APPENDIX D: SPECIALIST STUDIES

Appendix D1 – Marine Faunal Specialist Assessment

Appendix D2 – Fisheries Assessment

Appendix D3 – Underwater Heritage Impact Assessment

Appendix D1 – Marine Faunal Specialist Assessment

BASIC ASSESSMENT FOR A PROSPECTING PERMIT APPLICATION FOR OFFSHORE SEA AREAS 4C & 5C, EXCLUDING THE NAMAQUA FOSSIL FOREST MARINE PROTECTED AREA, WEST COAST, SOUTH AFRICA

Marine Faunal Specialist Assessment

Prepared for:

SLR

On behalf of

De Beers Consolidated Mines Limited

January 2023

PISCES ENVIRONMENTAL SERVICES (PTY) LTD

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EXECUTIVE SUMMARY

De Beers Marine (DBM), as the marine operator of De Beers Consolidated Mines Limited, is proposing to undertake prospecting operations within South African Sea Areas 4C and 5C. Before these activities can be undertaken, authorisation is required in terms of the National Environmental Management Act (NEMA), 1998 (No. 107 of 1998), as amended, and a Prospecting Right has to be obtained in terms of the Mineral and Petroleum Resources Development Act (MPRDA), 2002 (Act 28 of 2002).

SLR Consulting (South Africa) (Pty) Ltd has been appointed to undertake the necessary application processes and inturn have asked Pisces Environmental Services (Pty) Ltd to provide a specialist report on potential impacts of the proposed sampling operations on marine benthic fauna in the area.

Phase 1 entails exploration sampling (e.g. coring and / or wide spaced sampling) in target features of interest, enabling refinement of the definition of the target features. Geophysical survey may also be undertaken. Should the result of the survey(s) / exploration sampling indicate potential exists, then further follow-up sampling and infill survey may be undertaken to establish the distribution of the diamondiferous material. During Phase 1 of the project, various exploration geophysical tools may be used including swathe bathymetry systems, sub-bottom profilers, side-scan sonars, and electrical, magnetic and Electro-Magnetic systems. The geophysical systems could be deployed from various platforms (see Figure 3 1), such as towed systems, vessel mounted, pole mounted, Autonomous Underwater Vehicles (AUV) or Autonomous Surface Vehicle (ASV). Exploration sampling, may include sampling using either coring, a subsea sampling tool or a vertically mounted sampling tool.

Sea Areas 4C and 5C are located off the northern West Coast of South Africa roughly between Port Nolloth and Hondeklipbaai with water depths in the area targeted for sampling ranging between 70 m to 160 m. The seabed sediments comprise primarily muddy sands, with a north-south trending tongue of sand in the centre of the sea area and the innershelf mudbelt in the east. Winds come primarily from the southeast, whereas virtually all swells throughout the year come from the S and SSW direction. The bulk of the seawater in the study area is South Atlantic Central Water characterised by low oxygen concentrations, especially at depth. Inshore waters are turbid being influenced by coastal upwelling as well as discharges from the Orange River.

The sea areas fall into the cold temperate Southern Benguela Ecoregion. The benthic habitats potentially affected by sampling operations have been classified as 'least threatened'. Two geological features of note are found off the West Coast, namely Child's Bank, situated at about 31°S ~60 km to the south of Sea Areas 4C and 5C, and Tripp Seamount situated at about 29°40'S, ~50 km west of the Sea Areas. Features such as banks and seamounts often host deepwater corals and boast an enrichment of bottom-associated communities relative to the otherwise low profile homogenous seabed habitats.

The Sea Areas lie within the influence of the Namaqua upwelling cell and are characterised by seasonally high plankton abundance. The area is likely to host a variety of demersal fish species typical of the shelf community, including the Cape hake, jacopever and West Coast sole. The Sea Areas overlap with various lease areas for hydrocarbon exploration. Numerous conservation areas, as well as existing marine protected areas (MPAs) exist along the coastline and offshore of the Northern Cape. Sea Area 4C overlaps with the Namaqua Fossil Forest MPA, but this area has been excluded from the prospecting permit application.

The project area also overlaps with a number of proposed Critical Biodiversity 1: Natural and Critical Biodiversity 2: Natural areas as well as an Ecological Support Area (ESA), which in this case includes all portions of the Namaqua Fossil Forest EBSA not already within the MPA, and a proposed 5-km buffer area around the Namaqua Fossil Forest MPA (v1.2 released April 2022).

The potential environmental impacts to the marine environment of the proposed geophysical prospecting operations are:

- Disturbance of marine mammals by the sounds emitted by the geophysical survey equipment; and
- Marine pollution due to discharges such as deck drainage, machinery space wastewater, sewage, etc. and disposal of solid wastes from the survey vessel.

The potential environmental impacts to the marine environment of the sampling operations are:

- Disturbance and loss of benthic fauna in the drill sample footprints;
- Crushing of epifauna and infauna by the sampling tools;
- Generation of suspended sediment plumes through discard of fine tailings;
- Smothering of benthic communities through re-settlement of discarded tailings;
- Disturbance of marine biota by noise from the sampling vessel and sampling tools;
- Disturbance of marine biota due to vessel lighting; and
- Marine pollution due to discharges such as deck drainage, machinery space wastewater, sewage, etc. and disposal of solid wastes from the sampling vessel.

The potential environmental impacts to the marine environment as a result of unplanned events include:

- Potential loss of equipment on the seabed;
- Potential injury to marine mammals and turtles through vessel strikes; and
- Marine pollution due to fuel spills during refuelling, or resulting from collision or shipwreck.

The impacts before and after mitigation on marine habitats and communities associated with the proposed project are summarised below (Note: * indicates that no mitigation is possible and / or considered necessary, thus significance rating remains unchanged):

Impact	Probability	Significance (before mitigation)	Significance (after mitigation)
Noise from geophysical surveying on marine fauna	Probable	Very Low	Very Low
Noise from sampling operations on marine fauna	Definite	Very Low	Very Low*
Generation of Electromagnetic Fields	Possible	Insignificant	Insignificant
Disturbance and loss of benthic macrofauna	Definite	Very Low to Low	Very Low
Crushing of benthic macrofauna	Definite	Very Low	Very Low

Impact	Probability	Significance (before mitigation)	Significance (after mitigation)
Generation of suspended sediment plumes	Definite	Very Low	Very Low*
Smothering of benthos in unconsolidated sediments by redepositing tailings	Probable	Very Low	Very Low*
Smothering of vulnerable reef communities by redepositing tailings	Probable	Low	Very Low
Pollution of the marine environment through operational discharges to the sea from sampling vessel	Probable	Very Low	Very Low
Disturbance of marine fauna due to helicopter noise	Possible	Very Low	Very Low
Disturbance and behavioural changes in pelagic fauna due to vessel lighting	Possible	Very Low	Very Low
UNPLANNED EVENTS			
Potential loss of equipment to the seabed	Improbable	Very Low	Very Low
Vessel strikes and entanglement in gear	Possible	Very Low	Very Low
Operational spills or vessel accidents	Possible	Very Low	Very Low

Mitigation measures proposed during geophysical surveying include:

- 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 visual scans should be of at least 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 vicinity. Equipment without “soft start” capabilities (e.g. Chirp and Side Scan Sonar) should be turned on only once equipment that does have a soft start function (e.g. Multibeam Echosounder) has been ramped up to full volume.
- 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.
- Ensure that PAM (passive acoustic monitoring) is incorporated into any surveying taking place between June and November.
- A MMO should be appointed to ensure compliance with mitigation measures during geophysical surveying.
- Use standard operational procedure to warm up the electromagnetic source transmitter (i.e. equivalent to ramp-up of current in electric source). It is recommended that the electromagnetic source should be ramped up over a minimum period of 20 minutes.

- Turn off electromagnetic source when not collecting data.
- Use lowest field strengths required to successfully complete the survey.

Mitigation measures proposed during exploration sampling include:

- Remote sensing data should be used to conduct a pre-sampling analysis of the seabed to identify high-profile, rocky-outcrop areas without a sediment veneer. Exploration sampling targets gravel bodies in unconsolidated sediments and does not target these high-profile rocky-outcrops without a sediment veneer.
- The positions of all lost equipment must be accurately recorded, and reported to maritime authorities if requested. While every effort should be made to remove lost equipment, safety and metocean conditions should be assessed before performing any retrieval operations.
- Adhere strictly to best management practices recommended in the relevant Environmental Impact Report and EMPr and that of MARPOL 73/78 (International Convention for the Prevention of Pollution from Ships, 1973) for all necessary disposals at sea.
- Develop a waste management plan.
- Ensure all flight paths avoid coastal seal and penguin colonies.
- Avoid extensive low-altitude coastal flights (<762 m or <2 500 ft and within 1 nautical mile of the shore) by ensuring that the flight path is perpendicular to the coast, as far as possible.
- Maintain a flight altitude >1 000 m to be maintained at all times, except when taking off and landing or in a medical emergency.
- Maintain an altitude of at least 762 m or 2 500 ft above the highest point of a National Park or World Heritage Site.
- Brief all pilots on the ecological risks associated with flying at a low level along the coast or above marine mammals.
- Reduce lighting on the survey and sampling vessels to a minimum compatible with safe operations whenever and wherever possible. Light sources should, if possible and consistent with safe working practices, be positioned in places where emissions to the surrounding environment can be minimised.
- Keep disorientated, but otherwise unharmed, seabirds in dark containers for subsequent release during daylight hours. Ringed/banded birds should be reported to the appropriate ringing/banding scheme (details are provided on the ring).

Mitigation measures proposed for unplanned activities include:

- Vessel operators should keep watch for marine mammals and turtles in the path of the vessel.
- Ensure vessel transit speed is reduced to 10 knots (18 km/hr) when sensitive marine fauna are present in the immediate vicinity of the survey/sampling vessel.
- A non-dedicated marine mammal observer (MMO) must keep watch for marine mammals behind the vessel when tension is lost on the towed equipment. Either retrieve or regain tension on towed gear as rapidly as possible.
- Should a cetacean become entangled in towed gear, contact the South African Whale Disentanglement Network (SAWDN) formed under the auspices of DEFF to provide specialist assistance in releasing entangled animals.
- Report any collisions with large whales to the International Whaling Commission (IWC) database, which has been shown to be a valuable tool for identifying the species most

affected, vessels involved in collisions, and correlations between vessel speed and collision risk (Jensen & Silber 2003).

- In the case of a marine diesl spill, use low toxicity dispersants cautiously and only with the permission of DFFE.
- As far as possible, and whenever the sea state permits, attempt to control and contain the spill at sea with suitable recovery techniques to reduce the spatial and temporal impact of the spill.
- Ensure adequate resources are provided to collect and transport oiled birds to a cleaning station.
- Ensure offshore bunkering is not undertake in the following circumstances:
    - Wind force and sea state conditions of ≥6 on the Beaufort Wind Scale;
    - During any workboat or mobilisation boat operations;
    - During helicopter operations;
    - During the transfer of in-sea equipment; and
    - At night or times of low visibility.

If all environmental guidelines, and appropriate mitigation measures advanced in this report, and the EMPr for the proposed operations as a whole, are implemented, there is no reason why the proposed prospecting should not proceed.

ACRONYMS, ABBREVIATIONS and UNITS

A	Amperes
AUV	Autonomous Underwater Vehicle
ASV	Autonomous Surface Vehicle
BCC	Benguela Current Commission
BCLME	Benguela Current Large Marine Ecosystem
CBA	Critical Biodiversity Area
cm	centimetres
cm/s	centimetres per second
CITES	Convention on International Trade in Endangered Species
CSIR	Council for Scientific and Industrial Research
dB	decibell
DBCM	De Beers Consolidated Mines
DBM	De Beers Marine
DEA	Department of Environmental Affairs
DMS	Dense Medium Separation
E	East
EBSA	Ecologically and Biologically Significant Area
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EM	Electromagnetic
EMP	Environmental Management Programme
ESA	Ecological Support Area
FAMDA	Fishing and Mariculture Development Association
FAO	Food and Agricultural Organisation
FeSi	ferrosilicon
g/m^2	grams per square metre
$g\ C/m^2/day$	grams Carbon per square metre per day
GIS	Global Information System
HABs	Harmful Algal Blooms
Hz	Herz
IBA	Important Bird Area
ICNIRP	International Commission on Non-Ionizing Radiation Protection
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
km/h	kilometres per hour
kts	knots
MBES	Multibeam Echosounder
MFMR	Ministry of Fisheries and Marine Resources (Namibia)
MMOs	Marine Mammal Observers

MPA	Marine Protected Area
MPRDA	Mineral and Petroleum Resources Development Act
m	metres
m^2	square metres
m^3	cubic metre
mm	millimetres
m/s	metres per second
mg/ℓ	milligrams per litre
N	north
NDP	Namibian Dolphin Project
NEMA	National Environmental Management Act
NNW	north-northwest
nm	nautical mile
NMMU	Nelson Mandela Metropolitain University
NOAA	National Oceanic and Atmospheric Administration
nT	Nanno tesla
nV/cm	nannoVolt per centimetre
NW	north-west
PAM	Passive Acoustic Monitoring
PIM	Particulate Inorganic Matter
PNSF	Port Nolloth Sea Farms
POM	Particulate Organic Matter
ppm	parts per million
PTS	Permanent Threshold Shift
ROVs	Remotely Operated Vehicles
S	south
SACW	South Atlantic Central Water
SADCO	Southern Africa Data Centre for Oceanography
SANBI	South African National Biodiversity Institute
SASTN	South Atlantic Sea Turtle Network
SAWDN	South African Whale Disentanglement Network
SBP	Sub-bottom Profiling
SFRI	Sea Fisheries Research Institute, Department of Environmental Affairs
SPRFMA	South Pacific Regional Fisheries Management Authority
SST	Sea Surface Temperature
SSW	South-southwest
SW	south-west
TSPM	Total Suspended Particlate Matter
TTS	Temporary Threshold Shift
UNEP	United Nations Environmental Programme
V/m	Volts per metre
VMEs	Vulnerable Marine Ecosystems
VOS	Voluntary Observing Ships
µg	micrograms
µm	micrometre

µM	microMol
µg/l	micrograms per litre
µPa	micro Pascal
˚C	degrees Centigrade
%	percent
‰	parts per thousand
~	approximately
<	less than
>	greater than

EXPERTISE AND DECLARATION OF INDEPENDENCE

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

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

This specialist report was compiled for SLR Environmental Consulting (Pty) Ltd on behalf of De Beers Consolidated Mines Limited for their use in preparing an Basic Impact Assessment for proposed offshore prospecting operations in Sea Areas 4C and 5C off the West Coast of South Africa. I do hereby declare that Pisces Environmental Services (Pty) Ltd is financially and otherwise independent of the Applicant and SLR.

Andrea Pulfrich

Dr Andrea Pulfrich

1 GENERAL INTRODUCTION

De Beers Marine (DBM), as the marine operator of De Beers Consolidated Mines Limited (DBCM), is proposing to undertake prospecting operations for diamonds within Sea Areas 4C and 5C. Before these activities can be undertaken, authorisation is required in terms of the National Environmental Management Act (NEMA), 1998 (No. 107 of 1998), as amended, and a Prospecting Right has to be obtained in terms of the Mineral and Petroleum Resources Development Act (MPRDA), 2002 (Act 28 of 2002).

SLR Consulting (South Africa) (Pty) Ltd (SLR) has been appointed to undertake the necessary application processes in terms of the NEMA, as amended, and in turn have asked Pisces Environmental Services (Pty) Ltd to provide a specialist report on potential impacts of the proposed operations on marine benthic fauna in the area.

1.1 Scope of Work

This specialist report was compiled as a desktop study on behalf of SLR, for their use in preparing a Basic Assessment Report for the proposed prospecting activities off the South African West Coast.

The following general terms of reference apply to the specialist study:

- Describe the baseline conditions that exist in the study area and identify any sensitive areas that would need special consideration;
- Identify and assess potential impacts of the proposed operations;
- Identify and list all legislation and permit requirements that are relevant to the development proposal;
- Identify areas where issues could combine or interact with issues likely to be covered by other specialists, resulting in aggravated or enhanced impacts;
- Indicate the reliability of information utilised in the assessment of impacts as well as any constraints to which the assessment is subject (e.g. any areas of insufficient information or uncertainty);
- Where necessary consider the precautionary principle in the assessment of impacts;
- Identify feasible ways in which impacts could be mitigated and benefits enhanced giving an indication of the likely effectiveness of such mitigation and how these could be implemented in the management of the proposed operation;
- To ensure that specialists use a common standard, the determination of the significance of the assessed impacts will be undertaken in accordance with a common Convention (see Section 5.1);
- Comply with DEA guidelines as well as any other relevant guidelines on specialist study requirements for Environmental Impact Assessments (EIAs);
- Include specialist expertise and a signed statement of independence; and
- Comply with Regulation 12 and Appendix 6 of the EIA Regulations 2014, which specifies requirements for all specialist reports.

The terms of reference specific to the marine faunal assessment are:

- Provide a general description of the local marine fauna (including cetaceans, seals, turtles, seabirds, fish, invertebrates and plankton species) within Sea Areas 4c and 5c and greater West Coast. The description is to be based on, *inter alia*, a review of existing information and data from the international scientific literature, the Generic EMP prepared for marine diamond mining off the West Coast of South Africa (Lane & Carter 1999) and information sourced from the internet;
- Identify, describe and assess the significance of potential impacts of the proposed prospecting operations on the local marine fauna, including but not limited to:
    - physiological injury;
    - behavioural avoidance of the prospecting area;
    - masking of environmental sounds and communication; and
    - indirect impacts due to effects on prey.
- Identify practicable mitigation measures to avoid/reduce any negative impacts and indicate how these could be implemented in the start-up and management of the proposed project.

1.2 Approach to the Study

As determined by the terms of reference, this study has adopted a 'desktop' approach. The Sea Areas are situated offshore of the West Coast, and have been adequately described in the scientific literature. A detailed site investigation was thus not deemed necessary and no new data have been collected. Consequently, the description of the natural baseline environment in the Study Area is based on a review and collation of existing information and data from the scientific literature, various internal reports and the Generic EMP prepared for marine diamond mining off the West Coast of South Africa (Lane & Carter 1999) and information sourced from the internet. The sources consulted are listed in the Reference chapter.

All identified marine and coastal impacts are summarised, categorised and ranked in an appropriate impact assessment table, to be incorporated in the overall Basic Assessment Report.

1.3 Assumptions, Limitations and Information Gaps

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**.

Information gaps include:

- details of the benthic macrofaunal communities and potentially vulnerable species on deep water reef habitats;
- 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.

1.4 Assessment Procedure

The following convention was used to determine significance ratings in the assessment. For further details the reader is referred to Appendix E of the Basic Assessment Report.

1.4.1 Criteria for Impact Assessment

The criteria for impact assessment are provided below.

Criteria	Rating	Description
Criteria for ranking of the INTENSITY (SEVERITY) of environmental impacts	**ZERO TO VERY LOW**	Negligible change, disturbance or nuisance. The impact affects the environment in such a way that natural functions and processes are not affected. Communities are able to adapt with relative ease and maintain pre-impact Status.
	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.
Criteria for ranking the DURATION of impacts	**SHORT TERM**	< 5 years.
	MEDIUM TERM	5 to < 15 years.
	LONG TERM	> 15 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 will not occur in such a way or in such time span that the impact can be considered transient.
Criteria for ranking the EXTENT / SPATIAL SCALE of impacts	**LOCAL**	Impact is confined to project or study area or part thereof, e.g. limited to the area of interest and its immediate surroundings.
	REGIONAL	Impact is confined to the region, e.g. coast, basin, catchment, municipal region, etc.
	NATIONAL	Impact is confined to the country as a whole, e.g. South Africa, etc.
	INTERNATIONAL	Impact extends beyond the national scale.

Criteria	Rating	Description
Criteria for determining the PROBABILITY of impacts	**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.
	POSSIBLE	Where there is a distinct possibility that the impact would occur, i.e. > 30 to ≤ 60% chance of occurring.
	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.
Criteria for determining the DEGREE OF CONFIDENCE of the assessment	**LOW**	≤ 35% sure of impact prediction.
	MEDIUM	> 35% and ≤ 70% sure of impact prediction.
	HIGH	> 70% sure of impact prediction.
Criteria for the 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.
Criteria for 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 but where the natural functions and processes are not affected.
	MEDIUM	Where the loss of a resource occurs, but natural functions and processes continue, albeit in a modified way.
	HIGH	Where the activity results in an irreplaceable loss of a resource.

1.4.2 Determining Consequence

Consequence attempts to evaluate the importance of a particular impact, and in doing so incorporates extent, duration and intensity. The ratings and description for determining consequence are provided below.

Rating	Description
VERY HIGH	Impacts could be EITHER: of ***high intensity*** at a ***regional level*** and endure in the ***long term***; OR of ***high intensity*** at a ***national level*** in the ***medium term***; OR of ***medium intensity*** at a ***national level*** in the ***long term***.
HIGH	Impacts could be EITHER: of ***high intensity*** at a ***regional level*** and endure in the ***medium term***; OR of ***high intensity*** at a ***national level*** in the ***short term***; OR of ***medium intensity*** at a ***national level*** in the ***medium term;*** OR of ***low intensity*** at a ***national level*** in the ***long term***; OR of ***high intensity*** at a ***local level*** in the ***long term***; OR of ***medium intensity*** at a ***regional level*** in the ***long term***.
MEDIUM	Impacts could be EITHER: of ***high intensity*** at a ***local level*** and endure in the ***medium term***; OR of ***medium intensity*** at a ***regional level*** in the ***medium term***; OR of ***high intensity*** at a ***regional level*** in the ***short term***; OR of ***medium intensity*** at a ***national level*** in the ***short term***; OR of ***medium intensity*** at a ***local level*** in the ***long term***; OR of ***low intensity*** at a ***national level*** in the ***medium term;*** OR of ***low intensity*** at a ***regional level*** in the ***long term***.
LOW	Impacts could be EITHER of ***low intensity*** at a ***regional level*** and endure in the ***medium term***; OR of ***low intensity*** at a ***national level*** in the ***short term***; OR of ***high intensity*** at a ***local level*** and endure in the ***short term***; OR of ***medium intensity*** at a ***regional level*** in the ***short term***; OR of ***low intensity*** at a ***local level*** in the ***long term***; OR of ***medium intensity*** at a ***local level*** and endure in the ***medium term***.
VERY LOW	Impacts could be EITHER of ***low intensity*** at a ***local level*** and endure in the ***medium term***; OR of ***low intensity*** at a ***regional level*** and endure in the ***short term***; OR of ***low to medium intensity*** at a ***local level*** and endure in the ***short term***. OR **Zero to very low intensity** with any combination of extent and duration.

1.4.3 Determining Significance

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	VERY LOW	INSIGNIFICANT	INSIGNIFICANT	VERY LOW	VERY LOW
	LOW	VERY LOW	VERY LOW	LOW	LOW
	MEDIUM	LOW	LOW	MEDIUM	MEDIUM
	HIGH	MEDIUM	MEDIUM	HIGH	HIGH
	VERY HIGH	HIGH	HIGH	VERY HIGH	VERY HIGH

In certain cases it may not be possible to determine the significance of an impact. In these instances the significance is **UNKNOWN**.

2 DESCRIPTION OF THE PROPOSED PROJECT

A phased approach is proposed for the prospecting, with each phase dependant on results of the previous phase. The two phases, which will run over a five year period, are:

- Phase I - Survey, Sampling & Desktop studies; and
- Phase II - Economic Assessment.

Due to the dynamic nature of mineral exploration and evaluation, the work programme may have to be modified, extended or curtailed as results and data become available. The proposed prospecting activities in Sea Areas 4(c) and 5(c) will be undertaken in conjunction with proposed activities in other De Beers Consolidated Mines (DBCM) prospecting rights within the South African Sea Areas. Results obtained from these prospecting activities will be used to develop the regional geological framework that will guide the prospecting work programme.

This study deals only with the Phase I activities. The project description below was provided by De Beers Marine.

2.1 Geophysical Surveys

Various exploration geophysical tools (Figure 1) could be deployed from a fit-for-purpose vessel, including:

- swathe bathymetry systems, which produces a digital terrain model of the seafloor; backscatter data may be acquired as part of the process to determine textural models. Typical multi-beam echo sounders (MBES) emit a fan of acoustic beams from a transducer, providing depth sounding information on either side of the vessel's track across a swath width of approximately two times the water depth.
- sub-bottom profiler systems (e.g. boomer, chirp and sleeve gun) are echo-sounders that operate at lower frequencies than the MBES, which generate profiles beneath the seafloor to give a cross section view of the upper sediment layers. SBP systems transmit acoustic energy to the seabed and use reflected or refracted sound energy from subsurface boundaries to infer information of seabed conditions relating to depth and shallow sub-surface geology. Penetrations typically varying between 5 to 100 m below the seabed, depending on the particular system being used.
- 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. A sonar device that emits conical or fan-shaped pulses toward the seafloor across a wide angle perpendicular to the path of the sensor through the water.
- electrical, Magnetic, Electro-Magnetic surveys, which measure local variations in the intensity of the Earth's magnetic fields (magnetometer), electrical impedance of the seabed layers (electrical resistivity) and variations in electrical properties of the seabed and bulk conductivity (electromagnetic).
- video and photographic equipment, (such as ROVs, drop cameras, SkiMonkey, etc.) may be used for visualising the seabed as part of groundtruthing studies.
- Underwater manned submersibles, used for visualisation purposes.

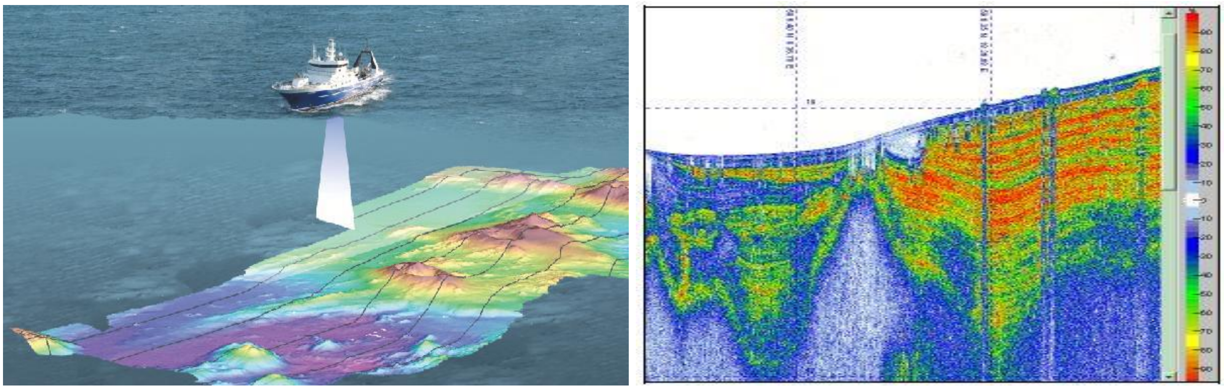

Figure 1: The geophysical survey techniques employed during Phase I of the proposed prospecting operations would include swath bathymetry (left) and sub-bottom profiling (right).

Wide spaced geophysical survey data (e.g. 100 – 2 000 km line spacing) may be acquired to refine the geological model and to identify geological features of interest/targets for follow-up survey/sampling. Further localised geophysical survey may be undertaken, enabling refinement of the definition of the target features. These detailed high resolution geophysical surveys will utilise similar tools with the likely inclusion of an Autonomous Underwater Vehicle (AUV), which is typically used for surveying in areas where survey line-spacing is generally <100 m apart.

The systems are either towed, vessel mounted, pole mounted, AUV or Autonomous Surface Vehicle (ASV). Sound levels from the acoustic equipment would range from 190 to 230 dB re 1 µPa at 1 m (Table 1). Further details on sub-bottom profilers and MBES used by the mineral exploration industry are provided below.

Table 1: specifications of acoustic equipment that may be utilised in the proposed geophysical surveys.

Sound type	Frequency	Source level (dB re 1 µPa at 1m)	Soft Start Capability
Multibeam Echo Sounder	70 – 455 kHz	190 – 232	Yes
Sub Bottom Profiler - Chirp	1.5 – 12.5 kHz	195-220	No
Sub Bottom Profiler - IXSEA	1.7 – 5.5 kHz	224 - 227	No
Sub Bottom Profiler - Boomer	100 Hz - 5 kHz	200-222	Yes
	300 Hz - 3 kHz	Typically 215	
Sub Bottom Profiler - Sparker	200 Hz - 3 kHz	≤229	Yes
Sub Bottom Profiler - Sleeve gun system	100 – 800 Hz	≤225	Yes
Sub Bottom Profiler - Innomar	60 – 80 kHz (Primary) 1.5 – 15 kHz (Secondary)	<243	No
Sub Bottom Profiler - Parametric	35 – 45 kHz (Primary) 1 - 10 kHz (Secondary)	190-220	No
Side Scan Sonar	100 – 850 kHz	190 - 242	No
Magnetometer	Passive system - unchanged		

Sub Bottom Profilers

The frequency and power of the sound source determines the depth of penetration into the sediment or rock column. Low frequency sound penetrates deeper (100s to 1000s of meters) compared to higher frequency sound (up to 10s of meters penetration) (OTA 2004).

Low frequency systems for deep penetration are in the range of 5 Hz to 1 kHz (OTA 2004). These systems are used by the Oil and Gas Industry and include the large airguns and vibroseis systems, which are typically multi-channel systems (OTA 2004; Kearey & Brooks, 1991).

In contrast, the mineral exploration industry typically uses shallow penetration systems as they require high resolution, shallow penetration data (OTA 2004). Therefore higher frequency sources are used by this industry with frequencies falling in the 1-14 kHz range (Figure 2) (OTA 2004). These systems are known as sub-bottom profilers and are typically single channel systems (OTA 2004; Kearey & Brooks, 1991).

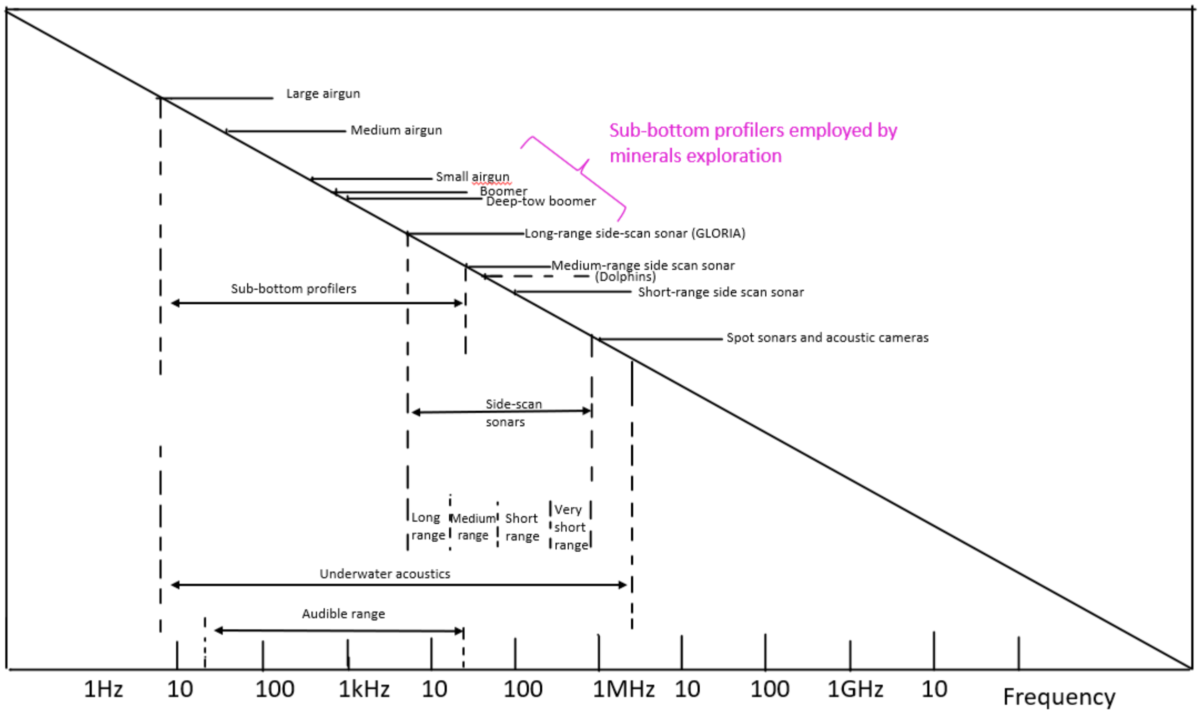

Figure 2: Frequency spectra of various acoustic imaging methods (Adapted from: OTA 2004).

Seafloor Mapping

The Multi-Beam Echo Sounders (MBES) used for seafloor mapping are High Frequency systems that transmit sound pulses in a fan shape beneath its transceiver. These High Frequency systems are available in a range of frequencies depending on the required water depth.

Lower frequency MBES (12 kHz) are intended for deep water surveys with water depths of 4000 – 6000 m. For shallow to intermediate water depths (200 – 1 000 m) MBES systems of 70-150 kHz are used, whereas for shallow to very shallow water depths (<200 m) higher frequency MBES systems of 200 kHz and above, are used (Lurton 2016).

The source level and pulse duration of the lower frequency MBES systems used for deep water surveys are higher than that of the higher frequency systems used for shallow water surveys. Lower frequency, 12 kHz systems, may emit sound levels as high as 240 dB re 1 µPa at 1 m and more, while higher frequency MBES systems of 100 kHz and above do not normally exceed 220 dB re 1 µPa at 1 m (Lurton 2016). Lower frequency systems have a typical pulse duration range of 2-20 ms, while higher frequency systems have ranges of 0.2 – 2 ms (Lurton 2016).

2.2 Exploration Sampling

Exploration sampling (including coring) within the Area of Interest will be undertaken using a fit-for-purpose vessel suitable to the water depth and sampling method (e.g. mv *The Explorer*) in water depths ranging from 70 to 160 m. The planned sampling methodology will take advantage of the latest technologies available to DBM. The sampling may be divided into stages with reviews and gate releases. The decision will be made to select the fit-for-purpose sampling technology appropriate to each target area based on the results of the preceding stage. Depending on the outcomes of previous stage work, samples may be collected in a fixed pattern over an identified target area. Samples may be taken along lines spaced 10 m to 500 m apart, with samples spacing based on the geological nature of the target area. Once a decision is made on the selected sampling tool technology chosen for taking samples from the seabed, the accompanying metallurgical sample processing technology on board the relevant vessel would then also be determined. Possible sampling tool technologies that could be employed include; coring, the use of a subsea sampling tool and a vertically-mounted tool. Groundtruthing studies may include the use of equipment such as box corers, van Veen grab samplers, etc.

2.2.1 Coring (e.g. vibrocoring)

A vibrocorer consists of a core barrel in a landing frame with a vibrating motor on top. The vibrocorer is landed on the seafloor, the motor turned on and the barrel penetrates the unconsolidated sediment. Once the core stops penetrating, the motor is turned off and the vibrocorer is raised back up to the deck. A PVC pipe is placed inside the core barrel prior to coring and the core sample is collected in this pipe. Cores can typically penetrate up to 6 m and typically have a diameter of approximately 11 cm.

2.2.2 Subsea Sampling Tool

Sampling would be undertaken using a subsea sampling tool comprising of a 5-10 m^2 footprint operated from a drill frame structure (see Figure 3), which is launched through the moon pool of the support vessel and positioned on the seabed. The unconsolidated sediments are fluidised with strong water jets and airlifted to the support vessel where they are treated in the onboard mineral recovery plant. All oversized and undersized tailings are discharged back to the sea on site. The depth of sediment sampled would typically be from 0.5 to 5 m below the seafloor surface. Depending on sea and the subseabed geotechnical conditions, up to 60 samples can be successfully taken per day.

2.2.3 Vertically Mounted Sampling Tool

Sampling could potentially be undertaken using a vertically mounted tool suspended from a derrick mounted on the ship. The drill stem is suspended in a state of constant tension by means of a compensation system that absorbs the motion of the ship, enabling the tool to remain in contact with the seabed. The tool agitates the unconsolidated sediments and airlifts sediment particles of typically up to 250 mm in diameter to the vessel for processing. The tool removes a discrete sample with a seabed surface footprint of approximately 30 m^2. As with the Subsea Sampling Tool, all oversized and undersized tailings are discharged back to the sea on site. The depth of sediment sampled would typically be from 0.5 to 5 m below the seafloor surface.

Figure 3: Illustrative example of a drill bit operated from a drill frame structure located onboard a vessel of opportunity.

For the purposes of this assessment it is assumed that up to 22 500 samples could be taken within the potential deposit area(s) during the 5 years of prospecting. The sample spacing for the initial wide spaced exploration sampling/coring, will be dependent on the geological feature size. The follow-up sample spacing is expected to typically vary between 50 and 200 m apart. The cumulative area of disturbance would be approximately 0.225 km^2 but would not be contiguous.

2.3 Emissions and Discharges to Sea

During geophysical and sampling operations, normal discharges to the sea from ythe vessels can come from a variety of sources. These discharges are regulated by onboard waste management plans and shall be MARPOL compliant. For the sake of completeness they are discussed briefly below:

2.3.1 Vessel machinery spaces (bilges), ballast water and deck drainage

The concentration of oil in discharge water from any vessel (bilge and ballast) would comply with the MARPOL Regulation 21 standard of less than 15 ppm oil in water. Any oily water would be processed through a suitable separation and treatment system to meet the MARPOL standard before discharge overboard. Drainage from marine (weather) deck spaces would wash directly overboard.

2.3.2 Sewage

South Africa is a signatory to MARPOL Annex IV Regulations for the Prevention of Pollution by Sewage from Ships and contracted vessels would be required to comply with the legislated requirements of this Annex.

2.3.3 Food (galley) wastes

The disposal into the sea of food waste is permitted in terms of MARPOL Annex V when it has been comminuted or ground and the vessel is located more than 3 nautical miles (approximately 5.5 km) from land. Such comminuted or ground food wastes shall be capable of passing through a screen with openings no greater than 25 mm. Disposal overboard without macerating can occur when more than 12 nautical miles (approximately 22 km) from the coast. Although De Beers vessels macerate food regardless of the distance, this may not be the case for all contracted vessels, although it would encourage this best practice.

2.3.4 Detergents

Detergents used for washing exposed marine deck spaces would be discharged overboard. The toxicity of detergents varies greatly depending on their composition. Water-based detergents are low in toxicity and are preferred for use. Preferentially biodegradable detergents would be used. Detergents used on work deck space would be collected with the deck drainage and treated as described under deck drainage (see above).

2.4 Support and supply vessels

The exploration vessels typically have the capability to be fully autonomous and operational for long periods of time before bunkering. Spares, consumables and victuals can be supplied by support vessels while the exploration vessel is operational. Personnel changes may be undertaken by helicopter or sea transport (similarly for emergency equipment supplies, medical evacuations of injured personnel). Helicopter operations to and from the vessel would thus occur sporadically only, if at all.

3 DESCRIPTION OF THE BASELINE MARINE ENVIRONMENT

The descriptions of the physical and biological environments along the South African West Coast focus primarily on the study area between the Orange River mouth and Lamberts Bay. The description of the marine environment includes the various biophysical receptors that may be affected both directly and indirectly by the project activities. The purpose of this environmental description is to provide the marine baseline environmental context within which the proposed exploration activities would take place. The summaries presented below are based on information gleaned from Lane & Carter (1999), Morant (2006), and Penney *et al.* (2007). The description of benthic macrofaunal communities was provided by Natasha Karenyi of the South African National Biodiversity Institute, and the section on marine mammals was provided by Dr Simon Elwen of the Namibian Dolphin Project and Mammal Research Institute (University of Pretoria) for other projects undertaken previously in the region. Information has been updated where necessary.

3.1 Geophysical Characteristics

3.1.1 Bathymetry

The continental shelf along the West Coast is generally wide and deep, although large variations in both depth and width occur. The shelf maintains a general NNW trend, widening north of Cape Columbine and reaching its widest off the Orange River (180 km) (see Figure 4). 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 inshore[1] 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 (-50 to -150 m) and outer shelf (-150 to -350 m) normally lacks relief and slopes gently seawards reaching the shelf edge at a depth of between -350 to -500 m (Sink *et al.* 2019). The three shelf zones characterising the West Coast are recognised following both abiotic (de Wet 2013) and biotic (Karenyi *et al.* 2016) patterns.

Banks on the continental shelf 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, and ~75 km south of the Sea Areas. Child's Bank is a major feature on the West Coast margin and 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. It is a rounded, flat topped, sandy plateau, which lies at the edge of the continental shelf. The bank has a gentle northern, eastern and southern margin but a steep, slump-generated outer face (Birch & Rogers 1973; Dingle *et al.* 1983; de Wet 2013). At its southwestern edge, the continental slope drops down steeply from -350 to -1 500 m over a distance of less than 60 km (de Wet 2013) creating precipitous cliffs at least 150 m high (Birch & Rogers 1973). The bank consists of resistant, horizontal beds of Pliocene sediments, similar to that of the Orange Banks, and represents another perched erosional outlier formed by Post-Pliocene erosion (Dingle 1973; Siesser *et al.* 1974). The top of this feature, has been estimated to cover some 1 450 km^2 (Sink *et al.* 2012). Tripp Seamount is a

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[1] As per the 2019 National Biodiversity Assessment inshore is defined as the area influenced by wave energy and light, with the fair weather wave base at a depth ranging between -30 to -50 m used to determine the outer limits of this zone in South Africa. Offshore areas are those that extend beyond this zone.

geological feature ~50 km to the west of the Licence Area, which rises from the seabed at ~1 000 m to a depth of 150 m. It is a roughly circular feature with a flat apex that drops steeply on all sides.

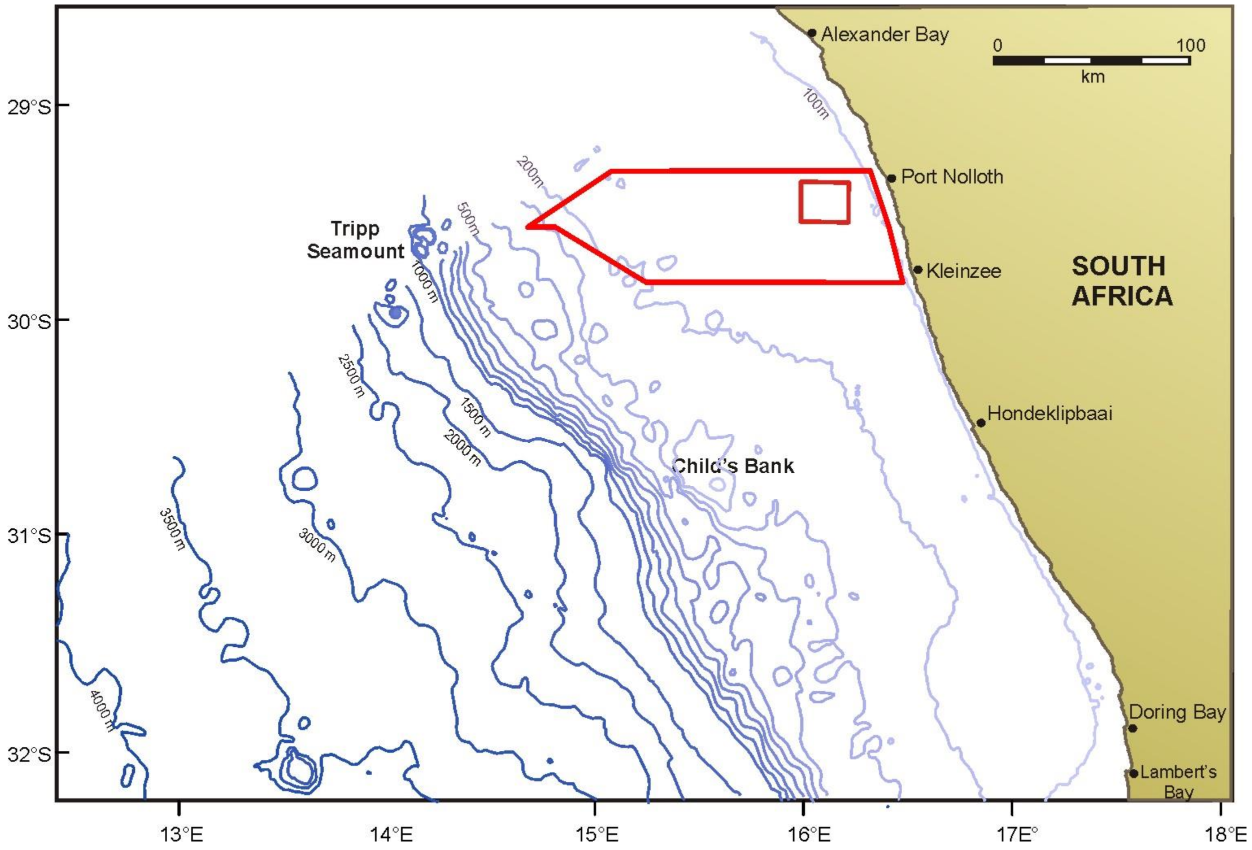

Figure 4: Map indicating location of the Sea Area 4C and 5C in relation to bathymetric features off the West Coast. Places mentioned in the text are also indicated.

3.1.2 Coastal and Inner-shelf Geology and Seabed Geomorphology

Figure 5 illustrates the distribution of seabed surface sediment types off the South African north-western coast. The inner shelf is underlain by Precambrian bedrock (Pre-Mesozoic basement), whilst the middle and outer shelf areas are composed of Cretaceous and Tertiary sediments (Dingle 1973; Dingle *et al*. 1987; Birch *et al*. 1976; Rogers 1977; Rogers & 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. An ~500-km long mud belt (up to 40 km wide, and of 15 m average thickness) is situated over the innershelf shelf between the Orange River and St Helena Bay (Birch *et al*. 1976). Further offshore and within the Licence Area, sediment is dominated by muddy sands and sand. The continental slope, seaward of the shelf break, has a smooth seafloor, underlain by calcareous ooze.

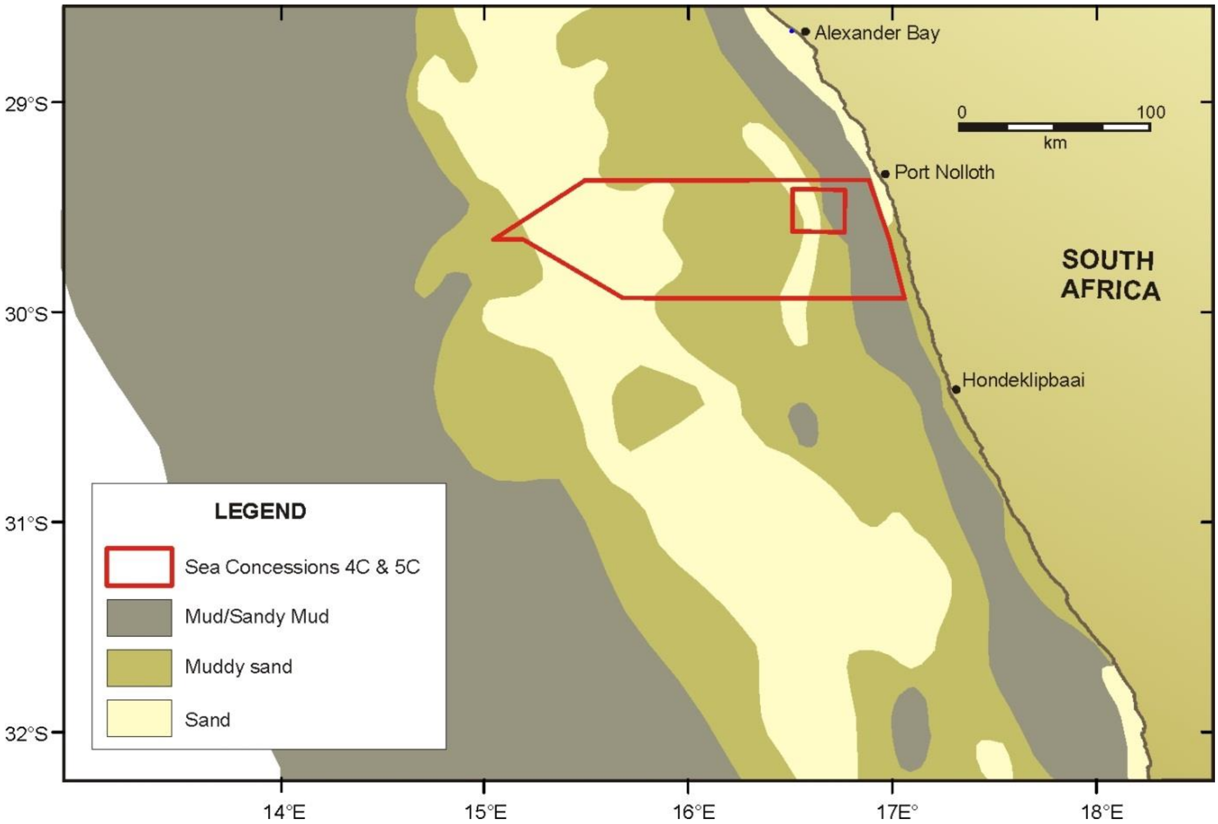

Figure 5: Sediment distribution on the continental shelf of the South African West Coast (Adapted from Rogers 1977). Based on information in Holness *et al*. (2014) and Sink *et al*. (2019), the mud/sandy mud sediments have been extended to the edge of the EEZ beyond that shown in Rogers (1977).

Present day sedimentation is limited to input from the Orange River. This sediment is generally transported northward. Most of the sediment in the area is therefore considered to be relict deposits by now ephemeral rivers active during wetter climates in the past. The Orange River, when in flood, still contributes largely to the mud belt as suspended sediment is carried southward by poleward flow. In this context, the absence of large sediment bodies on the inner shelf reflects on the paucity of terrigenous sediment being introduced by the few rivers that presently drain the South African West Coast coastal plain.

The benthic habitat types of the West Coast were classified and mapped in detail through the 2011 National Biodiversity Assessment (NBA) (Sink *et al*. 2012a). These were refined in the 2018 NBA (Sink *et al*. 2019) to provide substratum types (Figure 6).

In Sea Areas 4C and 5C the water depth ranges from approximately 50 m up to ~200 m. The Southern Benguela Muddy Shelves substratum dominates across the prospecting right application area, with the deepest portions in the west being characterised by Southern Benguela Sandy Shelves. Southern Benguela Sandy Shelves substratum is also present as a narrow band in the eastern third of the Sea Area and Namaqua Mid-Shelf Fossils present in the omitted section covering the Namaqua Fossil Forest Marine Protected Area (MPA). Only four ecosystem types are represented in the block, these being Namaqua Muddy Mid-Shelf Mosaic, Namaqua Sandy Mid-Shelf, Namaqua Muddy Sands, and Southern Benguela Sandy Outer Shelf (Sink *et al*. 2019) (see Figure 15).

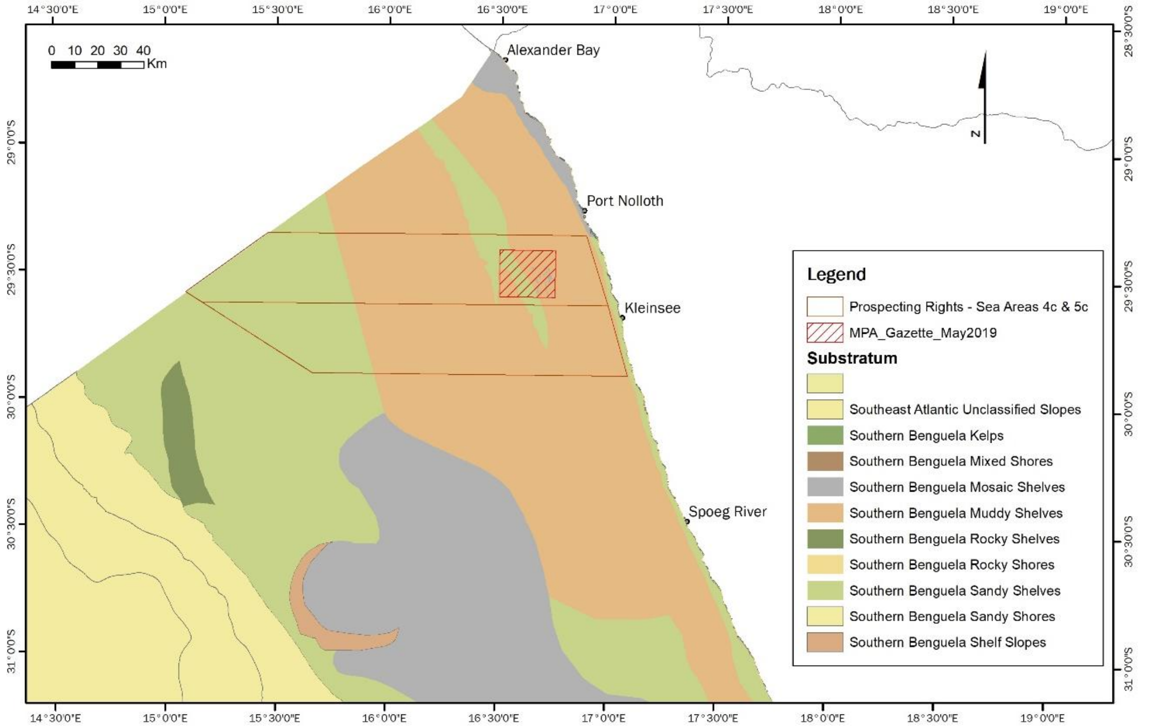

Figure 6: Sea Areas 4C and 5C (red polygon) in relation to the distribution of seabed substratum types along the West Coast (adapted from Sink *et al*. 2019).

3.2 Biophysical Characteristics

3.2.1 Wind Patterns

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

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

These seasonal changes result in substantial differences between the typical summer and winter wind patterns in the region, as the southern hemisphere anti-cyclonic high-pressures system, and the associated series of cold fronts, moves northwards in winter, and southwards in summer. The strongest winds occur in summer (October to March), during which winds blow 98% of the time (PRDW

2013), with a total of 226 gales (winds exceeding 18 m/s or 35 kts) being recorded over the period (CSIR 2006). Virtually all winds in summer come from the south to south-southeast (Figure 7). These southerlies occur over 40% of the time, averaging 20 – 30 kts and reaching speeds in excess of 60 kts, bringing cool, moist air into the coastal region and driving the massive offshore movements of surface water, and the resultant strong upwelling of nutrient-rich bottom waters, which characterise this region in summer. The winds also play an important role in the loss of sediment from beaches. These strong equatorwards winds are interrupted by the passing of coastal lows with which are associated periods of calm or north or northwest wind conditions. These northerlies occur throughout the year, but are more frequent in winter.

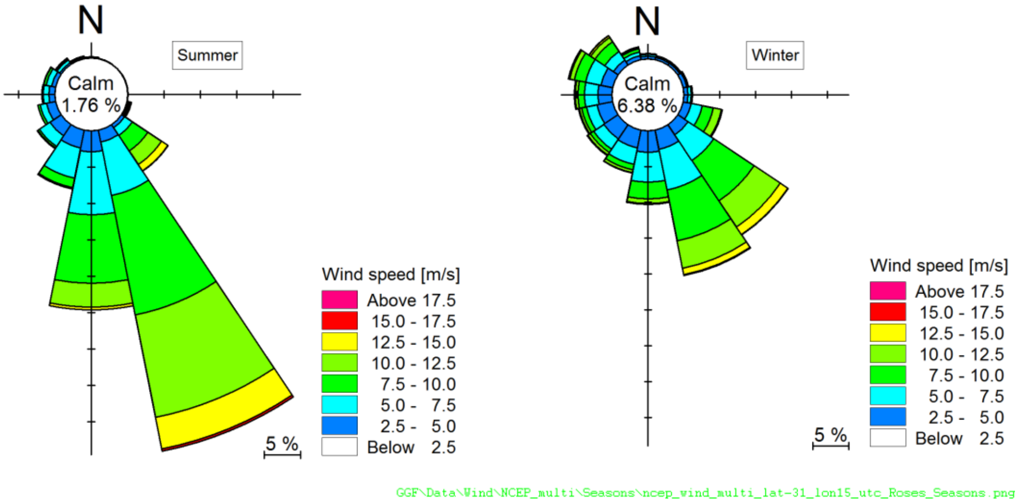

Figure 7: Wind Speed vs. Wind Direction for NCEP hind cast data at location 15°E, 31°S (From PRDW 2013).

Winter remains dominated by southerly to south-easterly winds, but the closer proximity of the winter cold-front systems results in a significant south-westerly to north-westerly component (Figure 7). 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 3% 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 in winter.

During autumn and winter, catabatic, or easterly 'berg' winds can also occur. These powerful offshore winds can exceed 50 km/h, producing sandstorms that considerably reduce visibility at sea and on land. Although they occur intermittently for about a week at a time, they have a strong effect on the coastal temperatures, which often exceed 30°C during 'berg' wind periods (Shannon & O'Toole 1998). The winds also play a significant role in sediment input into the coastal marine environment with transport of the sediments up to 150 km offshore (Figure 8).

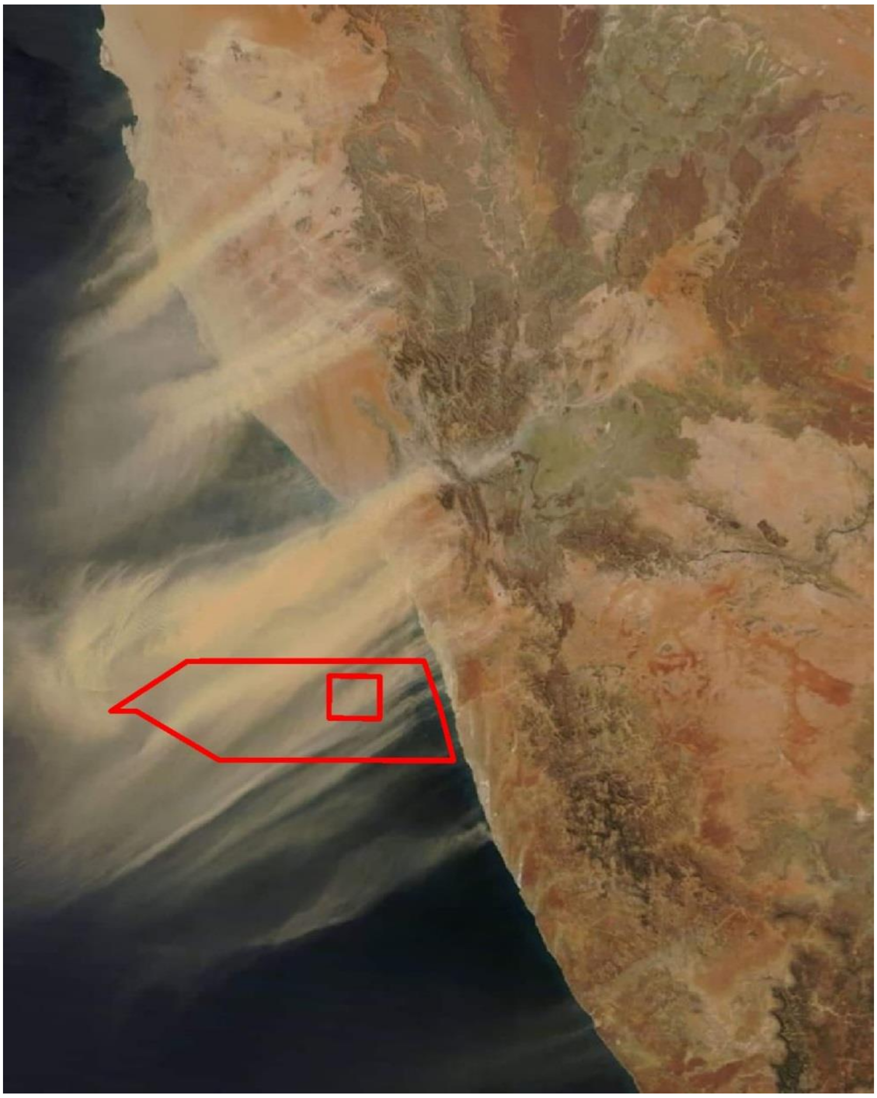

Figure 8: Sea Areas 4C and 5C (red polygon) in relation to aerosol plumes of sand and dust due to a 'berg' wind event on the southern African west coast in October 2019 (Image Source: LandWaterSA).

3.2.2 Large-Scale Circulation and Coastal Currents

The southern African West Coast is strongly influenced by the Benguela Current. Current velocities in continental shelf areas generally range between 10–30 cm/s (Boyd & 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. This results 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 & Hutchings 1983) (Figure 9). 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; PRDW 2013). The poleward flow becomes more consistent in the southern Benguela.

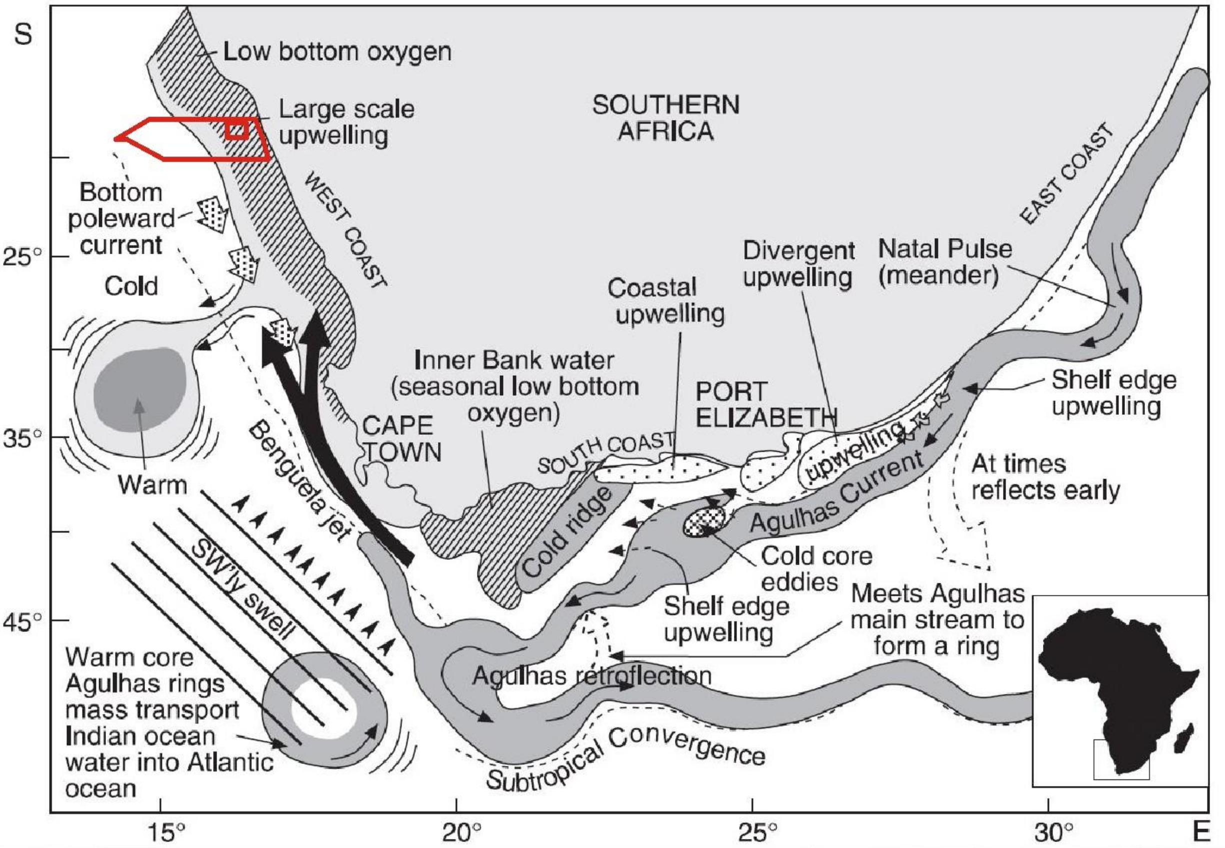

Figure 9: Physical processes and features associated with the South African Coast (adapted from Roberts 2005) in relation to Sea Areas 4C and 5C (red polygon).

The major feature of the Benguela Current is coastal upwelling and the consequent high nutrient supply to surface waters leads to high biological production and large fish stocks. The prevailing longshore, equatorward winds move nearshore surface water northwards and offshore. To balance the displaced water, cold, deeper water wells up inshore. Although the rate and intensity of upwelling fluctuates with seasonal variations in wind patterns, the most intense upwelling tends to occur where the shelf is narrowest and the wind strongest. There are three upwelling centres in the southern Benguela, namely the Namaqua (30°S), Cape Columbine (33°S) and Cape Point (34°S) upwelling cells (Taunton-Clark 1985) (Figure 10; left). Upwelling in these cells is seasonal, with maximum upwelling occurring between September and March. An example of one such strong upwelling event in December 1996, followed by relaxation of upwelling and intrusion of warm Agulhas waters from the south, is shown in the satellite images in Figure 10. Sea Areas 4C and 5C overlap with the Namaqua upwelling cell.

Where the Agulhas Current passes the southern tip of the Agulhas Bank (Agulhas Retroflection area), it may shed a filament of warm surface water that moves north-westward along the shelf edge towards Cape Point, and Agulhas Rings, which similarly move north-westwards into the South Atlantic Ocean (Figure 10, right). These rings may extend to the seafloor and west of Cape Town may split, disperse or join with other rings. During the process of ring formation, intrusions of cold subantarctic water moves into the South Atlantic. The contrast in warm (nutrient-poor) and cold (nutrient-rich) water is thought to be reflected in the presence of cetaceans and large migratory pelagic fish species (Best 2007).

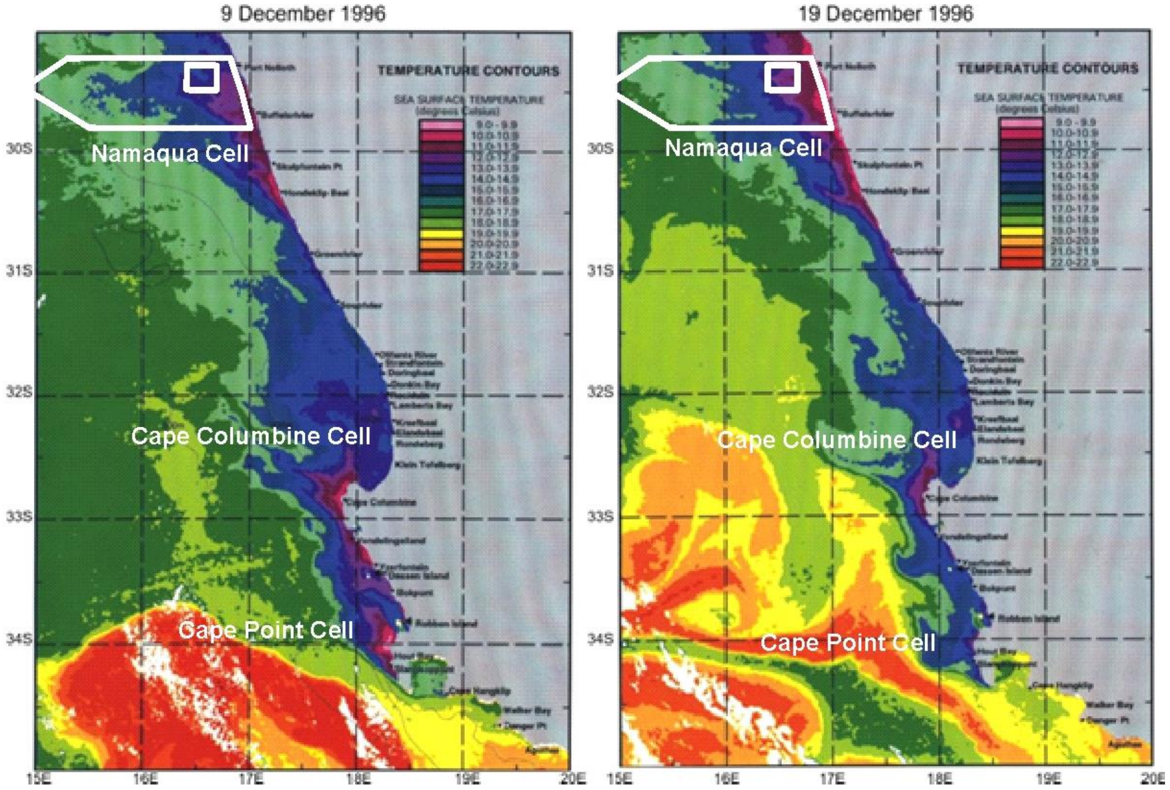

Figure 10: Satellite sea-surface temperature images showing upwelling intensity along the South African west coast on four days in December 1996 (from Lane & Carter 1999), in relation to Sea Areas 4C and 5C (white polygon).

3.2.3 Waves and Tides

Most of the west coast of southern Africa is classified as exposed, experiencing strong wave action, rating between 13-17 on the 20 point exposure scale (McLachlan 1980). Much of the coastline is therefore impacted by heavy south-westerly swells generated in the roaring forties, as well as significant sea waves generated locally by the prevailing moderate to strong southerly winds characteristic of the region (Figure 11). The peak wave energy periods fall in the range 9.7 – 15.5 seconds.

The wave regime along the southern African west coast shows only moderate seasonal variation in direction, with virtually all swells throughout the year coming from the 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.

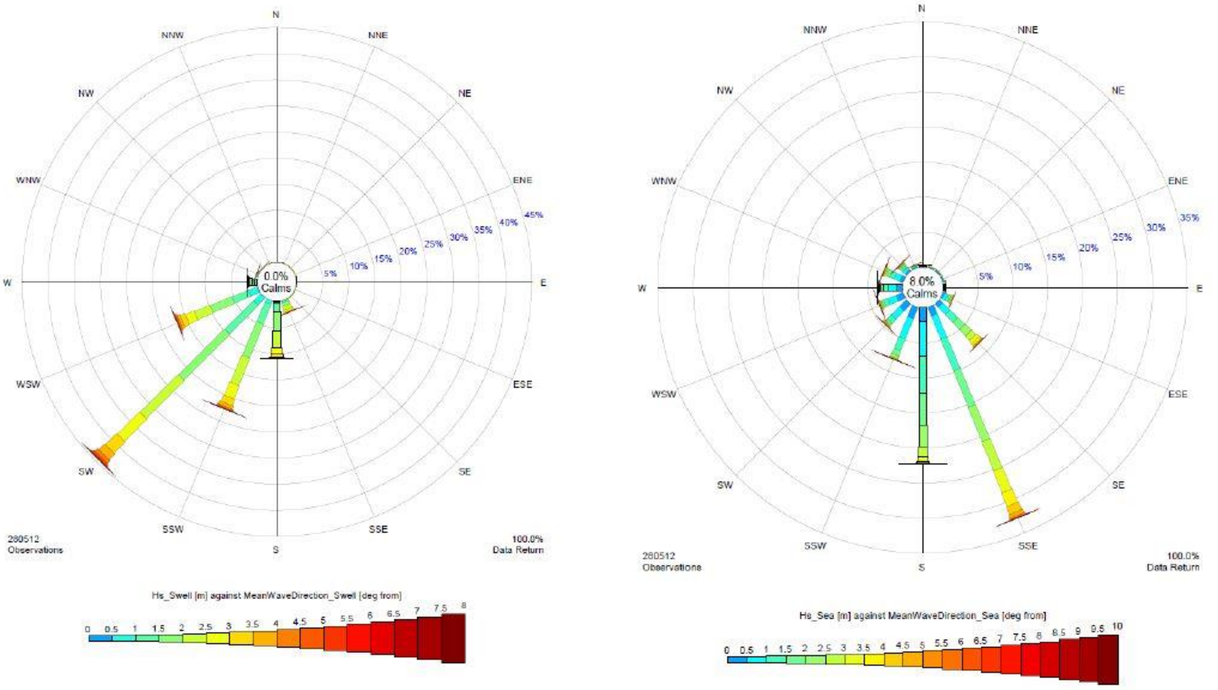

Figure 11: Annual roseplots of significant wave height partitions of swell (left) and wind-sea (right) for GROW1012 hind cast data at location 15°E, 31°S.

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

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

3.2.4 Water

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

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

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 & Shannon 1985).

Nutrient concentrations of upwelled water of the Benguela system attain 20 µM nitrate-nitrogen, 1.5 µM phosphate and 15-20 µM silicate, indicating nutrient enrichment (Chapman & 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.

3.2.5 Upwelling & Plankton Production

The cold, upwelled water is rich in inorganic nutrients, the major contributors being various forms of nitrates, phosphates and silicates (Chapman & Shannon 1985). During upwelling the comparatively nutrient-poor surface waters are displaced by enriched deep water, supporting substantial seasonal primary phytoplankton production. This, in turn, serves as the basis for a rich food chain up through zooplankton, pelagic baitfish (anchovy, pilchard, round-herring and others), to predatory fish (hake and snoek), mammals (primarily seals and dolphins) and seabirds (jackass penguins, cormorants, pelicans, terns and others). High phytoplankton productivity in the upper layers again depletes the nutrients in these surface waters. This results in a wind-related cycle of plankton production, mortality, sinking of plankton detritus and eventual nutrient re-enrichment occurring below the thermocline as the phytoplankton decays. Sea Areas 4C and 5C are located within the Namaqua upwelling cell and waters are expected to be cold and nutrient rich (see Figure 10).

3.2.6 Organic Inputs

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

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

An associated phenomenon ubiquitous to the Benguela system are red tides (dinoflagellate and/or ciliate blooms) (see Shannon & Pillar 1985; Pitcher 1998). Also referred to as Harmful Algal Blooms (HABs), these red tides can reach very large proportions, extending over several square kilometres of ocean (Figure 12, 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 12, right). Being associated primarily with upwelling cells, HABs could occur in Sea Areas 4C and 5C.

Figure 12: Red tides can reach very large proportions (Left, Photo: www.e-education.psu.edu) and can lead to mass stranding, or 'walk-out' of rock lobsters, such as occurred at Elands Bay in March 2022 (Photo: www.waterencyclopedia.com).

3.2.7 Low Oxygen Events

The continental shelf waters of the Benguela system are characterised by low oxygen concentrations with <40% saturation occurring frequently (e.g. Visser 1969; Bailey *et al.* 1985). The low oxygen concentrations are attributed to nutrient remineralisation in the bottom waters of the system (Chapman & Shannon 1985). The absolute rate of this is dependent upon the net organic material build-up in the sediments, with the carbon rich mud deposits playing an important role. As the mud on the shelf is distributed in discrete patches (see Figure 5), there are corresponding preferential areas for the formation of oxygen-poor water. The two main areas of low-oxygen water formation in the southern Benguela region are in the Orange River Bight and St Helena Bay (Chapman & Shannon 1985; Bailey 1991; Shannon & O'Toole 1998; Bailey 1999; Fossing *et al.* 2000). The spatial distribution of oxygen-poor water in each of the areas is subject to short- and medium-term variability in the volume of hypoxic water that develops. De Decker (1970) showed that the occurrence of low oxygen water off Lambert's Bay is seasonal, with highest development in summer/autumn. Bailey & Chapman (1991), on the other hand, demonstrated that in the St Helena Bay area daily variability exists as a result of downward flux of oxygen through thermoclines and short-term variations in upwelling intensity. Subsequent upwelling processes can move this low-oxygen water up onto the inner shelf, and into nearshore waters, often with devastating effects on marine communities.

Periodic low oxygen events in the nearshore region can have catastrophic effects on the marine communities leading to large-scale stranding of rock lobsters, and mass mortalities of marine biota and fish (Newman & Pollock 1974; Matthews & Pitcher 1996; Pitcher 1998; Cockcroft *et al.* 2000). 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 most recent walkout occurred in early March 2022 at Elands Bay, when some 500 tons of rocklobster were reported stranded on the beach. The blooms develop over a period of unusually calm wind conditions when sea surface temperatures where high. Algal blooms usually occur during summer-autumn (February to April) but can also develop in winter during the 'berg' wind periods, when similar warm windless conditions occur for extended periods.

3.2.8 Turbidity

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulate matter. Total Suspended Particulate Matter (TSPM) can be divided into Particulate Organic Matter (POM) and Particulate Inorganic Matter (PIM), the ratios between them varying considerably. The POM usually consists of detritus, bacteria, phytoplankton and zooplankton, and serves as a source of food for filter-feeders. Seasonal microphyte production associated with upwelling events will play an important role in determining the concentrations of POM in coastal waters. PIM, on the other hand, is primarily of geological origin consisting of fine sands, silts and clays. Off Namaqualand, the PIM loading in nearshore waters is strongly related to natural inputs from the Orange River or from 'berg' wind events (see Figure 8). Although highly variable, annual discharge rates of sediments by the Orange River is estimated to vary from 8 - 26 million tons/yr (Rogers 1979). 'Berg' wind events can potentially contribute the same order of magnitude of sediment input as the annual estimated input of sediment by the Orange River (Shannon & Anderson 1982; Zoutendyk 1992, 1995; Shannon & O'Toole 1998; Lane & Carter 1999). For example, a 'berg' wind event in May 1979 described by Shannon and Anderson (1982) was estimated to have transported in the order of 50 million tons of sand out to sea, affecting an area of 20 000 km^2.

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

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

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

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

Offshore of the continental shelf, the oceanic waters are typically clear as they are beyond the influence of aeolian and riverine inputs. The waters in the offshore portions of Sea Areas 4C and 5C are thus expected to be comparatively clear.

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

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

3.3 The Biological Environment

Biogeographically, the study area falls into the cold temperate Namaqua Bioregion, which extend from Sylvia Hill, north of Lüderitz in Namibia to Cape Columbine (Emanuel *et al.* 1992; Lombard *et al.* 2004). Sea Areas 4C and 5C fall within the Southern Benguela Ecoregion (Sink *et al.* 2019) (Figure 13), which extends from Namibia to the southern tip of the Agulhas Bank. The coastal, wind-induced upwelling characterising the western Cape coastline, is the principle physical process which shapes the marine ecology of the southern Benguela region. The Benguela system is characterised by the presence of cold surface water, high biological productivity, and highly variable physical, chemical and biological conditions.

Communities within marine habitats are largely ubiquitous throughout the southern African West Coast region, being particular only to substrate type or depth zone. These biological communities consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales). The offshore marine ecosystems comprise a limited range of habitats, namely unconsolidated seabed sediments, deepwater reefs and the water column. 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 exploration activities.

3.3.1 Demersal Communities

3.3.1.1 Benthic Invertebrate Macrofauna

The seabed communities in Sea Areas 4C and 5C lie within the Namaqua sub-photic and continental slope biozones, which extend from a 30 m depth to the shelf edge. 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 14) and assigned an ecosystem threat status based on their level of protection (Figure 15). Sea Areas 4C and 5C are characterised by only four ecosystem types, namely, Namaqua Muddy Mid-Shelf Mosaic, Namaqua Sandy Mid-Shelf, Namaqua Muddy Sands, and Southern Benguela Sandy Outer Shelf (Sink *et al.* 2019).

The benthic biota of unconsolidated marine sediments constitute invertebrates that live on (epifauna) or burrow within (infauna) the sediments, and are generally divided into macrofauna (animals >1 mm) and meiofauna (<1 mm). Numerous studies have been conducted on southern African West Coast continental shelf benthos, mostly focused on mining, pollution or demersal trawling impacts (Christie & Moldan 1977; Moldan 1978; Jackson & McGibbon 1991; Field *et al.* 1996; Field & Parkins 1997; Parkins & Field 1998; Pulfrich & Penney 1999; Goosen *et al.* 2000; Savage *et al.* 2001; Steffani & Pulfrich 2004a, 2004b; 2007; Steffani 2007a; 2007b; Atkinson 2009; Steffani 2009a, 2009b, 2010a, 2010b, 2010c; Atkinson *et al.* 2011; Steffani 2012a, 2012b, 2014; Karenyi 2014; Steffani *et al.* 2015; Biccard & Clark 2016; Biccard *et al.* 2016; Duna *et al.* 2016; Karenyi *et al.* 2016; Biccard *et al.* 2017, 2018; Gihwala *et al.* 2018; Biccard *et al.*2019; Giwhala *et al.* 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.

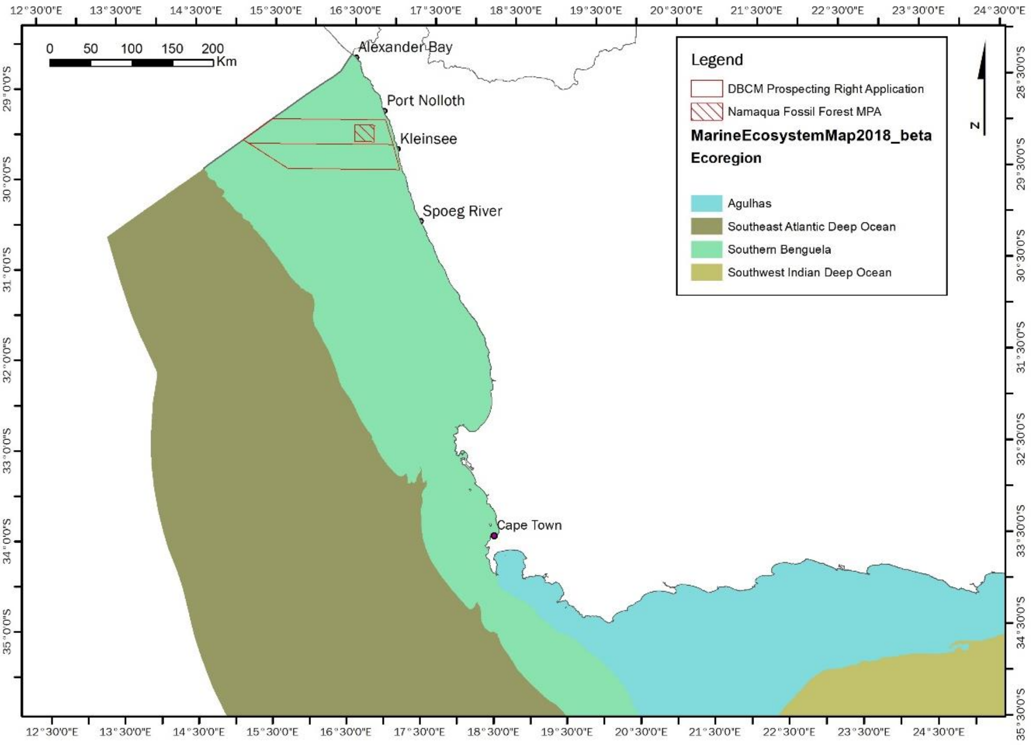

Figure 13: Sea Areas 4C and 5C (red outline) in relation to the inshore and offshore ecoregions of the South African West Coast (adapted from Sink *et al*. 2019).

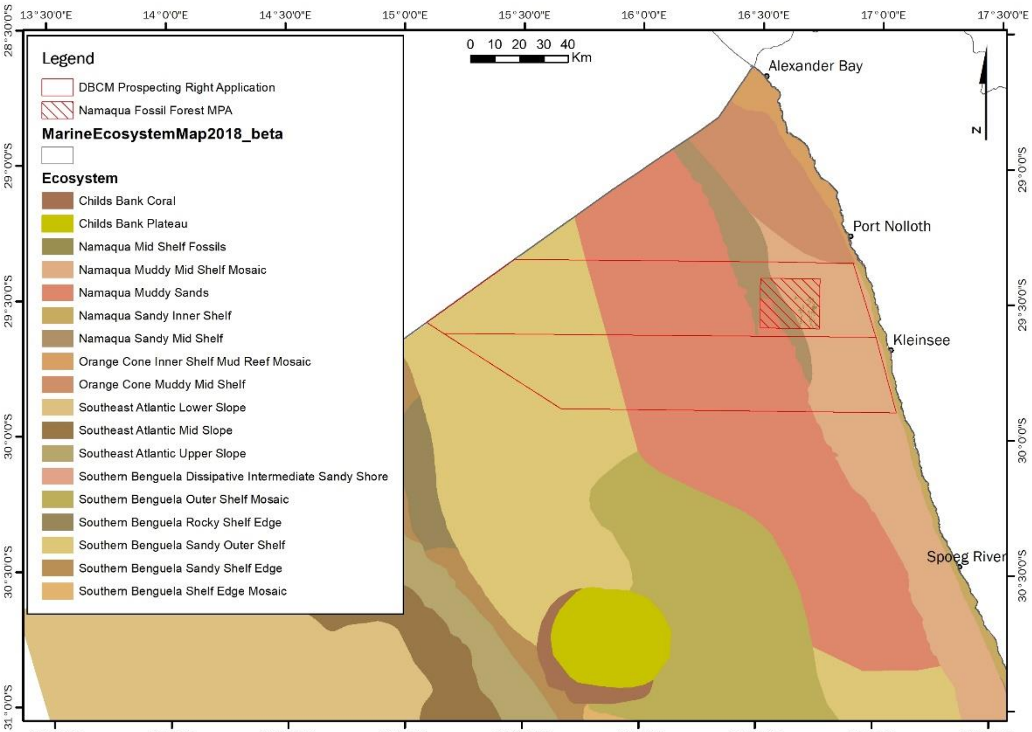

Figure 14: Sea Areas 4C and 5C (red polygon) in relation to the distribution of ecosystem types along the West Coast (adapted from Sink *et al*. 2019).

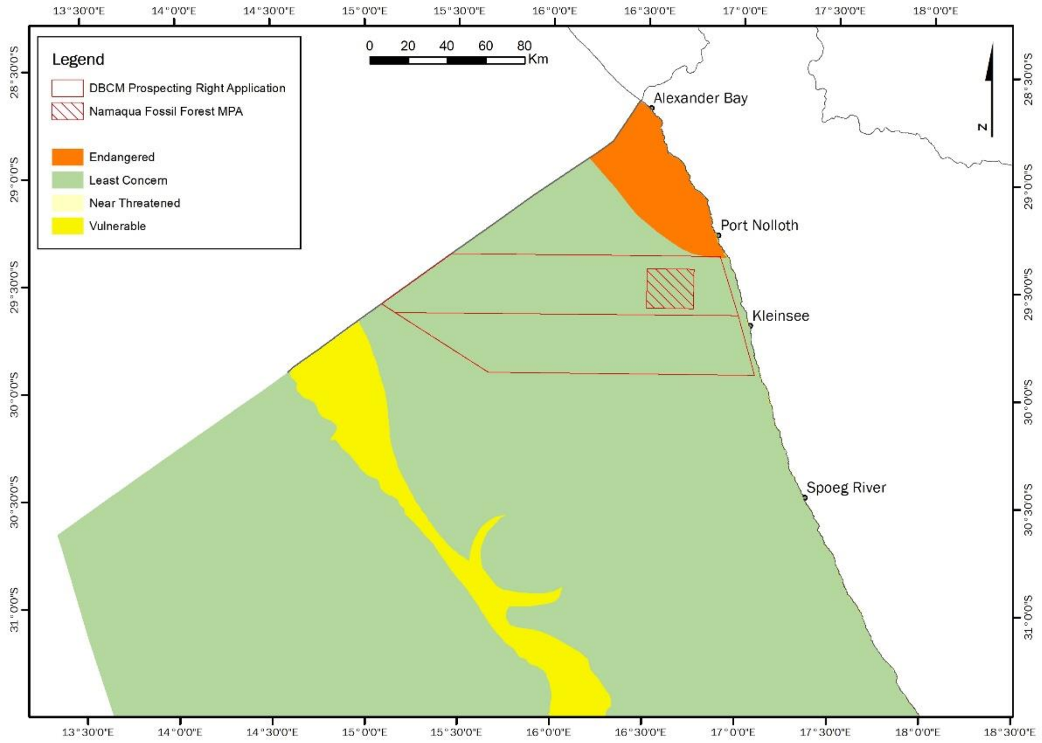

Figure 15: Sea Areas 4C and 5C (red outline) in relation to the ecosystem threat status for coastal and offshore benthic and pelagic habitat types on the South African West Coast (adapted from Sink *et al.* 2019).

To date very few areas on the continental slope off the West Coast have been biologically surveyed (Sink *et al.* 2019; Harris *et al.* 2022). Although sediment distribution studies (Rogers & Bremner 1991) suggest that the outer shelf is characterised by unconsolidated sediments (see Figure 5), recent surveys conducted between 180 m and 480 m depth offshore of the Northern Cape coast revealed high proportions of hard ground rather than unconsolidated sediment, although this requires further verification (Karenyi unpublished data).

To date there have been no studies examining connectivity between slope, plateau or abyssal ecosystems in South Africa and there is thus limited knowledge on the benthic biodiversity of all three of these broad ecosystem groups in South African waters (Sink *et al.* 2019). The description below from the continental shelf of the project area is drawn from 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 *et al.* 2016). Polychaetes, crustaceans and molluscs make up the largest proportion of individuals, biomass and species on the west coast (Figure 16). The inner-shelf community, which is affected by wave action, is characterised by various mobile gastropod and polychaete predators and sedentary polychaetes and isopods. The mid-shelf community inhabits the mudbelt and is characterised by mud prawns. A second mid-shelf community occurring in sandy sediments, is characterised by various deposit-feeding polychaetes. 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 & 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 & Pulfrich 2004).

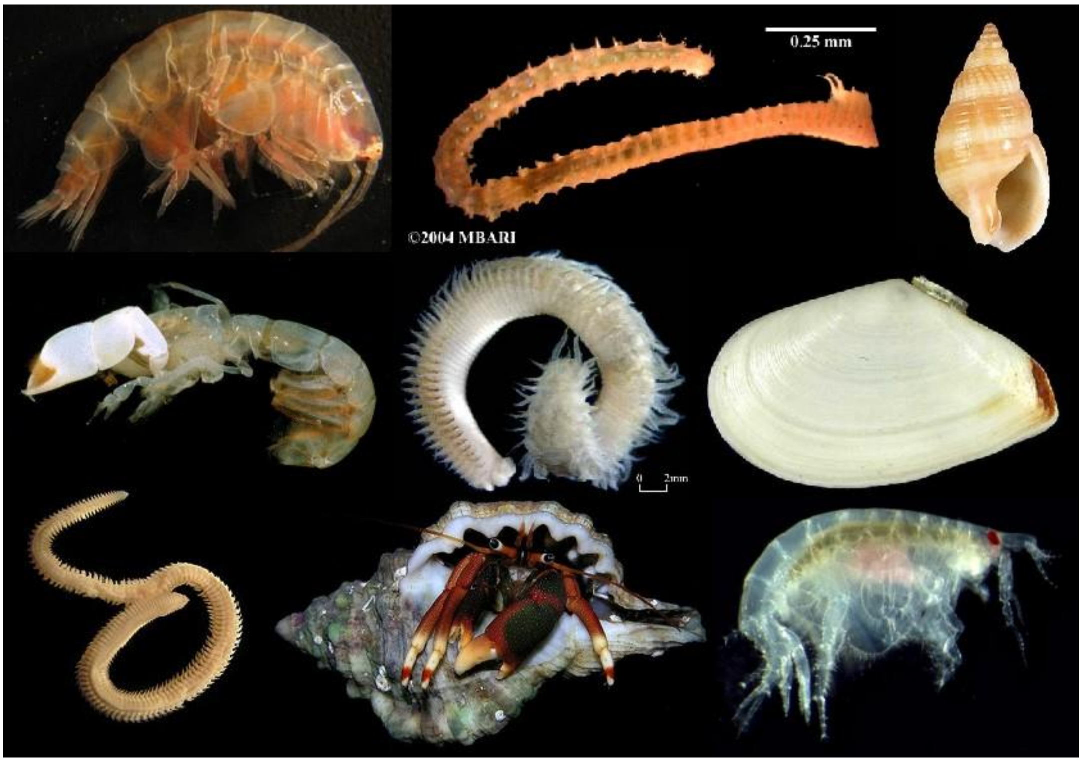

Figure 16: Benthic macrofaunal genera commonly found in nearshore sediments include: (top: left to right) *Ampelisca*, *Prionospio*, *Nassarius*; (middle: left to right) *Callianassa*, *Orbinia*, *Tellina*; (bottom: left to right) *Nephtys*, hermit crab, *Bathyporeia*.

Despite the current lack of knowledge of the community structure and endemicity of South African macro-infauna on the continental shelf, the marine component of the 2018 National Biodiversity Assessment (Sink *et al.* 2019), rated the habitat types that characterise Sea Areas 4C and 5C, as being of 'Least concern' (Figure 15), with only those communities occurring along the shelf edge (-500 m) beyond the western extreme of the Sea Areas as 'Vulnerable'. This primarily reflects the great extent of these habitats in the South African Exclusive Economic Zone (EEZ). The Orange Cone Muddy Mid-Shelf and Inner Shelf Mud Reef Mosaic, which lie adjacent to the north eastern corner of the Sea Area has, however, been rated as 'Endangered' (Sink *et al.* 2019).

Karenyi *et al.* (2016) found that off Namaqualand, species richness increases from the inner-shelf across the mid-shelf and is influenced by sediment type. 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 off the northern Namaqualand coast.

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 & Pulfrich 2004a, 2004b; 2007; Steffani 2007a; 2007b) 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, 2013), 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 deep water 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 & 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.

The 2018 National Biodiversity Assessment for the marine environment (Sink *et al.* 2019) points out that very few national IUCN Red List assessments have been conducted for marine invertebrate species to date owing to inadequate taxonomic knowledge, limited distribution data, a lack of systematic surveys and limited capacity to advance species red listing for these groups.

3.3.1.2 Deep-water coral communities

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). Cold water corals have been observed at shallower depths in high profile rocky outcrop areas within the Namaqua Fossil Forest MPA and to the south-east of Child's Bank (see Section 3.3.2 below). In the productive Benguela region, areas on and off the edge of the shelf could thus potentially be capable of supporting cold water, benthic, filter-feeding communities.

3.3.1.3 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 both latitudinally (Shine 2006, 2008; Yemane *et al.* 2015) and with increasing depth (Roel 1987; Smale *et al.* 1993; Macpherson & Gordoa 1992; Bianchi *et al.* 2001; Atkinson 2009; Yemane *et al.* 2015), 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 in the general project area and on the continental shelf inshore thereof, and their approximate depth range, are listed in Table 2 The distribution of some of these species is provided in Harris *et al.* (2022) (Figure 17a, 17b).

Table 2: 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) and their IUCN conservation status. The National Assessment is provided in parentheses where available.

Common Name	Scientific name	Depth Range (m)	IUCN Conservation Status
Frilled shark	*Chlamydoselachus anguineus*	200-1 000	LC
Six gill cowshark	*Hexanchus griseus*	150-600	NT
Gulper shark	*Centrophorus granulosus*	480	EN
Leafscale gulper shark	*Centrophorus squamosus*	370-800	EN
Bramble shark	*Echinorhinus brucus*	55-285	EN
Black dogfish	*Centroscyllium fabricii*	>700	LC
Portuguese shark	*Centroscymnus coelolepis*	>700	NT
Longnose velvet dogfish	*Centroscymnus crepidater*	400-700	NT
Birdbeak dogfish	*Deania calcea*	400-800	NT
Arrowhead dogfish	*Deania profundorum*	200-500	NT
Longsnout dogfish	*Deania quadrispinosa*	200-650	VU
Sculpted lanternshark	*Etmopterus brachyurus*	450-900	DD
Brown lanternshark	*Etmopterus compagnoi*	450-925	LC
Giant lanternshark	*Etmopterus granulosus*	>700	LC
Smooth lanternshark	*Etmopterus pusillus*	400-500	LC
Spotted spiny dogfish	*Squalus acanthias*	100-400	VU
Shortnose spiny dogfish	*Squalus megalops*	75-460	LC
Shortspine spiny dogfish	*Squalus mitsukurii*	150-600	EN
Sixgill sawshark	*Pliotrema warreni*	60-500	LC
Goblin shark	*Mitsukurina owstoni*	270-960	LC
Smalleye catshark	*Apristurus microps*	700-1 000	LC
Saldanha catshark	*Apristurus saldanha*	450-765	LC
“grey/black wonder” catsharks	*Apristurus* spp.	670-1 005	LC
Tigar catshark	*Halaelurus natalensis*	50-100	VU
Izak catshark	*Holohalaelurus regani*	100-500	LC
Yellowspotted catshark	*Scyliorhinus capensis*	150-500	NT
Soupfin shark/Vaalhaai	*Galeorhinus galeus*	<10-300	CR (EN)
Houndshark	*Mustelus mustelus*	<100	EN (DD)
Whitespotted houndshark	*Mustelus palumbes*	>350	LC
Little guitarfish	*Rhinobatos annulatus*	>100	VU (LC)
Atlantic electric ray	*Torpedo nobiliana*	120-450	LC
African softnose skate	*Bathyraja smithii*	400-1 020	LC
Smoothnose legskate	*Cruriraja durbanensis*	>1 000	DD
Roughnose legskate	*Cruriraja parcomaculata*	150-620	LC
African dwarf skate	*Neoraja stehmanni*	290-1 025	LC
Thorny skate	*Raja radiata*	50-600	VU
Bigmouth skate	*Raja robertsi*	>1 000	LC

Common Name	Scientific name	Depth Range (m)	IUCN Conservation Status
Slime skate	*Dipturus pullopunctatus*	15-460	LC
Rough-belly skate	*Raja springeri*	85-500	LC
Yellowspot skate	*Raja wallacei*	70-500	VU
Roughskin skate	*Dipturus trachydermus*	1 000-1 350	EN
Biscuit skate	*Raja clavata*	25-500	NT
Munchkin skate	*Rajella caudaspinosa*	300-520	LC
Bigthorn skate	*Raja confundens*	100-800	LC
Ghost skate	*Rajella dissimilis*	420-1 005	LC
Leopard skate	*Rajella leopardus*	300-1 000	LC
Smoothback skate	*Rajella ravidula*	500-1 000	LC
Spearnose skate	*Rostroraja alba*	75-260	EN
St Joseph	*Callorhinchus capensis*	30-380	LC (LC)
Cape chimaera	*Chimaera notafricana*	680-1 000	LC
Brown chimaera	*Chimaera carophila*	420-850	LC
Spearnose chimaera	*Rhinochimaera atlantica*	650-960	LC

LC - Least Concern	VU - Vulnerable	NT - Near Threatened
EN - Endangered	CR - Critically Endangered	DD - Data Deficient

3.3.2 Seamount Communities

Two geological features of note are found off the West Coast of southern Africa, namely Child's Bank (situated ~75 km south of the southern boundary of Sea Area 5C at about 31°S) and Tripp Seamount (situated at about 29°40'S, ~50 km west of the western tip of Sea Area 4C). Child's Bank was described by Dingle *et al.* (1987) to be a carbonate mound (bioherm). Tripp Seamount is a roughly circular feature with a flat apex that rises from the seabed at ~1 000 m to a depth of 150 m. Features such as banks, knolls and seamounts (referred to collectively here as "seamounts"), which protrude into the water column, are subject to, and interact with, the water currents surrounding them. The effects of such seabed features on the surrounding water masses can include the up-welling of relatively cool, nutrient-rich water into nutrient-poor surface water thereby resulting in higher productivity (Clark *et al.* 1999), which can in turn strongly influences the distribution of organisms on and around seamounts. Evidence of enrichment of bottom-associated communities and high abundances of demersal fishes has been regularly reported over such seabed features.

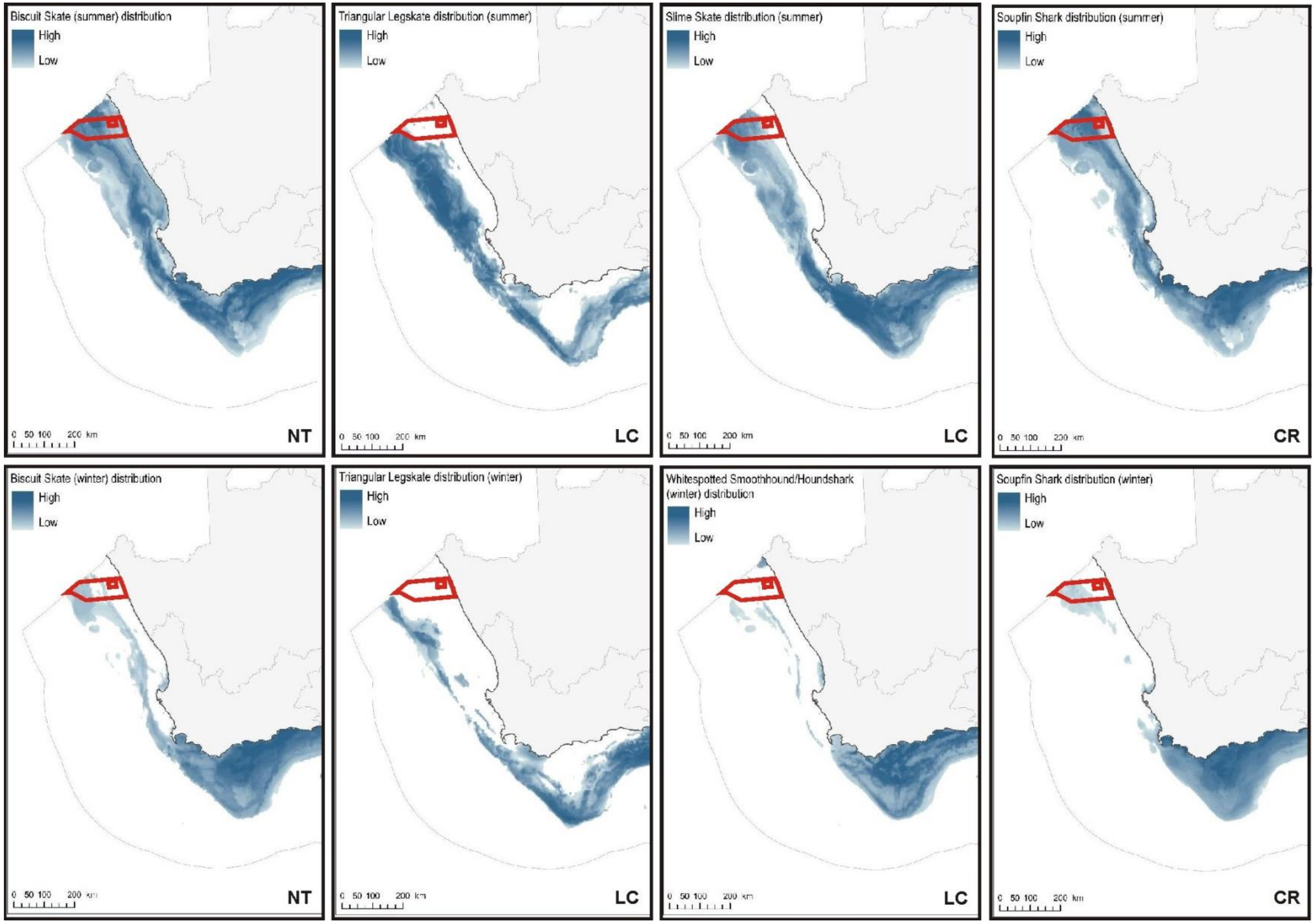

Figure 17a: The summer (top) and winter (bottom) distribution of biscuit skate, triangular legskate, slime skate, whitespotted smoothhound and soupfin shark in relation to Sea Areas 4C and 5C (red polygon) (adapted from Harris *et al*. 2022). The IUCN conservation status is provided.

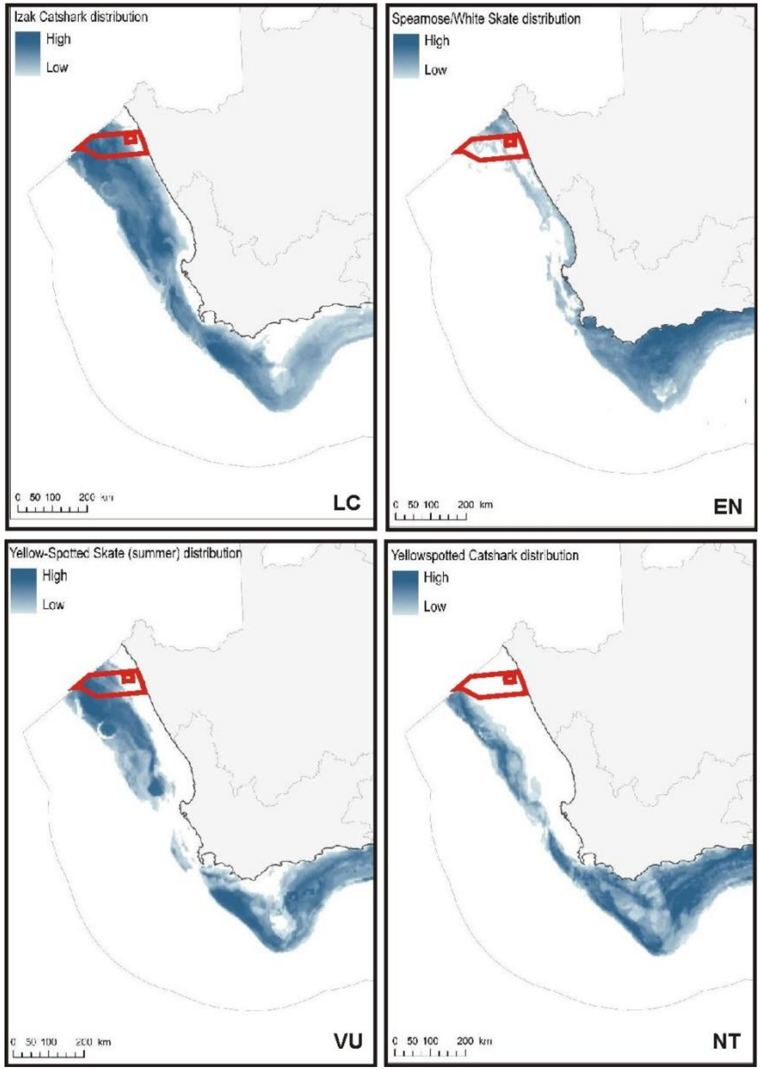

Figure 17b: The distribution of various cartilaginous species mentioned in Table 2 in relation to Sea Areas 4C and 5C (red polygon) (adapted from Harris *et al*. 2022). The IUCN conservation status is provided.

The enhanced fluxes of detritus and plankton that develop in response to the complex current regimes lead to the development of detritivore-based food-webs, which in turn lead to the presence of seamount scavengers and predators. Seamounts provide an important habitat for commercial deepwater fish stocks such as orange roughy, oreos, alfonsino and Patagonian toothfish, which aggregate around these features for either spawning or feeding (Koslow 1996).

Such complex benthic ecosystems in turn enhance foraging opportunities for many other predators, serving as mid-ocean focal points for a variety of pelagic species with large ranges (turtles, tunas and billfish, pelagic sharks, cetaceans and pelagic seabirds) that may migrate large distances in search of food or may only congregate on seamounts at certain times (Hui 1985; Haney *et al*. 1995). Seamounts thus serve as feeding grounds, spawning and nursery grounds and possibly navigational markers for a large number of species (SPRFMA 2007).

Deep- and cold-water corals (including stony corals, black corals and soft corals) (Figure 18, left) are a prominent component of the suspension-feeding fauna of many seamounts, accompanied by barnacles, bryozoans, polychaetes, molluscs, sponges, sea squirts, basket stars, brittle stars and crinoids (reviewed in Rogers 2004) (Figure 18, right). There is also associated mobile benthic fauna that includes echinoderms (sea urchins and sea cucumbers) and crustaceans (crabs and lobsters) (reviewed by Rogers 1994; Kenyon *et al*. 2003). Some of the smaller cnidarians species remain solitary while others form reefs thereby adding structural complexity to otherwise uniform seabed habitats.

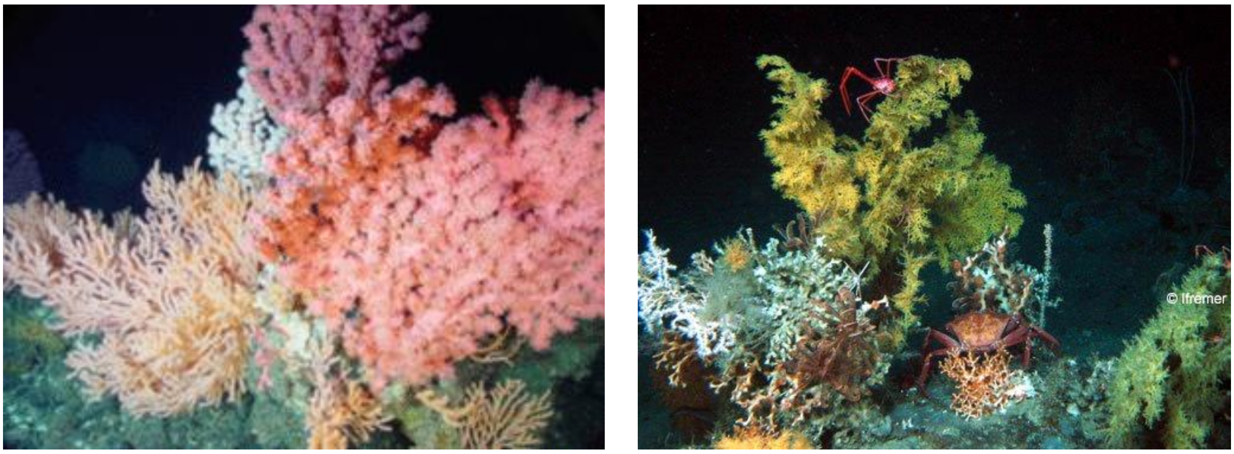

Figure 18: Seamounts are characterised by a diversity of deep-water corals that add structural complexity to seabed habitats and offer refugia for a variety of invertebrates and fish (Photos: www.dfo-mpo.gc.ca/science/Publications/article/2007/21-05-2007-eng.htm, Ifremer & AWI 2003).

Consequently, the fauna of seamounts is usually highly unique and may have a limited distribution restricted to a single geographic region, a seamount chain or even a single seamount location (Rogers *et al*. 2008). As a result of conservative life histories (*i.e*. very slow growing, slow to mature, high longevity, low fecundity and unpredictable recruitment) and sensitivity to changes in environmental conditions, such biological communities have been identified as Vulnerable Marine Ecosystems (VMEs). They are recognised as being particularly sensitive to anthropogenic disturbance (primarily deep-water trawl fisheries and mining), and once damaged are very slow to recover, or may never recover (FAO 2008).

South Africa's seamounts and their associated benthic communities have not been extensively sampled by either geologists or biologists (Sink & Samaai 2009). While it is not always the case that seamount habitats are VMEs, some of the deep water habitats on the West Coast are thought to be characterised by a number of VME indicator species such as sponges, soft corals and hard corals (Table 3) (Figure 19). The distribution of 22 potential VME indicator taxa for the South African EEZ were recently mapped, with those from the northern West Coast listed in Table 3 (Atkinson & Sink 2018; Sink *et al*. 2019). Of these only the sponge *Suberites dandelenae* has been recorded from the 4C and 5C Sea Areas, with all others recorded from deeper waters only (Atkinson & Sink 2018).

Table 3: Table of Potential VME species from the continental shelf and shelf edge on the West Coast (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

3.3.3 Pelagic Communities

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

3.3.3.1 Plankton

Plankton is particularly abundant in the shelf waters off the West Coast, being associated with the upwelling characteristic of the area. Plankton range from single-celled bacteria to jellyfish of 2-m diameter, and include bacterio-plankton, phytoplankton, zooplankton, and ichthyoplankton (Figure 20).

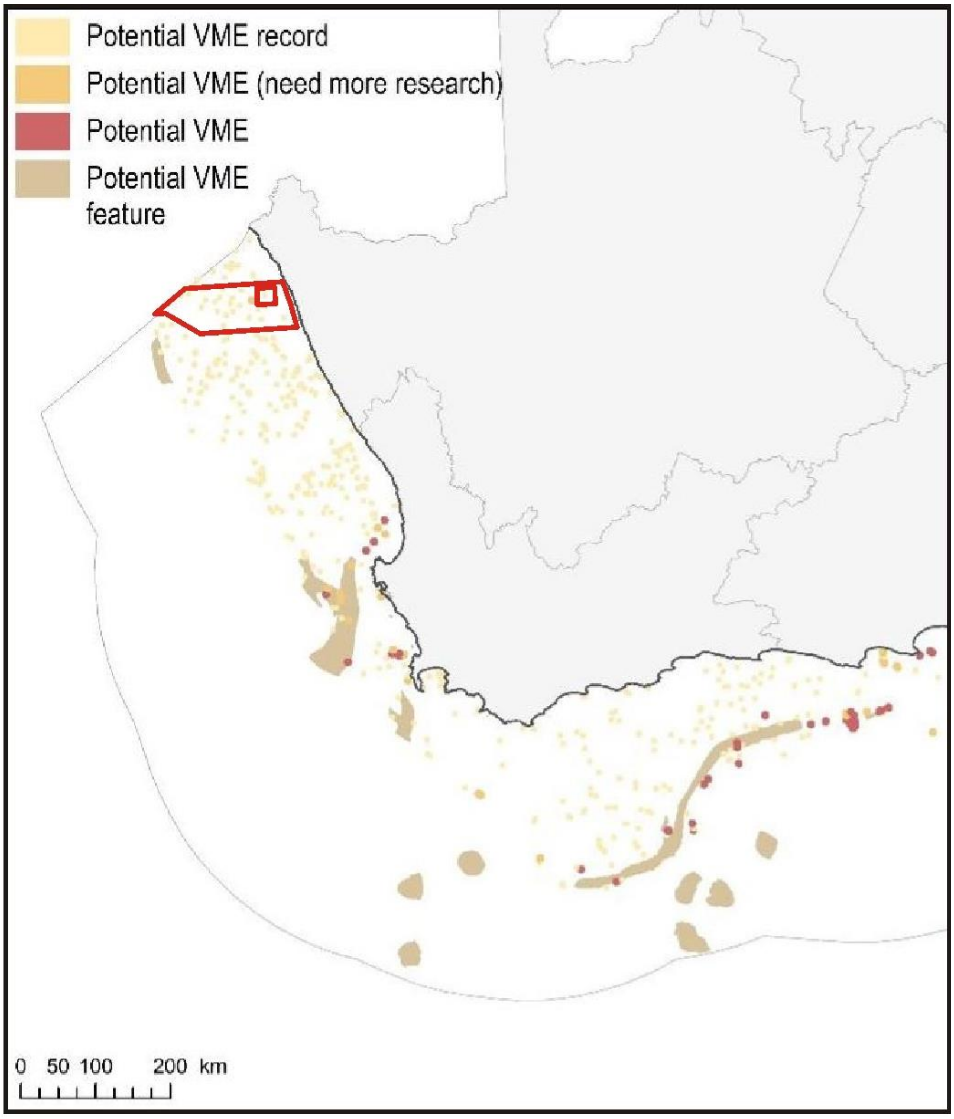

Figure 19: Sea Areas 4C and 5C (red polygon) in relation to the distribution of known and potential Vulnerable Marine Ecosystem habitat (adaptef from Harris *et al*. 2022).

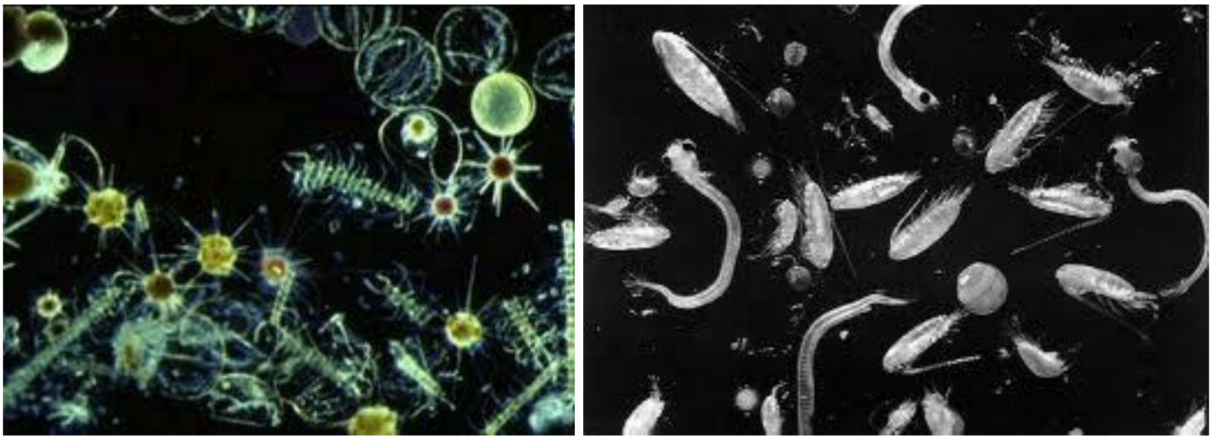

Figure 20: Phytoplankton (left, photo: hymagazine.com) and zooplankton (right, photo: mysciencebox.org) is associated with upwelling cells.

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

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

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

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

Standing stock estimates of mesozooplankton for the southern Benguela area range from 0.2 - 2.0 g C/m^2, with maximum values recorded during upwelling periods. Macrozooplankton biomass ranges from 0.1-1.0 g C/m^2, with production increasing north of Cape Columbine (Pillar 1986). Although it shows no appreciable onshore-offshore gradients, standing stock is highest over the shelf, with accumulation of some mobile zooplanktors (euphausiids) known to occur at oceanographic fronts. Beyond the continental slope biomass decreases markedly. Localised peaks in biomass may, however, occur in the vicinity of Child's Bank and Tripp seamount in response to topographically steered upwelling around such seabed features.

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

Although ichthyoplankton (fish eggs and larvae) comprise a minor component of the overall plankton, it remains significant due to the commercial importance of the overall fishery in the region. Various pelagic and demersal fish species are known to spawn in the inshore regions of the southern Benguela, (including pilchard, round herring, chub mackerel lanternfish and hakes (Crawford *et al.* 1987; Hutchings 1994; Hutchings *et al.* 2002) (see Figure 21, Figure 22a and 22b, and Figure 23), and their eggs and larvae form an important contribution to the ichthyoplankton in the region. Spawning of key species is presented below.

- Hake, snoek and round herring move to the western Agulhas Bank and southern west coast to spawn in late winter and early spring (key period), when offshore Ekman losses are at a minimum and their eggs and larvae drift northwards and inshore to the west coast nursery grounds. Figure 22a and 22b highlight the temporal variation in hake eggs and larvae with there being a greater concentration of eggs and larvae between September - October compared to March - April. However, hake are reported to spawn throughout the year (Strømme *et al.* 2015). Snoek spawn along the shelf break (150-400 m) of the western Agulhas Bank and the West Coast between June and October (Griffiths 2002).
- Horse mackerel spawn over the east/central Agulhas Bank during winter months.
- Sardines spawn on the whole Agulhas Bank during November, but generally have two spawning peaks, in early spring and autumn, on either side of the peak anchovy spawning period (Figure 23, left). There is also sardine spawning on the east coast and even off KwaZulu-Natal, where sardine eggs are found during July–November.
- Anchovies spawn on the whole Agulhas Bank (Figure 23, right), with spawning peaking during mid-summer (November–December) and some shifts to the west coast in years when Agulhas Bank water intrudes strongly north of Cape Point.

The eggs and larvae are carried around Cape Point and up the coast in northward flowing surface waters. At the start of winter every year, the juveniles recruit in large numbers into coastal waters across broad stretches of the shelf between the Orange River and Cape Columbine 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. Following spawning, the eggs and larvae of snoek are transported to inshore (<150 m) nursery grounds north of Cape Columbine and east of Danger Point, where the juveniles remain until maturity. There is limited overlap of Sea Areas 4C and 5C with the northward egg and larval drift of commercially important species, and the return migration of recruits (Figure 21). Ichthyoplankton abundance in Sea Areas 4C and 5C may, therefore, be seasonally high, especially in the 5C area.

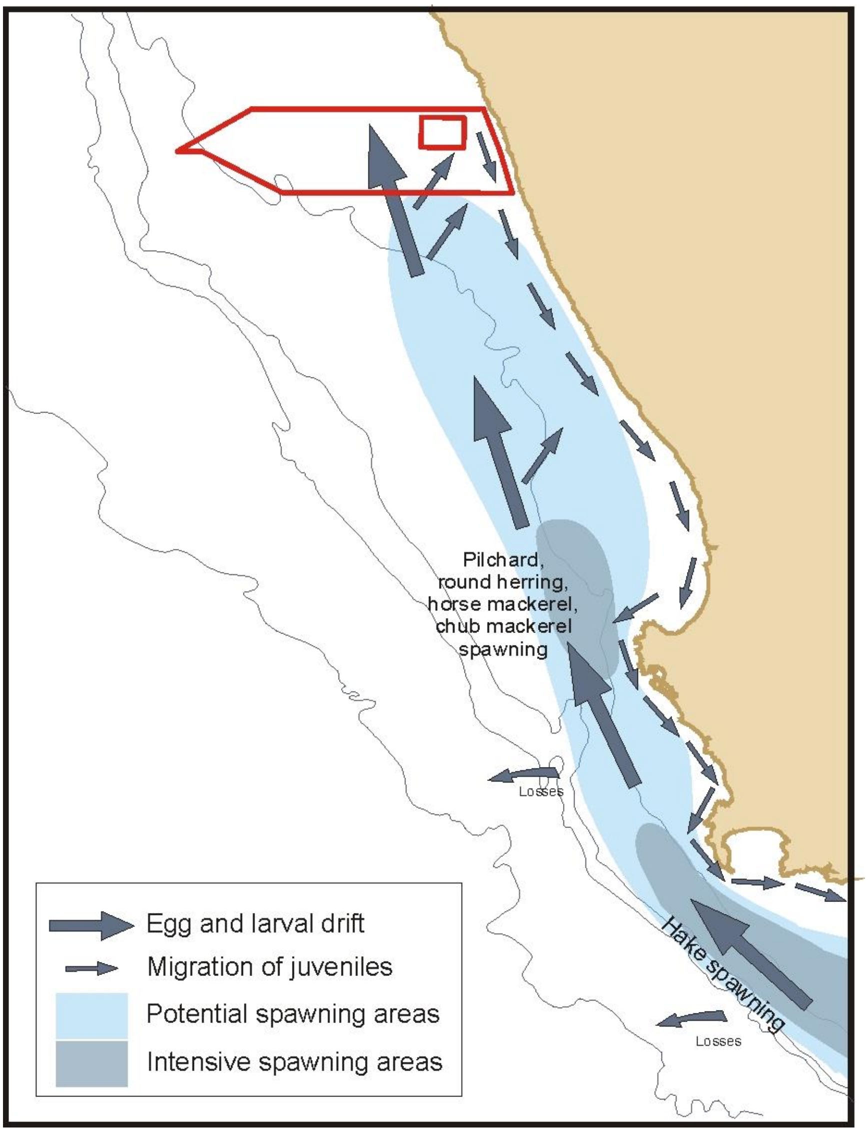

Figure 21: Sea Areas 4C and 5C (red polygon) in relation to major spawning, recruitment and nursery areas in the southern Benguela region (adapted from Crawford *et al*. 1987; Hutchings 1994; Hutchings *et al*. 2002).

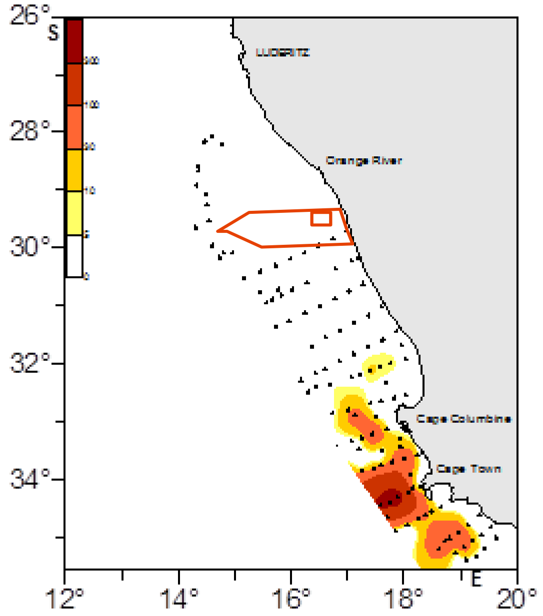

Figure 22a: Distribution of hake eggs (left) and larvae (right) off the West Coast of South Africa between September and October 2005 (adapted from Stenevik *et al*. 2008) in relation to the the Sea Areas 4C and 5C (red polygon).

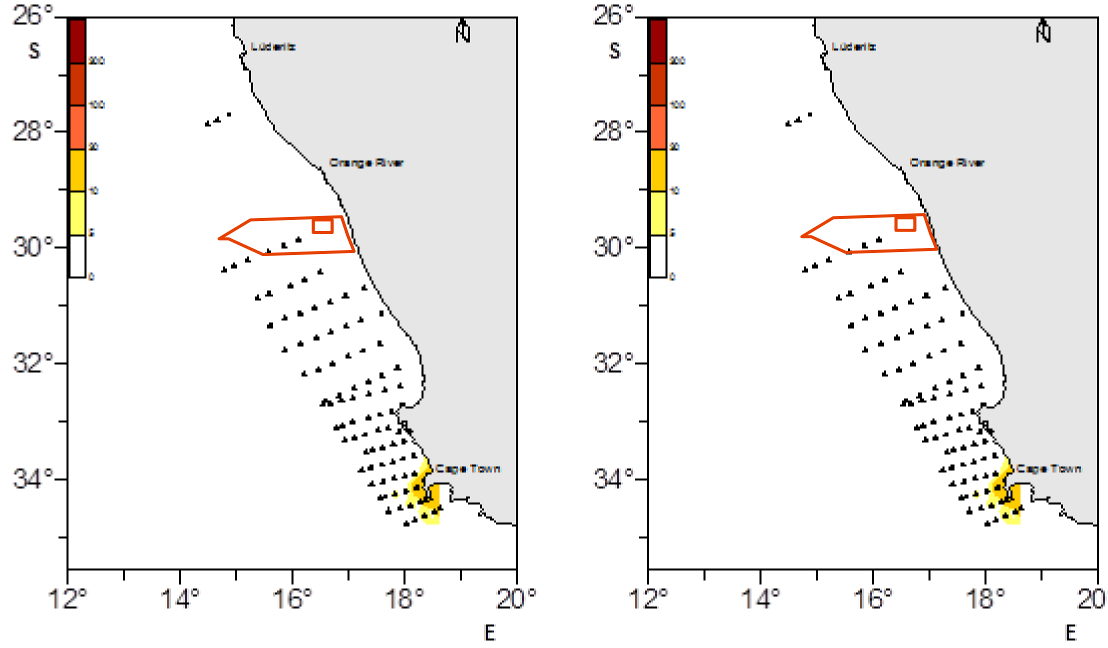

Figure 22b: Distribution of hake eggs (left) and larvae (right) off the West Coast of South Africa between March and April 2007 (adapted from Stenevik *et al*. 2008) in relation to the Sea Areas 4C and 5C (red polygon).

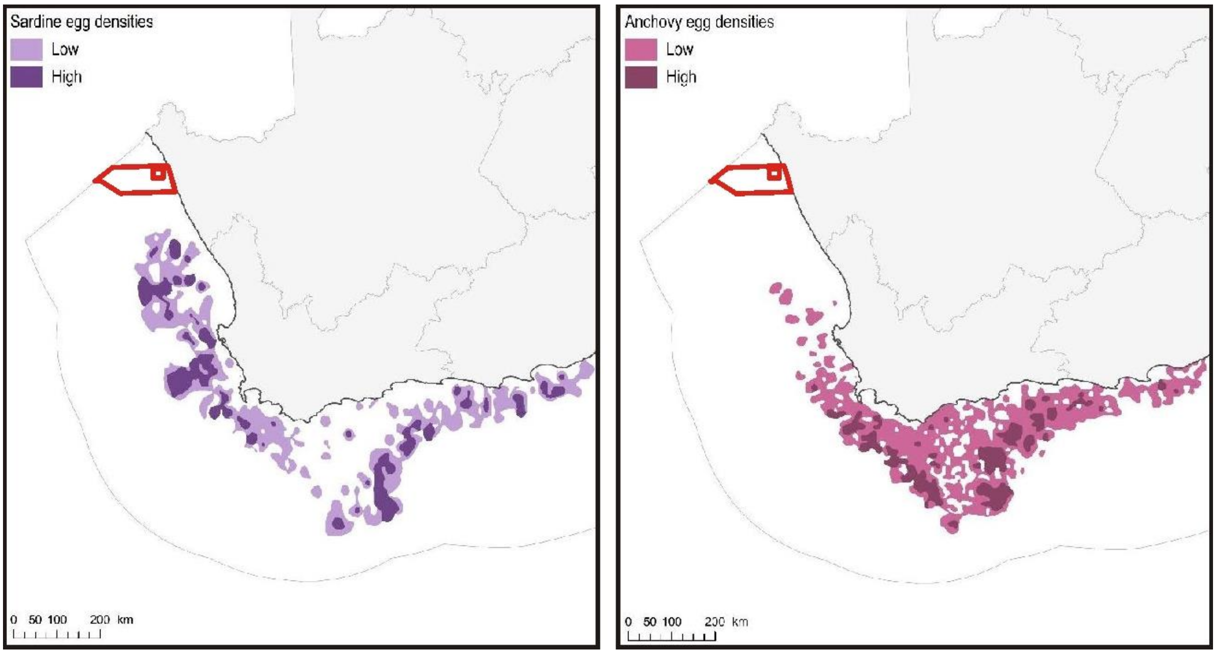

Figure 23: Distribution of sardine (left) and anchovy (right) spawning areas, as measured by egg densities, in relation to Sea Areas 4C and 5C (red polygon) (adapted from Harris *et al*. 2022).

3.3.3.2 Cephalopods

Fourteen species of cephalopds 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 colossal squid *Mesonychoteuthis hamiltoni* and the giant squid *Architeuthis* sp. may also be encountered in the project area. Both are deep dwelling species, with the colossal squid's distribution confined to the entire circum-antarctic Southern Ocean (Figure 24, top) while the giant squid is usually found near continental and island slopes all around the world's oceans (Figure 24, bottom). Both species could thus potentially occur in the pelagic habitats of the project area, 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 sleeper sharks. 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. They lack gas-filled swim bladders and maintain neutral buoyancy through an ammonium chloride solution occurring throughout their bodies.

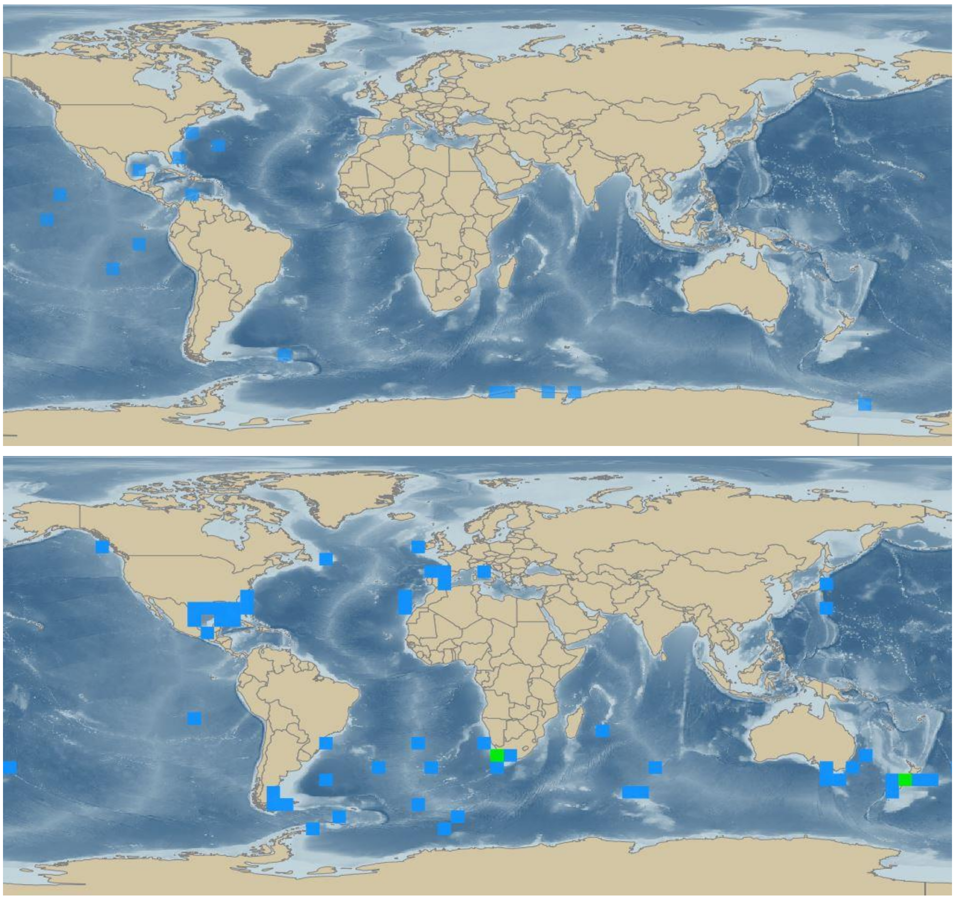

Figure 24: Distribution of the colossal squid (top) and the giant squid (bottom). Blue squares <5 records, green squares 5-10 records (Source: http://iobis.org).

3.3.3.3 Pelagic Fish

Small pelagic species include the sardine/pilchard (*Sadinops ocellatus*) (Figure 25, left), anchovy (*Engraulis capensis*), chub mackerel (*Scomber japonicus*), horse mackerel (*Trachurus capensis*) (Figure 25, right) and round herring (*Etrumeus whiteheadi*). These species typically occur in mixed shoals of various sizes (Crawford *et al.* 1987), and generally occur within the 200 m contour. Most of the pelagic species 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 & Pillar 1986) (see Figure 21). They spawn downstream of major upwelling centres in spring and summer, and their eggs and larvae are subsequently carried around Cape Point and up the coast in northward flowing surface waters.

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

Figure 25: Cape fur seal preying on a shoal of pilchards (left). School of horse mackerel (right) (photos: www.underwatervideo.co.za; www.delivery.superstock.com).

Two species that migrate along the West Coast following the shoals of anchovy and pilchards are snoek *Thyrsites atun* and chub mackerel *Scomber japonicas*. Both these species have been rated as 'Least concern' on the national assessment (Sink *et al.* 2019). While the appearance of chub mackerel along the West and South-West coasts is highly seasonal, adult snoek are found throughout their distribution range and longshore movement are random and without a seasonal basis (Griffiths 2002). Initially postulated to be a single stock that undergoes a seasonal longshore migration from southern Angola through Namibia to the South African West Coast (Crawford & De Villiers 1985; Crawford *et al.* 1987), Benguela snoek are now recognised as two separate sub-populations separated by the Lüderitz upwelling cell (Griffiths 2003). On the West Coast, snoek move offshore to spawn and there is some southward dispersion as the spawning season progresses, with females on the West Coast moving inshore to feed between spawning events as spawning progresses. In contrast, those found further south along the western Agulhas Bank remain on the spawning grounds throughout the spawning season (Griffiths 2002) (Figure 26). The spawning grounds for the species are therefore extensive ranging between the western edge of the Agulhas Bank and most of the South African west coast. There is also no single inshore or offshore migration of the snoek stock, rather numerous inshore-offshore movements during the spawning season. Snoek are serial batch spawners with females releasing batches of eggs at 10-40 day intervals on offshore spawning grounds (150 – 400 m depth). They are voracious predators occurring throughout the water column, feeding on both demersal and pelagic invertebrates and fish. Chub mackerel similarly migrate along the southern African West Coast reaching South-Western Cape waters between April and August. They move inshore in June and July to spawn before starting the return northwards offshore migration later in the year. Their abundance and seasonal migrations are thought to be related to the availability of their shoaling prey species (Payne & Crawford 1989). The distribution of snoek and chub mackerel therefore overlaps with Sea Areas 4C and 5C.

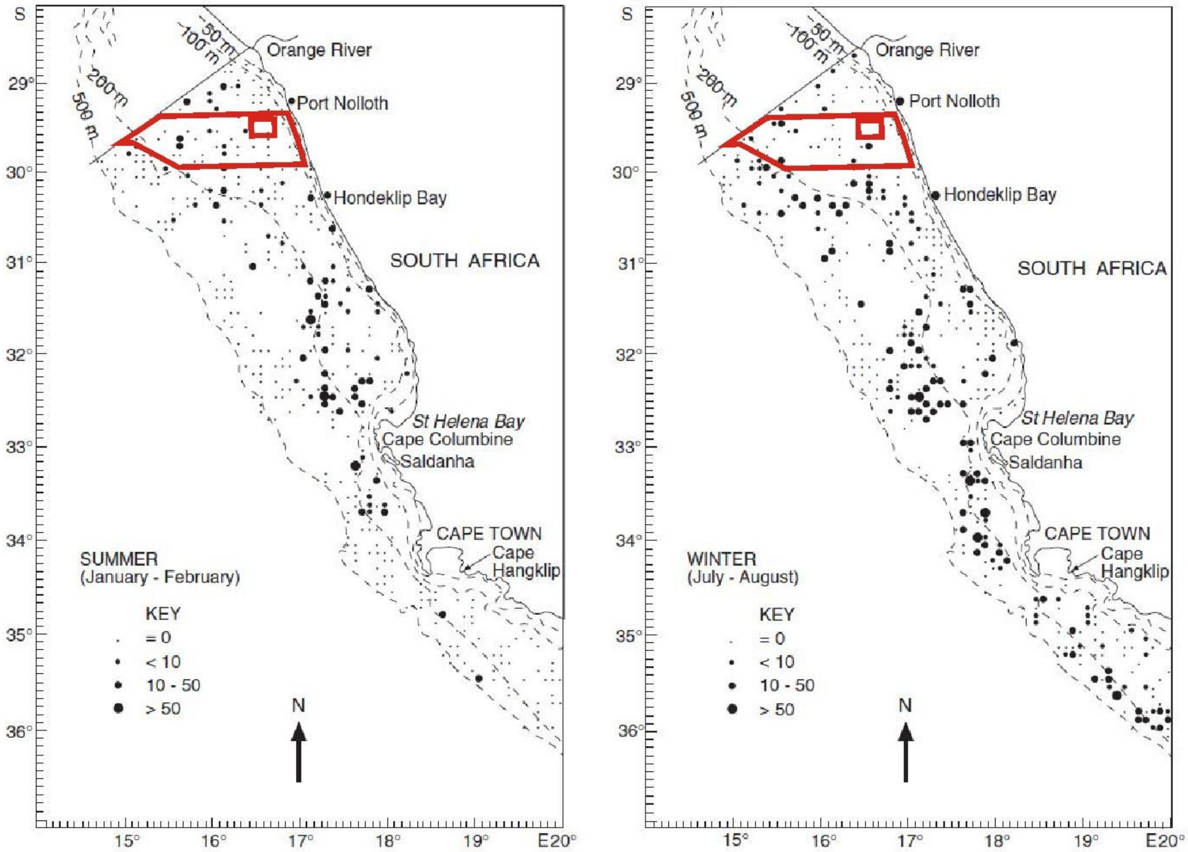

Figure 26: Mean number of snoek per demersal trawl per grid block (5 × 5 Nm) by season for (A) the west coast (July 1985–Jan 1991) and (B) the south coast in relation to Sea Areas 4C and 5C (red polygon) (adapted from Griffiths 2002).

The fish most likely to be encountered on the shelf and in the offshore waters of Sea Areas 4C and 5C are the large migratory pelagic species, including various tunas, billfish and sharks, many of which are considered threatened by the International Union for the Conservation of Nature (IUCN), primarily due to overfishing (Table 4). Tuna and swordfish are targeted by high seas fishing fleets and illegal overfishing has severely damaged the stocks of many of these species. Similarly, pelagic sharks, are either caught as bycatch in the pelagic tuna longline fisheries, or are specifically targeted for their fins, where the fins are removed and the remainder of the body discarded.

Table 4: Some of the more important large migratory pelagic fish likely to occur in the offshore regions of the West Coast (TOPS list under NEMBA, Act 10 of 2004; Sink *et al*. 2019; www.iucnredlist.org;). The Global and National IUCN Conservation Status are also provided.

Common Name	Species	IUCN Conservation Status	National Assessment
Tunas			
Southern Bluefin Tuna	*Thunnus maccoyii*	Endangered	Not Assessed
Bigeye Tuna	*Thunnus obesus*	Vulnerable	Vulnerable
Longfin Tuna/Albacore	*Thunnus alalunga*	Least concern	Near Threatened

Common Name	Species	IUCN Conservation Status	National Assessment
Yellowfin Tuna	*Thunnus albacares*	Least concern	Near Threatened
Frigate Tuna	*Auxis thazard*	Least concern	Not Assessed
Eastern Little Tuna	*Euthynnus affinis*	Least concern	Least concern
Skipjack Tuna	*Katsuwonus pelamis*	Least concern	Least concern
Atlantic Bonito	*Sarda sarda*	Least concern	Not Assessed
Billfish			
Black Marlin	*Istiompax indica*	Data deficient	Data deficient
Blue Marlin	*Makaira nigricans*	Vulnerable	Vulnerable
Striped Marlin	*Kajikia audax*	Least concern	Near Threatened
Sailfish	*Istiophorus platypterus*	Vulnerable	Least concern
Swordfish	*Xiphias gladius*	Near Threatened	Data deficient
Pelagic Sharks			
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Critically Endangered	Not Assessed
Dusky Shark	*Carcharhinus obscurus*	Endangered	Data deficient
Bronze Whaler Shark	*Carcharhinus brachyurus*	Vulnerable	Data deficient
Great White Shark	*Carcharodon carcharias*	Vulnerable	Least concern
Shortfin Mako	*Isurus oxyrinchus*	Endangered	Vulnerable
Longfin Mako	*Isurus paucus*	Endangered	Not Assessed
Whale Shark	*Rhincodon typus*	Endangered	Not Assessed
Blue Shark	*Prionace glauca*	Near Threatened	Least concern

*Until recently Southern Bluefin Tuna was globally assessed as 'Critically Endangered' by the IUCN. Although globally the stock remains at a low state, it is not considered overfished as there have been improvements since previous stock assessments. Consequently, the list of species changing IUCN Red List Status for 2020-2021 now list Southern Bluefin Tuna is globally 'Endangered'. in South Africa the stock is considered collapsed (Sink *et al.* 2019).

These large pelagic species migrate throughout the southern oceans, between surface and deep waters (>300 m) and have a highly seasonal abundance in the Benguela. Species occurring off western southern Africa include the albacore/longfin tuna *Thunnus alalunga* (Figure 27, right), yellowfin *T. albacares*, bigeye *T. obesus*, and skipjack *Katsuwonus pelamis tunas*, as well as the Atlantic blue marlin *Makaira nigricans* (Figure 27, left), the white marlin *Tetrapturus albidus* and the broadbill swordfish *Xiphias gladius* (Payne & Crawford 1989). The distribution 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 (Shannon *et al.* 1989; Penney *et al.* 1992). Seasonal association with Child's Bank and Tripp Seamount occurs between October and June, with commercial catches often peaking in March and April (www.fao.org/fi/fcp/en/ NAM/body.htm; see CapMarine 2023 – Fisheries Specialist Study).

A number of species of pelagic sharks are also known to occur on the West and South-West Coast, including blue *Prionace glauca*, short-fin mako *Isurus oxyrinchus* and oceanic whitetip sharks *Carcharhinus longimanus*. Occurring throughout the world in warm temperate waters, these species are usually found offshore of the continental shelf on the West Coast. Great whites *Carcharodon carcharias* and whale sharks *Rhincodon typus* may also be encountered in coastal and offshore areas, although the latter occurs more frequently along the South and East coasts. The recapture of a juvenile blue shark off Uruguay, which had been tagged off the Cape of Good Hope, supports the hypothesis of a single blue shark stock in the South Atlantic (Hazin 2000; Montealegre-Quijano & Vooren 2010) and Indian Oceans (da Silva *et al*. 2010). Using the Benguela drift in a north-westerly direction, it is likely that juveniles from the parturition off the south-western Cape would migrate through the project area *en route* to South America (da Silva *et al*. 2010).

The shortfin mako inhabits offshore temperate and tropical seas worldwide. It can be found from the surface to depths of 500 m, and as one of the few endothermic sharks is seldom found in waters <16 °C (Compagno 2001; Loefer *et al*. 2005). As the fastest species of shark, shortfin makos have been recorded to reach speeds of 40 km/h with burst of up to 74 km/h, and can jump to a height of 9 m (http://www.elasmo-research.org/education/shark_profiles/ i_oxyrinchus.htm). Most makos caught by longliners off South Africa are immature, with reports of juveniles and sub-adults sharks occurring near the edge of the Agulhas Bank and off the South Coast between June and November (Groeneveld *et al*. 2014), whereas larger and reproductively mature sharks were more common in the inshore environment along the East Coast (Foulis 2013).

Figure 27: Large migratory pelagic fish such as blue marlin (left) and longfin tuna (right) occur in offshore waters (photos: www.samathatours.com; www.osfimages.com).

Whale sharks are regarded as a broad ranging species typically occurring in offshore epipelagic areas with sea surface temperatures of 18–32°C (Eckert & Stewart 2001). Adult whale sharks reach an average size of 9.7 m and 9 tonnes, making them the largest non-cetacean animal in the world. They are slow-moving filter-feeders and therefore particularly vulnerable to ship strikes (Rowat 2007). Although primarily solitary animals, seasonal feeding aggregations occur at several coastal sites all over the world, those closest to the project area being off Sodwana Bay in KwaZulu Natal (KZN) in the Greater St. Lucia Wetland Park (Cliff *et al*. 2007). Satellite tagging has revealed that individuals may travel distances of tens of 1 000s of kms (Eckert & Stewart 2001; Rowat & Gore 2007; Brunnschweiler *et al*. 2009). On the West Coast their summer and winter distributions are centred around the Orange River mouth and between Cape Columbine and Cape Point (Harris *et al*. 2022). The likelihood of an encounter in the offshore waters of Sea Areas 4C and 5C is relatively low.

The whale shark and shortfin mako 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 Appendix I and/or II of the Bonn Convention for the Conservation of Migratory Species (CMS). The whale shark is also listed as 'vulnerable' in the List of Marine Threatened or Protected Species (TOPS) as part of the National Environmental Management: Biodiversity Act (Act 10 of 2004) (NEMBA).

The distributions of some of the pelagic sharks (Great white, Bronze whaler, shortfin mako and whale shark) are provided in Harris *et al.* (2022) (Figure 28).

3.3.3.4 Turtles

Three species of turtle occur along the West Coast, namely the Leatherback (*Dermochelys coriacea*) (Figure 29, left), and occasionally the Loggerhead (*Caretta caretta*) (Figure 29, right) and the Green (*Chelonia mydas*) turtle. Loggerhead and Green turtles are expected to occur only as occasional visitors along the West Coast. The most recent conservation status, which assessed the species on a sub-regional scale, is provided in 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

The Leatherback is the only turtle likely to be encountered in the offshore waters of west South Africa. The Benguela ecosystem, especially the northern Benguela where jelly fish numbers are high, is increasingly being recognized as a potentially important feeding area for leatherback turtles from several globally significant nesting populations in the south Atlantic (Gabon, Brazil) and south east Indian Ocean (South Africa) (Lambardi *et al.* 2008, Elwen & Leeney 2011; SASTN 2011[2]). 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 30).

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[2] *SASTN Meeting – Second meeting of the South Atlantic Sea Turtle Network, Swakopmund, Namibia, 24-30 July 2011.*

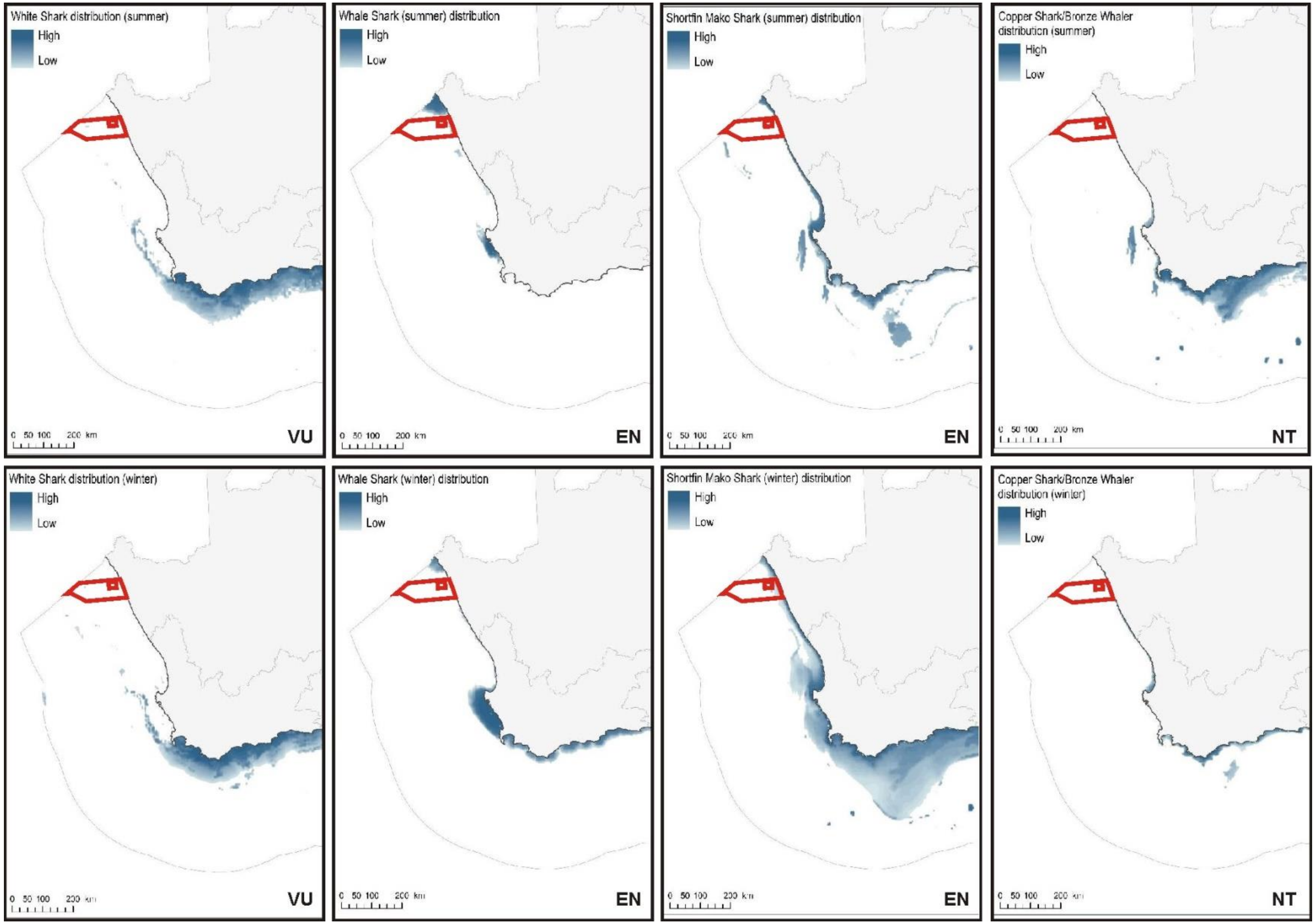

Figure 28: The summer (top) and winter (bottom) distribution of white shark, whale shark, shortfin mako and bronze whaler shark in relation to Sea Areas 4C and 5C (red polygon) (adapted from Harris *et al*. 2022).

Figure 29: Leatherback (left) and loggerhead turtles (right) occur along the West Coast of Southern Africa (Photos: Ketos Ecology 2009; www.aquaworld-crete.com).

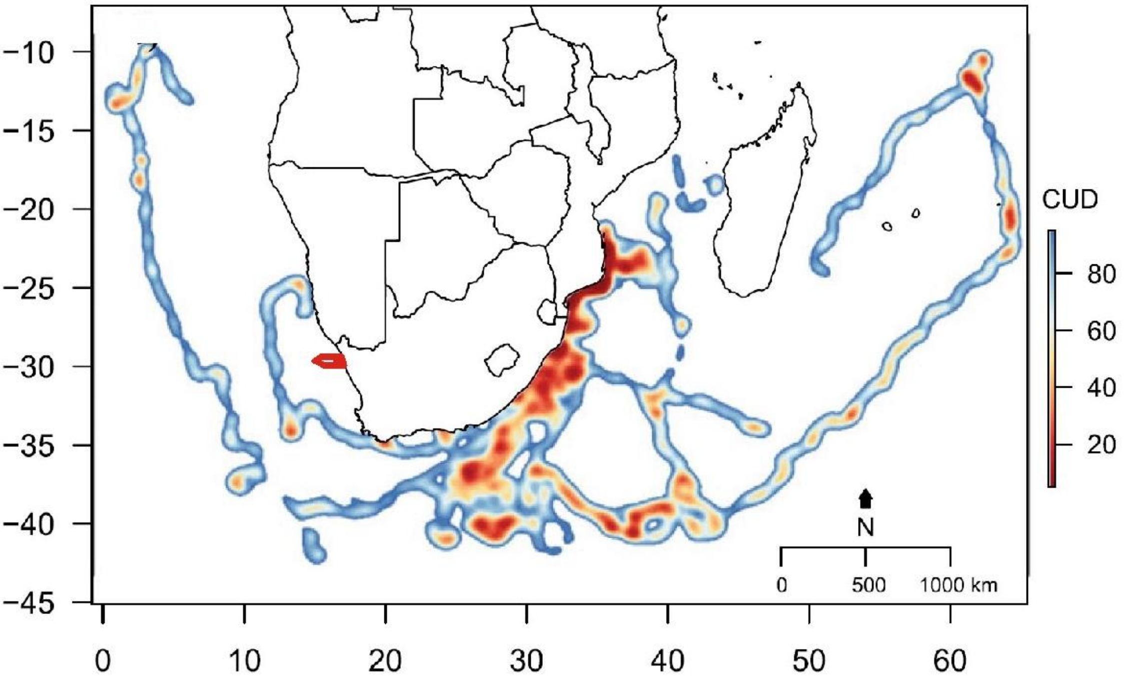

Figure 30: Sea Areas 4C and 5C (red polygon) in relation to the migration corridors of leatherback turtles in the south-western Indian Ocean. Relative use (CUD, cumulative utilization distribution) of corridors is shown through intensity of shading: light, low use; dark, high use (adapted from Harris *et al.* 2018).

Leatherback turtles typically inhabit deeper waters and are considered a pelagic species, travelling the ocean currents in search of their prey (primarily jellyfish). While hunting they may dive to over 600 m and remain submerged for up to 54 minutes (Hays *et al.* 2004). Their abundance in the study area is unknown but expected to be low. Leatherbacks feed on jellyfish and are known to have mistaken plastic marine debris for their natural food. Ingesting this can obstruct the gut, lead to absorption of toxins and reduce the absorption of nutrients from their real food. Leatherback Turtles are listed as 'Critically endangered' worldwide by the IUCN and are in the highest categories in terms of need for conservation in CITES (Convention on International Trade in Endangered Species), and CMS

(Convention on Migratory Species). The 2017 South African list of Threatened and Endangered Species (TOPS) similarly lists the species as 'Critically endangered', whereas on the National Assessment (Hughes & Nel 2014) leatherbacks were listed as 'Endangered', whereas Loggerhead and green turtles are listed globally as 'Vulnerable' and 'Endangered', respectively, whereas on TOPS both species are listed as 'Endangered'. As a signatory of CMS, South Africa has endorsed and signed a CMS International Memorandum of Understanding specific to the conservation of marine turtles. South Africa is thus committed to conserve these species at an international level.

3.3.3.5 Seabirds

Large numbers of pelagic seabirds exploit the pelagic fish stocks of the Benguela system. Of the 49 species of seabirds that occur in the Benguela region, 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 are listed in

. The area between Cape Point and the Orange River supports 38% and 33% of the overall population of pelagic seabirds in winter and summer, respectively. Most of the species in the region reach highest densities offshore of the shelf break (200 – 500 m depth), well offshore of the proposed area of interest, with highest population levels during their non-breeding season (winter). Pintado petrels and Prion spp. show the most marked variation here.

Fifteen species of seabirds breed in southern Africa; Cape Gannet (Figure 31, left), African Penguin (Figure 31, right), four species of Cormorant, White Pelican, African Black Oystercatcher, three Gull and four Tern species (**Error! Not a valid bookmark self-reference.**). The breeding areas are distributed around the coast with islands being especially important. The closest breeding islands to the project area are Bird Island at Lambert's Bay, ~225 km west of the eastern boundary of the Block, and Sinclair Island over 300 km to the north in Namibia. The number of successfully breeding birds at the particular breeding sites varies with food abundance. Most of the breeding seabird species forage at sea with most birds being found relatively close inshore (10-30 km). Cape Gannets, which breed at only three locations in South Africa (Bird Island Lamberts Bay, Malgas Island and Bird Island Algoa Bay) are known to forage within 200 km offshore (Dundee 2006; Ludynia 2007; Grémillet *et al.* 2008; Crawford *et al.* 2011), and African Penguins have also been recorded as far as 60 km offshore. Sea Areas 4C and 5C lie well to the north of the aggregate core home ranges of Cape Gannet (Figure 32), but overlaps with the aggregate core home ranges of African Penguin (Figure 32) (BirdLife South Africa 2022). Aggregate core home ranges and foraging areas for Cape Cormorant and Bank Cormorant similarly lie well inshore of the Prospecting Right Application (see Harris *et al.* 2022). There is, however, overlap of the foraging areas of Wandering Albatross and Atlantic Yellow-nosed Albatross with the Prospecting Right Application (Figure 32) (BirdLife South Africa 2022; Harris *et al.* 2022).

Table 6: Pelagic seabirds common in the southern Benguela region (Crawford *et al*. 1991; BirdLife 2021). IUCN Red List and Regional Assessment status are provided (Sink *et al*. 2019).

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

Table 7: Breeding resident seabirds present along the South-West Coast (adapted from CCA & CMS 2001). IUCN Red List and National Assessment status are provided (Sink *et al*. 2019). * denotes endemicity.

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

Figure 31: Cape Gannets *Morus capensis* (left) (Photo: NACOMA) and African Penguins *Spheniscus demersus* (right) (Photo: Klaus Jost) breed primarily on the offshore Islands.

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

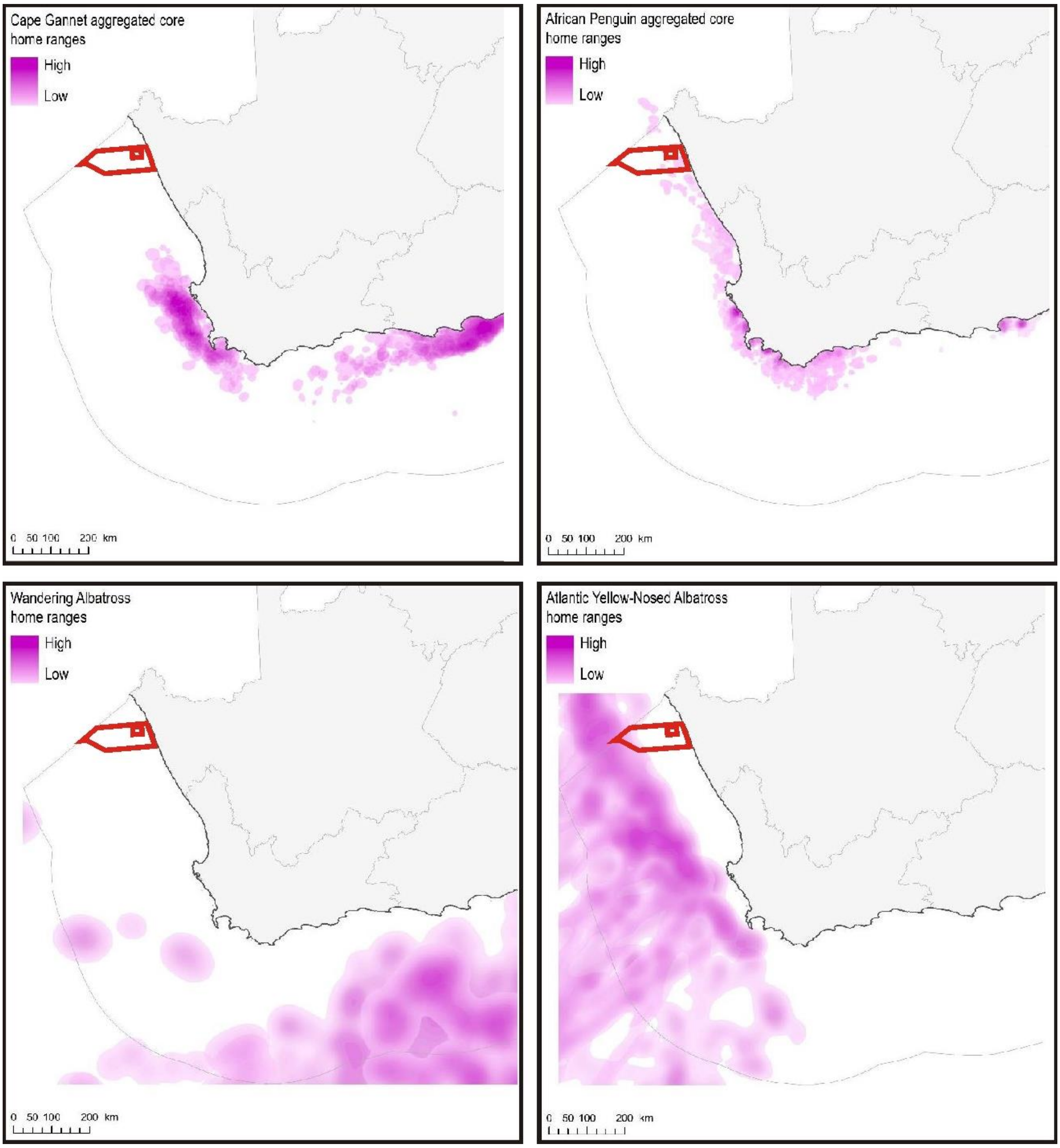

Figure 32: Sea Areas 4C and 5C (red polygon) in relation to aggregate core home ranges of Cape Gannet (top left), African Penguin (top right) for different colonies and life-history stages, and foraging areas of Wandering Albatross (bottom left) and Atlantic Yellow-nosed Albatross (bottom right). For foraging areas, darker shades are areas of higher use and where foraging areas from different colonies overlap (adapted from Harris *et al*. 2022).

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

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

3.3.3.6 Marine Mammals

The marine mammal fauna occurring off the southern African coast includes several species of whales and dolphins and one resident seal species. Thirty-three 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 (**Error! Reference source not found.**). The known s easonality of their occurrence within waters of the West Coast is provided Table 9. Of the species listed, the blue whale is considered 'Critically endangered', fin and sei whales are 'Endangered' and one is considered vulnerable (IUCN Red Data list Categories). Altogether 17 species are listed as "data deficient" underlining how little is known about cetaceans, their distributions and population trends. The offshore areas have been particularly poorly studied with most available information from deeper waters (>200 m) arising from historic whaling records prior to 1970. In the past ten years, passive acoustic monitoring and satellite telemetry have begun to shed light on current patterns of seasonality and movement for some large whale species (Best *et al.* 2009; Elwen *et al.* 2011; Rosenbaum *et al.* 2014; Shabangu *et al.* 2019; Thomisch *et al.* 2019) but information on smaller cetaceans in deeper waters remains poor. Records from marine mammal observers on seismic survey vessels have provided valuable data into cetacean presence although these are predominantly during summer months (Purdon *et al.* 2020). Information on general distribution and seasonality is improving but data population sizes and trends for most cetacean species occurring on the west coast of southern Africa is lacking.

Records from stranded specimens show that the area between St Helena Bay (~32° S) and Cape Agulhas (~34° S, 20° E) is an area of transition between Atlantic and Indian Ocean species, as well as those more commonly associated with colder waters of the west coast (e.g. dusky dolphins and long finned pilot whales) and those of the warmer east coast (e.g. striped and Risso's dolphins) (Findlay *et al.* 1992). The project area lies north of this transition zone and can be considered to be truly on the 'west coast'. However, the warmer waters that occur offshore of the Benguela ecosystem (more than ~100 km offshore) 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 such as rough toothed dolphins, Pan-tropical spotted dolphins and short finned pilot whales. Owing to the uncertainty of species occurrence offshore, species that may occur there have been included here for the sake of completeness.

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 (200 – 2 000 m) making this the most species rich area for cetaceans and also high in density (De Rock *et al.* 2019, SLR data). 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. The most common species within the project area (in terms of likely encounter rate not total population sizes) are likely to be the long-finned pilot whale, Risso's dolphin, common dolphin, sperm whale (winter distribution) and humpback whale (Figure 33) (Harris *et al.* 2022).

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.

Error! Reference source not found. lists the cetaceans likely to be found within the project area, b ased on all available data sources but mainly: Findlay *et al.* (1992), Best (2007), Weir (2011), De Rock *et al.* (2019), Purdon *et al.* (2020a, 2020b, 2020c), and unpublished records held by Sea Search and those held by SLR consulting and shared for this report (see also Figure 34a-b, Figure 35). The majority of data available on the seasonality and distribution of large whales in the project area is the result of commercial whaling activities mostly dating from the 1960s. Changes in the timing and distribution of migration may have occurred since these data were collected due to extirpation of populations or behaviours (e.g. migration routes may be learnt behaviours). The large whale species for which there are current data available 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 project area 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.

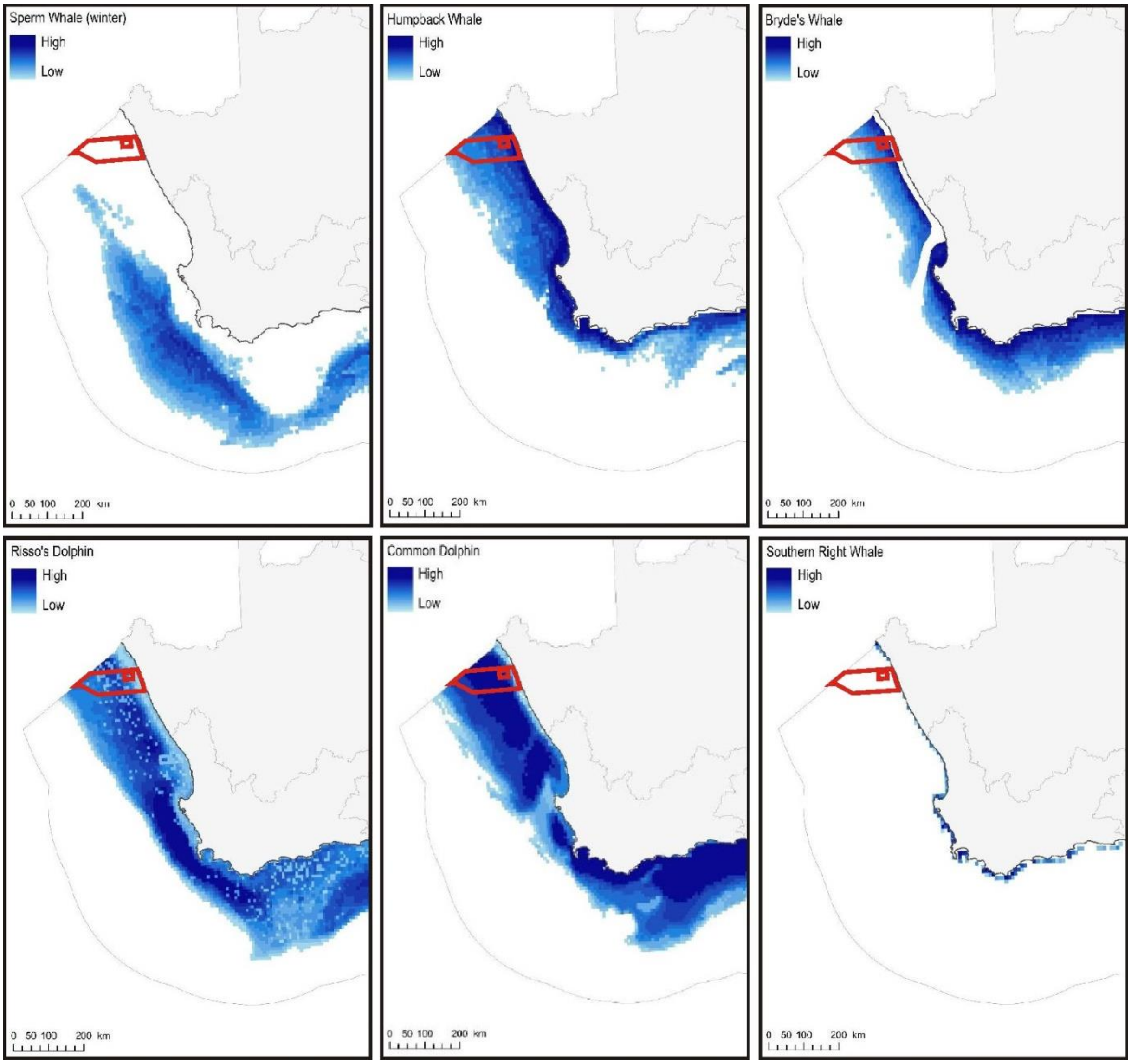

Figure 33: Sea Areas 4C and 5C (red polygon) in relation to the predicted distribution of Sperm whales (winter distribution)(top left), humpback whale (top right) and Risso's dolphin (bottom left) and common dolphin (bottom right) with darker shades of blue indicating highest likelihood of occurrence (adapted from Harris *et al*. 2022).

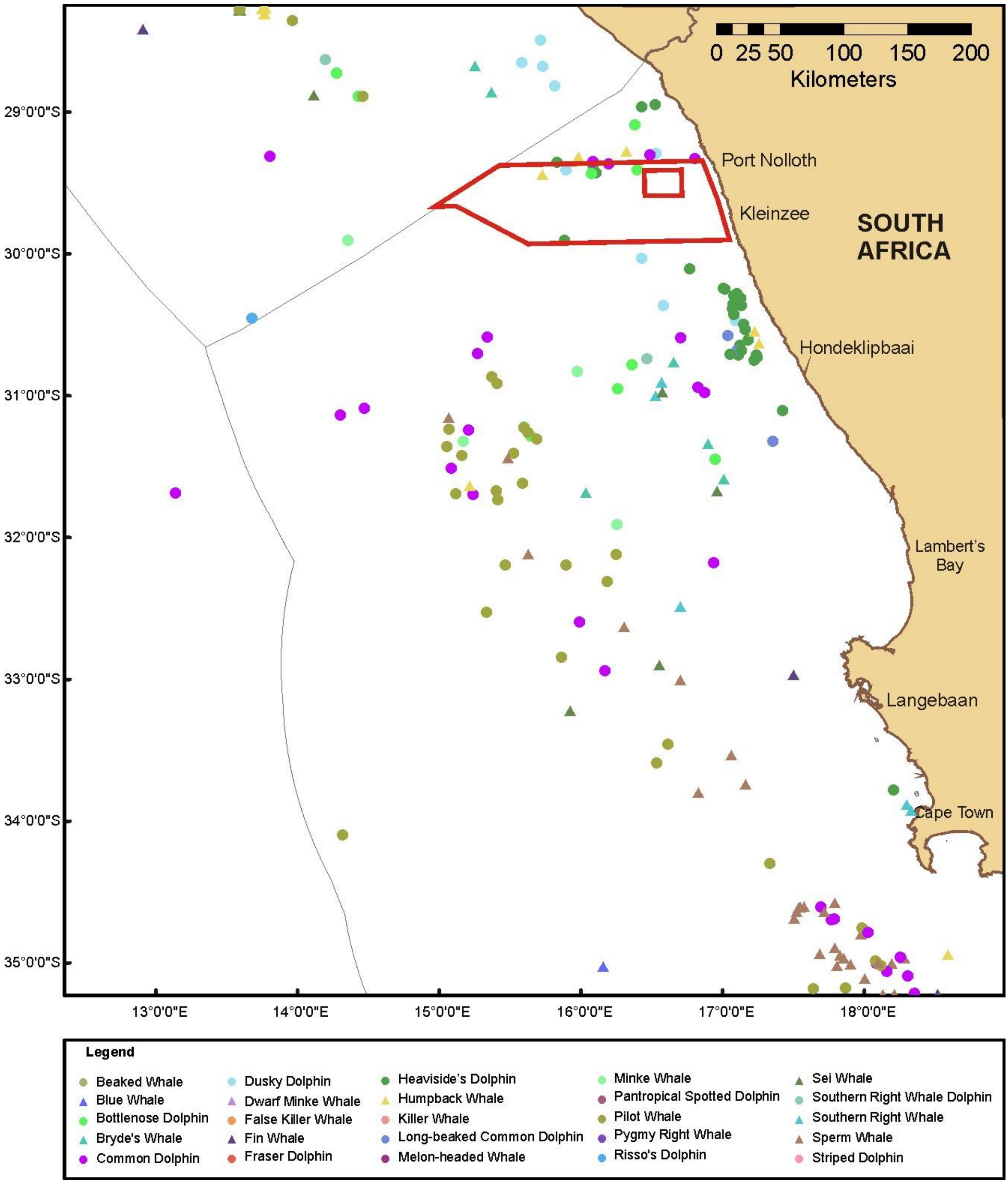

Figure 34a: Sea Areas 4C and 5C (red polygon) in relation to the distribution and movement of cetaceans along the West Coast collated between 2001 and 2020 (SLR MMO database).

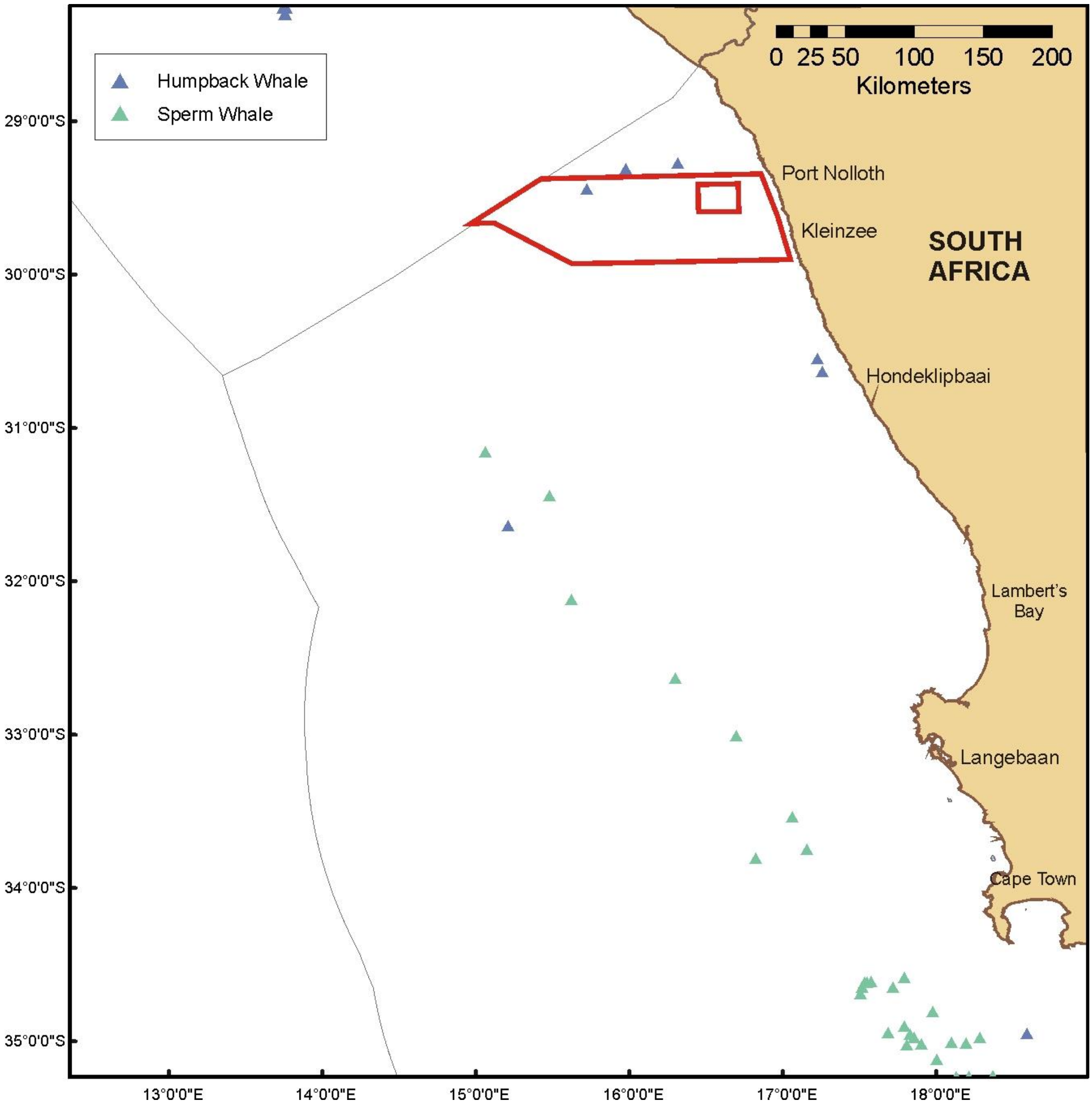

Figure 34b: Sea Areas 4C and 5C (red polygon) in relation to the distribution and movement of Humpback whales and Sperm whales along the West Coast collated between 2001 and 2020 (SLR MMO database).

Table 8: Seasonality of baleen whales in the broader project area 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) are relative within each row (species) and not comparable between species. For abundance / likely encounter rate within the broader project area, see **Error! Reference source not found.**.

	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

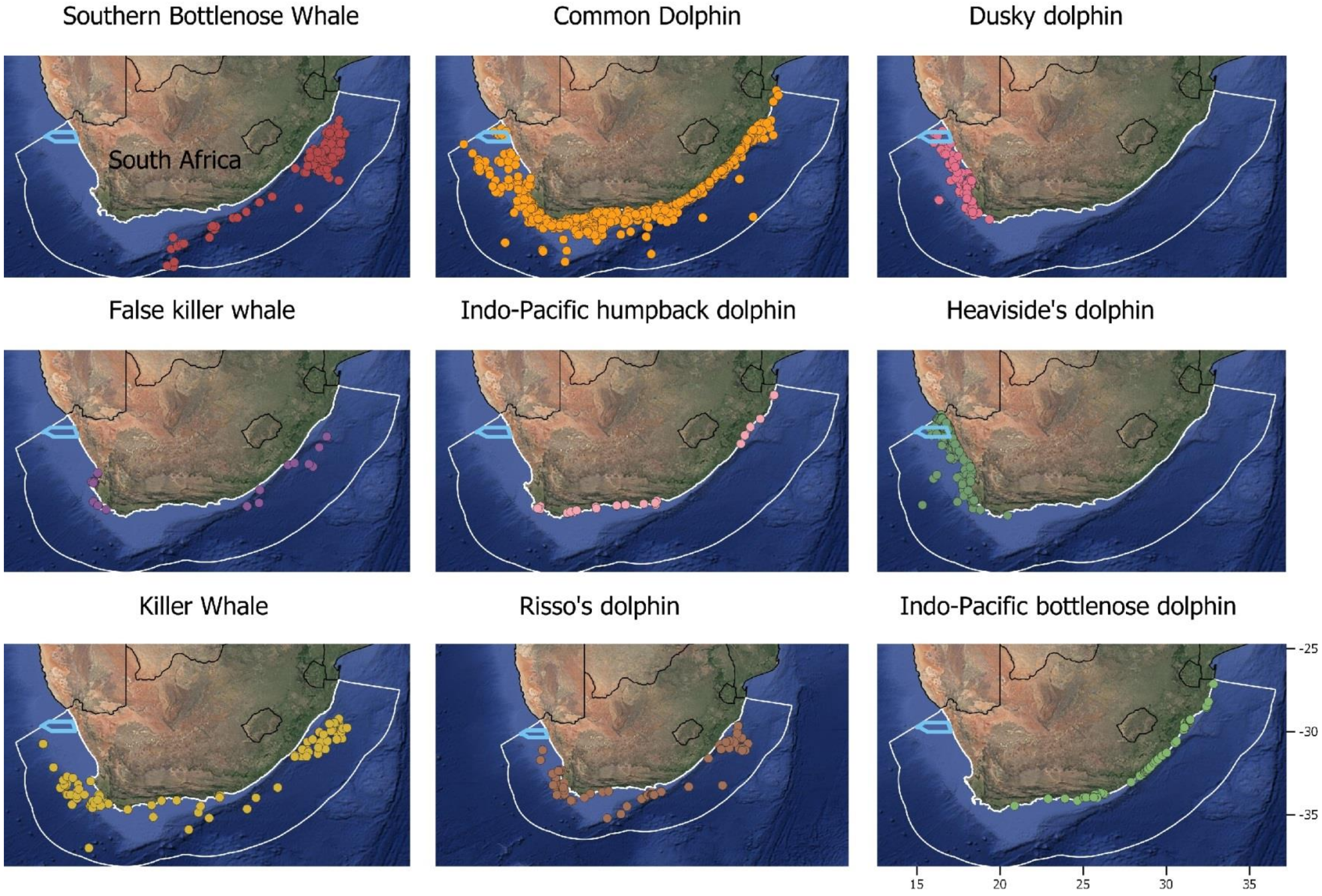

Figure 35: Sea Areas 4C and 5C (cyan polygon) in relation to projections of predicted distributions for nine odontocete species off the West Coast of South Africa (adapted from: Purdon *et al*. 2020).

Bryde's whales: Two genetically and morphologically distinct populations of Bryde's whales (Figure 36, left) live off the coast of southern Africa (Best 2001; Penry 2010). The "offshore population" lives beyond the shelf (>200 m depth) off west Africa and migrates between wintering grounds off equatorial west Africa (Gabon) and summering grounds off western South Africa. Its seasonality on the West Coast is thus opposite to the majority of the balaenopterids with abundance likely to be highest in the broader project area in January - March. Several strandings of adult offshore Bryde's whales in central Namibia confirm that the species passes through the project area. The "inshore population" of Bryde's whale live mainly on the continental shelf and Agulhas Bank, and are unique amongst baleen whales in the region by being non-migratory. The inshore population has recently been recognised as its own (yet to be named) sub species (*Balaenoptera brydei edeni*, Penry *et al.* 2018) with a total population for this subspecies of likely fewer than 600 individuals. The published range of the population is the continental shelf and Agulhas Bank of South Africa ranging from Durban in the east to at least St Helena Bay off the west coast with possible movements further north up the West Coast and into Namibia during the winter months (Best 2007). The offshore stock was subjected to heavy whaling in the mid-20th century (Best 2001) and there are no current data on population size or stock recovery therefrom and is currently listed as 'Data deficient' on the South African Red List. The inshore stock is regarded as extremely 'Vulnerable' and listed as such on the South African red list as it regularly suffers losses from entanglement in trap fisheries and has been subject to significant changes in its prey base due to losses and shifts in the sardine and small pelgic stocks around South Africa.

Sei whales: Almost all information is based on whaling records 1958-1963, most from shore-based catchers operating within a few hundred kilometres of Saldanha Bay. At this time the species was not well differentiated from Bryde's whales and records and catches of the two species intertwined. There is no current information on population recovery, abundance or much information on distribution patterns outside of the whaling catches and the species remains listed as 'Endangered' on the SA Red List. Sei whales feed at high altitudes (40-50°S) during summer months and migrate north through South African waters (where they were historically hunted in relatively high numbers) to unknown breeding grounds further north (Best 2007). 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 & 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. A recent survey to Vema Seamount (located ~700 km south-west of Sea Area 5C) during Oct-Nov 2019, encountered a broadly spread feeding aggregation of over 30 sei and fin whales at around 200 m water depth (Elwen *et al.* in prep.). This poorly surveyed area (roughly 32°S, 15°E) is just to the NW of the historic whaling grounds suggesting this region remains an important feeding area for the species.

Figure 36: The Bryde's whale *Balaenoptera brydei* (left) and the Minke whale *Balaenoptera bonaerensis* (right) (Photos: www.dailymail.co.uk; www.marinebio.org).

Fin whales: Fin whales were historically caught off the West Coast of South Africa, with a bimodal peak in the catch data suggesting animals were migrating further north during May-June to breed, before returning during August-October *en route* to Antarctic feeding grounds. However, the location of the breeding ground (if any) and how far north it is remains a mystery (Best 2007). Some juvenile animals may feed year round in deeper waters off the shelf (Best 2007). Aggregations of up to eight animals have been seen on multiple occasions on the coast either side of Lüderitz in Apr-May of 2014 and January 2015 (Sea Search unpubl. Data), the occasional single whale has been reported during humpback whale research in November in the southern Benguela, and a feeding aggregation of ~30 animals was observed in November 2019 ~200 km west of St Helena Bay in ~2 000 m of water (see above). Current sightings records support the bimodal peak in presence observed from whaling data (but with some chance of year-round sightings) with animals apparently feeding in the nutrient rich Benguela during their southward migration as is observed extensively for humpback and right whales (see below) there clearly is a chance of encounters within the project area year round. There are no recent data on abundance or distribution of fin whales off western South Africa.

Blue whales: Antarctic blue whales were historically caught in high numbers off the South African West Coast, with a single peak in catch rates during July in Namibia and Angola suggesting that these latitudes are close to the northern migration limit for the species in the eastern South Atlantic (Best 2007). Although there had been only two confirmed sightings of the species in the area since 1973 (Branch *et al.* 2007), evidence of blue whale presence off Namibia is increasing. Recent acoustic detections of blue whales in the Antarctic peak between December and January (Tomisch *et al.* 2016), off western South Africa (Shanbangu *et al.* 2019) and in northern Namibia between May and July (Thomisch 2017). Several recent (2014-2015) sightings of blue whales during seismic surveys off the southern part of Namibia in water >1 000 m deep confirm their existence in the area and occurrence in Autumn months. The chance of encountering the species in the proposed survey area is considered low.

Minke whales: Two forms of minke whale (Figure 36, 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. Recent data available from passive acoustic monitoring over a two-year period off the Walvis Ridge shows acoustic presence in June - August and November - December (Thomisch *et al.* 2016), supporting a bimodal distribution in the area. 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 and have been seen <2 km from shore on several occasions around South Africa. Both species are generally solitary and densities are likely to be low in the project area, although sightings have been reported (SLR data).

The **pygmy right whale** 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 with records from southern and central Namibia being the northern most for the species (Leeney *et al.* 2013). Its distribution off the west coast of South Africa is thus likely to be limited to the cooler shelf waters of the main Benguela upwelling areas.

The most abundant baleen whales in the Benguela are southern right whales and humpback whales (Figure 37). Both species have long been known to feed in the Benguela Ecosystem and numbers since 2000 have grown substantially. The feeding peak in the Benguela is spring and early summer (October – February) and follows the ‘traditional’ South African breeding season (June – November) and its’ associated migrations (Johnson *et al.* 2022). Some individual right whales are known to move directly from the south coast breeding area into the west coast feeding area where they remained for several months (Barendse *et al.* 2011; Mate *et al.* 2011). Increasing numbers of summer records of both species, from the southern half of Namibia suggest that animals may also be feeding in the Lüderitz upwelling cell (NDP unpubl. data).

Humpback whales: The majority of humpback whales passing through the Benguela are migrating to breeding grounds off tropical west Africa, between Angola and the Gulf of Guinea (Rosenbaum *et al.* 2009; Barendse *et al.* 2010). Until recently it was believed that that these breeding grounds were functionally separate from those off east (Mozambique-Kenya-Madagascar), with only rare movements between them (Pomilla & Rosenbaum 2005) and movements to other continental breeding grounds being even more rare. Recent satellite tagging of animals between Plettenberg Bay and Port Alfred during the northward migration, showed them to turn around and end up feeding in the Southern Benguela (Seakamela *et al.* 2015) before heading offshore and southwards using the same route as whales tracked off Gabon and the West Coast of South Africa. Unexpected results such as this highlight the complexities of understanding whale movements and distribution patterns and the fact that descriptions of broad season peaks in no way captures the wide array of behaviours exhibited by these animals. Furthermore, three separate matches have been made between individuals off South Africa and Brazil by citizen scientist photo-identification (www.happywhale.com). This included whales from the Cape Town and Algoa Bay-Transkei areas. Analysis of humpback whale breeding song on Sub-Antarctic feeding grounds also suggests exchange of singing male whales from western and eastern South Atlantic populations (Darling & Sousa-Lima 2005; Schall *et al.* 2021; but see also Darling *et al.* 2019; Tyarks *et al.* 2021).

In southern African coastal waters, the northward migration stream is larger than the southward peak (Best & Allison 2010; Elwen *et al.* 2014), suggesting that animals migrating north strike the coast at varying places north of St Helena Bay, resulting in increasing whale density on shelf waters and into deeper pelagic waters as one moves northwards. On the southward migration, many humpbacks follow the Walvis Ridge offshore then head directly to high latitude feeding grounds, while others follow a more coastal route (including the majority of mother-calf pairs) possibly lingering in the feeding grounds off west South Africa in summer (Elwen *et al.* 2014; Rosenbaum *et al.* 2014). Although migrating through the Benguela, there is no existing evidence of a clear 'corridor' and humpback whales appear to be spread out widely across the shelf and into deeper pelagic waters, especially during the southward migration (Barendse *et al.* 2010; Best & Allison 2010; Elwen *et al.* 2014). The only available abundance estimate put the number of animals in the West African breeding population (Gabon) to be in excess of 9 000 individuals in 2005 (IWC 2012) and it is likely to have increased substantially since this time at about 5% per annum (IWC 2012; see also Wilkinson 2021). 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. It has been suggested that the formation of these super-groups may be in response to anomalous oceanographic conditions in the Southern Benguela, which result in favourable food availability, thereby leading to these unique humpback whale feeding aggregations (Dey *et al.* 2021; see also Avila *et al.* 2019; Meynecke *et al.* 2020; Cade *et al.* 2021). Humpback whales are thus likely to be the most frequently encountered baleen whale in the project area (see Figure 34b), ranging from the coast out beyond the shelf, with year round presence but numbers peaking during the northward migration in June – February and a smaller peak with the southern breeding migration around September – October but with regular encounters until February associated with subsequent feeding in the Benguela ecosystem.

Figure 37: 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).

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 South African west coasts. A similar event was recorded in late 2021-early 2022 when numerous strandings of young humpbacks were reported along the Western Cape Coast and in Namibia (Simon Elwen, Sea Search, pers. comm.). The cause of these deaths is not known, but a similar event off Brazil in 2010 (Siciliano *et al.* 2013) was linked to possible infectious disease or malnutrition. Unusual mortality events of humpback whales between 2016 and 2022 have similarly been reported along the US Atlantic Coast from Maine to Florida (https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2022-humpback-whale-unusual-mortality-event-along-atlantic-coast). The West African population may be undergoing similar stresses in response to changes in their ecosystem (see for example Kershaw *et al.* 2021). It is not yet understood what may be driving these ecosystem changes and what the long-term effects to populations could potentially be.

Southern right whales: 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). The most recent abundance estimate for this population is available for 2017 which estimated the population at ~6 100 individuals including all age and sex classes, and still growing at ~6.5% per annum (Brandaõ *et al.* 2017). 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 Namibia (Roux *et al.* 2001, 2015; de Rock *et al.* 2019) and Mozambique (Banks *et al.* 2011). Southern right whales are seen regularly in the nearshore waters of the West Coast (<3 km from shore), extending north into southern Namibia (Roux *et al.* 2001, 2011) (see Figure 33). Southern right whales have been recorded off the West Coast in all months of the year, but with numbers peaking in winter (June - September).

Some southern right whales move from the South Coast breeding ground directly to the West Coast feeding ground (Mate *et al.* 2011). When departing from feeding ground all satellite tagged animals in that study took a direct south-westward track. 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.* 2011). While annual surveys have revealed a steady population increase since the protection of the species from commercial whaling, the South African right whale population has undergone substantial changes in breeding cycles and feeding areas (Van Den Berg *et al.* 2020), and numbers of animal using our coast since those studies were done – notably a significant decrease in the numbers of cow-calf-pairs following the all-time record in 2018, a marked decline of unaccompanied adults since 2010 and variable presence of mother-calf pairs since 2015 (Roux *et al.* 2015; Vermeulen *et al.* 2020). The change in demographics are indications of a population undergoing nutritional stress and has been attributed to likely spatial and/or temporal displacement of prey due to climate variability (Vermeulen *et al.* 2020; see also Derville *et al.* 2019, 2020; Kershaw *et al.* 2021; van Weelden *et al.* 2021). Recent sightings (2018-2021) confirm that there is still a clear peak in numbers on the West Coast (Table Bay to St Helena Bay) between February and April. Given this high proportion of the population known to feed in the southern Benguela, and the historical records, it is highly likely that several hundreds of right whales can be expected to pass directly through the Sea Areas between May and June and then again November to January.

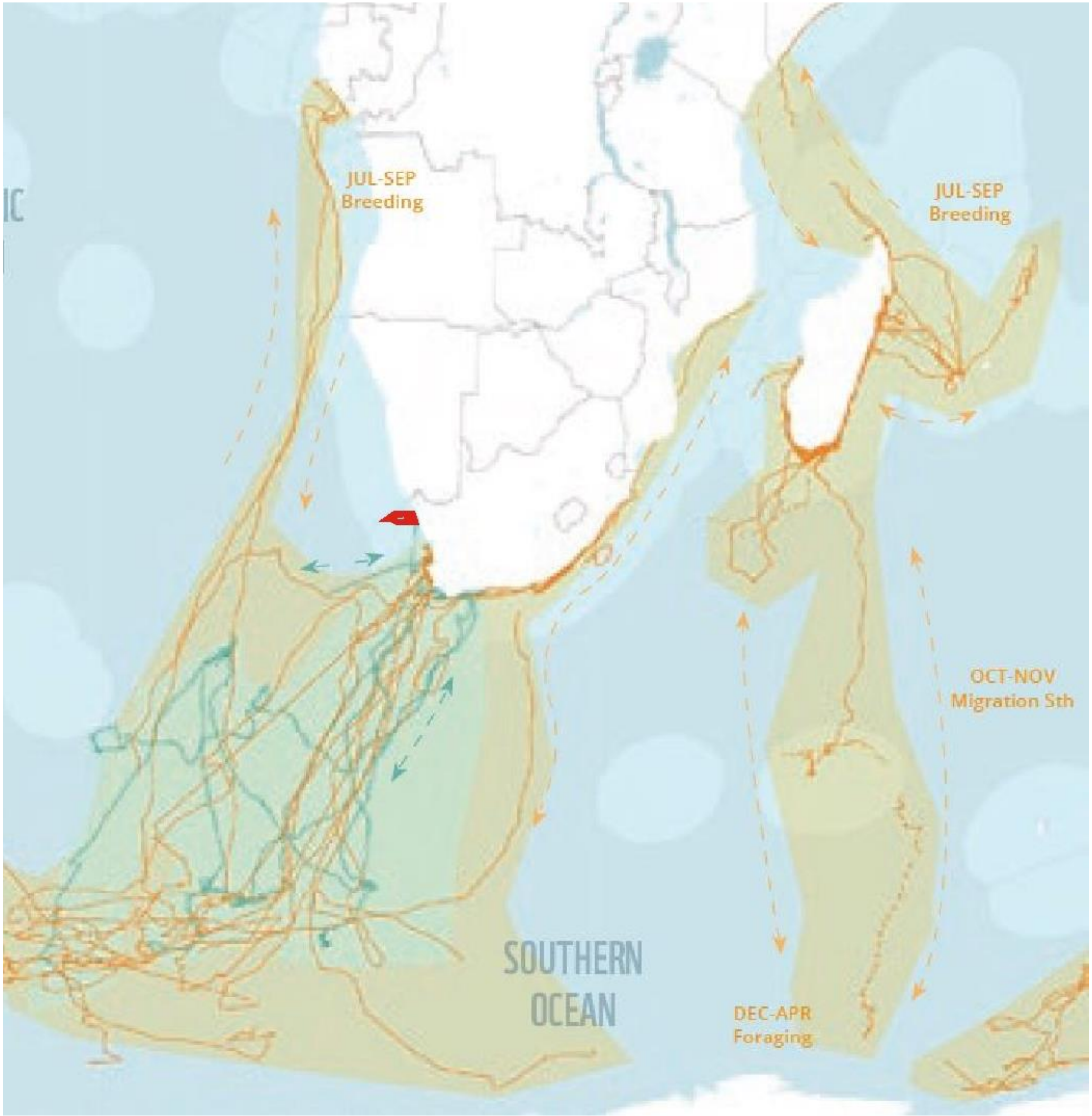

Figure 38: Sea Areas 4C and 5C (red polygon) in relation to 'blue corridors' or 'whale superhighways' showing tracks of Humpback whales (orange) and Southern Right whales (green) between southern Africa and the Southern Ocean feeding grounds (adapted from Johnson *et al*. 2022).

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 (see Figure 35). Those in the region can range in size from 1.6-m long (Heaviside's dolphin) to 17 m (bull sperm whale).

Sperm whales: 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 39, 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). Analysis of recent passive acoustic monitoring data from the edge of the continental shelf (800 - 1 000 m water depth, roughly 80 km WSW of Cape Point) confirms year-round presence. Sperm whales may thus be encountered 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 Passive Acoustic Monitoring (PAM).

Figure 39: 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).

Pygmy and Dwarf Sperm Whales: The genus *Kogia* currently contains two recognised species, the pygmy (*K. breviceps*) and dwarf (*K. sima*) sperm whales, both of which occur worldwide in pelagic and shelf edge waters, with with few sighting records of live animals in their natural habitat (McAlpine 2018). Their abundance, population trends and seasonality in South African waters are unknown (Seakamela *et al*. 2021). Due to their small body size, cryptic behaviour, low densities and small school sizes, these whales are difficult to observe at sea, and morphological similarities make field identification to species level problematic, although their narrow-band high frequency echolocation clicks make them detectable and identifiable (at leas to the genus) using passive acoustic monitoring equipment. The majority of what is known about the distribution and ecology of Kogiid whales in the southern African subregion is derived mainly from stranding records (e.g. Ross 1979; Findlay *et al*. 1992; Plön 2004; Elwen *et al*. 2013, but see also Moura *et al*. 2016). *Kogia* species are most frequently occur in pelagic and shelf edge waters, are thus likely to occur in the survey area at low levels; seasonality is unknown. Dwarf sperm whales are associated with warmer tropical and warm-temperate waters, being recorded from both the Benguela and Agulhas ecosystem (Best 2007) in waters deeper than ~1 000 m. Abundance in the 4C and 5C Sea Areas is likely to be very low.

During 2020 the incidence of kogiid strandings between Strandfontein on the West Coast and Groot Brak River on the South Coast (n=17), was considerably higher than the annual average during the previous 10 years (n=7). The dwarf sperm whale (*K. sima*) accounted for 60% of these strandings, of which most were recorded during autumn and winter. These seasonal stranding patterns are consistent with previously published accounts for the South African coast. In 2020, 40% of the total strandings were recorded in winter and 15% during summer. The occurrence of strandings throughout the year may, however, indicate the presence of a resident population with a seasonal distributiuon off the South Coast in autumn and winter (Seakamela *et al.* 2020, 2021). The cause of the strandings is unknown.

Killer whales: 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 but only 5 records are known all from strandings (Best *et al.* 2014). Killer whales (Figure 39) 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 South Africa (Best *et al.* 2010, Elwen *et al.* in prep.), Namibia (Elwen & Leeney 2011) and in the Eastern Tropical Atlantic (Weir *et al.* 2010). 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 long-line fishing vessels on the southern and eastern Agulhas Bank, and the Cape Canyon to the south-west of Cape Point. Killer whales are found in all depths from the coast to deep open ocean environments and may thus be encountered in the project area at low levels.

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

Pilot Whales: Long finned pilot whales display a preference for temperate waters and are usually associated with the continental shelf or deep water adjacent to it, but moving inshore to follow prey (primarily squid) (Mate *et al.* 2005; Findlay *et al.* 1992; Weir 2011; Seakamela *et al.* 2022). They are regularly seen associated with the shelf edge by MMOs, 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 confined to the southwest Indian Ocean (Best 2007), it is likely that the majority of pilot whales encountered in the project area will be long-finned. There are many confirmed sighting of pilot whales along the shelf edge of South Africa and Namibia including within the project area since 2010 (de Rock *et al.* 2019; Sea Search unpublished data, SLR data). Observed group sizes range from 8-100 individuals (Seakamela *et al.* 2022). Pilot whales are commonly sighting by MMOs and detected by PAM during a seismic surveys. A recent tagging study showed long-finned pilot whale movements within latutudes of 33-36°S, along the shelf-edge from offshore of Cape Columbine to the Agulhas Bank, with concentrations in canyon areas, especially around the Cape Point Valley, and to a lesser degree around the Cape Canyon. It is postulated that the pilot whales target prey species in these productive areas (Seakamela *et al*. 2022). Abundance in the 4C and 5C Sea Areas is likely to be low.

Common dolphin: Two forms of common dolphins occur around southern Africa, a long-beaked and short-beaked form (Findlay *et al*. 1992; Best 2007), although they are currently considered part of a single global species (Cunha *et al*. 2015). The long-beaked common dolphin lives on the continental shelf of south Africa rarely being observed north of St Helena Bay on the west coast or in waters more 500 m deep (Best 2007), although more recent sightings, including those from MMOs, suggest sightings regularly out to 1 000 m or more (SLR data, Sea Search data). Group sizes of common dolphins can be large, averaging 267 (± *SD* 287) for the South Africa region (Findlay *et al*. 1992). Far less is known about the short-beaked form, which is challenging to differentiate at sea from the long-beaked form. Group sizes are also typically large. It is likely that common dolphins encountered in the Northern Cape or deeper than 2 000 m are of the short-beaked form. The extent to which they occur in the project area is unknown but likely to be low.

Dusky dolphin: In water <500 m deep, dusky dolphins (Figure 40, 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 500 m deep (Findlay *et al*. 1992). Although no information is available on the size of the population, they are regularly encountered in near shore waters between Cape Town and Lamberts Bay (Elwen *et al*. 2010; NDP unpubl. data) with group sizes of up to 800 having been reported (Findlay *et al*. 1992). A hiatus in sightings (or low density area) is reported between ~27°S and 30°S, associated with the Lüderitz upwelling cell (Findlay *et al*. 1992). Dusky dolphins are resident year round in the Benguela.

Figure 40: The endemic Heaviside's Dolphin *Cephalorhynchus heavisidii* (left) (Photo: De Beers Marine Namibia), and Dusky dolphin *Lagenorhynchus obscurus* (right) (Photo: scottelowitzphotography.com).

Heaviside's dolphins: Heaviside's dolphins (Figure 40, left) are relatively abundant in the Benguela ecosystem region with 10 000 animals estimated to live in the 400 km of coast between Cape Town and Lamberts Bay (Elwen *et al*. 2009). This species occupies waters from the coast to at least 200 m depth, (Elwen *et al*. 2006; Best 2007; Martin *et al*. 2020), and may show a diurnal onshore-offshore movement pattern (Elwen *et al*. 2010a, 2010b), but this varies throughout the species range. Heaviside's dolphins are resident year round.

Bottlenose dolphin: 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). The larger common bottlenose dolphin (*truncatus* form) is widely distributed in tropical and temperate waters throughout the world, but frequently occur in small (10s to low 100s) isolated coastal populations. An offshore 'form' of common bottlenose dolphins occurs around the coast of southern Africa including Namibia and Angola (Best 2007) with sightings restricted to the continental shelf edge and deeper. Offshore bottlenose dolphins frequently form mixed species groups, often with pilot whales or Risso's dolphins.

Risso’s Dolphin: A medium sized dolphin with a distinctively high level of scarring and a proportionally large dorsal fin and blunt head. Risso’s dolphins are distributed worldwide in tropical and temperate seas and show a general preference for shelf edge waters <1 500 m deep (Best 2007; Purdon *et al*. 2020a, 2020b). Many sightings in southern Africa have occurred around the Cape Peninsula and along the shelf edge of the Agulhas Bank. Presence within Sea Areas 4C and 5C is likely (see Figure 33).

Other Delphinids: Several other species of dolphins that might occur in deeper waters at low levels include the pygmy killer whale, southern right whale dolphin, rough toothed dolphin, pantropical 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: These 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 deep (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 in the project area are pelagic species that tend to occur in small groups usually less than five, although larger aggregations of some species are known (MacLeod & D’Amico 2006; Best 2007). The long, deep dives of beaked whales make them difficult to detect visually, but PAM will increase the probability of detection as animals are frequently echo-locating when on foraging dives. Beaked whales seem to be particularly susceptible to man-made sounds and several strandings and deaths at sea, often *en masse*, have been recorded in association with naval sonar (Cox *et al*. 2006; MacLeod & D’Amico 2006), a survey vessel running a low-frequency multi-beam echo-sounder and a research survey using seismic airguns, a low-frequency multi-beam sonar and a sub bottom profiler (Southall *et al*. 2008; Cox *et al*. 2006; DeRuiter *et al*. 2013). Although the exact reason that beaked whales seem particularly vulnerable to man-made noise is not yet fully understood, existing evidence suggests that animals change their dive behaviour in response to acoustic disturbance (Tyack *et al*. 2011), showing a fear-response and surfacing too quickly with insufficient time to release nitrogen resulting in a form on decompression sickness. 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) (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). Thus, although hard to detect and avoid – beaked whales are amongst the most sensitive marine mammals to noise exposure and all cautions must be taken to reduce impact. Presence in the project area may fluctuate seasonally, but insufficient data exist to define this clearly. Sightings of beaked whales in the project area are expected to be very low.

In summary, the humpback and southern right whale are likely to be encountered year-round, with numbers in the Cape Columbine area highest between September and February, and not during winter as is common on the South Coast breeding grounds. Several other large whale species are also most abundant on the West Coast during winter: fin whales peak in May-July and October-November; sei whale numbers peak in May-June and again in August-October and offshore Bryde's whale numbers are likely to be highest in January-February. Whale numbers on the shelf and in offshore waters are thus likely to be highest between October and February.

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

The Cape fur seal (*Arctocephalus pusillus pusillus*) (Figure 41) is the only species of seal resident along the west coast of Africa, occurring at numerous breeding and non-breeding sites on the mainland and on nearshore islands and reefs. The South African population, which includes the West Coast colonies, was estimated at ca. 725 000 individuals in 2020. This is about 40% of the total southern African population, which has previously been estimated at up to 2 million (Seakamela *et al*. 2022). 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 41: Colony of Cape fur seals *Arctocephalus pusillus pusillus* (Photo: Dirk Heinrich).

There are a number of Cape fur seal colonies within the study area: at Bucchu Twins near Alexander Bay, at Cliff Point (~17 km north of Port Nolloth), at Kleinzee (incorporating Robeiland),and Strandfontein Point (south of Hondeklipbaai). The colony at Kleinzee has the highest seal population and produces the highest seal pup numbers on the South African Coast (Wickens 1994). The colony at Buchu Twins, formerly a non-breeding colony, has also attained breeding status (M. Meÿer, SFRI, pers. comm.). Non-breeding colonies and haul-out sites occur occur at Doringbaai south of Cliff Point, Rooiklippies, Swartduin and Noup between Kleinzee and Hondeklipbaai, at Spoeg River and Langklip south of Hondeklip Bay, and on Bird Island at Lambert's Bay. All have important conservation value since they are largely undisturbed at present. Seals are highly mobile animals with a general foraging area covering the continental shelf up to 120 nautical miles offshore (Shaughnessy 1979), with bulls ranging further out to sea than females. Their diet varies with season and availability and includes pelagic species such as horse mackerel, pilchard, and hake, as well as squid and cuttlefish. Although Cape fur seals are primarily epipelagic foragers, some degree of geographic and temporal variation in resource and habitat use have been demonstrated (Botha et al. 2023). Benthic feeding to depths of up to 454 m has been recorded in females from the Kleinzee colony on the West Coast, with individual modal dive durations of 0.2 – 5.6 minutes (Kirkman et al. 2015; Kirkman et al. 2019). Botha et al. (2020) reported diel foraging patterns in females from the Kleinzee and False Bay colonies, with dive depth and benthic foraging increasing during daylight hours likely reflecting the vertical movements of prey species. 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).

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 (Figure 42). Their diet varies with season and availability and includes pelagic species such as horse mackerel, pilchard, and hake, as well as squid and cuttlefish.

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).

An unprecedented mortality event was recorded in South Africa between September and December 2021 at colonies around the West Coast Peninsula and north to Lambert's Bay and Elands Bay. Primarily pups and juveniles were affected. Post-mortem investigations revealed that seals died in a poor condition with reduced blubber reserves, and protein energy malnutrition was detected for aborted foetuses, for juveniles and subadults. Although no unusual environmental conditions were identified that may have triggered the die-off, or caused it indirectly (e.g. HABs), 2021 was a year of below average recruitment of anchovy and sardine, the main food source for seals. While a lack of food, as a result of possibly climate change and/or overfishing, has been predicted to be the cause of this mass mortality, the underlying causes of the mortality event remain uncertain (Seakamela *et al.* 2022).

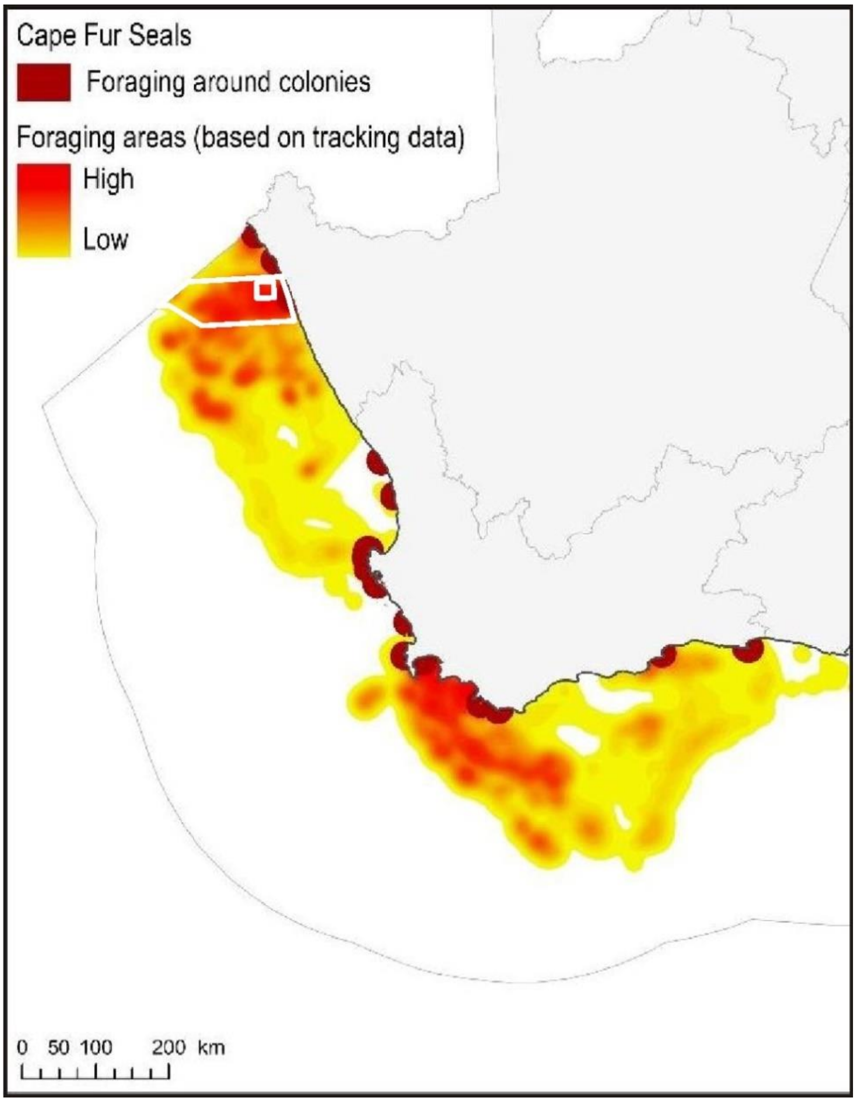

Figure 42: Sea Areas 4C and 5C (red polygon) in relation to seal foraging areas on the West and South Coasts (adapted from Harris *et al*. 2022). Brown areas are generalised foraging areas around colonies, and areas in shades of red are foraging areas based on tracking data. Darker shades of red indicate areas of higher use. Note that gaps in foraging areas, especially on the west coast, are more an artefact of incomplete coverage than areas of avoidance or absence.

3.4 Other Uses of the Area

3.4.1 Beneficial Uses

3.4.1.1 Diamond Mining

The marine diamond Sea Areas are split into four or five zones (Surf zone and (a) to (c) or (d)-sea areas), which together extend from the high water mark out to approximately 500 m depth. Off Namaqualand, marine diamond mining activity is primarily restricted to the surf-zone and (a)-Sea Areas. Nearshore shallow-water mining is conducted by divers using small-scale suction hoses operating either directly from the shore in small bays or from converted fishing vessels out to ~30 m depth. However, over the past few years there has been a substantial decline in small-scale diamond mining operations due to the global recession and depressed diamond prices, although some vessels do still operate out of Alexander Bay and Port Nolloth.

Diamond prospecting and mining rights in the "C" Sea Areas of the Northern Cape Province (Figure 43) are currently limited to :

- Mining Right held by Belton Park Trading 127 (Pty) Ltd in 2C and 3c;
- Mining Right held by Alexkor in 1C; and
- Prospecting Right held by DBCM in 6C.

In Namibia, diamond mining at similar water depths of between 90 m -150 m is undertaken by Debmarine Namibia (Pty) Ltd in the Atlantic 1 Mining Licence Area.

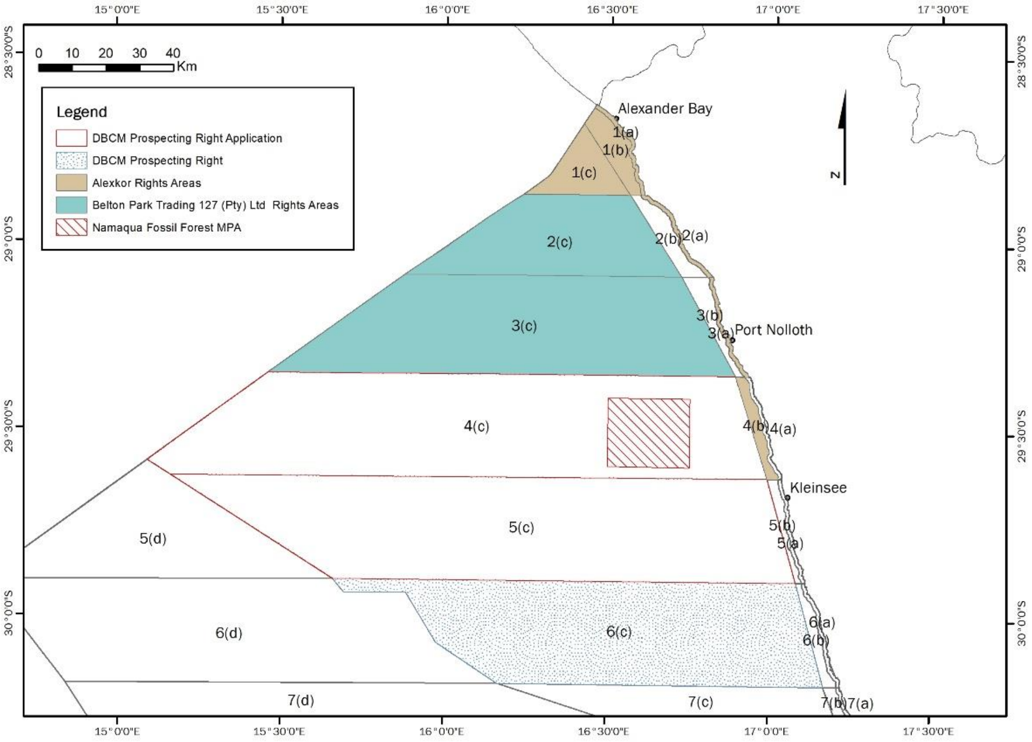

Figure 43: Sea Areas 4C and 5C in relation to known marine diamond mining and prospecting areas and ports for commercial and fishing vessels.

3.4.1.2 Hydrocarbons

The South African continental shelf and economic exclusion zone (EEZ) have similarly been partitioned into Licence blocks for petroleum exploration and production activities. Exploration has included extensive 2D and 3D seismic surveys and the drilling of numerous exploration wells, with ~40 wells having been drilled in the Namaqua Bioregion since 1976 (Figure 44). The majority of these occur in the iBhubesi gas field in Block 2A. Prior to 1983, technology was not available to remove wellheads from the seafloor and currently 35 wellheads remain on the seabed.

The most recent well to be drilled and plugged (October 2022) was in Block 2B. Further exploratory drilling is proposed for inshore and offshore portions of Block 1, with further target areas in Block

3A/4A and the Deep Western Orange Basin. A subsea pipeline to export gas from the iBhubesi field to a location either on the Cape Columbine peninsula or to Ankerlig ~25 km north of Cape Town is also proposed.

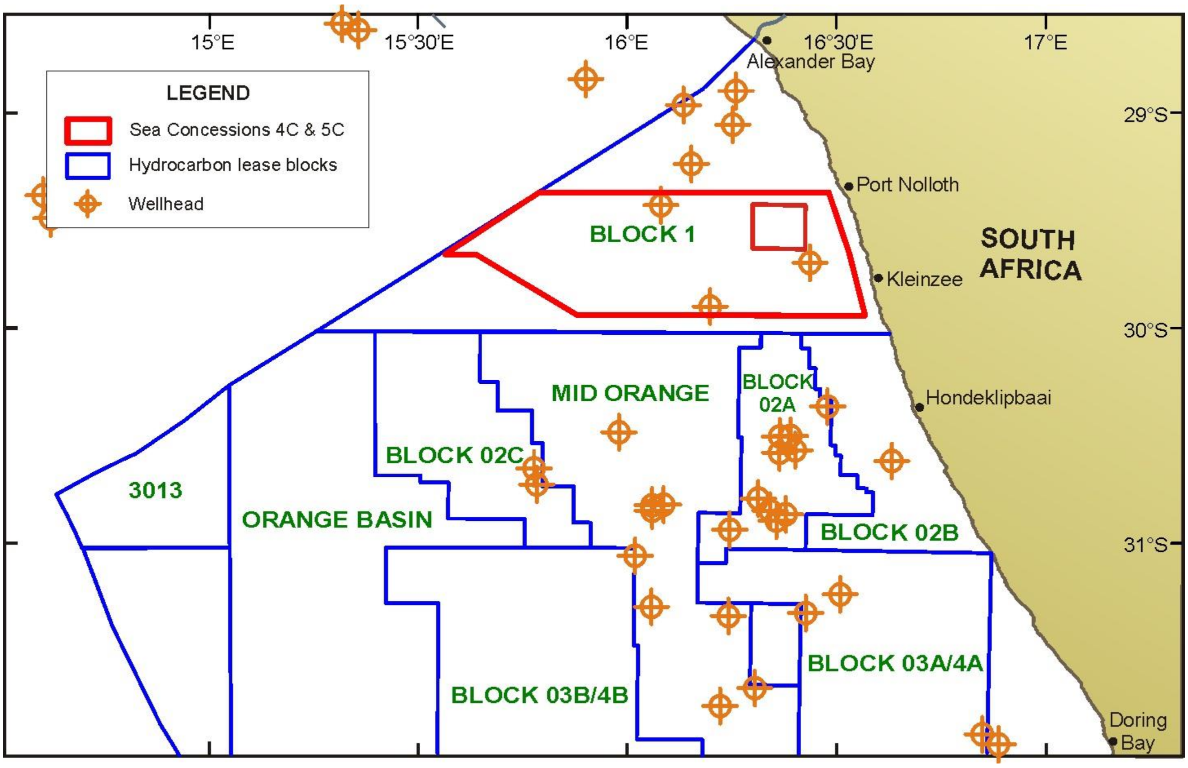

Figure 44: Project - environment interaction points on the West Coast, illustrating the location of hydrocarbon lease blocks, existing well heads, proposed areas for exploratory wells and the routing of the proposed iBhubesi gas export pipeline, in relation to the prospecting application area.

3.4.1.3 Development Potential of the Marine Environment in the Project Area

The economy of the Namaqualand region is dominated by mining. However, with the decline in the mining industry and the closure of many of the coastal mines, the economy of the region is declining and jobs are being lost with potential devastating socio-economic impacts on the region. The Northern Cape provincial government has recognized the need to investigate alternative economic activities to reduce the impact of minerals downscaling and has commissioned a series of baseline studies of the regional economy (Britz & Hecht 1997, Britz *et al*. 1999, 2000, Mather 1999). These assessments concluded that fishing and specifically mariculture offer a significant opportunity for long term (10+ years) sustainable economic development along the Namaqualand coast. The major opportunities cited in these studies include hake and lobster fishing (although the current trend in quota reduction is likely to limit development potentials), seaweed harvesting and aquaculture of abalone, seaweeds, oysters and finfish. The Northern Cape provincial government facilitated the development of the fishing and mariculture sectors by means of a holistic sector planning approach in the early 2000s.

Abalone ranching (i.e. the release of abalone seeds into the wild for harvesting purposes after a growth period) has been identified as one of the key opportunities to develop in the short- to medium-term and consequently the creation of abalone ranching enterprises around Hondeklip Bay and Port Nolloth forms part of the sector plan's development targets (www.northern-cape.gov.za). In the past, experimental abalone ranching concessions have been granted to Port Nolloth Sea Farms (PNSF) in Concession areas 5a and 6a, effectively a 60 km strip of coastline, and to Ritztrade in the Port Nolloth area (www.northern-cape.co.za). These experimental operations have shown that although abalone survival is highly variable depending on the site characteristics and sea conditions, abalone ranching on the Namaqualand coast has the potential for a lucrative commercial business venture (Sweijd *et al*. 1998, de Waal 2004). As a result, the government publication 'Guidelines and potential areas for marine ranching and stock enhancement of abalone *Haliotis midae* in South Africa' (GG No. 33470, Schedule 2, April 2010) identified broad areas along the South African coastline that might be suitable for abalone ranching. Along the Northern Cape coast, four specific zones were marked, separated by 6-13 km wide buffer zones. Currently, applications for abalone ranching projects have been submitted and permits for pilot projects for some of the zones have been granted.

Besides abalone sea-ranching, several other potential projects were identified in the sector plan. Most of these are land-based aquaculture projects (e.g. abalone and oyster hatcheries in Port Nolloth and abalone grow-out facility in Hondeklip Bay), but included was a pilot project to harvest natural populations of mussels and limpets in the intertidal coastal zone along the entire Northern Cape coast. The objective of the project was to determine the stock levels and to ascertain what percentage of the biomass of each species can be sustainably harvested, as well as the economic viability of harvesting the resource.

Other industrial uses of the marine environment include the intake of feed-water for mariculture, or diamond-gravel treatment. None of these activities should in any way be affected by offshore exploration activities.

3.4.2 Conservation Areas and Marine Protected Areas

Conservation Areas

Numerous conservation areas and a marine protected area (MPA) exist along the coastline of the Western Cape, although none fall within Sea Areas 4C and 5C. The only conservation area in the vicinity of the project area in which restrictions apply is the McDougall's Bay rock lobster sanctuary near Port Nolloth, which is closed to commercial exploitation of rock lobsters.

The Orange River Mouth wetland located ~75 km to the north of the project area provides an important habitat for large numbers of a great diversity of wetland birds and is listed as a Global Important Bird Area (IBA) (ZA023/NA 019)(BirdLife International 2005). The area was designated a Ramsar site in June 1991, and processes are underway to declare a jointly-managed transboundary Ramsar reserve.

Various marine IBAs have also been proposed in South African and Namibian territorial waters, with a candidate trans-boundary marine IBA suggested off the Orange River mouth (Figure 45). Sea Areas 4C and 5C lie south of these marine IBAs.

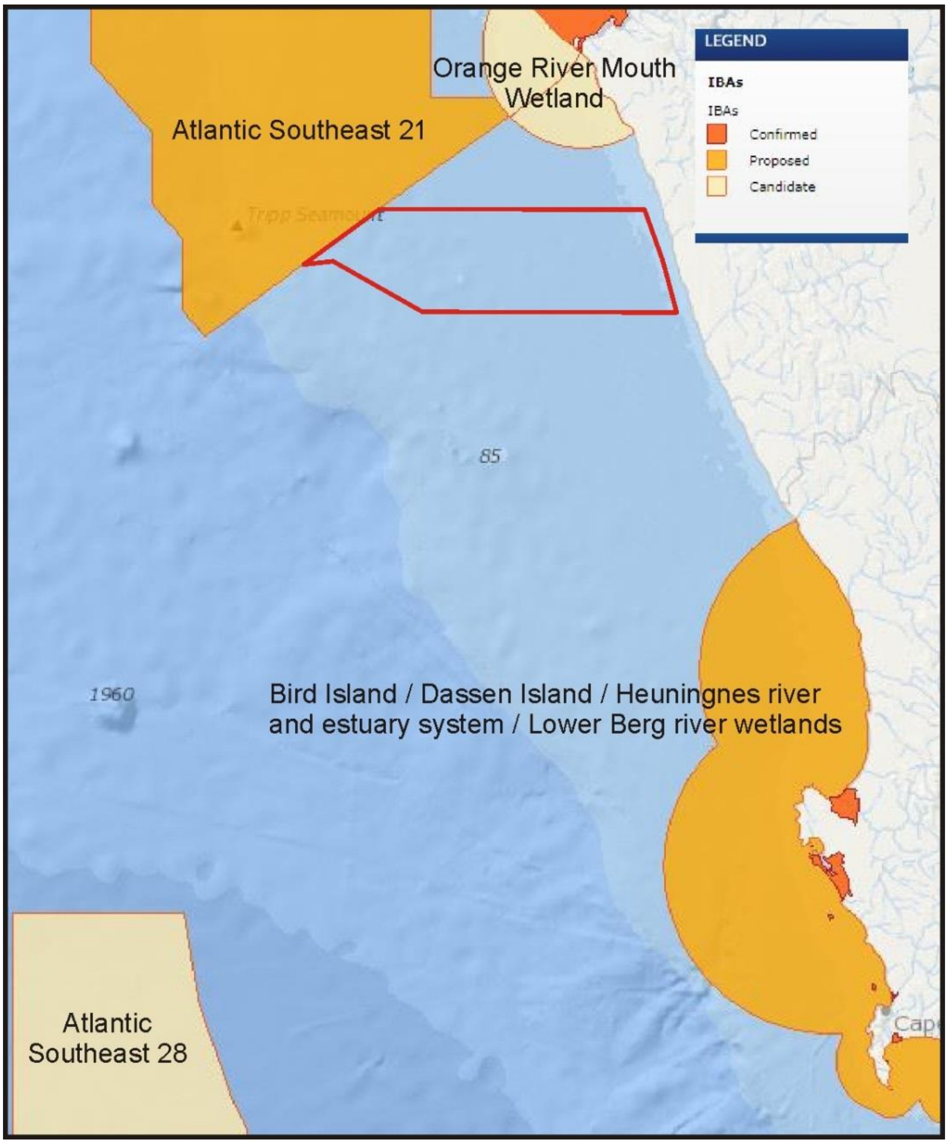

Figure 45: Sea Areas 4C and 5C in relation to coastal and marine IBAs in Namibia (Source: https://maps.birdlife.org/marineIBAs).

Marine Protected Areas

'No-take' MPAs offering protection of the Namaqua biozones (sub-photic, deep-photic, shallow-photic, intertidal and supratidal zones) were absent northwards from Cape Columbine (Emanuel et al. 1992, Lombard et al. 2004). This resulted in substantial portions of the coastal and shelf-edge marine biodiversity in the area being assigned a threat status of 'Critically endangered', 'Endangered' or 'Vulnerable' in the 2011 National Biodiversity Assessment (NBA) (Lombard *et al.* 2004; Sink et al. 2012). Using biodiversity data mapped for the 2004 and 2011 NBAs a systematic biodiversity plan was developed for the West Coast (Majiedt *et al.* 2013) with the objective of identifying both coastal and offshore priority areas for MPA expansion. Potentially vulnerable marine ecosystems (VMEs) that were explicitly considered during the planning included the shelf break, seamounts, submarine canyons, hard grounds, submarine banks, deep reefs and cold water coral reefs. To this end, nine focus areas were identified for protection on the West Coast between Cape Agulhas and the South African –

Namibian border. These focus areas were carried forward during Operation Phakisa, which identified potential offshore MPAs. A network of 20 MPAs was gazetted on 23 May 2019, thereby increasing the ocean protection within the South African Exclusive Economic Zone (EEZ) to 5%. The approved MPAs within the broad project area are shown in Figure 46. Sea Areas 4C and 5C overlap with the Namaqua Fossil Forest MPA (Figure 46), although the area has been excluded from the prospecting application and no geophysical surveying and sampling activities will occur there.

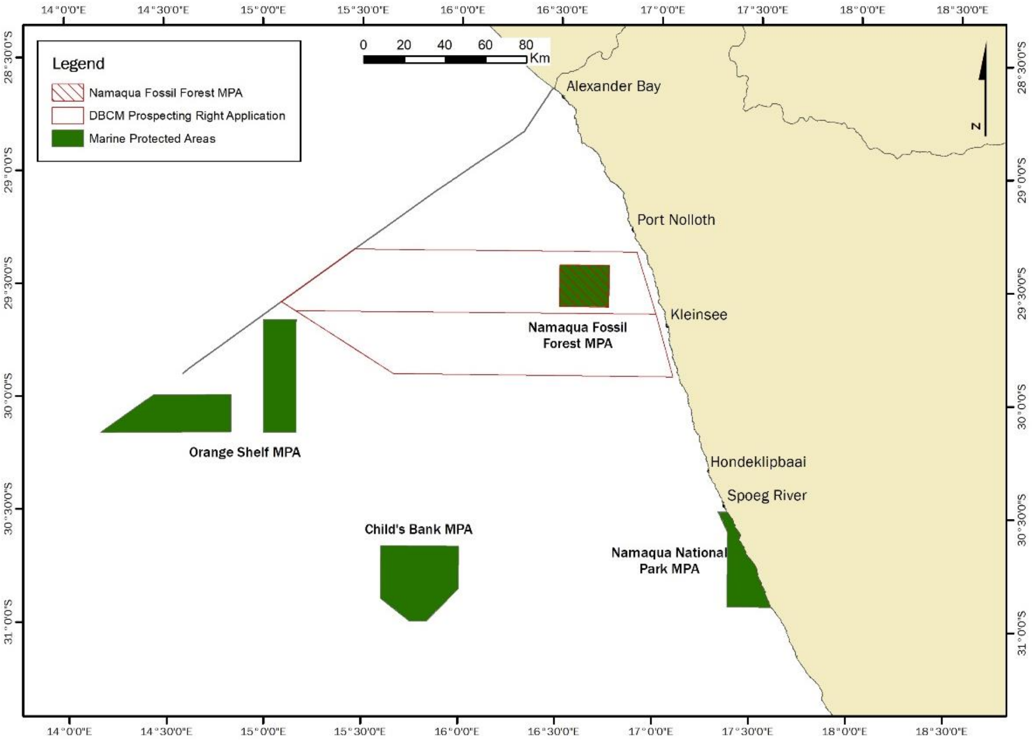

Figure 46: Sea Areas 4C and 5C (red polygon) in relation to Marine Protected Areas.

The **Namaqua Fossil Forest** Marine Protected Area in the Northern Cape is an offshore Marine Protected Area in the 120 m to 150 m depth range lying approximately 15 nautical miles offshore of the coastal area between Port Nolloth and Kleinsee. The area includes the sea bed, water column and subsoil within these boundaries. The purpose for declaring this Marine Protected Area is:

- to contribute to a national and global representative system of marine protected areas by providing protection to the benthic ecosystems of the inner shelf in this region;
- to conserve and protect an in-situ fossilised forest and its associated cold water corals; and
- to conserve and protect the biodiversity and ecological processes associated with these features.

The Namaqua Fossil Forest feature is a small unique seabed outcrop composed of fossilized yellowwood at 136 – 140 m depth, which have been colonized by habitat-forming scleractinian corals. This feature was observed within a 2 km^2 area (as described in Stevenson & Bamford, 2003) and received full protection through the declaration in May 2019 of the much larger (~516 km^2) encompassing Namaqua Fossil Forest MPA.

Other MPAs located off the West Coast are described briefly below (www.marineprotectedareas.org.za/offshore-mpas):

The **Orange Shelf Edge MPA** covers depths of between 250 m and 1 500 m and comprises three separate areas and includes the sea bed, water column and subsoil. The key purpose of this MPA is to protect remnants of threatened seabed ecosystems particularly untrawled shelf edge areas which is an area of importance for migratory species. The MPA is designed to facilitate species management by protecting components of aggregating areas for sharks and other species.

The 1 335 km^2 **Child's Bank MPA**, located to the south of Sea Areas 4C and 5C, supports seabed habitats inhabited by a diversity of starfish, brittle stars and basket stars, many of which feed in the currents passing the bank's steep walls. The MPA provides critical protection of the Childs Bank feature and associated ecosystems including cold water coral colonies.

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

Sensitive Areas

Despite the development of the offshore MPA network a number of 'Endangered' and 'Vulnerable' ecosystem types (i.e. Orange Cone Inner Shelf Mud Reef Mosaic, Orange Cone Muddy mid Shelf, Namaqua Muddy Sands, Southern Benguela Outer Shelf Mosaic, Southern Benguela Shelf Edge Mosaic and Southeast Atlantic Lower Slope) are currently 'not well protected' and further effort is needed to improve protection of these threatened ecosystem types (Sink *et al.* 2019) (Figure 47). Ideally, all highly threatened ('Critically Endangered' and 'Endangered') ecosystem types should be well protected. Currently, however, most of the Southern Benguela Sandy Shelf Edge and Southeast Atlantic Upper- and Mid-Slope are poorly protected receiving only 0.2-10% protection, whereas the Southeast Atlantic Lower Slope receives no protection at all (Sink *et al.* 2019). Expanding the size of the Orange Shelf Edge MPA to form a single MPA along the South African Border could improve protection of these threatened habitats. Most of the ecosystem types in Sea Areas 4C and 5C are either poorly protected or not protected.

Ecologically or Biologically Significant Areas

As part of a regional Marine Spatial Management and Governance Programme (MARISMA) 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 (Figure 48) 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 11 EBSAs solely within its national jurisdiction with a further four having recently been proposed. It also shares five trans-boundary EBSAs with Namibia (3) and Mozambique (2). The principal objective of these EBSAs is identification of features of higher ecological value that may require enhanced conservation and management measures. They currently carry no legal status. The impact management and conservation zones within the EBSAs are under review and currently constitute a subset of the biodiversity priority areas map (see next section); EBSA conservation zones equate to Critical Biodiversity Areas (CBAs), whereas impact management zones equate to Ecological Support Area (ESAs). The relevant sea-use guidelines accompanying the CBA areas would apply.

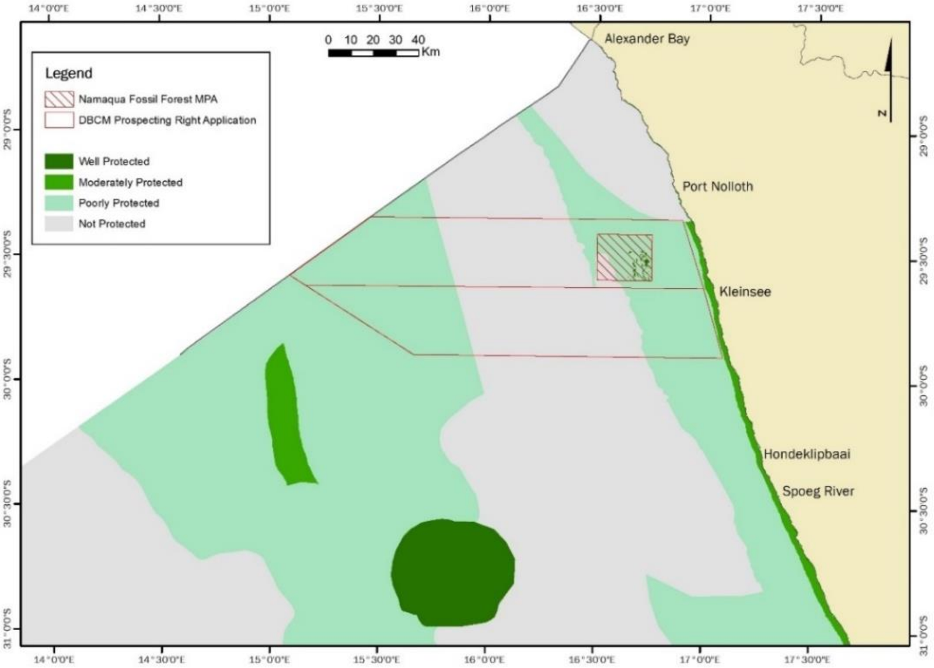

Figure 47: Protection levels of 150 marine ecosystem types as assessed by Sink *et al*. (2019) in relation to the Sea Areas 4C and 5C.

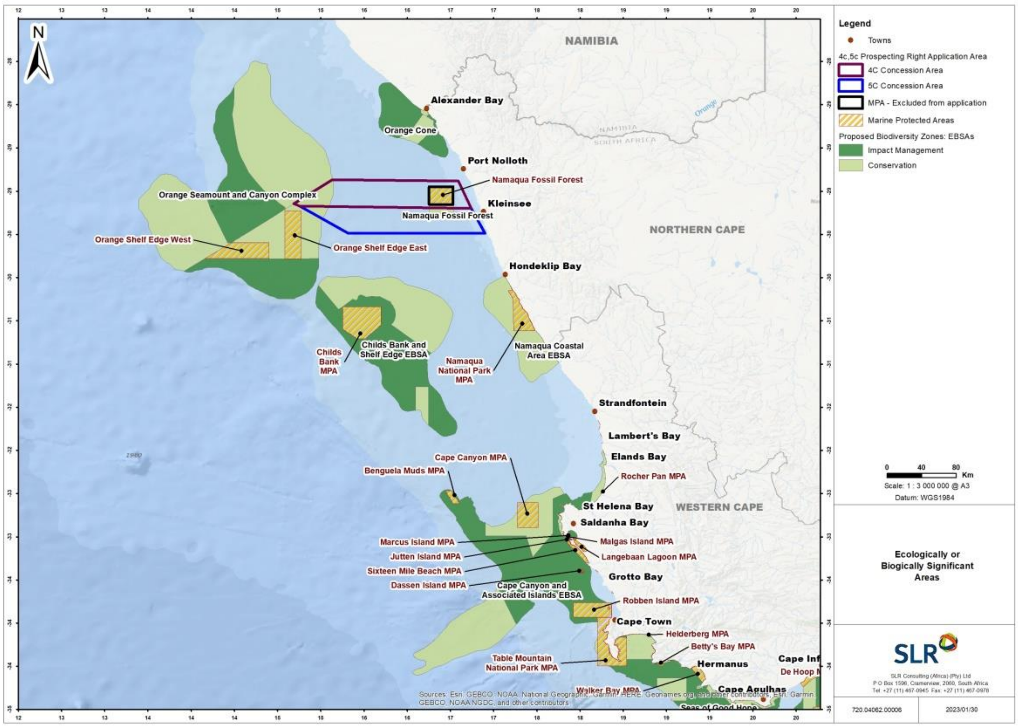

Figure 48: Sea Areas 4C and 5C (red polygon) in relation to Ecologically and Biologically Significant Areas (EBSAs).

Sea Areas 4C and 5C overlap with the following EBSAs:

- The **Namaqua Fossil Forest** is a small unique seabed outcrop composed of fossilized yellowwood at 136-140 m depth, which have been colonised by habitat-forming scleractinian corals and a habitat-forming sponge species. This feature was observed within a 2 km^2 area and received full protection through the declaration in May 2019 of the much larger (~516 km^2) encompassing Namaqua Fossil Forest MPA. The larger Namaqua Fossil Forest EBSA (total of ~830 km^2) encompasses this MPA and extends spatially beyond the MPA boundaries. Sea Areas 4c and 5c overlap with a portion of the Namaqua Fossil Forest EBSA that is not included within the boundaries of the Namaqua Fossil MPA, but which falls outside of the area where the unique fossilised feature was observed.
- The **Orange Seamount and Canyon Complex**, located to the west of Sea Areas 4C and 5C, occurs at the western continental margin of southern Africa, spanning the border between South Africa and Namibia. On the Namibian side, it includes the Tripp Seamount and a shelf-indenting canyon. The EBSA comprises shelf and shelf-edge habitat with hard and unconsolidated substrates, including at least eleven offshore benthic habitat types of which four habitat types are ‘Threatened’, one is ‘Critically endangered’ and one ‘Endangered’. The Orange Shelf Edge EBSA is one of few places where these threatened habitat types are in relatively natural/pristine condition. The local habitat heterogeneity is also thought to contribute to the Orange Shelf Edge being a persistent hotspot of species richness for demersal fish species. Although focussed primarily on the conservation of benthic biodiversity and threatened benthic habitats, the EBSA also considers the pelagic habitat, which is characterized by medium productivity, cold to moderate Atlantic temperatures (SST mean = 18.3°C) and moderate chlorophyll levels related to the eastern limit of the Benguela upwelling on the outer shelf.
- The **Benguela Upwelling System** is a transboundary EBSA which 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 following EBSAs have also been identified off the West coast of South Africa. Although they do not overlap with the 4C and 5C sea areas, they are described briefly for the sake of completeness:

- The **Orange Cone transboundary EBSA** lies north of Sea Areas 4C and 5C and spans the mouth of the Orange River. The estuary is biodiversity-rich but modified, and the coastal area includes many ‘Critically endangered’, ‘Endangered’ and ‘Vulnerable’ habitat types (with the area being particularly important for the ‘Critically Endangered’ Namaqua Sandy Inshore, Namaqua Inshore Reef and Hard Grounds and Namaqua Intermediate and Reflective Sandy Beach habitat types). The marine environment experiences slow, but variable currents and weaker winds, making it potentially favourable for reproduction of pelagic species. An ecological dependence on river outflow for fish recruitment on the inshore Orange Cone is also likely. The Orange River Mouth is a transboundary Ramsar site and falls within the Tsau//Khaeb (Sperrgebiet) National Park.

It is also under consideration as a protected area by South Africa and is an Important Bird and Biodiversity Area.

- The **Childs Bank and Shelf Edge EBSA**, which lies to the south of Sea Areas 4C and 5C, is a unique submarine bank feature rising from -400 m to -180 m on the western continental margin on South Africa. This area includes five benthic habitat types, including the bank itself, the outer shelf and the shelf edge, supporting hard and unconsolidated habitat types. Childs Bank and associated habitats are known to support structurally complex cold-water corals, hydrocorals, gorgonians and glass sponges; species that are particularly fragile, sensitive and vulnerable to disturbance, and recover slowly.
- The **Namaqua Coastal Area EBSA**, which lies to the south of Sea Areas 4C and 5C and encompasses the Namaqua Coastal Area MPA, is characterized by high productivity and community biomass along its shores. The area is important for several threatened ecosystem types represented there, including two 'Endangered' and four 'Vulnerable' ecosystem types, and is important for conservation of estuarine areas and coastal fish species.

Biodiversity Priority Areas

The National Coastal and Marine Spatial Biodiversity Plan[3] comprises a map of Critical Biodiversity Areas (CBAs), Ecological Support Area (ESAs) and accompanying sea-use guidelines. The CBA Map presents a spatial plan for the marine environment, designed to inform planning and decision-making in support of sustainable development. The sea-use guidelines enhance the use of the CBA Map in a range of planning and decision-making processes by indicating the compatibility of various activities with the different biodiversity priority areas so that the broad management objective of each can be maintained. The intention is that the CBA Map (CBAs and ESAs) and sea-use guidelines inform the MSP Conservation Zones and management regulations, respectively.

Sea Areas 4C and 5C overlap with areas mapped as Critical Biodiversity Area 1 (CBA 1): Natural and Critical Biodiversity Area 2: (CBA 2) Natural. Approximately 20% and 12% of the project area is covered by CBA 1 and CBA 2: Natural, respectively (see

Figure 49). ESA comprise 8% of Sea Areas 4C and 5C. CBA 1 indicates irreplaceable or near-irreplaceable sites that are required to meet biodiversity targets with limited, if any, option to meet targets elsewhere, whereas CBA 2 are "best design sites" and there often alternative areas where feature targets can be met; however, these will be of higher cost to other sectors and / or will be larger areas.

Regardless of how CBAs are split, CBAs are generally areas of low use and with low levels of human impact on the marine environment, but can also include some moderately to heavily used areas with higher levels of human impact. Given that some CBAs are not in natural or near-natural ecological

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

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

Activities within these management zones are classified into those that are "compatible", those that are "not compatible", and those that have "restricted compatibility". Non-destructive prospecting (e.g. geophysical surveys) are classified as having "restricted compatibility" within CBA1 and CBA2 natural areas, whereas destructive prospecting (e.g. bulk sampling) is considered "not compatible" in CBA1 and CBA2 natural areas. Both activities are considered having "restricted compatibility" within ESAs. Activities with restricted compatibility require a detailed assessment to determine whether the recommendation is that they should be permitted (general), permitted subject to additional regulations (consent), or prohibited, depending on a variety of factors. Mining construction and operations[4] are, however, classified as "not compatible" in CBAs, but may be compatible, subject to certain conditions, in ESAs (Harris *et.al.* 2022).

The CBA maps are currently used to inform the Marine Spatial Planning zones, and the seas-use guidelines used to inform the regulations under development. The MSP process is multi-sectoral, with the inputs by Harris *et al.* (2022) providing inputs on biodiversity only. Furthermore, the draft MSP has not yet been published for comment, with the plans from other sectors such as mining, fisheries and hydrocarbon exploration and production still being outstanding.

Important Marine Mammal Areas (IMMAs)

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

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[4] The activity should not be permitted to occur in CBAs because it is not compatible with the respective management objective. However, if significant mineral resources are identified during prospecting, then the selection of the site as a CBA could be re-evaluated as part of compromises negotiations in current or future MSP processes. This would require alternative CBAs and/or biodiversity offsets to be identified. However, if it is not possible to identify alternative CBAs to meet targets for the same biodiversity features that are found at the site, it is recommended that the activity remains prohibited.

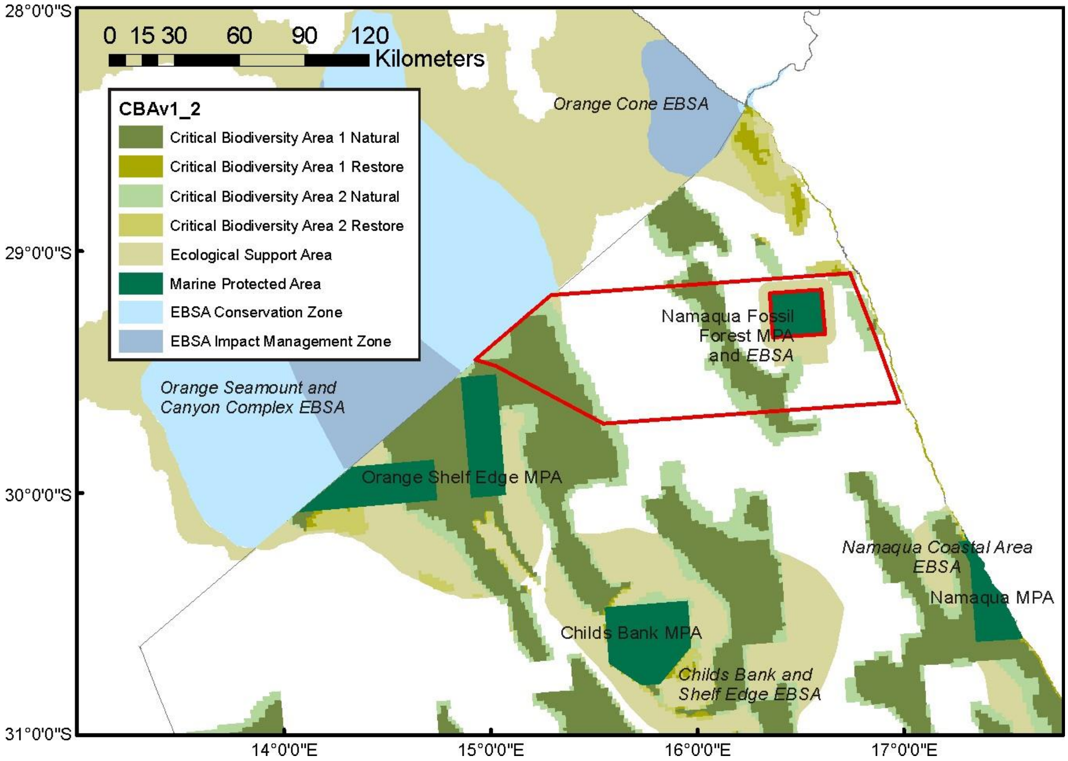

Figure 49: Sea Areas 4C and 5C (red polygon) in relation to the National Coastal and Marine Critical Biodiversity Areas (version 1.0 (Beta 2)) (adapted from Harris *et al.* (2022)). The southern Namibian EBSA zones and ESAs are also shown

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

Criterion A - Species or Population Vulnerability

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

Criterion B - Distribution and Abundance

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

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

Criterion C - Key Life Cycle Activities

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

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

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

Criterion D - Special Attributes

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

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

Although much of the West Coast of South Africa has not yet been assessed with respect to its relevance as an IMMA, the coastline from the Olifants River mouth on the West Coast to the Mozambiquan border overlaps with three declared IMMAs (Figure 50) namely the

- Southern Coastal and Shelf Waters of South Africa IMMA (166 700 km^2),
- Cape Coastal Waters IMMA (6 359 km^2), and
- South East African Coastal Migration Corridor IMMA (47 060 km^2).

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

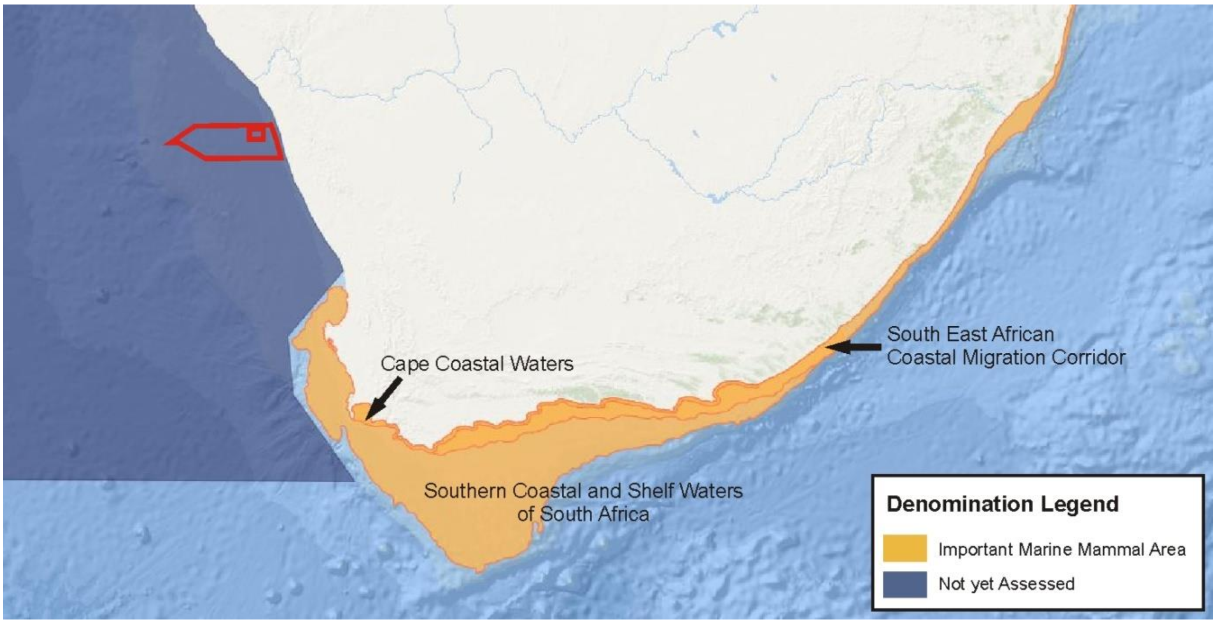

Figure 50: Sea Areas 4C and 5C (red polygon) in relation to coastal and marine IMMAs (Source: www.marinemammalhabitat. org/imma-eatlas/).

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

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

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

There is no overlap of Sea Areas 4C and 5C with these IMMAs as it falls within the area along the West Coast of South Africa that has not yet been assessed.

4. ASSESSMENT OF IMPACTS

This chapter describes and assesses the significance of potential impacts related to the proposed exploration activities in the prospecting application area. All impacts are assessed according to the rating scale defined in Section 1.4. Where appropriate, mitigation measures are proposed, which could ameliorate the negative impacts or enhance potential benefits, respectively. The status of all impacts should be considered negative unless otherwise stated. The significance of impacts with and without mitigation is assessed.

4.1 Identification of Impacts

The potential environmental impacts to the marine environment of the proposed geophysical prospecting operations are:

- Disturbance of marine mammals by the sounds emitted by the geophysical survey equipment;
- Disturbance of marine mammals by the electromagnetic/electric fields emitted by the geophysical survey equipment;
- Potential injury to marine mammals and turtles through vessel strikes;
- Marine pollution due to discharges such as deck drainage, machinery space wastewater, sewage, etc. and disposal of solid wastes from the survey vessel; and
- Marine pollution due to fuel spills during refuelling, or resulting from collision or shipwreck.

The potential environmental impacts to the marine environment of the sampling operations are:

- Disturbance and loss of benthic fauna in the drill sample footprints;
- Crushing of epifauna and infauna;
- Generation of suspended sediment plumes through discard of fine tailings;
- Smothering of benthic communities through re-settlement of discarded tailings;
- Potential loss of equipment on the seabed;
- Disturbance of marine biota by noise from the sampling vessel and sampling tools; and
- Marine pollution due to discharges such as deck drainage, machinery space wastewater, sewage, etc. and disposal of solid wastes from the sampling vessel.

4.2 Assessment of Impacts

4.2.1 Acoustic Impacts of Geophysical Prospecting and Sampling

Description of Impact

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 may thus interfere directly or indirectly with such activities. 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) aircraft flyovers, 2) multi-beam sonar systems, 3) seismic acquisition, 4) hydrocarbon and mineral exploration and recovery, and 5) noise associated with underwater blasting, pile driving, and construction (Figure 51).

As the offshore portion of Sea Areas 4C and 5C is located within the main offshore shipping routes that pass around southern Africa (Figure 52), the shipping noise component of the ambient noise environment is expected to be significant within and around the proposed geophysical survey area (OceanMind Limited 2020). 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 2020, 2021).

Typical natural ambient noise levels in the study area are estimated to have overall root-mean-square sound pressure levels (RMS SPLs) in the range of 80 – 120 dB re 1 µPa, with a median level around 100 dB re 1µPa upon calm to strong sea state conditions (SLR Consulting Australia 2020). 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), 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.

The noise generated by the acoustic equipment utilized during geophysical surveys falls within the hearing range of most fish, turtles and marine mammals (Table 9), and at sound levels of between 140 to 230 dB re 1 µPa at 1 m, will be audible for considerable distances (in the order of tens of km) before attenuating to below threshold levels (Findlay 2005). High frequency active sonar sources, in particular, have energy profiles that clearly overlap with cetacean's hearing sensitivity frequency range, particularly for cetaceans of High Frequency (e.g. odontocetes: dolphins, toothed whales (e.g. sperm), beaked whales, bottle-nose whales) and Very High Frequency (e.g. Heavisides dolphins, pygmy sperm and dwarf sperm whales) hearing groups. However, unlike the noise generated by airguns during seismic surveys, the emission of underwater noise from geophysical surveying and vessel activity is not considered to be of sufficient amplitude to cause auditory or non-auditory trauma in marine animals in the region. The noise emissions are highly directional, spreading as a fan from the sound source, predominantly in a cross-track direction, and only directly

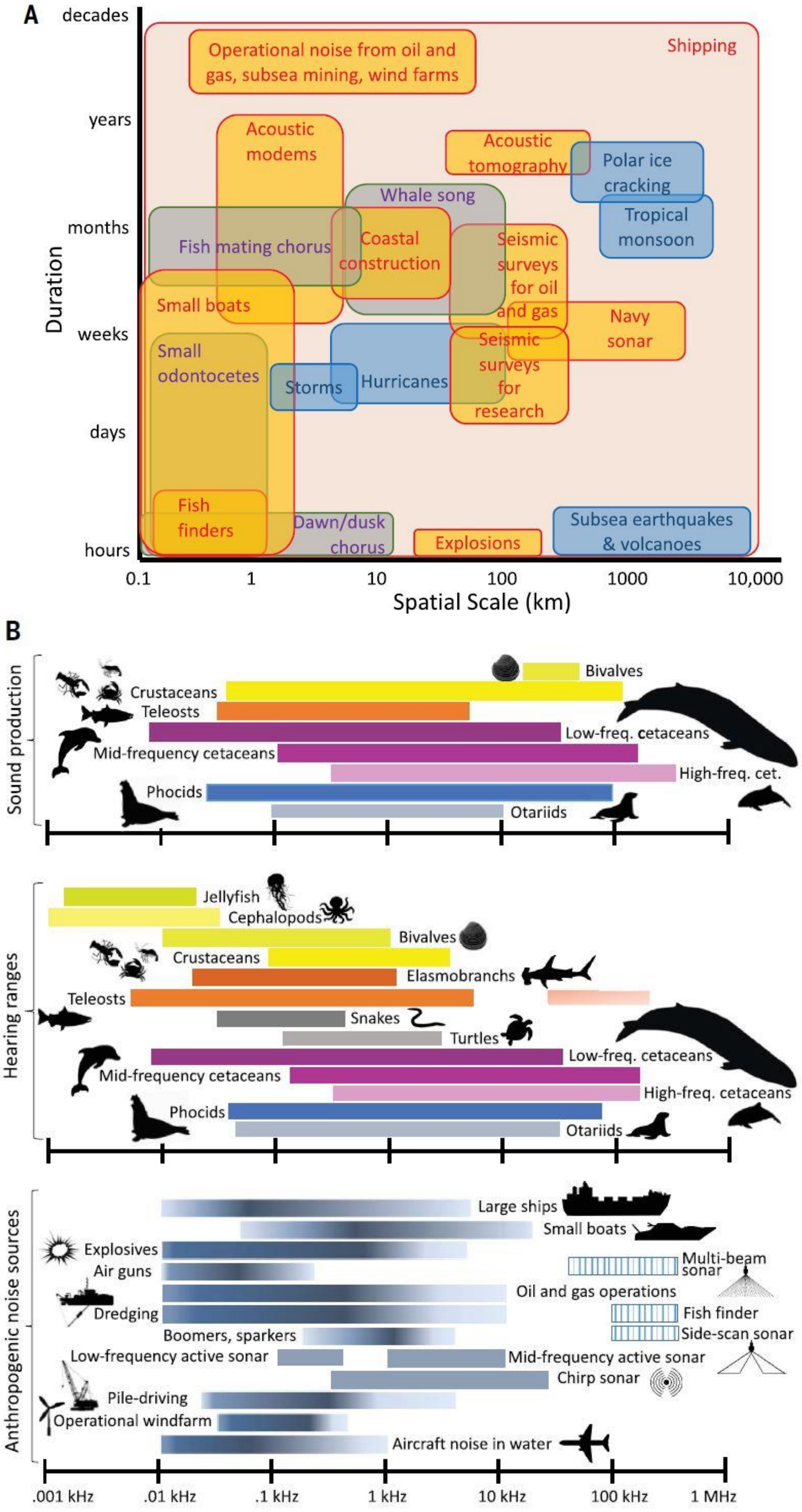

Figure 51: Sources and animal receivers of sound in the ocean. A) Spatial extent and duration of selected sound producing events, and B) Approximate sound production and hearing ranges of marine taxa and frequency ranges of selected anthropogenic sound sources. (Source: Duarte *et al*. 2021).

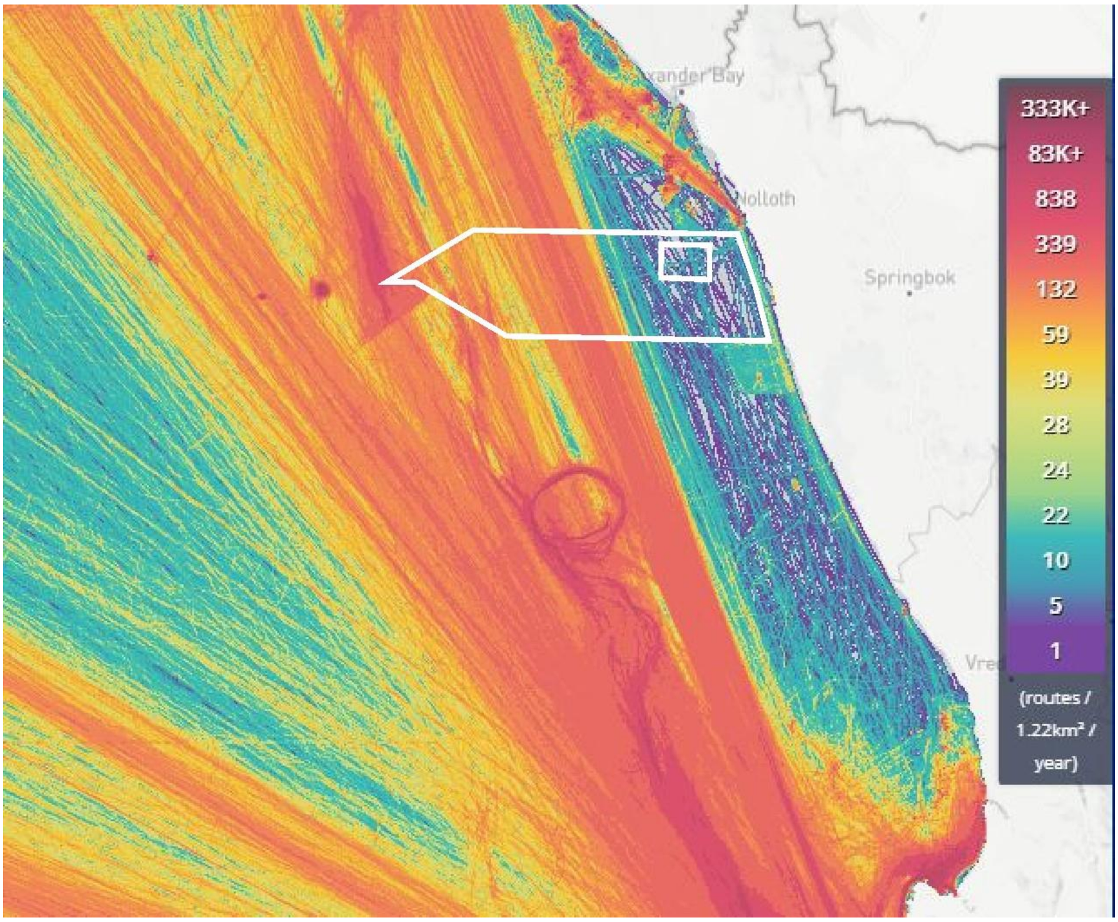

Figure 52: Sea Areas 4C and 5C (white polygon) in relation to offshore vessel traffic (adapted from www.marinetraffic.com/en/ais/home, accessed 30 November 2022).

below or adjacent to the systems (within 10 m of the source) would sound levels be in the 230 dB range where exposure would result in permanent threshold shifts (PTS[5]). In the case of very-high-frequency cetaceans the maximum zones of PTS effect were predicted to occur within 70 m from the source along the cross-track direction. Temporary threshold shifts (TTS[6]) for marine mammals of all hearing groups except very-high-frequency cetaceans were predicted to be within approximately 25 m from the sonar source, extending to within 140 m from the source along the cross-track direction for very-high frequency cetaceans (Li & Lewis 2020). Therefore, only directly below or within the sonar beam would received sound levels be in the range where exposure results in trauma or physiological injury. As most pelagic species likely to be encountered within the Sea Areas are highly mobile, they would be expected to flee and move away from the sound source before trauma could occur. Furthermore, the statistical probability of crossing a cetacean or pinniped with the narrow multi-beam fan several times, or even once, is very small.

The underwater noise from the survey systems may, however, induce localised behavioural changes (e.g. avoidance of the source) in some marine mammal, but there is no evidence of significant

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[5] A permanent threshold shift is a shift in the auditory threshold, which results in permanent hearing loss.

[6] A temporary threshold shift is a shift in the auditory threshold, which results in temporary hearing loss.

behavioural changes that may impact on the wider ecosystem (Perry 2005) and no evidence of physical damage (i.e. PTS and TTS) (Childerhouse & Douglas 2016). The maximum impact distance for behavioural disturbance caused by the immediate exposure to individual sonar pulses was predicted to be within 1.8 km from the source for marine mammals of all hearing groups, at cross-track directions (Li & Lewis 2020).

Similarly, the sound level generated by sampling operations fall within the 120-190 dB re 1 µPa range at the sampling unit, with main frequencies between 3 – 10 Hz. The noise generated by sampling operations thus falls within the hearing range of most fish and marine mammals, and depending on sea state would be audible for up to 20 km around the vessel before attenuating to below threshold levels (Table 9). In a study evaluating the potential effects of vessel-based diamond mining on the marine mammals community off the southern African West Coast, Findlay (1996) concluded that the significance of the impact is likely to be minimal based on the assumption that the radius of elevated noise level would be restricted to ~20 km around the vessel. Whereas the underwater noise from sampling operations may induce localised behavioural changes in some marine mammal, it is unlikely that such behavioural changes would impact on the wider ecosystem (see for example Perry 2005). The responses of cetaceans to noise sources are often also dependent on the perceived motion of the sound source as well as the nature of the sound itself. For example, many whales are more likely to tolerate a stationary source than one that is approaching them (Watkins 1986; Leung-Ng & Leung 2003), or are more likely to respond to a stimulus with a sudden onset than to one that is continuously present (Malme *et al*. 1985).

Table 9: Known hearing frequency and sound production ranges of various marine taxa (adapted from Koper & Plön 2012).

Taxa	Order	Hearing frequency (kHz)	Sound production (kHz)
Shellfish	Crustaceans	0.1 – 3	
Snapping shrimp	*Alpheus/ Synalpheus* spp.		0.1 - >200
Ghost crabs	*Ocypode* spp.		0.15 – 0.8
Fish	Teleosts		0.4 – 4
Hearing specialists		0.03 - >3	
Hearing generalists		0.03 – 1	
Sharks and skates	Elasmobranchs	0.1 – 1.5	Unknown
African penguins	Sphenisciformes	0.6 - 15	Unknown
Sea turtles	Chelonia	0.1 – 1	Unknown
Seals	Pinnipeds	0.25 – 10	1 – 4
Northern elephant seal	*Mirounga agurostris*	0.075 – 10	
Manatees and dugongs	Sirenians	0.4 – 46	4 - 25
Toothed whales	Odontocetes	0.1 – 180	0.05 – 200
Baleen whales	Mysticetes	0.005 – 30	0.01 – 28

Sensitive Receptors

The taxa most vulnerable to disturbance by high-frequency underwater sonar noise are marine mammals, particularly the very-high frequency (e.g. Heaviside's dolphin, pygmy sperm and dwarf sperm whales) and high-frequency species (e.g. odontocetes: dolphins, toothed whales (e.g. sperm), beaked whales, bottle-nose whales). Some of the species potentially occurring in the project area, are considered regionally or globally 'Endangered' (e.g. fin and sei whales), 'Vulnerable' (e.g. Bryde's (inshore), sperm whale, Humpback B2). Although species listed as 'Endangered' or 'Vulnerable' may potentially occur in the project area, due to their extensive distributions their numbers are expected to be low.

Assessment

The effects of high frequency sonars on marine fauna is considered to be localised, short-term (for duration of survey i.e. weeks) and of medium intensity. The significant of the impact is considered of **VERY LOW** significance both without and with mitigation.

The impact of underwater noise generated during sampling operations is considered to be of low intensity in the target area and for the duration of the sampling campaign. The impact of underwater noise is considered of **VERY LOW** significance without mitigation.

Mitigation

No mitigation measures are possible, or considered necessary for the generation of noise by the sampling tools and vessels.

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 2010). These have been revised to be more applicable to the southern African situation. Recommendations for mitigation include:

- 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 vicinity.
- 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 between June and November.

- A MMO should be appointed to ensure compliance with mitigation measures during geophysical surveying.

Impacts of multi-beam and sub-bottom profiling sonar on marine fauna

	Without Mitigation	**Assuming Mitigation**
Intensity	Medium	Low
Duration	Short-term: for duration of survey	Short-term
Extent	Local: limited to survey area	Local
Consequence	Very Low	Very Low
Probability	Probable	Probable
Significance	Very Low	Very Low
Status	Negative	Negative
Confidence	Medium	Medium

Nature of Cumulative impact	Considering the number of seismic surveys and geophysical surveys recently conducted along the West Coast, some cumulative impacts can be anticipated. However, any direct impact is likely to be at individual level rather than at species level.
Reversibility	Fully reversible – any disturbance of behaviour, auditory “masking” or reductions in hearing sensitivity that may occur as a result of survey noise below 220 dB would be temporary.
Loss of resources	Negligible
Mitigation potential	Low

Impacts of noise from sampling operations on marine fauna

	Without Mitigation	**Assuming Mitigation**
Intensity	Low	No mitigation is proposed
Duration	Short-term: for duration of sampling operations	
Extent	Local: limited to target area	
Consequence	Very Low	
Probability	Definite	
Significance	Very Low	
Status	Negative	
Confidence	High	

Nature of Cumulative impact	None
Reversibility	Fully Reversible - any disturbance of behaviour, auditory “masking” or reductions in hearing sensitivity that may occur would be temporary.
Loss of resources	N/A
Mitigation potential	None

4.2.2 Generation of Electromagnetic Fields

Description of Impact

Various electrical, magnetic and/or electro-magnetic methods may be used during geophysical surveys including towed magnetometers and probes to measure electrical resistivity of seabed sediments. These are passive systems and no impacts on marine biota are therefore expected. In the case of electromagnetic (EM) surveys, an example is provided below based on information from the hydrocarbon industry. During electromagnetic surveys, a horizontal electric dipole source containing electrodes is towed above the sea floor. An alternating current is set up to flow between the electrodes thereby injecting a current of up to 1 250 amperes (A)[7] into the sea water and generating both an electric and magnetic field. The repetitive electromagnetic signal is transmitted at a frequency of 0.05 - 10 Hz, upwards into the overlying water column and downwards into the underlying sediments and recorded by an array of receivers placed on the seabed or behind the towed dipole-source.

No specific information is available at this stage on the electromagnetic fields strengths anticipated from the equipment proposed for the current project. However, it can safely be assumed that the field strengths will be considerably lower than those used by the hydrocarbon industry, which is described below. Controlled Source Electromagnetism is typically **classified as *ultra low frequency*** (0.05 - 10 Hz), with low electric field strengths (<30 mV/m) and low magnetic field strengths (<7 400 nT) (Buchanan *et al*. 2011). Depending on the species, electromagnetic fields (EMFs) above corresponding thresholds can affect marine fauna by:

- Inducing micro-currents in marine organisms possibly disrupting their normal electrical functions resulting in potential physiological or behavioural impacts;
- Disruption of migratory behaviour in animals that use geomagnetism to assist navigation; and
- Disruption of feeding behaviour in animals that use electro-reception to assist in finding food.

The human health guidelines for the general public (400 000 000 nT for static magnetic fields and 400 mV for time-varying electrical fields in the 1 Hz to 3 kHz range) (ICNIRP 2009, 2010) are well above the levels generated during EM surveys. Low frequency EM covering a small area over a short period of time is thus unlikely to have any discernible health effects on marine biota. Direct faunal health effects are therefore not considered further here.

Sensitive Receptors

Magnetic orientation has been reported from a wide diversity of marine animals including Western Atlantic spiny lobsters (*Panulirus argus*) (Lohmann 1985; Lohmann *et al*. 1995), salmon (Kirschvink *et al*. 1985; Walker *et al*. 1988; Moore *et al*. 1990), loggerhead and leatherback turtle hatchings (Lohmann & Lohmann 1994a, 1994b; 1996a, 1996b) and loggerhead juveniles (Avins & Lohmann 2003), and cetaceans (Pacific dolphins: Zoegler *et al*. 1981; Humpback whales: Fuller *et al*. 1985). Marine species shown to use magnetic orientation during navigation are listed by Buchanan *et al*. (2006), of which Leatherback and Loggerhead turtle hatchlings and Yellowfin tuna potentially occur in the Sea Areas. Other marine species listed include a nudibranch, various crustaceans (talitrid amphipods, isopods and spiny lobster), and numerous bony fish species. None of these occur off the West Coast, but related species that may similarly have the ability to use either an inclination, polarity, or field

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[7] For deep applications used during hydrocarbon prospecting.

intensity magnetic compass do occur there, and these may therefore potentially be affected by the EM surveys.

The principal group of electroreceptive marine fishes are the Chondrichthyes: sharks, skates, rays, and chimaeras (see review in von der Emde 1998), who can detect weak electric fields for use in prey location, communication, and possibly navigation (Meyer *et al.* 2004). Just as the electromagnetic signal from an EM source is rapidly attenuated, so the voltage gradients of the bioelectric fields generated by marine animals fall off rapidly with distance (Kalmijn 1971).

A wide variety of taxa are therefore sensitive to EMFs, of which some potentially occurring in the Sea Areas are considered regionally or globally 'Critically Endangered' (e.g. oceanic whitetip shark, leatherback turtle), 'Endangered' (e.g. shortfin and Longfin mako sharks, dusky shark, southern bluefin tuna, leatherback turtles, fin and sei whales), 'Vulnerable' (e.g. bigeye tuna, blue marlin, sailfish, loggerhead turtles, great white shark, and sperm whale, Bryde's and humpback whales) or 'Near Threatened' (e.g. blue shark, swordfish, longfin tuna/albacore and yellowfin tuna).

Assessment

The marine environment is by no means devoid of electric and magnetic fields. The Earth's geomagnetic field is ever-present, with typical magnetic flux densities from 30 000 nT at the equator, through 40 000 - 50 000 nT at mid-latitudes to 60 000 nT at the magnetic poles. Natural disturbances in the earth's magnetic field are caused by coronal mass ejections or solar flares from the Sun. Geomagnetic storms range from minor storms (70-120 nT occurring 9.7 to 19.3 times per year);, through moderate storms (120-200 nT occurring 3.4 to 6.8 times), strong storms (200-330 nT occurring 1.1 to 2.3); and severe storms (330-500 nT occurring every one to two years).

An electrical current is generated (induced) in any conductor moving through a magnetic field (as per Faraday's Law). Seawater flowing through the Earth's geomagnetic field, may thus also create electric fields. Voltage gradients from currents in the Atlantic typically are reported to range from 50-500 nV/cm, but can reach up to 750 nV/cm in the Schelde Estuary in the Netherlands. A mean of 386 nV/cm has been defined as a threshold reference (Buchanan *et al.* 2011). 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. In fact, many marine animals have evolved the capacity to perceive and utilise EMFs to detect prey or navigate during migrations.

Electromagnetism and its potential effects on marine organisms has been comprehensively reviewed by Johnsson & Ramstad (2004), Buchanan et al. (2006) and Buchanan *et al.* (2011). Based on available information, Buchanan *et al.* (2011) selected 200 nT and 386 nV/cm as generic thresholds of effects for magnetic and electric fields generated by electromagnetic surveys. 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.

At the present stage of knowledge, however, the use of electromagnetic seabed logging techniques does not appear to involve substantial deleterious effects on marine life. Using data from the application of Controlled Source EM surveys undertaken by the hydrocarbon industry, electromagnetic fields strengths were calculated for variable source frequencies ranging for 0.25 to 10 Hz assuming a towed source antenna 30-50 m above the seafloor in a total water depth of 4 000 m. In all cases, field strengths attenuated to less than 200 nT within 400 vertical metres above the source. The magnetic field generated during EM applications decreases rapidly with distance from the source, and 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 without being negatively affected. Similarly, electric field strengths for variable source frequencies ranging from 0.25 to 10 Hz were calculated from industry data. Electric field strengths were maximal at 100 m radial distance from the source, attenuating to less than 386 nV/cm within 400 - 800 m vertical distance and 1 000 – 1 900 m radial distance from the source. However, in contrast to the deep-towed source, a shallow-towed source radiates electrical energy over a wider area and the radial area increases with frequency while the vertical area decreases with frequency. This may be due to the characteristics of the wave form (Buchanan *et al.* 2011).

Most cetaceans, sea turtles, pinnipeds, and seabirds that spend the majority of their time in the upper 200 m of the water column, are highly unlikely to be affected by an EM source towed at depth. Only the deep diving species (e.g. sperm whales, beaked whales) may detect the electromagnetic field generated by the source should they pass into the “zone of influence” (i.e. <400 m) of a typical source during a deep dive. Since most species are likely to have rapid escape mechanisms and will thus be able to avoid any field from the moving EM source, exposure times will be short and any pathological injury is highly unlikely. Animals would need to come in very close contact (within a few 100 m) of the electrodes in order to show behavioural response. It is only benthic and demersal species living in, or associated with the seabed, that may show behavioural response when they are exposed to the “zone of influence” (i.e. <400 m) of a typical source passing overhead. Any effects will be localised at any one time, affect relatively few members of a population, and will be of relatively short duration. EM surveys are therefore not expected to produce significant effects on the marine environment.

No information is available at this stage on the electromagnetic fields strengths anticipated from the equipment proposed for the current project. It can safely be assumed, however, that the field strengths will be considerably lower than those used by the hydrocarbon industry and quoted here. Recognising the different sensitivities of the various faunal groups and applying the precautionary principle, the impact of the EMF generated during an EM survey would potentially be of medium intensity, be highly localised at any one time (i.e. within metres from source within the survey area) and persisting only over the short term. Although it is possible that the towed EM source may affect some fauna at close range, the potential impact of EM surveys causing physiological injury to, or behavioural avoidance by benthic invertebrates, boney and cartilaginous fish, turtles, seabirds and marine mammals is deemed to be **INSIGNIFICANT**.

Identification of Mitigation Measures

As EM surveys are not analogous to seismic surveys, the same type of mitigations are not warranted. Mitigation measures implemented (Buchanan *et al.* 2006; LGL Limited 2009; Woodside 2010) to reduce the impact of CSEM surveys on marine fauna include:

- Use standard operational procedure to warm up the electromagnetic source transmitter (i.e. equivalent to ramp-up of current in electric source). It is recommended that the electromagnetic source should be ramped up over a minimum period of 20 minutes.

- Turn off electromagnetic source when not collecting data.
- Use lowest field strengths required to successfully complete the survey.

Impacts of electromagnetic surveys on marine fauna		
	Without Mitigation	**Assuming Mitigation**
Intensity	Medium	Low
Duration	Short-term: for duration of survey	Short-term
Extent	Local: limited to survey area	Local
Consequence	Very Low	Very Low
Probability	Possible	Improbable
Significance	Insignificant	Insignificant
Status	Negative	Negative
Confidence	Medium	Medium

Nature of Cumulative impact	Cumulative impacts are not anticipated. However, any direct impact is likely to be at individual level rather than at species level.
Reversibility	Fully reversible – any disturbance of behaviour would be temporary.
Loss of resources	Negligible
Mitigation potential	Low

4.2.3 Disturbance and loss of benthic fauna during sampling (including coring)

Description of Impact

The proposed sampling activities are expected to result in the disturbance and loss of benthic macrofauna through removal of sediments by the corer or sampling tool. For the purposes of this assessment it is assumed that up to 22 500 samples may be obtained within the potential deposit areas during the 5 years of prospecting, with the cumulative area of disturbance amounting to approximately 0.225 km^2. Samples will be discrete, i.e. not contiguous and as a result recolonisation from adjacent undisturbed areas is possible.

As benthic fauna typically inhabits the top 20 - 30 cm of sediment, the sample operations would result in the elimination of the benthic infaunal and epifaunal biota in the sample footprints. As many of the macrofaunal species serve as a food source for demersal and epibenthic fish, cascade effects on higher order consumers may result. However, considering the available area of similar habitat on the continental shelf of the West Coast, this reduction in benthic biodiversity can be considered negligible and impacts on higher order consumers are thus unlikely.

The ecological recovery of the disturbed seafloor is generally defined as the establishment of a successional community of species that achieves a community similar in species composition, population density and biomass to that previously present (Ellis 1996). The rate of recovery (recolonisation) depends largely on the magnitude of the disturbance, the type of community that inhabits the sediments in the sampling area, the extent to which the community is naturally adapted to high levels of sediment disturbances, the sediment character (grain size) that remains following the disturbance, and physical factors such as depth and exposure (waves, currents) (Newell *et al.* 1998). Generally, recolonisation starts rapidly after a sampling/mining disturbance, and the number of individuals (*i.e.* species density) may recover within short periods (weeks). Opportunistic species may recover their previous densities within months. Long-lived species like molluscs and echinoderms, however, need longer to re-establish the natural age and size structure of the population. Biomass therefore often remains reduced for several years (Kenny & Rees 1994, 1996; Kenny *et al.* 1998).

The structure of the recovering communities is typically also highly spatially and temporally variable reflecting the high natural variability in benthic communities at depth. The community developing after an impact depends on (1) the nature of the impacted substrate, (2) differential re-settlement of larvae in different areas, (3) the rate of sediment movement back into the disturbed areas and (4) environmental factors such as near-bottom dissolved oxygen concentrations etc. For the current project, the proposed sampling would be undertaken in depths beyond the wave base (>40 m) and near-bottom sediment transport is thus expected to be less than in shallower waters affected by swell. Excavations are therefore expected to have slow infill rates and may persist for extended periods (years). Long-term or permanent changes in grain size characteristics of sediments may thus occur, potentially resulting in a shift in community structure if the original community is unable to adapt to the new conditions. Depending on the texture of the sediments at the sampling target sites, slumping of adjacent unconsolidated sediments into the excavations can, however, be expected over the very short-term. Although this may result in localised disturbance of macrofauna associated with these sediments and alteration of sediment structure, it also serves as a means of natural recovery of the excavations.

Natural rehabilitation of the seabed following sampling operations, through a process involving influx of sediments and recruitment of invertebrates, has been demonstrated on the southern African continental shelf (Penney & Pulfrich 2004; Steffani 2007, 2009, 2010, 2012). Recovery rates of impacted communities were variable and dependent on the sampling /mining approach, sediment influx rates and the influence of natural disturbances on succession communities. Results of on-going research on the southern African West Coast suggest that differences in biomass, biodiversity or community composition following mining with drill ships or crawlers below the wave base may endure beyond the medium term (6-15 years) (Parkins & Field 1998; Pulfrich & Penney 1999; Steffani 2012). Savage *et al.* (2001), however, noted similarities in apparent levels of disturbance between mined and unmined areas off the southern African west coast, and areas of the Oslofjord in the NE Atlantic Ocean, which is known to be subject to periodic low oxygen events. Similarly, Pulfrich & Penney (1999) provided evidence of significant recruitments and natural disturbances in recovering succession communities off southern Namibia. These authors concluded that the lack of clear separation of impacted from reference samples suggests that physical disturbance resulting from sampling or mining may be no more stressful than the regular naturally occurring anoxic events typical of the West Coast continental shelf area.

Sensitive Receptors

The sampling activities would be undertaken in the offshore marine environment where the Namaqua Muddy Midshelf Mosaic, Namaqua Muddy Sands and Southern Benguela Sandy Outer Shelf ecosystem types have been rated as of ‘Least Concern’. The benthic fauna inhabiting unconsolidated sediments at the depths of the proposed sampling are expected to be relatively ubiquitous, varying only with sediment grain size, organic carbon content of the sediments and/or near-bottom oxygen concentrations. These benthic communities usually comprise fast-growing species able to rapidly recruit into areas that have suffered natural environmental disturbance. Epifauna living on the sediment typically comprise urchins, burrowing anemones, molluscs, seapens and sponges, many of which are longer lived and therefore more sensitive to disturbance. No rare or endangered species have been reported or are known from the unconsolidated sediments in Sea Areas 4C and 5C. The sensitivity of the benthic communities of unconsolidated sediments is therefore considered LOW.

In contrast, the benthos of hard substrata, such as those occurring in the Namaqua Fossil Forest MPA, are typically vulnerable to disturbance due to their long generation times, and numerous potential VME indicator taxa have been reported for that area. While the sensitivity of such cold water reef communities is considered HIGH, the area of interest for sampling has specifically been planned to avoid such sensitive habitats.

Assessment

The medium-intensity negative impact of sediment removal during sampling operations and its effects on the associated communities is unavoidable, but as it will be extremely localised (i.e. discrete samples of typically 5-10 m^2) amounting to a total of only 0.225 km^2 should the maximum potential of 22 500 samples be taken. The area disturbed constitutes ~ 0.0024% of the overall area of 4c and 5c, the impact can confidently be rated as being of **VERY LOW** significance with mitigation.

Mitigation

No mitigation measures are possible, or considered necessary for the direct loss of macrobenthos due to sampling. However, remote sensing data should be used to conduct a pre-sampling analysis of the seabed to identify high-profile, rocky-outcrop areas without a sediment veneer, which may have sensitive fauna. Exploration sampling targets gravel bodies in unconsolidated sediments and does not target these high-profile rocky-outcrops without a sediment veneer.

Disturbance and loss of benthic fauna during sampling		
	Without Mitigation	**Assuming Mitigation**
Intensity	Medium	Medium
Duration	Short- to Medium-term	Short- to Medium-term
Extent	Local: limited to target area	Local
Consequence	Very Low to Low	Low
Probability	Definite	Definite
Significance	Very Low to Low	Very Low
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	No cumulative impacts are anticipated during the sampling phase
Reversibility	Fully Reversible
Loss of resources	N/A
Mitigation potential	None

4.2.4 Crushing of benthic fauna during sampling (including coring)

Description of Impact

Some disturbance or loss of benthic biota adjacent to the sample footprint can also be expected as a result of the placement on the seabed of the either the corer frame or the sampling tool structure (during coring/sampling). Epifauna and infauna beneath the footprint of the sampling tool structure would be crushed by the weight of the equipment resulting in a reduction in benthic biodiversity.

Sensitive Receptors

The sampling activities would be undertaken in the offshore marine environment (45 km and 80 km, respectively, from the coastline at their nearest points) where the Namaqua Muddy Midshelf Mosaic, Namaqua Muddy Sands and Southern Benguela Sandy Outer Shelf ecosystem types have been rated as of 'Least Concern'. The benthic fauna inhabiting unconsolidated sediments at the depths of the proposed sampling are expected to be relatively ubiquitous, varying only with sediment grain size, organic carbon content of the sediments and/or near-bottom oxygen concentrations. These benthic communities usually comprise fast-growing species able to rapidly recruit into areas that have suffered natural environmental disturbance. Epifauna living on the sediment typically comprise urchins, burrowing anemones, molluscs, seapens and sponges, many of which are longer lived and therefore more sensitive to disturbance. No rare or endangered species have been reported or are known from the unconsolidated sediments in Sea Areas 4C and 5C. The sensitivity of the benthic communities of unconsolidated sediments is therefore considered LOW.

In contrast, the benthos of cold-water hard substrata, such as those occurring in the Namaqua Fossil Forest MPA, are typically vulnerable to disturbance due to their long generation times, and numerous potential VME indicator taxa have been reported for that area. While the sensitivity of deep water reef communities is considered HIGH, the area of interest for sampling has specifically been planned to avoid such sensitive habitats.

Assessment

Crushing is likely to primarily affect soft-bodied species as some molluscs and crustaceans may be robust enough to survive (see for example Savage *et al*. 2001). Considering the available area of similar habitat on the continental shelf of the West Coast, the reduction in benthic biodiversity through crushing can be considered negligible. The impacts would be of medium intensity but highly localised, and short-term as recolonization would occur rapidly from adjacent undisturbed sediments. The potential impact is consequently deemed to be of **VERY LOW** significance.

Mitigation

No direct mitigation measures are possible, or considered necessary for the indirect loss of benthic macrofauna due to crushing by the drill-frame structure and the seabed crawler tracks. However, it is recommended that:

- remote sensing data should be used to conduct a pre-sampling analysis of the seabed to identify high-profile, rocky-outcrop areas without a sediment veneer. Exploration sampling targets gravel bodies in unconsolidated sediments and does not target these high-profile rocky-outcrops without a sediment veneer;

- dynamically positioned sampling vessels are implemented in preference to vessels requiring anchorage.

Crushing of benthic fauna during sampling		
	Without Mitigation	**Assuming Mitigation**
Intensity	Medium	Medium
Duration	Short-term	Short-term
Extent	Local: limited to target area	Local
Consequence	Very Low	Very Low
Probability	Definite	Definite
Significance	Very Low	Very Low
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	No cumulative impacts are anticipated during the sampling phase
Reversibility	Fully Reversible
Loss of resources	N/A
Mitigation potential	None

4.2.5 Generation of suspended sediment plumes during sampling

Description of Impact

The sampled seabed sediments are pumped to the surface and discharged onto sorting screens on the sampling vessel. This does not apply to coring activities. The screens separate the fine sandy silt and large gravel and cobbles from the size fraction of interest, the 'plantfeed' (usually 2 - 20 mm). The heavier sediments would settle below the vessel where a localised smothering effect can be expected. The fine sediments are also immediately returned overboard where they result in increased water turbidity and reduced light penetration resulting in both direct and indirect effects on primary producers (phytoplankton) in surface waters, and on pelagic fish and invertebrate communities in the water column. The finer sediment discharged at the surface generate a plume in the upper water column, which is dispersed away from the sampling vessel by prevailing currents, diluting rapidly to background levels at increasing distances from the vessel. The 'plantfeed' is mixed with a high density ferrosilicon (FeSi) slurry and pumped under pressure into a Dense Medium Separation (DMS) plant resulting in a high density concentrate. The majority of the ferrosilicon is magnetically recovered for re-use in the DMS plant and the fine tailings (-2 mm) from the DMS process are similarly deposited over board. Furthermore, fine sediment re-suspension by the sampling tools will generate suspended sediment plumes near the seabed.

Sensitive Receptors

The taxa most vulnerable to increased turbidity and reduced light penetration are phytoplankton. Due to the location of the Sea Areas within the Namaqua upwelling cell, the abundance of phytoplankton can be expected to be seasonally high. Being dependent on nutrient supply, plankton abundance is typically spatially and temporally highly variable and is thus considered to have a low sensitivity. Pelagic fish likely to be encountered in the water column are highly mobile and would be expected to avoid elevated suspended sediment plumes in the water column. Likewise demersal fish would be expected to avoid elevated suspended sediment plumes near the seabed. These fauna are thus considered to have a low sensitivity.

Assessment

Distribution and re-deposition of suspended sediments are the result of a complex interaction between oceanographic processes, sediment characteristics and engineering variables that ultimately dictate the distribution and dissipation of the plumes in the water column. Ocean currents, both as part of the meso-scale circulation and due to local wind forcing, are important in distribution of suspended sediments. Turbulence generated by surface waves can also increase plume dispersion by maintaining the suspended sediments in the upper water column. The main effect of plumes is an increase in water column turbidity, leading to a reduction in light penetration with potential adverse effects on the photosynthetic capability of phytoplankton. Poor visibility may also inhibit pelagic visual predators. Egg and/or larval development may be impaired through high sediment loading. Benthic species that may be impacted by near-bottom plumes include bivalves and crustaceans. Suspended sediment effects on juvenile and adult bivalves occur mainly at the sublethal level with the predominant response being reduced filter-feeding efficiencies at concentrations above about 100 mg/ℓ. Lethal effects are seen at much higher concentrations (>7 000 mg/ℓ) and at exposures of several weeks. In circumstances where heavy metals or contaminants are associated with the fine sediments, these could possibly be remobilised and negative impacts could occur.

In general though, the low-intensity negative impact of suspended sediments generated during sampling and onboard processing operations and its effects on the associated communities is extremely localised and short-term. The suspended sediments in plumes settle fairly rapidly and water sampling undertaken by De Beers Marine in the MPT 25/2011 area has confirmed that contaminant levels in plumes are well below water quality guideline levels (Carter 2008). The impacts from suspended sediment plumes can confidently be rated as being **VERY LOW**.

Mitigation

No mitigation measures are possible, or considered necessary for the discharge of fine tailings from the sampling vessel.

Impacts of Suspended sediment plumes		
	Without Mitigation	**Assuming Mitigation**
Intensity	Low	No mitigation is proposed
Duration	Short-term	
Extent	Local: limited to around the vessel	
Consequence	Very Low	
Probability	Definite	
Significance	Very Low	
Status	Negative	
Confidence	High	

Nature of Cumulative impact	None
Reversibility	Fully Reversible
Loss of resources	N/A
Mitigation potential	None

4.2.6 Smothering of benthos in redepositing tailings

Description of Impact

The sampled seabed sediments are pumped to the surface and discharged onto sorting screens, which separate the large gravel, cobbles and fine silts from the 'plantfeed'. The oversize tailings are discarded overboard and settle back onto the seabed beneath the vessel where they can result in a localised smothering of benthic communities adjacent to the sampled areas. Smothering involves physical crushing, a reduction in nutrients and oxygen, clogging of feeding apparatus, as well as affecting choice of settlement site, and post-settlement survival. This impact is not relevant for coring activities.

Sensitive Receptors

The sampling activities would be undertaken in the offshore marine environment where the Namaqua Muddy Midshelf Mosaic, Namaqua Muddy Sands and Southern Benguela Sandy Outer Shelf ecosystem types have been rated as of 'Least Concern'. The benthic fauna inhabiting unconsolidated sediments at the depths of the proposed sampling are expected to be relatively ubiquitous, varying only with sediment grain size, organic carbon content of the sediments and/or near-bottom oxygen concentrations. These benthic communities usually comprise fast-growing species able to rapidly recruit into areas that have suffered natural environmental disturbance. Epifauna living on the sediment typically comprise urchins, burrowing anemones, molluscs, seapens and sponges, many of which are longer lived and therefore more sensitive to disturbance. No rare or endangered species have been reported or are known from the unconsolidated sediments in Sea Areas 4C and 5C. The sensitivity of the benthic communities of unconsolidated sediments is therefore considered LOW.

In contrast, the benthos of cold-water hard substrata, such as those occurring in the Namaqua Fossil Forest MPA, are typically vulnerable to disturbance due to their long generation times, and numerous potential VME indicator taxa have been reported for that area. High proportions of hard ground have been also been identified outside of De Beers' area of interest, between 180 m and 480 m depth in Sea Areas 4C and 5C, and to the south-east of Childs Bank has identified vulnerable communities including gorgonians, bryozoans and octocorals. The potential occurrence of such sensitive hard substrata ecosystems in Sea Areas 4C and 5C cannot be excluded. While the sensitivity of such ecosystems is unknown it could be considered to be high from a precautionary principle approach, however the area of interest for sampling has specifically been planned to avoid such sensitive habitats.

Assessment

In general terms, the rapid deposition of the coarser fraction from the water column is likely to have more of an impact on the soft-bottom benthic community than gradual sedimentation of fine sediments to which benthic organisms are adapted and able to respond. However, this response depends to a large extent on the nature of the receiving community. Studies have shown that some mobile benthic animals are capable of actively migrating vertically through overlying sediment thereby significantly affecting the recolonization of impacted areas and the subsequent recovery of disturbed areas of seabed (Maurer *et al.* 1979, 1981a, 1981b, 1982, 1986; Ellis 2000; Schratzberger *et al.* 2000; but see Harvey *et al.* 1998; Blanchard & Feder 2003). In contrast, sedentary communities may be adversely affected by both rapid and gradual deposition of sediment. Filter-feeders are generally more sensitive to suspended solids than deposit-feeders, since heavy sedimentation may clog the gills. Impacts on highly mobile invertebrates and fish are likely to be negligible since they can move away from areas subject to redeposition.

Of greater concern is that sediments discarded during sampling operations may impact rocky outcrop communities adjacent to sampling target areas potentially hosting cold-water coral communities. Such communities would be expected in the Namaqua Fossil Forest habitat, which has been excluded from the prospecting right area. Rocky seabed outcrops are known to host habitat-forming scleractinian corals. Deep-water corals tend to occur in areas with low sedimentation rates (Mortensen *et al.* 2001). Those species occurring in the shallower portions of Sea Areas 4C and 5C are, however, likely to be adapted to elevated suspended sediment cocentrations as the nearshore waters in the area are frequently characterised by elevated turbidity levels. Nonetheless, these benthic suspension-feeders and their associated faunal communities could potentially show sensitivity to increased turbidity and sediment deposition associated with tailings discharges. Exposure of elevated suspended sediment concentrations can result in mortality of the colony due to smothering, alteration of feeding behaviour and consequently growth rate, disruption of polyp expansion and retraction, physiological and morphological changes, and disruption of calcification. While tolerances to increased suspended sediment concentrations will be species specific, concentrations as low as 100 mg/ℓ have been shown to have noticeable effects on coral function (Roger 1999).

Considering the available area of unconsolidated seabed habitat on the continental shelf of the West Coast, the reduction in biodiversity of macrofauna associated with unconsolidated sediments through smothering can be considered negligible. The impacts would be of low intensity but highly localised, and short-term as recolonization would occur rapidly. The potential impact of smothering on communities in unconsolidated habitats is consequently deemed to be of **VERY LOW** significance. In the case of rocky outcrop communities, however, impacts would be of medium intensity and highly localised, but potentially enduring over the medium-term due to their slow recovery rates. The potential impact of smothering on rocky outcrop communities is consequently deemed to be of **LOW** significance without mitigation.

Mitigation

No mitigation measures are possible, or considered necessary for the loss of macrobenthos due to smothering by redepositing sediments. However, sampling activities of any kind should avoid rocky outcrops without a sediment veneer or other identified sensitive habitats in the Sea Areas. Remote sensing data should be used to conduct a pre-sampling analysis of the seabed to identify high-profile, rocky-outcrop areas without a sediment veneer, with potentially sensitive fauna. Exploration sampling targets gravel bodies in unconsolidated sediments and does not target these high-profile rocky-outcrops without a sediment veneer.

Redeposition of discarded sediments on soft-sediment macrofauna		
	Without Mitigation	**Assuming Mitigation**
Intensity	Low	No mitigation is proposed
Duration	Short-term	
Extent	Local	
Consequence	Very Low	
Probability	Probable	
Significance	Very Low	
Status	Negative	
Confidence	High	

Nature of Cumulative impact	None
Reversibility	Fully Reversible
Loss of resources	N/A
Mitigation potential	Very Low

Redeposition of discarded sediments: smothering effects on rocky outcrop communities		
	Without Mitigation	**Assuming Mitigation**
Intensity	Medium	Low
Duration	Medium-term	Short-term
Extent	Local	Local
Consequence	Low	Very Low
Probability	Probable	Improbable
Significance	Low	Very Low
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	None
Reversibility	Fully Reversible
Loss of resources	N/A
Mitigation potential	Very Low

4.2.7 Noise from Helicopters

Description of Impact

Possible crew transfers by helicopter to the survey/sampling vessels will generate noise in the atmosphere that may disturb coastal species such as seabirds and seals resulting in behavioural changes or displacement from important feeding or breeding areas (direct negative impact). Noise source levels from helicopters flying at an altitude of 150 m or more above sea level are expected to be around 109 dB re 1µPa at the most noise-affected point (SLR Consulting Australia 2019).

The dominant low-frequency components of aircraft engine noise (10-550 Hz) penetrate the water only in a narrow (26° for a smooth water surface) sound cone directly beneath the aircraft, with the angle of the cone increasing in Beaufort wind force >2 (Richardson *et al*. 1995). The peak sound level received underwater is inversely related to the altitude of the aircraft.

Available data indicate that the expected frequency range and dominant tones of sound produced by smaller, fixed-wing aircraft and helicopters overlap with the hearing capabilities of most odontocetes and mysticetes (Richardson *et al.* 1995; Ketten 1998; Erbe *et al.* 2017). Determining the reactions of cetaceans to over flights is difficult, however, since most observations are made from either the disturbing aircraft itself (Richardson & Würsig 1997), or from a small nearby vessel. Reactions to aircraft flyovers vary both within and between species, and range from no or minimal observable behavioural response (Belugas: Stewart *et al.* 1982; Richardson *et al.* 1991; Sperm: Clarke 1956; Gambell 1968; Green *et al.* 1992), to avoidance by diving, changes in direction or increased speed of movement away from the noise source (Gray: Withrow 1983; Belugas: Richardson *et al.* 1991, Patenaude *et al.* 2002; Sperm: Clarke 1956; Fritts *et al.* 1983; Mullin *et al.* 1991; Würsig *et al.* 1998; Minke: Leatherwood *et al.* 1982; Bowhead: Patenaude *et al.* 2002; Humpbacks: Smultea *et al.* 1995), separation of cow-calf pairs (Gray: Withrow 1983), increased surface intervals (Belugas: Awbrey & Stewart 1983; Stewart *et al.* 1982; Patenaude *et al.* 2002), changes in vocalisation (Sperm whales: Watkins & Schevill 1977; Richter *et al.* 2003, 2006) and dramatic behavioural changes including breaching and lobtailing (Minke: Leatherwood *et al.* 1982; Sperm: Fritts *et al.* 1983; Bowhead: Patenaude *et al.* 2002; Beluga: Patenaude *et al.* 2002), and active and tight clustering behaviour at the surface (Sperm: Smultea *et al.* 2008).

Most authors established that the reactions resulted from the animals presumably receiving both acoustic and visual cues (the aircraft and/or its shadow). As would be expected, sensitivity of whales to disturbance by an aircraft generally lessened with increasing distance, or if the flight path was off to the side and downwind, and if its shadow did not pass directly over the animals (Watkins 1981; Smultea *et al.* 2008). Smultea *et al.* (2008) concluded that the observed reactions of whales to brief over flights were short-term and isolated occurrences were probably of no long-term biological significance and Stewart *et al.* (1982) suggested that disturbance could be largely eliminated or minimised by avoiding flying directly over whales and by maintaining a flight altitude of at least 300 m. However, repeated or prolonged exposures to aircraft over flights have the potential to result in significant disturbance of biological functions, especially in important nursery, breeding or feeding areas (Richardson *et al.* 1995).

The reactions of pinnipeds to aircraft noise was reviewed by Richardson *et al.* (1995). As the frequency of aircraft engine noise overlaps with the hearing ranges of seals, these will likely similarly receive both acoustic and visual cues from aircraft flyovers. Richardson *et al.* (1995), however, point out that in very few cases was it determined that responses were specifically to aircraft noise as opposed to visual cues. Furthermore, most reported observations relate to pinnipeds on land or ice, with few data specifically on the reactions of pinnipeds in water to either airborne or waterborne sounds from aircraft. Reactions to flyovers vary between species, ranging from stampeding into the water, through temporary abandonment of pupping beaches to alertness at passing aircraft. When in the water, seals have been observed diving when the aircraft passes overhead. Pinnipeds thus exhibit varying intensities of a startle response to airborne noise, most appearing moderately tolerant to flyovers and habituating over time (Richardson *et al.* 1995; Laws 2009). The rates of habituation also vary with species, populations, and demographics (age, sex). Any reactions to over flights would thus be short-term and, except for cases where commercial airports are located close to the coast and overflights are frequent (Erbe *et al.* 2018), isolated occurrences around the project area would unlikely be of any long-term biological significance or have population-level effects.

The hazards of aircraft activity to birds include direct strikes as well as disturbance, the degree of which varies greatly. The negative effects of disturbance of birds by aircraft were reviewed by Drewitt (1999) and include loss of usable habitat, increased energy expenditure, reduced food intake and resting time and consequently impaired body condition, decreased breeding success and physiological changes. Nesting birds may also take flight and leave eggs and chicks unattended, thus affecting hatching success and recruitment success (Zonfrillo 1992). Differences in response to different types of aircraft have also been identified, with the disturbance effect of helicopters typically being higher than for fixed-wing aeroplanes. Results from a study of small aircraft flying over wader roosts in the German Wadden Sea showed that helicopters disturbed most often (in 100% of all potentially disturbing situations), followed by jets (84 %), small civil aircraft (56 %) and motor-gliders (50 %) (Drewitt 1999).

Sensitivity of birds to aircraft disturbance are not only species specific, but generally lessened with increasing distance, or if the flight path was off to the side and downwind. However, the vertical and lateral distances that invoke a disturbance response vary widely, with habituation to the frequent loud noises of landing and departing aircraft without ill effects being reported for species such as gulls, lapwings, ospreys and starlings, amongst others (reviewed in Drewitt 1999). Further work is needed to examine the combined effects of visual and acoustic stimuli, as evidence suggests that in situations where background noise from natural sources (e.g. wind and surf) is continually high, the visual stimulus may have the greater effect.

Sensitive Receptors

The taxa most vulnerable to disturbance by helicopter noise are pelagic seabirds (except where the flight path crosses the coastal zone), turtles, and large migratory pelagic fish and marine mammals. In addition, seabirds and seals in breeding colonies and roosts along coast could be impacted where the flight path crosses the coastal zone. Some of the seabirds roosting and nesting along the coast are listed by the IUCN as ‘Endangered’ (e.g. African Penguin, Bank Cormorant, Cape Cormorant and Cape Gannet), ‘Near threatened’ (e.g. African Black Oystercatcher and Crowned Cormorant) or ‘Vulnerable’ (e.g. Damara Tern). The overall sensitivity is considered to be high.

Assessment

Helicopter operations to and from the vessel would occur sporadically only, if at all. Nonetheless, indiscriminate low altitude flights over whales, seals, seabird colonies and turtles by helicopters could thus have an impact on behaviour and breeding success. The intensity of disturbance would depend on the distance and altitude of the aircraft from the animals (particularly the angle of incidence to the water surface) and the prevailing sea conditions and could range from low to high intensity for individuals but of LOW intensity for the populations as a whole. As such impacts would be REGIONAL (although temporary in nature a few minutes in every week while the helicopter passes overhead) and SHORT TERM, impacts would be of **VERY LOW** consequence.

The potential impact of aircraft noise causing physiological injury to, or behavioural avoidance by, pelagic and coastal sensitive species, is deemed to be of **VERY LOW** significance considering their high sensitivity and very low consequence. Aircraft noise would, however, likely contribute to the growing suite of cumulative acoustic impacts to marine fauna in the area, but assessing the population level consequences of multiple smaller and more localised stressors (see for example Booth *et al.* 2020; Derous *et al.* 2020) is difficult to determine.

Mitigation

Recommendations for mitigation include:

- Ensure all flight paths avoid coastal seal and penguin colonies.
- Avoid extensive low-altitude coastal flights (<762 m or <2 500 ft and within 1 nautical mile of the shore) by ensuring that the flight path is perpendicular to the coast, as far as possible.
- Maintain a flight altitude >1 000 m to be maintained at all times, except when taking off and landing or in a medical emergency.
- Maintain an altitude of at least 762 m or 2 500 ft above the highest point of a National Park or World Heritage Site.
- Brief all pilots on the ecological risks associated with flying at a low level along the coast or above marine mammals.

Impacts of noise from helicopters on marine fauna		
	Without Mitigation	**Assuming Mitigation**
Intensity	Low	Low
Duration	Short-term: for duration of surveying/sampling operations	Short-term
Extent	Regional: limited to flight path	Regional
Consequence	Very Low	Very Low
Probability	Possible	Possible
Significance	Very Low	Very Low
Status	Negative	Negative
Confidence	High	High
Nature of Cumulative impact	Possible	
Reversibility	Fully Reversible - any disturbance of behaviour that may occur would be temporary.	
Loss of resources	N/A	
Mitigation potential	Low	

4.2.8 Impact of Survey Vessel Lighting on Pelagic Fauna

Description of Impact

The survey activities would be undertaken in the nearshore marine environment, about 2 km from the shore, some distance from sensitive coastal receptors (e.g. bird or seal colonies), but could still directly affect migratory pelagic species (pelagic seabirds, turtles, marine mammals and fish) transiting through Sea Areas 4C and 5C. The strong operational lighting used to illuminate the survey vessel at night 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.

Sensitive Receptors

The taxa most vulnerable to ambient lighting are pelagic seabirds, although turtles (particularly hatchlings and neonates), large migratory pelagic fish, and both migratory and resident cetaceans transiting through the survey area may also be attracted by the lights. Some of the species potentially occurring in the survey area, are considered regionally or globally 'Critically Endangered' (e.g. oceanic whitetip shark, leatherback turtle), 'Endangered' (e.g. shortfin and Longfin mako sharks, dusky shark, southern bluefin tuna, leatherback turtles, fin and sei whales), 'Vulnerable' (e.g. bigeye tuna, blue marlin, sailfish, loggerhead turtles, great white shark, and sperm whale, Bryde's and humpback whales) or 'Near Threatened' (e.g. blue shark, swordfish, longfin tuna/albacore and yellowfin tuna).. Although species listed as 'Critically Endangered' or 'Endangered' may potentially occur in the survey area, due to their extensive distributions their numbers are expected to be low. Based on the low numbers of listed species, the sensitivity is considered to be **MEDIUM**.

Assessment

Although little can be done on the survey vessel to prevent seabird collisions, reports of collisions or death of seabirds on vessels are rare. Should they occur, the light impacts would primarily take place in the survey area and along the route taken by the survey vessel between the survey area and Saldanha Bay/Cape Town. Most of the seabird species breeding along the West Coast feed relatively close inshore (10-30 km), with African Penguins recorded as far as 60 km offshore and Cape Gannets up to 140 km offshore. Pelagic species occurring further offshore would be unfamiliar with artificial lighting and may be attracted to the survey vessel. Fish and squid may also be attracted to the light sources potentially resulting in increased predation on these species by higher order consumers. It is expected, however, that seabirds and marine mammals in the area would become accustomed to the presence of the survey vessel within a few days. Since the offshore portions of the survey area is located within the main traffic routes that pass around southern Africa, which experience high vessel traffic, animals in the area should be accustomed to vessel traffic.

Operational lights may also result in physiological and behavioural effects of turtles fish and cephalopods, as these may be drawn to the lights at night where they may be more easily preyed upon by other fish, marine mammals and seabirds. The dispersal of turtle hatchlings is reported to be disrupted by light, causing them to linger, become disoriented in the nearshore and expend energy swimming against ocean currents (Wilson *et al.* 2018). Although seals are known to forage up to 120 nautical miles (~220 km) offshore, the proposed survey area fall within the foraging range of seals from the Kleinzee, Bucchu Twins and Cliff Point colonies. Odontocetes are also highly mobile, supporting the notion that various species are likely to occur in Sea Areas 4C and 5C and thus potentially attracted to survey and sampling vessels operational in the area.

Due to their extensive distributions, the numbers of pelagic species (large pelagic fish, turtles and cetaceans) encountered during the proposed geophysical survey and sampling is expected to be low. Due to anticipated numbers and the proximity of project area to the main traffic routes, the increase in ambient lighting in the near- and offshore environment would be of LOW intensity and REGIONAL in extent (although limited to the area in the immediate vicinity of the vessel) over the SHORT-TERM. The potential for behavioural disturbance as a result of vessel lighting would thus be of **VERY LOW** significance.

Mitigation

The use of lighting on the survey and sampling vessels cannot be eliminated due to safety, navigational and operational requirements. Recommendations for mitigation include:

- reduce lighting on the survey and sampling vessels to a minimum compatible with safe operations whenever and wherever possible. Light sources should, if possible and consistent with safe working practices, be positioned in places where emissions to the surrounding environment can be minimised.
- keep disorientated, but otherwise unharmed, seabirds in dark containers for subsequent release during daylight hours. Ringed/banded birds should be reported to the appropriate ringing/banding scheme (details are provided on the ring).

Disturbance and behavioural changes in pelagic fauna due to vessel lighting

	Without Mitigation	**Assuming Mitigation**
Intensity	Low	Very Low
Duration	Short-term	Short-term
Extent	Local: limited to around the vessels	Local
Consequence	Very Low	Very Low
Probability	Possible	Possible
Significance	Very Low	Very Low
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	No cumulative impacts are anticipated
Reversibility	Fully Reversible
Loss of resources	Low
Mitigation potential	Low

4.2.9 Pollution of the marine environment through Operational Discharges from the Survey and Sampling Vessel(s)

Description of Impact

During the geophysical surveying and seabed sampling, normal discharges to the sea can come from a variety of sources (from sampling unit and sampling vessel) potentially leading to reduced water quality in the receiving environment. These discharges are regulated by onboard waste management plans and shall be MARPOL compliant. For the sake of completeness they are listed and briefly discussed below:

- **Deck drainage**: all deck drainage from work spaces is collected and piped into a sump tank on board the vessel to ensure MARPOL compliance (15 ppm oil in water). The fluid would be analysed and any hydrocarbons skimmed off the top prior to discharge. The oily substances would be added to the waste (oil) lubricants and disposed of on land.
- **Sewage**: sewage discharges would be comminuted and disinfected. In accordance with MARPOL Annex IV, the effluent must not produce visible floating solids in, nor causes discolouration of, the surrounding water. The treatment system must provide primary

settling, chlorination and dechlorination before the treated effluent can be discharged into the sea. The discharge depth is variable, depending upon the draught of the vessel / support vessel at the time, but would not be less than 5 m below the surface.

- **Vessel machinery spaces and ballast water**: the concentration of oil in discharge water from vessel machinery space or ballast tanks may not exceed 15 ppm oil in water. If the vessel intends to discharge bilge or ballast water at sea, this is achieved through use of an oily-water separation system. Oily waste substances must be shipped to land for treatment and disposal.
- **Food (galley) wastes**: food wastes may be discharged after they have been passed through a comminuter or grinder, and when the vessel is located more than 12 nautical miles from land. For vessels outside of special areas, discharge of comminuted food wastes is permitted when >3 nautical miles from land and *en route*. Discharge of food wastes not comminuted may be discharged from vessels *en route* when >12 nautical miles from shore. The ground wastes must be capable of passing through a screen with openings <25 mm. The daily volume of discharge from a standard mining/survey vessel is expected to be <0.5 m^3.
- **Detergents**: detergents used for washing exposed marine deck spaces are discharged overboard. The toxicity of detergents varies greatly depending on their composition, but low-toxicity, biodegradable detergents are preferentially used. Those used on work deck spaces would be collected with the deck drainage and treated as described for deck drainage above.
- **Cooling Water:** electrical generation on sampling vessels is typically provided by large diesel-fired engines and generators, which are cooled by pumping water through a set of heat exchangers. The cooling water is then discharged overboard. Other equipment is cooled through a closed loop system, which may use chlorine as a disinfectant. Such water would be tested prior to discharge and would comply with relevant Water Quality Guidelines[8].

Sensitive Receptors

The operational waste discharges would primarily take place in the Sea Areas and along the route taken by the support vessels between the survey area / sampling site(s) and Port Nolloth (or Cape Town). The Sea Areas are located >20 km offshore and far removed from coastal MPAs and any sensitive coastal receptors (e.g. key faunal breeding/feeding areas, bird or seal colonies). Vessel discharges *en route* to the onshore supply base in Port Nolloth (Cape Town) could result in discharges closer to shore, thereby potentially having an environmental effect on the sensitive coastal environment.

The taxa most vulnerable to routine operational discharges are pelagic seabirds, turtles, and large migratory pelagic fish and marine mammals. Some of the species potentially occurring in the Sea Areas, are considered regionally or globally ‘Critically Endangered’ (e.g. oceanic whitetip shark), ‘Endangered’ (e.g. shortfin and Longfin mako sharks, dusky shark, southern bluefin tuna, leatherback turtles, fin and sei whales), ‘Vulnerable’ (e.g. bigeye tuna, blue marlin, sailfish, loggerhead turtles, great white shark, and sperm whale, Bryde’s and humpback whales) or ‘Near Threatened’ (e.g. blue shark, swordfish, longfin tuna/albacore and yellowfin tuna). Although species listed as ‘Critically Endangered’ or ‘Endangered’ may potentially occur in the Sea Areas, compliance with MARPOL will ensure reduced discharges and reduced sensitivity of marine fauna to these discharges. In addition,

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[8] No South African guideline exists for residual chlorine in coastal waters. The Australian/New Zealand (ANZECC 2000) guidelines give a value of 3 µg Cl/ℓ, wheras the World Bank (1998) guidelines stipulate 0.2 mg/ℓ at the point of discharge prior to dilution

the Sea Areas are located on the boundary of a main marine traffic route and thus in an area already experiencing increased vessel operational discharges. Thus, the overall sensitivity is considered to be **MEDIUM**.

Assessment

The potential impact on the marine environment of such operational discharges from the sampling vessel would be limited to the sampling target areas over the short-term. As volumes discharged would be low, they would be of low intensity, and are therefore considered to be of **VERY LOW** significance, both without or with mitigation.

Mitigation

The following mitigation measures are recommended:

- Ensure compliance with MARPOL 73/78 standards,
- Develop a waste management plan.

Impacts of operational discharges to the sea from the sampling vessel

	Without Mitigation	**Assuming Mitigation**
Intensity	Low	Low
Duration	Short-term	Short-term
Extent	Local: limited to immediate area around exploration vessel	Local
Consequence	Very Low	Very Low
Probability	Probable	Probable
Significance	Very Low	Very Low
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	None
Reversibility	Fully Reversible
Loss of resources	N/A
Mitigation potential	High

4.2.10 Impacts of Noise at Ecosystem Level

Figure 53 provides a simplified conceptual model for the nearshore and offshore receiving environment on the West Coast illustrating key variables, processes, linkages, relationships, dependencies and feed-back-loops.

The upwelling of nutrients in the southern Benguela is the main driver that supports substantial seasonal phytoplankton production, which in turn serves as the basis for a rich food chain up through zooplankton, pelagic fish, cephalopods, and marine mammals, as well as demersal species and benthic fauna. High phytoplankton productivity in the upper layers again depletes the nutrients in these surface waters, resulting in a wind-related cycle of plankton production, mortality, sinking of detritus and eventual nutrient enrichment and remineralisation through the microbial loops active in the water column and on the seabed. The natural annual input of millions of tons of organic material onto the seabed provides most of the food requirements of the particulate and filter-feeding benthic communities, resulting in the high organic content of the muds in the region. Organic detritus not directly consumed enters the seabed decomposition cycle, potentially resulting in the depletion of oxygen in deeper waters and the formation of hydrogen sulphide by anaerobic bacteria.

Ecosystem functions of the offshore environment include the support of highly productive fisheries, the dissolution of CO_2 from the atmosphere and subsequent sequestering of carbon in seabed sediments, as well as waste absorption and detoxification.

The structure and function of these nearshore and offshore marine ecosystems is influenced both by natural environmental variation (e.g. El Niño Southern Oscillation (ENSO)) and multiple human uses, such as hydrocarbon developments and the harvest of marine living resources. The review provided in the impact assessment illustrates that the impacts of anthropogenic noise, at various scales surrounding the stressor, have been recorded in a diverse range of faunal groups. Studies on acoustic impacts, however, largely deal with effects upon individual animals or species, with impacts across large spatial scales, cumulative effects (both of ocean noise and factors other than sound pollution) or multiple species and/or food web levels having rarely been considered.

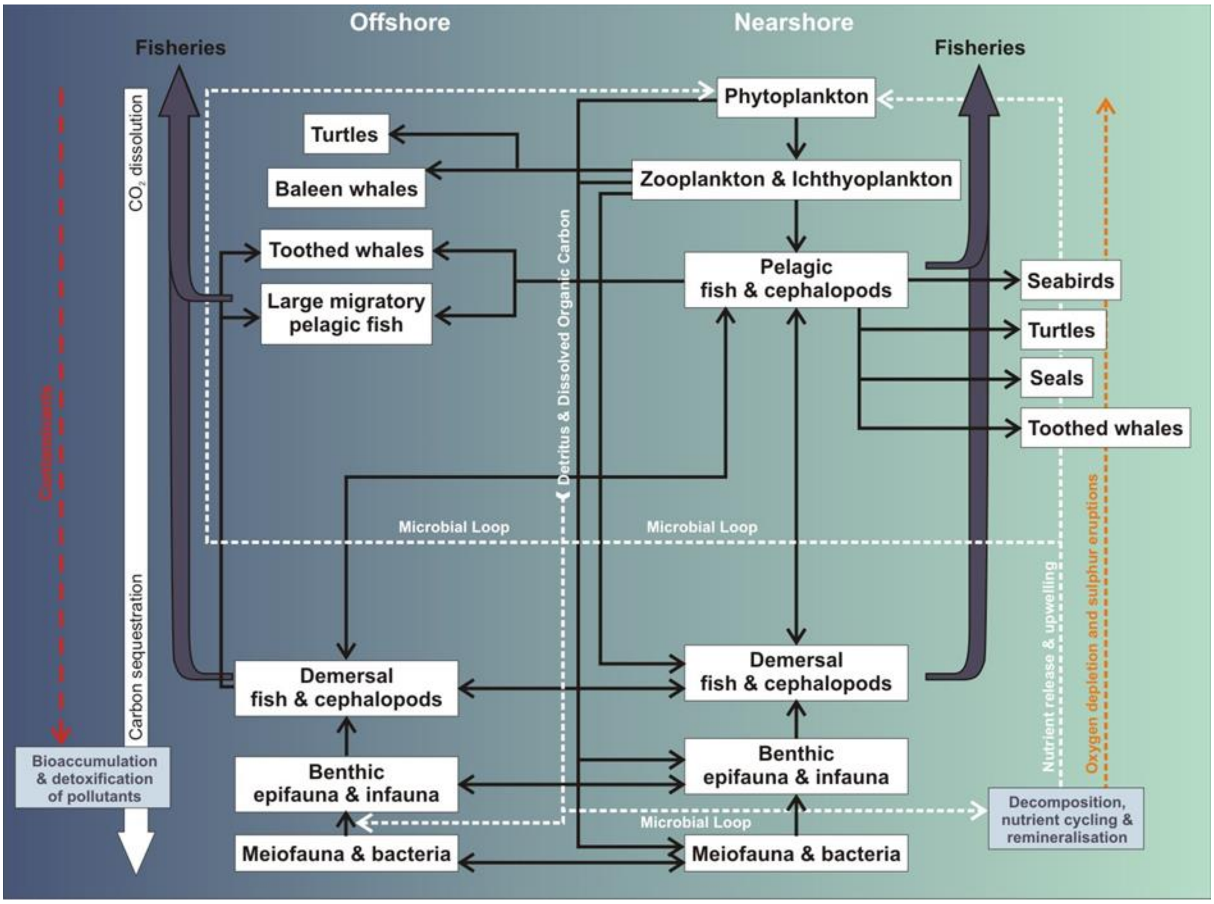

Figure 53: Simplified network diagram indicating the interaction between the key ecosystem components off the West Coast.

Below follows a brief discussion of potential population-level and ecosystem-wide effects of disturbance and the application of the integrated ecosystem assessment framework for evaluating the cumulative impacts of multiple pressures on multiple ecosystem components.

With growing evidence of the ecosystem-wide effects of seismic noise (Nieukirk *et al.* 2012; Kavanagh *et al.* 2019; Kyhn *et al.* 2019) and the potential consequences of sub-lethal anthropogenic sounds affecting marine animals at multiple levels (e.g. behaviour, physiology, and in extreme cases survival), there is increasing recognition for the need to consider the effects of anthropogenic noise at population and ecosystem level. The sub-lethal effects of sound exposure may seem subtle, but small changes in behaviour can lead to significant changes in feeding behaviour, reductions in growth and reproduction of individuals (Pirotta *et al.* 2018), but can have effects that go beyond a single species and may cause changes in food web interactions (Francis *et al.* 2009; Hubert *et al.* 2018; Slabbekoorn & Halfwerk 2009).

For example, the intensified upwelling events associated with the Namaqua Cell, provide highly productive surface waters, which power feeding grounds for cetaceans and seabirds (www.environment.gov.za/dearesearchteamreturnfromdeepseaexpedition). Roman & McCarthy (2010) demonstrated the importance of marine mammal faecal matter in replenishing nutrients in the euphotic zone, thereby locally enhancing primary productivity in areas where whales and/or seals gather to feed (see also Kanwisher & Ridgeway 1983; Nicol *et al.* 2010). Surface excretion may also extend seasonal plankton productivity after a thermocline has formed, and where diving and surfacing of deep-feeding marine mammals (e.g. pilot whales, seals) transcends stratification, the vertical movement of these air-breathing predators may act as a pump bringing nutrients below the thermocline to the surface thereby potentially increasing the carrying capacity for other marine consumers, including commercial fish species and pelagic and coastal seabirds (Roman & McCarthy 2010). Behavioural avoidance of marine mammals from such seasonal feeding areas in response to increasing anthropogenic disturbance may thus alter the nutrient fluxes in these zones, with possible ecosystem repercussions.

Likewise, long-lived, slow-reproducing species play important stabilizing roles in the marine ecosystem, especially through predation, as they play a vital role in balancing and structuring food webs, thereby maintaining their functioning and productivity. Should such predators be impacted by hydrocarbon and mineral exploration at population level (either directly on individuals or indirectly through loss of prey) and this have repercussions across multiple parts of a food web, top-down trophic cascades in the marine ecosystem could result (Ripple *et al.* 2016).

At the other end of the scale, significant impacts on plankton by anthropogenic sources can have significant bottom-up ripple effects on ocean ecosystem structure and health as phytoplankton and their zooplankton grazers underpin marine productivity. Healthy populations of fish, top predators and marine mammals are not possible without viable planktonic productivity. Furthermore, as a significant component of zooplankton communities comprises the egg and larval stages of many commercial fisheries species, large-scale disturbances (both natural and anthropogenic) on plankton communities can therefore have knock-on effects on ecosystem services across multiple levels of the food web.

Due to the difficulties in observing population-level and/or ecosystem impacts, numerical models are needed to provide information on the extent to which sound or other anthropogenic disturbances may affect the structure and functioning of populations and ecosystems. Attempts to model noise-induced changes in population parameters were first undertaken for marine mammals using the population consequences of acoustic disturbance (PCAD) or Population Consequences of Disturbance (PCoD) approach (NRC 2005). The PCAD/PCoD framework assesses how observed behavioural responses on the health of an individual translates into changes in critical life-history traits (e.g. growth, reproduction, and survival) to estimate population-level effects. Since then various frameworks have been developed to enhance our understanding of the consequences of behavioural responses of individuals at a population level. This is typically done through development of bio-energetics models that quantify the reduction in bio-energy intake as a function of disturbance and assess this reduction against the bio-energetic need for critical life-history traits (Costa *et al.* 2016; Keen *et al.* 2021). The consequences of changes in life-history traits on the development of a population are then assessed through population modelling. These frameworks are usually complex and under continual development, but have been successfully used to assess the population consequences and ecosystem effects of disturbance in real-life conditions both for marine mammals (Villegas-Amtmann 2015, 2017; Costa *et al.* 2016; Ellison *et al.* 2016; McHuron *et al.* 2018; Pirotta *et al.* 2018; Dunlop *et al.* 2021), fish (Slabbekoorn & Halfwerk 2009; Hawkins *et al.* 2014; Slabbekoorn *et al.* 2019) and invertebrates (Hubert *et al.* 2018). The PCAD/PCoD models use and synthesize data from behavioural monitoring programs, ecological studies on animal movement, bio-energetics, prey availability and mitigation effectiveness to assess the population-level effects of multiple disturbances over time (Bröker 2019).

Ecosystem-based management is a holistic living resource management approach that concurrently addresses multiple human uses and the effect such stressors may have on the ability of marine ecosystems to provide ecosystem services and processes (e.g. recreational opportunities, consumption of seafood, coastal developments) (Holsman *et al.* 2017; Spooner *et al.* 2021). Within complex marine ecosystems, the integrated ecosystem assessment framework, which incorporates ecosystem risk assessments, provides a method for evaluating the cumulative impacts of multiple pressures on multiple ecosystem components (Levin *et al.* 2009, 2014; Holsman *et al.* 2017; Spooner *et al.* 2021). It therefore has the potential to address cumulative impacts and balance multiple, often conflicting, objectives across ocean management sectors and explicitly evaluate tradeoffs. It has been repeatedly explored in fisheries management (Large *et al.* 2015) and more recently in marine spatial planning (Hammar *et al.* 2020; Carlucci *et al.* 2021; Jonsson *et al.* 2021; Harris *et al.* 2022).

However, due primarily to the multi-dimensional nature of both ecosystem pressures and ecosystem responses, quantifying ecosystem-based reference points or thresholds has proven difficult (Large *et al.* 2015). Ecosystem thresholds occur when a small change in a pressure causes either a large response or an abrupt change in the direction of ecosystem state or function. Complex numerical modelling that concurrently identifies thresholds for a suite of ecological indicator responses to multiple pressures is required to evaluate ecosystem reference points to support ecosystem-based management (Large *et al.* 2015).

The required data inputs into such models are currently limited in southern Africa. Slabbekoorn *et al.* (2019) point out that in such cases expert elicitation would be a useful method to synthesize existing knowledge, potentially extending the reach of explicitly quantitative methods to data-poor situations.

4.3 Unplanned Events

4.3.1 Potential loss of Equipment

Description of Impact

Equipment such as anchors and sampling tools are occasionally lost on the seabed, although every effort is usually made to retrieve them.

Sensitive Receptors

The benthic fauna inhabiting unconsolidated sediments at the depths of the proposed sampling are expected to be relatively ubiquitous, varying only with sediment grain size, organic carbon content of the sediments and/or near-bottom oxygen concentrations. These benthic communities usually comprise fast-growing species able to rapidly recruit into areas that have suffered natural environmental disturbance. Epifauna living on the sediment typically comprise urchins, burrowing anemones, molluscs, seapens and sponges, many of which are longer lived and therefore more sensitive to disturbance. No rare or endangered species have been reported or are known from the unconsolidated sediments in Sea Areas 4C and 5C. The sensitivity of the benthic communities of unconsolidated sediments is therefore considered LOW.

In contrast, the benthos of cold-water hard substrata, are typically vulnerable to disturbance due to their long generation times. High proportions of hard ground have been also been identified between 180 m and 480 m depth in Sea Areas 4C and 5C. The sensitivity of such deep water reef communities is considered HIGH.

Assessment

If left on the seabed, large items such as anchors and sampling tools would form a hazard to other users. Although they would eventually be colonised by benthic organisms typical of hard seabeds, every effort should be made to remove such foreign objects. The low-intensity negative impact of lost equipment would be extremely localised but if not retrieved would endure permanently and would thus be rated as being of **VERY LOW** significance.

Mitigation

The positions of all lost equipment must be accurately recorded in a hazards database, and reported to maritime authorities. Every effort should be made to remove lost equipment.

Equipment lost to the seabed		
	Without Mitigation	**Assuming Mitigation**
Intensity	Low	Low
Duration	Permanent	Short-term
Extent	Local	Local
Consequence	Very Low	Very Low
Probability	Improbable	Improbable
Significance	Very Low	Very Low
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	None
Reversibility	Fully Reversible
Loss of resources	N/A
Mitigation potential	Very Low

4.3.2 Collision of Vessels with Marine Fauna and Entanglement in Gear

Description of Impact

The potential effects of vessel presence and towed equipment on turtles and cetaceans include physiological injury or mortality due to the survey/sampling vessel, or support vessels colliding with animals basking or resting at the sea surface. Entanglement of cetaceans in towed equipment lines and is also possible if tension is lost.

Sensitive Receptors

The leatherback turtle that occur in offshore waters around southern Africa, and likely to be encountered in Sea Areas is considered regionally ‘Critically Endangered’. However, due to their extensive distributions and feeding ranges, the numbers of individuals encountered during the survey are likely to be low.

Thirty three species or sub species/populations of cetaceans (whales and dolphins) are known or likely to occur off the West Coast. The majority of migratory cetaceans in South African waters are baleen whales (mysticetes), while toothed whales (odontocetes) may be resident or migratory. Of the 33 species, the blue whale is listed as ‘Critically Endangered’, the fin and sei whales are ‘Endangered’ and the sperm, Bryde’s (inshore) and humpback whales are considered ‘Vulnerable’ (South African Red Data list Categories). However, due to the extensive distributions of the various species concerned and mobility of these animals to avoid project vessels, the numbers of individuals encountered during the surveys are likely to be low.

The overall sensitivity is considered to be MEDIUM.

Assessment

Collisions between turtles or cetaceans and vessels are not limited to survey and sampling vessels. Given the slow speed (about 2 - 3 kts) of the vessel while towing the sonar sources, ship strikes and entanglement whilst surveying are unlikely, but may occur during the transit of the survey/sampling vessel to or from the area of interest. Ship strikes by the support vessels may also occur.

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. Any increase in vessel traffic through areas used as calving grounds or through which these species migrate will increase the risk of collision between a whale and a vessel. The chances of collisions would increase between May and December when humpback and fin whales are known to migrate through the area.

The sidescan sonar towfish and MBES towed astern of the survey vessel also increases the potential for collision with towed streamers when these are being lowered from the vessel into the water. Entanglement of cetaceans in gear is possible in situations where tension is lost on the towed array. The major cause of large whale entanglements (mainly southern right and humpback whales) in South Africa are static fishing gear, anchor, mooring and buoy lines and the large-mesh shark nets set off KwaZulu-Natal to reduce shark attacks (Meÿer et al. 2011).

Basking turtles are particularly slow to react to approaching objects and may not be able to move rapidly away from approaching equipment. Entanglement may occur as a result of 'startle diving' in front of towed equipment.

Due to their extensive distributions and feeding ranges, and the extended distance (over 1 000 km) from their nesting sites, the number of turtles encountered during the proposed geophysical survey is expected to be low. Should collisions or entanglements occur, the impacts would be of high intensity for individuals but of LOW intensity for the population as a whole. Furthermore, as the duration of the impact would be limited to the short-term (3 months) and be restricted to the survey area (LOCAL), the potential for collision and entanglement in equipment is therefore considered to be of **VERY LOW** significance.

The potential for ship strikes and entanglement of cetaceans in the towed equipment, is similarly highly dependent on the abundance and behaviour of cetaceans in the survey area at the time of the survey and vessel speed. Due to their extensive distributions and feeding ranges, the number of cetaceans encountered is expected to be low. Should entanglements occur, the impacts would be of high intensity for individuals but of LOW intensity for the population as a whole. Furthermore, as the duration of the impact would be limited to the short-term, and be restricted to the Sea Areas, the potential for entanglement in moored equipment is therefore considered to be of **VERY LOW** significance.

Mitigation

The following mitigation measures are recommended:

- Vessel operators should keep watch for marine mammals and turtles in the path of the vessel.
- Ensure vessel transit speed of 10 knots (18 km/hr) when sensitive marine fauna are present in the vicinity.
- A non-dedicated marine mammal observer (MMO) must keep watch for marine mammals behind the vessel when tension is lost on the towed equipment. Either retrieve or regain tension on towed gear as rapidly as possible.
- Should a cetacean become entangled in towed gear, contact the South African Whale Disentanglement Network (SAWDN) formed under the auspices of DEFF to provide specialist assistance in releasing entangled animals.
- Report any collisions with large whales to the International Whaling Commission (IWC) database, which has been shown to be a valuable tool for identifying the species most affected, vessels involved in collisions, and correlations between vessel speed and collision risk (Jensen & Silber 2003).

Impacts on turtles and cetaceans due to ship strikes, collision and entanglement with towed or moored equipment		
	Without Mitigation	**Assuming Mitigation**
Intensity	Low	Very Low
Duration	Short-term	Short-term
Extent	Local: limited to immediate area around exploration vessel	Local
Consequence	Very Low	Very Low
Probability	Possible	Unlikely
Significance	Very Low	Very Low
Status	Negative	Negative
Confidence	High	High
Nature of Cumulative impact	Considering the number of seismic and geophysical surveys recently conducted along the West Coast, some cumulative impacts can be anticipated. However, any direct impact is likely to be at individual level rather than at species level.	
Reversibility	Partially Reversible	
Loss of resources	N/A	
Mitigation potential	High	

4.3.3 Release of diesel to sea during bunkering or due to vessel accident

Description of Impact

Accidental spills and loss of marine diesel during bunkering or in the event of a vessel collision could take place in the survey area and along the route taken by the survey and sampling vessels between the survey area and the logistics base at Saldanha Bay or Cape Town. Marine diesel spilled in the marine environment would have an immediate detrimental effect on water quality, with the toxic effects potentially resulting in mortality (e.g. suffocation and poisoning) of marine fauna or affecting faunal health (e.g. respiratory damage). If the spill reaches the coast, it can result in the smothering of sensitive coastal habitats.

Sensitive Receptors

The survey area is located in the near marine environment, more than 2 km offshore at its closest point, and therefore in close proximity to sensitive coastal receptors (e.g. key faunal breeding/feeding areas, bird or seal colonies and nursery areas for commercial fish stocks). Discharges could also directly affect migratory pelagic species transiting through the survey area. Diesel spills or accidents *en route* to the onshore supply base could result in fuel loss closer to shore, where encounters with sensitive coastal receptors will be higher.

Oil or diesel spilled in the marine environment will have an immediate detrimental effect on water quality. Being highly toxic, marine diesel released during an operational spill would negatively affect any marine fauna it comes into contact with. The taxa most vulnerable to hydrocarbon spills are coastal and pelagic seabirds. Some of the species potentially occurring in Sea Areas 4C and 5C, are considered regionally or globally 'Critically Endangered' (e.g. Tristan Albatross, Cape Gannet) or 'Endangered' (e.g. Black-Browed and Yellow-Nosed Albatross, African Penguin, Bank and Cape Cormorant) or 'Vulnerable' (e.g. Hartlaub's Gull, Swift Tern). The sensitivity of marine fauna to diesel spill is thus considered to be HIGH.

Assessment

Various factors determine the impacts of oil released into the marine environment. The physical properties and chemical composition of the oil, local weather and sea state conditions and currents greatly influence the transport and fate of the released product. The physical properties that affect the behaviour and persistence of an oil spilled at sea are specific gravity, distillation characteristics, viscosity and pour point, all of which are dependent on the oils chemical composition (e.g. the amount of asphaltenes, resins and waxes). Spilled oil undergoes physical and chemical changes (collectively termed 'weathering'), which in combination with its physical transport, determine the spatial extent of oil contamination and the degree to which the environment will be exposed to the toxic constituents of the released product.

As soon as oil is spilled, various weathering processes come into play. Although the individual processes may act simultaneously, their relative importance varies with time. Whereas spreading, evaporation, dispersion, emulsification and dissolution are most important during the early stages of a spill, the ultimate fate of oil is determined by the longer term processes of oxidation, sedimentation and biodegradation.

As a general rule, oils with a volatile nature, low specific gravity and low viscosity (e.g. marine diesel) are less persistent and tend to disappear rapidly from the sea surface. In contrast, high viscosity oils containing bituminous, waxy or asphaltenic residues, dissipate more slowly and are more persistent, usually requiring a clean-up response.

Oil spilled in the marine environment will have an immediate detrimental effect on water quality. Any release of liquid hydrocarbons thus has the potential for direct, indirect and cumulative effects on the marine environment. These effects include physical oiling and toxicity impacts to marine fauna and flora, localised mortality of plankton (particularly copepods), pelagic eggs and fish larvae, and habitat loss or contamination (CSIR 1998; Perry 2005).

The consequences and effects of small (2 000 – 20 000 litres) diesel fuel spills into the marine environment are summarised below (NOAA 1998). Diesel is a light oil that, when spilled on water, spreads very quickly to a thin film and evaporates or naturally disperses within a few days or less, even in cold water. Diesel oil can be physically mixed into the water column by wave action, where it adheres to fine-grained suspended sediments, which can subsequently settle out on the seafloor. As it is not very sticky or viscous, diesel tends to penetrate porous sediments quickly, but also to be washed off quickly by waves and tidal flushing. In the case of a coastal spill, shoreline cleanup is thus usually not needed. Diesel oil is degraded by naturally occurring microbes within one to two months. Nonetheless, in terms of toxicity to marine organisms, diesel is considered to be one of the most acutely toxic oil types. Many of the compounds in petroleum products are known to smother organisms, lower fertility and cause disease. Intertidal invertebrates and seaweed that come in direct contact with a diesel spill may be killed. Fish kills, however, have never been reported for small spills in open water as the diesel dilutes so rapidly. Due to differential uptake and elimination rates, filter-feeders (particularly mussels) can bio-accumulate hydrocarbon contaminants. Crabs and shellfish can be tainted from small diesel spills in shallow, nearshore areas.

Chronic and acute oil pollution is a significant threat to both pelagic and inshore seabirds. Diving sea birds that spend most of their time on the surface of the water are particularly likely to encounter floating oil and will die as a result of even moderate oiling which damages plumage and eyes. The majority of associated deaths are as a result of the properties of the oil and damage to the water repellent properties of the birds' plumage. This allows water to penetrate the plumage, decreasing buoyancy and leading to sinking and drowning. In addition, thermal insulation capacity is reduced requiring greater use of energy to combat cold.

Impacts of oil spills on turtles are thought to primarily affect hatchling survival (CSIR & CIME 2011). Turtles encountered in the project area would mainly be migrating adults and vagrants. Similarly, little work has been done on the effect of an oil spill on fur seals.

The effects of oil pollution on marine mammals is poorly understood (White *et al.* 2001), with the most likely immediate impact of an oil spill on cetaceans being the risk of inhalation of volatile, toxic benzene fractions when the oil slick is fresh and unweathered (Geraci & St Aubin 1990, cited in Scholz *et al.* 1992). Common effects attributable to the inhalation of such compounds include absorption into the circulatory system and mild irritation to permanent damage to sensitive tissues such as membranes of eyes, mouth and respiratory tract. Direct oiling of cetaceans is not considered a serious risk to the thermoregulatory capabilities, as cetacean skin is thought to contain a resistant dermal shield that acts as a barrier to the toxic substances in oil. Baleen whales may experience fouling of the baleen plates, resulting in temporary obstruction of the flow of water between the plates and, consequently, reduce feeding efficiency. Field observations record few, if any, adverse effects among cetaceans from direct contact with oil, and some species have been recorded swimming, feeding and surfacing amongst heavy concentrations of oil (Scholz *et al.* 1992) with no apparent effects.

In the unlikely event of an operational spill or vessel collision, the magnitude of the impact would depend on whether the spill occurred in offshore waters where encounters with pelagic seabirds, turtles and marine mammals would be low due to their extensive distribution ranges, or whether the spill occurred closer to the shore where encounters with sensitive receptors will be higher. A diesel slick in the survey area would likely be blown in a north-westerly direction due to the dominant winds and currents in the survey area. The diesel would most likely remain at the surface for <36 hours with low probability of reaching sensitive coastal habitats. In offshore environments, impacts associated with a spill or vessel collision would thus be of LOW intensity, REGIONAL (depending on the nature of the spill) over the SHORT-term (<5 days). The impact significance for a marine diesel spill is therefore considered **VERY LOW**.

However, in the case of a spill or vessel collision *en route* to the survey area, the spill may extend into coastal MPAs or EBSAs, and may reach the shore affecting intertidal and shallow subtidal benthos and sensitive coastal bird species, in which case the intensity would be considered HIGH, but still remaining REGIONAL over the SHORT-TERM. The magnitude would, however, remain **MEDIUM**.

Mitigation

In addition to compliance with MARPOL 73/78 regulations regarding waste discharges mentioned above, the following measures will be implemented:

- Use low toxicity dispersants cautiously and only with the permission of DFFE.
- As far as possible, and whenever the sea state permits, attempt to control and contain the spill at sea with suitable recovery techniques to reduce the spatial and temporal impact of the spill.
- Ensure adequate resources are provided to collect and transport oiled birds to a cleaning station.
- Ensure offshore bunkering is not undertake in the following circumstances:
- – Wind force and sea state conditions of ≥6 on the Beaufort Wind Scale;
- – During any workboat or mobilisation boat operations;
- – During helicopter operations;
- – During the transfer of in-sea equipment; and
- – At night or times of low visibility.

Impacts of an operational spill or vessel collision on marine fauna

	Without Mitigation	**Assuming Mitigation**
Intensity	Low to High*	Low
Duration	Short-term	Short-term
Extent	Regional	Local
Consequence	Medium	Very Low
Probability	Possible	Possible
Significance	Very Low	Very Low
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	Unlikely
Reversibility	Reversible
Loss of resources	Low to Medium*
Mitigation potential	Medium

* if the spill occurs near the coast and/or in proximity to sensitive coastal or offshore receptors.

4.4Confounding Effects and Cumulative Impacts

Cumulative impacts are the combined potential impacts from different actions that result in a significant change larger than the sum of all the impacts. Consideration of 'cumulative impact' should include “past, present and reasonably foreseeable future developments or impacts”. This requires a holistic view, interpretation and analysis of the biophysical, social and economic systems (DEAT 2004).

Cumulative impact assessment is limited and constrained by the method used for identifying and analysing cumulative effects. As it is not practical to analyse the cumulative effects of an action on every environmental receptor, the list of environmental effects being considered to inform descision makers and stakeholders should focus on those that can be meaningfully interpretted (DEAT 2004).

The primary impacts associated with the geophysical prospecting and sediment sampling in the Namaqua Bioregion on the West Coast of South Africa, relate to cumulative anthropogenic noise, physical disturbance of the seabed, discharges of tailings to the benthic environment, and associated vessel presence. With respect to activities that may contribute to cumulative impacts, there are many other rights holders in the South African offshore environment. Historic and currently ongoing, activities within these areas would contribute to cumulative impacts in the offshore marine environment. It is noted that a number of applications / environmental assessment processes for minerals prospecting and petroleum exploration off the West Coast have recently been undertaken. However, a small percentage of the applications submitted (and potentially approved) have advanced to implementation/completion. Furthermore, the proposed activities in each of these applications are generally restricted to a significantly smaller footprint within the overall prospecting/exploration right area. Thus, the number of available licences and application processes being undertaken off the West Coast is not an indication of the actual cumulative impacts which have taken place or that could take place in the future.

With respect to possible future activities, there is also currently insufficient information available to make reasonable assertions as to the nature of future mining activities. This is primarily due to the current lack of relevant geological information, which the proposed prospecting process aims to address. Thus, the possible range of the future prospecting, mining, exploration and production activities that could arise will vary significantly in scope, location, extent, and duration depending on whether a resource(s) is discovered, its size, properties and location, etc. As these cannot at this stage be reasonably defined, it is not possible to undertake a reliable assessment of the potential cumulative environmental impacts. It is also possible that the proposed, or future, prospecting fails to identify an economic mineral resource, in which case the potential impacts associated with the mining phase would not be realised.

Furthermore, the assessment methodology used in the Basic Assessment by its nature already considers past and current activities and impacts. In particular, when rating the sensitivity of the receptors, the status of the receiving environment (benthic ecosystem threat status, protection level, protected areas, etc.) or threat status of individual species is taken into consideration, which is based to some degree on past and current actions and impacts (e.g. the IUCN conservation rating is determined based on criteria such as population size and rate of decline, area of geographic range / distribution, and degree of population and distribution fragmentation).

The most reliable guage of cumulative pressures is provided by Sink *et al.* (2019) and Harris *et al.* (2022). The map was generated as part of the NBA 2018 by doing a cumulative pressure assessment in which the impact of both current and historical ocean-based activities on marine biodiversity was determined by spatially evaluating the intensity of each activity and the functional impact to, and recovery time of, the underlying ecosystem types (Figure 54, left). Based on the severity of modification across the marine realm, a map of ecological condition was generated (Figure 54, right).

From this it can be determined that Sea Areas 4C and 5C are located in an area experiencing very low cumulative impacts and that the ecological condition is therefore still natural or near-natural.

Assessment

Biological communities within marine habitats are largely ubiquitous throughout the southern African West Coast region. The West Coast is characterised by low marine species richness and low endemicity. Unique sea-mount environments such as Child's Bank and Tripp Seamount are located over 70 km offshore of Sea Areas 4C and 5C. While the Namaqua Fossil Forest MPA is located within Sea Area 4C, no prospecting activities will be undertaken in this area; the Namaqua Fossil Forest MPA was specifically excluded by DBCM from this Prospecting Right application.

With respect to physical disturbance impacts, the existing cumulative impacts to the benthic environment include the development of hydrocarbon wells (see Section 4.3.4). Since 1976 approximately 40 wells have been drilled in the Southern Benguela Ecoregion. The majority of these occur in the iBhubesi Gas field in Block 2A to the south of Sea Areas 4C and 5C (Eco Atlantic recently completed the drilling of the Gazania-1 well in Block 2B which was spudded on 10 October 2022). Prior to 1983, technology was not available to remove wellheads from the seafloor, thus of the approximately 40 wells drilled on the West Coast, 35 wellheads remain on the seabed. The total area impacted by 40 petroleum exploration wells is estimated at around 10 km^2. Cumulative impacts from other hydrocarbon ventures in the area are likely to increase in future. Other activities that may have contributed to cumulative impacts to the benthic environment in the licence area include limited historical deep water trawling in the offshore portions of Sea Areas 4C and 5C.

The proposed sampling operations likely to result as part of the proposed prospecting activities would impact a maximum cumulative area of <0.3 km^2 in the Namaqua Bioregion (which has a total extent of 222 240 km^2),, which can be considered an insignificant percentage (0.002%) of the prospecting right area, excluding the Namaqua Fossil Forest MPA, and an even more insignificant percentage (0.00013%) of the ecoregion as a whole and which will not significantly affect the near-natural ecological condition of the area. The cumulative impact as a result of the proposed sampling activities on the benthic environment is, thus considered to be **INSIGNIFICANT**.

The assessments of impacts of anthropogenic sounds provided in the scientific literature usually consider short-term responses at the level of individual animals only, as our understanding of how such short-term effects relate to adverse residual effects at the population level are limited. Data on behavioural reactions to anthropogenic noise acquired over the short-term could, however, easily be misinterpreted as being less significant than the cumulative effects over the long-term and with multiple exposures, i.e. what is initially interpreted as an impact not having a detrimental effect and thus being of low significance, may turn out to result in a long-term decline in the population, particularly when combined with other acoustic and non-acoustic stressors stressors (e.g. temperature, competition for food, climate change, shipping noise) (Przeslawski *et al.* 2015; Erbe *et al.* 2018, 2019; Booth *et al.* 2020; Derous *et al.* 2020). Physiological stress, for example, may not be easily detectable in marine fauna, but can affect reproduction, immune systems, growth, health, and other important life functions (Rolland *et al.* 2012; Lemos *et al.* 2021). Confounding effects are, however, difficult to separate from those due to geophysical surveys.

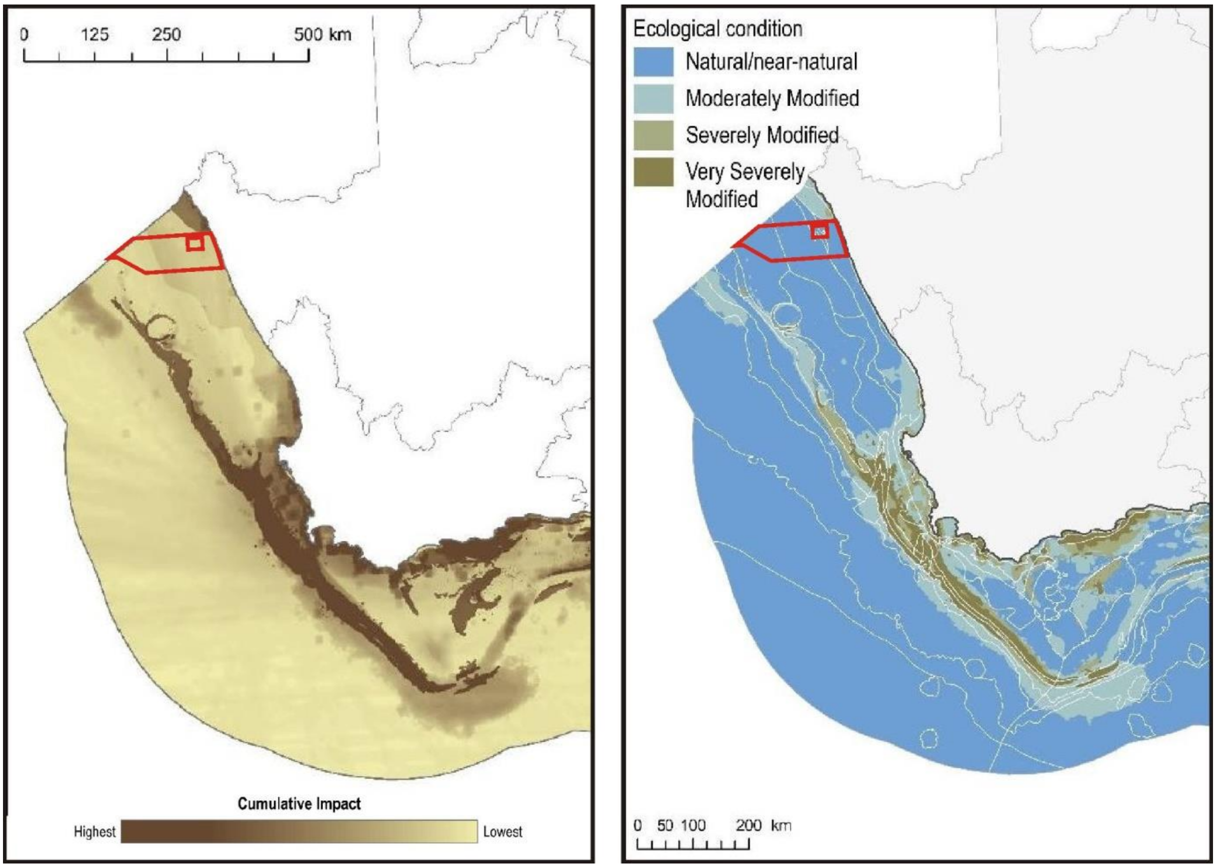

Figure 54: Sea Areas 4C and 5C (red polygon) in relation to cumulative impact on marine biodiversity, based the intensity of all cumulative pressures and the sensitivity of the underlying ecosystem types to each of those pressures (left) and the ecological condition of the marine realm based on the severity of modification as a result of the cumulative impacts (adapted from Sink *et al*. 2019 and Harris *et al*. 2022).

Similarly, potential cumulative impacts on individuals and populations as a result of other geophysical and seismic surveys undertaken previously, concurrently or subsequently are difficult to assess. A significant adverse residual environmental effect is considered one that affects marine biota by causing a decline in abundance or change in distribution of a population(s) over more than one generation within an area. Natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent. Historic survey data acquired by the Petroleum industry off the West Coast is illustrated in

Figure 55, which shows the 2D survey lines shot between 2001 and 2018, and indicates 3D survey areas on the West Coast. Despite the density of the Petroleum industry's seismic survey coverage over the past 17 years, the southern right whale population is reported to be increasing by 6.5% per year (Brandaõ *et al*. 2017), and the humpback whale by at least 5% per annum (IWC 2012) over a time when seismic surveying frequency has increased, suggesting that, for these population at least, there is no evidence of long-term negative change to population size as a direct result of seismic survey activities.

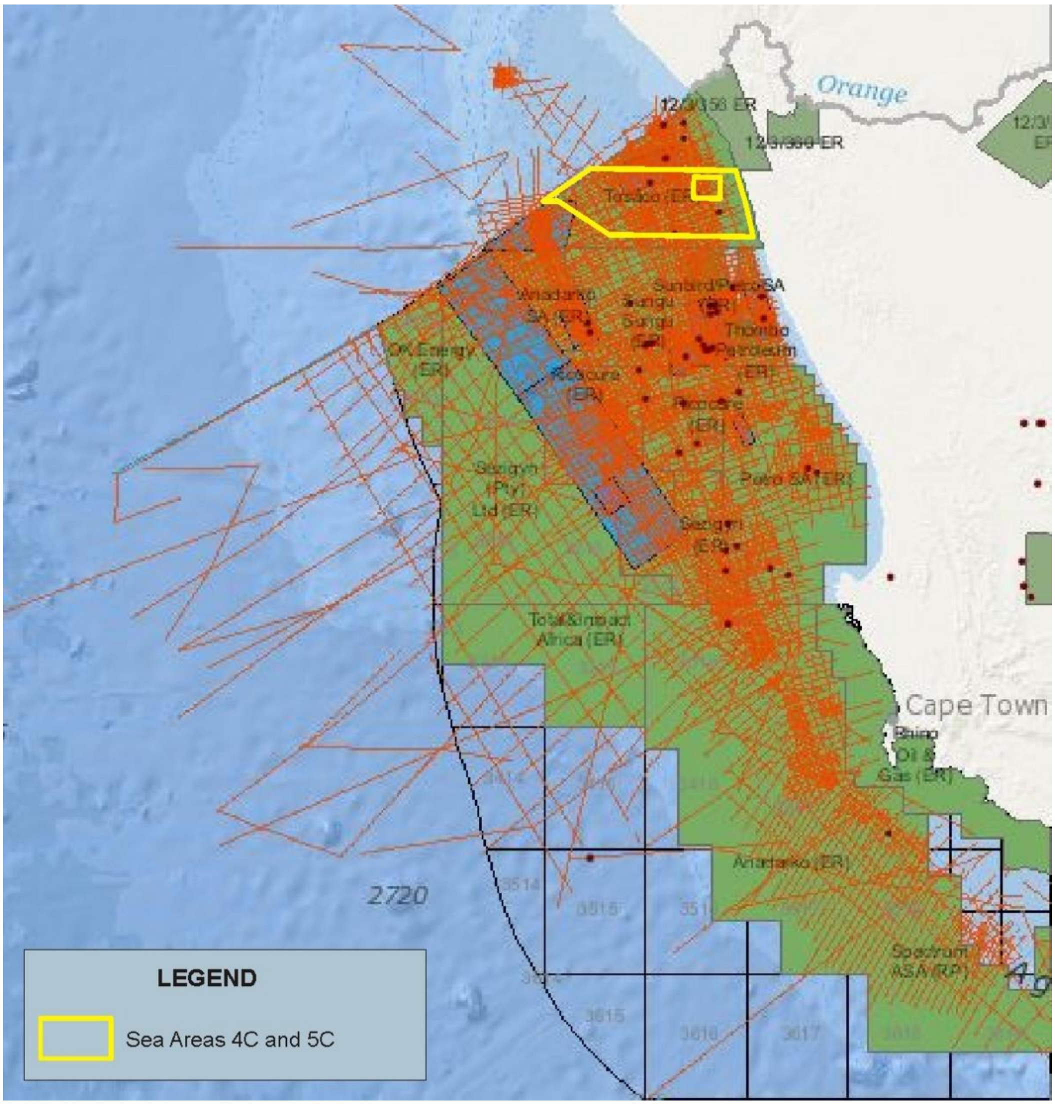

Figure 55: Sea Areas 4C and 5C in relation to historical 2D (red lines) and 3D (blue and purple polygons) surveys conducted on the West Coast between 2001 and 2018 (Source: PASA).

Reactions to sound by marine fauna depend on a multitude of factors including species, state of maturity, experience, current activity, reproductive state, time of day (Wartzok *et al*. 2004; Southall *et al.* 2007). If a marine animal does react briefly to an underwater sound by changing its behaviour or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the population as a whole (NRC 2005). However, if a sound source displaces a species from an important feeding or breeding area for a prolonged period, impacts at the population level could be significant. The increasing numbers of southern right and humpback whales around the Southern African coast, and their lingering on West Coast feeding grounds long into the summer, suggest that those surveys (both geophysical and seismic) conducted over the past 17 years have not negatively influenced the distribution patterns of these two migratory species at least. Information on the population trends of resident species of baleen and toothed whales is unfortunately lacking, and the potential effects of seismic surveys on such populations remains unknown.

Consequently, suitable mitigation measures must be implemented during geophysical and seismic data acquisition to ensure the least possible disturbance of marine fauna in an environment where the cumulative impact of increased background anthropogenic noise levels has been recognised as an ongoing and widespread issue of concern (Koper & Plön 2012; Simmonds *et al.* 2014; Williams *et al.* 2015; Chahouri *et al.* 2021). Should other concurrent geophysical or seismic exploration activities be undertaken in the project area, cumulative impacts can be expected.

5. RECOMMENDATIONS AND CONCLUSIONS

5.1 Key Findings

The impacts on marine habitats and communities associated with the proposed exploration activities in Sea Areas 4C and 5C are summarised in the Table below (Note: * indicates that no mitigation is possible, thus significance rating remains). The total area to be impacted by the proposed sampling operations can be considered negligible with respect to the total area of the Southern Benguela Ecoregion.

Impact	Probability	Significance (before mitigation)	Significance (after mitigation)
Noise from geophysical surveying on marine fauna	Probable	Very Low	Very Low
Noise from sampling operations on marine fauna	Definite	Very Low	Very Low*
Generation of Electromagnetic Fields	Possible	Insignificant	Insignificant
Disturbance and loss of benthic macrofauna	Definite	Very Low to Low	Very Low*
Crushing of benthic macrofauna	Definite	Very Low	Very Low
Generation of suspended sediment plumes	Definite	Very Low	Very Low*
Smothering of benthos in unconsolidated sediments by redepositing tailings	Probable	Very Low	Very Low*
Smothering of vulnerable reef communities by redepositing tailings	Probable	Low	Very Low
Pollution of the marine environment through operational discharges to the sea from sampling vessel	Probable	Very Low	Very Low
Disturbance and behavioural changes in pelagic fauna due to vessel lighting	Possible	Very Low	Very Low
Disturbance of marine fauna due to helicopter noise	Possible	Very Low	Very Low
UNPLANNED EVENTS			
Potential loss of equipment to the seabed	Improbable	Very Low	Very Low
Vessel strikes and entanglement in gear	Possible	Very Low	Very Low
Operational spills or vessel accidents	Possible	Very Low	Very Low

5.2 Recommended Mitigation Measures

Mitigation measures proposed during geophysical surveying include:

- 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 visual scans should be of at least 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 vicinity. Equipment without “soft start” capabilities (e.g. Chirp and Side Scan Sonar) should be turned on only once equipment that does have a soft start function (e.g. Multibeam Echosounder) has been ramped up to full volume.
- 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.
- Ensure that PAM (passive acoustic monitoring) is incorporated into any surveying taking place between June and November.
- A MMO should be appointed to ensure compliance with mitigation measures during geophysical surveying.
- Use standard operational procedure to warm up the electromagnetic source transmitter (i.e. equivalent to ramp-up of current in electric source). It is recommended that the electromagnetic source should be ramped up over a minimum period of 20 minutes.
- Turn off electromagnetic source when not collecting data.
- Use lowest field strengths required to successfully complete the survey.

Mitigation measures proposed during exploration sampling include:

- Remote sensing data should be used to conduct a pre-sampling analysis of the seabed to identify high-profile, rocky-outcrop areas without a sediment veneer. Exploration sampling targets gravel bodies in unconsolidated sediments and does not target these high-profile rocky-outcrops without a sediment veneer.
- The positions of all lost equipment must be accurately recorded, and reported to maritime authorities if requested. While every effort should be made to remove lost equipment, safety and metocean conditions should be assessed before performing any retrieval operations.
- Adhere strictly to best management practices recommended in the relevant Environmental Impact Report and EMPr and that of MARPOL 73/78 (International Convention for the Prevention of Pollution from Ships, 1973) for all necessary disposals at sea.
- Develop a waste management plan.
- Ensure all flight paths avoid coastal seal and penguin colonies.
- Avoid extensive low-altitude coastal flights (<762 m or <2 500 ft and within 1 nautical mile of the shore) by ensuring that the flight path is perpendicular to the coast, as far as possible.
- Maintain a flight altitude >1 000 m to be maintained at all times, except when taking off and landing or in a medical emergency.
- Maintain an altitude of at least 762 m or 2 500 ft above the highest point of a National Park or World Heritage Site.
- Brief all pilots on the ecological risks associated with flying at a low level along the coast or above marine mammals.

- Reduce lighting on the survey and sampling vessels to a minimum compatible with safe operations whenever and wherever possible. Light sources should, if possible and consistent with safe working practices, be positioned in places where emissions to the surrounding environment can be minimised.
- Keep disorientated, but otherwise unharmed, seabirds in dark containers for subsequent release during daylight hours. Ringed/banded birds should be reported to the appropriate ringing/banding scheme (details are provided on the ring).

Mitigation measures proposed for unplanned activities include:

- Vessel operators should keep watch for marine mammals and turtles in the path of the vessel.
- Ensure vessel transit speed is reduced to 10 knots (18 km/hr) when sensitive marine fauna are present in the vicinity.
- A non-dedicated marine mammal observer (MMO) must keep watch for marine mammals behind the vessel when tension is lost on the towed equipment. Either retrieve or regain tension on towed gear as rapidly as possible.
- Should a cetacean become entangled in towed gear, contact the South African Whale Disentanglement Network (SAWDN) formed under the auspices of DEFF to provide specialist assistance in releasing entangled animals.
- Report any collisions with large whales to the International Whaling Commission (IWC) database, which has been shown to be a valuable tool for identifying the species most affected, vessels involved in collisions, and correlations between vessel speed and collision risk (Jensen & Silber 2003).
- In the case of a marine diesl spill, use low toxicity dispersants cautiously and only with the permission of DFFE.
- As far as possible, and whenever the sea state permits, attempt to control and contain the spill at sea with suitable recovery techniques to reduce the spatial and temporal impact of the spill.
- Ensure adequate resources are provided to collect and transport oiled birds to a cleaning station.
- Ensure offshore bunkering is not undertake in the following circumstances:
- Wind force and sea state conditions of ≥6 on the Beaufort Wind Scale;
- During any workboat or mobilisation boat operations;
- During helicopter operations;
- During the transfer of in-sea equipment; and
- At night or times of low visibility.

5.2 Recommended Environmental Management Actions

Most potential environmental impacts resulting from the proposed exploration activities would be integrally managed in such a way as to prevent or minimise them. This is particularly the case for waste management, pollution control, equipment recovery and disaster prevention. Other potential but unlikely impacts (e.g. occurrence / behaviour of marine mammals around survey and mining vessels) should be closely monitored to ensure that adequate responses can be implemented, should a significant impact be detected.

The only impact which cannot be prevented or minimised through these integrated environmental management measures is the primary impact resulting from the removal of seabed sediments as part of the sampling itself. As there is no practical way of actively ‘rehabilitating’ these excavations other than discarding tailings back into the sampled area, recovery of the impacted habitats must rely on the gradual but continuous natural movement and deposition of fine sediments onto the seabed. Considering the comparatively small area of seabed impacted by sampling activities, the development of a monitoring plan to demonstrate natural recovery processes is not deemed necessary at the exploration stage.

Should exploration activities indicate economic viability of the resource, allowances for a well-designed benthic monitoring programme should be made during the feasibility phase of the project.

5.3 Conclusions

If all environmental guidelines, and appropriate mitigation measures and management actions advanced in this report, and the Basic Assessment and EMPr for the proposed prospecting operations as a whole, are implemented, there is no reason why the proposed prospecting activities 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.

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

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.

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.

AVILA, I.C., DORMANN, C.F., GARCÍA, C., PAYÁN, L.F. & M.X. ZORRILLA, 2019. Humpback whales extend their stay in a breeding ground in the Tropical Eastern Pacific. *ICES J. Mar. Sci.*, 77: 109–118.

AVINS, L. & K.J. LOHMANN, 2003. Use of multiple orientation cues by juvenile loggerhead sea turtles *Caretta caretta. The Journal of Experimental Biology* **206**: 44317-4325.

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

AWBREY, F.T. & B.S. STEWART, 1983. Behavioural responses of wild beluga whales *(Delphinapterus leucas*) to noise from oil drilling. *Journal of the Acoustical Society of America, Suppl*. 1, 74: S54.

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.

BANKS, A. BEST, P.B., GULLAN, A., GUISSAMULO, A., COCKCROFT, V. & K. FINDLAY, 2011. Recent sightings of southern right whales in Mozambique. Document SC/S11/RW17 submitted to IWC Southern Right Whale Assessment Workshop, Buenos Aires 13-16 Sept. 2011.

BARENDSE, J., THORNTON, M.T., ELWEN, S.E. and P.B. BEST, 2002. Migrations of humpback whales on the West Coast of South Africa: preliminary results. Paper SC/54/H21 submitted to the Scientific Committee of the International Whaling Commission, Shimonoseki, Japan, April/May 2002.

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.

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

BERG, J.A. and R.I.E. NEWELL, 1986. Temporal and spatial variations in the composition of seston available to the suspension-feeder Crassostrea virginica. 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. and C. ALLISON, 2010. Catch History, seasonal and temporal trends in the migration of humpback whales along the west coast of southern Africa. IWC sc/62/SH5.

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. & C. LOCKYER, 2010. Killer whales in South African waters – a review of their biology. African Journal of Marine Science. 32: 171–186.

BEST, P.B., MEŸER, M.A., THORNTON, M., KOTZE, P.G.H., SEAKAMELA, S.M., HOFMEYR, G.J.G., WINTNER, S., WELAND, C.D. and D. STEINKE, 2014. Confirmation of the occurrence of a second killer whale morphotype in South African waters. African Journal of Marine Science 36: 215-224.

BEST, P.B., SEKIGUCHI, K. and K.P. FINDLAY, 1995. A suspended migration of humpback whales Megaptera novaeangliae on the west coast of South Africa. Marine Ecology Progress Series, 118: 1–12.

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.

BICCARD, A., K. GIHWALA, B.M. CLARK, E.A. BROWN, B.P. MOSTERT, A. MASOSONKE, C. SWART, S. SEDICK, B. TSHINGANA & 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.

BIRCH, G. & J. ROGERS, 1973. Nature of the seafloor between Lüderitz and Port Elizabeth. South African Shipping News and Fishing Industry Review 39: 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.

BIRDLIFE INTERNATIONAL 2013. Important Bird Areas factsheets. Download from http://www.birdlife.org

BIRDLIFE SOUTH AFRICA, 2021. Threatened seabird habitats in the South African Economic Exclusive Zone: biodiversity feature layer submission to the National Coastal and Marine Spatial Biodiversity Plan. BirdLife South Africa SCP Report 2021/1.

BIRDLIFE SOUTH AFRICA, 2022. Threatened seabird habitats in the South African Exclusive Economic Zone: biodiversity feature layer submission to the National Coastal and Marine Spatial Biodiversity Plan. BirdLife South Africa SCP Report 2022/1.

BLANCHARD, A.L. and H.M. FEDER, 2003. Adjustment of benthic fauna following sediment disposal at a site with multiple stressors in Port Valdez, Alaska. Marine Pollution Bulletin, 46: 1590-1599.

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.

BOOTH, C.G., SINCLAIR, R.R. & J. HARWOOD, 2020. Methods for Monitoring for the Population Consequences of Disturbance in Marine Mammals: A Review. *Front. Mar. Sci.*, 7: 115. doi: 10.3389/fmars.2020.00115

BOTHA, J. A., TRUEMAN, C. N., KIRKMAN, S. P., ARNOULD, J. P. Y., LOMBARD, A. T., CONNAN, M., HOFMEYR, G. J. G., SEAKAMELA, S. M., & PISTORIUS, P. A., 2023. Geographical, temporal, and individual-based differences in the trophic ecology of female Cape fur seals. Ecology and Evolution, 13, e9790

BOTHA, J. A., KIRKMAN, S. P., ARNOULD, J. P. Y., LOMBARD, A. T., HOFMEYR, G. J. G., MEŸER, M. A., KOTZE, P. G. H., & PISTORIUS, P. A., 2020. Geographic variation in at-sea movements, habitat use and diving behavior of female Cape fur seals. Marine Ecology Progress Series, 649, 201–218.

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.

BRANCH, T.A., STAFFORD, K.M., PALACIOS, D.M., ALLISON, C., BANNISTER, J.L., BURTON, C.L.K., CABRERA, E., CARLSON, C.A., GALLETTI VERNAZZANI, B., GILL, P.C., HUCKE-GAETE, R., JENNER, K.C.S., JENNER, M.-N.M., MATSUOKA, K., MIKHALEV, Y.A., MIYASHITA, T., MORRICE, M.G., NISHIWAKI, S., STURROCK, V.J., TORMOSOV, D., ANDERSON, R.C., BAKER, A.N., BEST, P.B., BORSA, P., BROWNELL JR, R.L., CHILDERHOUSE, S., FINDLAY, K.P., GERRODETTE, T., ILANGAKOON, A.D., JOERGENSEN, M., KAHN, B., LJUNGBLAD, D.K., MAUGHAN, B., MCCAULEY, R.D., MCKAY, S., NORRIS, T.F., OMAN WHALE AND DOLPHIN RESEARCH GROUP, RANKIN, S., SAMARAN, F., THIELE, D., VAN WAEREBEEK, K. and R.M. WARNEKE, 2007. Past and present distribution, densities and movements of blue whales in the Southern Hemisphere and northern Indian Ocean. Mammal Review, 37 (2): 116-175.

BRANDÃO, A., VERMEULEN, E., ROSS-GILLESPIE, A., FINDLAY, K. and D.S. BUTTERWORTH, 2017. 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/SH22 to the 67th Meeting of the Scientific Committee of the International Whaling Commission, Bled, Slovenia.

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.

BREMNER, J.M., ROGERS, J. & J.P. WILLIS, 1990. Sedimentological aspects of the 1988 Orange River floods. Trans. Roy. Soc. S. Afr. 47 : 247-294.

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. 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.

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

BRÖKER, K.C.A., 2019. An Overview of Potential Impacts of Hydrocarbon Exploration and Production on Marine Mammals and Associated Monitoring and Mitigation Measures. *Aquatic Mammals,* 45(6): 576-611.

BRUNNSCHWEILER, J.M., BAENSCH, H., PIERCE, S.J. & D.W. SIMS, 2009. Deep-diving behaviour of a whale shark *Rhincodon typus* during long-distance movement in the western Indian Ocean. Journal of Fish Biology, 74: 706–714.

BUCHANAN, R.A., FECHHELM, R., ABGRALL, P. & A.L. LANG, 2011. Environmental Impact Assessment of Electromagnetic Techniques Used for Oil & Gas Exploration & Production. LGL Rep. SA1084. Rep. by LGL Limited, St. John's, NL, for International Association of Geophysical Contractors, Houston, Texas. 132 p. + app.

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.

CADE, D.E., SEAKAMELA, S.M., FINDLAY, K.P., FUKUNAGA, J., KAHANE-RAPPORT, S.R., WARREN, J.D., et al., 2021. Predator-scale spatial analysis of intra-patch prey distribution reveals the energetic drivers of rorqual whale super-group formation. *Funct. Ecol.*, 35: 894–908.

CARDER, D.A. and S.H. RIDGWAY, 1990. Auditory brainstem response in a neonatal sperm whale, Physeter spp. J Acoust. Soc. Am., 88(suppl 1): S4.

CARLUCCI, R., MANEA, E., RICCI, P., CIPRIANO, G., FANIZZA, C., MAGLIETTA, R. & E. GISSI, 2021. Managing multiple pressures for cetaceans' conservation with an Ecosystem-Based Marine Spatial Planning approach. Journal of Environmental Management, 287:112240.

CARTER, R.A., 2008. Evaluation of water quality risks in the SASA ML3 Mining Licence Area. Prepared for Pisces Environmental Services on behalf of De Beers Marine, Report No. LT-08-056. pp24.

CARVALHO, I., LOO, J., COLLINS, T., POMILLA, C., BEST, P.B., HERSCH, R., LESLIE, M.S., & H.C. ROSENBAUM, 2010. Temporal patterns of population structure of humpback whales in West coast of Africa (B stock). Paper SC/62/SH8 Submitted to the Scientific Committee of the International Whaling Commission. 1-13.

CHAHOURI, A., ELOUAHMANI, N. & H. OUCHENE, 2021. Recent progress in marine noise pollution: A thorough review. *Chemosphere*, in press.

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

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).

CHIVERS, S., LEDUC, R., ROBERTSON, K., BARROS, N. & A. DIZON, 2004. Genetic variation of Kogia spp. With preliminary evidence for two species of Kogia sima. Marine Mammal Science, 21: 619-634.

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 & 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 Bulletin, 8: 41-45.

CLARK, M.R., O'SHEA, S., TRACEY, D. and B. GLASBY, 1999. New Zealand region seamounts. Aspects of their biology, ecology and fisheries. Report prepared for the Department of Conservation, Wellington, New Zealand, August 1999. 107 pp.

CLARKE, R., 1956. Marking whales from a helicopter. *Norsk Hvalfangst-Tidende* **45**: 311-318.

CLIFF, G., ANDERSON-READE, M.D., AITKEN, A.O., CHARTER, G.E. & V.M. PEDDEMORS, 2007. Aerial census of whale sharks (*Rhincodon typus*) on the northern KwaZulu-Natal coast, South Africa. *Fish Res.*, 84: 41−46.

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.

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.

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, T., CERCHIO, S., POMILLA, C., LOO, J., CARVALHO, I., NGOUESSONO, S. and H.C. ROSENBAUM, 2008. Revised estimates of abundance for humpback whale breeding stock B1: Gabon. Paper SC60/SH28 submitted to the 60th Meeting of the Scientific Committee of the International Whaling Commission. www.iwcoffice.org

COMPAGNO, L.J.V., 2001. Sharks of the World: an annotated and illustrated catalogue of shark species known to date. Bullhead, mackerel and carpet sharks (Heterodontiformes, Lamniformes and Orectolobiformes). FAO Species Catalogue for Fisheries Purposes No. 1, vol. 2. Food and Agriculture Organization of the United Nations, Rome, Italy

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.

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.

COSTA, D., SCHWARZ, L., ROBINSON, P., SCHICK, R., MORRIS, P.A., CONDIT, R., et al., 2016. A bioenergetics approach to understanding the population consequences of disturbance: Elephant seals as a model system. In: POPPER, A.N. & A. HAWKINS (Eds.), *The effects of noise-on aquatic life II: Advances in experimental medicine and biology,* 875: 161-169.

COX, T.M. and 35 others. 2006. Understanding the impacts of anthropogenic sound on beaked whales. J. Cetacean Res. Manage., 7(3): 177-187.

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., DUNDEE, B.L., DYER, B., KLAGES, N.T.W., MEYER, M.A. & L. UPFOLD, 2011. Trends in numbers of Cape gannets (*Morus capensis*), 1956/1957-2005/2006, with consideration of the influence of food and other factors. *ICES Journal of Marine Science*, 64: 169-177.

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., MAKHADO, A.B., WALLER, L.J. & P.A. WHITTINGTON, 2014. Winners and losers–Responses to recent environmental change by South African seabirds that compete with purse-seine fisheries for food. *Ostrich* 85: 111–117.

CRAWFORD, R.J., 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: 1–10.

CROWTHER CAMPBELL & ASSOCIATES CC and CENTRE FOR MARINE STUDIES (CCA & 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 Namibiadeduced 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. 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.

CSIR & CIME, 2011. Environmental Impact Assessment for Exploration Drilling Operations, Yoyo Mining Concession and Tilapia Exploration Block, Offshore Cameroon. CSIR Report no. CSIR/CAS/EMS/ER/2011/0015/A.

CUNHA, H.A., DE CASTRO, R.L., SECCHI, E.R., CRESPO, E.A., LAILSON-BRITO, J., AZEVEDO, A.F., LAZOSKI, C. & A.M. SOLÉ-CAVA, 2015. Molecular and morphological differentiation of common dolphins (*Delphinus* spp.) in the southwestern Atlantic: testing the two species hypothesis in sympatry. PloS One 10:e0140251.

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.

DARLING, J.D., ACEBES, J.M.V., FREY, O., URBÁN, R.J. & M. YAMAGUCHI, 2019. Convergence and divergence of songs suggests ongoing, but annually variable, mixing of humpback whale populations throughout the North Pacific. *Sci. Rep.*, 9: 1–14.

DARLING, J.D. & R. SOUSA-LIMA, 2005. Songs indicate interaction between humpback whale (*Megaptera novaeangliae*) populations in the Western and Eastern South Atlantic Ocean. Marine Mammal Science, 21(3): 557-566.

DA SILVA, C., KERWATH, S.E., WILKE, C., MEŸER, M. & S.J. LAMBERT, 2010. First documented southern transatlantic migration of blue shark *Prionace glauca* tagged off South Africa. *African Journal of Marine Science*, 32(3) : 639-642.

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.

DEAT (Department of Environmental Affairs and Tourism). 2004. Cumulative Effects Assessment, Integrated Environmental Management, Information Series 7, Department of Environmental.

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

DEROUS, D., TEN DOESCHATE, M., BROWNLOW, A.C., DAVISON, N.J. & D. LUSSEAU, 2020. Toward New Ecologically Relevant Markers of Health for Cetaceans. *Front. Mar. Sci.*, 7: 367. doi: 10.3389/fmars.2020.00367

DeRUITER, S.L., SOUTHALL, B.L., CALAMBOKIDIS, J., ZIMMER, W.M.X., SADYKOVA, D., FALCONE, E.A., FRIEDLAENDER, A.S., JOSEPH, J.E., MORETTI, D., SCHORR, G.S., THOMAS, L. & P.L. TYACK, 2013. First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. *Biol. Lett.,* 9: 2013022320130223.

DERVILLE, S., TORRES, L.G., ALBERTSON, R., ANDREWS, O., BAKER, C.S., CARZON, P., et al., 2019. Whales in warming water: assessing breeding habitat diversity and adaptability in Oceania's changing climate. *Glob. Change Biol.*, 25: 1466–1481.

DERVILLE, S., TORRES, L.G., ZERBINI, A.N., OREMUS, M. & C. GARRIGUE, 2020. Horizontal and vertical movements of humpback whales inform the use of critical pelagic habitats in the western South Pacific. *Sci. Rep.*, 10: 4871.

DE WET, W.M., 2013. Bathymetry of the South African Continental Shelf. MSc Thesis, University of Cape Town, South Africa.

DEY, S.P., VICHI, M., FEARON, G. *et al.*, 2021. Oceanographic anomalies coinciding with humpback whale super-group occurrences in the Southern Benguela. *Sci Rep.,* 11, 20896.

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).

DINGLE, R.V., SIESSER, W.G. & A.R. NEWTON, 1983. Mesozoic and Tertiary Geology of southern Africa. Rotterdam, Netherlands: Balkema.

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. Journal of the Marine Biological Association of the United Kingdom 88: 1121-1132.

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.

DREWITT, A., 1999. Disturbance effects of Aircraft on birds. English Nature. Birds Network Information Note. 14pp.

DUARTE, C.M., CHAPUIS, L., COLLIN, S.P., COSTA, D.P., DEVASSY, R.P., EGUILUZ, V.M., ERBE, C., GORDON, T.A., HALPERN, B.S., HARDING, H.R., HAVLIK, M.N., *et al.*, 2021. The soundscape of the Anthropocene ocean. *Science*, 371 (6529).

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 by Anchor Environmental Consultants (PTY) Ltd. Report no. 1646/1.

DUNCAN, C. and J.M. ROBERTS, 2001. Darwin mounds: deep-sea biodiversity 'hotspots'. Marine Conservation 5: 12.

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.

DUNLOP, R.A., BRAITHWAITE, J., MORTENSEN, L.O. & C.M. HARRIS, 2021. Assessing Population-Level Effects of Anthropogenic Disturbance on a Marine Mammal Population. *Front. Mar. Sci.*, 8: 1 12.

ECKERT, S.A. & B.S. STEWART, 2001. Telemetry and satellite tracking of whale sharks, *Rhincodon typus*, in the Sea of Cortez, Mexico, and the north Pacific Ocean. *Environmental Biology of Fishes*, **60**: 299–308.

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.

ELLISON, W.T., RACCA, R., CLARK, C.W., STREEVER, B. et al. 2016. Modeling the aggregated exposure and responses of bowhead whales *Balaena mysticetus* to multiple sources of anthropogenic underwater sound. *Endang. Species Res.*, 30: 95−108.

ELLISON, W.T., SOUTHALL, B.L., FRANKEL, A.S., VIGNESS-RAPOSA, K. & C.W. CLARK, 2018. An acoustic scene perspective on spatial, temporal, and spectral aspects of marine mammal behaviour responses to noise. *Aquat. Mamm.*, 44: 239−243.

ELVIN S.H. and 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. and P.B. BEST, 2004. Environmental factors influencing the distribution of southern right whales (Eubalaena australis) on the South Coast of South Africa I: Broad scale patterns. Mar. Mammal Sci., 20 (3): 567-582.

ELWEN, S.H., GRIDLEY, T., ROUX, J.-P., BEST, P.B. & 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, 2008. Report of the Namibian Dolphin Project 2008: Ecology & conservation of coastal dolphins in Namibia. Submitted to the Ministry of Fisheries & Marine Resources, 28 Oct 2008. 24 pp. & 4 appendices.

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. & 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. 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, 2009. 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., BEST, P.B., THORNTON, M., and D. REEB, 2010. Near-shore distribution of Heaviside's (Cephalorhynchus heavisidii) and dusky dolphins (Lagenorhynchus obscurus) at the southern limit of their range in South Africa. African Zoology, 45(1).

ELWEN S.H., REEB D., THORNTON M. & P.B. BEST, 2009. 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., SNYMAN L. & R.H. LEENEY, 2010a. Report of the Nambian Dolphin Project 2010: Ecology and consevation of coastal dolphins in Namibia. Submitted to the Ministry of Fisheries and Marine Resources, Namibia. Pp. 1-36.

ELWEN S.H., THORNTON M., REEB D. & 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.

ERBE, C., DUNLOP, R.A. & S.J. DOLMAN, 2018. Effects of Noise on Marine Mammals. In: SLABBEKOORN, H., DOOLING, R. & A.N. POPPER (eds) Effects of Anthropogenic Noise on Animals. Springer, New York, p277 309.

ERBE, C., DUNLOP, R., JENNER, K.C.S., JENNER, M.N.M., MCCAULEY, R.D., PARNUM, I., PARSONS, M., ROGERS, T. & C. SALGADO-KENT, 2017. Review of Underwater and In-Air Sounds Emitted by Australian and Antarctic Marine Mammals. *Acoust Aust* **45,** 179–241 (2017).

ERBE, C., MARLEY, S.A., SCHOEMAN, R.P., SMITH, J.N., TRIGG, L.E. & C.B. EMBLING, 2019. The effects of ship noise on marine mammals—a review. *Front. Mar. Sci.*, 6: 606.

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, 2008. International Guidelines for the Management of Deep-Sea Fisheries in the High Seas. SPRFMO-VI-SWG-INF01

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.

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., PARKINS, C.A., WINCKLER, H., SAVAGE, C. & K. VAN DER MERWE, 1996. Specialist study #9: Impact on benthic communities. In: 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.

FIELD J.G. & C.A. PARKINS, 1998. A Baseline Study of the Benthic Communities of the Unmined Sediments of the De Beers Marine SASA Grid. Marine Biology Research Institute, University of Cape Town. Compiled for De Beers Marine (Pty) Ltd. pp 29.

FINDLAY, K.P., 1996. The impact of diamond mining noise on marine mammal fauna off southern Namibia. Specialist Study #10. In: Environmental Impact Report. Environmental Evaluation Unit (ed.) Impacts of deep sea diamond mining, in the Atlantic 1 Mining Licence Area in Namibia, on the natural systems of the marine environment. No. 11-96-158, University of Cape Town. Report to De Beers Marine (Pty) Ltd. pp. 370

FINDLAY, K., 2005. Assessment of the Potential Acoustic Impacts of Marine Diamond Prospecting on Marine Mammals of the South African West Coast Region. Prepared by Cetus Projects cc for De Beers Marine (Pty) Ltd. 64pp.

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., 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

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.

FOULIS, A.J., 2013. A retrospective analysis of shark catches made by pelagic longliners off the east coast of South Africa and biology and life history of shortfin mako shark, *Isurus oxyrinchus*. MSc. Thesis, University of KwaZulu-Natal, Durban, South Africa. pp. 117.

FRANCIS, C.D., ORTEGA, C.P. & A. CRUZ, 2009. Cumulative consequences of noise pollution: Noise changes avian communities and species interactions. *Current Biology*, 19: 1415–1419.

FRITTS, T.H., IRVINE, A.B., JENNINGS, R.D., COLLUM, L.A., HOFFMAN, W. & M.A. McGEHEE, 1983. Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. FWS/OBS-82/65. Technical Report. U.S. Fish and Wildlife Service, Washington, D.C., USA.

FULLER, M., GORSE, W.S. & W.L. GOODMAN, 1985. An introduction to the use of squid magnetometers in biomagnetism. pp. 103-151. In: KIRSCHVINK, J.L., JONES, D.S. & B.J. MACFADDEN (eds) Magnetite Biomineralization and Magnetoreception in Organisms. Plenum Press, New York.

GAMBELL, R., 1968. Aerial observations of sperm whale behaviour. *Norsk Hvalangst-Tidende* **57**: 126-138.

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.

GOOLD, J. and 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.

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.

GRAY, J.S., WU, R.S. and Y.Y. OR, 2002. Effects of hypoxia and organic enrichment on the coastal marine environment. Mar. Ecol. Prog. Ser., 238: 249-279.

GREEN, G.A., BRUEGGEMAN, J.J., GROTEFENDT, R.A., C.E. BOWLBY, C.E., M.L. BONNELL, M.L. & K.C. BALCOMB III., 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. In: J.J. BRUEGGEMAN, ed. Oregon and Washington Marine Mammal and Seabird Surveys. OCS Study MMS 91-0093. Minerals Management Service, Pacific OCS Region, Los Angeles, CA, USA, p. 1-100.

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 sea surface temperature to predict marine predator distributions? J Appl. Ecol., 45: 610–621

GRIFFITHS, M.H., 2002. Life history of South African snoek *Thyrsites atun* (Pisces: Gempylidae): a pelagic predator of the Benguela ecosystem. *Fishery Bull., Wash.* 100(4): 690-710.

GRIFFITHS, M.H., 2003. Stock structure of snoek *Thyrsites atun* in the Benguela: a new hypothesis. *Afr. J. Mar. Sci.*, 25: 383-386.

GROENEVELD, J.C., G. CLIFF, S.F.J. DUDLEY, A.J. FOULIS, J. SANTOS & S. P. WINTNER, 2014. Population structure and biology of Shortfin Mako, *Isurus oxyrinchus*, in the south-west Indian Ocean. *Marine and Freshwater Research* 65:1045–1058.

HALL-SPENCER, J., ALLAIN, V. and J.H. FOSSA, 2002. Trawling damage to Northeast Atlantic ancient coral reefs. Proceedings of the Royal Society of London Series B – Biological Sciences 269: 507–511.

HAMMAR, L., MOLANDER, S., PÅLSSON, J., CRONA SCHMIDTBAUER, J., CARNEIRO, C., JOHANSSON, T., HUME, D., KÅGESTEN, G., MATTSSON, D., TÖRNQVIST, O., ZILLÉN, L., MATTSSON, M., BERGSTRÖM, U., PERRY, D., CALDOW, C. & J. ANDERSEN, 2020. Cumulative impact assessment for ecosystem- based marine spatial planning. *Science of The Total Environment*, 734: 139024.

HAMPTON, I., BOYER, D.C., PENNEY, A.J., PEREIRA, A.F. and M. SARDINHA, 1999. BCLME Thematic Report 1: Integrated Overview of Fisheries of the Benguela Current Region. Unpublished Report, 89pp.

HANEY, J.C., HAURY, L.R., MULLINEAUX, L.S. and C.L. FEY, 1995. Sea-bird aggregation at a deep North Pacific seamount. Marine Biology, 123: 1-9.

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.

HARRIS, L.R., HOLNESS, S.D., KIRKMAN, S.P., SINK, K.J., MAJIEDT, P. & A. DRIVER, 2022. National Coastal and Marine Spatial Biodiversity Plan, Version 1.2 (Released 12-04-2022): Technical Report. Nelson Mandela University, Department of Forestry, Fisheries and the Environment, and South African National Biodiversity Institute. South Africa. 280 pp.

HARVEY, M., GAUTHIER, D. and J. MUNRO, 1998. Temporal changes in the composition and abundance of the macro-benthic invertebrate communities at dredged material disposal sites in the Anse a Beaufils, Baie des Chaleurs, Eastern Canada. Marine Pollution Bulletin, 36: 41-55.

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, A.D., ROBERTS, L. & S. CHEESMAN, 2014. Responses of freeliving coastal pelagic fish to impulsive sounds. *Journal of the Acoustical Society of America*, 135: 3101–3116.

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.

HAZIN, F.H.V., PINHEIRO, P.B. & M.K. BROADHURST, 2000. Further notes on reproduction of the blue shark, *Prionace glauca*, and a postulated migratory pattern in the South Atlantic Ocean. *Cienca e Cultura* 52: 114–120.

HOLNESS, S., KIRKMAN, S., SAMAAI, T., WOLF, T., SINK, K., MAJIEDT, P., NSIANGANGO, S., KAINGE, P., KILONGO, K., KATHENA, J., HARRIS, L., LAGABRIELLE, E., KIRCHNER, C., CHALMERS, R. and M. LOMBARD, 2014. Spatial Biodiversity Assessment and Spatial Management, including Marine Protected Areas. Final report for the Benguela Current Commission project BEH 09-01.

HOLSMAN, K., JAMEAL SAMHOURI, J., COOK, G., HAZEN, E., OLSEN, E., DILLARD, M., KASPERSKI, S., GAICHAS, S., KELBLE, C.R., FOGARTY, M. & K. ANDREWS, 2017. An ecosystem-based approach to marine risk assessment, Ecosystem Health and Sustainability, 3: 1, e01256.

HOVLAND, M. and E. THOMSEN, 1997. Cold-water corals – are they hydrocarbon seep related? Marine Geology 137: 159-164.

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.

HUBERT, J., CAMPBELL, J., VAN DER BEEK, J. G., DEN HAAN, M. F., VERHAVE, R., VERKADE, L. S. & H. SLABBEKOORN, 2018. Effects of broadband sound exposure on the interaction between foraging crab and shrimp – A field study. *Environmental Pollution*, 243: 1923–1929.

HUGHES, G. & R. NEL, 2014a. Family Cheloniidae. In: BATES, M.F., BRANCH, W.R., BAUER, A.M., BURGER, M., MARAIS, J., ALEXANDER, G.J., DE VILLIERS, M.S. (eds) Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. Suricata 1, SANBI, Pretoria.

HUGHES, G. & R. NEL, 2014b. Family Dermochelyidae. In: BATES, M.F., BRANCH, W.R., BAUER, A.M., BURGER, M., MARAIS, J., ALEXANDER, G.J., DE VILLIERS, M.S. (eds) Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. Suricata 1, SANBI, Pretoria.

HUI, C,A., 1985. Undersea topography and the comparative distributions of two pelagic cetaceans. Fishery Bulletin, 83(3): 472-475.

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., 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.

HUTCHINGS L., BECKLEY L. E., GRIFFITHS M.H., ROBERTS M. J. SUNDBY S. & VAN DER LINGEN C. 2002. Spawning on the edge: spawning grounds and nursery areas around the southern African coastline. *Marine and Freshwater Research* **53**:307-318.

ICNIRP (INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION), 2009. Guidelines on limits of exposure to static magnetic fields. Health Physics, 96: 504-514.

ICNIRP, 2010. Guidelines on limits of exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz). Health Physics, 99: 818-836.

IUCN, 2011. IUCN Red List of Threatened Species. Version 2011.2. www.iucnredlist.org. Downloaded on 5 June 2012.

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

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.

JENSEN, A.S. & G.K. SILBER, 2003. Large Whale Ship Strike Database. NOAA Technical Memorandum NMFS-OPR. Silver Spring, MD: US Department of Commerce.

JEPSON, P.D., ARBELO, M., DEAVILLE,R., PATTERSON, I.A.P., CASTRO, P., BAKER, J.R., DEGOLLADA, E., ROSS, H.M., HERRÁEZ, P., POCKNELL, A.M., RODRÍGUEZ, F., HOWIE, F.E., ESPINOSA, A., REID, R.J., JABER, J.R., MARTIN, V., CUNNINGHAM, A.A. & A. FERNÁNDEZ, 2003. Gas–bubble lesions in stranded cetaceans. Nature, 425: 575.

JEPSON, P.D., DEAVILLE, R., ACEVEDO-WHITEHOUSE, K,, BARNETT, J., BROWNLOW, A., *et al.*, 2013. What Caused the UK's Largest Common Dolphin (*Delphinus delphis*) Mass Stranding Event? PLoS ONE 8(4): e60953. doi:10.1371/journal.pone.0060953

JOHNSON, C., REISINGER, R., PALACIOS, D., FRIEDLAENDER, A., ZERBINI, A., WILLSON, A., LANCASTER, M. , BATTLE, J., GRAHAM, A., COSANDEY-GODIN, A., JACOB T., FELIX, F., GRILLY, E., SHAHID, U., HOUTMAN, N., ALBERINI, A., MONTECINOS, Y., NAJERA, E. & S. KELEZ, 2022. Protecting Blue Corridors, Challenges and Solutions for Migratory Whales Navigating International and National Seas. WWF, Oregon State University, University of California, Santa Cruz, Publisher: WWF International, Switzerland.

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

JONSSON, P.R., HAMMAR, L., WÅHLSTRÖM, I., et al. 2021. Combining seascape connectivity with cumulative impact assessment in support of ecosystem-based marine spatial planning. *J Appl Ecol.*, 58: 576–586.

KALMIJN, A.J., 1971. The electric sense of sharks and rays. *Journal of Experimental Biology* **55**: 371-383.

KANWISHER, J.W. & S.H. RIDGWAY, 1983. The physiological ecology of whales and porpoises. *Scientific American*, 248: 110–120.

KARENYI, N., 2014. Patterns and drivers of benthic macrofauna to support systematic conservation planning for marine unconsolidated sediment ecosystems. PhD Thesis, Nelson Mandela Metropolitan University, South Africa.

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.

KAVANAGH, A.S., NYKÄNEN, M., HUNT, W., RICHARDSON, N. & M.J. JESSOPP, 2019. Seismic surveys reduce cetacean sightings across a large marine ecosystem. *Scientific Reports*, 9(1): 1-10.

KEAREY, P. & M. BROOKS, 1991. An Introduction to Geophysical Exploration. Blackwell Science Ltd., Oxford, United Kingdom. 254pp.

KEEN, K., BELTRAN, R., & PIROTTA, E. & D. COSTA, 2021. Emerging themes in Population Consequences of Disturbance models. *Proceedings of the Royal Society B: Biological Sciences*. 288. 20210325. 10.1098/rspb.2021.0325.

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.

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

KENNY, A.J. & REES H.L., 1996. The effects of marine gravel extraction on the macrobenthos: Results 2 years post-dredging. Mar. Poll. 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.

KENYON, N.H., AKHMETZHANOV, A.M, WHEELER, A.J., VAN WEERING, T.C.E., DE HAAS, H. and M.K. IVANOV, 2003. Giant carbonate mud mounds in the southern Rockall Trough. Marine Geology 195: 5-30.

KERSHAW, J.L., RAMP, C.A., SEARS, R., PLOURDE, S., BROSSET, P., MILLER, P.J.O., et al., 2021. Declining reproductive success in the Gulf of St. Lawrence's humpback whales (*Megaptera novaeangliae*) reflects ecosystem shifts on their feeding grounds. *Glob. Change Biol.*, 27: 1027–1041.

KETTEN, D.R., 1998. Marine Mammal Auditory Systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-256.

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.

KIRKMAN, S. P., COSTA, D. P., HARRISON, A., KOTZE, P. G. H., OOSTHUIZEN, W.H., WEISE, M., BOTHA, J. A., & ARNOULD, J. P. Y., 2019. Dive behaviour and foraging effort of female Cape fur seals Arctocephalus pusillus pusillus. Royal Society Open Science, 6, 191369.

KIRSCHVINK, J.L., WALKER, M.M., CHANG, S-B., DIZON, A.E. & K.A. PETERSON, 1985. Chains of single-domain magnetite particles in Chinook salmon, *Oncorhynchus tshawytscha*. *Journal of Comparative Physiology*. **157**: 375-381.

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.

KYHN, L.A., WISNIEWSKA, D.M., BEEDHOLM, K., TOUGAARD, J., SIMON, M., MOSBECH, A., et al. 2019. Basin-wide contributions to the underwater soundscape by multiple seismic surveys with implications for marine mammals in Baffin Bay, Greenland. *Mar. Pollut. Bull.*, 138: 474–490.

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.

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

LARGE, S.I., FAY, G., FRIEDLAND, K.D. & J.S. LINK, 2015. Quantifying Patterns of Change in Marine Ecosystem Response to Multiple Pressures. PLoS ONE 10(3): e0119922. doi:10.1371/journal.

LAWS, R.M. (Ed.), 2009. Antarctic Seals: Research Methods and Techniques. Cambridge University Press, Cambridge. 390pp.

LEATHERWOOD, S., AWBREY, F.T. & J.A. THOMAS, 1982. Minke whale response to a transiting survey vessel. *Report of the International Whaling Commission* **32**: 795-802.

LEENEY, R.H., POST, K., HAZEVOET, C.J. AND S.H. ELWEN, 2013. Pygmy right whale records from Namibia. African Journal of Marine Science 35(1): 133-139.

LEMOS, L.S., HAXEL, J.H., OLSEN, A., BURNETT, J.D., SMITH, A., CHANDLER, T.E., NIEUKIRK, S.L., LARSON, S.E., HUNT, K.E. & L.G. TORRES, 2021. Sounds of stress: Assessment of relationships between ambient noise, vessel traffic, and gray whale stress hormones. *Proc R Soc B Biol Sci:* (in press).

LEUNG-NG, S. and S. LEUNG, 2003. Behavioral response of Indo-Pacific humpback dolphin (Sousa chinensis) to vessel traffic. Mar. Env. Res., 56: 555-567.

LEVIN, P.S., FOGARTY, M.J., MURAWSKI, S.A. & D. FLUHARTY, 2009. Integrated ecosystem assessments: developing the scientific basis for ecosystem-based management of the ocean. PLoS Biology, 7: e1000014.

LEVIN, P.S., et al. 2014. Guidance for implementation of integrated ecosystem assessments: a US perspective. ICES Journal of Marine Science, 71:1198–1204.

LI, B. & D. LEWIS, 2020. TEPNA Block Deep Western Orange Basin Offshore Seismic Survey: 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. pp48.

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

LGL LIMITED, 2009. *Orphan Basin controlled source electromagnetic survey program environmental assessment: Supplement 2009*. LGL Rep. SA1038. Rep. by LGL Limited, St. John’s, NL, for ExxonMobil Canada Ltd., St. John’s, NL. 19 p. + appendices.

LOEFER, J.K., SEDBERRY, G.R. & J.C. MCGOVERN, 2005. Vertical movements of a shortfin mako in the Western North Atlantic as determined by pop-up satellite tagging. *Southeastern Naturalist* 4, 237-246.

LOHMANN, K.J., 1985. Geomagnetic field detection by the western Atlantic spiny lobster, *Panulirus argus*. *Marine Behavior and Physiology* **12**: 1-17.

LOHMANN, K.J. & C.M.F. LOHMANN, 1994a. Acquisition of magnetic directional preference in hatchling loggerhead sea turtles. *The Journal of Experimental Biology* **190**: 1-8.

LOHMANN, K.J. & C.M.F. LOHMANN, 1994b. Detection of magnetic inclination angles by sea turtles: a possible mechanism for determining latitude. *Journal of Experimental Biology* **194**: 23-32.

LOHMANN, K.J., PENTCHEFF, N.D., NEVITT, G.A., STETTEN, G.D., ZIMMER-FAUST, R.K., JARRARD, H.E. & L.C. BOLES, 1995. Magnetic orientation of spiny lobsters in the ocean: experiments with undersea coil systems. *The Journal of Experimental Biology* **198**: 2041-2048.

LOHMANN, K.L. & C.M.F. LOHMANN, 1996a. Orientation and open-sea navigation in sea turtles. *The Journal of Experimental Biology* **199**: 73-81.

LOHMANN, K.L. & C.M.F. LOHMANN, 1996b. Detection of magnetic field intensity by sea turtles. *Nature* **380**: 59-61.

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

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

LURTON, X., 2016. Modelling of the sound field radiated by multibeam echosounders for acoustical impact assessment. *Applied Acoustics*, 101 (2016): 201-221.

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.

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, C.D. & 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. & P. CHADWICK, 2013. Systematic Marine Biodiversity Plan for the West Coast of South Africa. South African National Biodiversity Institute, Cape Town. Pp 46.

MALME, C.I., MILES, P.R., TYACK, P., CLARK, C.W. and J.E. BIRD, 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. BBN Report

5851, OCS Study MMS 85-0019. Report from BBN Laboratories Inc., Cambridge, MA, for U.S. Minerals Management Service, NTIS PB86-218385. Bolt, Beranek, and Newman, Anchorage, AK.

MARTIN, M.J., GRIDLEY, T., ROUX, J.P. & S.H. ELWEN, 2020. First Abundance Estimates of Heaviside's (*Cephalorhynchus heavisidii*) and Dusky (*Lagenorhynchus obscurus*) Dolphins Off Namibia Using a Novel Visual and Acoustic Line Transect Survey. Front Mar Sci., 7: 1–20.

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. & 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., KECK, R.T., TINSMAN, J.C. and W.A. LEATHEM, 1981a. Vertical migration and mortality of benthos in dredged material: Part I – Mollusca. Marine Environmental Research, 4: 299-319.

MAURER, D., KECK, R.T., TINSMAN, J.C. and W.A. LEATHEM, 1981b. Vertical migration and mortality of benthos in dredged material: Part II – Crustacea. Marine Environmental Research, 5: 301.317.

MAURER, D., KECK, R.T., TINSMAN, J.C. and W.A. LEATHEM, 1982. Vertical migration and mortality of benthos in dredged material: Part III – Polychaeta. Marine Environmental Research, 6: 49-68.

MAURER, D.L., LEATHEM, W., KINNER, P. and J. TINSMAN, 1979. Seasonal fluctuations in coastal benthic invertebrate assemblages. Estuarine and Coastal Shelf Science, 8: 181-193.

MAURER, D., KECK, R.T., TINSMAN, J.C. and W.A. LEATHAM, 1986. Vertical migration and mortality of marine benthos in dredged material: A synthesis. Int. Revue Ges. Hydrobiologia, 71: 49-63.

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.

McHURON, E.A., SCHWARZ, L.K., COSTA, D.P. & M. MANGEL, 2018. A state-dependent model for assessing the population consequences of disturbance on income-breeding mammals. *Ecological Modelling*, 385: 133-144.

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

MEYER, C.G., HOLLAND, K.N. & Y.P. PAPASTAMATIOU, 2004. Sharks can detect changes in the geomagnetic field. *Journal of the Royal Society Interface*. Published online.

MEŸER, M.A., BEST, P.B., ANDERSON-READE, M.D., CLIFF, G., DUDLEY, S.F.J. & S.P. KIRKMAN, 2011. Trends and interventions in large whale entanglement along the South African coast, African Journal of Marine Science, 33(3): 429-439

MEYNECKE, J.-O., SEYBOTH, E., DE BIE, J., MENZEL BARRAQUETA, J.-L., CHAMA, A., PRAKASH DEY, S., et al., 2020. Responses of humpback whales to a changing climate in the Southern Hemisphere: priorities for research efforts. *Mar. Ecol.*, 41: e12616.

MEYNECKE, J.-.O, DE BIE, J., BARRAQUETA, J.-L.M., SEYBOTH, E., DEY, S.P., LEE, S.B., SAMANTA, S., VICHI, M., FINDLAY, K., ROYCHOUDHURY, A. & B. MACKEY, 2021. The Role of Environmental Drivers in Humpback Whale Distribution, Movement and Behavior: A Review. *Front. Mar. Sci.*, 8: 720774.

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.

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.

MONTEALEGRE-QUIJANO, S. & C.M. VOOREN, 2010. Distribution and abundance of the life stages of the blue shark *Prionace glauca* in the Southwest Atlantic. *Fisheries Research* 101: 168–179.

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.

MOORE, A., FREAKE S.M. & I.M. THOMAS, 1990. Magnetic particles in the lateral line of the Atlantic salmon (*Salmo salar* L.). *Philosophical Transaction of the Royal Society of London B* **329**: 11-15.

MORTENSEN, P.B., HOVLAND, T., FOSSÅ, J.H. and D.M. FUREVIK, 2001. Distribution, abundance and size of Lophelia perusa coral reefs in mid-Norway in relation to seabed characteristics. Journal of the Marine Biological Association of the UK 81(4): 581-597.

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

MULLIN, K., HOGGARD, W., RODEN, C., LOHOEFENER, R., ROGERS, C. & B. TAGGART, 1991. Cetaceans on the upper continental slope in the north-central Gulf of Mexico. OCS Study MMS 91-0027. Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, USA.

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.

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.

NICOL, S., BOWIE, A., JARMON, S., LANNUZEL, D., MEINERS, K.M., et al. 2010. Southern Ocean iron fertilization by baleen whales and Antarctic krill. *Fish and Fisheries*, 11: 203–209.

NIEUKIRK, S.L., MELLINGER, D.K., MOORE, S.E., KLINCK, K., DZIAK, R.P. & J. GOSLIN, 2012. Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999–2009. *Journal of the Acoustical Society of America*, 131: 1102–1112.

NOAA, 1998. Fact Sheet: Small Diesel Spills (500-5000 gallons) Available at: http://response.restoration.noaa.gov/oilaids/diesel.pdf

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

OCEANMIND LIMITED, 2020. A Geospatial Analysis of Vessel Traffic in Important Marine Mammal Areas. Using the Automatic Identification System to Monitor the Important Marine Mammal Areas (01Sep2018 – 01Sep2019). Report by WWF-IUCN-IWC-OceanMind, pp409.

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.

OTA, 2004. [Congress of the United States Office of Technical Assessment] Marine Minerals: Exploring Our New Ocean Frontier. University Press of the Pacific, Honolulu, Hawaii.

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.

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.

PATENAUDE, N.J., RICHARDSON, W.J., SMULTEA, M.A., KOSKI, W.R., MILLER, G.W., WÜRSIG, B. & C.R. GREENE, JR., 2002. Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. *Marine Mammal Science* **18**: 309-335.

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

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. & A. PULFRICH, 2004. Recovery and Rehabilitation of Deepwater Marine Diamond Mining Operations off the Southern African West Coast. Report to De Beers Marine, South Africa, May 2004. 92pp.

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.

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., BEST, P.B. and M. THORNTON, 2011. Abundance estimates of right whales on a feeding ground off the west coast of South Africa. Paper SC/S11/RW11 submitted to the IWC Southern Right Whale Assessment Workshop, Buenos Aires 13-16 Sept. 2011.

PIDCOCK, S., BURTON, C. & 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, Cranberra, Australia. pp. 85.

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.

PIROTTA, E., BOOTH, C.G., COSTA, D.P., et al. 2018. Understanding the population consequences of disturbance. *Ecol Evol.*, 8: 9934–9946. https://doi.org/10.1002/ece3.4458.

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

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 & Entomology (Rhodes University), p. 551.

POMILLA, C. & H.C. ROSENBAUM, 2005. Against the current: an inter-oceanic whale migration event. *Biol. Lett.*, 1: 476-479.

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.

PRDW, 2013. Impact Assessment for Proposed Exploration Drilling in the Orange Basin Deep Water Licence Area off the West Coast of South Africa. Drill Cuttings and Oil Spill Modelling Specialist Study, November 2013. 126pp.

PRZESLAWSKI, R., BYRNE, M., MELLIN, C., 2015. A review and meta-analysis of the effects of multiple abiotic stressors on marine embryos and larvae. *Glob. Chang. Biol.* **21**: 2122–2140.

PULFRICH, A., 2013. South African Sea Area MPT 25/2011 Closure Report – comprising Closure Plan, Final Environmental Performance Report and Environmental Risk Assessment. Compiled for concession holder De Beers Consolidated Mines (Pty) Ltd by Pisces Environmental Services (Pty) Ltd, 70 pp.

PULFRICH, A., 2014. Basic Assessment and Environmental Management Programme for Well Drilling in the Orange Basin Deepwater Block off the South African West Coast. Marine Faunal Assessment. Prepared for CCA Environmental (Pty) Ltd. on behalf of Shell South Africa Upstream B.V. January 2014. 152pp.

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, 2020a. 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.

PURDON, J., SHABANGU, F., PIENAAR, M., SOMERS, M.J. & K.P. FINDLAY, 2020b. Cetacean species richness in relation to anthropogenic impacts and areas of protection in South Africa's mainland Exclusive Economic Zone. Ocean Coast Manag., 197: 105292

PURDON, J., SHABANGU, F.W., YEMANE, D., PIENAAR, M., SOMERS, M.J. & K. FINDLAY, 2020c. Species distribution modelling of Bryde's whales, humpback whales, southern right whales, and sperm whales in the southern African region to inform their conservation in expanding economies. PeerJ. 8:e9997. doi: 10.7717/peerj.9997. PMID: 33024637; PMCID: PMC7518163.

RICHARDSON, W.J., GREENE, C.R., JR., KOSKI, W.R. & M.A. SMULTEA, 1991. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska-1990 phase: Sound propagation and whale responses to playbacks of continuous drilling noise from an ice platform, as studied in pack ice conditions. Unpublished report to U.S. Minerals Management Service, Procurement Operations, Herndon, Virginia: Contract 14-12-0001-30412 (LGL Report TA848-)

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

RICHARDSON, W.J. & B. WÜRSIG, 1997. Influences of man-made noise and other human actions on cetacean behaviour. *Marine and Freshwater Behaviour and Physiology* **29**: 183-209.

RICHTER, C.F., DAWSON, S.M. & E. SLOOTEN, 2003. Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalisation patterns. Science for Conservation Report No. 219. Department of Conservation, Wellington, New Zealand.

RICHTER, C., DAWSON, S. & E. SLOOTEN, 2006. Impacts of commercial whale watching on male sperm whales at Kaikoura, New Zealand. *Marine Mammal Science* **22**: 46-63.

RIPPLE, W.J., ESTES, J.A., SCHMITZ, O.J., CONSTANT, V., KAYLOR, M.J., LENZ, A., MOTLEY, J.L., SELF, K.E., TAYLOR, D.S. & C. WOLF, 2016. What is a trophic cascade?. Trends in ecology & evolution, 31(11):.842-849.

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

ROBERTS, J.M. and J.D. GAGE, 2003. Scottish Association for Marine Science Work Package 3 of ACES project: To describe the deep-water coral ecosystem, its dynamics and functioning; investigate coral biology and behaviour and assess coral sensitivity to natural and anthropogenic stressors. Final Report to the Atlantic Coral Ecosystem Study," Internal SAMS Report, 2003.

ROGERS, A.D., 1994. The biology of seamounts. Advances in Marine Biology, 30: 305–350.

ROGERS, A.D., 2004. The biology, ecology and vulnerability of seamount communities. IUCN, Gland, Switzerland. Available at: www.iucn.org/themes/ marine/pubs/pubs.htm 12 pp.

ROGERS, A.D., CLARK, M.R., HALL-SPENCER, J.M. and K.M. GJERDE, 2008. The Science behind the Guidelines: A Scientific Guide to the FAO Draft International Guidelines (December 2007) For the Management of Deep-Sea Fisheries in the High Seas and Examples of How the Guidelines May Be Practically Implemented. IUCN, Switzerland, 2008.

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.

ROLLAND, R.M., PARKS, S.E. HUNT, K.E., CASTELLOTE, M., CORKERON, P.J., NOWACEK, D.P., WASSER, S.K. &S.D. KRAUS, 2012. **Evidence that ship noise increases stress in right whales**. Proceedings of the Royal Society B: Biological Sciences, 279 (1737): 2363-2368.

ROLLINSON, D., WANLESS, R. & P. RYAN, 2017. Patterns and trends in seabird bycatch in the pelagic longline fishery off South Africa. *African Journal of Marine Science* 39: 9–25.

ROMAN, J. & J.J. McCARTHY, 2010. The Whale Pump: Marine Mammals Enhance Primary Productivity in a Coastal Basin. PLoS ONE 5(10): e13255. doi:10.1371/

ROMANO, T.A., KEOGH, M.J., KELLY, C., FENG, P., BERK, L., SCHLUNDT, C.E., CARDER, D.A. & J.J. FINNERAN, 2004. Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure., Canadian Journal of Fisheries and Aquatic Sciences, 61: 1124-1134.

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 Activities 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.

ROUX, J-P., BEST, P.B. and P.E. STANDER. 2001. Sightings of southern right whales (Eubalaena australis) in Namibian waters, 1971-1999. J. Cetacean Res. Manage. (Special Issue). 2: 181–185.

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. and P.B. BEST, 2015. Does Disappearance Mean Extirpation? The Case of Right Whales off Namibia. Marine Mammal Science, 31 (3): 1132–52. doi:10.1111/mms.12213.

ROWAT, D., 2007. Occurrence of the whale shark (*Rhincodon typus*) in the Indian Ocean: a case for regional conservation. *Fisheries Research*, **84**: 96-101.

ROWAT, D. & M. GORE, 2007. Regional scale horizontal and local scale vertical movements of whale sharks in the Indian Ocean off Seychelles. *Fisheries Research* **84**: 32–40.

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.

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.

SCHALL, E., THOMISCH, K., BOEBEL, O. et al. 2021. Humpback whale song recordings suggest common feeding ground occupation by multiple populations. *Sci. Rep.*, 11, 18806. https://doi.org/10.1038/s41598-021-98295-z

SCHOLZ, D., MICHEL, J., SHIGENAKA, G. & R. HOFF, 1992. Biological resources. In: An Introduction to Coastal habitats and Biological Resources for Oil Spill Response. Report HMRAD 92-4 pp (4)-1-66. NOAA Hazardous Materials Response and Assessment Division, Seattle.

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.

SEAKAMELA, S.M., MEŸER, M.A., KOTZE, P.G.H., MCCUE, S. & S.P. KIRKMAN, 2015. Humpback whale (*Megaptera novaeangliae*): Suspended migration or confused individuals off the east coast? In: VERHEYE, H., HUGGETT, J. & R. CRAWFORS (Eds) State of ohe Oceans and Coasts Around South Africa - 2015 Report Card.

SEAKAMELA, S.M., KOTZE, P.H.G., MCCUE, S.A. & S. BENJAMIN, 2022. 23. The first satellite tracking of movements of long-finned pilot whales in South Africa. In: KIRKMAN, S.P., HUGGETT, J.A., LAMONT, T. & T. HAUPT (Eds.) Oceans and Coasts Annual Science Report 2021. Department of Forestry, Fisheries and the Environment, p26.

SEAKAMELA, S.M., McCUE, S.A. & P.G.H. KOTZE, 2020. Unusual mortality events of whales of the genus *Kogia* along the South Afrcan coastline. Top Predator Research Programme, Report for External Distribution, July 2020, Department of Environment, Forestry and Fisheries, pp15.

SEAKAMELA, S.M., KOTZE, P.G.H. & S.A. McCUE, 2021. 18. Unusual Mortality level of Kogiid whales in 2020. In: KIRKMAN, S.P., HUGGETT, J.A., LAMONT, T. & M.C. PFAFF (Eds.) Oceans and Coasts Annual Science Report 2020. Department of Forestry, Fisheries and the Environment, p23.

SEAKAMELA, S.M., KOTZE, P.H.G., McCUE, S.A., DE GOEDE, J., LAMONT, T., PIETERSE, J., SMITH, M. & T. ANTHONY, 2022. 25. Mortality event of Cape fur seals in South Africa during 2021. In: KIRKMAN, S.P., HUGGETT, J.A., LAMONT, T. & T. HAUPT (Eds.) Oceans and Coasts Annual Science Report 2021. Department of Forestry, Fisheries and the Environment, p28.

SHABANGU, F.W. & R.K. ANDREW, 2020. Clicking throughout the year: sperm whale clicks in relation to environmental conditions off the west coast of South Africa. Endanger Species Res., 43:475–494

SHABANGU, F.W., FINDLAY, K.P., YEMANE, D., STAFFORD, K.M., VAN DEN BERG, M., BLOWS, B. & R.K. ANDREW, 2019. Seasonal occurrence and diel calling behaviour of Antarctic blue whales and fin whales in relation to environmental conditions off the west coast of South Africa. J. Mar. Syst., 190: 25–39.

SHABANGU, F.W., PHILLIPS, M., GEJA, Y., BALI, A., PETERSEN, J., MHLONGO, N., MERKLE, D. & J. COETZEE, 2019. Branch: Fisheries Management Scientific Working Group – Small Pelagics. Final Results of the 2019 Pelagic Biomass Survey. Fisheries/2019/DEC/SWG-PEL/41Rev

SHABANGU, F.W., YEMANE, D., BEST, G. & B.J. ESTABROOK, 2022. Acoustic detectability of whales amidst underwater noise off the west coast of South Africa, Marine Pollution Bulletin, 184: 114122.

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.J., C.L. MOLONEY, A. JARRE & 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. & F.P. ANDERSON, 1982. Application of satellite ocean colour imagery in the study of the Benguela Current system. S. Afr. J. Photogrammetry, Remote Sensing and Cartography, 13(3): 153-169.

SHANNON, L.V. & 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. & 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

SHANNON, L., VAN DER ELST, R. & R. CRAWFORD, 1989. Tunas, bonitos, spanish mackerels and billfish. In: PAYNE, A. & R. CRAWFORD (eds), *Oceans of Life off southern Africa*. Cape Town, South Africa: Vlaeberg Publishers. pp 188–197.

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

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

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.

SHINE, K., 2006. Biogeographic patterns and diversity in demersal fish off the south and west coasts of south Africa: Implications for conservation. MSc thesis, Universty of Cape Town.

SHINE, K.H., 2008. Biogeographic Patterns and Assemblages of Demersal Fishes on the south and west coasts of South Africa. BCLME Project BEHP/BAC/03/03 Report. Cape Town, South Africa: Benguela Current Large Marine Ecosystem Programme.

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

SIESSER, W.G., SCRUTTON, R.A. & E.S.W. SIMPSON, 1974 . Atlantic and Indian Ocean margins of southern Africa. In: Burk CA, Drake CL (eds), The Geology of Continental Margins. New York: Springer-Verlag. pp 641–654.

SIMMONDS, M.P., DOLMAN, S.J., JASNY, M., PARSONS, E.C.M., WEILGART, L., WRIGHT, A.J. & R. LEAPER, 2014. Marine noise pollution – increasing recognition but need for more practical action. *J. Ocean Technol.*, 9: 71–90

SINK, K. & T. SAMAAI, 2009. Identifying Offshore Vulnerable Marine Ecosystems in South Africa. Unpublished Report for South African National Biodiversity Institute, 29 pp.

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. & N. KARENYI (eds), 2019. South African National Biodiversity Assessment 2018 Technical Report Volume 4: Marine Realm. South African National Biodiversity Institute, Pretoria. South Africa.

SLABBEKOORN, H., DALEN, J., DE HAAN, D., WINTER, H.V., RADFORD, C., AINSLIE, M.A., HEANEY, K.D., VAN KOOTEN, T., THOMAS, L. & J. HARWOOD, 2019. Population-level consequences of seismic surveys on fishes: An interdisciplinary challenge. *Fish and Fisheries* 20(4): 653-685.

SLABBEKOORN, H. & W. HALFWERK, 2009. Behavioural ecology: Noise annoys at community level. *Current Biology*, 19: R693–R695.

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.

SLR CONSULTING AUSTRALIA, 2020. TEPNA Blocks 2912 and 2913B 3D Seismic Survey: Sound Transmission Loss Modelling. Prepared by SLR Consulting Australia Pty Ltd for SLR Consulting (Cape Town) on behalf of Total Exploration and Production Namibia B.V. pp56.

SLR CONSULTING AUSTRALIA, 2021. Searcher Seismic Orange Basin South Africa: 2D and 3D Seismic Survey Underwater Acoustic Modelling. Prepared by SLR Consulting Australia Pty Ltd for SLR Consulting (Cape Town) on behalf of Spectrum Geo South Africa. pp69.

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.

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.

SMULTEA, M.A., MOBLEY, J.R., FERTL, D. & G.L. FULLING, 2008. An unusual reaction and other observations of sperm whales near fixed-wing aircraft. *Gulf and Caribbean Research* **20**: 75-80.

SMULTEA, M.A. & B. WÜRSIG, 1995. Behavioral reactions of bottlenose dolphins to the Mega Borg oil spill, Gulf of Mexico 1990. Aquat. Mamm., 21: 171–181.

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.

SPOONER, E., KARNAUSKAS, M., HARVEY, C.J., KELBLE, C., ROSELLON-DRUKER, J., KASPERSKI, S., LUCEY, S.M., ANDREWS, K.S., GITTINGS, S.R., MOSS, J.H., GOVE, J.M., SAMHOURI, J.F., ALLEE, R.J., BOGRAD, S.J., MONACO, M.E., CLAY, P.M., ROGERS, L.A., MARSHAK, A., WONGBUSARAKUM, S., BROUGHTON, K. & P.D. LYNCH, 2021. Using Integrated Ecosystem Assessments to Build Resilient Ecosystems, Communities, and Economies, Coastal Management, 49:1, 26-45, DOI: 10.1080/08920753.2021.1846152

SPRFMA, 2007. Information describing seamount habitat relevant to the South Pacific Regional Fisheries Management Organisation.

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 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.

STENEVIK, E.K., VERHEYE, H.M., LIPINSKI, M.R., OSTROWSKI, M. and T. STRØMME, 2008. Drift routes of Cape hake eggs and larvae in the southern Benguela Current system. Journal of Plankton Research Vol. 30:10. Pp. 1147 – 1156.

STEVENSON, I.R. and M.K. BAMFORD, 2003. Submersible-based observations of in-situ fossil tree trunks in Late Cretaceous seafloor outcrops, Orange Basin, western offshore, South Africa. South African Journal of Geology, 106: 315-326.

STEWART, B.S., EVANS, W.E. & F.T. AWBREY, 1982. Effects of man-made waterborne noise on behaviour of belukha whales (*Delphinapterus leucas*) in Bristol Bay, Alaska. Unpublished report for National Oceanic and Atmospheric Administration, Juneau, Alaska, by Hubbs/Sea World Research Institute, San Deigo, California. HSWRI Technical Report 82-145.

STRØMME, T., LIPINSKI, M.R. & P. KAINGE, 2015. Life cycle of hake and likely management implications. Rev. Fish. Biol. Fisheries, DOI 10.1007/s11160-015-9415-9

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.

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.

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

TYARKS, S.C., ANICETO, A.S., AHONEN, H., PEDERSEN, G. & U. LINDSTRØM, 2021. Humpback Whale (*Megaptera novaeangliae*) Song on a Subarctic Feeding Ground. F*rontiers in Marine Science*, https://doi.org/10.3389/fmars.2021.669748.

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 DEN BERG, G.L., VERMEULEN, E., VALENZUELA, L.O., *et al.* 2020. Decadal shift in foraging strategy of a migratory southern ocean predator. *Global Change Biology*, 27: 1052–1067.

VAN WEELDEN, C., TOWERS, J.R. & T. BOSKER, 2021. Impacts of climate change on cetacean distribution, habitat and migration. *Clim. Change Ecol.*, 1: 100009.

VERMEULEN, E., WILKINSON, C., & G. VAN DEN BERG, 2020. Report of the 2019 South African southern right whale aerial survey. Report to IWC. 10.13140/RG.2.2.29556.37766.

VILLEGAS-AMTMANN, S., SCHWARZ, L.K., GAILEY, G., SYCHENKO, O. & D.P. COSTA, 2017. East or west: the energetic cost of being a gray whale and the consequence of losing energy to disturbance. *Endangered Species Research*, 34: 167-183.

VILLEGAS-AMTMANN, S., SCHWARZ, L.K., SUMICH, J.L. & D.P. COSTA, 2015. A bioenergetics model to evaluate demographic consequences of disturbance in marine mammals applied to gray whales. *Ecosphere,* 6(10): art183.

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.

VON DER EMDE, G., 1998. Electroreception. pp. 313-343. *In:* D.H. EVANS, (Ed.) The Physiology of Fishes. CRC Press, Boca Raton.

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, M.M., QUINN, T.P., KIRSCHVINK, J.L. & C. GROOT, 1988. Production of single-domain magnetite throughout life by sockeye salmon, *Oncorhynchus nerka*. *Journal of Experimental Biology* **140**: 51-63.

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

WARTZOK, D., A.N. POPPER, J. GORDON, & J. MERRILL, 2004. Factors affecting the responses of marine mammals to acoustic disturbance. Mar. Technology Soc. J., 37(4): 6-15.

WATKINS, W.A., 1986. Whale reactions to human activities in Cape Cod waters. Mar. Mamm. Sci., 2(4): 251-262.

WATKINS, W.A. & W.E. SCHEVILL, 1977. Sperm whale codas. *Journal of the Acoustical Society of America* **62**: 1485-90 + disk in pocket.

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. & 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.

WHITE, R.W., GILLON, K.W., BLACK, A.D. & J.B. REID, 2001. Vulnerable concentrations of seabirds in Falkland Islands waters.. JNCC, Peterborough.

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

WICKENS, P., 1994. Interactions between South African Fur Seals and the Purse-Seine Fishery. Marine Mammal Science, 10: 442–457.

WILKINSON, C., 2021. Estimating population changes in humpback whales (*Megaptera novaeangliae*) migrating past Cape Vidal, South Africa. MSc Thesis, Cape Peninsula University of Technology, pp108.

WILLIAMS, R., WRIGHT, A.J., ASHE, E., BLIGHT, L.K., BRUINTJES, R., CANESSA, R., CLARK, C.W.,CULLIS-SUZUKI, S., DAKIN, D.T., ERBE, C., HAMMOND, P.S., MERCHANT, N.D., O'HARA,P.D., PURSER, J., RADFORD, A.N., SIMPSON, S.D., THOMAS, L. & M.A. WALE, 2015. Impacts of anthropogenic noise on marine life: publication patterns, newdiscoveries, and future directions in research and management. *Ocean Coast.Manage*., 115: 17–24,

WILSON, P., THUMS, M., PATTIARATCHI, C., MEEKAN, M., PENDOLEY, K., FISHER, R. & S. WHITING, 2018. Artificial light disrupts the nearshore dispersal of neonate flatback turtles *Natator depressus*. *Marine Ecology Progress Series*, 600: 179-192.

WITHROW, D.E., 1983. Gray whale research in Scammon's Lagoon (Laguna Ojo de Liebre). *Cetus* **5(1)**: 8-13.

WOODSIDE, 2010. Ragnar Hub Marine Controlled Source Electromagnetic Survey (CSEM). Environment Plan Summary.

WÜRSIG, B., LYNN, S.K., JEFFERSON, T.A. & K.D. MULLIN, 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquatic Mammals* **24**: 41-50.

YEMANE, D., MAFWILA, S.K., KATHENA, J., NSIANGANGO, S.E. & S.P. KIRKMAN, 2015. Spatio-temporal trends in diversity of demersal fish species in the Benguela current large marine ecosystem region. Fisheries Oceanography, 24(S1): 102-121.

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.

ZETTLER, M.L., BOCHERT, R. and F. POLLEHNE. 2013. Macrozoobenthic biodiversity patterns in the northern province of the Benguela upwelling system. African Journal of Marine Science, 35(2): 283-290.

ZOEGLER, J., DUNN, J.R. & M. FULLER, 1981. Magnetic material in the head of the common Pacific Dolphin. *Science* **213**: 892-894.

ZONFRILLO, B., 1992. The menace of low-flying aircraft to Ailsa Craig. *Scottish Bird News*, 28 :4.

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

ZOUTENDYK, P., 1995. Turbid water literature review: a supplement to the 1992 Elizabeth Bay Study. CSIR Report EMAS-I 95008.