PROPOSED EXPLORATION DRILLING IN THE ORANGE BASIN DEEP WATER LICENCE AREA OFF THE WEST COAST OF SOUTH AFRICA

DRAFT SCOPING REPORT

Prepared for:
Department of Environmental Affairs

On behalf of:
Shell South Africa Upstream B.V.

Prepared by:
CCA Environmental (Pty) Ltd

cca ENVIRONMENTAL

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Prepared for:

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SHE01WD/DSR/Rev.0 JULY 2014

PROJECT INFORMATION

TITLE	Draft Scoping Report for proposed exploration drilling in the Orange Basin Deep Water Licence Area off the West Coast of South Africa
APPLICANT	Shell South Africa Upstream B.V.
ENVIRONMENTAL CONSULTANT	CCA Environmental (Pty) Ltd
REPORT REFERENCE	SHE01WD/DSR/Rev.0
REPORT DATE	16 July 2014

REPORT COMPILED BY: Jeremy Blood

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Jonathan Crowther (Pr.Sci.Nat.; CEAPSA)
Managing Director

EXPERTISE OF ENVIRONMENTAL ASSESSMENT PRACTITIONER

NAME	Jonathan Crowther
RESPONSIBILITY ON PROJECT	Project leader and quality control
DEGREE	B.Sc. Hons (Geol.), M.Sc. (Env. Sci.)
PROFESSIONAL REGISTRATION	Pr.Sci.Nat., CEAPSA
EXPERIENCE IN YEARS	26
EXPERIENCE	Jonathan Crowther has been involved in environmental consulting since 1988 and is currently the Managing Director of CCA Environmental (Pty) Ltd. He has expertise in a wide range of environmental disciplines, including Environmental Impact Assessments (EIA), Environmental Management Plans/Programmes, Environmental Planning & Review, Environmental Auditing & Monitoring, Environmental Control Officer services, and Public Consultation & Facilitation. He has project managed a number of offshore oil and gas EIAs for various exploration and production activities in South Africa and Namibia. He also has extensive experience in projects related to roads, property developments and landfill sites.

NAME	Jeremy Blood
RESPONSIBILITY ON PROJECT	Project management, report writing and specialist study review
DEGREE	B.Sc. Hons (Bot.), M.Sc. (Cons. Ecol.)
PROFESSIONAL REGISTRATION	Pr.Sci.Nat., CEAPSA
EXPERIENCE IN YEARS	15
EXPERIENCE	Jeremy Blood has been working as an environmental assessment practitioner since 1999 and has project managed a number of large-scale projects covering a range of environmental disciplines, including Environmental Impact Assessments, Environmental Management Plans/Programmes, Environmental Auditing & Monitoring and Environmental Control Officer related work in South Africa, Namibia, Mozambique and Kenya. He has expertise in a wide range of projects relating to mining (oil/gas, heavy mineral mining and borrowpits), housing/industrial developments and infrastructure projects (e.g. roads, railway line, power lines and pipelines).

EXECUTIVE SUMMARY

1. INTRODUCTION

1.1 OPPORTUNITY TO COMMENT

This Executive Summary summarises the main findings of the Draft Scoping Report (DSR) prepared as part of the Scoping and Environmental Impact Assessment (hereafter referred to as EIA) process being undertaken for the proposal by Shell South Africa Upstream B.V. (hereafter referred to as "Shell") to undertake exploration drilling in the Orange Basin Deep Water Licence Area off the West Coast of South Africa.

The DSR has been distributed for a 40-day comment period from **28 July 2014 to 8 September 2014** (which makes provision for the public holiday on 9 August 2014) in order to provide Interested and Affected Parties (I&APs) with an opportunity to comment on any aspect of the proposed project and the findings of the scoping process. Copies of the full report have been made available on the CCA Environmental (Pty) Ltd (CCA) website (www.ccaenvironmental.co.za) and at the following locations:

Location	Name of Facility	Physical Address
Cape Town	Cape Town Central Library	Drill Hall, Darling Street, Cape Town
Vredenburg	Vredenburg Library	2 Akademie Street, Louwville, Vredenburg
Saldanha Bay	Saldanha Library	Berg Street, Saldanha
Lamberts Bay	Lamberts Bay Public Library	Church Street, Lamberts Bay
Kleinzee	Kleinzee Tourism Information Centre	1-3rd Street, Kleinzee
Springbok	Matjieskloof Library	Brissonstraat, Matjieskloof, Springbok
Springbok	Moberg Library	Tempelstraat, Bergsig, Springbok
Springbok	Springbok Library	Namakwa Street, Springbok
Port Nolloth	AJ Bekeur Library	Robson Street, Port Nolloth

For comments to be included in the Final Scoping Report (FSR) they should reach the offices of NMA Effective Social Strategists (Pty) Ltd (NMA) **no later than 8 September 2014**. Contact details are as follows:

NMA EFFECTIVE SOCIAL STRATEGISTS
Development Through Participation

Please contact:

Nomi Muthialu
NMA Effective Social Strategists (Pty) Ltd
PO BOX 32097, BRAAMFONTEIN, 2107
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1.2 PROJECT BACKGROUND

In February 2012 Shell, a subsidiary of Royal Dutch Shell plc, obtained an exploration right for the Orange Basin Deep Water Licence Area in terms of the Mineral and Petroleum Resources Development Act, 2002 (No. 28 of 2002) (MPRDA). The licence area is approximately 37 290 km^2 in extent. The eastern border of the licence area is located between approximately 150 km and 300 km off the West Coast of South Africa roughly between Saldanha Bay (33ºS) and Kleinzee (30ºS), with water depths ranging from 500 m to 3 500 m (see Figure 1).

As part of the process of applying for the exploration right, an Environmental Management Programme (EMPr) was compiled and approved for the undertaking of seismic surveys and exploration drilling within the licence area. Shell subsequently undertook a 3D seismic survey in an 8 000 km^2 portion of the licence area, which was completed on 22 February 2013.

Based on analysis of the seismic data, Shell proposes to drill one or possibly two exploration wells in the northern portion of the licence area (see Figure 1) in order to determine whether identified geological structures or "prospects" contain oil or gas in potentially commercial extractable amounts.

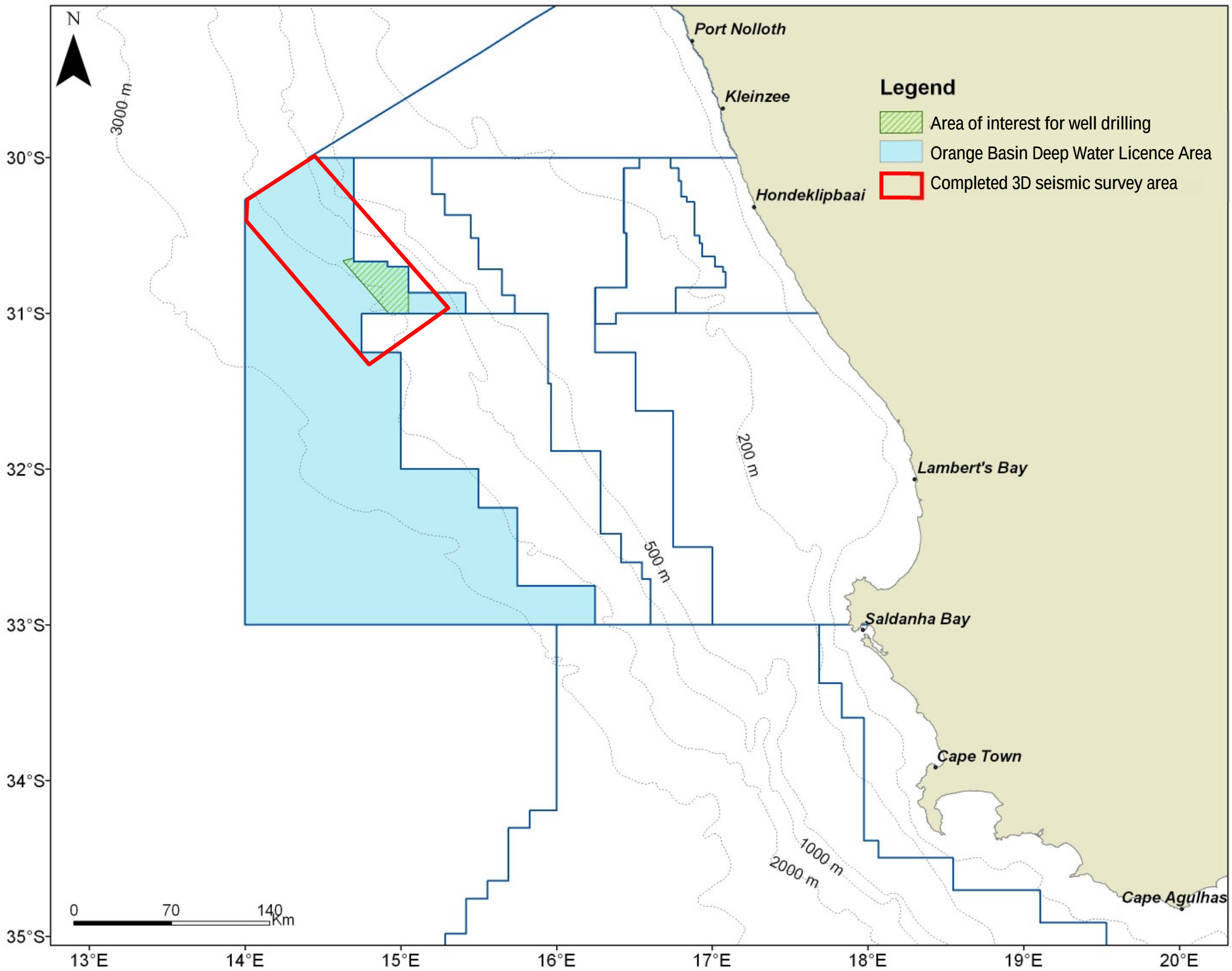

Figure 1: Locality of the Orange Basin Deep Water Licence Area off the West Coast of South Africa. The 2012/2013 seismic survey area is also shown.

1.3 AUTHORISATION REQUIREMENTS

The proposed exploration drilling programme requires authorisation in terms of both the MPRDA and the National Environmental Management Act, 1998 (No. 107 of 1998) (NEMA), as amended.

In terms of Section 102 of the MPRDA, Shell is required to compile an EMPr Addendum to take account of any changes in the project scope on which the current approved exploration right work programme is based, and submit it to the Petroleum Agency of South Africa (PASA) for consideration and approval by the Minister of Mineral Resources (or the delegated authority).

The Environmental Impact Assessment (EIA) Regulations 2010, promulgated in terms of Chapter 5 of NEMA, require that environmental authorisation is obtained from the competent authority, the Department of Environmental Affairs (DEA), to carry out the proposed exploration drilling programme. In order for DEA to consider the application for authorisation an EIA process must be undertaken.

CCA, in association with NMA, has been appointed by Shell to compile the EMPr Addendum and to undertake the EIA process. CCA is responsible for managing and undertaking the EMPr Addendum and EIA processes, while NMA is responsible for managing the associated public participation process.

2. SCOPING PROCESS

2.1 PROJECT REGISTRATION

An "Application Form for Environmental Authorisation" was submitted to DEA on 2 October 2013 to, *inter alia*, register the proposed project and indicate which listed activities are applicable to the proposed project. DEA accepted the application on 17 October 2013.

Initially CCA commenced with a Basic Assessment. However, in March 2014 a decision was taken in conjunction with DEA that a full EIA process should be undertaken. The initial application was subsequently withdrawn and an amended application form was submitted to DEA on 11 April 2014. DEA accepted the amended application on 28 May 2014 (DEA reference number: 14/12/16/3/3/2/704).

2.2 INITIAL PUBLIC PARTICIPATION PROCESS

The initial public participation process involved an open, participatory approach to ensure that I&APs were notified of the proposed project and given a reasonable opportunity to register on the project database and provide initial comments. Steps undertaken during this phase are summarised below:

- A preliminary I&AP database was compiled using Shell's existing database for the Orange Basin Deep Water Licence Area, as well as other databases of previous studies undertaken in the area. Additional I&APs were added to the database based on responses to the advertisements and notification letter;
- A notification letter / email and Background Information Document (BID) were distributed for a 30-day registration and comment period from 31 October to 2 December 2013;
- Advertisements announcing the proposed project, the availability of the BID, I&AP registration / comment period and Information-sharing Meetings were placed in national (Sunday Times and Rapport), regional (Cape Times and Die Burger) and local (Weslander and Ons Kontrei) newspapers;
- Authority meetings were held with PASA, DEA, Department of Agriculture, Forestry and Fisheries (DAFF), Namakwa District Municipality, Nama-Khoi Municipality and Richtersveld Municipality, and Northern Cape Provincial Coastal Committee;
- Public Open Days and Information-sharing Meetings were held in Cape Town and Saldanha on 11 and 12 November 2013, respectively.

A total of 26 written submissions were received during the initial public participation process, many of which related to registration on the project database, obtaining additional project information and potential work opportunities.

The key issues identified by the project team, with I&AP input, are summarised in Section 5. All comments received (including written correspondence and those raised at the authority- / information-sharing meetings) have been collated, and responded to, into an Issues and Responses Trail.

2.3 COMPILATION AND REVIEW OF DSR

The DSR has been prepared in compliance with Section 28(1) of the EIA Regulations 2010 and has been informed by comments received during the BID comment period. This report presents all information in a clear and understandable format suitable for easy interpretation by I&APs and authorities and provides an opportunity for I&APs to comment on the proposed project and findings of the scoping process to date (see Section 1.1 for details of the comment period).

2.4 COMPLETION OF THE SCOPING PHASE

The following steps are envisaged for the remainder of the scoping phase:

- After closure of the comment period, the DSR will be updated into a FSR. All comments received during the review of this DSR will be assimilated and responded to in an updated Issues and Responses Trail that will be included in the final report;
- The FSR will be released for a further 30-day comment period. All I&APs on the project database will be notified when the FSR is available for comment; and
- The FSR, including any comments received from I&APs on the FSR, will be submitted to DEA for acceptance.

If the FSR is accepted, the project will proceed onto the EIA Phase, which will include the undertaking of specialist studies (see Section 6) and the preparation of an Environmental Impact Report (EIR).

3. PROJECT OVERVIEW

3.1 WELL LOCATION, PRE-DRILLING SITE SURVEY AND AND DRILLING PROGRAMME

As previously mentioned, Shell is proposing to drill one or possibly two wells in the northern portion of the licence area. At this stage an area of interest has been defined for the well locations (see Figure 1), which is approximately 900 km^2 in extent with water depths ranging between 1 500 m and 2 100 m. The final well location will be based on a number of factors, including further analysis of the 3D seismic data, the geological target and seafloor location obstacles. The area of the proposed drill location would be analysed for hazards on a special high definition seismic dataset, which is a subset of the acquired 3D data. Pre-drilling site surveys may also involve side-scan sonar, core / grab samples, multi-beam bathymetry and current measurements.

The expected final depth of the well is between 2 700 m and 3 000 m below the seafloor and is expected to take in the order of three months to drill and complete. For operational reasons (i.e. optimal sea state and weather conditions), drilling is expected to take place in a future summer window period between November to April.

Depending on the success of the first well, a second well may be drilled to establish the quantity and potential flow rate of the resource. The “appraisal” well would be drilled in a location and to a depth determined by the results of the first well. It is anticipated that the appraisal well would be drilled at least one year after completion of the first well in order to allow sufficient time for data analysis and planning.

3.2 DRILLING UNIT OPTIONS

Shell is currently considering two alternative drilling units, either a semi-submersible drilling unit (see Figure 2a) or a drill-ship (see Figure 2b). The advantage of a drill ship over the majority of semi-submersible units is that the drill ship is independently mobile, not requiring any towing or transport vessel. In deeper water where anchoring is not practical such as in the area of interest, both the semi-submersible drilling unit and drill ship would be held in position by dynamic positioning thrusters (no anchoring).

While the drilling unit is operational at a well location, a temporary 500 m operational safety zone around the unit would be in force, i.e. no other vessels (except the support vessels) may enter this area. The safety zone would be described in a Notice to Mariners as a navigational warning.

Figure 2a: Photograph of a semi-submersible drilling unit (Source: Shell).	**Figure 2b: Photograph of a drill ship (Source: Shell).**

3.3 EXPLORATION DRILLING, TESTING AND COMPLETION

The well would be created by jetting and drilling a hole into the seafloor with a drilling unit that rotates a drill string with a bit attached. After the hole is drilled, sections of steel pipe (or casings), slightly smaller in diameter than the borehole, are placed in the hole and permanently cemented in place. The hole diameter decreases with increasing depth as progressively smaller diameter casings are inserted into the hole at various stages and cemented into place. The casing provides structural integrity to the newly drilled wellbore, in addition to isolating potentially dangerous high pressure zones from each other and from the surface.

Drilling is essentially undertaken in two stages, namely the riserless and risered drilling stages.

- During the riserless stage hole sections would be drilled using seawater (with viscous sweeps) and water-based mud (WBM). All cuttings and WBM from this initial drilling stage would be discharged directly onto the seafloor adjacent to the wellbore.
- During the risered drilling stage when WBMs cannot provide the necessary characteristics, a low toxicity synthetic-based mud (SBM) would be used to (a) obtain critical reservoir parameters, b) provide a greater level of lubrication, and (c) provide more tolerance to high temperatures. During this stage a riser connects the drilling unit to the well and allows the drilling fluid and rock cuttings to be circulated back to the drilling unit, thereby isolating the drilling fluid and cuttings from the marine environment. The returned drilling fluid is treated to remove solids and drill cuttings from the re-circulating mud stream. During this stage a Blow-out Preventer (BOP) is also installed on the wellhead, which is designed to close in the well to prevent the uncontrolled flow of hydrocarbons from the reservoir.

The "appraisal" well may be flow-tested to determine the economic potential of the discovery before the well is either abandoned or suspended for later re-entry and completion. If flow testing is required, hydrocarbons would be burned at the well site using a high-efficiency flare to maximise combustion of the hydrocarbons.

Based on the results of the drilling, logging and possible testing of the well, a decision would be made as to whether to suspend the well on the seafloor or decommission it. If the well is decommissioned, the wellhead would either remain on or be removed from the seafloor. The preferred option would be to leave the wellhead on the seafloor.

3.8 LOGISTICS

3.8.1 Onshore logistics base

A logistics shore base would be located in either Cape Town or Saldanha Bay. The shore base would provide for the storage of materials (including wellbore materials, diesel, water and drilling fluids) and equipment that would be transported from/to the drilling unit by sea.

3.8.2 Support and supply vessels

The drilling unit will be supported by at least three vessels, namely one standby and two supply vessels. The standby vessel would provide support for firefighting, oil containment / recovery, rescue and any equipment that may be required in case of an emergency. The standby vessel would also be used to patrol the area to ensure that other vessels adhere to the 500 m safety zone around the drilling unit. The supply vessels would provide equipment and material transport between the drilling unit and the port.

3.8.3 Crew transfers

Transportation of personnel to and from the drilling unit would be provided by helicopter operations from the Kleinzee airport. Transportation to Kleinzee would be provided by fixed-wing flights from Cape Town. The drilling unit would accommodate in the order of 100 - 150 personnel. Crews would work in 12-hour shifts in 4-5 week cycles. Thus helicopter operations to and from the drilling unit and fixed wing operations between Kleinzee and Cape Town would occur on an almost daily basis.

4. DESCRIPTION OF THE AFFECTED ENVIRONMENT

4.1 PHYSICAL ENVIRONMENT

The Orange Basin Deep Water Licence Area lies within the southern zone of the Benguela Current region and is characterised by the cool Benguela upwelling system. The dominant southerly and south-easterly winds in summer drive the massive offshore movement of surface water, resulting in strong upwelling of nutrient-rich bottom waters. Nutrient-rich upwelled water enhances primary production, and the West Coast region consequently supports substantial pelagic fisheries.

The area of interest lies beyond the continental shelf. Two geological features of note within the vicinity of the proposed area of interest include Childs Bank, situated approximately 75 km east, and Tripp Seamount, situated in Namibia approximately 120 km north-northwest of the target area.

4.2 BIOLOGICAL OCEANOGRAPHY

South Africa is divided into nine bioregions, one of which occurs in the proposed area of interest (namely the Atlantic Offshore Bioregion). Communities within marine habitats are largely ubiquitous throughout the southern African West Coast region, being particular only to substrate type or depth zone. These biological communities consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales).

As the area of interest lies well offshore of the influence of coastal upwelling, waters are likely to be comparatively warm and clear with low abundances of phytoplankton, zooplankton and ichthyoplankton. The seabed sediments in the area of interest are likely to host a range of benthic macrofaunal species.

The fish species likely to be encountered comprise primarily the large pelagic species (e.g. tunas, billfish and pelagic sharks), which migrate throughout the southern oceans, between surface and deep waters (>300 m).

Although most seabirds in the region reach highest densities offshore of the shelf break (200 to 500 m depth), well inshore of the proposed area of interest, a variety of pelagic seabirds are likely to be encountered during well drilling. Marine mammals likely to be encountered include sperm whales, migrating humpback whales and various baleen and toothed whales known to frequent offshore waters.

4.3 HUMAN UTILISATION

The only commercial fishing sector that could be affected by the proposed exploration drilling is the large pelagic long-line fishery. All other sectors occur inshore of the proposed area of interest. The large pelagic long-line fishery operates extensively from the continental shelf break into deeper waters, year-round and can be expected within the area of interest.

The majority of shipping traffic is located on the outer edge of the continental shelf with traffic inshore of the continental shelf along the South-West Coast largely comprising fishing vessels, especially between Kleinsee and Oranjemund. The majority of the shipping traffic *en route* to and from Cape Town would pass though the licence area and possibility though the area of interest.

Exploration for oil and gas is currently undertaken in a number of licence blocks off the West Coast. There is no current development or production from the South African West Coast offshore. More than half of the proposed area of interest overlaps with a recently approved large phosphate prospecting area. There are no diamond mining concessions within the licence area.

5. KEY PROJECT ISSUES

Key issues to be addressed in the EIA Phase are summarised below.

Potential impact on marine ecology:

- Normal discharges to sea, including sewage, galley waste, and deck and machinery space drainage;
- Localised disturbance of marine fauna due to noise and lighting from the drilling unit and support vessels;
- Physical damage to the seabed and sediment disturbance due to drilling activities and placement of infrastructure on the seafloor;
- Smothering of relatively immobile or sedentary benthic species or biochemical effects (e.g. direct toxicity and bioaccumulation) due to the discharge of cuttings, drilling fluid and cement during well drilling;
- Increased biodiversity and biomass on wellhead due to the increased amount of hard substrate available for colonisation by benthic organisms;

- Introduction of alien invasive marine species through vessels and equipment transfer and ballast water discharge; and
- Accidental release of oil.

Potential impact on fishing:
- Loss of access to fishing grounds; and
- Accidental release of oil.

Potential impact on other marine mining and exploration operations:
- Disruption of activities as a result of the imposition of a statutory activity safety zone.

Potential impact on marine transport routes:
- Interference with shipping routes as a result of the imposition of a statutory activity safety zone.

Physical damage to shipwrecks:
- Disturbance of shipwrecks due to drilling activities and the installation of subsea infrastructure on the seabed.

Potential socio-economic impacts:
- Employment and business opportunities;
- Skills development; and
- Generation of direct revenues.

Specialist studies will be undertaken to address those issues that require further investigation and detailed assessment. The remainder of the issues will be assessed based on experience gained from the environmental assessment of similar operations elsewhere in the region.

6. SPECIALIST STUDIES

Three specialist studies have been identified for the EIA phase, namely: (1) drill cuttings and oil spill modelling, (2) fishing industry assessment, and (3) marine faunal assessment.

Cuttings and oil spill modelling will use the metocean data available for the area of interest in order to model the extent and concentration of various discharge scenarios (including drilling cuttings and hydrocarbon spills). The other two specialist studies will involve the gathering of data relevant (including the results of the modelling study) to identifying and assessing environmental impacts that may occur as a result of the proposed project. These impacts will then be assessed according to pre-defined rating scales. Specialists will also recommend appropriate mitigation or optimisation measures to minimise potential impacts or enhance potential benefits, respectively.

The terms of reference for these studies are presented in Chapter 6.2 of the DSR. The findings of the specialist investigations will be integrated into the Draft EIR.

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LIST OF ACRONYMS, ABBREVIATIONS AND UNITS

BID	Background Information Document
AABW	Antarctic Bottom Water
AAIW	Antarctic Intermediate Water
BOD	Biological oxygen demand
CCA	CCA Environmental (Pty) Ltd
CITES	Convention on International Trade in Endangered Species
cm	centimetres
cm/s	centimetres per second
CO	Carbon monoxide
CO_2	Carbon dioxide
COLREGS	Convention on the International Regulations for Preventing Collisions at Sea
CMS	Convention on Migratory Species
DAFF	Department of Agriculture, Forestry and Fisheries
dB	Decibel
DEA	Department of Environmental Affairs
DEA: BOC	Department of Environmental Affairs: Branch Oceans and Coasts
DSR	Draft Scoping Report
DWA	Department of Water Affairs
E	East
EASSy	Eastern Africa Submarine Cable System
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EMPr	Environmental Management Programme
FSR	Final Scoping Report
g/m^2	grams per square metre
g/m^3	grams per cubic metre
GN	Government Notice
GRT	Gross Registered Tonnage
IAEA	International Atomic Energy Agency
I&APs	Interested & Affected Parties
IBA	Important Bird Area
ICRC	International Commission on Radiological Protection
IMO	International Maritime Organisation
ISO	International Standards Organisation
IUCN	International Union for Conservation of Nature
m	Metres
m^2	Square metres
m^3	Cubic metre
MARPOL	International Convention for the Prevention of Pollution from Ships, 1973/1978
mg/l	Milligrams per litre
mm	Millimetres
MPA	Marine Protected Area
MPRDA	Mineral and Petroleum Resources Development Act, 2002 (No. 28 of 2002)
m/s	Metres per second
mT	Metric tons
N	North
NADF	Non-aqueous drilling fluid
NADW	North Atlantic Deep Water
NBSA	National Biodiversity Spatial Assessment Report
NEMA	National Environmental Management Act, 1998 (No. 107 of 1998)
NEM:AQA	National Environmental Management: Air Quality Act, 2004 (No. 39 of 2004
NEM:WA	National Environmental Management: Waste Act, 2008 (No. 59 of 2008)
nm	Nautical mile (1 nm = 1.852 km)
NMA	NMA Effective Social Strategists (Pty) Ltd
NNW	North-north-west

NO_X	Nitrogen oxides
NW	North-west
OPRC	Oil Pollution Preparedness, Response and Co-operation
PASA	Petroleum Agency of South Africa
PIM	Particulate Inorganic Matter
POM	Particulate Organic Matter
PRDW	Prestedge Retief Dresner Wijnberg Coastal Engineers
PTS	Permanent Threshold Shifts
psi	Per square inch
ROV	Remotely Operated Vehicle
S	South
EIA	Scoping and Environmental Impact Assessment
SAFE	South Africa Far East
SAHRA	South African Heritage Resources Agency
SAMSA	South African Maritime Safety Authority
SAN	South African Navy
SANBI	South African National Biodiversity Institute
SASAR	South African Search and Rescue
SAT3	South Atlantic Telecommunications cable no.3
SAWS	South African Weather Service
SBM	Synthetic-based mud
SO_X	Sulphur oxides
SSW	South-south-west
SW	South-west
t	Tons
TAC	Total Allowable Catch
TAE	Total Applied Effort
TSPM	Total Suspended Particulate Matter
TTS	Temporary Threshold Shifts
UNCLOS	United Nations Convention on Law of the Sea, 1982
VMEs	Vulnerable Marine Ecosystems
VOS	Voluntary Observing Ships
W	West
WACS	West Africa Cable System
WASC	West African Submarine Cable
WBM	Water-based mud
WSW	West-south-west
µg	Micrograms
µm	Micrometre
µg/l	Micrograms per litre
µPa	Micro Pascal
°C	Degrees Centigrade
%	Percent
‰	Parts per thousand
<	Less than
>	Greater than
"	Inch

GLOSSARY

Abandoned well	A well which is officially plugged and abandoned.
Annulus	The space between the casing and the wall of the borehole.
Appraisal well	A well drilled to determine the physical extent, reserves and likely production rate of a field.
Bit	The cutting or boring element used in well drilling.
Blow-out	An uncontrolled flow of oil or gas occurring when formation pressure exceeds the pressure applied to it by the column of drilling fluid.
Blow-out preventers	High pressure wellhead valves designed to shut off the uncontrolled flow of hydrocarbons
Borehole	The hole as drilled by the drill bit.
Casing	Steel pipe cemented in the well to seal off formation fluids or keep the hole from caving in.
Cement casing	To fill the annulus between the casing and hole with cement to support the casing and prevent fluid migration between permeable zones.
Conductor pipe	A conductor pipe is a large diameter pipe that is set into the ground to provide the initial stable structural foundation for the well.
Cuttings	The fragments of rock dislodged by the bit and brought to the surface in the drilling mud.
Drill string	The column, or string, of drill pipe. Often loosely applied to both the drill pipe and drill collars.
Drilling unit	Drilling unit that is not permanently fixed to the seabed, e.g. a drill-ship or a semi-submersible drilling vessel.
Drilling fluid / mud	A mixture of clays, chemicals and water pumped down the drill pipe to lubricate and cool the drilling bit and to flush out the cuttings, as well as to strengthen the sides of the hole. Two main categories of drilling fluids are water-based muds (WBM) and synthetic-based muds (SBM).
Exploration well	A well drilled in an unproven area in order to verify the presence or absence of a hydrocarbon reservoir.
Riser	A pipe between a seabed blow-out preventer and a drilling unit.
Rotary drilling	A drilling method in which the hole is drilled by a rotating bit to which a downward force is applied.
Suspended well	A well that has been capped off temporarily.
Well log	A record of geological formation penetrated during drilling, including technical details of the operation.
Wellbore	A borehole – the hole drilled by the bit.
Wellhead	The equipment installed at the surface of the well bore.

1. INTRODUCTION

This chapter describes the purpose of this report, provides a brief description of the project background, summarises the legislative authorisation requirements, presents the assumptions and limitations of the study, and describes the structure of the report and the opportunity for comment.

1.1 PURPOSE OF THIS REPORT AND OPPORTUNITY TO COMMENT

This Draft Scoping Report (DSR) has been compiled and distributed for review and comment as part of a Scoping and Environmental Impact Assessment (hereafter referred to as EIA) process that is being undertaken for the proposal by Shell South Africa Upstream B.V. (hereafter referred to as “Shell”) to undertake exploration drilling in the Orange Basin Deep Water Licence Area off the West Coast of South Africa.

This report presents the process followed and findings of the scoping process to date. Interested and Affected Parties (I&APs) are asked to comment on the DSR (see Section 1.6). The document will then be updated to a Final Scoping Report (FSR), giving due consideration to the comments received. Comments will be collated into an updated Issues and Responses Trail, which will form part of the FSR.

1.2 PROJECT BACKGROUND

In February 2012 Shell, a subsidiary of Royal Dutch Shell plc, obtained an exploration right for the Orange Basin Deep Water Licence Area in terms of the Mineral and Petroleum Resources Development Act, 2002 (No. 28 of 2002) (MPRDA), as amended. The licence area is approximately 37 290 km^2 in extent. The eastern border of the licence area is located between approximately 150 km and 300 km off the West Coast of South Africa roughly between Saldanha Bay (33ºS) and Kleinzee (30ºS), with water depths ranging from 500 m to 3 500 m (see Figure 1.1).

As part of the process of applying for the exploration right, an Environmental Management Programme (EMPr) was compiled and approved for the undertaking of seismic surveys and exploration drilling within the licence area. Shell subsequently undertook a 3D seismic survey in an 8 000 km^2 portion of the licence area, which was completed on 22 February 2013.

Based on analysis of the seismic data, Shell proposes to drill one or possibly two exploration wells in the northern portion of the licence area (see Figure 1.1) in order to determine whether identified geological structures or “prospects” contain oil or gas in potentially commercial extractable amounts.

1.3 AUTHORISATION REQUIREMENTS

The proposed exploration drilling programme requires authorisation in terms of both the MPRDA and the National Environmental Management Act, 1998 (No. 107 of 1998) (NEMA), as amended. These two regulatory processes are summarised below and presented in more detail in Chapter 2.

In terms of Section 102 of the MPRDA, Shell is required to compile an EMPr Addendum to take account of any changes in the project scope on which the current approved exploration right work programme is based, and submit it to the Petroleum Agency of South Africa (PASA) for consideration and approval by the Minister of Mineral Resources (or the delegated authority).

The Environmental Impact Assessment (EIA) Regulations 2010, promulgated in terms of Chapter 5 of NEMA, require that environmental authorisation is obtained from the competent authority, the Department of Environmental Affairs (DEA), to carry out the proposed exploration drilling programme. In order for DEA to consider the application for authorisation an EIA process must be undertaken.

CCA Environmental (Pty) Ltd (CCA), in association with NMA Effective Social Strategists (Pty) Ltd (NMA), has been appointed by Shell to compile the EMPr Addendum and to undertake the EIA process. CCA is responsible for managing and undertaking the EMPr Addendum and EIA processes, while NMA is responsible for managing the associated public participation process.

In order to avoid duplication, where possible, the NEMA and MPRDA processes have been combined and undertaken in parallel.

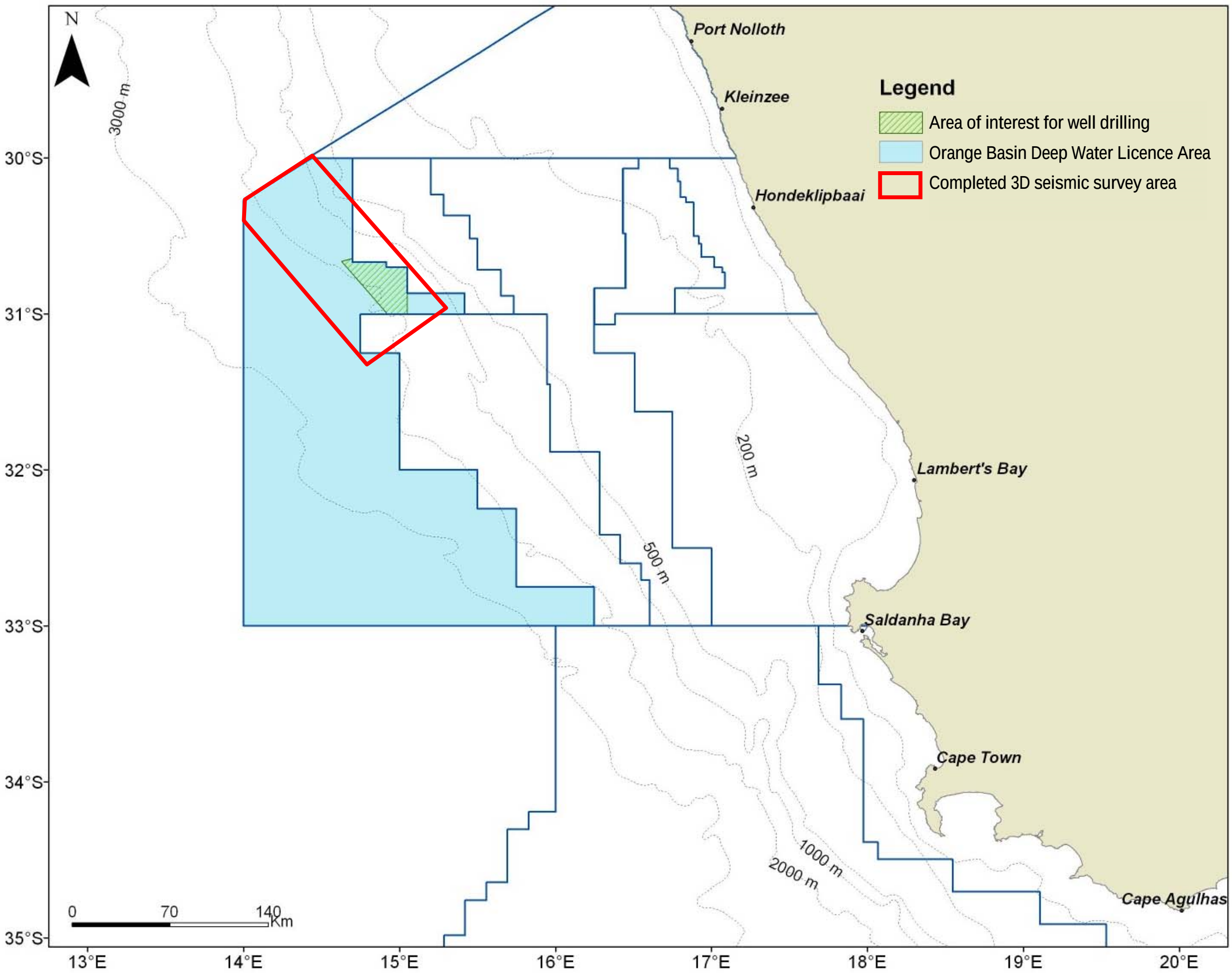

Figure 1.1: Locality of the Orange Basin Deep Water Licence Area off the West Coast of South Africa. The 2012/2013 seismic survey area and proposed area of interest for well drilling are also shown.

1.4 TERMS OF REFERENCE

The terms of reference for the proposed project are as follows:

1. To undertake the EIA for the proposed exploration drilling in the Orange Basin Deep Water Licence Area in accordance with the EIA Regulations 2010 promulgated in terms of Sections 24(5), 24M and 44 of NEMA;
2. To compile an EMPr Addendum in order to meet the requirements of Section 39 and Regulation 52 of the MPRDA; and
3. To combine the NEMA and MPRDA processes, where possible, in order to avoid duplication but meet the legal requirements of both Acts.

1.5 STRUCTURE OF THIS REPORT

This report consists of seven chapters and three appendices, the contents of which are outlined below.

Section	Contents
Executive Summary	Provides an overview of the main findings of the scoping process.
Chapter 1	**Introduction** Describes the purpose of this report, provides a brief description of the project background, summarises the legislative authorisation requirements, presents the terms of reference and assumptions and limitations of the study, and describes the structure of the report and the opportunity for comment.
Chapter 2	**Legislative requirements and study process** Outlines the key legislative requirements applicable to the proposed exploration drilling programme and outlines the methodology and I&AP consultation process followed in the study.
Chapter 3	**Project overview** Describes the need and desirability for the proposed project, provides general project information, an overview of the proposed exploration drilling programme and a description of the project alternatives.
Chapter 4	**Description of the affected environment** Describes the existing biophysical and social environment that could potentially be affected by the proposed project.
Chapter 5	**Key project issues** Describes key issues associated with the proposed project.
Chapter 6	**Proposed specialist studies** Identifies the specialist studies that would be undertaken in the next phase of the EIA and provides their Terms of Reference. The predefined rating scales that would be used to assess the significance of potential impacts are also presented.
Chapter 7	**References** Provides a list of the references used in compiling this report.
Appendices	Appendix 1: DEA correspondence Appendix 2: Public Participation Process: Appendix 2.1: I&AP database Appendix 2.2: I&AP notification letter and BID Appendix 2.3: Advertisements Appendix 2.4: Notices Appendix 2.5: Minutes of authority meetings Appendix 2.6: Public Open Day posters Appendix 2.7: Minutes of information-sharing meetings Appendix 2.8: Correspondence from I&APs Appendix 2.9: Issues and Responses Trail Appendix 3: Plan of Study for EIA

1.6 OPPORTUNITY TO COMMENT

This DSR has been distributed for a 40-day comment period from **28 July 2014 to 8 September 2014** (which makes provision for the public holiday on 9 August 2014) in order to provide I&APs with an opportunity to comment on any aspect of the proposed project and the findings of the scoping process. Copies of the full report have been made available on the CCA website (www.ccaenvironmental.co.za) and at the following locations:

Location	Name of Facility	Physical Address
Cape Town	Cape Town Central Library	Drill Hall, Darling Street, Cape Town
Vredenburg	Vredenburg Library	2 Akademie Street, Louwville, Vredenburg
Saldanha Bay	Saldanha Library	Berg Street, Saldanha
Lamberts Bay	Lamberts Bay Library	Church Street, Lamberts Bay
Kleinzee	Kleinzee Tourism Information Centre	1-3rd Street, Kleinzee
Springbok	Matjieskloof Library	Brissonstraat, Matjieskloof, Springbok
Springbok	Moberg Library	Tempelstraat, Bergsig, Springbok
Springbok	Springbok Library	Namakwa Street, Springbok
Port Nolloth	AJ Bekeur Library	Robson Street, Port Nolloth

Any comments should be forwarded to NMA at the address, telephone/fax numbers or e-mail address shown below. For comments to be included in the Final BAR, comments should reach NMA **no later than 8 September 2014**

NMA EFFECTIVE SOCIAL STRATEGISTS
Development Through Participation

Please contact:

Nomi Muthialu
NMA Effective Social Strategists (Pty) Ltd
PO BOX 32097, BRAAMFONTEIN, 2107

Tel: (011) 447 9737 Fax: 086 601 0381
E-mail: nomim@nma.org.za

2. LEGISLATIVE REQUIREMENTS AND EIA PROCESS

This chapter outlines the key legislative requirements applicable to the proposed well drilling programme and outlines the methodology and I&AP consultation process followed in the EIA.

2.1 LEGISLATIVE REQUIREMENTS

2.1.1 NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998

Section 2 of NEMA sets out a range of environmental principles that are to be applied by all organs of state when taking decisions that significantly affect the environment. Included amongst the key principles is that all development must be socially, economically and environmentally sustainable and that environmental management must place people and their needs at the forefront of its concern, and serve their physical, psychological, developmental, cultural and social interests equitably. NEMA also provides for the participation of I&APs and stipulates that decisions must take into account the interests, needs and values of all I&APs.

Chapter 5 of NEMA outlines the general objectives and implementation of Integrated Environmental Management (IEM), which provides a framework for the integration of environmental issues into the planning, design, decision-making and implementation of plans and development proposals. Section 24 provides a framework for granting of environmental authorisations. In order to give effect to the general objectives of IEM, the potential impacts on the environment of listed activities must be considered, investigated, assessed and reported on to the competent authority. Section 24(4) provides the minimum requirements for procedures for the investigation, assessment and communication of the potential impact of activities.

The EIA Regulations 2010 promulgated in terms of Chapter 5 of NEMA, and published in Government Notice (GN) No. R543, provides for the control of certain listed activities. These activities are listed in GN No. R544 (Listing Notice 1), R545 (Listing Notice 2) and R546 (Listing Notice 3) of 18 June 2010, and are prohibited until environmental authorisation has been obtained from the competent authority, in this case DEA[1]. Such environmental authorisation, which may be granted subject to conditions, will only be considered once there has been compliance with GN No. R543.

GN No. R543 sets out the procedures and documentation that need to be complied with when applying for environmental authorisation. A *Basic Assessment* process must be applied to an application if the authorisation applied for is in respect of an activity(ies) listed in GN No. R544 and / or R546 and an *EIA* process must be applied to an application if the authorisation applied for is in respect of an activity(ies) listed in GN No. R545.

The proposed project includes activities contained in both Listing Notice 1 and 2 (see Table 2.1), thus a full EIA process must be undertaken in order for DEA to consider the application in terms of NEMA. It should be noted that Activity 21 in Listing Notice 2 relating to "any activity which requires an Exploration Right or renewal thereof" in terms of the MPRDA has not yet come into force. In terms of Section 14 of the National Environmental Management Amendment Act, 2008 (No. 62 of 2008), any provision relating to exploration only comes into effect on a date 18 months after the date of commencement of Section 2 of the National Environmental Management Amendment Act, 2008 or the Mineral and Petroleum Resources Development Amendment Act, 2008 (No. 49 of 2008), whichever is the later. As the Mineral and Petroleum Resources Development Amendment Act, 2008 came into effect on 7 June 2013, Activity 21 will only come into effect 18 months after this date (i.e. on 7 December 2014).

[1] DEA is the competent authority since the proposed project occurs offshore within the State-controlled Exclusive Economic Zone (EEZ) and the offshore EEZ does not fall within the borders of any province of South Africa, as set out in the Constitution.

Table 2.1: List of applicable activities in terms of Listing Notice 1 and 2.

Activity No.	Activity Description	Description of activity in relation to the proposed project
GN No. R544: Listing Notice 1		
13	*The construction of facilities or infrastructure for the storage, or for the storage and handling, of a dangerous good, where such storage occurs in containers with a combined capacity of 80 m^3 but not exceeding 500 m^3.*	The proposed drilling operation would make use of infrastructure which would handle and potentially store oil, gas and/or fuel (diesel). Information on the anticipated storage capacity for these substances is currently not available; thus this activity is included to provide for a situation where storage capacity exceeds 80 m^3 but falls below 500 m^3.
16	*Construction or earth moving activities in the sea, … in respect of:* *(iv) … stabilising structures including stabilizing walls; …*	Components of drilling infrastructure (particularly the pipes / casings inside the wellbore) may be viewed as stabilising structures. Note: Activity 16(vi) is not considered applicable as the wellheads and associated guide bases would not have a footprint of 50 m^2 or more.
18	*The infilling or depositing of any material of more than 5 m^3 into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock or more than 5 m^3 from:* *(ii) the sea; …*	The proposed exploration well drilling and appraisal programme would result in various forms of disturbance to the seafloor that would result in more than 5 m^3 of sediment being disturbed. Disturbance would be from: • Placement of equipment on the seafloor; • Drilling the well and removal of rock cuttings, sediment and drill core; and • Disposal of drill cuttings.
GN No. R545: Listing Notice 2		
3	*The construction of facilities or infrastructure for the storage, or storage and handling of a dangerous good, where such storage occurs in containers with a combined capacity of more than 500 m^3.*	The proposed drilling operation would make use of infrastructure which would handle and potentially store oil, gas and/or fuel (diesel). Information on the anticipated storage capacity for these substances is currently not available; thus this activity is included to provide for a situation where storage capacity exceeds 500 m^3.
4	*The construction of facilities or infrastructure for the refining, extraction or processing of gas, oil or petroleum products with an installed capacity of 50 m^3 or more per day, …*	The proposed project would result in the extraction of rock particles (termed "cuttings") which may contain traces of hydrocarbons. Furthermore, if hydrocarbons are encountered during the drilling operation, the well would be flow-tested. The infrastructure that would be established for these activities would have a design throughput exceeding 50 m^3 per day.
5	*The construction of facilities or infrastructure for any process or activity which requires a permit or license in terms of national or provincial legislation governing the generation or release of emissions, pollution or effluent and which is not identified in Notice No. 544 of 2010 or included in the list of waste management activities published in terms of Section 19 of the National Environmental Management: Waste Act, 2008 (No. 59 of 2008) in which case that Act will apply.*	Should Shell decide to incinerate waste on the drilling unit and support / supply vessels an Atmospheric Emission Licence may be required. CCA is currently in the process of trying to confirm the applicability of these activities with DEA: Air Quality Management Services. The incineration of waste is similar to that undertaken by the numerous vessels (including fishing boats, cargo vessels and ocean liners) that pass through or operate within South African waters on a daily basis, none of which to our knowledge have to comply with the licencing requirements of NEM:AQA. It is our understanding that these activities are dealt with under other South African legislation and international conventions, including the National Environmental Management: Integrated Coastal Management Act, 2008 (No. 24 of 2008) and MARPOL 73/78. *Note: this activity was not included in the Application Form submitted to DEA. An amended Application Form may be submitted to DEA to address this issue.*

Activity No.	Activity Description	Description of activity in relation to the proposed project
6	*The construction of facilities or infrastructure for the bulk transportation of dangerous goods:* *(ii) in liquid form, outside an industrial complex, using pipelines, exceeding 1 000 m in length, with a throughput capacity more than 50 m^3 per day;*	The proposed project would make use of drilling infrastructure (e.g. pipes, casings, etc.) which would extract oil and/or gas for testing on the drilling unit. Due to the anticipated depth of the proposed wells, this infrastructure would exceed 1 000 m in length. The designed throughput capacity of this infrastructure could exceed the thresholds specified in the listed activity.
14	*The construction of an …, anchored platform or any other permanent structure on or along the seabed,...*	The proposed drilling operations would result in the placement of equipment (i.e. a wellhead) on the seabed. During well abandonment the wellhead(s) may either remain on or be removed from the seafloor. The option would be to decommission the wellhead(s) and leave then on the seafloor.
26	*Commencing of an activity, which requires an atmospheric emission license in terms of section 21 of the National Environmental Management: Air Quality Act, 2004 (No. 39 of 2004), except where such commencement requires basic assessment in terms of Notice of No. R544 of 2010.*	Should Shell decide to incinerate waste on the drilling unit and support / supply vessels an Atmospheric Emission Licence may be required. As indicated above, CCA is currently in the process of trying to confirm the applicability of these activities with DEA: Air Quality Management Services. *Note: this activity was not included in the Application Form submitted to DEA. An amended Application Form may be submitted to DEA to address this issue.*

2.1.2 MINERAL AND PETROLEUM RESOURCES DEVELOPMENT ACT, 2002

In terms of the MPRDA, an exploration right must be approved prior to the commencement of an exploration activity. A requirement of obtaining an exploration right is that an EMPr[2] must be compiled in terms of Section 39 of the MPRDA and submitted to PASA for consideration and approval by the Minister of Mineral Resources (or the delegated authority). As noted earlier, an exploration right was issued for the Orange Basin Deep Water Licence Area in February 2012 and an EMPr has been approved for the undertaking of seismic surveys and exploration drilling within the licence area.

Since the approved EMPr provided a generic description of exploration drilling and an area of interest within the licence Area had not been identified, PASA requested that that the existing approved EMPr be amended to take account of any changes in the project scope on which the current approved exploration right work programme is based. In terms of Section 102 of the MPRDA, an EMPr may be amended with the written consent of the Minister (or the delegated authority). Thus an EMPr Addendum is required for the proposed exploration drilling programme in terms of Section 102 of the MPRDA in order to meet the requirements of Section 39 and Regulation 52 of the said Act.

In terms of Section 39[3] of the MPRDA an EMPr must:

3 (a) Establish baseline information concerning the affected environment to determine protection, remedial measures and environmental management objectives;

(b) Investigate, assess and evaluate the impact of the proposed project on:

(i) The environment; and

[2] In terms of Section 79(4)(b) of the MPRDA an Environmental Management Programme is a requirement for an Exploration Right. However, in terms of Section 69(2)(vii) "prospecting rights must be construed as reference to exploration rights" and a prospecting right requires an Environmental Management Plan in terms of Section 16(4)(a). Although the EMPr will be referred to as a Programme, it will include the contents of a Plan.

[3] Section 39(7) states that "the provisions of subsection (3)(b)(ii) and subsection (3)(c) do not apply to the applications for reconnaissance permissions, prospecting rights or mining permits." Since "prospecting rights must be construed as reference to exploration rights" (in terms of Section 69(2)(vii)), these sections are not applicable to the amendment application.

(iii) Any national estate referred to in Section 3(2) of the National Heritage Resources Act, 1999 (No. 25 of 1999), with the exception of the national estate contemplated in Section 3(2)(i)(vi) and (vii) of that Act.

(d) Describe the manner in which the Applicant intends to:
- (i) Modify, remedy, control or stop any action, activity or process which causes pollution or environmental degradation;
- (ii) Contain or remedy the cause of pollution or degradation and migration of pollutants; and
- (iii) Comply with any prescribed waste standard or management or practices.

In terms of Regulation 52 of the MPRDA an EMPr must include the following:

2 (a) A description of the environment likely to be affected by the proposed exploration;
- (b) An assessment of the potential impacts of the proposed exploration on the environment, socio-economic conditions and cultural heritage, if any;
- (c) A summary of the assessment of the significance of the potential impacts, and the proposed mitigation and management measures to minimise adverse impacts and benefits;
- (d) Financial provision;
- (e) Planned monitoring and performance assessment of the EMPr;
- (f) Closure and environmental objectives;
- (g) A record of the public participation process undertaken and the results thereof; and
- (h) An undertaking by the Applicant regarding the execution of the EMPr.

2.1.3 NATIONAL ENVIRONMENTAL MANAGEMENT: WASTE ACT, 2008

The National Environmental Management: Waste Act, 2008 (No. 59 of 2008) (NEM:WA) regulates all aspects of waste management and has an emphasis on waste avoidance and minimisation. NEM:WA creates a system for listing and licensing waste management activities. Listed waste management activities above certain thresholds are subject to a process of impact assessment and licensing. Activities listed in Category A require a Basic Assessment, while activities listed in Category B require an EIA.

DEA has indicated that the National Environmental Management: Waste Act, 2008 (No. 59 of 2008) is not applicable to offshore operations (see correspondence in Appendix 1). Although this Act is applicable to onshore operations, there are no proposed onshore activities that trigger the need for a Waste Management Licence.

2.1.4 NATIONAL ENVIRONMENTAL MANAGEMENT: AIR QUALITY ACT, 2004

On 1 April 2010, the National Environmental Management: Air Quality Act, 2004 (No. 39 of 2004) (NEM:AQA) came into force and repealed the Atmospheric Pollution Prevention Act, 1965. NEM:AQA regulates all aspects of air quality, including prevention of pollution, providing for national norms and standards and including a requirement for an Atmospheric Emissions Licence for listed activities, which result in atmospheric emissions and have or may have a significant detrimental effect on the environment. In terms of Section 22 no person may conduct a listed activity without an Atmospheric Emission Licence.

GN No. 893 (22 November 2013), published in terms of Section 21(1)((b) of the NEM:AQA, lists the activities that would require an Atmospheric Emission Licence. Activities that could be applicable to the proposed project are presented in Table 2.2. Should these activities be applicable to the proposed offshore activities an application for an Atmospheric Emission Licence would need to be made to DEA: Air Quality Management Services.

CCA is currently in the process of trying to confirm with DEA: Air Quality Management Services the applicability of these activities to offshore operations.

Table 2.2: List of possible listed activities in terms of the NEM:AQA.

Subcategory No.	Activity Description	Description of activity in relation to the proposed project
Category 8:	**Thermal treatment of hazardous and general waste**	
8.1	*Thermal treatment of general and hazardous waste:* Facilities where general and hazardous waste are treated by the application of heat. Application: All installations treating 10 kg per day of waste.	Shell may incinerate certain non-toxic combustible wastes (e.g. galley waste) on the drilling unit and support / supply vessels. If so, more than 10 kg per day of waste may be treated.

2.1.5 OTHER RELEVANT LEGISLATION

In addition to the foregoing, Shell must also comply with the provisions of other relevant conventions and legislation, which includes, amongst other, the following:

International Marine Pollution Conventions

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

Other International Legislation

- International Commission on Radiological Protection (ICRC);
- International Atomic Energy Agency (IAEA) Regulations for the Safe Transport of Radioactive Material, 1984;

Other South African legislation

- Carriage of Goods by Sea Act, 1986 (No. 1 of 1986);
- Dumping at Sea Control Act, 1980(No. 73 of 1980);
- Hazardous Substances Act, 1983 and Regulations (No. 85 of 1983);
- Marine Living Resources Act, 1998 (No. 18 of 1998);
- Marine Traffic Act, 1981 (No. 2 of 1981);
- Marine Pollution (Control and Civil Liability) Act, 1981 (No. 6 of 1981);
- Marine Pollution (Prevention of Pollution from Ships) Act, 1986 (No. 2 of 1986);
- Marine Pollution (Intervention) Act, 1987 (No. 65 of 1987);
- Maritime Safety Authority Act, 1998 (No. 5 of 1998);
- Maritime Safety Authority Levies Act, 1998 (No. 6 of 1998);
- Maritime Zones Act 1994 (No. 15 of 1994);
- Merchant Shipping Act, 1951 (No. 57 of 1951);

- Mine Health and Safety Act, 1996 (No. 29 of 1996);
- National Environmental Management: Biodiversity Act, 2004 (No. 10 of 2004);
- National Environmental Management: Integrated Coastal Management Act, 2008 (No. 24 of 2008);
- National Heritage Resources Act, 1999 (No. 25 of 1999);
- National Nuclear Energy Regulator Act, 1999 (No. 47 of 1999);
- National Ports Act, 2005 (No. 12 of 2005);
- National Water Act, 1998 (No. 36 of 1998);
- Nuclear Energy Act, 1999 (No. 46 of 1999);
- Occupational Health and Safety Act, 1993 (No. 85 of 1993) and Major Hazard Installation Regulations;
- Sea-Shore Act, 1935 (No. 21 of 1935);
- Sea Birds and Seals Protection Act, 1973 (No. 46 of 1973);
- Ship Registration Act, 1998 (No. 58 of 1998); and
- Wreck and Salvage Act, 1995 (No. 94 of 1995).

2.1.6 GUIDELINES AND POLICIES

The guidelines and policies listed in Table 2.3 have been / or will be taken into account during the EIA.

Table 2.3: Guidelines and policies relevant to the proposed project.

Guideline	Governing body	Applicability
IEM Guideline Series (Guideline 5): Companion to the EIA Regulations 2010 (October 2012)	DEA	This guideline was consulted to inform the applicability of listed activities to the proposed project.
Scoping, Integrated Environmental Management, Information Series 2 (2002)	DEA	This guideline was consulted to obtain guidance on how to implement scoping.
IEM Guideline Series (Guideline 9): Draft guideline on need and desirability in terms of the EIA Regulations 2010 (October 2012)	DEA	This guideline was consulted to inform the need and desirability of the proposed project.
Stakeholder Engagement, Integrated Environmental Management, Information Series 3 (2002)	DEA	The public participation guidelines were consulted to ensure that an adequate public participation process is undertaken.
IEM Guideline Series (Guideline 7): Public participation in the EIA process (October 2012)		
Guidelines – Consultation with I&APs (December 2011)	PASA	
Specialist Studies, Integrated Environmental Management, Information Series 4 (2002)	DEA	This guideline was consulted to ensure adequate development of terms of reference for specialist studies.
Impact significance, Integrated Environmental Management, Information Series 5 (2002)	DEA	This guideline was consulted to inform the assessment of significance of impacts of the proposed project.
Cumulative Effects Assessment, Integrated Environmental Management, Information Series 7 (2004)	DEA	This guideline will be consulted to inform the consideration of potential cumulative effects of the proposed project.
Criteria for determining Alternatives in EIA, Integrated Environmental Management, Information Series 11 (2004)	DEA	This guideline was consulted to inform the consideration of alternatives.
Environmental Management Plans, Integrated Environmental Management, Information Series 12 (2004)	DEA	This guideline will be consulted to ensure that the Environmental Management Programme (EMP) has been adequately compiled.
Environmental Impact Reporting, Integrated Environmental Management, Information Series 15 (2004)	DEA	This guideline was consulted to inform the approach to impact reporting.

2.2 EIA PROCESS

2.2.1 EIA OBJECTIVES

The EIA process has the following important objectives:

- To dovetail the processes required in terms of NEMA and MPRDA;
- To provide a reasonable opportunity for I&APs to be involved in the study;
- To ensure that all potential key environmental issues and impacts that would result from the proposed project are identified;
- To identify feasible alternatives related to the project proposal;
- To assess potential impacts of the proposed project alternatives during the different phases of project development;
- To present appropriate mitigation or optimisation measures to minimise potential impacts or enhance potential benefits, respectively; and
- Through the above, to ensure informed, transparent and accountable decision-making by the relevant authorities.

The EIA process consists of a series of steps to ensure compliance with these objectives and the EIA Regulations 2010 as set out in GN No. R543. The process involves an open, participatory approach to ensure to ensure that all impacts are identified and that decision-making takes place in an informed, transparent and accountable manner.

2.2.2 ASSUMPTIONS AND LIMITATIONS

The EIA assumptions and limitations are listed below:

- The EIA assumes that CCA has been provided with all relevant project information and that it was correct and valid at the time it was provided;
- Specialists will be provided with all the relevant project information in order to produce accurate and unbiased assessments;
- There will be no significant changes to the project description or surrounding environment between the completion of the Final Environmental Impact Report (EIR) and implementation of the proposed project that could substantially influence findings, recommendations with respect to mitigation and management, etc.; and
- Certain details regarding the proposed well drilling programme were not available at the time of report writing, e.g. the actual specific locations of the wells, drilling unit / vessels to be used, exact timing of well drilling, etc.).

These assumptions and limitations, however, are not considered to have any negative implications in terms of the credibility of the results of the scoping process.

2.2.3 EIA PROCESS

A flowchart indicating the study process is presented in Figure 2.1.

2.2.3.1 Scoping Phase

Project registration

An “Application Form for Environmental Authorisation” was submitted to DEA on 2 October 2013 to, *inter alia*, register the proposed project and indicate which listed activities are applicable to the proposed project. DEA accepted the application on 17 October 2013.

Initially CCA commenced with a Basic Assessment. However, in March 2014 a decision was taken in conjunction with DEA that a full EIA process should be undertaken. The initial application was subsequently withdrawn and an amended application form was submitted to DEA on 11 April 2014. DEA accepted the amended application on 28 May 2014 (DEA reference number: 14/12/16/3/3/2/704). Copies of the amended application form were forwarded to both the Department of Environment Affairs and Nature Conservation (Northern Cape) (DEA&NC) and the Western Cape Government: Department of Environmental Affairs and Development Planning (DEA&DP).

All correspondence from DEA is included in Appendix 1.

Initial public participation process

The objective of the initial public participation process was to ensure that I&APs were notified of the proposed project and given a reasonable opportunity to register on the project database and provide initial comments. Steps undertaken during this phase are summarised in Box 2.1 and all supporting information is presented in Appendix 2.

A total of 26 written submissions were received during the initial public participation process (see Appendix 2.8), many of which related to registration on the project database, obtaining additional project information and potential work opportunities. Written submissions were received from the following organisations / individuals:

Authorities	Organisations	Private
• Department of Agriculture, Forestry and Fisheries (Deon Durholtz) • Petroleum Agency SA (Phumla Ngesi) • Lamberts Bay Municipality (Shirlene Fransman) • Department of Environment and Nature Conservation (Wilna Oppel)	<u>Business</u> • Atlas Copco Group (Cindy Ross) • Toprope (Daniel Bottonley) • Duferco Steel Processing (Elmien de Bruyn) • Leapfrog (Esther Kluge) • MEK Drilling (Judith Vermeulen) • Umbono Capital (Richard Montjoie) • Matrikon Moore (Trevor Nell) • MECS (Roland Glass) <u>Fishing</u> • Sea Harvest (Greg Marshall) • FishSA (Jeremy Marillier) • Namibian Hake Association (Matti Amukwa) <u>Maritime</u> • Bidfreight Port Operations (Alet Fabicius) • Japan Marine Supplies & Services (Gill Maasburg) <u>Oil and gas</u> • Sunbird Energy (Anschen Friedrichs) • Thombo Petroleum (Trevor Ridley) • NOV Rig Solutions SSA (Oliver Römer) • South African Oil & Gas Alliance (Mthozami Xiphu) <u>Mining</u> • International Mining and Dredging (Bheki Ngcobo) • International Mining and Dredging (Paolo Esposito) <u>Environmental</u> • WESSA (Suzanne Erasmus)	• Francine Dieckmann • Steve Meyer

The key issues identified by I&APs and the project team are summarised in Figure 2.2. All comments received (including written correspondence and those raised at the authority- / information-sharing meetings) have been collated, and responded to, into an Issues and Responses Trail (see Appendix 2.9).

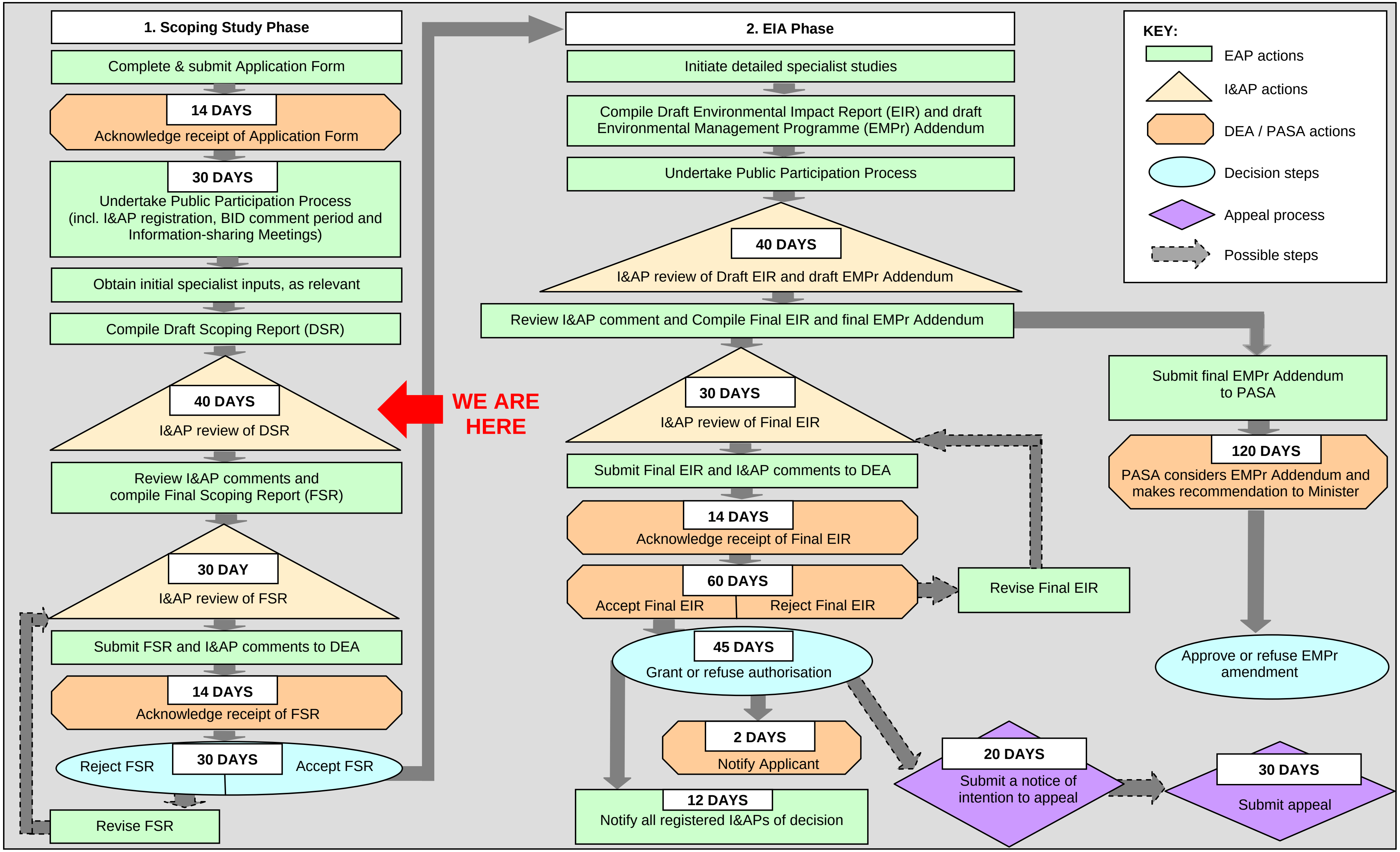

Figure 2.1: Flow diagram showing the EIA process (including EMPr addendum process).

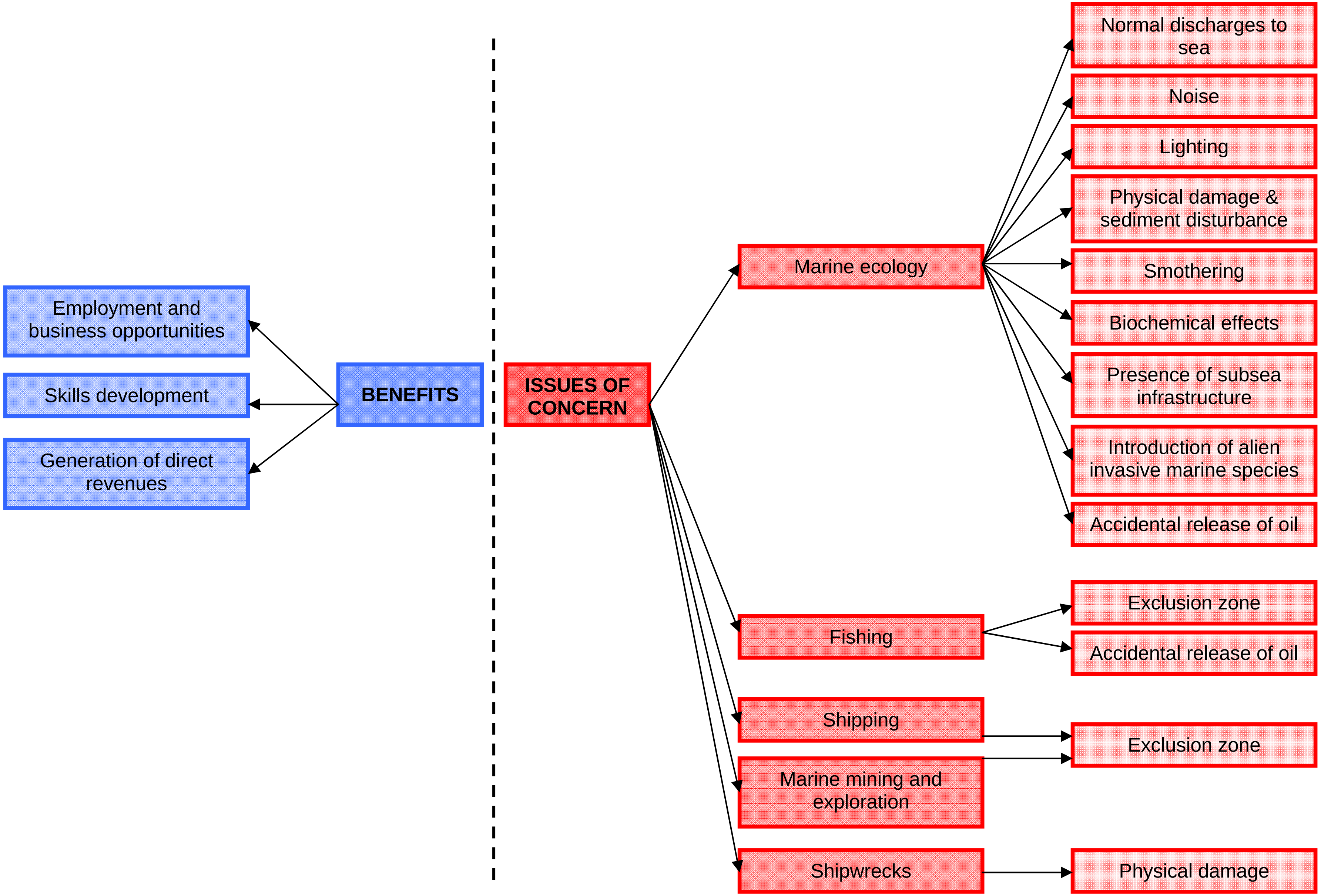

Figure 2.2: **Key issues identified by I&APs and the project team.**

Box: 2.1 Tasks undertaken during the initial public participation process.

1. Identification of I&APs

A preliminary I&AP database of authorities, Non-Governmental Organisations, Community-based Organisations and other key stakeholders was compiled using Shell's existing database for the Orange Basin Deep Water Licence Area, as well as other databases of previous studies undertaken in the area. Additional I&APs were added to the database based on responses to the advertisements and notification letter. To date 327 I&APs have been registered on the project database (see Appendix 2.1).

2. Distribution of Background Information Document (BID)

A notification letter and BID were distributed for a 30-day registration and comment period from 31 October to 2 December 2013 (see Appendix 2.2 for letter, BID and proof of distribution). The purpose of the letter and BID was to convey information on the proposed exploration drilling programme and to invite I&APs to register on the project database and provide initial comment. To simplify the registration process, a Registration and Comment Form was distributed with the BID. The letter, BID and Registration and Response Form were available in English, Afrikaans and isiXhosa.

3. Advertisements and notices

Advertisements announcing the proposed project, the availability of the BID, I&AP registration / comment period and Information-sharing Meetings were placed in the following national, regional and local newspapers in three languages (English, Afrikaans and isiXhosa) (see Appendix 2.3):

- National newspapers:
  - 27 October 2013: Sunday Times (English and isiXhosa) and Rapport (Afrikaans);
- Regional newspapers:
  - 30 October 2013: Cape Times (English and isiXhosa) and Die Burger (Afrikaans);
- Local newspapers:
  - 31 October 2013: Weslander (English, Afrikaans and isiXhosa); and
  - 1 November 2013[4]: Ons Kontrei (English, Afrikaans and isiXhosa).

Notices (in English, Afrikaans and isiXhosa) announcing the proposed project, the availability of the BID, I&AP registration / comment period and Information-sharing Meetings were erected in the following towns along the West Coast (see Appendix 2.4):

- Saldanha (Saldanha Bay Library and Saldanha Bay Municipality offices);
- Vredenburg (Vredenburg Public Library and Saldanha Bay Municipality offices);
- Lamberts Bay (Cederberg Municipality offices and the Lamberts Bay Public Library),
- Kleinzee (post office and café);
- Port Nolloth (Richtersveld Municipality offices and AJ Bekeur Library); and
- Springbok (Nama-Khoi Municipality offices and three libraries, including Matjieskloof, Moberg and Springbok).

4. Authority meetings

Authority meetings were held with:

- PASA on 3 October 2013 in Bellville, Cape Town;
- DEA on 17 October 2013 and 14 February 2014 in Pretoria;
- Department of Agriculture, Forestry and Fisheries (DAFF) on 11 November 2013;
- Namakwa District Municipality, Nama-Khoi Municipality and Richtersveld Municipality on 27 November 2013; and
- Northern Cape Provincial Coastal Committee on 28 November 2013.

At these meetings Shell and CCA provided a basic overview of the project proposal and study process, respectively, and provided stakeholders the opportunity to raise any issues or concerns regarding the proposed project. Minutes of these meetings (including attendance registers) are presented in Appendix 2.5.

[4] Note: Although the newspaper is dated 1 November 2013, it was released on 31 October 2013.

5. Public Open Days and Information-sharing Meetings

Two Public Open Days and Information-sharing Meetings were held during the BID comment period. The details of these are listed below.

Date:	11 November 2013	12 November 2013
Location:	Granger Bay Hotel School, Cape Town	Protea Hotel, Saldanha Bay
Time:	Open day: 14h00 - 17h30 Formal presentation: 17h30 - 20h00	
No. of attendees:	20	13

The Public Open Days included posters (in English, Afrikaans and Xhosa) summarising the proposed project, study process and key issues (see Appendix 2.6). A short video describing the proposed drilling procedure was also shown at the open days.

At these meetings Shell and CCA provided a basic overview of the project proposal and study process, respectively, and provided stakeholders the opportunity to raise any issues or concerns regarding the proposed project. The meetings were held in English, but Afrikaans and isiXhosa translators were available to translate were necessary. Copies of the BID and Registration and Response Form were available for attendees to record in writing any issues or concerns relating to the proposed development. Minutes of these meetings (including presentation and attendance register) are presented in Appendix 2.7.

Compilation of DSR

The DSR has been prepared in compliance with Section 28(1) of the EIA Regulations 2010 (see Table 2.4) and has also been informed by comments received during the BID comment period. This report aims to present all information in a clear and understandable format, suitable for easy interpretation by I&APs and authorities, and to provide an opportunity for I&APs to comment on the proposed project and findings of the scoping process to date (see Section 1.6 for details of the comment period).

Completion of the Scoping Phase

The following steps are envisaged for the remainder of the Scoping Phase (see Figure 2.1):

- After closure of the comment period, the draft report will be updated into a FSR. All comments received on the draft report will be incorporated into an updated Issues and Responses Trail that will be appended to the final report;
- The FSR will be released for a further 30-day comment period. All I&APs on the project database will be notified when the FSR is available for comment; and
- The FSR, including any comments received from I&APs on the FSR, will be submitted to DEA for acceptance.

If the FSR is accepted, the project will proceed onto the EIA Phase (see Section 2.2.3.2). A Plan of Study for EIA as required in terms of Regulation 28(1)(n) of GN R543 is included in Appendix 3.

Table 2.4: Requirements of a Basic Assessment Report in terms of the EIA Regulations 2010.

Section 28	Content of Scoping Report	Completed (Y/N or N/A)	Location in report
1(a)	(i & ii) Details and expertise of the Environmental Assessment Practitioner (EAP) who prepared the report.	Y	page ii
(b)	Description of the proposed activity.	Y	Chapter 3
(c)	A description of any feasible and reasonable alternatives that have been identified.	Y	Section 3.3
(d)	A description of the property on which the activity is to be undertaken and the location of the activity on the property, or if it is:	N/A	Section 3.2.2
	(i) A linear activity, a description of the route of the activity; or	N/A	
	(ii) An ocean-based activity, the co-ordinates where the activity is to be undertaken.	Y	
(e)	A description of the environment that may be affected by the activity and the manner in which activity may be affected by the environment.	Y	Chapter 4
(f)	An identification of all legislation and guidelines that have been considered in the preparation of the scoping report.	Y	Section 2.1
(g)	A description of environmental issues and potential impacts, including cumulative impacts that have been identified.	Y	Chapter 5
(h)	Details of the public participation process conducted in terms of regulation 27(a), including: (i) The steps that were taken to notify potentially interested and affected parties;	Y	Section 2.2.3.1
	(ii) Proof that notice boards, advertisements and notices notifying potentially interested and affected parties of the application have been displayed, placed or given;	Y	Appendix 2.3 & 2.4
	(iii) A list of all persons or organisations that were identified and registered in terms of regulation 55 as I&APs in relation to the application; and	Y	Appendix 2.1
	(iv) A summary of the issues raised by I&APs, the date of receipt of and the response of the EAP to those issues.	Y	Appendix 2.9
(i)	A description of the need and desirability of the proposed activity.	Y	Section 3.1
(j)	A description of identified potential alternatives to the proposed activity, including advantages and disadvantages that the proposed activity or alternatives may have on the environment and the community that may be affected.	Y	Section 3.3
(k)	Copies of any representations and comments received in connection with the application or the scoping report from I&APs.	Y	Appendix 2.8
(l)	Copies of the minutes of any meetings held by the EAP with I&APs and other role players which record the views of the participants.	Y	Appendix 2.5 & 2.7
(m)	Any responses by the EAP to those representations and comments and views.	Y	Appendix 2.9
(n)	A plan of study for environmental impact assessment which sets out the proposed approach to the environmental impact assessment of the application, which must include – (i) A description of the tasks that will be undertaken as part of the EIA process, including any specialist reports or specialised processes and the manner in which such tasks will be undertaken; (ii) An indication of the stages at which the competent authority will be consulted; (iii) A description of the proposed method of assessing the environmental	Y	Appendix 3

	issues and alternatives, including the option of not proceeding with the activity; and (iv) Particulars of the public participation process that will be conducted during the EIA process.		
(o)	Any specific information required by the competent authority. *DEA listed information requirements in their Letter of Acceptance of the Application Form and subsequent correspondence*.	Y	Appendix 1
(p)	Any other matters required in terms of sections 24(4)(a) and (b) of the Act. (This refers to Environmental Authorisations and procedures for the investigation, assessment and communication of the potential consequences or impacts of activities on the environment that the authority needs to consider when reviewing an Application).	Y	-

2.2.3.2 EIA Phase

Specialist studies

Three specialist studies will be undertaken to address the key issues that require further investigation and detailed assessment, namely: (1) cuttings and oil spill modelling, (2) the impact on fishing, and (3) the impact on marine fauna. A list of the specialists and their details are provided in Table 2.5.

Cuttings and oil spill modelling will use the metocean data available for the area of interest in order to model the extent and concentration of various discharge scenarios (including drilling cuttings and hydrocarbon spills). The other two specialist studies will involve the gathering of data relevant (including the results of the modelling study) to identifying and assessing environmental impacts that may occur as a result of the proposed project. These impacts will then be assessed according to pre-defined rating scales (see Section 6.3). Specialists will also recommend appropriate mitigation or optimisation measures to minimise potential impacts or enhance potential benefits, respectively. The terms of reference for these studies are presented in Chapter 6.

Table 2.5: List of specialist studies and specialists.

No.	Specialist study	Specialist/s	Qualifications	Company	Terms of Reference
1	Drill cuttings and oil spill modelling	Mr Stephen Luger	MSc (Engineering), University of Cape Town	Prestedge Retief Dresner Wijnberg (PRDW)	Section 6.2.2
2	Fishing	Mr Dave Japp	MSc (Ichthyology and Fisheries Science), Rhodes University	CapFish SA (Pty) Ltd	Section 6.2.3
		Ms Sarah Wilkinson	BSc (Hons) (Botany), University of Cape Town		
3	Marine fauna	Dr Andrea Pulfrich	PhD (Fisheries Biology), Christian-Albrechts University, Kiel, Germany	Pisces Environmental Services (Pty) Ltd	Section 6.2.4

Integration and Assessment

The specialist information and other relevant information will be integrated into a Draft EIR and draft EMPr Addendum. The specialist studies will be included as appendices to these reports. The Draft EIR and draft EMPr Addendum will be released for a 40-day comment period. The comment period will be advertised and all I&APs on the project database will be notified once the draft reports are available for comment.

After closure of the comment period, the reports will be updated into a Final EIR and final EMPr Addendum. All comments received on the draft reports will be incorporated into an Issues and Responses Trail that will be appended to the Final EIR and final EMPr Addendum.

The Final EIR will be released for a further 30-day comment period. All I&APs on the project database will be notified that the Final EIR is available for comment. After closure of the comment period, the Final EIR, including any comments received from I&APs on the Final EIR, will be submitted to DEA for consideration and decision-making in terms of NEMA. The Final EIR and final EMPr Addendum will also be submitted to PASA for consideration of the amendment application in terms of the MPRDA.

The decision taken by DEA will be advertised and distributed to all I&APs on the project database as part of the statutory appeal period.

3. PROJECT OVERVIEW

This chapter describes the need and desirability for the proposed project, provides general project information, an overview of the proposed exploration drilling programme and a description of the project alternatives.

3.1 NEED AND DESIRABILITY

Shell has a strategic vision to support future energy demands in South Africa by building a robust and successful integrated energy business in the country. The Orange Basin Deep Water Licence Area is part of this strategy, and is focussed on one of the key themes within Shell, namely deep water exploration and development.

Shell acquired the licence area after it was promoted by PASA in the 2009 Bid Round. The chance of success is considered to be low, but in the case of success long-term benefits for South Africa would consist of access to new energy sources, major in-country investments in a development project and less dependence on the importation of natural hydrocarbons.

There has been renewed interest in hydrocarbon exploration in South Africa following the substantial hydrocarbon resources identified in neighbouring countries and Sub-Saharan Africa. If successful, this presents an opportunity to develop a South African oil and gas industry. There is potential in the long-term for local economic stimulation through direct employment, future business opportunities, royalties and tax revenues.

3.2 GENERAL PROJECT INFORMATION

3.2.1 EXPLORATION RIGHT HOLDER

Shell is the Exploration Right holder of the Orange Basin Deep Water Licence Area.

Address:	Shell South Africa Upstream B.V.	
	PO Box 2231	10 Rua Vasco da Gama Plain
	CAPE TOWN	CAPE TOWN
	8000	8000

General Manager:	Jan Willem Eggink
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E-mail:	j.eggink@shell.com

3.2.2 LICENCE AREA DETAILS

The Orange Basin Deep Water Licence Area is located off the West Coast of South Africa and covers an area of approximately 37 290 km^2. The eastern border of the licence area is located between approximately 150 km and 300 km off the coast roughly between Saldanha Bay (33ºS) and Kleinzee (30ºS), with water depths ranging from 500 m to 3 500 m (see Figure 1.1). The co-ordinates of the licence area are provided Table 3.2.

Table 3.1: Co-ordinates of the Orange Basin Deep Water Licence Area (Co-ordinate system: WGS 84 Zone 33).

Point	Latitude (S)	Longitude (E)	Point	Latitude (S)	Longitude (E)
1	30º 00' 01.41"	14º 25' 59.41"	12	31º 15' 01.30"	14º 59' 56.53"
2	30º 00' 04.41"	14º 41' 56.43"	13	32º 00' 01.23"	14º 59' 56.77"
3	30º 40' 01.36"	14º 41' 56.44"	14	32º 00' 01.18"	15º 29' 56.85"
4	30º 40' 01.33"	14º 54' 56.46"	15	32º 15' 01.15"	15º 29' 56.88"
5	30º 42' 01.32"	14º 54' 56.46"	16	32º 15' 01.13"	15º 44' 56.90"
6	30º 42' 01.31"	15º 02' 56.47"	17	32º 45' 01.08"	15º 44' 56.99"
7	30º 52' 01.31"	15º 02' 56.48"	18	32º 45' 01.03"	16º 14' 57.07"
8	30º 52' 01.29"	15º 24' 56.53"	19	33º 00' 00.99"	16º 14' 57.11"
9	31º 00' 01.29"	15º 24' 56.55"	20	33º 00' 01.19"	13º 59' 56.70"
10	31º 00' 01.33"	14º 44' 56.47"	21	30º 16' 04.79"	13º 59' 56.31"
11	31º 15' 01.32"	14º 44' 56.49"			

3.2.3 FINANCIAL PROVISION

In terms of Sections 41 and 89 of the MPRDA and Regulation 51(b)(v), no exploration operation may commence unless the exploration right holder has provided for a financial provision acceptable to the designated agency guaranteeing the availability of sufficient funds to fulfil its obligations in terms of the exploration work programme and EMPr Addendum.

It is Shell's policy to ensure appropriate financial provision is in place prior to any work being undertaken in the exploration right area. Shell will discuss and conclude the nature and quantum of the financial provision required for the management of and remediation of environmental damage with PASA prior to any drilling activity being undertaken.

3.3 EXPLORATION DRILLING

3.3.1 WELL LOCATION, PRE-DRILLING SITE SURVEY AND DRILLING PROGRAMME

As previously mentioned, Shell is proposing to drill one or possibly two wells in the northern portion of the licence area. At this stage an area of interest has been defined for the well locations (see Figure 3.1), which is approximately 900 km^2 in extent with water depths ranging between 1 500 m and 2 100 m. The final well location will be based on a number of factors, including further analysis of the 3D seismic data, the geological target and seafloor location obstacles. The area of the proposed drill location would be analysed for hazards on a special high definition seismic dataset, which is a subset of the acquired 3D data. Pre-drilling site surveys may also involve side-scan sonar, core / grab samples, multi-beam bathymetry and current measurements.

The expected final depth of the well is between 2 700 m and 3 000 m below the seafloor and is expected to take in the order of three months to drill and complete. For operational reasons (i.e. optimal sea state and weather conditions), drilling is expected to take place in a future summer window period between November to April.

Depending on the success of the first well, a second well may be drilled to establish the quantity and potential flow rate of the resource. The "appraisal" well would be drilled in a location and to a depth determined by the results of the first well. It is anticipated that the appraisal well would be drilled at least one year after completion of the first well in order to allow sufficient time for data analysis and planning.

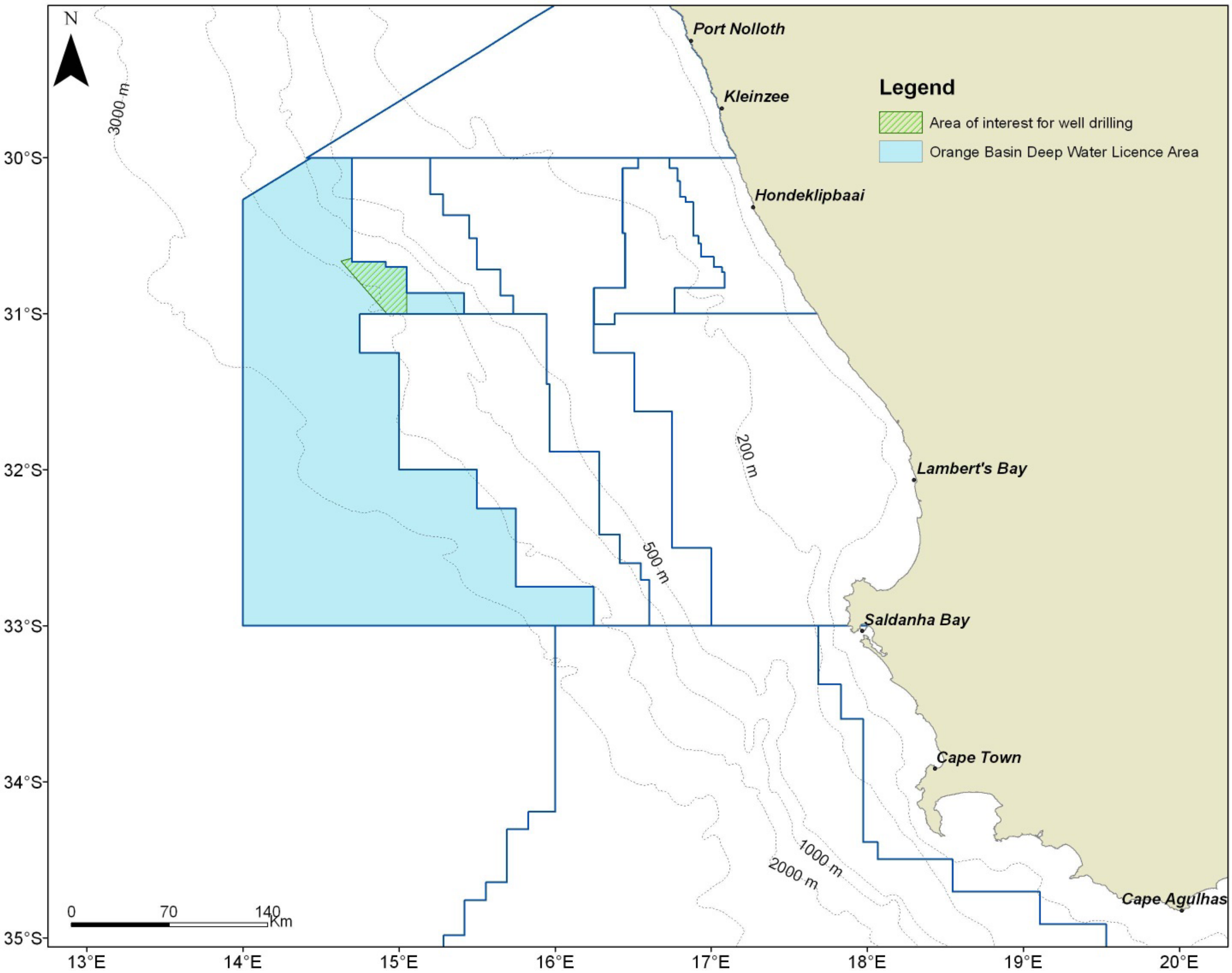


Figure 3.1: Locality of the area of interest for well drilling within the Orange Basin Deep Water Licence Area.

3.3.2 DRILLING UNIT OPTIONS

Various types of drilling technology can be used to drill an exploration well depending on, *inter alia*, the water depth and marine operating conditions experienced at the well site, e.g. barges, platform rigs, jack-up rigs, semi-submersible drilling units (rigs), drill ships and tension leg platform rigs. Shell is currently considering two alternative drilling units, either a semi-submersible drilling unit (see Figure 3.2a) or a drill-ship (see Figure 3.2b).

A semi-submersible drilling unit is essentially a drilling rig with auxiliary drilling and marine support equipment located on a floating structure comprised of one or a number of pontoons. A semi-submersible drilling unit typically, but not necessarily, requires a tow vessel or transport barge to transport the unit to its drilling location.

When at the well location, the pontoons are partially flooded (or ballasted), to submerge the pontoons to a pre-determined depth below the sea level where wave motion is minimised. This gives stability to the drilling unit thereby facilitating drilling operations. In deeper water where anchoring is not practical (such as in the area of interest), the drilling unit would be held in position by dynamic positioning thrusters. On-board computers are locked onto the well location and activate bow and stern thrusters to maintain the drilling unit on location with a high degree of precision.

A riser pipe on compensated hydraulic tensioners (which keep the tension of the riser pipe constant during wave motion) connects the drilling unit to the seabed during the drilling operation. The riser acts as a conduit through which drilling operations can proceed and drilling fluid can be circulated.

Figure 3.2a: Photograph of a semi-submersible drilling unit (Source: Shell).

Figure 3.2b: Photograph of a drill ship (Source: Shell).

3.3.2.1 Semi-submersible drilling unit (rig)

3.3.2.2 Drill ship

A drill-ship is essentially a self-sufficient ship with a drilling rig attached, normally located at the centre of the ship where drilling operations are conducted. The advantage of a drill ship over the majority of semi-submersible units is that the drill ship is independently mobile, not requiring any towing or transport vessel.

Drill ships may be held in position by anchors in the same way as semi-submersibles. However, in deeper water where anchoring is not practical (such as in the area of interest), they are similarly held in position by dynamic positioning thrusters.

The drill-ship, similar to the semi-submersible drilling unit, uses a riser pipe on compensated hydraulic tensioners to connect the vessel to the seabed and to act as a conduit through which drilling operations can proceed.

3.3.2.3 Safety standards

The drilling unit would be classified for seaworthiness through an appropriate marine classification programme (e.g. American Bureau of Shipping, Det Norske Veritas, Lloyds Register, etc.). The following documents define the safety standards which Shell would adopt:

- International Convention for Safety of Life at Sea. IMO/SOLAS consolidated edition 1997 plus ISM Code. ISBN 92-801-1433-6;
- Loading of Lifeboats during Drills. Report Step Change in Safety Committee 2003;
- Service Vessel Marine Safety Guidelines. Report OGP 213 Applicable to the extent referenced in Article 5 of Section VI;

- International Convention on Standards of Training, Certification and Watch-keeping for Seafarers. Report IMO 2001 Edition;
- International Maritime Dangerous Goods Code (IMDG). Report IMO 2008 edition;
- Convention on the International Regulations for Preventing Collisions at Sea. (COLREGS). Report IMO Consolidated edition 2003;
- Guidelines for Vessels with Dynamic Positioning Systems. Report IMO Circular MSC 645;
- Code of Safe Practices for Merchant Seamen. Report UK Maritime and Coastguard Agency. Consolidated Edition 2009;
- International Code of Practice for Offshore Diving. Report IMCA D014 Rev 1, 2007; and
- Diving Recommended Practices. Report OGP 411, 2008.

3.3.2.4 Exclusion zone

Under the Convention on the International Regulations for Preventing Collisions at Sea (COLREGS, 1972, Part B, Section II, Rule 18), a drilling unit that is engaged in underwater operations is defined as a “vessel restricted in its ability to manoeuvre” which requires that power-driven and sailing vessels give way to a vessel restricted in her ability to manoeuvre. Vessels engaged in fishing are required to, so far as possible, keep out of the way of the well drilling operation.

Furthermore, under the Marine Traffic Act, 1981 (No. 2 of 1981), an “exploration platform” or “exploration vessel” used in prospecting for or mining of any substance falls under the definition of an “offshore installation” and as such it is protected by a 500 m safety zone. It is an offence for an unauthorised vessel to enter the safety zone.

The temporary 500 m safety zone around the drilling unit (approximately 0.8 km^2 in extent) would be enforced around the drilling unit at all times. A support vessel equipped with appropriate radar and communications would be kept on 24-hour standby near the drilling unit and is used to patrol the area to ensure that other vessels adhere to the safety zone. The safety zone would be described in a Notice to Mariners as a navigational warning.

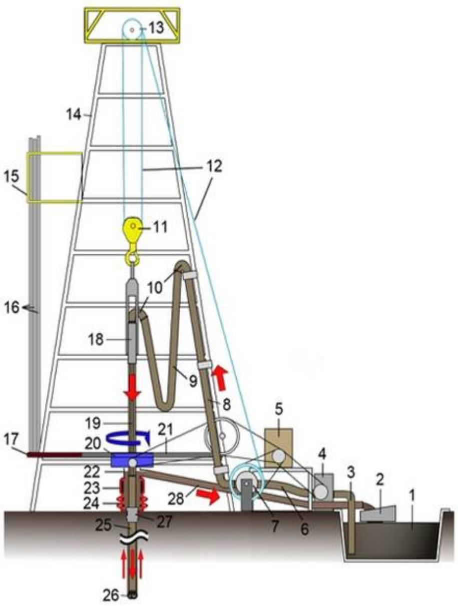
3.3.3 DRILLING EQUIPMENT AND PROCEDURE

3.3.3.1 Equipment

The essential elements of a drilling unit are: hoisting, rotating, circulating, power and safety equipment. These are described below (see Figure 3.3).

Hoisting System

The hoisting system is used to raise and lower drill pipe in and out of the hole and to support the drill string to control the weight on the drill bit during drilling. The hoisting system consists of the derrick, traveling and crown blocks, the drilling line and the draw works. The drilling unit uses a derrick, which is a steel tower that is used to support the traveling and crown blocks and the drill bit and pipe (string). The crown and traveling blocks are a set of pulleys that raise and lower the drill string. The crown block is a stationary pulley located at the top of the derrick. The traveling block moves up and down and is used to raise and lower the drill string. These pulleys are connected to the drill string with a large diameter steel cable. The cable is connected to a winch or draw-works. The draw-works contain a large drum around which the drilling cable is wrapped. As the drum rotates one way or the other, the drilling cable spools on or off the drum and raises or lowers the drill string.



1	Mud tank	15	Monkey board
2	Shale shakers	16	Stand (of drill pipe)
3	Suction line (mud pump)	17	Pipe rack (floor)
4	Mud pump	18	Swivel
5	Motor or power source	19	Kelly
6	Vibrating hose	20	Rotary table
7	Draw-works	21	Drill floor
8	Standpipe	22	Bell nipple
9	Kelly hose	23	Blow-out preventer annular
10	Goose-neck	24	Blow-out preventers
11	Traveling block	25	Drill string
12	Drill line	26	Drill bit
13	Crown block	27	Casing head
14	Derrick	28	Flow line

Figure 3.3: Flow path of the drilling fluid.

Rotating System

The rotating equipment turns the drilling bit. This equipment consists of the topdrive, the rotary table, the drill pipe and the drill collars (drill string) and the bit. The topdrive is attached to the bottom of the traveling block and permits the drill string to rotate. The topdrive consists of a strong engine that rotates the drill string. A hose, through which the drilling fluid enters the drill pipe, is connected at the top of the topdrive. The drill pipe is a round pipe about 9 m long with a diameter of from 5 inch (13 cm). Drill collars are heavy thick pipes that are used at the bottom of the drill string to add weight on the bit. The drill pipe has threaded connections on each end that allow the pipe to be joined together to form longer sections as the hole gets deeper. The drilling bit is used to create the hole. Drilling bit sizes typically range from 36 inches (91 cm) to 6 inches (15 cm) in diameter.

Circulating System

The drilling operation uses drilling fluids to reduce friction (lubricate and cool drill bit), remove the drilled rock fragments (cuttings), and to equalise pressure in the wellbore and prevent other fluids from flowing into the wellbore. The circulation system of drilling fluid consists of the suction pits, pumps, surface piping (flowlines and standpipe), rotary hose (or kelly hose) and swivel, which is connected to the topdrive.

Figure 3.3 shows the flow path of the drilling fluid. The circulating system pumps the drilling fluids (or drilling muds) down the hole, out of the nozzles in the drilling bit and returns them to the surface where the cuttings are separated from the drilling fluid.

The cuttings are separated from the mud by vibrating screens called a shale shakers. The cuttings are trapped on the screens and the mud passes through the screens into the mud pits. The circulating pumps pick up this clean mud and pump it back down the hole.

Safety System

Although the probability of a well blow-out is extremely low, it nonetheless provides the greatest environmental concern during drilling operations. The primary safeguard against a blow-out is the drilling fluid. The density of the fluid can be controlled to balance any abnormal formation pressures. Abnormal formation pressures are detected by primary well control equipment, which generally consists of two sets of pit level indicators and return mud-flow indicators with one set manned by the drill crew and the other by the mud logger. The mud logger also has a return mud gas detector, which monitors return mud temperature and changes in shale density for abnormal pressure detection. The drilling fluid is also tested frequently during drilling operations and its composition can be adjusted to account for changing downhole conditions.

The likelihood of a blow-out is further minimised by employing a specially designed item of safety equipment called a blow-out preventer (BOP), which is a secondary control system. The BOP is installed on the wellhead and is designed to close in the well to prevent the uncontrolled flow of hydrocarbons from the reservoir in case the pressure of the reservoir exceeds the pressure of the drilling fluid in the reservoir resulting in hydrocarbons entering the wellbore. If this cannot be controlled hydrocarbons could eventually exit the wellbore into the marine environment / atmosphere. Hence the BOP system plays a key role in preventing potential risks to people, the environment and equipment. The BOP would undergo a thorough inspection prior to installation and subsequently pressure and function tested on a regular basis.

A typical BOP stack is shown in Figure 3.4. The BOP stack usually consists of the following:

- Annular preventer: The annular-type blow-out preventer can close around the drill string, casing or a non-cylindrical object, such as a kelly. Drill pipe including the larger-diameter tool joints (threaded connectors) can be "stripped" (i.e. moved vertically while pressure is contained below) through an annular preventer by careful control of the hydraulic closing pressure. Annular BOPs are typically located at the top of a BOP stack, with one or two annular preventers positioned above a series of several ram preventers.
- Ram type preventers: Ram type preventers are similar in operation to gate valves but use a pair of opposing steel plungers or rams. The rams extend toward the centre of the wellbore to restrict flow or retract open in order to permit flow. There are four common types of rams or ram blocks used in a BOP stack (or combination thereof):
  - Pipe rams close around a drill pipe, restricting flow in the annulus (ring-shaped space between concentric objects) between the outside of the drill pipe and the wellbore, but do not obstruct flow within the drill pipe. Variable-bore pipe rams can accommodate tubing in a wider range of outside diameters than standard pipe rams, but typically with some loss of pressure capacity and longevity;
  - Blind rams (also known as sealing rams), which have no openings for tubing, can close off the well when the well does not contain a drill string or other tubing and seal it;
  - Shear rams cut through the drill string or casing with hardened steel shears; and
  - Blind shear rams (also known as shear seal rams or sealing shear rams) are intended to seal a wellbore, even when the bore is occupied by a drill string, by cutting through the drill string as the rams close off the well.

In deeper offshore operations, there are four primary ways in which a BOP can be controlled, including (in order of priority):

- Electrical control signal, which is sent from the surface through a control cable;
- Acoustical control signal, which is sent from the surface based on a modulated / encoded pulse of sound transmitted by an underwater transducer;
- Remotely Operated Vehicle (ROV) intervention, which mechanically controls valves and provides hydraulic pressure to the stack (via “hot stab” panels); and
- Deadman switch / auto shear, which is a fail-safe activation of selected BOPs during an emergency, and if the control, power and hydraulic lines have been severed.

In addition to the above, advanced well intervention and capping equipment is available in Saldanha Bay for deployment in the event of a subsea well control incident. The subsea well intervention system includes four capping stacks to shut-in an uncontrolled subsea well and two hardware kits to clear debris and apply subsea dispersant at a wellhead. This unique piece of equipment is only stored in four international locations, namely Norway, Brazil, Singapore and South Africa, and is maintained ready for immediate mobilisation in the event of an incident.

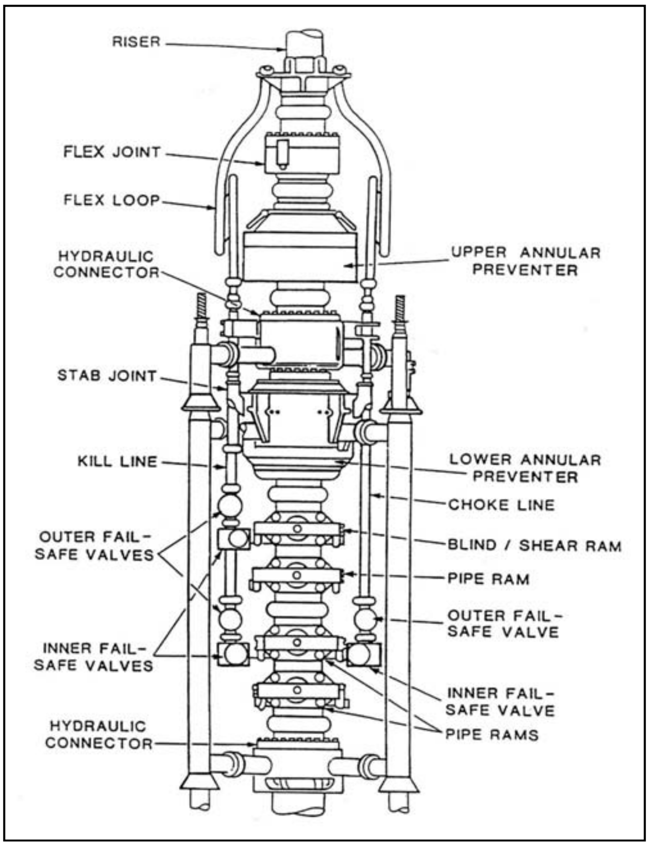


Figure 3.4: Schematic of a typical subsea BOP stack.

Power System

The drill unit would need power to operate the circulating, rotating and hoisting systems. This power is generated from diesel engines that power generators which transmit electricity to the drilling unit.

Storage Areas

The drilling unit would have dedicated storage for a variety of fluids and chemicals including:

- Fuel (diesel);
- Fresh (potable) water;
- Drilling water;
- Bulk mud and cement;
- Liquid mud;
- Mud chemicals; and
- Cementing chemicals.

3.3.3.2 Drilling method

Two drilling methods can be employed on a drilling unit, namely rotary or downhole motor drilling. The primary drilling method would be rotary drilling, where the whole drill string is rotated to penetrate the formations. However, a downhole motor may be included in the bottom hole assembly to provide additional power to the bit. The downhole motor is driven by the drilling fluid, which is pumped down the drill string.

The downhole motor drilling also allows a well to be directionally drilled to achieve any inclination from vertical to horizontal and to also change the azimuth direction in order to reach the geological target (Figure 3.5). The direction of the well is changed by holding the drill string stationary and pointing the downhole motor, which has a slight bend in its body, in the direction required and slide drilling ahead.

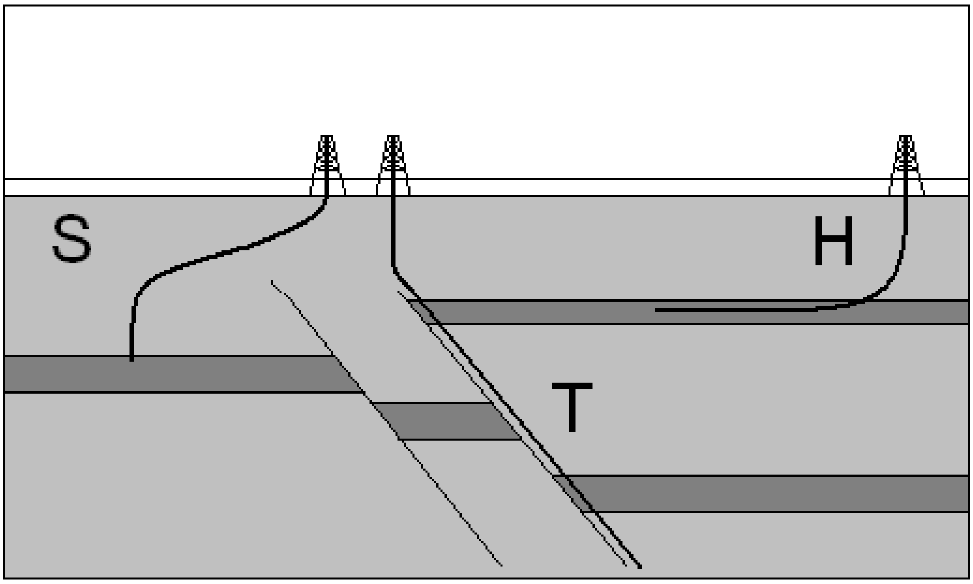


Figure 3.5: Tangent (T), Horizontal (H) or S shaped (S) drill trajectories.

3.3.3.3 Drilling sequence or stages

The well would be created by jetting and drilling a hole into the seafloor with a drilling unit that rotates a drill string with a bit attached. After the hole is drilled, sections of steel pipe (or casings), slightly smaller in diameter than the borehole, are placed in the hole and permanently cemented in place (cementing operations are described in Section 3.3.3.4). The hole diameter decreases with increasing depth as progressively smaller diameter casings are inserted into the hole at various stages and cemented into place.

The casing provides structural integrity to the newly drilled wellbore, in addition to isolating potentially dangerous high pressure zones from each other and from the surface. With these zones safely isolated and the formation protected by the casing, the well would be drilled deeper with a smaller bit, and also cased with a smaller size casing (see Figure 3.6). Shell is proposing to have four to six sets of subsequently smaller hole sizes drilled inside one another, each cemented with casing.

Drilling is essentially undertaken in two stages, namely the riserless and risered drilling stages.

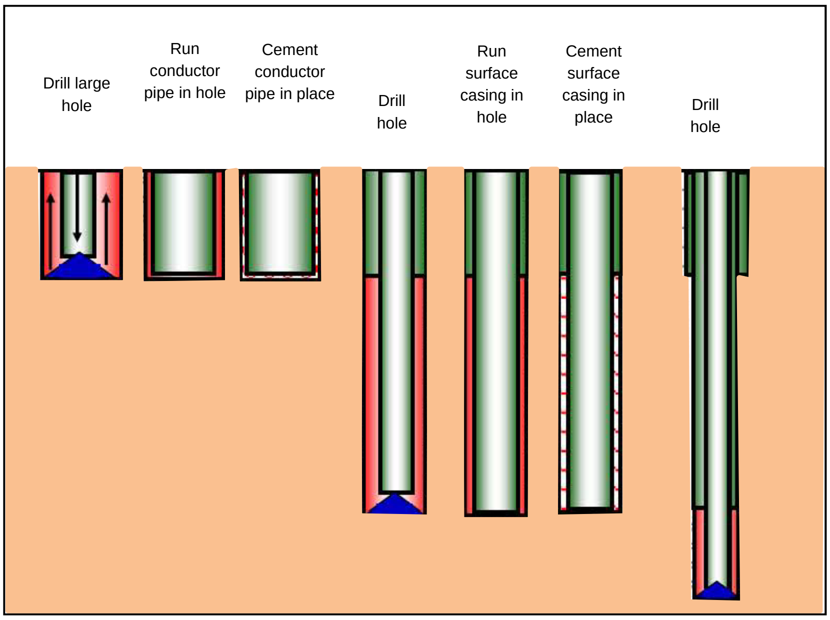


Figure 3.6: Simplified view of well drilling.

Initial (riserless) drilling stage

Sediments just below the seafloor are often very soft and loose, and to keep the well from caving in and to carry the weight of the wellhead a 36 inch (91 cm) diameter structural conductor pipe is jetted and / or drilled and cemented into place depending on the shallow seabed properties.

The conductor pipe is assembled at the drilling unit floor and a drill bit, connected to a drill pipe, is run through the inside to the bottom of the casing. The entire assembly is lowered to the seafloor by the rig hoist. At the seafloor the driller spuds the assembly into the seafloor sediments and then turns on a pump, which uses water or drilling fluid to jet the pipe into place.

When the conductor pipe and wellhead are at the correct depth the drill bit and drill string are released in order to commence with drilling operations. The rotating drill string, causes the drill bit to crush rock into small particles, called “cuttings”. While the wellbore is being drilled, drilling fluid is pumped from the surface down through the inside of the drill pipe, the drilling fluid passes through holes in the drill bit and travels back to the seafloor through the space between the drill string and the walls of the hole, thereby removing the cuttings from the hole. At the planned depth the drilling is stopped and the bit and drill string is pulled out of the hole, and a conductor pipe is run and cemented in place. This hole would be approximately 70 m deep.

Below the conductor pipe, typically a 26 inch (66 cm) diameter hole would be drilled for a 20 inch (51 cm) surface casing, which would extend to approximately 1 000 m below the seabed. The surface casing would be permanently cemented into place. In the event of technical issues in the riserless section, intermediate liners could be required in order for the surface casing to be installed at a sufficient depth to accommodate the drilling riser and BOP.

These initial hole sections would be drilled using seawater (with viscous sweeps) and water-based mud (WBM) (see Section 3.3.4.1 below for a description of WBMs). All cuttings and WBM from this initial drilling stage would be discharged directly onto the seafloor adjacent to the wellbore.

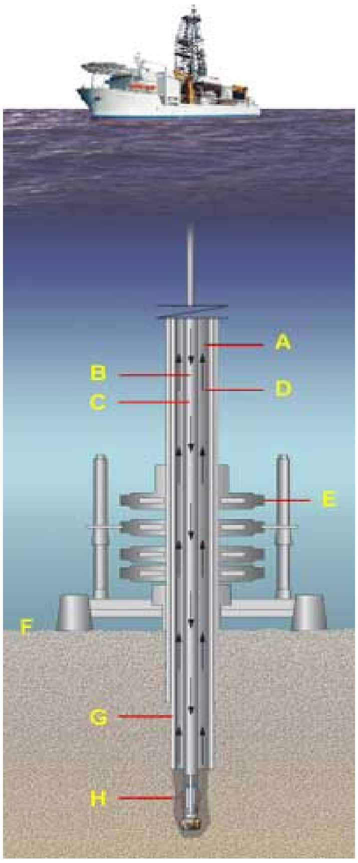
Risered drilling stage

Following the initial drilling stage described above, a BOP and marine riser (see Figure 3.7) is run and installed on the wellhead. The riser connects the drilling unit to the well and allows the drilling fluid and rock cuttings to be circulated back to the drilling unit, thereby isolating the drilling fluid and cuttings from the marine environment.

Drilling is continued by lowering the drill string, with a smaller bit, through the riser to the 20 inch (51 cm) diameter casing shoe and rotating the drill string. During the risered drilling stage when WBMs cannot provide the necessary characteristics, a low toxicity synthetic-based mud (SBM), which is a type of non-aqueous drilling fluid, would be used to (a) obtain critical reservoir parameters, b) provide a greater level of lubrication, and (c) provide more tolerance to high temperatures (see Section 3.3.4.2 below for a description of SBMs).

While drilling is in progress, drilling fluid is continuously recirculated to the drilling unit. The returned drilling fluid is treated to remove solids and drill cuttings from the re-circulating mud stream (see Section 3.3.3.5). The cuttings are also treated before being discharged overboard. Waste management is discussed further in Section 3.3.8.

The hole diameter decreases in steps with depth as progressively smaller diameter casings are inserted into the hole at various stages and cemented into place. As indicated previously, the expected final depth of the well is between 2 700 m and 3 000 m below the seafloor.



A - Riser
B - Drill pipe
C - Drilling fluid is pumped down through drill pipe
D - Drilling fluid and cuttings flow up between the drill pipe and the riser
E - Blow-out preventer
F - Seafloor
G - Casing
H - Open hole

Figure 3.7: Typical drilling operation (Source: http://www.planetseed.com).

3.3.3.4 Cementing operation

The casings are permanently secured into place by pumping cement slurry, followed by drilling fluid, through the drill pipe and/or cement stinger at the bottom of the hole and back up into the space between the casing and the borehole wall (annulus). To separate the cement from the drilling fluid in order to minimise cement contamination a cementing plug and/or spacer fluids are used. The plug is pushed by the drilling fluid to ensure the cement is placed outside the casing filling the annular space between the casing and the hole wall.

To ensure effective cementing, an excess of cement is often used. Until the marine riser is set, this excess emerges out of the top of the well onto the seafloor. This cement does not set and is slowly dissolved into the seawater (see Section 3.3.8 for operational discharges).

Offshore drilling operations typically use Portland cements, defined as pulverised clinkers consisting of hydrated calcium silicates and usually containing one or more forms of calcium sulphate. The raw materials used are lime, silica, alumina and ferric oxide. The cement slurry used is specially designed for the exact well conditions encountered.

Additives can be used to adjust various properties in order to achieve the desired results. There are over 150 cementing additives available. The amount (concentrations) of these additives generally make up only a small portion (<10%) of the overall amount of cement used for a typical well. Usually, there are three main additives used: retarders, fluid loss control agents and friction reducers. These additives are polymers generally made of organic material and are considered non-toxic.

Once the cement has set, a short section of new hole is drilled, then a pressure test is performed to ensure that the cement and formation are able to withstand the higher pressures of fluids from deeper formations.

3.3.3.5 Drilling fluid circulation system and solids control equipment

While drilling is in progress, drilling fluid is continuously pumped down the inside of the hollow drill string. The fluid emerges through ports ("nozzles") in the drill bit and then rises (carrying the rock cuttings with it) up the annular space between the sides of the hole (the casing and riser pipe) and the drill string, to the drilling unit. The returned drill mud is treated to remove the cuttings from the re-circulating mud stream (see Figure 3.3).

The solids control system sequentially applies different technologies to remove the cuttings from the drilling fluid and to recover drilling fluid so that it can be reused. A typical solids control system consists of the following main components:

- Shale shakers (removes large-sized cuttings);
- Degasser (removes entrained gas);
- Desanders (removes sand-sized cuttings);
- Desilters (removes silt-sized cuttings); and
- Centrifuge (recovers fine solids and weighting materials such as barite).

The components of the solids control system depends on the type of drilling fluid used, the formations being drilled, the available equipment on the drilling unit and the specific requirements of the disposal option. Solids control may involve both primary and secondary treatment steps.

3.3.3.6 Anticipated well design

The well design ultimately depends upon factors such as planned depths, expected pore pressures and anticipated hydrocarbon-bearing formations. The various components of the anticipated well design are shown in Table 3.2.

Table 3.2: Estimated well design and cutting volumes.

Drill Section	Hole diameter (in)	Pipe diameter (in)	Depth of section (m)	Drilling duration (days)	Type of drilling fluid used	Volume of drilling fluid discharged	Volume of cuttings (m^3)	Drilling fluid and cuttings discharge location
Riserless drilling stage								
1	36	30	70	1	Seawater, viscous sweeps & WBM	69 m^3	46.0	Seabed
2	26	20	1 000	2		480 m^3	342.5	Seabed
Risered drilling stage								
3	17.25	13 5/8	800	4	SBM	223 mT	120.6	Surface
4	12.25	9 7/8	450	4		10 mT	34.2	Surface
5	8.5	-	400	8		2.5 mT	14.6	Surface

3.3.4 DRILLING FLUIDS OR MUDS

An important component in the drilling operation is the drilling fluid or drilling mud, which is used for:

- Maintaining a stable wellbore and preventing the open hole from collapsing;
- Providing sufficient hydrostatic pressure to control subsurface pressures and prevent kicks or blow-outs;
- Transport of the cuttings to the surface;
- Cooling and lubrication of the drill bit and drill string (reduce friction);
- Powering mud motors / downhole tools during the drilling process;
- Regulation of the chemical and physical characteristics of returned mud slurry on the drilling unit; and
- Displacing cements during the cementing process.

Drilling fluid is a complex mixture of fluids, solids and chemicals that are carefully tailored to provide the correct physical and chemical characteristics required to safely drill the well.

3.3.4.1 Water-based muds

Due to the variability in conditions that can be encountered drilling fluid mixtures vary to some extent. Typically, the major ingredient making up 85 to 90 % of the total volume of a WBM is fresh and / or seawater, with the remaining 10 to 15 % of the volume being barite, potato or corn starch, cellulose-based polymers, xanthan gum, bentonite clay, soda ash, caustic soda and salts (these are usually either potassium chloride [KCl] or sodium chloride[NaCl]).

Barite (barium sulphate) is an inert compound used as a weighting agent. Potato or corn starch and other cellulose-based polymers are used to control the rate of filtration of water in the mud into the formation being drilled by forming a thin filter cake on the borehole wall. Xanthan gum and minor amounts of bentonite clay are used to provide viscosity and impart rheological properties to the mud for cuttings transport, as well as to provide gel strength for cuttings suspension. Caustic soda (sodium hydroxide) is used to maintain the required pH in the drilling fluid. KCl or NaCl are used to reduce the swelling tendencies of clays being drilled and help to maintain a stable wellbore. Other minor additives may be used in special circumstances. A listing of the WBM chemicals used on a typical well, their functions and comments on their ecotoxicity are provided in Table 3.3.

Table 3.3: Main components of water-based fluid (adapted from CCA & CSIR, 1997).

Material	Use	Ecotoxicity
Aluminium stearate	Defoamer	Non-toxic, insoluble
Barite	Weighting agent	Non-toxic, insoluble, non-biodegradable
Bentonite	Viscosifer	Non-toxic, insoluble, non-biodegradable
Calcium carbonate	Bridging, loss of circulation	Non-toxic, insoluble
Caustic soda	pH and alkalinity control	Soluble, corrosive
Cellulose based polymers	Fluid loss control	Insoluble, non-toxic
Citric acid	pH control	Soluble, low toxicity, irritant
Diesel oil pill (< 0.1 % mud volume)	Stuck pipe spotting fluid	Slightly soluble, 96 hr LC_{50} >0.1-1000 ppm
Gilsonite (asphalt based)	Lubricant, fluid loss reducer	Low toxicity, slightly soluble
Gluteraldehyde (0.01% mud vol)	Bactericide (biocide)	Noted for its toxic properties, irritant
Lime	Carbonate and CO_2 control	Slightly soluble, non-toxic, irritant
Organic synthetic polymer blends	Filtrate reducing agent	Non-toxic, 96 hr LC_{50} >500 ppm
Palm oil ester	Lubricant, stuck pipe pills	Slightly soluble, biodegradable
Potassium chloride	Shale / clay inhibitor	Soluble, non-toxic

Material	Use	Ecotoxicity
Soda ash	Alkalinity, calcium reducer	Soluble, non-toxic
Sodium bicarbonate	Alkalinity, calcium reducer	Soluble, non-toxic
Xanthan gum	Viscosity, rheology	Soluble, non-toxic

3.3.4.2 Non-aqueous drilling fluids

Non-aqueous drilling fluids (NADF) are used to:

- Provide optimum wellbore stability and enable a near gauge hole to be drilled;
- Reduce torque and drag in high angle to horizontal wells;
- Minimise damage to reservoirs that contain clays that react adversely to WBM; and
- Obtain irreducible water saturation log data for gas reservoirs.

The main chemicals used in a NADF are presented in Table 3.4.

Table 3.4: Main chemicals used in a non-aqueous drilling fluid (adapted from Swan *et al.* 1994).

Material	Description
Base oil	Non-aqueous drilling fluids use base fluids with significantly reduced aromatics and extremely low polynuclear aromatic compounds. New systems using vegetable oil, polyglycols or esters have been and continue to be used.
Brine phase	$CaCl_2$, NaCl, KCl.
Gelling products	Modified clays reacted with organic amines.
Alkaline chemicals	Lime e.g. $Ca(OH)_2$.
Fluid loss control	Chemicals derived from lignites reacted with long chain or quaternary amines.
Emulsifiers	Fatty acids and derivatives, rosin acids and derivatives, dicarboxylic acids, polyamines.

The disadvantage of using a NADF is that base fluid and other chemicals would result in an increase in toxicity. Drill cuttings that derive from the reservoir section contain residual base fluids, which cannot be removed easily. The trend in the industry has been to move towards low toxicity NADF (Group III NADF) that are biodegradable and will not persist in the long-term. There are three types of NADF that are used for offshore drilling and can be defined as follows:

- **Group I NADF (high aromatic content)**
  These base fluids were used during initial days of oil and gas exploration and include diesel and conventional mineral oil based fluids. They are refined from crude oil and are a non-specific collection of hydrocarbon compounds including paraffins, olefins and aromatic and polycyclic aromatic hydrocarbons (PAHs). Group 1 NADFs are defined by having PAH levels greater than 0.35%.
- **Group II NADF (medium aromatic content)**
  These fluids are sometimes referred to as Low Toxicity Mineral Oil Based Fluids (LTMBF) and were developed to address the rising concern over the potential toxicity of diesel-based fluids. They are also developed from refining crude oil but the distillation process is controlled such that the total aromatic hydrocarbon concentration is less than Group I NADFs (0.5 – 5%) and the PAH content is less than 0.35% but greater than 0.001%.
- **Group III NADF (low to negligible aromatic content)**
  These fluids are characterised by PAH contents less than 0.001% and total aromatic contents less than 0.5%. They include SBM which are produced by chemical reactions of relatively pure compounds and can include synthetic hydrocarbons (olefins, paraffins and esters). Using special refining and/or separation processes, base fluids of Group III can also be derived from highly processed mineral oils (paraffins, enhanced mineral oil based fluid (EMBF)). PAH content is less than 0.001%. Shell is proposing to use a SBM during the risered drilling stage.

3.3.5 WELL EVALUATION

3.3.5.1 Mud logging

Evaluation of the petro-physical properties of the formations that have been penetrated is carried out routinely during the drilling operation. Mud logging involves the examination of the drill cuttings brought to the surface by the drilling fluid.

Mud logging also monitors for hydrocarbon gases that relate to changes in formation pressure and the volume or rate of returning fluid, which is imperative to catch "kicks" early. A "kick" is when the formation pressure at the depth of the bit is more than the hydrostatic head of the mud above, which if not controlled temporarily by closing the BOP and ultimately by increasing the density of the drilling fluid would allow formation fluids and mud to come up through the drill pipe uncontrollably.

3.3.5.2 Downhole formation logging

Electrical logging and measurement while drilling logging are the two most widely used downhole formation evaluation methods. The use of wireline logging tools requires the drill string to be removed from the well so these logs are generally run at casing points. Radioactive sources may be used for certain types of data acquisition (see Section 3.3.5.3).

There are two fundamentally different uses of radioactive devices in wireline logging. In the first, the source is mounted in the wireline tool, where it generates a radioactive field that interacts with the rocks penetrated at the wellbore. The measured response is directly related to the physical properties of the rocks. The other usage is for calibrating wireline tools that measure either natural or induced radioactivity.

3.3.5.3 Radioactive sources

There are two standard types of wireline tools that use radioactive sources and measure formation porosity, namely:

1. The density log, which measures the electron density of a formation (this is a function of porosity); and
2. The neutron log, which measures the hydrogen ion concentration in a formation.

The radiation levels of the density and neutron tool activity are very low.

3.3.5.4 Radioactive calibration tools

Calibration tools generate a known level of low radioactivity, which is used to calibrate the receiver response for the neutron logging tool and for calibrating tools that measure the natural radiation of formations. The measurements are used for correlating zones between wells and for identifying lithologies, particularly volcanic ashes, organic rich shales, potassium feldspars, micas and glauconite. The radiation from the calibration tools is similar to the natural radiation from rocks.

3.3.5.5 Radiation level

The radioactive sources used in wireline logging would be stored in sealed containers. The radioactive material is encapsulated in ceramic cylinders and then sheathed in several layers of stainless steel. The size of the sealed sources is approximately 4 inches (length) x 1 inch (diameter) for the density tool and 7 inches (length) x 1.5 inches (diameter) for the neutron source.

The radiation levels are very low. The density tool activity can range from 0.1-2 curies (Ci) with a 0.5–200 milliroentgens per hour (mR/hr) maximum radiation level at the source surface. The neutron tool activity can range from 3-20 Ci with a 50-200 mR/hr maximum radiation level at the surface. The neutron tool, however, does not emit any external radiation at the tool surface when it is not energised.

The radiation from the calibration tools is similar to the natural radiation from rocks. Activities range from 0.000002–0.5 mR/hr maximum radiation levels.

Specific safety procedures would be established by the wireline logging contractor to handle the sources (see Section 3.3.5.6). In addition, the contractor has to set up incident and emergency reporting procedures for actual or suspected individual over-exposure, theft or loss, logging tools stuck downhole in wells and release or spillage into the environment. The contractor routinely tests the sources according to industry requirements to document leak levels.

3.3.5.6 Transport, storage and handling of radioactive devices

Radioactive devices are transported from the wireline contractor's base to a drilling unit in specially designed secured (locked) storage containers. The tools are inventoried upon arrival and tested for leaks. A detailed log is kept of any access to the storage container and tools.

Drilling units would have a special storage location designated for radioactive containers. The storage location would be specifically chosen to minimise the danger of fire, explosion and exposure, and are clearly identified by yellow radioactive warning signs.

Only certified wireline logging engineers would be allowed to handle the radioactive devices. Whenever the radioactive sources are used, the area between and around the storage containers and the drill floor would be secured and only key personnel would be allowed in the area. Long handling sticks would be used to transfer the density and neutron sources between the storage containers and the logging tools on the drill floor, but the calibration tools, being very low-level radioactive devices, would be hand-held.

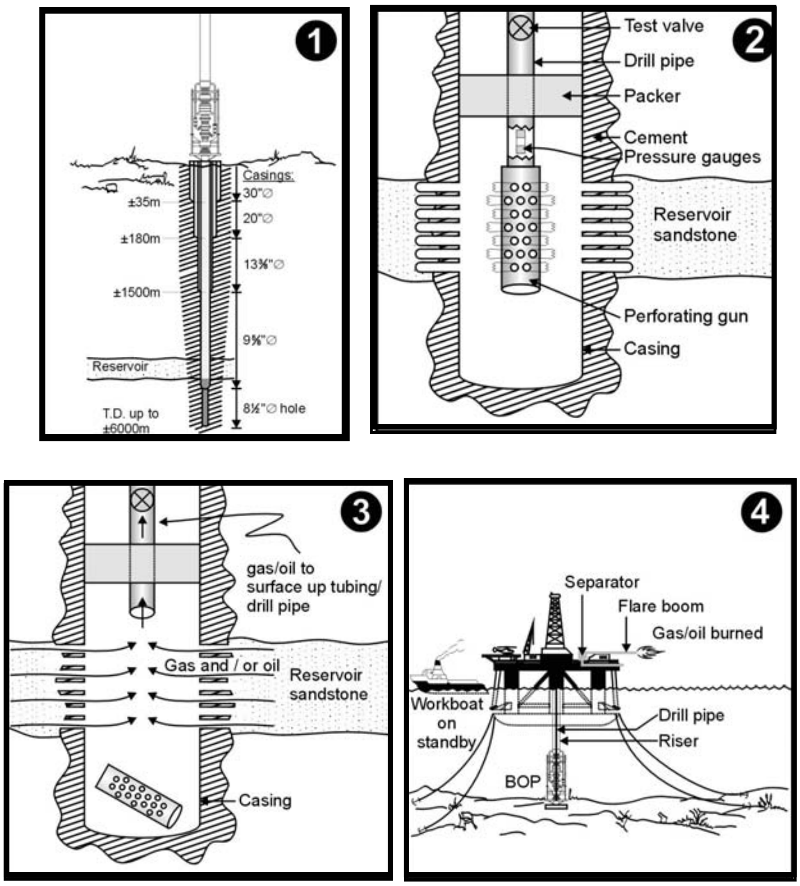
The engineers handling the devices would follow strict approved procedures. They would also wear personal monitoring devices to measure any unusual exposure. The equipment would be handled as little as possible by the engineers and returned immediately to the storage containers upon completion of the logging run.

3.3.6 WELL (FLOW) TESTING

Should the exploration well encounter hydrocarbons, an "appraisal" well may be drilled, which would be flow-tested (also called production testing) to determine the economic potential of the discovery before the well is either abandoned or suspended for later re-entry and completion (see Figure 3.8).

If flow testing is required, hydrocarbons would be burned at the well site. A high-efficiency flare is used to maximise combustion of the hydrocarbons. The amount of hydrocarbons produced would depend on the quality of the reservoir but is kept to a minimum to avoid wasting potentially marketable oil and/or gas. Thus the final well test programme would be prepared when the detailed geology and fluids are defined.

No produced water is anticipated. However, if water does flow with the hydrocarbons to the surface it would be flared off. Any water remaining would either be stored and brought to shore for treatment and disposal or treated and discharged offshore, both in accordance with regulatory requirements.



The purpose of the drill stem testing is to gain pressure, flow rate and fluid composition data to determine whether the prospect can be commercially produced.

1. Geophysical logs are interpreted to determine the exact position of the reservoir and its characteristics. Casing is run and cemented into place. Any open hole below the casing may be isolated, if necessary, with cement plugs.

2. Perforating gun (usually 12 shots/ft) at the end of the drill pipe is positioned over the interval being tested. Packer is set. Detonation of shaped charges perforates holes through casing and cement to open channels into the reservoir.

3. Gun may be dropped from drill string. Reservoir fluids (oil and/or gas) enter ports in the bottom of the drill pipe and flow to the surface under carefully controlled conditions.

4. On the rig, oil and/or gas passes a separator. Flow rates of oil and/or gas are measured. All oil and gas produced is efficiently burned through special burner heads.

Flow rates and down-hole reservoir pressures are carefully measured in a series of flow and shut-in periods. Samples of oil and gas are collected for analysis.

Figure 3.8: Diagrammatic presentation of a well test (drill stem test) (after Crowther Campbell & Associates and Centre for Marine Studies, 1999).

3.3.7 WELL SUSPENSION OR DECOMMISSIONING

Based on the results of the drilling, logging and possible testing of the well, a decision would be made as to the final state of the well, before the drilling unit is moved off location. The options are described below.

(a) *Suspended wells*: If it is verified that a well is commercially viable, it could be suspended. This would entail the following

- Cement plugs would be set inside the wellbore and tested for integrity;
- The BOP would be removed before the drilling unit is moved off location;
- The wellhead (total 3 to 4 m high) would remain on the seafloor; and
- A corrosion cap would be placed over the wellhead to facilitate re-entry.

(b) *Decommission wells*: If a well is unsuccessful, it would be decommissioned in a safe and stable condition. This would entail the following:

- Cement plugs would be set inside the wellbore and tested for integrity;
- The BOP would be removed before the drilling unit is moved off location; and
- The wellhead (total 3 to 4 m high) would either remain on or be removed from the seafloor. The preferred option would be to leave the wellhead on the seafloor.

3.3.8 SEA- AND LAND-BASED SUPPORT

3.3.8.1 Onshore logistics base

A logistics shore base would be located in either Cape Town or Saldanha Bay. The shore base would provide for the storage of materials (including wellbore materials, diesel, water and drilling fluids) and equipment that would be transported from/to the drilling unit by sea. The shore base would also be used for bunkering vessels.

It is anticipated that space and equipment requirements at the shore base to service the operation would consist of the following:

- Yard space (3 000 to 5 000 m^2);
- Covered warehouse (500 m^2);
- Office space;
- 45 t crane (yard operations);
- 80 to 100 t crane (quay side operations);
- 8 t forklift equipped with certified pipe clamp;
- Trucks and flatbed trailers;
- Fuel supply;
- Potable water supply; and
- Liquid and dry mud plant.

3.3.8.2 Support and supply vessels

The drilling unit will be supported by at least three vessels, namely one standby and two supply vessels. The standby vessel would provide support for firefighting, oil containment / recovery, rescue and any equipment that may be required in case of an emergency. The standby vessel would also be used to patrol the area to ensure that other vessels adhere to the 500 m safety zone around the drilling unit. The supply vessels would provide equipment and material transport between the drilling unit and the port.

It is envisioned that a supply vessel would call into port every week during the campaign.

3.3.8.3 Crew transfers

Transportation of personnel to and from the drilling unit would be provided by helicopter operations from the Kleinzee airport, which is located approximately 250 km from the proposed area of operation. Transportation to Kleinzee would be provided by fixed-wing flights from Cape Town, which is approximately 500 km to the south.

The drilling unit would accommodate in the order of 100 - 150 personnel. Crews would work in 12-hour shifts in 4-5 week cycles. Crew changes would be staggered, and in combination with *ad hoc* personnel requirements. Thus helicopter operations to and from the drilling unit and fixed wing operations between Kleinzee and Cape Town would occur on an almost daily basis.

A second helicopter would be kept on standby for rescue operations. This helicopter is kept in a high state of readiness, i.e. fuelled, setting on pad, pilot and crew at base in Kleinzee.

3.3.9 OPERATIONAL DISCHARGES

This section provides a brief description of the types of emissions and discharges that are expected from the activities relating to drilling a typical well. Normal emissions and discharges from an offshore drilling unit include emissions to air, discharges to sea and return of waste to shore. The management of these emissions and discharges will be included in a project-specific waste management plan.

Abnormal discharges such as spills or losses of oil and / or chemicals are possible, but are of low probability with the safety systems in place. Any such spills should be handled in accordance with procedures set forth in an operator’s contingency plan (see “Plans and Procedures for Environmental Related Emergencies and Remediation” in Section 3.2.8).

3.3.9.1 Emissions to air

A range of air emission types would be generated from a variety of sources during well drilling. These would include exhaust emissions from vessels and machinery, including the combustion of diesel fuel and gas product to power the drilling unit, as well as fugitive emissions from a wide variety of sources.

Combustion

Emissions to the air would be generated by combustion of diesel fuel in generators and other machinery used to power the drilling operation. Fuel consumption of a semi-submersible drilling unit is estimated to be between 75 and 100 bbl (barrels) of diesel per day. Typical emissions resulting from this consumption are as follows (Note: these levels are based on standard fuel emission factors for each compound):

- CO_2 = 0.32 tons/day;
- NO_2 = 0.6 tons/day; and
- CO = 0.015 tons/day.

Additional air emissions would be generated by vessels used to tow the drilling unit, operating support / supply vessels and helicopter operations. The air emissions from the support or supply vessels would be no greater than that from any other vessel of a similar tonnage.

Incineration of operational waste

Certain non-toxic combustible wastes (e.g. galley waste) may be incinerated on the drilling unit and support / supply vessels, creating smoke (particulate matter) emissions. If these wastes are not incinerated, they would either be treated and discharged overboard (see Section 3.3.9.2) or taken to shore for disposal (see Section 3.3.9.3).

Flaring

During well testing it may be necessary to flare off oil and gas. The amount of hydrocarbons produced would depend on the quality of the reservoir but is kept to a minimum to avoid wasting potentially marketable oil and/or gas. It is anticipated that the duration of flaring would be in the order of 2-5 days.

Other emissions to air

Additional air emissions would be generated by ventilation from mud pits and shakers during refuelling operations.

3.3.9.2 DISCHARGES TO SEA

Drilling cuttings and mud

During the drilling of a well, the primary discharges are the drilling cuttings. Cuttings range in size from clay to coarse gravel. The composition of the rock particles reflects the types of sedimentary rocks penetrated by the drill bit.

During the riserless drilling stage for each well, all cuttings and WBM would be discharged directly onto the seafloor. It is estimated that 350 to 400 m^3 of cuttings and approximately 550 m^3 of WBM would be discharged onto the seafloor for the initial 1 000 m of drilling (refer to Table 3.3). The cone created by the cuttings is predicted to be in the order of 80 cm thick close to the wellbore, thinning outwards to a thickness of 3 cm at a radius of 120 m. The total predicted area affected by the discharges would thus be in the order of 0.045 km^2. The cuttings themselves would deposit out within the cone of WBMs at average thicknesses of 15 to 25 cm.

Once the marine riser is connected (risered drilling stage), the drilling fluid and cuttings are circulated up to the drilling unit where the mud is cleaned and the cuttings discharged into the sea. The drill cuttings would be treated to reduce their oil content to less than 6.9% of dry cuttings weight. Although most of the drilling fluids are mechanically separated from the drilling cuttings, the discharged cuttings would contain some residual SBM.

Surface released cuttings would be dispersed by the current and settle to the seafloor. The rate of cuttings discharge decreases with increasing well depth because the hole diameter becomes smaller and penetration rates decrease (refer to Table 3.3). The total volume of surface released cuttings during the risered drilling stage is estimated to be in the order of 150 to 200 m^3 for each well, and is dependent on the well design. These cuttings would contain approximately 235 mT of residual SBM. Discharge is intermittent as actual drilling operations occur only about one-third to one-half of the total time the drilling unit is on location (National Research Council 1985). The results of the cuttings dispersion modelling study (see Appendix 2.2) show that the large depths at the well site (1 800 m to 2 040 m) combined with the moderate to strong current speeds (at 200 m depth the median speed is 0.12 m/s and the maximum 0.56 m/s) and relatively low mass of cuttings discharged (1 042 t) result in the drill cuttings being spread over a large area, with relatively low deposition thicknesses of less than 1 mm predicted for distances greater than about 150 m from the location of the well.

Cement and cement additives

Typically, cement and cement additives are not discharged from drilling units. However, during the initial cementing operation, excess cement emerges out of the top of the well and onto the seafloor in order to ensure the conductor pipe is cemented all the way to the seafloor. During this operation a maximum of 150% of the required cement volume would be pumped into the space between the casing and the borehole wall (annulus). Thus in the worst case scenario approximately 210 m^3 of cement would be discharged onto the seafloor. It should, however, be noted that if cement returns are observed on the seafloor pumping would be terminated.

BOP hydraulic fluid

As part of routine opening and closing operations the subsea BOP stack elements would vent hydraulic fluid into the sea at the seafloor. It is anticipated that approximately 500 – 1 000 litres of oil-based hydraulic emulsion fluid would be vented per month during the drilling of a well. Concentrated BOP fluids are mildly toxic to marine crustaceans and algae (LC_{50} 102-117 ppm), but they are diluted with fresh water 50-100:1 for application. BOP fluids are completely biodegraded in seawater in 28 days.

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

Sewage
Sewage discharge would meet the requirements of MARPOL Annex IV. MARPOL Annex IV requires that sewage discharged from vessels be comminuted and disinfected and that the effluent must not produce visible floating solids in, nor cause discoloration of the surrounding water. The treatment system must provide primary settling, chlorination and dechlorination. The treated effluent is then discharged into the sea, as is the practice aboard ocean-going vessels.

Food (galley) wastes
The disposal into the sea of food waste is permitted, in terms of MARPOL Annex V, when it has been comminuted or grinded to particle sizes smaller than 25 mm and the vessel is located more than 3 nautical miles (nm) (approximately 5.5 km) from land. Disposal overboard without macerating can occur greater than 12 nm (approximately 22 km) from the coast. The daily discharge from a drilling unit is typically about 0.2 m^3.

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

3.3.9.3 Land disposal

A number of other types of wastes generated during the exploration activities would not be discharged at sea but would be transported to shore for ultimate disposal. These wastes would be disposed at a licensed municipal landfill facility or at an alternative approved site. Operators would be required co-operate with local authorities to ensure that waste disposal is carried out in an environmentally acceptable manner.

A summary of these waste types generated by a drilling unit during a typical drilling operation, their expected amounts per well, environmental properties, and destination is given below. Typical volumes are presented in Table 3.5 (note: these quantities should be viewed as estimates based on experience).

Bulk volumes of SBM remaining at the end of well drilling, would either be shipped for onshore treatment and disposal through an approved waste disposal company or re-used during the drilling of the subsequent well.

Table 3.5: Estimated volume/mass of wastes produced during a drilling operation of 100 days (adapted from CSIR 1999).

Waste Type	Description	Volume / Mass produced per day	Total Volume / Mass produced during drilling
Rubbish/trash	This includes wastes originating from offshore accommodation, workshops, etc., including waste paper, plastics, wood, metal, glass, etc. All waste would be disposed of at an onshore landfill site.	200 kg	20 000 kg
Scrap metal	Surplus material would be re-used. Non-usable material (e.g. oiled machine cuttings) would be stored and disposed of on land.	50 kg	5 000 kg
Drums/containers	Empty drums containing residues, which may have adverse environmental effects (solvents, lubricating/gear oil, etc.), would be rinsed before disposal. If carried out on-board the vessel, the rinse water would be stored and transported to shore. Rinse water would be disposed of in a manner acceptable to the local authorities regardless of whether rinsing is carried out on board the drilling unit or onshore. Rinsed and non-rinsed drums brought ashore would be disposed of in a local landfill site after crushing to reduce volume.	5-10 units	500 – 1 000 units
Used oil	Examples include used lubricating and gear oil, solvents, hydrocarbon-based detergents, possible drilling fluids and machine oil. Toxicity varies depending on oil type. All non-recycled waste oils would be securely stored, transported to shore and disposed of at a licensed site acceptable to the relevant authorities.	0.1 m^3	10 m^3
Chemicals/hazardous water	Disposal of any unexpected chemical and hazardous substance (e.g. radioactive devices/materials, neon lights, fluorescent tubes, toner cartridges, batteries etc.) would be done on a case-by-case basis and in a manner acceptable to appropriate regulatory authorities.	0.05 m^3	5 m^3
Laboratory waste	Minor quantities of laboratory wastes would be generated (from water quality testing and retort analysis) that would be discharged to sea.	negligible	negligible
Infectious waste	Infectious wastes include bandages, dressings, surgical waste, tissues, medical laboratory wastes, needles, and food wastes from persons with infectious diseases. Only minor quantities of medical waste are expected. Prevention of exposure to contaminated materials is essential, requiring co-operation with local medical facilities to ensure proper disposal.	negligible	negligible
Filters and filter media	This includes air, oil and water filters from machinery. Oily residue and used media in oil filters that may contain metal (e.g. copper) fragments, etc. are possibly toxic. Filters and media would be transported ashore and disposed of at a licensed landfill facility.	10 kg	1 000 kg

4. THE AFFECTED ENVIRONMENT

This chapter provides a description of the biophysical and socio-economic environment focusing primarily on the study area between the Orange River mouth and St Helena Bay. However, the description has been extended into Namibia, where appropriate, to cater for any potential cross border impacts. The purpose of this biophysical and socio-economic description is to provide a baseline environmental context within which the proposed exploration drilling would take place.

4.1 MARINE ENVIRONMENT (OFFSHORE)

This section provides a general overview of the physical and biological oceanography and human utilisation of South African West Coast and, where applicable, detailed descriptions of the marine environment that may be directly affected by the proposed project.

The licence area lies within the southern zone of the Benguela Current region and is characterised by the cool Benguela upwelling system (Shillington 1998; Shannon 1985). A conceptual model of the Benguela system (see Figure 4.1) summarises much of the physical oceanography of the region.

4.1.1 METEOROLOGY

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

These seasonal changes result in substantial differences between the typical summer and winter wind patterns in the region, as the southern hemisphere anti-cyclonic high-pressures system and the associated series of cold fronts moves northwards in winter and southwards in summer. The strongest winds occur in summer (October to March), during which winds blow 98% of the time (PRDW in prep), with a total of 226 gales (winds exceeding 18 m/s or 35 kts) being recorded over the period (CSIR 2006). Virtually all winds in summer come from the south to south-southeast (see Figure 4.2), strongly dominated by southerlies which occur over 40% of the time, averaging 20 - 30 knots (kts) and reaching speeds in excess of 100 km/h (60 kts). South-easterlies are almost as common, blowing about one-third of the time and also averaging 20 - 30 kts. The combination of these southerly and south-easterly winds drive the massive offshore movement of surface water, resulting in strong upwelling of nutrient-rich bottom waters, which characterise this region in summer.

Winter remains dominated by southerly to south-easterly winds, but the closer proximity of the winter cold-front systems results in a significant south-westerly to north-westerly component (see Figure 4.2). This ‘reversal’ from the summer condition results in cessation of upwelling, movement of warmer mid-Atlantic water shorewards and breakdown of the strong thermoclines which typically develop in summer. There are also more calms in winter, occurring about 3% of the time, and wind speeds generally do not reach the maximum speeds of summer. However, the westerlies winds blow in synchrony with the prevailing south-westerly swell direction, resulting in heavier swell conditions in winter.

Another important wind type that occurs along the West Coast are katabatic 'berg' winds during the formation of a high-pressure system (lasting a few days) over, or just south of, the south-eastern part of the subcontinent. This results in the movement of dry adiabatically heated air offshore (typically at 15 m/s). At times, such winds may blow along a large proportion of the West Coast north of Cape Point and can be intensified by local topography. Aeolian transport of fine sand and dust may occur up to 150 km offshore.

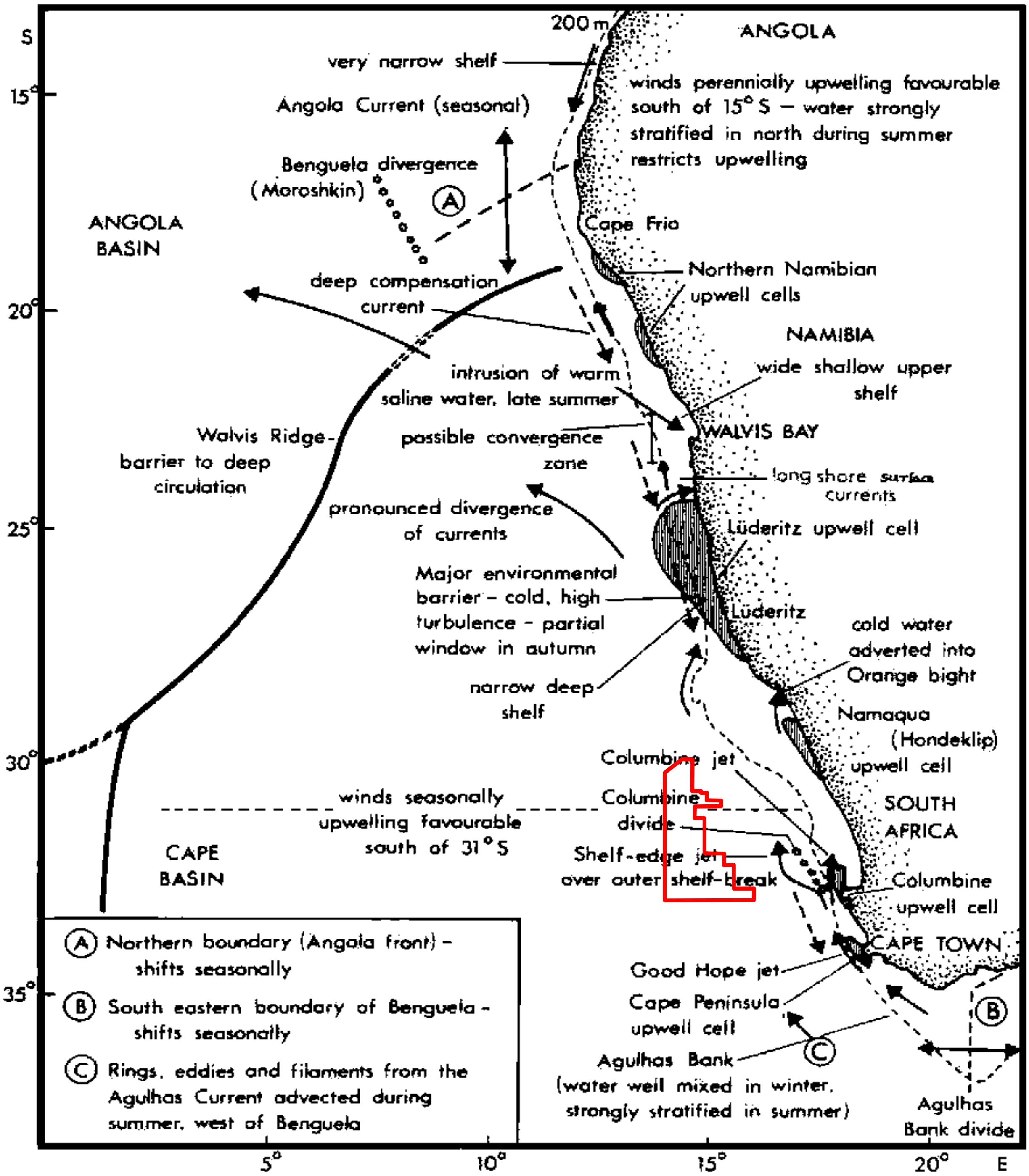


Figure 4.1: **A conceptual model of the Benguela system (after Shannon 1985). Approximate location of licence area is also indicated.**

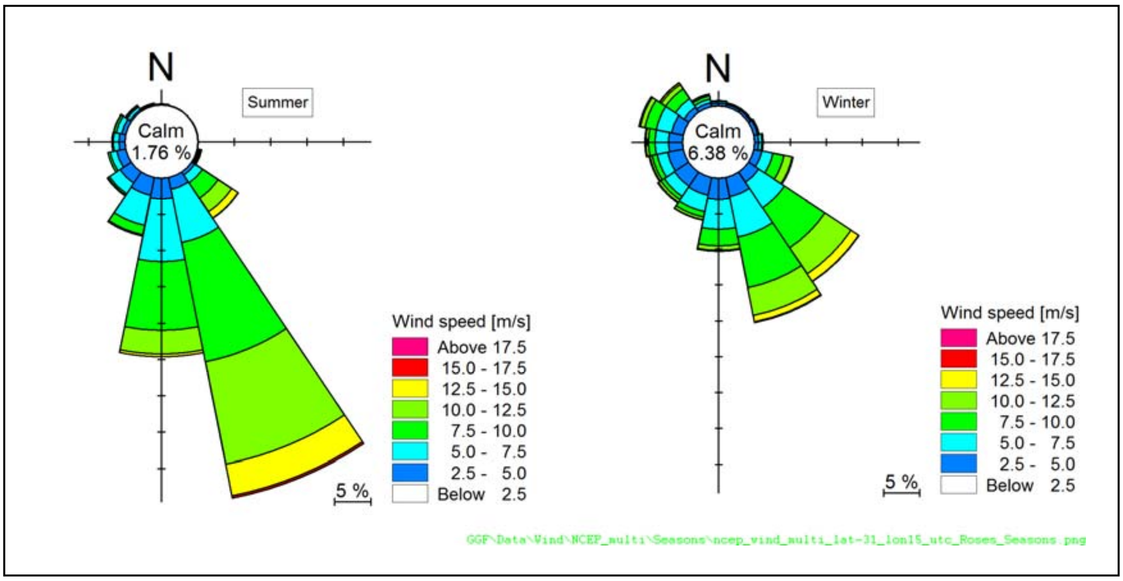


Figure 4.2: Wind Speed vs Wind Direction for NCEP hindcast data at location 15°E, 31°S (PRDW in prep).

4.1.2 PHYSICAL OCEANOGRAPHY

4.1.2.1 Waves

The direction and size of waves present at different sites along the West Coast have been reported by Heydorn and Tinley (1980), Bickerton (1981a and b, 1982) and Morant (1984).

Wave patterns along the West Coast are strongly influenced by the seasonal meteorology. The majority of swells are generated by mid-latitude cyclones to the south of the country, and thus originate from the SW. Wave period is similar and unimodal along the West Coast to the north of Cape Point. Peak energy periods range from 9.7 to 15.5 seconds.

Typical seasonal swell-height rose-plots, compiled from Voluntary Observing Ship (VOS) data off Oranjemund, are shown in Figure 4.3. The wave regime along the West Coast shows only moderate seasonal variation in direction, with virtually all swells throughout the year coming from the S and south-south-west (SSW) direction. Winter swells are strongly dominated by those from the S and SSW, which occur almost 80% of the time, and typically exceed 2 m in height, averaging about 3 m, and often attaining over 5 m. With wind speeds capable of reaching 100 km/h during heavy winter south-westerly storms, winter swell heights can exceed 10 m.

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

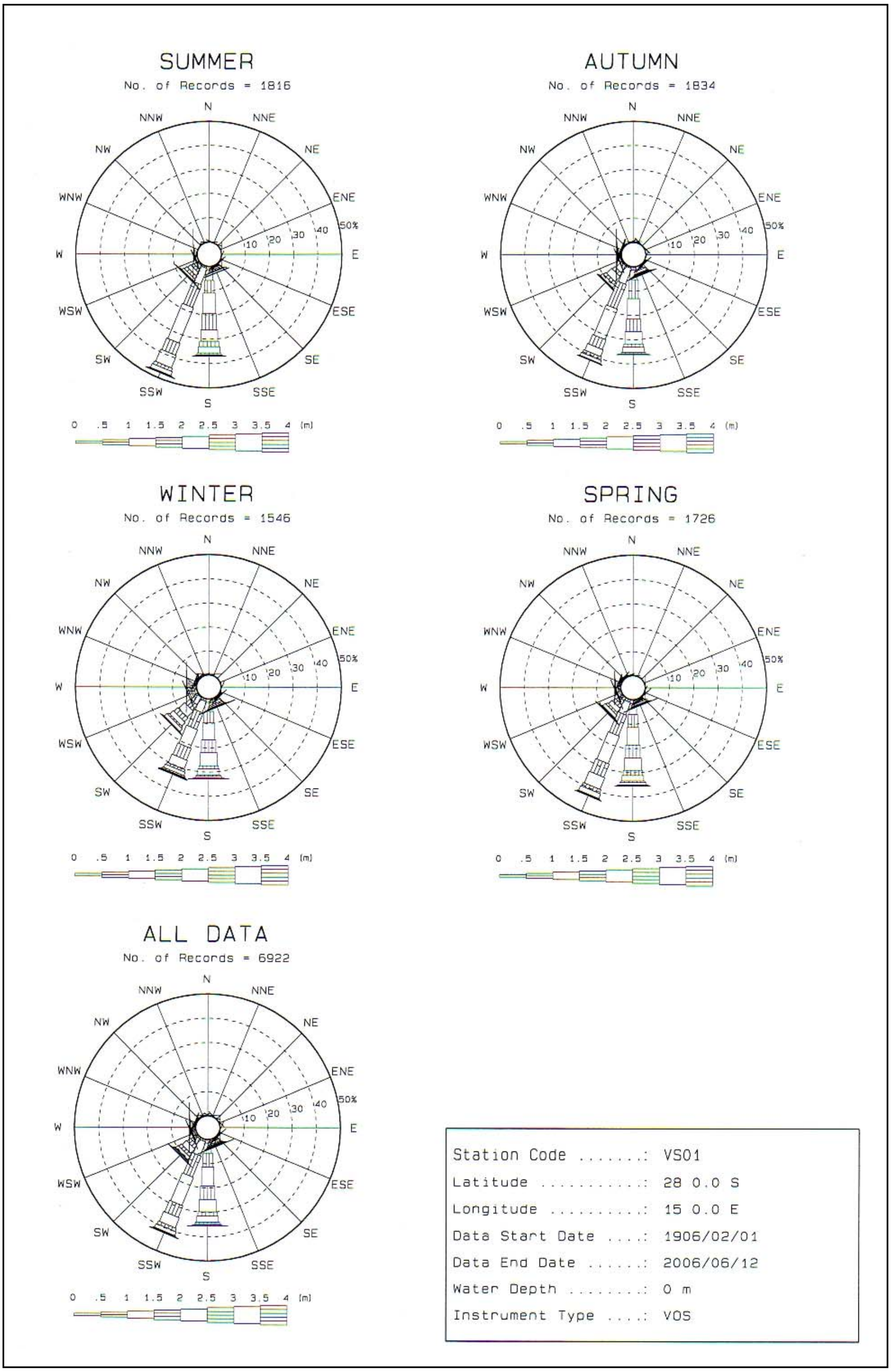


Figure 4.3: Voluntary Observing Ship (VOS) data Wave Height vs Wave Direction data for the offshore area (28°-29°S; 15°-16°E recorded during the period 1 February 1906 and 12 June 2006)) (Source: Southern African Data Centre for Oceanography (SADCO)).

4.1.2.2 Tides

Tides along the West Coast are subject to a simple semi-diurnal tidal regime with a mean tidal range of about 1.57 m (at least 50% of the time in the nearshore area), with spring tides as much as 2.24 m and neap tides in the order of 1 m. Tides arrive almost simultaneously (within 5 to 10 minutes) along the whole of the West Coast. Other than in the presence of constrictive topography, e.g. an entrance to enclosed bay or estuary, tidal currents are weak.

4.1.2.3 Bathymetry and topography

The bathymetry and topography of the West Coast offshore region has been described by Nelson and Hutchings 1983; Shannon 1985; Shannon and Nelson 1996 and Dingle *et al.* 1987.

The continental shelf along the West Coast is generally both wide and deep, although large variations in both depth and width occur (Figure 4.4). The shelf maintains a general north-north-west (NNW) trend north of Cape Point, being narrowest in the south between Cape Columbine and Cape Point (40 km) and widening to the north of Cape Columbine to its widest of the Orange River (180 km). Between Cape Columbine and the Orange River, there is usually a double shelf break, with the distinct inner (closest to shore) and outer slopes separated by a gently sloping ledge.

The immediate nearshore area consists mainly of a narrow (to about 8 km wide) rugged rocky zone which initially slopes steeply seawards to a depth of about 30 m and then gradually to about 80 m. The middle and outer shelf normally lacks relief and slope gently seawards reaching the shelf break (where the slope becomes significantly steeper) at a depth of approximately 300 m.

Banks on the continental shelf include the Orange Bank (Shelf or Cone), a shallow (160 to 190 m) zone that reaches maximal widths (180 km) offshore of the Orange River, and Childs Bank, situated about 75 km east of the area of interest. Child’s Bank is the only known submarine bank within South Africa’s Exclusive Economic Zone (EEZ), rising from a depth of 350 to 400 m water to less than 200 m at its shallowest point. The bank area has been estimated to cover approximately 1 450 km^2 (Sink *et al*. 2012). Tripp Seamount is a geological feature approximately 120 km north-northwest of the proposed area of interest, which rises from the seabed at approximately 1 000 m water depth to a depth of 150. A number of submarine canyons cut into the shelf between 31° and 35°S, the most prominent being the Cape Canyon and the Cape Point Valley.

The area of interest covers an area of approximately 900 km^2 with water depths ranging between 1 500 m and 2 100 m (see Figure 3.1).

4.1.2.4 Sediments

Figure 4.5 illustrates the distribution of seabed surface sediment types off the West Coast. The inner shelf is underlain by Precambrian bedrock (also referred to as Pre-Mesozoic basement), whilst the middle and outer shelf areas are composed of Cretaceous and Tertiary sediments (Dingle 1973; Birch *et al*. 1976; Rogers 1977; Rogers & Bremner 1991).

As a result of erosion on the continental shelf, the unconsolidated sediment cover is generally thin, often less than 1 m. Sediments are finer seawards, changing from sand on the inner and outer shelves to muddy sand and sandy mud in deeper water. However, this general pattern has been modified considerably by biological deposition (large areas of shelf sediments contain high levels of calcium carbonate) and localised river input. An almost 500 km long mud belt (of up to 40 km wide and of 15 m average thickness) is situated over the outer edge of the middle shelf between the Orange River and St Helena Bay (Birch et al. 1976). Further offshore, sediment is dominated by muddy sands, sandy muds, mud and some sand. The continental slope, seaward of the shelf break, has a smooth seafloor, underlain by calcareous ooze. Within the area of interest, sediment is dominated by muds and sandy muds (see Figure 4.5).

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

Nearshore sediments are subject to suspension by waves and longshore transport. This effect penetrates to 90 m. Natural turbidity levels range from 3 and 12 mg/l with significantly higher concentrations associated with storm waves and floods.

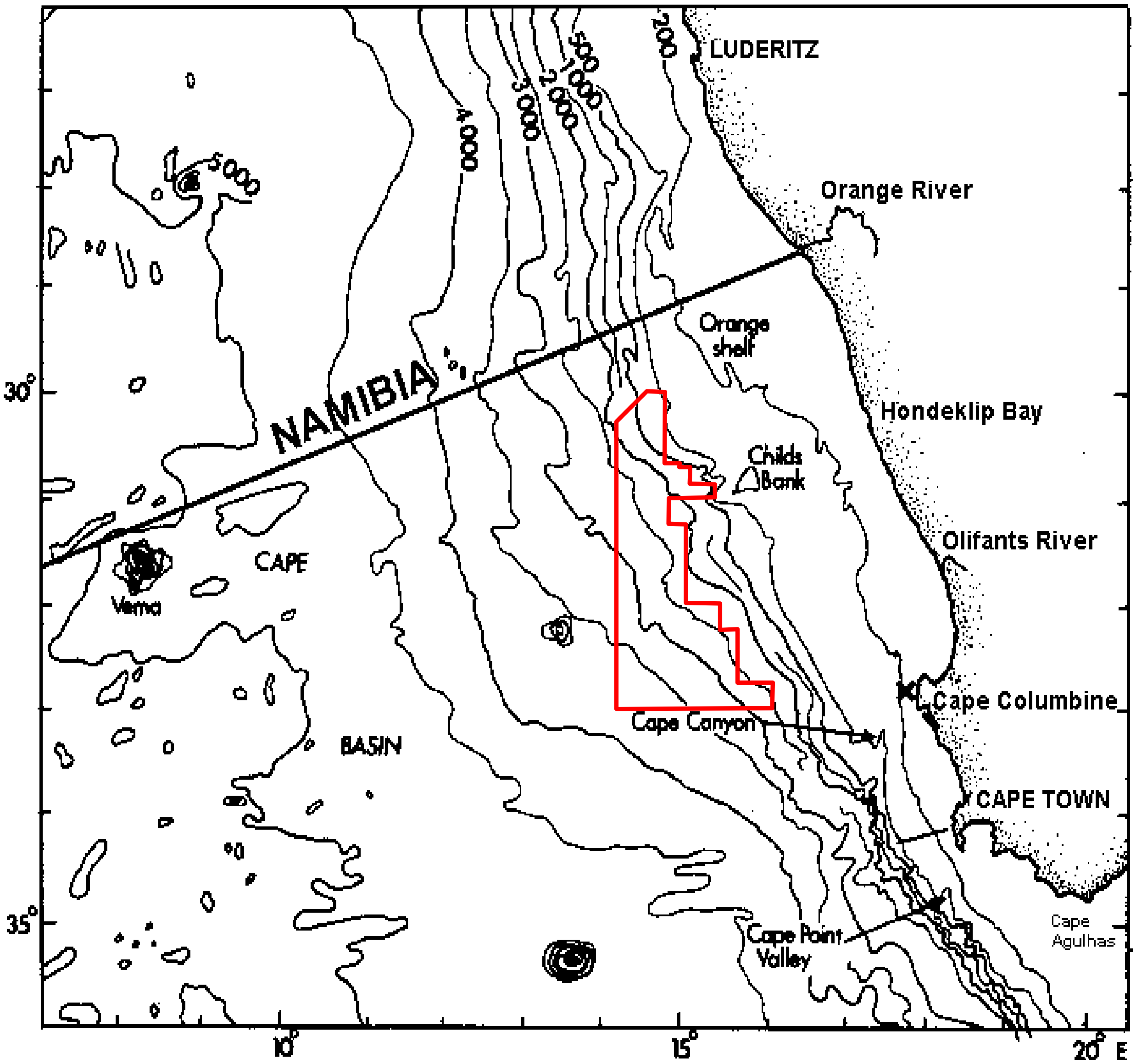


Figure 4.4: Bathymetry of the continental shelf off the West Coast of southern Africa (after Dingle *et al.* 1987). Approximate location of the licence area is also indicated.

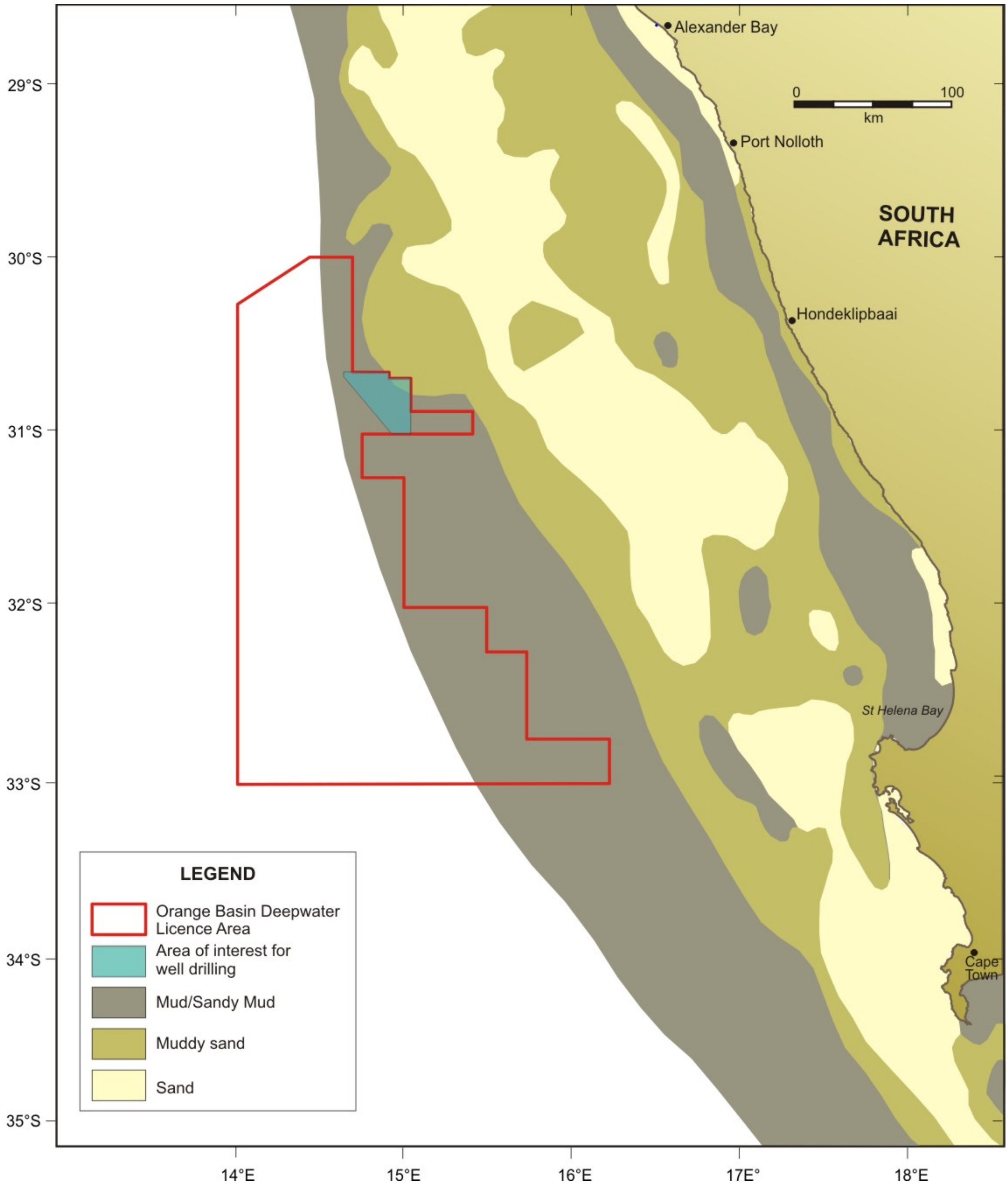


Figure 4.5: Sediment distribution on the continental shelf of the South African West Coast (Adapted from Rogers 1977). Approximate location of the licence area is also indicated.

4.1.2.5 Water masses and sea surface temperatures

A number of water masses are found along the West Coast, including tropical and sub-tropical surface waters, thermocline waters (comprising South Atlantic, South Indian and tropical Atlantic Central Water), Antarctic Intermediate Water (AAIW), North Atlantic Deep Water (NADW) and Antarctic Bottom Water (AABW). The thermocline water mass (6°C, 34.5 Practical Salinity Units (psu) – 16°C, 35.5 psu) is that which upwells along the coast and which constitutes the shelf waters of the Benguela, although in highly modified forms. Thermocline water overlies AAIW (34.2-34.5 psu with potential temperature 4-5°C). NADW has a potential temperature less than 3°C and salinity greater than 34.8 psu, and lies below the AAIW stratum. In the Cape Basin, it lies above the AABW, which is located deeper than about 3 800 m. AABW is cooler than 1.4°C and has a salinity of 34.82 psu.

Off the south-western Cape the upwelling of cool water occurs during the summer months stabilising the seawater temperature along this coastline to some extent so that the average sea surface temperature changes little throughout the year (13 to 15 °C). In the northern Benguela system where cool upwelling occurs during the winter months, a far more pronounced seasonal difference (12 to 17 °C) in sea surface temperatures occurs (Shannon 1985). The sea surface temperature along the coast of Namaqualand near Port Nolloth ranges from a minimum of 10 °C to a maximum of just over 20 °C, with 84 % of the temperatures falling within a range of 12 °C to 17 °C.

Over the continental margin, progressively colder waters encroach onto the continental shelf between the Orange River and the Cape Peninsula (Shannon and Nelson 1996). The area between 31°S and 33°S has the minimum shelf temperatures, with isotherms retreating into deeper water south of 34°S (Dingle and Nelson 1993).

4.1.2.6 Water Circulation

Water circulation off the West Coast is dominated by upwelling (see Section 4.1.2.7). Although the rate and intensity of upwelling fluctuates with seasonal variations in wind patterns, the most intense upwelling tends to occur where the shelf is narrowest and the wind strongest.

The ocean currents occurring off the West Coast are complex and are summarised in Figure 4.6. Data suggests that currents north of Cape Columbine are weaker and more variable than the currents to the south (Boyd *et al*. 1992). The most important is the Benguela current, which constitutes a broad, shallow and slow NW flow along the West Coast between the cool coastal upwelled waters and warmer Central Atlantic surface waters further offshore. The current is driven by the moderate to strong S to SE winds which are characteristic of the region and is most prevalent at the surface, although it does follow the major seafloor topographic features (Nelson and Hutchings 1983).

Current velocities in continental shelf areas generally ranges between 10 to 30 cm/s (Boyd & Oberholster 1994), although localised flows in excess of 50 cm/s occur associated with eddies (PRDW in prep). On its western side, flow is more transient and characterised by large eddies shed from the retroflection of the Agulhas Current. This results in considerable variation in current speed and direction over the domain. In the south the Benguela current has a width of 200 km, widening rapidly northwards to 750 km. The surface flows are predominantly wind-forced, barotropic and fluctuate between poleward and equatorward flow (Shillington *et al.* 1990; Nelson & Hutchings 1983) (see Figure 4.6). Fluctuation periods of these flows are 3 to 10 days, although the long-term mean current residual is in an approximate north-west (alongshore) direction. Current speeds decrease with depth, while directions rotate from predominantly north-westerly at the surface to south-easterly near the seabed. Near bottom shelf flow is mainly poleward with low velocities of typically <5 cm/s (Nelson 1989; PRDW in prep).

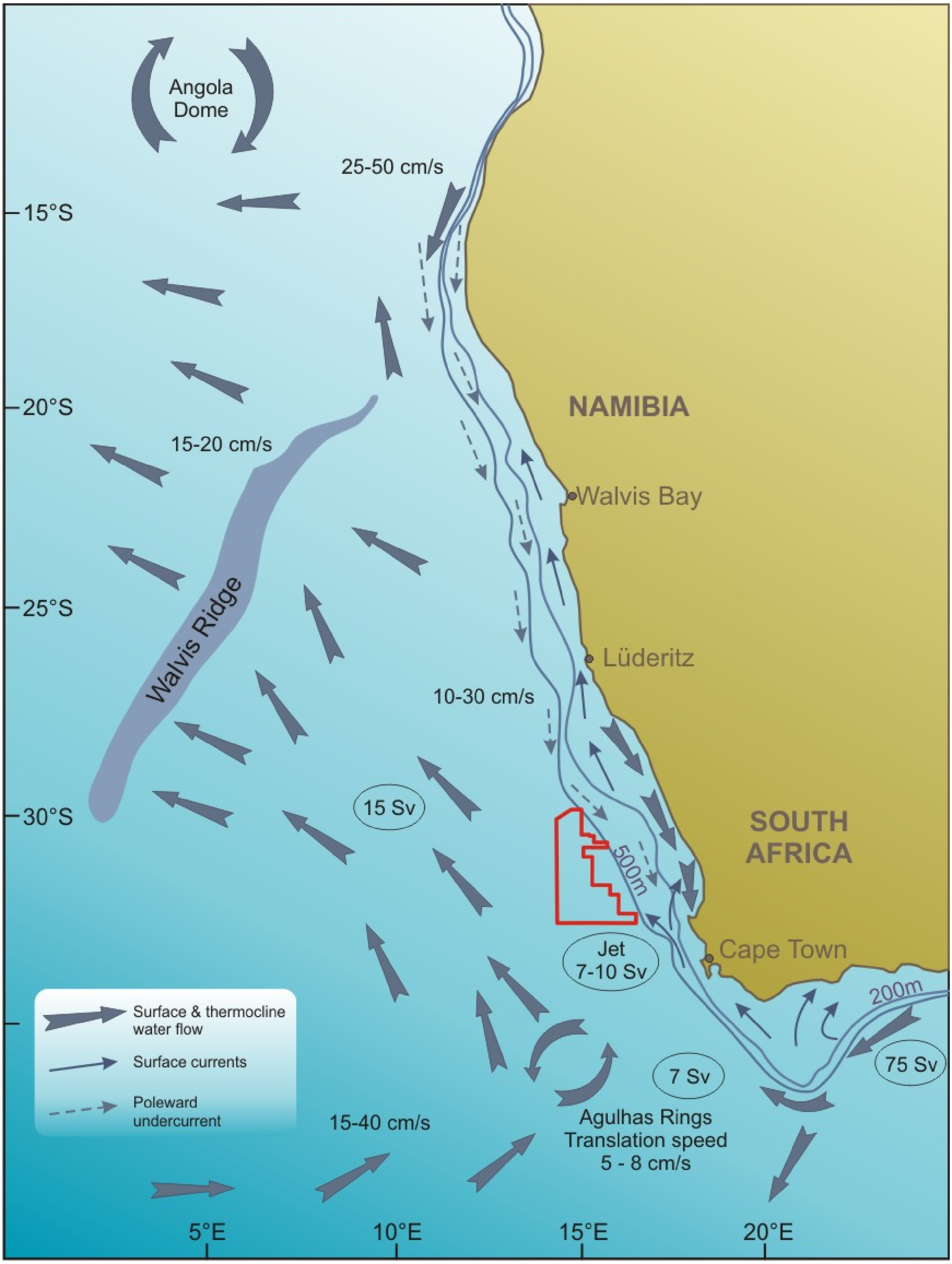


Figure 4.6: Major features of the predominant circulation patterns and volume flows in the Benguela System, along the southern Namibian and South African west coasts (re-drawn from Shannon & Nelson 1996). Approximate location of the licence area is also indicated.

4.1.2.7 Upwelling

The Benguela region is one of the world's major coastal upwelling systems, the majority of which are found off the west coasts of continents (e.g. off Chile and Peru, California and West Africa). This upwelling dominates the oceanography of the West Coast of South Africa (Andrews and Hutchings 1980; Nelson and Hutchings 1983). Upwelling is characterised by pulsed input of cold, nutrient-rich water into the euphotic zone, and in the Benguela region results from the wind-driven offshore movement of surface waters. The surface waters are replaced by cold nutrient-rich water that upwells from depth through Ekman transport. Once upwelled, this water warms and stabilises, and moves offshore where a thermocline usually develops. Nutrient-rich upwelled water enhances primary production, and the West Coast region consequently supports substantial pelagic fisheries (Heydorn and Tinley 1980; Shillington 1998).

Upwelling occurs along the West Coast from Cape Agulhas to northern Namibia. The principle upwelling centre on the West Coast lies off Lüderitz and the Lüderitz upwelling cell effectively divides the Benguela Upwelling system into a northern and southern region, which are meteorologically distinct (Pitcher *et al.* 1992). In the south upwelling-favourable SE winds are most prevalent during spring and summer, and upwelling occurs mostly between September and March. Upwelling in the southern Benguela area is highly variable on macro, meso and micro scales. Both continental shelf bathymetry and upwelling winds drive upwelling in the southern Benguela which is further influenced by local topography and meteorology (Shannon 1985), resulting in centres of enhanced upwelling off Namaqualand (30°S), Cape Columbine (33°S) and Cape Peninsula (34°S) (Figure 4.7).

The Namaqualand upwelling zone (or Hondeklipbaai Cell) is a cool wedge-shaped zone lying between Hondeklip Bay and the Orange Bight, where the narrow shelf to the south-west of Hondeklip Bay results in enhanced upwelling. Both bathymetry and orography control upwelling at Cape Columbine. Two fronts separate a divergence zone off the Columbine Peninsula, an oceanic front at the shelf edge and a shallower inshore front. Upwelling off the Cape Peninsula is among the most marked in the world with upwelling rates estimated to average 21 m/day (maximum of 32 m/day). A well-defined front exists over the shelf break off the Cape Peninsula, outside of which is a well-developed equatorward jet reaching speeds of 60 $cm.sec^{-1}$ on the surface and 120 $cm.sec^{-1}$ at 150 m (Andrews and Hutchings 1980).

Although the upwelling process is active within 10 to 20 km of the shore, the influence of cold upwelled water extends approximately 150 km (Shannon and Nelson 1996). However, distinctive cold water filaments can extend 200 km offshore perpendicular to the coast, some being more than 1 000 km long (Shannon and Nelson 1996, Shillington *et al.* 1992).

4.1.2.8 Nutrient distribution

Above thermoclines (that develop as water movement stabilises) phytoplankton production consumes nutrients, thus depleting the nutrients in the surface layer. Below the thermocline, nutrient re-enrichment occurs as biological decay occurs. As upwelled water is nutrient enriched compared to surface water, nutrient distribution on the West Coast are closely linked to upwelling (Chapman and Shannon 1985). Highest nutrient concentrations are thus located at the upwelling sites (Andrews and Hutchings 1980), offshore of which it decreases (Chapman and Shannon 1985).

Phosphate levels are low at the surface and offshore, but high (up to 3.0 μM) in bottom waters of the shelf and in newly upwelled waters. Upwelled waters can at times be enriched in phosphate as they pass over phosphorus rich shelf sediments. Phosphate is unlikely to ever become a limiting nutrient in the Benguela region.

Nitrate normally occurs in greater concentrations at the bottom than in upwelling source water, and decreases in availability at the surface (to less than 1 μM). Nitrate appears to be the limiting nutrient in the Benguela region.

Silicate levels range between 5-15 μM within the Benguela system, although these may at times be enhanced considerably over the shelf. It is not likely to be limiting in the southern Benguela.

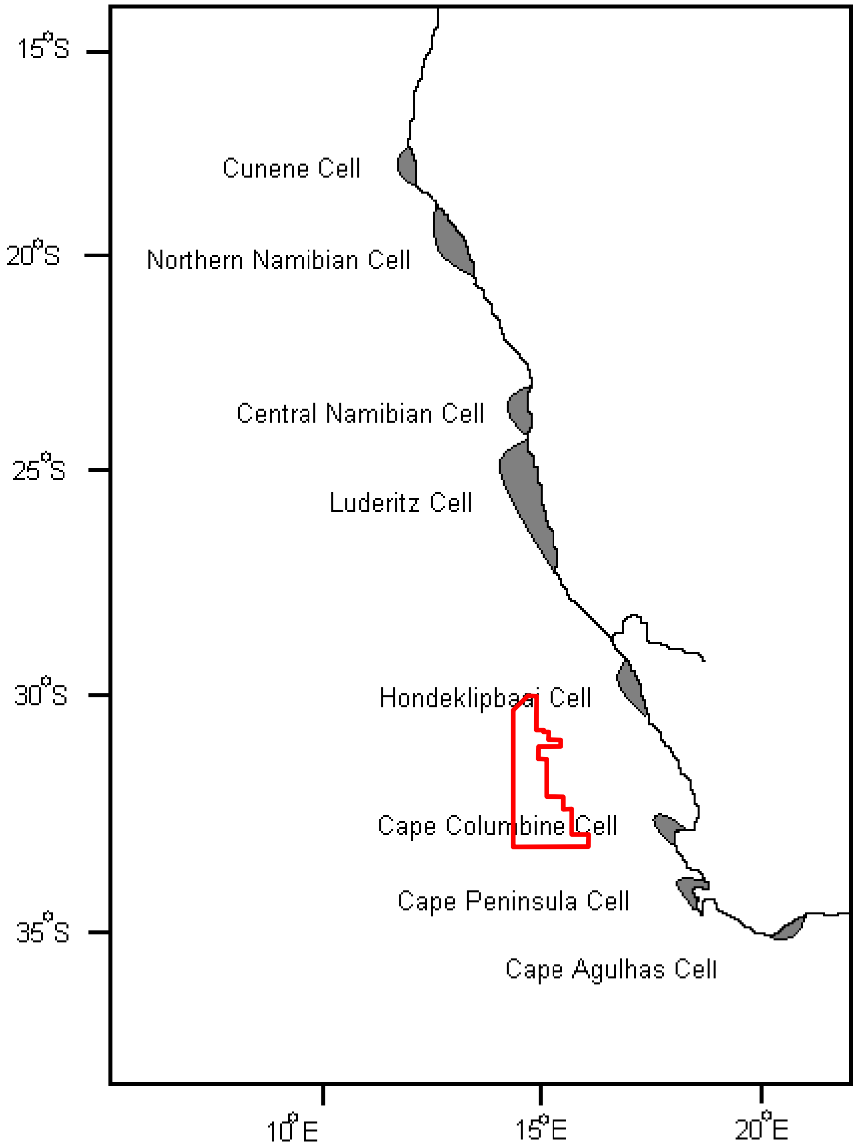


Figure 4.7: The location of three major upwelling cells along the West Coast (Shannon and Nelson, 1996). Approximate location of the licence area is also indicated.

4.1.2.9 Oxygen concentration

The Benguela system is characterised by large areas of very low oxygen concentrations with less than 40% saturation occurring frequently (Visser 1969; Bailey *et al*. 1985). The low oxygen concentrations are attributed to nutrient remineralisation in the bottom waters of the system (Chapman & Shannon 1985). The absolute rate of this is dependent upon the net organic material build-up in the sediments, with the carbon rich mud deposits playing an important role. As the mud on the shelf is distributed in discrete patches (see Figure 4.5), there are corresponding preferential areas for the formation of oxygen-poor water.

There are including three centres of oxygen-depleted shelf water; one of which is well north of the region (2°S to 24°S), another to the north of the Namaqualand upwelling cell and the third in St Helena Bay (Chapman and Shannon 1985). The spatial distribution of oxygen-poor water in each of the areas is subject to short- and medium-term variability in the volume of hypoxic water that develops.

Generally, oxygen concentrations appear to increase from the Orange River region southward. Surface oxygen levels are higher than bottom waters (water is regularly supersaturated) due to phytoplankton production, especially during less intense upwelling. Upwelling processes can move low-oxygen water up onto the inner shelf and into nearshore waters, often with devastating effects on marine communities.

Oxygen deficient water can affect the marine biota at two levels. It can have sub-lethal effects, such as reduced growth and feeding, and increased inter-moult period in the rock-lobster population (Beyers *et al*. 1994). Low-oxygen events associated with massive algal blooms can lead to large-scale stranding of rock lobsters, and mass mortalities of marine biota and fish (Newman & Pollock 1971; Matthews & Pitcher 1996; Pitcher 1998; Cockcroft *et al*. 2000). The development of anoxic conditions as a result of the decomposition of huge amounts of organic matter generated by phytoplankton blooms is the main cause for these mortalities and walkouts. Algal blooms usually occur during summer-autumn (February to April) but can also develop in winter during the 'berg' wind periods, when similar warm windless conditions occur for extended periods.

4.1.2.10 Turbidity

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

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

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

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

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

Offshore of the continental shelf, the oceanic waters are typically clear as they are beyond the influence of aeoloan and riverine inputs. The waters in the licence area are thus expected to be comparatively clear.

4.1.3 BIOLOGICAL OCEANOGRAPHY

South Africa is divided into nine bioregions (see Figure 4.8). The proposed area of interest area falls within the Atlantic Offshore Bioregion. The Namaqua and South-western Cape bioregions occur inshore of the licence area (Emanuel *et al*. 1992; Lombard *et al.* 2004).

The South African National Biodiversity Institute (SANBI) has initiated a process to identify potential priority areas for spatial management in the offshore environment that require protection (Sink, *et. al.,* 2012). Priority areas for protection are presented in Sections 4.1.4.6d and 4.2.3.4. The proposed Child's Bank protection area is located 75 km east of the proposed area of interest. Sink, *et. al.* (2012) also mapped the ecosystem threat status of offshore benthic and pelagic habitats. The proposed area of interest area coincides with areas mapped as Least Threatened benthic habitats and Least Threatened and Vulnerable pelagic habitat, which generally occur along the shelf break (see Figure 4.9).

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

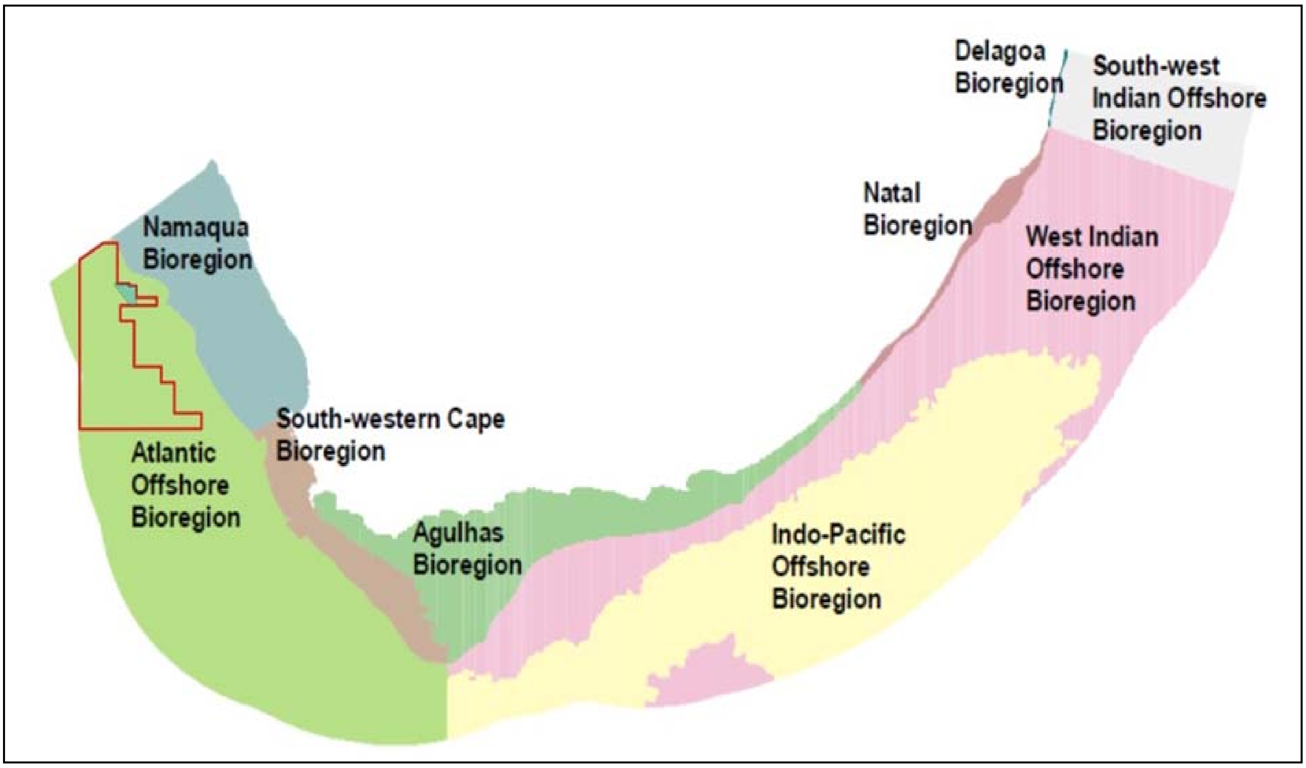


Figure 4.8: **The nine bioregions defined by the NBSA study (Lombard and Strauss 2004). The approximate location of the licence area is also shown.**

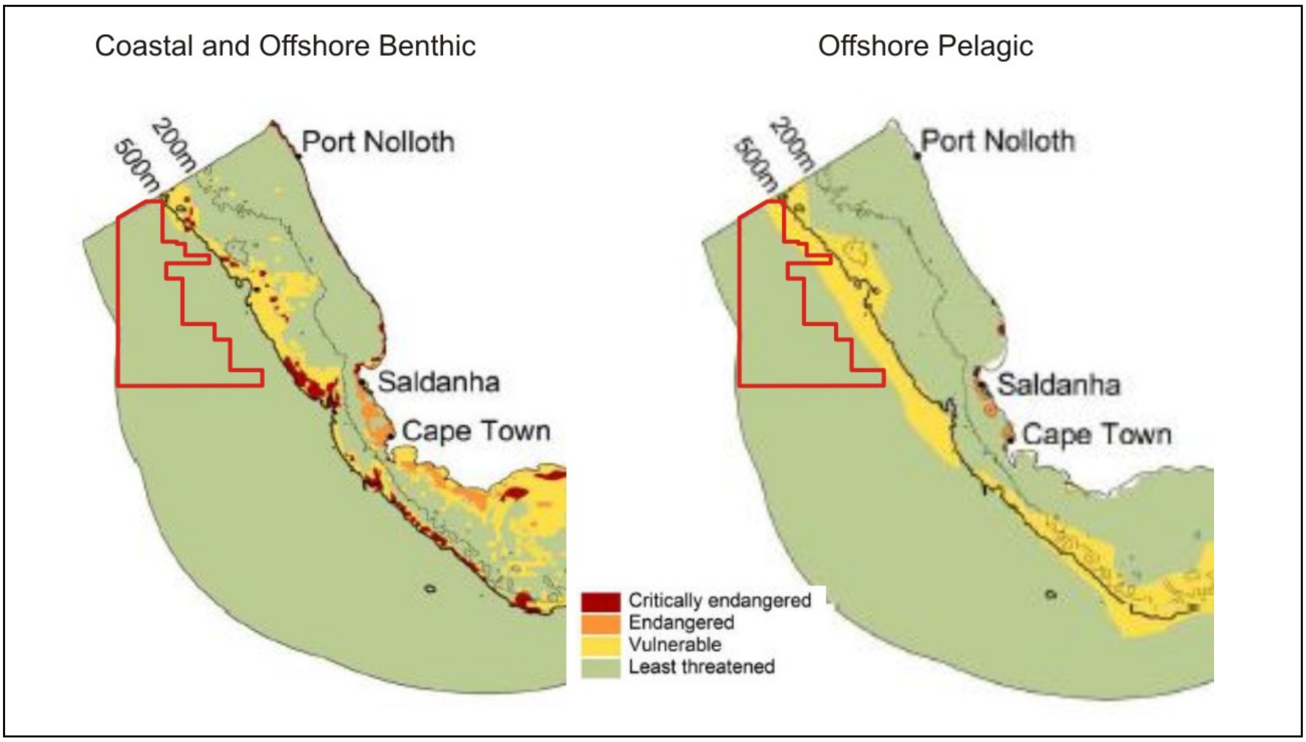


Figure 4.9: **Ecosystem threat status for coastal and offshore benthic and pelagic habitat types on the South African West Coast (adapted from Sink, et. al., 2012). The approximate location of the licence area is also shown.**

4.1.3.1 Plankton

Plankton comprises of three components:

(a) Phytoplankton

Features of phytoplankton distribution in the Benguela system are summarised in Figure 4.10.

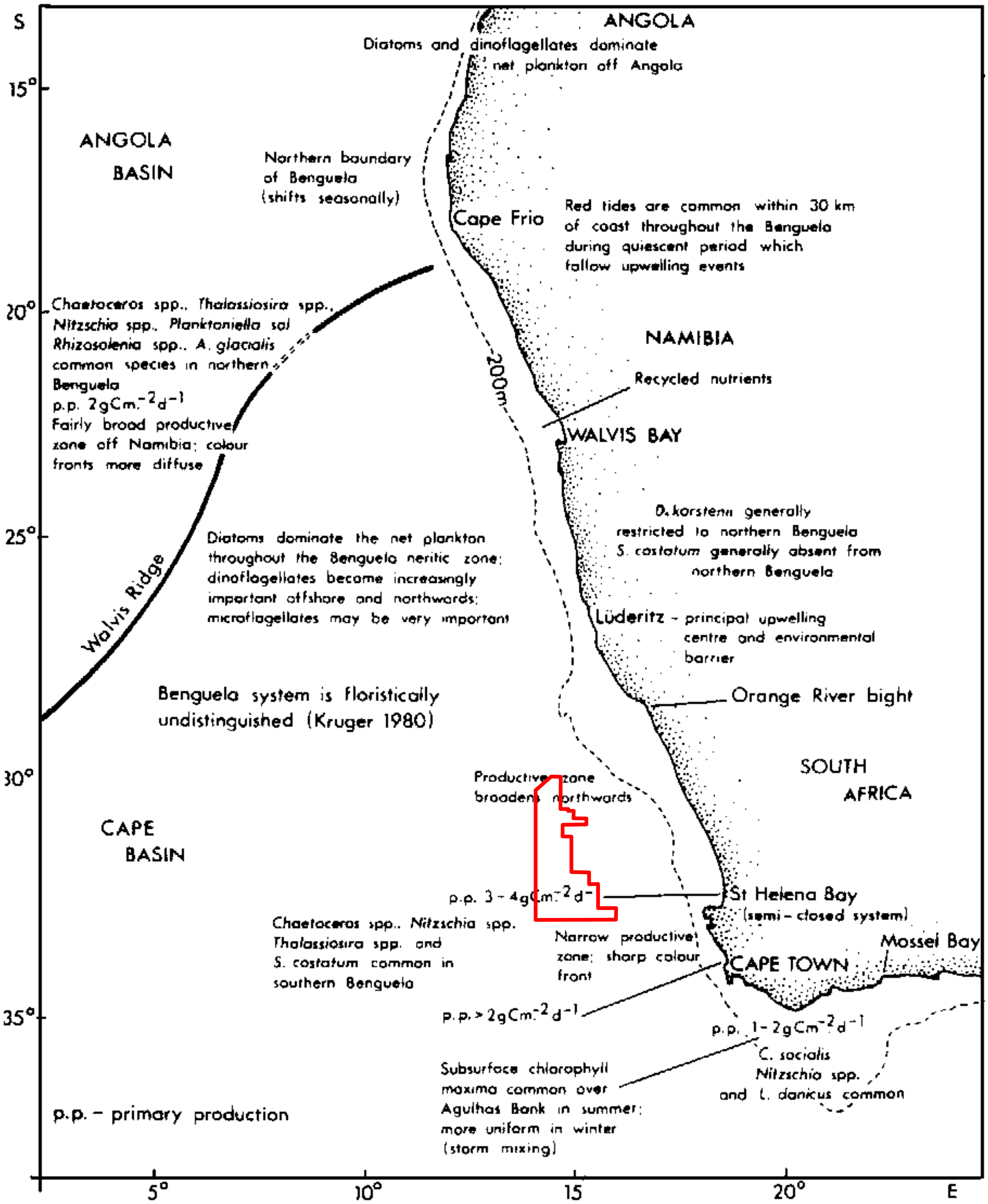


Figure 4.10: Features of phytoplankton distribution in the Benguela System (after Shannon and Pillar 1986). Approximate location of the licence area is also indicated.

Phytoplankton and "*chlorophyll a*" concentrations vary seasonally along the West Coast, being minimal in winter and summer (<1-2 mg/m³) and maximal (2-4 mg/m³) in spring and autumn. Productivity levels range from 2.5 to 3.5 g C/m^2/day for the midshelf region and decreasing to 1 g C/m^2/day inshore of 130 m (Shannon & Field 1985; Mitchell-Innes & Walker 1991; Walker & Peterson 1991).

Phytoplankton cells are greatest during upwelling. However, as phytoplankton production is related to nutrient supply, seeding and water column stability, production at the upwelling site *per se* is low (chlorophyll a levels range from 0.4 to 0.9 mg.m^{-3}), but increases offshore and 'downstream' (northward) from upwelling sites, where the water column is more stable.

Although diatoms are reported to contribute the bulk of the phytoplankton in the Benguela current (Andrews and Hutchings 1980; Olivieri 1983), dinoflagellates are also important (Chapman and Shannon 1985). An estimated 36 % of the phytoplankton is lost to the seabed annually. This natural annual input of millions of tons of organic material onto the seabed off the West Coast has a substantial effect on the ecosystems of the Benguela region. It provides most of the food requirements of the particulate and filter-feeding benthic communities that inhabit the sandy-muds and results in the high organic content of the muds in the area.

Red tides (dinoflagellate and/or ciliate blooms or harmful algal blooms) may occur inshore along the coast north of Cape Point (especially in the Lamberts Bay to St Helena Bay region), usually during relaxation of upwelling cells in late summer to autumn. The most common species associated with red tides are Noctiluca scintillans, Gonyaulax tamarensis, G. polygramma and the ciliate Mesodinium rubrum. Gonyaulax and Mesodinium. Red tides (which can range in colour) may be toxic and animals, particularly filter feeding species, may accumulate toxins in their tissues. Furthermore, decomposition of red tides may strip the remaining oxygen from the water and turn it anoxic (known as a "black tide"), having catastrophic consequences on the inshore fauna of the affected area.

(b) Zooplankton

Features of the zooplankton distribution in the Benguela system are summarised in Figure 4.11.

Zooplankton biomass is related to that of phytoplankton, and is thus seasonal, being minimal during winter when the rate of upwelling is lower (Andrews and Hutchings 1980). Zooplankton biomass is low in newly upwelled waters, but increases as these waters age and develops substantial phytoplankton. However, zooplankton blooms lag phytoplankton blooms and thus are found even further offshore, with zooplankton biomass being maximal 40 to 100 km offshore in summer. During winter (when no upwelling occurs in the southern Benguela region) maximal zooplankton biomass is observed close inshore, values being low offshore. An estimated 5 % of the zooplankton is lost to the seabed annually.

Zooplankton is best described divided into mesozooplankton (>200 µm) and macrozooplankton (>1 600 µm). Copepods dominate the mesozooplankton (Andrews and Hutchings 1980; Hutchings *et al.* 1991; Verheye *et al.* 1994), and most are found in the phytoplankton-rich upper mixed layer of the water column. Mesozooplankton standing stock estimates in the southern Benguela range from 0.237 to 2.520 gC.m^{-2} and generally increase from south (~0.5 to ~1.0 gC.m^{-2} between Cape Point and Cape Columbine) to north (~0.5 to ~2.5 gC.m^{-2} to the north of Cape Columbine); the higher northern biomass attributed to the region being downstream of two major upwelling cells.

Euphausiids (18 species) dominate the macrozooplankton (Pillar 1986), of which *Euphausia lucens* and *Nyctiphanes capensis* are the most abundant in the shelf region with *E. lucens* dominating the region between Lüderitz and Cape Agulhas (Pillar *et al.* 1992). Other important groups contributing to the southern Benguela macrozooplankton community are chaetognaths (24 species), hyperiid amphipods (over 70 species within the southern and northern Benguela) and tunicates (42 species) (see Gibbons *et al.* 1992).

Macrozooplankton standing stocks are greatest north of Cape Columbine (0.5 gC.m^{-2}) and decline southwards and eastwards to 0.1 gC.m^{-2} at the eastern boundary of the West Coast.

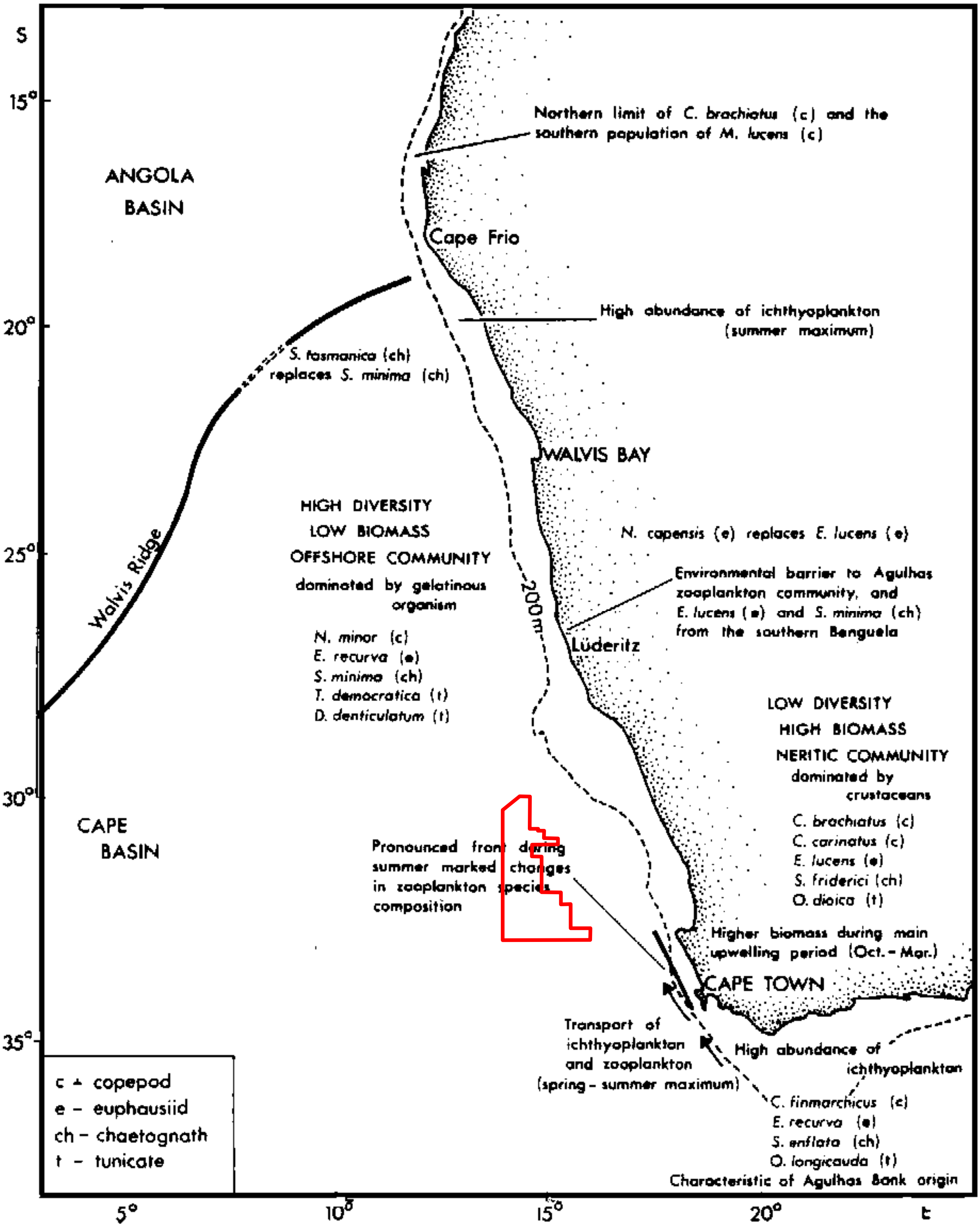


Figure 4.11: Features of zooplankton and ichtyoplankton distribution in the Benguela system (after Shannon and Pillar 1986). Approximate location of the licence area is also indicated.

(c) Ichthyoplankton

Ichthyoplankton comprises both fish eggs and larvae, and despite comprising a small component of the overall plankton, is important due to commercial fisheries. Features of the ichthyoplankton distribution in the Benguela system are summarised in Figure 4.11 (Shannon and Pillar 1986).

Spawning areas for pilchard (*Sardinops sagax*), anchovy (*Engraulis japonicus*) and round herring (*Etrumeus Whiteheadi*) along the West Coast in relation to licence area are shown in Figure 4.12. Each spring, anchovy migrate southwards from the West Coast to spawning grounds on the western Agulhas Bank (Peterson *et al.* 1992), where the fish spawn serially with frequency of spawning being dependent on food concentration (copepod biomass). Most spawning takes place to the east of Cape Point some 40 to 100 km offshore in 16 to 19°C water.

Of the demersal species, the two hake species (*Merluccius capensis* and *M. paradoxus*) spawn on the continental shelf off St Helena Bay and the western Agulhas Bank (see Figure 4.13). Hake spawning occurs in spring and early summer, with a secondary spawning peak in autumn. Kingklip (*Genypterus capensis*) spawning occurs along the southern African West Coast from Cape Point northwards (Payne 1977). Eggs and/or larvae of snoek (*Thyrsites atun*), jacopever (*Helicolenus dactylopterus*), dragonet (*Paracallionymus costatus*) and saury (*Scomberesox saurus scomberoides*) have also been reported in the southern Benguela.

Ichthyoplankton abundance in the offshore waters of the licence area is expected to be low.

4.1.3.2 Benthic invertebrate macrofauna

The benthic biota of unconsolidated marine sediments constitute invertebrates that live on (epifauna) or burrow within (infauna) the sediments and are generally divided into macrofauna (animals >1 mm) and meiofauna (<1 mm). Although sediment distribution studies (Rogers & Bremner 1991) suggest that the outer shelf is characterised by unconsolidated sediments (see Figure 4.5), recent surveys conducted between 180 m and 480 m depth inshore of the Orange Basin Deep Water Licence Area revealed high proportions of hard ground rather than unconsolidated sediment, although this requires further verification (Karenyi unpublished data).

Benthic communities are structured by the complex interplay of a large array of environmental factors. The structure and composition of benthic soft bottom communities is primarily a function of water depth and sediment composition (Steffani & Pulfrich 2004a, 2004b; 2007; Steffani 2007a; 2007b), but other factors such as current velocity, organic content and food abundance also play a role (Flach & Thomsen 1998; Ellingsen 2002). Water depth and sediment grain size are considered the two major factors that determine benthic community structure and distribution on the South African west coast (Christie 1974, 1976; Steffani & Pulfrich 2004a, 2004b; 2007; Steffani 2007a; 2007b) and elsewhere in the world (e.g. Gray 1981; Ellingsen 2002; Bergen *et al*. 2001; Post *et al*. 2006). However, studies have shown that shear bed stress (i.e. a measure of the impact of current velocity on sediment), oxygen concentration (Post *et al*. 2006; Currie *et al*. 2009; Zettler *et al*. 2009), productivity (Escaravage *et al*. 2009), organic carbon and seafloor temperature (Day *et al*. 1971) may also strongly influence the structure of benthic communities. There are clearly other natural processes operating in the deepwater shelf areas of the West Coast that can over-ride the suitability of sediments in determining benthic community structure, and it is likely that periodic intrusion of low oxygen water masses is a major cause of this variability (Monteiro & van der Plas 2006; Pulfrich *et al*. 2006). In areas of frequent oxygen deficiency, benthic communities will be characterised either by species able to survive chronic low oxygen conditions or colonising and fast-growing species able to rapidly recruit into areas that have suffered oxygen depletion. The combination of local, episodic hydrodynamic conditions and patchy settlement of larvae will tend to generate the observed small-scale variability in benthic community structure.

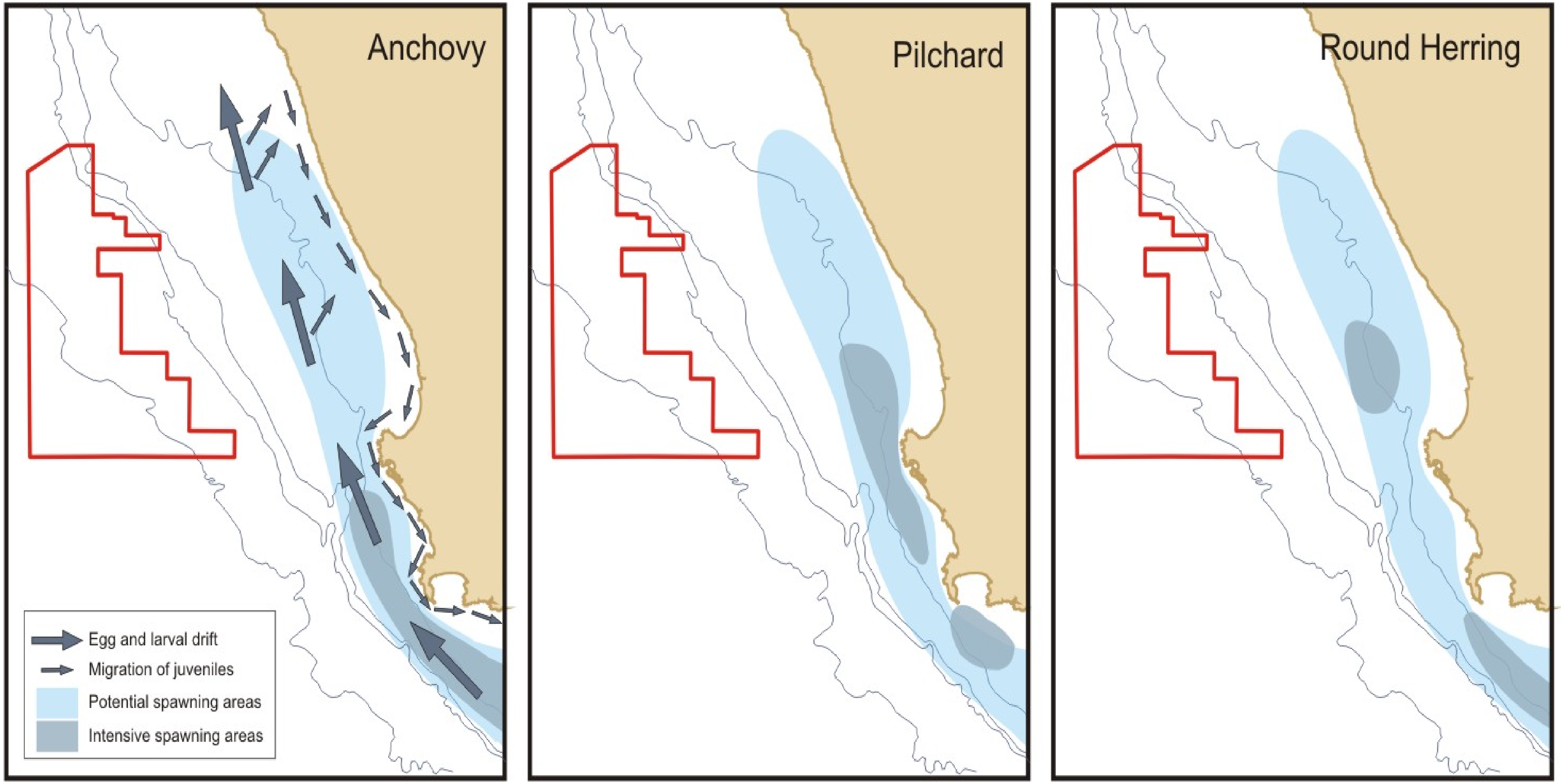


Figure 4.12: The licence area in relation to major spawning areas for different pelagic species in the southern Benguela region. Adapted from Cruikshank (1990).

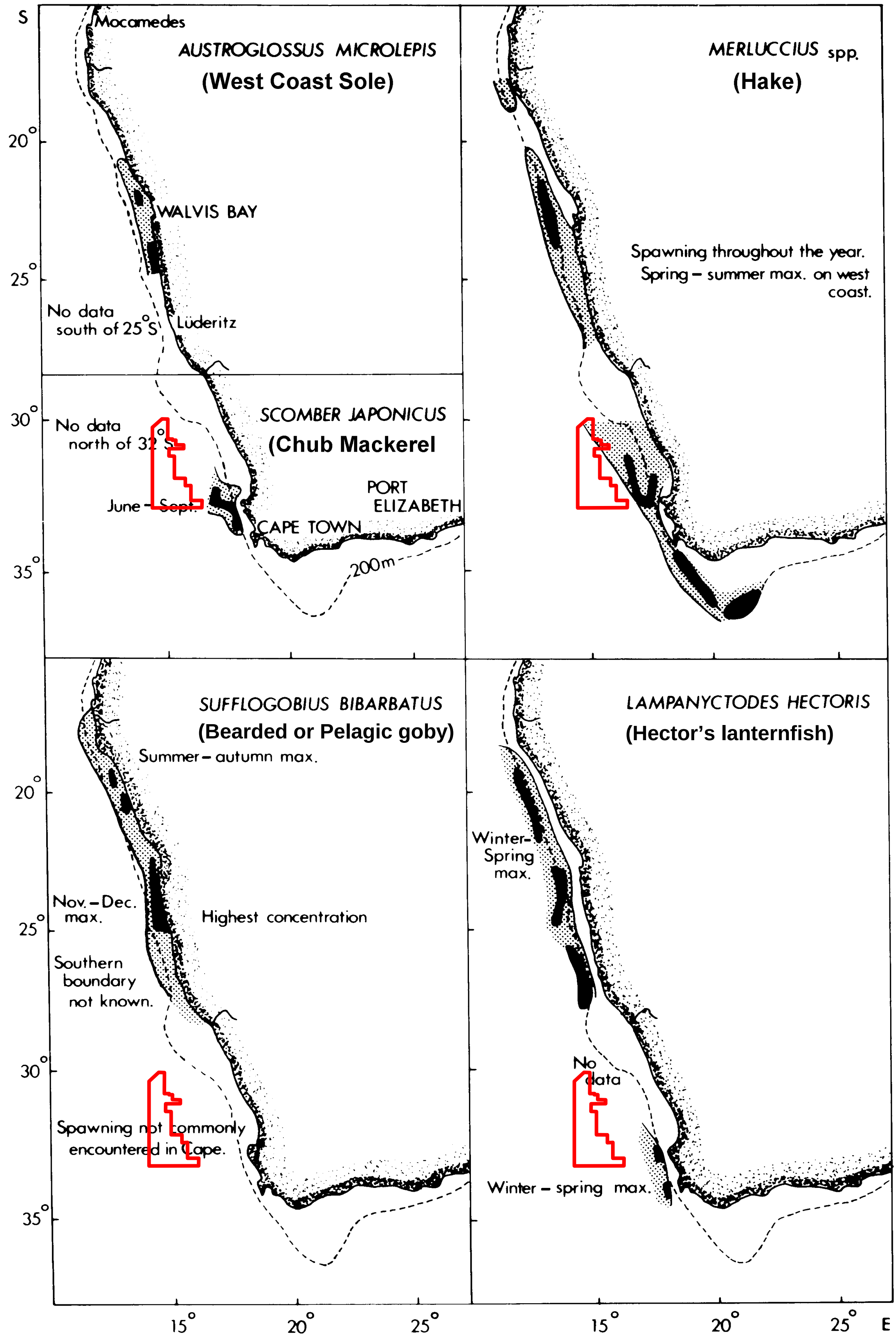


Figure 4.13: **Spawning and recruitment information for a number of pelagic and demersal fish species inhabiting the West Coast. Modified from Shannon & Pillar (1986). Approximate location of the licence area is also indicated.**

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

Three macro-infauna communities have been identified on the inner- (i.e. 0-30 m depth) and mid-shelf (i.e. 30-150 m depth, Karenyi unpublished data). The inner-shelf community, which is affected by wave action, is characterised by various mobile predators (e.g. the gastropod *Bullia laevissima* and polychaete *Nereis* sp.), sedentary polychaetes and isopods. The mid-shelf community inhabits the mudbelt and is characterised by the mud prawns *Callianassa* sp. and *Calocaris barnardi*. A second mid-shelf sandy community occurring in sandy sediments, is characterised by various polychaetes including deposit-feeding *Spiophanes soederstromi* and *Paraprionospio pinnata*.

Polychaetes, crustaceans and molluscs make up the largest proportion of individuals, biomass and species on the West Coast. The distribution of species within these communities are inherently patchy reflecting the high natural spatial and temporal variability associated with macro-infauna of unconsolidated sediments (e.g. Kenny *et al*. 1998; Kendall & Widdicombe 1999; van Dalfsen *et al*. 2000; Zajac *et al*. 2000; Parry *et al*. 2003), with evidence of mass mortalities and substantial recruitments recorded on the South African West Ciast (Steffani & Pulfrich 2004). Despite the current lack of knowledge of the community structure and endemicity of South African macro-infauna off the edge of the continental shelf, the South Atlantic bathyal and abyssal unconsolidated habitat types that characterise depths beyond 500 m are rated as 'Least Threatened' (see Figure 4.9). This primarily reflects the great extent of these habitats in the South African EEZ.

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

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

4.1.3.3 Invertebrates

The West Coast supports important commercial stocks of West Coast rock lobster (*Jasus lalandii*) between Cape Agulhas and about 25º S. While larvae normally move in offshore ocean currents before settling in the shallow kelp beds of the West Coast, the adults are generally found in water depths of between 10 and about 70 m. Female West Coast rock lobsters have a well-defined moulting and spawning cycle, with moulting between May and June and the berry season between May/June and October/November. Peak hatching in October/November is synchronised with strong wind upwelling especially in the southern Benguela. Newly hatched larvae drift northwards and offshore. The return of late stage larvae is believed to be controlled by large-scale ocean circulation systems.

Studies have shown that the majority of seabed species recorded from similar areas have short life spans (a few years or less) and relatively high reproductive rates, indicating the potential for rapid recovery after natural or anthropogenic disturbance of the soft sediment environment. The only species associated with these environments that are slow growing, slow to mature, long-lived and therefore slow to recover and consequently are regarded as vulnerable are the seapens - a list of species recorded by Lopez-Gonzales *et al.* (2001) is given in Table 4.1.

Table 4.1: List of seapen species sampled by Lopez-Gonzales *et al.* (2001) during cruises in the Benguela Region.

Species	Zoogeographic Region	Depth Range (m)*
Anthoptilum grandiflorum	Widespread	238-2 500
Amphibelemnon namibiensis	Benguela	91-304
Crassophyllum cristatum	Benguela	40-650
Distichoptilum gracile	Widespread	650-4 300
Funiculina quadriangularis	Widespread	60-2 600
Halipteris africana	Benguela	459-659
Kopholobelemnon stelliferum	Widespread	400-1 180
Pennatula inflata	Widespread	457-741
Scleroptilum grandiflorum	Widespread	500-4 200
Stylatula macpheersoni	Benguela	245-318
Umbellula thomsoni	Widespread	1 300-6 200
Virgularia mirabilis	Widespread	9-400
Virgularia tuberculata	Benguela	75-1 050

*Recorded to date, but these areas are not well sampled or studied.

4.1.3.4 Deep water coral communities

There has been increasing interest in deep-water corals (depths >150 m, with some species being recorded up to 3 000 m) in recent years because of their likely sensitivity to disturbance and their long generation times. Some species form reefs while others are smaller and remain solitary. Corals add structural complexity to otherwise uniform seabed habitats thereby creating areas of high biological diversity (Breeze *et al*. 1997; MacIssac *et al*. 2001).

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

4.1.3.5 Cephalopods

On the basis of abundance and trophic links with other species, eight species of cephalopod are important and a further five species have potential importance within the Benguela system (Table 4.2). The major cephalopod resource in the southern Benguela are sepiods/cuttlefish (Lipinski 1992; Augustyn *et al.* 1995). Most of the cephalopod resource is distributed on the mid-shelf with *Sepia australis* being most abundant at depths between 60-190 m, whereas *S. hieronis* densities were higher at depths between 110-250 m. *Rossia enigmatica* occurs more commonly on the edge of the shelf to depths of 500 m. Biomass of these species is generally higher in the summer than in winter.

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

Table 4.2: Cephalopod species of importance or potential importance within the Benguela System (after Lipinski 1992).

Scientific Name	Importance
Important species:	
Sepia australis	Very abundant in survey catches, prey of many fish species. Potential for fishery.
Sepia hieronis	Densities higher at depths between 110-250 m
Loligo vulgaris reynaudii	Fisheries exist, predator of anchovy and hake, prey of seals and fish.
Todarodes angolensis	Fisheries exist (mainly by-catch), predator of lightfish, lanternfish and hake, prey of seals.
Todaropsis eblanae	Some by-catch fishery, predator of lightfish and lanternfish, prey of seals and fish. Potential for fishery.
Lycoteuthis lorigera	Unconfirmed by-catch, prey of many fish species. Potential for fishery.
Octopus spp.	Bait and artinisal fishery, prey of seals and sharks.
Argonauta spp.	No fisheries, prey of seals.
Rossia enigmata	No fisheries, common in survey catches.
Potentially important species:	
Ommastrephes bartramii	No fisheries.
Abraliopsis gilchristi	No fisheries.
Todarodes filippovae	No fisheries.
Lolliguncula mercatoris	No fisheries.
Histioteuthis miranda	No fisheries.

4.1.3.6 Seamount Communities

Two geological features of note within the vicinity of the proposed area of interest include Childs Bank, situated approximately 75 km east (see Figure 4.4), and Tripp Seamount, situated approximately 120 km north-northwest of the target area. Child's Bank is described by Dingel *et al.* (1987) to be a carbonate mound (bioherm) composed of sediments and the calcareous deposits from an accumulation of carbonate skeletons of sessile organisms (e.g. cold-water coral, foraminifera or marl), such features typically have topographic relief, forming isolated seabed knolls in otherwise low profile homogenous seabed habitats (Kopaska-Merkel & Haywick 2001; Kenyon *et al*. 2003, Wheeler *et al.* 2005, Colman *et al*. 2005).

Features such as banks, knolls and seamounts (referred to collectively here as "seamounts"), which protrude into the water column, are subject to, and interact with, the water currents surrounding them. The effects of such seabed features on the surrounding water masses can include the upwelling of relatively cool, nutrient-rich water into nutrient-poor surface water thereby resulting in higher productivity (Clark *et al.* 1999), which can in turn strongly influence the distribution of organisms on and around seamounts. Evidence of enrichment of bottom-associated communities and high abundances of demersal fishes has been regularly reported over such seabed features.

The enhanced fluxes of detritus and plankton that develop in response to the complex current regimes lead to the development of detritivore-based food-webs, which in turn lead to the presence of seamount scavengers and predators. Deep- and cold-water corals (including stony corals, black corals and soft corals) are a prominent component of the suspension-feeding fauna of many seamounts, accompanied by barnacles, bryozoans, polychaetes, molluscs, sponges, sea squirts, basket stars, brittle stars and crinoids

(Rogers 2004). There is also associated mobile benthic fauna that includes echinoderms (sea urchins and sea cucumbers) and crustaceans (crabs and lobsters) (Rogers 1994). Seamounts also provide an important habitat for commercial deepwater fish stocks, such as orange roughy, oreos, alfonsino and Patogonian toothfish, which aggregate around these features for either spawning or feeding (Koslow 1996).

The coral frameworks offer refugia for a great variety of invertebrates and fish within, or in association with, the living and dead coral framework thereby creating spatially fragmented areas of high biological diversity (biological hotspots). Such complex benthic ecosystems in turn enhance foraging opportunities for many other predators, serving as mid-ocean focal points for a variety of pelagic species with large ranges (turtles, tunas and billfish, pelagic sharks, cetaceans and pelagic seabirds) that may migrate large distances in search of food or may only congregate on seamounts at certain times (Hui 1985; Haney *et al.* 1995). Seamounts thus serve as feeding grounds, spawning and nursery grounds and possibly navigational markers for a large number of species (SPRFMA 2007). Consequently, seamounts are usually highly unique and are usually, but not always, identified as Vulnerable Marine Ecosystems (VMEs). South Africa's seamounts and their associated benthic communities have not been sampled by either geologists or biologists (Sink & Samaai 2009). However, evidence from video footage taken on hard-substrate habitats to the south-east of the Child's Bank suggest that vulnerable communities, including gorgonians, octocorals and reef-building sponges, do occur on the continental shelf. Whether similar communities may thus be expected in the Orange Basin Deep Water Licence Area is, however, unknown.

4.1.3.7 Fishes

Marine fish can generally be divided in three different groups, namely demersal (those associated with the substratum), pelagic (those species associated with water column) or meso-pelagic (fish found generally in deeper water and may be associated with both the seafloor and the pelagic environment). Pelagic species include two major groups, the planktivorous clupeid-like fishes such as anchovy or pilchard and piscivorous predatory fish. Demersal fish can be grouped according to the substratum with which they are associated, for example rocky reef or soft substrata. It must be noted that such divisions are generally simplistic, as certain species associate with more than one community.

a) Demersal species

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

Roel (1987) showed seasonal variations in the distribution ranges of shelf communities, with species such as the pelagic goby *Sufflogobius bibarbatus*, and West Coast sole *Austroglossus microlepis* occurring in shallow water north of Cape Point during summer only. The deep-sea community was found to be homogenous both spatially and temporally. However, Atkinson (2009) identified two long-term community shifts in demersal fish communities; the first (early to mid-1990s) being associated with an overall increase in density of many species, whilst many species decreased in density during the second shift (mid-2000s). These community shifts correspond temporally with regime shifts detected in environmental forcing variables

(Sea Surface Temperatures and upwelling anomalies) (Howard *et al*. 2007) and with the eastward shifts observed in small pelagic fish species and rock lobster populations (Coetzee *et al*. 2008, Cockcroft *et al*. 2000).

(b) Pelagic species

Small pelagic species include sardine/pilchard (*Sadinops ocellatus*), anchovy (*Engraulis capensis*), chub mackerel (*Scomber japonicus*), horse mackerel (*Trachurus capensis*) and round herring (*Etrumeus whiteheadi*). These species typically occur in mixed shoals of various sizes, and generally occur within the 200 m contour and thus unlikely to be encountered in the proposed area of interest.

Most of the pelagic species exhibit similar life history patterns involving seasonal migrations between the west and south coasts. Apart from round herring which spawn offshore of the shelf break on the West Coast, the spawning areas of the major pelagic species are distributed on the continental shelf extending from south of St Helena Bay to Mossel Bay on the South Coast (Shannon & Pillar 1986). They spawn downstream of major upwelling centres in spring and summer, and their eggs and larvae are subsequently carried around Cape Point and up the coast in northward flowing surface waters (see Figure 4.12 and 4.13).

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

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

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

A number of species of pelagic sharks are also known to occur on the West Coast, including blue (*Prionace glauca)*, short-fin mako (*Isurus oxyrinchus)* and oceanic whitetip sharks (*Carcharhinus longimanus)*. Great whites (*Carcharodon carcharias)* and whale sharks (*Rhincodon typus)* may also be encountered in coastal and offshore areas, although the latter occurs more frequently along the South and East coasts. Of these the blue shark is listed as “Near threatened”, and the short-fin mako, whitetip, great white and whale sharks as “Vulnerable” by the International Union for Conservation of Nature (IUCN).

4.1.3.8 Turtles

Three species of turtles, namely the green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*) are found along the West Coast. Loggerhead and green turtles are expected to occur only as occasional visitors along the West Coast.

The leatherback turtle is likely to be encountered within the proposed area of interest. However, their abundance is expected to be low. Leatherback turtles inhabit deeper waters and are considered a pelagic species, travelling the ocean currents in search of their prey (primarily jellyfish).

The Benguela ecosystem, especially the northern Benguela where jelly fish numbers are high, is increasingly being recognised as a potentially important feeding area for leatherback turtles from several globally significant nesting populations in the south Atlantic (Gabon, Brazil) and south east Indian Ocean (South Africa) (Lambardi *et al*. 2008, Elwen & Leeney 2011, SASTN 2011[1]). While hunting they may dive to over 600 m and remain submerged for up to 54 minutes (Hays *et al*. 2004).

Leatherback turtles breed on the northern KwaZulu-Natal coastline of the East Coast and in the Republic of Congo and Gabon on the West Coast. Leatherback turtles from the east South Africa population have been satellite tracked swimming around the west coast of South Africa and remaining in the warmer waters west of the Benguela ecosystem (Lambardi *et al*. 2008) (see Figure 4.14).

Leatherback turtles are listed as Critically Endangered worldwide by the IUCN and are in the highest categories in terms of need for conservation in CITES (Convention on International Trade in Endangered Species), and CMS (Convention on Migratory Species). Loggerhead and green turtles are listed as "Endangered". As a signatory of CMS, South Africa has endorsed and signed a CMS International Memorandum of Understanding specific to the conservation of marine turtles.

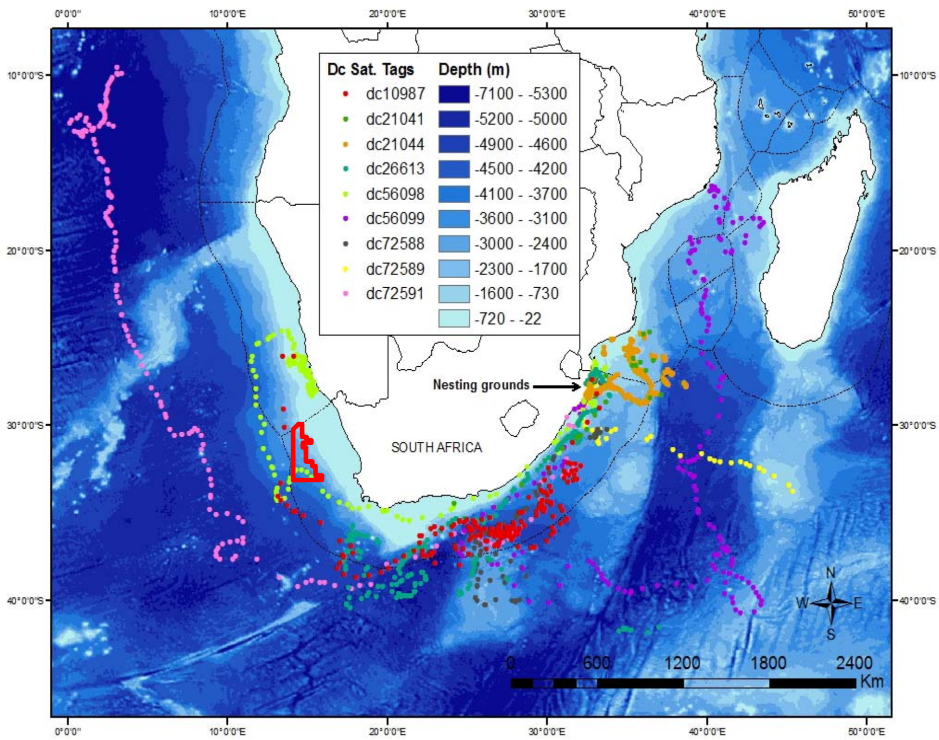


Figure 4.14: The post-nesting distribution of nine satellite tagged leatherback females (1996 – 2006; Oceans and Coast, unpublished data). The approximate location of the licence area is also shown.

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

4.1.3.9 Seabirds

There are a total of 49 species of seabirds occurring within the southern Benguela area, of which 14 are resident species, 25 are migrants from the southern ocean and 10 are visitors from the northern hemisphere. Table 4.3 provides a list of the common species occurring within the study area.

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

The availability of breeding sites is an extremely important determinant in the distribution of resident seabirds. Although breeding areas are distributed along the whole coast, islands are especially important, particularly those between Dyer Island and Lamberts Bay. Fourteen resident species breed along the West Coast, including Cape Gannet, African Penguin, four species of Cormorant, White Pelican, three Gull and four Tern species (Table 4.4).

Cape Gannets breed only on islands and Lamberts Bay and Malgas Island are important colonies. Cape cormorants breed mainly on offshore islands (Dyer, Jutten, Seal, Dassen, Bird (Lamberts Bay), Malgas and Vondeling Islands), although the large colonies may associate with estuaries, lagoons or sewerage works. The bank and crowned cormorants are endemic to the Benguela system and both breed between Namibia and just to the west of Cape Agulhas. Although white-breasted cormorants occur between northern Namibia and the Eastern Cape in southern Africa, the majority of the population is concentrated between Swakopmund and Cape Agulhas.

Most of these resident species feed on fish (with the exception of the gulls, which scavenge, and feed on molluscs and crustaceans). Feeding strategies can be grouped into surface plunging (gannets and terns), pursuit diving (cormorants and penguins) and scavenging and surface seizing (gulls and pelicans). Most of the breeding seabird species forage at sea with most birds being found relatively close inshore (10-30 km). Cape Gannets, however, are known to forage up to 140 km offshore (Dundee 2006; Ludynia 2007), and African Penguins have also been recorded as far as 60 km offshore.

African penguin colonies (*Spheniscus demersus*) occur at 27 localities around the coast of South Africa and Namibia (see Figure 4.15). The species forages at sea with most birds being found within 20 km of their colonies. African penguin distribution at sea is consistent with that of the pelagic shoaling fish, which generally occur within the 200 m isobath.

The Cape Gannet and Bank Cormorant are listed in the South African Red Data Book as "Vulnerable". The Caspian Tern, Cape Cormorant and Crowned Cormorant are listed in the South African Red Data Book as "Near-threatened", while the African Penguin and Damara Tern is listed as "Endangered". The decline in the African Penguin population is ascribed primarily to the removal of the accumulated guano from the islands during the nineteenth century. Penguins used to breed in burrows in the guano and are now forced to nest in the open, thereby being exposed to much greater predation and thermal stress.

The Cape Gannet, a plunge diver feeding on epipelagic fish, is thought to have declined as a result of the collapse of the pilchard, whereas the Cape Cormorant was able to shift its diet to pelagic goby. Furthermore, the recent increase in the seal population has resulted in seals competing for island space to the detriment of the breeding success of both gannets and penguins.

Table 4.3: Pelagic seabirds common in the southern Benguela region (Crawford *et al*. 1991).

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

Table 4.4: Breeding resident seabirds present along the West Coast (CCA & CMS 2001).

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

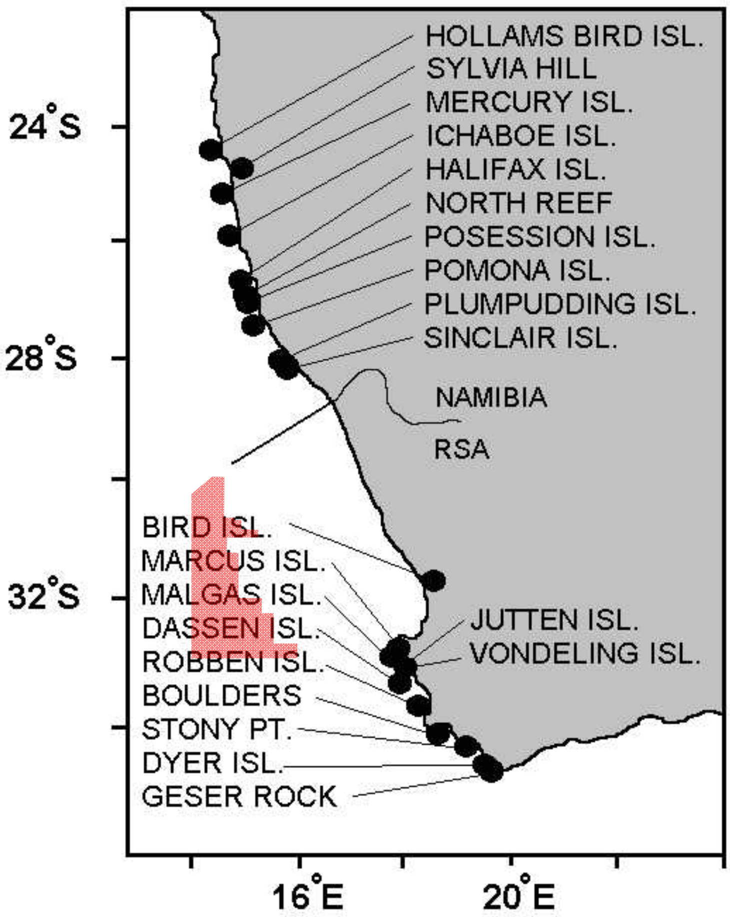


Figure 4.15: The distribution of breeding colonies of African penguins on the South African West Coast. The approximate location of the licence area is also shown.

4.1.3.10 Marine mammals

The marine mammal fauna occurring off the West Coast of South Africa, north of Cape Columbine, include whales, dolphins and seals.

(a) Cetaceans

The cetacean fauna of the West Coast comprises 33 species of whales and dolphins known or to occur here (see Table 4.5). The offshore areas have been particularly poorly studied with almost all available information from deeper waters (>200 m) arising from historic whaling records. Information on smaller cetaceans in deeper waters is particularly poor.

The distribution of whales and dolphins on the West 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. The most common species within the proposed area of interest (in terms of likely encounter rate not total population sizes) are likely to be the long-finned pilot whale and humpback whale.

Cetaceans comprised two basic taxonomic groups: the mysticetes (filter-feeding baleen whales) and the odontocetes (toothed predatory whales and dolphins).

Table 4.5: Cetaceans occurrence off the West Coast, their seasonality and likely encounter frequency.

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

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

Mysticete cetaceans occurring in the study area include the southern right, humpback, blue, fin, sei, Antarctic minke, dwarf minke and Bryde's whale. Most of these species occur in pelagic waters, with only occasional visits into shelf waters. All of these species show some degree of migration either to, or through, the latitudes encompassed by the broader study 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.

- <u>Southern right and humpback whales:</u> The most abundant baleen whales off the coast of South Africa are southern right (listed as Least Concern) and humpback whales (listed as Least Concern). Southern right whales 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). They typically arrive in coastal waters off the West Coast in June, increasing to a maximum number in September/October, with most departing in December (although animals may be sighted as early as April and as late as February). On the West Coast they are most common south of Lambert's Bay (CCA & CMS 2001), although a number of the bays between Chameis Bay (27°56'S) and Conception Bay (23°55'S) in Namibia have in recent years become popular calving sites (Currie *et al*. 2009), with sightings reported as far north as the Kunene and Möwe Bay (Roux *et al*. 2001). The Southern Right calving season extends from late June to late October, peaking in August (Best 1994; Roux *et al*. 2001), with cow-calf pairs remaining in sheltered bays for up to two months before starting their southern migration.

  The majority of humpback whales on the West Coast are migrating past the southern African continent to breeding grounds off Angola, Republic of Congo and Gabon (Rosenbaum *et al.* 2009, Barendse *et al*. 2010). On the West Coast it is thought that only a small proportion of the main migration comes close inshore, the majority choosing the shortest route to the central West African breeding grounds by following the edge of the continental shelf (Best 2007; Best & Allison 2010). Humpback whales migrate at various distances from the coast including pelagic waters (Barendse et al. 2002), and as they are likely to regularly cross the proposed area of interest, will probably be the most abundant large whale encountered. Most humpbacks reach 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).

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

  Since the southern right population is still continuing to grow at approximately 7% per year (Brandaõ *et al.* 2011), the population size in 2013 would number more than 6 000 individuals. Recent abundance estimates put the number of humpback whales in the west African breeding population to be in excess of 9 000 individuals in 2005 and it is likely to have increased since this time at about 5% per annum (IWC 2012).

- Bryde's whales: Two types of Bryde's whales are recorded from South African waters - a larger pelagic form described as *Balaenoptera brydei* and a smaller neritic form (of which the taxonomic status is uncertain) but included by Best (2007) with *B. brydei* for the subregion. The migration patterns of Bryde's whales differ from those of all other baleen whales in the region. The inshore population is unique in that it is resident year round on the Agulhas Bank ranging from Durban in the east to at least St Helena Bay off the West Coast, and does not migrate at all, although some movement up the West Coast in winter has been reported (Best 2007, 2001; Best *et al*. 1984). The offshore population of Bryde's whale lives off the continental shelf (>200 m depth) and migrates between wintering grounds off equatorial West Africa (Gabon) and summering grounds off the South African West Coast (Best 2001). Its seasonality within South African waters is thus opposite to the majority of the other migratory cetaceans, with abundance in the project area likely to be highest in January-February.

- Sei whales: Sei whales (listed as Endangered) spend time at high latitudes (40-50˚S) during summer months and migrate through South African waters to unknown breeding grounds further north. Their migration pattern shows a bimodal peak with numbers west of Cape Columbine highest in May and June, and again in August, September and October. Based on whaling records, all whales were caught in waters deeper than 200 m with most deeper than 1 000 m (Best & Lockyer 2002).

- Fin whales: Fin whales (listed as Vulnerable) have a bimodal peak in the catch data suggesting animals were migrating further north during May-June to breed, before returning during August-October *en route* to Antarctic feeding grounds. Some juvenile animals may feed year round in deeper waters off the shelf (Best 2007). There are no recent data on the abundance or distribution of fin whales off the west coast, although a sighting of a live animal in St Helena Bay in 2011 (MRI unpubl. data) confirm their contemporary occurrence in the region.

- Blue whales: Antarctic blue whales were historically caught in high numbers during commercial whaling activities, with a single peak in catch rates during July in Walvis Bay, Namibia and at Namibe, Angola suggesting that in the eastern South Atlantic these latitudes are close to the northern migration limit for the species (Best 2007). Only two confirmed sightings of blue whales have occurred off the entire west coast of Africa since 1973 (Branch *et al.* 2007), although search effort (and thus information), especially in pelagic waters is very low. This suggests that the population using the area may have been extirpated by whaling and there is a low chance of encountering the species in the area of interest.

- Minke whales: Two forms of minke whale occur in the southern Hemisphere, the Antarctic minke whale and the dwarf minke whale, both of which occur in the Benguela region (Best 2007, NDP unpublished data). Antarctic minke whales range from Antarctica to tropical waters and are usually seen more than approximately 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. The dwarf minke whale has a more temperate distribution than the Antarctic minke and they do not range further south than 60-65°S. Dwarf minkes have a similar migration pattern to Antarctic minkes with at least some animals migrating to the Southern Ocean during summer. Dwarf minke whales occur closer to shore than Antarctic minkes. Both species are generally solitary and densities are likely to be low in the project area.

- Pygmy right whale: The smallest of the baleen whales, the pygmy right whale occurs in the Benguela region (Leeney *et al.* 2013). The species is more commonly associated with cool temperate waters between 30°S and 55°S. There are no data on the abundance or conservation status of this species. As it was not subjected to commercial whaling, 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.

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. There is 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 the West Coast. Beaked whales are all considered to be true deep water species usually being seen in waters in excess of 1 000 – 2 000 m depth (Best 2007). Their presence in the area may fluctuate seasonally, but insufficient data exist to define this clearly.

- Sperm whales: 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 greater than 1 000 m depth, occasionally coming into depths of 500-200 m on the shelf (Best 2007). Seasonality of catches off the West Coast suggest that medium- and large-sized males are more abundant during winter, while female groups are more abundant in autumn (March-April), although animals occur year round (Best 2007). Sperm whales feed at great depth, during dives in excess of 30 minutes, making them difficult to detect visually. Sperm whales in the project area are likely to be encountered in relatively high numbers in deeper waters (>500 m), predominantly in the winter months (April - October).

- Pygmy and dwarf sperm whales: Dwarf sperm whales are associated with the warmer waters south and east of St Helena Bay. Abundance in the project area is likely to be very low and only in the warmer waters west of the Benguela current. Pygmy sperm whales are recorded from both the Benguela and Agulhas ecosystem (Best 2007) and are likely to occur in the project area at low levels in waters deeper than 1 000 m.

- Killer whales: 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 western South Africa (Best *et al.* 2010), Namibia (Elwen & Leeney 2011) and in the Eastern Tropical Atlantic (Weir *et al.* 2010). Killer whales are found in all depths from the coast to deep open ocean environments and may thus be encountered in the project area at low levels.

- False killer whales: The species has a tropical to temperate distribution and most sightings off southern Africa have occurred in water deeper than 1 000 m but with a few 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. There is no information on population numbers of conservation status and no evidence of seasonality in the region (Best 2007).

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

- Common bottlenose dolphins: Two species of bottlenose dolphins occur around southern Africa, the smaller Indo-Pacific bottlenose dolphins, which occurs exclusively to the east of Cape Point in water usually less than 30 m deep, and the larger common bottlenose dolphin forms. The larger common bottlenose dolphin species occur in two forms. The inshore form occurs as a small and apparently isolated population that occupies the very coastal (usually <15 m deep) waters of the central Namibian coast as far south as Lüderitz and is considered a conservation concern. Members of this population are unlikely to be encountered in the project area. Little is known about the offshore form in terms of their population size or conservation status. They sometimes occur in association with other species such as pilot whales (NDP unpublished data) or false killer whales (Best 2007) and are likely to be present year round in waters deeper than 200 m.

- Common dolphin: The common dolphin is known to occur offshore in West Coast waters (Findlay *et al.* 1992; Best 2007). The extent to which they occur in the project area is unknown, but likely to be low. Group sizes of common dolphins can be large, averaging 267 (± *SD* 287) for the South Africa region (Findlay *et al.* 1992) and 92 (± SD 115) for Angola (Weir 2011) and 37 (± *SD* 31) in Namibia (NDP unpubl. data). They are more frequently seen in the warmer waters offshore and to the north of the country, seasonality is not known.

- Southern right whale dolphins: The cold waters of the Benguela provide a northwards extension of the normally subantarctic habitat of this species (Best 2007). Most records in the region originate in a relatively restricted region between 26˚S and 28˚S off Lüderitz (Rose & Payne 1991) in water 100 – 2 000 m deep (Best, 2007), where they are seen several times per year (Findlay *et al*. 1992; JP Roux[2] pers comm.). It is possible that the Namibian sightings represent a resident population (Findlay *et al.* 1992). Encounters in the project area are unlikely.

- Dusky dolphins: In water <500 m deep, dusky dolphins are likely to be the most frequently encountered small cetacean as they are very "boat friendly" and often approach vessels to bowride. The species is resident year round throughout the Benguela ecosystem in waters from the coast to at least 500 m deep (Findlay *et al.* 1992). Although no information is available on the size of the population, they are regularly encountered in near shore waters between Cape Town and Lamberts Bay (Elwen *et al.* 2010a; NDP unpubl. data) with group sizes of up to 800 having been reported (Findlay *et al.* 1992). A hiatus in sightings (or low density area) is reported between ~27°S and 30°S, associated with the Lüderitz upwelling cell (Findlay *et al.* 1992). This area aligns fairly closely with the proposed area of interest, which suggests that sightings during drilling may be rare. Dusky dolphins are resident year round in the Benguela.

- Heaviside's dolphins: This species is relatively abundant in the Benguela ecosystem within the region of 10 000 animals estimated to live in the 400 km of coast between Cape Town and Lamberts Bay (Elwen *et al.* 2009). Individuals show high site fidelity to small home ranges, 50 - 80 km along shore (Elwen *et al*. 2006) and may thus be more vulnerable to threats within their home range. This species occupies waters from the coast to at least 200 m depth (Elwen *et al.* 2006; Best 2007), and may show a diurnal onshore-offshore movement pattern (Elwen *et al*. 2010b), but this varies throughout the species range. Heaviside's dolphins are resident year round.

- Beaked whales (various species): 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. All the beaked whales that may be encountered in the project area are pelagic species that tend to occur in small groups usually less than five, although larger aggregations of some species are known (MacLeod & D'Amico 2006; Best 2007). The long, deep dives of beaked whales make them both difficult to detect visually.

[2] Ministry of Fisheries and Marine Resources (Namibia).

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

(b) Seals

The Cape fur seal (*Arctocephalus pusillus pusillus*) congregates at numerous breeding and non-breeding sites on the mainland and on nearshore islands and reefs along the West Coast (Figure 4.16). Four other seal species may occasionally be found as vagrants along the West Coast, including southern elephant seal (*Mirounga leoninas),* subantarctic fur seal (Arctocephalus tropicalis), crabeater (Lobodon carcinophagus) and leopard seals (Hydrurga leptonyx) (David 1989).

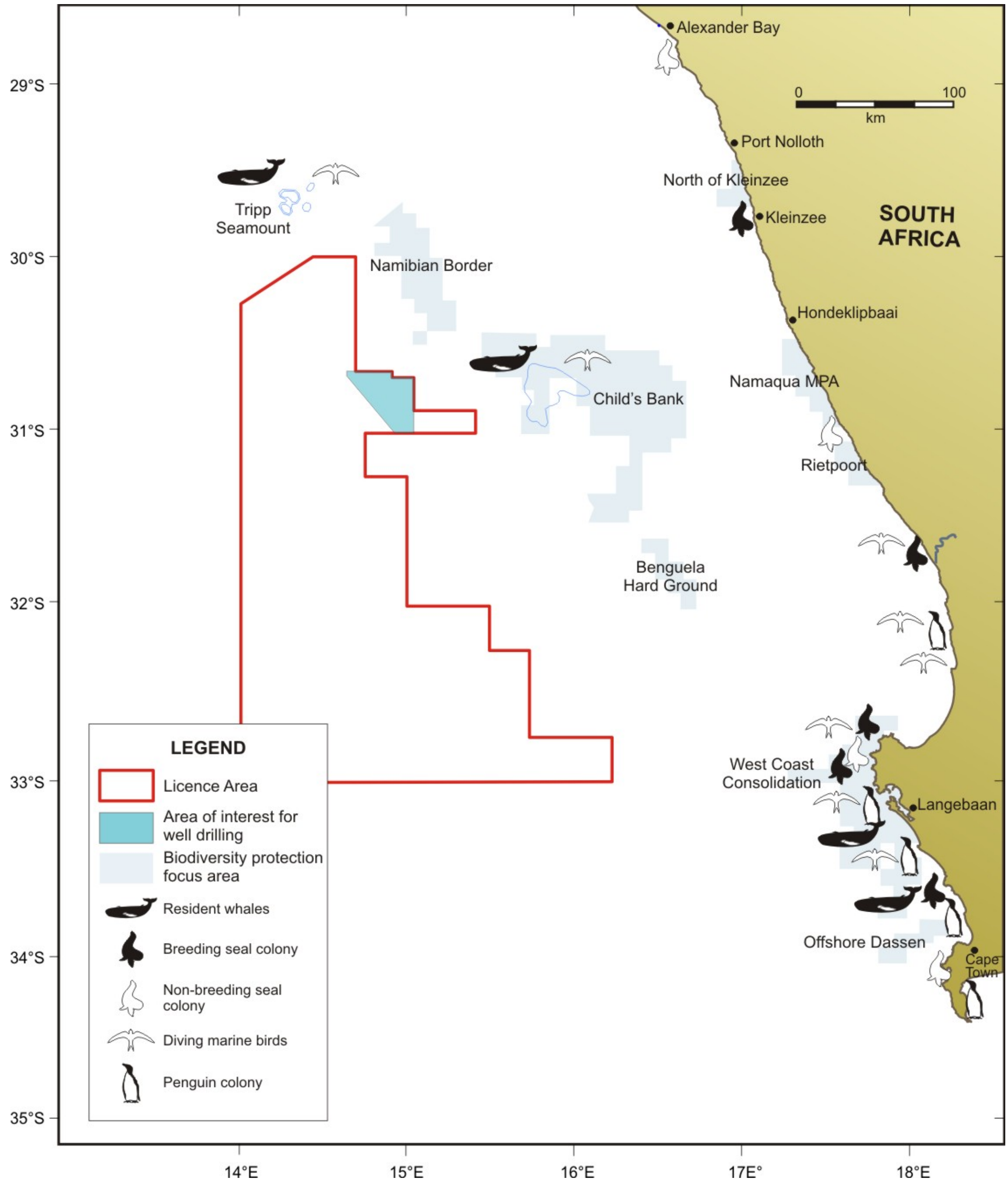


Figure 4.16: Location of the licence area in relation to seabird and seal colonies and resident whale populations. Areas identified by Majiedt *et al*. (2013) as priority areas for the protection of benthic and pelagic habitats are also shown.

There are a number of Cape fur seal colonies within the study area: at Kleinzee (incorporating Robeiland), at Bucchu Twins near Alexander Bay, and Strandfontein Point (south of Hondeklipbaai). The colony at Kleinzee has the highest seal population and produces the highest seal pup numbers on the South African Coast (Wickens 1994). The colony at Buchu Twins, formerly a non-breeding colony, has also attained breeding status (M. Meyer, SFRI, pers. comm.). Non-breeding colonies occur south of Hondeklip Bay at Strandfontein Point and on Bird Island at Lamberts Bay, with the McDougalls Bay islands and Wedge Point being haul-out sites only and not permanently occupied by seals. All have important conservation value since they are largely undisturbed at present.

Seals are highly mobile animals with a general foraging area covering the continental shelf up to 120 nautical miles (nm) offshore (Shaughnessy 1979), with bulls ranging further out to sea than females. The timing of the annual breeding cycle is very regular occurring between November and January. Breeding success is highly dependent on the local abundance of food, territorial bulls and lactating females being most vulnerable to local fluctuations as they feed in the vicinity of the colonies prior to and after the pupping season (Oosthuizen 1991).

4.1.4 HUMAN UTILISATION

4.1.4.1 Fisheries

The South African fishing industry consists of 14 commercial sectors operating within the country's 200 nautical mile (nm) EEZ. The following fisheries are active off the West Coast:

- Demersal trawl;
- Small pelagic purse-seine;
- Demersal long-line (hake and shark);
- Large pelagic long-line;
- Tuna pole;
- Traditional line fish; and
- West Coast rock lobster.

(a) Demersal trawl

Demersal trawl is South Africa's most valuable fishery accounting for approximately half of the income generated from commercial fisheries. Demersal trawlers operate extensively around the coast primarily targeting the bottom-dwelling (demersal) species of hake (*Merluccius paradoxus* and *M. capensis*). Main by-catch species include monkfish (*Lophius vomerinus*), kingklip (*Genypterus capensis*) and snoek (*Thyrsites atun*). The hake-directed trawl fishery is split into two sub-sectors: a small inshore trawling sector active off the South Coast and a large deep-sea trawl sector operating on both the South and West coasts. There are currently 45 trawlers operating within the offshore sector. The current annual hake Total Allowable Catch (TAC) of hake across all sectors is 156 075 tons (2013), of which the majority is landed by the demersal trawl sector. In 2012, of a total hake TAC of 144 671 tons, 118 688 tons (82%) was landed by the demersal trawl sector. Of this amount, 115 465 tons was landed by the offshore demersal trawl sector and 3 223 tons by the inshore trawl sector.

The deep-sea trawl sector on the West Coast operates mainly in a continuous band along the shelf edge between the 300 m and 1 000 m bathymetric contours (see Figures 4.17 and 4.18). Monk-directed trawlers tend to fish shallower waters compared to the hake-directed vessels on mostly muddy substrates. Trawl nets are generally towed along depth contours (thereby maintaining a relatively constant depth) running parallel to the depth contours in a north-westerly or south-easterly direction. Trawlers also target fish aggregations around bathymetric features, in particular seamounts and canyons (i.e. Child's Bank, Cape Columbine and

Cape Canyon), where there is an increase in seafloor slope and in these cases the direction of trawls follow the depth contours. Trawlers are prohibited from operating within 5 nm of the coastline.

Figures 4.17 to 4.18 show the demersal trawl effort and catch between 2000 and 2012 in relation to the area of interest, respectively. Over the period 2000 to 2012, the number of trawls per year averaged at 57 920 with an associated landed catch of 127 743 tons of hake and 166 902 tons of all species combined. Over the period 2008 to 2012, the demersal trawl fishery reported an average of 44 092 trawls per year with an associated catch of 113 607 tons of hake and 125 599 tons of all species landed per year. There is no evidence of any effort or catch in the area of interest.

The towed gear typically consists of trawl warps, bridles and trawl doors, a footrope, headrope, net and codend (see Figure 4.19). The monk-directed trawlers use slightly heavier trawl gear, trawl at slower speeds and for longer periods (up to eight hours) compared to the hake-directed trawlers (60 minutes to four hours). Monk gear includes the use of “tickler” chains positioned ahead of the footrope to chase the monk off the substrate and into the net.

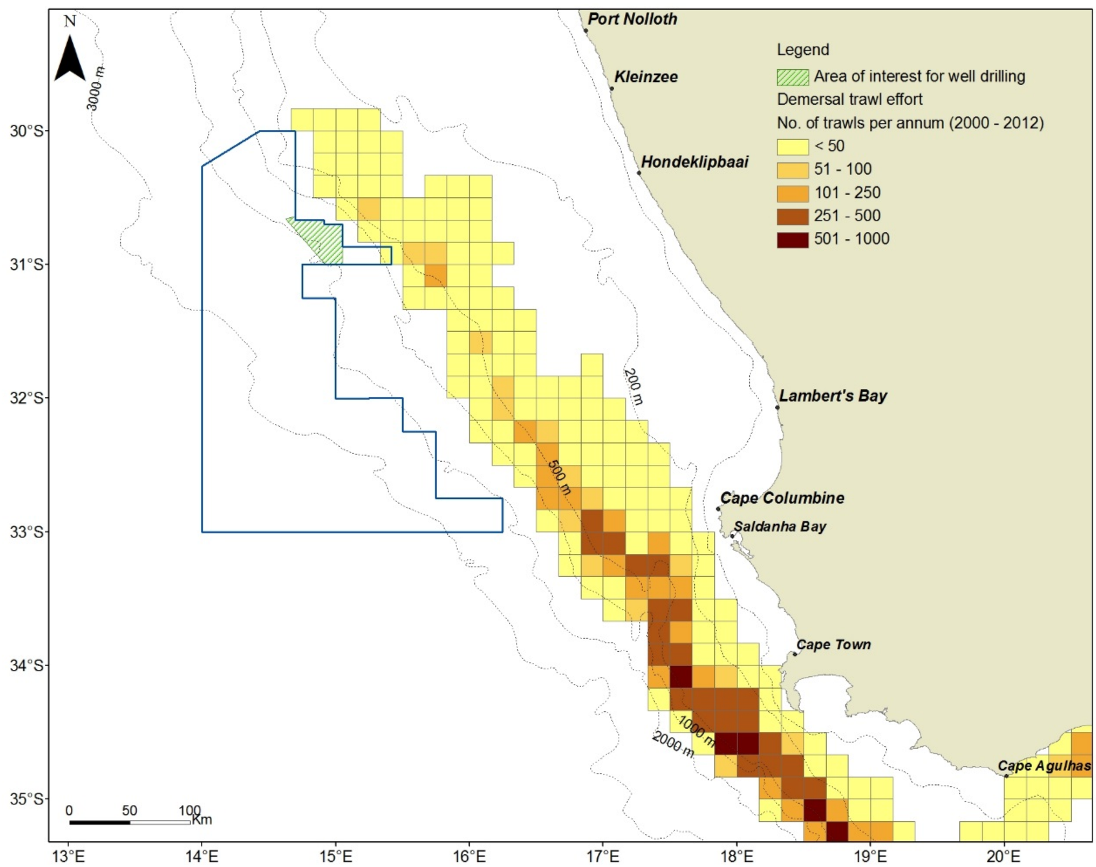


Figure 4.17: The proposed area of interest in relation to demersal trawl effort by the sector targeting hake (2000 to 2012).

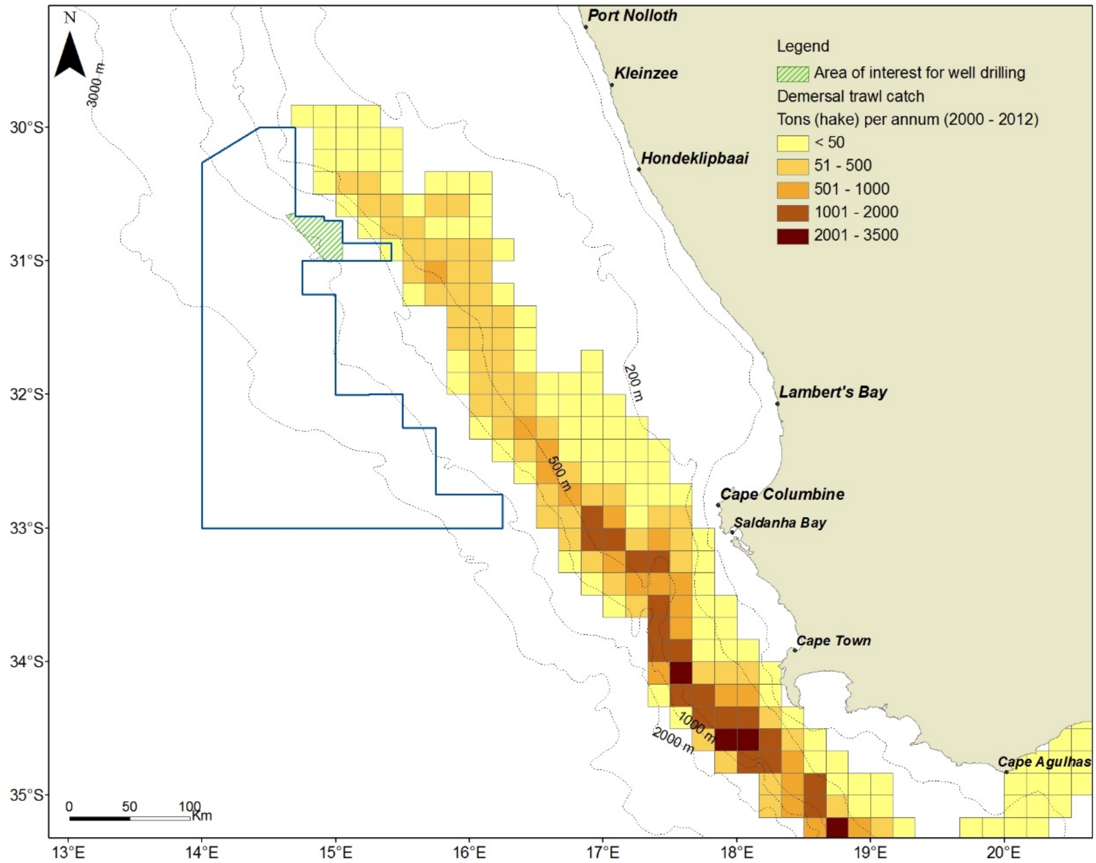


Figure 4.18: The proposed area of interest in relation to catch reported by the demersal trawl fishing sector (2000 to 2012).

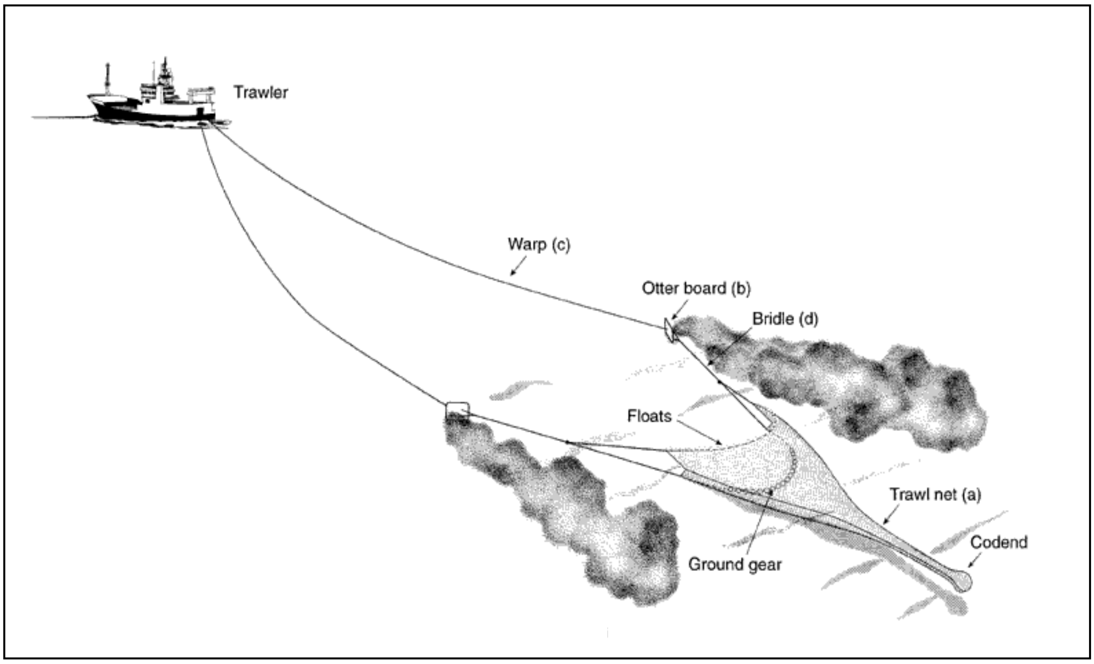


Figure 4.19: Typical gear configuration used by demersal trawlers (offshore) targeting hake.

(b) Small pelagic purse-seine

The South African small pelagic purse seine fishery is the largest fishery by volume and the second most important in terms of value. The pelagic purse-seine fishery targets small mid-water and surface-shoaling species such as sardine, anchovy, juvenile horse mackerel and round herring using purse-seine fishing techniques. Annual landings have fluctuated between 300 000 and 600 000 tons over the last decade, with landings of 391 000 tons recorded per annum between 2008 and 2012.

Once a shoal has been located the vessel steams around it and encircle it with a large net. The depth of the net is usually between 60 m and 90 m. Netting walls surround aggregated fish both from the sides and from underneath, thus preventing them from escaping by diving downwards. These are surface nets framed by lines: a float line on top and lead line at the bottom (see Figure 4.20). Once the shoal has been encircled the net is pursed and hauled in and the fish are pumped onboard into the hold of the vessel. After the net is deployed the vessel has no ability to manoeuvre until the net has been fully recovered onboard, which may take up to 1.5 hours. Vessels usually operate overnight and return to offload their catch the following day.

The South African fishery, consisting of approximately 101 vessels, is active all year round with a short break from mid-December to mid-January (to reduce impact on juvenile sardine), with seasonal trends in the specific species targeted. The geographical distribution and intensity of the fishery is largely dependent on the seasonal fluctuation and geographical distribution of the targeted species. Fishing grounds occur primarily along the Western Cape and Eastern Cape coast up to a distance of 100 km offshore, but usually closer inshore. The sardine-directed fishery tends to concentrate effort in a broad area extending from St Helena Bay, southwards past Cape Town towards Cape Point and then eastwards along the coast to Mossel Bay and Port Elizabeth. The anchovy-directed fishery takes place predominantly on the South-West Coast from St Helena Bay to Cape Point and is most active in the period from March to September. Round herring (non-quota species) is targeted when available and specifically in the early part of the year (January to March) and is distributed South of Cape Point to St Helena Bay. The fishing grounds of the small pelagic purse-seine fishery do not extend into the proposed area of interest, which is located approximately 180 km from the small pelagic purse-seine fishing grounds (see Figures 4.21 to 4.22).

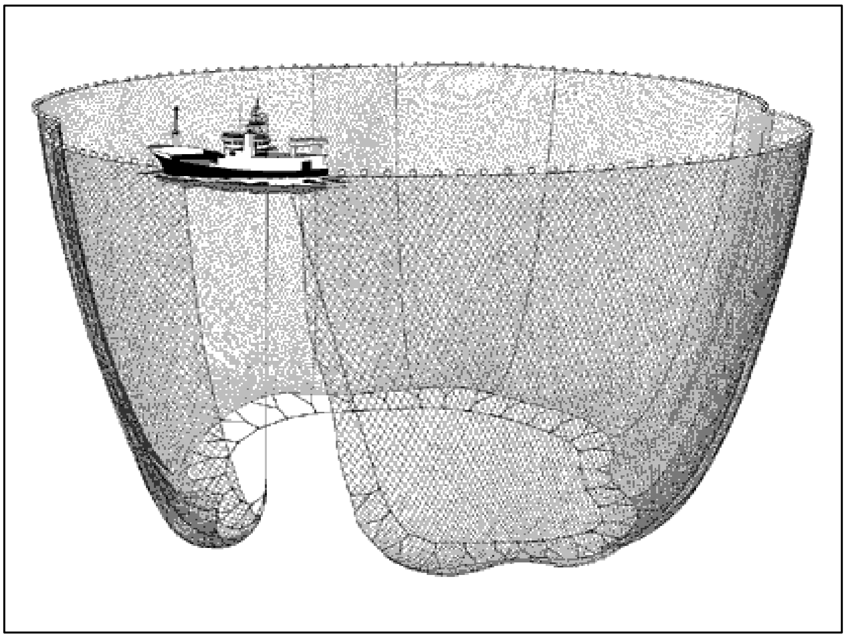


Figure 4.20: Pelagic purse-seine gear configuration.

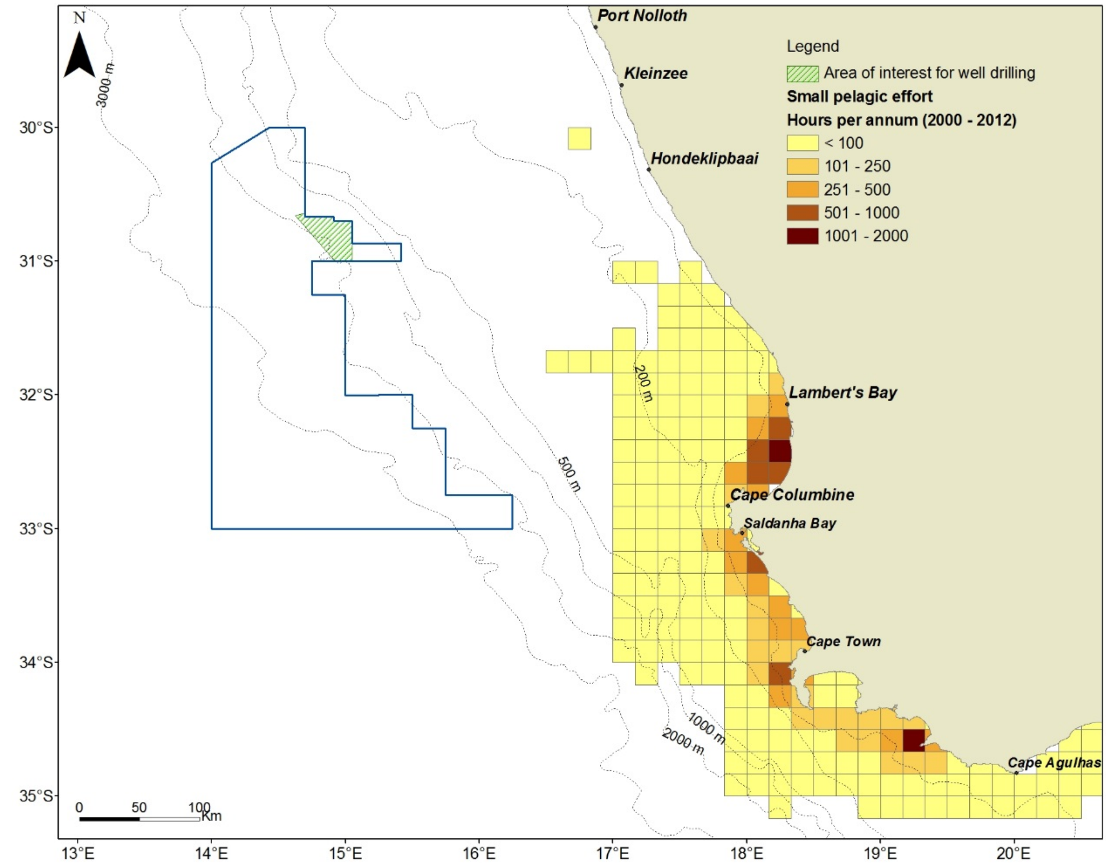


Figure 4.21: The proposed area of interest in relation to pelagic purse-seine effort (2000 - 2012).

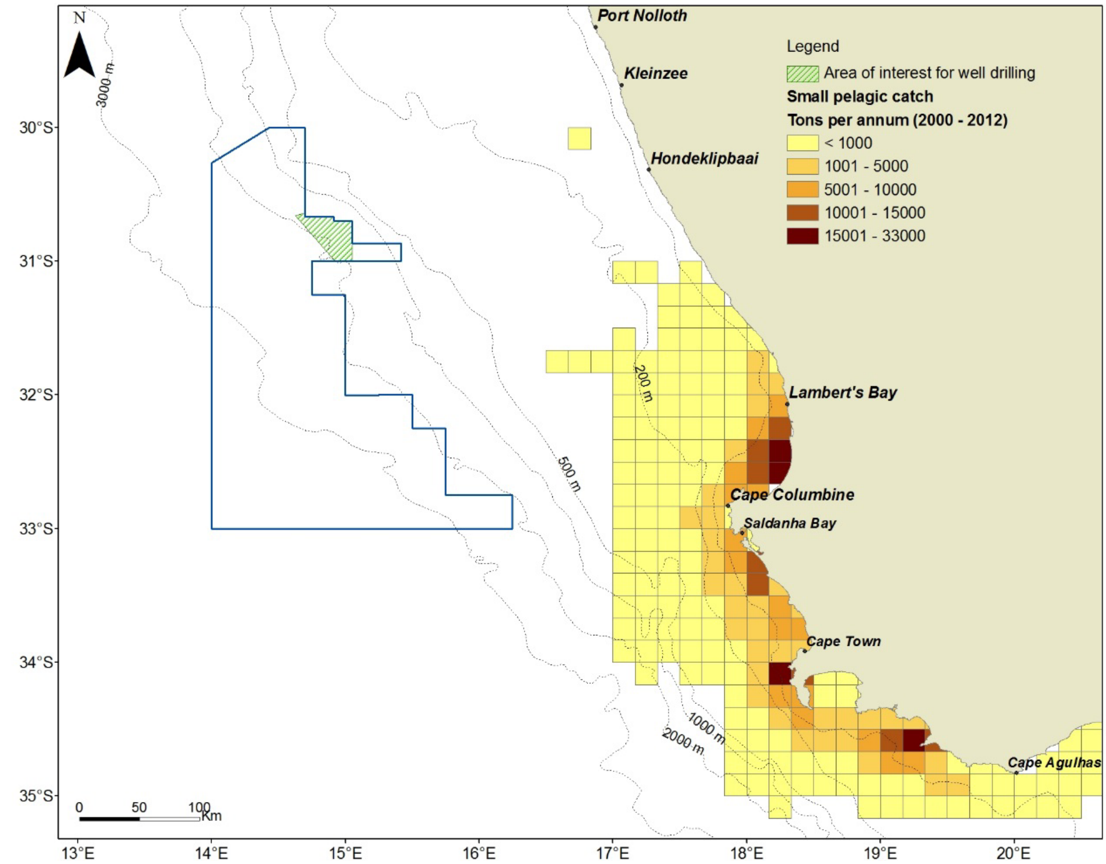


Figure 4.22: The proposed area of interest in relation to pelagic purse-seine catch (2000 - 2012).

(c) Demersal long-line

In South Africa the demersal long-line fishery operates in well-defined areas extending along the shelf break from Port Nolloth to Cape Agulhas and is comprised of the hake-directed, with a small non-targeted commercial by-catch that includes kingklip, and shark-directed demersal long-line sectors.

Bottom-set long-line gear is robust and comprises two lines as well as dropper lines with subsurface floats attached (see Figure 4.23). Lines are typically between 10 km and 20 km in length, carrying between 6 900 and 15 600 hooks each. Baited hooks are attached to the bottom line at regular intervals (1 to 1.5 m) by means of a snood. Gear is usually set at night at a speed of between five and nine knots. Once deployed the line is left for up to eight hours before it is retrieved. A line hauler is used to retrieve gear (at a speed of approximately one knot) and can take six to ten hours to complete. During hauling operations a demersal long-line vessel would be severely restricted in manoeuvrability.

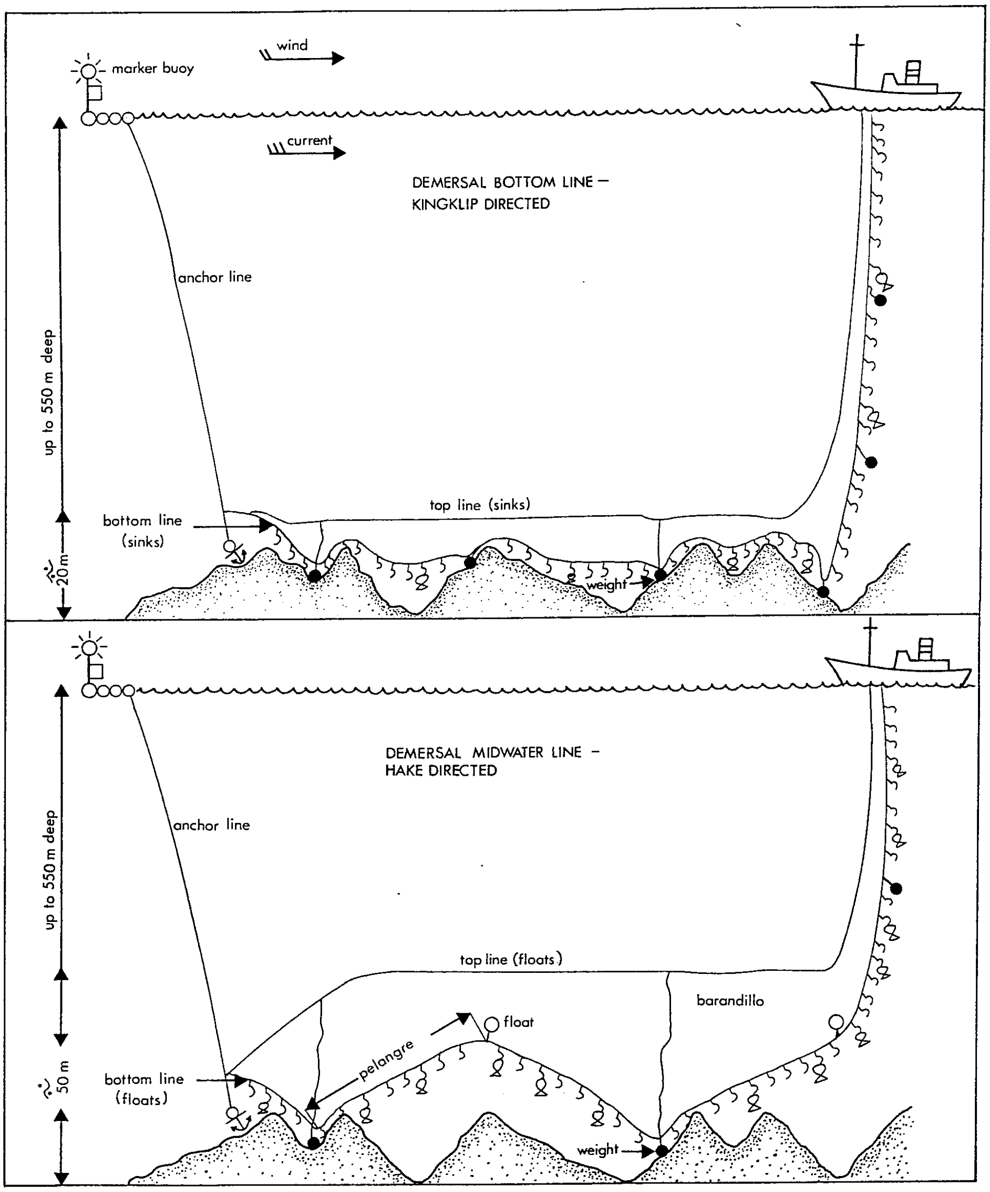


Figure 4.23: Typical configuration of demersal (bottom-set) hake long-line gear used in South African waters.

Hake-directed demersal long-line sector

Currently 64 hake-directed vessels are operational within the South African fishery, most of which are based at the harbours of Cape Town and Hout Bay. Operations are *ad hoc* and intermittent, subject to market demand. Of the total hake TAC of 144 671 tons set for 2012, the catch taken by the long-line fleet amounted to 8 399 tons (approximately 6%) or 9 257 tons including all other non-hake species landed.

Demersal long-lining is expected to occur in similar areas used by the hake-directed trawling, i.e. along the shelf edge from 300 m to a water depth of 1 000 m with lines usually set parallel to bathymetric contours. Figures 4.24 to 4.25 show the hake-directed demersal long-line effort and catch between 2000 and 2012 in relation to the area of interest, respectively. Over the period 2000 to 2012, an average of 30.7 million hooks were set and 8 791 tons of hake were landed per year. Over the period 2008 to 2012, the fishery set an average of 28.9 million hooks and landed 8 368 tons of hake per year.

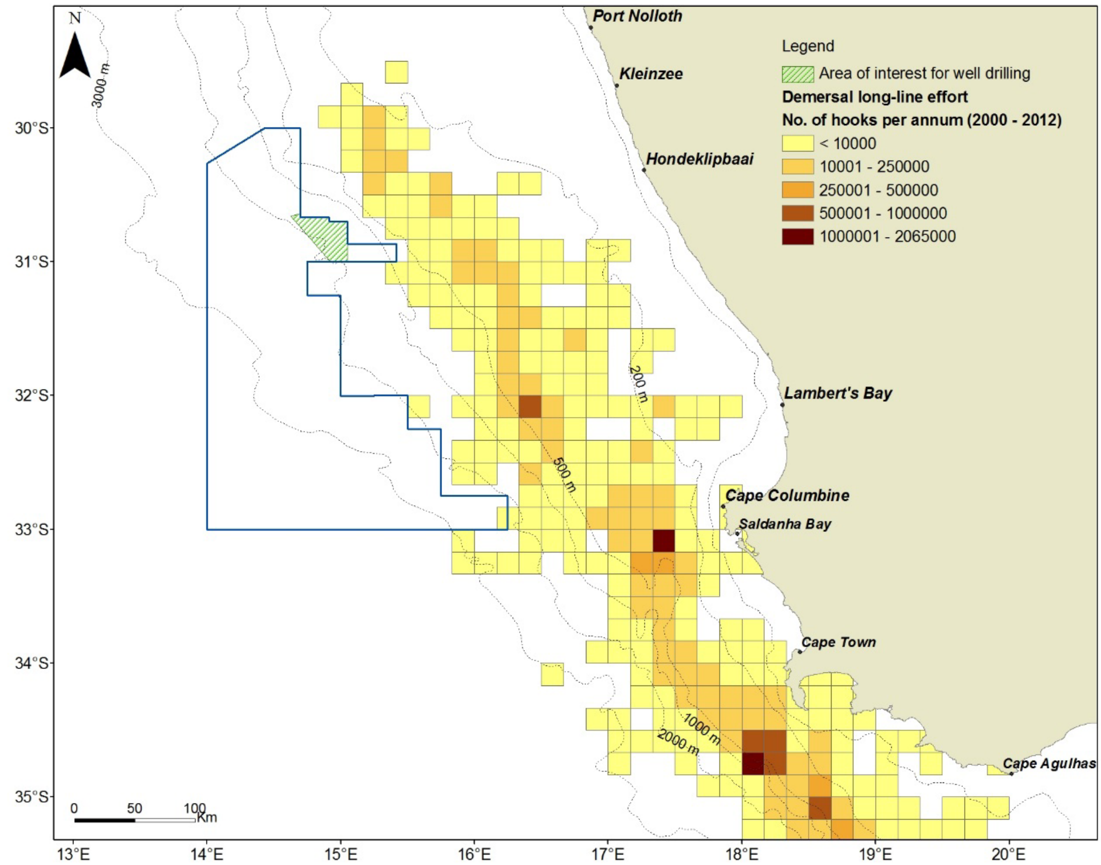


Figure 4.24: The proposed area of interest in relation to hake-directed demersal long-line effort (2000 - 2012).

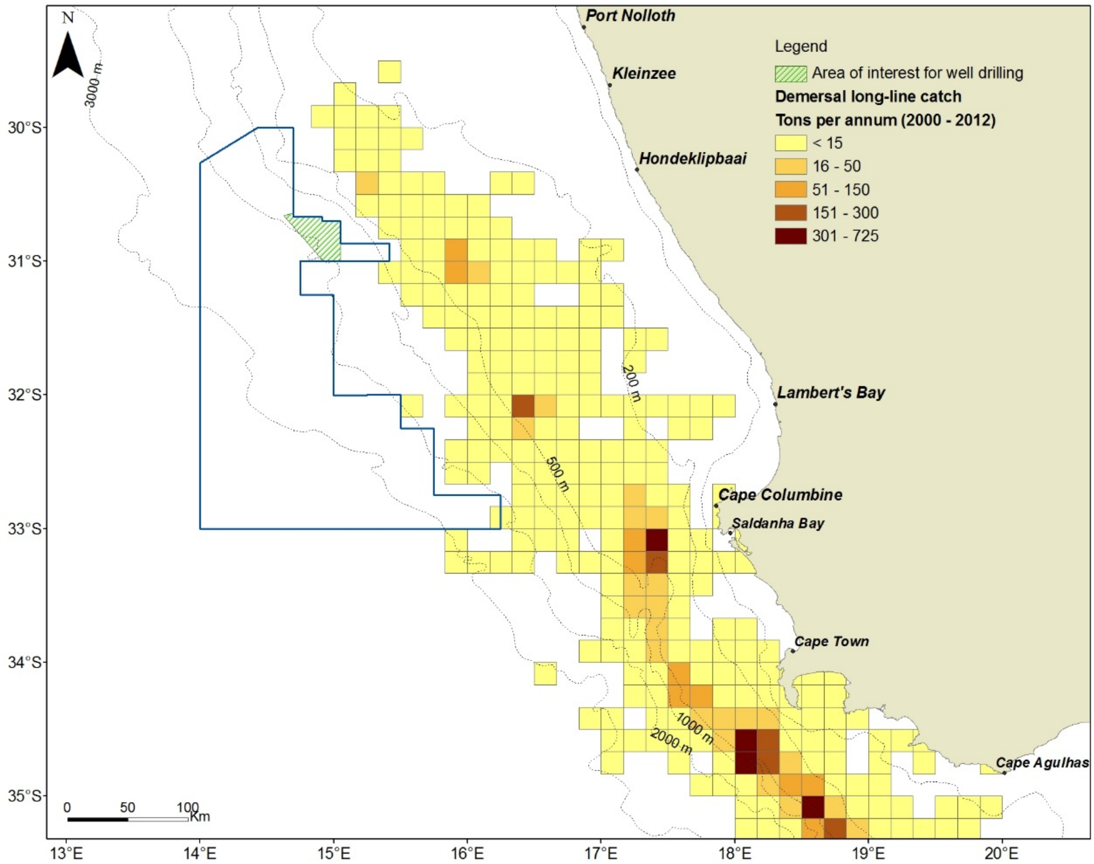


Figure 4.25: The proposed area of interest in relation to hake-directed demersal long-line catch (2000 - 2012).

<u>Shark-directed demersal long-line sector</u>

The demersal shark fishery targets soupfin shark, smooth-hound shark, spiny dogfish, St Joseph shark, *Charcharhinus* spp., rays and skates. Other species which are not targeted but may be landed include cape gurnards, jacopever and smooth hammerhead shark. Catches are landed at the harbours of Cape Town, Hout Bay, Mossel Bay, Plettenberg Bay, Cape St Francis, Saldanha Bay, St Helena Bay, Gansbaai and Port Elizabeth and currently six permit holders have been issued with long-term rights to operate within the fishery.

The fishery operates in coastal waters, predominantly inshore of the 150 m isobath. Figures 4.26 to 4.27 show the shark-directed demersal long-line effort and catch between 2007 and 2012 in relation to the area of interest, respectively. During the period 2007 to 2012, 430 500 hooks were set and 175 tons landed annually. Spatial records of effort and catch show the closest fishing effort located approximately 200 nm to the south-east of the proposed area of interest.

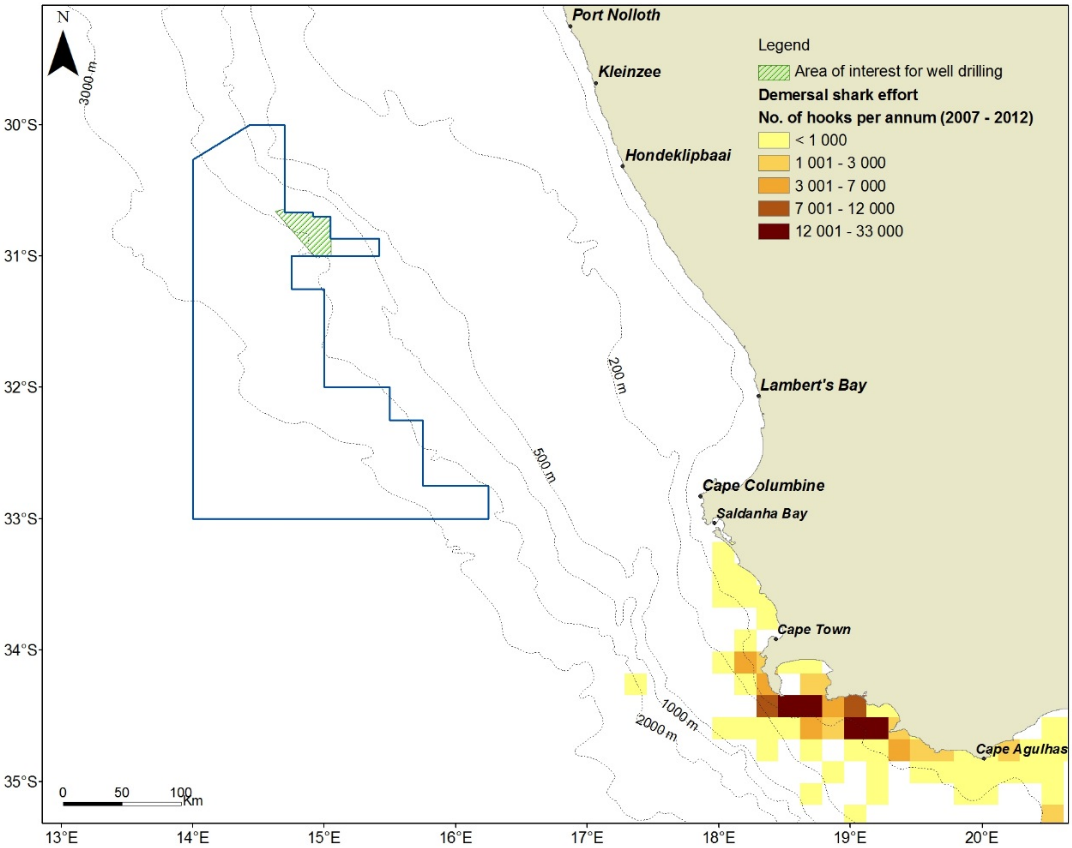


Figure 4.26: **The proposed area of interest in relation to recent shark-directed demersal long-line effort (2007 - 2012).**

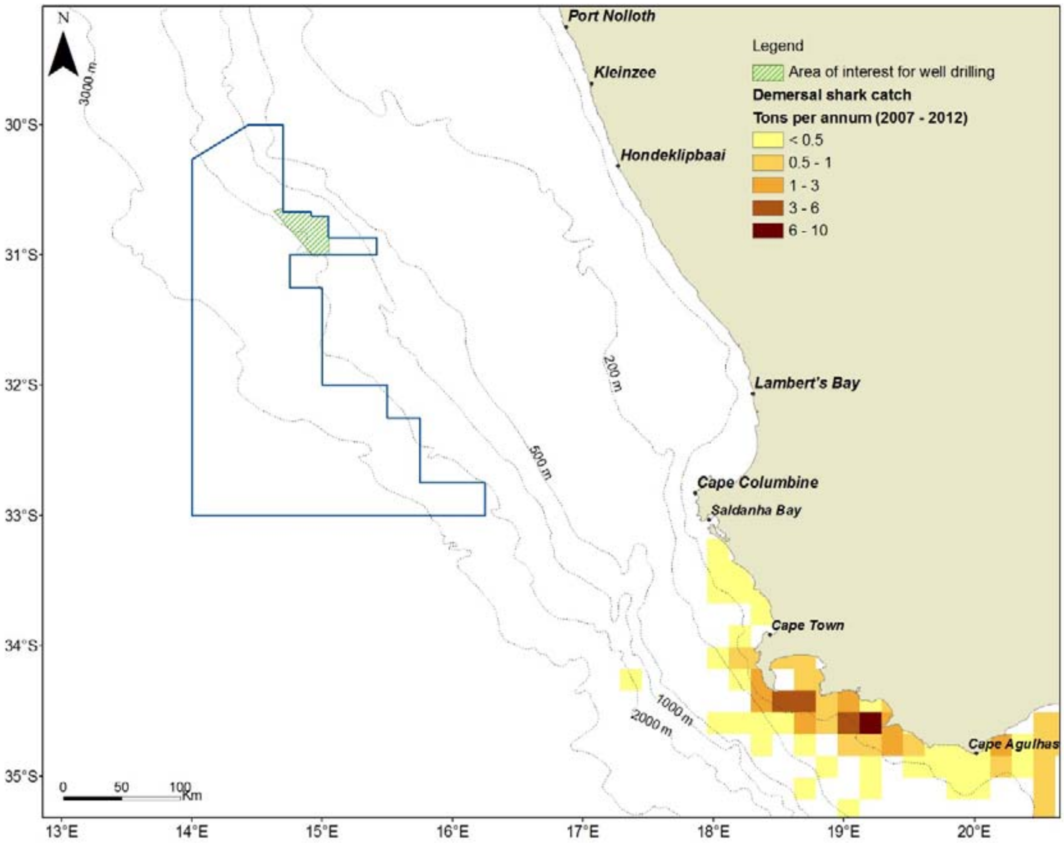


Figure 4.27: **The proposed area of interest in relation to recent shark-directed demersal long-line catch (2000 - 2012).**

(d) Pelagic long-line

The large pelagic long-line fishery operates year-round, extensively within the South African EEZ targeting primarily tuna and swordfish. Due to the highly migratory nature of these species, stocks straddle the EEZ of a number of countries and international waters. As such they are managed as a "shared resource" amongst various countries. There are currently 30 commercial large pelagic fishing rights issued for South African waters and there are 31 vessels active in the fishery.

Pelagic long-line vessels set a drifting mainline, which can be up to 100 km in length. The mainline is kept near the surface or at a certain depth (20 m below) by means of buoys connected via "buoy-lines", which are spaced approximately 500 m apart along the length of the mainline (see Figure 4.28). Hooks are attached to the mainline via 20 m long trace lines, which are clipped to the mainline at intervals of approximately 50 m. There can be up to 3 500 hooks per line. A single main line consists of twisted rope (6 to 8 mm diameter) or a thick nylon monofilament (5 to 7.5 mm diameter). Various types of buoys are used in combinations to keep the mainline near the surface and locate it should the line be cut or break for any reason. Each end of the line is marked by a Dahn Buoy and Radar reflector, which marks it's position for later retrieval by the fishing vessel. A line may be left drifting for up to 18 hours before retrieval by means of a powered hauler at a speed of approximately 1 knot. During hauling a vessel's manoeuvrability is severely restricted and, in the event of an emergency, the line may be dropped to be hauled in at a later stage.

The fishery operates extensively from the continental shelf break into deeper waters, year-round. Pelagic long-line vessels are primarily concentrated seawards of the 500 m depth contour where the continental slope is steepest and can be expected within the area of interest.

Figures 4.29 to 4.30 show the large pelagic long-line effort and catch between 2000 and 2012 in relation to the area of interest, respectively. During the period 2000 to 2012, the national catch and effort recorded within the large pelagic fishery amounted to an average of 3 018 tons and 3.49 million hooks set per year. Approximately 2.1% of the total catch and 1.8% of the total number of hooks set were recorded in the area of interest. During the period 2008 to 2012, the national catch and effort recorded within the large pelagic fishery amounted to an average of 3 047 tons and 4.84 million hooks set per year. Approximately 1.1% of the total catch and 0.9% of the total number of hooks set were recorded in the area of interest. These figures represent the combined catch and effort of both the domestic and foreign-flagged vessels.

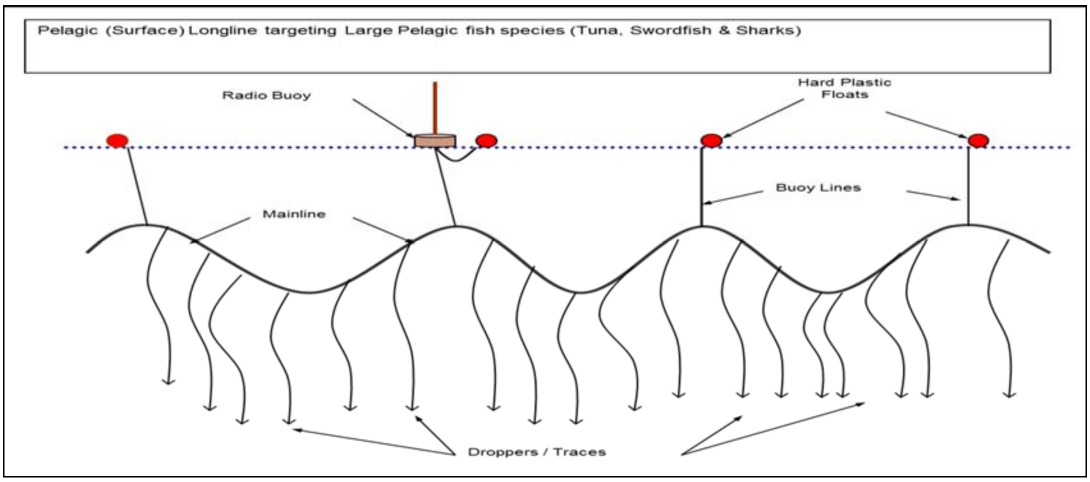


Figure 4.28: Typical pelagic long-line configuration targeting tuna, swordfish and shark species.

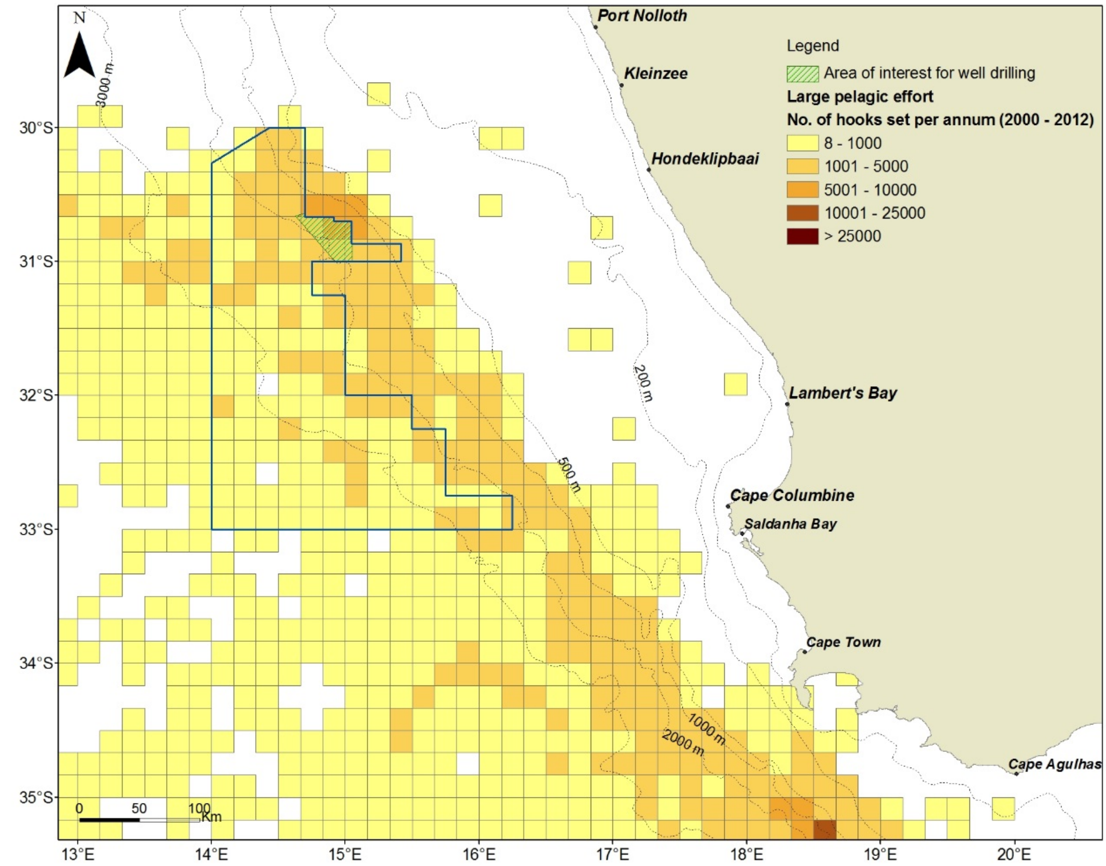


Figure 4.29: The proposed area of interest in relation to large pelagic long-line effort (2000 - 2012).

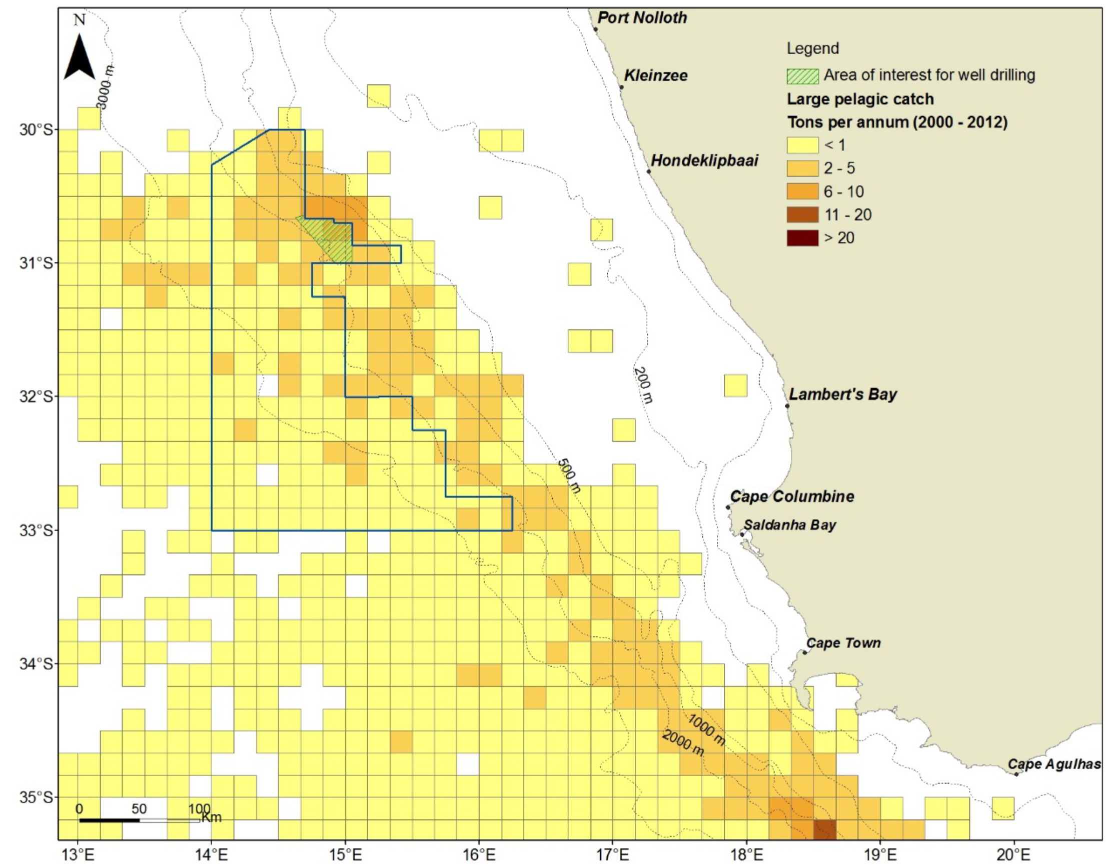


Figure 4.30: The proposed area of interest in relation to large pelagic long-line catch (2000 - 2012).

(e) Tuna pole

The tuna pole fishery is based on migratory species of tuna, predominantly Atlantic longfin tuna stock and a very small amount of skipjack tuna, yellowfin tuna and bigeye tuna. The South African fleet consists of approximately 128 pole-and-line vessels, which are based at the ports of Cape Town, Hout Bay and Saldanha Bay. The fishery is seasonal with vessel activity mostly between December and May and peak catches in February and March. The 2014 TAC for the South African tuna pole fishery (albacore) will be set at 4 400 tons.

Vessels drift whilst attracting and catching shoals of pelagic tunas. Sonars and echo sounders are used to locate schools of tuna. Once a school is located, water is sprayed outwards from high-pressure nozzles to simulate small baitfish aggregating near the water surface. Live bait is then used to entice the tuna to the surface (chumming). Tuna swimming near the surface are caught with hand-held fishing poles. The ends of the 2 to 3 m poles are fitted with a short length of fishing line leading to a hook. In order to land heavier fish, lines may be strung from the ends of the poles to overhead blocks to increase lifting power (see Figure 4.31). Vessels are relatively small (less than 25 m in length) and store catch on ice, thus staying at sea for short periods (approximately five days).

The nature of the fishery and communication between vessels often results in a large number of vessels operating in close proximity to each other at a time. The vessels fish predominantly during daylight hours and are highly manoeuvrable. However, at night in fair weather conditions the fleet of vessels may drift or deploy drogues to remain within an area and would be less responsive during these periods.

Fishing activity occurs along the entire West Coast beyond the 200 m bathymetric contour. Activity would be expected to occur along the shelf break with favoured fishing grounds including areas north of Cape Columbine and between 60 km and 120 km offshore from Saldanha Bay. Figures 4.32 to 4.33 show the tuna pole effort and catch between 2003 and 2012 in relation to the area of interest, respectively. The total catch landed and effort expended by the tuna pole sector over the period 2003 to 2012 was 4 110 tons (all species) and 5 723 fishing events per annum. The total catch landed and effort expended by the tuna pole sector over the period 2008 to 2012 was 4 221 tons (all species) and 4 707 fishing events per annum. There have been no records of historical or recent fishing effort by tuna pole sector within the Orange Basin Deep Water Licence Area and the closest recorded fishing position is situated 60 nm inshore (due East) of the proposed area of interest of interest.

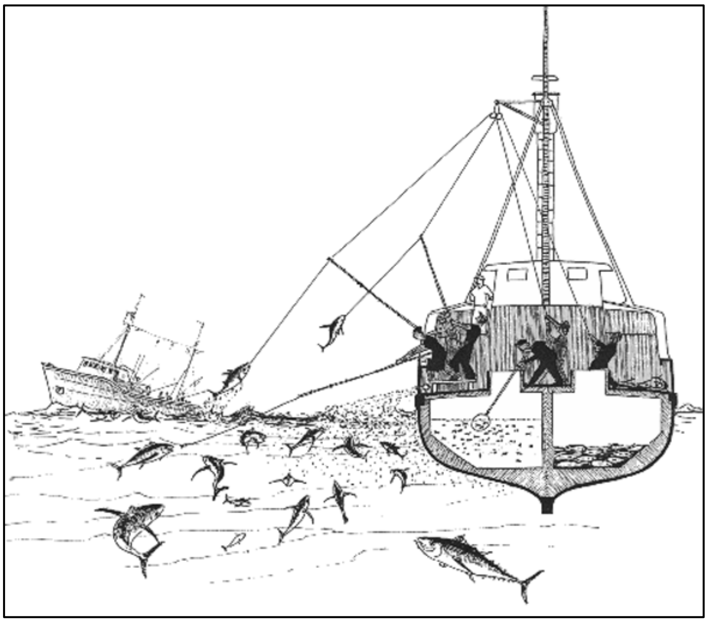


Figure 4.31: Schematic diagram of pole and line operation (www.fao.org/fishery).

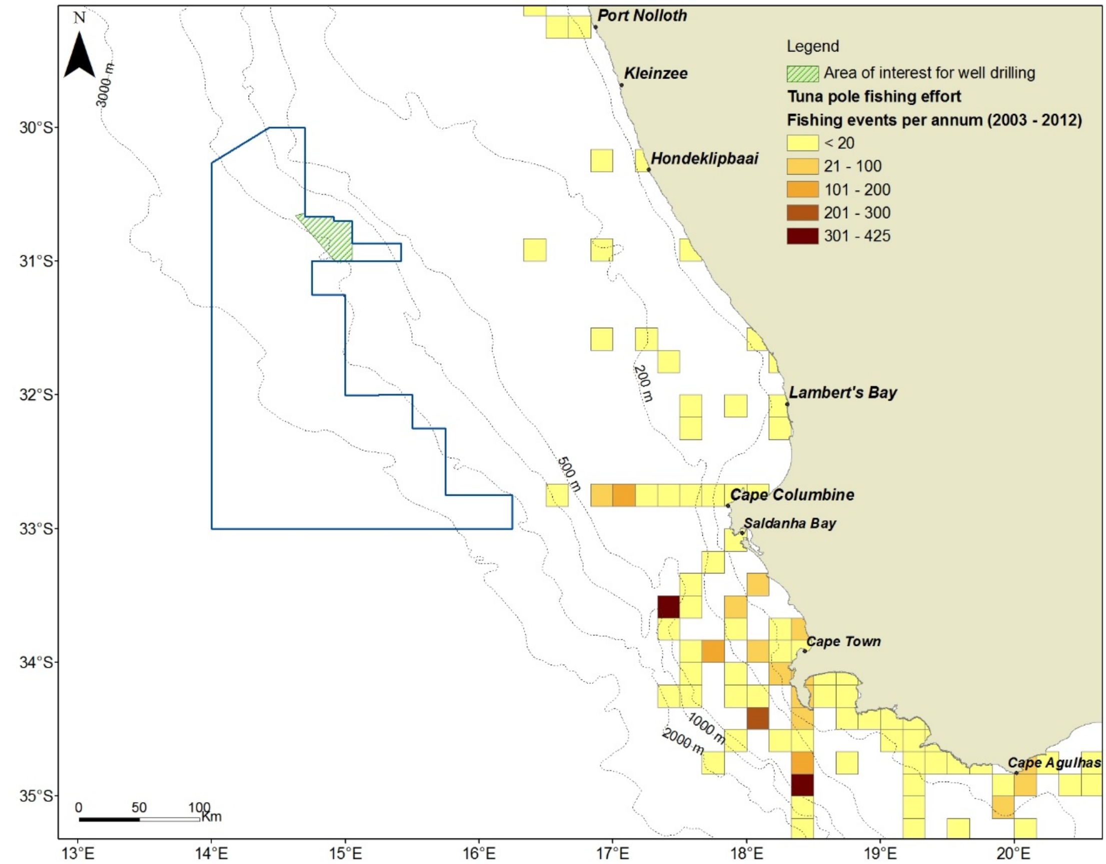


Figure 4.32: The proposed area of interest in relation to tuna pole effort (2003 - 2012).

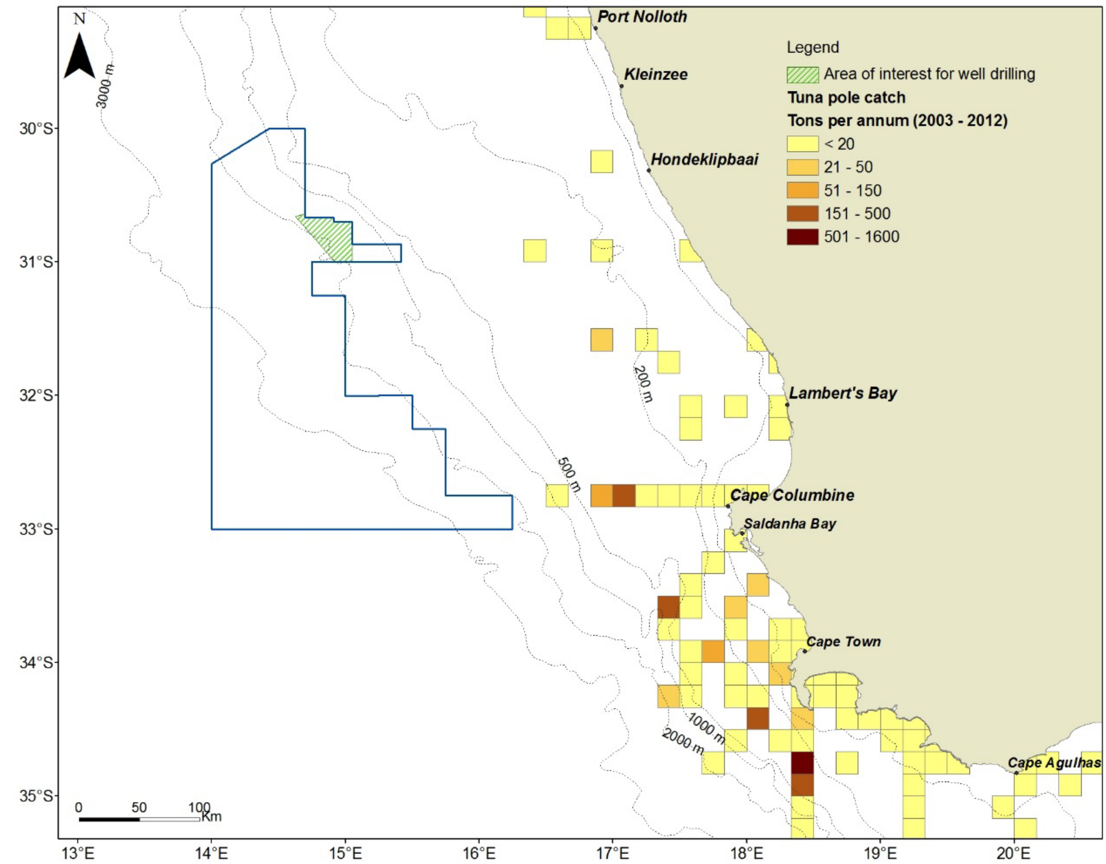


Figure 4.33: The proposed area of interest in relation to tuna pole catch (2003 - 2012).

(f) Traditional line-fish

This fishery includes commercial, subsistence and recreational sectors. The South African commercial line fishery is the country's third most important fishery in terms of total tons landed and economic value. The bulk of the fishery catch is made up of approximately 35 species. Different assemblages of species are targeted according to the region in which they are being fished and include tuna species, sparidae, serranidae, caragidae, scombridae and sciaenidae. In South Africa effort is managed geographically with the spatial effort of the fishery divided into three zones. The majority of the catch (up to 95%) is landed by the Cape commercial fishery, which operates on the continental shelf mostly up to a depth of 200 m from the Namibian border on the West Coast to the Kei River in the Eastern Cape. Up to 3 000 boats are involved in the fishery on the national level, 450 of which are involved in the commercial fishery.

Fishing vessels generally range up to a maximum of 40 nm offshore, although fishing at the outer limit of this range is sporadic. Figure 4.34 shows the traditional line-fish catch between 2000 and 2012 in relation to the area of interest. Over the period 2000 to 2012, the fishery reported an annual catch of 13 082 tons. Over the five-year period from 2008 to 2012, annual catches for the sector are lower at 8 551 tons. There are records of catch within the proposed area of interest.

Line fishing techniques consist of hook and line deployments (up to 10 hooks per line) and differ from the pelagic long-line fishing technique in that the use of set long-lines is not permitted.

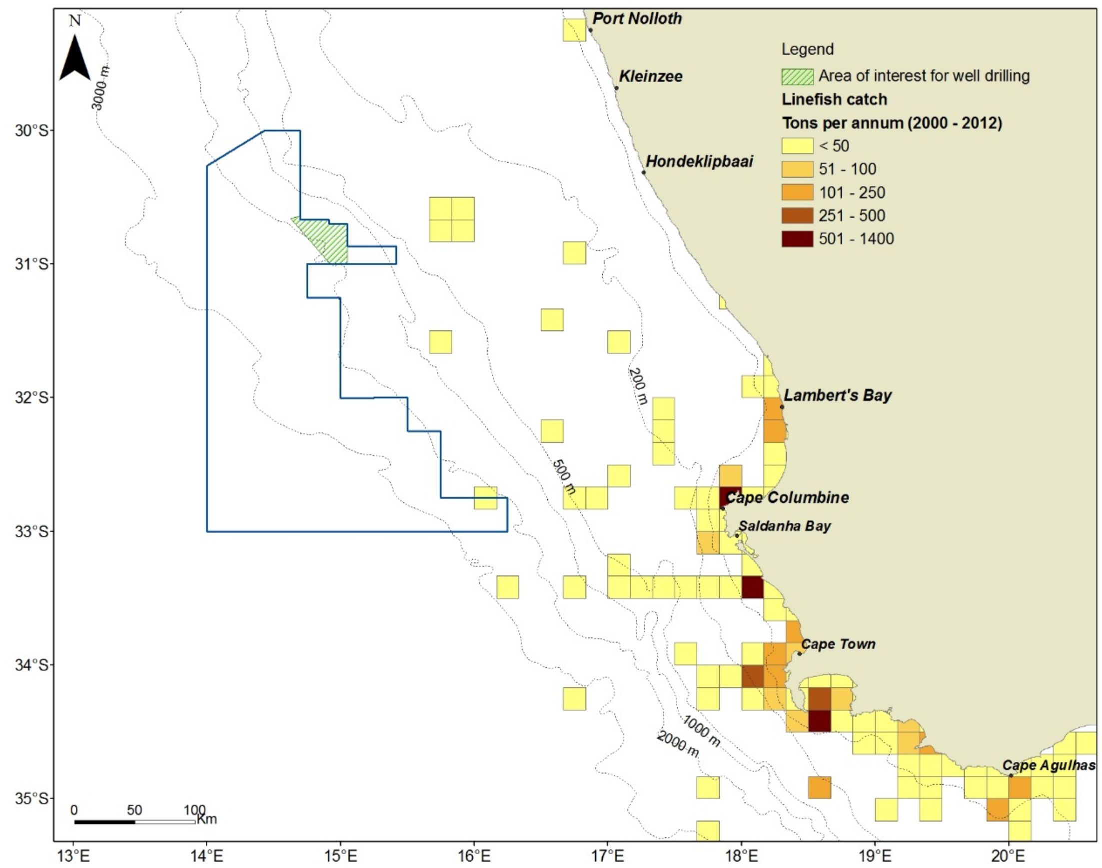


Figure 4.34: The proposed area of interest in relation to traditional line-fish catch (2000 - 2012).

(g) West Coast rock lobster

The West Coast rock lobster occurs inside the 200 m depth contour along the West Coast from Namibia to East London on the East Coast of South Africa. In South Africa the fishery is divided into the offshore fishery and the near-shore fishery, both directed inshore of the 100 m bathymetric contour. The offshore sector operates in a water depth range of 30 m to 100 m whilst the inshore fishery is restricted by the type of gear used to waters shallower than 30 m in depth.

Fishing grounds are divided into Zones stretching from the Orange River mouth to east of Cape Hangklip in the South-Eastern Cape. Effort is seasonal with boats operating from the shore and coastal harbours. Catch is managed using a TAC, 80% and 20% of which is allocated to the offshore and inshore fisheries respectively. A total national landing of approximately 1 879 tons (whole weight) was recorded for 2012. Figure 4.35 shows the West Coast rock lobster catch between 1969 and 2012 in the various management zones in relation to the area of interest. Catches of rock lobster have declined systematically due to heavy fishing pressure and are currently estimated to be at only 3% of their pristine state. The proposed area of interest lies approximately 125 nm (230 km) west of the fishing grounds.

The offshore sector makes use of traps consisting of rectangular metal frames covered by netting, which are deployed from trap boats, whilst the inshore fishery makes use of hoop nets deployed from small dinghy's. Traps are set at dusk and retrieved during the early morning. Vessels using traps will leave up to 30 traps per vessel in the fishing grounds overnight during the week.

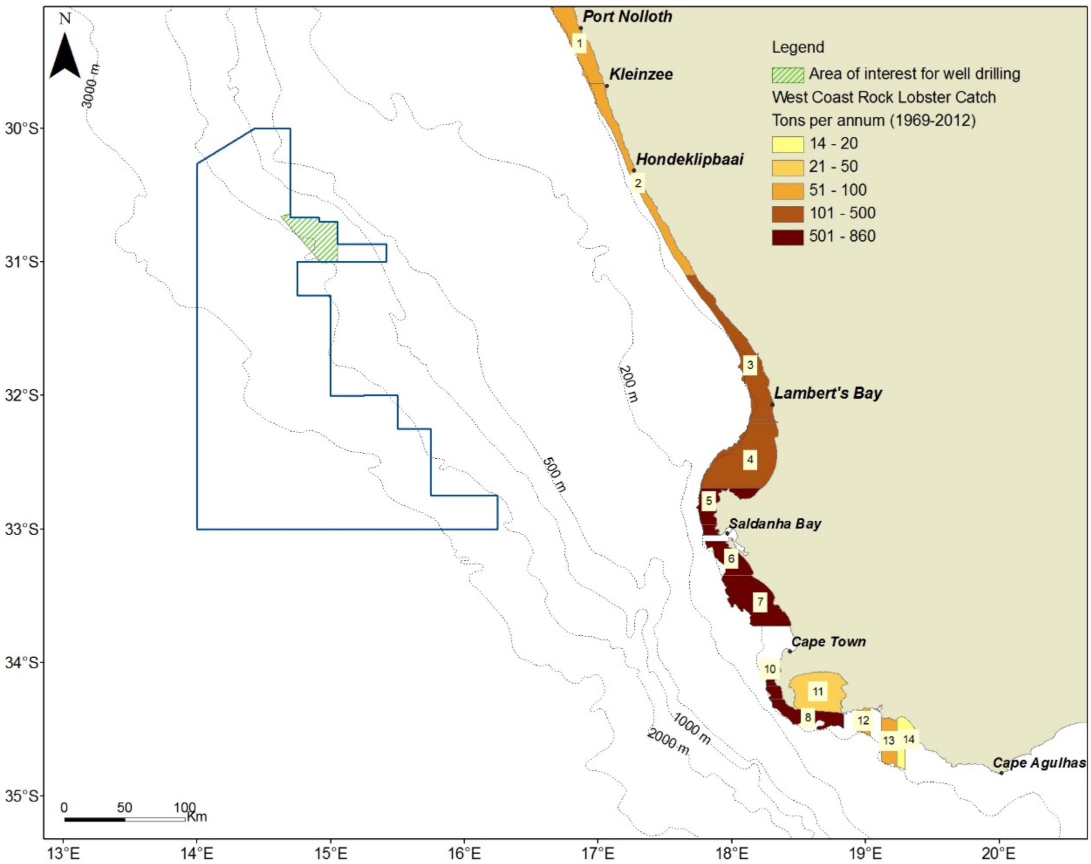


Figure 4.35: The proposed area of interest in relation to West Coast Rock Lobster catch (1969 - 2012).

(g) Fisheries research

Surveys of demersal fish resources are carried out in January (West Coast survey) and May (South Coast survey) each year by DAFF in order to set the annual TACs for demersal fisheries. Stratified, bottom trawls are conducted to assess the biomass, abundance and distribution of hake, horse mackerel, squid and other demersal trawl species on the shelf and upper slope of the South African coast. The gear configuration is similar to that of commercial demersal trawlers, however, nets are towed for a shorter duration of generally 30 minutes per tow. Trawl positions are randomly selected to cover specific depth strata that range from the coast to the 1 000 m bathymetric contour (see Figure 4.36), thus inshore of the proposed area of interest. Approximately 120 trawls are conducted during each survey over a period of approximately one month.

The biomass of small pelagic species is also assessed bi-annually by an acoustic survey. The first of these surveys is timed to commence mid-May and runs until mid-June while the second starts in mid-October and runs until mid-December. During these surveys the survey vessel travels pre-determined transects (perpendicular to bathymetric contours) running offshore from the coastline to approximately the 200 m bathymetric contour (thus inshore of the proposed area of interest). The survey is designed to cover an extensive area from the Orange River on the West Coast to Port Alfred on the East Coast.

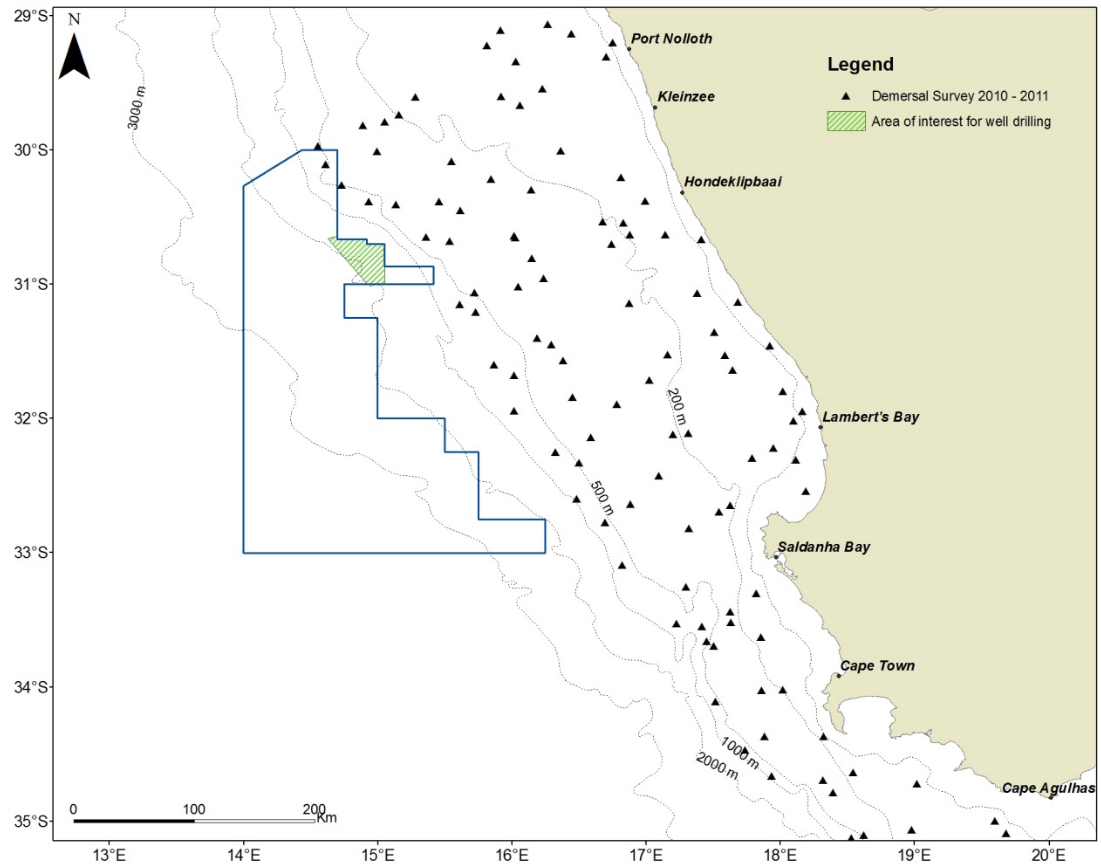


Figure 4.36: The proposed area of interest in relation to the spatial distribution of research trawls conducted between 2010 and 2011.

4.1.4.2 Shipping transport

The majority of shipping traffic is located on the outer edge of the continental shelf with traffic inshore of the continental shelf along the West Coast largely comprising fishing and mining vessels, especially between Kleinsee and Oranjemund. Figures 4.37 and 4.38 show that the majority of the shipping traffic en route to Cape Town would pass though the licence area and possibility though the area of interest.

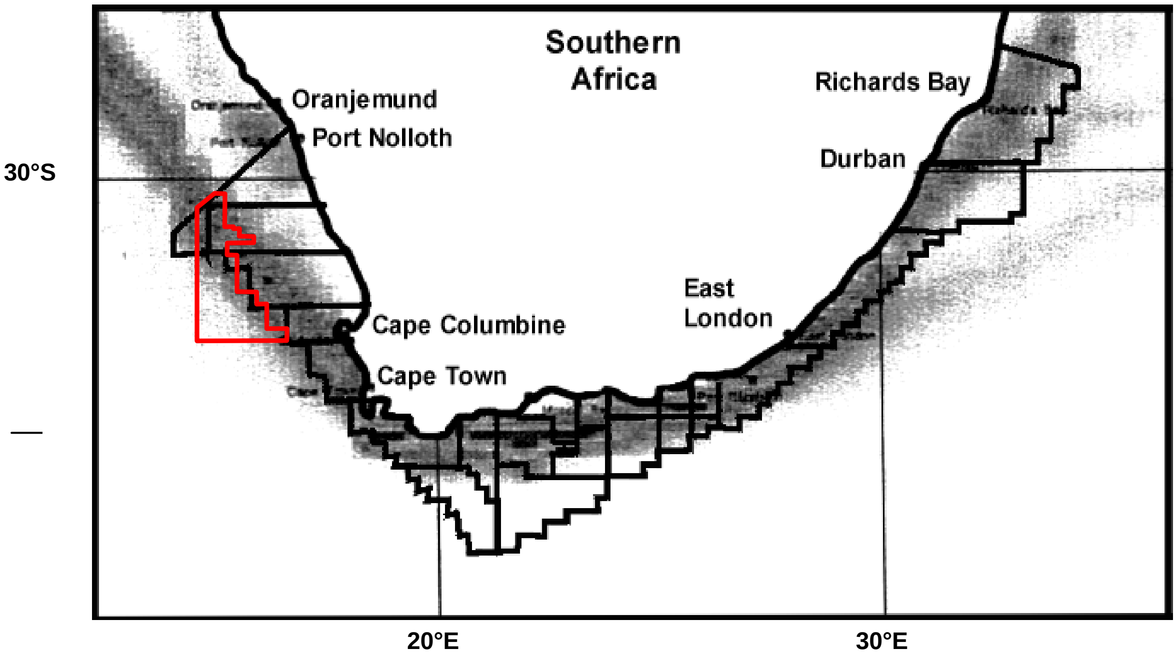


Figure 4.37: The major shipping routes along the west coast of South Africa showing petroleum license blocks (Data from the South African Centre for Oceanography). Approximate location of the licence area is also shown.

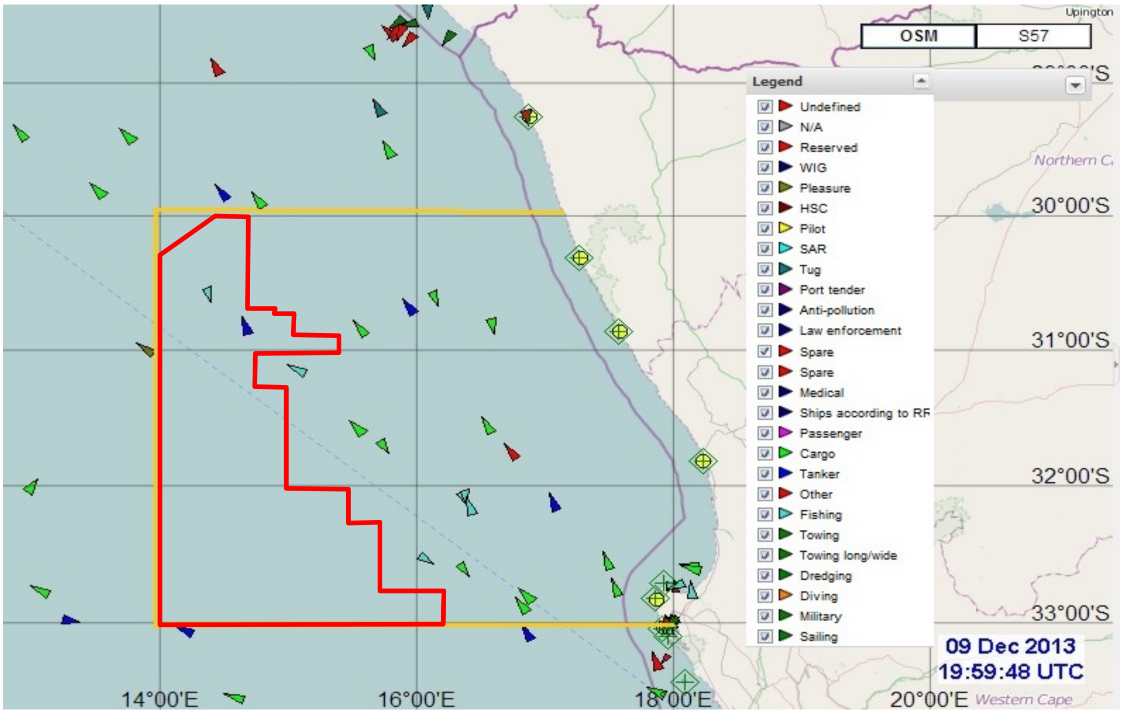


Figure 4.38: A typical representation (instantaneous) of the vessel type and numbers passing through the study area on a daily basis (after SAMSA, Capt Karl Otto, December 2013). Approximate location of the licence area is also shown.

4.1.4.3 Oil and Gas exploration and production

Exploration for oil and gas is currently undertaken in a number of licence blocks off the West, South and East coasts of South Africa (see Figure 4.39).

There is no current development or production from the South African West Coast offshore. The Ibhubesi Gas Field (Block 2A) and Kudu Gas Field (off southern Namibia) have been identified for development.

4.1.4.4 Diamond prospecting and mining

Marine diamonds are mined along the West Coast from just south of Lamberts Bay to the Orange River mouth. Twenty diamond mining concessions have been established along the West Coast with each concession divided into four zones from the coat seaward (a, b, c & d). There are no diamond mining concessions within the licence area (see Figure 4.40).

The majority of concessions worked at present are those closer inshore (water depths are mostly less than 150 m). No deep-water diamond mining is currently underway in the South African offshore concession areas. In Namibian waters, diamond mining by De Beers Marine Namibia is currently operational in the Atlantic 1 Mining Licence Area, approximately 250 km to the north-northeast of the proposed area of interest.

These mining operations are typically conducted from fully self-contained mining vessels with on board processing facilities, using either large-diameter drill or seabed crawler technology. The vessels operate as semi-mobile mining platforms, anchored by a dynamic positioning system, commonly on a three to four anchor spread. Computer-controlled positioning winches enable the vessels to locate themselves precisely over a mining block. These mining vessels thus have limited manoeuvrability.

4.1.4.5 Prospecting and mining of other minerals

(a) Heavy minerals

Heavy mineral sands containing, amongst other minerals, zircon, ilmenite, garnet and rutile may be found offshore of the West Coast. Tronox's Namakwa Sands is currently exploiting heavy minerals from onshore deposits near Brand-se-Baai (approximately 385 km north of Cape Town). In October 2009, De Beers secured a Prospecting Right for platinum group metals, gold and sapphires in the DMBC licence area (see Figure 4.41). Between December 2008 and March 2011, AuruMar (Pty) Ltd, a joint venture entity created by De Beers Group Exploration Holdings Limited and AngloGold Ashanti Marine Exploration Limited, secured Prospecting Rights (including heavy minerals, platinum group metals, gold and sapphire) for sea areas: 1c, inshore portions of 2c, 3c, 4c and 5c, as well as 6c, 7c, 8c, 9c, 10c, 12c, 14c, 15c, 16c, 17c, 18c and 20c (see Figure 4.41).

(b) Glauconite and phosphate

Glauconite pellets (an iron and magnesium rich clay mineral) and bedded and peletal phosphorite occur on the seafloor over large areas of the continental shelf on the West Coast. These represent potentially commercial resources that could be considered for mining as a source of agricultural phosphate and potassium (Birch 1979a & b; Dingle *et al*. 1987; Rogers and Bremner 1991).

A number of prospecting areas for glauconite and phosphorite / phosphate are located off the West Coast (see Figure 4.42), one of which is partially located within the proposed area of interest (i.e. Prospecting area 251). Green Flash Trading received their prospecting rights for Areas 251 and 257 in 2012/2013. The prospecting rights for Agrimin1, Agrimin2 and SOM1 have expired (Jan Briers, DMR *pers. comm.*, December 2013).

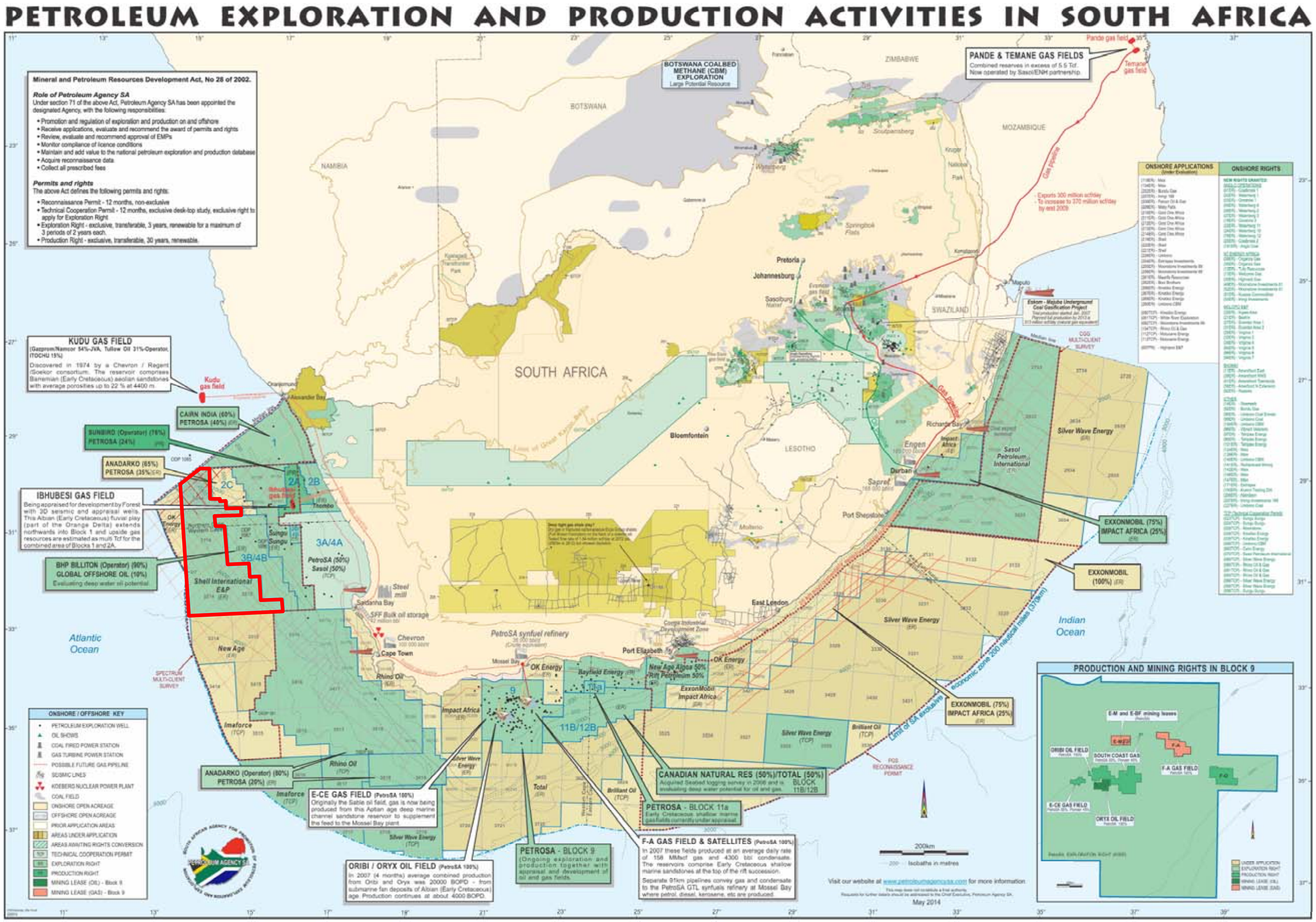


Figure 4.39: Petroleum licence blocks off the West, South and East coasts of South Africa (after PASA, May 2014). The Orange Basin Deep Water Licence Area is highlighted in red.

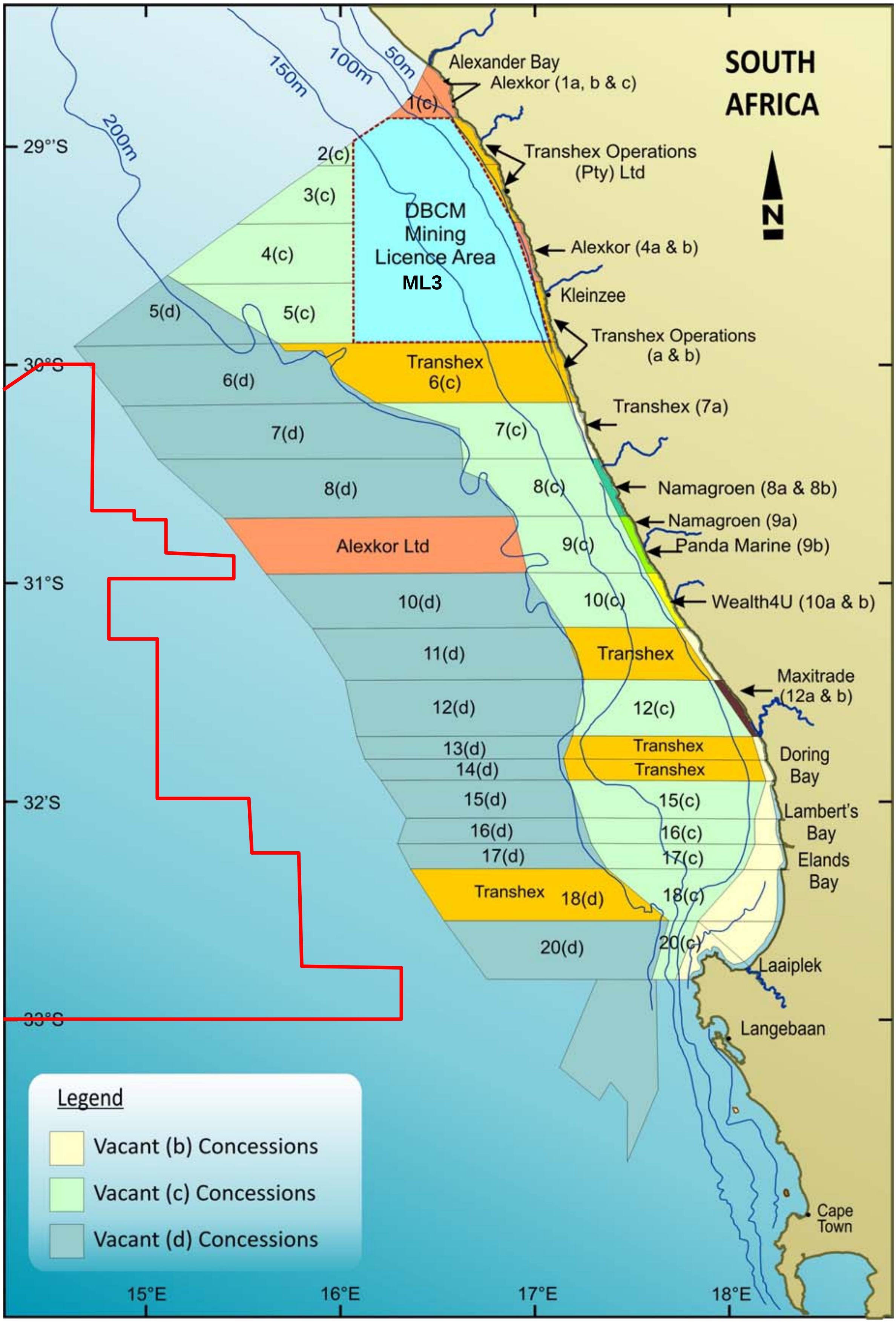


Figure 4.40: South African Diamond Rights Holders off the West Coast (compiled by De Beers, 2011). Approximate location of the licence area is also indicated.

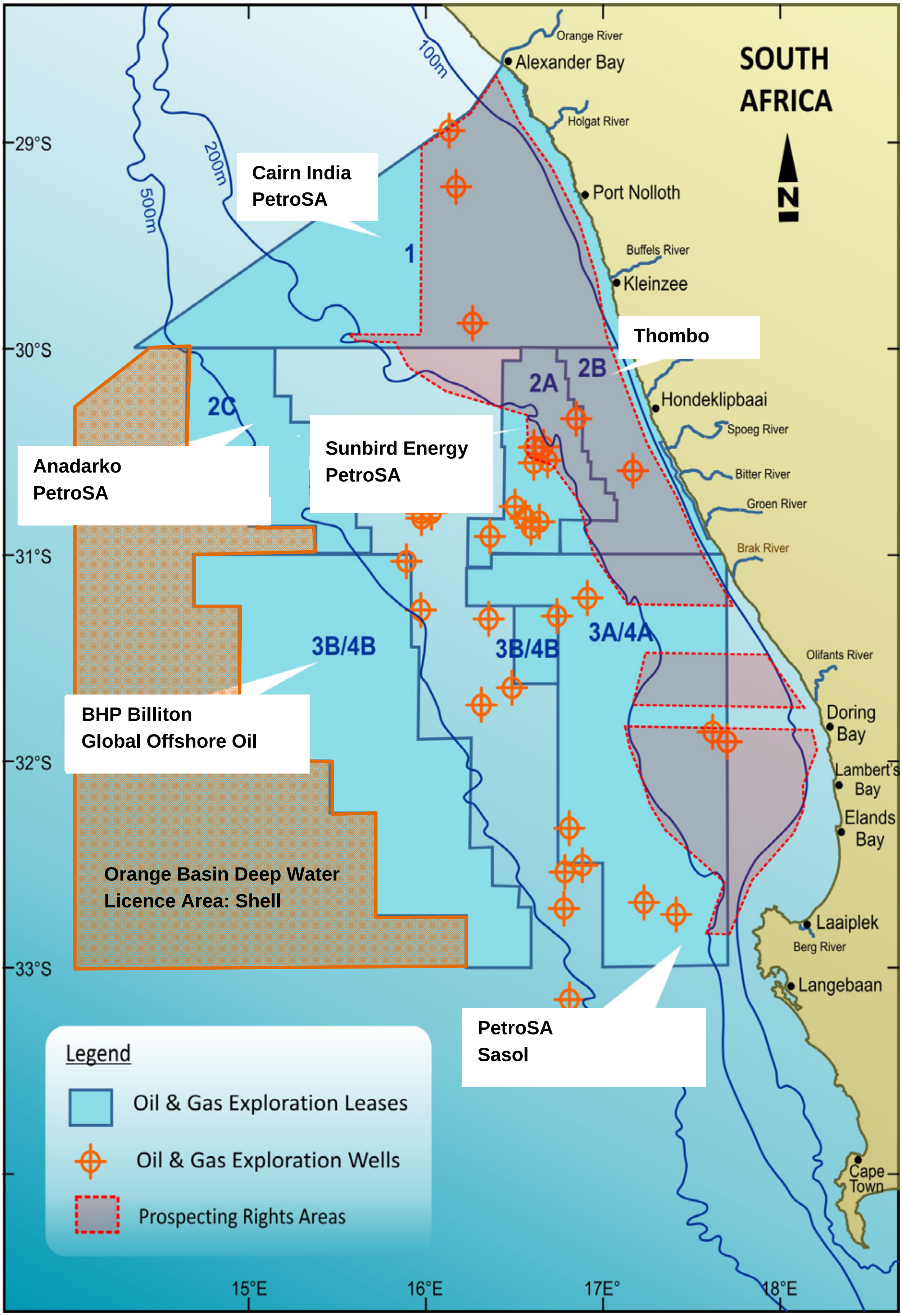


Figure 4.41: AuruMar's prospecting rights area in relation to Petroleum Licence Blocks off the West Coast of South Africa (adapted from De Beers, 2012).

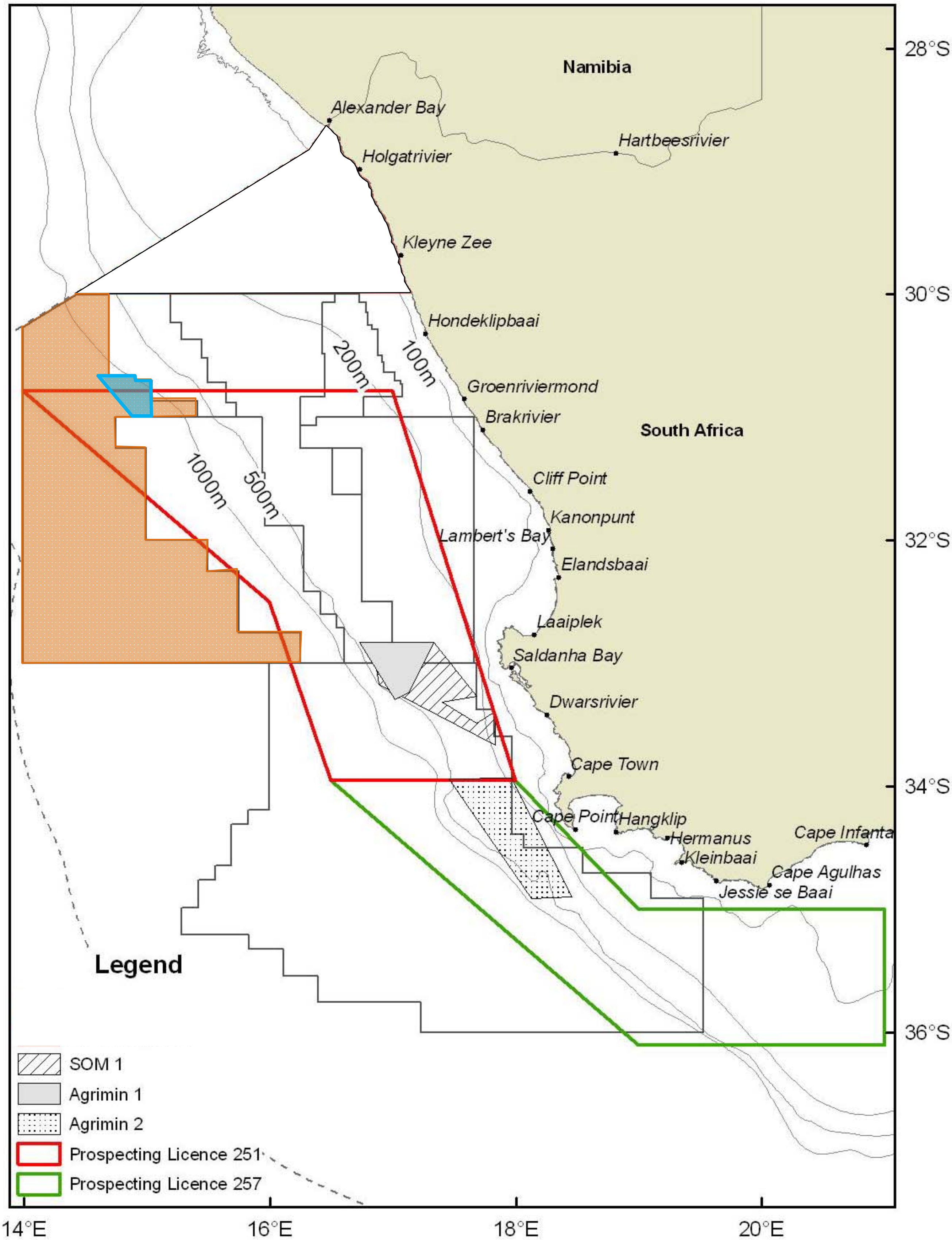


Figure 4.42: Location of the licence area and proposed area of interest in relation to glauconite and phosphorite / phosphate prospecting areas.

(c) Manganese nodules in ultra-deep water

Rogers (1995) and Rogers and Bremner (1991) report that manganese nodules enriched in valuable metals occur in deep water areas (>3 000 m) off the West Coast (see Figure 4.43). The nickel, copper and cobalt contents of the nodules fall below the current mining economic cut-off grade of 2% over most of the area, but the possibility exists for mineral grade nodules in the areas north of 33°S in the Cape Basin and off northern Namaqualand.

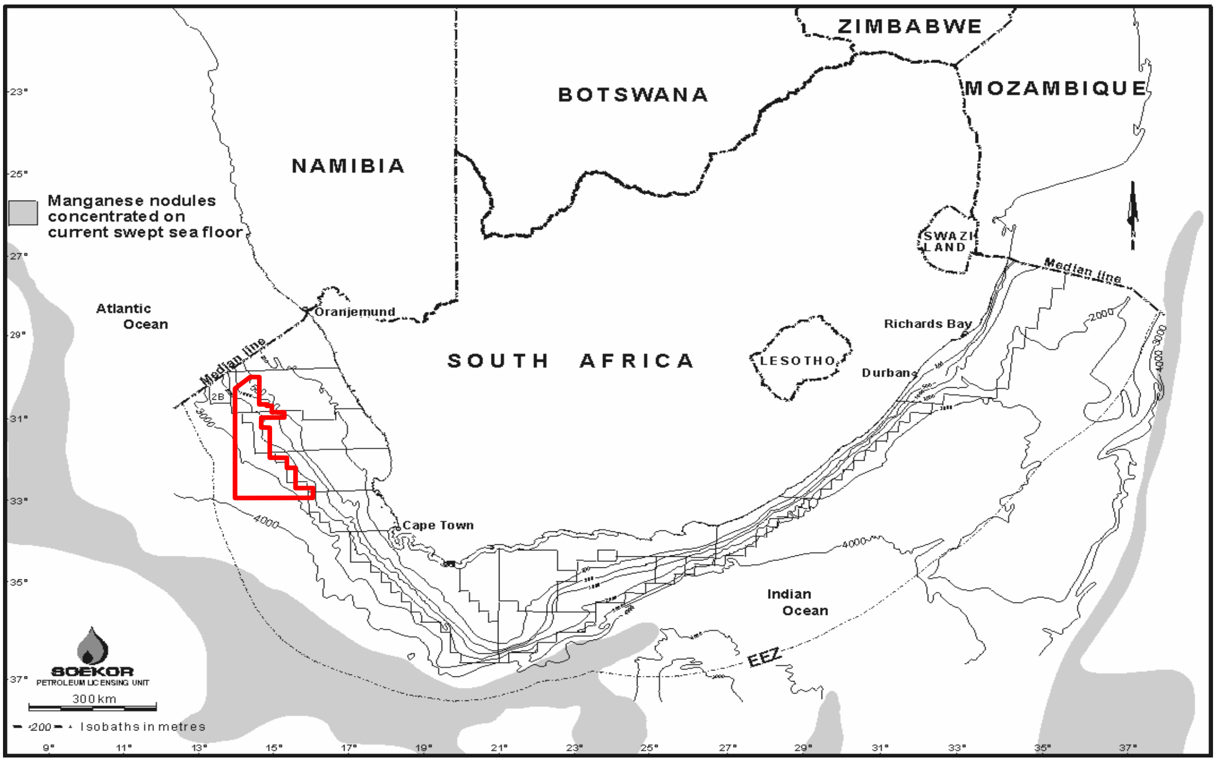


Figure 4.43: Schematic of location of manganese nodules off Southern Africa, showing petroleum licence blocks (Modified from Rogers 1995). Approximate location of the licence area is also shown.

4.1.4.6 Other

Human use of the marine environment has resulted in the addition of numerous hazards on the seafloor. The Annual Summary of South African Notices to Mariners No. 5 and charts from the South African Navy or Hydrographic Office provide detailed information on the location of different underwater hazards along the West Coast.

(a) Undersea cables

There are a number of submarine telecommunications cable systems across the Atlantic and the Indian Ocean (see Figure 4.44), including:

- South Atlantic Telecommunications cable No.3 / West African Submarine Cable / South Africa Far East (SAT3/WASC/SAFE): This cable system is divided into two sub-systems, SAT3/WASC in the Atlantic Ocean and SAFE in the Indian Ocean. The SAT3/WASC sub-system connects Portugal (Sesimbra) with South Africa (Melkbosstrand). From Melkbosstrand the SAT-3/WASC sub-system is extended via the SAFE sub-system to Malaysia (Penang) and has intermediate landing points at

Mtunzini South Africa, Saint Paul Reunion, Bale Jacot Mauritius and Cochin India (www.safe-sat3.co.za).

- Eastern Africa Submarine Cable System (EASSy): This is a high bandwidth fibre optic cable system, which connects countries of eastern Africa to the rest of the world. EASSy runs from Mtunzini (off the East Coast) in South Africa to Port Sudan in Sudan, with landing points in nine countries, and connected to at least ten landlocked countries.
- West Africa Cable System (WACS): WACS is 14 530 km in length, linking South Africa (Yzerfontein) and the United Kingdom (London). It has 14 landing points, 12 along the western coast of Africa (including Cape Verde and Canary Islands) and 2 in Europe (Portugal and England) completed on land by a cable termination station in London.
- African Coast to Europe (ACE): The ACE submarine communications cable is a 17 000 km cable system along the West Coast of Africa between France and South Africa (Yzerfontein).

Three new cable systems to link South America and Africa (SAex, WASACE and BRICS) are also being proposed for 2014 (see Figure 4.44).

There is an exclusion zone applicable to the telecommunication cables 1 nm (approximately 1.9 km) each side of the cable in which no anchoring is permitted. None of the submarine cables are located within the proposed area of interest (see Figure 4.45).

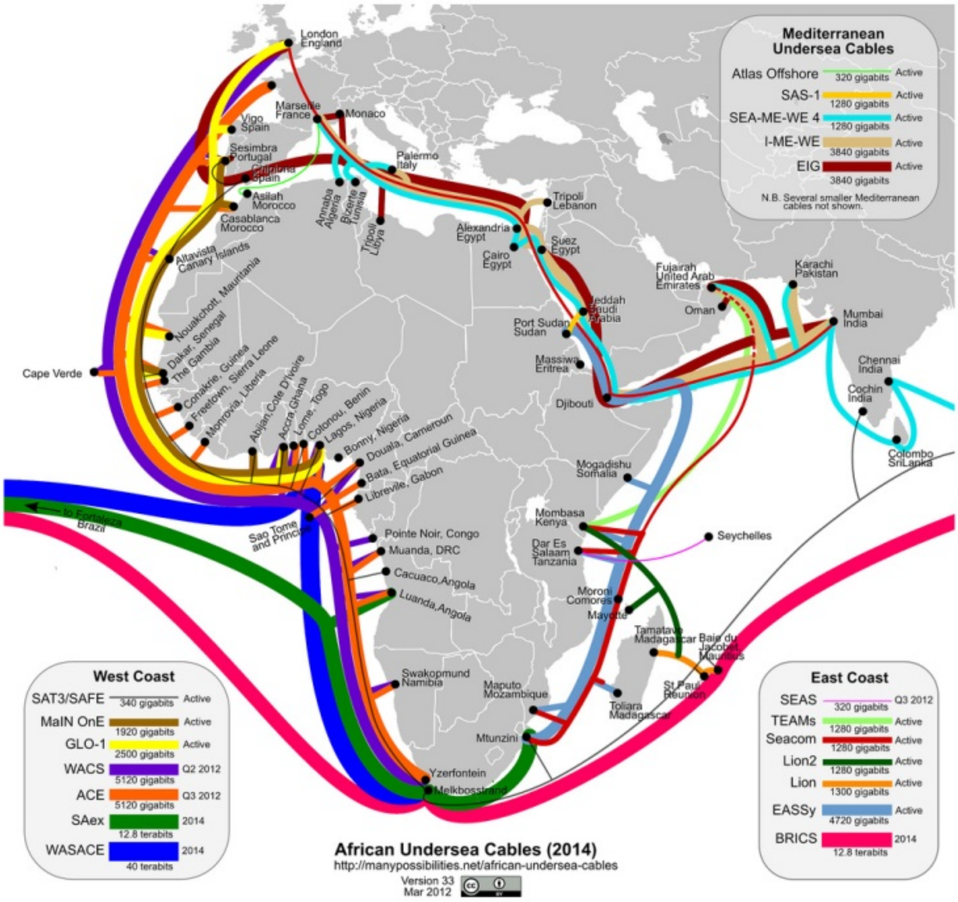


Figure 4.44: Configuration of the current African undersea cable systems as well as cables proposed for 2013 and 2014 (From http://www.manypossibilities.net).

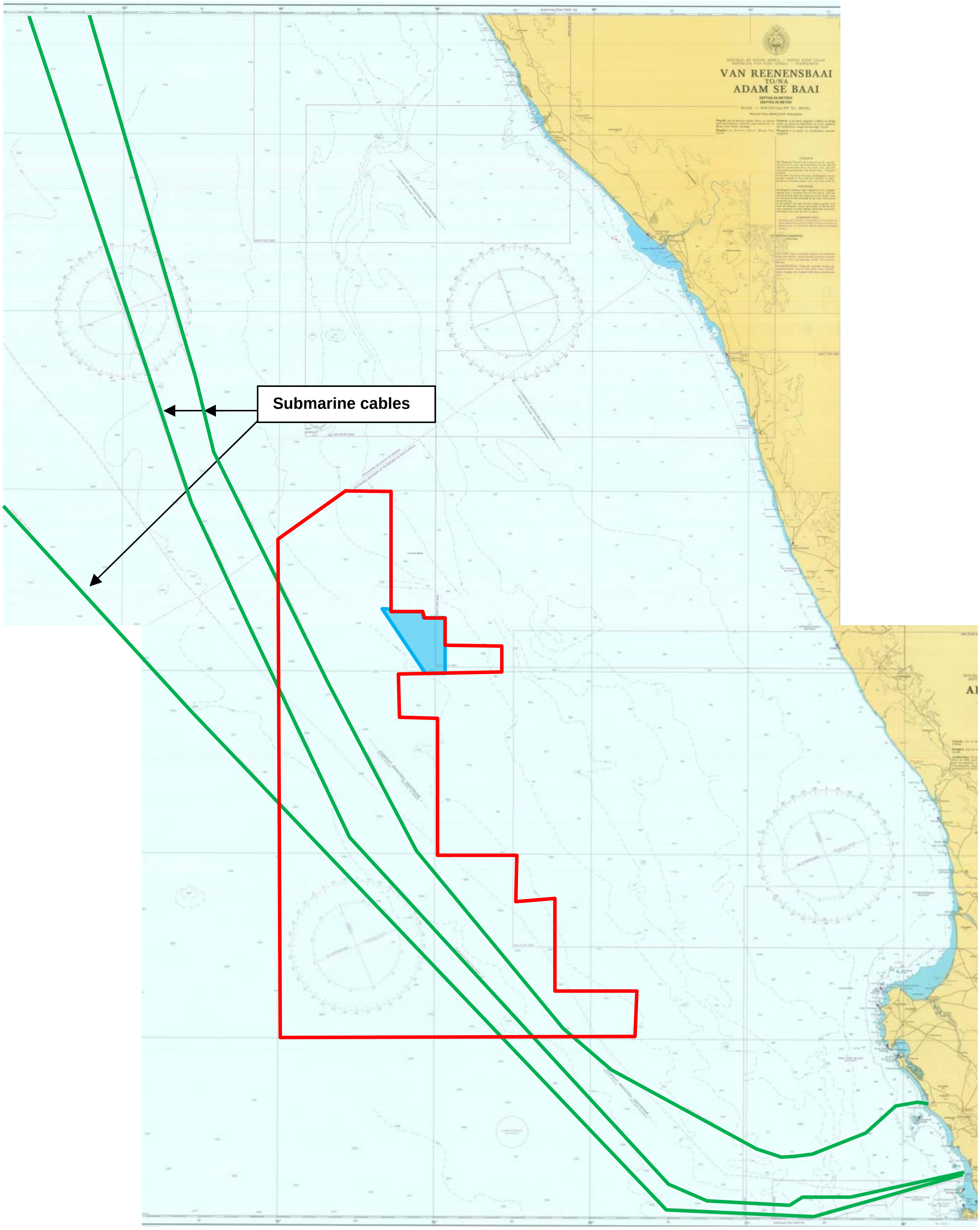


Figure 4.45: Location of the proposed area of interest in relation to submarine cables (Adapted from SAN Charts SAN54 and SAN55).

(b) Marine archaeological sites

Over 2 000 shipwrecks are present along the South African coastline. Wrecks older than 50 years old have National Monument status. All known shipwrecks off the coast of South Africa occur in waters shallower than 100 m within 50 km of the coast. No wrecks have been identified in the proposed area of interest.

(c) Ammunition dump sites

Ammunition and explosive dumpsites off the South-West Coast are presented on SAN Chart 56. Such sites are located well to the south of the area of interest.

(d) Offshore conservation areas

Marine protected areas (MPAs) offering protection of the Namaqua biozones (sub-photic, deep-photic, shallow-photic, intertidal and supratidal zones) are absent northwards from Cape Columbine (Emanuel *et al*. 1992, Lombard *et al*. 2004). This has resulted in substantial portions of the coastal and shelf-edge marine biodiversity in the area being assigned a threat status of 'critically endangered', 'endangered' or 'vulnerable' (Lombard *et al*. 2004; Sink *et al*. 2011) (see Figure 4.9). Using biodiversity data mapped for the 2004 and 2011 National Biodiversity Assessments a systematic biodiversity plan has been developed for the West Coast (Majiedt *et al*. 2013) with the objective of identifying both coastal and offshore priority areas for MPA expansion. To this end, nine focus areas have been identified for protection on the West Coast between Cape Agulhas and the South African – Namibian border (see Figure 4.16). The closest proposed offshore protection areas to the proposed area of interest are “Namibian Border” (25 km north), “Childs Bank” (75 km east) and “Benguela Hard Ground” (175 km south-east).

Nearshore conservation areas and marine protected areas (MPAs) are addressed in Section 4.2.3.4.

4.2 NEARSHORE REGION AND SHORELINE

4.2.1 INTRODUCTION

The National Biodiversity Spatial Assessment (NBSA) (Lombard and Strauss 2004) study analysed available data on rocky shores, mixed shores, sandy beaches, pebble beaches and boulder beaches and identified areas of high value / irreplaceability (see Figure 4.46). Four totally irreplaceable habitats have been identified on the West Coast.

Two coastal habitat types that dominate the Namaqua bioregion are rocky shores (approximately 53% of the coastline) and sandy shores (about 37%). Mixed shores make up a further 9%. Pebble or boulder beaches are very rare in the Namaqua bioregion, making up less than 1% of the coastline (Lombard & Strauss 2004).

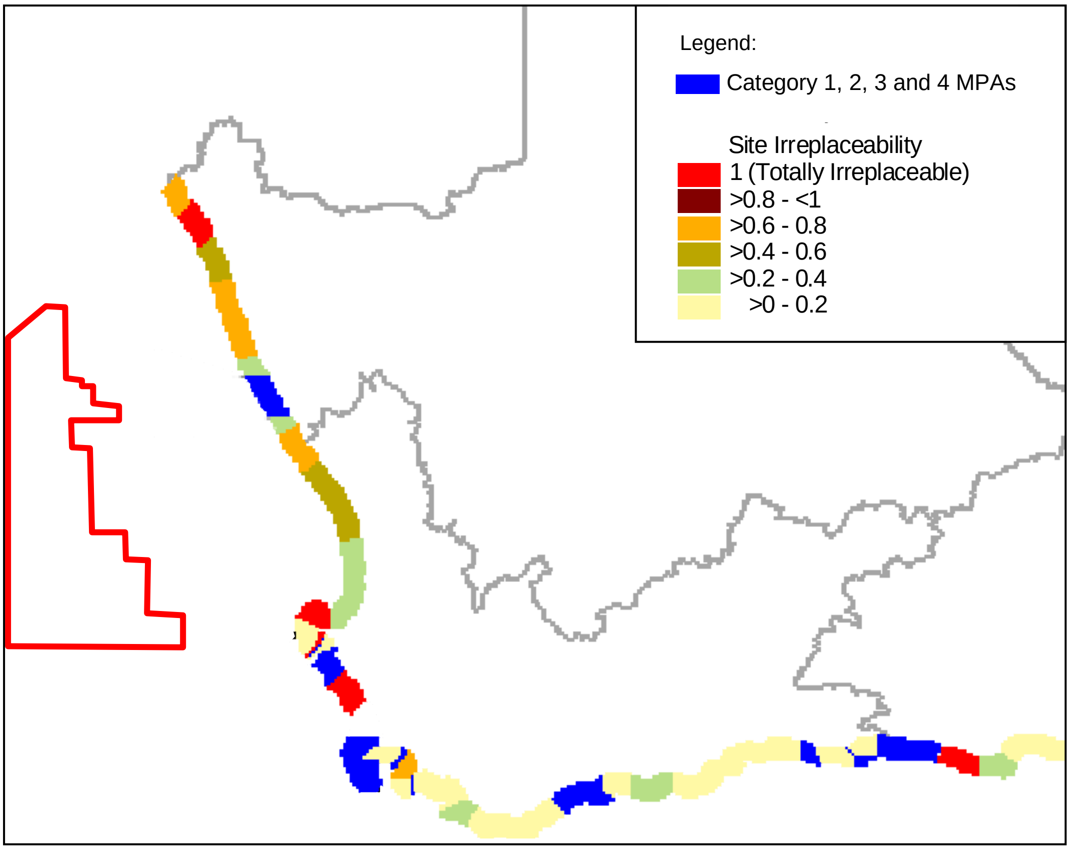


Figure 4.46: Irreplaceability analyses for intertidal habitats, in 50 km strips around South Africa, per bioregion (adapted from Lombard and Strauss 2004). The approximately location of the licence block is also shown.

4.2.2 OCEANOGRAPHY

This section briefly describes the oceanography of the coastal region of the West Coast of South Africa, which comprises rocky shores, sandy shores and kelp beds.

4.2.2.1 Rocky shores

Approximately 53% of the West Coast (west of Cape Agulhas) is rocky shore. Over 80% of this rocky shore comprises exposed rocky headlands, the balance being wave cut platforms (Jackson and Lipschitz 1984). The biota of the rocky shores of the study area is classified as cool temperate and forms one of the four main biogeographic provinces of southern Africa. Rocky shore faunal diversity is low although biomass may be high (Branch and Griffiths 1988), while floral diversity and biomass are high (Bolton 1986).

The fauna of rocky shores of the West Coast show distinct up/down-shore zonation into five zones including:

1. The *littorina zone* (also known as the supralittoral or splash zone) extends from the highest reaches of spring high tide to the normal high tide level. This area is dry much of the time, but is sprayed with salt water during high tides. It is only flooded during storms and extremely high tides. It is so named because of the dominance of small periwinkles of the genus *Littorina*. On the west coast the dominant periwinkle is *Littorina africana*. The red algae *Porphyra capensis* is the only notable floral representative of this zone.
2. The *upper balanoid zone* (also known as the upper-eulittoral, high tide or high intertidal zone) is flooded only during high tides. This zone is usually dominated by large numbers of barnacles.

However, although barnacles such as *Tetraclita serrata* and *Chthamalus dentatus* are present in the Namaqualand bioregion, the limpet *Patella granularis* (and to some extent *P. granatina*) is by far the most common animal species. The green alga called "sea lettuce" (*Ulva* spp.) is the most common floral representative found in this zone.

3. The *lower balanoid zone* (also known as the mid-eulittoral zone) is flooded twice a day. It is the first zone in which algae is well represented (Branch & Griffiths 1988). The red algae *Gigartina radula, Gigartina stiriata, Aeodes orbitosa* and *Champia lumbricalis* as well as the brown alga *Splachnidium rugosum* occur in this zone, whilst the limpet *P. granatina* is the most common faunal species. The tubeworm *Gunnarea capensis* may form distinctive colonies in this zone along the southern parts of the Namaqua bioregion.
4. The *cochlear / argenvillei zone* (also known as the lower-eulittoral zone) is covered and uncovered twice a day with salt water from the tides. Along the Namaqualand coast, the zone is dominated by very dense aggregations of the limpet *P. cochlear* in the south and *P. argenvillei* in the north. Depending on the local conditions, the black mussel, *Choromytilus meridionalis* is also present, and can completely displace the limpets along rocky shores exposed to strong wave action. The Mediterranean mussel (*Mytilus galloprovincialis*) appears to be displacing the black mussel along the Namaqualand coast, in turn. The definitive flora in this zone is coralline encrusting algae.
5. The *intertidal zone* can be divided into the sublittoral fringe, infratidal zone and sublittoral zone. In the study area the region stretching from the low tide level to, and including, the kelp beds is considered to be the sublittoral zone. Along the central Namaqualand coast this zone is dominated by the Mediterranean mussels, rock lobsters, sea urchins and various red algae.

A number of predatory species are associated with the fauna found along the rocky shores of the central parts of the Namaqualand coast. These include the whelks such as *Natica tecta*, *Nucella cinulata* and *N. dubia*; the starfish (*Marthasterias glacialis)*; tidal pool fish such as the klipvis (*Clinus superciliosus)*; the common octopus (*Octopus vulgaris)* and seabirds, primarily the African oyster catcher (*Haemaptopus moquini)*. The African oyster catcher is listed in the South African Red Data Book as "Near-threatened". Scavengers such as the shore crab (*Cyclograpsus puncatus)* and the kelp gull (*Larus dominicanus)* are also common along these shores.

4.2.2.2 Sandy shores

Approximately 37% of the West Coast comprises sandy beaches. Apart from the larger bays such as St Helena Bay, the sandy shores within the study area are exposed to strong wave action.

There has been little work on sandy beach ecology between Walvis Bay and St Helena Bay (Branch and Griffiths 1988). The invertebrate fauna is cool temperate and relatively consistent throughout the region (Field and Griffiths 1988). Sandy beaches have no stable substrate for plant attachment and consequently have little or no primary production. Major nutrient input into Benguela beaches arise from beach cast kelp wrack and upwelling-related coastal phytoplankton in the nearshore region. Macrofaunal species are generally primary or secondary consumers and can be divided into four major trophic groups, including air breathing scavengers, aquatic particle feeders, aquatic scavengers and predators.

The South African sandy beach up/down-shore environment can be divided into a number of zones (Brown and MacLachlan 1990) (see Figure 4.47) including:

1. The *supralittoral zone* runs from the foredunes to the high water drift line. The sand remains mostly dry. The dominant force disturbing the substrate in this zone is the wind. The zone is populated by insects and air-breathing crustaceans.
2. The *littoral or intertidal zone* extends from the high tide drift line down to the low tide mark. This zone is flushed periodically by the changing tide, and the sand is generally damp. The dominant force in this zone comes from the swash. No macro-flora grows in this zone, especially on an exposed beach. Near the drift line, air-breathing crustaceans such as the pill bug isopod (*Tylos granulatus)* or the

beach hopper amphipod (*Talorchestia capensis)* are common, as well as some oligochaete worms, usually found under rotting beach cast seaweed. Further down the beach, isopods such as the right-angle beach louse (*Eurydice longicornis)* and the wide-foot beach louse (*Pontogeloides laticeps)* typify the mid-shore region. Also common to this region of the zone are polychaete worms such as *Scolelepis squamata.* While the white sand mussel (*Donex serra)* occurs in certain instances, it apparently is not found in the Port Nolloth region. In the lower reaches of the intertidal zone, including the sublittoral fringe, the common organisms are the surf mysid shrimp (*Gastrosaccus psammodytes*) and a ubiquitous gastropod scavenger, the finger ploughshell (*Bullia digitalis)*.

3. The *surf zone* starts below the low water level. In the surf zone the sand substrate is always saturated, and experiences strong wave action and currents. The sand bed is generally in a state of mobility in this zone. The macro-fauna found in this zone are much the same as that which occurs in the sublittoral fringe, with some species of amphipods present. Micro-flora in the form of diatoms can be an important component in this zone, migrating between the water column during the day and the sandy substrate at night. High densities of these diatoms can result in semi-stable formations of foam in the inner surf zone.
4. The *transition zone* occurs between the turbulence of the surf zone and the more stable outer turbulent zone. This is the region across which the wave break line will range, depending on the prevailing weather conditions.
5. The *outer turbulent zone* is typified by a return to stability after the turbulence of the surf zone. The currents are weak compared to the surf zone, and although the effects of wave surge are apparent, the sandy substrate is stable enough to be colonised by macro-fauna including amphipods and other small crustaceans, tube-building polychaetes such as *Nephys* spp., delicate cnidarians and anemones such as *Anthopleura michaelseni.*

The three-spot swimming crab (*Ovalipes trimaculatus)* is probably the only resident predator on the sandy shores along the West Coast. The rest of the organisms that predate on the intertidal macro-fauna originate from outside of the sandy beaches. Birds are the most important predators when the shores are exposed during low tides; fish are most important when the shores are submerged during high tides. On exposed beaches the migratory sanderlings (*Calidris alba)* and white-fronted plovers (*Charadrius marginatus)* are the most common bird species, but African black oystercatchers (*Haematopus moquini)*, kelp gulls (*Larus dominicanus)*, Hartlaubs gulls (*Larus hartlaubii)*, turnstones (*Arenaria interpres)* and curlew sandpipers also visit the sandy shores of the West Coast. The galjoen (*Dichristius capensis)* and white steenbras (*Lithognathus lithognathus)* are representatives of the predatory teleost fishes in the region, as is the blue stingray (*Dasyatis chrysonota)* for elasmobranch fishes. There have also been reports of the West Coast sole (*Austroglossus microlepis)* occurring in the sheltered embayment during periods of warmer water temperatures.

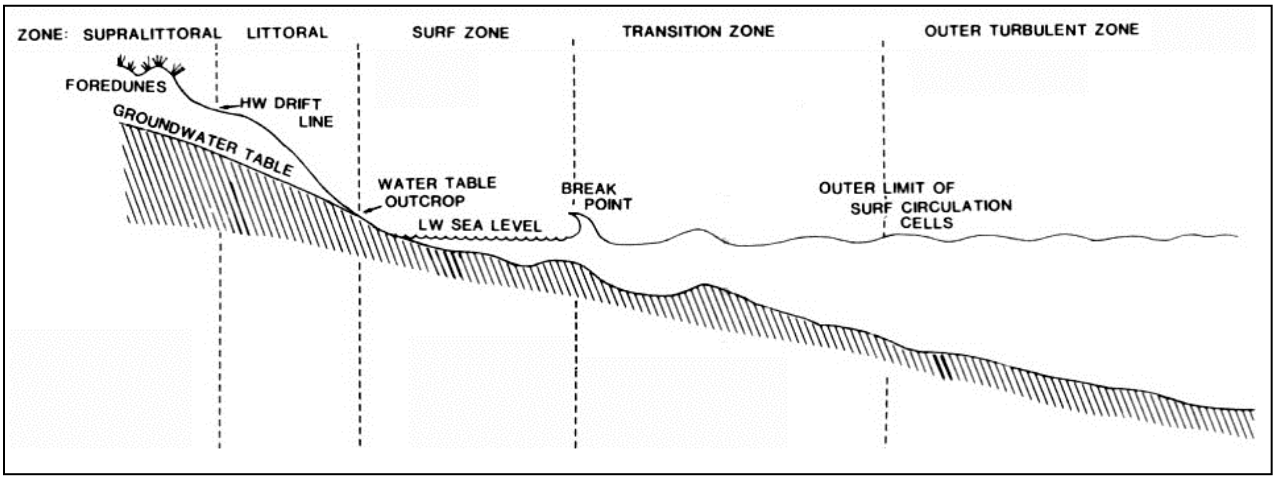


Figure 4.47: Generalised scheme of zonation on sandy shores (Modified from Brown & MacLachlan 1990).

4.2.2.3 Kelp beds

Kelp beds along the West coast of South Africa are characterised by four species, *Ecklonia maxima* reaching up to 12 m in length, *Laminaria pallida* and *Laminaria schintzei* reaching 5 m in length and the smaller species *Macrocystis angustifolia*. These kelp beds occur in shallow waters and extend from the shore to as much as 3 km offshore. Because of the clearer waters around Cape Point, kelp extends out to the 30 m depth contour (Branch, 1981).

The shallow kelp beds are colonised by relatively few faunal species, with diversity increasing on their deeper, seaward fringes (Branch and Griffiths, 1988). The faunal species include grazers such as the sea urchin (*Parechinus angulosus)*, limpet (*Patella compressa)*, kelp louse (*Paridotea reticulate)* and amphipods; and filter feeders including mussels, sponges, ascidians and barnacles. Carnivorous species are also represented, including anemones, whelks, starfish, fish and crustaceans (including the most important predator in the ecosystem, the West Coast rock lobster).

4.2.3 ANTHROPOGENIC ACTIVITIES

4.2.3.1 Mariculture industries

The following mariculture facilities can be found along the West Coast of South Africa (O'Sullivan 1998; DAFF 2011):

- Alexkor Diamond Mines has an oyster (*Crassostrea gigax*) growout system in the seawater reservoirs employed by diamond processing plants south of Alexander Bay, while a similar facility for oysters, perlemoen (*Haliotis midae*) and the red seaweed *Gracilaria gracilis* can be found at Kleinsee;
- A permit has been granted for perlemoen ranching within a 100 km long 0 to 20 m deep zone north and south of Port Nolloth. Oysters are also grown at Port Nolloth;
- A perlemoen aquaculture operation at Hondeklip Bay;
- Abalone, oysters and finfish are grown in Jacobs Bay;
- Abalone, mussels, seaweed, oysters, clams and scallops are grown in Paternoster;
- Oysters and seaweed are grown in St Helena Bay; and
- Mussels and oysters are grown within Saldanha Bay.

4.2.3.2 Recreational utilisation

Coastal recreation along the West Coast may be either consumptive or non-consumptive.

Consumptive recreational uses involve people collecting material from the sea for their own use. Recreational anglers (Brouwer, Mann, Lamberth, Sauer and Erasmus 1997) and divers (Mann, Scott, Mann-Lang, Brouwer, Lamberth, Sauer and Erasmus 1997) target linefish from either a boat or the shore, while shore-based divers also target perlemoen and West Coast rock lobsters. Rock lobsters are also exploited recreationally from boats with the use of hoop nets. The majority of recreational exploitation of marine resources occurs from inshore waters, and is not substantial compared to activities along the South and East Coasts.

Non-consumptive recreational uses of the marine environment include watersports, nature watching and beach recreation. Recreational practices are mostly undertaken near coastal settlements, and are largely practised for their aesthetic value. Recreational sites are listed by Jackson and Lipshitz (1984).

Although few resource economic studies exist for South African marine recreational use, the value of recreational coastal use and tourism should not be underestimated.

4.2.3.3 Marine outfall/intake pipes

Thirty-four outfalls, of which the majority are sewerage outfalls, and 17 intakes are located along the West Coast of South Africa. An important pipeline intake/outfall is the Koeberg Nuclear Power Station (located approximately 435 km to the south-east of the proposed area of interest); a thermal outfall, discharging warmed cooling water into the cooler coastal waters rather than a chemical effluent. A 2 nm marine exclusion zone exists offshore of the nuclear power station.

4.2.3.4 Marine Protected Areas

A number of conservation areas and marine protected areas (MPAs) exist along the West Coast, none of which are located within the licence area (see Figure 4.48 and Table 4.6).

As described in Section 4.1.4.6(d), a systematic biodiversity plan has been developed for the West Coast (Majiedt *et al*. 2013) with the objective of identifying both coastal and offshore priority areas for MPA expansion (see Figure 4.16). The closest coastal priority areas to the area of interest include the proposed “Namaqua MPA” focus area (250 km east), “Rietpoort” focus area (275 km east-southeast), and the focus area “North of Kleinzee” (225 km north-east).

The Orange River Mouth wetland located approximately 250 km to the north-east of the proposed area of interest provides an important habitat for large numbers of a great diversity of wetland birds and is listed as a Global Important Bird Area (IBA) (ZA023/NA 019) (BirdLife International 2005). The area was designated a Ramsar site in June 1991, and processes are underway to declare a jointly-managed transboundary Ramsar reserve. Further IBAs in the general project area include the Olifants River Estuary (ZA078), Verlorenvlei (ZA082), the Lower Berg River wetlands (ZA083) and the West Coast National Park and Saldanha Bay Islands (ZA 084).

There are also various conservation areas in southern Namibia (see Figure 4.49). The Sperrgebiet, which covers an area of approximately 26 000 km^2 between the Orange River in the south and latitude 26° in the north, extends inland from the coast for 100 km. The Sperrgebiet was proclaimed in 1908 to prevent public access to the rich surface diamond deposits occurring in the area. However, as diamond mining has remained confined to the narrow coastal strip and along the banks of the Orange River, most the area has effectively been preserved as a pristine wilderness. Although large parts of the Sperrgebiet have now reverted to unproclaimed State land, most of the area is not yet formally managed as a conservation area. The southern boundary of the Sperrgebiet is located at Oranjemund approximately 250 km north-east of the proposed area of interest.

The proposed Namibian Islands’ MPA (9 555 km^2), which comprises a coastal strip extending from Chamais Bay (27º57’S) in the south to Hollamsbird Island (24º38’S) in the north, has an average width of 30 km and includes 16 specified offshore islands, islets and rocks (Currie *et al.* 2008). The southern boundary of the proposed MPA is located approximately 300 km north of the project area of interest (see Figure 4.49). The purpose of the proposed MPA is to protect sensitive ecosystems and breeding and foraging areas for seabirds and marine mammals, as well as protecting important spawning and nursery grounds for fish and other marine resources (such as rock lobster). The proposed MPA includes a rock-lobster sanctuary constituting 478 km^2 between Chameis Bay and Prince of Wales Bay and a linefish sanctuary. The offshore islands, whose combined surface area amounts to only 2.35 km^2, have been given priority conservation and highest protection status as they serve as vital breeding grounds for a variety of seabirds that breed in Namibia, most of which are listed Red Data species in Namibia (Currie *et al.* 2009). Of particular importance are the African Penguin, Bank Cormorant and Cape Gannet, which are listed as Endangered and Near Threatened.

Table 4.6: List of marine conservation areas along the West Coast of South African.

Bioregion	Marine Protected Area	Protection	Location
Namaqualand	McDougall's Bay Rock Lobster Sanctuary: 2.5 km of coastline, 3 km south of Port Nolloth	No rock lobsters may be caught.	29°14' S 16°52' E
	Robeiland / Kleinzee Seal Colony Robeiland: 15 km north of Kleinzee	Island reserve for seabirds and seals, no access	29°33' S 16°59' E
	Elephant Rocks (Olifant's River Mouth)	Island reserve for seabirds and seals, no access	31°38' S 18°07' E
	Penguin / Bird Island (Lambert's Bay)	Island reserve for seabirds and seals, no access	32°05' S 18°18' E
	Rocherpan Marine Reserve: Adjacent to the Rocherpan Nature Reserve extending 500 m seaward, 2.75 km of coastline (in process of being registered as a declared reserve)	Exploitation limited to shore-based angling.	32°35'-37' S 18°07' E
	St Helena Bay Rock Lobster Sanctuary From Shelly Bay Point to Stompneus Point, extending three nautical miles seaward of the high-water mark; From Stompneus Point to SHBE/DR beacon, extending six nautical miles seaward of the high-water mark	No rock lobster may be caught	32°43' S 18°00'-07' E
South-Western Cape	Paternoster Rocks – Egg and Seal Island: Between Great Paternoster Point & Cape Columbine	Island reserve for seabirds and seals, no access.	32°44' S 17°51' E
	Jacob's Reef: Jacob's Baai	Island reserve for seabirds and seals, no access	32°57' S 17°51' E
	Malgas Island, Jutten Island and Marcus Island Marine Protected Areas: Saldanha Bay	No person permitted on the islands and no fishing allowed along the shores. Marcus Island is a 'no-take' MPA	33°02' S to 33°05' S
	West Coast National Park: Langebaan Lagoon north of a line drawn from beacon LB3 at Oesterwal to beacon LB4 at Preekstoel, south of Kraal Bay. Jutten, Malgas, Marcus and Schaapen. Langebaan Lagoon MPA Saldanha Bay	Only angling and bait collection are permitted Ramsar Site since 1988 and zoned MPA. Zone A: harvesting allowed; Zone B: no extractive removal; Zone C: no entry. No rock lobster fishing between North Head and South Head, No net, netting or long-line may be used.	33°02' S to 33°12' S
	Sixteen Mile Beach (including Vondeling Island): Plankies to Rooipan se Klippe (near Yzerfontein).	No fishing from the shore	33°08' S to 33°19' S

Bioregion	Marine Protected Area	Protection	Location
	Within 12 nm seaward of the high water mark between Melkbos Punt and “Die Josie” at Chapmans Peak	No fishing, collecting or disturbing of rock lobsters	33°44’S to 34°05’S
	Within 12 nm seaward of the high water mark between Klein Slangkop Point and Slangkop Point Lighthouse	No fishing, collecting or disturbing of rock lobsters by commercial permit holder	34°07’36S to 34°09’S
	Table Mountain National Park MPA	Fishing allowed in the majority of the MPA, subject Department of Agriculture, Fisheries and Forestry permits, regulations and seasons. Six "no-take" zones where no fishing or extractive activities are allowed.	33°54’S to 34°23’S

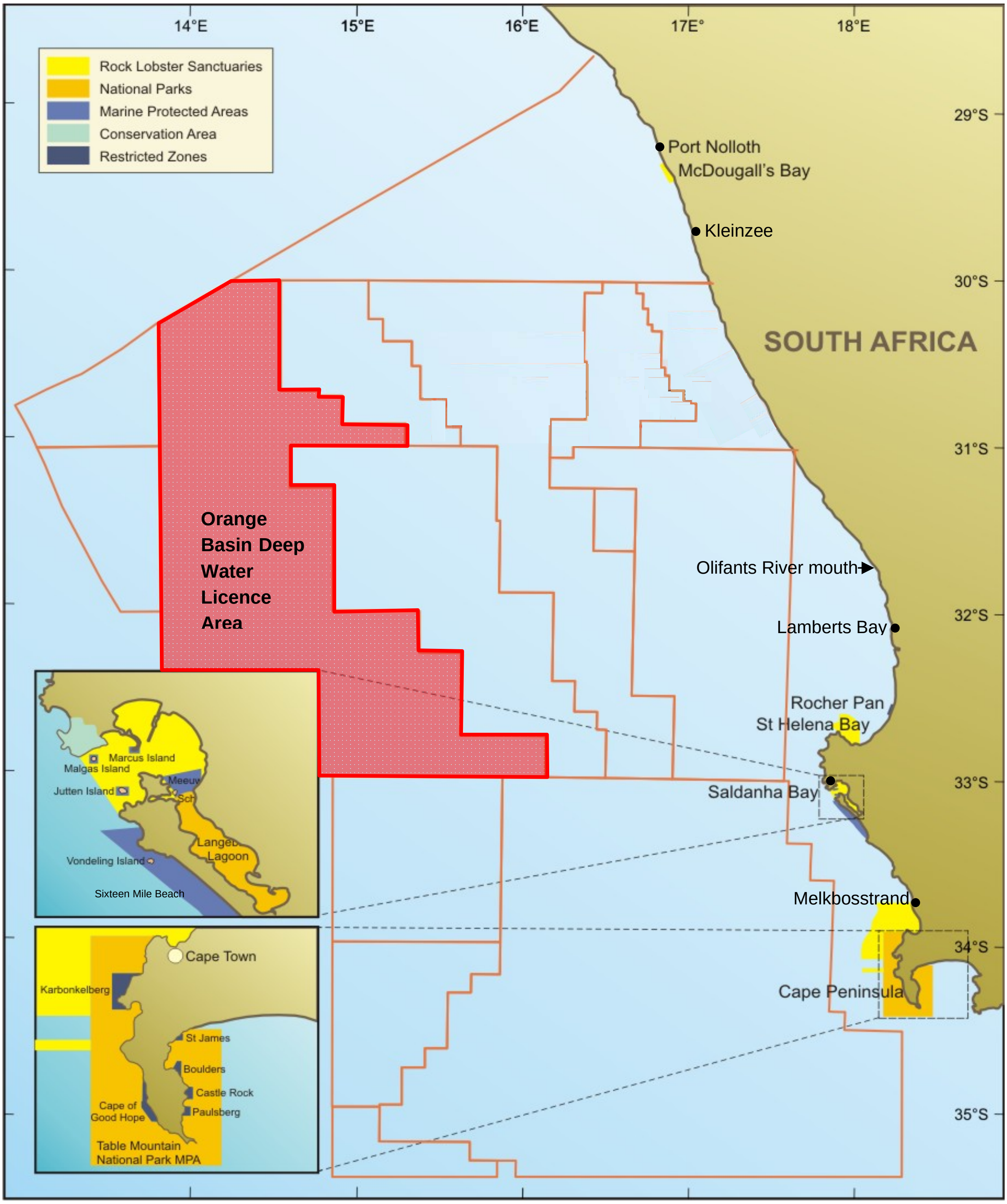


Figure 4.48: The Orange Basin Deep Water Licence Area in relation to reserves and Marine Protected Areas on the West Coast.

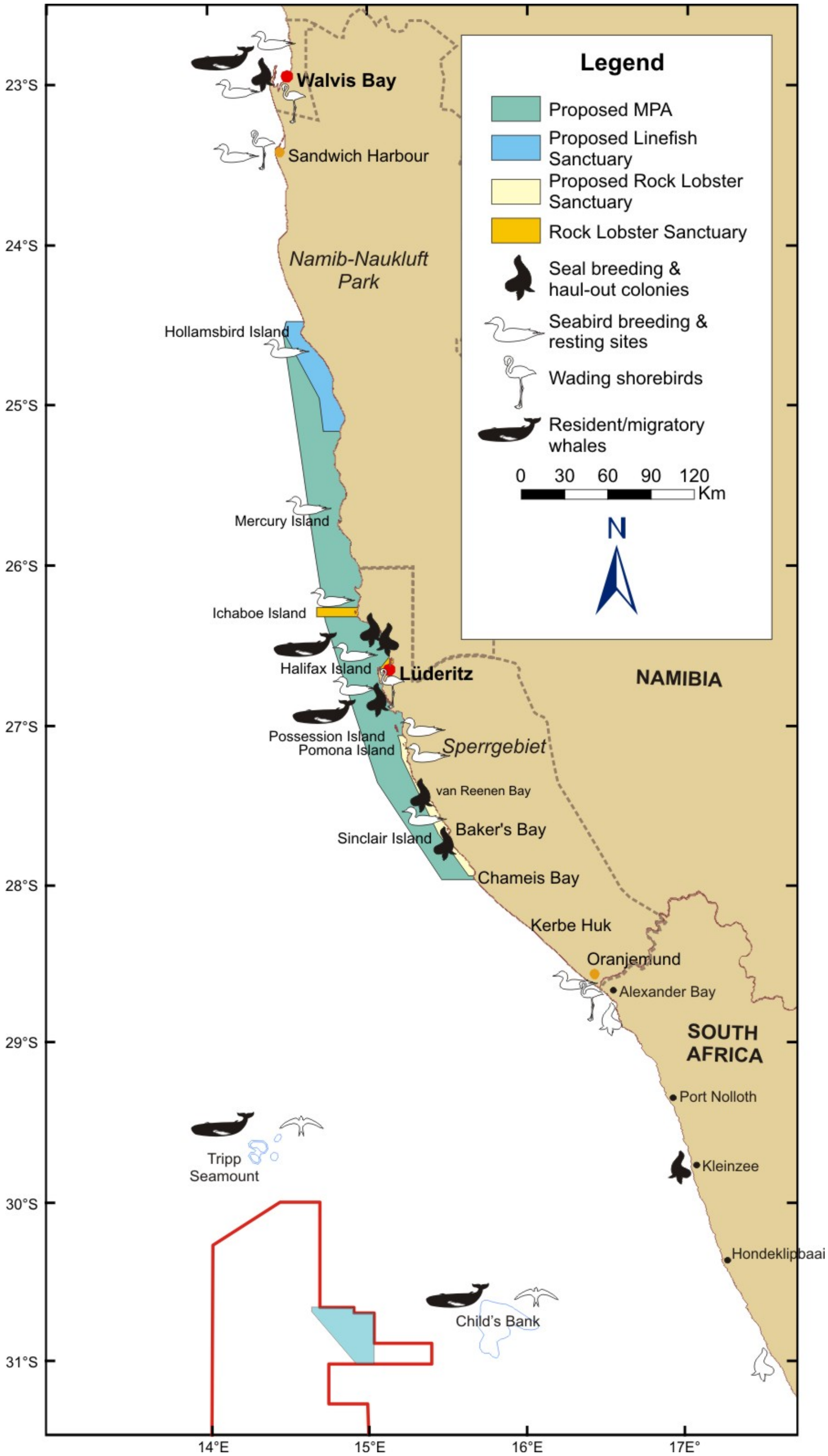


Figure 4.49: **Project - environment interaction points in southern and central Namibia illustrating conservation and marine protected areas, seal colonies and seabird breeding areas in the coastal region in relation to the licence area and proposed area of interest.**

5. KEY PROJECT ISSUES

A number of key issues have been identified during this Scoping Study to date. The key issues described in this chapter have been identified by the EIA project team with input from I&APs. These are presented below, together with responses by the EIA project team. The sequence in which the issues are listed are in no order of priority or importance.

The verbatim issues and concerns raised by I&APs during the Scoping Study to date have been compiled into a Comments and Responses Report (see Appendix 2.9). All written comments received from I&APs are included in Appendix 2.8.

5.1 EFFECT ON MARINE FAUNA

Issue: The proposed exploration drilling operation could result in a number of impacts on marine fauna, specifically marine benthic habitats. Potential impacts include:

- Emissions from the combustion of diesel fuel for generators and other machinery used to power the drilling operations and vessel engines, aviation fuel for aircrafts and helicopters, as well as the burning of wastes and flaring;
- Normal discharges to the marine environment from a variety of sources, including deck drainage, machinery space drainage, sewage and galley wastes from the drilling unit and support vessels;
- Localised disturbance of marine fauna due to noise and lighting from the drilling unit and support vessels;
- Physical damage to the seabed and sediment disturbance due to drilling activities and placement of infrastructure on the seafloor;
- Smothering of relatively immobile or sedentary benthic species or biochemical effects (e.g. direct toxicity and bioaccumulation) due to the discharge of cuttings, drilling fluid and cement during well drilling;
- Increased biodiversity and biomass on wellhead due to the increased amount of hard substrate available for colonisation by benthic organisms;
- Introduction of non-indigenous invasive marine species through vessels and equipment transfer and ballast water discharge; and
- Accidental oil spills during normal operations (e.g. bunkering at sea), as well as the unlikely event of a large blow-out. Oil spilled in the marine environment would have an immediate detrimental effect on water quality.

Response: Potential impacts on marine fauna will be addressed in the marine faunal assessment (see Section 6.2.3) with input from the oil spill and cuttings dispersion modelling (see Section 6.2.2).

The marine faunal assessment will assess the potential impacts relating to the proposed well drilling operation on the marine environment, as well as accidental oil spills during normal operations. In order to assess the potential impacts related to an accidental oil spill it is necessary to establish the likely extent of a small spill, which would depend on, *inter alia*, the size and nature of the spill and metocean conditions within the licence area. The information gained from the oil spill modelling would then be fed into the marine faunal assessment.

5.2 EFFECT ON FISHERIES

Issue: The proposed project could have an impact on commercial and recreational fishing activities, as a result of the proposed 500 m safety zones around the drilling unit during exploration and the presence of a wellhead on the seafloor in the case that the wells are abandoned on the seafloor. Impacts could include disruption to fishing activities and decreased fishing effort; loss-of-access to fishing grounds; and the subsequent loss of catch.

Accidental oil spills during normal operations, as well as the unlikely event of a large blow-out, could also have an impact on fishing activities.

Response: A fishing industry assessment will be commissioned to, *inter alia*, determine the fishing effort and catch (recent and historical) of all fisheries operating off the West Coast in relation to the proposed drilling area. The assessment will also assess the impact that the proposed project would have on these sectors during normal drilling operations and upset conditions (small accidental spills and large blow-out) with input from the oil spill modelling (see Section 6.2.2). The terms of reference for the fishing industry assessment are presented in Section 6.2.4.

5.3 EFFECT ON MARINE MINING AND EXPLORATION ACTIVITIES

Issue: Potential conflicts could result during the proposed well drilling operations if the spatial area of Shell's existing exploration right overlaps with mining rights holders in the area (e.g. diamonds, phosphate, heavy minerals, platinum group metals, gold, sapphires, manganese nodules and agricultural minerals, as well as oil and gas rights). While the drilling unit is operational, a temporary 500 m radius statutory activity safety zone around the drilling unit would be in force and localised temporary cessation of prospecting and mining in the safety zone could occur.

Response: The location of the proposed area of interest in relation to existing exploration and marine mining areas is presented in Sections 4.1.4.3 to 4.1.4.5. This impact will be assessed using experience gained from the environmental assessment of similar operations elsewhere in the region. Additional input from a specialist is not deemed necessary.

5.4 EFFECT ON MARINE TRANSPORT ROUTES

Issue: The presence of the drilling unit with the associated 500 m safety zone could interfere with shipping in the area.

Response: The majority of shipping traffic is located on the outer edge of the continental shelf with traffic inshore of the continental shelf along the West Coast largely comprising fishing and mining vessels, especially between Kleinzee and Oranjemund. Figure 4.51 & 4.52 show that the majority of the shipping traffic *en route* to and from Cape Town would pass though the licence area and possibility though the area of interest.

This impact will be assessed using experience gained from the environmental assessment of similar operations elsewhere in the region. Additional input from a specialist is not deemed necessary.

5.5 EFFECT ON SHIPWRECKS

Issue: Drilling activities and the installation of subsea infrastructure could disturb cultural heritage material on the seabed, particularly historical shipwrecks.

Response: The majority of known shipwrecks off the coast of South Africa occur in waters shallower than 100 m within 50 km of the coast. Thus the likelihood of disturbing a shipwreck is expected to be very small considering the vast size of the South African offshore area.

This unlikely impact will be assessed using experience gained from the environmental assessment of similar operations elsewhere in the region. Additional input from a specialist is not deemed necessary.

5.6 EFFECT ON SOCIO-ECONOMIC ENVIRONMENT

Issue: The proposed project could amongst others result in the following socio-economic impacts or benefits:

- Creation of limited employment opportunities;
- Skills development; and
- Generation of direct revenues associated with operational activities such as refuelling, vessel repair, etc.

Response: Exploration drilling is highly technical and requires specialised drilling units and crews, most of which are based outside South Africa. There would, however, be opportunities for local companies to provide support services in Cape Town / Saldanha and Kleinzee, e.g. vessel supplies, support vessels, helicopter operations, catering, cleaning, security, etc. Therefore, job creation opportunities would be limited and of very short duration (approximately three months per well).

Direct revenues would be generated as a result of the proposed drilling operations. Revenue generating activities are related to the actual operations and include refuelling, vessel / gear repair, port dues, helicopter services, hire of local fishing vessels as support vessel, and local employment and business opportunities.

These potential benefits will be assessed using experience gained from the environmental assessment of similar operations elsewhere in the region. Additional input from a specialist is not deemed necessary.

6. SPECIALIST STUDIES

This chapter presents the specialist studies that will be undertaken during the EIA Phase and the Terms of Reference for these studies, as well as the predefined rating scales that will be used to assess potential impacts.

6.1 INTRODUCTION

Three specialist studies will be undertaken to address the key issues that require further investigation and detailed assessment. These include:

1. Drill cuttings and oil spill modelling;
2. Marine faunal assessment; and
3. Fishing industry assessment.

Cuttings and oil spill modelling will use the metocean data available for the area of interest in order to model the extent and concentration of various discharge scenarios (including drilling cuttings and hydrocarbon spills). The other two specialist studies will involve the gathering of data relevant (including the results of the modelling study) to identifying and assessing environmental impacts that may occur as a result of the proposed project. These impacts will then be assessed according to pre-defined rating scales (see Section 6.3). Specialists will also recommend appropriate mitigation or optimisation measures to minimise potential impacts or enhance potential benefits, respectively. The results of the specialist studies will be integrated into a Draft EIR.

The terms of reference for these studies are presented in Section 6.2.

6.2 TERMS OF REFERENCE FOR THE SPECIALIST STUDIES

6.2.1 GENERAL TERMS OF REFERENCE FOR THE SPECIALIST STUDIES

The following general terms of reference will apply, where applicable, to the specialist studies:

- Describe the baseline conditions that exist in the study area and identify any sensitive areas that would need special consideration;
- Review the Issues and Responses Trail (see Appendix 2.9) to ensure that all relevant issues and concerns relevant to fields of expertise are addressed;
- Identify and assess potential impacts of the proposed operations;
- Identify areas where issues could combine or interact with issues likely to be covered by other specialists, resulting in aggravated or enhanced impacts;
- Indicate the reliability of information utilised in the assessment of impacts as well as any constraints to which the assessment is subject (e.g. any areas of insufficient information or uncertainty);
- Where necessary consider the precautionary principle in the assessment of impacts;
- Identify feasible ways in which impacts could be mitigated and benefits enhanced giving an indication of the likely effectiveness of such mitigation and how these could be implemented in the management of the proposed operation;
- To ensure that specialists use a common standard, the determination of the significance of the assessed impacts will be undertaken in accordance with a common Convention (see Section 6.3);
- Comply with DEA guidelines as well as any other relevant guidelines on specialist study requirements for EIAs;
- Include specialist expertise and a signed statement of independence; and
- Comply with Sections 17 and 32 of the EIA Regulations 2010, which specifies requirements for all specialist reports.

6.2.2 DRILL CUTTINGS AND OIL SPILL MODELLING

The specific terms of reference for the drill cuttings and oil spill modelling are as follows:

- Provide a description of the metocean conditions, such as winds and ocean currents in the licence area;
- Model the transport, dispersion and bottom deposition of drill cuttings discharged during drilling operations;
- Model the trajectory and fate of hydraulic fluid (1 ton) and diesel (10 tons) due to a small operational spill on the water surface at the drilling unit; and
- Model the trajectory and fate of crude oil due to a large blow-out spill under a 5-day and 20-day blow-out scenario.

6.2.3 MARINE FAUNAL ASSESSMENT

The specific terms of reference for the marine faunal assessment are as follows:

- Provide a general description of the local marine fauna and benthic biodiversity in the Orange Basin Deep Water Licence Area based on current available literature.
- Identify, describe and assess the significance of potential impacts of normal drilling operations and upset conditions (small accidental spills and large blow-out) on the local marine fauna. Impacts of normal drilling operations should focus particularly on the benthic environment, but including generic effects on cetaceans, turtles, seals, fish and pelagic invertebrates;
- Identify practicable mitigation measures to reduce the significance of any negative impacts and indicate how these can be implemented in the start-up and management of the proposed project.

6.2.4 FISHING INDUSTRY ASSESSMENT

The specific terms of reference for the fishing industry assessment are as follows:

- Provide a description of the fisheries sectors operating off the West Coast of South Africa;
- Undertake a spatial and temporal assessment of recent and historical fishing effort and catch in the proposed drilling area. Provide detailed maps delineating fishing grounds relative to the offshore Orange Basin Deep Water Block and proposed drilling site(s);
- Assess the risk of impact of the drilling activities on specific commercial fish species and the consequential implications for fish catch by the different fishing sectors;
- Assess the potential impacts of normal drilling operations (namely the proposed safety zones around the drilling unit) and upset conditions (small accidental spills and large blow-out) on the fishing activities in terms of estimated catch and effort loss; and
- Identify practicable mitigation measures to reduce any negative impacts on the fishing industry.

6.3 CONVENTION FOR ASSIGNING SIGNIFICANCE RATINGS TO IMPACTS

The marine faunal and fishing specialists will consider seven rating scales when assessing potential impacts. These include:

- Extent of impact;
- Duration of impact;
- Intensity of impact;
- Significance of impact;
- Status of impact;
- Probability of impact occurring; and
- Degree of confidence of assessment.

In assigning significance ratings to potential impacts before and after mitigation, specialists are instructed to follow the approach presented below:

- The core criteria for determining significance ratings are "extent" (Section 6.3.1), "duration" (Section 6.3.2) and "intensity" (Section 6.3.3). The preliminary significance ratings for combinations of these three criteria are given in Section 6.3.4.
- The status of an impact is used to describe whether the impact would have a negative, positive or zero effect of the surrounding environment. An impact may therefore be negative, positive (or referred to as a benefit) or neutral.
- Describe the impact in terms of the probability of the impact occurring (Section 6.3.5) and the degree of confidence in the impact predictions, based on the availability of information and specialist knowledge (Section 6.3.6).
- Additional criteria to be considered, which could "increase" the significance rating if deemed justified by the specialist, with motivation, are the following:
  - 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 if deemed justified by the specialist, with motivation, are the following:
  - Improbable impact, where confidence level in prediction is high.
- When assigning significance ratings to impacts *after mitigation*, the specialist needs to:
  - First, consider probable changes in intensity, extent and duration of the impact after mitigation, assuming effective implementation of mitigation measures, leading to a revised significance rating; and
  - Then moderate the significance rating after taking into account the likelihood of proposed mitigation measures being effectively implemented. Consider:
    - Any potentially significant risks or uncertainties associated with the effectiveness of mitigation measures;
    - The technical and financial ability of the proponent to implement the measure; and
    - The commitment of the proponent to implementing the measure, or guarantee over time that the measures would be implemented.

The fundamental question in the assessment of impacts is "to whom are the impacts significant". The significance ratings are based on professional scientific judgement criteria and inform decision-making from a scientific perspective. There may be instances, for particular impacts, where the significance ratings assigned by the specialists are deemed to be "low" or "very low", but in the opinion and perspective of an individual are unacceptable and of high significance. To resolve potential differences in perspective, the importance which I&APs attach to impacts must be taken into consideration.

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

Significance rating	Effect on decision-making
Very Low; Low	Would 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.

6.3.1 EXTENT

"Extent" defines the physical extent or spatial scale of the impact.

Rating	Description
LOCAL	Extending only as far as the activity, limited to the site and its immediate surroundings. Specialist studies to specify extent.
REGIONAL	West Coast. Specialist studies to specify extent.
NATIONAL	South Africa
INTERNATIONAL	

6.3.2 DURATION

"Duration" gives an indication of how long the impact would occur.

Rating	Description
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 process or 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.

6.3.3 INTENSITY

"Intensity" establishes whether the impact would be destructive or benign.

Rating	Description
ZERO TO VERY LOW	Where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected.
LOW	Where the impact affects the environment in such a way that natural, cultural and social functions and processes continue, albeit in a slightly modified way.
MEDIUM	Where the affected environment is altered, but natural, cultural and social functions and processes continue, albeit in a modified way.
HIGH	Where natural, cultural and social functions or processes are altered to the extent that it will temporarily or permanently cease.

6.3.4 SIGNIFICANCE

"Significance" attempts to evaluate the importance of a particular impact, and in doing so incorporates the above three scales (i.e. extent, duration and intensity).

Rating	Description
VERY HIGH	Impacts could be EITHER: of ***high intensity*** at a ***regional level*** and endure in the ***long term***; OR of ***high intensity*** at a ***national level*** in the ***medium term***; OR of ***medium intensity*** at a ***national level*** in the ***long term.***
HIGH	Impacts could be EITHER: of ***high intensity*** at a ***regional level*** and endure in the ***medium term***; OR of ***high intensity*** at a ***national level*** in the ***short term***; OR of ***medium intensity*** at a ***national level*** in the ***medium term;*** OR of ***low intensity*** at a ***national level*** in the ***long term***; OR of ***high intensity*** at a ***local level*** in the ***long term***; OR of ***medium intensity*** at a ***regional level*** in the ***long term.***

Rating	Description
MEDIUM	Impacts could be EITHER: of ***high intensity*** at a ***local level*** and endure in the ***medium term***; OR of ***medium intensity*** at a ***regional level*** in the ***medium term***; OR of ***high intensity*** at a ***regional level*** in the ***short term***; OR of ***medium intensity*** at a ***national level*** in the ***short term***; OR of ***medium intensity*** at a ***local level*** in the ***long term***; OR of ***low intensity*** at a ***national level*** in the ***medium term;*** OR of ***low intensity*** at a ***regional level*** in the ***long term.***
LOW	Impacts could be EITHER of ***low intensity*** at a ***regional level*** and endure in the ***medium term***; OR of ***low intensity*** at a ***national level*** in the ***short term***; OR of ***high intensity*** at a ***local level*** and endure in the ***short term***; OR of ***medium intensity*** at a ***regional level*** in the ***short term***; OR of ***low intensity*** at a ***local level*** in the ***long term***; OR of ***medium intensity*** at a ***local level*** and endure in the ***medium term.***
VERY LOW	Impacts could be EITHER of ***low intensity*** at a ***local level*** and endure in the ***medium term***; OR of ***low intensity*** at a ***regional level*** and endure in the ***short term***; OR of ***low to medium intensity*** at a ***local level*** and endure in the ***short term.***
INSIGNIFICANT	Impacts with: ***Zero to very low intensity*** with any combination of extent and duration.
UNKNOWN	In certain cases it may not be possible to determine the significance of an impact.

Note: For any impact that is considered to be “Permanent” apply the “Long-Term” rating.

6.3.5 STATUS OF IMPACT

The status of an impact is used to describe whether the impact would have a negative, positive or zero effect on the affected environment. An impact may therefore be negative, positive (or referred to as a benefit) or neutral.

6.3.6 PROBABILITY

“Probability” describes the likelihood of the impact occurring.

Rating	Description
IMPROBABLE	Where the possibility of the impact to materialise is very low either because of design or historic experience.
PROBABLE	Where there is a distinct possibility that the impact would occur.
HIGHLY PROBABLE	Where it is most likely that the impact would occur.
DEFINITE	Where the impact would occur regardless of any prevention measures.

6.3.7 DEGREE OF CONFIDENCE

This indicates the degree of confidence in the impact predictions, based on the availability of information and specialist knowledge.

Rating	Description
HIGH	Greater than 70% sure of impact prediction.
MEDIUM	Between 35% and 70% sure of impact prediction.
LOW	Less than 35% sure of impact prediction.

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