# ENVIRONMENTAL MANAGEMENT PLAN FOR PROPOSED BATHYMETRY SURVEYS AND SEABED SEDIMENT SAMPLING IN BLOCK11B/12B, OFF THE SOUTH COAST OF SOUTH AFRICA

## MARINE FAUNAL ASSESSMENT

Prepared for

CCA Environmental (Pty) Ltd

On behalf of

TOTAL Exploration & Production South Africa B.V.

Prepared by

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TABLE OF CONTENTS

**ABBREVIATIONS and UNITS**

| | |
|---|---|
| CBD | Convention on Biological Diversity |
| CCA | CCA Environmental (Pty) Ltd |
| CITES | Convention on International Trade in Endangered Species |
| cm | centimetres |
| cm/sec | centimetres per second |
| CMS | Centre for Marine Studies |
| CMS | Convention on Migratory Species |
| CSIR | Council for Scientific and Industrial Research |
| dB | decibells |
| E | East |
| EBSA | Ecologically or Biologically Significant Areas |
| EIA | Environmental Impact Assessment |
| EMPr | Environmental Management Programme report |
| g C/m$^2$ | grams Carbon per square metre |
| h | hour |
| ha | hectare |
| HAMs | harmful algal blooms |
| Hz | Herz |
| IUCN | International Union for the Conservation of Nature |
| JNCC | Joint Nature Conservation Committee |
| kHz | kiloHerz |
| kg | kilogram |
| km | kilometre |
| km$^2$ | square kilometre |
| KZN | KwaZulu Natal |
| Ma | megaannun; one million years |
| MMO | Marine Mammal Observer |
| MPA | Marine Protected Area |
| MPRDA | Mineral and Petroleum Resources Development Act |
| m | metres |
| m$^2$ | square metre |
| m$^3$ | cubic metre |
| m/sec | metres per second |
| mg/m$^3$ | milligrams per cubic metre |
| mg C/m$^2$/hr | milligrams Carbon per square metre per hour |
| mm | millimetre |
| NE | northeast |
| NRC | National Research Council |
| $P_2O_5$ | phosphorous pentoxide |
| PAM | Passive Acoustic Monitoring |
| PASA | Petroleum Agency of South Africa |
| ppt | parts per thousand |
| ROV | remotely operated vehicle |
| S | south |

| | |
|---|---|
| SW | southwest |
| SWIO | South Western Indian Ocean |
| TEPSA | TOTAL Exploration & Production South Africa |
| US | United States of America |
| USBL | Ultra Short Base Line |
| VME | Vulnerable Marine Ecosystem |
| WWF | World Wildlife Fund |
| µm | microns |
| µM/l | micro Mols per litre |
| µPa | micro Pascal |
| °C | degrees Centigrade |
| % | percent |
| ~ | 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 BSc (Hons) and MSc degree in Zoology from the University of Cape Town and 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 CCA Environmental (Pty) Ltd on behalf of TOTAL Exploration & Production South Africa B.V. (hereafter referred to as "TEPSA") for their use in compiling an Addendum to the Environmental Management Programme report (EMPr) to cover the proposed bathymetry surveys and seabed sediment sampling programme. The compilation followed a review process of published (peer reviewed) and unpublished literature and the assessment of potential impacts based on proposed activities and identification of impacts (and their mitigation) within the available literature.

I do hereby declare that Pisces Environmental Services (Pty) Ltd is financially and otherwise independent of the Applicants and CCA Environmental.

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# 1. GENERAL INTRODUCTION

Hydrocarbon deposits occur in reservoirs in sedimentary rock layers. Being lighter than water they accumulate in traps where the sedimentary layers are arched or tilted by folding or faulting of the geological layers. Marine hydro-acoustic surveys are the primary methods for locating such deposits and are thus an indispensable component of offshore oil or gas exploration. In shallower water exploration approaches may include surface heat flow measurements and seabed drop-core sampling.

For this investigation TOTAL Exploration & Production South Africa B.V. (TEPSA) is proposing an exploration programme to enable the rapid collection of data and provide critical information regarding the exploration potential of the licence area to guide future exploration efforts. The exploration programme would commence with the acquisition of bathymetric data using either depth sounders, side scan sonar, bottom profilers or multi-beam bathymetry. The collection of sediment samples (piston coring, box or grab sampling) would subsequently be undertaken for laboratory geochemical analyses to determine if there is any naturally occurring hydrocarbon seepage at the seabed.

In terms of the of Section 29(6) and 102 of the Mineral and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA), an Addendum to the approved Environmental Management Programme report (EMPr) covering the proposed bathymetry survey and seabed sediment sampling must be compiled and submitted to the Petroleum Agency of South Africa (PASA) for consideration and approved by the Minister of Mineral Resources (or the delegated authority). CCA Environmental has been appointed to compile the EMPr Addendum for the proposed survey. CCA in turn has approached Pisces Environmental Services (Pty) Ltd for a specialist report on potential impacts of the proposed operations on marine fauna in the area.

## 1.1. Scope of Work

This specialist report was compiled as a desktop study on behalf of CCA Environmental, for their use in preparing an EMPr Addendum for a proposed exploration programme in the Block 11B/12B Area off the South Coast of South Africa.

The terms of reference for this study, as specified by CCA, are:

- Provide a general description of the local marine fauna in and around the proposed exploration area.
- Identify, describe and assess the significance of potential impacts of the proposed bathymetric and sediment sampling surveys on the local marine fauna.
- Identify practicable mitigation measures to reduce any negative impacts and indicate how these could be implemented in the implementation 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. Consequently, the description of the natural baseline environment in the study area is based on a review and collation of existing information and data from the scientific literature, internal reports and the Generic Environmental Management Programme report (EMPr) compiled for oil and gas exploration in South Africa (CCA & CMS 2001). The information for the identification of potential impacts on marine fauna was drawn from various scientific publications and the Generic EMPr as well as information sourced from the Internet. The 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 in the overall EMPr for the proposed project.

## 2. DESCRIPTION OF THE PROPOSED PROJECT

Block 11B/12B is located off the South Coast of South Africa roughly between Mossel Bay and St Francis Bay, and is approximately 18,734 $km^2$. Water depths in the exploration area range between 500 m and 2,000 m (Figure 1). TEPSA took over as operator of Block 11B/12B from CNR International (South Africa) Limited, which has retained a 50% working interest in the block.

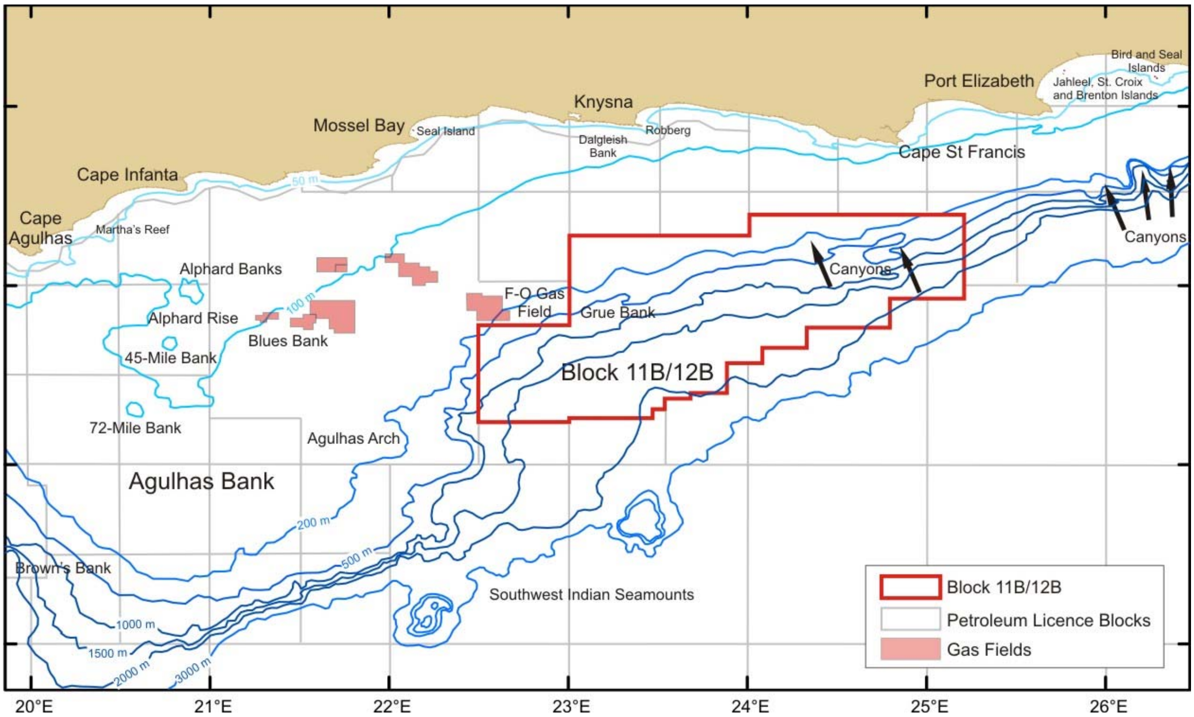

Figure 1: Bathymetry (after Sink *et al*. 2012b) and seabed features of the South Coast in relation to Block 11B/12B (red outline).

The proposed exploration activities would include a bathymetry survey and seabed sediment sampling, and are described in more detail below.

### 2.1. Bathymetry Survey

There are a number of different sonar surveying tools for investigating the structure of the ocean bed sediment layers (including depth sounders, side-scan sonar, bottom profilers and multi-beam bathymetry). Multi-beam bathymetry surveying is the most likely technique that would be used. However, the other techniques will also be considered in view of the tough operating conditions across the block.

The multi-beam bathymetry survey would be undertaken in small specific areas across the block, in order to produce a digital terrain model of the seafloor in the target area (Figure 2). The survey vessel would be equipped with a multi-beam echo sounder to obtain swath bathymetry, and a sub-bottom profiler to image the seabed and the near-surface geology. Alternatively depth sounders or side-scan sonar may be used. Although this type of survey typically does not require the vessel to tow any cables, it is "restricted in its ability to manoeuvre" due to the operational nature of this work.

### 2.1.1 Depth Sounders and Bottom Profilers

The majority of hydrographic depth/echo sounders are dual frequency, transmitting a low frequency pulse (typically around 24 kHz) at the same time as a high frequency pulse (typically around 200 kHz). Dual frequency depth/echo sounding has the ability to identify a vegetation layer or a layer of soft mud on top of a layer of rock. The pulse emitted would be for a duration of more than 0.025 seconds and typically produces sound levels in the order 180+ dB re 1 μPa at 1m.

Bottom profilers are powerful low frequency echo-sounders that provide profiles of the upper layers of the ocean floor. A typical bottom profiler emits an acoustic pulse at frequencies ranging from 0.4 to 30 kHz and typically produces sound levels in the order of 200-230 db re 1μPa at 1m.

### 2.1.2 Side-Scan Sonar

Side-scan sonar systems produce acoustic intensity images of the seafloor and are used to map different sediment textures. Side-scan uses a sonar device, towed from a surface vessel or mounted on the ship's hull, that emits conical or fan-shaped pulses toward the seafloor across a wide angle perpendicular to the path of the sensor through the water. The intensity of the acoustic reflections from the seafloor of the beam is recorded in a series of cross-track slices. When stitched together along the direction of motion, these slices form an image of the sea bottom within the swath of the beam. A typical side scan sonar emits a pulse at frequencies ranging from 50 to 500 kHz and typically produces sound levels in the order of 220-230 db re 1μPa at 1m.

### 2.1.3 Multi-beam Bathymetry

Multi-beam technology is a complex sonar array that allows surveying of the seafloor at a resolution and accuracy sufficient to image the typical scale of active seafloor seeps. The multi-beam system provides depth-sounding information on either side of the vessel's track across a swath width of approximately two times the water depth, thereby allowing for highly accurate imaging and mapping of seafloor topography in the form of digital terrain models. The multi-beam echo sounder emits a fan of acoustic beams from a transducer at frequencies ranging from 10 kHz to 200 kHz and typically produces sound levels in the order of 207 db re 1 μPa at 1 m (approximately 1,000 times less than a seismic survey). The sub-bottom profiler emits an acoustic pulse from a transducer at frequencies ranging from 3 kHz to 40 kHz and typically produces sound levels in the order of 206 db re 1 μPa at 1 m. The operating frequencies of the acoustic equipment used in sonar surveys typically fall into the high frequency kHz range, and are thus beyond the hearing abilities of most marine fauna.

These bathymetric data alone are not sufficient to identify all possible hydrocarbon seeps, as many seeps have no bathymetric expression. Backscatter data is typically collected concurrently by multi-beam echosounders as it can measure several properties of the seafloor associated with hydrocarbon seeps including; hardness; roughness; and volumetric heterogeneity. One or more of these three properties can result in an increase in backscatter intensity recorded by the multi-beam system and aid in the identification of potential natural hydrocarbon seeps on the seafloor in the survey area.

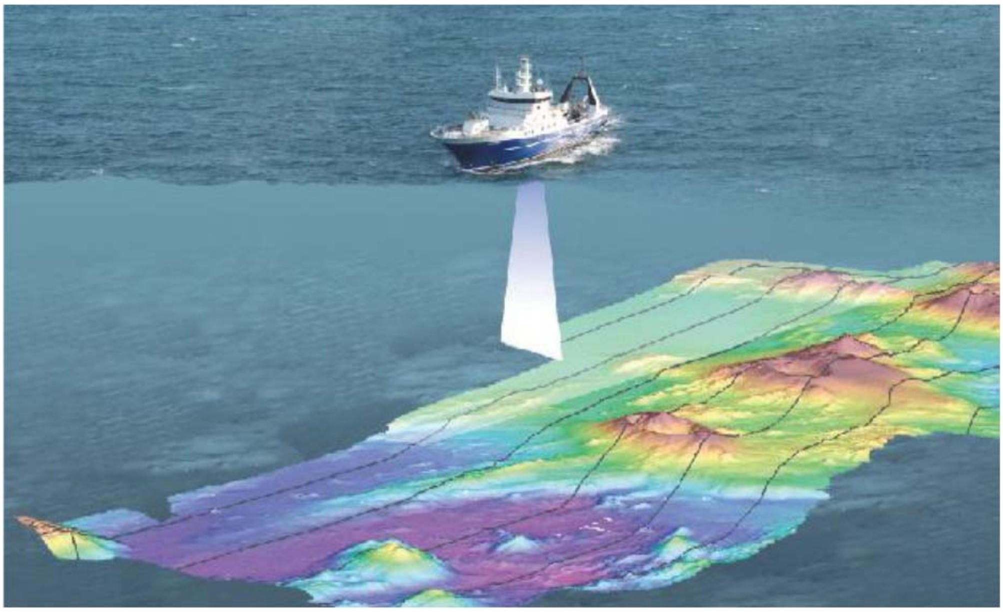

Figure 2: Schematic of a vessel using multi-beam depth/echo sounders (http://www.gns.cri.nz/).

It is anticipated that each data acquisition operation would take in the order of three to four weeks to complete. The data acquired by these sonar techniques would be used to identify, prioritise, and target potential sediment sampling locations.

## 2.2. Seabed Sediment Sampling

Having identified possible locations of natural hydrocarbon seeps on the seafloor using geophysical surveying techniques, targeted sediment sampling would be undertaken to collect seabed geochemical samples. The piston and box coring (or grab samples) techniques that would be used to collect seabed sediment samples are described in more detail below.

### 2.2.1 Piston coring

Piston core (or drop core) is one of the more common seafloor sampling methods. A piston coring device with ultra-short baseline (USBL) navigation would be used to accurately target and collect the seafloor samples (Figure 3). The programme would likely utilise a piston corer (~1,000 kg) capable of retrieving sediment samples that are up to a maximum of 6 m in length and 0.032 m in diameter.

The piston coring operation is carried out by winching the tool over the side of the vessel and lowering the corer to just above the seabed (A). As the trigger weight hits the bottom (B), it releases the weight on the trigger arm and the trigger arm begins to rise. Once the trigger arm has risen through its full 1.2 m of travel (C), the corer is released to "free-fall" the 3 m distance to the bottom, forcing the core barrel to travel down over the piston into the sediment. When the corer hits the end of its 3 m slack loop, the piston starts up the core barrel (D) creating suction below the piston, and expelling the water out the top of the corer. When forward momentum of the core has stopped, a slow pullout on the winch is begun. The suction created by the core sample in the liner prevents movement of the piston to the top of the core barrel in response to tension on the core wire. This suction triggers the separation of the top and bottom sections of the piston (E). The bottom half of the piston remains in place over the sediment to maintain integrity of the sample, while the top half (attached to the coring wire) "fetches up" against the stop in the core head, allowing the corer to be pulled out of the sediment and the sample to be hauled onboard. The recovered cores are visually examined at the surface for indications of hydrocarbons (gas hydrate, gas parting, or oil staining) and three sets of sub-samples retained for further geochemical analysis. Any material having geologic or environmental interest would be preserved for further study. The remaining sediment would be returned to the seabed.

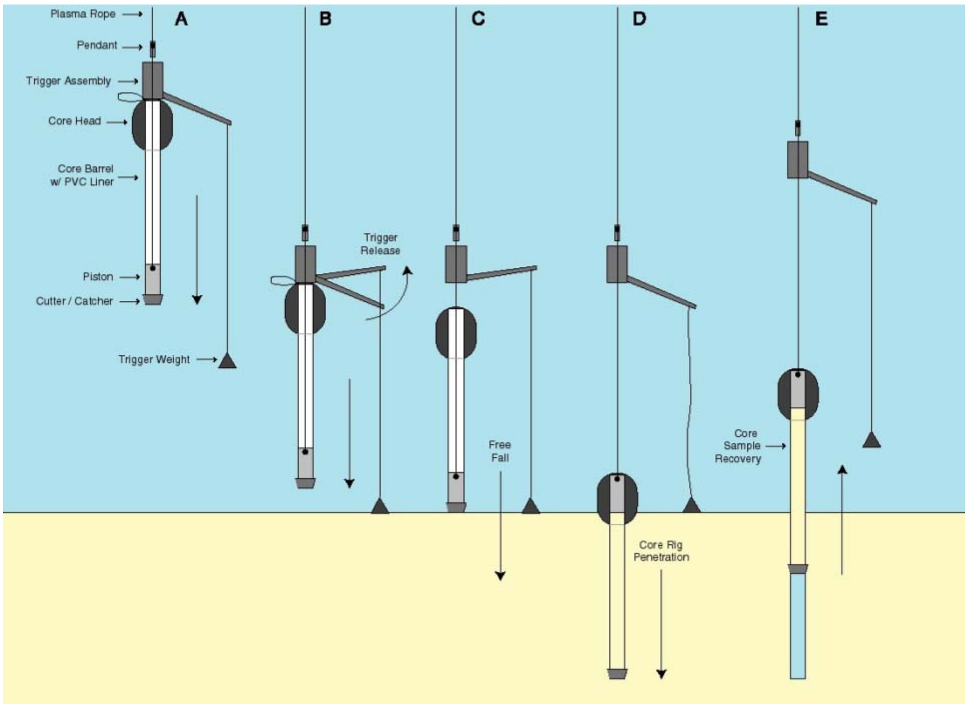


Figure 3: Schematic of a drop piston core operation at the seabed (from TDI Brooks).

### 2.2.2 Box Coring / Grab Sampling

The box corer (Figure 4) is deployed from a survey vessel by lowering it vertically to the seabed, where it is triggered by a trip as the main coring stem passes through its frame. The stem has a weight of up to 800 kg to aid penetration. While pulling the corer out of the sediment a spade swings underneath the sample to prevent loss. When hauled back on board, the spade is under the box thereby completely enclosing the recovered sample and reducing the loss of finer materials. Stainless steel doors, kept open during the deployment to reduce any "bow-wave effect" during sampling, are triggered on sampling and remain tightly closed, sealing the sampled water from that of the water column. On recovery, the sample can be processed directly through the large access doors or *via* the removal of the box, together with its cutting blade. A spare box and spade can then be added, ready for an immediate redeployment.

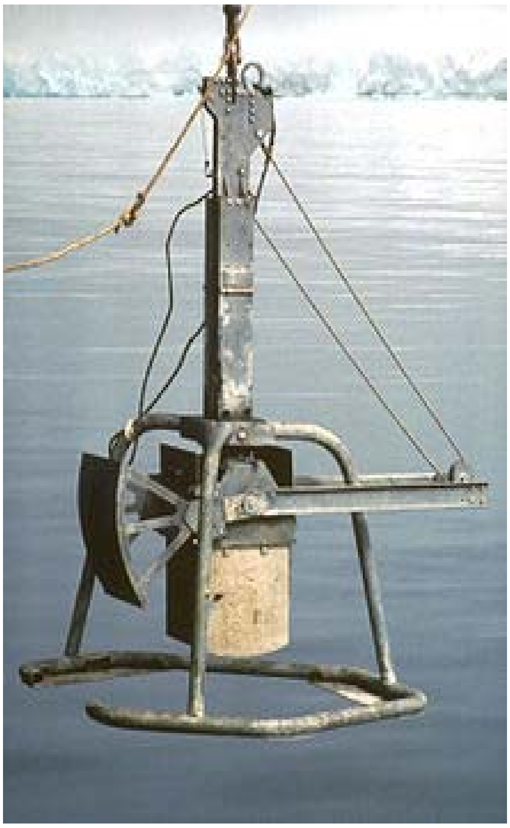

Figure 4: Box corer (http://en. wikipedia.org/ wiki/Box corer).

Grab sampling (Figure 5) is typically undertaken with a Van Veen grab, which samples an area of 0.2 $m^2$ of seabed, penetrating the sediment to a maximum of ~20 cm. As the grab retrieves only surficial sediments, this method cannot be used to characterise different sedimentary layers since a mixture of sediments is produced. Once the grab sampler is launched, the jaws open and it descends to the seafloor. On impact with the seabed, a spring is triggered, closing the jaws and trapping sediments or loose substrate. The grab sampler is then brought up to the surface where its contents are studied in detail.

The seabed sediment sampling would be undertaken in small specific areas across the block. Each individual piston and box core would have a maximum volume of 0.02 $m^3$ and 0.03 $m^3$, respectively. It should be noted that the total cumulative volume of material that would be removed from the seabed would be less than 5 $m^3$.

It is anticipated that the seafloor sampling would take in the order of three to five weeks to complete per sampling campaign.

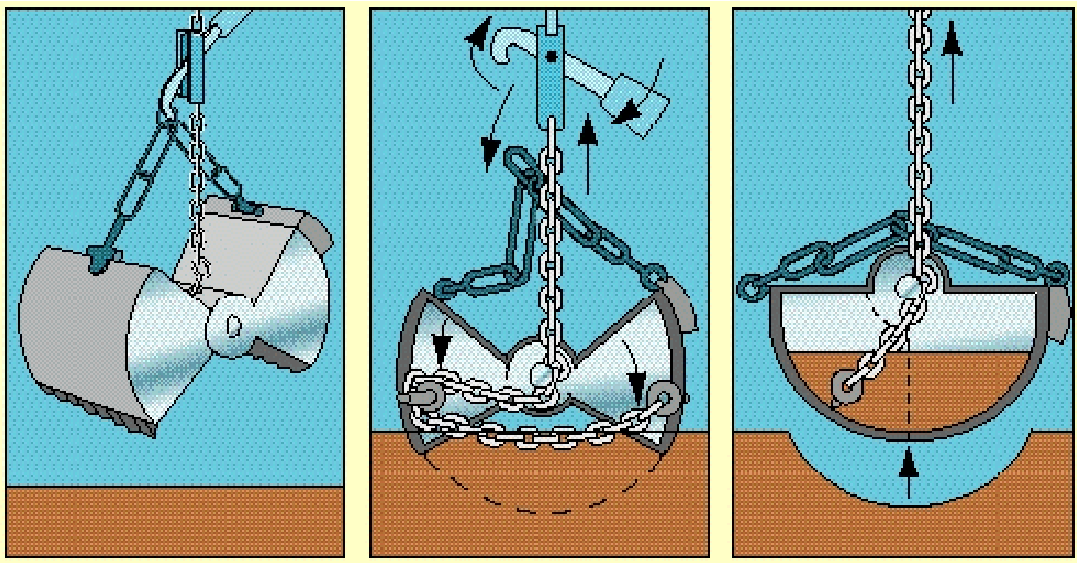

Figure 5: Grab sampler (Source: http://www.jochemnet.de/fiu/OCB3043_35.html).

# 3. DESCRIPTION OF THE AFFECTED MARINE ENVIRONMENT

Block 11B/12B is located on the warm temperate South Coast, which stretches from Cape Agulhas to Cape Padrone. Descriptions of the physical and biological environments are summarised primarily from information provided in the Generic EMPr for Oil and Gas Prospecting off the Coast of South Africa (CCA & CMS 2001) and more recent scientific studies undertaken in the general area.

## 3.1. The Physical Environment

### 3.1.1 Bathymetry and Sediments

Along the East coast, the bathymetry is characterised by a very narrow shelf, which widens in the region of Algoa Bay to the east of the project area. Moving westwards, depth increases more gradually to the shelf break, which is located at a depth of 140 m off Port Elizabeth, 130 m off Cape St Francis, and 300 m south of Cape Agulhas (Birch & Rogers 1973) (Figure 1). Between 22 and 23°E, the shelf break indents towards the coast forming the Agulhas 'bight' (Schumann 1998). At the apex of the Agulhas Bank the shelf widens to 250 km. Major bathymetric features on the Agulhas Bank include various banks (Alphard, 6-Mile, 12-Mile, 45-Mile and 72-Mile Banks, and the "Blues" and "Browns" Banks), situated south of Cape Infanta and off Cape Agulhas, the Agulhas Arch and Alphard Rise (Birch & Rogers 1973; CCA & CSIR 1998). Dalgleish Bank and Grue Bank lie due south of Knysna, with Grue Bank situated within Block11b/12B. Outside the shelf break, depth increases rapidly to more than 1,000 m (Hutchings 1994). Submarine canyons occur in the shelf break off Knysna, Plettenberg Bay and Port Elizabeth, with the Southwest Indian Seamounts situated to the east of the Agulhas Bank beyond 3,000 m depth (Sink *et al*. 2012a).

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

The seabed in the inshore region of the South Coast is largely dominated by rocky reefs. Westwards of Mossel Bay, an inner shelf sediment wedge extends up to 30 km offshore comprising soft liquid muds, whilst firm terrigenous sediment extends to the east of Mossel Bay. A large expanse of the Agulhas Bank mid-shelf seafloor comprises both rock and areas with sparse sediment cover (relic shelly sands, Dingle *et al* 1987). Along the eastern half of the South Coast, the seabed is predominantly rocky reefs (Birch & Rogers 1973). The benthic habitat types of the Agulhas Bank have been classified and mapped in detail through the 2011 National Biodiversity Assessment (Sink *et al.* 2012a, but see also Sink *et al*. 2012b).

In Block11B/12B the water depth ranges from 150 m to ~2,000 m. In the north of the block, the hard outer shelf sediments give way to sandy outer shelf and shelf edge sediments in the northeast and hard shelf edge sediments to the west. The seabed beyond 1,000 m depth is characterised by Southwest Indian upper bathyal unconsolidated sediments (Figure 6).

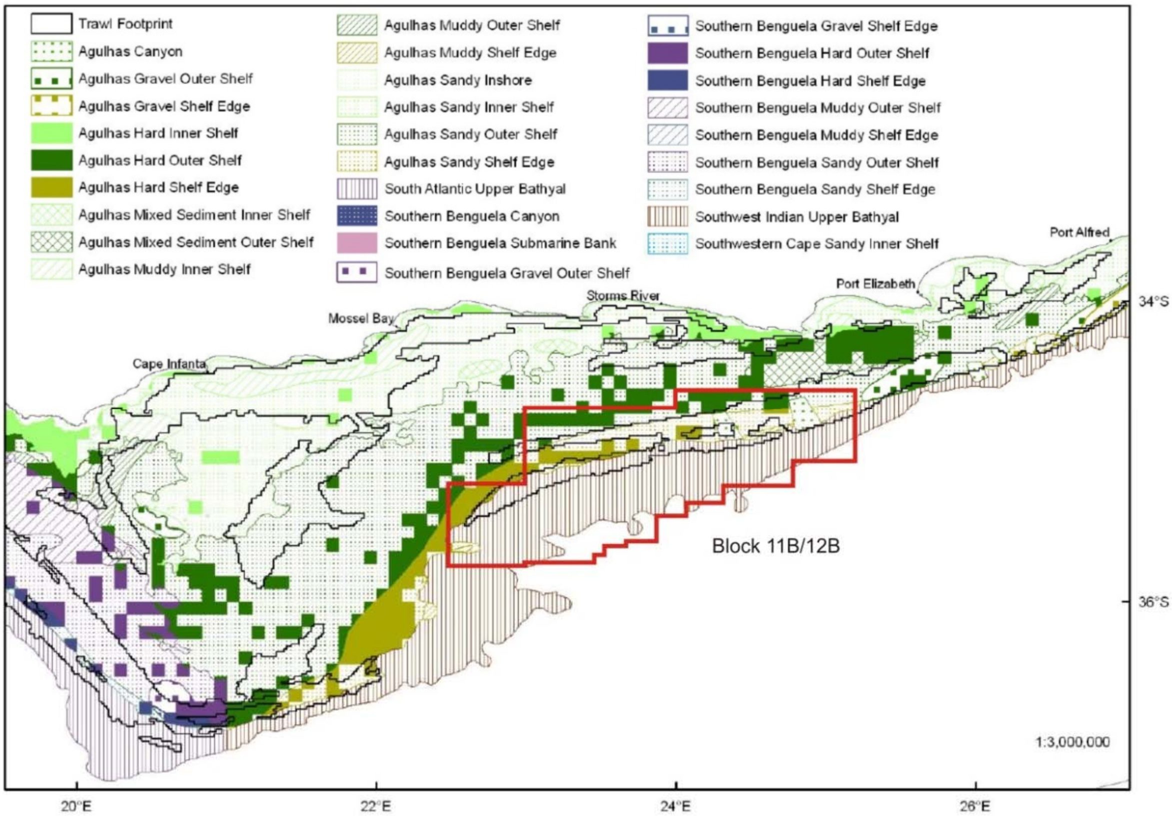


Figure 6: The distribution of benthic habitat types along the South Coast (adapted from Sink *et al*. 2012b). The location of Block 11B/12B (red polygon) is also indicated.

### 3.1.2 Water Masses and Circulation

The oceanography of this coast is almost totally dominated by the warm Agulhas Current (Figure 7). The current forms between 25° and 30° S, flowing southwards along the shelf edge of the southern African East Coast (Schumann 1998) as part of the anticyclonic Indian Ocean gyre. It is a well-defined and intense jet some 100 km wide and 1,000 m deep (Schumann 1998), flowing in a south-west direction at a rapid rate, with current speeds of 2.5 m/sec or more, and water transport rates of over 60 × $10^6$ $m^3$/sec have being recorded (Pearce *et al.* 1978; Gründlingh 1980). Following its divergence into deep water off the Tugela Bank, the Agulhas Current re-attaches itself to the coast south of Durban, where the continental shelf again narrows, until off Port Edward it is so close inshore that the inshore edge (signified by a temperature front) is rarely discernible (Pearce 1977). On the eastern half of the South Coast, the Agulhas Current flows along the shelf break at speeds of up to 3 m/sec, diverging inshore of the shelf break south of Still Bay (34° 28'S, 21° 26'E) before realigning to the shelf break off Cape Agulhas (Heydorn & Tinley 1980). The Agulhas Current may produce large meanders with cross shelf dimensions of approximately 130 km, which move downstream at approximately 20 km per day (Lutjeharms 2006). It may also shed eddies, which travel at around 20 cm/sec and advect onto the Agulhas Bank (Swart & Largier 1987; Penven *et al*. 2001) (Figure 8). After detaching from the shelf edge at 15°E, the Agulhas Current retroflects and flows eastwards (Schumann 1998).

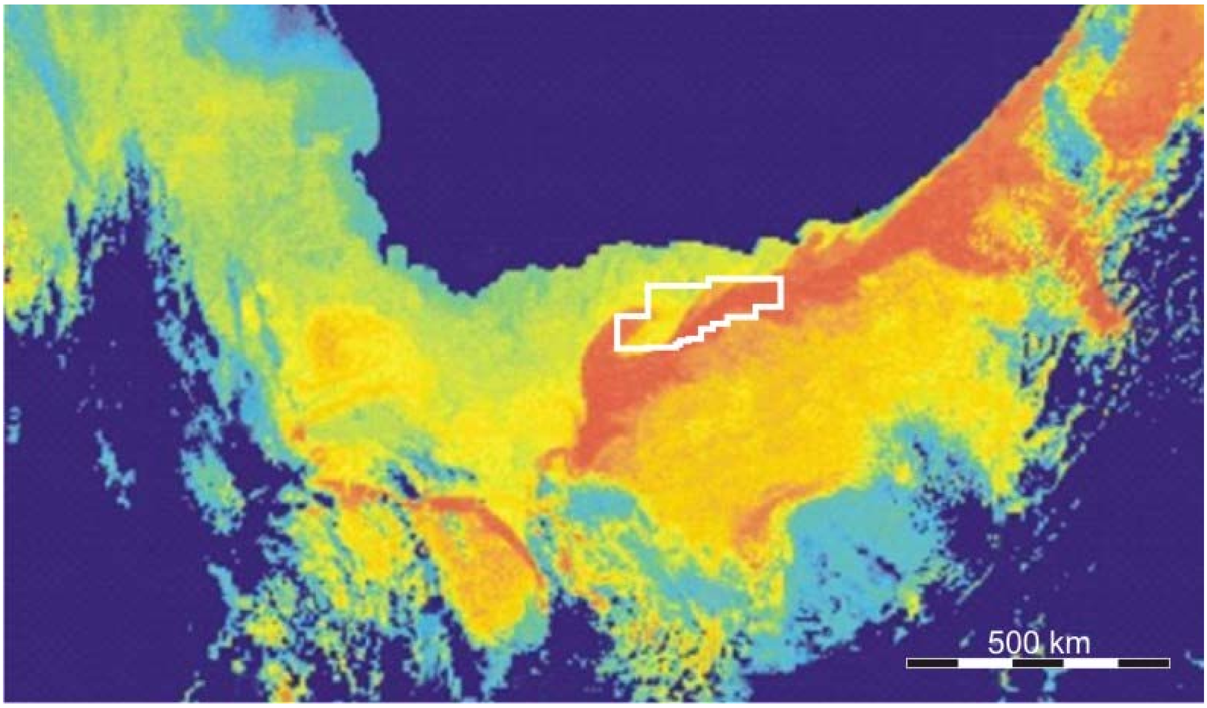


Figure 7: The predominance of the Agulhas current in the oceanography of the Block 11B/12B area (white outline).

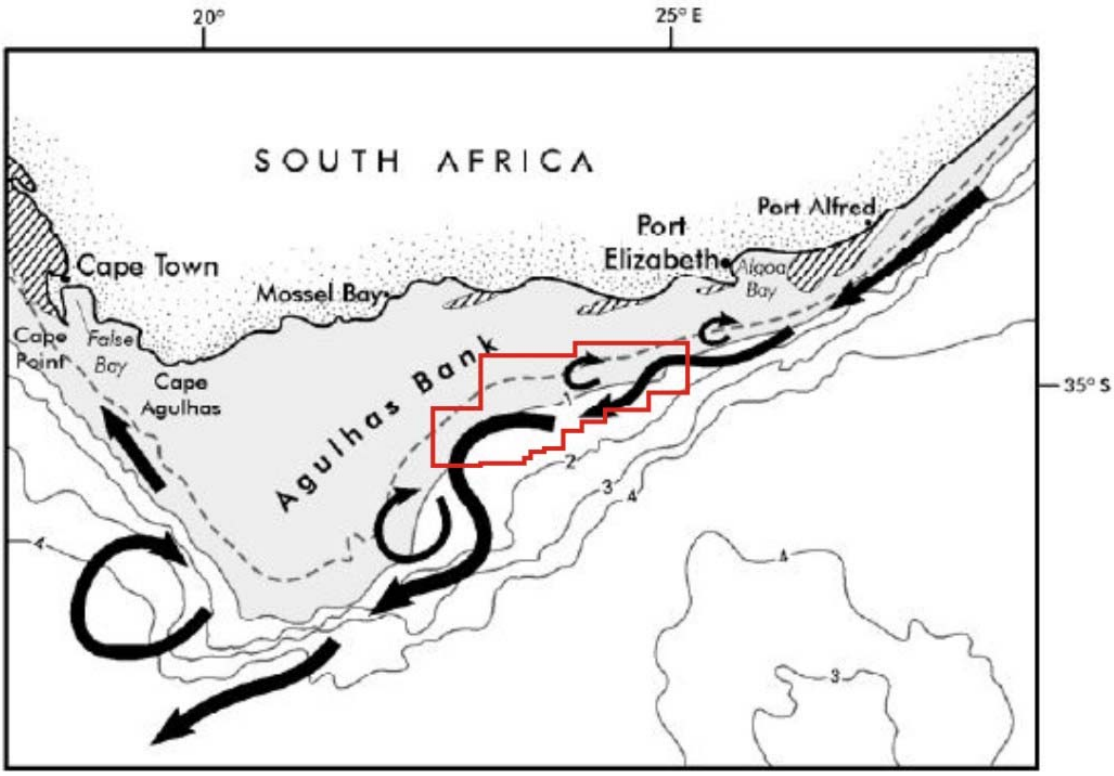


Figure 8: The major circulatory elements along the South Coast in relation to the Block 11B/12B area (red polygon). The broken line denotes the edge of the continental shelf (200 m isobath) and upwelling is shown by hatching. (adapted from Lutjeharms 2006).

Currents over the inner and mid-shelf (to depths of 160 m) are weak and variable, with velocities along the eastern half of the South Coast ranging from 25 - 75 cm/sec midshelf and 10 - 40 cm/sec nearshore. Eastward flow may occur close inshore (Boyd *et al*. 1992; Boyd & Shillington 1994), being particularly strong off Port Elizabeth. Bottom water shows a persistent westward movement, although short-term current reversals may occur (Swart & Largier 1987; Boyd & Shillington 1994; CCA & CSIR 1998).

As the Agulhas Current originates in the equatorial region of the western Indian Ocean its waters are typically blue and clear, with low nutrient levels. The surface waters are a mix of Tropical Surface Water (originating in the South Equatorial Current) and Subtropical Surface Water (originating from the mid-latitude Indian Ocean). The surface waters of the Agulhas Current may be over 25°C in summer and 21°C in winter and have lower salinities than the Equatorial Indian Ocean, South Indian Ocean Central water masses found below. Surface water characteristics, however, vary due to insolation and mixing (Schumann 1998). South Indian Ocean Central Water of 14°C and a salinity of 35.3 ppt occurs below the surface water layers at between 150 - 800 m depth. The deeper waters comprise, from shallowest to deepest, Antarctic Intermediate Water, North Indian Deep Water, North Atlantic Deep Water and Antarctic Bottom Water. Sub-tropical Surface Water of between 15 and 20º C often intrudes into the Agulhas Current at depths of 150 - 200 m from the east (Schumann 1998).

Seasonal variation in temperatures is limited to the upper 50 m of the water column (Gründlingh 1987), increasing offshore towards the core waters of the Agulhas Current. Inshore, waters are warmest during autumn, with warm water tongues found off Cape Recife (near Port Elizabeth) from January to March, and Knysna from October to January and during August. Warm water also tends to bulge towards Knysna between April and July and during September (Christensen 1980).

### 3.1.3 Thermal Structure and Variability

The thermal structure of Agulhas Bank waters is mediated by the intrusions of Agulhas Current water at surface and subsurface depths, upwelling and surface heating by insolation. At the inner boundary of the Agulhas current, cold bottom water is advected onto the Agulhas Bank via shelf-edge upwelling (Schumann 1998). This process is primarily due to frictional interactions between the Agulhas Current and bottom topography (Hutchings 1994), and is most intense at the eastern boundary of the South Coast, where the cold bottom layer breaks the surface. Such shelf-edge upwelling largely defines the strong thermocline and halocline topography that typically develops between the cold bottom water and the sun warmed surface layer during spring, summer and autumn.

On the central bank, a prominent feature of the midshelf is the ridge of cool water that extends in a north-east (NE) – south-west (SW) direction between the shelf-edge upwelling and inshore waters close to the coast (Swart & Largier 1987; Boyd & Shillington 1994; Schumann 1998). The ridge has its 'base' at the coast between Cape Seal and Cape St Francis and appears to be most prominent under SE wind conditions, which cause coastal upwelling in the Knysna region (Walker 1986; Boyd & Shillington 1994; Jury 1994). As easterly winds dominate in the spring-autumn period the cool water ridge is a semi-permanent feature during much of the year. Inshore of the cool water ridge, the thermoclines may be disrupted by coastal upwelling on the lee side of capes under easterly wind conditions (Schumann *et al*. 1982; Walker 1986;

Schumann 1998). Such upwelling usually begins at the prominent capes and progresses westwards (Schumann *et al*. 1982; Schumann 1988), and can result in temperature changes of up to 8°C within a few hours (Hutchings 1994).

The thermoclines on the central and eastern Agulhas Bank are resistant to breakdown under strong wind conditions due to their strong gradients and the fact that they are maintained by advection. Temperature gradients are usually around 5-6°C/10 m close inshore east of Cape Agulhas but reaching extremes of 10°C/10 m around the Alphard Banks and eastwards inshore towards Cape St. Francis. The thermoclines at the eastern edge of the South Coast are located at 20-40 m depth (Largier & Swart 1987). During strong winds, the isothermal upper mixed layer erodes down into the top of the thermocline, thereby increasing the temperature gradient and thus thermocline stability (Carter *et al*. 1987). In contrast, on the outer Bank, offshore of the cold water ridge, thermocline development is weak. In winter, when westerly winds dominate, the cold bottom water recedes to the shelf break and the nearer shore water column tends to become isothermal (Schumann & Beekman 1984; Boyd & Shillington 1994).

### 3.1.4 Winds and Swells

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

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

### 3.1.5 Nutrient Distributions

Nitrate-nitrogen concentrations in Agulhas Current source water range from 7-10 μM/l, while those of sub-thermocline water may be up to 20 μM/l (Carter *et al.* 1987). During winter, when the water column is well mixed, bottom nutrients mix upwards and nutrient concentrations in the surface waters are higher than in summer (CSIR & CCA 1998).

Primary production is nitrogen-limited in the upper layers of the euphotic zone, but light-limited in the sub-surface chlorophyll maximum layer (Probyn & Lucas 1987). It is unlikely that phosphorous would ever become limiting, except perhaps at the primary production maximum. Much of the ammonia and phosphorous needed for phytoplankton growth in the surface layers is supplied by heterotrophic microflagellates (1 - 5 μm) and nanoplankton (1 - 15 μm). However, size-related differences in the relative importance of the microplanktonic groups to the immobilization and recycling of different nutrients occur (Probyn & Lucas 1987). On the Agulhas Bank, the 1 – 5 μm size class were found to be a proportionally greater sink for phosphorous than for ammonium, immobilising on average 36% of the total phosphorous assimilated (Probyn & Lucas 1987). However, microplankton uptake and regeneration of both ammonium and phosphorus were approximately in balance, indicating that variations in assimilation ratios were the result of heterotrophic excretory activity. Here, picoplankton in the 15 – 200 µm size range were more important in the regeneration of phosphorous than of ammonium, the latter primarily being regenerated by the nanoplankton (1 – 15 µm).

### 3.1.6 Sedimentary phosphates

Phosphorite, or phosphate-rich rock is defined as sedimentary rock typically containing between 5%-20% phosphate. In the marine environment, it occurs either as a nodular hard ground capping of a few metres thick (Figure 9, left) or as series of unconsolidated sediments (Morant 2013). Several types of sedimentary phosphates occur offshore and onshore in South Africa, the largest of which is the diagenetic replacement resource on the Agulhas Bank. These replacement phosphate resources occur as near-continuous ‘pavements’ or cappings of limestones at depths between 200 m and 500 m on the continental shelf between Cape Agulhas and Cape Recife, covering an approximate area of 21,500 $km^2$. Further sporadic phosphate mantles over the continental shelf are known to occur from Lamberts Bay, north to the mouth of the Orange River (Figure 9, right).

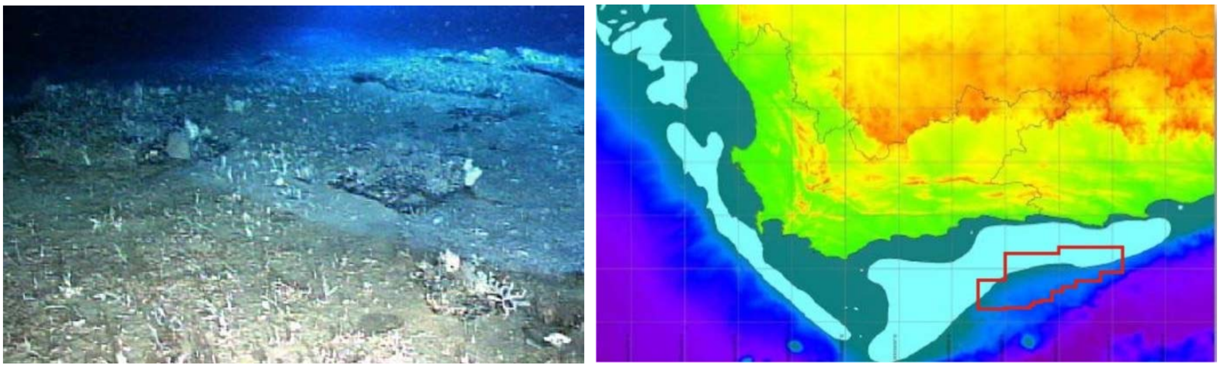

Figure 9: Phosphorite hard ground (left) and its distribution (blue) on the South African continental shelf (right) in relation to Block11B/12B (red polygon) (adapted from Morant 2013).

The “open shelf” phosphorite deposits, were formed during several episodes over the last 1.7 – 65 million years. They originated from the precipitation of phosphate in the form of calcium phosphate in an environment of intense upwelling and high biological activity along the continental margin of South Africa. The upwelling resulted in a change in temperature and pressure of the phosphate-laden oceanic waters, thus lowering the solubility of the phosphate salts they contained, and consequently precipitating the phosphates (in the form of apatite) over the continental shelf to form phosphatic packstones and colitic pellets at the sediment-water interface. The precipitation iis facilitated by the decay of siliceous phytoplankton. The precipitated phosphates subsequently combined with calcium, derived from the disaggregation of calcareous foraminiferal and coccolithophorid debris on the outer continental shelf, to form phosphatised lime-rich muds. These muds subsequently lithified or consolidated through their replacement by secondary calcium phosphate (francolite), to form a near continuous hard capping of phosphate rock over the seafloor sediments (Birch 1990; Morant 2013).

During repeated sea level changes, the phosphate-rich rocks were extensively re-worked, eroding the hard capping pavements thereby liberating the heavy phosphate-bearing minerals (mainly glauconite and apatite) and concentrating them in the overlying unconsolidated sediments. Migrating zones of deposition and erosion occurred during repeated transgressive/regressive cycles. Renewed carbonate deposition and a further period of phosphatization occurred when the deposition zones migrated back across the shelf in response to a rising sea level, thereby incorporating boulders and cobbles of phosphatized limestone and glauconite left behind after the previous regressive cycle into the second-generation phosphatic deposits, forming conglomeratic rock types. Two main periods of phosphatization have been identified, namely the Middle Miocene (ca. 15 Ma), and possibly the Upper Eocene (ca. 37 Ma) (Birch 1990; Morant 2013).

The ore bearing lithologies comprise three non-conglomeratic and two conglomeratic rock types. The non-conglomeratic types are phosphatized foraminiferal lime packstones (a type of limestone), which are either poor in glauconite and quartz, rich in goethite, or highly glauconitic. The first conglomeratic type is also rich in glauconite, but contains pebble inclusions of phosphatized foraminiferal limestone. The second conglomeratic type is distinguished by its low glauconite content and high macrofossil and goethite abundance. The depth of mineralization within the conglomeratic ores is typically restricted to the upper few metres of sediment. The phosphate-rich rocks on the Agulhas Bank are estimated to have an average $P_2O_5$ content of 16.2%. With an area of 35,000 million $m^2$, an average thickness of 0.5 m, the Agulhas Bank offshore phosphate deposits are estimated to contain in the order of 5,000 million tons of $P_2O_5$ (Birch 1990).

Although not mined at present, an application application to prospect for marine phosphate in the Outeniqua West Licence Area, Offshore Mossel Bay, was submitted to the Department of Mineral Resources by Diamond Fields International Ltd in June 2013 (Morant 2013).

## 3.2. The Biological Environment

The Block 11B/12B petroleum Exploration Area is located between the coastline and ~2,000 m depth contour and falls within the Agulhas Inshore and West Indian Offshore bioregions (Emanuel *et al* 1992; Bustamante & Branch 1996; Lombard *et al*. 2004) (Figure 10). Communities within marine habitats are largely ubiquitous throughout the southern African South Coast region, being particular only to substrate type or depth zone. The biological communities occurring in the Block 11B/12B area consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales). Beyond the surf-zone, marine ecosystems comprise a limited range of habitats, namely unconsolidated seabed sediments, rocky 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 species.

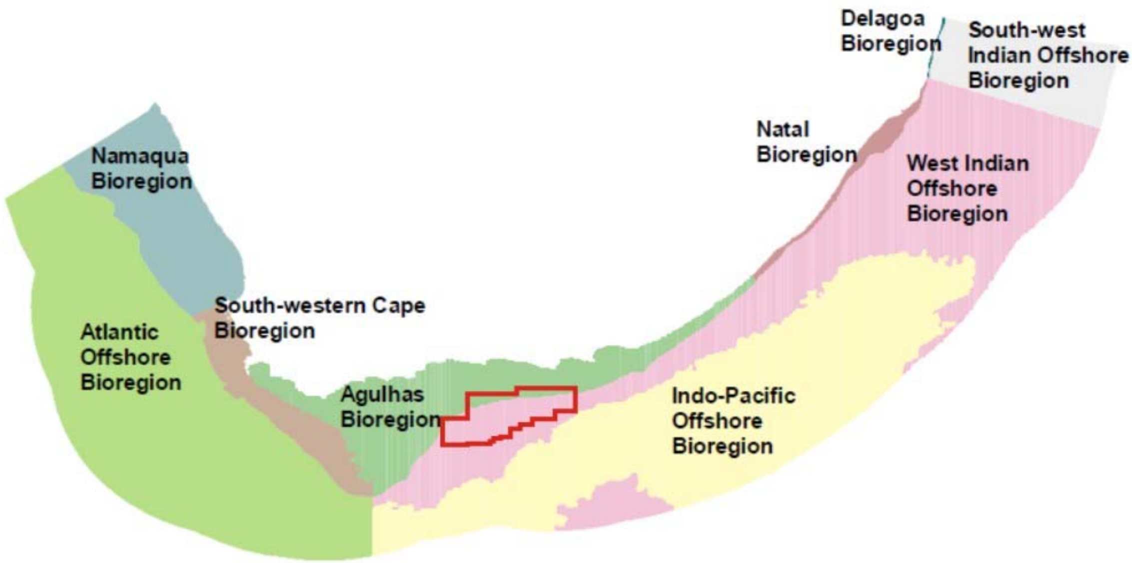


Figure 10: The inshore and offshore bioregions of the South African coast in relation to Block 11B/12B (red polygon) (adapted from Lombard *et al*. 2004).

### 3.2.1 Phytoplankton

Agulhas Bank surface waters are characterised by generally low phytoplankton biomass due to nutrient limitation during periods when strong thermoclines occur, or during deep mixing in winter (Probyn *et al.* 1994). Phytoplankton biomass is generally restricted to a <10 m thick layer, but can increase dramatically when thermocline falls within chlorophyll concentrations in excess of 10 mg/m$^3$ having frequently been observed (Carter *et al*. 1987; Hutchings 1994). Overall phytoplankton production is 200 – 800 mg C/m$^2$/hr with generally large-celled diatoms and dinoflagellates dominating the subsurface phytoplankton community (Figure 11), but declining to near zero concentrations of phytoplankton in bottom waters.

Chlorophyll concentrations can also be high where upwelling occurs at the coast (Probyn *et al*. 1994). Along the eastern half of the South Coast (Knysna to Cape Padrone), phytoplankton concentrations are usually higher than further west and the phytoplankton comprises predominantly large cells (Hutchings 1994). In inshore areas (<200 m depth), mean chlorophyll *a* concentrations of 1.46 mg/m$^3$ in the top 30 m of the water column have been reported, dropping to 1.00 mg/m$^3$ further offshore (200 m – 500 m depth)(Brown *et al*. 1991; Brown 1992). Chlorophyll *a* concentrations vary seasonally, being minimal in winter and summer (<1 – 2 mg/m$^3$), and maximal (2 - 4 mg/m$^3$) in spring and autumn (Brown 1992).

Although seasonal diatom blooms do occur along the South Coast and on the Agulhas Bank, the red tides (harmful algal blooms (HAMs)) characteristic of the Benguela upwelling system are seldom reported east of Cape Agulhas (Pitcher & Calder 2000).

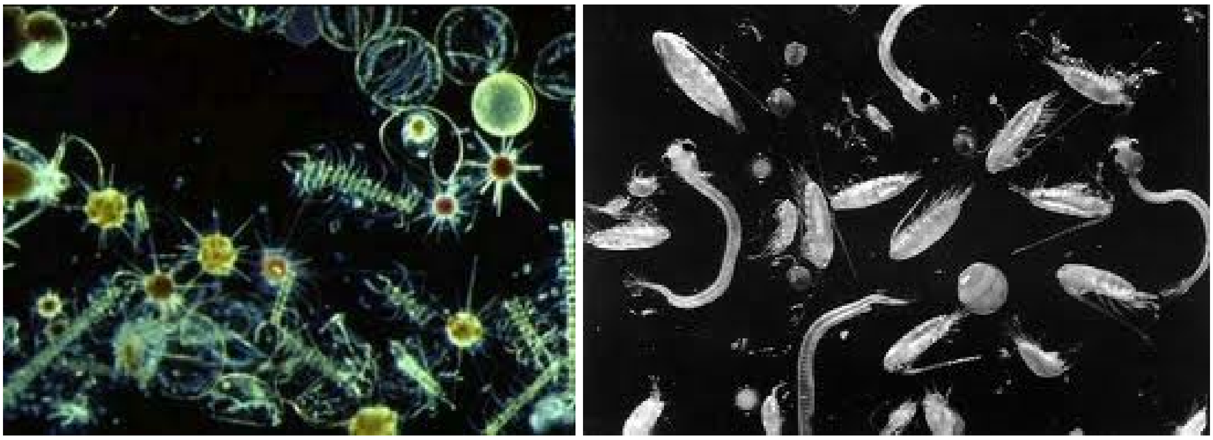

Figure 11: Phytoplankton (left, photo: hymagazine.com) and zooplankton (right, photo: mysciencebox.org) is associated with upwelling cells on the Namibian shelf.

### 3.2.2 Zooplankton

On the South Coast zooplankton communities (Figure 11) have comparatively high species diversity (De Decker 1984), with standing stocks along the eastern half of the South Coast ranging from 3 – 6 g C/m$^2$. The South Coast mesozooplankton (>200 µm) is dominated by the calanoid copepod *Calanus aghulensis*, which associates with shallow thermoclines and the mid-shelf cool water ridge (Verheye *et al*. 1994). This species may contribute up to 85% of copepod biomass in the region, and is an important food source for pelagic fishes (Peterson *et al*. 1992). Biomass of mesozooplankton increases from west (~0.5-~1.0 g C/m$^2$) to east (~1.0-~2.0 g C/m$^2$), mirroring the eastward increase in *chlorophyll a* concentrations, peaking on the central and eastern Agulhas Bank during summer in association with the subsurface ridge of cool upwelled water. Macrozooplankton (>1,600 µm) standing stocks are estimated to be 0.079 gC/m$^2$ between Cape Agulhas and Cape Recife (Verheye, unpublished data). Dense swarms of euphausiids dominate this zooplankton component, and form an important food source for pelagic fishes (Cornew *et* al. 1992; Verheye *et al*. 1994). Salps and doliolids sometimes reach very high biomass levels on the Agulhas Bank and form large swarms (De Decker 1973). There are insufficient data available on these phenomena to identify the oceanographic conditions that allow these swarms to develop.

### 3.2.3 Ichthyoplankton

A variety of pelagic species, including anchovy, pilchard, and horse mackerel, are reported to spawn east of Cape Agulhas between the shelf-edge upwelling and the cold-water ridge, where copepod availability is highest (Crawford 1980; Hutchings 1994; Roel & Armstrong 1991; Hutchings *et al*. 2002) (Figure 12). The eggs and larvae spawned in this area are thought to largely remain on the Agulhas Bank, although some may be carried to the West Coast or be lost to the Agulhas Current retroflection (Hutchings 1994; Duncombe Rae *et al*. 1992; Hutchings *et al*. 2002). Pilchards also spawn on the Agulhas Bank (Crawford 1980), with adults moving eastwards and northwards after spawning. Round herring are also reported to spawn along the South Coast (Roel & Armstrong 1991). Demersal species that spawn along the South Coast include the cape hakes and kingklip. Spawning of the shallow-water hake occurs primarily over the shelf (<200 m) whereas that by the deep-water hake occurs off the shelf. Similarly, kingklip spawn off the shelf edge to the south of St Francis and Algoa Bays, and thus on the eastern edge of Block 11B/12B (Shelton 1986; Hutchings 1994) (Figure 12). Squid (*Loligo* spp.) spawn principally in the inshore waters (<50 m) between Knysna and Port Elizabeth, with larvae and juveniles spreading westwards. Their distribution and abundance is highly erratic and linked to temperature, turbidity, and currents (Augustyn *et al*. 1994).

The inshore area of the Agulhas Bank, especially between the cool water ridge and the shore, serve as an important nursery area for numerous linefish species (e.g. elf *Pomatomus saltatrix*, leervis *Lichia amia*, geelbek *Atractoscion aequidens,* carpenter *Argyrozona argyrozona*) (Wallace *et al*. 1984; Smale *et al*. 1994). Adults undertake spawning migrations along the South Coast into KwaZulu-Natal waters (Van der Elst 1976, 1981; Griffiths 1987; Garret 1988; Beckley & van Ballegooyen 1992). The eggs and larvae are subsequently dispersed southwards by the Agulhas Current, with juveniles occurring on the inshore Agulhas Bank (Van der Elst 1976, 1981; Garret 1988). In the case of the carpenter, a high proportion of the reproductive output comes from the central Agulhas Bank and the Tsitsikama Marine Protected Area (MPA), and two separate nursery grounds appear to exist, one near Port Elizabeth and a second off the deep reefs off Cape Agulhas, with older fish spreading eastwards and westwards (van der Lingen *et al*. 2006)

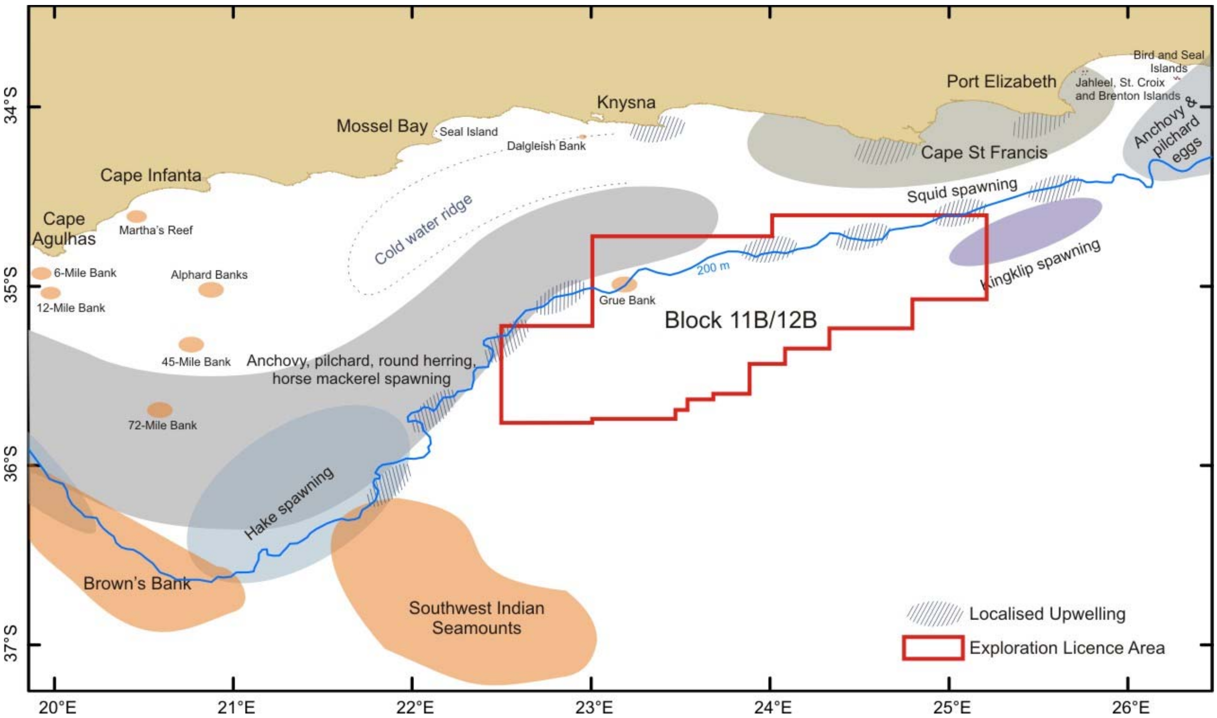


Figure 12: Important fishing banks, seamounts, pelagic and demersal fish and squid spawning areas in relation to Block 11B/12B (red outline) (after Anders 1975; Crawford *et al*. 1987; Hutchings 1994).

### 3.2.4 Benthic Invertebrate Communities

The seabed communities in the Block 11B/12B area lie within the Agulhas sub-photic and continental slope biozones, which extend from a 30 m depth to the shelf edge, and beyond to the lower slope, respectively. These biozones lies within the 'minimal protected category' (1 - 5%) and portions of the shelf area are defined as 'Vulnerable', 'Endangered' or 'Critically Endangered' as existing Marine Protected Areas (MPAs) are insufficient for conserving marine habitats and their associated biodiversity (Lombard *et al*. 2004; Sink *et al*. 2012a) (Figure 13). Based on the high endemism known to occur there, the coastal area in the vicinity of Mossel Bay has been recognised as one of seven areas in the biozone in need of additional protection. Extractive utilisation of marine resources has been identified as the greatest threat to biodiversity in the biozones (Lombard *et al*. 2004; Sink *et al*. 2012a).

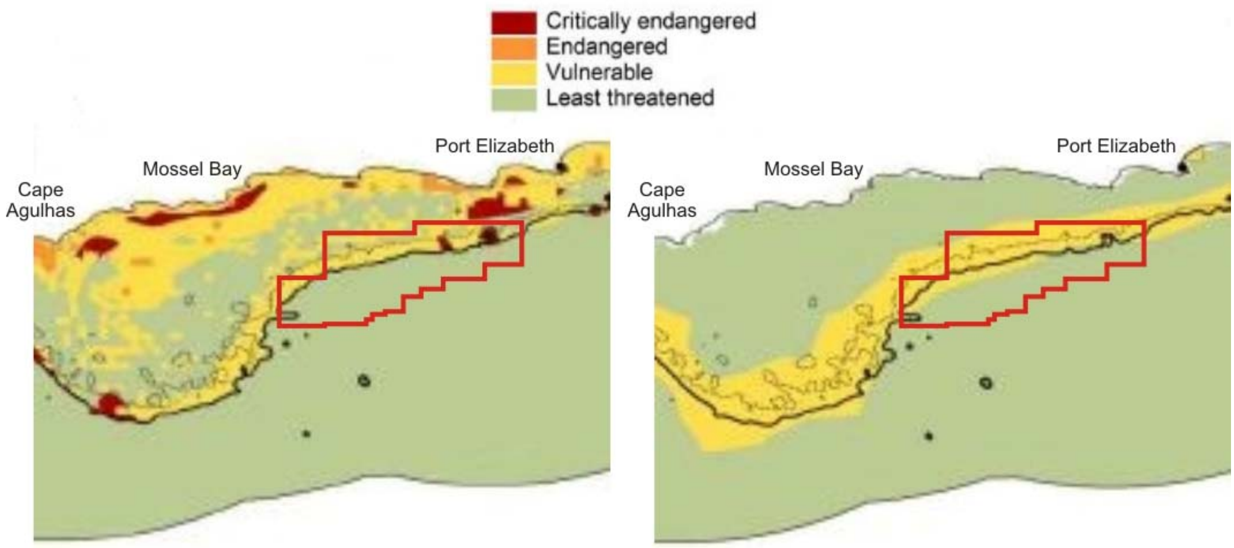


Figure 13: Ecosystem threat status for coastal and offshore benthic habitat types (left), and offshore pelagic habitat types on the South African South Coast in relation to Block 11B/12B (red outline) (adapted from Sink *et al*. 2012).

The benthic biota of offshore substrates constitutes invertebrates that live on (epifauna), or burrow within (infauna), the sediments, and are generally divided into megafauna (animals >10 mm), macrofauna (>1 mm) and meiofauna (<1 mm). The structure and composition of benthic communities is primarily a function of abiotic factors such as water depth and substratum (e.g. sediment grain size in unconsolidated sediments; reef structure/topography in areas of hard ground), but others such as current velocity and organic content abundance also play a role (Snelgrove & Butman 1994; Flach & Thomsen 1998; Ellingsen 2002). Further shaping is derived from biotic factors such as predation, food availability, larval recruitment and reproductive success. In unconsolidated sediments, the high spatial and temporal variability of these factors, results in seabed communities being both patchy and variable. In nearshore waters (<50 m) where sediment composition is naturally patchy, and significant sediment movement may be induced by the dynamic wave and current regimes (Fleming & Hay 1988), the benthic macrofauna are typically adapted to frequent disturbance. In contrast, further offshore where near-bottom conditions are more stable, the macrofaunal communities will primarily be determined by sediment characteristics and depth.

As information on offshore benthic invertebrate communities occurring along the South Coast is sparse, and no formally, peer-reviewed literature is currently available, PetroSA funded a study through a sponsorship agreement with WWF, to assess the offshore benthic biodiversity on the Agulhas Bank (Sink *et al*. 2010). Much of the description below is taken from that report, and from the specialist reports by Quick & Sink (2005) and Shipton & Atkinson (2010) compiled as part of the EIAs for the South Coast Gas project and development of the F-O Gas Field, respectively.

These authors categorised the benthic communities expected to occur on the Agulhas Bank into four main groups, based on the distribution of the main seabed types identified by Dingle *et al*. (1987). These were:

1. **Terrigenous muds**: although no studies have specifically examined the biota of this habitat type in South Africa, a high biodiversity of benthic macrofauna (polychaetes, nematodes, amphipods, isopods, molluscs, echinoderms etc.) is expected.
2. **Relict shelly sands**: sandy habitats of varying grain size typically provide relatively stable environments and are thus able to support highly diverse benthic communities, including seapens, molluscs, echinoderms (brittle stars and heart urchins), cerianthids (tube anemones), sponges and the deep-water rock lobster *Palinurus gilchristi*. A wide diversity of infauna also occurs, including polychaetes, amphipods, isopods, molluscs, etc.
3. **Pre-Mesozoic basement rock:** this low profile habitat typically hosts sponges, black corals, gorgonians and ascidians (Sink *et al.* 2006). Although often covered in a thin layer of sediment, the scattered, emergent rock fragments or debris support colonisation by colonial benthic invertebrates.
4. **Pre-Mesozoic rock outcrops** – these highly structured reef areas are likely to be characterised by highly diverse benthic and motile biota including sponges, azooxanthellate corals, octocorals, gorgonians, black corals, cerianthids and stylasterine lace corals, bryozoans, ascidians, basket stars and the South Coast rock lobster *Palinurus gilchristi*. Fauna occurring in the deeper reef areas and canyons have community assemblages distinctly different to those from shallower reefs, as also evident in the Greater St Lucia Wetland Park, where deep reefs and canyons support unique and diverse invertebrate fauna (Sink *et al.* 2006).

These stable habitats have been identified as sensitive, as the fauna typically associated with them are frequently slow-growing, slow to mature and long-lived, making them particularly vulnerable to disturbance. The Agulhas Bank hosts a diversity of deep-water corals and sponges (Figure 14 and Figure 15), that have 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. Reef-building cold water corals have also been documented within the Southwest Indian Upper Bathyal, Agulhas Sandy Shelf Edge and in association with deep reefs and submarine canyons on the Agulhas Inner Shelf and Shelf Edge respectively (Sink & Samaai 2009; Sink *et al.* 2011). Substantial shelf areas should thus potentially be capable of supporting rich, deep-water benthic, filter-feeding communities. Corals and sponges add structural complexity to otherwise uniform seabed habitats thereby creating areas of high biological diversity (Breeze *et al*. 1997; MacIssac *et al*. 2001). Their frameworks offer refugia for a great variety of invertebrates and fish (including commercially important species) within, or in association with, the living and dead frameworks.

Nonetheless, our understanding of the invertebrate fauna of the sub-photic zone is relatively poor (Gibbons *et al*. 1999) and the conservation status of the majority of invertebrates in this bioregion is not known. Quick & Sink (2005) collated records from the South African Museum of species from the Agulhas Bank area. These included a wide variety of seapens, alcyonacean soft corals, gorgonians and ascidians, many of which are regarded as endemic to the bioregion (see Tables 5.1 and 5.2 in Quick & Sink 2005 for details). This was supplemented by information obtained through analysis of ROV footage taken in reef and unconsolidated habitats and on gas-field infrastructure, SAT diver collections, trap sampling and grab sampling as part of the dedicated PetroSA-WWF study (Sink *et al*. 2010). A synthesis of the invertebrate and fish fauna reported from these studies is provided below.

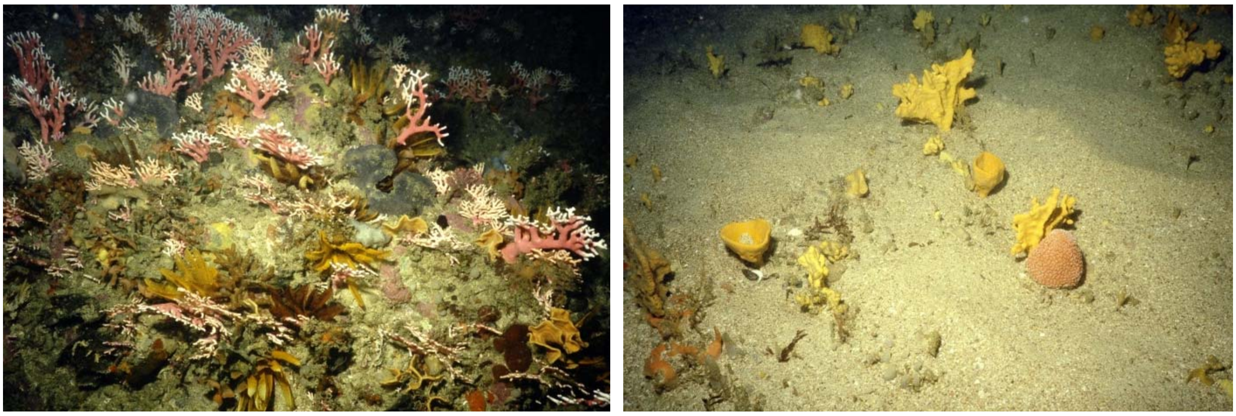

Figure 14: Offshore benthic communities occurring on reefs on the central Agulhas Bank include protected cold water porcelain coral *Allopora nobilis*, sponges, crinoids and bryozoans (Left), whereas a variety of habitat-forming sponges, colonial ascidians and hydroids occur on sandy seabed (Right) (Photos: Andrew Penney).

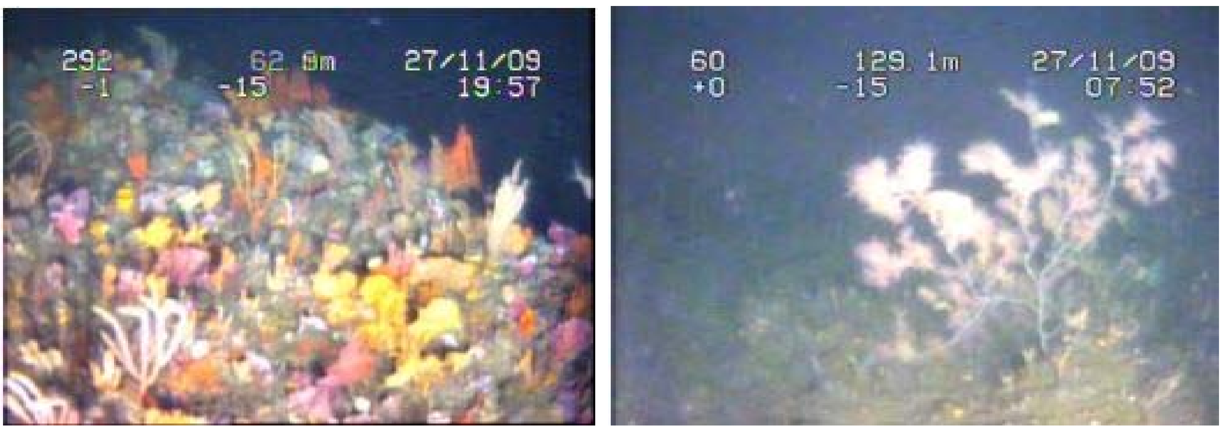


Figure 15: Vulnerable sponge- and soft coral-dominated biota at the Alphard Bank (Left) and black coral at the 72-Mile Bank (from Sink *et al*. 2010).

The deep water reefs (Alphard, 45-Mile and 72-Mile Banks) support exceptionally diverse and dense assemblages with clear depth zonation patterns. Whereas the shallower regions of the Alphard Banks (16 to 90 m) supported a kelp community dominated by *Ecklonia radiate,* the invertebrate fauna in deeper regions included a high diversity of sponge species (*Antho kellyae*, *Biemna anisotoxa*, *Clathria* spp., *Isodictya elastic, I. frondosa* and *Polymastia* sp.), fragile bryozoans, slow-growing hydrocorals (*Allopora nobilis* and *A. subviolacea*), gorgonians (*Eunicella albicans*, *Eunicella tricorona, Leptogorgia palma* and *Homophyton verrucosum*), gorgonian whip corals (resembling *Ctenocella* sp.) and black corals (*Antipathes* sp.).

In the 68 – 75 m depth range of the 45-Mile Bank (60 and 100 m), the invertebrate fauna included large cup- and vase-shaped sponges (*Hemiasterella vasiformis*, *Suberites* sp. and *Axinella* spp.), Geodiid and stove-pipe sponges, black corals, gorgonians, alcyonarian soft corals and slow growing hydrocorals, as well as a diverse fish assemblage. The 110 to 140 m depth range of the 72-Mile Bank revealed a "mass occurrence" of the tubular sponge *Biemna anisotoxa*, as well as *Geodia* sp. *Geodia megastar*, *Pachastrella* sp., *Stelleta trisclera* and *Erylus* sp. Hard corals (*Balanophyllia* and *Caryophyllia*), black corals, hydrocorals and gorgonians (*Eunicella papillosa)* are also present, with high variability in terms of invertebrate diversity and abundance within the reef complex again being evident. Echinoderms included the urchin *Echinus gilchristi* and an unidentified conspicuous orange starfish. Broken bryozoans (*Reteporella* spp.) and solitary hard corals (*Caryophyllia* spp.), occurred at deeper depths.

Benthic epifaunal assemblages on unconsolidated sediments near the 45-Mile Bank were dominated by spiral whelk shells and various isolated sponges, bryozoans and/or soft corals, suggesting the area may be low profile reef inundated with a layer of sand. Unconsolidated sediments within Block 9 and the frequently-trawled "Blues" area were dominated by the urchins (*Spatangus capensis*, *Brissopsis lyrifera capensis* and *Echinus gilchristi*), starfish (*Marthasterias glacialis, Toraster* sp.), sponges, spiral whelk shells, horsemussels, crabs (*Mursia cristiata, Gonoplax angulatus*), seapens, soft corals (possibly *Alcyonarium variable*) and burrowing tube anemones (*Cerianthus* sp.).

The benthic environment within the vicinity of the F-O Gas Field was characterised by sandy unconsolidated sediment with several isolated rocky outcrops (Figure 16). Bioturbation at the sediment surface suggests a rich infaunal community. The rocky outcrops also support a diverse range of gorgonians, bryozoans and sponges. The combination of habitat types (soft sediments and rocky formations) results in a highly diverse benthic fauna.

In addition to the benthic invertebrates inhabiting deep reefs and unconsolidated sediments in the general project area, distinct communities have developed associated with petroleum infrastructure on the Agulhas Bank oil fields. The fouling assemblages are structured with depth; invertebrate communities in shallower water (0 - 30 m) resemble communities typical of rocky intertidal and shallow subtidal ecosystems in the region. In deeper water, however, there is only partial overlap with species recorded on deep reefs in the area, with sponges, soft corals, anemones and bryozoans associated with petroleum infrastructure being distinct from those of deep reef ecosystems. Furthermore, several areas of infrastructure were dominated by introduced taxa that are not representative of the indigenous biodiversity of the region.

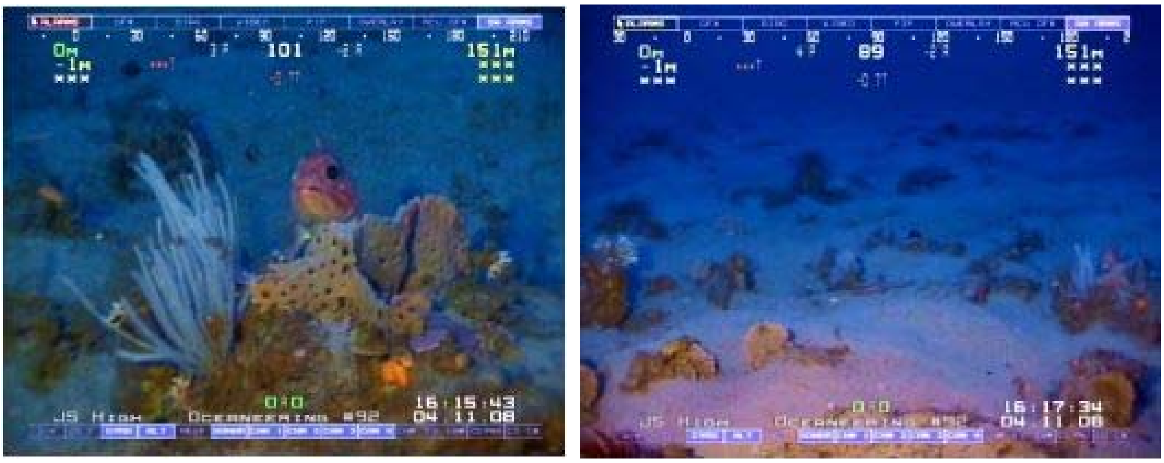

Figure 16: Sandy seabed with rocky outcrops characterising the F-O Field area (from Shipton & Atkinson 2008).

Inshore of Block 11B/12B, at depths between 5 m and 30 m lie the Agulhas Inshore Reef and Agulhas Inshore Hard Ground benthic habitats, identified by Sink *et al*. (2012a) as 'Critically endangered - Moderately protected', and 'Vulnerable - Moderately protected', respectively. These reefs and hard grounds extend from the Mbashe River (east of East London) to Cape Point (Figure 17). The reefs are considered to be warm temperate reefs, which have have a more heterogeneous community structure when compared with those in the Southwestern Cape and Natal inshore regions

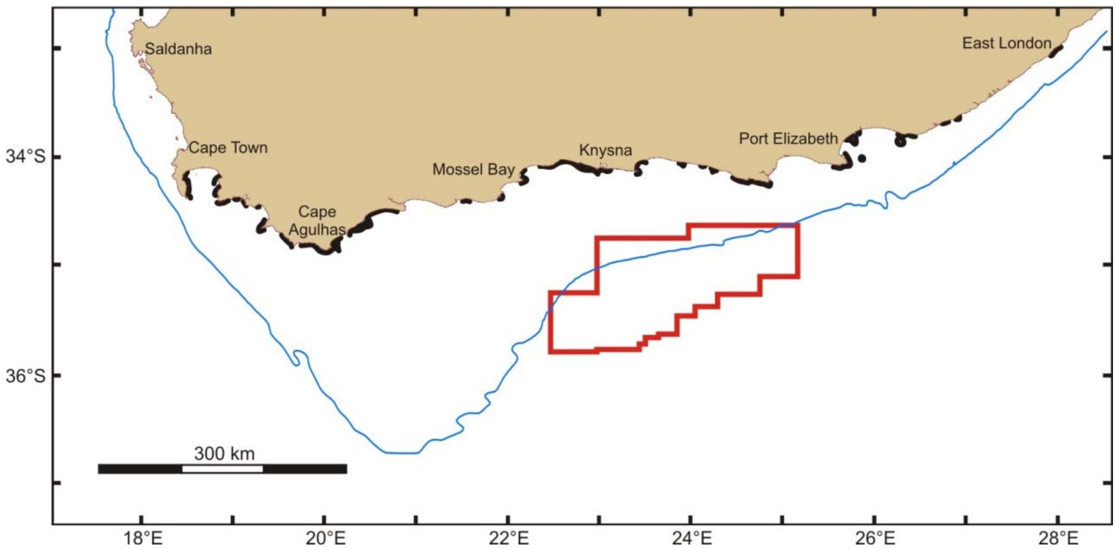


Figure 17: The extent of the Agulhas Inshore Reef and Hard Ground habitat types in relation to Block11B/12B (adapted from Sink *et al*. 2012a).

Agulhas reefs are dominated by sponges (e.g. golf ball sponge *Tethya aurantium*, the black stink sponge *Ircinia arbuscula*, the orange teat sponge *Polymastia mamillaris* and *Clathria* *spp*.), ascidians (e.g. *Gynandrocarpa placenta*, *Sycozoa arborescens*, *Didemnum* sp., *Pycnoclavella narcissus*, and the endemic *Clavellina lepadiformis)*, bryozoans (e.g. *Schizoretepora tessellata*, *Laminopora jellyae* and *Gigantopora polymorpha*) and a variety of octocorals (noble coral *Stylaster nobilis,* the sunburst soft coral *Malacacanthus capensis*, cauliflower soft coral *Drifa thyrsoidea*, purple soft coral *Alcyonium fauri,* Valdivian soft coral *A. valdiviae*, and the Variable soft coral *A. variabile*). Large gorgonians are conspicuous on these reefs with key species including *Leptogorgia palma*, *Eunicella tricoronata, E. papillosa, E. albicans,* and *Acabaria rubra.* Other important invertebrates include the red-chested sea cucumber *Pseudocnella insolens,* basketstars *Astroclades euryale*, featherstars *Comanthus wahlbergi* and *Tropiometra carinata*. Algal species include *Plocamium* spp., articulated corallines *Corallina* spp. and *Arthrocardia* spp., with the articulated coralline algae *Amphiroa ephedrae* being a dominant species in the shallow subtidal. Although abalone *Haliotis midae* were dominant space occupiers in shallow waters, poaching and overexploitation have severely depleted the population in their core habitat (Sink *et al.* 2012a).

In the Port Elizabeth and Mossel Bay areas, inshore reefs to -30 m depth show relatively distinct changes in community structure from those described above, being characterised by uniquely diverse reef assemblages dominated by cauliflower soft coral (Sink *et al*. 2012a) (Figure 18). In particular, the islands in Algoa Bay form ecological distinct subtidal habitats, containing many endemic species of invertebrates and seaweeds.

Figure 18: Diverse and unique reef assemblages, dominated by cauliflower soft coral occur on the inshore reefs to -30 m depth off Port Elizabeth (Source: Sink *et al*. 2011).

The Agulhas Reefs and Hard Grounds have been identified as being sensitive to overfishing, pollution impacts, anchor damage and impacts associated with mariculture, mining and petroleum activities, with specifiec reef habitats being identified as 'endangered' and 'critically endangered' (see Figure 13) Key areas to increase reef protection along the South Coast are within the Robberg MPA, Goukamma MPA and south of Goukamma (see Figure 32).

Information on offshore invertebrates occurring in the general project area is sparse. The more motile invertebrate fauna that occurs on the Agulhas Bank includes the squid (*Loligo vulgaris reynaudii*) (Figure 19, left) and the rock lobster (*Palinurus gilchristi*) (Figure 19, right). Squid occur extensively out to the shelf edge (500 m depth contour) increasing in abundance towards the eastern boundary of the South Coast, especially between Plettenberg Bay and Algoa Bay (Augustyn 1990; Sauer *et al*. 1992; Augustyn *et al*. 1994). Adults are normally distributed in waters >100 m, except along the eastern half of the South Coast where they also occur inshore, forming dense spawning aggregations at depths between 20 - 130 m. These spawning aggregations are a seasonal occurrence reaching a peak in November and December.

The deep-water rock lobster is associated with rocky substrate in depths of 90 - 170 m between Cape Agulhas and southern KwaZulu-Natal (Groeneveld & Branch 2002). Larvae drift southwards in the Agulhas Current, settling in the southern portion of the Agulhas Bank before migrating northwards again against the current to the adult grounds (Branch *et al*. 2010). Both juveniles and adults can thus be expected in the proposed exploration area. The species is fished commercially along the southern Cape Coast between the Agulhas Bank and East London, with the main fishing grounds being in the 100 – 200 m depth range south of Cape Agulhas on the Agulhas Bank.


Figure 19: Squid spawn in nearshore areas off the South Coast (left) and South Coast rock lobster occur in deep water (right) (photos: www.mpa.wwf.org.za; Steve Kirkman).

Other deep-water crustaceans that may occur inshore of the project area are the shovel-nosed crayfish (*Scyllarides elisabethae*), which occurs primarily on gravelly seabed at depths of around 150 m, although it is sometimes found in shallower water. Its distribution range extends from Cape Point to Maputo. Another rock lobster species occurring on the south coast is the West Coast rock lobster (*Jasus lalandii*), which are typically associated with shallow-water reefs, although the West Coast lobster has been recorded at depths of 120 m (Branch *et al*. 2010).

### 3.2.5 Pelagic and Demersal Fish

The South Coast ichthyofauna is diverse, comprising a mixture of temperate and tropical species. As a transition zone between the Agulhas and Benguela current systems, the South Coast ichthyofauna includes many species occurring also along the West and/or East Coasts. The seabed of the Agulhas Bank substrate is also diverse comprising areas of sand, mud and coral thereby contributing to increased benthic fauna and fish species.

Small pelagic shoaling species occurring along the South Coast include anchovy (*Engraulis encrasicolus*), pilchard (*Sardinops sagax*) (Figure 20, left), round herring (*Etrumeus japonicas*), chub mackerel (*Scomber japonicas*) and horse mackerel (*Trachurus trachurus capensis*) (Figure 20, right). Anchovies are usually located between the cool upwelling ridge and the Agulhas Current (Hutchings 1994), and are larger than those of the West Coast. Having spawned intensively in an area around the 200 m depth contour between Mossel Bay and Plettenberg Bay between October and January, most adults move inshore and eastwards ahead of warm Agulhas Current water. The Agulhas Bank area is, however, is not considered an important anchovy recruitment ground (Hampton 1992). Round herring juveniles similarly occur inshore along the South Coast, but move offshore with age (Roel *et al*. 1994; Hutchings 1994).


Figure 20: Cape fur seal preying on a shoal of pilchards (left). School of horse mackerel (right) (photos: www.underwatervideo.co.za; www.delivery.superstock.com).

Pilchards are typically found in water between 14°C and 20°C. Spawning occurs on the Agulhas Bank during spring and summer (Crawford 1980), with recruits being found inshore along the South Coast (Hutchings 1994). There is also recent evidence for winter (June-July) spawning of sardines on the central Agulhas Bank in patches of high concentrations of phytoplankton (van der Lingen *et al*. 2006). It is thought that the Agulhas Bank may be a refuge for pilchard under low population levels, and therefore vital for the persistence of the species (CCA & CSIR 1998). In late summer and during winter, the penetration of northerly-flowing cooler water along the Eastern Cape coast effectively expands the suitable habitat available for this species, resulting in a 'leakage' of large shoals northwards into southern KwaZulu-Natal in what has traditionally been known as the 'sardine run'. The shoals begin gathering in Algoa Bay as early as Late February, moving northwards up the coast between March and May and reach the KwaZulu-Natal coastline in June. The cool band of inshore water is critical to the 'run' as the sardines will either remain in the south or only move northwards further offshore if the inshore waters are above 20°C. The shoals can attain lengths of 20-30 km and are typically pursued by Great White Sharks, Copper Sharks, Common Dolphins, Cape Gannets and various other large pelagic predators (www.sardinerun.co.za). Other pelagic species that migrate along the coast include elf (*Pomatomus saltatrix*), geelbek (*Atractoscion aequidens*), yellowtail (*Seriola lalandi*), kob (*Argyrosomus* sp) seventy-four (*Cymatoceps nasutus*), strepie (*Sarpa salpa*), Cape stumpnose (*Rhabdosargus holubi*) and mackerel (*Scomber japonicus*)(Van der Elst 1988).

The fish most likely to be encountered on the shelf, beyond the shelf break and in the offshore waters of Block 11B/12B are the large migratory pelagic species, including various tunas (Figure 21, left), billfish (Figure 21, right) and sharks (Figure 22), many of which are considered threatened by the International Union for the Conservation of Nature (IUCN), primarily due to overfishing (Table 1). 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.



Figure 21: Large migratory pelagic fish such as longfin tuna (left) and sailfish (right) occur in offshore waters (photos: www.arkive.org; www.osfimages.com).



Figure 22: The great white shark *Carcharodon carcharias* (left) and the dusky shark *Charcharhinus obscurus* (right) (photos: www.flmnh.ufl.edu).

The great white shark *Carcharodon carcharias* is a significant apex predator in the Algoa Bay area, particularly in the vicinity of the seal colony at Black Rocks. 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 IUCN Red listing. In response to global declines in abundance, white sharks were legislatively protected in South Africa in 1991. Long-term catch-per-unit-effort data from protective gillnets in KwaZulu-Natal, however, suggest a 1.6% annual increase in capture rate of this species following protection, although high interannual variation in these data lessen the robustness of the trend (Dudley & Simpfendorfer 2006).

White sharks migrate along the entire South African coast, typically being present at seal colonies during the winter months, but moving nearshore during summer (Johnson *et al.* 2009). Recent research at Mossel Bay into the residency patterns of white sharks revealed that male sharks display low site fidelity, often rapidly moving in an out of the area. Females in contrast, display high site fidelity and may remain resident in the area for up to two months (Koch & Johnson 2006). Great white sharks are, however, capable of transoceanic migrations (Pardini *et al.* 2001; Bonfil *et al.* 2005; Koch & Johnson 2006), with recent electronic tag data suggesting links between widely separated populations in South Africa and Australia and possible natal homing behaviour in the species. Although during transoceanic migrations they appear to spend most of the time just below the sea surface, frequent deep dives to a much as 980 m are made whilst *en route*. Long-distance return migrations along the South African coast are also frequently undertaken (Figure 23), particularly by immature individuals (Bonfil *et al.* 2005). These coastal migrations are thought to represent feeding-related events.

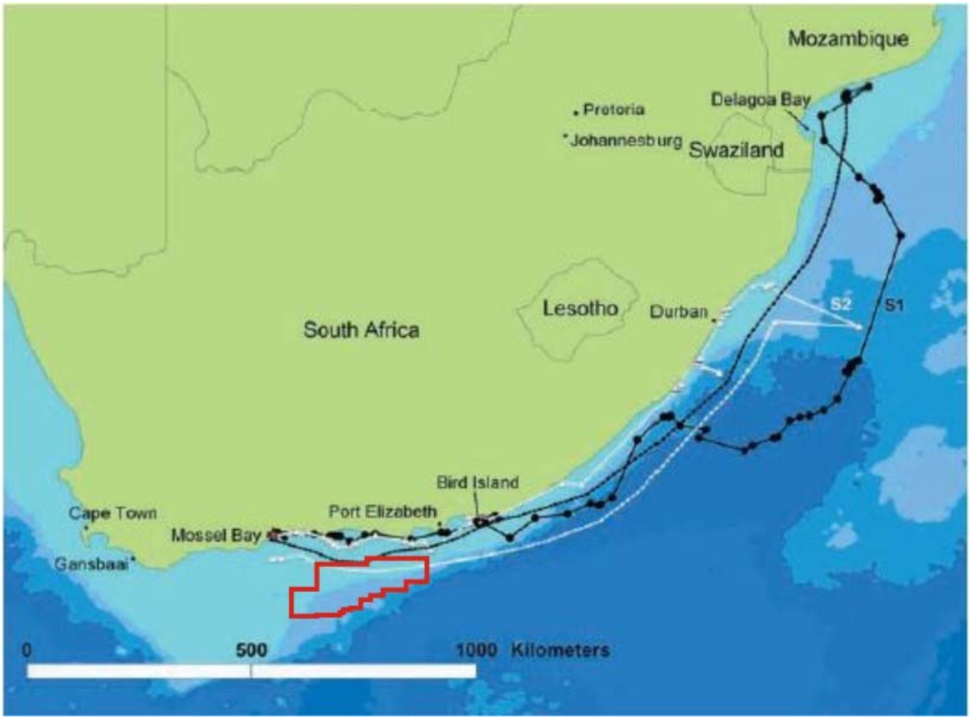


Figure 23: Long-distance return migrations of two tracked great white sharks along the South African coast in relation to Block 11B/12B (red polygon). The black trace shows a migration from 24 May – 2 November 2003; the white trace shows a migration from 31 May – 1 October 2004 (adapted from Bonfil *et al.* 2005).

Table 1: 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 |
| Eastern Little Tuna/Kawakawa | *Euthynnus affinis* | Least concern |
| Skipjack Tuna | *Katsuwonus pelamis* | Least concern |
| **Billfish** | | |
| Blue Marlin | *Makaira nigricans* | Vulnerable |
| Striped Marlin | *Kajikia audax* | Near Threatened |
| Sailfish | *Istiophorus platypterus* | Least concern |
| Swordfish | *Xiphias gladius* | Least concern |
| Black Marlin | *Istiompax indica* | Data deficient |
| **Pelagic Sharks** | | |
| Great Hammerhead Shark | *Sphyrna mokarran* | Endangered |
| Smooth Hammerhead shark | *Sphyrna zygaena* | Vulnerable |
| Pelagic Thresher Shark | *Alopias pelagicus* | Vulnerable |
| Bigeye Thresher Shark | *Alopias superciliosus* | Vulnerable |
| Common Thresher Shark | *Alopias vulpinus* | Vulnerable |
| Dusky Shark | *Carcharhinus obscurus* | Vulnerable |
| Great White Shark | *Carcharodon carcharias* | Vulnerable |
| Shortfin Mako | *Isurus oxyrinchus* | Vulnerable |
| Longfin Mako | *Isurus paucus* | Vulnerable |
| Whale Shark | *Rhincodon typus* | Vulnerable |
| Blue Shark | *Prionace glauca* | Near Threatened |

There is a high diversity of Teleosts (bony fish) and Chondrichthyans (cartilaginous fish) associated with the inshore and shelf waters of the South Coast, many of which are endemic to the Southern African coastline and form an important component of the demersal trawl and long-line fisheries. The Cape hake (*Merluccius capensis*), is distributed widely on the Agulhas Bank, while the deep-water hake (*Merluccius paradoxus*) is found further offshore in deeper water (Boyd *et al*. 1992; Hutchings 1994). The nursery grounds for both species are located off the west coast and fish move southwards onto the Agulhas Bank as they grow. Juveniles of both species occur throughout the water column in shallower water than the adults. Kingklip (*Genypterus capensis*) is also an important demersal species, with adults distributed in deeper waters along the whole of the South Coast, especially on rocky substrate (Japp *et al*. 1994).

They are reported to spawn in an isolated area beyond the 200 m isobaths between Cape St Francis and Port Elizabeth, in the north-eastern portion of Block 11B/12B during spring (see Figure 12). Juveniles occur further inshore along the entire south coast. The Agulhas or East Coast sole (*Austroglossus pectoralis*) inhabits inshore muddy seabed (<125 m) on the shelf between Cape Agulhas and Algoa Bay (Boyd *et al*. 1992). Apart from the above-mentioned target species, numerous other by-catch species are landed by the South Coast demersal trawling fishery including panga (*Pterogymnus laniarius)*, kob (*Argyrosomus hololepidotus*), gurnard (*Chelidonichthyes* spp.), monkfish (*Lophius* sp.), John Dory (*Zeus capensis*) and angel fish (*Brama brama*).

The shallower inshore areas (<100 m) along the South Coast comprise a varied habitat of rocky reefs and soft-bottom substrates, which support a high diversity of endemic sparid and other teleost species (Smale *et al*. 1994) (Figure 24), some of which move into inshore protected bays to spawn (Buxton 1990) or undertake spawning migrations eastwards up the coast. Those species that undertake migrations along the South Coast include Red Steenbras, White Steenbras (summer), Kob, Geelbek and Elf (winter). Spawning of the majority of species endemic to the area occurs in spring and summer. Many of these species, as well as numerous pelagic species that frequent nearshore waters are targeted by line-fishermen and form an important component of the commercial and recreational linefishery (Table 2).

Furthermore, a wide variety of chondrichthyans occur in nearshore waters of the South Coast (Table 3), some of which, such as St Joseph shark (*Callorhincus capensis*), Soupfin shark (*Galeorhinus galeus*) and Biscuit skate (*Raja straeleni*), are also landed by the trawl and line fishery.


Figure 24: The Agulhas Inshore and offshore reefs support a wide diversity of teleost species including musselcracker (left) and red stumpnose (right) (photos: http://spearfishingsa.co.za, www.easterncapescubadiving.co.za).

Table 2: Some of the more important demersal and pelagic linefish species landed by commercial and recreational boat fishers and shore anglers along the South Coast (adapted from CCA & CMS 2001).

| Name | Species Name |
|---|---|
| **Demersal teleosts** | |
| Bank steenbras | *Chirodactylus grandis* |
| Belman | *Umbrina canariensis* |
| Blacktail | *Diplodus sargus* |
| Blue hottentot | *Pachymetopon aeneum* |
| Bronze bream | *Pachymetopon grande* |
| Cape stumpnose | *Rhabdosargus holubi* |
| Carpenter | *Argyrozona argyrozona* |
| Dageraad | *Chrysoblephus christiceps* |
| Englishman | *Chrysoblephus anglicus* |
| Fransmadam | *Boopsoidea inornata* |
| Galjoen | *Dichistius capensis* |
| Grey chub | *Kyphosus biggibus* |
| Kob | *Argyrosomus hololepidotus* |
| Mini kob | *Johnius dussumieri* |
| Musselcracker | *Sparodon durbanensis* |
| Natal stumpnose | *Rhabdosargus sarba* |
| Poenskop | *Cymatoceps nasutus* |
| Pompano | *Trachinotus africanus* |
| Red roman | *Chrysoblephus laticeps* |
| Red steenbras | *Petrus rupestris* |
| Red stumpnose | *Chrysoblephus gibbiceps* |
| River bream | *Acanthopagrus berda* |
| Rockcod | *Epinephalus* spp. |
| Sand steenbras | *Lithognathus mormyrus* |
| Santer | *Cheimerius nufar* |
| Scotsman | *Polysteganus praeorbitalis* |
| Seventyfour | *Polysteganus undulosus* |
| Slinger | *Chrysoblephus puniceus* |
| Snapper salmon | *Otolithes ruber* |
| Spotted grunter | *Pomadasys commersonnii* |
| Squaretail kob | *Argyrosomus thorpei* |
| Steentjie | *Spondyliosoma emarginatum* |
| Strepie | *Sarpa salpa* |
| White steenbras | *Lithognathus lithognathus* |
| White stumpnose | *Rhabdosargus globiceps* |
| Wreckfish | *Polyprion americanus* |
| Zebra | *Diplodus cervinus* |
| **Pelagic teleosts** | |
| Elf | *Pomatomus saltatrix* |
| Garrick/leerfish | *Lichia amia* |
| Geelbek | *Atractoscion aequidens* |
| Green jobfish | *Aprion virescens* |
| King mackerel | *Scomberomorus commerson* |
| Kingfish species | *Caranx* spp. |
| Queenfish | *Scomberoides commersonianus* |
| Queen mackerel | *Scomberomorus plurilineatus* |
| Tenpounder | *Elops machnata* |
| Wahoo | *Acanthocybium solandri* |
| Yellowtail | *Seriola lalandi* |

Table 3: Some of the chondrichthyan species occurring along the South Coast (CCA & CMS 2001).

| Name | Species Name |
|---|---|
| Great white shark | *Carcharodon carcharias* |
| Ragged-tooth shark | *Odontaspis taurus* |
| Bronze whaler shark | *Carcharhinus brachyurus* |
| Dusky shark | *Carcharhinus obscures* |
| Blacktip shark | *Carcharhinus limbatus* |
| Hammerhead shark | *Sphyrna* spp. |
| Lesser Sandshark | *Rhinobatus annulatus* |
| Milkshark | *Rhizoprionodon acutus* |
| Gully shark | *Triakis megalopterus* |
| Skates | Rajiformes |
| Stingrays | Dasyatidae |
| St Joseph shark | *Callorhincus capensis* |
| Soupfin shark | *Galeorhinus galeus* |
| Diamond ray | *Gymnura natalensis* |
| Tiger catshark | *Halaelurus natalensis* |
| Izak | *Halohalaelurus regani* |
| Puffadder shyshark | *Haploblepharus edwardsii* |
| Houndsharks | *Mustelus* spp. |
| Bullray | *Myliobatis aquilla* |
| Yellowspotted catshark | *Scyliorhinus capensis* |
| Spiny dogfish | *Squalus* spp. |
| Electric ray | *Torpedo fuscomaculata* |

### 3.2.6 Turtles

Three species of turtle occur along the South Coast; the leatherback (*Dermochelys coriacea*) (Figure 25, left), the loggerhead (*Caretta caretta*) (Figure 25, right), and occasionally the green (*Chelonia mydas*) turtle. Green turtles are non-breeding residents often found feeding on inshore reefs. They nest mainly along the coast of Mozambique and on both Europa and Tromelin Islands (Lauret-Stepler *et al*. 2007). Leatherback turtles inhabit the deeper waters of the Atlantic Ocean and are considered a pelagic species. They travel the ocean currents in search of their prey (primarily jellyfish) and may dive to over 600 m and remain submerged for up to 54 minutes (Hays *et al*. 2004; Lambardi *et al*. 2008). They come into coastal bays and estuaries to mate, and lay their eggs on the adjacent beaches. Loggerheads tend to keep more inshore, hunting around reefs, bays and rocky estuaries along the African East Coast, where they feed on a variety of benthic fauna including crabs, shrimp, sponges, and fish. In the open sea their diet includes jellyfish, flying fish, and squid (www.oceansafrica.com/turtles.htm).

Loggerheads and leatherbacks nest along the sandy beaches of the northeast coast of KwaZulu-Natal, South Africa, as well as southern Mozambique during summer months. These loggerhead and leatherback nesting populations are the southern-most in the world (Nel *et al*. 2013). Even though these populations are smaller (in nesting numbers) than most other populations, they are genetically unique (Dutton *et al*. 1999; Shamblin *et al*. Submitted) and thus globally important populations in terms of conservation of these species.


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

Loggerhead and leatherback females come ashore to nest from mid-October to mid-January each year. The eggs incubate for two months and hatchlings emerge from their nests from mid-January to mid-March. The mean hatching success for loggerheads (73%) and leatherbacks (76%) on the South African nesting beaches (de Wet 2013) is higher than reported at other nesting sites globally. Those hatchlings that successfully escape predation on their route to the sea, enter the surf and are carried ~10 km offshore by coastal rip currents to the Agulhas Current (Hughes 1974b). As hatchlings are not powerful swimmers they drift southwards in the current. During their first year at sea, the post-hatchlings feed on planktonic prey items (Hughes 1974a), with their activities largely remaining unknown (Hughes 1974a). After ~10 years, juvenile loggerheads return to coastal areas to feed on crustaceans, fish and molluscs and subsequently remain in these neritic habitats (Hughes 1974b). In contrast, leatherbacks remain in pelagic waters until they become sexually mature and return to coastal regions to breed. Loggerheads reach sexual maturity at about 36 years of age whereas leatherbacks reach maturity sooner, at approximately 15 years (Tucek *et al*. Submitted). It has been estimated that only 1 to 5 hatchlings survive to adulthood (Hughes 1974b; de Wet 2013).

Female loggerhead and leatherback turtles, however, do not nest every year due to the high energetic costs of reproduction (Wallace & Jones 2008). During this remigration interval they travel thousands of kilometres (particularly leatherbacks) with ocean currents in search of foraging grounds (Luschi *et al*. 2003a; Luschi *et al*. 2003b). Turtles marked with titanium flipper tags have revealed that South African loggerheads and leatherbacks have a remigration interval of 2 – 3 years, migrating to foraging grounds throughout the South Western Indian Ocean (SWIO) as well as in the eastern Atlantic Ocean. They follow different post-nesting migration routes (Hughes *et al*. 1998; Luschi *et al*. 2006), with loggerheads preferring to stay inshore whilst travelling northwards to foraging grounds along the southern Mozambican coastline or crossing the Mozambique Channel to forage in the waters off Madagascar (Figure 26). In contrast, leatherbacks move south with the Agulhas Current to deeper water in high-sea regions to forage (Hughes *et al*. 1998; Luschi *et al*. 2003b; Luschi *et al.* 2006), with some individuals following the Benguela Current along the west coast of South Africa, as far north as central Angola (Figure 27, de Wet (2013)). Both species are likely to be encountered in Block 11B/12B.

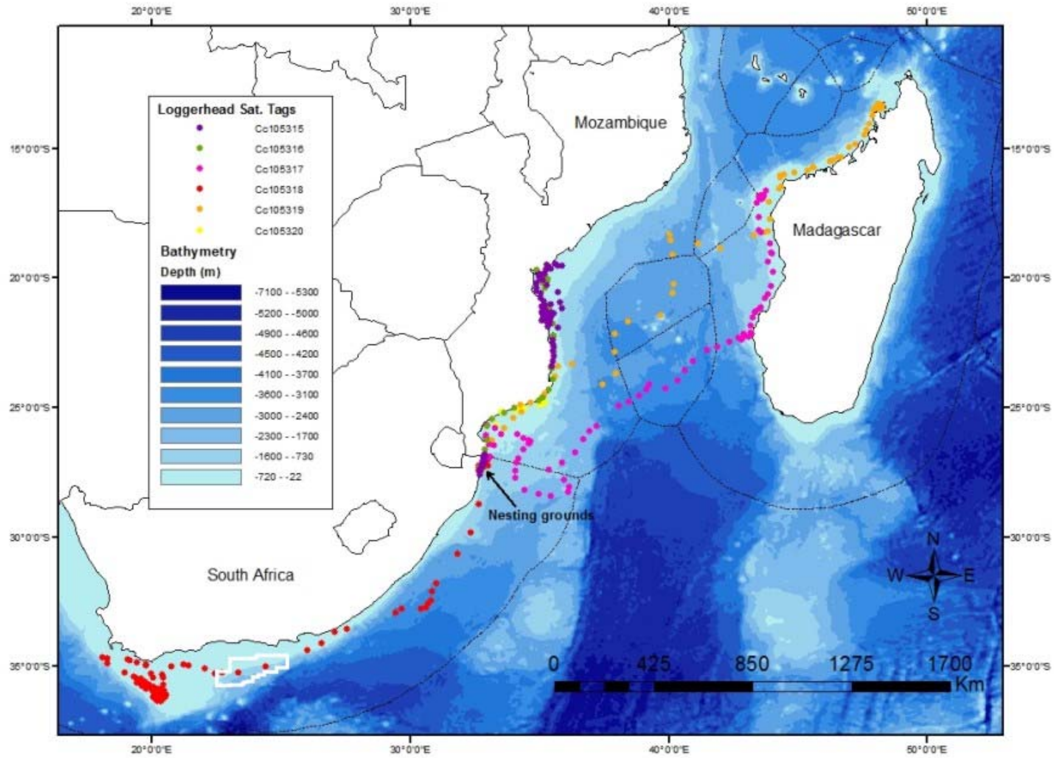


Figure 26: Spatial distribution of satellite tagged loggerhead females (2011/2012; Oceans and Coast, unpublished data) in relation to proposed survey area (white polygon).

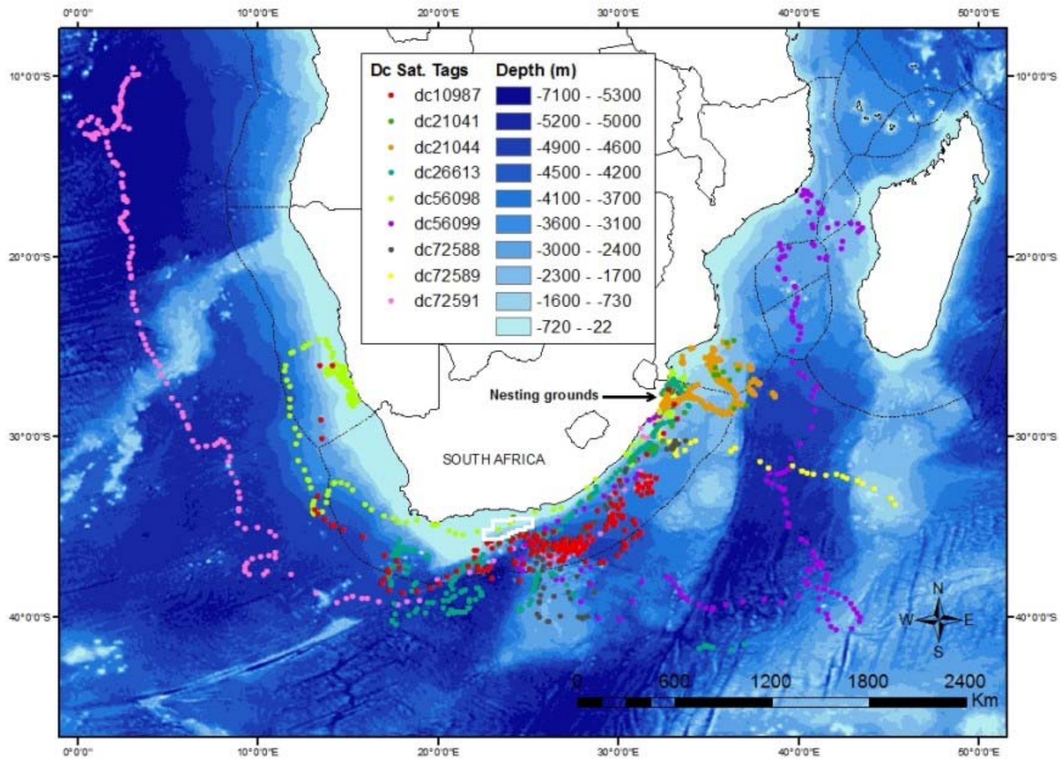


Figure 27: The post-nesting distribution of nine satellite tagged leatherback females (1996 – 2006; Oceans and Coast, unpublished data) in relation to proposed survey area (white polygon).

In the IUCN Red listing, the leatherback turtles are described as "Critically Endangered", and the loggerhead and green turtles are "Endangered" on a global scale. Leatherback Turtles are thus in the highest categories in terms of need for conservation in CITES (Convention on International Trade in Endangered Species), and CMS (Convention on Migratory Species). As a signatory of CMS, South Africa has endorsed and signed two sister agreements specific to the conservation and management of sea turtles (these are the Africa-Atlantic and Indian Ocean South East Asia Memoranda of Understanding). South Africa, as a nation, is therefore committed to the protection of all species of sea turtles occupying its national waters, whether they are non-resident nesters (loggerhead and leatherback turtles) or resident foragers (green turtles; Oceans and Coast, unpublished data).

### 3.2.7 Seabirds

South Coast seabirds can be categorised into three categories: 'breeding resident species', 'non-breeding migrant species' and 'rare vagrants' (Shaughnessy 1977; Harrison 1978; Liversidge & Le Gras 1981; Ryan & Rose 1989). Overall, 60 species are known, or thought likely to occur, along the South Coast. Fifteen species breed within the South Coast region (Table 4), including Cape Gannets, African Penguins, Cape Cormorants, White-breasted Cormorant, Roseate Tern, Damara Tern, Swift Term and Kelp Gulls. Recent changes in bird populations in the South Coast region include eastward extensions of the breeding range of Hartlaub's gull (*Larus hartlaubii*) and crowned cormorant (*Phalacrocorax coronatus*) and the development of a new African penguin (*Spheniscus demersus*) colony in the De Hoop Reserve east of Cape Agulhas (van der Lingen *et al*. 2006).

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

| Species name | Common name | Global IUCN Status |
|---|---|---|
| *Haematopus moquini* | African black oystercatcher | Near Threatened |
| *Spheniscus demersus* | African Penguin | Endangered |
| *Phalacrocorax carbo* | Great Cormorant | Least Concern |
| *Phalacrocorax capensis* | Cape Cormorant | Near Threatened |
| *Phalacrocorax neglectus* | Bank Cormorant | Endangered |
| *Phalacrocorax coronatus* | Crowned Cormorant | Least Concern |
| *Phalacrocorax lucidus* | White-breasted Cormorant | Not assessed |
| *Morus capensis* | Cape Gannet | Vulnerable |
| *Larus dominicanus* | Kelp Gull | Least Concern |
| *Larus cirrocephalus* | Greyheaded Gull | Least Concern |
| *Larus hartlaubii* | Hartlaub's Gull | Least Concern |
| *Hydroprogne caspia* | Caspian Tern | Vulnerable |
| *Sterna bergii* | Swift Tern | Least Concern |
| *Sterna dougallii* | Roseate Tern | Least Concern |
| *Sterna balaenarum* | Damara Tern | Near Threatened |

On the Agulhas Bank sea-birds at times intensively target shoals of pelagic fish. Small pelagic species such as anchovy and pilchard form important prey items for Agulhas Bank seabirds, particularly the Cape Gannet (Figure 28, left), the African Penguin (Figure 28, right) and the various cormorant species. Most of the breeding resident seabird species feed on fish (with the exception of the gulls, which scavenge, and feed on molluscs and crustaceans). Feeding strategies include surface plunging (gannets and terns), pursuit diving (cormorants and penguins), and scavenging and surface seizing (gulls). All these species feed relatively close inshore, although gannets and kelp gulls may feed further offshore. Increases in numbers of breeding pairs at eastern colonies of kelp gull (*L. dominicanus*), crowned cormorant, swift terns (*Sterna bergii*), and Cape gannet (*Morus capensis*) but not African penguins, in response to the eastward shift of sardines (van der Lingen *et al*. 2006).

African Penguin colonies along the South Coast occur at Dyer Island, east of Cape Agulhas, Cape Recife, and on the Algoa Bay islands (St Croix Island, Jaheel Island, Bird Island, Seal Island, Stag Island and Brenton Rocks). This species forages at sea with most birds being found within 20 km of the coast. The majority of Algoa Bay penguins forage to the south of Cape Recife and thus inshore of Block 11B/12B. African Penguins mainly consume pelagic shoaling fish species such as anchovy, round herring, horse mackerel and pilchard and their distribution is consistent with that of the pelagic shoaling fish, which occur within the 200 m isobath.


Figure 28: Typical diving seabirds on the South Coast are the Cape Gannets (left) (Photo: NACOMA) and the flightless African Penguin (right) (Photo: Klaus Jost).

### 3.2.8 Marine Mammals

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 the waters of the South Coast (Table 5) and one seal species, the Cape fur seal (*Arctocephalus pusillus*) (Findlay 1989; Findlay *et al*. 1992; Ross 1984; Peddemors 1999). Of the 34 species listed, three are 'endangered' and one is considered 'vulnerable' (IUCN Red Data list Categories). Nineteen species are listed as 'data deficient' underlining how little is known about cetaceans, their distributions and population trends. The offshore areas have been particularly poorly studied with almost all available information from deeper waters (>200 m) arising from historic whaling records mostly dating from the 1960s. The large whale species for which there are current data available are the humpback and southern right whale, although

Table 5: Cetaceans occurrence off the South Coast of South Africa, their seasonality, likely encounter frequency and conservation status (adapted from S. Elwen, Mammal Research Institute, pers. comm., Best 2007).

| Common Name | Species | Shelf (<200 m) | Offshore (>200 m) | Seasonality | Likely encounter freq. | IUCN Conservation Status |
|---|---|---|---|---|---|---|
| *Delphinids* | | | | | | |
| Common bottlenose dolphin | *Tursiops truncatus* | Yes | Yes | Year round | Monthly | Least Concern |
| Indo-Pacific bottlenose dolphin | *Tursiops aduncus* | Yes | | Year round | Monthly | Data Deficient |
| Common (short beaked) dolphin | *Delphinus delphis* | Yes | Yes | Year round | Monthly | Least Concern |
| Common (long beaked) dolphin | *Delphinus capensis* | Yes | | Year round | Monthly | Data Deficient |
| Fraser's dolphin | *Lagenodelphis hosei* | | Yes | Year round | Occasional | Least Concern |
| Spotted dolphin | *Stenella attenuata* | Yes | Yes | Year round | Occasional | Least Concern |
| Striped dolphin | *Stenella coeruleoalba* | | Yes | Year round | Occasional | Least Concern |
| Indo-Pacific humpback dolphin | *Sousa chinensis* | Yes | | Year round | Monthly | Near Threatened |
| Long-finned pilot whale | *Globicephala melas* | | Yes | Year round | <Weekly | Data Deficient |
| Short-finned pilot whale | *Globicephala macrorhynchus* | | Yes | Year round | <Weekly | Data Deficient |
| Killer whale | *Orcinus orca* | Occasional | Yes | Year round | Occasional | Data Deficient |
| False killer whale | *Pseudorca crassidens* | Occasional | Yes | Year round | Monthly | Data Deficient |
| Risso's dolphin | *Grampus griseus* | Yes (edge) | Yes | Year round | Occasional | Data Deficient |
| Pygmy killer whale | *Feresa attenuata* | | Yes | Year round | Occasional | Least Concern |
| *Sperm whales* | | | | | | |
| Pygmy sperm whale | *Kogia breviceps* | | Yes | Year round | Occasional | Data Deficient |
| Dwarf sperm whale | *Kogia sima* | | Yes | Year round | Occasional | Data Deficient |
| Sperm whale | *Physeter macrocephalus* | | Yes | Year round | Occasional | Vulnerable |

| Common Name | Species | Shelf (<200 m) | Offshore (>200 m) | Seasonality | Likely encounter freq. | IUCN Conservation Status |
|---|---|---|---|---|---|---|
| *Beaked whales* | | | | | | |
| Cuvier's | *Ziphius cavirostris* | | Yes | Year round | Occasional | Least Concern |
| Arnoux's | *Beradius arnouxii* | | Yes | Year round | Occasional | Data Deficient |
| Southern bottlenose | *Hyperoodon planifrons* | | Yes | Year round | Occasional | Not assessed |
| Hector's | *Mesoplodon hectori* | | Yes | Year round | Occasional | Data Deficient |
| Layard's | *Mesoplodon layardii* | | Yes | Year round | Occasional | Data Deficient |
| True's | *Mesoplodon mirus* | | Yes | Year round | Occasional | Data Deficient |
| Gray's | *Mesoplodon grayi* | | Yes | Year round | Occasional | Data Deficient |
| Blainville's | *Mesoplodon densirostris* | | Yes | Year round | Occasional | Data Deficient |
| *Baleen whales* | | | | | | |
| Antarctic Minke | *Balaenoptera bonaerensis* | Yes | Yes | >Winter | Monthly | Data Deficient |
| Dwarf minke | *B. acutorostrata* | Yes | | Year round | Occasional | Least Concern |
| Fin whale | *B. physalus* | | Yes | MJJ & ON, rarely in summer | Occasional | Endangered |
| Blue whale | *B. musculus* | | Yes | MJJ | Occasional | Endangered |
| Sei whale | *B. borealis* | | Yes | MJ & ASO | Occasional | Endangered |
| Bryde's (inshore) | *B brydei (subspp)* | | Yes | Year round | Occasional | Data Deficient |
| Pygmy right | *Caperea marginata* | Yes | | Year round | Occasional | Least Concern |
| Humpback | *Megaptera novaeangliae* | Yes | Yes | AMJJASOND | Daily | Least Concern |
| Southern right | *Eubalaena australis* | Yes | | JJASON | Daily | Least Concern |

almost all data is limited to that collected on the continental shelf close to shore. Information on smaller cetaceans in deeper waters is particularly poor.

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

The distribution of whales and dolphins on the South Coast can largely be split into those associated with the continental shelf and those that occur in deep, oceanic waters. Species from both environments may, however, be found associated with the shelf (200 – 1,000 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 kilometres.

### Mysticete (Baleen) whales

The majority of baleen whales fall into the family Balaenidae. Those occurring in the proposed survey area include the blue, fin, sei, minke, dwarf minke, Bryde's, Pygmy Right, Humpback and Southern Right. Most of these species occur in pelagic waters, with only occasional visits into shelf waters. Humpbacks and Southern Rights, however, are likely to be encountered frequently inshore during winter months. All of these species show some degree of migration either to, or through, the proposed survey area when *en route* between higher-latitude feeding grounds (Antarctic or Subantarctic) and lower-latitude breeding grounds. Depending on the ultimate location of these feeding and breeding grounds, seasonality off South Africa can be either unimodal (usually in June-August, e.g. minke and blue whales) or bimodal (usually May-July and October-November, e.g. fin whales), reflecting a northward and southward migration through the area. As whales follow geographic or oceanographic features, the northward and southward migrations may take place at difference distances from the coast, thereby influencing the seasonality of occurrence at different locations. Due to the complexities of the migration patterns, each species is discussed in further detail below.

The most abundant baleen whales off the coast of South Africa are southern right and humpback whales (Figure 29). The southern African population of southern right whales historically extended from southern Mozambique (Maputo Bay) to southern Angola (Baie dos Tigres) and is considered to be a single population within this range (Roux *et al.* 2011). The most recent abundance estimate for this population is available for 2008 which estimated the population at ~4,600 individuals including all age and sex classes, which is thought to be at least 23% of the original population size (Brandaõ *et al.* 2011). Since the population is still continuing to grow at ~7% per year (Brandaõ *et al.* 2011), the population size in 2013 would number more than 6,000 individuals. 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 Mozambique (Banks *et al.* 2011) and Namibia (Roux *et al.* 2001). They migrate to the southern Africa subcontinent to breed and calve, where they tend to have an extremely coastal distribution mainly in sheltered bays (90% <2 km from shore; Best 1990; Elwen & Best 2004). Winter concentrations have been recorded all along the southern and eastern coasts of South Africa as far north as Maputo Bay, with the most significant concentration currently on the South Coast between Cape Town and Port Elizabeth. They typically arrive in coastal waters off the South Coast between June and November each year, although animals may be sighted as early as April and as late as January. While in local waters, southern rights are found in groups of 1-10 individuals, with cow-calf pairs predominating in inshore nursery areas. From July to October, animals aggregate and become involved in surface-active groups, which can persist for several hours.


Figure 29: The humpback whale (left) and the southern right whale (right) migrate along the East Coast during winter (Photos: www.divephotoguide.com; www.aad.gov.au).

The majority of humpback whales on the south and east coasts of South Africa are migrating past the southern African continent. The main winter concentration areas for Humpback whales on the African east coast include Mozambique, Madagascar, Kenya and Tanzania on the east coast. Three principal migration routes for Humpbacks in the south-west Indian Ocean have been proposed. On the first route up the East Coast, the northern migration reaches the coast in the vicinity of Knysna continuing as far north as central Mozambique. The second route approaches the coast of Madagascar directly from the south, possibly via the Mozambique Ridge. The third, less well established route, is thought to travel up the centre of the Mozambique Channel to Aldabra and the Comore Islands (Findlay *et al*. 1994; Best *et al*. 1998). Humpbacks have a bimodal distribution off the East coast, most reaching southern African waters around April, continuing through to September/October when the southern migration begins and continues through to December. The calving season for Humpbacks extends from July to October, peaking in early August (Best 2007). Cow-calf pairs are typically the last to leave southern African waters on the return southward migration, although considerable variation in the departure time from breeding areas has been recorded (Barendse *et al*. 2010). Off Cape Vidal whale abundances peak around June/July on their northward migration, although some have been observed still moving north as late as October. Southward moving animals on their return migration were first seen in July, peaking in August and continuing to late October (Findlay & Best 1996a, 1996b).

The smallest of the baleen whales, the pygmy right whale occurs along the southern African east coast to as far north as 30°S. There are no data on the abundance or conservation status of this species, although it was not subjected to commercial whaling so the population is expected to be near to original numbers. Sightings of this species at sea are rare (Best 2007) due in part to their small size and inconspicuous blows. Density in the project area is likely to be low.

Two forms of minke whale occur in the southern Hemisphere, the Antarctic minke whale (*Balaenoptera bonaerensis*) and the dwarf minke whale (*B. acutorostrata* subsp.); both species occur off the South coast (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 of the species do migrate from the Southern Ocean (summer) to tropical/temperate waters (winter) where they are thought to breed, some animals, especially juveniles, are known to stay in tropical/temperate waters year round. Off Durban Antarctic minke whales were reported to increase in numbers in April and May, remaining at high levels through June to August and peaking in September (Best 2007). 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 minke whales have a similar migration pattern to Antarctic minkes with at least some animals migrating to the Southern Ocean in summer months. Dwarf minke whales occur closer to shore than Antarctic minkes and have been seen <2 km from shore on several occasions around South Africa, particularly on the East Coast during the 'sardine run' (O'Donoghue *et al*. 2010a, 2010b, 2010c). Historic whaling records indicate that off Durban they were taken mainly between April and June. Both species are generally solitary and densities in Block 11B/12B are likely to be low.

Two genetically and morphologically distinct populations of Bryde's whales whales live off the coast of southern Africa - a larger pelagic form described as *Balaenoptera brydei,* and a smaller neritic form (of which the taxonomic status is uncertain, but is included by Best (2007) with the *B. brydei* of the subregion). The "offshore population" lives beyond the shelf (> 200 m depth) off west Africa and migrates between wintering grounds off equatorial west Africa (Gabon) and summering grounds off western South Africa. Its seasonality on the west coast is thus opposite to the majority of the balaenopterids with abundances highest during summer (January – March). The "inshore population" is unique amongst baleen whales in the region by being resident year round on the continental shelf and Agulhas Bank ranging from ~Durban in the east to at least St Helena Bay off the west coast. Sightings over the last two decades suggest that its distribution may be shifting eastwards (Best 2001, 2007; Best *et al*. 1984). This is a small population, which may be decreasing in size (Penry 2010) suggesting that it is unlikely to be frequently encountered in the proposed survey area. The offshore form is unlikely to be encountered off the South Coast.

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 on the East Coast highest in June (on the northward migration), and with a second larger peak in September. 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 East Coast of South Africa, with a unimodal winter (June-July) peak in catches off Durban. However, as northward moving whales were still observed as late as August/September, it is thought that the return migration may occur further offshore. The location of their winter breeding grounds remains a mystery (Best 2007).

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 Southern Africa.

Blue whales were historically caught in high numbers off Durban, showing a single peak in catches in June/July. Sightings of the species in the area between 1968-1975 were rare and concentrated in March to May (Branch *et al*. 2007) and only from far offshore (40-60 nautical miles). However, scientific search effort (and thus information) in pelagic waters is very low. The chance of encountering blue whales in the proposed survey area is considered low.

### 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 1.9 m long (Spinner dolphin) to 17 m (bull sperm whale).

All information about sperm whales in the southern African subregion 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, well-structured social system with adult males behaving differently from younger males and female groups. They live in deep ocean waters usually >1,000 m, but occasionally come inshore on the shelf into depths of 500-200 m (Best 2007). Seasonality of catches off the East Coast suggest that medium- and large-sized males are more abundant during winter (June to August), while female groups are more abundant in summer (December - February), although animals occur year round (Best 2007). Although considered relatively abundant worldwide (Whitehead 2002), no current data are available on density or abundance of sperm whales in African waters. Sperm whales feed at great depth, during dives in excess of 30 minutes, making them difficult to detect visually. The regular echolocation clicks made by the species when diving, however, 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 off the shelf of eastern South Africa. Beaked whales are all considered to be true deep water species usually being seen in waters in excess of 1,000 - 2,000 m depth (see various species accounts in Best 2007). Their presence in the area may fluctuate seasonally, but insufficient data exist to define this clearly.

The genus *Kogia* currently contains two recognised species, the pygmy (*K. breviceps*) and dwarf (*K. sima*) sperm whales. Due to their small body size, cryptic behaviour, low densities and small school sizes, these whales are difficult to observe at sea, and morphological similarities make field identification to species level problematic. The majority of what is known about Kogiid 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). *Kogia* species are most frequently occur in pelagic and shelf edge waters, are thus likely to occur in the survey area at low levels; seasonality is unknown. Dwarf sperm whales are associated with warmer tropical and warm-temperate waters. However abundance in the impact area is likely to be very low.

Killer whales 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 the South Africa coast (Best *et al.* 2010). Killer whales are found in all depths from the coast to deep open ocean environments and may thus be encountered at low levels in Block 11B/12B.

Although the false killer whale is globally recognized as one species, clear differences in morphological and genetic characteristics between different study sites show that there is substantial difference between populations and a revision of the species taxonomy may be needed (Best 2007). The species has a tropical to temperate distribution and most sightings off southern Africa have occurred in water deeper than 1,000 m but with a few close to shore as well (Findlay *et al*. 1992). False killer whales usually occur in groups ranging in size from 1-100 animals (mean 20.2) (Best 2007), and are thus likely to be fairly easily seen in most weather conditions. However, 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, 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 operating off southern Africa. 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 Block 11B/12B will be long-finned. However, due to the influence of the Agulhas Current in the area, the occurrence of short-finned pilot whales cannot be excluded. Pilot whales are likely to be among the most commonly encountered odontocetes in the project area.

Two species of bottlenose dolphins occur around southern Africa, the smaller Indo-Pacific bottlenose dolphin (*aduncus* form), which occurs exclusively to the east of Cape Point in water usually less than 30 m deep and generally within 1 km of the shore (Ross 1984), and the larger common bottlenose dolphin (*truncatus* form) (Figure 30, left), which on the South Coast occurs further offshore. Their distribution is essentially continuous from Cape Agulhas eastwards to southern Mozambique, although along the KZN coast the Indo-Pacific bottlenose dolphins seem to have 'preferred areas' (Ross *et al*. 1987; Cockcroft *et al*. 1990, 1991). These areas in which they are more frequently encountered are about 30 km apart, and are thought to correspond to discrete home ranges within a resident population occurring along the KZN coast. There are also seasonal movements of a genetically distinct 'migratory stock' of Indo-Pacific bottlenose dolphins along the South and East Coasts in association with the 'sardine run' (Natoli *et al*. 2008). Although listed as 'Data deficient' in the IUCN Red Data book, the *aduncus* form in general is listed as 'Vulnerable' in the South African Red Data Book, while the migratory subpopulation is considered 'Endangered' (Peddemors & Oosthuizen 2004). Little is known about the offshore form of the species, and nothing about their population size or conservation status. They sometimes occur association with other species such as pilot whales or false killer whales (Best 2007) and are likely to be present year round in waters deeper than 200 m.

Two species of common dolphin are currently recognised, the short-beaked common dolphin (*Delphinus delphis*) and the long-beaked common dolphin (*Delphinus capensis*). Although common dolphins occur world-wide in warm-temperate and tropical waters, off South Africa the short-beaked appear to prefer offshore habitats, whereas the long-beaked seems to be distributed as a series of disjunct populations in nearshore waters <500 m deep. During winter they migrate from the Eastern Cape into KZN waters following the 'sardine run' (Cockcroft & Peddemors 1990; O'Donoghue *et al*. 2010a, 2010b, 2010c). In 1988/89 the population of long-beaked common dolphins between Port Elizabeth and Richard's Bay was estimated at 15,000 – 20,000 animals, although this is thought to be an underestimate. The species most likely to be encountered in the survey area is the short-beaked common dolphin, but estimates of the population size and seasonality for the subregion is lacking.


Figure 30: Toothed whales that occur on the South Coast include the Bottlenose dolphin (left) and the Indo-pacific humpback dolphin (right) (Photos: www.fish-wallpapers.com; www.shutterstock.com).

The Indo-Pacific humpback dolphin (Figure 30, right) has a more or less continuous distribution from Danger Point in the Western Cape to Mozambique, Tanzania, Kenya, the Comoros Islands and the western coast of Madagascar. It is primarily a shallow-water species restricted to <50 m depth. Localised populations in the Plettenberg Bay - Algoa Bay region are concentrated around shallow reefs. Seasonal movements and migrations are not characteristic of the species, but in Algoa Bay sightings rate and group size appears to increase between January and April, and again in September. This was accompanied by an apparent influx of previously unidentified individuals into the bay. In Algoa Bay the population was estimated at 466 individuals of all age groups, with modelled population growth estimated to vary between -3% and 2% annually. The population for South Africa numbers no more than 1,000. There is considerable concern over the future of this species in the subregion resulting in it being listed as 'Vulnerable' in the South African Red Data Book (Peddemors *et al*. 2004), but 'Data deficient' by the IUCN. Encounters with this species in Block 11B/12B is likely to be very low.

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

Beaked whales were never targeted commercially and their pelagic distribution makes them largely inaccessible to most researchers making them the most poorly studied group of cetaceans. They are all considered to be true deep water species usually being seen in waters in excess of 1,000 - 2,000 m depth (see various species accounts in Best 2007). With recorded dives of well over an hour to depths in excess of 2 km, beaked whales are amongst the most extreme divers of air breathing animals (Tyack *et al.* 2011). All the beaked whales that may be encountered in the survey area are pelagic species that tend to occur in small groups of usually less than five individuals, although larger aggregations of some species are known (MacLeod & D'Amico 2006, Best 2007). The long, deep dives of beaked whales make them both difficult to detect visually, but PAM will increase the probability of detection as animals are frequently echo-locating when on foraging dives. Beaked whales are particularly vulnerable to certain types of man-made noise, particularly mid-frequency naval sonar. The exact reason why is not yet fully understood, but necropsy of stranded animals has revealed gas embolisms and haemorrhage in the brain, ears and acoustic fat - injuries consistent with decompression sickness (acoustically mediated bubble formation may also play a role) (Fernadez *et al.* 2005).

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In summary, the majority of data available on the seasonality and distribution of large whales in the proposed survey area is largely the result of commercial whaling activities mostly dating from the 1960s. Changes in the timing and distribution of migration may have occurred since these data were collected due to extirpation of populations or behaviours (e.g. migration routes may be learnt behaviours). The large whale species for which there are current data available are the humpback and southern right whale, although with almost all data being limited to the continental shelf. Data on the abundance, distribution or seasonality of the smaller odontocetes (including the beaked whales and dolphins) known to occur in oceanic waters off the shelf south of the Agulhas Bank is lacking. Beaked whales are all considered to be true pelagic species usually being seen in small groups in waters in excess of 1,000 - 2,000 m depth. Their presence in the area may fluctuate seasonally, but insufficient data exist to define this clearly.

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[1], killed or fished. No vessel or aircraft may approach closer than 300 m to any whale and a vessel should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m from a vessel or aircraft.

[1] In the Regulations for the management of boat-based whale watching and protection of turtles as part of the Marine Living Resources Act of 1998 the definition of "harassment" is given as "behaviour or conduct that threatens, disturbs or torments cetaceans".

The Cape fur seal (*Arctocephalus pusillus pusillus*) (Figure 31) is the only seal species that has breeding colonies along the South Coast, namely at Seal Island in Mossel Bay, on the northern shore of the Robberg Peninsula in Plettenberg Bay and at Black Rocks (Bird Island group) in Algoa Bay (Figure 32). The population at Seal Island in Mossel Bay is currently estimated at over 4,000 individuals (Gubili *et al*. 2009). The timing of the annual breeding cycle is very regular occurring between November and January, after which the breeding colonies break up and disperse. Breeding success is highly dependent on the local abundance of food, territorial bulls and lactating females being most vulnerable to local fluctuations as they feed in the vicinity of the colonies prior to and after the pupping season (Oosthuizen 1991).

Seals are highly mobile animals with a general foraging area covering the continental shelf up to 120 nautical miles offshore (Shaughnessy 1979), with bulls ranging further out to sea than females. The movement of seals from the three South Coast colonies are poorly known, however, limited tracking of the Algoa Bay colony has suggested these seals generally feed in the inshore region south of Cape Recife. The diet varies with season and availability and includes pelagic species such as horse mackerel, pilchard, and hake, as well as squid and cuttlefish.

Historically the Cape fur seal was heavily exploited for its luxurious pelt. Sealing restrictions were first introduced to southern Africa in 1893, and harvesting was controlled until 1990 when it was finally prohibited. The protection of the species has resulted in the recovery of the populations, and numbers continue to increase. Consequently, their conservation status in not regarded as threatened.

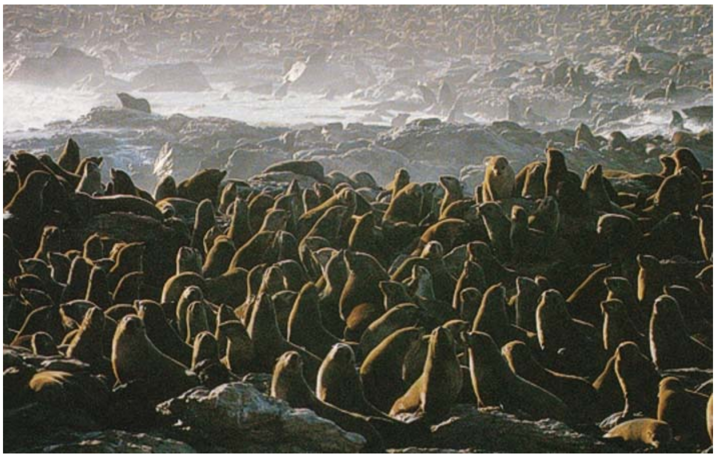

Figure 31: Colony of Cape fur seals (Photo: Dirk Heinrich).

### 3.2.9 Marine Protected Areas and Potential VMEs

Numerous marine protected areas (MPAs) exist along the South Coast (Figure 32).

There are four MPAs on the Western Cape coast east of Cape Agulhas namely De Hoop, Goukamma, Robberg, and Tsitsikama. Of these, the Goukamma, Robberg and Tsitsikama MPAs are located inshore of Block 11B/12B. The Goukamma MPA has a coastline of approximately 14 km from Buffalo Bay to Platbank and stretches one nautical mile (1.85 km) out to sea. The specific objectives of the Goukamma MPA are protection of intertidal species with an emphasis on protection of sought after bait species, the protection of important offshore reefs that provide habitat for commercially threatened sparid species, particularly red steenbras and black musselcracker, and the natural functioning of marine and estuarine ecosystems. The MPA contains rocky platforms, sandy beaches, sub tidal rocky reefs and sub tidal sandy benthos. Unfortunately, however, the seaward extent of the MPA does not adequately protect the reefs from utilisation by recreational or commercial fishers.

Robberg MPA is adjacent to Robberg Nature Reserve, which forms a peninsula with a single access point. The length of the Robberg MPA shoreline is 9km and includes rocky platforms, sandy beaches, subtidal rocky reefs and subtidal sandy benthos. A Cape Fur Seal colony is also present.

The Tsitsikamma National Park, proclaimed in 1964, is the oldest and largest 'no-take' MPA in Africa. It extends from Groot River West (33°59"S, 23°34"E) to the Groot River East (34°04"S, 24°12"E) and covers 57 km of coastline with a total surface area of 32,300 hectares. The majority of the MPAs coastline is rugged with high rocky ridges, but boulder bays, subtidal rocky reefs and subtidal sandy benthos also occur. Considered a biodiversity 'hotspot', the MPA provides extensive reef habitats for benthic invertebrates and algae, as well as many endemic slow-growing, and long-lived linefish fish species, many of which are over-exploited. The MPA is thus crucial for the conservation of species such as dageraad, red stumpnose, red steenbras, seventy-four, musselcracker, poenskop, white steenbras and dusky kob.

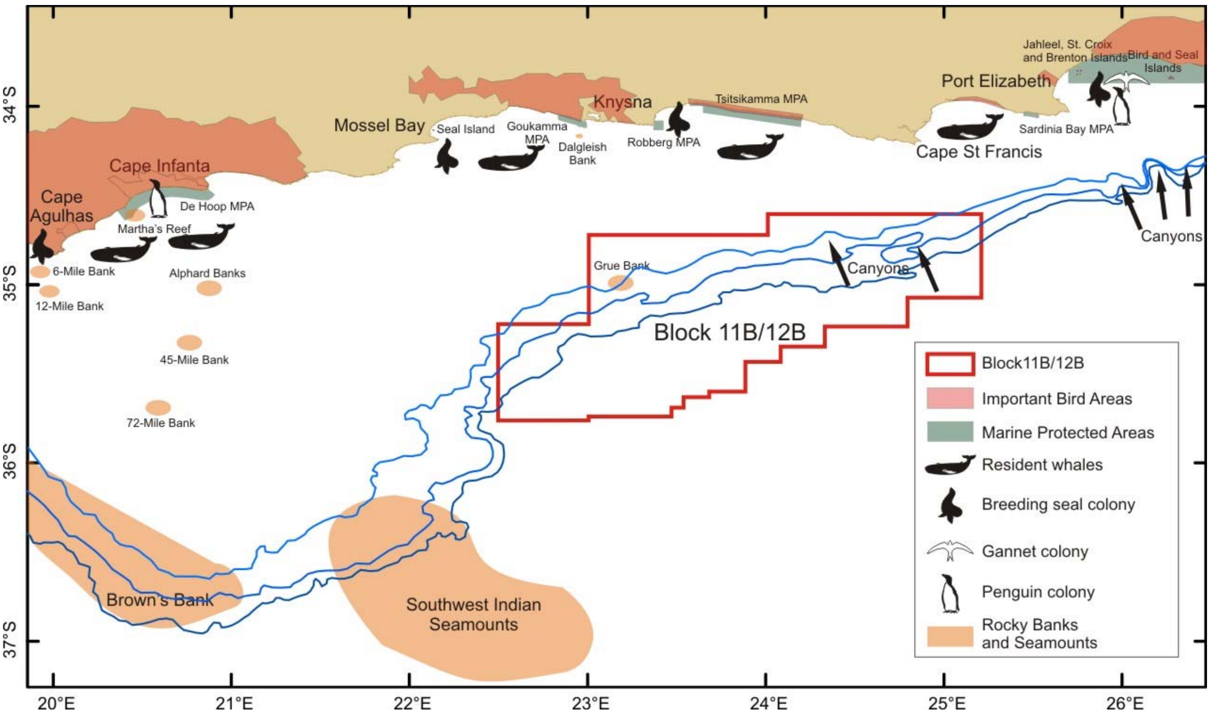


Figure 32: Project - environment interaction points on the South Coast, illustrating the location of seabird and seal colonies, seasonal whale populations, and marine protected areas in relation to Block 11B/12B. The location of offshore banks and seamounts, which could potentially be Vulnerable Marine Ecosytems (VMEs) are also shown.

Other MPAs in the broader project area are the De Hoop MPA, the Sardinia Bay MPA and the Bird Island MPA in Algoa Bay.

The De Hoop MPA was declared in 1985, with the adjacent De Hoop Nature Reserve being listed as a World Heritage Site in 2004. The MPA extends along a 46-km stretch of coastline between Stilbaai Point and Skipskop and extends three nautical miles offshore covering an area of approximately 25,300 ha. It is currently the only conservation area that affords protection to the unique intertidal system of large, eroding, soft sandstone and limestone platforms. The intertidal biota represent both warm-water east coast and cold-water west coast species, resulting in highly diverse communities. The MPA has played an important role in the protection of over-exploited reef fishes (e.g. red steenbras) and provides migrant recruits of many sought-after linefish species into neighbouring fishing areas. De Hoop MPA is also critically important for the conservation of the Southern Right whale and together with St. Sebastian Bay contains 70-80% of cow-calf pairs on the South African coast, thus ranking as probably the most important nursery area for Southern Right whales in the world. The MPA also contains an important breeding area for the near-threatened African black oystercatcher, and an African penguin breeding colony has recently established itself within the MPA, making it one of only three mainland penguin colonies in Southern Africa, the other two being Boulders and Stony Point within the Table Mountain National Park and Betty´s Bay MPAs, respectively.

The Sardinia Bay MPA has a shoreline 7 km in length and extends one nautical mile seawards of the high-water mark, between Schoenmakerskop and Bushy Park. It contains representative habitat including rocky platforms, sandy beaches, subtidal rocky reefs, and subtidal sandy benthos.

Bird Island MPA was declared in 2004 for biodiversity conservation reasons, and declared as part of Addo Elephant National Park in 2005. The reserve boundaries of the Algoa Bay Island nature reserve extend 500 m offshore of the islands as MPAs. The Bird Island group (Bird, Seal, Stag and Black Rock) are situated at the north eastern end of Algoa Bay close to Woody Cape. These islands are the only important seabird islands along a 1,800 km stretch of coastline between Dyer Island near Hermanus in the Western Cape and Inhaca Island in Mozambique. Together with St Croix, Jahleel and Brenton Islands (also in Algoa Bay), they are classed as Important Bird Areas (IBAs), because they regularly support significant numbers of globally threatened bird species as well as holding large concentrations of seabirds. Six of the 14 South African resident seabird species breed either on the islands or at the adjacent coast. The islands play an important national and international role in the conservation of Cape Gannet (*Morus capensis*), African Penguin (*Spheniscus demersus*) and Roseate Tern (*Sterna dougallii*). Of these, the African Penguin is listed as vulnerable and the Roseate Tern as endangered in the South African Red Data Book (Brooke 1984). The islands form ecological distinct subtidal habitats, containing many endemic invertebrates, algae and linefish (e.g. santer and red roman). Black Rocks is an important seal breeding colony, and serves as a great white shark feeding area. The MPA is also of particular importance to the threatened abalone as abalone poaching activities are strictly controlled. A larger MPA of an envisaged 120,000 ha, which will form part of a national conservation area, the Greater Addo Elephant National Park, has been proposed.

The national plan to identify focus areas for offshore biodiversity protection (Sink *et al*. 2011) identified that various pelagic and seabed habitats on the South Coast warrant protection. In particular 1) the Agulhas Bank, 2) Southwest Indian Seamounts and 3) Offshore of Port Elizabeth (Figure 33). the deep reef and palaeo-shoreline habitats are considered important for the recovery of overexploited linefish species, whereas the canyons and shelf edge are important habitats for cold water corals. Bycatch management in the crustacean trawl fishery and the protection of threatened linefish and turtles were also identified as key objectives.

In the Brown's Bank area sector specific fishery management areas, seabed protection zones or MPAs would be considered. Brown's Bank is an important spawning area for hake, with large fish frequenting the area. A small closed area, including the more vulnerable hard ground habitat, would thus support the sustainability of the hake fisheries. Hard grounds in this focus area should receive formal protection from fishing and mining. It was recommended that activities that affect the seabed be prevented from extending into deeper water along this portion of the shelf edge.

For the Agulhas Bank area, a zoned MPA was recommended to represent poorly protected mud and gravel habitats, protect vulnerable marine ecosystems (deep reefs, hard grounds) and threatened linefish species, and support inshore trawl and linefish fisheries sustainability. This would either include or supplement independent spatial management aimed at supporting bycatch management for the inshore trawl sector. A network of linked (but not necessarily contiguous) spatial management measures across the bank was considered most appropriate. Key features for inclusion include the Alphard Banks, the 45-Mile Bank, unrepresented gravel and mud habitats and the different fish communities caught by the inshore trawl sector.

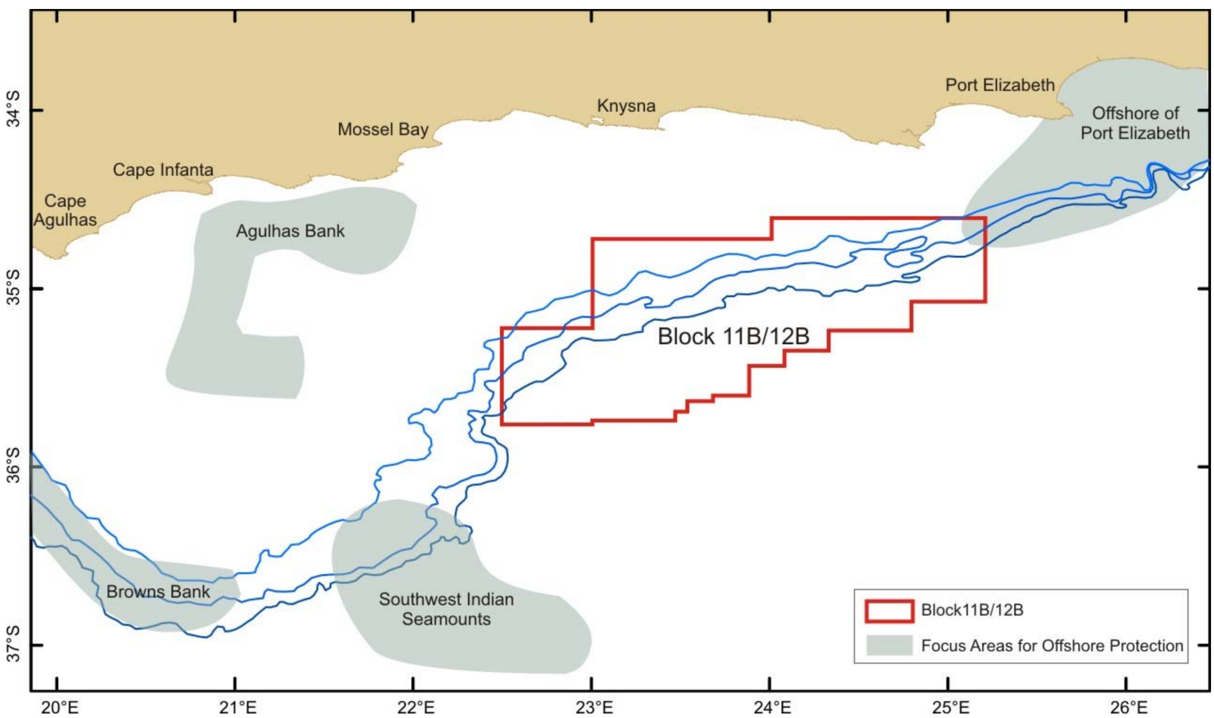


Figure 33: Focus Areas for Offshore Protection on the South Coast in relation to Block 11B/12B.

A fully protected or zoned MPA was suggested for the Southwest Indian Seamounts. Very rough ground and strong currents already offer some protection to this area, which has lower cost than many other shelf edge areas. Unprotected habitats of very limited spatial extent (e.g. shelf edge gravels) would be considered for inclusion, as would either two separate management areas or a large single zoned area. Management objectives include offshore habitat representation, protection of shelf edge and seamount benthic habitats, fisheries sustainability for small pelagic species and bycatch reduction in the large pelagic fishery.

The Offshore Port Elizabeth area is complex and spatial management measures would include seabed protection zones, fishery management areas and the expansion of existing or proposed MPAs. The offshore features in this area have few alternative options prompting the selection of this area despite its relatively high cost values. Existing planning for the proposed Addo MPA and the existing seasonal kingklip closure would be considered in the development of offshore spatial management measures for this area, with a suite of smaller appropriately zoned areas across this focus area being appropriate.

Following application of the Convention on Biological Diversity's (CBD) Ecologically or Biologically Significant marine Areas (EBSA) criteria[2], three of these areas (Agulhas Bank, Southwest Indian Seamounts and Offshore Port Elizabeth) formed part of a total of five areas around South Africa presented at the CBD regional workshop for the description of ecologically or biologically significant marine areas in the Southern Indian Ocean (July/August 2012) (CBD 2013). In meeting the criteria for the three areas, various endemic and rare teleost and seabird species were listed, and IUCN listed species and threatened habitat types identified.

### 3.2.10 Coastal Sensitivity

The last coastal sensitivity map for the South African coastline was compiled by Jackson & Lipschitz (1984). An updated sensitivity atlas is currently being established by the Department of Environmental Affairs. This will take the form of a website with customisable GIS layers including natural resources, ecosystem infrastructure and services, human infrastructure, threats etc. Harris (2012) compiled a GIS habitat map for the entire South African coastline, but the biodiversity layers, threats layers, and critical biodiversity areas have not yet been published or released.

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2. In 2008, the Conference of the Parties to the Convention on Biological Diversity (COP 9) adopted the following scientific criteria for identifying ecologically or biologically significant marine areas in need of protection in open-ocean waters and deep-sea habitats (further details available at http://www. cbd.int/marine/doc/azores-brochure-en.pdf):
    1. Uniqueness or Rarity
    2. Special importance for life history stages of species
    3. Importance for threatened, endangered or declining species and/or habitats
    4. Vulnerability, Fragility, Sensitivity, or Slow recovery
    5. Biological Productivity
    6. Biological Diversity
    7. Naturalness

In 2010, COP 10 noted that the application of EBSA criteria was a scientific and technical exercise, and that areas found to meet the criteria may require enhanced conservation and management measures. This could be achieved through means such as marine protected areas and impact assessments. It was emphasised that the identification of EBSAs and the selection of conservation and management measures was a matter for States and competent intergovernmental organisations, in accordance with international law, including the UN Convention on the Law of the Sea.

Lombard *et al.* (2004), however, provided an indication of the irreplaceability of intertidal habitats (Figure 34), from which some indication of sensitivity can be deduced. Two totally irreplaceable areas inshore of the Block 11B/12B licence Area are the sandy beaches within Algoa Bay, and the stretch of coastline between the Tsitsikamma MPA and Cape St Francis.

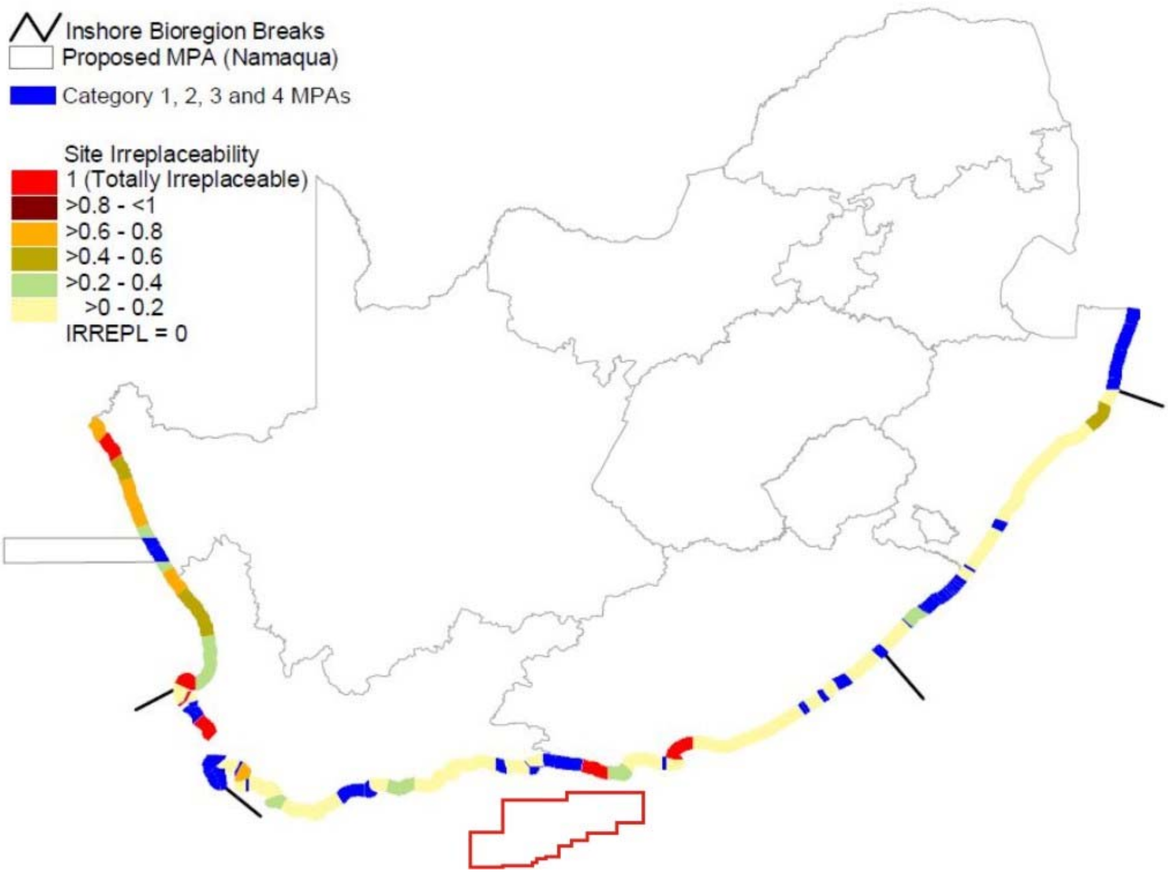


Figure 34: Irreplaceability analyses for intertidal habitats, in 50 km strips around South Africa, per bioregion (adapted from Lombard *et al*. 2004).

# 4. ASSESSMENT OF IMPACTS

## 4.1. Assessment Procedure

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

| Rating | Definition of Rating |
|---|---|
| *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 | Limited to the South African West Coast |
| National | Limited to the coastline of South Africa |
| International | Extending beyond the borders of South Africa |
| *Duration – the time frame over which the impact will be experienced* | |
| Short-term | 0 – 5 years |
| Medium-term | 6 - 15 years |
| Long-term | Where the impact would cease after the operational life of the activity, 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 |
| *Intensity – establishes whether the magnitude of the impact is destructive or benign in relation to the sensitivity of the receiving environment* | |
| Zero - Very Low | Where natural environmental functions and processes are not affected. |
| Low | Where the affected environment is noted, but natural functions and processes continue, albeit in a slightly modified way |
| Medium | Where the affected environment is altered, but natural functions and processes continue, albeit in a modified way |
| High | Where environmental functions and processes are altered to the extent that they temporarily or permanently cease |

Using the core criteria above, the significance of the impact is determined:

| *Significance – attempts to evaluate the importance of a particular impact, and in doing so incorporates extent, duration and intensity* | |
|---|---|
| VERY HIGH | Impacts could be EITHER:<br>of high intensity at a regional level and endure in the long term;<br>OR of high intensity at a national level in the medium term;<br>OR of medium intensity at a national level in the long term. |
| HIGH | Impacts could be EITHER:<br>of high intensity at a regional level enduring in the medium term;<br>OR of high intensity at a national level in the short term;<br>OR of medium intensity at a national level in the medium term;<br>OR of low intensity at a national level in the long term;<br>OR of high intensity at a local level in the long term;<br>OR of medium intensity at a regional level in the long term. |

| *Significance – attempts to evaluate the importance of a particular impact, and in doing so incorporates extent, duration and intensity* | |
|---|---|
| MEDIUM | Impacts could be EITHER:<br>of high intensity at a local level and endure in the medium term;<br>OR of medium intensity at a regional level in the medium term;<br>OR of high intensity at a regional level in the short term;<br>OR of medium intensity at a national level in the short term;<br>OR of medium intensity at a local level in the long term;<br>OR of low intensity at a national level in the medium term;<br>OR of low intensity at a regional level in the long term. |
| LOW | Impacts could be EITHER<br>of low intensity at a regional level, enduring in the medium term;<br>OR of low intensity at a national level in the short term;<br>OR of high intensity at a local level and endure in the short term;<br>OR of medium intensity at a regional level in the short term;<br>OR of low intensity at a local level in the long term;<br>OR of medium intensity at a local level, enduring in the medium term. |
| VERY LOW | Impacts could be EITHER<br>of low intensity at a local level and endure in the medium term;<br>OR of low intensity at a regional level and endure in the short term;<br>OR of low to medium intensity at a local level, enduring in the short term. |
| INSIGNIFICANT | Impacts with:<br>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. |

| *Status 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 |
| *Probability – the likelihood of the impact occurring* | |
| Improbable | Possibility very low either because of design or historic experience |
| Probable | Distinct possibility |
| Highly Probable | Most likely |
| Definite | Impact will occur regardless of preventive measures |
| *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 |

Additional criteria to be considered, which could "increase" the significance rating are:

- Permanent / irreversible impacts (as distinct from long-term, reversible impacts);
- Potentially substantial cumulative effects; and
- High level of risk or uncertainty, with potentially substantial negative consequences.

Additional criteria to be considered, which could "decrease" the significance rating are:

- Improbable impact, where confidence level in prediction is high.

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

| *Significance after Mitigation - considering changes in intensity, extent and duration after mitigation and assuming effective implementation of mitigation measures* | |
|---|---|
| Very Low; Low | Will not have an influence on the decision to proceed with the proposed project, provided that recommended measures to mitigate negative impacts are implemented. |
| Medium | Should influence the decision to proceed with the proposed project, provided that recommended measures to mitigate negative impacts are implemented. |
| High; Very High | Would strongly influence the decision to proceed with the proposed project. |

## 4.2. Acoustic Impacts on Marine Fauna

The ocean is a naturally noisy place and marine animals are continually subjected to both physically produced sounds from sources such as wind, rainfall, breaking waves and natural seismic noise, or biologically produced sounds generated during reproductive displays, territorial defence, feeding, or in echolocation (see references in McCauley 1994). Such acoustic cues are thought to be important to many marine animals in the perception of their environment as well as for navigation purposes, predator avoidance, and in mediating social and reproductive behaviour. Anthropogenic sound sources in the ocean can thus be expected to interfere directly or indirectly with such activities thereby affecting the physiology and behaviour of marine organisms (NRC 2003). Of all human-generated sound sources, the most persistent in the ocean is the noise of shipping. Depending on size and speed, the sound levels radiating from vessels range from 160 to 220 dB re 1 μPa at 1 m (NRC 2003). Especially at low frequencies between 5 to 100 Hz, vessel traffic is a major contributor to noise in the world's oceans, and under the right conditions, these sounds can propagate 100s of kilometres thereby affecting very large geographic areas (Coley 1994, 1995; NRC 2003; Pidcock *et al.* 2003). Other forms of anthropogenic noise include 1) multi-beam sonar systems, 2) aircraft flyovers, 3) seismic acquisition, 4) hydrocarbon and mineral exploration and recovery, and 5) noise associated with underwater blasting, pile driving, and construction (Figure 35).

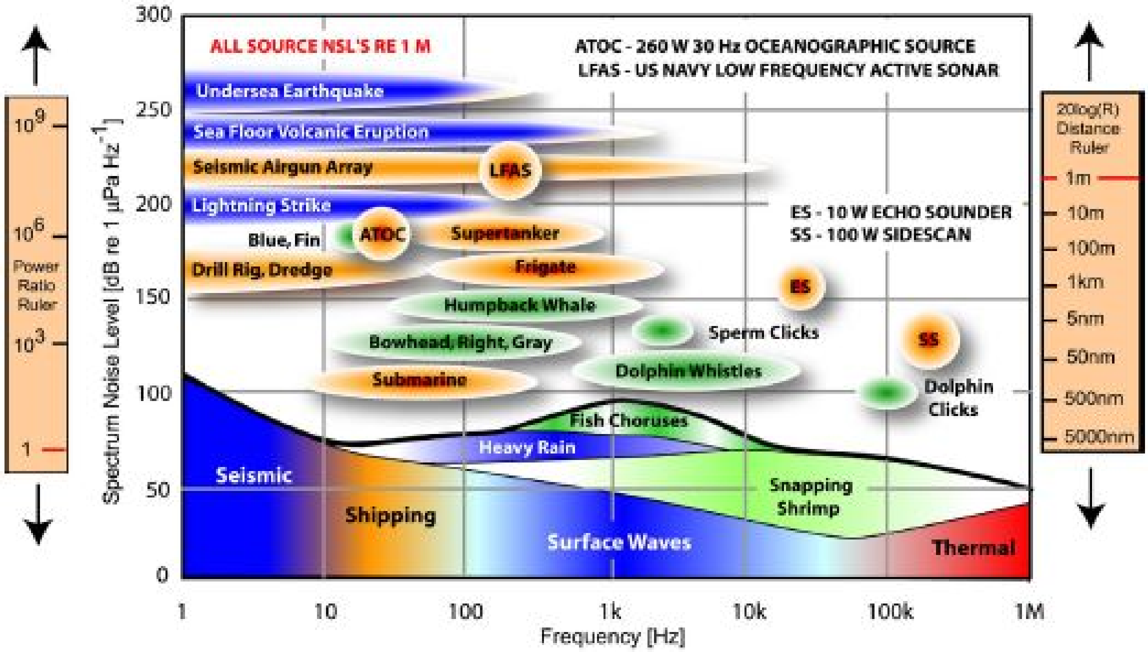


Figure 35: Comparison of noise sources in the ocean (Goold & Coates 2001).

### 4.2.1 Vessel Noise

The cumulative impact of increased background anthropogenic noise levels in the marine environment is an ongoing and widespread issue of concern (Koper & Plön 2012). The sound level generated by vessels fall within the 160-170 dB re 1 µPa range close to the vessel, with main frequencies from 1-10 kHz. The noise generated by the bathymetric and sediment sampling vessel(s) thus falls within the hearing range of most fish and marine mammals, and will be audible for considerable ranges (in the order of tens of km) before attenuating to below threshold levels (Table 6).

However, the emission of underwater noise from survey and sampling operations is not considered to be of sufficient amplitude to cause direct harm to marine life. Whereas the underwater noise from vessel operations may induce localised behavioural changes in some marine mammals, there is no evidence of significant behavioural changes that may impact on the wider ecosystem (Perry 2005). 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 will be restricted to ~20 km around the mining vessel. 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 they are 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 6: Known hearing frequency and sound production ranges of various marine taxa (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 | |
| Sea turtles | Chelonia | 0.1 - 1 | Unknown |
| Sharks and skates | Elasmobranchs | 0.1 - 1.5 | 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 |

The impact of underwater noise generated by the survey and sampling vessels during the proposed exploration activities is thus considered to be of low intensity in Block 11B/12B and for the duration of the survey/sampling campaign. The impact of vessel noise is considered of **VERY LOW** significance without mitigation and consequently no specific mitigation measures are deemed necessary.

**Mitigation**

No mitigation is proposed or deemed necessary.

| *Disturbance of marine fauna by noise from survey and sampling vessels* | | |
|---|---|---|
| | **Without Mitigation** | **Assuming Mitigation** |
| **Extent** | Local: limited to survey area | No mitigation is proposed |
| **Duration** | Short-term: for duration of bathymetry survey and sampling operations | |
| **Intensity** | Low | |
| **Significance** | Very Low | |
| **Status** | Negative | |
| **Probability** | Highly Probable | |
| **Confidence** | High | |

### 4.2.2 Multi-beam Sonars

There are significant differences in the effects of seismic and multi-beam/side-scan surveys. Despite having similar sound levels to seismic surveys, the higher frequency emissions utilised in normal multi-beam and sub-bottom profiling operations tend to be dissipated to safe levels over a relatively short distance. The anticipated radius of influence of multi-beam sonar would thus be significantly less than that for a seismic airgun array. Hence the most likely scenario for injury to an animal by acoustic equipment would be if the equipment were turned on full power while the animal was close to it (Anon 2007). Active sonar systems operate at frequency ranges >10 kHz, producing levels of sound pressure ranging from about 200 dB re 1µPa to 240 dB re 1µPa. Although these higher frequency sounds attenuate more rapidly in seawater than do lower frequency sounds, they do have the potential to impact marine fauna. Available information on cetacean hearing suggests that baleen whales are most sensitive to sounds from 10's of Hz to around 10 kHz (Southall *et al.,* 2007), while toothed whale and dolphin hearing is centred at frequencies of between 10 and 100 kHz (Richardson *et al.*1995) (Table 6). Both baleen whales and toothed whales would thus be expected to hear sonar signals from most types of oceanographic sonars at frequencies within their functional hearing range if the whales are within the sonar beam. Similarly, pinnipeds are also expected to hear sonar signals at frequencies within their functional hearing range if the animals are within the sonar beam, and phocids (true seals) and otariids (fur seals) would hear sonars operating at frequencies up to about 75 kHz and 35 kHz, respectively (Richardson *et al.*1995). Marine turtles, however, appear to have their highest auditory sensitivity at frequencies of 250 – 700 Hz, and thus well below the frequency ranges typically used by oceanographic sonars.

In 2003, the German Federal Environmental Agency decreed restrictions on the use of multi-beam systems in Antarctic waters, with the argument that marine mammals could theoretically be ensonified by the fan-shaped sonar beam, potentially resulting in a temporary threshold shift or permanent threshold shift, and leading to disorientation. However, the statistical probability of crossing a cetacean with a narrow multi-beam fan several times, or even once, is very small. In contrast, the US National Marine Fisheries Service, believed that marine mammals were unlikely to be harassed or injured from the multi-beam sonar or the sub-bottom profiler as the multi-beam sonar had an anticipated radius of influence significantly less than that for an airgun array.

It is thus generally understood that in open coastal waters the effects of multi-beam sonars on marine fauna are of **VERY LOW** significance without mitigation. However, despite the low significance of impacts, 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. 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.
- 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.
- Ensure that PAM (Passive Acoustic Monitoring) is incorporated into any surveying taking place in June and / or November;
- A Marine Mammal Observer would be appointed to ensure compliance with mitigation measures during geophysical surveying.

| *Impacts of multi-beam and sub-bottom profiling sonar on cetaceans* | | |
|---|---|---|
| | **Without Mitigation** | **Assuming Mitigation** |
| **Extent** | Local: limited to bathymetry survey area | Local |
| **Duration** | Short-term | Short-term |
| **Intensity** | Low | Low |
| **Significance** | Very Low | Very Low |
| **Status** | Negative | Negative |
| **Probability** | Improbable | Improbable |
| **Confidence** | High | High |

#### 4.2.3 Seabed Sediment Sampling

The proposed seabed sediment sampling activities are expected to result in the disturbance and loss of benthic macrofauna through removal of sediments and potential crushing of benthic epifauna in the trigger weight footprint of the piston corer or the supporting frame of the box corer.

Assuming a piston core diameter of 0.16 m, each drop-core sample will remove a surface area of ~0.02 $m^2$. Core barrels are typically 6 m in length thus potentially resulting in the removal of 0.12 $m^3$ of sediment per sample at maximum penetration. However, due to the hardness of the seabed in the Block 11B/12B exploration area, penetration beyond 1 m is not expected, thus amounting to an average of 0.02 $m^3$ of sediment per sample. Grabs typically sample a surface area of 0.2 $m^2$ of seabed, penetrating the sediment to a maximum of ~20 cm and potentially removing ~0.02 $m^3$ of sediment per sample. The box corer would sample a surface area of 0.75 $m^2$ of seabed. Assuming a maximum penetration of 40 cm, ~0.03 $m^3$ of sediment would potentially be removed per sample. Regardless of the sediment sampler ultimately implemented, less than 5 $m^3$ of sediment would be removed from the seabed during the proposed sampling campaign.

As benthic fauna typically inhabit the top 20 - 30 cm of sediment, and removal of the sediment samples will result in the elimination of the benthic infaunal and epifaunal biota in the sample footprints. Considering the available area of similar habitat in the Western Indian Offshore and Agulhas bioregions, this reduction in benthic biodiversity can be considered negligible.

Depending on the texture of the sediments at the target sites, slumping of adjacent unconsolidated sediments into the excavation can 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. 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).

Natural rehabilitation of the seabed following sampling or dredging 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 2007a, 2007b, 2009, 2010). Recovery rates of impacted communities are variable and dependent on the sampling/dredging/mining approach, sediment influx rates and the influence of natural disturbances on succession communities. Although recovery in the deep offshore habitats is likely to be very slow, this is offset by the insignificant seabed area disturbed by the proposed seabed sampling.

The structure of the recovering communities is also highly spatially and temporally variable confirming the high natural variability in benthic communities in the region. The community developing after an impact depends on (1) the nature of the impacted substrate, (2) differential re-settlement of larvae in different areas, and (3) environmental factors such as bedload transport, near-bottom dissolved oxygen concentrations etc. Indications of significant recruitments and natural mortalities in recovering succession communities has provided evidence of natural disturbances (Pulfrich & Penney 1999). Savage *et al*. (2001) 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. They concluded that the lack of clear separation between impacted and reference samples suggests that short-term physical disturbance resulting from mining or dredging is no more stressful than the regular naturally occurring anoxic events typical of the West Coast continental shelf area.

The high-intensity negative impact of sediment removal is unavoidable, but as it will be extremely localised (i.e. confined to the core footprints) the impact can confidently be rated as being **INSIGNIFICANT**.

Some disturbance or loss of adjacent benthic biota can also be expected as a result of the placement on the seabed of the trigger weight, and the supporting frame of the box corer. Epifauna and infauna beneath the footprint of the weight/frame may be smothered or crushed resulting in a reduction in benthic biodiversity. 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). The impacts will be of medium to high intensity but highly localised, and short-term as recolonization will occur rapidly from adjacent undisturbed sediments. The potential impact is consequently deemed to **INSIGNIFICANT**.

| *Impacts of seabed sediment sampling on benthic macrofauna through removal or crushing* | | |
|---|---|---|
| | **Without Mitigation** | **Assuming Mitigation** |
| **Extent** | Local: limited to core area or trigger weight/supporting frame footprint | Local |
| **Duration** | Short-term | Short-term |
| **Intensity** | Low | Low |
| **Significance** | Insignificant | Insignificant |
| **Status** | Negative | Negative |
| **Probability** | Definite | Definite |
| **Confidence** | High | High |

Discarding overboard of excess sediment may result in limited smothering effects on the seabed. Depending on the volume discarded, the size of the material and the prevailing current, most of the discarded material will be dispersed as it settles through the water column and any smothering effects would be negligible.

One of the more apparent effects of increased concentrations of suspended sediments and consequent increase in turbidity, is a reduction in light penetration through the water column with potential adverse effects on the photosynthetic capability of phytoplankton (Poopetch 1982; Kirk 1985; Parsons *et al.* 1986a, 1986b; Monteiro 1998; O'Toole 1997) and the foraging efficiency of visual predators (Simmons 2005; Braby 2009; Peterson *et al*. 2001). However, due to the rapid dilution and widespread dispersion of settling particles, any adverse effects in the water column would be ephemeral and highly localised. Any biological effects on nectonic and planktonic communities would thus be negligible (Aldredge *et al*. 1986). Turbid water is a natural occurrence along much of the southern African coast, resulting from riverine inputs, resuspension of seabed sediments in the wave-influenced nearshore areas and seasonal phytoplankton production in the upwelling zones. However, further offshore surface waters tend to be clearer and less productive as they are beyond the influence of coastal and shelf-edge upwelling (see Figure 12). Consequently, most of the major spawning areas are all located on the continental shelf, inshore of the proposed sampling area. Any potential effects of turbid water plumes generated during the discard of excess seabed sediment material on phytoplankton and ichthyoplankton production, fish migration routes and spawning areas, or on benthic and demersal species in the area would thus be negligible.

The impact of increased turbidity in the water column would thus be of zero to very low intensity, persist only over the very short term (days), and would be extremely localised around the survey vessel. Any potential adverse effects on pelagic biota would be negligible. The biochemical impact of reduced water quality through increased turbidity can thus confidently be rated as being **INSIGNIFICANT**.

| *Impacts of core sediment disposal on water column biochemistry (turbidity and light)* | | |
|---|---|---|
| | **Without Mitigation** | **Assuming Mitigation** |
| **Extent** | Local: limited to within metres of the survey vessel | No mitigation is deemed necessary |
| **Duration** | Short-term: rapid dispersion and dilution | |
| **Intensity** | Zero – Very Low | |
| **Significance** | Insignificant | |
| **Status** | Negative | |
| **Probability** | Probable | |
| **Confidence** | High | |

**Mitigation**

No mitigation measures are possible, or considered necessary for the direct loss of macrobenthos due to core sampling or indirect loss due to crushing by the trigger weight or the box core frame. Similarly, no mitigation measures are possible, or considered necessary for biochemical effects in the water column as a result of the discard of excess sediments.

## 5. CONCLUSIONS AND RECOMMENDATIONS

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

Reactions to sound by marine fauna depend on a multitude of factors including species, state of maturity, experience, current activity, reproductive state, time of day (Wartzok *et al*. 2004; Southall *et al.* 2007). If a marine animal does react briefly to an underwater sound by changing its behaviour or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the population as a whole (NRC 2005). However, if a sound source displaces a species from an important feeding or breeding area for a prolonged period, impacts at the population level could be significant.

**Vessel Noise**

| Impact | Significance (before mitigation) | Significance (after mitigation) |
|---|---|---|
| Auditory and behavioural disturbance of marine fauna, particularly cetaceans | Very Low | Very Low* |

(* indicates that no mitigation is possible or considered necessary, thus significance rating remains)

**Bathymetry Surveys**

| Impact | Significance (before mitigation) | Significance (after mitigation) |
|---|---|---|
| Auditory and behavioural disturbance of marine fauna, particularly cetaceans | Very Low | Very Low |

The few studies investigating benthic communities, habitats or ecosystems in South Africa's offshore environments have focussed primarily on the impacts of offshore diamond mining activities along the West Coast. As they provided some level of information on disturbance and recovery of benthic habitats and communities, these studies were used to guide the assessment of seabed sediment sampling in this report.

The impacts on marine habitats and communities associated with the proposed seabed sampling in Block 11B/12B are summarised in the Tables below. Impacts that would occur and negatively affect the benthic environment as a result of the proposed seabed sampling can primarily be attributed to benthic habitat disturbance, and unavoidable loss of biota in the sampled sediments. The total area to be impacted by the proposed sampling can, however, be considered negligible with respect to the total area of the Western Indian Offshore and Agulhas bioregions.

**Seabed Sediment Sampling**

| Impact | Significance (before mitigation) | Significance (after mitigation) |
|---|---|---|
| **Benthic Macrofauna** | | |
| Injury and loss of benthic macrofauna through seabed sediment sampling | Insignificant | Insignificant |
| Reduced physiological functioning of marine organisms due to increased water column turbidity following discard of excess core material | Insignificant | Insignificant |

The proposed exploration activities to be undertaken by TEPSA in Block 11B/12B are thus expected to result in impacts on marine invertebrate fauna ranging from insignificant to very low significance.

## 5.1. Recommended Mitigation Measures

The mitigation measures recommended for multi-beam and sub-bottom profiling surveys are:

- Onboard 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.
- 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.
- Ensure that PAM (Passive Acoustic Monitoring) is incorporated into any surveying taking place in June and / or November;
- A Marine Mammal Observer would be appointed to ensure compliance with mitigation measures during geophysical surveying.

No mitigation measures are possible, or considered necessary for the direct loss of macrobenthos due to core sampling or indirect loss due to crushing by the trigger weight or the box core frame. Similarly, no mitigation measures are possible, or considered necessary for biochemical effects in the water column as a result of the discard of excess sediments.

## 6. LITERATURE CITED

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

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

ANON, 2007. Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters. Department of the Environment, Heritage and Local Government. *www.npws.ie/media/npws/publications/marine/media,5176,en.pdf.*

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

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

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

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

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

BEST, P.B., 1990. Trends in the inshore right whale population off South Africa, 1969-1987. *Marine Mammal Science*, **6**: 93-108.

BEST, P.B., 2000. Coastal distribution, movements and site fidelity of right whales (*Eubalaena australis*) off South Africa, 1969-1998. *S. Afr. J. mar. Sci*., **22**: 43 – 56.

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

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

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

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

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

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

BIRCH, G., 1990. Phosphorite deposits on the South African continental margin and coastal terrace. In: BURNETT, W.C. and S.R. RIGGS (eds.) Phosphate deposits of the world, Vol. 3, Neogene to modern phosphorites. Cambridge University Press, Cambridge, UK:153-158

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

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

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

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

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

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

BRANCH, G.M., GRIFFITHS, C.L., BRANCH, M.L., and BECKLEY, L.E. 2010. *Two Oceans*. Struik Nature, Cape Town, South Africa, revised edition, 456pp

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

BRANDÃO, A., BEST, P.B. & D.S. BUTTERWORTH, 2011. Monitoring the recovery of the southern right whale in South African waters. Paper SC/S11/RW18 submitted to IWC Southern Right Whale Assessment Workshop, Buenos Aires 13-16 Sept. 2011.

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

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

BROWN, P.C., PAINTING, S.J. and COCHRANE, K.L. 1991. Estimates of phytoplankton and bacterial biomass and production in the northern and southern Benguela ecosystems. *S. Afr. J. mar. Sci.*, **11**: 537-564.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

DE DECKER, A.H.B., 1973. Agulhas Bank Plankton. In : Zeitzschel, B. (ed.) Ecological Studies. Analysis and Synthesis, 3: 189-219.

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

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

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

DUDLEY, S.F.J. and SIMPFENDORFER, C.A., 2006. Population status of 14 shark species caught in the protective gillnets off KwaZulu-Natal beaches, South Africa, 1978 – 2003. *Marine and Freshwater Research* **57**: 225 – 240.

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

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

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

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

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

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

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

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

FINDLAY, K.P. 1989. The distribution of cetaceans off the coast of South Africa and South West Africa/Namibia. Unpublished MSc. Thesis, University of Pretoria Town. 110pp.

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

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

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

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

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

FLACH, E. and THOMSEN, L. 1998. Do physical and chemical factors structure the macrobenthic community at a continental slope in the NE Atlantic? *Hydrobiologia,* **375/376**: 265-285.

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

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

GIBBONS, M.J., ABIAHY, B.B., ANGEL, M., ASSUNCAO, C.M.L., BARTSCH, I., BEST, P., BISESWAR, R., BOUILLON, J., BRADFORD-GRIEVE, J.M., BRANCH, W., BURRESON, E., CANNON, L., CASANOVA, J.-P., CHANNING, A., CHILD, C.A., CORNELIUS, P.F.S., DAVID, J.H.M., DELLA CROCE, N., EMSCHERMANN, P., ERSEUS, C., ESNAL, G., GIBSON, R., GRIFFITHS, C.L., HAYWARD, P.J., HEARD, R., HEEMSTRA, P. C., HERBERT, D., HESSLER, R., HIGGINS, R., HILLER, N., HIRANO, Y.M., KENSLEY, B., KILBURN, R., KORNICKER, L., LAMBSHEAD, J., MANNING, R., MARSHALL, D., MIANZAN, H., MONNIOT, C., MONNIOT, F., NEWMAN, W., NIELSEN, C., PATTERSON, G., PUGH, P., ROELEVELD, M., ROSS, A., RYAN, P., RYLAND, J.S., SAMAAI, T., SCHLEYER, M., SCHOCKAERT, E., SEAPY, R., SHIEL, R., SLUYS, R., SOUTHWARD,

E.C., SULAIMAN, A., THANDAR, A., VAN DER LAND, J., VAN DER SPOEL, S., VAN SOEST, R., VETTER, E., VINOGRADOV, G., WILLIAMS, G. and WOOLDRIDGE, T., 1999. The taxonomic richness of South Africa's marine fauna: crisis at hand. *South African Journal of Science* **95**: 8-12.

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

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

GROENEVELD, J.C. & BRANCH, G.M., 2002. Long-distance migration of South African deep-water rock lobster *Palinurus gilchristi*. *Marine Ecology Progress Series* **232**: 225–238.

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

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

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

HAMPTON, I, 1992. The role of acoustic surveys in the assessment of pelagic fish resources on the South African continental shelf. In: Benguela Trophic Functioning, PAYNE, A.I.L., BRINK, K.H., MANN, K.H. and HILBORN, R. (Eds.) *S. Afr. J. mar. Sci*., **12**: 1031-1050.

HARRIS, L.R., 2012. *An ecosystem-based spatial conservation plan for the South African sandy beaches*. PhD thesis. Nelson Mandela Metropolitan University, South Africa.

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

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

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

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

HEYDORN, A.E.F. and TINLEY, K.L. 1980. Estuaries of the Cape, Part I. Synopsis of the Cape coast.

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

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

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

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

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

JACKSON L.F. & S. LIPSCHITZ, 1984. Coastal Sensitivity Atlas of Southern Africa. Department of Transport. South Africa.

JAPP, D.W., SIMS, P. and SMALE, M.J. 1994. A review of the fish resources of the Agulhas Bank. *S. Afr. J. Sci.*, **90**: 123-134.

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

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

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

KIRK, J.T.O., 1985. Effects of suspensoids on penetration of solar radiation in aquatic ecosystems. *Hydrobiologia*, **125**: 195-208.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

MALME, C.I., MILES, P.R., TYACK, P., CLARK, C.W. and BIRD, J.E. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. *BBN Report 5851, OCS Study MMS 85-0019.* Report from BBN Laboratories Inc., Cambridge, MA, for U.S. Minerals Management Service, NTIS PB86-218385. Bolt, Beranek, and Newman, Anchorage, AK.

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

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

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

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

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

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

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

MONTEIRO, P.M.S., 1998. Assessment of sediment biogeochemical characteristics in the Espirito Santo Estuary-Maputo, Bay system in order to devise a low risk dredging-disposal management plan linked to the proposed MOZAL Matola Terminal. CSIR Report No: ENV/s-C98131 A. pp 39.

MORANT, P.D., 2013. Environmental Management Plan for the proposed marine phosphate prospecting in the Outeniqua West Licence Area on the eastern Agulhas Bank, offshore Mossel Bay. Prepared for Diamond Fields International Ltd. CSIR/CAS/EMS/ER/2013/0000/A, pp266.

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

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

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

O'DONOGHUE, S.H., DRAPEAU, L., DUDLEY, S.F.J. & V.M. PEDDEMORS, 2010a. The KwaZulu-Natal sardine run: shoal distribution in relation to nearshore environmental conditions, 1997 to 2007. *African Journal of Marine Science* **32**: 293–307.

O'DONOGHUE, S.H., DRAPEAU, L. & V.M. PEDDEMORS, 2010b. Broad-scale distribution patterns of sardine and their predators in relation to remotely sensed environmental conditions during the KwaZulu-Natal sardine run. *African Journal of Marine Science* **32**: 279–291.

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

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

O'TOOLE, M.J., 1997. A baseline environmental assessment and possible impacts of exploration and mining of diamond deposits (Prospecting Grants Areas M46/3/1946, 1950) off the coast of Namibia. In: LANE, S & CMS, 1996. Environmental Assessment and Management Plan report for deep sea diamond mining in Namibia by Arena Mining (Pty) Ltd.

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

PARSONS, T.R., KESSLER T.A. and L. GUANGUO, 1986a. An ecosystem model analysis of the effect of mine tailings on the euphotic zone of a pelagic ecosystem. *Acta Oceanol. Sin.*, **5**: 425-436.

PARSONS, T.R., THOMPSON, P., WU YONG, LALLI, C.M., HOU SHUMIN and XU HUAISHU, 1986b. The effect of mine tailings on the production of plankton. *Acta Oceanol. Sin.*, **5**: 417-423.

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

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

PEDDEMORS, V.M. 1999. Delphinids of southern africa. A review of their distribution, status and life history. *J. Cetacean Res. Manage.*, **1(2)**: 157-166.

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

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

PENNEY, A.J. and A. PULFRICH, 2004. Recovery and Rehabilitation of Deepwater Marine Diamond Mining Operations off the Southern African West Coast. Prepared by PISCES Environmental Services (Pty) Ltd for De Beers Marine. 92pp.

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

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

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

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

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

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

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

POOPETCH, T. 1982. Potential effects of offshore tin mining on marine ecology. Proceedings of the Working Group Meeting on environmental management in mineral resource development, *Mineral Resource Development Series*, **49**: 70-73.

PROBYN, T.A. and M.I. LUCAS, 1987. Ammonium and phosphorus flux through the microplankton community in Agulhas Bank waters. *S. Afr. J. mar. Sci*., **5**: 209-221.

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

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

QUICK, R and SINK, K. 2005. Specialist benthic study – PetroSA: South Coast Gas Development Project. Report prepared for CCA Environmental pp. 37.

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

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

ROEL, B.A., HEWITSON, J., KERSTAN, S. and HAMPTON, I. 1994. The role of the Agulhas Bank in the life cycle of pelagic fish. *S. Afr. J. Sci*., **90**: 185-196.

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

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

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

ROSS, G.J.B., COCKCROFT, V.G., MELTON D.A. & D.S. BUTTERWORTH, 1989. Population estimates for bottlenose dolphins *Tursiops truncatus* in Natal and Transkei waters. *S. Afr. J. mar. Sci.* **8**: 119-129.

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

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

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

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

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

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

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

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

SHAMBLIN, B.M., BOLTEN, A.B., ABREU-GROBOIS, F.A., BJORNDAL, K.A., CARDONA, L., CARRERAS, C.C., CLUSA, M., MONZÓN-ARGÜELLO, C., NAIRN, C.J., NIELSEN, J.T., NEL, R., SOARES, L.S., STEWART, K.R., TÜRKOZAN, O. & P.H. DUTTON, (Submitted). Loggerhead turtle phylogeography and stock structure revisited with expanded mitochondrial control region sequences. *PLoS ONE.*

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

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

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

SHIPTON, T. & ATKINSON, L.J., 2010. Benthic specialist impact report for the proposed F-O Gas Field development off the South Coast of South Africa. Enviro-Fish Africa (Pty) Ltd, Grahamstown. 48pp

SIMMONS, R.E., 2005. Declining coastal avifauna at a diamond mining site in Namibia: comparisons and causes. *Ostrich*, **76**: 97-103.

SINK, K.J., ATKINSON, L.J., KERWATH, S. and SAMAAI, T., 2010. Assessment of offshore benthic biodiversity on the Agulhas Bank and the potential role of petroleum infrastructure in offshore spatial management. Report prepared for WWF South Africa and PetroSA through a SANBI initiative 78pp.

SINK, K.J., BOSHOFF, W., SAMAAI, T., TIMM, P.G. and S. E. KERWATH, 2006. Observations of the habitats and biodiversity of the submarine canyons at Sodwana Bay. *South African Journal of Science* **102 (9)**: 466-474.

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

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

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

SINK, K.J, WILKINSON, S., ATKINSON, L.J, SIMS, P.F, LESLIE, R.W. and C.G. ATTWOOD, 2012b. The potential impacts of South Africa's demersal hake trawl fishery on benthic habitats: historical perspectives, spatial analyses, current review and potential management actions. Unpublished report, South African National Biodiversity Institute.

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

SNELGROVE, P.V.R. and BUTMAN, C.A. 1994. Animal-sediment relationships revisited: cause versus effect. *Oceanography & Marine Biology: An Annual Review*, **32**: 111-177.

SOUTHALL, B.L., A.E. BOWLES, W.T. ELLISON, J.J. FINNERAN, R.L. GENTRY, C.R. GREENE, JR., D. KASTAK, D.R. KETTEN, J.H., MILLER, P.E. NACHTIGALL, W.J. RICHARDSON, J.A. THOMAS and P.L. TYACK, 2007. Marine mammal noise exposure criteria: initial scientific recommendations. *Aquatic Mammals*, **33(4)**: 411-522.

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

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

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

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

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

SWART, D.H. and SERDYN, J. de V. 1981. Statistical analysis of visually observed wave data from voluntary observing ships (VOS) for the South African east coast. Stellenbosch. NRIO. Unpublished data.

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

TUCEK, J., NEL, R., GIRANDOT, M. & G. HUGHES, (Submitted). Estimating reproductive age and size of loggerhead sea turtles. *Endangered Species Research*.

TYACK, P.4L., ZIMMER, W.M.X., MORETTI, D., SOUTHALL, B.L., CLARIDGE, D.E., DURBAN, J.W., CLARK, C.W., *et al.*, 2011. Beaked Whales Respond to Simulated and Actual Navy Sonar, 6(3). doi:10.1371/journal.pone.0017009

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

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

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

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

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

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

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

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

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

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

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

WHITEFIELD, A.K., ALLANSON, B.R. and HEINECKEN, T.J.E. 1983 Estuaries of the Cape, Part II: Synopses of available information on individual systems. Report No. 22: Swartvlei (CMS 11). HEYDORN, A.E.F. and GRINDLEY, J.R. (eds). Stellenbosch, CSIR Research Report 421, 62pp.

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