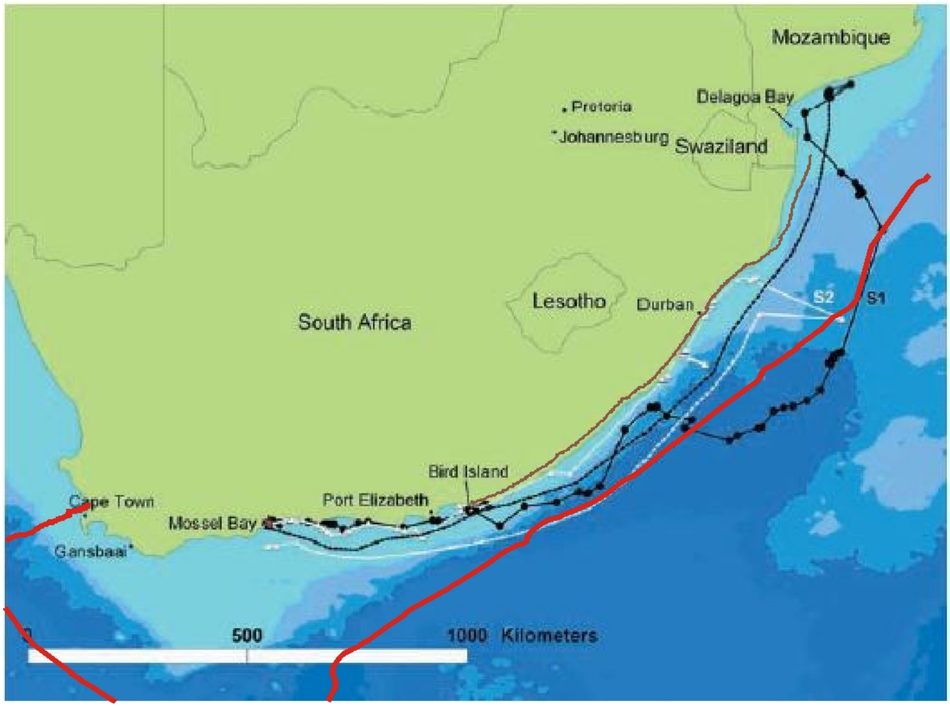


Figure 24: The Cable Route (red line) in relation to the long-distance return migrations of two tracked great white sharks along the South African coast. The black trace shows a migration from 24 May – 2 November 2003; the white trace shows a migration from 31 May – 1 October 2004 (adapted from Bonfil *et al.* 2005).

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.

Turtles

Five species of turtle occur along the South African coast, namely the green turtle (*Chelonia mydas*), olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*) (Figure 25, left), hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*)(Figure 25, right). Green turtles are non-breeding residents often found feeding on inshore reefs. They nest mainly along the coast of Mozambique and on both Europa and Tromelin Islands, well to the north of the South African section of the ASN Cable (Lauret-Stepler *et al.* 2007). Hawksbills also occur on inshore reefs but nest along the coastlines of Madagascar and the Seychelles (Mortimer 1984). Olive ridleys are infrequent visitors to South African waters and nest throughout the central and northern regions of Mozambique (Pereira *et al.* 2008). Leatherback turtles inhabit the deeper waters of the Atlantic Ocean and are considered a pelagic species. They travel the ocean currents in search of their prey (primarily jellyfish) and may dive to over 600 m and remain submerged for up to 54 minutes (Hays *et al.* 2004; Lambardi *et al.* 2008). They come into coastal bays and estuaries to mate, and lay their eggs on the adjacent beaches. The Benguela ecosystem, especially the northern Benguela where jelly fish numbers are high, is increasingly being recognized as a potentially important feeding area for leatherback turtles from several globally significant nesting populations in the south Atlantic (Gabon, Brazil) and south east Indian Ocean (South Africa) (Lambardi *et al.* 2008, Elwen & Leeney 2011). Leatherback turtles from the east South Africa population have been satellite tracked swimming around the west coast of South Africa and remaining in the warmer waters west of the Benguela ecosystem (Lambardi *et al.* 2008) (Figure 26).

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

Loggerheads tend to keep more inshore, hunting around reefs, bays and rocky estuaries along the African East Coast, where they feed on a variety of benthic fauna including crabs, shrimp, sponges, and fish. In the open sea their diet includes jellyfish, flying fish, and squid (www.oceansafrica.com/turtles.htm).

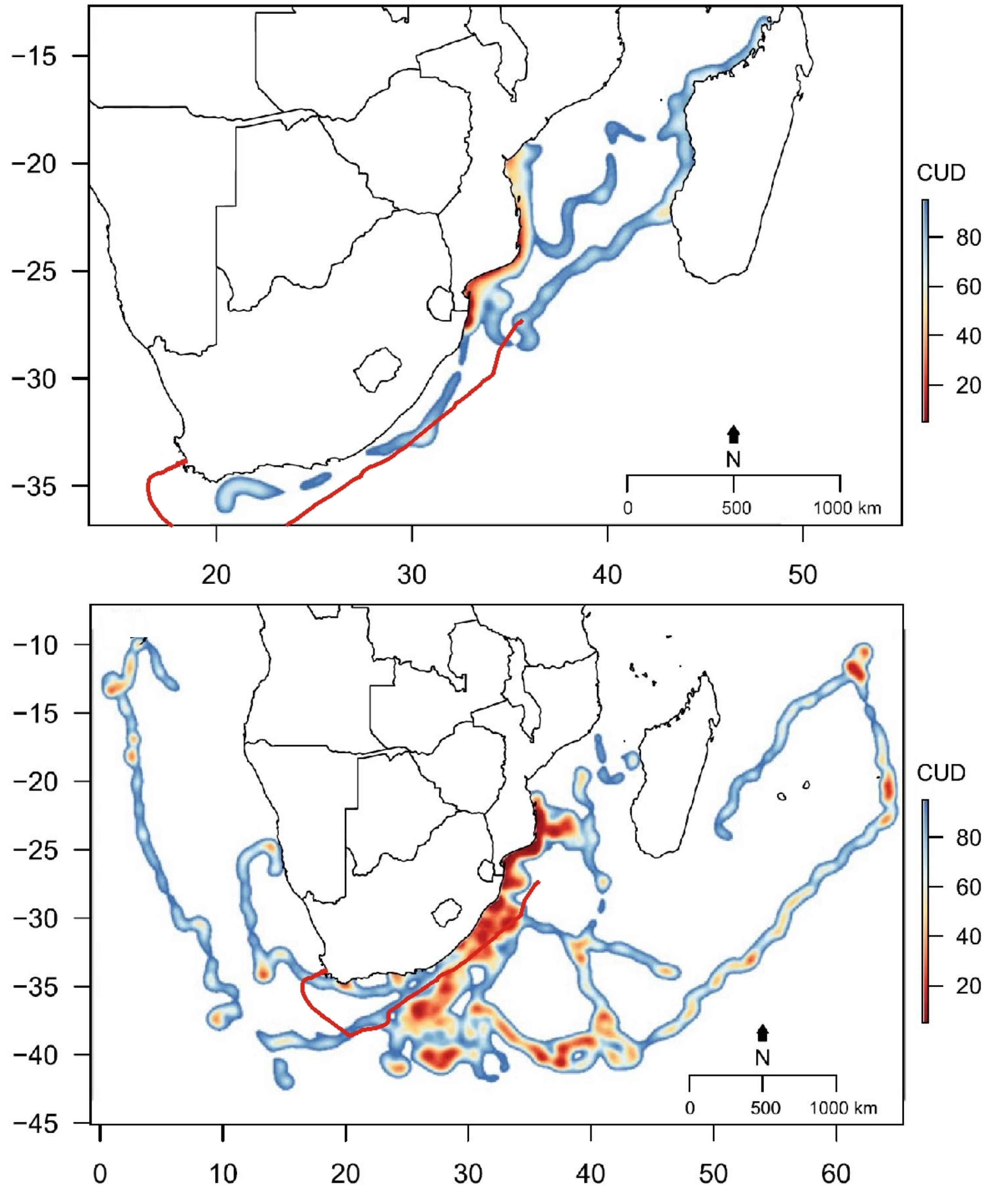


Figure 26: The ASN 2AFRICA/GERA (East) cable route (red line) in relation to the migration corridors of loggerhead (top) and leatherback (bottom) turtles in the southwestern Indian Ocean. Intensity of shading for Cumulative Utilization Distribution (CUD): light, low use; dark, high use (adapted from Harris *et al.* 2018).

Loggerhead and leatherback females come ashore to nest along the sandy beaches of the northeast coast of KZN from mid-October to mid-January each year, as well as southern Mozambique during summer months. Hatchlings emerge from their nests from mid-January to mid-March. The mean hatching success for loggerheads (73 %) and leatherbacks (76 %) on the South African nesting beaches (de Wet 2013) is higher than reported at other nesting sites globally as mortality is largely limited to natural sources due to strong conservation presence on the nesting beach, which has reduced incidents of egg poaching and female harvesting to a minimum (Nel 2010). The production of both loggerhead and leatherback hatchlings is thus remarkably high in South Africa, making the nesting beaches in northern KZN some of the most productive (relative to nesting numbers) in the world. These loggerhead and leatherback nesting populations are the southern-most in the world (Nel *et al.* 2013). Even though these populations are smaller (in nesting numbers) than most other populations, they are genetically unique (Dutton *et al.* 1999; Shamblin *et al.* 2014) and thus globally important populations in terms of conservation of these species.

Those hatchlings that successfully escape predation *en route* to the sea, enter the surf and are carried ~10 km offshore by coastal rip currents to the Agulhas Current (Hughes 1974b). As they are not powerful swimmers they drift southwards in the current and during their first year at sea, their activities largely remaining unknown (Hughes 1974a). After ~10 years, juvenile loggerheads return to coastal areas to feed on crustaceans, fish and molluscs and subsequently remain in these neritic habitats (Hughes 1974b). In contrast, leatherbacks remain in pelagic waters until they become sexually mature and return to coastal regions to breed. Loggerheads reach sexual maturity at about 36 years of age, whereas leatherbacks reach maturity at ~15 years Tucek *et al.* 2014). It has been estimated that only 1 to 5 hatchlings survive to adulthood (Hughes 1974b; de Wet 2013).

Sea turtles are highly migratory and travel extensively throughout their entire life cycle. Adult turtles migrate thousands of kilometres between foraging and breeding grounds, returning to their natal beaches (Hughes 1996; Papi *et al.* 2000; Schroeder *et al.* 2003) by using geomagnetic (Lohmann *et al.* 2007) and olfactory cues (Grassman *et al.* 1984), hearing (Wyneken & Witherington 2001) as well as vision (Witherington 1992) to find their way back to the beach. Post-nesting females and hatchlings use natural ambient light to orientate towards the ocean (Bartol & Musick 2002).

Satellite tracking of female loggerhead and leatherback turtles during inter-nesting periods revealed that loggerheads remained close to the shore (within the boundaries of the iSimangaliso Wetland Park) between nesting events, whereas leatherbacks travelled greater distances (more than 300 km) and beyond the borders of the MPA (Figure 26). This led to a southward extension of the MPA in order to include a greater portion of the core range of inter-nesting leatherbacks and provide better protection. The proposed cable route lie well offshore of the inter-nesting migration area.

Female turtles do not nest every year due to the high energetic costs of reproduction (Wallace & Jones 2008). During this remigration interval they travel thousands of kilometres (particularly leatherbacks) with ocean currents in search of foraging grounds (Luschi *et al.* 2003a; Luschi *et al.* 2003b). Turtles marked with titanium flipper tags have revealed that South African loggerheads and leatherbacks have a remigration interval of 2 – 3 years, migrating to foraging grounds throughout the South Western Indian Ocean (SWIO) as well as in the eastern Atlantic Ocean. They follow different post-nesting migration routes (Hughes *et al.* 1998; Luschi *et al.* 2006), with loggerheads preferring to stay inshore whilst travelling northwards to foraging grounds along the southern Mozambican coastline or crossing the Mozambique Channel to forage in the waters off Madagascar (Figure 26). In contrast, leatherbacks move south with the Agulhas Current to deeper water in high-sea regions to forage (Hughes *et al.* 1998; Luschi *et al.* 2003a; Luschi *et al.* 2006), with some individuals following the Benguela Current along the west coast of South Africa, as far north as central Angola (Figure 26, de Wet (2013)). Both species are thus highly likely to be encountered during their foraging migrations.

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.

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 Southern Benguela and Agulhas Bank. 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 species classified as being common in the southern Benguela and off the South Coast are listed in

Table 6. 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.

Along the South Coast South, 60 species are known or thought likely to occur. South Coast seabirds can be categorised into three categories: 'breeding resident species', 'non-breeding migrant species' and 'rare vagrants' (Shaughnessy 1977; Harrison 1978; Liversidge & Le Gras 1981; Ryan & Rose 1989). Forty-six seabird species occur commonly along the KwaZulu-Natal coast. The birds most likely to be encountered off the East Coast are the pelagic migrant species such as albatross, petrels and shearwaters. Encounter rates are likely to be higher during winter months and during the inshore sardine 'run', when many of the pelagic species come inshore to follow the shoals northwards up the coast (O'Donoghue *et al.* 2010).

Table 6: Pelagic seabirds common off Southern Africa (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
Tristan Albatross	*Diomedea dabbenena*	Critically Endangered	Critically Endangered
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

Fifteen species of seabirds breed in southern Africa, these include: 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 in the vicinity of the cable landing site are 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.

On the Agulhas Bank, seabirds at times intensively target shoals of pelagic fish where small pelagic species such as anchovy and pilchard form important prey items, particularly for the Cape Gannet, the African Penguin and the various cormorant species. Most of the breeding resident seabird species feed on fish (with the exception of the gulls, which scavenge, and feed on molluscs and crustaceans). Feeding strategies include surface plunging (gannets and terns), pursuit diving (cormorants and penguins), and scavenging and surface seizing (gulls, White-breasted Cormorants). All these species feed relatively close inshore, although Cape Gannets and Kelp Gulls may feed further offshore. There have been increases in numbers of breeding pairs at eastern colonies of Kelp Gull (L. dominicanus), Crowned Cormorant, Swift Terns (Sterna bergii), and Cape Gannet (Morus capensis) but not African Penguins, in response to the eastward shift of sardines (van der Lingen *et al.* 2006).

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 South African Coast (CCA and CMS 2001).

Common Name	Species Name	National Assessment	Global Assessment
African Penguin	*Spheniscus demersus*	Endangered	Endangered
African Black Oystercatcher	*Haematopus moquini*	Least Concern	Near Threatened
White-breasted Cormorant	*Phalacrocorax carbo*	Least Concern	Least Concern
Cape Cormorant	*Phalacrocorax capensis*	Endangered	Endangered
Bank Cormorant	*Phalacrocorax neglectus*	Endangered	Endangered
Crowned Cormorant	*Phalacrocorax coronatus*	Near Threatened	Near Threatened
White Pelican	*Pelecanus onocrotalus*	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*	Vulnerable	Vulnerable

On the South Coast, Damara Terns breed inshore between Cape Agulhas and Cape Infanta, with the bulk of the South African population breeding in Algoa Bay (Taylor *et al.* 2015; Whittington *et al.* 2015). A breeding colony of Cape Cormorant has recently established on Robberg Peninsula (Marnewick *et al.* 2015). Kelp Gulls breed in high numbers on the Keurbooms River estuary spit (Witteveen 2015, but see also Whittington *et al.* 2006) and African Black Oystercatcher, Caspian Tern and White-fronted Plover breed on many of the beaches between Plettenberg Bay and the eastern boundary of the Tsitsikamma Section of the Garden Route National Park (http://www.birdlife.org.za/component/k2/item/240-sa098-tsitsikamma-plettenberg-bay). African Black Oystercatchers breed as far east as East London while breeding of Whitefronted Plovers extends into KwaZulu-Natal (Hockey *et al.* 2005). Recent changes in bird populations in the South Coast region include eastward extensions of the breeding range of Hartlaub's Gull, Crowned Cormorant (Whittington 2004; van der Lingen *et al.* 2006; Crawford *et al.* 2012), White-breasted Cormorants (Crawford *et al.* 2013), and Cape Gannet (Crawford *et al.* 2015).

African Penguin colonies along the South Coast occur at Dyer Island, east of Cape Agulhas and on the Algoa Bay islands (St Croix Island, Jaheel Island, Bird Island, Seal Island, Stag Island and Brenton Rocks). The colony that established in the De Hoop Reserve east of Cape Agulhas (van der Lingen *et al.* 2006) was subsequently abandoned due to the number of terrestrial predators present, although attempts are being made by BirdLife South Africa to artificially re-establish this colony. Plettenberg Bay has also recently been identified as a suitable area in which to establish a new African Penguin colony, in attempts to conserve this species. The number of successfully breeding birds at the particular breeding sites varies with food abundance. This species forages at sea with most birds being found within 20 km of the coast, although they have been recorded as far as 60 km offshore. The majority of Algoa Bay penguins forage to the south of Cape Recife and well inshore of the cable route. African Penguins mainly consume pelagic shoaling fish species such as anchovy, round herring, horse mackerel and pilchard and their distribution is consistent with that of the pelagic shoaling fish, which occur within the 200 m isobath.

As the East Coast provides few suitable breeding sites for coastal and seabirds, only three species (Grey-headed gull, Caspian tern and Swift tern) breed regularly along the coast (CSIR 1998). Many of the river mouths and estuaries along the East Coast, however, serve as important roosting and foraging sites for coastal and seabirds birds, especially those at St Lucia and Richards Bay (Underhill & Cooper 1982; Turpie 1995).

Shore birds likely to be encountered in the area of the proposed 2AFRICA/GERA (East) 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. As they nest and breed on beaches between the Eastern Cape and southern Namibia, the breeding success of this species is particularly susceptible to disturbance from off-road vehicles and coastal developments.

Marine Mammals

The marine mammal fauna occurring off the southern African coast includes several species of whales and dolphins and one resident seal species. Forty 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 off the South African coast 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), Sink *et al.* (2019) and unpublished records held by Sea Search / Namibian Dolphin Project (see also Figure 28). Of the 40 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 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

Table 8: Cetaceans occurrence off the Coast of South Africa, their seasonality, and South African Regional Assessment status (Child *et al.* 2016).

Common Name	Species	Shelf	Offshore	Seasonality	South African Regional Assessment
Delphinids (18 spp)					
Dusky dolphin	*Lagenorhynchus obscurus*	Yes (0- 800 m)	No	Year round	Data Deficient
Common bottlenose dolphin	*Tursiops truncatus*	Yes	Yes	Year round	Least Concern
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*-Ifafa-Kosi Bay subpop.	Yes		Year round	Vulnerable
	Tursiops aduncus-Ifafa-False Bay subpop.	Yes		Year round	Near threatened
	Tursiops aduncus-Seasonal subpop.	Yes		Year round	Data Deficient
Common (short beaked) dolphin	*Delphinus delphis*	Yes	Yes	Year round	Least Concern
Common (long beaked) dolphin	*Delphinus capensis*	Yes		Year round	Least Concern
Heaviside's dolphin	*Cephalorhynchus heavisidii*	Yes (0-200 m)	No	Year round	Least Concern
Fraser's dolphin	*Lagenodelphis hosei*		Yes	Year round	Least Concern
Pantropical Spotted dolphin	*Stenella attenuata*	Yes	Yes	Year round	Least Concern
Spinner dolphin	*Stenella longirostris*	Yes		Year round	Least Concern
Striped dolphin	*Stenella coeruleoalba*	No	?	?	Least Concern
Indian Ocean humpback dolphin	*Sousa plumbea*	Yes		Year round	Endangered
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

Common Name	Species	Shelf	Offshore	Seasonality	South African Regional Assessment
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
Beaked whales (9 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/Strap-toothed	*Mesoplodon layardii*	No	Yes	Year round	Data Deficient
Longman's	*Mesoplodon pacificus*	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 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
Pygmy Blue whale	*B. musculus brevicauda*	No	Yes	MJJ	Data Deficient
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

Common Name	Species	Shelf	Offshore	Seasonality	South African Regional Assessment
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 along the cable route 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

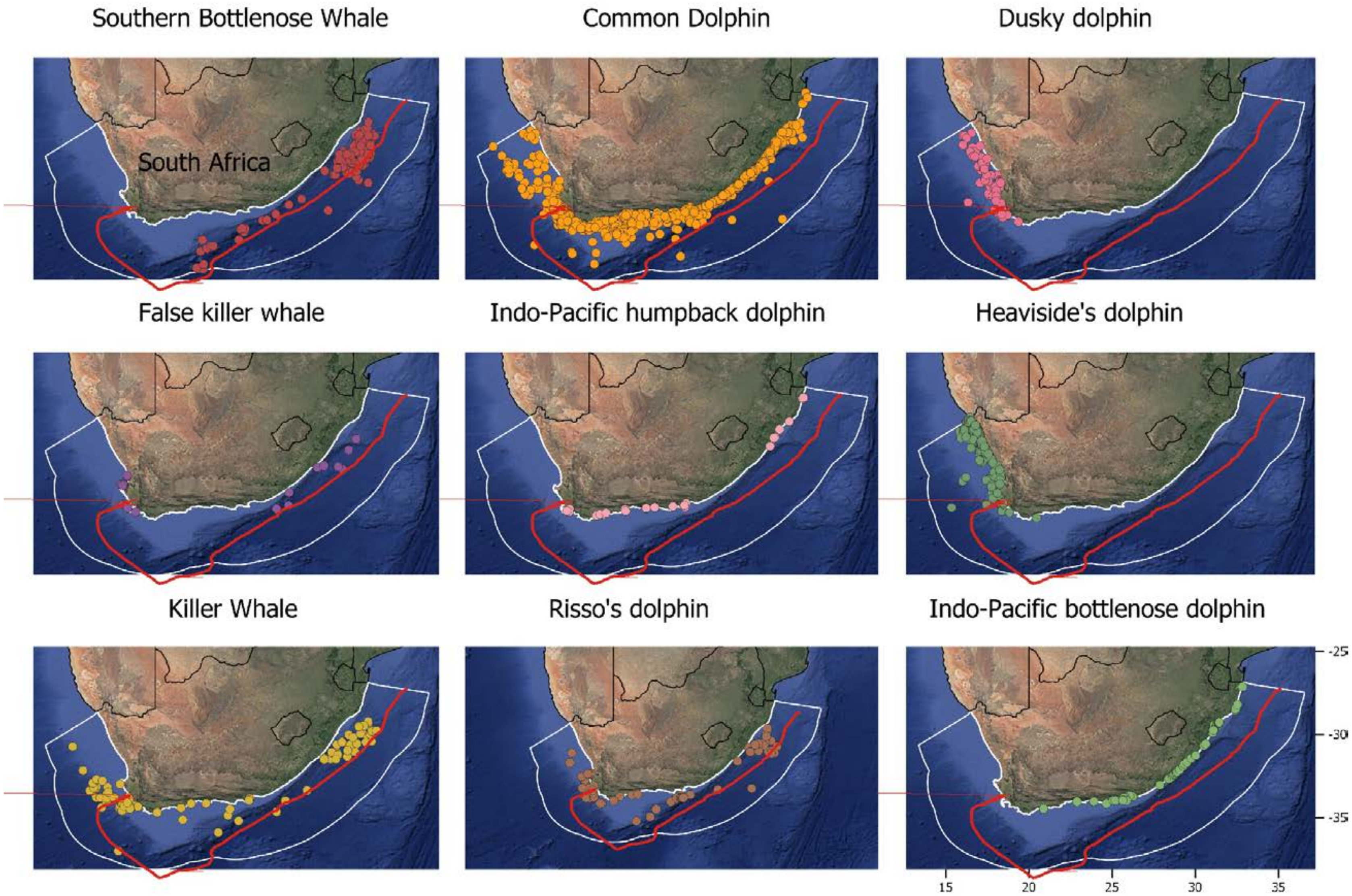


Figure 28: The proposed ASN 2AFRICA/GERA (East) cable route in relation to projections of predicted distributions for nine odontocete species off the Coast of South Africa (adapted from: Purdon *et al.* 2020).

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; Penry *et al.* 2018) - a larger pelagic form described as *Balaenoptera brydei,* and a smaller neritic form (of which the taxonomic status is uncertain, but is included by Best (2007) with the *B. brydei* of the subregion). 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 abundances highest during summer (January – March). The offshore form is unlikely to be encountered off the South Coast. The "inshore population" is unique amongst baleen whales in the region by being resident year round on the continental shelf and Agulhas Bank, only undertaking occasional small seasonal excursions up the east coast in winter during the annual sardine migration (Caputo *et al.* 2017). Sightings over the last two decades suggest that its distribution may be shifting eastwards (Best 2001, 2007; Best *et al.* 1984). This is a small genetically isolated population (~600 individuals) with a small distributional range largely concentrated on the Agulhas Banks, and which is possibly decreasing in size; an abundance estimate of 150 – 250 individuals was made for Bryde's whales using the Plettenberg Bay/Knysna area in 2005-2008 (Best *et al.* 1984; Penry 2010) with peak encounter rates reported in late summer and Autumn (Mar – May) (Penry *et al.* 2011).. The recent South African National Red Data list assessment has also reclassified this population as 'vulnerable' (Penry *et al.* 2016). Its current distribution implies that it is unlikely to be encountered during cable installation.

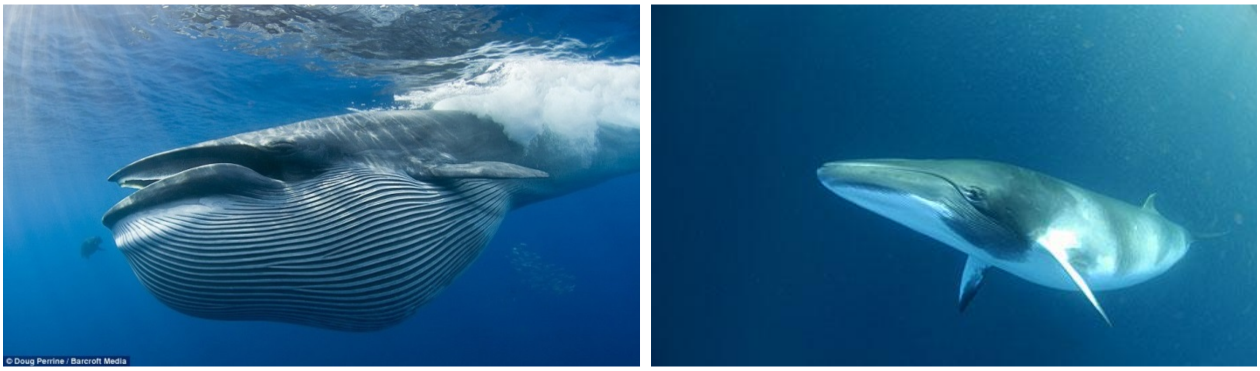


Figure 29: The Bryde's whale Balaenoptera brydei (left) and the Minke whale Balaenoptera bonaerensis (right) (Photos: www.dailymail.co.uk; www.marinebio.org).

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.

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.

On the African east coast, the main winter concentration areas for Humpback whales include Mozambique, Madagascar, Kenya and Tanzania on the east coast. Those migrating up the east coast of South Africa form breeding stock C1, which was estimated at 7 035 (Confidence Interval: 5 742 – 8 824) individuals in 2010 and with a population growing at approximately 10% per annum (Findlay *et al.* 2011). Three principal migration routes for humpbacks in the south-west Indian Ocean have been identified. On the first route up the East Coast, the northern migration reaches the coast in the vicinity of Knysna continuing as far north as central Mozambique. This migration route therefore crosses the proposed cable route. The second route approaches the coast of Madagascar directly from the south, possibly *via* the Mozambique Ridge. The third, less well-established route, is thought to travel up the centre of the Mozambique Channel to Aldabra and the Comore Islands (Findlay *et al.* 1994; Best *et al.* 1998). Humpbacks have a bimodal distribution off the East coast, most reaching southern African waters around April, continuing through to September/October when the southern migration begins and continues through to December. The calving season for humpbacks extends from July to October, peaking in early August (Best 2007). Cow-calf pairs are typically the last to leave southern African waters on the return southward migration, although considerable variation in the departure time from breeding areas has been recorded (Barendse *et al.* 2010). Off Cape Vidal in KwaZulu Natal whale abundances peak around June/July on their northward migration, although some have been observed still moving north as late as October. Southward moving animals on their return migration were first seen in July, peaking in August and continuing to late October (Findlay & Best 1996a, 1996b).

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). When the population numbers crashed in 1920, the range contracted down to just the south coast of South Africa, but as the population recovers, it is repopulating its historic grounds including Mozambique (Banks *et al.* 2011) and Namibia (Roux *et al.* 2001). They migrate to the southern Africa subcontinent to breed and calve, where they tend to have an extremely coastal distribution mainly in sheltered bays (90% <2 km from shore; Best 1990; Elwen & Best 2004). 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 South African 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.

Winter concentrations have been recorded all along the southern and eastern coasts of South Africa as far north as Maputo Bay, with the most significant concentration currently on the South Coast between Cape Town and Port Elizabeth. They typically arrive in coastal waters off the South Coast between June and November each year, although animals may be sighted as early as April and as late as January. While in local waters, southern rights are found in groups of 1-10 individuals, with cow-calf pairs predominating in inshore nursery areas. From July to October, animals aggregate and become involved in surface-active groups, which can persist for several hours.

Many southern right whales remain in the Southern Benguela during summer to feed off Cape Columbine and St Helena Bay on the South African West Coast (Mate *et al.* 2011). 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 in South African waters were referred to a single morphotype, Type A, although recently a second 'flat-toothed' morphotype that seems to specialise in an elasmobranch diet has been identified (Best *et al.* 2014). 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. Historically sightings were correlated with that of baleen whales, especially sei whales on their southward migration. In more recent years – their presence in coastal waters (e.g. False Bay) has been strongly linked to the presence and hunting of common dolphins (Best *et al.* 2010; Sea Search unpublished data). Further from shore, there have been regular reports of killer whales associated with fishing vessels on the southern and eastern Agulhas Bank, and the Cape Canyon to the south-west of Cape Point.

FALSE KILLER WHALE (*PSEUDORCA CRASSIDENS*) – Although the false killer whale is globally recognized as one species, clear differences in morphological and genetic characteristics between different study sites show that there is substantial difference between populations and a revision of the species taxonomy may be needed (Best 2007). False killer whales are more likely to be confused with melon-headed or pygmy killer whales than with killer whales. 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 (mean 20.2) (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.

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

BOTTLENOSE DOLPHINS (*TURIOPS* SPP.): - Two species of bottlenose dolphins occur around southern Africa. The smaller Indo-Pacific bottlenose dolphin (*aduncus* form) occurs exclusively to the east of Cape Point in water usually less than 50 m deep and generally within 1 km of the shore (Ross 1984; Ross *et al.* 1987), and the larger common bottlenose dolphin (*truncatus* form) (Figure 33, left), which on the South Coast occurs around the shelf edge and pelagic waters beyond that. Their distribution is essentially continuous from Cape Agulhas eastwards to southern Mozambique, although along the KZN coast the Indo-Pacific bottlenose dolphins seem to have 'preferred areas' (Ross *et al.* 1987; Cockcroft *et al.* 1990, 1991). The areas in which they are more frequently encountered are about 30 km apart, and are thought to correspond to discrete home ranges within a resident population occurring along the KZN coast. There are also seasonal movements of a genetically distinct 'migratory stock' of Indo-Pacific bottlenose dolphins along the South and East Coasts in association with the 'sardine run' (Natoli *et al.* 2008). Regular sightings of this species have been made by offshore observers in South Africa, especially around the Cape Point and Agulhas Bank area (De Rock *et al.* 2019; Sea Search unpubl. Data.).

The Indo-Pacific bottlenose dolphin is relatively abundant and the population inhabiting the South Coast has been estimated as between between 16,000 and 41,000 based on data collected within Algoa Bay (Reisinger & Karczmarski 2010). The species tends to occur in large groups of 10s to 100s of individuals. Although listed as 'Data deficient' in the IUCN Red Data book, the *aduncus* form in general is listed as 'Vulnerable' in the South African Red Data Book, while the migratory subpopulation is considered 'Endangered' (Peddemors & Oosthuizen 2004; Cockcroft *et al.* 2016). Little is known about the offshore form of the species, and nothing about their population size or conservation status. They sometimes occur in association with other species such as pilot whales or false killer whales (Best 2007) and are likely to be present year round in waters deeper than 200 m.

COMMON DOLPHINS (*DEPHINUS* SPP.): - Two species of common dolphin are currently recognised, the short-beaked common dolphin (*Delphinus delphis*) and the long-beaked common dolphin (*Delphinus capensis*). Historically these have been considered as two species but a recent global analysis suggests they comprise a single species with multiple 'forms' (Cunha *et al.* 2015). Although common dolphins occur world-wide in warm-temperate and tropical waters, off South Africa the short-beaked appear to prefer offshore habitats, whereas the long-beaked seems to be distributed as a series of disjunct populations in nearshore waters <500 m deep. Individual common dolphins are known to be wide ranging along the South African coast and may move hundreds of kilometres in short periods of time. They are not known to show any degree of residency to coastal areas. Group sizes in this species tend to be large: 100s to even 1,000s of animals. The long-beaked common dolphin is a resident to the temperate Agulhas Bank out to the continental shelf edge with sightings extending as far up the west coast as St Helena Bay and up the east coast to Richards Bay, in waters less than 500 m deep (**Error! Reference source not found.**). During winter they migrate from the Eastern Cape into KZN waters following the 'sardine run' (Cockcroft & Peddemors 1990; O'Donoghue *et al.* 2010a, 2010b, 2010c). In 1988/89 the population of long-beaked common dolphins between Port Elizabeth and Richard's Bay was estimated at 15,000 – 20,000 animals, although this is thought to be an underestimate (Cockcroft & Peddemors, 1990; Peddemors 1999) and estimates of the population size and seasonality for the subregion is lacking.

Figure 33: Odontocetes that occur on the South Coast include the Bottlenose dolphin *Turiops truncates* (left) and the Indo-pacific humpback dolphin *Sousa plumbea* (right) (Photos: www.fish-wallpapers.com; www.shutterstock.com).

INDO-PACIFIC HUMPBACK DOLPHIN (*SOUSA PLUMBEA)*: The Indian Ocean humpback dolphin (Figure 33, right) has a more or less continuous distribution from Danger Point in the Western Cape to Mozambique, Tanzania, Kenya, the Comoros Islands and the western coast of Madagascar. It is primarily a shallow-water species restricted to <50 m depth and are usually observed within 500 m from shore. Due to the recent recognition of the western Indian Ocean population as a separate species, their conservation status is internationally regarded as 'Vulnerable' and within South Africa as 'Endangered', and the species is accepted to be South Africa's most endangered resident cetacean (Child *et al.* 2016). Overall, it is expected that the distribution of the species in the Indian Ocean is not continuous but rather consists of many subpopulations that should be regarded as separate management units (Durham 1994; Karczmarski 1996; Keith 1999; Karczmarski 2000a). Several lines of evidence suggest a decline in the population numbers and changes in behaviour (Peddemors *et al.* 2004; Plön *et al.* 2015; Vermeulen *et al.* 2017). Localised populations in the Plettenberg Bay -

Algoa Bay region are concentrated around shallow reefs, predominantly within 10 km of river mouths (Melly 2011; Koper *et al.* 2016). This is similar to findings from the early 1990s, where 87% of sightings were observed within 400 m of land, and almost all the sightings were in waters less than 15 m deep (Karczmarski 1996; Karczmarski *et al.* 2000a). It appears that the species is more closely associated with estuaries and rivers than other shallow-water cetaceans.

Seasonal movements and migrations are not characteristic of Indo-Pacific humpback dolphins, but in Algoa Bay sightings rate and group size appears to increase between January and April, and again in September. This was accompanied by an apparent influx of previously unidentified individuals into the bay. The species also shows diurnal cycles within the bay (Karczmarski *et al.* 2000b). In Algoa Bay the population was estimated at 466 individuals of all age groups, with modelled population growth estimated to vary between -3% and 2% annually. This population was found to be separated from all other populations of the species, making them particularly vulnerable (Vermeulen *et al.* 2017).

Recent studies in Plettenberg Bay and Algoa Bay indicated a decrease in sightings and group sizes in both locations by approximately 50% in the last decade and a reduction in mean group sizes from 7 to 4 individuals (Greenwood 2013; Koper *et al.* 2016). Several hypotheses have been suggested as likely reasons for the decline; a decrease in prey availability, prolonged disturbance from whale and dolphin watching tourism and other marine recreation, coastal development and sustained pollution that contaminates the prey on which this species depends. Due to their limited spatial distribution (restricted to shallow, coastal areas) this species is unlikely to occur in or near the exploration area.

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.

BEAKED WHALES (VARIOUS SPECIES) – Beaked whales were never targeted commercially and their pelagic distribution makes them the most poorly studied group of cetaceans. They are all considered to be true deep water species usually being seen in waters in excess of 1 000 – 2 000 m depth (see various species accounts in Best 2007). 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). All the beaked whales that may be encountered along the cable route are pelagic species that tend to occur in small groups of usually less than five individuals, although larger aggregations of some species are known (MacLeod & D'Amico 2006, Best 2007). Beaked whales appear to be particularly vulnerable to certain types of anthropogenic noise. The exact reason why is not yet fully understood, but necropsy of stranded animals has revealed gas embolisms and haemorrhage in the brain, ears and acoustic fat - injuries consistent with decompression sickness (acoustically mediated bubble formation may also play a role) (Fernandez *et al.* 2005). Beyond decompression sickness, the fear/flee response may be the first stage in a multi-stage process ultimately resulting in stranding (Southall *et al.* 2008; Jepson *et al.* 2013). This type of stranding event has been linked to both naval sonar and multi-beam echosounders used for commercial scale side scan sonar (Southall *et al.* 2008).

All whales and dolphins are given protection under the South African Law. The Marine Living Resources Act, 1998 (No. 18 of 1998) states that no whales or dolphins may be harassed, killed or fished. No vessel or aircraft may approach closer than 300 m to any whale and a vessel should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m from a vessel or aircraft.

Pinnepeds

The Cape fur seal (*Arctocephalus pusillus pusillus*) (Figure 34) is the only species of seal resident along the west and south coasts 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).

Figure 34: Colony of Cape fur seals *Arctocephalus pusillus pusillus* (Photo: Dirk Heinrich).

There are a number of Cape fur seal colonies on the West Cioast: 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.

Along the South Coast, they occur at numerous breeding and non-breeding sites on the mainland, namely at Seal Island in Mossel Bay (Oosthuizen 1991; Wickens *et al.* 1991), on the northern shore of the Robberg Peninsula in Plettenberg Bay (Huisamen *et al.* 2011, 2012) and at Black Rocks (Bird Island group) in Algoa Bay (Hofmeyr *et al.* 2011). The population at Seal Island in Mossel Bay is currently estimated at over 4 000 individuals (Gubili *et al.* 2009). At the Robberg Peninsula in Plettenberg Bay a rapid increase in seal numbers, from <300 to >3,100, was observed between 2000 and 2009 (Kirkman *et al.* 2011; Huisamen *et al.* 2011). Subsequent to the 2011 study, the colony has increased further to approximately 5 000 individuals (CapeNature). This rapid influx of seals to the Robberg Peninsula is thought to be associated with shifts in prey availability (Huisamen *et al.* 2012). 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).

Historically the Cape fur seal was heavily exploited for its luxurious pelt. Sealing restrictions were first introduced to southern Africa in 1893, and harvesting was controlled until 1990 when it was finally prohibited. The protection of the species has resulted in the recovery of the populations, and numbers continue to increase. Consequently, their conservation status is not regarded as threatened. The Cape Fur Seal population in South Africa is regularly monitored by the Department of Environment, Forestry and Fisheries (DEFF) (e.g. Kirkman *et al.* 2013). The overall population is considered healthy and stable in size, although there has been a westward and northward shift in the distribution of the breeding population (Kirkman *et al.* 2013).

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. Other industrial uses of the marine environment include the intake of feed-water for power plants, desalination plants, mariculture, fish processing or diamond-gravel treatment. Most of these are located well to the north or south of the proposed Cable route, with the exception of the cooling water intake for Koeberg Nuclear Power Station, which is located 2 km from the proposed landing site. This and other intakes should in no way be affected by installation of the cable system. Recreational use of the area offshore of Duynefontein 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 South Africa. They are illustrated in Figure 35 and briefly summarised below.

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 being a warm oligotrophic lagoon, along the cold, nutrient-rich and wave exposed West Coast.

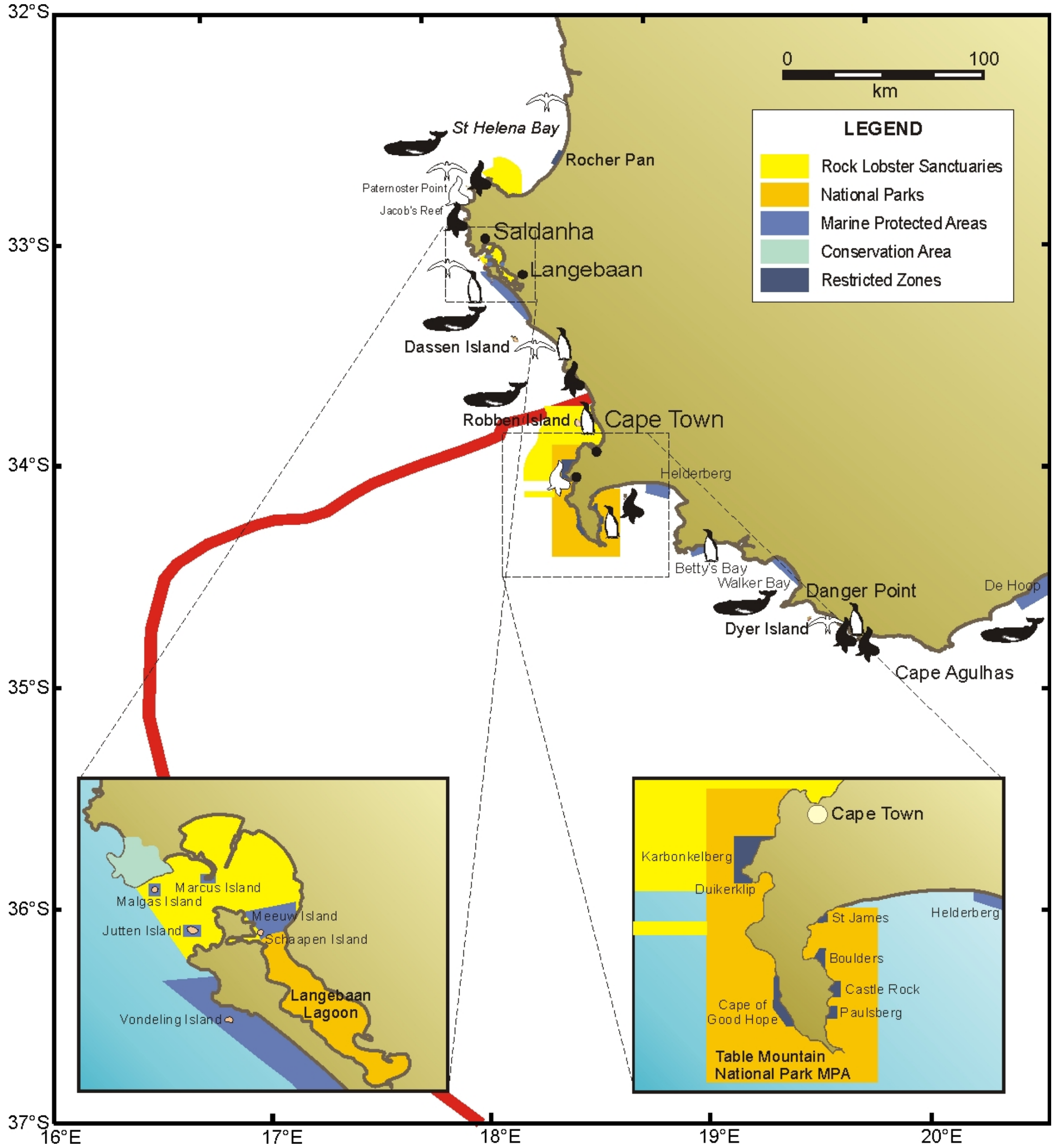


Figure 35: Project - environment interaction points on the West Coast, illustrating the location of seabird and seal colonies and resident whale populations and coastal conservation zones and Marine Protected Areas in relation to the proposed 2AFRICA/GERA (East) Cable route.

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.

'No-take' MPAs offering protection of the offshore biozones (sub-photic, deep-photic and shallow-photic) were until recently absent around the South African coast. This resulted in substantial portions of the shelf-edge marine biodiversity in the area being assigned a threat status of 'Critically endangered', 'Endangered' or 'Vulnerable' (Lombard *et al.* 2004; Sink *et al.* 2012). Using biodiversity data mapped for the 2004 and 2011 National Biodiversity Assessments a systematic biodiversity plan was developed for the Southwest 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. The biodiversity data were used to identify numerous focus areas for protection. 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 those lying in the path of the proposed cable routing are described briefly below (https://www.marineprotectedareas.org.za/).

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. The MPA consists of four distinct zones – a Restricted Zone (RIRZ)and three controlled zones - Offshore Controlled Zone (RIOCZ), a Middle Controlled Zone (RIMCZ) and an Inner Controlled Zone (RIICZ). Although the ASN 2AFRICA/GERA (East) Cable would pass through the RIOCZ and RIMCZ, the proposed routing follows that of the decommissioned SAT-2 cable. All other cables that land in the vicinity of Melkbosstrand and Duynefontein also pass through the RIOCZ (Figure 37).

The **Southeast Atlantic Seamounts MPA** covers 6,000 km^2 and protects South Africa's Protea and Argentina Seamounts. These seamounts rise up from 2,500 m depth in the Cape Basin abyss to 700 m deep. Formed by volcanic activity, they are recognised as biological hotspots due to their high diversity of marine animals, which results from the interaction of their steep slopes with deep oceanic currents. This upwelling of nutrient-rich water fuels enhanced productivity, which in turn

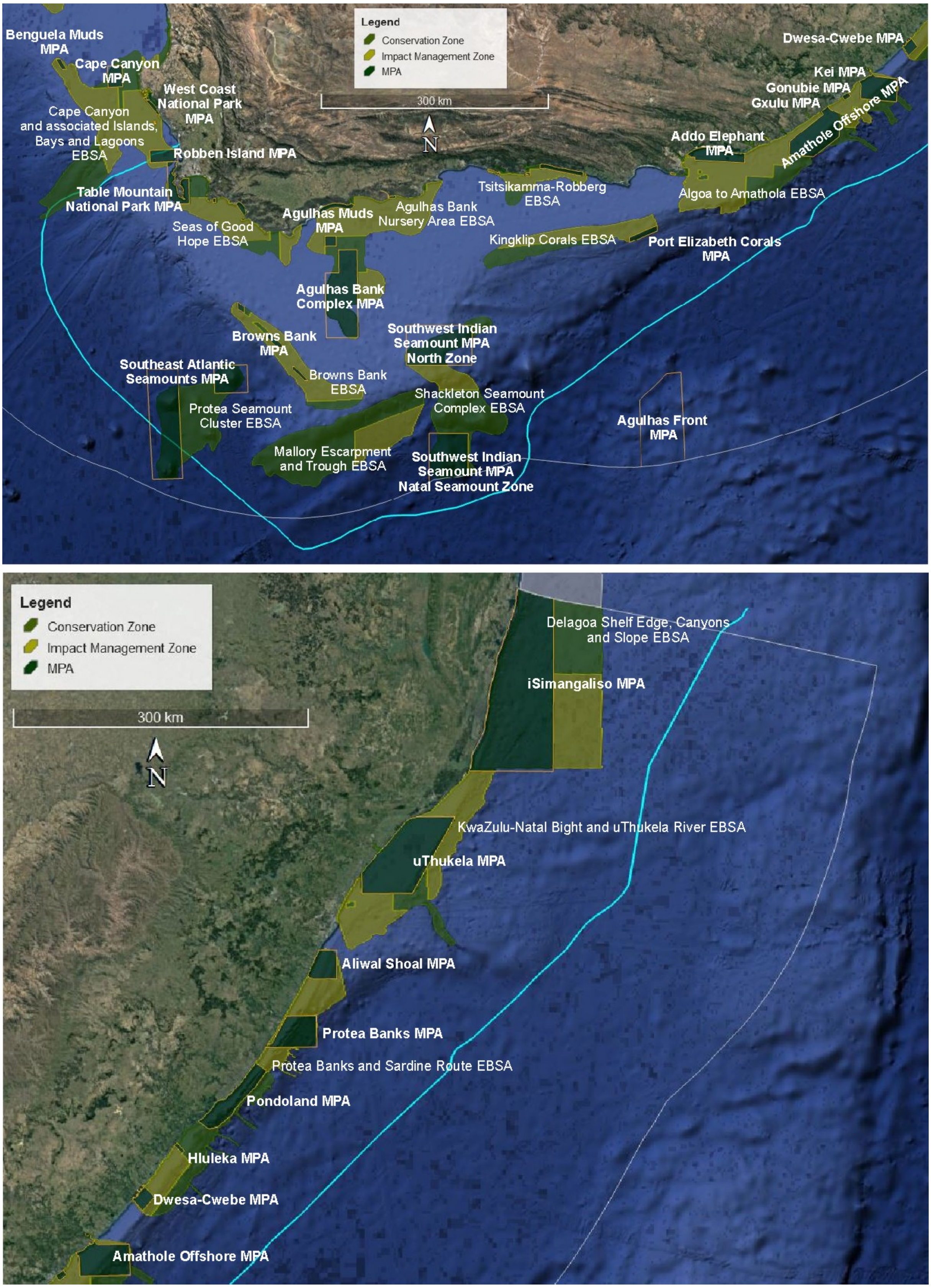


Figure 36: Marine Protected Areas (MPAs) and Ecologically and Biologically Significant Areas (EBSAs) off the South African Coast, in relation to the proposed 2AFRICA/GERA (East) Cable route (cyan line).

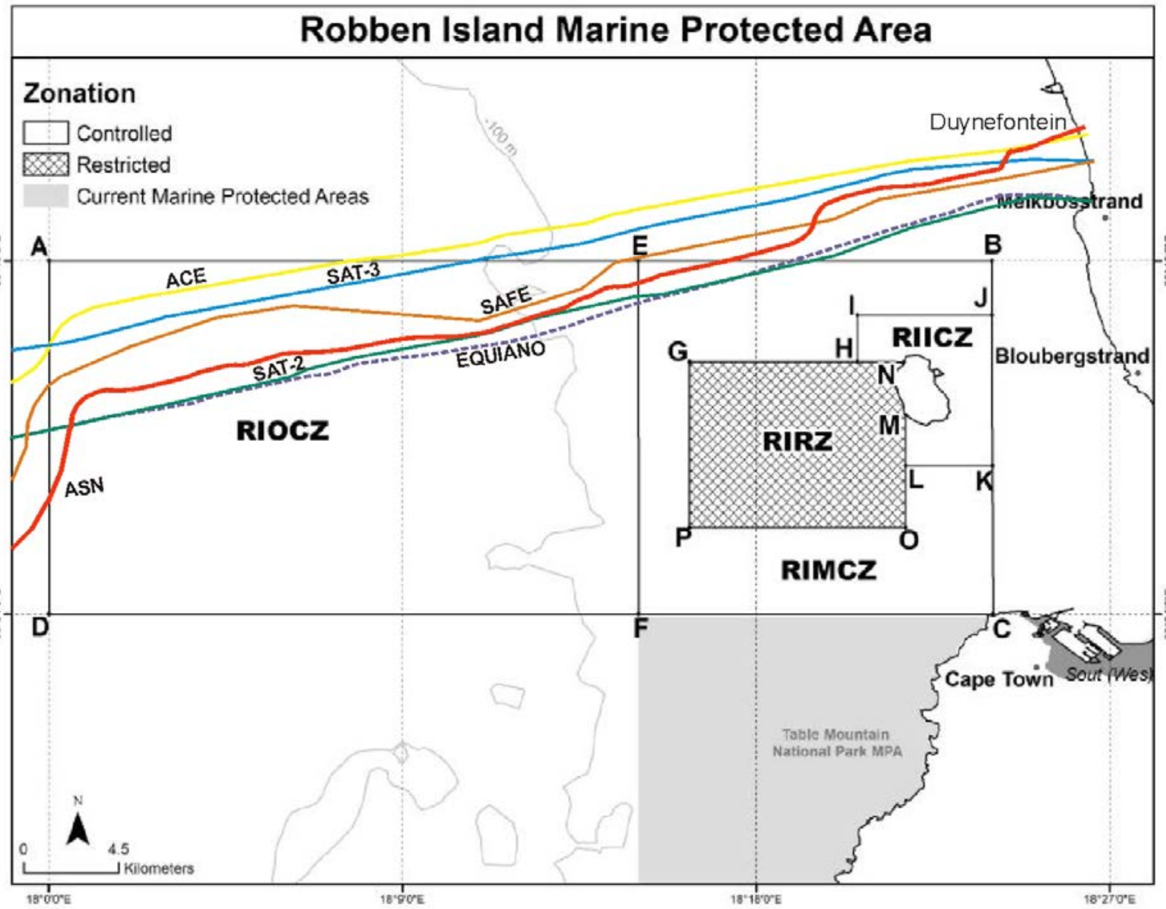


Figure 37: The Robben Island Marine Protected Area showing the zonation and the routing of the proposed ASN 2AFRICA/GERA (East) Cable in relation to other existing cables (adapted from Government Gazette 2019). The proposed Equiano Cable is also shown.

provides food for a wide diversity of marine biota ranging from corals to fish and turtles. The MPA, which spans a depth range of 750 to 4,600 m was proclaimed in 2019 and protects seamount, slope and abyssal ecosystems. The proposed routing of the ASN 2AFRICA/GERA (East) Cable would pass through the western section of this MPA, routing across Southeast Atlantic Rocky Abbyssal substratum between the Protea and ARgetina seamounts and thereby avoiding the sensitive habitats associated with seamounts.

Sensitive Areas

Despite the development of the offshore MPA network a number of 'Vulnerable' ecosystem types are currently 'poorly protected' (e.g. Southern Benguela Sandy Outer Shelf, Southeast Atlantic Upper Slope, Cape Basin Abyss, Cape Basin Complex Abyss, Agulhas Basin Abyss and Southwest Indian Mid Slope) or 'not protected' at all (e.g. Cape Lower Canyon, Southeast Atlantic Lower Slope, Southwest Indian Lower Slope, Transkei Basin Abyss) and further effort is needed to improve protection of these threatened ecosystem types (Sink *et al.* 2019) (Figure 38). Ideally, all highly threatened ('Critically Endangered' and 'Endangered') ecosystem types should be well protected. Currently, however, most of the abyssal habitats along the proposed cable route are poorly protected receiving only 0.2-10% protection, whereas off the east coast such habitats generally receive no protection at all (Sink *et al.* 2019). Most of the ecosystem types in the proposed ASN 2AFRICA/GERA (East) cable route are either poorly protected or not protected, with only the portion inshore of the 100 m depth contour receiving 'moderate protection' and the habitat characterising the shore crossing being considered 'well protected'.

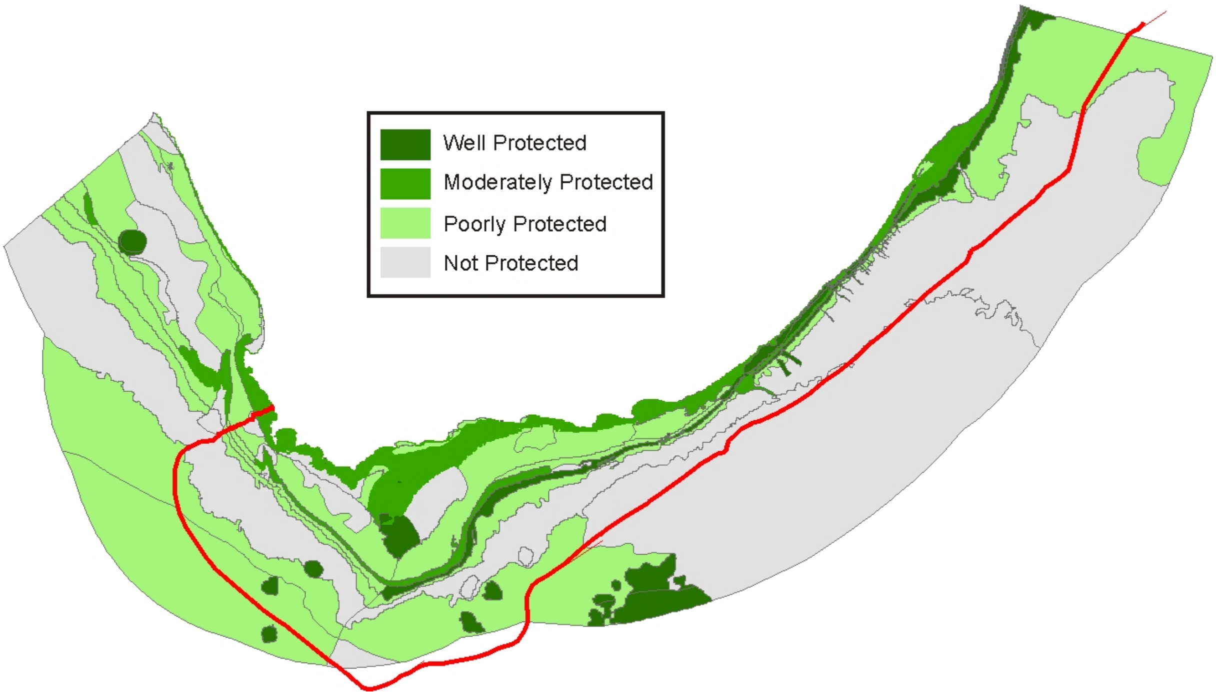


Figure 38: Protection levels of marine ecosystem types as assessed by Sink *et al.* (2019) in relation to the proposed ASN 2AFRICA/GERA (East) cable routing.

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.

Those EBSAs lying in the path of the proposed cable routing are described briefly below (see Figure 36).

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 **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 proposed cable route traverses through a small portion of the southwestern extension of the EBSA, which has been assigned as a conservation zone.

The proposed **Protea Seamount Cluster** area is important for both its benthic and pelagic features, notably for supporting threatened habitats and species, and vulnerable, fragile and sensitive ecosystems and species. It comprises a seamount cluster that includes the Protea and Argentina Seamounts that rise from the southeast Atlantic abyss. The Agulhas Current, which flows south-westward along the eastern coast of South Africa, has its retroflection in this area. Given this position, and its location relative to the Agulhas basin and Agulhas continental shelf, local productivity is high and consequently, it serves as an important aggregation site for migratory species, such as sharks, seabirds and tuna. Adult female leatherback turtles have been satellite tracked to these seamounts and surrounds following nesting, with the site likely also used by juvenile turtles. In between the seamounts there is a matrix of abyssal and and bathyal habitat, which represent the broader area where top predators aggregate in the water column in response to the elevated productivity, likely also encompassing the full extent of seamount-related ecological processes. The proposed cable route traverses through the southern portion of the EBSA, which has been assigned as a conservation zone.

Important Bird Areas (IBAs)

IBAs in the general project area are illustrated in Figure 40. The cable landing crosses through the proposed Bird Island / Dassen Island / Heuningnes River and estuary system /Lower Berg river wetlands – Marine IBA with confirmed coastal IBAs in the vicinity of the shore crossing including Dassen and Robben Islands, Rietvlei Wetland and False Bay Nature Reserve. Various marine IBAs have also been proposed in South African territorial waters.

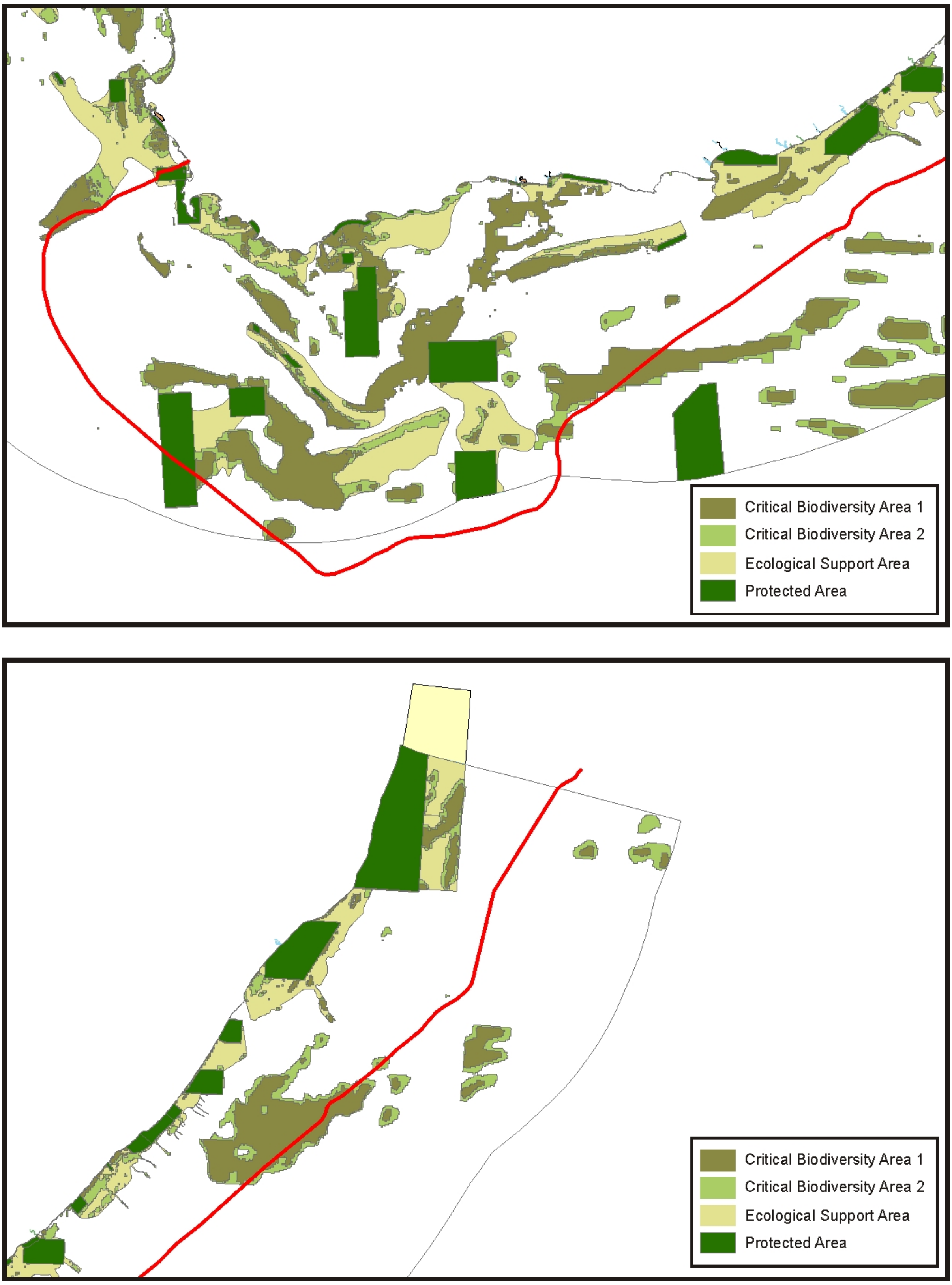


Figure 39: The proposed ASN 2AFRICA/GERA (East) cable routing (red line) in relation to the National Coastal and Marine Critical Biodiversity Areas (version 1.0 (Beta 2)) (adapted from Harris *et al.* (2020)).

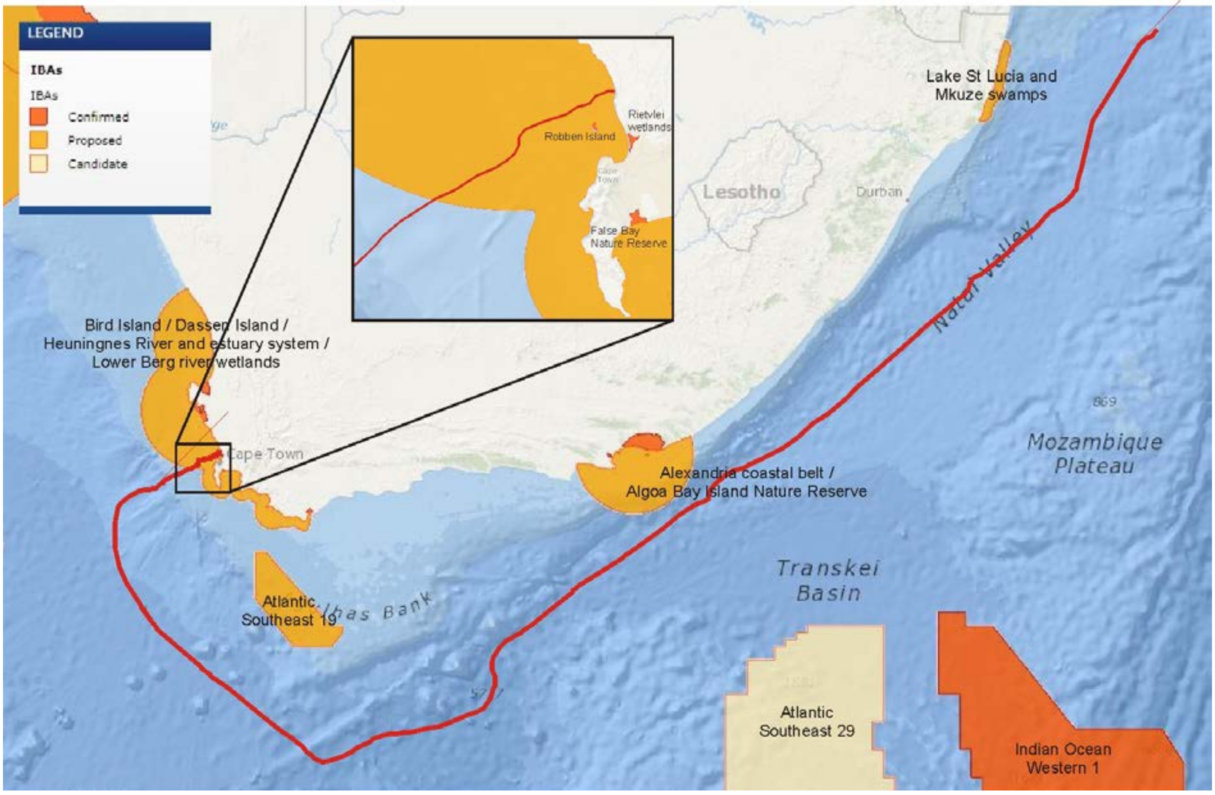


Figure 40: The ASN 2AFRICA/GERA (East) cable route in relation to coastal and marine IBAs (Source: https://maps.birdlife.org/marineIBAs).

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 41).

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.

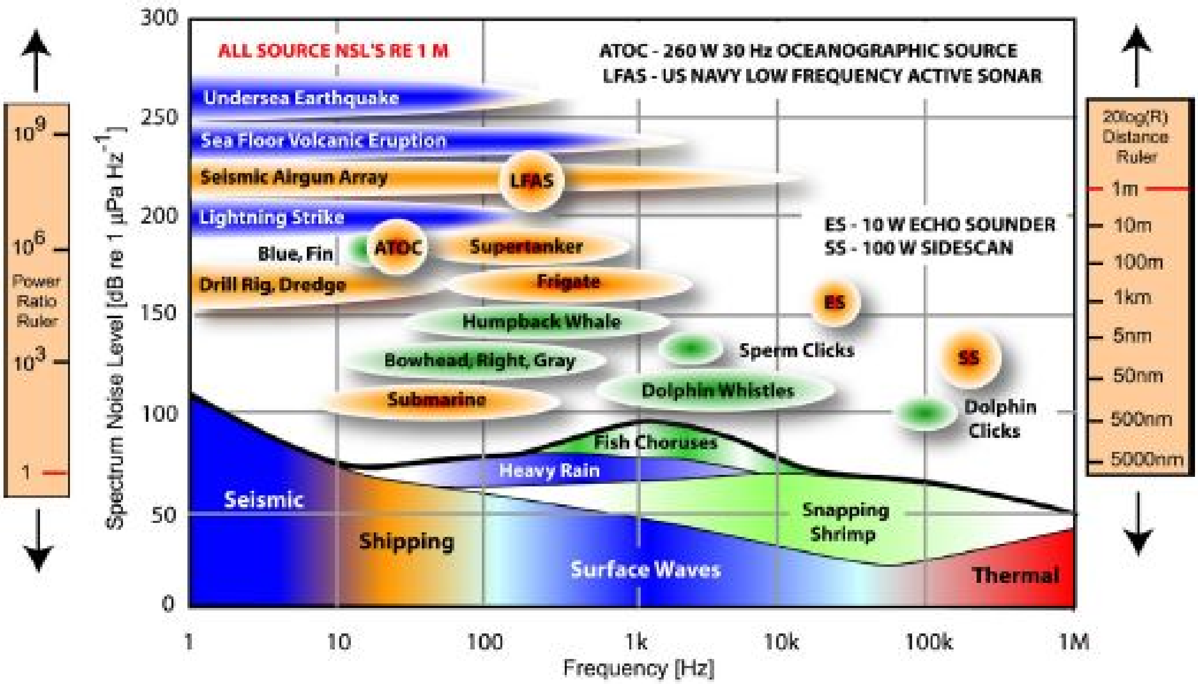


Figure 41: Comparison of noise sources in the ocean (Goold & Coates 2001).

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) (**Error! Reference source not found.**). 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

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

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 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; Lurton 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 (e.g. Heaviside's dolphins, pygmy sperm whale, dwarf sperm whale) 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 (baleen whales and most delphinids and beaked whales, respectively), 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.

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).

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 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. Although the subsea cable routing passes through inshore benthic habitats identified as 'vulnerable' (Cape Sandy Inner Shelf) the loss of resources would be low and impacts would be fully reversible. The shore crossing itself passes through Southern Benguela Dissipative Sandy Shore, which is identified as of 'least concern'. 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 and Cape Rocky Mid Shelf Mosaic), 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 0.007%, 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 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.

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 disturbs 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 oarganisms (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 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 inabiting 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 11,500 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 '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: 0.0005% of Southern Benguela Sandy Shelf Edge; 0.004% of Cape Rocky Mid-Shelf Mosaic.

The following best-practice mitigation measures are recommended:

- 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.

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 ove 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 mattresseseffectively 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 42). 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).

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;

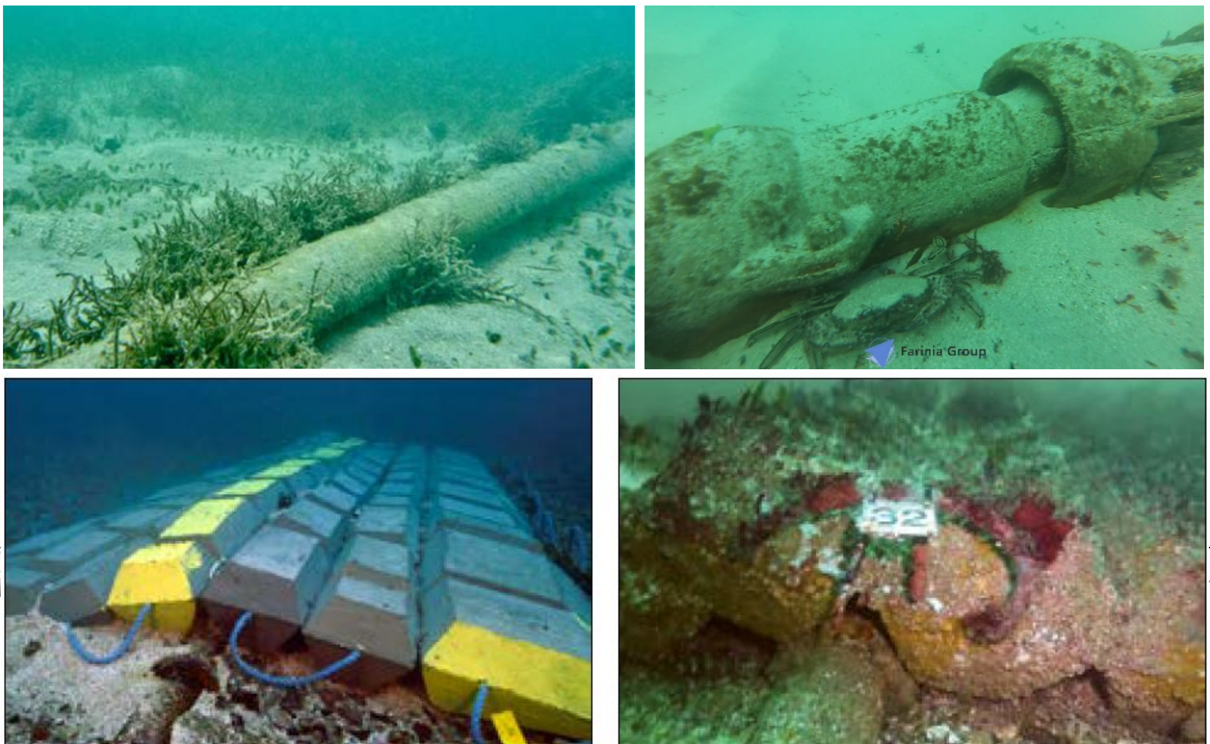


Figure 42: Subsea cables and their protective armouring can provide alternative substratum for colonising benthic biota and shelter for mobile invertebrates (Source: www.digit.in/telecom/reliance-jio-launches-longest-100gbps-subsea-cable-system-aae-1-35827; www.farinia.com; Copping & Hemery 2020).

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 'least concern' (Southern Benguela Dissipative Sandy 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/GERA (East) 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 2AFRICA/GERA (East) 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, Southeast Atlantic Deep Ocean and Southwest Indian 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 2AFRICA/GERA (East) cable routing will largely follow that of the existing SAFE cable, cumulative impacts need to be considered.

The proposed cable route, where possible, avoids sensitive reef areas and environments such as MPAs and EBSAs. 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 Robben Island MPA and at the Duynefontein 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 four existing cables in the 'cable corridor' passing through the Robben Island MPA, are likely to have already fully recovered, and so additional impacts in the same general area through routing of the proposed 2AFRICA/GERA (East) 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/GERA (East) fibre optics cable should not proceed.

6. LITERATURE CITED

AIROLDI, L., 2003. The effects of sedimentation on rocky coast assemblages. *Oceanogr. Mar. Biol. Ann. Rev.,* 41: 161–236.

AIROLDI, L. and F. CINELLI, 1997. Effects of sedimentation on subtidal macroalgal assemblages: an experimental study from a Mediterranean rocky shore. *Journal of Experimental Marine Biology & Ecology* **215**: 269-288.

ALDREDGE, A.L., M. ELIAS & C.C. GOTSCHALK, 1986. Effects of drilling muds and mud additives on the primary production of natural assemblages of marine phytoplankton. *Mar. Environ. Res*. **19**: 157-176.

ANDERS, A.S., 1975. Pilchard and anchovy spawning along the Cape east coast. *S. Afr. ship. news fish. ind. rev*. **30 (9)**: 53-57.

ASHFORD, O.S., KENNY, A.J., BARRIO FROJÁN, C.R.S., DOWNIE, A-L., HORTON, T. & A.D. ROGERS, 2019. On the Influence of Vulnerable Marine Ecosystem Habitats on Peracarid Crustacean Assemblages in the Northwest Atlantic Fisheries Organisation Regulatory Area. Frontiers in Marine Science 11.

ATKINSON, L.J., 2009. Effects of demersal trawling on marine infaunal, epifaunal and fish assemblages: studies in the southern Benguela and Oslofjord. PhD Thesis. University of Cape Town, pp 141.

ATKINSON, L.J., FIELD, J.G.and L. HUTCHINGS, 2011. Effects of demersal trawling along the west coast of southern Africa: multivariate analysis of benthic assemblages. *Marine Ecology Progress Series* **430**: 241-255.

ATKINSON, L.J. & K.J. SINK (eds), 2018. Field Guide to the Offshore Marine Invertebrates of South Africa. Malachite Marketing and Media, Pretoria, pp498.

AUGUSTYN, C.J. 1990. Biological studies on the chokker squid *Loligo vulgaris reynaudii* (Caphalopoda: Myopsida) on spawning grounds off the south-east coast of South Africa. *S. Afr. J. mar. Sci*., **9**: 11-26.

AUGUSTYN, C.J., SAUER, W.H.H. LIPINSKI, M.R., 1992. Can the *Loligo* squid fishery be managed effectively? A synthesis of research on *Loligo vulgaris reynaudii*. *S. Afr. J. mar. Sci*., **12**: 903-918.

AUGUSTYN, C.J., LIPINSKI, M.R., SAUER, W.H.H., ROBERTS, M.J., MITCHELL-INNES, B.A., 1994. Chokka squid on the Agulhas Bank: life history and ecology. *S. Afr. J. Sci*., **90**: 143-153.

AUGUSTYN C.J., LIPINSKI, M.R. and M.A.C. ROELEVELD, 1995. Distribution and abundance of sepioidea off South Africa. *S. Afr. J. Mar. Sci.* 16: 69-83.

AUSTER, P.J., GJERDE, K., HEUPEL, E., WATLING, L., GREHAN, A. & A.D. ROGERS, 2011. Definition and detection of vulnerable marine ecosystems on the high seas: problems with the “move-on” rule. ICES Journal of Marine Science 68: 254–264.

AWAD, A.A., GRIFFITHS, C.L. and J.K. TURPIE, 2002. Distribution of South African benthic invertebrates applied to the selection of priority conservation areas. *Diversity and Distributions* **8**: 129-145.

BAILEY, G.W., 1991. Organic carbon flux and development of oxygen deficiency on the modern Benguela continental shelf south of 22°S: spatial and temporal variability. In: TYSON, R.V., PEARSON, T.H. (Eds.), Modern and Ancient Continental Shelf Anoxia. *Geol. Soc. Spec. Publ.*, **58**: 171–183.

BAILEY, G.W., 1999. Severe hypoxia and its effect on marine resources in the southern Benguela upwelling system. Abstract, *International Workshop on Monitoring of Anaerobic processes in the Benguela Current Ecosystem off Namibia.*

BAILEY, G.W., BEYERS, C.J. DE B. and S.R. LIPSCHITZ, 1985. Seasonal variation of oxygen deficiency in waters off southern South West Africa in 1975 and 1976 and its relation to catchability and distribution of the Cape rock-lobster *Jasus lalandii*. *S. Afr. J. Mar. Sci.*, **3**: 197-214.

BAILEY G.W. and P. CHAPMAN, 1991. Chemical and physical oceanography. In: Short-term variability during an Anchor Station Study in the southern Benguela Upwelling system. *Prog. Oceanogr.*, **28**: 9-37.

BAILLON, S., HAMEL, J-F., WAREHAM, V.E. & A. MERCIER, 2012. Deep cold-water corals as nurseries for fish larvae. Frontiers in Ecology and the Environment 10: 351–356.

BALLY, R., 1987. The ecology of sandy beaches of the Benguela ecosystem. *S. Afr. J. mar. Sci.,* 5: 759-770

BARENDSE, J., BEST, P.B., THOMTON, M., POMILLA, C. CARVALHO, I. and H.C. ROSENBAUM, 2010. Migration redefined ? Seasonality, movements and group composition of humpback whales *Megaptera novaeangliae* off the west coast of South Africa. *Afr. J. mar. Sci.*, **32(1)**: 1-22.

BARENDSE, J., BEST, P.B., THORNTON, M., ELWEN, S.H., ROSENBAUM, H.C., CARVALHO, I., POMILLA, C., COLLINS, T.J.Q. and M.A. MEŸER, 2011. Transit station or destination? Attendance patterns, regional movement, and population estimate of humpback whales *Megaptera novaeangliae* off West South Africa based on photographic and genotypic matching. *African Journal of Marine Science*, **33(3)**: 353-373.

BARKAI, A. and G.M.BRANCH, 1988. Contrasts between the benthic communities of subtidal hard substrata at Marcus and Malgas Islands: a case of alternative states? *S Afr J mar Sci* **7**: 117-137.

BARLOW, R.G., LAMONT, T., GIBBERD, M.J., VAN DEN BERG, M. and K. BRITZ, 2015. Chemotaxonomic investigation of phytoplankton in the shelf ecosystem of the KwaZulu-Natal Bight, South Africa. *African Journal of Marine Science* 37: 467–484.

BARRIO FROJÁN, C.R.S., MACISAAC, K.G., MCMILLAN, A.K., DEL MAR SACAU CUADRADO, M., LARGE, P.A., KENNY, A.J., KENCHINGTON, E. & E. DE CÁRDENAS GONZÁLEZ, 2012. An evaluation of benthic community structure in and around the Sackville Spur closed area (Northwest Atlantic) in relation to the protection of vulnerable marine ecosystems. ICES Journal of Marine Science 69: 213–222.

BARTOL, S.M. & J.A. MUSICK, 2002. 3 Sensory Biology of Sea Turtles. *The biology of sea turtles*, **79**.

BEAL, L.M., BIASTOCH, A. & R. ZAHN, 2011. On the role of the Agulhas system in ocean circulation and climate. *Nature* 472: 429–436.

BEAZLEY. L., KENCHINGTON, E., YASHAYAEV, I. & F.J. MURILLO, 2015. Drivers of epibenthic megafaunal composition in the sponge grounds of the Sackville Spur, northwest Atlantic. Deep Sea Research Part I: Oceanographic Research Papers 98: 102–114.

BEAZLEY, L.I., KENCHINGTON, E.L., MURILLO, F.J. & M DEL M.SACAU, 2013. Deep-sea sponge grounds enhance diversity and abundance of epibenthic megafauna in the Northwest Atlantic. ICES Journal of Marine Science 70: 1471–1490.

BECKLEY, L.E. and VAN BALLEGOOYEN, R.C. 1992. Oceanographic conditions during three ichthyoplankton surveys of the Agulhas Current in 1990/91. *S. Afr. J. mar. Sci.*, **12**: 83-93.

BEJDER, L., SAMUELS, A., WHITEHEAD, H. & N. GALES, 2006. Interpreting short-term behavioral responses to disturbance within a longitudinal perspective. *Animal Behavior* 72: 1149-1158.

BEN-AVRAHAM, Z., HARTNADY, C.J.H. & K.A. KITCHIN, 1997. Structure and tectonics of the Agulhas-Falkland fracture zone. *Tectonophysics* 282: 83–98.

BERG, J.A. and R.I.E. NEWELL, 1986. Temporal and spatial variations in the composition of seston available to the suspension-feeder *Crassostrea virginic*a. *Estuar. Coast. Shelf. Sci*., **23**: 375–386.

BERGEN, M., WEISBERG, S.B., SMITH, R.W., CADIEN, D.B., DALKEY, A., MONTAGNE, D.E., STULL, J.K., VELARDE, R.G. and J. ANANDA RANASINGHE, 2001. Relationship between depth, sediment, latitude and the structure of benthic infaunal assemblages on the mainland shelf of southern California. *Marine Biology* **138**: 637-647.

BEST, P.B., 2001. Distribution and population separation of Bryde's whale *Balaenoptera edeni* off southern Africa. *Mar. Ecol. Prog. Ser.*, 220: 277 – 289.

BEST, P.B., 2007. Whales and Dolphins of the Southern African Subregion. Cambridge University Press, Cape Town, South Africa.

BEST, P.B., BUTTERWORTH, D.S. & L.H. RICKETT, 1984. An assessment cruise for the South African inshore stock of Bryde's whale (*Balaenoptera edeni*). Report of the International Whaling Commission, 34: 403-423.

BEST, P.B., FINDLAY, K.P., SEKIGUCHI, K., PEDDEMORS, V.M., RAKOTONIRINA, B., ROSSOUW, A. AND D. GOVE, 1998. Winter distribution and possible migration routes of humpback whales *Megaptera novaeangliae* in the southwest Indian Ocean. *Mar. Ecol. Prog. Ser.* **162**: 287 - 299.

BEST, P.B. and C.H. LOCKYER, 2002. Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s. *South African Journal of Marine Science*, **24**: 111-133.

BEST P.B., MEŸER, M.A. and C. LOCKYER, 2010. Killer whales in South African waters – a review of their biology. *African Journal of Marine Science*. **32**: 171–186.

BETT, B.J. & A.L. RICE, 1992. The influence of hexactinellid sponge (Pheronema carpenteri) spicules on the patchy distribution of macrobenthos in the porcupine seabight (bathyal ne atlantic). *Ophelia* 36: 217–226.

BIANCHI, G., HAMUKUAYA, H. and O. ALVHEIM, 2001. On the dynamics of demersal fish assemblages off Namibia in the 1990s. *South African Journal of Marine Science* 23: 419-428.

BICCARD, A. & B.M. CLARK, 2016. De Beers Marine Namibia Environmental Monitoring Programme in the Atlantic 1 Mining Licence Area: 2013 Benthic Sampling Campaign. Report prepared for De Beers Marine Namibia by Anchor Environmental Consultants (Pty) Ltd. Report no. 1527/3.

BICCARD, A., CLARK, B.M. & E.A. BROWN, 2016. De Beers Marine Namibia Environmental Monitoring Programme in the Atlantic 1 Mining Licence Area: 2014 Benthic Sampling Campaign. Report prepared for De Beers Marine Namibia by Anchor Environmental Consultants (Pty) Ltd. Report no. 1527/4.

BICCARD, A., CLARK, B.M., BROWN, E.A., DUNA, O., MOSTERT, B.P., HARMER, R.W., GIHWALA, K. & A.G. WRIGHT, 2017. De Beers Marine Namibia Environmental Monitoring Programme: Atlantic 1 Mining Licence Area 2015 Benthic Sampling Campaign. Report prepared for De Beers Marine Namibia by Anchor Environmental Consultants (Pty) Ltd. Report no. 1527/4.

BICCARD A, GIHWALA K, CLARK BM, HARMER RW, BROWN EA, MOSTERT BP, WRIGHT AG & A MASOSONKE. 2018. De Beers Marine Namibia Environmental Monitoring Programme: Atlantic 1 Mining Licence Area 2016 Benthic Sampling Campaign. Report prepared for De Beers Marine Namibia by Anchor Environmental Consultants (Pty) Ltd. Report no. 1726/1.BIRCH G.F., ROGERS J., BREMNER J.M. and G.J. MOIR, 1976. Sedimentation controls on the continental margin of Southern Africa. *First Interdisciplinary Conf. Mar. Freshwater Res. S. Afr.*, Fiche 20A: C1-D12.

BICCARD, A., K. GIHWALA, B.M. CLARK, E.A. BROWN, B.P. MOSTERT, A. MASOSONKE, C. SWART, S. SEDICK, B. TSHINGANA and J. DAWSON, 2019. De Beers Marine Namibia Environmental Monitoring Programme: Atlantic 1 Mining Licence Area 2017 Benthic Sampling Campaign. Report prepared for De Beers Marine Namibia by Anchor Environmental Consultants (Pty) Ltd. Report no. 1775/1.

BICKNELL, A.W.J., SHEEHAN, E.V., GODLEY, B.J., DOHERTY, P.D. & M.J. WITT, 2019. Assessing the impact of introduced infrastructure at sea with cameras: A case study for spatial scale, time and statistical power. *Marine Environmental Research,* 147, 126-137.

BIRCH, G.F. & J. ROGERS, 1973. Nature of the seafloor between Lüderitz and Port Elizabeth. *S. Afr. ship. news fish. ind. rev.*, **39 (7)**: 56-65.

BIRCH G.F., ROGERS J., BREMNER J.M. and G.J. MOIR, 1976. Sedimentation controls on the continental margin of Southern Africa. *First Interdisciplinary Conf. Mar. Freshwater Res. S. Afr.*, Fiche 20A: C1-D12.

BIRKELAND, C., REIMER, A.A. & J.R. YOUNG, 1976. Survey of marine communities in Panama and experiments with oil. US EPA Research Series, 600/3-76-028.

BLABER, S.J.M. and T.G. BLABER, 1980. Factors affecting the distribution of juvenile estuarine and inshore fish. *J. Fish Biol.,* 17: 143-162.

BLOOM, P. & M. JAGER, 1994. The injury and subsequent healing of a serious propeller strike to a wild bottlenose dolphin (*Tursiops truncatus*) resident in cold waters off the Northumberland coast of England. *Aquatic Mammals*, 20(2: 59-64.

BOLTON, J.J., 1986. Seaweed biogeography of the South African west coast - A temperature dependent perspective. *Bot. Mar.*, **29**: 251-256.

BOMBACE, G., FABI, G., FIORENTINI, L. and S. SPERANZA, 1994. Analysis of the efficacy of artificial reefs located in five different areas of the Adriatic Sea. *Bulletin of Marine Science* **55**: 559-580.

BONFIL, R., MEYER, M., SCHOLL, M.C., JOHNSON, R., O'BRIEN, S., OOSTHUIZEN, H., SWANSON, S., KOTZE, D. and PATERSON, M., 2005. Transoceanic migration, spatial dynamics, and population linkages of white sharks. *Science* **310**: 100-103.

BOYD, A..J. and G.P.J. OBERHOLSTER, 1994. Currents off the west and south coasts of South Africa. *S. Afr. Shipping News and Fish. Ind. Rev.*, **49**: 26-28.

BOYD, A.J. and SHILLINGTON, F.A. 1994. Physical forcing and circulation patterns on the Agulhas Bank. *S. Afr. J. Sci.*, **90**: 114-120.

BOYD, A.J., TAUNTON-CLARK, J. and OBERHOLSTER, G.P.J. 1992. Spatial features of the nearsurface and midwater circulation patterns off western and southern South Africa and their role in the life histories of various commercially fished species. *S. Afr. J. mar. Sci.*, **12**: 189-206.

BRABY, J., 2009. The Damara Tern in the Sperrgebiet: Breeding productivity and the impact of diamond mining. Unpublished report to Namdeb Diamond Corporation (Pty) Ltd.

BRANCH, G.M., 2008. Trophic Interactions in Subtidal Rocky Reefs on the West Coast of South Africa . In: MCCLANAHAN, T. and G.M. BRANCH (eds). Food Webs and the Dynamics of Marine Reefs. New York: Oxford University Press, 2008. Oxford Scholarship Online.Oxford University Press. pp 50-79

BRANCH, G.M. and M. BRANCH, 1981. The Living Shores of Southern Africa. Struik. Cape Town, South Africa.

BRANCH, G. & M. BRANCH, 2018. *Living Shores : Interacting with southern Africa's marine ecosystems*. Struik Nature. Cape Town, South Africa.

BRANCH, G.M. and C.L. GRIFFITHS, 1988. The Benguela ecosystem part V: the coastal zone. *Oceanog. Marine Biology: An Annual Rev*iew, **26**: 395-486.

BRANCH, G.M., GRIFFITHS. C.L., BRANCH, M.L. and L.E. BECKLEY, 2010. Two Oceans - A guide to the marine life of Southern Africa, David Philip, Cape Town and Johannesburg. Revised edition

BRANDÃO, A., VERMEULEN, E., ROSS-GILLESPIE, A., FINDLAY, K. & D.S. BUTTERWORTH, 2018. Updated application of a photo-identification based assessment model to southern right whales in South African waters, focussing on inferences to be drawn from a series of appreciably lower counts of calving females over 2015 to 2017. Paper Sc/67B/SH/22 submitted to the scientific Committee of the International Whaling Commission, Bled, Slovenia, May 2018

BREEZE, H., DAVIS, D.S. BUTLER, M. and V. KOSTYLEV, 1997. Distrbution and status of deep sea corals off Nova Scotia. Marine Issues Special Committee Special Publication No. 1. Halifax, NS: Ecology Action Centre. 58 pp.

BROUWER, S.L., MANN, B.Q., LAMBERTH, S.J., SAUER, W.H.H. and C. ERASMUS, 1997. A survey of the South African shore angling fishery. *South African Journal of Marine Science* **18**: 165-178.

BROWN, A.C. and A. McLACHLAN, 1994. *Ecology of sandy shores*, pp. 1-328 Amsterdam, Elsevier.

BROWN, A.C., STENTON-DOZEY, J.M.E. and E.R. TRUEMAN, 1989. Sandy beach bivalves and gastropods: a comparison between *Donax serra* and *Bullia digitalis*. *Adv. Mar. Biol.,* **25**: 179-247.

BROWN, P.C., 1984. Primary production at two contrasting nearshore sites in the southern Benguela upwelling region, 1977-1979. *S. Afr. J. mar. Sci.*, **2** : 205-215.

BROWN, P.C. 1992. Spatial and seasonal variation in chlorophyll distribution in the upper30m of the photic zone in the southern Benguela/Agulhas region. *S. Afr. J. mar. Sci.*, **12**: 515-525.

BROWN, P.C. and J.L. HENRY, 1985. Phytoplankton production, chlorophyll a and light penetration in the southern Benguela region during the period between 1977 and 1980. In: SHANNON, L.V. (Ed.) South African Ocean Colour and Upwelling Experiment. Cape Town, SFRI : 211-218.

BROWN, A.C. and F.J. ODENDAAL, 1994. The biology of Oniscid Isopoda of the genus *Tylos*. *Adv. Mar. Biol.*, **30**: 89-153.

BRICELJ, V.M. and R.E. MALOUF, 1984. Influence of algal and suspended sediment concentrations on the feeding physiology of the hard clam *Mercenaria mercenari*a. *Mar. Biol.*, **84**: 155–165.

BUCHANAN, R.A., R. FECHHELM, J. CHRISTIAN, V.D. MOULTON, B.D. MACTAVISH, R. PITT & S. CANNING. 2006. Orphan Basin controlled source electromagnetic survey program environmental assessment. LGL Rep.

SA899. Rep. by LGL Limited and Canning & Pitt Associates Inc., St. John's, NL, for ExxonMobil Canada Ltd., St. John's, NL. 128 p. + appendices.

BUHL-MORTENSEN, L. & P.B. MORTENSEN, 2005. Distribution and diversity of species associated with deep-sea gorgonian corals off Atlantic Canada. Cold-water corals and ecosystems. Springer. pp 849–879.

BUHL-MORTENSEN, L., VANREUSEL, A., GOODAY, A.J., LEVIN, L.A., PRIEDE, I.G., BUHL-MORTENSEN, P., GHEERARDYN, H., KING, N.J. & M. RAES, 2010. Biological structures as a source of habitat heterogeneity and biodiversity on the deep ocean margins. Marine Ecology 31: 21–50.

BULL, A.S. and J.J. KENDALL, Jr., 1994. An indication of the process: offshore platforms as artificial reefs in the Gulf of Mexico. *Bull. Mar. Sci*. **55**: 1086-1098.

BURKHARDT, E., BOEBEL, O., BORNEMANN, H. & C. RUHOLL, 2008. Risk assessment of scientific sonars. Bioacoustics;17(1–3): 235–7.

BUSTAMANTE, R.H. and G.M. BRANCH, 1996a. The dependence of intertidal consumers on kelp-derived organic matter on the west coast of South Africa. *J. Exp. Mar. Biol. Ecol.*, **196**: 1-28.

BUSTAMANTE, R.H. and G.M. BRANCH, 1996b. Large scale patterns and trophic structure of southern African rocky shores: the role of geographic variation and wave exposure. *J. Biography,* **23**: 339-351.

BUSTAMANTE, R.H., BRANCH, G.M. and S. EEKHOUT, 1995b. Maintenance of exceptional intertidal grazer biomass in South Africa: Subsidy by subtidal kelps. *Ecology* **76(7)**: 2314-2329.

BUSTAMANTE, R.H., BRANCH, G.M. and S. EEKHOUT, 1997. The influences of physical factors on the distribution and zonation patterns of South African rocky-shore communities. *South African Journal of marine Science* **18**: 119-136.

BUSTAMANTE, R.H., BRANCH, G.M., EEKHOUT, S., ROBERTSON, B., ZOUTENDYK, P., SCHLEYER, M., DYE, A., HANEKOM, N., KEATS, D., JURD, M. and C. MCQUAID, 1995a. Gradients of intertidal primary productivity around the coast of South Africa and their relationships with consumer biomass. *Oecologia* **102**: 189-201.

BUXTON, C.D., 1990. The reproductive biology of *Chrysoblephus laticeps* and *C. christiceps* (Teleostei: Sparidae). *J. Zool. Lond*. **220**: 497-511.

CAMPBELL, K., 2016. Factors influencing the foraging behaviour of African Penguins (*Spheniscus demersus*) provisioning chicks at Robben Island, South Africa. PhD Thesis, University of Cape Town, pp258.

CARTER, L., BURNETT, D., DREW, S., MARLE, G., HAGADORN, L., BARTLETT-MCNEIL, D. & N. IRVINE, 2009. Submarine Cables and the Oceans – Connecting the World. UNEP-WCMC Biodiversity Series No. 31. ICPC/UNEP/UNEP-WCMC.

CARTER, R.A. and BROWNLIE, S. 1990. Estuaries of the Cape, Part II: Synopses of available information on individual systems. Report No. 34: Kafferkuils (CSW 24) and Duiwenshok (CSW 23). Heydorn, A.E.F. and Morant, P.D. (eds). Stellenbosch, CSIR Research Report 43, 86pp.

CARTER, R.A. and D'AUBREY, J. 1988. Inorganic nutrients in Natal continental shelf waters. In: Coastal ocean sciences of Natal, South Africa (Ed. E.H. Schumann). Springer-Verlag, Berlin., 131-151.

CARTER, R.A., McMURRAY, H.F. and LARGIER, J.L. 1987. Thermocline characteristics and phytoplankton dynamics in Agulhas Bank waters. *S. Afr. J. mar. Sci.*, **5**: 327-336.

CARTER, R.A. and M.H. SCHLEYER, 1988. Plankton distributions in Natal coastal waters. In: Coastal ocean sciences of Natal, South Africa (Ed. E.H. Schumann). Springer-Verlag, Berlin., 152-177.

CATHALOT. C., VAN OEVELEN, D., COX, T.J.S., KUTTI, T., LAVALEYE, M., DUINEVELD, G. & F.J.R. MEYSMAN, 2015. Cold-water coral reefs and adjacent sponge grounds: Hotspots of benthic respiration and organic carbon cycling in the deep sea. Frontiers in Marine Science 2: 37.

CCA and CSIR, 1998. Environmental Impact Assessment for the proposed extension of the ORIBI oil production facility and hydrocarbon exploration off the Southern Cape Coast. Report No. SOE01OE/2.

CHAPMAN, P. and L.V. SHANNON, 1985. The Benguela Ecosystem. Part II. Chemistry and related processes. *Oceanogr. Mar. Biol. Ann. Rev.*, **23**: 183-251.

CHENELOT, H., JEWETT, S. and M. HOBERG, 2008. Invertebrate Communities Associated with Various Substrates in the Nearshore Eastern Aleutian Islands, with Emphasis on Thick Crustose Coralline Algae. In: BRUEGGEMAN, P. and N.W. POLLOCK (eds.) Diving for Science. Proceedings of the American Academy of Underwater Sciences 27th Symposium.Dauphin Island, Alaska, AAUS, pp13-36.

CHILD, M.F., ROXBURGH, L., DO LINH SAN, E., RAIMONDO, D. and H.T. DAVIES-MOSTERT, (editors). 2016. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa (https://www.ewt.org.za/Reddata/Order%20Cetacea.html).

CHILDERHOUSE, S. & L. DOUGLAS, 2016. Information Document: Review of multibeam echosounder surveys and potential impacts on marine mammals, Document Reference Number: BPM-16-MDC-Review of multibeam echosounder surveys and marine mammals v1.2.

CHRISTENSEN, M.S. 1980. Sea-surface temperature charts for southern Africa, south of 26°S. *S. Afr. J. Sci.*, **76 (12)**: 541-546.

CHRISTIE, N.D., 1974. Distribution patterns of the benthic fauna along a transect across the continental shelf off Lamberts Bay, South Africa. Ph.D. Thesis, University of Cape Town, 110 pp and Appendices.

CHRISTIE, N.D., 1976. A numerical analysis of the distribution of a shallow sublittoral sand macrofauna along a transect at Lambert's Bay, South Africa. *Transactions of the Royal Society of South Africa*, **42**: 149-172.

CHRISTIE N.D. and A.G. MOLDAN, 1977. Effects of fish factory effluent on the benthic macro-fauna of Saldanha Bay. *Marine Pollution Bull*etin, **8**: 41-45.

CLARK, B.M., 1997a. Variation in surf zone fish community structure across a wave exposure gradient. *Estuarine and Coastal Shelf Science* **44**: 659-674.

CLARK, B.M., 1997b. Dynamics and Utilisation of Surf Zone Habitats by Fish in the South-Western Cape, South Africa. Unpublished PhD Thesis, University of Cape Town.

CLARK, B.M., BENNETT, B.A. and S.J. LAMBERTH, 1994. A comparison of the ichthyofauna of two estuaries and their adjacent surf-zones, with an assessment of the effects of beach-seining on the nursery function of estuaries for fish. *South African Journal of Marine Science* **14**: 121-131.

COCKCROFT, A.C, SCHOEMAN, D.S., PITCHER, G.C., BAILEY, G.W.AND D.L. VAN ZYL, 2000. A mass stranding, or 'walk out' of west coast rock lobster, *Jasus lalandii*, in Elands Bay, South Africa: Causes, results and implications. In: VON VAUPEL KLEIN, J.C.and F.R. SCHRAM (Eds), *The Biodiversity Crisis and Crustacea: Proceedings of the Fourth International Crustacean Congress*, Published by CRC press.

COCKCROFT, A.C., VAN ZYL, D. AND L. HUTCHINGS, 2008. Large-Scale Changes in the Spatial Distribution of South African West Coast Rock Lobsters: An Overview. *African Journal of Marine Science 2008, 30 (1) : 149–159.*

COCKCROFT, V.G. & V.M. PEDDEMORS, 1990. Seasonal distribution and density of common dolphins *Delphinus delphis* off the south-east coast of southern Africa. *S. Afr. J. mar. Sci.* **9:** 371-377.

COCKCROFT, V.G., ROSS G.J.B. & V.M. PEDDEMORS, 1990. Bottlenose dolphin *Tursiops truncatus* distribution in Natal's coastal waters. *South African Journal of Marine Science* **9:** 1-10.

COCKCROFT, V.G., ROSS G.J.B. & V.M. PEDDEMORS, 1991. Distribution and status of bottlenose dolphin *Tursiops truncatus* on the south coast of Natal, South Africa. *S. Afr. J. mar. Sci.* **11:** 203-209.

COCKCROFT, V., NATOLI, A., REISINGER, R., ELWEN, S., HOELZEL, R., ATKINS, S. and PLÖN, S., 2016. A conservation assessment of Tursiops aduncus. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

COETZEE, J.C., VAN DER LINGEN, C.D., HUTCHINGS, L. and T.P. FAIRWEATHER, 2008. Has the fishery contributed to a major shift in the distribution of South African sardine? *ICES Journal of Marine Science* 65: 1676–1688.

COETZEE, J.C., MERCKLE, D., HUTCHINGS, L., VAN DER LINGEN, C.D., VAN DEN BERG, M. & M.D.DURHOLTZ, 2010. The 2005 KwaZulu-Natal sardine run survey sheds new light on the ecology of small fish off the east coast of South Africa. *African Journal of Marine Science* **32**: 337–360.

COLEY, N.P. 1994. Environmental impact study: Underwater radiated noise. Institute for Maritime Technology, Simon's Town, South Africa. pp. 30.

COLEY, N.P. 1995. Environmental impact study: Underwater radiated noise II. Institute for Maritime Technology, Simon's Town, South Africa. pp. 31.

COLLINS, K., 2007. Isle Of Man Cable Study – Preliminary Material Environmental Impact Studies. Preliminary Report, University of Southampton.

COMPAGNO, L.J.V., EBERT, D.A. and P.D. COWLEY, 1991. Distribution of offshore demersal cartilaginous fish (Class Chondrichthyes) off the West Coast of southern Africa, with notes on their systematics. *S. Afr. J. Mar. Sci.* 11: 43-139.

CONNELL, A.D., 2010. A 21-year ichthyoplankton collection confirms sardine spawning in KwaZulu-Natal waters. *African Journal of Marine Science* **32**: 331–336.

CONNELL, S.D., 2001. Urban structures as marine habitats: an experimental comparison of the composition and abundance of subtidal epibiota among pilings, pontoons and rocky reefs. *Marine Environmental Research* **52**: 115-125.

CONNELL, S.D. and T.M. GLASBY, 1999. Do urban structures influence local abundance and diversity of subtidal epibiota? A case study from Sydney Harbour. *Marine Environmental Research* **47**: 373-387.

CONNELL, S.D. and R.O. SLAYTER, 1977. Mechanisms of succession in natural communities and their role on community stability and organisation. *American Naturalist* **111**: 1119-1144.

CONSTANTINE, R., 2001. Increased avoidance of swimmers by wild bottlenose dolphins (Tursiops truncatus) due to long-term exposure to swim-with-dolphin tourism. *Marine Mammal Science* 17: 689-702.

CONVENTION ON BIOLOGICAL DIVERSITY (CBD), 2013. Report of the Southern Indian Ocean regional workshop to facilitate the description of ecologically or biologically significant marine areas. UNEP/CBD/RW/EBSA/SIO/1/4. www.cbd.int/doc/?meeting=EBSA-SIO-01

COPPING, A. & L. HEMERY, 2020. OES-Environmental 2020 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. **Ocean Energy Systems (OES).**

CORNEW, S., STUART, V. and BECKLEY, L.E. 1992. Population structure, biomass and distribution of *Nyctiphanes capensis* (Euphausiacea) in the vicinity of Algoa Bay, South Africa. *S. Afr. J. Zoo.*, **27 (1)**: 14-20.

CRAWFORD, R.J.M. 1980. Seasonal patterns in South Africa's western Cape purse-seine fishery. *J. Fish. Biol.*, **16 (6)**: 649-664.

CRAWFORD R.J.M., RYAN P.G. and A.J. WILLIAMS. 1991. Seabird consumption and production in the Benguela and western Agulhas ecosystems. *S. Afr. J. Mar. Sci.* 11: 357-375.

CRAWFORD, R.J.M., SHANNON, L.V. and D.E. POLLOCK, 1987. The Benguela ecosystem. 4. The major fish and invertebrate resources. *Oceanogr. Mar. Biol. Ann. Rev.*, **25**: 353 - 505.

CRAWFORD, R.J.M., MAKHADO, A.B., WHITTINGTON, P.A., RANDALL, R.M., OOSTHUIZEN, W.H. & L.J. WALLER, 2015. A changing distribution of seabirds in South Africa – the possible impact of climate and its consequences. *Frontiers in Ecology and Evolution*, 3(10): 1-10.

CRAWFORD, R.J M., DYER, B.M., GELDENHUYS, D., MAKHADO, A.B., RANDALL, R.M., UPFOLD, L., *et al.*, 2012. Trends in numbers of crowned cormorants in South Africa, with information on diet. *Afr. J. Mar. Sci.* 34: 411–424. doi: 10.2989/1814232X.2012.716373

CRAWFORD, R.J M., RANDALL, R.M., WHITTINGTON, P.A., WALLER, L.J., DYER, B.M., ALLAN, D.G., *et al.* (2013). South Africa's coastal-breeding white-breasted cormorants: population trends, breeding season and movements, and diet. *Afr. J. Mar. Sci*. 35, 473–490.

CROFT, B. and B. Li, 2017. Shell Namibia Deepwater Exploration Drilling: Underwater Noise Impact Assessment. Prepared by SLR Consulting Australia Pty Ltd. for SLR Consulting (Cape \Town) Pty Ltd. 19pp.

CROWTHER CAMPBELL and ASSOCIATES CC and CENTRE FOR MARINE STUDIES (CCA and CMS). 2001. Generic Environmental Management Programme Reports for Oil and Gas Prospecting off the Coast of South Africa. Prepared for Petroleum Agency SA, October 2001.

CRUIKSHANK, R.A., 1990. Anchovy distribution off Namibia deduced from acoustic surveys with an interpretation of migration by adults and recruits. *S. Afr. J. Mar. Sci.*, **9**: 53-68.

CSIR, 1996. Elizabeth Bay monitoring project: 1995 review. *CSIR Report ENV/S-96066.*

CSIR, 1998. Environmental Impact Assessment for the Proposed Exploration Drilling in Petroleum Exploration Lease 17/18 on the Continental Shelf of KwaZulu-Natal, South Africa. CSIR Report ENV/S-C 98045.

CSIR, 2006. The development of a common set of water and sediment quality guidelines for the coastal zone of the BCLME. *CSIR Report No CSIR/NRE/ECO/ER/2006/0011/C,* prepared for the Benguela Current Large Marine Ecosystem Programme, January 2006.

CSIR, 2006. Environmental Management Programme Report for Exploration/Appraisal Drilling in the Kudu Gas Production Licence No 001 on the Continental Shelf of Namibia. Prepared for: Energy Africa Kudu Limited, CSIR Report: CSIR/NRE/ECO/2006/0085/C.

CURRIE, D.R., SOROKIN, S.J. and T.M. WARD, 2009. Infaunal macroinvertebrate assemblages of the eastern Great Australian Bight: effectiveness of a marine protected area in representing the region's benthic biodiversity. *Marine and Freshwater Research* **60**: 459-474.

DANNHEIM, J., BERGSTRÖM, L., BIRCHENOUGH, S.N.R., BRZANA, R., BOON, A.R., COOLEN, J.W.P., DAUVIN, J.-C., DE MESEL, I., DERWEDUWEN, J., GILL, A.B., HUTCHISON, Z.L., JACKSON, A.C., JANAS, U., MARTIN, G., RAOUX, A., REUBENS, J., ROSTIN, L., VANAVERBEKE, J., WILDING, T.A., WILHELMSSON, D. & S. DEGRAER, 2019. Benthic effects of offshore renewables: identification of knowledge gaps and urgently needed research. *ICES Journal of Marine Science*

DAVID, J.H.M, 1989., Seals. In: Oceans of Life off Southern Africa, Eds. Payne, A.I.L. and Crawford, R.J.M. Vlaeberg Publishers. Halfway House, South Africa.

DAY, J.H., FIELD, J.G. and M. MONTGOMEREY, 1971. The use of numerical methods to determine the distribution of the benthic fauna across the continental shelf of North Carolina. *Journal of Animal Ecology* **40**:93-126.

DE DECKER, A.H., 1970. Notes on an oxygen-depleted subsurface current off the west coast of South Africa. *Invest. Rep. Div. Sea Fish. South Africa*, **84**, 24 pp.

DE DECKER, A.H.B. 1984. Near-surface copepod distribution in the South-Western Indian and South-Eastern Atlantic Ocean. *Ann. S. Afr. Mus.*, **93 (5)**: 303-370.

DE GREEF, K., GRIFFITHS, C.L. and Z. ZEEMAN, 2013. Deja vu? A second mytilid mussel, *Semimytilus algosus*, invades South Africa's west coast. *African Journal of Marine Science* **35(3)**: 307-313.

DE LECEA, A.M., COOPER, R. and A.J. SMIT, 2015. Identifying the drivers of the pelagic ecosystem of an oligotrophic bight (KwaZulu–Natal, South Africa) using stable isotopes (δ13C, δ15N) and C:N ratio analysis. *Marine and Freshwater Research*. DOI:org/10.1071/MF15256.

DEMETRIADES N.T. & A.T. FORBES, 1993. Seasonal changes in the species composition of the penaeid prawn catch on the Tugela Bank, Natal, South Africa. *South African Journal of Marine Science* **13**: 317-322.

DE ROCK, P., ELWEN, S.H., ROUX, J-P., LEENEY, R.H., JAMES, B.S., VISSER, V., MARTIN, M.J. & T. GRIDLEY, 2019. Predicting large-scale habitat suitability for cetaceans off Namibia using MinxEnt. *Marine Ecology Progress Series*, **619**: 149-167.

DE WET, A. 2013. *Factors affecting survivorship of loggerhead (Caretta caretta) and leatherback (Dermochelys coriacea) sea turtles of South Africa.* MSc, Nelson Mandela Metropolitan University.

DINGLE, R.V., 1973. The Geology of the Continental Shelf between Lüderitz (South West Africa) and Cape Town with special reference to Tertiary Strata. *J. Geol. Soc. Lond.*, **129**: 337-263.

DINGLE, R.V., BIRCH, G.F., BREMNER, J.M., DE DECKER, R.H., DU PLESSIS, A., ENGELBRECHT, J.C., FINCHAM, M.J., FITTON, T, FLEMMING, B.W. GENTLE, R.I., GOODLAD, S.W., MARTIN, A.K., MILLS, E.G., MOIR, G.J., PARKER, R.J., ROBSON, S.H., ROGERS, J. SALMON, D.A., SIESSER, W.G., SIMPSON, E.S.W., SUMMERHAYES, C.P., WESTALL, F., WINTER, A. and M.W. WOODBORNE, 1987. Deep-sea sedimentary environments around Southern Africa (South-east Atlantic and South-west Indian Oceans). *Annals of the South African Museum* 98(1).

DOUGLAS, A.B., CALAMBOKIDIS, J., RAVERTY, S., JEFFRIES, S.J., LAMBOURN, D.M.& S.A. NORMA, 2008. Incidence of ship strikes of large whales in Washington State. J*ournal of the Marine Biological Association of the United Kingdom* 88: 1121-1132.

DOWNEY, N.J., 2014. The Role of the Deep Spawning Grounds in Chokka Squid (Loligo reynaudi D'Orbigny, 1845) Recruitment. PhD Thesis, Rhodes University, Grahamstown, pp135.

DOWNEY, N.J., ROBERTS, M.J., BAIRD, D., 2010. An investigation of the spawning behaviour of the chokka squid *Loligo reynaudii* and the potential effects of temperature using acoustic telemetry. *ICES Journal of Marine Science*, **67**: 231–243.

DRAKE, D.E., CACCHIONE, D.A. and H.A. KARL, 1985. Bottom currents and sediment transport on San Pedro Shelf, California. *J. Sed. Petr.*, **55**: 15-28.

DUGAN J.E., HUBBARD, D.M., MCCRARY, M.D. and M.O. PIERSON, 2003. The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of southern California. *Estuarine, Coastal and Shelf Science*, **58S**: 133-148.

DUNA, O., CLARK, B.M., BICCARD, A., HUTCHINGS, K., HARMER, R., MOSTERT, B., BROWN, E., MASSIE, V., MAKUNGA, M., DLAKU, Z. & A, MAKHOSONKE, 2016. Assessment of mining-related impacts on macrofaunal benthic communities in the Northern Inshore Area of Mining Licence Area MPT 25-2011 and subsequent recovery. Technical Report. Report prepared for De Beers Marine Namibia by Anchor Environmental Consultants (PTY) Ltd. Report no. 1646/1.

DUNCOMBE RAE, C.M., F.A. SHILLINGTON, J.J. AGENBAG, J. TAUNTON-CLARK and GRUNDLINGH, M.L. 1992. An Agulhas ring in the South Atlantic Ocean and its interaction with the Benguela upwelling frontal system. *Deep-Sea Research* **39**: 2009-2027.

DUNDEE, B.L., 2006. *The diet and foraging ecology of chick-rearing gannets on the Namibian islands in relation to environmental features: a study using telemetry*. MSc thesis, University of Cape Town, South Africa.

DUNHAM, A., PEGG, J. R., CAROLSFELD, W., DAVIES, S., MURFITT, I. & J. BOUTILLIER, 2015. Effects of submarine power transmission cables on a glass sponge reef and associated megafaunal community. *Marine Environmental Research,* 107, 50-60.

DURHAM, B., 1994. The distribution and abundance of the humpback dolphin (Sousa chinensis) along the Natal coast, South Africa. University of Natal.

DUTTON, P.H., BOWEN, B.W., OWENS, D.W., BARRAGAN, A. and S.K. DAVIS, 1999. Global phylogeography of the leatherback turtle (Dermochelys coriacea). *Journal of Zoology*, 248, 397-409.

ELLINGSEN, K.E., 2002. Soft-sediment benthic biodiversity on the continental shelf in relation to environmental variability. *Marine Ecology Progress Series*, **232**: 15-27.

ELLIS, D.V., 1996. Practical mitigation of the environmental effect of offshore mining. Offshore Technology Conference, Houston Texas, 6-9 May 1996.

ELLIS, D.V., 2000. Effect of Mine Tailings on the Biodiversity of the Seabed: Example of the Island Copper Mine, Canada. In: SHEPPARD, C.R.C. (Ed), Seas at The Millennium: An Environmental Evaluation. Pergamon, Elsevier Science, Amsterdam, pp. 235-246.

ELLIS, D.V. and R.H.T. GARNETT, 1996. Practical Mitigation of the Environmental Effect of Offshore Mining. *Proc. Offshore Technology Conference, Houston Texas, 6-9 May 1996*: 611-615.

ELLIS, M.S., WILSON-ORMOND, E.A. and E.N. POWELL, 1996. Effects of gas-producing platforms on continental shelf macroepifauna in the northwestern Gulf of Mexico: abundance and size structure. *Can. J. Fish. Aquat. Sci.*, **53**: 2589-2605.

ELVIN, S.S. & C.T. TAGGART, 2008. Right whales and vessels in Canadian waters. *Marine Policy* 32 (3): 379-386.

ELWEN, S.H., 2008. The distribution, movements and abundance of Heaviside's dolphins in the nearshore waters of the Western Cape, South Africa. Ph.D. dissertation, University of Pretoria, Pretoria, South Africa. 211 pp.

ELWEN, S.H., GRIDLEY, T., ROUX, J.-P., BEST, P.B. and M.J. SMALE, 2013. Records of Kogiid whales in Namibia, including the first record of the dwarf sperm whale (*K. sima*). *Marine Biodiversity Records*. 6, e45 doi:10.1017/S1755267213000213.

ELWEN, S.H. & R.H. LEENEY, 2010. Injury and Subsequent Healing of a Propeller Strike Injury to a Heaviside's dolphin (*Cephalorhynchus heavisidii*). *Aquatic Mammals* 36 (4): 382-387.

ELWEN, S.H. and R.H. LEENEY, 2011. Interactions between leatherback turtles and killer whales in Namibian waters, including predation. *South African Journal of Wildlife Research,* **41(2)**: 205-209.

ELWEN, S.H. MEŸER, M.A.M, BEST, P.B., KOTZE, P.G.H, THORNTON, M. and S. SWANSON, 2006. Range and movements of a nearshore delphinid, Heaviside's dolphin *Cephalorhynchus heavisidii* a determined from satellite telemetry. *Journal of Mammalogy*, **87(5)**: 866–877.

ELWEN, S.H., BEST, P.B., REEB, D. and M. THORNTON, 2009a. Near-shore diurnal movements and behaviour of Heaviside's dolphins (*Cephalorhynchus heavisidii*), with some comparative data for dusky dolphins (*Lagenorhynchus obscurus*). *South African Journal of Wildlife Research,* **39(2)**: 143-154.

ELWEN S.H., REEB D., THORNTON M. and P.B. BEST, 2009b. A population estimate of Heaviside's dolphins *Cephalorhynchus heavisidii* in the southern end of their range. *Marine Mammal Science* 25: 107-124.

ELWEN S.H., THORNTON M., REEB D. and P.B. BEST, 2010b. Near-shore distribution of Heaviside's (*Cephalorhynchus heavisidii*) and dusky dolphins (*Lagenorhynchus obscurus*) at the southern limit of their range in South Africa. *African Journal of Zoology* 45: 78-91.

ELWEN, S.H., TONACHELLA, N., BARENDSE, J,. COLLINS, T.J.Q., BEST, P.B., ROSENBAUM, H.C., LEENEY, R.H. and T. GRIDLEY. 2014. Humpback Whales off Namibia: Occurrence, Seasonality, and a Regional Comparison of Photographic Catalogs and Scarring. Journal of Mammalogy, 95 (5): 1064–76. doi:10.1644/14-MAMM-A-108.

EMANUEL, B.P., BUSTAMANTE, R.H., BRANCH, G.M., EEKHOUT, S. and F.J. ODENDAAL, 1992. A zoogeographic and functional approach to the selection of marine reserves on the west coast of South Africa. *S. Afr. J. Mar. Sci.*, **12**: 341-354.

ENGLEDOW, H.R. & J.J. BOLTON, 1994. Seaweed alpha-diversity within the lower eulittoral zone in Namibia: the effects of wave action, sand inundation, mussels and limpets. *Bot. Mar.*, **37**: 267-276.

ENVIRONMENTAL EVALUATION UNIT, 1996. Impacts of Deep Sea Diamond Mining, in the Atlantic 1 Mining Licence Area in Namibia, on the Natural Systems of the Marine Environment. *Environmental*

Evaluation Unit Report No. 11/96/158, University of Cape Town. Prepared for De Beers Marine (Pty) Ltd. 370 pp.

ESCARAVAGE, V., HERMAN, P.M.J., MERCKX, B., WŁODARSKA-KOWALCZUK, M., AMOUROUX, J.M., DEGRAER, S., GRÉMARE, A., HEIP, C.H.R., HUMMEL, H., KARAKASSIS, I., LABRUNE, C. and W. WILLEMS, 2009. Distribution patterns of macrofaunal species diversity in subtidal soft sediments: biodiversity-productivity relationships from the MacroBen database. *Marine Ecology Progress Series* **382**: 253-264.

FAO, 2009. International Guidelines for the Management of Deep-Sea Fisheries in the High Seas. SPRFMO-VI-SWG-INF01

FECHHELM, R.G., GALLAWAY, B.J., HUBBARD, G.F., MACLEAN, S. and L.R. MARTIN, 2001. Opportunistic sampling at a deep-water synthetic drilling fluid discharge site in the Gulf of Mexico. *Gulf of Mexico Science*, **2**: 97-106.

FEGLEY, S.R., MACDONALD, B.A. and T.R. JACOBSEN, 1992. Short-term variation in the quantity and quality of seston available to benthic suspension feeders. *Estuar. Coast. Shelf Sci.*, **34**: 393–412.

FENNESSY, S.T., 1994a. The impact of commercial prawn trawlers on linefish off the north coast of Natal, South Africa. *South African Journal of Marine Science* **14**: 263-279.

FENNESSY, S.T., 1994b. Incidental capture of elasmobranchs by commercial prawn trawlers on the Tugela Bank, Natal, South Africa. *South African Journal of Marine Science* **14**: 287-296.

FERNANDEZ, A., EDWARDS, J.F., RODRIGUEZ, F., ESPINOSA DE LOS MONEROS, A., HERRAEZ, P., CASTRO, P., JABER, J., *et al.*, 2005. "'Gas and Fat Embolic Syndrome'" Involving a Mass Stranding of Beaked Whales (Family Ziphiidae) Exposed to Anthropogenic Sonar Signals. Veterinary Pathology, 457: 446–457.

FIELD, J.G. and C.L. GRIFFITHS, 1991. Littoral and sublittoral ecosystems of southern Africa. In: Mathieson AC,. Nienhuis PH (eds.): Ecosystems of the World 24: Intertidal and Littoral Ecosystem.. Elsevier, Amsterdam. Pp. 323-346.

FIELD, J.G., GRIFFITHS, C.L., GRIFFITHS, R.J., JARMAN, N., ZOUTENDYK, P., VELIMIROV, B. and A. BOWES, 1980. Variation in structure and biomass of kelp communities along the south-west cape coast. *Trans. Roy. Soc. S. Afr.,* **44**: 145-203.

FIELD, J.G. & C.A. PARKINS, 1997. A baseline study of the benthic communities of the unmined sediments of the De Beers Marine SASA grid. Report prepared for De Beers Marine (Pty) Ltd by Marine Biology Research Institute. Zoology Department. University of Cape Town. pp. 29.

FINDLAY, K.P., 1996. The impact of diamond mining noise on marine mammal fauna off southern Namibia. In: Environmental Evaluation Unit Report, Impacts of deep sea diamond mining, in the Atlantic 1 mining licence area in Namibia, on the natural systems of the marine environment. EEU Unpublished Report No. 11/96/158.

FINDLAY, K.P. AND P.B. BEST, 1996a. Estimates of the numbers of humpback whales observed migrating past Cape Vidal, South Africa, 1988-1991. *Mar Mammal Sci.,* **12(3)**: 354-370.

FINDLAY, K.P. AND P.B. BEST, 1996b. The Migrations of Humpback Whales past Cape Vidal, South Africa, and a Preliminary Estimate of the Population Increase Rate. *Rep Int Whal Commn*. SC/A06/HW16

FINDLAY K.P., BEST P.B., ROSS G.J.B. and V.C. COCKROFT. 1992. The distribution of small odontocete cetaceans off the coasts of South Africa and Namibia. *S. Afr. J. Mar. Sci.* 12: 237-270.

FINDLAY, K.P., BEST, P.B., PEDDEMORS, V.M. AND D. GOVE, 1994. The distribution and abundance of humpback whales on the southern and central Mozambique winter grounds. *Rep Int Whal Commn* **44**: 311-320.

FINDLAY, K.P., MEYER, M., ELWEN, S.H., KOTZE, D., JOHNSON, R., TRUTER, P., UAMUSSE, C., SITOE, S., WILKE, C., KERWATH, S., SWANSSON, S., STAVEREES, L. and J. VAN DER WESTHUIZEN, 2011. Distribution and abundance of humpback whales, *Megaptera novaeangliae*, off the coast of Mozambique. *J Cetacean Resource Manag*., :163–174.

FINDLAY, K.P., SEAKAMELA, S.M., MEŸER, M.A., KIRKMAN, S.P., BARENDSE, J., CADE, HURWITZ, D., KENNEDY, A.S., KOTZE, P.G.H., MCCUE, S.A., THORNTON, M., VARGAS-FONSECA, O.A., & C.G. WILKE, 2017. Humpback whale "super-groups" - A novel low-latitude feeding behaviour of Southern Hemisphere humpback whales (*Megaptera novaeangliae*) in the Benguela Upwelling System. PLoS ONE 12(3): e0172002. doi:10.1371/journal.pone.0172002

FLEMMING, B. and HAY, R., 1988. Sediment distribution and dynamics on the Natal continental shelf. In: *Coastal ocean sciences of Natal, South Africa* (Ed. E.H. SCHUMANN). Springer-Verlag, Berlin., 47-80.

FOELL, E. J., THIEL, H. and G. SCHRIEVER, 1990. DISCOL: A long-term, large-scale disturbance recolonization experiment in the abyssal eastern tropical South Pacific Ocean. *Proc. Offshore Technol. Conf., Houston, OTC*, Paper 6328: 497-503.

FOELL, E.J., THIEL, H. and G. SCHRIEVER, 1992a. DISCOL: A long-term, large-scale, disturbance-recolonization experiment in the abyssal eastern tropical South Pacific Ocean. *Mining Engineering*, January 1992: pp. 90-94.

FOELL, E.J., SCHRIEVER, G., BLUHM, H., BOROWSKI, C., BUSSAU, C. and H. THIEL, 1992b. Disturbance and Recolonization Experiment in the Abyssal South Pacific Ocean (DISCOL): An Update. *Proceedings of the 24th Annual Offshore Technology Conference,Houston, Texas*, May 4-7, 1992, pp. 25-34.

FOSSING, H., FERDELMAN, T.G. and P. BERG, 2000. Sulfate reduction and methane oxidation in continental margin sediments influenced by irrigation (South-East Atlantic off Namibia). *Geochim. Cosmochim. Acta*. **64(5)**: 897–910.

FUGRO, 2020a. Survey Report for cable route design and engineering for 2Africa Cable Route Survey Segment E1.1 (BMH Duynefontein to BU PEZ). South Atlantic to South-east Indian Ocean. Prepared for Alcatel Submarine Networks, November 2020, pp335.

FUGRO, 2020b. Survey Report for cable route design and engineering for 2Africa Cable Route Survey Segment E1.2 (BU PEZ to BU AMZ). South-west Indian Ocean. Prepared for Alcatel Submarine Networks, November 2020, pp94.

FUGRO, 2020c. Survey Report for cable route design and engineering for 2Africa Cable Route Survey Segment E1.3 (BU Amanzimtoti to BU Maputo). West Indian Ocean. Prepared for Alcatel Submarine Networks, November 2020, pp92.

GARRATT, P.A., 1988. Notes on seasonal abundance and spawning of some important offshore linefish in in Natal and Transkei waters, southern Africa *South African Journal of Marine Science* **7**: 1-8

GIHWALA, K., BICCARD, A., CLARK, B.M., BROWN, E.A., MAKHOSONKE, A., SWART, C. & B. TSHINGANA, 2018. De Beers Marine Namibia Environmental Monitoring Programme: Mining-related impacts in mining license area MPT 25-2011 and subsequent recovery. Report prepared for De Beers Marine Namibia by Anchor Environmental Consultants (Pty) Ltd. Report no. 1800/1.

GIHWALA, K., BICCARD, A., CLARK, B.M., BROWN, E.A., MAKHOSONKE, A., SWART, C. & B. TSHINGANA, 2019. Mining-related impacts to soft bottom benthic habitats and associated macrofauna assemblages in mining license area SASA 2C and subsequent recovery. Report prepared for De Beers Group of Companies by Anchor Environmental Consultants (Pty) Ltd. Report no. 1800/1.

GILL, A.E. and SCHUMANN, E.H. 1979. Topographically induced changes in the structure of an inertial jet: Application to the Agulhas Current. *Journal of Physical Oceanography*, **9**: 975-991.

GOODING, S., BLACK, K., BOYDE, P. & S. BOYES, 2012. Environmental Impact of Subsea Trenching Operations, Offshore Site Investigation and Geotechnics: Integrated Technologies - Past, Present, and Future, 12-14 Sept. 2012. Society of Underwater Technology, London, pp. 213–221.

GOODLAD, S.W., 1986. Tectonic and sedimentary history of the mid-Natal Valley (South West Indian Ocean). *Joint GSO/UCT Marine Geoscience Unit Bulletin* **15**: 414 pp.

GOOLD, J. & R. COATES, 2001. Acoustic Monitoring of Marine Wildlife. Seiche.Com Ltd. 182pp.

GOOSEN, A.J.J., GIBBONS, M.J., MCMILLAN, I.K., DALE, D.C. and P.A. WICKENS, 2000. Benthic biological study of the Marshall Fork and Elephant Basin areas off Lüderitz. Prepared by De Beers Marine (Pty) Ltd. for Diamond Fields Namibia, January 2000. 62 pp.

GORDON, J. & A. MOSCROP, 1996. Underwater noise pollution and its significance for whales and dolphins. pp 281-319 In SIMMONDS. M.P. and HUTCHINSON, J.D. (eds.) The conservation of whales and dolphins. John Wiley and Sons, London.

GOSCHEN, W.S. & E.H. SCHUMANN, 1988. Ocean current and temperature structures in Algoa Bay and beyond in November 1986. South African Journal of Marine Science 7: 101–116.

GOSCHEN, W.S. & E.H. SCHUMANN, 1994. An Agulhas Current intrusion into Algoa Bay during August 1988. South African Journal of Marine Science 14: 47–57.

GOSCHEN, W.S. & E.H. SCHUMANN. 1995, Upwelling and the occurrence of cold water around Cape Recife, Algoa Bay, South Africa, *South African Journal of Marine Science*, 16(1): 57-67.

GOSCHEN, W.S., BORNMAN, T.G., DEYZEL, S.H.P. and E.H. SCHUMANN. 2015. Coastal upwellig on the far eastern Agulhas Bank associated with large meanders in the Agulhas Current. Continental Shelf Science, 101: 34-46.

GOSCHEN, W.S., SCHUMANN, E.H., BERNARD, K.S., BAILEY, S.E. and DEYZEL. 2012. Upwelling and ocean structures off Algoa Bay and the south-east coast of South Africa, African Journal of Marine Science, 34:4, 525-536.

GRANNIS, B.M., 2005. Impacts of Mobile Fishing Gear and a Buried Fiber-optic Cable on Soft-sediment Benthic Community Structure. The Graduate School. The University of Maine, p. 73

GRASSMAN, M.A., OWENS, D.W. and J.P.McVEY, 1984. Olfactory-based orientation in artificially imprinted sea turtles. *Science*, **224**: 83-84.

GRAY, J.S. 1974. Animal-sediment relationships. *Oceanography and Marine Biology Annual Reviews* **12**: 223-261.

GRAY, J. S. 1981. The ecology of marine sediments: an introduction to the structure and function of benthic communities. Cambridge University Press, Cambridge.

GREEN, A.N. and C.F. MACKAY, 2016. Unconsolidated sediment distribution patterns in the KwaZulu-Natal Bight, South Africa: the role of wave ravinement in separating relict versus active sediment populations, African Journal of Marine Science, 38:sup1, S65-S74, DOI: 10.2989/1814232X.2016.1145138

GREENWOOD, G., 2013. Population changes and spatial distribution of Indo-pacific humpback dolphins (*Sousa plumbea*) within the Plettenberg Bay area. BSc Honours, Department of Zoology, Faculty of Science, Nelson Mandela Metropolitan University.

GRÉMILLET, D., LEWIS, S., DRAPEAU, L., VAN DER LINGEN, C.D., *et al.* 2008. Spatial match-mismatch in the Benguela upwelling zone:should we expect chlorophyll and seasurface temperature to predict marine predator distributions? *J Appl. Ecol.*, **45**: 610–621

GRIFFITHS, C.L., HOCKEY, P.A.R., VAN ERKOM SCHURINK, C. and P.J.L. ROUX, 1992. Marine invasive aliens on South African shores: implications for community structure and trophic functioning. *South African Journal of marine Science* **12**: 713-722.

GRIFFITHS, C.L. and J.L. SEIDERER, 1980. Rock-lobsters and mussels - limitations and preferences in a predator-prey interaction. J*. Expl Mar. Biol. Ecol*., **44(1)**: 95-109.

GRIFFITHS, M.H., 1987. Aspects of the biology and population dynamics of the geelbek *Atractoscion aequidens* (Curvier) (Pisces: Sciaenidae) off the South African coast. *M.Sc. thesis, Rhodes University, Grahamstown*: 149

GRÜNDLINGH, M.L. 1980. On the volume transport of the Aguhas Current. *Deep-Sea Res*., **27**: 557-563.

GRÜNDLINGH, M.L. 1987. On the seasonal temperature variation in the southwestern Indian Ocean. *S. Afr. Geogr. J*., **69 (2)**: 129-139.

GRÜNDLINGH, M. 1988. Review of cyclonic eddies of the Moçambique Ridge Current. *South African Journal of Marine Science*, 6: 193–206.

GUASTELLA, L.A. and M.J. ROBERTS, 2016. Dynamics and role of the Durban cyclonic eddy in the KwaZulu-Natal Bight ecosystem, *African Journal of Marine Science*, 38:sup1, S23-S42, DOI: 10.2989/1814232X.2016.1159982

GUBILI, C., JOHNSON, R., GENNARI, E., OOSTHUIZEN, W.H., KOTZE, D., MEYER, M., SIMS, D.W., JONES, C.S., NOBLE, L.R., 2009. Concordance of genetic and fin photo identification in the great white shark, *Carcharodon carcharias*, off Mossel Bay, South Africa. *Marine Biology*, **156 (10)**: 2199-2207.

HALL, S.J., 1994. Physical disturbance and marine benthic communities: life in unconsolidated sediments. *Oceanography and Marine Biology: An Annual Review*, **32**: 179-239.

HALL, S.J. and M.J.C. HARDING, 1997. Physical disturbance and marine benthic communities: the effects of mechanical harvesting of cockles on non-target benthic infauna. *J. Appl. Ecol*., **34**: 497– 517.

HANSEN, S., WARD, P. & A. PENNEY, 2013. Identification of vulnerable benthic taxa in the western SPRFMO Convention Area and review of move-on rules for different gear types. La Jolla, United States of America.

HARRIS, L.R., 2012. An ecosystem-based patial conservation plan for the South African sandy beaches. Published PhD Thesis, Nelson Mandela University, Port Elizabeth.

HARRIS, L.R., NEL, R., OOSTHUIZEN, H., MEŸER, M., KOTZE, D., ANDERS, D., MCCUE, S. & S. BACHOO, 2018. Managing conflict between economic activities and threatened migratory species toward creating a multiobjective blue economy. *Conservation Biology,* 32(2): 411-423.

HARRIS, L.R., SINK, K.J., HOLNESS, S.D., KIRKMAN, S.P. AND A. DRIVER, 2020. National Coastal and Marine Spatial Biodiversity Plan, Version 1.0 (Beta 2): Technical Report. South African National Biodiversity Institute, South Africa. 105 pp.

HARRISON, P., 1978. Cory's Shearwater in the Indian Ocean. *Cormorant*. **5**: 19-20.

HASTIE, G.D., WILSON, B., TUFFT, L.H. & P.M. THOMPSON, 2003. Bottlenose dolphins increase breathing synchrony in response to boat traffic. *Marine Mammal Science* 19: 74-84.

HAWKINS, S.J. and R.G. HARTNOLL, 1983. Grazing of intertidal algae by marine invertebrates. *Oceanogr. Mar. Biol. Ann. Rev.*, **21**: 195-282.

HAYS, G.C. HOUGHTON, J.D.R., ISAACS, C. KING, R.S. LLOYD, C. and P. LOVELL, 2004. First records of oceanic dive profiles for leatherback turtles, *Dermochelys coriacea*, indicate behavioural plasticity associated with long-distance migration. *Animal Behaviour,* **67**: 733-743.

HEATH, J., 2001. Benign use of the seabed by telecommunications cables. AP11 from Copenhagen Plenary, pp6.

HERRMANN, C., KRAUSE, J. Chr., TSOUPIKOVA, N. and K. HANSEN, 1999. Marine Sediment extraction in the Baltic Sea. Status Report. Baltic Sea Env. Proc., 76. 29 pp.

HEYDORN, H.J. 1989. Estuaries of the Cape, Part II: Synopses of available information on individual systems. Report No. 39: Quko (CSE 56). HEYDORN, A.E.F. and MORANT, P.D. (eds). Stellenbosch, CSIR Research Report 437, 66pp.

HEYDORN, A.E.F., BANG, N.D., PEARCE, A.F., FLEMMING, B.W., CARTER, R.A., SCHLEYER, M.H., BERRY, P.F., HUGHES, G.R., BASS, A.J., WALLACE, J.H. VAN DER ELST, R.P., CRAWFORD, R.J.M. AND SHELTON, P.A. 1978. Ecology of the Agulhas Current region: an assessmnet of biological responses to environmental parameters in the south- west Indian ocean. *Trans. roy. Soc. S. Afr*., **43(2)** : 151-190.

HEYDORN, A.E.F. and TINLEY, K.L. 1980. Estuaries of the Cape, Part I. Synopsis of the Cape coast. Natural features, dynamics and utilization. Stellenbosch, CSIR Research Report 380, 97 pp.

HUECKEL, G.J., BUCKLEY, R.M. and B.L. BENSON, 1989. Mitigating rocky habitat loss using artificial reefs. *Bulletin of Marine Science* **44**: 913-922.

HOCKEY, P.A.R. and C. VAN ERKOM SCHURINK, 1992. The invasive biology of the mussel *Mytilus galloprovincialis* on the southern African coast. *Transactions of the Royal Society of South Africa* **48**: 123-139.

HOCKEY, P.A.R, DEAN, W.R.J. & P.G. RYAN, 2005. Roberts Birds of Southern Africa: 7th edition. John Voelker Bird Book Fund.

HOFMEYR, G.J.G., DU TOIT, M. and SP KIRKMAN, 2011. Early post-release survival of stranded Cape fur seal pups at Black Rocks, Algoa Bay, South Africa, African Journal of Marine Science, 33:3, 463-468, DOI: 10.2989/1814232X.2011.637352

HOGG, M.M., TENDAL, O.S., CONWAY, K.W., POMPONI, S.A., VAN SOEST, R.W.M., GUTT, J., KRAUTTER, M. & J.M. ROBERTS, 2010. Deep-sea sponge grounds: reservoirs of biodiversity. UNEP-WCMC Biodiversity Series No. 32. Cambridge, UK: UNEP-WCMC.

HOVLAND, M., VASSHUS, S., INDREEIDE, A., AUSTDAL, L. and Ø. NILSEN, 2002. Mapping and imaging deep-sea coral reefs off Norway, 1982-2000. *Hydrobiol*. **471**: 13-17.

HOWARD, J.A.E., JARRE, A., CLARK, A.E. and C.L. MOLONEY, 2007. Application of the sequential t-test algorithm or analyzing regime shifts to the southern Benguela ecosystem. *African Journal of Marine Science* 29(3): 437-451.

HUGHES, G.R., 1974a. The sea turtles of south-east Africa I: Status, morphology and distributions. Durban, South Africa: Oceanographic Research Institute.

HUGHES, G.R., 1974b. *The sea turtles of south east Africa*. PhD, University of Natal.

HUGHES, G.R., 1996. Nesting of the Leatherback turtle (*Dermochelys coriacea*) in Tongaland, KwaZulu-Natal, South Africa 1963-1995. *Chelonian Conservation and Biology*, 2, 153 - 158.

HUGHES, G.R., LUSCHI, P., MENCACCI, R. & F. PAPI, 1998. The 7000 km journey of a leatherback turtle tracked by satellite. *Journal of Experimental Marine Biology and Ecology*, **229**: 209 - 217.

HUISAMEN, J., KIRKMAN, S.P., WATSON, L.H., COCKCROFT, V.G., PISTORIUS, P.A., 2011. Recolonisation of the Robberg Peninsula (Plettenberg Bay, South Africa) by Cape fur seals, African Journal of Marine Science, 33:3, 453-461.

HUISAMEN, J., KIRKMAN, S.P., VAN DER LINGEN, C.D., WATSON, L.H., COCKCROFT, V.G., JEWELL, R., PISTORIUS, P.A., 2012. Diet of the Cape fur seal *Arctocephalus pusillus pusillus* at the Robberg Peninsula, Plettenberg Bay, and implications for local fisheries, African Journal of Marine Science, 34:3, 431-441, DOI: 10.2989/1814232X.2012.725524

HUNTER, I.T., 1988. Climate and weather off Natal. In: Coastal ocean sciences of Natal, South Africa (Ed. E.H. Schumann). Springer-Verlag, Berlin, 81-100.

HURME, A.K. and E.J. PULLEN, 1988. Biological effects of marine sand mining and fill placement for beach replenishment: Lessons for other uses. *Mar. Min.*, **7**: 123-136.

HUSEBØ, Å., NØTTESTAD, L., FOSSÅ, J.H., FUREVIK, D.M. & S.B. JØRGENSEN, 2002. Distribution and abundance of fish in deep-sea coral habitats. Hydrobiologia 471: 91–99.

HUTCHINGS, L. 1994. The Agulhas Bank: a synthesis of available information and a brief comparison with other east-coast shelf regions. *S. Afr. J. Sci.*, **90**: 179-185.

HUTCHINGS, L., BECKLEY, L.E., GRIFFITHS, M.H., ROBERTS, M.J., SUNDBY, S. and VAN DER LINGEN C. 2003. Spawning on the edge: spawning grounds and nursery areas around the southern African coastline. *Marine and Freshwater Research* **53**: 307-318.

HUTCHINGS L., NELSON G., HORSTMANN D.A. and R. TARR, 1983. Interactions between coastal plankton and sand mussels along the Cape coast, South Africa. *In: Sandy Beaches as Ecosystems.* Mclachlan A and T E Erasmus (eds). Junk, The Hague. pp 481-500.

IGLESIAS, J.I.P., URRUTIA, M.B., NAVARRO, E., ALVAREZ-JORNA, P., LARRETXEA, X., BOUGRIER, S. and M. HERAL, 1996. Variability of feeding processes in the cockle Cerastoderma edule (L.) in response to changes in seston concentration and composition. J. Exp. Mar. Biol. Ecol., 197: 121–143.

INTERNATIONAL WHALING COMMISSION (IWC), 2012. Report of the Scientific Committee. Annex H: Other Southern Hemisphere Whale Stocks Committee 11–23.

JACKSON, J., RAINVILLE, L., ROBERTS, M., McQUAID, C. & J.R.E. LUTJEHARMS, 2012. Mesoscale bio-physical interactions between the Agulhas Current and the Agulhas Bank, South Africa. *Continental Shelf Research*, 49: 10-24.

JACKSON, L.F. ad S. McGIBBON, 1991. Human activities and factors affecting the distribution of macro-benthic fauna in Saldanha Bay. *S. Afr. J. Aquat. Sci.*, **17**: 89-102.

JARAMILLO, E., MCLACHLAN, A. and J. DUGAN, 1995. Total sample area and estimates of species richness in exposed sandy beaches. *Marine Ecology Progress Series* **119**: 311-314.

JARMAN N.G. and R.A. CARTER, 1981. The primary producers of the inshore regions of the Benguela. *Trans. Roy. Soc. S. Afr.*, **44(3)**: 321-325.

JENSEN, A.S. & G.K. SILBER, 2003. Large whale ship strike database. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-F/OPR 25. 37 pp.

JEPSON, P.D., DEAVILLE, R., ACEVEDO-WHITEHOUSE, K., BARNETT, J., BROWNLOW, A., JR BROWNELL, R.L., CLARE F.C., DAVISON, N., LAW, R.J., LOVERIDGE, J., PENROSE, R., PERKINS, M.W., MACGREGOR, S.K., MORRIS, S., TREGENZA, N.J.C., CUNNINGHAM, A.A., & A. FERNA, 2013. What Caused the UK' s Largest Common Dolphin (*Delphinus delphis*) Mass Stranding Event? PLoS ONE 8(4): e60953. https://doi.org/10.1371/journal.pone.0060953.

JOHNSON, R., BESTER M.N., DUDLEY, S.F.J., OOSTHUIZEN, W.H., MEŸER, M., HANCKE, L. & E. GENNARI, 2009. Coastal swimming patterns of white sharks (*Carcharodon carcharias*) at Mossel Bay, South Africa. *Environ Biol Fish*, **85**: 189–200.

JOHNSSON, A. & S. RAMSTAD, 2004. Seabed Logging Environmental Study: Possible Biological Effects of Electromagnetic Fields on Marine Life. Report to EMGS, Norwegian University of Science and Technology. pp 34

JOINT NATURE CONSERVATION COMMITTEE (JNCC), 2017. JNCC guidelines for minimising the risk of injury to marine mammals from geohysical surveys. August 2017. 28pp.

JURY, M.R. 1994. Meteorology of eastern Agulhas Bank. *S. Afr. J. Sci.,* **90**: 109-113.

JURY, M.R. and DIAB, R., 1989. Wind energy potential in the Cape coastal belt. *S. Afr. Geogr. J.*, **71**: 3-11.

KAISER, M. J., HILL, A. S., RAMSAY, K., SPENCER, B. E., BRAND, A. R., VEALE, L. O., PRUDDEN, K., REES, E. I. S., MUNDAY, B. W., BALL, B. and S. J. HAWKINS, 1996. Benthic disturbance by fishing gear in the Irish Sea: a comparison of beam trawling and scallop dredging. *Aquatic Cons.*, **6**: 269–285.

KARCZMARSKI, L., 1996. Ecological studies of humpback dolphins *Sousa chinensis* in the Algoa Bay region, Eastern Cape, South Africa. University of Port Elizabeth.

KARCZMARSKI, L., COCKCROFT, V.G., McLACHLAN, A., 2000a. Habitat use and preferences of Indo-Pacific humpback dolphins *Sousa chinensis* in Algoa Bay, South Africa. *Marine Mammal Science*, 16(1): 65–79.

KARCZMARSKI, L., THORNTON, M. and V COCKCROFT, 2000b. Daylight occurrence of humpback dolphins *Sousa chinensis* in Algoa Bay, South Africa. *African Journal of Ecology* 38(1): 86 – 90.

KARENYI, N., 2014. Patterns and drivers of benthic macrofauna to support systematic conservation planning for marine unconsolidated sediment. Nelson Mandela Metropolitan University. Port Elizabeth. pp. 249.

KARENYI, N., SINK, K. & R. NEL, 2016., Defining seascapes for marine unconsolidated shelf sediments in an eastern boundary upwelling region: The southern Benguela as a case study. Estuarine, Coastal and Shelf Science 169: 195-206.

KENDALL, M.A. and S. WIDDICOMBE, 1999. Small scale patterns in the structure of macrofaunal assemblages of shallow soft sediments. *Journal of Experimental Marine Biology and Ecology*, **237**:127-140.

KEITH, M., 1999. Population biology of humpback dolphins in Richards Bay, South Africa. Population (English Edition). University of Pretoria.

KENNY, A.J. and H.L. REES, 1994. The effects of marine gravel extraction on the macrobenthos: Early post-dredging recolonisation. *Mar. Pollut. Bull*., **28**: 442-447.

KENNY, A.J. and H.L. REES, 1996. The effects of marine gravel extraction on the macrobenthos: results 2 years postdredging. *Mar. Pollut. Bull*., **32**: 615–622.

KENNY, A.J., REES, H.L., GREENING, J. and S. CAMPBELL, 1998. The effects of marine gravel extraction on the macrobenthos at an experimental dredge site off north Norfolk, U.K. (Results 3 years post-dredging). *ICES CM 1998/V*:14, pp. 1-8.

KINOSHITA, I. and S. FUJITA, 1988. Larvae and juveniles of blue drum, *Nibea mitsukurii*, occurring in the surf zone of Tosa Bay, Japan. *Jap. J. Ichthyology*, **35**: 25-30.

KIRKMAN, S.P. MEŸER, M.A. & M. THORNTON, 2010. False killer whale *Pseudorca crassidens* mass stranding at Long Beach on South Africa's Cape Peninsula, 2009, African Journal of Marine Science, 32(1): 167-170.

KIRKMAN, S.P., OOSTHUIZEN, W.H., MEŸER, M.A., SEAKAMELA, S.M., UNDERHILL, L.G., 2011. Prioritising range-wide scientific monitoring of the Cape fur seal in southern Africa. In: KIRKMAN, S., ELWEN, S.H., PISTORIUS, P.A., THORNTON, M., WEIR, C.R., (eds), Conservation biology of marine mammals in the southern African subregion. *African Journal of Marine Science* **33**: 495–509.

KIRKMAN, S.P., YEMANE, D., OOSTHUIZEN, W.H., MEYER, M.A., KOTZE, P.G.H., SKRYPZECK, H., VAZ VELHO, F., UNDERHILL, L.G., 2013. Spatio-temporal shifts of the dynamic Cape fur seal population in southern Africa, based on aerial censuses (1972-2009). *Marine Mammal Science* **29**: 497-524.

KOCH, A. & R. JOHNSON, 2006. White Shark abundance: not a causative factor in numbers of shark bite incidents. In NEL, D.C. & T.P. PESCHAK (eds) Finding a balance: White shark conservation and recreational safety in the inshore waters of Cape Town, South Africa; proceedings of a specialist workshop. WWF South Africa Report Series - 2006/Marine/001.

KOGAN, I., PAULL, C.K., KUHNZ, L.A., BURTON, E.J., VON THUN, S., GARY GREENE, H. & J.P. BARRY, 2006. ATOC/Pioneer Seamount cable after 8 years on the seafloor: observations, environmental impact. Continent. Shelf Res., 26: 771–787.

KOPER, R.P and S. PLÖN, 2012. The potential impacts of anthropogenic noise on marine animals and recommendations for research in South Africa. EWT Research & Technical Paper No. 1. Endangered

Wildlife Trust, South Africa.KRAUS, C. & L. CARTER, 2018. Seabed recovery following protective burial of subsea cables – Observations from the continental margin. Ocean Engineering, 157: 251-261.

KOPER, R.P., KARCZMARSKI, L., DU PREES, D., PLÖN S., 2016. Sixteen years later: Occurrence, group sizes, and habitat use of humpback dolphins (*Sousa plumbea*) in Algoa Bay, South Africa.

KRIEGER, K.J. & B.L. WING, 2002. Megafauna associations with deepwater corals (Primnoa spp.) in the Gulf of Alaska. Hydrobiologia 471: 83–90.

KRUG, M., TOURNADRE, J. & F. DUFOIS, 2014. Interactions between the Agulhas Current and the eastern margin of the Agulhas Bank. *Continental Shelf Research*, 81: 67-79.

KUHNZ, L.A., BUCK, K., LOVERA, C., WHALING, P.J. & J.P. BARRY, 2015. Potential Impacts of the Monterey Accelerated Research System (MARS) Cable on the Seabed and Benthic Faunal Assemblages. MARS Biological Survey Report. Monterey Bay Aquarium Research Institute, pp33.

LAIRD, M. and C.L. GRIFFITHS, 2008. Present distribution and abundance of the introduced barnacle Balanus glandula Darwin in South Africa. *African Journal of Marine Science* **30**: 93-100.

LAIST, D. W., KNOWLTON, A. R., MEAD, J. G., COLLET, A. S. & M. PODESTA, 2001. Collisions between ships and whales. *Mar. Mamm. Sci.* 17, 35–75.

LAMBARDI, P., LUTJEHARMS, J.R.E., MENACCI, R., HAYS, G.C. and P. LUSCHI, 2008. Influence of ocean currents on long-distance movement of leatherback sea turtles in the Southwest Indian Ocean. *Marine Ecology Progress Series*, **353**: 289–301.

LAMBERTH, S.J., DRAPEAU, L & G.M. BRANCH, 2009. The effects of altered freshwater inflows on catch rates of non-estuarine-dependent fish in a multispecies nearshore linefishery. *Estuarine, Coastal and Shelf Science* **84**: 527–538.

LANE, S.B. and R.A. CARTER, 1999. *Generic Environmental Management Programme for Marine Diamond MIning off the West Coast of South Africa*. Marine Diamond Mines Association, Cape Town, South Africa. 6 Volumes.

LANGE, L., 2012. Use of demersal bycatch data to determine the distribution of soft-bottom assemblages off the West and South Coasts of South Africa. PhD thesis, University of Cape Town.

LARGIER, J.L., CHAPMAN, P., PETERSON, W.T. & V.P. SWART, 1992. The western Agulhas Bank: Circulation stratification and ecology. South African Journal of Marine Science, 12(1): 319–339.

LARGIER, J.L. and SWART, V.P. 1987. East-west variation in thermocline breakdown on the Agulhas Bank. In: The Benguela and Comparable Ecosystems, PAYNE, A.I.L., GULLAND, J.A. and BRINK, K.H. (Eds.), *S. Afr. J. mar. Sci.*, **5**: 263-272.

LASIAK, T.A. 1981. Nursery grounds of juvenile teleosts: evidence from surf zone of King's beach, Port Elizabeth. *S. Afr. J. Sci.*, **77**: 388-390.

LAURET-STEPLER, M., BOURJEA, J., ROOS, D., PELLETIER, D., RYAN, P., CICCIONE, S. and H. GRIZEL, 2007. Reproductive seasonality and trend of Chelonia mydas in the SW Indian Ocean: a 20 yr study based on track counts. *Endangered Species Research,* 3**,** 217-227.

LEVITT, G.J., ANDERSON, R.J., BOOTHROYD, C.J.T. and F.A. KEMP, 2002. The effects of kelp harvesting on its regrowth and the understorey benthic community at Danger Point, South Africa, and a new method of harvesting kelp fronds. *South African Journal of Marine Science* **24**: 71-85.

LI, B. & D. LEWIS, 2020. TEPSA Block South Outeniqua Seismic and Sonar Surveys: Sound Transmission Loss Modelling. Prepared by SLR Consulting Australia Pty Ltd for SLR Cosulting (Cape Town) on behalf of Total Exploration and Production B.V. pp61.

LIPINSKI, M.R., 1992. Cephalopods and the Benguela ecosystem: trophic relationships and impacts. *S. Afr. J. Mar. Sci.,* 12 : 791-802.

LITTLER, M.M., MARTZ, D.R. and D.S. LITTLER, 1983. Effects of recurrent sand deposition on rocky intertidal organisms: importance of substrate heterogeneity in a fluctuating environment. *Mar. Ecol. Prog. Ser*., **11**: 129-139.

LIVERSIDGE, R. and LE GRAS, G.M. 1981. Observations of seabirds off the eastern Cape, South Africa, 1953-1963. In: *Proceedings of the symposium on birds of the sea and shore, 1979*. COOPER, J. (Ed.). 149-167.

LOMBARD, A.T., STRAUSS, T., HARRIS, J., SINK, K., ATTWOOD, C. and L. HUTCHINGS, 2004. *National Spatial Biodiversity Assessment 2004: South African Technical Report Volume 4: Marine Component.*

LOHMANN, K. J., LOHMANN, C. M. & PUTMAN, N. F. 2007. Magnetic maps in animals: nature's GPS. *Journal of Experimental Biology,* 210**,** 3697-3705.

LOPEZ-JAMAR, E., FRANCESCH, O., DORRÍO, A.V. and S. PARRA, 1995. Long-term variation of the infaunal benthos of La Coruña Bay (NW Spain): results from a 12-year study (1982-1993). *Sci. Mar.*, **59**: 49-61.

LUDYNIA, K., 2007. *Identification and characterisation of foraging areas of seabirds in upwelling systems: biological and hydrographic implications for foraging at sea*. PhD thesis,

LURTON, X., 2015. Modelling of the sound field radiated by multibeam echosounders for acoustical impact assessment. Applied Acoustics, 101: 201-221.

LURTON, X. & S. DERUITER, 2011. Sound radiation of seafloor-mapping echosounders in the water column, in relation to the risks posed to marine mammals. Int. Hydrogr. Rev., 6: 7–18.

LUSCHI, P., HAYS, G. C. & F. PAPI, 2003b. A review of long-distance movements by marine turtles, and the possible role of ocean currents. *Oikos,* 103**,** 293 – 302.

LUSCHI, P., LUTJEHARMS, J. R. E., LAMBARDI, P., MENCACCI, R., HUGHES, G. R. & G. C. HAYS, 2006. A review of migratory behaviour of sea turtles off southeastern Africa. *South African Journal of Science,* 102**,** 51 - 57.

LUSCHI, P., SALE, A., MENCACCI, R., HUGHES, G. R., LUTJEHARMS, J. R. E. & F. PAPI, 2003a. Current transport of leatherback sea turtles (*Dermochelys coriacea*) in the ocean. *Proceedings of the Royal Society: Biolgical Sciences,* 270**,** 129 - 132.

LUSSEAU, D., 2004. The hidden cost of tourism: Effects of interactions with tour boats on the behavioral budget of two populations of bottlenose dolphins in Fiordland, New Zealand. Ecology and Society 9 (1): Part. 2.

LUSSEAU, D., 2005. Residency pattern of bottlenose dolphins *Tursiops* spp. in Milford Sound, New Zealand, is related to boat traffic. Marine Ecology Progress Series 295: 265-272.

LUSSEAU, D., BAIN, D.E., WILLIAMS, R. & J.C. SMITH, 2009. Vessel traffic disrupts the foraging behavior of southern resident killer whales *Orcinus orca*. *Endangered Species Research* 6: 211-221.

LUTJEHARMS, J.R.E., 2006. *The Agulhas Current*. Springer Verlag, 314pp.

LUTJEHARMS, J.R.E., GRÜNDLINGH, M.L. & R.A. CARTER, 1989. Topographically induced upwelling in the Natal Bight. *S. Afr. J. Sci.*, **85 (5)**: 310-316.

LUTJEHARMS, J.R.E. & H.R. ROBERTS, 1988. The Agulhas Pulse: an extreme transient on the Agulhas Current. *Journal of Geophysical Research*, **93**: 631-45.

LUTJEHARMS, J.R.E, VALENTINE, H.R. & R.C. VAN BALLEGOOYEN, 2000a. The hydrography and water masses of the Natal Bight, South Africa. *Continental Shelf Research*, **20**: 1907-39.

LUTJEHARMS J.R.E., COOPER, J. & M. ROBERTS, 2000b. Dynamic upwelling at the inshore edge of the Agulhas Current. *Continental Shelf Research*, **20**: 737761.

MacISSAC, K., BOURBONNAIS, C., KENCHINGTON, E.D., GORDON JR. and S. GASS, 2001. Observations on the occurrence and habitat preference of corals in Atlantic Canada. *In:* (eds.) J.H.M. WILLISON, J. HALL, S.E. GASS, E.L.R. KENCHINGTON, M. BUTLER, and P. DOHERTY. Proceedings of the First International Symposium on Deep-Sea Corals. Ecology Action Centre and Nova Scotia Museum, Halifax, Nova Scotia.

MACLEOD, A.K., STANLEY, M.S., DAY, J. G. & E.J. COOK, 2016. Biofouling community composition across a range of environmental conditions and geographical locations suitable for floating marine renewable energy generation. *Biofouling,* 32(3), 261-276.

MacLEOD, C.D. and A. D'AMICO, 2006. A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. *Journal of Cetacean Research and Management* **7(3)**: 211–221.

MacPHERSON, E. and A. GORDOA, 1992. Trends in the demersal fish community off Namibia from 1983 to 1990. *South African Journal of Marine Science* **12**: 635-649.

MAJIEDT, P., HOLNESS, S., SINK, K., OOSTHUIZEN, A. and P. CHADWICK, 2013. Systematic Marine Biodiversity Plan for the West Coast of South Africa. South African National Biodiversity Institute, Cape Town. Pp 46.

MALAN, N., BACKEBERG, B., BIASTOCH, A., DURGADOO, J.V. SAMUELSEN, A., REASON, C. and J. HERMES, 2018. Agulhas Current meanders facilitate shelf-slope exchange on the eastern Agulhas Bank. JGR Oceans, 123(7): 4762-4778.

MARSHALL, D.J. and C.D. McQUAID, 1993. Differential physiological and behavioural responses of the intertidal mussels, *Choromytilus meridionalis* (Kr.) and *Perna perna* L., to exposure to hypoxia and air: a basis for spatial separation. *J. Exp. Mar. Biol. Ecol.*, **171**: 225-237.

MARTIN, A.K. and FLEMMING, B.W. 1988. Physiography, structure and geological evolution of the Natal continental shelf. In: *Coastal ocean sciences of Natal, South Africa* (Ed. E.H. Schumann). Springer-Verlag, Berlin., 11-46.

MATE, B.R., BEST, P.B., LAGERQUIST, B.A. and M.H. WINSOR, 2011. Coastal, offshore and migratory movements of South African right whales revealed by satellite telemetry. *Marine Mammal Science*, **27(3)**: 455-476.

MATE, B.R., LAGERQUIST, B.A., WINDSOR, M., GERACI, J. and J.H. PRESCOTT, 2005. Movements and dive habits of a satellite-monitoring longfinned pilot whales (*Globicephala melas*) in the northwet Atlantic. *Marine Mammal Science* **21(10)**: 136-144.

MATTHEWS, S.G. and G.C. PITCHER, 1996. Worst recorded marine mortality on the South African coast. In: YASUMOTO, T, OSHIMA, Y. and Y. FUKUYO (Eds), *Harmful and Toxic Algal Blooms*. Intergovernmental Oceanographic Commission of UNESCO, pp 89-92.

MAURER, D.L., LEATHEM, W., KINNER, P. and J. TINSMAN, 1979. Seasonal fluctuations in coastal benthic invertebrate assemblages. *Est. Coast. Shelf Sci*., **8**: 181-193.

MAYFIELD, S., 1998. Assessment of predation by the West Coast rock lobster (*Jasus lalandii*): relationships among growth rate, diet and benthic community composition, with implications for the survival of juvenile abalone (*Haliotis midae*) Unpusblished PhD Thesis, University of Cape Town

MAYFIELD, S., BRANCH, G.M. and A.C. COCKCROFT, 2000. Relationships among diet, growth rate and food availability for the South African rock lobster, *Jasus lalandii*. *Crustaceana* **73(7)**: 815–834.

McCAULEY, R.D. 1994. Seismic surveys. In: Swan, J.M., Neff, J.M., Young, P.C. (Eds.). Environmental implications of offshore oil and gas development in Australia - The findings of an Independent Scientific Review. APEA, Sydney, Australia, 695 pp.

McLACHLAN, A., 1980. The definition of sandy beaches in relation to exposure: a simple rating system. *S. Afr. J. Sci*., **76**: 137-138.

McLACHLAN, A., JARAMILLO, E., DONN, T.E. and F. WESSELS. 1993. Sandy beach macrofauna communities and their control by the physical environment: a geographical comparison. *Journal of coastal Research, Special Issue*, **15**: 27-38.

McQUAID, C.D. and G.M. BRANCH, 1985. Trophic structure of rocky intertidal communities: response to wave action and implications for energy flow. *Mar. Ecol. Prog. Ser.,* **22**: 153-161.

McQUAID, C.D. and K.M. DOWER, 1990. Enhancement of habitat heterogeneity and species richness on rocky shores inundated by sand. *Oecologia* **84**: 142-144.

MEIßNER, K., SCHABELON, H., BELLEBAUM, J. & H. SORDYL, 2006. Impacts of submarine cables on the marine environment - a literature review. Institut für Angewandte Okosystemforschung, Neu Broderstorf 88. Germany.

MELLY, B., 2011. The zoogeography of the cetaceans in Algoa Bay. Rhodes University. Retrieved from http://eprints.ru.ac.za/2489/1/MELLY-MSc-TR11-.pdf

MILLER, D.C. and R.W. STERNBERG, 1988. Field measurements of the fluid and sediment dynamic environment of a benthic deposit feeder. *J. Mar. Res*., **46**: 771-796.

MITCHELL-INNES, B.A. and D.R. WALKER. 1991. Short-term variability during an Anchor Station study in the southern Benguela upwelling system. Phytoplankton production and biomass in relation to species changes. *Prog. Oceanogr*., **28**: 65-89.

MODDE, T. 1980. Growth and residency of juvenile fishes within a surf zone habitat in the Gulf of Mexico. *Gulf Research Reports*, **6**: 377-385.

MOLDAN, A.G.S., 1978. A study of the effects of dredging on the benthic macrofauna in Saldanha Bay. *South African Journal of Science*, **74**: 106-108.

MONTEIRO, P.M.S. and A.K. VAN DER PLAS, 2006. Low Oxygen Water (LOW) variability in the Benguela System: Key processes and forcing scales relevant to forecasting. In: SHANNON, V., HEMPEL, G., MALANOTTE-RIZZOLI, P., MOLONEY, C. and J. WOODS (Eds). *Large Marine Ecosystems*, Vol. 15, pp 91-109.

MORTIMER, J., 1984. Marine Turtles in the Republic of the Seychelles: Status and Management Report on Project 1809 (1981-1984). International Union for Conservation of Nature and Natural Resources World Wildlife Fund.

MORTON, J.W., 1977. Ecological effects of dredging and dredge disposal: a literature review. Tech. Papers. *U.S. Fish Wildl. Serv.*, **94**: 1-33.

MOSTERT, B.P., BICCARD, A., DUNA, O. & B.M. CLARK, 2016. Baseline survey of the benthic marine environment in the South African diamond mining Concession areas 1B and 1C. Report prepared for Alexkor and Placer Resource Management by Anchor Environmental Consultants, Report No. 1696/1

MUIR, D., KUNNEN, T. and U.M. SCHARLER, 2016. A seasonal comparison of prokaryote numbers, biomass and heterotrophic productivity in waters of the KwaZulu-Natal Bight, South Africa. In: Roberts MJ, Fennessy ST, Barlow RG (eds), Ecosystem processes in the KwaZulu-Natal Bight. *African Journal of Marine Science* 38(Supplement): S123–S138.

NATOLI, A., PEDDEMORS, V.M. & A.R. HOELZEL, 2008. Population structure of bottlenose dolphins (*Tursiops aduncus*) impacted by bycatch along the east coast of South Africa. *Conservation Genetics* **9**: 627–636.

NEL, P., 2001. Physical and biological factors structuring sandy beach macrofauna communities. PhD Thesis, University of Cape Town, Cape Town, South Africa: pp 202

NEL, R. 2010. Sea turtles of KwaZulu-Natal: Data report for the 2009/10 season. *In:* HUGHES, G. R. & BACHOO, S. (eds.). Ezemvelo.

NEL, R., PUNT, A.E. and G.R. HUGHES, 2013. Are coastal protected areas always effective in achieving population recovery for nesting sea turtles? *PloS one*, 8, e63525.

NEL, R. and A. PULFRICH, 2002. An assessment of the impacts of beach mining operations on beach macrofaunal communities between the Sout River and Olifants River mouth. Pisces Environmental Services (Pty) Ltd. Report to Trans Hex Operations (Pty) Ltd. September 2002, 38pp.

NEL, P., PULFRICH, A. and A.J. PENNEY, 2003. Impacts of beach mining operations on sandy beach macrofaunal communities on the beaches of Geelwal Karoo, Report by Pisces Environmental Services (Pty) Ltd prepared for Trans Hex Operations (Pty) Ltd, Cape Town.

NELSON, G., 1989. Poleward motion in the Benguela area. In: Poleward Flows along Eastern Ocean Boundaries. NESHYBA *et al.* (eds) New York; Springer: 110-130 (Coastal and Estuarine Studies 34).

NELSON G. and L. HUTCHINGS, 1983. The Benguela upwelling area. *Prog. Oceanogr.*, 12: 333-356.

NEWELL, R.C., SEIDERER, L.J. and D.R. HITCHCOCK, 1998. The impact of dredging work in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. *Oceanogr. Mar. Biol. Ann. Rev.*, **36**: 127–178.

NEWMAN, G.G. and D.E. POLLOCK, 1971. Biology and migration of rock lobster *Jasus lalandii* and their effect on availability at Elands Bay, South Africa. *Investl. Rep. Div. Sea Fish. S. Afr.*, **94**: 1-24.

NOAA, 2005. Final Environmental Analysis of Remediation Alternatives for the Pacific Crossing-1 North and East Submarine Fiber-optic Cables in the Olympic Coast National Marine Sanctuary. National Oceanographic and Atmospheric Administration, 77 pp plus appendix. http://sanctuaries.noaa.gov/library/alldocs.html

NRC, 2003. Ocean noise and marine mammals. National Academy Press, Washington, DC.

O'DONOGHUE, S.H., WHITTINGTON, P.A., DYER, B.M. & V.M. PEDDEMORS, 2010. Abundance and distribution of avian and marine mammal predators of sardine observed during the 2005 KwaZulu-Natal sardine run survey. *African Journal of Marine Science* **32**: 361–374.

OLIFF, W.D. 1973. Chemistry and productivity at Richards Bay. CSIR/NPRC Oceanography Division Contract Report CFIS 37B. Durban, South Africa.

OOSTHUIZEN W.H., 1991. General movements of South African (Cape) fur seals *Arctocephalus pusillus pusillus* from analysis of recoveries of tagged animals. *S. Afr. J. Mar. Sci.*, **11**: 21-30.

PANIGADA, S., PESANTE, G., ZANARDELLI, M., CAPOULADE, F., GANNIER, A. & M.T. WEINRICH, 2006. Mediterranean fin whales at risk from fatal ship strikes. *Marine Pollution Bulletin* 52 (10): 1287-98.

PAPI, F., LUSCHI, P., AKESSON, S., CAPOGROSSI, S. & G. HAYS, 2000. Open-sea migration of magnetically disturbed sea turtles. *Journal of Experimental Biology*, **203**: 3435-3443.

PARDINI, A.T., JONES, C.S., NOBLE, L.R., KREISER, B., MALCOLM, H., BRUCE, B.D., STEVENS, J.D., CLIFF, G., SCHOLL, M.C., FRANCIS, M., DUFFY, C.A.J. and MARTIN, A.P., 2001. Sex-biased dispersal of great white sharks. *Nature* **412**: 139 – 140.

PARKER, S.J., PENNEY, A.J. & M.R. CLARK, 2009. Detection criteria for managing trawl impacts on vulnerable marine ecosystems in high seas fisheries of the South Pacific Ocean. Marine Ecology Progress Series 397: 309–317.

PARKINS, C.A. and J. G. FIELD, 1997. A baseline study of the benthic communities of the unmined sediments of the De Beers Marine SASA Grid. Unpublished Report to De Beers Marine, October 1997, pp 29.

PARKINS, C.A. and J.G.FIELD, 1998. The effects of deep sea diamond mining on the benthic community structure of the Atlantic 1 Mining Licence Area. Annual Monitoring Report – 1997. Prepared for De Beers Marine (Pty) Ltd by Marine Biology Research Institute, Zoology Department, University of Cape Town. pp. 44.

PARRY, D.M., KENDALL, M.A., PILGRIM, D.A. and M.B. JONES, 2003. Identification of patch structure within marine benthic landscapes using a remotely operated vehicle. *J. Exp. Mar. Biol. Ecol.,* **285– 286**: 497–511.

PAYNE, A.I.L. and R.J.M. CRAWFORD, 1989. *Oceans of Life off Southern Africa.* Vlaeberg, Cape Town, 380 pp.

PEARCE, A.F. 1977. The shelf circulation off the east coast of South Africa. *CSIR Professional Research Series*, **1**, 220 pp.

PEARCE, A.F., SCHUMANN, E.H. and LUNDIE, G.S.H. 1978. Features of the shelf circulation off the Natal Coast. *S. Afr. J. Sci.*, **74**: 328-331.

PEDDEMORS, V.M., ATKINS S. & W.H. OOSTHUIZEN, 2004. *Sousa plumbea*-Indian Ocean Humpback Dolphin. Pages 660-661. In: FRIEDMANN Y. & B. DALY eds. *Red Data Book of the Mammals of South Africa: A Conservation Assessment.* CBSG Southern Africa, Conservation Breeding Specialist Group (SSC/IUCN), Endangered Wildlife Trust, South Africa.

PEDDEMORS, V.M. & W.H. OOSTHUIZEN, 2004. *Tursiops aduncus*- Indian Ocean Bottlenose Dolphin. Pages 666-667. In: FRIEDMANN Y. & B. DALY eds. *Red Data Book of the Mammals of South Africa: A Conservation Assessment.* CBSG Southern Africa, Conservation Breeding Specialist Group (SSC/IUCN), Endangered Wildlife Trust, South Africa.

PEETERS, F.J., ACHESON, R., BRUMMER, G-JA., DE RUIJTER, W.P., SCHNEIDER, R.R., GANSSEN, G.M., UFKES, E. & D. KROON, 2004. Vigorous exchange between the Indian and Atlantic oceans at the end of the past five glacial periods. *Nature* 430: 661.

PENNEY, A.J., KROHN, R.G. and C.G. WILKE. 1992. A description of the South African tuna fishery in the southern Atlantic Ocean. *ICCAT Col. Vol. Sci. Pap.* XXIX(1) : 247-253.

PENNEY, A.J., PULFRICH, A., ROGERS, J., STEFFANI, N. and V. MABILLE, 2007. *Project: BEHP/CEA/03/02: Data Gathering and Gap Analysis for Assessment of Cumulative Effects of Marine Diamond Mining Activities on the BCLME Region.* Final Report to the BCLME mining and petroleum activities task group. December 2007. 410pp.

PENRY, G.S., 2010. *Biology of South African Bryde's whales*. PhD Thesis. University of St Andrews, Scotland, UK.

PENRY, G.S., COCKCROFT, V.G., HAMMOND, P.S., 2011. Seasonal fluctuations in occurrence of inshore Bryde's whales in Plettenberg Bay, South Africa, with notes on feeding and multispecies associations, African Journal of Marine Science, 33/3: 403-414.

PENRY, G., FINDLAY, K., BEST, P., 2016. A Conservation Assessment of Balaenoptera edeni. In: M.F. CHILD, L. ROXBURGH, D. RAIMONDO, E. DO LINH SAN, J. SELIER AND H. DAVIES-MOSTERT (eds), The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

PENVEN, P., LUTJEHARMS, J.R.E., MARCHESIELLO, P., WEEKS, S.J. and C. ROY, 2001. Generation of cyclonic eddies by the Agulhas Current in the lee of the Agulhas Bank. *Geophys. Res. Lett.*, **26**: 1055-1058.

PEREIRA, M. A. M., VIDEIRA, E. J. S. & LOURO, C. M. M. 2008. Sea turtles of Mozambique: Report. *In:* PEREIRA, M. A. M. (ed.). Cabo Delgado Biodiversity and Tourism.

PERRY, C., 1998. A review of the impacts of anthropogenic noise on cetaceans. Document SC/50/E9 submitted to the scientific committee of the International Whaling Commission, Muscat, Oman, 1998. 28 pp + 8 pp appendices.

PERRY, J., 2005. Environmental Impact Assessment for Offshore Drilling the Falkland Islands to Desire Petroleum Plc. 186pp.

PETERS, I.T, BEST, P.B. & M. THORNTON, 2005. Abundance Estimates of Right Whales on a Feeding Ground off the West Coast of South Africa. Paper SC/S11/RW11. Submitted to the International Whaling Commission.

PETERSON, C.H., LANEY, W. & T. RICE, 2001. Biological impacts of beach nourishment. Workshop on the Science of Beach Renourishment, May 7-8, 2001. Pine Knoll Shores, North Carolina.

PETERSON, C.H., HICKERSON, D.H.M. and G.G. JOHNSON, 2000. Short-Term Consequences of Nourishment and Bulldozing on the Dominant Large Invertebrates of a Sandy Beach. *J. Coast. Res.*, **16(2)**: 368-378.

PETERSON, W.T., HUTCHINGS, L., HUGGETT, J.A. and LARGIER, J.L. 1992. Anchovy spawning in relation to the biomass and the replenishment rate of their copepod prey on the western Agulhas Bank. In: Benguela Trophic Functioning. PAYNE, A.I.L., BRINK, K.H., MANN, K.H. and HILBORN, R. (Eds.). *S. Afr. J. mar. Sci.*, **12**: 487-500.

PHAM, C.K., VANDEPERRE, F., MENEZES, G., PORTEIRO, F., ISIDRO, E. & T. MORATO, 2015. The importance of deep-sea vulnerable marine ecosystems for demersal fish in the Azores. Deep-Sea Research Part I: Oceanographic Research Papers 96: 80–88.

PIDCOCK, S., BURTON, C. and M. LUNNEY, 2003. The potential sensitivity of marine mammals to mining and exploration in the Great Australian Bight Marine Park Marine Mammal Protection Zone. An independent review and risk assessment report to Environment Australia. Marine Conservation Branch. Environment Australia, Canberra, Australia. pp. 85.

PILE, A.J. & C.M. YOUNG, 2006. The natural diet of a hexactinellid sponge: benthic--pelagic coupling in a deep-sea microbial food web. Deep Sea Research Part I: Oceanographic Research Papers 53: 1148-1156.

PILLAR, S.C., 1986. Temporal and spatial variations in copepod and euphausid biomass off the southern and and south-western coasts of South Africa in 1977/78. *S. Afr. J. mar. Sci*., **4**: 219-229.

PILLAR, S.C., BARANGE, M. and L. HUTCHINGS, 1991. Influence of the frontal sydtem on the cross-shelf distribution of Euphausia lucens and Euphausia recurva (Euphausiacea) in the Southern Benguela System. *S. Afr. J. mar. Sci*., **11** : 475-481.

PITCHER, G.C., 1998. *Harmful algal blooms of the Benguela Current*. IOC, World Bank and Sea Fisheries Research Institute Publication. 20 pp.

PITCHER, G.C. and D. CALDER, 2000. Harmful algal blooms of the southern Benguela Current: a review and appraisal of monitoring from 1989 to 1997. *South African Journal of Marine Science* **22**: 255-271.

PLÖN, S., 2004. The status and natural history of pygmy (*Kogia breviceps*) and dwarf (*K. sima*) sperm whales off Southern Africa. PhD Thesis. *Department of Zoology and Entomology* (Rhodes University), p. 551.

PLÖN, S., COCKCROFT, V.G. & W.P. FRONEMAN, 2015. The Natural History and Conservation of Indian Ocean Humpback Dolphins (*Sousa plumbea*) in South African Waters. *Advances in Marine Biology* 72:143–162.

PORTER-SMITH, R., HARRIS, P.T., ANDERSEN, O.B., COLEMAN, R., GREENSLADE, D. & C.J. JENKINS, 2004. Classification of the Australian continental shelf based on predicted sediment threshold exceedance from tidal currents and swell waves. Mar. Geol., 211: 1–20.

POST, A.L., WASSENBERG, T.J.and V. PASSLOW, 2006. Physical surrogates for macrofaunal distributions and abundance in a tropical gulf. Marine and Freshwater Research, 57: 469-483.

POTTER, I.C., BECKLEY, L.E., WHITFIELD, A.K. and R.C.J. LENANTON, 1990. Comparisons between the roles played by estuaries in the life cycles of fishes in temperate Western Australia and southern Africa. *Environ. Biol. of Fishes*, **28**: 143-178.

PRESTEDGE RETIEF DRESNER WIJNBERG (PRDW), 2013. Impact Assessment for proposed exploration drilling in the Orange Basin Deepwater Licence Area off the West Coast of South Africa.

PROBYN, T.A., MITCHELL-INNES, B.A., BROWN, B.A., HUTCHINGS, L. and CARTER, R.A., 1994. A review of primary production and related processes on the Agulhas Bank. *S. Afr. J. Sci*., **90**: 160-173.

PULFRICH, A., 2013. Intertidal Rocky-Shore Communities of the Sperrgebiet Coastline: Consolidated Rocky-shores Monitoring Report – 2013. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 126pp.

PULFRICH, A. & G.M. BRANCH, 2014. Effects of sediment deposition from Namibian diamond mines on intertidal and subtidal rocky-reef communities and the rock lobster *Jasus lalandii*. *Estuarine, Coastal and Shelf Science*, 150: 179-191.

PULFRICH, A., HUTCHINGS, K., A. BICCARD and CLARK, B.M., 2015. Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2015. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 186pp.

PULFRICH, A., NEL, P. and A.J PENNEY, 2004. Impacts of Beach Mining Operations on Sandy Beach Macrofaunal Communities on the Beaches of Geelwal Karoo: 2004 Beach Survey. Pisces Environmental Services (Pty) Ltd. Report to Trans Hex Operations (Pty) Ltd. October 2004, 42pp.

PULFRICH, A., PARKINS, C.A. and G.M. BRANCH, 2003a. The effects of shore-based diamond-diving on intertidal and subtidal biological communities and rock lobsters in southern Namibia. *Aquatic Conservation: Marine & Freshwater Ecosystems* **13**: 257-278.

PULFRICH, A., PARKINS, C.A., BRANCH, G.M., BUSTAMANTE, R.H. and C.R. VELÁSQUEZ, 2003b. The effects of sediment deposits from Namibian diamond mines on intertidal and subtidal reefs and rock-lobster populations. *Aquatic Conservation: Marine & Freshwater Ecosystems* **13**: 233-255.

PULFRICH, A. and A.J. PENNEY, 1999. The effects of deep-sea diamond mining on the benthic community structure of the Atlantic 1 Mining Licence Area. Annual Monitoring Report – 1998. Prepared for De Beers Marine (Pty) Ltd by Marine Biology Research Institute, Zoology Department, University of Cape Town and Pisces Research and Management Consultants CC. pp 49.

PULFRICH, A., PENNEY, A.J., BRANDÃO, A., BUTTERWORTH, D.S. and M. NOFFKE, 2006. Marine Dredging Project: FIMS Final Report. Monitoring of Rock Lobster Abundance, Recruitment and Migration on the Southern Namibian Coast. *Prepared for De Beers Marine Namibia, July 2006*. 149pp.

PURDON, J., SHABANGU, F., PIENAAR, M., SOMERS, M.J. & K.P. FINDLAY, 2020**.** South Africa's newly approved marine protected areas have increased the protected modelled habitat of nine odontocete species SUPPLEMENT 2. Mar Ecol Prog Ser 633:1–21.

RAES, M & A. VANREUSEL, 2005. The metazoan meiofauna associated with a cold-water coral degradation zone in the Porcupine Seabight (NE Atlantic). Cold-water corals and ecosystems. Springer. pp 821–847.

RAND, A.M., 2006. Using Geographic Information Systems and Remote Sensing to improve the management of kelp resources in South Africa. MSc Thesis, University of Cape Town.

REISINGER, R., KARCZMARSKI, L., 2010. Population size estimate of Indo-Pacific bottlenose dolphins in the Algoa Bay region, South Africa. *Journal of Marine Mammal Science* 26(1): 86–97.

RELINI, G., ZAMBONI, N., TIXI, F. and G. TORCHIA, 1994. Patterns of sessile macrobenthos community development on an artificial reef in the Gulf of Genoa (northwestern Mediterranean). *Bulletin of Marine Science* **55**: 745-771.

RICHARDSON, W.J., GREENE, C.R., MALME, C.I. and THOMSON, D.H. 1995. Marine Mammals and Noise. Academic Press, San Diego, CA.

ROEL, B.A., 1987. Demersal communities off the west coast of South Africa. *South African Journal of Marine Science* **5**: 575-584.

ROEL, B.A. and ARMSTRONG, M.J. 1991. The round herring *Etrumeus whiteheadi* and anchovy *Engraulis capensis* off the east coast of southern Africa. *S. Afr. J. mar. Sci*., **11**: 227-249.

ROBERTS, M.J., 1998. The influence of the environment on chokka squid *Loligo vulgaris reynaudii* spawning aggregations: Steps towards a quantified model. *South African Journal of Marine Science*, **20**: 267–284.

ROBERTS, M.J., 2005. Chokka squid (*Loligo vulgaris reynaudii*) abundance linked to changes in South Africa's Agulhas Bank ecosystem during spawning and the early life cycle. *ICES Journal of Marine Science*, **62**: 33–55.

ROBERTS, M.J., SAUER, W.H.H., 1994. Environment: the key to understanding the South African chokka squid (*Loligo vulgaris reynaudii*) life cycle and fishery? *Antarctic Science*, **6**: 249-258.

ROBERTS, M.J., VAN DER LINGEN, C.D. & M. VAN DEN BERG, 2010. Shelf currents, lee-trapped and transient eddies on the inshore boundary of the Agulhas Current, South Africa: their relevance to the KwaZulu-Natal sardine run. *African Journal of Marine Science* **32**: 423–447.

ROBERTS, M.J. and C. NIEUWENHUYS, 2016. Observations and mechanisms of upwelling in the northern KwaZulu-Natal Bight, South Africa, *African Journal of Marine Science*, 38:sup1, S43-S63, DOI: 10.2989/1814232X.2016.1194319

ROBERTS, M.J., NIEUWENHUYS, C. AND L.A. GUASTELLA, 2016. Circulation of shelf waters in the KwaZulu-Natal Bight, *South Africa, African Journal of Marine Science*, 38:sup1, S7-S21, DOI: 10.2989/1814232X.2016.1175383

ROBINSON, T., GRIFFITHS, C., McQUAID, C. and M. RIUS, 2005. Marine alien species of South Africa - status and impacts. *African Journal of Marine Science* **27**: 297-306.

ROGERS, J., 1977. *Sedimentation on the continental margin off the Orange River and the Namib Desert.* Unpubl. Ph.D. Thesis, Geol. Dept., Univ. Cape Town. 212 pp.

ROGERS, J., 1979. Dispersal of sediment from the Orange River along the Namib Desert coast. *S. Afr. J. Sci.*, **75**: 567 (abstract).

ROGERS, J. and J.M. BREMNER, 1991. The Benguela Ecosystem. Part VII. Marine-geological aspects. *Oceanogr. Mar. Biol. Ann. Rev*., **29**: 1-85.

ROSENBAUM, H.C., POMILLA, C., MENDEZ, M., LESLIE, M.S., BEST, P.B., FINDLAY, K.P., MINTON, G., ERSTS, P.J., COLLINS, T., ENGEL, M.H., BONATTO, S., KOTZE, P.G.H., MEŸER, M., BARENDSE, J., THORNTON, M., RAZAFINDRAKOTO, Y., NGOUESSONO, S., VELY, M. and J. KISZKA, 2009. Population structure of humpback whales from their breeding grounds in the South Atlantic and Indian Oceans. *PLoS One*, **4 (10)**: 1-11.

ROSENBAUM, H.C., MAXWELL, S., KERSHAW, F. and B.R. MATE, 2014. Long-range movement of humpback whales and their overlap with anthropogenic activity in the South Atlantic Ocean. *Conservation Biology*, 28(2): 604-615.

ROSS, G.J.B., 1979. Records of pygmy and dwarf sperm whales, genus *Kogia*, from southern Africa, with biological notes and some comparisons. *Annals of the Cape Province Museum (Natural History)* **11**: 259-327.

ROSS, G.J.B., 1984. The smaller cetaceans of the east coast of southern Africa. *Ann. Cape. Prov. Mus. (nat. Hist.)*., 15 (2).

ROSS, G.J.B., COCKCROFT V.G. & D.S. BUTTERWORTH, 1987. Offshore distribution of bottlenosed dolphins in Natal coastal waters and Algoa Bay, Eastern Cape. *S. Afr. J. Zool.* **22:** 50-56.

ROTHMAN, M.D., ANDERSON, R.J. and A.J. SMITH, 2006. The effects of harvesting of the South African kelp (*Ecklonia maxima*) on kelp population structure, growth rate and recruitment. *Journal of Applied Phycology* **18**: 1-7.

ROUX, J-P., BRADY, R. and P.B. BEST, 2011. Southern right whales off Namibian and their relationship with those off South Africa. Paper SC/S11/RW16 submitted to IWC Southern Right Whale Assessment Workshop, Buenos Aires 13-16 Sept. 2011.

ROUX, J-P., BRADY, R. & P.B. BEST, 2015. Does disappearance mean extirpation? The case of right whales off Namibia. Marine Mammal Science 31(3): 1132-1152.

RYAN, P.G. & B. ROSE, 1989. Migrant seabirds. In: Oceans of life off southern Africa. PAYNE, A.I.L. and CRAWFORD, R.J.M. (Eds.). Cape Town. Vlaeberg Publishers, pp. 274-287.

SALAS, F., MARCOS, C., NETO, J.M., PATRICIO, J., PÉREZ-RUZAFA, A. and J.C. MARQUES, 2006. User-friendly guide for using benthic ecological indicators in coastal and marine quality assessment. *Ocean and Coastal management* **49**: 308-331.

SALOMAN, C.H., NAUGHTON, S.P. and J.L. TAYLOR, 1982. Benthic community response to dredging borrow pits, Panama City Beach, Florida. *U.S. Army, Corps of Engineers, Coastal Engineering Research Centre, Miscellaneous Report*, **82-3**: pp. 139.

SANTOS, C., 1993. A multivariate study of biotic and abiotic relationships in a subtidal algal stand. *Marine Ecology Progress Series* **94**: 181-190.

SAUER, W.H.H., SMALE, M.J., LIPINSKI, M.R., 1992. The location of spawning grounds, spawning and shoaling behaviour of the squid *Loligo vulgaris reynaudii* (D'Orbigny) off the eastern Cape coast, South Africa. Mar. Biol., 114: 97-107.

SAUER, W.H.H., PENNEY, A.J., ERASMUS, C., MANN, B.Q., BROUWER, S.L.,. LAMBERTH, S.J. and T.J. STEWART, 1997. An evaluation of attitudes and responses to monitoring and management measures for the South African boat-based linefishery. *S. Afr. J. Mar. Sci*., **18**: 147-164.

SAVAGE, C., FIELD, J.G. and R.M. WARWICK, 2001. Comparative meta-analysis of the impact of offshore marine mining on macrobenthic communities versus organic pollution studies. *Mar Ecol Prog Ser.*, **221**: 265-275.

SCHIEL, D.R. and M.S. FOSTER, 1986. The structure of subtidal algal stands in temperate waters. *Oceanography & Marine Biology: An Annual Review* **24**, 265-307.

SCHLEYER, M.H., 1985. Chaetognaths as indicators of water masses in the Agulhas Current system. Investl. Rep. Oceanogr. Res. Inst., Durban, 61, 20 pp.

SCHOEMAN, D.S., McLACHLAN, A. and J.E. DUGAN, 2000. Lessons from a Disturbance Experiment in the Intertidal Zone of an Exposed Sandy Beach. *Estuar. Coast. Shelf Sci.*, **50(6)**: 869-884.

SCHÖN, P.-J., SAUER, W.H.H., ROBERTS, M.J., 2002. Environmental influences on spawning aggregations and jig catches of chokka squid *Loligo vulgaris reynaudii*: a "black box" approach. *Bulletin of Marine Science*, **71**: 783–800.

SCHRATZBERGER, M., REES, H.L. and S.E. BOYD, 2000a. Effects of simulated deposition of dredged material on structure of nematode assemblages - the role of burial. *Mar. Biol.*, **136**: 519-530.

SCHRATZBERGER, M., REES, H.L. and S.E. BOYD, 2000b. Effects of simulated deposition of dredged material on structure of nematode assemblages - the role of contamination. *Mar. Biol.*, **137**: 613-622.

SCHRATZBERGER, S. and R. WARWICK, 1999. Differential effects of various types of disturbances on the structure of nematode assemblages: an experimental approach. *Mar. Ecol. Prog. Ser.*, **181**: 227– 236.

SCHRIEVER, G., AHNERT, A., BLUHM, H., BOROWSKI, C. and H. THIEL, 1997. Results of the large scale deep-sea environmental impact study DISCOL during eight years of investigation. *Proc. 7th ISOPE Conf., Honolulu, USA*: 438-444.

SCHUMANN, E.H. 1988. Physical oceanography off Natal. In: Coastal ocean sciences of Natal. South Africa (Ed. E.H. Schumann). Springer Verlag, Berlin. 101-130.

SCHUMANN, E.H. 1998. The coastal ocean off southeast Africa, including Madagascar coastal segment (15, W). In: The Sea, Vol.11. Robinson, A.R. and Brink, K. (eds). John Wiley & Sons, Inc.

SCHUMANN, E.H., PERRINS, L.–A. and HUNTER, I.T., 1982. Upwelling along the south coast of the Cape Province, South Africa. *S. Afr. J. Sci.*, **78**: 238-242.

SCHUMANN, E.H., ROSS, G.J.B. and GOSCHEN, W.S., 1988. Cold water events in Algoa Bay and Cape south coast, South Africa, in March/April, 1987. *S. Afr. J. Sci.*, **84**: 579-584.

SCHUMANN, E.H. and BEEKMAN, L.J. 1984. Ocean temperature structures on the Agulhas Bank. Trans. *R. Soc. S. Afr.*, **45**: 191-203.

SCHUT, E.W., UENZELMANN-NEBEN, G. & R. GERSONDE, 2002. Seismic evidence for bottom current activity at the Agulhas Ridge. *Global and Planetary Change* 34: 185–198.

SEAPY, R.R. and M.M. LITTLER, 1982. Population and species diversity fluctuations in a rocky intertidal community relative to severe aerial exposure and sediment burial. *Mar. Biol.,* **71**: 87-96.

SEIDERER, L.J. and R.C. NEWELL, 2000. TRANS HEX-SEACORE Mobile Dredging Platform Environmental Impact of Mining Trials at Greenbank Cove, Cornwall, U.K. July-August 2000. Marine Ecological Surveys Limited report to Transhex Group, August 2000, pp. 45.

SHAMBLIN, B.M., BOLTEN, A.B., ABREU-GROBOIS, F.A., BJORNDAL, K.A., CARDONA, L., CARRERAS, C.C., CLUSA, M., MONZÓN-ARGÜELLO, C., NAIRN, C.J., NIELSEN, J.T., NEL, R., SOARES, L.S., STEWART, K.R., TÜRKOZAN, O., YILMAZ, C. and P.H. DUTTON, (2014). Geographic Patterns of Genetic Variation in a Broadly Distributed Marine Vertebrate: New Insights into Loggerhead Turtle Stock Structure from Expanded Mitochondrial DNA Sequences. *PLoS ONE.* 9(1): e85956. doi:10.1371/ journal.pone.0085956

SHANNON, L.J., C.L. MOLONEY, A. JARRE and J.G. FIELD, 2003. Trophic flows in the southern Benguela during the 1980s and 1990s. *Journal of Marine Systems*, **39**: 83 - 116.

SHANNON, L.V., 1985. The Benguela Ecosystem. Part 1. Evolution of the Benguela, physical features and processes. *Oceanogr. Mar. Biol. Ann. Rev.*, **23**: 105-182.

SHANNON, L.V. and J.G. FIELD, 1985. Are fish stocks food-limited in the southern Benguela pelagic ecosystem ? *Mar. Ecol. Prog. Ser.*, **22(1)** : 7-19.

SHANNON, L.V. and G. NELSON, 1996. The Benguela: Large scale features and processes and system variability. In: *The South Atlantic: Present and Past Circulation*. WEFER, G., BERGER, W. H., SIEDLER, G. and D. J. WELLS (eds.). Berlin; Springer: 163-210.

SHANNON L.V. and S. PILLAR, 1985. The Benguela Ecosystem III. Plankton. *Oceanography and Marine Biology: An Annual Review*, **24**: 65-170.

SHANNON, L.V. and M.J. O'TOOLE, 1998. BCLME Thematic Report 2: Integrated overview of the oceanography and environmental variability of the Benguela Current region. Unpublished BCLME Report, 58pp

SHAUGHNESSY, P.D. 1977. Flock size in Sabine's Gull. *Cormorant*. **3**: 17.

SHAUGHNESSY P.D., 1979. Cape (South African) fur seal. In: Mammals in the Seas. *F.A.O. Fish. Ser.*, 5, **2**: 37-40.

SHEARS, N.T. & N.R. USMAR, 2006. The role of the Hauraki Gulf Cable Protection Zone in protecting exploited fish species: De facto marine reserve? Department of Conservation Research and Development Series 253, 27 pp

SHEEHAN, E.V., CARTWRIGHT, A.Y., WITT, M.J., ATTRILL, M.J., VURAL, M. & L.A. HOLMES, 2018. Development of epibenthic assemblages on artificial habitat associated with marine renewable infrastructure. *ICES Journal of Marine Science*.

SHELTON, P.A. 1986. Life-history traits displayed by neritic fish in the Benguela Current Ecosystem. In: The Benguela and Comparable Ecosystems, PAYNE, A.I.L., GULLAND, J.A. and BRINK, K.H. (Eds.). *S. Afr. J. mar. Sci.*, **5**: 235-242.

SHENG, Y.P., CHEN, X. and E.A. YASSUNDA, 1994. Wave-induced sediment resuspension and mixing in shallow waters. *Coastal Engineering* : 3281-3294.

SHERWOOD, J., CHIDGEY, S., CROCKETT, P., GWYTHER, D., HO, P., STRONG, D., WHITELY, B. & A. WILLIAMS, 2016. Installation and operational effects of a HVDC submarine cable in a continental shelf setting. Bass Strait Journal of Ocean Engineering and Science, 1: 337–353.

SHILLINGTON, F. A., PETERSON, W. T., HUTCHINGS, L., PROBYN, T. A., WALDRON, H. N. and J. J. AGENBAG, 1990. A cool upwelling filament off Namibia, South West Africa: Preliminary measurements of physical and biological properties. *Deep-Sea Res.*, **37 (11A)**: 1753-1772.

SHORT, A.D. and P.A. HESP, 1985. Wave, beach and dune interactions in southern Australia. *Marine Geology*, **48**: 259-284.

SIMMONS, R.E., 2005. Declining coastal avifauna at a diamond mining site in Namibia: comparisons and causes. *Ostrich*, **76**: 97-103.SIMON-BLECHER, N., GRANEVITZE, Z. and Y. ACHITUV, 2008. *Balanus glandula*: from North-West America to the west coast of South Africa. *African Journal of Marine Science* **30**: 85-92.

SICILIANO, S., DE MOURA, J.F., BARATA, P.C.R., DOS PRAZERES RODRIGUES D., MORAES ROGES, E., LAINE DE SOUZA, R., HENRIQUE OTT P. AND M. TAVARES, 2013. An unusual mortality of humpback whales in 2010 on the central-northern Rio de Janeiro coast, Brazil. Paper to International Whaling Commission SC63/SH1

SINK, K.J., ATTWOOD, C.G., LOMBARD, A.T., GRANTHAM, H., LESLIE, R., SAMAAI, T., KERWATH, S., MAJIEDT, P., FAIRWEATHER, T., HUTCHINGS, L., VAN DER LINGEN, C., ATKINSON, L.J., WILKINSON, S., HOLNESS, S. and T. WOLF, 2011. Spatial planning to identify focus areas for offshore biodiversity protection in South Africa. Unpublished Report. Cape Town: South African National Biodiversity Institute.

SINK, K., HOLNESS, S., HARRIS, L., MAJIEDT, P., ATKINSON, L., ROBINSON, T., KIRKMAN, S., HUTCHINGS, L., LESLIE, R., LAMBERTH, S., KERWATH, S., VON DER HEYDEN, S., LOMBARD, A., ATTWOOD, C., BRANCH, G., FAIRWEATHER, T., TALJAARD, S., WEERTS, S., COWLEY, P., AWAD, A., HALPERN, B., GRANTHAM, H. and T. WOLF, 2012. National Biodiversity Assessment 2011: Technical Report. Volume 4: Marine and Coastal Component. South African National Biodiversity Institute, Pretoria.

SINK, K.J., VAN DER BANK, M.G., MAJIEDT, P.A., HARRIS, L.R., ATKINSON, L.J., KIRKMAN, S.P. and N. KARENYI (eds), 2019. South African National Biodiversity Assessment 2018 Technical Report Volume 4: Marine Realm. South African National Biodiversity Institute, Pretoria. South Africa.

SLATTERY, M. & D. BOCKUS, 1997. Sedimentation in McMurdo Sound, Antarctica: A disturbance mechanism for benthic invertebrates. Polar Biology 18(3): 172-179.

SLR CONSULTING AUSTRALIA, 2019. Proposed Offshore Exploration Drilling in PEL83, Orange Basin, Namibia. Underwater Noise Preliminary Modelling Prediction and Impact Assessment. Prepared for SLR Consulting (Namibia)(Pty) Ltd. July 2019. 47pp.

SMALE, M.J., ROEL, B.A., BADENHORST, A. and J.G. FIELD, 1993. Analysis of demersal community of fish and cephalopods on the Agulhas Bank, South Africa. *Journal of Fisheries Biology* 43:169-191.

SMALE, M.J., KLAGES, N.T., DAVID, J.H.M. and COCKROFT, V.G. 1994. Predators of the Agulhas Bank. *S. Afr. J. Sci.*, **90**: 135-142.

SMITH, G.G and G.P. MOCKE, 2002. Interaction between breaking/broken waves and infragravity-scale phenomena to control sediment sediment suspension and transport in the surf zone. *Marine Geology*, **187**: 320-345.

SOARES, A.G., 2003. Sandy beach morphodynamics and macrobenthic communities in temperate, subtropical and tropical regions - a macroecological approach. PhD, University of Port Elizabeth

SOARES, A.G., McLACHLAN, A. and T.A. SCHLACHER, 1996. Disturbance effects of stranded kelp on populations of the sandy beach bivalve *Donax serra* (Röding). *Journal of Experimental Marine Biology and Ecology* **205**: 165-186.

SOARES, A.G., SCHLACHER, T.A. and A. McLACHLAN, 1997. Carbon and nitrogen exchange between sandy beach clams. *Marine Biology* **127**: 657-664.

SOUTHALL, B.L., ROWLES, T., GULLAND, F., BAIRD, R.W. & P.D. JEPSON, 2008. Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melon-headed whales (*Peponocephala electra*) in Antsohihy, Madagascar.

SOUTHALL, B.L., FINNERAN, J.J., REICHMUTH, C., NACHTIGALL, P.E., KETTEN, D.R., BOWLES, A.E., ELLISON, W.T., NOWACEK, D.P. & P.L. TYACK, 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals 2019, 45(2), 125-232, DOI 10.1578/AM.45.2.2019.125.

STEFFANI, N., 2007a. Biological Baseline Survey of the Benthic Macrofaunal Communities in the Atlantic 1 Mining Licence Area and the Inshore Area off Pomona for the Marine Dredging Project. *Prepared for De Beers Marine Namibia (Pty) Ltd*. pp. 42 + Appendices.

STEFFANI, N., 2007b. Biological Monitoring Survey of the Macrofaunal Communities in the Atlantic 1 Mining Licence Area and the Inshore Area between Kerbehuk and Bogenfels. 2005 Survey. *Prepared for De Beers Marine Namibia (Pty) Ltd.* pp. 51 + Appendices.

STEFFANI, N., 2009a. Biological monitoring surveys of the benthic macrofaunal communities in the Atlantic 1 Mining Licence Area and the inshore area - 2006/2007. Prepared for De Beers Marine Namibia (Pty) Ltd. pp. 81 + Appendices.

STEFFANI, C.N., 2009b. *Assessment of Mining Impacts on Macrofaunal Benthic Communities in the Northern Inshore Area of the De Beers ML3 Mining Licence Area - 18 Months Post-mining.* Prepared for De Beers Marine (South Africa), 47pp.

STEFFANI, C.N., 2010a. Biological monitoring surveys of the benthic macrofaunal communities in the Atlantic 1 Mining Licence Area - 2008. Prepared for De Beers Marine Namibia (Pty) Ltd. pp. 40 + Appendices.

STEFFANI, C.N., 2010b. Benthic grab monitoring survey in the Atlantic 1 Mining Licence Area -2009- sediment composition. Prepared for De Beers Marine Namibia (Pty) Ltd. pp. 19 + Appendix.

STEFFANI, C.N., 2010c. *Assessment of mining impacts on macrofaunal benthic communities in the northern inshore area of the De Beers Mining Licence Area 3 – 2010* . Prepared for De Beers Marine (South Africa). pp 30 + Appendices.

STEFFANI, C.N., 2012a. *Assessment of Mining Impacts on Macrofaunal Benthic Communities in the Northern Inshore Area of the ML3 Mining Licence Area - 2011.* Prepared for De Beers Marine (South Africa), July 2012, 54pp.

STEFFANI, C.N., 2012b. Assessment of mining impacts on macrofaunal benthic communities in the northern inshore area of mining licence area 3.

STEFFANI, C.N., 2014. Assessment of mining impacts on macrofaunal benthic communities in the northern inshore area of mining licence area MPT 25-2011.

STEFFANI, C.N. and G.M. BRANCH, 2003a. Spatial comparisons of populations of an indigenous limpet *Scutellastra argenvillei* and an alien mussel *Mytilus galloprovincialis* along a gradient of wave energy. *African Journal of Marine Science* **25**: 195-212.

STEFFANI, C.N. and G.M. BRANCH, 2003b. Temporal changes in an interaction between an indigenous limpet *Scutellastra argenvillei* and an alien mussel *Mytilus galloprovincialis*: effects of wave exposure. *African Journal of Marine Science* **25**: 213-229.

STEFFANI, C.N. and G.M. BRANCH, 2005. Mechanisms and consequences of competition between an alien mussel, *Mytilus galloprovincialis*, and an indigenous limpet, *Scutellastra argenvillei*. *Journal of Experimental Marine Biology and Ecology* **317**: 127-142.

STEFFANI, C.N. and A. PULFRICH, 2004a. *Environmental Baseline Survey of the Macrofaunal Benthic Communities in the De Beers ML3/2003 Mining Licence Area.* Prepared for De Beers Marine South Africa, April 2004., 34pp.

STEFFANI, N. and A. PULFRICH, 2004b. The potential impacts of marine dredging operations on benthic communities in unconsolidated sediments. Specialist Study 2. Specialist Study for the Environmental Impact Report for the Pre-feasibility Phase of the Marine Dredging Project in Namdeb's Atlantic 1 Mining Licence Area and in the nearshore areas off Chameis. Prepared for PISCES Environmental Services (Pty) Ltd, September 2004.

STEFFANI, C.N. and A. PULFRICH, 2007. Biological Survey of the Macrofaunal Communities in the Atlantic 1 Mining Licence Area and the Inshore Area between Kerbehuk and Lüderitz 2001 – 2004 Surveys. *Prepared for De Beers Marine Namibia, March 2007*, 288pp.

STEFFANI, N., SEDICK, S., ROGERS, J. & M.J. GIBBONS, 2015. Infaunal benthic communities from the inner shelf off Southwestern Africa are characterised by generalist species. PLoS ONE 10(11): e0143637. doi:10.1371/journal.pone.0143637.

STEGENGA, H., BOLTON, J.J. and R.J. ANDERSON, 1997. Seaweeds of the South African West Coast. *Contributions from the Bolus Herbarium, No. 18*. Creda Press, Cape Town. 655 pp.

SWANSON, J.C., GALAGAN, C. & T. ISAJI, 2006. Transport and fate of sediment suspended from jetting operations for undersea cable burial. OCEANS 2006 1–6.

SWART, D.H. and SERDYN, J. de V. 1982. Statistical analysis of visually observed wave data from voluntary observing ships (VOS) for the South African east coast. CSIR Report T/ (to be published).

SWART, V.P. and LARGIER, J.L. 1987. Thermal structure of Agulhas Bank water. In: The Benguela and Comparable Ecosystems, PAYNE, A.I.L., GULLAND, J.A. and BRINK, K.H. (Eds.), *S. Afr. J. mar. Sci*., **5**: 243-254.

TAORMINA, B., BALD, J., WANT, A., THOUZEAU, G., LEJART, M., DESROY, N., & A. CARLIER, 2018. A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions. *Renewable and Sustainable Energy Reviews,* 96, 380-391.

TAUNTON-CLARK, J., 1985. The formation, growth and decay of upwelling tongues in response to the mesoscale windfield during summer. *In*: South African Ocean Colour and Upwelling Experiment. Shannon L.V. (ed.). Sea Fisheries Research Institute, Cape Town. pp 47-62.

TAYLOR, M.R., PEACOCK, F. & R.W. WANLESS, 2015. The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. BirdLife South Africa: Johannesburg, South Africa.

THIEL, H. and G. SCHRIEVER, 1994. Environmental Consequences of using the Deep Sea – exemplified by mining of polymetallic nodules. *Nord-Süd Aktuell*, **8**: 404-408.

THOMISCH, K., 2017. Distribution patterns and migratory behavior of Antarctic blue whales. *Reports on Polar and Marine Research* 707: pp194. doi:10.2312/BzPM_0707_2017

THOMISCH, K., BOEBEL, O', CLARK, C.W., HAGEN, W., SPIESECKE, S., ZITTERBART, D.P. and I. VAN OPZEELAND, 2016. Spatio-temporal patterns in acoustic presence and distribution of Antarctic blue whales *Balaenoptera musculus intermedia* in the Weddell Sea. doi: 10.3354/esr00739.

TISSOT, B.N., YOKLAVICH, M.M., LOVE, M.S., YORK, K. & M. AMEND, 2006. Benthic invertebrates that form habitat on deep banks off southern California, with special reference to deep sea coral. *Fishery Bulletin* 104: 167–181.

TUCEK, J., NEL, R., GIRANDOT, M. & G. HUGHES, 2014. Estimating reproductive age and size of loggerhead sea turtles. *Endangered Species Research*, 23: 167-175.

TURPIE, J.K., 1995. Prioritizing South African estuaries for conservation: A practical example using waterbirds. *Biol. Cons.*, **74**: 175-185.

TYACK, P.L., ZIMMER, W.M.X., MORETTI, D., SOUTHALL, B.L., CLARIDGE, D.E., DURBAN, J.W., CLARK, C.W., *et al.*, 2011. Beaked Whales Respond to Simulated and Actual Navy Sonar, 6(3). doi:10.1371/journal.pone.0017009.

UENZELMANN-NEBEN, G., & K. GOHL, 2004. The Agulhas Ridge, South Atlantic: The Peculiar Structure of a Fracture Zone. *Marine Geophysical Researches* 25: 305–319.

UKEN, R & N. MKIZE, 2012. Unconsolidated sediment distribution within the KwaZulu-Natal Bight. Extended Abstract, ACEP. Pp4.

UNDERHILL, L.G. and COOPER, J. 1982. Counts of waterbirds at coastal wetlands in southern Africa. 1978 to 1981. Unpublished MS. PFIAO.

UNITED NATIONS ENVIRONMENTAL PROGRAMME (UNEP), 1995. *Global biodiversity assessment*. UNEP Nairobi: Cambridge University Press.

VAN DALFSEN, J.A., ESSINK, K., TOXVIG MADSEN, H., BIRKLUND, J., ROMERO, J. and M. MANZANERA, 2000. Differential response of macrozoobenthos to marine sand extraction in the North Sea and the Western Mediterranean. *ICES J. Mar. Sci.,* **57**: 1439–1445.

VAN DER ELST, R. 1976. Game fish of the east coast of southern Africa. I: The biology of the elf *Pomatomus saltatrix* (Linneaus) in the coastal waters of Natal. *ORI Investl. Rep.*, 44. 59pp.

VAN DER ELST, R. 1981. A Guide to the Common Sea Fishes of Southern Africa. Struik, Cape Town: 367pp.

VAN DER ELST, R. 1988. Shelf ichthyofauna of Natal. In: Coastal ocean sciences of Natal, South Africa (Ed. E.H. Schumann). Springer-Verlag, Berlin: 209-225.

VAN DER LINGEN, C.D., COETZEE, J.C., DEMARCQ, H., DRAPEAU, L., FAIRWEATHER, T.P. & L. HUTCHINGS, 2005. An eastward shift in the distribution of southern Benguela sardine. *GLOBEC Newsletter,* 11(2): 17–22.

VAN DER LINGEN, C.D., HUTCHINGS, L., BRUNDRIT, G.B., BYRNE, D.A., DUNCOMBE RAE, C.M., DURHOLTZ, M.D., HUNTER, I., LUTJEHARMS, J.R.E., SHANNON, L.V. and L.A. STAEGEMANN, 2006. Report of the BCLME Southern Boundary Workshop. Cape Town, 3-5 May 2006.

VAN DER MERWE, D. and D. VAN DER MERWE, 1991. Effects of off-road vehicles on the macrofauna of a sandy beach. *S. Afr. J. Sci.*, **87**: 210-213.

VAN DER MOLEN, J.S., SCHARLER, U.M. and D. MUIR, 2016. Species composition, abundance and biomass of microphytoplankton in the KwaZulu-Natal Bight on the east coast of South Africa. In: ROBERTS, M.J., FENNESSY, S.T., BARLOW, R.G. (eds), Ecosystem processes in the KwaZulu-Natal Bight. *African Journal of Marine Science* 38(Supplement): S139–S153.

VAN DER VEER, H.W., BERGMAN, M.J.N. and J.J. BEUKEMA, 1985. Dredging activities in the Dutch Wadden Sea: effects on macrobenthic fauna. *Neth. J. Sea Res.*, **19**: 183–190.

VELIMIROV, B., FIELD, J.G., GRIFFITHS, C.L. and P. ZOUTENDYK, 1977. The ecology of kelp bed communities in the Benguela upwelling system. *Helgoländer Meeresunters*, **30**: 495-518.

VERHEYE, H.M., HUTCHINGS, L., HUGGETT, J.A., CARTER, R.A., PETERSON, W.T. and PAINTING, S.J. 1994. Community structure, distribution and trophic ecology of zooplankton on the Agulhas Bank with special reference to copepods. *S. Afr. J. Sci*., **90**: 154-165.

VERMEULEN, E., BOUVEROUX, T., PLÖN, S., ATKINS, S., CHIVELL, W., COCKCROFT, V., CONRY, D., GENNARI, E., HÖRBST, S., JAMES, B.S., KIRKMAN, S., PENRY, G., PISTORIUS, P., THORNTON, M., VARGAS-FONSECA, A. & S.H. ELWEN, 2017. Indian Ocean humpback dolphin (*Sousa plumbea*) movement patterns along the South African coast. *Aquatic Conservation*, 28(1): 231-240.

VINDING, K. BESTER, M., KIRKMAN, S.P., CHIVELL, W. & S.H. ELWEN, 2015. The use of data from a platform of opportunity (whale watching) to study coastal cetaceans on the Southwest Coast of South Africa. Tourism in Marine Environments, 11(1) : 33-54.

VISSER, G.A., 1969. Analysis of Atlantic waters off the coast of southern Africa. *Investigational Report Division of Sea Fisheries, South Africa*, 75: 26 pp.

WANT, A., CRAWFORD, R., KAKKONEN, J., KIDDIE, G., MILLER, S., HARRIS, R.E. & J.S. PORTER, 2017. Biodiversity characterisation and hydrodynamic consequences of marine fouling communities on marine renewable energy infrastructure in the Orkney Islands Archipelago, Scotland, UK. *Biofouling,* 33(7), 567-579.

WARD, L.G., 1985. The influence of wind waves and tidal currents on sediment resuspension in Middle Chesapeake Bay. *Geo-Mar. Letters*, **5**: 1-75.

WALKER, D.R and W.T. PETERSON, 1991. Relationships between hydrography, phytoplankton production, biomass, cell size and species composition, and copepod production in the southern Benguela upwelling system in April 1988. *S. Afr. J. mar. Sci.*, **11**: 289-306

WALKER, N.D., 1986. Satellite observations of the Agulhas Current and episodic upwelling south of Africa. *Deep-Sea Research*. **33**: 1083-1106.

WALLACE, J.H., KOK, H.M., BUXTON, C.D. and BENNETT, B. 1984. Inshore small-meshed trawling survey of the Cape South Coast. Part 1. Introduction, methods, stations and catches. *S. Afr. J. Zool*., **19 (3)**: 154-164.

WALLACE, B.P. & T.T. JONES, 2008. What makes marine turtles go: a review of metabolic rates and their consequences. *Journal of Experimental Marine Biology and Ecology*, **356**: 8-24.

WARWICK, R.M., 1993. Environmental impact studies on marine communities: Pragmatical considerations. *Australian Journal of Ecology,* **18**: 63-80.

WEIR, C.R., 2011. Distribution and seasonality of cetaceans in tropical waters between Angola and the Gulf of Guinea. *African Journal of Marine Science* **33(1)**: 1-15.

WEIR, C.R., COLLINS, T., CARVALHO, I. and H.C. ROSENBAUM, 2010. Killer whales (*Orcinus orca*) in Angolan and Gulf of Guinea waters, tropical West Africa. *Journal of the Marine Biological Association of the U.K*. **90**: 1601– 1611.

WHITEHEAD, H., 2002. Estimates of the current global population size and historical trajectory for sperm whales. *Marine Ecology Progress Series*, **242**: 295-304.

WHITTINGTON, P.A., 2004. Extension to the breeding range of the Crowned Cormorant. *Koedoe*, 47(2): 125–126.

WHITTINGTON, P.A., MARTIN, A.P. & N.T.W. KLAGES, 2006. Status, distribution and conservation implications of the kelp gull (*Larus dominicanus vetula*) within the Eastern Cape region of South Africa. *Emu* 106, 127–139. doi: 10.1071/MU05049

WHITTINGTON, P.A., TREE, A.J., CONNAN, M. & E.G. WATKINS, 2015. The status of the Damara Tern in the Eastern Cape, South Africa. *Ostrich*, 86 (1&2): 65–73.

WICKENS, P.A., DAVID, J.H.M., SHELTON, P.A. and J.G. FIELD, 1991. Trends in harvest and pup numbers of the South African fur seal: Implications for management. *South African Journal of Marine Science* 11:307–326.

WILES, E., GREEN, A., WATKEYS, M., JOKAT, W. & R. KROCKER, 2013. The evolution of the Tugela Canyon and submarine fan: A complex interaction between margin erosion and bottom current sweeping, southwest Indian Ocean, South Africa. *Marine and Petroleum Geology* **44**: 60-70.

WITHERINGTON, B.E., 1992. Behavioral responses of nesting sea turtles to artificial lighting. *Herpetologica*, 31-39.

WITTEVEEN, M., 2015. The influence of a changing environment on the breeding biology and diet of Kelp Gulls (*Larus dominicanus vetula*) in Plettenberg Bay, South Africa. MSc Thesis, University of Cape Town, pp130.

WYNEKEN, J. & D. WITHERINGTON, 2001. The anatomy of sea turtles, Southeast Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, US Department of Commerce.

ZAJAC, R.N., LEWIS, R.S., POPPE, L.J., TWICHELL, D.C., VOZARIK, J., and M.L. DIGIACOMO-COHEN, 2000. Relationships among sea-floor structure and benthic communities in Long Island Sound at regional and benthoscape scales. *J. Coast. Res.,* **16**: 627– 640.

ZETTLER, M.L., BOCHERT, R. and F. POLLEHNE. 2009. Macrozoobenthos diversity in an oxygen minimum zone off northern Namibia. Marine Biology **156**:1949-1961.

ZOUTENDYK, P., 1992. Turbid water in the Elizabeth Bay region: A review of the relevant literature. CSIR Report EMAS-I 92004.

ZOUTENDYK, P. & I.R. DUVENAGE, 1989. Composition and biological implications of a nepheloid layer over the inner Agulhas Bank near Mossel Bay, South Africa. *Trans. Roy. Soc. S. Afr.*, **47**: 187-197.

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
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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/GERA (East) CABLE SYSTEM) TO BE LANDED AT DUYNEFONTEIN ON THE WEST COAST OF SOUTH AFRICA

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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 December 2020

Date: