BASIC ASSESSMENT FOR A PROSPECTING RIGHT APPLICATION FOR OFFSHORE SEA CONCESSION 6C WEST COAST, SOUTH AFRICA

Marine Faunal Assessment

Prepared for:

SLR

On behalf of:

De Beers Consolidated Mines Limited

July 2018

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FOR OFFSHORE SEA CONCESSION 6C
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MARINE FAUNAL ASSESSMENT

Prepared for

SLR Consulting (South Africa) (Pty) Ltd

On behalf of:

De Beers Consolidated Mines Limited

Prepared by

Andrea Pulfrich
Pisces Environmental Services (Pty) Ltd

July 2018

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 Sea Concession 6C. 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.

During Phase 1 of the project, various exploration geophysical tools would be implemented including swathe bathymetry systems, sub-bottom profilers, side-scan sonars, magnetometer surveys. Follow-up localised geophysical surveys during Phase 2 may be undertaken using an Autonomous Underwater Vehicle (AUV) enabling refinement of the definition of the target features. Should the result of the survey(s) indicate potential, follow-up sampling may be undertaken to establish the distribution of the diamondiferous material. Future exploration sampling, may include bulk sampling using either vertical or horizontal methods

Sea Concession 6C is located off the northern West Coast of South Africa roughly between Kleinzee and Hondeklipbaai with water depths in the area targeted for sampling ranging between 100 m to 200 m. The seabed sediments comprise primarily muddy sands, with a north-south trending tongue of sand in the centre of the concession 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 concession falls into the cold temperate Namaqua Bioregion. The benthic habitats potentially affected by sampling operations have been classified as ‘least threatened’ and ‘vulnerable’. Two geological features of note in the vicinity of the proposed area of interest are Child’s Bank, situated at about 31°S ~60 km to the south of Concession 6C, and Tripp Seamount situated at about 29°40’S ~150 km, to the WNW of the concession. 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 concession lies within the influence of the Namaqua upwelling cell and is 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 concession overlaps with various lease areas for hydrocarbon exploration. Numerous conservation areas, as well as existing and proposed marine protected areas (MPAs) exist along the coastline and offshore of the Northern Cape, but none fall directly within the concession area.

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;
- 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 and future bulk sampling operations are:

- Disturbance and loss of benthic fauna in the drill sample footprints and crawler excavated trenches;
- Crushing of epifauna and infauna by the crawler tracks;
- 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.

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*
Disturbance and loss of benthic macrofauna	Definite	Low	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
Potential loss of equipment	Improbable	Very Low	Very Low
Pollution of the marine environment through operational discharges to the sea from vessel	Probable	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 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 seismic geophysical surveying.

Mitigation measures proposed during exploration sampling include:

- Exploration sampling targets gravel bodies and would thus avoid known sensitive habitats and high-profile, predominantly rocky-outcrop areas without a sediment veneer. Prior to bulk sampling, a visual sampling programme must be undertaken in rocky-outcrop areas to identify sensitive communities.
- Implement dynamically positioned sampling vessels in preference to vessels requiring anchorage.
- Use geophysical data to conduct a pre-sampling geohazard analysis of the seabed, and near-surface substratum to map potentially vulnerable habitats and prevent potential conflict with the sampling targets.
- 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.
- 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 using waste hierarchy.

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.

ABBREVIATIONS and UNITS

AUV	Autonomous Underwater Vehicle
BCLME	Benguela Current Large Marine Ecosystem
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
EMPr	Environmental Management Programme
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
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
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

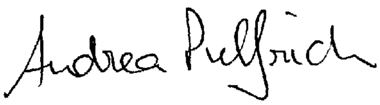
mg/ℓ	milligrams per litre
N	north
NDP	Namibian Dolphin Project
NEMA	National Environmental Management Act
NNW	north-northwest
nm	nautical mile
NMMU	Nelson Mandela Metropolitain University
NOAA	National Oceanic and Atmospheric Administration
NW	north-west
PAM	Passive Acoustic Monitoring
PIM	Particulate Inorganic Matter
PNSF	Port Nolloth Sea Farms
POM	Particulate Organic Matter
ppm	parts per million
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
SFRI	Sea Fisheries Research Institute, Department of Environmental Affairs
SPRFMA	South Pacific Regional Fisheries Management Authority
SSW	South-southwest
SW	south-west
TSPM	Total Suspended Particlate Matter
UNEP	United Nations Environmental Programme
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 Concession 6C 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.



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 within Sea Concession 6C. 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 Concession 6C 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 literature sources consulted are listed in the Reference chapter.

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

2. DESCRIPTION OF THE PROPOSED PROJECT

A phased approach is proposed for the prospecting. The initial phase would involve a regional scale geophysical survey to identify geological features of interest for further exploration.

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;
- sub-bottom profiler seismic systems (e.g. boomer, chirp and sleeve gun), which generate profiles beneath the seafloor to give a cross section view of the sediment layers;
- side-scan sonar systems, which systems produce acoustic intensity images of the seafloor and are used to map the different sediment textures from associated lithology of the seafloor; and
- magnetometer surveys, which measures local variations in the intensity of the Earth's magnetic fields, which are caused by differences in composition of the sediment layers on or beneath the seafloor.

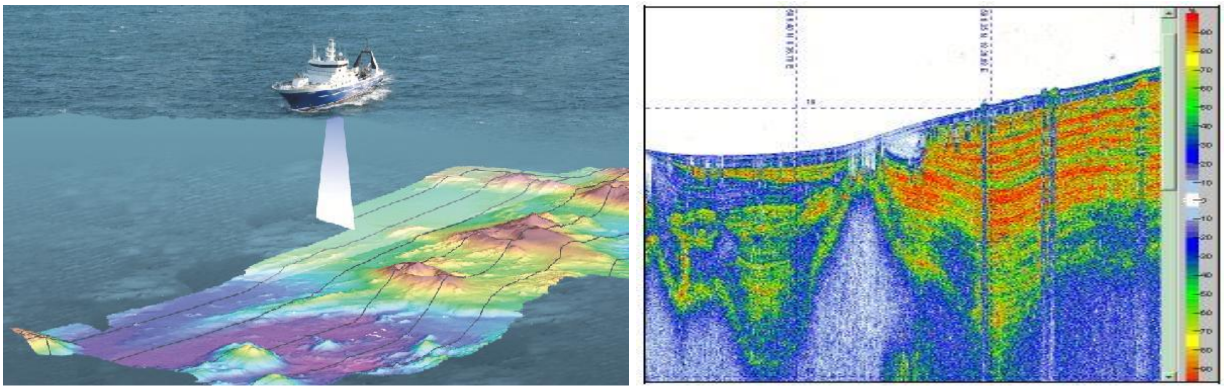


Figure 1: The geophysical survey techniques employed during Phase I of the proposed prospecting operations would include swath bathymetry (left) and sub-bottom profiling (right).

The line spacing for prospecting would be planned to enable full regional scale seabed coverage. Sound levels from the acoustic equipment would range from 190 to 242 dB re 1 μPa at 1 m.

Should geological features of interest be identified, a decision regarding the feasibility of proceeding to Phase 2 of the exploration will be made. During this phase follow-up localised geophysical surveys would 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.

2.2. Exploration Sampling

Should survey results indicate resource potential, subsequent exploration sampling to establish the distribution of diamondiferous material would be undertaken to determine mining performance characteristics (e.g. mining rate and metallurgical recovery information) that would be used in determining economic viability during feasibility studies. Sampling would be undertaken from a sampling vessel of opportunity (e.g. mv The Explorer and/or DBM's mv Coral Sea) using a fit-for-purpose tool and taking full advantage of the latest sampling technologies available. Sampling technologies selected would be appropriate to each target area and based on the results of the preceding stage. The sampling would likely be divided into stages with reviews and gate releases.

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. Typical sampling tool technologies that could be employed are described in more detail below.

2.2.1 Coring (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 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 2), 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 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.

Figure 2: Illustrative example of a drill bit operated from a drill frame structure located onboard a vessel of opportunity.

Sampling would be undertaken using a vertically mounted drill suspended from a derrick mounted mid ships and deployed through a moon pool. 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 bit to remain in contact with the seabed. The head of the sampling tool is a circular steel disk with channels which feed loose sediment to a central aperture through which they are airlifted to the surface and fed to the processing plant. Samples consist of individual holes drilled at a site. The evaluation drill bit removes a sample of 10 m^2 and is referred to as a decadrill. 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 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.

For the purposes of this assessment it is assumed that up to 9,000 samples could be taken within the potential deposit area(s). The sample spacings would be between 50 and 200 m apart. The total area of disturbance would be approximately 0.09 km^2.

2.3. Bulk Sampling

Based on the results of the sampling programme, future bulk sampling may also be undertaken.

Should bulk sampling be undertaken, this would be conducted by one of the vessels operated by DBM's sister company De Beers Marine Namibia (Pty) Ltd, or a similar vessel of opportunity. The vessels available for bulk sampling adopt either the vertical or horizontal methods (Figure 3).

The vertical method involves a vertically mounted, large-diameter drill-head (currently ranging from 5.2 - 6.8 m in diameter), used to excavate diamond-bearing gravel in a systematic pattern of overlapping circles in the target area. The drill-head consists of a large-diameter circular disc fitted with wheel cutters and hardened steel scrapers, and is lowered to the seabed on an extendable pipe 'drill string'. Loosened rocks and sediment are fed along a semi-circular channel across the lower surface of the plate, extracted through a central aperture and pumped to the surface through the drill string for onboard processing. The drill is capable of penetrating about 2 - 3 m of sediment and partially consolidated conglomerate or calcareous sandstone in water depths down to 150 m.

The horizontal method involves the use of a track-mounted seabed crawler fitted with highly accurate acoustic seabed navigation and imaging systems, and equipped with an anterior suction system. The crawler is lowered to the seabed and is controlled remotely from the surface support vessel through power and signal umbilical cables. Water jets in the crawler's suction head loosen seabed sediments, and sorting bars filter out oversize boulders. The sampled sediments are pumped to the surface for shipboard processing. Crawlers are capable of working to 200 m depth.

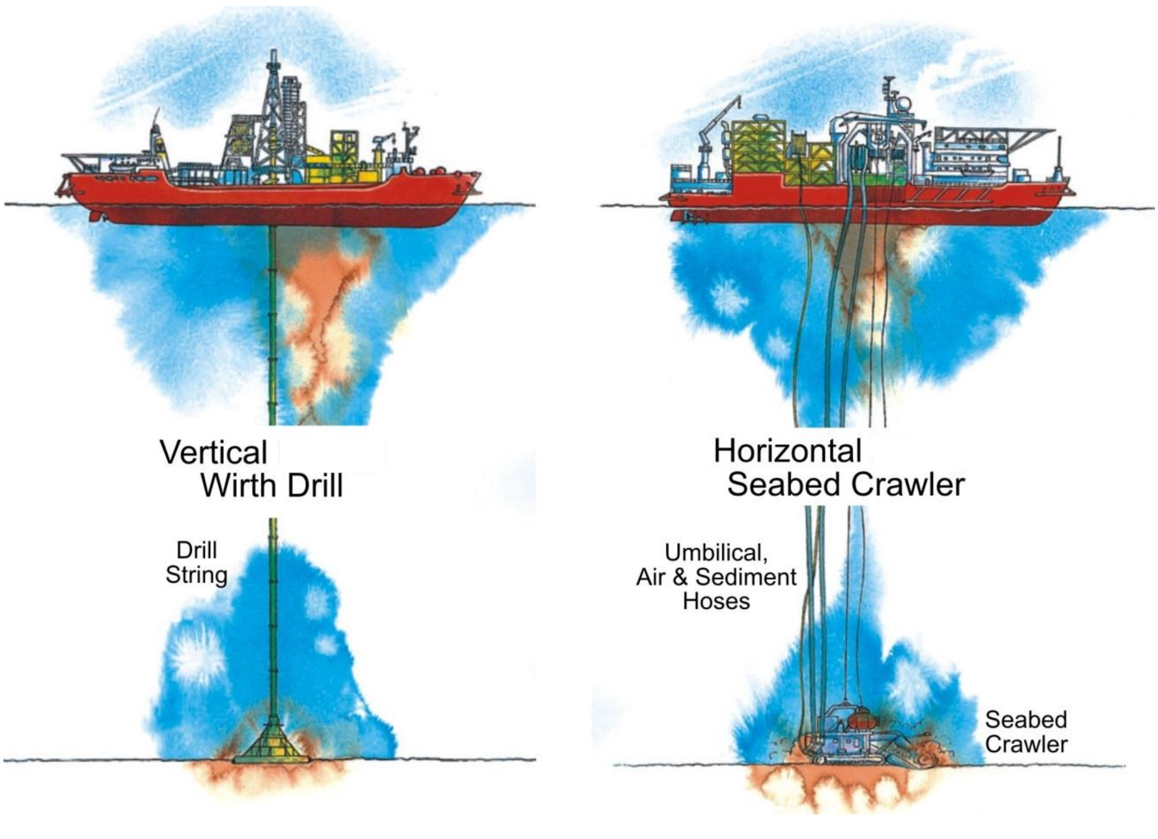


Figure 3: Illustration of the current bulk sampling methods that may be used to bulk sample diamond-bearing gravels; a) Vertical method, and b) horizontal method (Source: De Beers Marine).

2.4. Emissions and Discharges to Sea

During geophysical and sampling operations, normal discharges to the sea from the 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

Although South Africa is not yet a signatory to MARPOL Annex IV Regulations for the Prevention of Pollution by Sewage from Ships, the contracted vessels would be required to comply, wherever possible, with the requirements of this Annex.

2.3.3 Food (galley) wastes

The disposal into the sea of food waste is permitted in terms of MARPOL 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. The daily discharge from the vessel would be approximately 0.15 m^3.

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).

2.5. 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 evaculations 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 Hondeklipbaai. 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) and Penney *et al.* (2007).

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) (Figure 4). Between Cape Columbine and the Orange River, there is usually a double shelf break, with the distinct inner and outer slopes, separated by a gently sloping ledge. The immediate nearshore area consists mainly of a narrow (about 8 km wide) rugged rocky zone, sloping steeply seawards to a depth of around 80 m. The middle and outer shelf typically lacks relief, sloping gently seawards before reaching the shelf break at a depth of ~300 m.

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. Tripp Seamount is a geological feature to the west-southwest of the western extent of Concession 6C (Figure 4), which rises from ~1,000 m to a depth of 150 m.

3.1.2 Coastal and Inner-shelf Geology and Seabed Geomorphology

The inner shelf is underlain by Precambrian bedrock (also referred to as Pre-Mesozoic basement), whilst the middle and outer shelf areas are composed of Cretaceous and Tertiary sediments (Dingle 1973; Birch *et al.* 1976; Rogers 1977; Rogers & Bremner 1991). As a result of erosion on the continental shelf, the unconsolidated surface 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 (Figure 5). An ~500-km long mud belt (up to 40 km wide, and of 15 m average thickness) is situated over the inner edge of the middle shelf between the Orange River and St Helena Bay (Birch *et al.* 1976). Further offshore, sediment is dominated by muddy sands, sandy muds, mud and some sand. The continental slope, seaward of the shelf break, has a smooth seafloor, underlain by calcareous ooze.

Present day sedimentation is limited to input from the Orange River. As these sediments are generally transported northward, most of the sediment in the project area is 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.

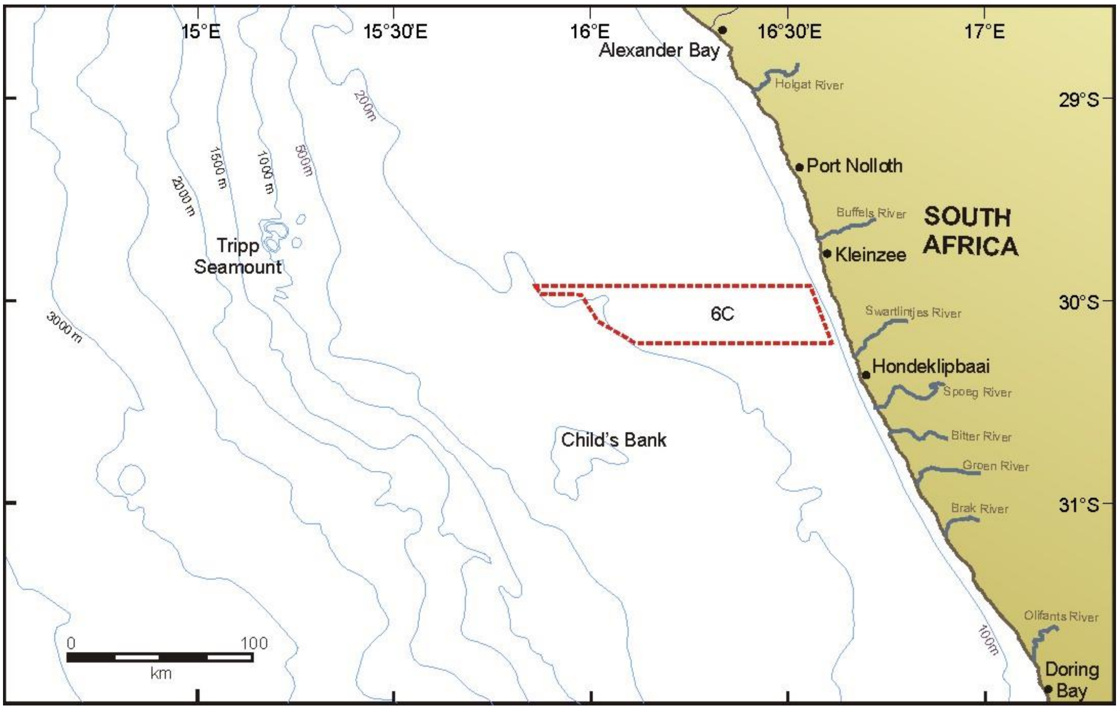


Figure 4: Sea Concession 6C (red polygon) in relation to the regional bathymetry and showing proximity of prominent seabed features.

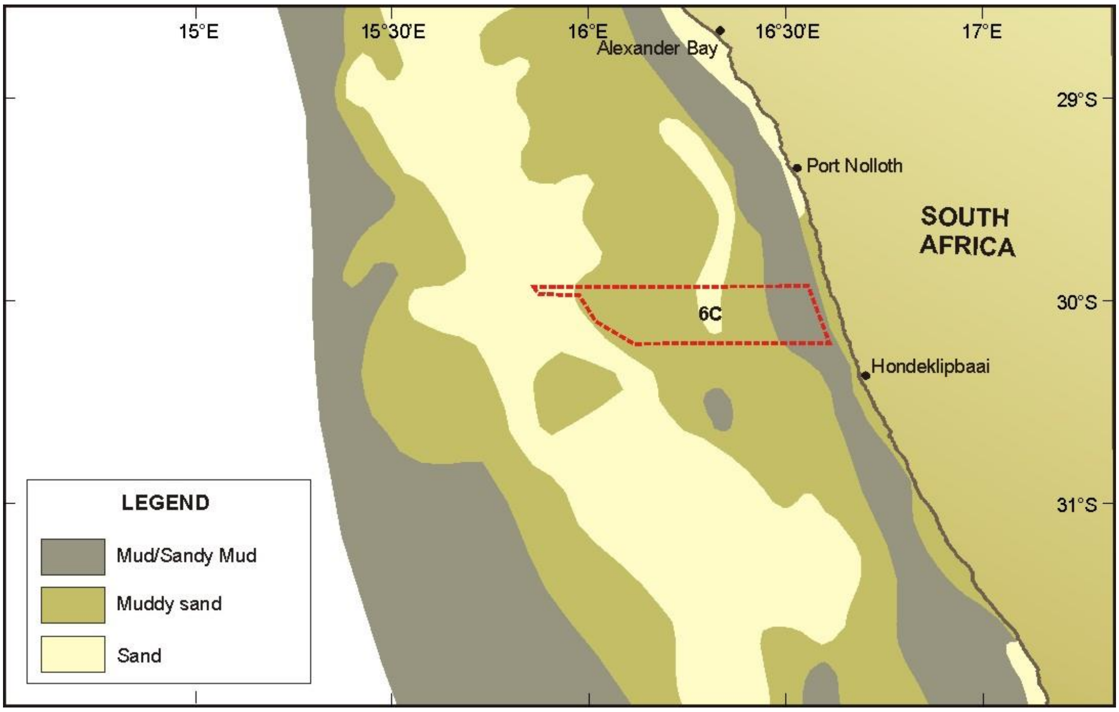


Figure 5: Concession 6C in relation to sediment distribution on the continental shelf (Adapted from Rogers 1977).

3.2. Biophysical Characteristics

3.2.1 Wind Patterns

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

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

These seasonal changes result in substantial differences between the typical summer and winter wind patterns in the region, as the southern hemisphere anti-cyclonic high-pressure systems, and the associated series of cold fronts, move northwards in winter, and southwards in summer. The strongest winds occur in summer, during which winds blow 99% of the time Virtually all winds in summer come from the southeast to south-west (Figure 6; supplied by CSIR), strongly dominated by southerlies which occur over 40% of the time, averaging 20 - 30 kts and reaching speeds in excess of 100 km/h (60 kts). South-easterlies are almost as common, blowing about one-third of the time, and also averaging 20 - 30 kts. The combination of these southerly/south-easterly winds drives the offshore movements of surface water, and the resultant strong upwelling of nutrient-rich bottom waters, which characterise this region.

Winter remains dominated by southerly to south-easterly winds, but the closer proximity of the winter cold-front systems results in a significant south-westerly to north-westerly component (Figure 6). This 'reversal' from the summer condition results in cessation of upwelling, movement of warmer mid-Atlantic water shorewards and breakdown of the strong thermoclines which develop in summer. There are more calms in winter, occurring about 3% of the time, and wind speeds generally do not reach the maximum speeds of summer. However, the westerlies winds blow in synchrony with the prevailing south-westerly swell direction, resulting in heavier swell conditions in winter.

3.2.2 Large-Scale Circulation and Coastal Currents

The West Coast is strongly influenced by the Benguela Current, with current velocities in continental shelf areas ranging between 10–30 cm/s (Boyd & Oberholster 1994). On its western side, flow is more transient and characterised by large eddies shed from the retroflection of the Agulhas Current. The Benguela current widens northwards to 750 km, with flows being predominantly wind-forced, barotropic and fluctuating between poleward and equatorward flow (Shillington *et al.* 1990; Nelson & Hutchings 1983). The long-term mean current residual is in an approximate northwest (alongshore) direction, whereas near-bottom shelf flow is mainly poleward (Nelson 1989) with low velocities of typically 5 cm/s.

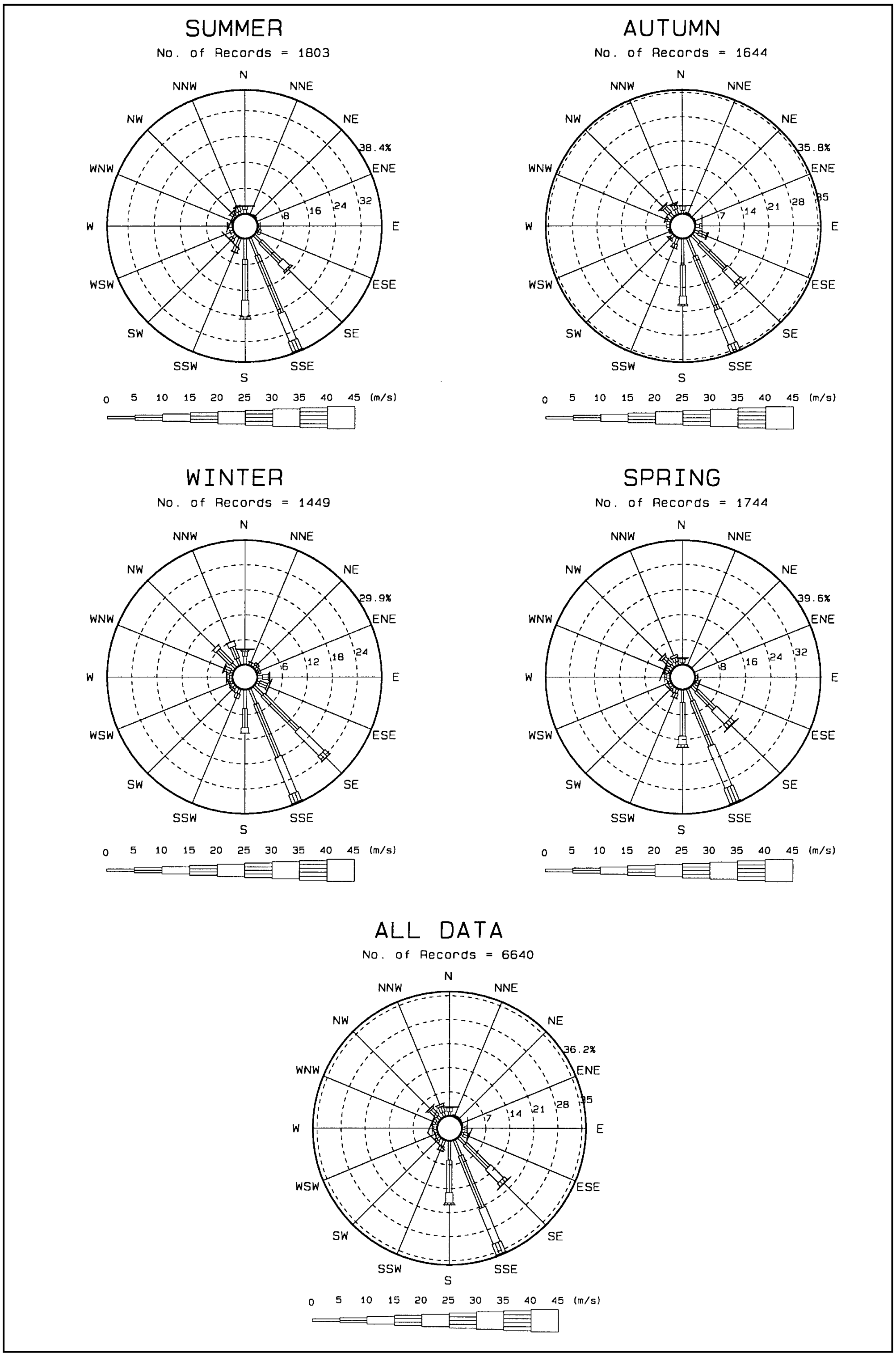


Figure 6: VOS Wind Speed vs Wind Direction data for the offshore area 28°-29°S; 15°-16°E (Oranjemund) (Source: Voluntary Observing Ship (VOS) data from the Southern Africa Data Centre for Oceanography (SADCO)).

The major feature of the Benguela Current Coastal is upwelling and the consequent high nutrient supply to surface waters leads to high biological production and large fish stocks. The prevailing longshore, equatorward winds move nearshore surface water northwards and offshore. To balance the displaced water, cold, deeper water wells up inshore. Although the rate and intensity of upwelling fluctuates with seasonal variations in wind patterns, the most intense upwelling tends to occur where the shelf is narrowest and the wind strongest. There are three upwelling centres in the southern Benguela, namely the Namaqua (30°S), Cape Columbine (33°S) and Cape Point (34°S) upwelling cells (Taunton-Clark 1985) (Figure 7; bottom 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 7.

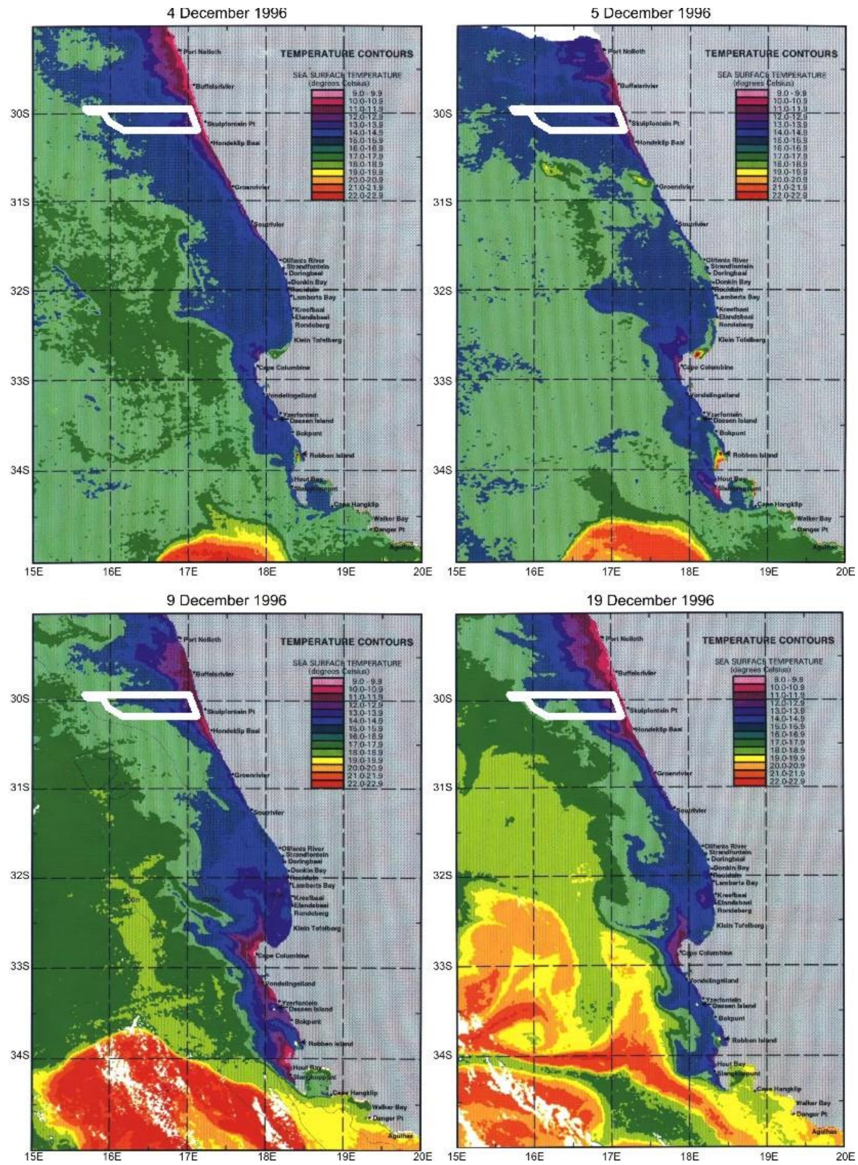


Figure 7: Satellite sea-surface temperature images showing upwelling intensity along the South African west coast on four days in December 1996 (from Lane & Carter 1999). The location of the Concession 6C (white polygon) is indicted.

3.2.3 Waves and Tides

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

The wave regime along the southern African west coast shows only moderate seasonal variation in direction, with virtually all swells throughout the year coming from the SW - S direction (Figure 8). Winter swells are strongly dominated by those from the SW - SSW, which occur almost 80% of the time, and typically exceed 2 m in height, averaging about 3 m, and often attaining over 5 m. With wind speeds capable of reaching 100 km/h during heavy winter south-westerly storms, winter swell heights can exceed 10 m.

Summer swells tend to be smaller on average (~2 m), with a more pronounced southerly component. These southerly swells tend to be wind-induced, with shorter wave periods (~8 seconds), and are generally steeper than swell waves (CSIR 1996).

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

3.2.4 Water

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

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

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

Nutrient concentrations of upwelled water attain 20 μM nitrate-nitrogen, 1.5 μM phosphate and 15-20 μM silicate, indicating nutrient enrichment (Chapman & Shannon 1985). This is mediated by nutrient regeneration from biogenic material in the sediments (Bailey *et al.* 1985). Modification of these peak concentrations depends upon phytoplankton uptake which varies according to phytoplankton biomass and production rate. The range of nutrient concentrations can thus be large but, in general, concentrations are high.

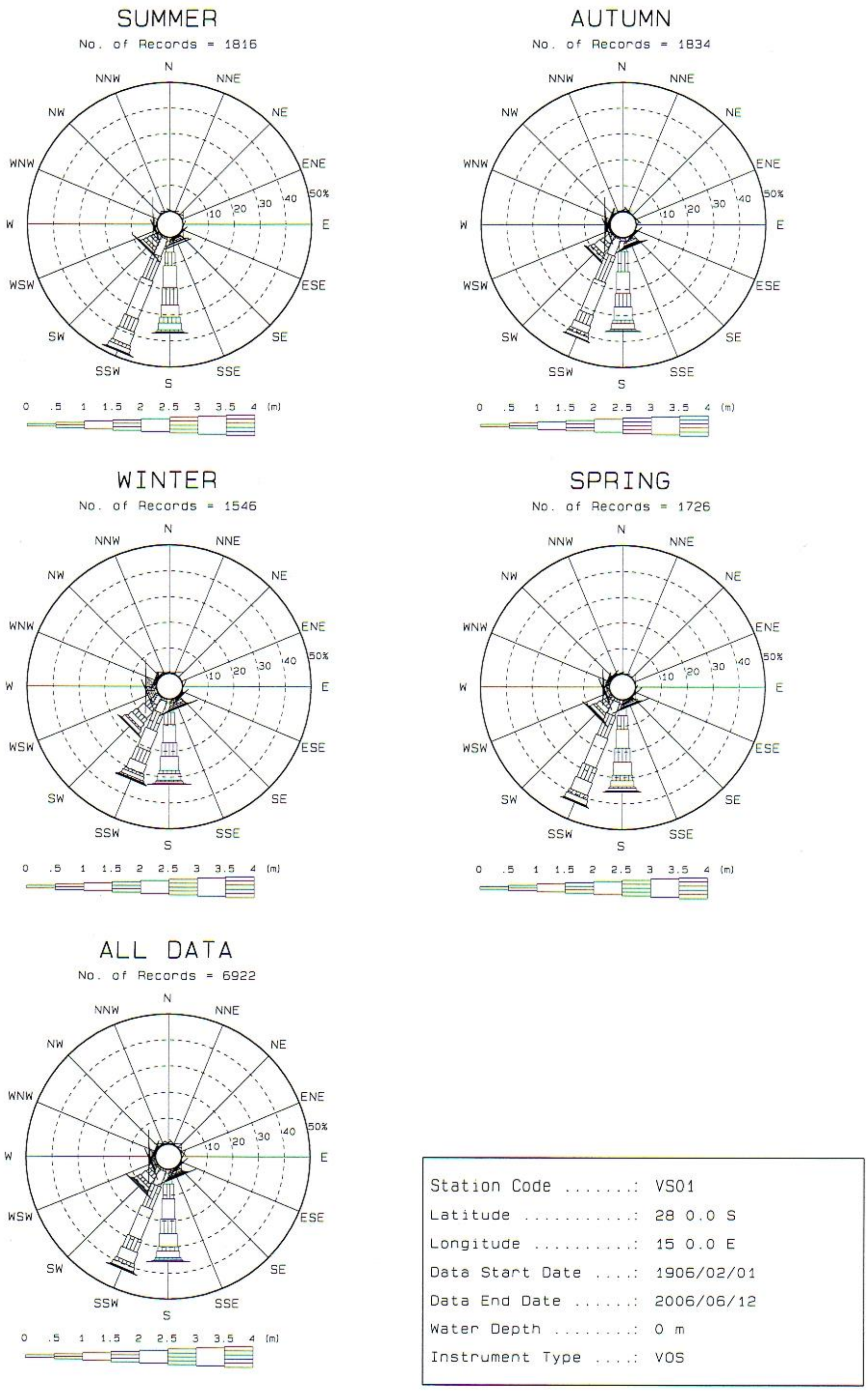


Figure 8: VOS Wave Height vs Wave Direction data for the offshore area (28°-29°S; 15°-16°E recorded during the period 1 February 1906 and 12 June 2006)) (Source: Voluntary Observing Ship (VOS) data from the Southern African Data Centre for Oceanography (SADCO)).

3.2.5 Upwelling & Plankton Production

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

3.2.6 Organic Inputs

The Benguela upwelling region is an area of particularly high natural productivity, with extremely high seasonal production of phytoplankton and zooplankton. These plankton blooms in turn serve as the basis for a rich food chain in which all of the species are subject to natural mortality. A proportion of the annual production of all the 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 9, 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 9, right).

Figure 9: Red tides can reach very large proportions (Left, Photo: www.e-education.psu.edu) and can lead to mass stranding, or 'walk-out' of rock lobsters, such as occurred at Elands Bay in February 2002 (Right, 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) (see Figure 9, right). The development of anoxic conditions as a result of the decomposition of huge amounts of organic matter generated by algal blooms is the main cause for these mortalities and walkouts. The blooms develop over a period of unusually calm wind conditions when sea surface temperatures where high. Algal blooms usually occur during summer-autumn (February to April) but can also develop in winter during the 'berg' wind periods, when similar warm windless conditions occur for extended periods.

3.2.8 Turbidity

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulate matter. Total Suspended Particulate Matter (TSPM) can be divided into Particulate Organic Matter (POM) and Particulate Inorganic Matter (PIM), the ratios between them varying considerably. The POM usually consists of detritus, bacteria, phytoplankton and zooplankton, and serves as a source of food for filter-feeders. Seasonal microphyte production associated with upwelling events will play an important role in determining the concentrations of POM in coastal waters. PIM, on the other hand, is primarily of geological origin consisting of fine sands, silts and clays. Off Namaqualand, the PIM loading in nearshore waters is strongly related to natural inputs from the Orange River or from 'berg' wind events. 'Berg' wind events can potentially contribute the same order of magnitude of sediment input as the annual estimated input of sediment by the Orange River (Shannon & Anderson 1982; Zoutendyk 1992, 1995; Shannon & O'Toole 1998; Lane & Carter 1999). For example, a 'berg' wind event in May 1979 described by Shannon and Anderson (1982) was estimated to have transported in the order of 50 million tons of sand out to sea, affecting an area of 20,000 km^2 (Figure 10).

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

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

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

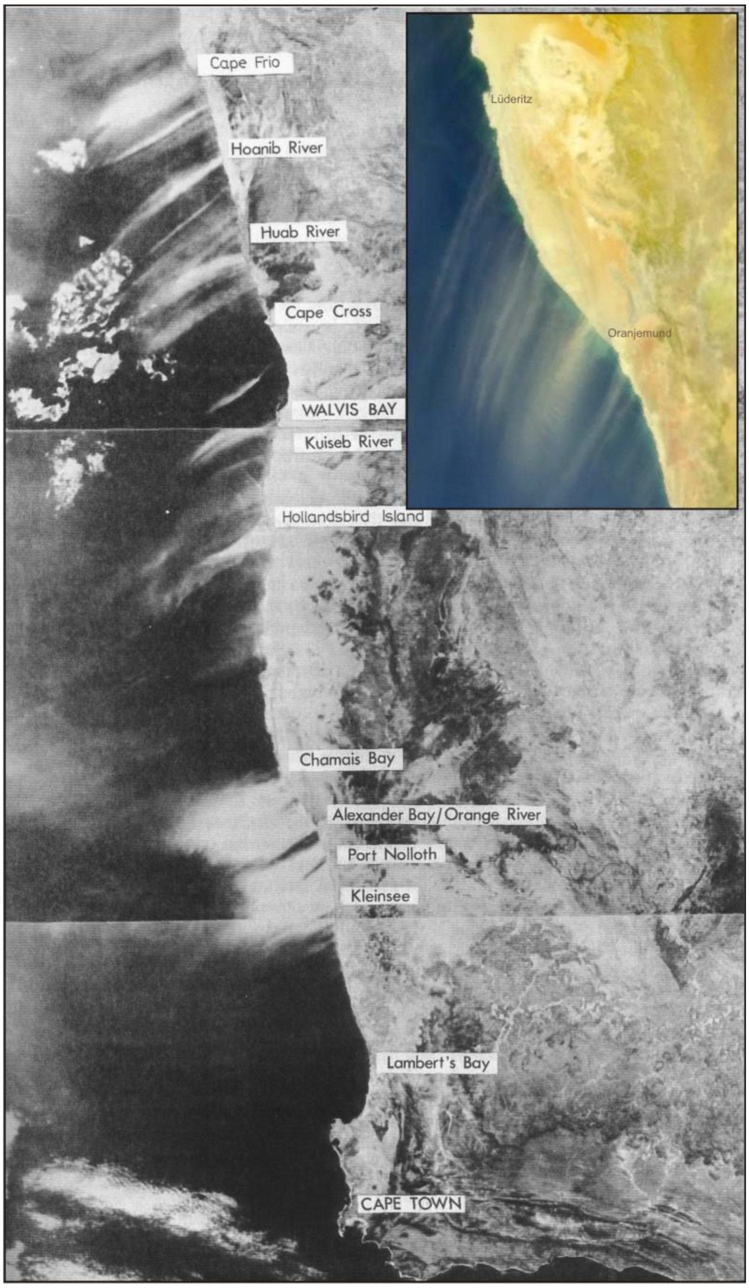


Figure 10: Aerosol plumes of sand and dust due to a 'berg' wind event: NIMBUS 7 CZCS orbit 2726, 9 May 1979 (690 nm) (Shannon & Anderson 1982).

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

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

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

3.3. The Biological Environment

Biogeographically, Sea Concession 6C 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) (Figure 11). The coastal, wind-induced upwelling characterising the western Cape coastline, is the principle physical process which shapes the marine ecology of the southern Benguela region. The Benguela system is characterised by the presence of cold surface water, high biological productivity, and highly variable physical, chemical and biological conditions. The West Coast is, however, characterized by low marine species richness and low endemicity (Awad *et al*. 2002).

Communities within marine habitats are largely ubiquitous throughout the southern African West Coast region, being particular only to substrate type or depth zone. These biological communities consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales). The majority of the proposed prospecting right area is located beyond the 100 m depth contour. The near- and offshore marine ecosystems comprise a limited range of habitats, namely unconsolidated seabed sediments, deep water 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 prospecting activities.

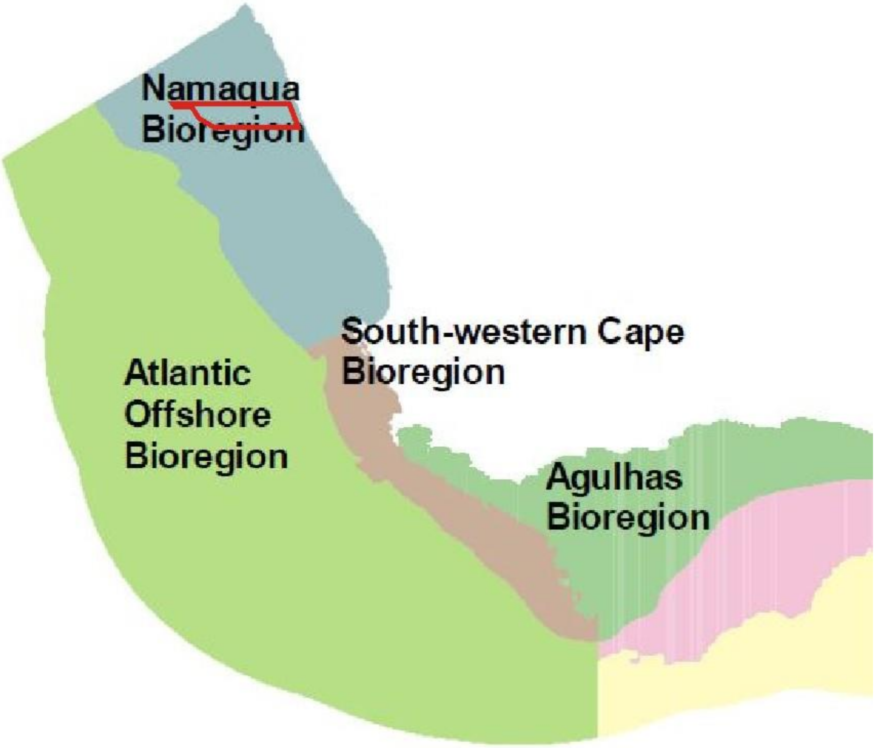


Figure 11: Sea Concession 6C (red polygon) in relation to the South African inshore and offshore bioregions (adapted from Lombard *et al.* 2004).

3.3.1 Demersal Communities

3.3.1.1 Nearshore and Offshore unconsolidated habitats

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; Environmental Evaluation Unit 1996; Parkins & Field 1997; 1998; Pulfrich & Penney 1999; Goosen *et al.* 2000; Savage *et al.* 2001; Steffani & Pulfrich 2004a, 2004b; 2007; Steffani 2007a; 2007b; Steffani 2009, 2010; Atkinson *et al.* 2011; Steffani 2012). The description below is drawn from recent surveys by Karenyi (unpublished data), De Beers Marine Ltd surveys in 2008 and 2010 (unpublished data), and Atkinson *et al.* (2011).

Sea Concession 6C includes three macro-infauna communities on the inner- (i.e. 0-30 m depth) and midshelf (i.e. 30-150 m depth, Karenyi unpublished data). The inner-shelf community, which is affected by wave action, is characterised by various mobile predators (e.g. the gastropod *Bullia laevissima* and polychaete *Nereis* sp.), sedentary polychaetes and isopods. The mid-shelf community in Sea Concession 6C inhabits the mudbelt and is characterised by the mud prawns *Callianassa* sp. and *Calocaris barnardi*. A second mid-shelf sandy community occurring in sandy sediments, is characterised by various polychaetes including deposit-feeding *Spiophanes soederstromi* and *Paraprionospio pinnata*. Polychaetes, crustaceans and molluscs make up the largest proportion of individuals, biomass and species on the west coast

(Figure 12). 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). Given the state of our current knowledge of South African macro-infauna it is not possible to determine the threat status or endemicity of macro-infauna species on the West Coast, although such research is currently underway (pers. comm. Ms N. Karenyi, SANBI and NMMU). However, the marine component of the 2011 National Biodiversity Assessment (Sink *et al.* 2012), rated portions of the outer continental shelf on the West Coast as 'vulnerable' and 'critically endangered' (Figure 13, left). However, none of these fall within Sea Concession 6C.

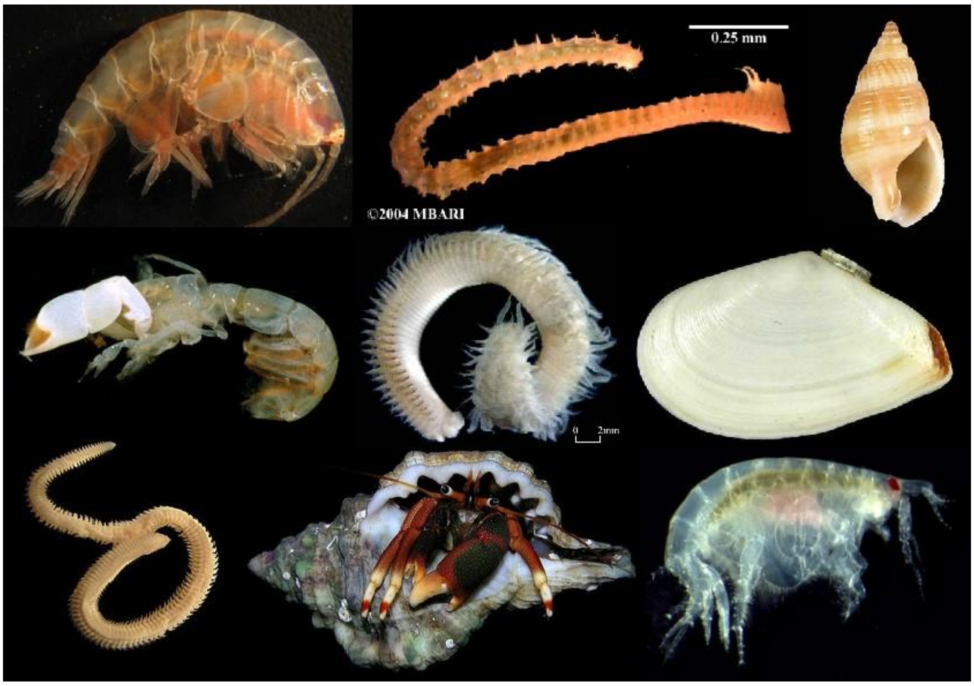


Figure 12: Benthic macrofaunal genera commonly found in nearshore sediments include: (top: left to right) *Ampelisca*, *Prionospio*, *Nassarius*; (middle: left to right) *Callianassa*, *Orbinia*, *Tellina*; (bottom: left to right) *Nephtys*, hermit crab, *Bathyporeia*.

Generally species richness increases from the inner shelf across the mid shelf and is influenced by sediment type (Karenyi unpublished data). The highest total abundance and species diversity was measured in sandy sediments of the mid-shelf. Biomass is highest in the inshore (± 50 g/m^2 wet weight) and decreases across the mid-shelf averaging around 30 g/m^2 wet weight. This is contrary to Christie (1974) who found that biomass was greatest in the mudbelt at 80 m depth off Lamberts Bay, south of Sea Concession 6C, where the sediment characteristics and the impact of environmental stressors (such as low oxygen events) are likely to differ from those in Sea Concession 6C.

Surveys conducted between 180 m and 480 m depth in the vicinity of Sea Concession 6C revealed high proportions of hard ground rather than unconsolidated sediment on the outer shelf, although this requires further verification (Karenyi unpublished data). The benthic fauna of the outer shelf and continental slope (beyond ~450 m depth) are very poorly known largely, due to limited opportunities for sampling as well as the lack of access to Remotely Operated Vehicles (ROVs) for visual sampling of hard substrata. To date very few areas of the continental slope off the West Coast have been biologically surveyed.

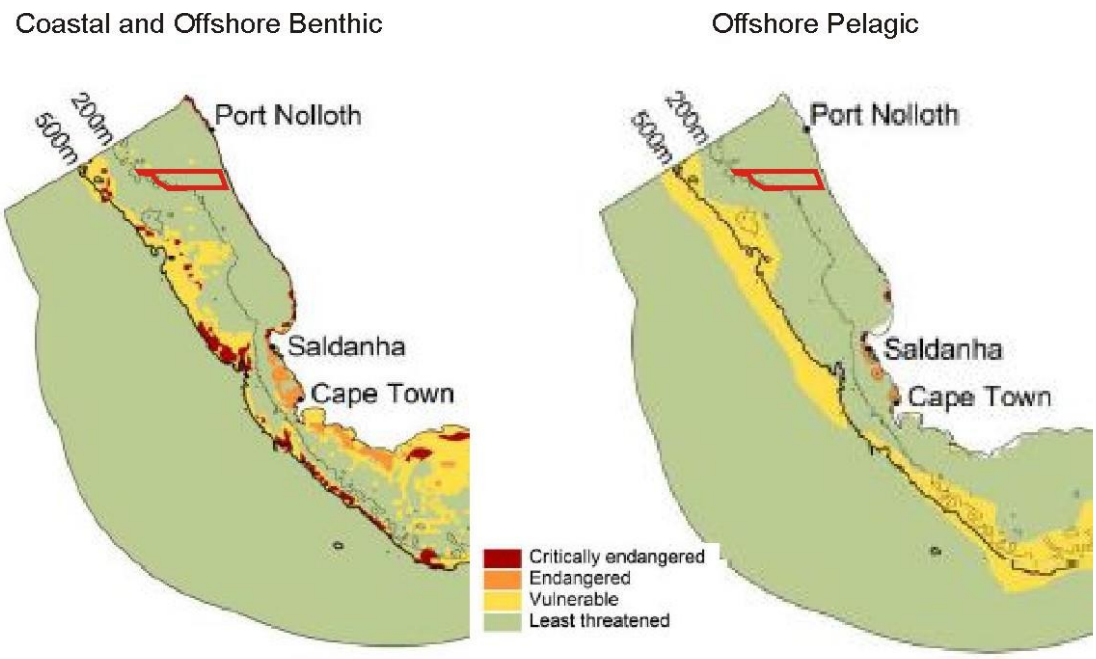


Figure 13: Concession 6C (red polygon) in relation to the South African inshore and offshore bioregions (adapted from Lombard *et al*. 2004).

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), productivity (Escaravage *et al*. 2009), organic carbon and seafloor temperature (Day *et al*. 1971) may also strongly influence the structure of benthic communities. There are clearly other natural processes operating in the deepwater shelf areas of the West Coast that can over-ride the suitability of sediments in determining benthic community structure, and it is likely that periodic intrusion of low oxygen water masses is a major cause of this variability (Monteiro & 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), a single epifaunal community exists between the depths of 100 m and 250 m characterised by the hermit crabs *Sympagurus dimorphus* and *Parapaguris pilosimanus,* the prawn *Funchalia woodwardi* and the sea urchin *Brisaster capensis*. Atkinson (2009) also reported numerous species of urchins and burrowing anemones beyond 300 m depth off the West Coast.

3.3.1.2 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) (Figure 14). Deep water corals establish themselves below the thermocline where there is a continuous and regular supply of concentrated particulate organic matter, caused by the flow of a relatively strong current over special topographical formations which cause eddies to form. Nutrient seepage from the substratum might also promote a location for settlement (Hovland *et al.* 2002). In the productive Benguela region, substantial areas on the shelf should thus potentially be capable of supporting rich, cold water, benthic, filter-feeding communities.

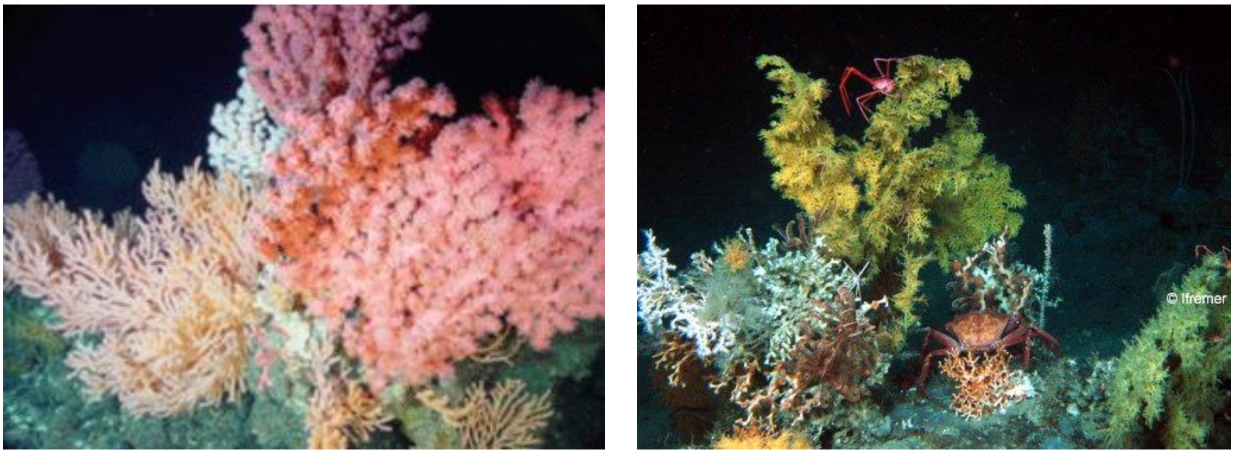


Figure 14: Seamounts are characterised by a diversity of deep-water corals that add structural complexity to seabed habitats and offer refugia for a variety of invertebrates and fish (Photos: www.dfo-mpo.gc.ca/science/Publications/article/2007/21-05-2007-eng.htm, Ifremer & AWI 2003).

Two geological features of note in the vicinity of Sea Concession 6C are Child's Bank, situated ~150 km offshore at about 31°S and ~60 km due south of the concession area, and Tripp Seamount situated ~250 km offshore at about 29°40'S and ~150 km to the west-northwest of the concession area. Child's Bank was described by Dingel *et al.* (1987) to be a carbonate mound (bioherm). Composed of sediments and the calcareous deposits from an accumulation of carbonate skeletons of sessile organisms (e.g. cold-water coral, foraminifera or marl), such features typically have topographic relief, forming isolated seabed knolls in otherwise low profile homogenous seabed habitats (Kopaska-Merkel & Haywick 2001; Kenyon *et al.* 2003, Wheeler *et al.* 2005, Colman *et al.* 2005). 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.

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).

Enhanced currents, steep slopes and volcanic rocky substrata, in combination with locally generated detritus, favour the development of suspension feeders in the benthic communities characterising seamounts (Rogers 1994). Deep- and cold-water corals (including stony corals, black corals and soft corals) (Figure 15, 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). 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. The coral frameworks offer refugia for a great variety of invertebrates and fish (including commercially important species) within, or in association with, the living and dead coral framework (Figure 15, right) thereby creating spatially fragmented areas of high biological diversity. Compared to the surrounding deep-sea environment, seamounts typically form biological hotspots with a distinct, abundant and diverse fauna, many species of which remain unidentified. 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). Levels of endemism on seamounts are also relatively high compared to the deep sea. As a result of conservative life histories (*i.e.* very slow growing, slow to mature, high longevity, low levels of 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).

It is not always the case that seamount habitats are VMEs, as some seamounts may not host communities of fragile animals or be associated with high levels of endemism. South Africa's seamounts and their associated benthic communities have not been extensively sampled by either geologists or biologists (Sink & Samaai 2009). Deep water corals are known from Child's Bank (see below) as well as the iBhubezi Reef to the south-east of Child's Bank. Furthermore, evidence from video footage taken on hard-substrate habitats in 100 - 120 m depth off South Africa (De Beers Marine, unpublished data) (Figure 15) suggest that vulnerable communities including gorgonians, octocorals and reef-building sponges do occur on the continental shelf, and similar communities may thus be expected in Sea Concession 6C.

Sediment samples collected at the base of Norwegian cold-water coral reefs revealed high interstitial concentrations of light hydrocarbons (methane, propane, ethane and higher hydrocarbons C4+) (Hovland & Thomsen 1997), which are typically considered indicative of localised light hydrocarbon micro-seepage through the seabed. Bacteria and other micro-organisms thrive on such hydrocarbon pore-water seepages, thereby providing suspension-feeders, including corals and gorgonians, with a substantial nutrient source. Some scientists believe there is a strong correlation between the occurrence of deep-water coral reefs and the relatively high values of light hydrocarbons (methane, ethane, propane and n-butane) in near-surface sediments (Hovland *et al.* 1998; Duncan & Roberts 2001; Hall-Spencer *et al.* 2002; Roberts & Gage 2003).

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

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 with increasing depth (Roel 1987; Smale *et al.* 1993; Macpherson & Gordoa 1992; Bianchi *et al.* 2001; Atkinson 2009), with the most substantial change in species composition occurring in the shelf break region between 300 m and 400 m depth (Roel 1987; Atkinson 2009). The shelf community (<380 m) is dominated by the Cape hake *M. capensis*, and includes jacopever *Helicolenus dactylopterus*, Izak catshark *Holohalaelurus regain*, soupfin shark *Galeorhinus galeus* and whitespotted houndshark *Mustelus palumbes*. The more diverse deeper water community is dominated by the deepwater hake *Merluccius paradoxus*, monkfish *Lophius vomerinus*, kingklip *Genypterus capensis*, bronze whiptail *Lucigadus ori* and hairy conger *Bassanago albescens* and various squalid shark species. There is some degree of species overlap between the depth zones.

Roel (1987) showed seasonal variations in the distribution ranges of 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 likely to occur in the concession area, and their approximate depth range, are listed in Table 1.

Table 1: Demersal cartilaginous species found on the continental shelf along the West Coast, with approximate depth range at which the species occurs (Compagno *et al.* 1991).

Common Name	Scientific name	Depth Range
Frilled shark	*Chlamydoselachus anguineus*	200-1,000
Six gill cowshark	*Hexanchus griseus*	150-600
Gulper shark	*Centrophorus granulosus*	480
Leafscale gulper shark	*Centrophorus squamosus*	370-800
Bramble shark	*Echinorhinus brucus*	55-285
Black dogfish	*Centroscyllium fabricii*	>700
Portuguese shark	*Centroscymnus coelolepis*	>700
Longnose velvet dogfish	*Centroscymnus crepidater*	400-700
Birdbeak dogfish	*Deania calcea*	400-800
Arrowhead dogfish	*Deania profundorum*	200-500
Longsnout dogfish	*Deania quadrispinosum*	200-650

Common Name	Scientific name	Depth Range
Sculpted lanternshark	*Etmopterus brachyurus*	450-900
Brown lanternshark	*Etmopterus compagnoi*	450-925
Giant lanternshark	*Etmopterus granulosus*	>700
Smooth lanternshark	*Etmopterus pusillus*	400-500
Spotted spiny dogfish	*Squalus acanthias*	100-400
Shortnose spiny dogfish	*Squalus megalops*	75-460
Shortspine spiny dogfish	*Squalus mitsukurii*	150-600
Sixgill sawshark	*Pliotrema warreni*	60-500
Goblin shark	*Mitsukurina owstoni*	270-960
Smalleye catshark	*Apristurus microps*	700-1,000
Saldanha catshark	*Apristurus saldanha*	450-765
“grey/black wonder” catsharks	*Apristurus* spp.	670-1,005
Tigar catshark	*Halaelurus natalensis*	50-100
Izak catshark	*Holohalaelurus regani*	100-500
Yellowspotted catshark	*Scyliorhinus capensis*	150-500
Soupfin shark/Vaalhaai	*Galeorhinus galeus*	<10-300
Houndshark	*Mustelus mustelus*	<100
Whitespotted houndshark	*Mustelus palumbes*	>350
Little guitarfish	*Rhinobatos annulatus*	>100
Atlantic electric ray	*Torpedo nobiliana*	120-450
African softnose skate	*Bathyraja smithii*	400-1,020
Smoothnose legskate	*Cruriraja durbanensis*	>1,000
Roughnose legskate	*Crurirajaparcomaculata*	150-620
African dwarf skate	*Neoraja stehmanni*	290-1,025
Thorny skate	*Raja radiata*	50-600
Bigmouth skate	*Raja robertsi*	>1,000
Slime skate	*Raja pullopunctatus*	15-460
Rough-belly skate	*Raja springeri*	85-500
Yellowspot skate	*Raja wallacei*	70-500
Roughskin skate	*Raja spinacidermis*	1,000-1,350
Biscuit skate	*Raja clavata*	25-500
Munchkin skate	*Raja caudaspinosa*	300-520
Bigthorn skate	*Raja confundens*	100-800
Ghost skate	*Raja dissimilis*	420-1,005
Leopard skate	*Raja leopardus*	300-1,000
Smoothback skate	*Raja ravidula*	500-1,000
Spearnose skate	*Raja alba*	75-260
St Joseph	*Callorhinchus capensis*	30-380
Cape chimaera	*Chimaera* sp.	680-1,000
Brown chimaera	*Hydrolagus* sp.	420-850
Spearnose chimaera	Rhinochimaera atlantica	650-960

3.3.2 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.

3.3.2.1 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 16).

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.

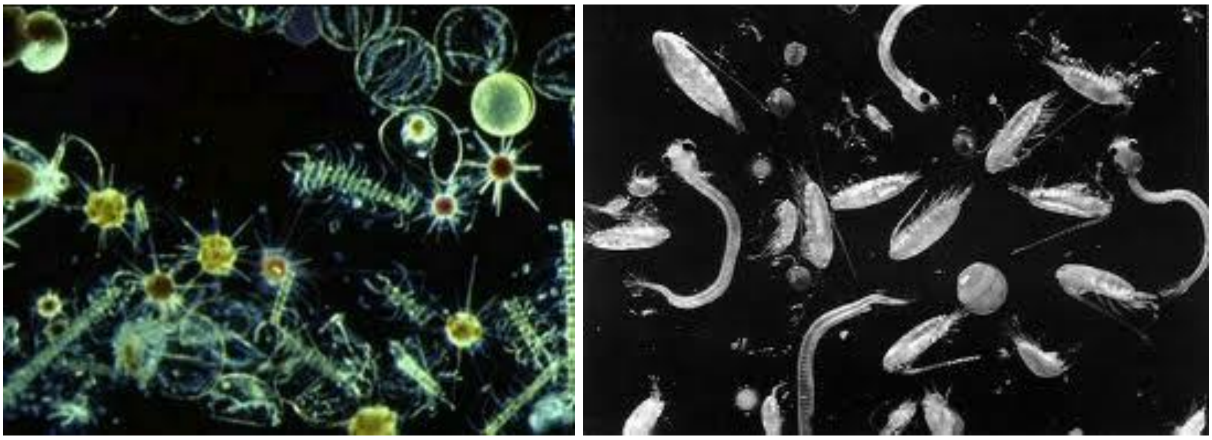


Figure 16: Phytoplankton (left, photo: hymagazine.com) and zooplankton (right, photo: mysciencebox.org) is associated with upwelling cells.

Red-tides are ubiquitous features of the Benguela system (see Shannon & 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. They are unlikely to occur in the offshore regions of the Sea Concession area.

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

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

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

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

Sea Concession 6C lies within the influence of the Namaqua upwelling cell, and seasonally high phytoplankton abundance can be expected, providing favourable feeding conditions for micro-, meso- and macrozooplankton, and for ichthyoplankton. However, in the Orange River Cone area immediately to the north of the upwelling cell, high turbulence and deep mixing in the water column result in diminished phytoplankton biomass and consequently the area is considered to be an environmental barrier to the transport of ichthyoplankton from the southern to the northern Benguela upwelling ecosystems. Important pelagic fish species, including anchovy, redeye round herring, horse mackerel and shallow-water hake, are reported as spawning on either side of the Orange River Cone area, but not within it (Figure 17). Phytoplankton, zooplankton and ichthyoplankton abundances in the eastern portions of the Sea Concession area are thus expected to be comparatively high relative to the Orange River Cone area. In the offshore portions of the Sea Concession area plankton abundance is expected to be low, with the major fish spawning and migration routes occurring further inshore on the shelf.

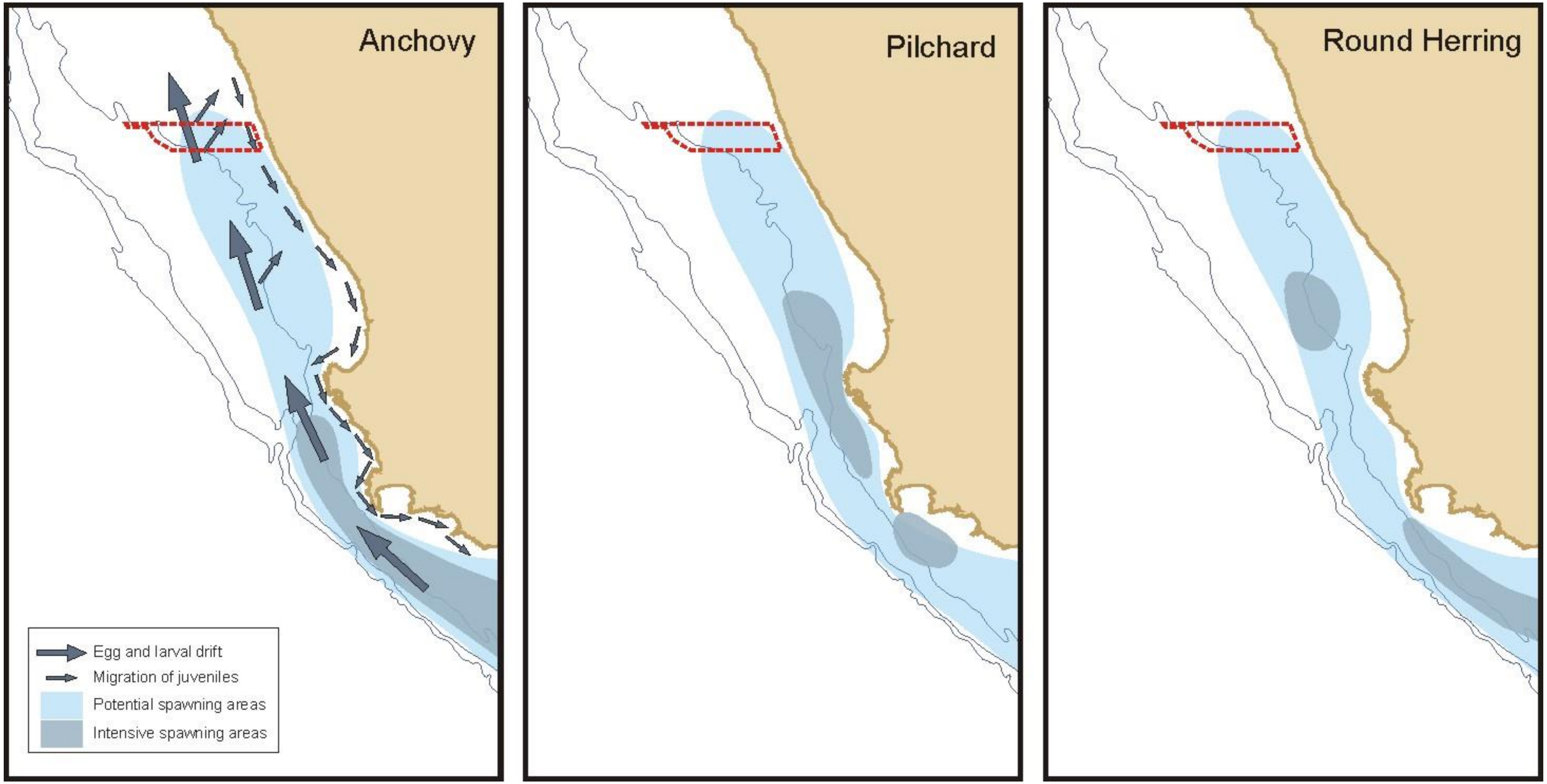


Figure 17: Concession 6C (red polygon) in relation to major spawning areas in the southern Benguela region (adapted from Cruikshank 1990).

3.3.2.2 Cephalopods

The major cephalopod resource in the southern Benguela 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.

3.3.2.3 Pelagic Fish

Small pelagic species occurring beyond the surfzone and generally within the 200 m contour include the sardine/pilchard (*Sadinops ocellatus*) (Figure 18, left), anchovy (*Engraulis capensis*), chub mackerel (*Scomber japonicus*), horse mackerel (*Trachurus capensis*) (Figure 18, right) and round herring (*Etrumeus whiteheadi*). These species typically occur in mixed shoals of various sizes (Crawford *et al*. 1987), and exhibit similar life history patterns involving seasonal migrations between the west and south coasts. The spawning areas of the major pelagic species are distributed on the continental shelf and along the shelf edge from south of St Helena Bay to Mossel Bay on the South Coast (Shannon & Pillar 1986). They spawn downstream of major upwelling centres in spring and summer, and their eggs and larvae are subsequently carried around Cape Point and up the coast in northward flowing surface waters.

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

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

Large pelagic species include tunas, billfish and pelagic sharks, which migrate throughout the southern oceans, between surface and deep waters (>300 m) and have a highly seasonal abundance in the Benguela. Species occurring off western southern Africa include the albacore/longfin tuna *Thunnus alalunga* (Figure 19, right), yellowfin *T. albacares*, bigeye *T. obesus*, and skipjack *Katsuwonus pelamis tunas*, as well as the Atlantic blue marlin *Makaira nigricans* (Figure 19, left), the white marlin *Tetrapturus albidus* and the broadbill swordfish *Xiphias gladius* (Payne & Crawford 1989). The distributions of these species is dependent on food availability in the mixed boundary layer between the Benguela and warm central Atlantic waters. Concentrations of large pelagic species are also known to occur associated with underwater feature such as canyons and seamounts as well as meteorologically induced oceanic fronts (Penney *et al*. 1992).

Figure 19: Large migratory pelagic fish such as blue marlin (left) and longfin tuna (right) occur in offshore waters (photos: www.samathatours.com; www.osfimages.com).

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

Many of the large migratory pelagic species are considered threatened by the IUCN, primarily due to overfishing (Table 2). 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 2: Some of the more important large migratory pelagic fish likely to occur in the offshore regions of the South Coast.

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

3.3.2.4 Turtles

Three species of turtle occur along the West Coast, namely the Leatherback (*Dermochelys coriacea*) (Figure 20, left), and occasionally the Loggerhead (*Caretta caretta*) (Figure 20, right) and the Green (*Chelonia mydas*) turtle. Loggerhead and Green turtles are expected to occur only as occasional visitors along the West Coast.

Figure 20: Leatherback (left) and loggerhead turtles (right) occur along the West Coast of Southern Africa (Photos: Ketos Ecology 2009; www.aquaworld-crete.com).

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[1]). 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 21).

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

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

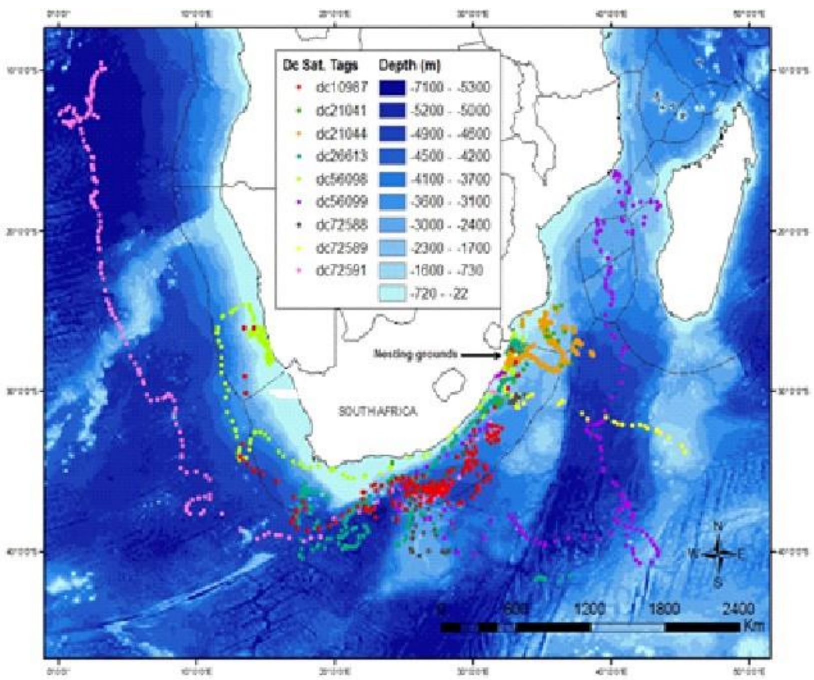


Figure 21: The post-nesting distribution of nine satellite tagged leatherback females (1996 – 2006; Oceans and Coast, unpublished data). The location of Concession 6C is indicated.

3.3.2.5 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 18 species classified as being common in the southern Benguela are listed in Table 3. The area between Cape Point and the Orange River supports 38% and 33% of the overall population of pelagic seabirds in winter and summer, respectively. Most of the species in the region reach highest densities offshore of the shelf break (200 – 500 m depth) with highest population levels during their non-breeding season (winter). Pintado petrels and Prion spp. show the most marked variation here.

14 species of seabirds breed in southern Africa; Cape Gannet (Figure 22, left), African Penguin (Figure 22, right), four species of Cormorant, White Pelican, three Gull and four Tern species (Table 4). The breeding areas are distributed around the coast with islands being especially important. The number of successfully breeding birds at the particular breeding sites varies with food abundance. Most of the breeding seabird species forage at sea with most birds being found relatively close inshore (10-30 km). Cape Gannets, however, are known to forage up to 140 km offshore (Dundee 2006; Ludynia 2007), and African Penguins have also been recorded as far as 60 km offshore.

Figure 22: Cape Gannets *Morus capensis* (left) (Photo: NACOMA) and African Penguins *Spheniscus demersus* (right) (Photo: Klaus Jost) breed primarily on the offshore Islands.

Table 3: Pelagic seabirds common in the southern Benguela region (Crawford *et al.* 1991).

Common Name	Species name	Global IUCN
Shy albatross	*Thalassarche cauta*	Near Threatened
Black browed albatross	*Thalassarche melanophrys*	Endangered[1]
Yellow nosed albatross	*Thalassarche chlororhynchos*	Endangered
Giant petrel sp.	*Macronectes halli/giganteus*	Near Threatened
Pintado petrel	*Daption capense*	Least concern
Greatwinged petrel	*Pterodroma macroptera*	Least concern
Soft plumaged petrel	*Pterodroma mollis*	Least concern
Prion spp	*Pachyptila* spp.	Least concern
White chinned petrel	*Procellaria aequinoctialis*	Vulnerable
Cory's shearwater	*Calonectris diomedea*	Least concern
Great shearwater	*Puffinus gravis*	Least concern
Sooty shearwater	*Puffinus griseus*	Near Threatened
European Storm petrel	*Hydrobates pelagicus*	Least concern
Leach's storm petrel	*Oceanodroma leucorhoa*	Least concern
Wilson's storm petrel	*Oceanites oceanicus*	Least concern
Blackbellied storm petrel	*Fregetta tropica*	Least concern
Skua spp.	*Catharacta/Stercorarius* spp.	Least concern
Sabine's gull	*Larus sabini*	Least concern

[1]. May move to Critically Endangered if mortality from long-lining does not decrease.

Table 4: Breeding resident seabirds present along the West Coast (CCA & CMS 2001).

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

3.3.2.6 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 four species of whales and dolphins are known (based on historic sightings or strandings records) or likely (based on habitat projections of known species parameters) to occur in these waters (Table 5). The offshore areas have been particularly poorly studied with almost all available information from deeper waters (>200 m) arising from historic whaling records prior to 1970. Current information on the distribution, population sizes and trends of most cetacean species occurring on the west coast of southern Africa is lacking. Information on smaller cetaceans in deeper waters is particularly poor and the precautionary principal must be used when considering possible encounters with cetaceans in this area.

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

Table 5: Cetaceans occurrence off the West Coast of South Africa, their seasonality, likely encounter frequency with proposed exploration operations and IUCN conservation status, based on the SA Red List Assessment (2014) (Child *et al*. 2016).

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

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

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. Cetacean density on the continental shelf is usually higher than in pelagic waters as species associated with the pelagic environment tend to be wide ranging across 1,000s of km. As the project target areas are located on the continental shelf, cetacean diversity in the area can be expected to be high. In the offshore portions of Concession 6C abundances will, however, be low compared to further inshore. 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 and humpback whale.

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 (typically those over 4 m in total length) and is taxonomically meaningless (e.g. the killer whale and pilot whale are members of the Odontoceti, family Delphinidae and are thus dolphins). Due to differences in sociality, communication abilities, ranging behavior and acoustic behavior, these two groups are considered separately.

Table 5 lists the cetaceans likely to be found within the project area, based on data sourced from: Findlay *et al*. (1992), Best (2007), Weir (2011), Dr J-P. Roux, (MFMR pers. comm.) and unpublished records held by the Namibian Dolphin Project. Of the 34 species listed, one is critically endangered, two are endangered and two are considered vulnerable (South African Red Data list Categories, 2016). Altogether 10 species are listed as "data deficient" underlining how little is known about cetaceans, their distributions and population trends. 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). Some data on species occurrence is available from newer datasets, mainly from marine mammal observers working on earlier seismic surveys, but these are almost all confined to the summer months.

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.

Two genetically and morphologically distinct populations of Bryde's whales (Figure 23, 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. The "inshore population" of Bryde's, which lives on the continental shelf and Agulhas Bank, is unique amongst baleen whales in the region by being non-migratory. It may move further north into the Benguela current areas of the west of coast of South Africa and Namibia, especially in the winter months (Best 2007).

Figure 23: The Bryde's whale *Balaenoptera brydei* (left) and the Minke whale *Balaenoptera bonaerensis* (right) (Photos: www.dailymail.co.uk; www.marinebio.org).

Sei whales migrate through South African waters, where they were historically hunted in relatively high numbers, to unknown breeding grounds further north. Their migration pattern thus shows a bimodal peak with numbers west of Cape Columbine highest in May and June, and again in August, September and October. All whales were caught in waters deeper than 200 m with most deeper than 1,000 m (Best & 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.

Fin whales were historically caught off the West Coast of South Africa, with a bimodal peak in the catch data suggesting animals were migrating further north during May-June to breed, before returning during August-October *en route* to Antarctic feeding grounds. Some juvenile animals may feed year round in deeper waters off the shelf (Best 2007). There are no recent data on abundance or distribution of fin whales off western South Africa.

Although blue whales were historically caught in high numbers off the South African West Coast, with a single peak in catch rates during June to July in Walvis Bay, Namibia and at Namibe, Angola suggesting that in the eastern South Atlantic these latitudes are close to the northern migration limit for the species (Best 2007). Several recent (2014-2015) sightings of blue whales have occurred during seismic surveys off the southern part of Namibia in water >1,000 m deep confirming their current existence in the area and occurrence in Autumn months. The chance of encountering the species in the Sea Concession area is considered low.

Two forms of minke whale (Figure 23, right) occur in the southern Hemisphere, the Antarctic minke whale (*Balaenoptera bonaerensis*) and the dwarf minke whale (*B. acutorostrata* subsp.); both species occur in the Benguela (Best 2007). Antarctic minke whales range from the pack ice of Antarctica to tropical waters and are usually seen more than ~50 km offshore. Although adults migrate from the Southern Ocean (summer) to tropical/temperate waters (winter) to breed, some animals, especially juveniles, are known to stay in tropical/temperate waters year round. The dwarf minke whale has a more temperate distribution than the Antarctic minke and they do not range further south than 60-65°S. Dwarf minkes have a similar migration pattern to Antarctic minkes with at least some animals migrating to the Southern Ocean during summer. Dwarf minke whales occur closer to shore than Antarctic minkes. Both species are generally solitary and densities are likely to be low in the project area.

The most abundant baleen whales in the Benguela are southern right whales and humpback whales (Figure 24). In the last decade, both species have been increasingly observed to remain on the west coast of South Africa well after the 'traditional' South African whale season (June – November) into spring and early summer (October – February) where they have been observed feeding in upwelling zones, especially off Saldanha and St Helena Bay (Barendse *et al.* 2011; Mate *et al.* 2011).

Figure 24: The Humpback whale *Megaptera novaeangliae* (left) and the Southern Right whale *Eubalaena australis* (right) are the most abundant large cetaceans occurring along the southern African West Coast (Photos: www.divephotoguide.com; www.aad.gov.au).

The 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). In coastal waters, the northward migration stream is larger than the southward peak (Best & Allison 2010; Elwen *et al.* 2013), 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, but no clear migration 'corridor'. 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.* 2013, Rosenbaum *et al.* in press). Recent abundance estimates put the number of animals in the west African breeding population to be in excess of 9,000 individuals in 2005 (IWC 2012) and it is likely to have increased since this time at about 5% per annum (IWC 2012). Humpback whales are thus likely to be the most frequently encountered baleen whale in the project area, ranging from the coast out beyond the shelf, with year round presence but numbers peaking in July – February associated with the breeding migration and subsequent feeding in the Benguela.

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.* 2015). 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, 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.*, in review) 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). Southern right whales have been recorded off the West Coast in all months of the year, but with numbers peaking in winter (June - September). Notably, all available records have been very close to shore with only a few out to 100m depth, so they are unlikely to be encountered in the concession area.

In the last decade, deviations from the predictable and seasonal migration patterns of these two species have been reported from the Cape Columbine – Yzerfontein area (Best 2007; Barendse *et al.* 2010). High abundances of both Southern Right and Humpback whales in this area during spring and summer (September-February), indicates that the upwelling zones off Saldanha and St Helena Bay may serve as an important summer feeding area (Barendse *et al.* 2011, Mate *et al.* 2011). It was previously thought that whales feed only rarely while migrating (Best *et al.* 1995), but these localised summer concentrations suggest that these whales may in fact have more flexible foraging habits.

Odontocetes (toothed) whales

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

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 25, left). They are considered to be relatively abundant globally (Whitehead 2002), although no estimates are available for South African waters.

Seasonality of catches suggests that medium and large sized males are more abundant in winter months while female groups are more abundant in autumn (March - April), although animals occur year round (Best 2007). Sperm whales are thus likely to be encountered in relatively high numbers in deeper waters (>500 m), predominantly in the winter months (April - October). Sperm whales feed at great depths during dives in excess of 30 minutes making them difficult to detect visually, however the regular echolocation clicks made by the species when diving make them relatively easy to detect acoustically using Passive Acoustic Monitoring (PAM).

There are almost no data available on the abundance, distribution or seasonality of the smaller odontocetes (including the beaked whales and dolphins) known to occur in oceanic waters (>200 m) off the shelf of the southern African West Coast. Beaked whales are all considered to be true deep water species usually being seen in waters in excess of 1,000-2,000 m deep (see various species accounts in Best 2007). Presence in the project area may fluctuate seasonally, but insufficient data exist to define this clearly.

Figure 25: 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).

The genus *Kogia* currently contains two recognised species, the pygmy (*K. breviceps*) and dwarf (*K. sima*) sperm whales, both of which most frequently occur in pelagic and shelf edge waters, although their seasonality is unknown. The majority of what is known about Kogiidae whales in the southern African subregion results from studies of stranded specimens (e.g. Ross 1979; Findlay *et al.* 1992; Plön 2004; Elwen *et al.* 2013).

Killer whales (Figure 25 right) have a circum-global distribution being found in all oceans from the equator to the ice edge (Best 2007). Killer whales occur year round in low densities off western South Africa (Best *et al.* 2010), Namibia (Elwen & Leeney 2011) and in the Eastern Tropical Atlantic (Weir *et al.* 2010). Killer whales are found in all depths from the coast to deep open ocean environments and may thus be encountered in the project area at low levels.

The false killer whale has a tropical to temperate distribution and most sightings off southern Africa have occurred in water deeper than 1,000 m, but with a few recorded close to shore (Findlay *et al.* 1992). They usually occur in groups ranging in size from 1 - 100 animals (Best 2007). The strong bonds and matrilineal social structure of this species makes it vulnerable to mass stranding (8 instances of 4 or more animals stranding together have occurred in the

Western Cape, all between St Helena Bay and Cape Agulhas). There is no information on population numbers or conservation status and no evidence of seasonality in the region (Best 2007).

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

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

In water <500 m deep, dusky dolphins (Figure 26, 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*. 2010a; NDP unpubl. data) with group sizes of up to 800 having been reported (Findlay *et al*. 1992). A hiatus in sightings (or low density area) is reported between ~27°S and 30°S, associated with the Lüderitz upwelling cell (Findlay *et al*. 1992). Dusky dolphins are resident year round in the Benguela.

Heaviside's dolphins (Figure 26, left) are relatively abundant in the Benguela ecosystem region with 10,000 animals estimated to live in the 400 km of coast between Cape Town and Lamberts Bay (Elwen *et al*. 2009). This species occupies waters from the coast to at least 200 m depth, (Elwen *et al*. 2006; Best 2007), and may show a diurnal onshore-offshore movement pattern (Elwen *et al*. 2010b), but this varies throughout the species range. Heaviside's dolphins are resident year round.

Figure 26: The endemic Heaviside's Dolphin *Cephalorhynchus heavisidii* (left) (Photo: De Beers Marine Namibia), and Dusky dolphin *Lagenorhynchus obscurus* (right) (Photo: scottelowitzphotography.com).

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

Beaked whales were never targeted commercially and their pelagic distribution makes them the most poorly studied group of cetaceans. With recorded dives of well over an hour and in excess of 2 km deep, beaked whales are amongst the most extreme divers of any air breathing animals (Tyack *et al*. 2011). They also appear to be particularly vulnerable to certain types of anthropogenic noise, although reasons are not yet fully understood. All the beaked whales that may be encountered 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).

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.

Of the migratory cetaceans, the Blue is listed as 'critically endangered', Fin and Sei whales are listed as 'Endangered' and the Bryde's (inshore) and Humpback whale as 'Vulnerable' in the IUCN Red Data book. 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 27) is the only species of seal resident along the west coast of Africa, occurring at numerous breeding and non-breeding sites on the mainland and on nearshore islands and reefs (see Figure 28). Vagrant records from four other species of seal more usually associated with the subantarctic environment have also been recorded: southern elephant seal (*Mirounga leoninas),* subantarctic fur seal (*Arctocephalus tropicalis),* crabeater *(Lobodon carcinophagus)* and leopard seals (*Hydrurga leptonyx)* (David 1989).

There are a number of Cape fur seal colonies within the study area: at Kleinzee (incorporating Robeiland), at Bucchu Twins near Alexander Bay, 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. Meyer, SFRI, pers. comm.). Non-breeding colonies occur south of Hondeklip Bay at Strandfontein Point and on Bird Island at Lamberts Bay, with the McDougall's Bay islands and Wedge Point being haul-out sites only and not permanently occupied by seals. All have important conservation value since they are largely undisturbed at present. Seals are highly mobile animals with a general foraging area covering the continental shelf up to 120 nautical miles offshore (Shaughnessy 1979), with bulls ranging further out to sea than females. The timing of the annual breeding cycle is very regular, occurring between November and January. Breeding success is highly dependent on the local abundance of food, territorial bulls and lactating females being most vulnerable to local fluctuations as they feed in the vicinity of the colonies prior to and after the pupping season (Oosthuizen 1991).

Figure 27: Colony of Cape fur seals *Arctocephalus pusillus pusillus* (Photo: Dirk Heinrich).

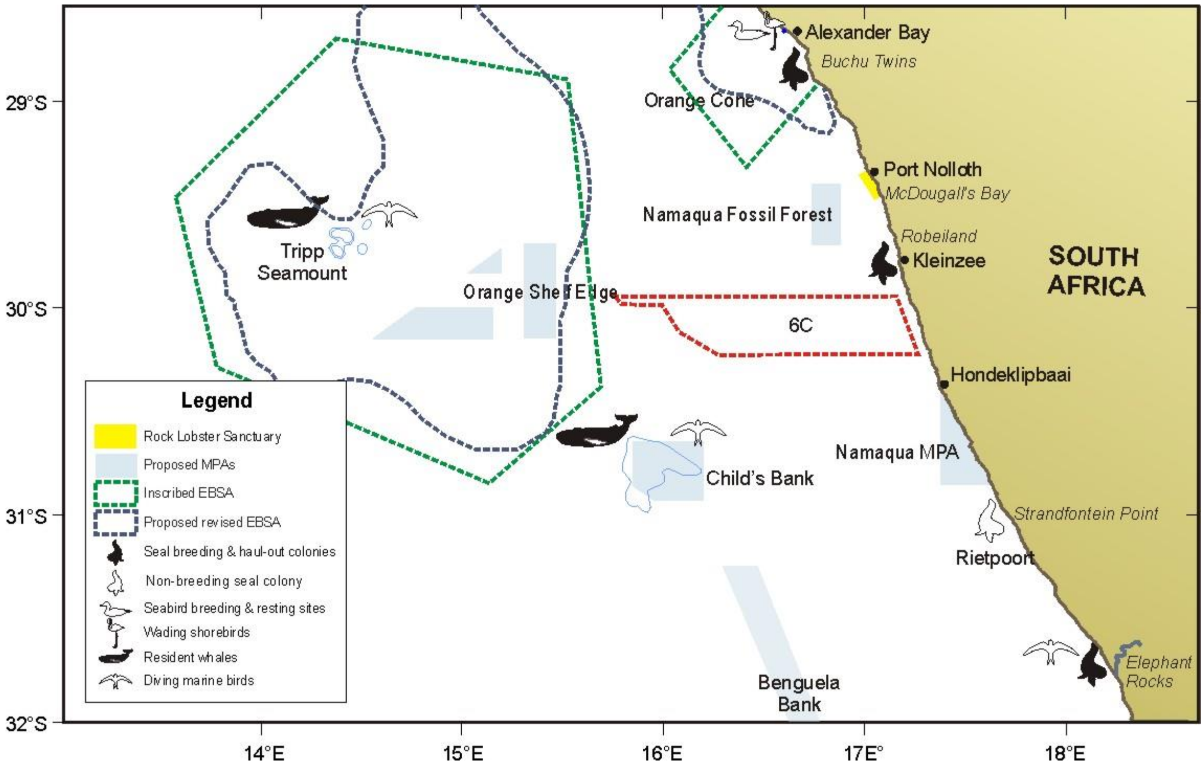


Figure 28: Project - environment interaction points on the West Coast, illustrating the location of Sea Concession 6C (red polygon) in relation to seabird and seal colonies and resident whale populations. Proposed MPAs identified by Operation Phakisa and enscribed EBSAs are also shown.

3.4. Other Uses in proximity to Sea Concession 6C

3.4.1 Beneficial Uses

The Sea Concesssion area is located offshore beyond the 100 m depth contour. Other users within and surrounding the Concession area include the commercial fishing industry (see Specialist Report on Fisheries), neighbouring marine diamond mining concession holders (see Figure 29) and hydrocarbon exploration and production licences (see Figure 31).

3.4.1.1 Diamond Mining

The coastal area onshore of Sea Concession 6C falls within the West Coast Resources coastal diamond mining areas and as public access is restricted, recreational activities along the coastline between Hondeklipbaai and Alexander Bay is limited to the area around Port Nolloth.

The licence areas lie adjacent to a number of marine diamond mining concession areas (Figure 29). The marine diamond mining concession areas are split into four or five zones (Surf zone and (a) to (c) or (d)-concessions), which together extend from the high water mark out to approximately 500 m depth (Figure 30). On the Namaqualand coast marine diamond mining

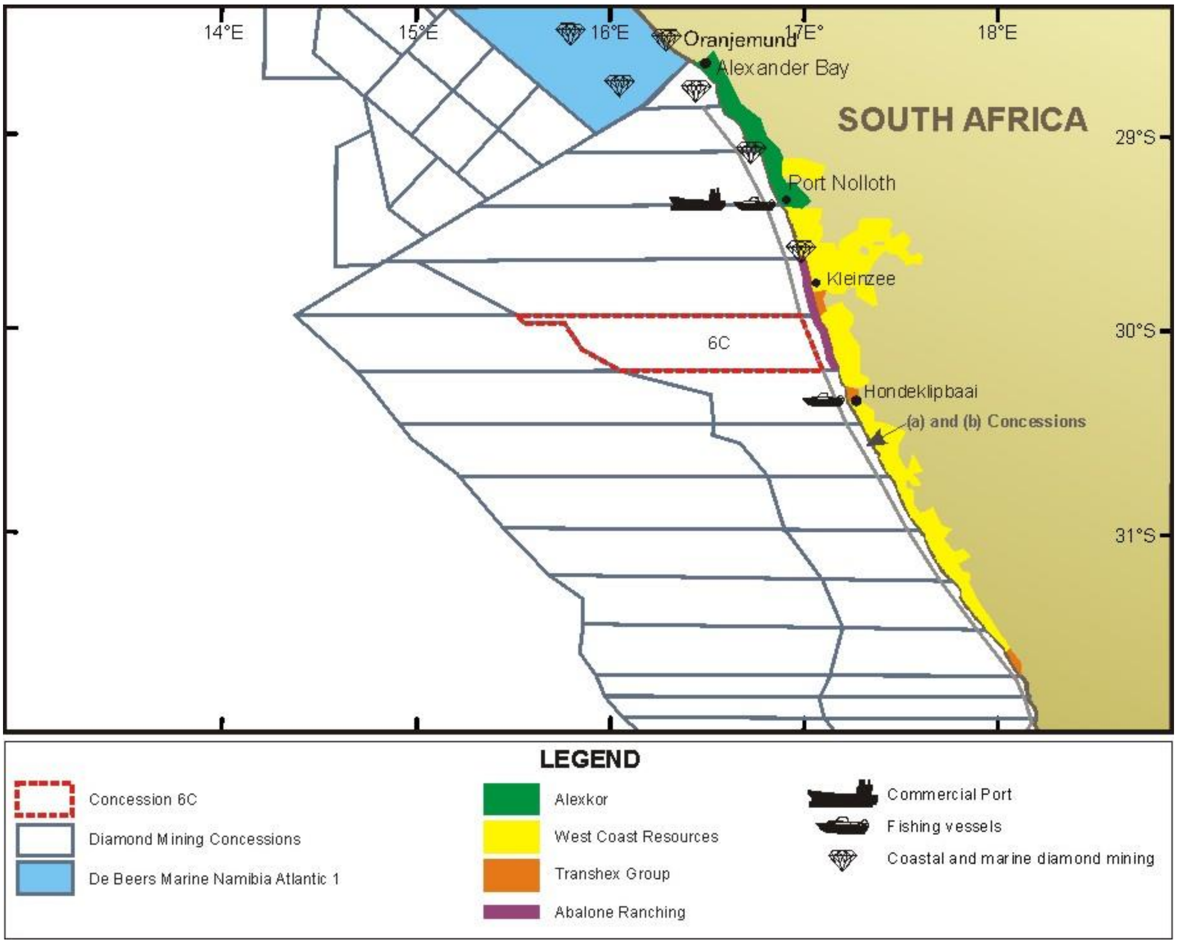


Figure 29: Project - environment interaction points on the West Coast, illustrating the location of marine diamond mining concessions and ports for commercial and fishing vessels, in relation to Sea Concession 6C.

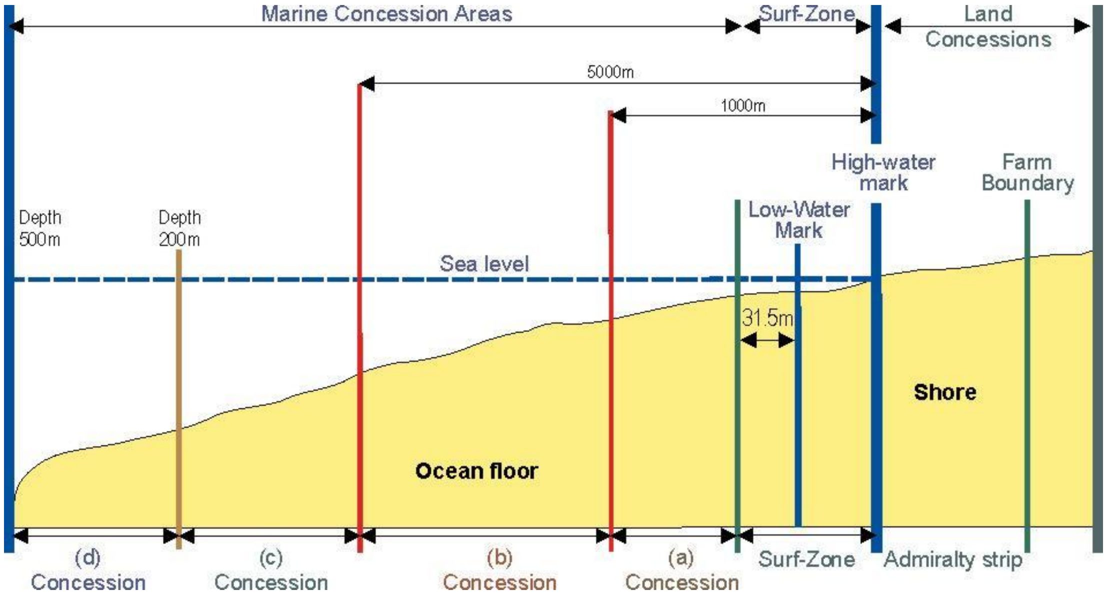


Figure 30: Diagram of the onshore and offshore boundaries of the South African (a) to (d) marine diamond mining concession areas.

activity is primarily restricted to the surf-zone and (a)-concessions. Nearshore shallow-water mining is typically conducted by divers using small-scale suction hoses operating either directly from the shore in small bays or from converted fishing vessels out to ~30 m depth. However, over the past few years there has been a substantial decline in small-scale diamond mining operations due to the global recession and depressed diamond prices, although some vessels do still operate out of Alexander Bay and Port Nolloth.

Deep-water diamond mining and exploration is currently limited to operations by Belton Park Trading 127 (Pty) Ltd in concession 2C for mining and 3C -5C for exploration. In Namibian waters, deep-water diamond mining by De Beers Marine Namibia is currently operational in the Atlantic 1 Mining Licence Area.

De Beers Consolidated Mines (Pty) Ltd hold prospecting rights for diamonds, gold platinum group elements and other specific minerals in Concessions 7C – 10C and for gold and other specific minerals in Concessions 2C – 5C. There are also a number of proposed prospecting areas for glauconite and phosphorite / phosphate, all of which are located south of Sea Concession 6C.

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 31). 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.

Although no wells have recently been drilled in the area, further exploratory drilling is proposed for inshore and offshore portions of Block 1, with further target areas in Block 02B and the 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.

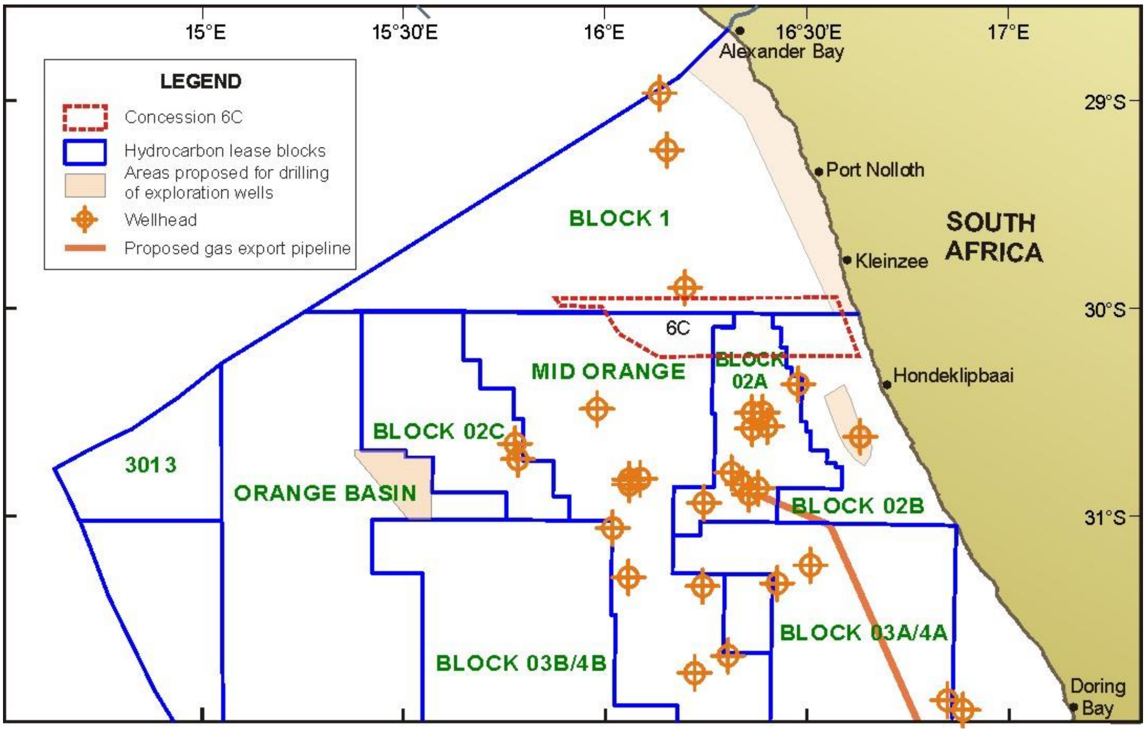


Figure 31: Project - environment interaction points on the West Coast, illustrating the location of hydrocarbon lease blocks, existing well heads, proposed areas for exploratory wells and the routing of the proposed iBhubesi gas export pipeline, in relation to Sea Concession 6C.

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 is facilitating the development of the fishing and mariculture sectors by means of a holistic sector planning approach and has in partnership with a representative community and industry based Fishing and Mariculture Development Association (FAMDA), developed the Northern Cape Province Fishing and Mariculture Sector Plan. This plan forms part of the 'Northern Cape - Fishing and Mariculture Sector Development Strategy' (www.northern-cape.gov.za, accessed December 2013) whereby implementation of the plan will be coordinated and driven by FAMDA.

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 Sea Concession areas 5 and 6 (see Figure 31), 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.

3.4.2 Conservation Areas and Marine Protected Areas

Numerous conservation areas and a marine protected area (MPA) exist along the coastline of the Western Cape, although none fall within the proposed prospecting rights area. The only conservation area in the vicinity of Concession 6C in which restrictions apply is the McDougall's Bay rock lobster sanctuary near Port Nolloth, which is closed to commercial exploitation of rock lobsters (see Figure 28). This area lies inshore and north of Concession 6C.

Using biodiversity data mapped for the 2004 and 2011 National Biodiversity Assessments a systematic biodiversity plan has been developed for the West Coast with the objective of identifying coastal and offshore priority focus areas for MPA expansion (Sink *et al.* 2011; Majiedt *et al.* 2013). Potentially vulnerable marine ecosystems (VMEs) that were explicitly considered during the planning included the shelf break, seamounts, submarine canyons, hard grounds, submarine banks, deep reefs and cold water coral reefs. The biodiversity data were used to identify nine focus areas 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 MPAs. The draft regulations for the proposed MPAs were published in February 2016 and are currently out for review. Those proposed MPAs within the broad project area are shown in Figure 28. None fall within Concession 6C.

In the spatial marine biodiversity assessment undertaken for Namibia (Holness *et al*. 2014), the Orange Shelf Edge area, which includes Tripp Seamount and a shelf-indenting submarine canyon, was identified as being of high priority for place-based conservation measures. To this end, Ecologically or Biologically Significant Areas (EBSA) spanning the border between Namibia and South Africa were proposed and inscribed under the Convention of Biological Diversity (CBD). The proposed Orange Shelf Edge EBSA comprises shelf/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 proposed 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. A more focussed version of the EBSA has been submitted and is currently undergoing discussions at national and transboundary level, following which it will be submitted to the CBD for official recognition at the Review Workshop scheduled for early 2018. The principal objective of the EBSA is identification of features of higher ecological value that may require enhanced conservation and management measures. No specific management actions have been formulated for the Orange Shelf Edge area at this stage.

A further EBSA – the transbounday Orange Cone - is located to the north of the Sea Concession area, while the Benguela Upwelling System transboundary EBSA extends along the entire southern African West Coast from Cape Point to the Kunene River and includes a portion of the high seas beyond the Angolan EEZ.

The Orange River Mouth wetland located to the north of Concession 6C 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. Further IBAs south of the project area include the Olifants River Estuary (ZA078), Verlorenvlei (ZA082), the Lower Berg River wetlands (ZA083) and the West Coast National Park and Saldanha Bay Islands (ZA084). All of these are located well to the south and inshore of the Sea Area.

3.4.3 Threat Status and Vulnerable Marine Ecosystems

'No-take'[2] MPAs offering protection of the Namaqua biozones (sub-photic, deep-photic, shallow-photic, intertidal and supratidal zones) are absent northwards from Cape Columbine (Emanuel *et al*. 1992, Lombard *et al*. 2004). Rocky shore and sandy beach habitats are generally not particularly sensitive to disturbance and natural recovery occurs within 2-5 years. However, much of the Namaqualand coastline has been subjected to decades of disturbance by shore-based diamond mining operations (Penney *et al*. 2007). These cumulative impacts and the lack of biodiversity protection has resulted in most of the coastal habitat types in Namaqualand being assigned a threat status of 'critically endangered' (Lombard *et al*. 2004; Sink *et al*. 2012) (

[2] *no-take* means that extraction of any resources is prohibited.

Table 6). Using the SANBI benthic and coastal habitat type GIS database (Figure 32), the threat status of the benthic habitats within Concession 6C, and those potentially affected by proposed prospecting operations, were identified (

Table 6).

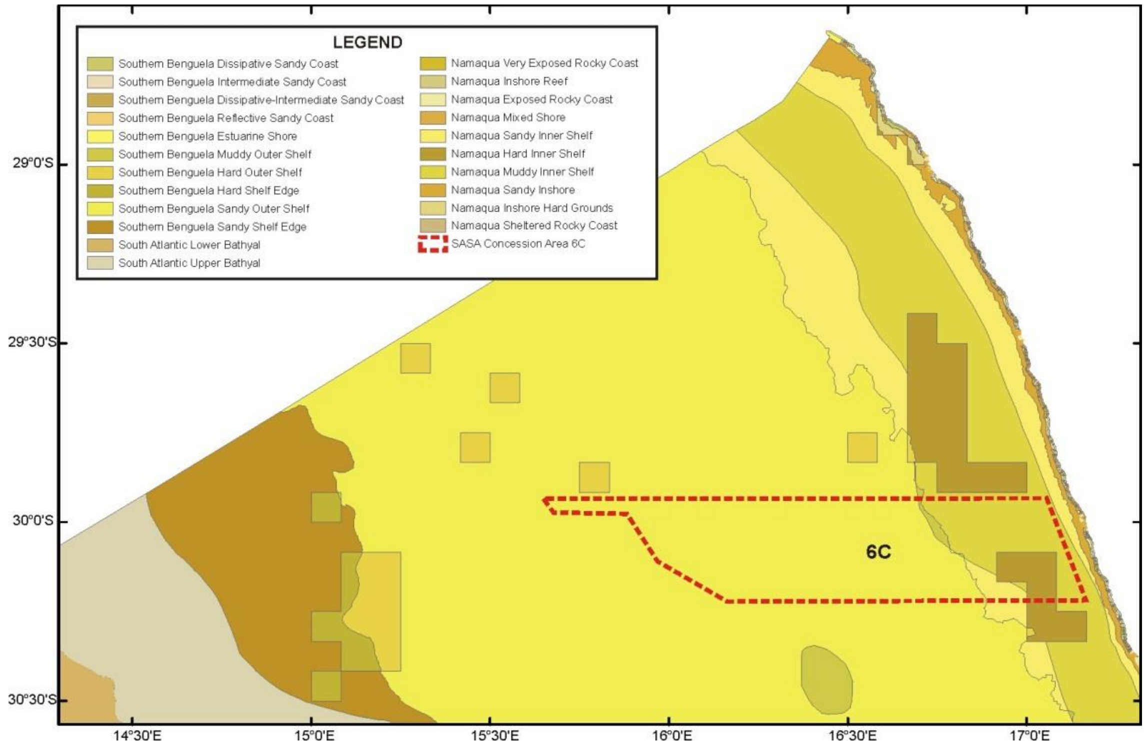


Figure 32: Benthic and coastal habitat types in Concession 6C (red polygon). The habitats affected by the proposed prospecting are identified in Table 6.

Table 6: Ecosystem threat status for marine habitat types in Sea Concession 6C (adapted from Sink *et al*. 2011).

Habitat Type	Threat Status
Namaqua Hard Inner Shelf	Least Threatened
Namaqua Sandy Inner Shelf	Least Threatened
Namaqua Muddy Inner Shelf	Least Threatened
Southern Benguela Sandy Outer Shelf	Least Threatened
Southern Benguela Muddy Outer Shelf	Least Threatened

4. LEGISLATIVE REQUIREMENTS

Details of the legislative requirements are provided in Chapter 2 of the Basic Assessment Report. What follows below is a brief summary of the key legislative requirements that the proposed bulk sampling activities must comply with.

4.1. National Legislation

The key legislations include:

- Minerals and Petroleum Resources Development Act (No. 28 of 2002); and
- National Environmental Management Act (No. 107 of 1998) (NEMA).

4.2. International Marine Pollution Conventions

- International Convention for the Prevention of Pollution from Ships, 1973/1978 (MARPOL);
- Amendment of the International Convention for the Prevention of Pollution from Ships, 1973/1978 (MARPOL) (Bulletin 567 – 2/08);
- International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990 (OPRC Convention);
- United Nations Convention on Law of the Sea, 1982 (LOSC);
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (the London Convention) and the 1996 Protocol (the Protocol);
- International Convention relating to Intervention on the High Seas in case of Oil Pollution Casualties (1969) and Protocol on the Intervention on the High Seas in Cases of Marine Pollution by substances other than oil (1973);
- Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (1989); and
- Convention on Biological Diversity (1992).

4.3. Other South African Legislation

- Carriage of Goods by Sea Act, 1986 (No. 1 of 1986);
- Dumping at Sea Control Act, 1980(No. 73 of 1980);
- Hazardous Substances Act, 1983 and Regulations (No. 85 of 1983);
- Marine Living Resources Act, 1998 (No. 18 of 1998);
- Marine Traffic Act, 1981 (No. 2 of 1981);
- Marine Pollution (Control and Civil Liability) Act, 1981 (No. 6 of 1981);
- Marine Pollution (Prevention of Pollution from Ships) Act, 1986 (No. 2 of 1986);
- Marine Pollution (Intervention) Act, 1987 (No. 65 of 1987);
- Maritime Safety Authority Act, 1998 (No. 5 of 1998);
- Maritime Safety Authority Levies Act, 1998 (No. 6 of 1998);
- Maritime Zones Act 1994 (No. 15 of 1994);

- Merchant Shipping Act, 1951 (No. 57 of 1951);
- National Environmental Management: Integrated Coastal Management Act, 2008 (No. 24 of 2008);
- National Heritage Resources Act, 1999 (No. 25 of 1999);
- Occupational Health and Safety Act, 1993 (No. 85 of 1993);
- Sea-Shore Act, 1935 (No. 21 of 1935);
- Sea Birds and Seals Protection Act, 1973 (No. 46 of 1973);
- Ship Registration Act, 1998 (No. 58 of 1998); and
- Wreck and Salvage Act, 1995 (No. 94 of 1995).

5. ASSESSMENT OF IMPACTS OF OFFSHORE BULK SAMPLING ON MARINE FAUNA

This chapter describes and assesses the significance of potential impacts related to the proposed exploration activities in Concession 6C. All impacts are assessed according to the rating scale defined in Section 5.1. 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.

5.1. Assessment Procedure

The following convention was used to determine significance ratings in the assessment:

Rating	Definition of Rating
Intensity *– establishes whether the magnitude of the impact is destructive or benign in relation to the sensitivity of the receiving environment*	
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.
Low	Minor (Slight) change, disturbance or nuisance. The impact on the environment is not detectable.
Medium	Moderate change, disturbance or discomfort. Where the affected environment is altered, but natural functions and processes continue, albeit in a modified way.
High	Prominent change, disturbance or degradation. Where natural functions or processes are altered to the extent that they will temporarily or permanently cease.
Duration *- the time frame over which the impact will be experienced*	
Short-term	<5 years
Medium-term	5 – 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 would not occur in such a way or in such time span that the impact can be considered transient
Extent *- defines the physical extent or spatial scale of the impact*	
Local	Extending only as far as the activity, limited to the site and its immediate surroundings
Regional	Impacts are confined to the region; e.g. coast, basin, etc.
National	Limited to the coastline of South Africa
International	Extending beyond the borders of South Africa
Reversibility - defines the potential for recovery to pre-impact conditions	
Irreversible	Where the impact is permanent
Partially Reversible	Where the impact can be partially reversed
Fully Reversible	Where the impact can be completely reversed

Probability *– the likelihood of the impact occurring*	
Improbable	Where the possibility of the impact to materialise is very low either because of design or historic experience, i.e. ≤ 30% chance of occurring.
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.
Degree of confidence in predictions *– in terms of basing the assessment on available information and specialist knowledge*	
Low	Less than 35 % sure of impact prediction.
Medium	Between 35 % and 70 % sure of impact prediction.
High	Greater than 70 % sure of impact prediction
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.
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, cultural and social functions and processes are not affected.
Medium	Where the loss of a resource occurs, but natural, cultural and social functions and processes continue, albeit in a modified way.
High	Where the activity results in an irreplaceable loss of a resource.

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

Consequence *– attempts to evaluate the importance of a particular impact, and in doing so incorporates extent, duration and intensity*	
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.

***Consequence** – attempts to evaluate the importance of a particular impact, and in doing so incorporates extent, duration and intensity*	
HIGH	Impacts could be EITHER: of high intensity at a regional level enduring 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, enduring 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, enduring 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, enduring in the short term; OR Zero to very low intensity with any combination of extent and duration.
UNKNOWN	Where it is not possible to determine the significance of an impact.

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

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

Type of impacts assessed:

Type of impacts assessed	
Direct (Primary)	Impacts that result from a direct interaction between a proposed project activity and the receiving environment.
Secondary	Impacts that follow on from the primary interactions between the project and its environment as a result of subsequent interactions within the environment (e.g. loss of part of a habitat affects the viability of a species population over a wider area).
Indirect	Impacts that are not a direct result of a proposed project, often produced away from or as a result of a complex impact pathway.
Cumulative	*Additive*: impacts that may result from the combined or incremental effects of future activities (i.e. those developments currently in planning and not included as part of the baseline).
	In-combination: impacts where individual project-related impacts are likely to affect the same environmental features. For example, a sensitive receptor being affected by both noise and drill cutting during drilling operations could potentially experience a combined effect greater than the individual impacts in isolation.

The relationship between the significance ratings after mitigation and decision-making can be broadly defined as follows:

***Significance of residual impacts after Mitigation -** considering changes in intensity, extent and duration after mitigation and assuming effective implementation of mitigation measures*	
Very Low; Low	Activity could be authorised with little risk of environmental degradation.
Medium	Activity could be authorised with conditions and inspections.
High	Activity could be authorised but with strict conditions and high levels of compliance and enforcement.
Very High	Potential fatal flaw

5.2. 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;
- 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 and crawler excavated trenches;
- Crushing of epifauna and infauna by the crawler tracks;
- 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.

5.3. Assessment of Impacts

5.3.1 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 33).

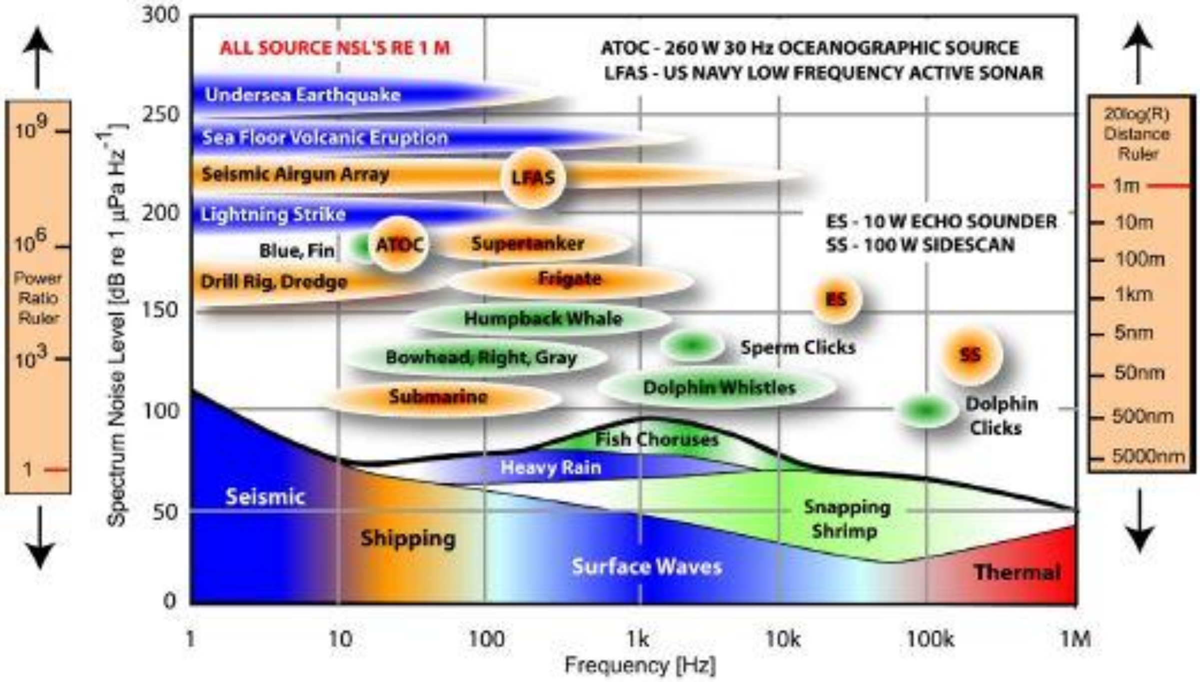


Figure 33: Comparison of noise sources in the ocean (Goold & Coates 2001).

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 and marine mammals (Table 7), and at sound levels of between 190 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). 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. Only directly below the systems (within metres of the sources) would sound levels be in the 230 dB range where exposure result in trauma. As most pelagic species likely to be encountered within the concessions are highly mobile, they would be expected to flee and move away from the sound source before trauma could occur. Whereas the underwater noise from the survey systems may induce localised behavioural changes in some marine mammal, there is no evidence of significant behavioural changes that may impact on the wider ecosystem (Perry 2005).

Similarly, the sound level generated by drilling and seabed crawler 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 7). 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 sampling 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 7: 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

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.

- 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 seismic 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 recently conducted in the area, 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	

5.3.2 Disturbance and loss of benthic fauna during sampling

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 drill bit and crawler suction head. As the number of samples required can only be determined once the geophysical data have been analysed, and the sampling drill technology has not yet been finalised, the volume of sediment likely to be removed and disturbed, or the area of seabed impacted during the sampling campaign(s) cannot be provided at this stage. Similarly, the area of seabed disturbed during bulk sampling by crawler can only be determined following analysis of drill samples and development of the inferred resource model.

As benthic fauna typically inhabit 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.

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 amounting to only 0.09 km^2 should all anticipated 9,000 samples be taken. The area disturbed constitutes ~ 0.003% of the overall area of Concession 6C, the impact can confidently be rated as being of **LOW** significance without mitigation.

Mitigation

No mitigation measures are possible, or considered necessary for the direct loss of macrobenthos due to drill and bulk sampling. However, sampling activities of any kind should avoid rocky outcrop areas or other identified sensitive habitats in the concession area.

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	Low	Low
Probability	Definite	Definite
Significance	Low	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	

5.3.3 Crushing of benthic fauna during sampling

<u>Description of Impact</u>

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 drill frame structure (during sampling) and the seabed crawler tracks (during bulk sampling). Epifauna and infauna beneath the footprint of the drill frame or crawler tracks would be crushed by the weight of the equipment resulting in a reduction in benthic biodiversity.

<u>Assessment</u>

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.

<u>Mitigation</u>

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:

- sampling activities of any kind avoid rocky outcrop areas or other identified sensitive habitats in the concession areas;
- 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

5.3.4 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. The screens separate the fine sandy silt and large gravel, cobbles and boulders from the size fraction of interest, the 'plantfeed' (usually 2 - 20 mm). The fine tailings are immediately discarded overboard where they form a suspended sediment plume in the water column which dissipates with time. 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.

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. Negative impacts may also occur when heavy metals or contaminants associated with fine sediments are remobilised.

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.

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	

5.3.5 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 boulders and fine silts from the ‘plantfeed’. The oversize tailings are discarded overboard and settle back onto the seabed beneath the vessel.

Assessment

Following discharge overboard of the fine and coarse tailings, these settle back onto the seabed where they can result in 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. 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 sensitive deep-water coral communities. Within the sampling target areas, such communities would be expected in the Namaqua Hard Inner Shelf habitats (see Figure 32). Rocky seabed outcrops are known to host fragile, habitat forming scleractinian corals. As deep-water corals tend to occur in areas with low sedimentation rates (Mortensen *et al.* 2001), these benthic suspension-feeders and their associated faunal communities are likely to show particular 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). As high proportions of hard ground have been identified between 180 m and 480 m depth to the north of Concession 6C, and video footage from southern Namibia and to the south-east of Childs Bank has identified vulnerable communities including gorgonians, bryozoans and octocorals, the potential occurrence of such sensitive deep-water ecosystems in Concession 6C cannot be excluded.

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.

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 outcrop areas or other identified sensitive habitats in the concession area. Use should be made of geophysical data to conduct a pre-sampling geohazard analysis of the seabed, and near-surface substratum to map potentially vulnerable habitats and prevent potential conflict with the sampling targets.

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	Medium

5.3.6 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.

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

5.3.7 Pollution of the marine environment through Operational Discharges from the Sampling Vessel(s)

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 drilling unit 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 drilling unit / 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 drilling unit 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[3].

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,

[3] 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

- Develop a waste management plan using waste hierarchy.

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

5.3.8 Cumulative impacts

The primary impacts associated with the geophysical exploration 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. Considering the number of seismic surveys recently conducted in the general project area, some cumulative impacts can be anticipated. However, any direct noise impact is likely to be at individual level rather than at species level. The sampling operations likely to result as part of the proposed exploration activities would impact an area of <0.1 km^2 in the Namaqua Bioregion, which can be considered an insignificant percentage of the bioregion as a whole.

The area of seabed disturbed during bulk sampling by crawler can only be determined following analysis of drill samples and development of the inferred resource model. Once bulk sampling commence, it is recommended that detailed records of annual and cumulative areas sampled be maintained, and that these be submitted to the authorities should future informed decisions need to be made regarding disturbance limits to benthic habitat types in the Namaqua Bioregion.

Cumulative impacts to the benthic environment also include the development of hydrocarbon wells. Since 1976~40 wells have been drilled in the Namaqua Bioregion. The majority of these occur in the iBhubesi Gas field in Block 2A to the south of Concession 6C. Prior to 1983, technology was not available to remove wellheads from the seafloor. 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, or ~0.038% of the Namaqua bioregion. Cumulative impacts from other hydrocarbon ventures in the area are likely to increase in future, particularly with the planned development of the iBhubesi Gas Field. Further exploratory drilling has also being proposed in Block 2B.

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 Concession 6C.

6. RECOMMENDATIONS AND CONCLUSIONS

The impacts on marine habitats and communities associated with the proposed exploration activities in Concession 6C 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 Namaqua Bioregion.

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*
Disturbance and loss of benthic macrofauna	Definite	Low	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
Potential loss of equipment	Improbable	Very Low	Very Low
Pollution of the marine environment through operational discharges to the sea from sampling vessel	Probable	Very Low	Very Low

6.1. Recommended Mitigation Measures

The following mitigation measures are proposed during geophysical surveying:

- 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 seismic geophysical surveying.

The following mitigation measures are proposed during exploration sampling:

- Exploration sampling targets gravel bodies and would thus avoid known sensitive habitats and high-profile, predominantly rocky-outcrop areas without a sediment veneer. Prior to bulk sampling, a visual sampling programme must be undertaken in rocky-outcrop areas to identify sensitive communities.
- Implement dynamically positioned sampling vessels in preference to vessels requiring anchorage.
- Use geophysical data to conduct a pre-sampling geohazard analysis of the seabed, and near-surface substratum to map potentially vulnerable habitats and prevent potential conflict with the sampling targets.
- 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.
- Adhere strictly to best management practices recommended in the relevant Basic Assessment 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 using waste hierarchy.

6.2. 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 sampling 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.

6.3. 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.

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APPENDIX A: SPECIALIST CV

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- PhD, Department of Fisheries Biology of the Institute for Marine Science at the Christian-Albrechts University, Kiel, Germany, 1995

Membership in Professional Societies

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

Employment History and Professional Experience

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

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

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

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

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

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

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

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

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