Mnr. Julius Malema

ANC-hoës na Italië waar Malema vakansie hou

MARIETTE LOUW-CARSTENS
Polokwane

'n Afvaardiging van senior regeringsleiers van Limpopo besoek Italië vandeesweek wanneer mnr. Julius Malema, leier van die ANC-jeugliga, glo daar met vakansie is.

The Sunday Times het eergister berig Malema span vir 'n week uit in Italië. Hoewel Malema nie wou erken hy gaan Italië toe nie, het van sy senior kollegas dit bevestig.

Malema het gesê hy wil rus ná die vol program wat hy gehad het sedert die munisipale verkiesing en die onlangse nasionale kongres van die ANC-jeugliga.

Dit is nie duidelik waar in Italië hy met vakansie is nie.

Luidens 'n verklaring van mnr. Cassel Mathale, premier van Limpopo, het hy en 'n afvaardiging Saterdag Italië toe gevlieg. Hulle keer Sondag terug.

Malema het aan die koerant gesê hy kom Saterdag terug.

Mathale lei 'n regeringsafvaardiging van Limpopo om handelsbetrekkinge met Italië te bevorder. Hulle wil ook beleggings van Italië na Limpopo lok.

Mathale word vergesel van mnr. Pitsi Moloto, LUR vir ekonomiese ontwikkeling, omgewingsake en toerisme, en me. Dipuo Letsatsi-Duba, LUR van landbou.

Mnr. Lawrence Mapoulo, uitvoerende burgemeester van die Capricorn-distriksmunisipaliteit, en mnr. Freddy Greaver, Polokwane se burgemeester, is deel van die afvaardiging.

Die afvaardiging sal kyk na maniere hoe om klein ondernemings in Limpopo uit te brei. Daar gaan ook 'n besoek gebring word aan 'n koömark wat deur die nywerheidsvereniging van Italië bedryf word.

Die handelsooreenkoms tussen die Noord-Italiaanse stad Reggio Emilia en Polokwane, wat in 2004 van stapel gestuur is, sal ook bespreek word.

Mnr. Pinti Mosomane, Mathale se woordvoerder, het gister uit Italië bevestig hulle is reeds daar. Hy het gesê hy dra geen kennis van Malema se vakansie in Italië nie.

Kaartjies van MyCiTi duurder

Kaapstad. – Pryse van die MyCiTi-lughawebusdiens styg Vrydag van R50 tot R53 per rit.

Dié styging is deel van die stadsraad se tariefverhogings wat aan die begin van die nuwe munisipale boekjaar op 1 Julie in werking tree.

Goeie nuus vir die MyCiTi-pendelaars op die Weskus- en binnestedelike roete is dat dié tariewe vir eers dieselfde bly. Dit kos R10 vir die hoofroete tussen Table View en die burgersentrum en R5 vir die aansluitingsroetes.

Die stadsraad het egter gewaarsku dat dié pryse verhoog kan word as die grootmaat-dieselprys tot meer as R10/ℓ styg.

Die verhoogde pryse van die lughawaroete gaan ook van toepassing wees op maandkaartjies. Kaartjies vir kinders onder 12 jaar oud en grootmaat-aankope.

Meer inligting oor die MyCiTi-busstelsel kan verkry word by www.capetown.gov.za/myciti of by die tolvry-inbelsentrum by ☎ 0800 65 64 63.

COSATU-KOMITEEVERGADERING

Gierigheid is nou siekte in ANC, erken Zuma

JAN DE LANGE
Aktueel

Pres. Jacob Zuma het gister vir die eerste keer erken dat geldgierigheid, magshonger en 'n gebrek aan dissipline enorme probleme in die ANC geword het.

Dit is dieselfde beskuldigings wat mnr. Zwelinzima Vavi, hoofsekretaris van Cosatu, die afgelope maande gemaak het.

"Die probleem is dat die regerende party se krag in sy oorheersing van die land se politieke toneel sy swak plek geword het," het Zuma gesê.

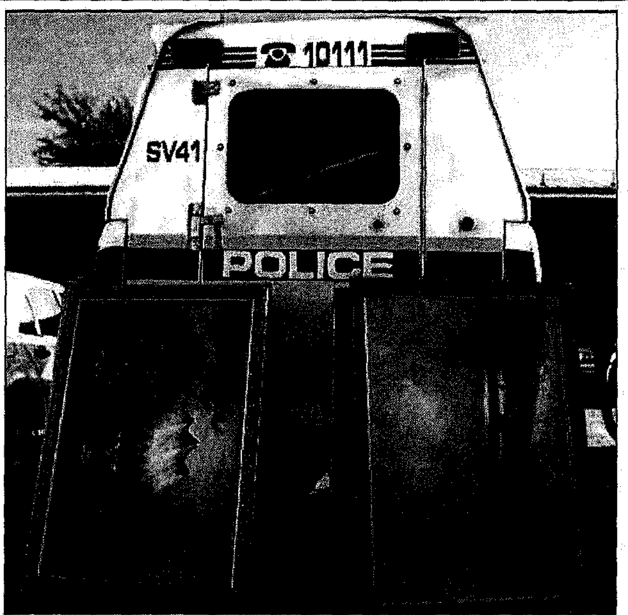
"Lede van kragtige organisasies glo hulle kan alles hanteer op maniere wat hulle pas en nie op maniere wat die omstandighede vereis nie.

"Ons beweging word deur 'n krisis in die gees geteister – dieselfde krisis wat alle sterk organisasies bedreig."

Geld het 'n siekte in die ANC geword. Dit word gebruik om selfbelange in die party te bevorder en het 'n uitwerking op hoe die hele organisasie bestuur word, het Zuma gesê.

Dit is waarskynlik voorbrand vir 'n striemende politieke verslag

[illegible]



Van die gesteelde goedere wat teruggevind is ná die rooftog by lt.genl. Mzwandile Petros, Gautengse polisiehoof (foto bo), se huis in Bryanston in Johannesburg. Nege mense is die naweek vasgetrek in verband met die voorval.
Foto's: THEANA BREUGEM

Nege vas ná rooftog by Petros se huis

HILDA FOURIE
Pretoria

[illegible]

Van die verdagtes wat sedert Saterdag aangekeer is in verband met die bewerde betrokkenheid by 'n rooftog by die huis van lt.genl. Mzwandile Petros.

...of die sindikaat toerusting eerder as spesifieke mense teiken.

"Huisrooftogte neem steeds toe," het Cele gesê.

"Miskien het die onsus wat die transitorooftogte en bankrooftogte uitvoer, geskuif na sagter teikens, soos huise en sakeondernemings. Ons glo ons het nou 'n ernstige sindikaat verspinter. Tog het ons steeds 'n probleem om op te los," het hy bygevoeg.

Lt.kol. Tshilizikhawe Ndou, [illegible]

Hoofregter 'sal berus' by besluit

Kaapstad. – Hoofregter Sandile Ngcobo gaan nie vier instellings se aansoeke in die konstitusionele hof beveg om die verlenging van sy ampstermyn ongrondwetlik te verklaar nie.

Ngcobo het gister in al vier die gevalle kennisgewings by die griffier van sy eie hof ingedien waarin hy sê hy berus hom by die besluit wat die konstitusionele hof, waarvan hy die hoof is, oor hom neem.

Die vier aansoeke is deur Freedom Under Law, die Justice Alliance of South Africa, die Sentrum vir Toegepaste Regstudies aan die Universiteit van die Witwatersrand en die Raad vir die Bevordering van die Grondwet ingedien.

Ngcobo se medeverweerders in al vier die aansoeke – pres. Jacob Zuma en mnr. Jeff Radebe, minister van justisie – het egter gister kennisgewings by die hof ingedien waarin hulle kennis gee dat hulle inderdaad al vier aansoeke gaan beveg.
– Philip de Bruin

Verslae oor watergehalte kom dié week

[illegible]

Suid-Afrikaners ingelig kan wees oor hul munisipaliteite se vermoë om watergehalte te bestuur.

Me. Edna Molewa, minister van waterwese, het egter volgehou dat die inligting eers hierdie week gedurende 'n drie dae lange waterberaad bekend gemaak sal word.

Die geleentheid word by die Kaapstadse Internasionale Konferensiesentrum gehou. – Politieke redaksie

Wedstryde van Bafana Bafana ook bekyk in hoëvlak-ondersoek na knoeiery

[illegible]

...se kragmeting met Colombia in die FNB-stadion (voorheen Soccer City) vier dae voor die stryd in Polokwane.

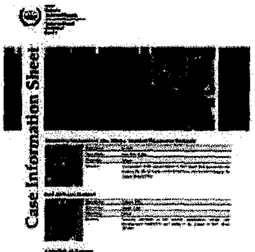
■ *Intuasen* het een van die voorste doelwagters in Korea se K-Liga gister glo erken hy het gehelp om die uitslag van wedstryde te knoei, berig Sapa. Griekse wetstoepassers het ook 83 name bekend gemaak as deel van 'n ondersoek na die knoeiery in dié land se voorste liga.

■ Phil Setshedi, 'n voormalige afrigter van Orlando Pirates, is vroeër uitgewys as die meesterbrein agter 'n poging om die uitslag van 'n uitspeelwedstryd tussen Vasco da Gama en Black Leopards te beïnvloed. – Sportredaksie

Internasionale strafhof het visier op Ghaddafi

LEOPOLD SCHOLTZ
Den Haag

[illegible]



Foto's van en inligting oor kol. Moeammar Ghaddafi, sy seun Saif al-Islam en Libië se intelligensiehoof, genl. Abdulla al-Senoessi, soos dit verskyn op 'n dokument in besit van die Internasionale Strafhof. Dié hof het gister lasbriewe op aanklagte van misdade teen die mensdom vir die drie mans uitgereik.
Foto: REUTERS

...bloedvergieting van Libiese burgerlikes veroorsaak.

Geweldlose betogings het eers geëis 'n demokrasie moet die Ghaddafi-diktatuur vervang.

Maar toe dié protes met bloed-

[illegible]

...van Ghaddafi insluit.

Maar pres. Jacob Zuma het Navo die naweek skerp aangeval en gesê hy oorskry die VN se Resolusie 1973, wat lugaanvalle toelaat.

Mnr. Luis Moreno-Campo, die internasionale strafhof se hoofvervolger, het al op 16 Mei gevra dié hof moet 'n lasbrief vir Ghaddafi, Al-Islam en Al-Senoessi se inhegtenisneming uitreik.

Is sé lasbrief 'kwel' Zuma

[illegible]

APPENDIX 3.4:

NOTES FROM INFORMATION-SHARING MEETING

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC ND CONTROLLED SOURCE ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA

Notes from Information-sharing Meeting held at the Cape Town Hotel School, Granger Bay, on 11 July 2011, 16h00

1. Welcome and introduction — Jonathan Crowther

Mr Jonathan Crowther (JC) of CCA Environmental (Pty) Ltd (CCA) opened the meeting and welcomed all those present (see attached Attendance Register). JC went through the agenda, ground rules and aims of the meeting (see attached presentation). The key aims were to provide a reasonable opportunity for Interested and Affected Parties (I&APs) to be involved in the study, ensure all potential key issues / impacts are identified and identify what issues / impact require further investigation.

2. Background and project description — Varsha Singh and Jessica Courtoreille

Ms Varsha Singh (VS) of PetroSA (Pty) Ltd presented the background to and details of the proposed project and associated exploration programme (see attached presentation). VS indicated that the proposed work programme for the first exploration period may include the undertaking of seismic and Controlled Source Electromagnetic (CSEM) surveys. The presentation included two short videos on seismic and CSEM surveys.

Ms Jessica Courtoreille (JCo) of PetroSA presented information on some of the standard mitigation measures implemented as part of PetroSA's normal operating procedure for a seismic survey in order to mitigate some of the anticipated impacts (see attached presentation).

3. Environmental Management Programme (EMP) study — Jeremy Blood

Mr Jeremy Blood (JB) of CCA gave a presentation on the key legislation related to the proposed project and the anticipated EMP study process. JB highlighted the key issues / impacts identified to date and indicated what specialist studies were envisaged (see attached presentation).

4. Discussion and questions

4.1 Russell Hall (RH) of Sea Harvest asked when the surveys would commence.

JCo indicated that PetroSA is hoping to commence with the first 2D seismic survey in February 2012, assuming the Exploration Right was issued before then. However, if the awarding of the Exploration Rights was delayed for whatever reason then the surveys may only commence in early 2013, as PetroSA would aim to miss the sensitive whale migration period and weather window, which is normally between June and December.

4.2 Roy Bross (RB) of the South African Deep-Sea Trawling Industry Association indicated that undertaking the survey in February 2012 would probably coincide with the annual fisheries survey on the West Coast, which is carried out by the fishery research vessel, *Afrikaner*.

RH indicated that the survey is undertaken along the entire West Coast of South Africa.

JC asked Sarah Wilkinson (SW) of Capfish (specialist sub-consultant) to contact the Department of Agriculture, Fisheries and Forestry (DAFF) to ascertain where and when the survey would be undertaken in order to determine the implications of the fisheries survey on the exploration programme.

RB indicated that there would be a certain amount of randomness in the fisheries survey sampling (stratified random sampling).

4.3 RH asked who would be undertaking the two identified specialist studies.

JB indicated that Capfish would be undertaking the fishing assessment and Pisces Environmental Services (Dr Andrea Pulfrich) would be undertaking the marine faunal assessment.

4.4 RB stated that the proposed survey lines seem to cut directly across the trawl grounds. He recommended that in order to reduce the impact on the trawling sector PetroSA should rather survey parallel to the bathymetry contours (i.e. follow the depth gradient as far as possible).

JC stated that some survey lines would more than likely be required to be undertaken perpendicularly to the bathymetry contours.

VS stated that this comment would be taken into consideration during detailed programme design, which would be in the order to 4 000 to 5 000 line kilometres.

4.5 JC asked if fishing was seasonal in the survey area.

SW indicated that most of the fishing sectors are active all year round. However, some are seasonal, e.g. Tuna Pole.

Steve Cameron-Dow (SC) of Fresh Tuna Exporters Association stated that the Tuna Pole sector operates between late October and June.

4.6 RH asked when "mining" would commence, if a survey was planned for February 2012.

VS indicated that once the 2D survey had been undertaken the data would be analysed. After data analysis target areas would be identified for further 3D seismic surveying, which could commence in 2014. Only if any likely targets were identified would well drilling take place, e.g. 2015/2016. VS indicated that the current EMP and exploration right application was only focussing on 2D/3D seismic and CSEM surveys.

4.7 RB asked if the impact on teleosts as a result of 2D/3D surveys was known. He asked if there was evidence of dead fishing floating on the sea surface during / after surveying.

JC indicated that there had been a lot of research done on the impacts relating to seismic surveys, and the marine faunal specialist study will include a review of some of this literature.

JC indicated that one of the duties of the MMO was to monitor marine faunal behaviour and injury / mortality. If it was noticed that there was mass mortality to fish or abnormal bird behaviour the survey would be temporarily terminated.

4.8 Annabelle Solle (AS) noted that there are some resident Southern Right whales off Yzerfontein. She indicated that there was enough food for them in the area.

JB stated that the scope of the marine faunal study included resident and migratory cetaceans.

JC stated that this information would be given to Dr Andrea Pulfrich (marine faunal specialist) for consideration in her report.

4.9 AS enquired about the potential income relating to the proposed project.

JCo explained that during the Exploration Phase this would be limited to refuelling and replenishment of supplies in the Cape Town Harbour. She indicated that it would be irresponsible for her to speculate on future income generation.

JC indicated that only once drilling had taken place would one know what the oil / gas reserves are or speculate what they could be.

4.10 AS asked if all exploration would be undertaken offshore.

JC confirmed that all exploration in Block 5/6 would be undertaken offshore.

4.11 RH asked if the CSEM survey would extend the total survey time.

JCo stated that the seismic and CSEM surveys were complimentary, but PetroSA would need to process data between surveys.

JB stated that the CSEM survey would effectively increase the duration of the total exploration programme, but noted it would not be continuous.

4.12 RB asked if the fishing industry had any concerns about the concrete anchor blocks required for the CSEM survey.

JCo indicted that the anchor blocks would be approximately 15 cm in height.

RH indicated that the anchors could be a problem for some of the demersal trawlers who trawled deeper into the sediment to catch certain fish species, as they would pick up the anchors in their nets. He stated that if the position of the anchors was made known, it could mitigate the impact to some extent.

4.13 Mike Shands (MS) of Oceana / BCP asked how long the CSEM receptors would be left on the seafloor before retrieval. He also queried the length of the CSEM survey lines.

VS indicated that the receivers would be picked up after one to two days.

JCo noted that the survey lines shown in the presentation were the indicative 2D survey lines. She noted that there would be fewer 3D and CSEM survey lines and that they would in all likelihood be shorter and be in a more concentrated area.

4.14 Carol de Kock (CdK) of Fresh Tuna Exporters Association expressed her concern as Block 5/6 covered their entire fishing ground. She asked if PetroSA could accommodate any changes to their survey programme if they where given two to three days notice of where they were fishing.

JCo indicated that the survey vessel operated on set survey lines and that it would probably be difficult to alter the programme at such short notice. However, she did indicate that this was something that they would need to consider.

JC stated that it was something that needed to be considered as possible mitigation in the EMP.

4.15 CdK noted that if PetroSA proposed to survey at night the fishing vessels might not be able to respond in time. This issues was supported by SW.

JC stated that this issue needed to be flagged and that possible mitigation needed to be considered.

JCo stated that there are a number of fisheries operating in the area and that PetroSA would need to develop a communication strategy (including who needed to be consulted and how this needed to be undertaken, etc.).

JC stated that PetroSA would need to discuss the survey programme with the fishing industry prior to surveying.

4.16 MS asked if the proposed survey in Block 5/6 would be the same as the pervious surveys along the West Coast. He also asked if any surveys had been undertaken in the 1990s.

JCo stated that the proposed survey would be similar to the 2D/3D survey they undertook in Block 1 in 2009.

VS indicated that there had been some surveys undertaken along the West Coast in the 1970s.

JC indicated that Soekor has undertaken a lot of historical seismic surveys and well drilling off the South African coastline.

4.17 CdK asked if any research had been done on the electromagnetic effects on fish.

JC indicated that the marine faunal specialist has been asked to look into this issue.

4.18 SW noted that no one from the hake long-line sector was present at the meeting and that they might be affected by the proposed exploration programme.

JC stated that it might be necessary to speak to the hake long-line sector.

JC closed the meeting stating that the comment period closes on the 17 July 2011. Meeting closed around 17h15.

PetroSA

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND CONTROLLED SOURCE ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA

ATTENDANCE LIST

PUBLIC INFORMATION-SHARING MEETING

MONDAY 11 JULY 2011, CAPE TOWN HOTEL SCHOOL, GRANGER BAY

NAME (& ORGANISATION) NAAM (& ORGANISASIE) IGAMA (& UMBUTHO)	POSTAL ADDRESS POSADRES DILESI YEPOSI	TEL. / FAX / E-MAIL TEL. / FAKS / E-POS IFOWUNI / IFEKSI / IMEYILI
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ROY BROSS	PO Box 2066 Cape Town 8000	Tel: 4252727 Fax: 4190785 Email: deepsea@iafrica.com
V. SINGH + J. COURTOREILLE PETROSA	151 FRANS CONRADIE DR, PAROW	Tel: 021 929 3000 Fax: 021 929 0423 Email: Varsha.Singh@petrosa.co.za
M. Sands Oceana / BCP	PO Oceana House Jan Smuts Avenue Foreshore C.T.	Tel: 021-5089745 Fax: Email: msands@bluecon.co.za
J. Coen APC	Stuiperlaan 6 1640 St-Genesius-Rode BELGIUM	Tel: +32 2 306 62 51 Fax: / Email: /
Greg Jewell APC	1 Waterway Ave The Woodlands TX	Tel: 832-636 ~~[illegible]~~ Fax: Email:
SARAH WILKINSON CAPFISH		Tel: Fax: Email: Sarah@capfish.co.za
Steve Cameron-Dow Fresh Tuna Exporters Association	~~Hout Bay Harbour~~ (24 ~~Stuartfield~~ Avenue ~~Wynberg~~. 7800)	Tel: 0837111072 Fax: 021 7905113 Email: longfin@iafrica.com
Annabelle Solke	POBOX 5809 Waterfront 8002	Tel: 0825777988 Fax: Email:

cca ENVIRONMENTAL

PetroSA

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND CONTROLLED SOURCE ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA

ATTENDANCE LIST

PUBLIC INFORMATION-SHARING MEETING

MONDAY 11 JULY 2011, CAPE TOWN HOTEL SCHOOL, GRANGER BAY

NAME (& ORGANISATION) NAAM (& ORGANISASIE) IGAMA (& UMBUTHO)	POSTAL ADDRESS POSADRES DILESI YEPOSI	TEL. / FAX / E-MAIL TEL. / FAKS / E-POS IFOWUNI / IFEKSI / IMEYILI
Greg de Vock. FTEA	PO Box 26973 Hout Bay 7872	Tel: 021 7905113 Fax: Email: longfin@iafrica.com
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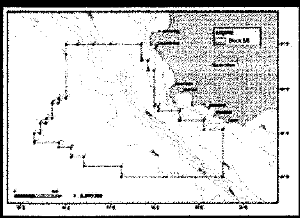
* Russell Hall of Sea Harvest also attended meeting

cca ENVIRONMENTAL

PetroSA

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND CONTROLLED SOURCE ELECTRO-MAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA



Information-sharing Meeting

11 July 2011

cca ENVIRONMENTAL

AGENDA

cca ENVIRONMENTAL PetroSA

- Welcome and Introduction (Jonathan Crowther of CCA)
- Background & Project Description (Varsha Singh & Jessica Courtoreille of PetroSA)
- Legislation and Study process (Jeremy Blood of CCA)
- Discussion & Questions

GROUND RULES

cca ENVIRONMENTAL PetroSA

- Please turn off cell phones
- Points of clarity only during presentations
- Discussion after presentation
- Please indicate by hand if you wish to comment
- Please identify yourself and which organisation you represent (if applicable)
- Please sign the Attendance Register
- Notes are being taken

AIMS OF MEETING

cca ENVIRONMENTAL PetroSA

- To provide information on the proposed exploration programme and study process.
- To provide I&APs a reasonable opportunity to be involved in the study.
- To ensure that all potential key environmental issues and impacts are identified.
- To identify any potential environmental issues and impacts requiring further investigation.

PetroSA

Block 5/6: Proposed Exploration Programme

11 July 2011

Introduction to PetroSA

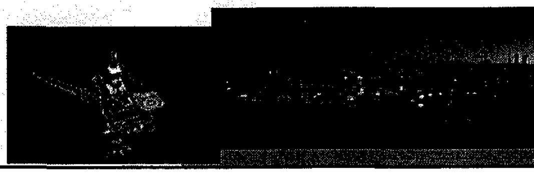
PetroSA is the state owned national oil company

South African operations include:

- Mossel Bay GTL Refinery and associated offshore gas operations via the F-A gas platform
- Orca oil production facility

South African exploration rights include:

- Block 9 and 11A
- Block 1
- Interests in Blocks 2A/2C and 3A/4A



Block 5/6

PetroSA has held a Technical Co-operation Permit over Block 5/6 since 2009.

During this time PetroSA has undertaken a number of desktop studies to assess the potential for hydrocarbons (oil and/or gas).

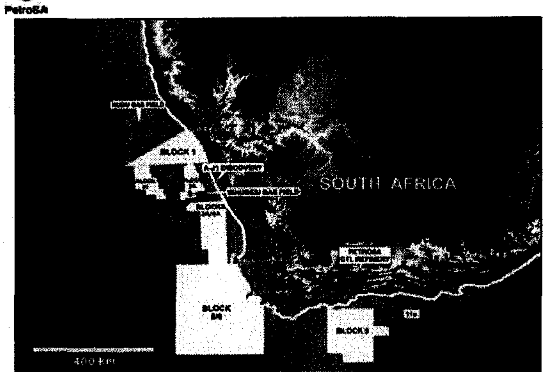
PetroSA now proposes to conduct additional studies in the block to further evaluate oil and/or gas potential. These may include:

- 2D and 3D seismic survey and
- Controlled Source Electromagnetic survey

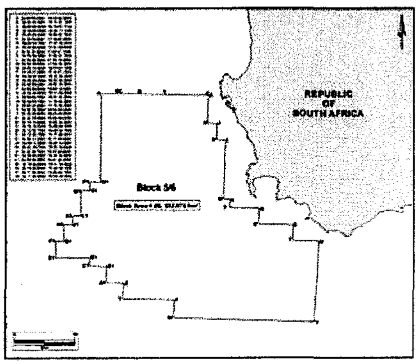
PetroSA has applied for an Exploration Right for Block 5/6 in order to conduct these studies and process the resulting data.

Exploration Activities in South Africa

PetroSA South African Assets

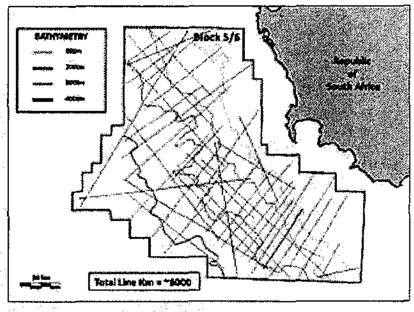


Block 5/6: Revised shape



PetroSA

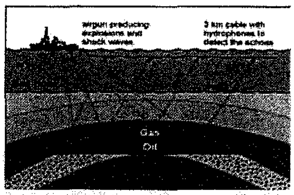
Diagrammatic representation of the survey lines within Block 5/6



These positions are only indicative at this stage and the location could change.

PetroSA

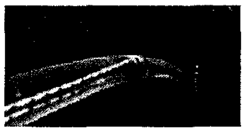
Seismic survey



High-level, low frequency sounds ara directed towards the seabed from near-surfaca airguns towed by a ship.

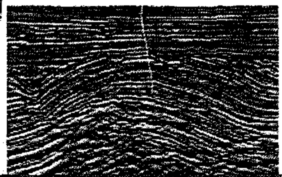
The airgun is fired at approximately 10-20 second intervals and the sound waves are reflected by boundaries between sediments of different densities within the seafloor.

Returned signals are processed by computer after being recorded by the hydrophone streamer.



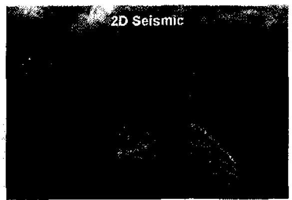
Analyses of the returned signals allow for interpretation of subsea geological formations.

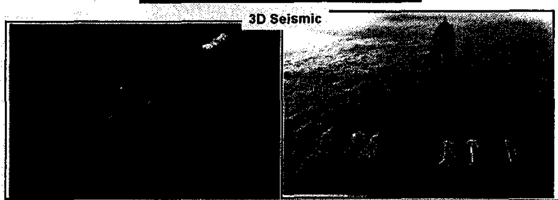
Seismic surveys are undertaken to collect either 2D or 3D data.



PetroSA

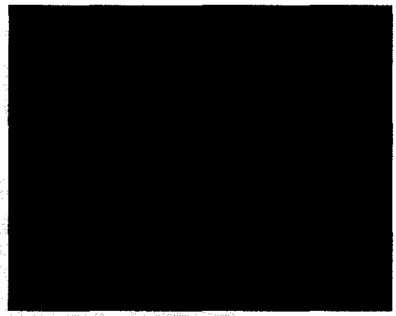
2D and 3D Seismic Acquisition





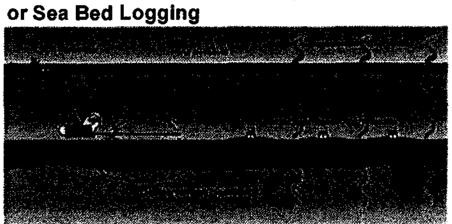
PetroSA

Introduction To Seismic



PetroSA

Controlled Source Electromagnetic Survey or Sea Bed Logging



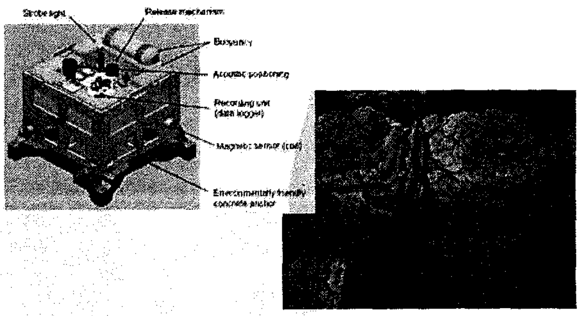
- CSEM uses electromagnetic remote sensing. A dipole source in a tow-fish is towed behind a vessel above the seafloor and transmits a time-varying electromagnetic field into the esrth.
- The electromagnetic field is modified by the presence of subsurface resistive layers. These changes are logged by an array of receivars placed on the seabed.
- CSEM can indicate the pressnce of oil and gas as hydrocarbon-bearing formstions are highly resistive compared with surrounding formations.
- CSEM is also used to determine whether seismically mapped reservoirs contain hydrocarbons or water.

PetroSA

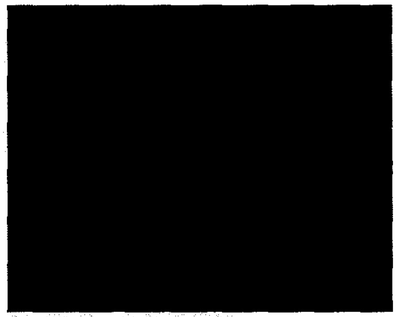
CSEM: The sequence of a typical survey

- Vessel arrives in the survey area and records a bathymetry profile along all the survey lines. This detailed bathymetry information is used when deploying the receivers and while towing the source.
- Receivers are deployed to the sea floor on all lines with approximately 1km spacing.
- The source is deployed and towed approximately 30-50m above the seabed across the receiver line or receiver field
- The receivers are recovered after completing the towed source lines, leaving their anchors behind to dissolve.

Seabed Logging Receiver



Controlled Source Electromagnetic Survey



Manoeuvrability

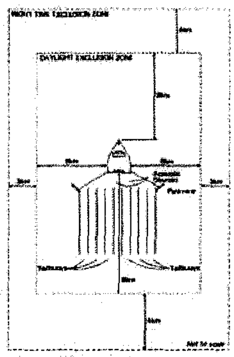
While surveying, a seismic or CSEM survey vessel is defined as a "vessel restricted in its ability to manoeuvre" (Merchant Shipping Act (No. 57 of 1951))

- Requires that vessels engaged in fishing shall, so far as possible, keep out of the way of such a vessel.

A survey vessel and its array of airguns and hydrophones also fall under the definition of an "offshore installation" (Marine Traffic Act (No. 2 of 1981))

- Protected by a 500 m safety zone.
- In addition to the statutory 500 m safety zone, a seismic contractor would request a safe operational limit (that is greater than the 500 m safety zone).

Typical Safe Operation Limits



Standard Mitigation Measures

- Survey periods are timed, where possible, to avoid marine mammal breeding period.
- Vessels required to apply a minimum soft-start procedure of 20 minutes.
- All vessels are required to comply with MARPOL requirements.
- Notification of all IAPs prior, during and at completion of survey.
- Marine Navigation Warnings issued via HydroSAN at the beginning and end of survey.
- Compliance with standard Health Safety and Environmental procedures.

Standard Mitigation Measures *cont.*

All vessels will have an Independent Observer / Marine Mammal Observer on board.

The functions of an MMO are to:

- Monitor and record/identify all marine fauna in the proximity of the survey vessel and specifically to note reactions and behaviour before, during and after the firing of the airguns during the survey operation;
- Monitor and ensure compliance of the operator to prescribed conditions as stated in the EMP;
- Submit a prescribed Daily Report on vessel activity, vessel sightings (and their reaction to the survey operations), marine fauna and environmental conditions; and
- Facilitate communications with mariners and specifically the fishing industry in the proximity of the survey area.

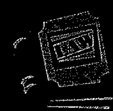
EMP STUDY PROCESS

- Legislative requirements
- Study process
- Issues to be investigated
- Specialist studies

LEGISLATIVE REQUIREMENTS

- Mineral and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA) and Regulations thereto:
  - An Exploration Right is required prior to the commencement of exploration activities.
  - Compile an EMP in term of Section 39.
  - Undertake a Public Consultation Process in terms of Section 10.

PetroSA has appointed CCA to undertake the public participation process and to prepare the EMP.

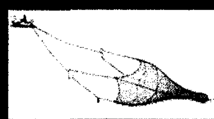


STUDY PROCESS

- Undertaken initial Public Consultation Process:
  - Advertise.
  - Distribute BID for 21-day comment period.
  - Information-sharing meeting.
- Undertake Specialist Studies.
- Compile EMP and release for 30-day comment period.
- Assimilate comments and finalise EMP.
- Submit to PASA for consideration.

ISSUES TO BE INVESTIGATED

- Noise and electromagnetic effects on marine fauna.
- Potential effects on the fishing industry due to temporary displacement of fishing activities.
- Interference with marine recreational activities and transport routes.
- Waste discharge to sea and atmosphere.



SPECIALIST STUDIES

- Fishing:
  - Terms of Reference:
    - Define the spatial extent of fishing activities.
    - Determine the fishing effort (no. of trawls/sets) as a percentage of total national effort.
    - Assess the potential impact and propose mitigation.
  - Fishing sectors operating in or around Block 5/6:
    - Tuna pole
    - Demersal trawl
    - Long-line (demersal and pelagic)
    - Pelagic purse-seine
    - Traditional line (recreational & commercial)

SPECIALIST STUDIES

- Marine fauna:
  - Terms of Reference:
    - Provide a general description of the local marine fauna.
      - marine mammals
      - fish
      - turtles
      - invertebrates
    - Assess the potential impacts on the local marine fauna, incl:
    - Identify practicable mitigation measures.
  - Impacts to be assessed:
    - Pathological injury and mortality.
    - Behavioural avoidance.
    - Reproductive success / spawning (where applicable).
    - Masking of environmental sounds and communication.
    - Indirect impacts due to effects on predators or prey.

BLOCK 5/6 EXPLORATION

cca ENVIRONMENTAL PetroSA

DISCUSSION & QUESTIONS

APPENDIX 3.5:

WRITTEN COMMENTS

WRITTEN COMMENTS RECEIVED ON EMP

DEPARTMENT of
ENVIRONMENTAL AFFAIRS
& DEVELOPMENT PLANNING
Provincial Government of the Western Cape

DIRECTORATE: LAND MANAGEMENT
REGION 2

Taryn.Maart@pgwc.gov.za
tel: +27 21 483 2707/2596; fax:+27 21 483 4372
1 Dorp Street, Cape Town, 8001
Private Bag X9086 Cape Town, 8000
www.capegateway.gov.za/eadp

REFERENCE: E12/2/4/7-F4/16-3257/11
ENQUIRIES: MS. T. MAART
DATE OF ISSUE: 31 AUG 2011

The Director
CCA Environmental (Pty) Ltd.
P.O. Box 10145
CALEDON SQUARE
7905

Attention: Mr. J. Blood

Tel: (021)461 1118
Fax: (021)461 1120

Dear Sir

RE: APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGENETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA (THE PETROLEUM AGENCY OF SOUTH AFRICA ("PASA") REFERENCE NUMBER IS: 12/3/1/224).

The Background Information Document dated 27 June 2011 and received by the Department on 04 July 2011, this Directorate's correspondence dated 06 July 2011 and your correspondence dated 24 June 2011 and received by this Directorate on 25 August 2011 refer.

Having considered the information contained in your correspondence dated 24 August 2011, you are hereby informed that this Directorate will provide comment on the Environmental Management Programme on receipt of the relevant documentation from the PASA.

You are required to quote the above-mentioned reference number in any future correspondence in respect of the application.

This Department reserves the right to revise or withdraw comments or request further information from you based on any information that might be received.

Yours faithfully

HEAD OF DEPARTMENT

Subject: Seismic Survey Around the South West Coast
From: "Judian Bruk" <judianbruk@telkomsa.net>
Date: 2011/09/01 03:09 PM
To: <jeremy@ccaenvironmental.co.za>
CC: "longline" <longline@mweb.co.za>

Dear Mr. Blood

The Demersal Shark Longline Association represent rights holders in the demersal shark longline sector.

The demersal shark longline fishery does not seem to appear in your assesment.

Please could you include us as IAP's and also ammend your material to reflect the oversight.

Kind Regards

Judian Bruk

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Enquiries: Dr A J Boyd
ajboyd@environment.gov.za
021 819 2470
25 September 2011

CCA ENVIRONMENTAL (Pty) Ltd
Unit 35 Roeland Square
30 Drury Lane
CAPE TOWN
8001
Info@ccaenvironmental.co.za
Jeremy@ccaenvironmental.co.za

ENVIRONMENTAL MANAGMEMENT PROGRAMME FOR EXPLORATION OFF THE SW CAPE BY SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENCE BLOCKS 5/6 (PASA REF NO. 12/3/1/224)

Dear Mr Blood

Thank you for the opportunity to comment on this Programme Report.

The area of proposed survey activities comprises the entire SW Cape Marine Area from approximately 120m deep to depths in excess of 3000m between Saldanha Bay and Cape Agulhas. No areas are excluded.

The EIA is supported through two specialist studies, looking at impacts on fishing issues and marine fauna.

The potential impact of exploitation activities which could follow successful exploration results are not considered.

This comment formal letter would like to focus on two areas, namely (1) the matter of the way the programme deals with mitigating the impact of survey activities on marine fauna such as whales, and (2) the way the programme does not deal with the potential impacts of subsequent exploitation which may follow exploration on marine biodiversity in the area in general.

1. The report recognises the effect of the proposed survey activities on large marine mammals in particular whales. This is rated as medium (without mitigation) and low (with mitigation). The sensitive period of June to December each year is noted in a number of places. Nevertheless the report is not unequivocal about avoiding such times entirely. Both sections 5 and 6.2 note that surveys need to avoid surveying during such times, but only as far as possible. In addition it is noted that decisions whether to survey in June and December could be done with consideration of whether and to what extent whales are present.

From the Oceans and Coasts (DEA) viewpoint this vagueness is not acceptable. The work must simply be properly planned not to start earlier than January and not to finish later than the end of May, namely outside the identified migratory and whale calving season.

Thus if the survey is to be undertaken in 2012 starting in February (as stated) it should be done so that it could be complete by the end of May with allowance for bad weather and other factors, or else restarted in January 2013 or else done entirely in 2013. These decisions are not mine to advise on but I AM LABOURING THE POINT - that the survey should not for whatever reason be allowed to run into June, or else start early in December. In any event the environmentally available months of January to May include most of settled weather months in the Southern Benguela Current System.

Within the period January to May best practise measures regarding such surveys should be followed.

2. The second point is that the planned surveys are being done for the purposes of guiding future exploitation. If the whole area is being surveyed, without acknowledging areas of potential high conservation importance, will the next phase build on this and similarly not exclude these areas? At what stage can the need for bioregionally representative protection of the south west coast (as per the National Protected Area Strategy and other documents) be accommodated through not letting activities be "wall-to wall"?

   In this particular instance the benthic biodiversity is impacted already by fishing, leaving less potential areas available for conservation of such features, which at this stage are still being investigated as part of conservation planning being undertaken by SANBI. Only when the current National Biodiversity Assessment due out later this year is finalized, will we be able to provide better context to threatened status of the region and the shelf edge region in particular, and therefore the Branch Oceans and Coasts of Department would like to reserve the position to place such areas outside those for which exploitation will be allowed, particularly in such context of very vulnerable or irreplaceable biodiversity as per such information becoming available in the next 6-12 months.

Dr Alan Boyd
Coastal and Biodiversity Conservation
Department of Environment Affairs
Cape Town
South Africa
Ph 021 819 2470 , Cell: 083 4123965, email: ajboyd@environment.gov.za

Sent from home - sandboyd@telkomsa.net - as the closing day for comments of 25 Sept 2011 is a Sunday.

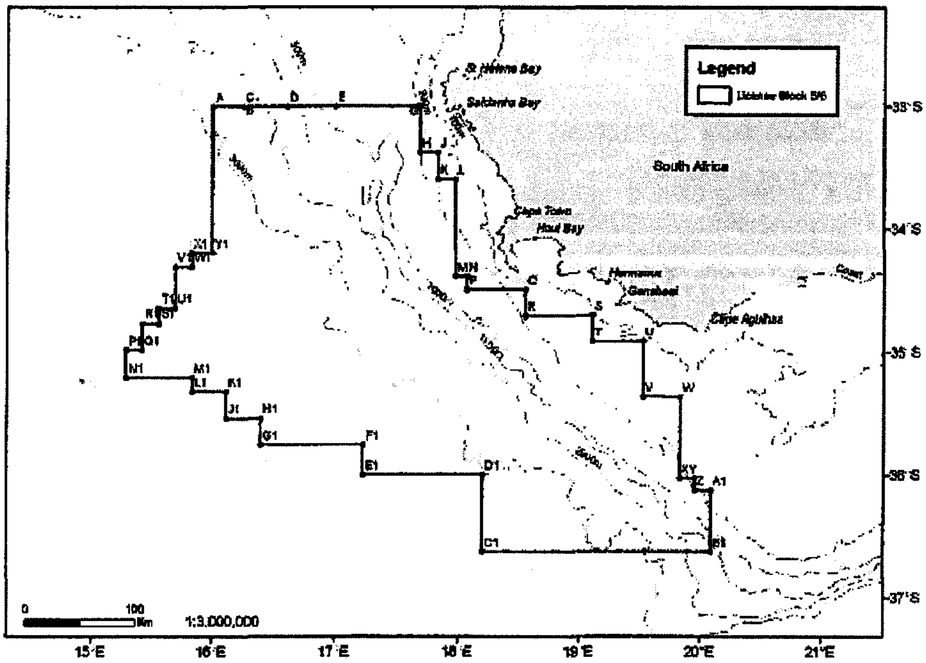


Figure 1: Locality of Blocks 5/6 off the South-West Coast of South Africa (source, Capfish).

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Private Bag X 447 · PRETORIA · 0001 · Fedsure Building · 315 Pretorius Street · PRETORIA
Tel (+ 27 12) 310 3911 · Fax (+ 2712) 322 2682

Ref: PASA 12/3/1/224
Enquiries: J Geeringh
Tel: (012) 310 3491 **Fax:** (012) 320 7539 **e-mail:** jgeeringh@deat.gov.za

Mr Jonathan Crowther
CCA Environmental
P O Box 10145
CALEDON SQUARE
7905

Fax no: 021 461 1120

PER FACSIMILE / MAIL

Dear Mr Crowther

ENVIRONMENTAL MANAGEMENT PROGRAMME (EMPR) IN RESPECT OF AN EXPLORATION RIGHT APPLICATION FOR TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH WEST COAST, SOUTH AFRICA (PASA REF: 12/3/1/224) IN TERMS OF THE MINERAL AND PETROLEUM RESOURCES DEVELOPMENT ACT, 2002 (ACT 28 OF 2002)

The letter dated 24 August 2011 regarding the above matter refers (Reference: 12/3/1/224)

The Department has considered the Environmental Management Programme Report (EMPR) and made the following findings.

The report is very comprehensive and the Department is of the opinion that the proposed seismic survey activity will not have a significant detrimental effect on the environment. The Department is however concerned about the possible timing of the project and the impact it may have on marine mammals. The implementation of the activity should be limited to the period between January and June to limit the possible impact on marine mammals as was also indicated by the submission by the Branch: Oceans and Coasts, a copy of which is attached to this letter.

The Department reserves the right to participate on the proposed activity in future, should further exploration activities be undertaken. Please be advised that the Applicant should ensure that the activities currently planned conform to all legislative requirements and the duty of care principal in terms of the National Environmental Management Act, Act 107 of 1998 as amended and the Regulations, 2010 as promulgated in terms of GN R 543, 544, 545 and 546.

The requirements of the National Environmental Management; Biodiversity Act (NEMBA), Act 10 of 2004 and the National Environmental Management: Protected Areas Act (NEMPAA), Act 57 of 2003, is of particular importance and must be adhered to by the Applicant. The Applicant must also ensure that the National Protected Area Expansion Strategy (NPAES) is duly considered when identifying the final areas of activity.

The Applicant must also ensure that the requirements of the Heritage Resources Act, Act 25 of 1999 are complied with and the necessary permits are obtained where applicable prior to any activity taking place which may have an impact on Heritage Resources.

Yours sincerely

Mr Ishaam Abader
Deputy Director-General: Environmental Quality And Protection
Department of Environmental Affairs
Letter signed by: Mr Dumisane Mthembu
Designation: Director: Environmental Impact Evaluation

Date: 29/09/2011

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Enquiries: Dr A J Boyd
ajboyd@environment.gov.za
021 819 2470
25 September 2011

CCA ENVIRONMENTAL (Pty) Ltd
Unit 35 Roeland Square
30 Drury Lane
CAPE TOWN
8001
info@ccaenvironmental.co.za
Jeremy@ccaenvironmental.co.za

ENVIRONMENTAL MANAGMEMENT PROGRAMME FOR EXPLORATION OFF THE SW CAPE BY SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENCE BLOCKS 5/6 (PASA REF NO. 12/3/1/224)

Dear Mr Blood

Thank you for the opportunity to comment on this Programme Report.

The area of proposed survey activities comprises the entire SW Cape Marine Area from approximately 120m deep to depths in excess of 3000m between Saldanha Bay and Cape Agulhas. No areas are excluded.

The EIA is supported through two specialist studies, looking at impacts on fishing issues and marine fauna.

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This comment formal letter would like to focus on two areas, namely (1) the matter of the way the programme deals with mitigating the impact of survey activities on marine fauna such as whales, and (2) the way the programme does not deal with the potential impacts of subsequent exploitation which may follow exploration on marine biodiversity in the area in general.

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Dr Alan Boyd
Coastal and Biodiversity Conservation
Department of Environment Affairs
Cape Town
South Africa
Ph 021 819 2470 , Cell: 083 4123965, email: ajboyd@environment.gov.za

Sent from home - sandboyd@telkomsa.net - as the closing day for comments of 25 Sept 2011 is a Sunday.

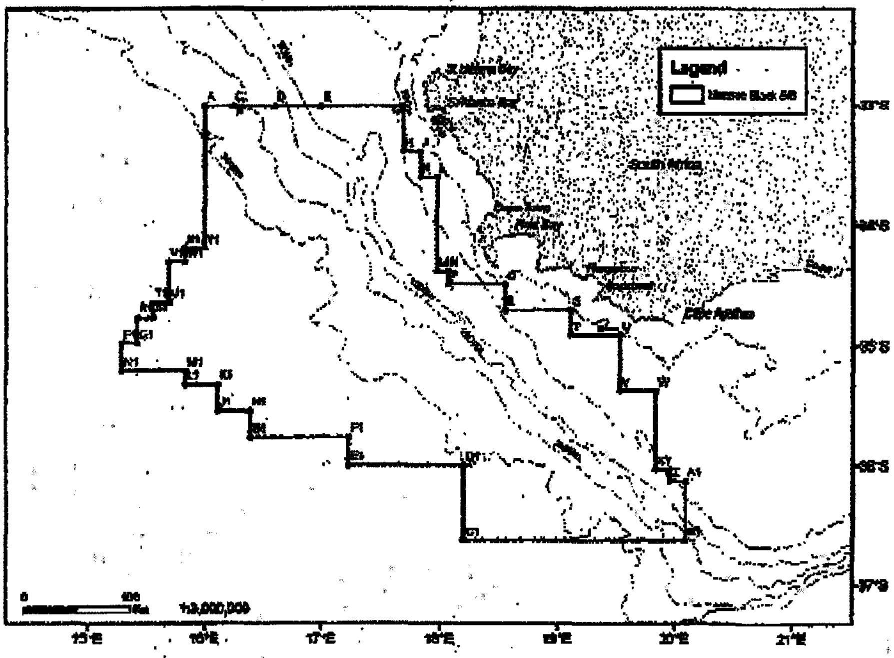

Figure 1: Locality of Blocks 5/6 off the South-West Coast of South Africa (source, CapGIS).

WRITTEN COMMENTS RECEIVED PRIOR TO THE RELEASE OF THE EMP FOR COMMENT

15 JUL 2011

DEPARTMENT of
ENVIRONMENTAL AFFAIRS
& DEVELOPMENT PLANNING
Provincial Government of the Western Cape

DIRECTORATE: LAND MANAGEMENT
REGION 2

Taryn.Maart@pgwc.gov.za
tel: +27 21 483 2707/2596; fax:+27 21 483 4372
1 Dorp Street, Cape Town, 8001
Private Bag X9086 Cape Town, 8000
www.capegateway.gov.za/eadp

REFERENCE: E12/2/4/7-F4/16-3257/11
ENQUIRIES: MS. T. MAART
DATE OF ISSUE: 06 JUL 2011

The Director

CCA Environmental (Pty) Ltd.

P.O. Box 10145

CALEDON SQUARE

7905

Attention: Mr. J. Blood

Tel: (021)461 1118
Fax: (021)461 1120

Dear Sir

RE: BACKGROUND INFORMATION DOCUMENT SUBMITTED WITH RESPECT TO THE APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGENETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA.

The above-mentioned document dated 27 June 2011 and received by the Department on 04 July 2011 refers. The Petroleum Agency of South Africa ("PASA") reference number is: 12/3/1/224.

This letter serves as an acknowledgement of receipt of the above-mentioned document by this Department.

Having considered the information contained in the above-mentioned document, it is hereby confirmed that this Department will be a commenting authority and will provide comment on the Environmental Management Programme.

You are required to quote the above-mentioned reference number in any future correspondence in respect of the application.

This Department reserves the right to revise or withdraw comments or request further information from you based on any information that might be received.

Yours faithfully

HEAD OF DEPARTMENT

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND CONTROLLED SOURCE ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA

INTERESTED AND AFFECTED PARTY (I&AP) REGISTRATION AND RESPONSE FORM

Would you or your organisation like to become a registered I&AP and continue to receive information on the proposed project?

Yes X **No** ______

Name: CAROL DE KOCK

Organisation: FRESH TUNA EXPORTERS ASSOCIATION

Postal address: P O BOX 26973
HOUT BAY 7872

Email address: longfin@iafrica.com

Telephone number: 021 7905113 **Fax number:** 021 7905113

Do you or your organisation have any issues or concerns regarding the proposed exploration in Block 5/6?

Yes X **No** ______

If yes, please provide details below:

CONCERN OVER IMPACT ON MIGRATORY FISH STOCKS SUCH AS TUNA
THE AREA COVERS OUR ENTIRE FISHING GROUNDS AND WILL AFFECT 100% OF OUR SECTOR.

Please forward to:
CCA ENVIRONMENTAL (PTY) LTD
Attention: Jeremy Blood
Unit 35, Roeland Square, 30 Drury Lane, CAPE TOWN, 8001
PO Box 10145, Caledon Square, 7905
Tel: (021) 461 1118/9 Fax: (021) 461 1120
Email: jeremy@ccaenvironmental.co.za

Comments must reach CCA Environmental no later than 17 July 2011.

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND CONTROLLED SOURCE ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA

INTERESTED AND AFFECTED PARTY (I&AP) REGISTRATION AND RESPONSE FORM

Would you or your organisation like to become a registered I&AP and continue to receive information on the proposed project?

Yes ✓ **No** ____

Name: S A Deepsea T.

Organisation: South African Deep-Sea Trawling Industry Association

Postal address: PO Box 2066 Cape Town . 8000

Email address: deepsea @ iafrica . com

Telephone number: 4252727 **Fax number:** 4170785

Do you or your organisation have any issues or concerns regarding the proposed exploration in Block 5/6?

Yes ✓ **No** ____

If yes, please provide details below:

We are a major stakeholder and interested / Party inasmuch as the exploration takes place in our best trawl grounds.

Please forward to:
CCA ENVIRONMENTAL (PTY) LTD
Attention: Jeremy Blood
Unit 35, Roeland Square, 30 Drury Lane, CAPE TOWN, 8001
PO Box 10145, Caledon Square, 7905
Tel: (021) 461 1118/9 Fax: (021) 461 1120
Email: jeremy@ccaenvironmental.co.za

Comments must reach CCA Environmental no later than 17 July 2011.

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND CONTROLLED SOURCE ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA

INTERESTED AND AFFECTED PARTY (I&AP) REGISTRATION AND RESPONSE FORM

Would you or your organisation like to become a registered I&AP and continue to receive information on the proposed project?

Yes X **No**

Name: CHARLES THOMAS

Organisation: EMGS A.S.A

Postal address: FLAT 5, TUIN ZICHT, 4 HOF STREET, GARDENS, CAPE TOWN

Email address: ctHomas@emgs.com

Telephone number:

Fax number:

Do you or your organisation have any issues or concerns regarding the proposed exploration in Block 5/6?

Yes **No** X

If yes, please provide details below:

Please forward to:
CCA ENVIRONMENTAL (PTY) LTD
Attention: Jeremy Blood
Unit 35, Roeland Square, 30 Drury Lane, CAPE TOWN, 8001
PO Box 10145, Caledon Square, 7905
Tel. (021) 461 1118/9 Fax: (021) 461 1120
Email: jeremy@ccaenvironmental.co.za

Comments must reach CCA Environmental no later than 17 July 2011.

Subject: Aansoek vir 'n Eksplorasiereg om seismiese en eletromagnetiese opnames te onderneem in Lisensieblok 5/6, Suidweskus, Suid-Afrika
From: Franci Gresse <Franci.Gresse@aurecongroup.com>
Date: 2011/06/29 08:16 AM
To: "jeremy@ccaenvironmental.co.za" <jeremy@ccaenvironmental.co.za>
CC: Amy Towers <Amy.Towers@aurecongroup.com>, Nelis Bezuidenhout <Nelis.Bezuidenhout@aurecongroup.com>

Dear Mr Blood

Your advert in Die Burger on 28 June 2011 regarding the above mentioned project has reference. We would appreciate if you could please register the following two people, as well as myself, as Interested and Affected Parties:

Amy Towers:
Tel: 021 481 2508
Email: amy.towers@aurecongroup.com

Nelis Bezuidenhout:
Tel: 021 481 2510
Email: nelis.bezuidenhout@aurecongroup.com

We would also appreciate if you could provide us with a copy of the Background Information Document mentioned in your advert.

Thank you
Franci

Franci Gresse
Environmental Practitioner I Aurecon
T +27 21 481 2511 I F +27 21 424 5588 I
E Franci.Gresse@aurecongroup.com
81 Church Street, Cape Town I South Africa
www.aurecongroup.com

DISCLAIMER

Subject: RE: APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA
From: "Roy Bross" <deepsea@iafrica.com>
Date: 2011/07/01 11:23 AM
To: "'Jeremy Blood'" <jeremy@ccaenvironmental.co.za>
CC: "'Chris Schoeman'" <chriss@ij.co.za>, "'George Bezuidenhout \(George Bezuidenhout\)'" <georgeb@seaharvest.co.za>, "'John Pope'" <johnp@ij.co.za>, "'R Ventura'" <ventura@fishingco.co.za>, "'Rory Williams \(RoryWilliams\)'" <rory@vikingfishing.co.za>, "'Tim Reddell'" <tim@reddell.org.za>

Dear Jeremy

Thank you for the notification

We would like to record at this very early stage that the shoreward portion of Block 5/6 (down to more than 900 metres) constitutes our most productive fishing grounds by some margin. It is far the area of most intense trawling and fishing activity and as such I daresay we will be the most interested party and a primary stakeholder should the exploration right be granted. Kindly note our intimate interest.

Notwithstanding the potential differences that could arise between ourselves and PetroSA, we trust that, if exploration eventuates, the good established relationship between the fishing industry and the Company will facilitate amicable resolution of any "conflict of rights" situations that may arise.

Sincerely
C A R Bross
Secretary
South African Deep-Sea Trawling Industry Association
FishSA

From: Jeremy Blood [mailto:jeremy@ccaenvironmental.co.za]
Sent: 27 June 2011 04:18 PM
To: andrew@kaytrad.co.za; longfin@iafrica.com; chris@africantuna.com; dan@new.co.za; Sarah Wilkinson; Dave Japp; comfish@mweb.co.za; gduplessis@pioneerfishing.co.za; cttopsradio@lf.co.za; agency@jmss.co.za; johnp@ij.co.za; lauren@tunahake.co.za; mfishing@mweb.co.za; mario@lusitaniafishing.co.za; jung@telkomsa.net; taiyoct@mweb.co.za; pnb@vikingfishing.co.za; ppkuttel@iafrica.com; rob@kzntuna.com; rob@bigcatch.co.za; deepsea@iafrica.com; vnt@netactive.co.za; russellh@seaharvet.co.za; msands@bluecon.co.za; ttraut@marpro.co.za; tim@selectafish.co.za; eddie.bremner@transnet.net; ladymfishing@telkomsa.net; yellowtail@xsinet.co.za; sailorsjoy@absamail.co.za; ockieviljoen@webmail.co.za; info@kbboa.za.org; witsands2@mwen.co.za; stu2dive@yahoo.com; etienneb@nda.agric.za
Subject: APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA

Dear Sir / Madam

Please find attached a notification letter and Background Information Document regarding PetroSA's application for an Exploration Right in Block 5/6.

Kind regards

Subject: RE: APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA
From: "WadeT" <WadeT@nda.agric.za>
Date: 2011/07/04 01:19 PM
To: "Jeremy Blood" <jeremy@ccaenvironmental.co.za>

Hi

Sorry for the late reply, I was out of office. Please register me as interested and affected party.

Thanks.

Wade Theron

Chief Marine Conservation Inspector
Station Manager Saldanha Compliance
Department Agriculture, Forestry & Fisheries
PO Box 92, Saldanha, 7395
Tel: 022 714 1710
Cell: 082 771 8910
Fax: 022 714 3997
Email: WadeT@nda.agric.za

From: Jeremy Blood [mailto:jeremy@ccaenvironmental.co.za]
Sent: 28 June 2011 12:22 PM
To: bigbluestruis@yahoo.com; bakkies52@gmail.com; williams@nda.gov.za; WadeT; JohanDW; PatricS; WelnyH; waldermarrc@daff.gov.za; HendrikS
Subject: APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA

Dear Sir / Madam

Please find attached a notification letter and Background Information Document regarding PetroSA's application for an Exploration Right in Block 5/6.

Kind regards

Jeremy Blood Pr.Sci.Nat., CEAPSA
Senior Environmental Scientist

CCA ENVIRONMENTAL (Pty) Ltd • Consulting Services
Unit 35 Roeland Square 30 Drury Lane Cape Town 8001 • PO Box 10145 Caledon Square 7905
Tel + 27 (21) 461 1118/9 • Fax + 27 (21) 461 1120 • jeremy@ccaenvironmental.co.za • website: www.ccaenvironmental.co.za
Directors: J Crowther F Fredericks • Reg No 2003/019026/07

APPENDIX 3.6:

COMMENTS REPORT

PetroSA

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND CONTROLLED SOURCE ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA

COMMENTS REPORT

cca ENVIRONMENTAL

TABLE OF CONTENTS

1. INTRODUCTION

The purpose of this Comments Report is to record comments received from Interested and Affected Parties (I&APs) during the Public Participation Process undertaken as part of PetroSA's application process for an Exploration Right in License Block 5/6 off the South-West Coast of South Africa.

2. PUBLIC PARTICIPATION PROCESS

The public participation process undertaken included the following:

- A preliminary I&AP database of authorities, Non-Governmental Organisations, Community-based Organisations and other key stakeholders was compiled using databases of previous studies in the area, responses to the newspaper advertisements, notification letter and Background Information Document (BID), and attendees at the information-sharing meeting);
- A notification letter and BID were prepared and distributed to an initial 103 I&APs for a 21-day comment period (27 June 2011 to 17 July 2011). The purpose of the BID was to convey information on the proposed exploration programme to I&APs, invite them to an information-sharing meeting and allowed them the opportunity to comment and/or raise any concerns they may have regarding the planned activities;
- Advertisements announcing the proposed project, the availability of the BID and information-sharing meeting were placed in the Cape Times and Die Burger (Western Cape) on 28 June 2011;
- An Information-sharing Meeting was held at the Cape Town Hotel School, Granger Bay, on 11 July 2011 at 16h00. This meeting provided a basic overview of the exploration programme and Environmental Management Programme (EMP) study process and allowed I&APs the opportunity to raise any issues or concerns regarding the planned activities;
- The EMP was distributed for a 30-day I&AP review / comment period from 26 August 2011 to 25 September 2011 in order to provide I&APs and authorities with an opportunity to comment on any aspect of the proposed project and the findings and recommendations of the EMP. Copies of the full EMP were made available at the Cape Town Central Library and on the CCA Environmental website (www.ccaenvironmental.co.za);
- Electronic copies of the full EMP were sent directly to the following I&APs / authorities:
    1. Petroleum Agency South Africa (Ms Phumla Ngesi);
    2. Department of Environmental Affairs (Mr John Geeringh);
    3. Department of Mineral Resources (Ms Sivuyele Mpakane);
    4. Department of Environmental Affairs & Development Planning (Ms Taryn Maart);
    5. Department of Environmental Affairs: Branch Oceans and Coasts (Dr Razeena Omar);
    6. Department of Agriculture, Fisheries and Forestry: Fisheries Branch (Dr Johan Augustyn);
    7. South African Heritage Resources Agency (Ms Mariagrazia Galimberti); and
    8. South African Maritime Safety Authority (Mr Dave Colley).
- A general notification letter was sent to all I&APs registered on the project database informing them of the release of the EMP for review / comment. A copy of the EMP Executive Summary was enclosed with the letter.

3. COMMENTS AND ISSUES RAISED

Comment was received from the following I&APs, either in writing or at meetings undertaken as part of the EMP process.

Submitted by:	Method, date received:
A) Comments received from I&APs prior to the release of the EMP for comment	
1. Russell Hall, Sea Harvest	Information-sharing Meeting (11 July 2011)
2. Annabelle Solle	Information-sharing Meeting (11 July 2011)
3. Mike Shands, Oceana / BCP	Information-sharing Meeting (11 July 2011)
4. Roy Bross, South African Deep-Sea Trawling Industry Association	Email (1 July 2011) Information-sharing Meeting (11 July 2011) Response Form (11 July 2011)
5. Steve Cameron-Dow, Fresh Tuna Exporters Association	Information-sharing Meeting (11 July 2011)
6. Carol de Kock, Fresh Tuna Exporters Association	Information-sharing Meeting (11 July 2011) Response Form (5 July 2011)
7. Head of Department, Department of Environmental Affairs & Development Planning (DEA&DP)	Letter (6 July 2011)
8. Charles Thomas, EMGS A.S.A	Response Form (11 July 2011)
9. Franci Gresse, Aurecon	Email (29 June 2011)
10. Wade Theron, Department of Agriculture, Forestry & Fisheries	Email (4 July 2011)
B) Comments received from I&APs on the EMP	
11. Taryn Maart, Department of Environmental Affairs & Development Planning (DEA&DP)	Letter/ Fax (31 August 2011)
12. Judian Bruk, Demersal Shark Longline Association	Email (1 September 2011)
13. Alan Boyd, Department of Environmental Affairs (DEA): Branch Oceans & Coasts	Letter (via email on 25 September 2011)
14. Ishaam Abader, DEA	Fax (29 September 2011)

Comments are presented and responded to in two sections, namely:

- Section 4: Comments received prior to the release of the EMP for comment; and
- Section 5: Comments received on the EMP.

No importance should be given to the order in which the categories within each section are presented. As far as possible, comments are presented verbatim from written submissions.

4. COMMENTS RECEIVED PRIOR TO THE RELEASE OF THE EMP FOR COMMENT

= Letter/Fax = E-mail = Information-sharing Meeting

NO.	ISSUE	NAME	METHOD	COMMENT	RESPONSE
4.1.1	Survey timing	Russell Hall, Sea Harvest	(11 July 2011)	Mr Hall asked when the surveys would commence.	PetroSA proposes to commence with a 2D seismic survey in February 2012. However, if the awarding of the Exploration Rights is delayed for whatever reason then the survey may only commence in early 2013, as PetroSA would aim to miss the sensitive whale migration period and weather window, which is normally between June and December. Once the 2D survey has been undertaken the data will be analysed. After data analysis, target areas will be identified for further 3D seismic and (Controlled Source ElectroMagnetic) CSEM surveying.
4.1.2	Survey timing	Russell Hall, Sea Harvest	(11 July 2011)	Mr Hall asked if the Controlled Source Electromagnetic (CSEM) survey would extend the total survey time.	PetroSA's proposed work programme for the first exploration period of three years may include the undertaking of 2D/3D seismic and CSEM surveys. Therefore, CSEM surveys, if undertaken, would effectively increase the duration of the total exploration programme. It should be noted that the survey time would not be continuous (see Response 4.1.1).
4.1.3	Location of exploration activities	Annabelle Solle	(11 July 2011)	Ms Solle asked if all exploration would be undertaken offshore.	All proposed exploration activities would be undertaken in Block 5/6, which is located offshore. The licence block extends from roughly the 120 m depth contour to beyond the continental shelf with depths beyond 4 000 m.

NO.	ISSUE	NAME	METHOD	COMMENT	RESPONSE
4.1.4	Income generation	Annabelle Solle	(11 July 2011)	Ms Solle enquired about the potential income relating to the proposed exploration programme.	PetroSA has indicated that income generation during the Exploration Phase would be limited to refuelling and replenishment of supplies in the Cape Town Harbour.
4.1.5	Retrieval of receivers	Mike Shands, Oceana / BCP	(11 July 2011)	Mr Shands asked how long the CSEM receivers would be left on the seafloor before retrieval.	PetroSA has indicated that the receivers would be retrieved after one to two days. The receivers would be released remotely, leaving the concrete anchors behind. However, as the concrete is a patented mixture that contains anhydrate, which starts to deteriorate when it comes into contact with seawater, they will dissolve within 6 to 8 months. The concrete mixture contains no chemicals considered harmful to the environment. Only the sand medium is left on the seabed or dispersed by seafloor currents.
4.2.1	Impact on fisheries research	Roy Bross, South African Deep-Sea Trawling Industry Association	(11 July 2011)	Mr Boss noted that if the survey commenced in February 2012 it may coincide with the annual fisheries survey on the West Coast.	Fisheries research on small pelagic and demersal fish resources are undertaken off the South African coastline on a bi-annual basis in order to set the annual Total Allowable Catch. The potential impact on these demersal and acoustic surveys has been investigated and assessed in the EMP (see Section 2.4.3.1.2). The entire fishing assessment is presented in Appendix 5.1 of the EMP.

NO.	ISSUE	NAME	METHOD	COMMENT	RESPONSE
4.2.2	Possibility of altering the survey programme	Steve Cameron-Dow & Carol de Kock, Fresh Tuna Exporters Association	(11 July 2011) (5 July 2011)	Mr Cameron-Dow and Ms de Kock noted their concern on the impact on migratory fish stocks. Mr Cameron-Dow stated that the Tuna Pole sector operates between late October and June, which is similar to the "normal" survey period. Ms de Kock asked if PetroSA could accommodate any changes to their survey programme if they where given two to three days notice of where they were fishing.	The potential impact on fish and the various fishing sectors active in the area has been assessed in the EMP (see Section 2.4.2.1.3 and 2.4.3.1.1, respectively). It is recommended that prior to the commencement of the seismic and CSEM surveys, PetroSA and the fishing industry meet to discuss their respective survey and fishing programmes and the possibility of altering the exploration programme during surveying in order to minimise or avoid disruptions to both parties. PetroSA would accommodate the fishing industry where possible. The entire Fishing Assessment is presented in Appendix 5.1 of the EMP.
4.2.3	Impact on trawling	Roy Bross, South African Deep-Sea Trawling Industry Association	(11 July 2011) (11 July 2011) (11 July 2011)	Mr Bross noted that the shoreward portion of Block 5/6 (up to 900 m water depth) constitutes the most productive trawl grounds.	Noted. The impact on demersal trawling is assessed in Section 2.4.3.1.1. The entire Fishing Assessment is presented in Appendix 5.1 of the EMP.
				Mr Bross recommended that in order to reduce the impact on the trawling sector PetroSA should rather survey parallel to the bathymetry contours (i.e. follow the depth gradient as far as possible).	The specific survey details are not known at this stage. However, PetroSA has indicated that some survey lines would, in all likelihood, be required perpendicularly to the bathymetry contours. A diagrammatic representation of the 2D seismic survey lines within Block 5/6 is presented in Figure 1.9.
4.2.4	Possibility of altering the survey programme	Carol de Kock, Fresh Tuna Exporters Association	(11 July 2011)	Ms de Kock stated that if PetroSA proposed to survey at night fishing vessels might not be able to respond in time.	Noted. It is important that PetroSA and the fishing industry meet to discuss their respective survey and fishing programmes and that regular communication is maintained with vessels in the vicinity as this would minimise the potential disruption to fishing operations and risk of gear entanglements.

NO.	ISSUE	NAME	METHOD	COMMENT	RESPONSE
4.2.5	Anchor blocks	Roy Bross, South African Deep-Sea Trawling Industry Association	(11 July 2011)	Mr Bross noted that the anchor block, which would be left on the seafloor, could pose a problem for the demersal trawlers.	The anchor blocks, which would be approximately 15 cm in height, are unlikely to be an obstruction to trawl boards. Anchor blocks would start to breakdown when they come into contact with seawater and would dissolve within 6 to 8 months (see Response 4.1.5). It has been recommended that the location of any concrete anchors (used along CSEM transects) must made available to the trawling industry (see Section 2.4.3.1.1).
4.2.6	Conflict resolution	Roy Bross, South African Deep-Sea Trawling Industry Association	(11 July 2011)	Mr Bross hopes that good relationship between PetroSA and the fishing industry will help to facilitate amicable resolution of any conflict situations.	A key mitigation measures is that PetroSA and the fishing industry meet to discuss their respective survey and fishing programmes and that regular communication is maintained with vessels in the vicinity as this would minimise the potential disruption to fishing operations and risk of gear entanglements.
4.3.1	Impact on fish	Roy Bross, South African Deep-Sea Trawling Industry Association	(11 July 2011)	Mr Bross asked if the impact on teleosts as a result of 2D/3D surveys was known.	The impact on fish has been researched and assessed in the EMP (see Section 2.4.2.1.3). The entire Marine Faunal Assessment is presented in Appendix 5.2 of the EMP.

NO.	ISSUE	NAME	METHOD	COMMENT	RESPONSE
4.3.2	Resident Southern Right whales	Annabelle Solle	(11 July 2011)	Ms Solle noted that there are some resident Southern Right whales off Yzerfontein.	Noted. Southern Right whales generally migrate into the extreme near-shore region of the South-West Coast (mainly south of Lamberts Bay) between June and January each year, with maximum numbers occurring in September / October (animals may be sighted as early as April and as late as February). However, a high abundance of Southern Right whales and Humpback whales have been reported from Cape Columbine to Yzerfontein area during spring and summer and their occurrence further offshore indicates that the area may serve as an important summer feeding ground. The resident population of cetaceans has been taken into consideration in assessing the impact (see Section 2.4.2.1.7). The entire Marine Faunal Assessment is presented in Appendix 5.2 of the EMP.
4.3..3	Electromagnetic effects on fish	Carol de Kock, Fresh Tuna Exporters Association	(11 July 2011)	Ms de Kock asked if any research had been done on the electromagnetic effects on fish.	The impact of electromagnetic effects on fish has been assessed in Section 2.4.2.2. The entire Marine Faunal Assessment is presented in Appendix 5.2 of the EMP.
4.1	Specialist studies	Russell Hall, Sea Harvest	(11 July 2011)	Mr Hall asked who would be undertaking the two identified specialist studies.	Dr Andrea Pulfrich of Pisces Environmental Services (Pty) Ltd undertook the Marine Faunal Assessment, and Mr Dave Japp and Ms Sarah Wilkinson of Capfish cc undertook the Fishing Assessment.

NO.	ISSUE	NAME	METHOD	COMMENT	RESPONSE
4.2	EMP review	Head of Department, Department of Environmental Affairs & Development Planning (DEA&DP)	(6 July 2011)	DEA&DP confirmed that they will be a commenting authority.	Noted. A copy of the EMP was sent to DEA&DP for comment (see DEA&DP subsequent response in Comment 5.3.1 below).
4.3	I&AP registration	Charles Thomas, EMGS	(11 July 2011)	Mr Thomas requested to be registered as an I&AP.	All have been registered as I&APs on the project database (see Appendix 3.1).
4.4	I&AP registration	Franci Gresse, Aurecon	(29 June 2011)	Ms Greese requested that Amy Towers, Nelis Bezuidenhout and herself be registered as I&APs.	
4.5	I&AP registration	Wade Theron, DAFF	(4 July 2011)	Mr Theron requested to be registered as an I&AP.	

5. COMMENTS RECEIVED ON THE EMP

= Letter/Fax = E-mail = Information-sharing Meeting

NO.	ISSUE	NAME	METHOD	COMMENT	RESPONSE
5.1.1	Survey timing	Alan Boyd, DEA: Branch Oceans & Coasts Ishaam Abader, DEA	(25 Sept 2011)	The EMP states that the proposed seismic surveys should, only as far as possible, be undertaken outside the sensitive period from June to December. In addition, decisions as to whether or not to allow surveying in June and December should be based on the extent of whales present. Dr Boyd considers this vagueness to be unacceptable. He recommends that the proposed surveys should not commence earlier than January or finish later than the end of May.	It is agreed that the proposed surveys should ideally be undertaken outside of the cetacean migration and breeding period from June to December. However, it also needs to be recognised that surveys can be delayed / impacted by a number of uncontrollable factors (e.g. vessel availability, technical downtime, weather-related downtime, etc.) and the survey may be required to commence / extend slightly into the cetacean migration and breeding period in order to avoid unnecessary delays, survey costs and potential additional impacts should the survey be required to resume at a later date. If this situation arises, it is recommended that that a formal request / motivation must be submitted to PASA for consideration (see Sections 2.4.2.1.7 & 2.5.2.2 of the EMP). Limiting surveying to between the months of January and May will significantly reduce the existing window in which seismic surveys can be undertaken. The assessment has also indicated that with mitigation, the significance of the potential impact on cetaceans is expected to be LOW.

NO.	ISSUE	NAME	METHOD	COMMENT	RESPONSE
5.1.2	Potential impacts of future exploration	Alan Boyd, DEA: Branch Oceans & Coasts	(25 Sept 2011)	It is acknowledged that the proposed surveys would guide future exploration activities. However, the EMP does not address the potential impacts on marine biodiversity related to any subsequent exploration. Dr Boyd notes that SANBI is currently identifying benthic priority areas for conservation (to be published later in 2011) and that exploration should be located outside of these proposed conservation areas. Dr Boyd asks at what stage can these conservation areas be accommodated.	The current EMP and exploration right application only deals with the proposed 2D/3D seismic and CSEM surveys. Should further exploration (namely well drilling) be proposed based on the results of the initial exploitation, an EMP Addendum would be required in terms of Section 39(5) of the Mineral and Petroleum Resources Development Act, 2002 (No. 28 of 2002) (MPRDA). The EMP Addendum (and associated specialist studies, as appropriate) would be required to consider any proposed benthic priority areas (should this information be available) and assess the potential impacts related to well drilling. At this stage it is not considered realistic to address future potential impacts related to subsequent exploration, as future exploration areas have not yet been defined.
5.1.3	Potential impacts of future exploration	Ishaam Abader, DEA	(29 Sept 2011)	The Applicant must ensure that the National Protected Area Expansion Strategy (NPAES) is duly considered when identifying the final areas of activity.	See Response 5.1.2.

NO.	ISSUE	NAME	METHOD	COMMENT	RESPONSE
5.2.1	Impact on the demersal shark long-ling sector	Judian Bruk, Demersal Shark Longline Association	(1 Sept 2011)	Mr Bruk noted that the demersal shark long-line fishery had not been included in the fishery assessment.	The potential impact on the demersal long-line fishery has been updated to include both the hake and shark demersal long-line sectors (see Section 2.4.3.1.1 and Appendix 5.1 of the EMP). The shark demersal long-line sector operates relatively close to shore, generally inshore of the 200 m isobath and, therefore, inshore of the proposed survey area. However, if the survey vessel moves out of the block into shallower waters (e.g. during line changes) fishing operations may be affected. The potential impact on the demersal long-line fishery is considered to remain of LOW significance, as previously assessed. It should also be noted that the potential impact on the pelagic long-line fishery has been updated to include both the tuna and shark pelagic long-line sectors (see Section 2.4.3.1.1 and Appendix 5.1 of the EMP). The shark pelagic long-line sector is located primarily along the 200 m isobath and, therefore, falls within the proposed survey area. The significance of the potential impact on the pelagic long-line fishery has increase from VERY LOW to LOW.
5.3.1	Comment on EMP	Taryn Maart, DEA&DP	(31 Aug 2011)	DEA&DP indicated that they would provide comment on the EMP on receipt of the relevant documentation from PASA.	Noted. PASA is requested to forward a copy of the EMP onto DEA&DP for comment.
5.3.2	I&AP registration	Judian Bruk, Demersal Shark Longline Association	(1 Sept 2011)	Mr Bruk requested that the Demersal Shark Longline Association be registered on the I&AP database.	The Demersal Shark Longline Association has been registered as an I&AP on the project database (see Appendix 3.1).

APPENDIX 3.7:

I&AP NOTIFICATION LETTERS

ENVIRONMENTAL

Psa10/Let-24Aug11

24 August 2011

General Manager: Regulation
Petroleum Agency South Africa
Tygerpoort Building
7 Mispel Road
BELLVILLE, 7530

ATTENTION: Ms Phumla Ngesi

Dear Ms Ngesi

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA (PASA REF NO. 12/3/1/224; DEA&DP REF: E12/2/4/7-F4/16-3257/11): AVAILABILITY OF ENVIRONMENTAL MANAGEMENT PROGRAMME FOR REVIEW AND COMMENT

Our previous correspondence of 4 August 2011 refers. This letter provides information on the availability for review and comment of the Environmental Management Programme (EMP) prepared for the above-mentioned project.

Notice is hereby given in terms of the Minerals and Petroleum Resources Development Act, 2002 (No. 28 of 2002) (MPRDA) that the EMP is available for a 30-day public review and comment period. The EMP has addressed the written submissions received on the Background Information Document, as well as the issues raised at the Information-sharing Meeting held on 11 July 2011.

Copies of the EMP will be available at the following locations from **Friday 26 August 2011**:

1. Cape Town Central Library, City Hall, Darling Street, Cape Town; and
2. On the CCA Environmental website (www.ccaenvironmental.co.za).

If your organisation would like to submit comments on the EMP it should do so **no later than 25 September 2011**. An electronic copy of the EMP is enclosed for your reference. After closure of the review / comment period, the EMP will be updated and submitted to your department for consideration.

Should you have any queries on the above, or require any further information, please do not hesitate to contact us.

Yours sincerely

Jeremy Blood Pr.Sci.Nat., CEAPSA
CCA ENVIRONMENTAL (PTY) LTD

Encl.

PSA10BFS/corr/I&AP/PASA let – EMP comment period (24 Aug 2011)

cca ENVIRONMENTAL

Psa10/Let-24Aug11

24 August 2011

Director: Environmental Impact Evaluation
Department of Environmental Affairs
Fedsure Forum Building (corner of Pretorius and Van der Walt Streets)
2nd Floor North Tower, 315 Pretorius Street
PRETORIA, 0002

ATTENTION: Mr John Geeringh

Dear Mr Geeringh

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA (PASA REF NO. 12/3/1/224; DEA&DP REF: E12/2/4/7-F4/16-3257/11): AVAILABILITY OF ENVIRONMENTAL MANAGEMENT PROGRAMME FOR REVIEW AND COMMENT

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If your organisation would like to submit comments on the EMP it should do so **no later than 25 September 2011**. An electronic copy of the EMP is enclosed for your reference. It should be noted that hardcopies of the EMP will be distributed to government departments by the Petroleum Agency South Africa (PASA) in terms of Section 40(2) of the MPRDA.

Should you have any queries on the above, or require any further information, please do not hesitate to contact us.

Yours sincerely

Jeremy Blood Pr.Sci.Nat., CEAPSA
CCA ENVIRONMENTAL (PTY) LTD

Encl.

PSA10BFS/corr/I&AP/DEA let – EMP comment period (24 Aug 2011)

ENVIRONMENTAL

Psa10/Let-24Aug11

24 August 2011

The Regional Manager: Mineral Regulation
Department of Mineral Resources
Private Bag X9
ROGGEBAAI, 8012

Attention: Ms Sivuyele Mpakane

Dear Madam

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA (PASA REF NO. 12/3/1/224; DEA&DP REF: E12/2/4/7-F4/16-3257/11): AVAILABILITY OF ENVIRONMENTAL MANAGEMENT PROGRAMME FOR REVIEW AND COMMENT

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Should you have any queries on the above, or require any further information, please do not hesitate to contact us.

Yours sincerely

Jeremy Blood Pr.Sci.Nat., CEAPSA
CCA ENVIRONMENTAL (PTY) LTD

Encl.

PSA10BFS/corr/I&AP/DMR let – EMP comment period (24 Aug 2011)

ENVIRONMENTAL

Psa10/Let-24Aug11

24 August 2011

The Director: Integrated Environmental Management (Region 2)
Department of Environmental Affairs and Development Planning
1 Dorp Street
CAPE TOWN
8001

ATTENTION: Ms Taryn Maart

Dear Ms Maart

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA (PASA REF NO. 12/3/1/224; DEA&DP REF: E12/2/4/7-F4/16-3257/11): AVAILABILITY OF ENVIRONMENTAL MANAGEMENT PROGRAMME FOR REVIEW AND COMMENT

Our previous correspondence of 27 June 2011 and your response of 6 July 2011, have reference. This letter provides information on the availability for review and comment of the Environmental Management Programme (EMP) prepared for the above-mentioned project.

Notice is hereby given in terms of the Minerals and Petroleum Resources Development Act, 2002 (No. 28 of 2002) (MPRDA) that the EMP is available for a 30-day public review and comment period. The EMP has addressed the written submissions received on the Background Information Document, as well as the issues raised at the Information-sharing Meeting held on 11 July 2011.

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If your organisation would like to submit comments on the EMP it should do so **no later than 25 September 2011**. An electronic copy of the EMP is enclosed for your reference. It should be noted that hardcopies of the EMP will be distributed to government departments by the Petroleum Agency South Africa (PASA) in terms of Section 40(2) of the MPRDA.

Should you have any queries on the above, or require any further information, please do not hesitate to contact us.

Yours sincerely

Jeremy Blood Pr.Sci.Nat., CEAPSA
CCA ENVIRONMENTAL (PTY) LTD

Encl.

cc. Mr Paul Hardcastle, Department of Environmental Affairs & Development Planning
Mr Zaahir Toefy, Department of Environmental Affairs & Development Planning

CCA ENVIRONMENTAL (Pty) Ltd • Consulting Services
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Directors: J Crowther F Fredericks • Associate: J Blood • Reg No 2003/019026/07

Psa10/Let-24Aug11

ENVIRONMENTAL

24 August 2011

Chief Director: Integrated Coastal Management
Department of Environmental Affairs: Branch Oceans and Coasts
2 East Pier Shed, East Pier Road
V&A Waterfront
CAPE TOWN, 8000

Attention: Dr Razeena Omar

Dear Madam

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA (PASA REF NO. 12/3/1/224; DEA&DP REF: E12/2/4/7-F4/16-3257/11): AVAILABILITY OF ENVIRONMENTAL MANAGEMENT PROGRAMME FOR REVIEW AND COMMENT

This letter provides information on the availability for review and comment of the Environmental Management Programme (EMP) prepared for the above-mentioned project.

Notice is hereby given in terms of the Minerals and Petroleum Resources Development Act, 2002 (No. 28 of 2002) (MPRDA) that the EMP is available for a 30-day public review and comment period. The EMP has addressed the written submissions received on the Background Information Document, as well as the issues raised at the Information-sharing Meeting held on 11 July 2011.

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Yours sincerely

Jeremy Blood Pr.Sci.Nat., CEAPSA
CCA ENVIRONMENTAL (PTY) LTD

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PSA10BFS/corr/I&AP/DEABOC let – EMP comment period (24 Aug 2011)

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CCA ENVIRONMENTAL

Psa10/Let-24Aug11

24 August 2011

Chief Director: Marine Resource Management
Department of Agriculture, Forestry and Fisheries
Private Bag X2
ROGGEBAAI
8012

ATTENTION: Dr Johan Augustyn

Dear Sir

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA (PASA REF NO. 12/3/1/224; DEA&DP REF: E12/2/4/7-F4/16-3257/11): AVAILABILITY OF ENVIRONMENTAL MANAGEMENT PROGRAMME FOR REVIEW AND COMMENT

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Yours sincerely

Jeremy Blood Pr.Sci.Nat., CEAPSA
CCA ENVIRONMENTAL (PTY) LTD

Encl.

PSA10BFS/corr/I&AP/DAFF let – EMP comment period (24 Aug 2011)

Psa10/Let-24Aug11

24 August 2011

South African Heritage Resources Agency
111 Harrington Street
CAPE TOWN
8000

Attention: Ms Mariagrazia Galimberti

Dear Madam

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA (PASA REF NO. 12/3/1/224; DEA&DP REF: E12/2/4/7-F4/16-3257/11): AVAILABILITY OF ENVIRONMENTAL MANAGEMENT PROGRAMME FOR REVIEW AND COMMENT

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Should you have any queries on the above, or require any further information, please do not hesitate to contact us.

Yours sincerely

Jeremy Blood Pr.Sci.Nat., CEAPSA
CCA ENVIRONMENTAL (PTY) LTD

Encl.

PSA10BFS/corr/I&AP/SAHRA let – EMP comment period (24 Aug 2011)

CCA ENVIRONMENTAL

Psa10/Let-24Aug11

24 August 2011

South African Maritime Safety Authority
19th Floor
2 Long Street
CAPE TOWN
8001

Attention: Mr Dave Colley

Dear Sir

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA (PASA REF NO. 12/3/1/224; DEA&DP REF: E12/2/4/7-F4/16-3257/11): AVAILABILITY OF ENVIRONMENTAL MANAGEMENT PROGRAMME FOR REVIEW AND COMMENT

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Yours sincerely

Jeremy Blood Pr.Sci.Nat., CEAPSA
CCA ENVIRONMENTAL (PTY) LTD

Encl.

PSA10BFS/corr/I&AP/SAMSA let – EMP comment period (24 Aug 2011)

cca
ENVIRONMENTAL

PSA10/Let–24Aug11

24 August 2011

Dear Sir / Madam

APPLICATION FOR AN EXPLORATION RIGHT TO UNDERTAKE SEISMIC AND ELECTROMAGNETIC SURVEYS IN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA (PASA REF NO. 12/3/1/224): AVAILABILITY OF ENVIRONMENTAL MANAGEMENT PROGRAMME FOR REVIEW AND COMMENT

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1. Cape Town Central Library, City Hall, Darling Street, Cape Town; and
2. On the CCA Environmental website (www.ccaenvironmental.co.za).

If you or your organisation would like to submit comments on the EMP you should do so **no later than 25 September 2011**. A copy of the executive summary of the EMP is enclosed for your reference.

Should you have any queries on the above, or require any further information, please do not hesitate to contact us.

Yours sincerely

Jeremy Blood Pr.Sci.Nat., CEAPSA
CCA ENVIRONMENTAL (PTY) LTD

Encl.

PSA10BFS/corr/I&APs/let – EMP comment period (24 Aug 11)

APPENDIX 4:

CONVENTION FOR ASSIGNING SIGNIFICANCE RATINGS TO IMPACTS

CONVENTION FOR ASSIGNING SIGNIFICANCE RATINGS TO IMPACTS

Specialists will consider ten rating scales when assessing potential impacts. These include:

- Extent of impact;
- Duration of impact;
- Intensity of impact;
- Status of impact;
- Probability of impact occurring;
- Degree of confidence of assessment;
- Significance of impact;
- Degree to which a resource is lost;
- Degree to which impact can be mitigated; and
- Reversibility of impact

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

1. The core criteria for determining significance ratings are "extent" (Section 1.1), "duration" (Section 1.2) and "intensity" (Section 1.3). The preliminary significance ratings for combinations of these three criteria are given in Section 1.8.

2. 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 (see Item 9 below); and
   - High level of risk or uncertainty, with potentially substantial negative consequences.

3. Additional criteria to be considered, which could "decrease" the significance rating if deemed justified by the specialist, with motivation, is the following:
   - Improbable impact, where confidence level in prediction is high.

4. The status of an impact is used to describe whether the impact will have a negative, positive or neutral effect on the surrounding environment. An impact may therefore be negative, positive (or referred to as a benefit) or neutral (Section 1.5).

5. Describe the degree to which a resource is impacted (Section 1.4).

6. Describe the impact in terms of the probability of the impact occurring (Section 1.6) and the degree of confidence in the impact predictions, based on the availability of information and specialist knowledge (Section 1.7).

7. 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.

8. Describe the degree to which an impact can be mitigated or enhanced (Section 1.9) and reversed (Section 1.10).

9. The cumulative impacts of a project should also be considered. "Cumulative impacts" refer to the impact of an activity that may become significant when added to the existing activities currently taking place within the surrounding environment.

10. Where applicable, assess the degree to which an impact may cause irreplaceable loss of a resource. A resource assists in the functioning of human or natural systems, i.e. specific vegetation, minerals, water, agricultural land, etc.

The significance ratings are based on largely objective criteria and inform decision-making at a project level as opposed to a local community level. In some instances, therefore, whilst the significance rating of potential impacts might be "low" or "very low", the importance of these impacts to local communities or individuals might be extremely high. The importance which I&APs attach to impacts must be taken into consideration, and recommendations should be made as to ways of avoiding or minimising these negative impacts through project design, selection of appropriate alternatives and / or management.

The relationship between the significance ratings after mitigation and decision-making can be broadly defined as follows (see overleaf): substance

Significance rating	Effect on decision-making
VERY LOW; LOW	Will not have an influence on the decision to proceed with the proposed project, provided that recommended measures to mitigate negative impacts are implemented.
MEDIUM	Should influence the decision to proceed with the proposed project, provided that recommended measures to mitigate negative impacts are implemented.
HIGH; VERY HIGH	Would strongly influence the decision to proceed with the proposed project.

1.1 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	South-Western Cape coast
NATIONAL	South Africa
INTERNATIONAL	

1.2 DURATION

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

Rating	Description
SHORT TERM	0 - 5 years
MEDIUM TERM	5 - 15 years
LONG TERM	Where the impact will cease after the operational life of the activity, either because of natural processes or by human intervention.
PERMANENT	Where mitigation either by natural processes or by human intervention will not occur in such a way or in such time span that the impact can be considered transient.

1.3 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.

1.4 LOSS OF RESOURCES

"Loss of resource" refers to the degree to which a resource is permanently affected by the activity, i.e. the degree to which a resource is irreplaceable.

Rating	Description
LOW	Where the activity results in a loss of a particular resource but where the natural, cultural and social functions and processes are not affected.
MEDIUM	Where the loss of a resource occurs, but natural, cultural and social functions and processes continue, albeit in a modified way.
HIGH	Where the activity results in an irreplaceable loss of a resource.

1.5 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.

1.6 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 will occur.
HIGHLY PROBABLE	Where it is most likely that the impact will occur.
DEFINITE	Where the impact will occur regardless of any prevention measures.

1.7 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.

1.8 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.***
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.

1.9 DEGREE TO WHICH IMPACT CAN BE MITIGATED

This indicates the degree to which an impact can be reduced / enhanced.

Rating	Description
NONE	No change in impact after mitigation.
VERY LOW	Where the significance rating stays the same, but where mitigation will reduce the intensity of the impact.
LOW	Where the significance rating drops by one level, after mitigation.
MEDIUM	Where the significance rating drops by two to three levels, after mitigation.
HIGH	Where the significance rating drops by more than three levels, after mitigation.

1.10 REVERSIBILITY OF AN IMPACT

This refers to the degree to which an impact can be reversed.

Rating	Description
IRREVERSIBLE	Where the impact is permanent.
PARTIALLY REVERSIBLE	Where the impact can be partially reversed.
FULLY REVERSIBLE	Where the impact can be completely reversed.

APPENDIX 5:

SPECIALIST STUDIES

APPENDIX 5.1:

FISHING ASSESSMENT

PROPOSED SEISMIC AND CONTROLLED SOURCE ELECTROMAGNETIC SURVEYS WITHIN LICENSE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA

Specialist Report on Fisheries Interactions

Compiled for:

CCA Environmental (Pty) Ltd

On behalf of:

The Petroleum Oil & Gas Corporation of South Africa (Pty) Ltd

Prepared by:

CapFish

D.W. Japp and S. Wilkinson
CapFish SA (Pty) Ltd
Cape Town

September 2011

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CAPFISH SA (PTY) LTD

Reg. No. 2004 / 004844 / 07

Unit 15 Foregate Square, Table Bay Blvd, Cape Town South Africa.

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Web: www.capfish.co.za

4 July 2011

EXPERTISE AND DECLARATION OF INDEPENDENCE

This report was prepared by Dave Japp and Sarah Wilkinson of CapFish SA (Pty) Ltd. Dave Japp has a BSC in Zoology, University of Cape Town (UCT) and a MSc degree in Fisheries Science from Rhodes University. Sarah Wilkinson has a BSc (Hons) degree in Botany from UCT.

Both have considerable experience in undertaking specialist environmental impact assessments relating to fishing and fish stocks. Dave Japp has worked in the field of Fisheries Science and resource assessment since 1987. His work has included environmental economic assessments and the evaluation of the environmental impacts on fishing. Sarah Wilkinson has worked on marine resource assessments, specializing in spatial and temporal analysis (GIS) as well as the economic impacts of fisheries exploitation.

This specialist report was compiled for CCA Environmental (Pty) Ltd for their use in compiling an Environmental Management Programme (EMP) for the proposed seismic and CSEM surveys in Blocks 5/6 located on the South-West Coast of South Africa. We do hereby declare that we are financially and otherwise independent of the Applicant and of CCA Environmental (Pty) Ltd.

Dave Japp

Sarah Wilkinson

EXECUTIVE SUMMARY

PetroSA (Pty) Ltd has applied to the Petroleum Agency of South Africa (PASA) for an Exploration Right in License Block 5/6, covering an area of approximately 94,118 km^2 off the South-West Coast of South Africa. This block forms a component of PetroSA's strategy to develop the Western Gas Cluster, which has the potential to assist with security of oil and gas supply for South Africa. PetroSA proposes to explore for oil and gas using methodologies which may include 2D/3D seismic survey acquisition and Controlled Source ElectroMagnetic (CSEM) acquisition. This report provides an assessment of the impact of the proposed survey activities on the fishing industry and was commissioned as part of the undertaking of an Environmental Management Programme (EMP) which has to be approved by PASA prior to the granting of an Exploration Right.

The demersal trawl, small pelagic purse-seine, demersal long-line, tuna pole, pelagic long-line and traditional line fisheries were identified as possibly being affected by the proposed survey operations, as these sectors operate within the area covered by Block 5/6. The intensity of the impacts on the demersal trawl, demersal long-line, pelagic long-line, tuna pole fisheries and fisheries research cruises was assessed to be high, although the significance of the impact was deemed LOW due to the short-term duration of the survey activities. The intensity of the impact on the small pelagic fishery and traditional line fishery was assessed to be low and of VERY LOW significance. The West Coast rock lobster fishery was not expected to be impacted by the proposed survey as their areas of operations occur inshore of Block 5/6.

In terms of minimizing the impact on the fishing industry it is recommended that affected parties are identified and that sufficient notification of the proposed survey operations be given prior to the commencement of the survey. This would be achieved through email, advertisements in local newspapers and the distribution of posters and flyers to harbour masters, skiboat and yacht clubs and slipways around the South/South-Western Cape coastline. Furthermore, it is essential that good liaison be maintained between fishing vessel operators, skippers and the survey vessel for the duration of the survey in order to avoid potential gear interactions. Prior to the commencement of the survey, PetroSA and fishing industry should meet to discuss programme and the possibility of streamlining the survey and fishing programmes.

It is advised that the location of any concrete anchors (used along CSEM transects) be made available to the trawling industry so that they can be avoided by vessels that do not use "rock-hopper" gear until such time as they disintegrate (six to eight months after deployment).

Due the high level of interaction with fishers and fishing gear it is strongly recommended that the survey vessel be accompanied by a chase vessel with staff familiar with the fisheries expected in the area. It is

recommended that an experienced on-board Observer should be deployed on the survey vessel to facilitate communication with maritime vessels. The on-board Observer should be familiar with fisheries operational in the area, as well as with environmental monitoring protocols relating specifically to marine mammals, birds and other fauna. A daily electronic reporting routine should be set up to keep interested and affected parties informed of survey activity, fisheries interactions and environmental issues.

With respect to the research cruises undertaken by the Department of Agriculture, Forestry and Fisheries (DAFF), demersal surveys and acoustic surveys are undertaken within the License Block area and it therefore suggested that a consultation programme be set up between PetroSA and DAFF prior to the commencement of the survey to negotiate the timing and/or placement of seismic transects and research trawls.

A summary table of the impact on commercial fishing industry sectors and fisheries research cruises is presented below:

NATURE OF IMPACT	*SMALL PELAGIC PURSE-SEINE*	*DEMERSAL TRAWL*	*DEMERSAL LONG-LINE*	*LARGE PELAGIC LONG-LINE*	*TUNA POLE*	*TRADITIONAL LINE FISH*	*WEST COAST ROCK LOBSTER*	*FISHERIES RESEARCH*
EXTENT	LOCAL	LOCAL	LOCAL	LOCAL	LOCAL	LOCAL	LOCAL	LOCAL
DURATION	SHORT TERM	SHORT TERM	SHORT TERM	SHORT TERM	SHORT TERM	SHORT TERM	SHORT TERM	SHORT TERM
INTENSITY	LOW	HIGH	HIGH	HIGH	HIGH	LOW	ZERO	HIGH
STATUS	NEGATIVE	NEGATIVE	NEGATIVE	NEGATIVE	NEGATIVE	NEGATIVE	NEGATIVE	NEGATIVE
PROBABLILITY	PROBABLE	DEFINITE	DEFINITE	PROBABLE	PROBABLE	PROBABLE	IMPROBABLE	PROBABLE
SIGNIFICANCE	VERY LOW	LOW	LOW	LOW	LOW	VERY LOW	INSIGNIFICANT	LOW
DEGREE OF CONFIDENCE	HIGH	HIGH	HIGH	HIGH	MEDIUM	MEDIUM	HIGH	HIGH

1. INTRODUCTION

The Petroleum Oil and Gas Corporation of South Africa (Pty) Ltd (PetroSA) is applying to the Petroleum Agency South Africa (PASA) for an Exploration Right in Licence Block 5/6, off the South-West Coast of South Africa (see Figure 1). License Block 5/6 covers an area of approximately 94,118 km^2, extending from roughly the 120 m depth contour to beyond the continental shelf. This block forms a component of PetroSA's strategy to develop the Western Gas Cluster and to explore for oil and gas using methodologies which may include 2D/3D seismic survey acquisition and Controlled Source ElectroMagnetic (CSEM) acquisition. The proposed surveys could be in the order of 6,000 km in length.

This report provides a synopsis of commercial fish resources and fisheries activity which may be affected by PetroSA's proposed exploration programme within License Block 5/6.

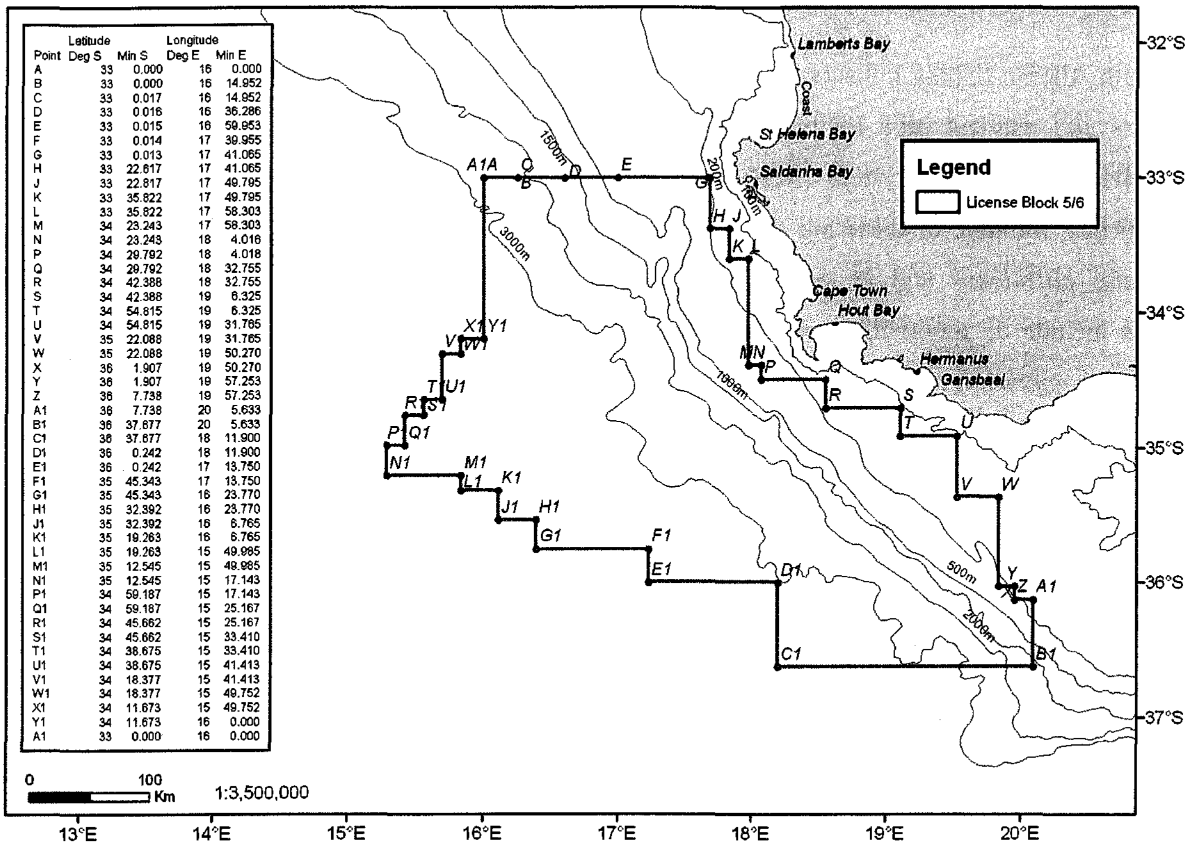
A 2D seismic survey typically involves a towed airgun array and single receiver streamer cable which extends astern of the vessel to a distance of up to 8000 m, whereas a 3D survey uses multiple streamers. The array would be towed at a depth of 5 m to 6 m below the surface and would therefore not be visible, except for a surface tail-buoy with radar reflectors which is attached to the end of the streamer cable. A towing speed of 4 to 6 knots is expected. The seismic operation involves firing an array of airguns every 10 to 20 seconds to generate an acoustic signal which is reflected by boundaries between sediments of different densities. These sound-waves are recorded by hydrophones housed within the streamer cable, and the returned signal is processed on board. Because the sound-waves are extremely weak as they are recorded, the operation is very sensitive to outside sources of vibration, such as vessels, rigs and engineering activity.

The CSEM method is an offshore geophysical technique which uses electromagnetic remote-sensing technology to detect the presence and extent of potential hydrocarbon accumulations below the seabed. The technique uses a dipole source that is towed above the seafloor and transmits a time-varying electromagnetic field into the earth. The electromagnetic field is modified by the presence of subsurface resistive layers and these changes are logged by an array of receivers placed on the seabed. The method is used usually in conjunction with seismic surveys in order to determine whether seismically mapped reservoirs contain hydrocarbons or water. Receivers with concrete anchors are placed on the seafloor on all proposed survey lines at a spacing of approximately 1 km. The dimensions of these anchors are 1 m x 1 m and 15 cm in height and each weights approximately 180 kg. The seabed logging source is deployed and towed at a distance of approximately 30 m to 50 m above the seabed across the survey line. Receivers are recovered at the end of the survey; however the concrete anchors remain behind. The concrete is a patented mixture that starts to deteriorate when it comes into contact with seawater and would dissolve within six to eight months.

The survey design for both seismic and CSEM acquisition would follow a prescribed grid of transects within the proposed survey area, which is chosen to cross any known or suspected geological structure in the area. On completion of a transect, the survey vessel would be required to make a "turning circle" in order to shift to the next transect, thereby effectively extending the area surveyed beyond the acquisition area. In addition, the vessel may move out of the acquisition area due to inclement weather and adverse sea conditions during which times the gear is likely to remain in the water (streamed). Inclement weather conditions would occasionally affect data acquisition and lead to an extended survey duration.

Under the Merchant Shipping Act (Act No. 57 of 1951), seismic and CSEM survey vessels that are engaged in surveying are defined as vessels restricted in their ability to manoeuvre. As such it is a requirement that sea-going vessels that are engaged in fishing activities when surveys are underway shall be warned to stay as far as safely possible from vessels with restricted manoeuvrability. It should also be noted that under the Marine Traffic Act (Act No. 2 of 1981), seismic and CSEM survey vessels are considered to be "offshore installations" and as such are protected by a 500 m safety zone. It is an offence for an unauthorised vessel to enter these safety zones. In addition to the statutory 500 m safety zone, a seismic or CSEM contractor may request a safe operational limit of approximately 5 nm for the safe operation of the seismic or CSEM vessel conducting the survey.

This report provides an assessment of the potential effects on the fishing industry due to temporary displacement of fishing activities resulting from the 500 m exclusion zone and larger safe operational limit required around the survey vessel and gear as well as for the concrete anchors and attached receivers on the seafloor used during the CSEM method. The survey operation itself could potentially be affected by interaction with fishing gear that could result in costly downtime.



Point	Latitude Deg S	Latitude Min S	Longitude Deg E	Longitude Min E
A	33	0.000	16	0.000
B	33	0.000	16	14.952
C	33	0.017	16	14.952
D	33	0.016	16	36.286
E	33	0.015	16	59.953
F	33	0.014	17	39.955
G	33	0.013	17	41.065
H	33	22.617	17	41.065
J	33	22.817	17	49.795
K	33	35.822	17	49.795
L	33	35.822	17	58.303
M	34	23.243	17	58.303
N	34	23.243	18	4.016
P	34	29.792	18	4.018
Q	34	29.792	18	32.755
R	34	42.388	18	32.755
S	34	42.388	19	6.325
T	34	54.815	19	6.325
U	34	54.815	19	31.765
V	35	22.088	19	31.765
W	35	22.088	19	50.270
X	36	1.907	19	50.270
Y	36	1.907	19	57.253
Z	36	7.738	19	57.253
A1	36	7.738	20	5.633
B1	36	37.677	20	5.633
C1	36	37.677	18	11.900
D1	36	0.242	18	11.900
E1	36	0.242	17	13.750
F1	35	45.343	17	13.750
G1	35	45.343	16	23.770
H1	35	32.392	16	23.770
J1	35	32.392	16	6.765
K1	35	19.263	16	6.765
L1	35	19.263	15	49.985
M1	35	12.545	15	49.985
N1	35	12.545	15	17.143
P1	34	59.187	15	17.143
Q1	34	59.187	15	25.167
R1	34	45.662	15	25.167
S1	34	45.662	15	33.410
T1	34	38.675	15	33.410
U1	34	38.675	15	41.413
V1	34	18.377	15	41.413
W1	34	18.377	15	49.752
X1	34	11.673	15	49.752
Y1	34	11.673	16	0.000
A1	33	0.000	16	0.000

Figure 1. Location and bounding co-ordinates of License Block 5/6 on the South-West coast, R.S.A.

2. DATA SOURCES

Relevant fisheries data was sourced from the Department of Agriculture, Forestry and Fisheries (Branch: Fisheries) (DAFF) record of commercial catch and effort. The most current complete dataset available was used for each sector – with 2010 data not yet processed for many of the sectors. Data was obtained for the following sectors; small pelagic (2000 to 2009), demersal trawl (2000 to 2008), demersal long-line (2002 to 2008), large pelagic (1998 to 2007), shark long-line (2003 – 2008), West Coast rock lobster (2000 to 2007), tuna pole (2000 to 2010) and traditional line fishery (1985 to 2010). Catch and effort statistics are captured on broad-scale areas of either 20 x 20 or 10 x 10 minutes of latitude and longitude. There is an associated minimal amount of incorrectly-reported data associated with the commercial datasets. Where possible, the commercial catch and effort data were supplemented with Offshore Resources Observer Programme (OROP) dataset to depict fishing activity at a more fine-scale resolution. Additional information was obtained from the Marine Administration System from DAFF and from the *South Africa, Namibia and Mozambique Fishing Industry Handbook 2010*.

3. BACKGROUND TO FISHERIES

The South African fishing industry consists of at least 20 commercial fishing sectors operating within the country's 200 nautical mile Exclusive Economic Zone (EEZ). The western coastal shelf is a highly productive upwelling ecosystem (Benguela Current) and supports a diversity of fisheries. The most economically valuable of these are the demersal trawl and long-line fisheries, targeting the cape hakes *Merluccius paradoxus* and *M. capensis*. Secondary commercial species landed in the hake-directed fisheries include an assemblage of demersal fish of which monk fish (*Lophius vomerinus*), Kingklip (*Genypterus capensis*) and snoek (*Thyrsites atun*) are the most important. However, the largest fishery by volume is the one for small pelagic species using small pelagic purse-seine gear. This fishery targets sardine (*Sardinops sagax*), anchovy (*Engraulis encrasicolus*) and round herring (*Etrumeus whitheadii*). Other fisheries active on the South-West Coast are the pelagic long-line fishery for tunas and swordfish, and the tuna pole and traditional linefish sectors. West Coast rock lobster (*Jasus lalandii*) is an important commercial trap fishery exploited close to the shoreline.

Historically and currently the bulk of the main commercial fish stocks caught on the South-West Coast of South Africa have been landed and processed at the Western Cape ports of Cape Town and Saldanha. The main nodes of deployment for fisheries operating on the South-West Coast are Cape Town, Saldanha, St Helena Bay and Hout Bay.

The main commercial sectors assessed for the purposes of this report are listed in Table 1:

Table 1. List of commercial fisheries that operate on the South-West Coast of South Africa, targeted species and gear types used.

No.	Fishery	Gear Type	Targeted Species
1.	Small pelagic purse-seine	Purse-Seine	Sardine (*Sardinops sagax*), anchovy (*Engraulis encrasicolus*), round herring (*Etrumeus whitheadii*)
2.	Demersal offshore trawl	Demersal trawl	Cape hakes (*Merluccius paradoxus, M. capensis*)
3.	Demersal long-line	Demersal long-line	Cape hakes (*M. paradoxus, M. capensis*)
4.	Demersal shark	Demersal long-line	Soupfin shark (*Galeorhinus galeus*), smooth-hound shark (*Mustelus spp.*)
5.	Large pelagic long-line	Pelagic long-line	Yellowfin tuna (*Thunnus albacares*), bigeye tuna (*T. obesus*), swordfish (*Xiphias gladius*), mako shark (*Isurus oxyrinchus*), blue shark (*Prionace glauca*)
6.	Tuna pole	Pole and line	Longfin tuna (*T. alalunga*), yellowfin tuna
7.	Traditional line fish: Recreational & Commercial	Hand line or rod-and-reel	Snoek (*Thyrsites atun*), longfin tuna, sparidae, serranidae, caragidae, scombridae, sciaenidae
8.	West Coast rock lobster	Trap and hoop net	Rock lobster (*Jasus lalandii*)

4.0 COMMERCIAL FISHING SECTORS

4.1 Small Pelagic Purse Seine Fishery

The small pelagic fishery is the largest South African fishery by volume and the second most important in terms of value. Small pelagic species abundance and distribution fluctuates considerably in accordance with the upwelling ecosystem in which they exist. Annual landings have fluctuated between 300 000 and 600 000 tons over the last decade[1], with landings of 312 000 tons recorded for 2009. The two main targeted species are sardine and anchovy, with associated by-catch of round herring (red-eye) and juvenile horse mackerel. Fishing grounds occur primarily along the West and South coasts of the Western Cape and the Eastern Cape coast up to a distance of 50 nautical miles offshore, but usually closer inshore than this (Figure 3). The majority of the fleet of 78 vessels operates from St Helena Bay, Saldanha Bay and Hout Bay (all in the vicinity of the survey area) with fewer vessels operating on the South Coast from the harbours of Gansbaai, Mossel Bay and Port Elizabeth. Ports of deployment correspond to the location of canning factories and fish reduction plants along the coast.

The small pelagic sector operates throughout the year with a short break over the Christmas and New Year period. The geographical distribution and intensity of the fishery is largely dependent on the seasonal fluctuation and geographical distribution of the targeted species. The sardine-directed fleet consists of larger vessels that tend 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 similarly the intensity of this fishery is dependent on fish availability 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. This fishery may extend further offshore than the sardine and anchovy-directed fisheries.

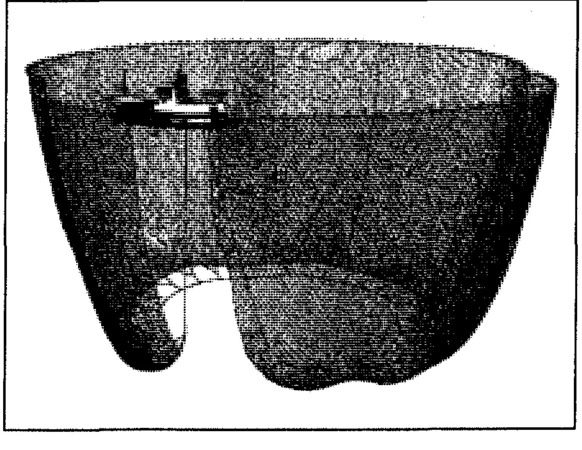


Figure 2. Typical gear configuration of a pelagic purse-seine vessel targeting small pelagic species

The fleet consists of wooden, glass-reinforced plastic and steel-hulled vessels ranging in length from 11 m to 48 m. The targeted species are surface-shoaling and once a shoal has been located the vessel will steam around it and encircle it with a large net, extending to a depth of 60 to 90 m (see Figure 2).

[1] Acoustic surveys are conducted to assess the pre- and post-spawning biomass of small pelagic species and the TAC is set and adjusted accordingly each year.

Netting walls surround aggregated fish, 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. Once the shoal has been encircled the net is pursed, hauled in and the fish pumped onboard into the hold of the vessel. It is important to note that after the net is deployed the vessel has no ability to manoeuvre until the net has been fully recovered onboard and this may take up to 1.5 hours. Therefore, direct communication from the survey vessel would be required to ensure pure-seine vessels stay clear of the survey vessel. Vessels usually operate overnight and return to offload their catch the following day.

Approximately 15.6% of the total fishing ground area available to the small pelagic fishery falls within License Block 5/6. Since most fishing activity is concentrated inshore of the 400 m bathycontour a relatively low percentage of total catch is taken within Block 5/6 (see Figure 3a and b). An average annual purse-seine catch of 16,334 tons has been recorded within the area for the period 2000 to 2009, representing 4.2% of the total catch for the fishery. The intensity of the impact of the proposed surveys on the pelagic purse-seine fishery is assessed to be **low**, with an overall significance assessed to be **VERY LOW**.

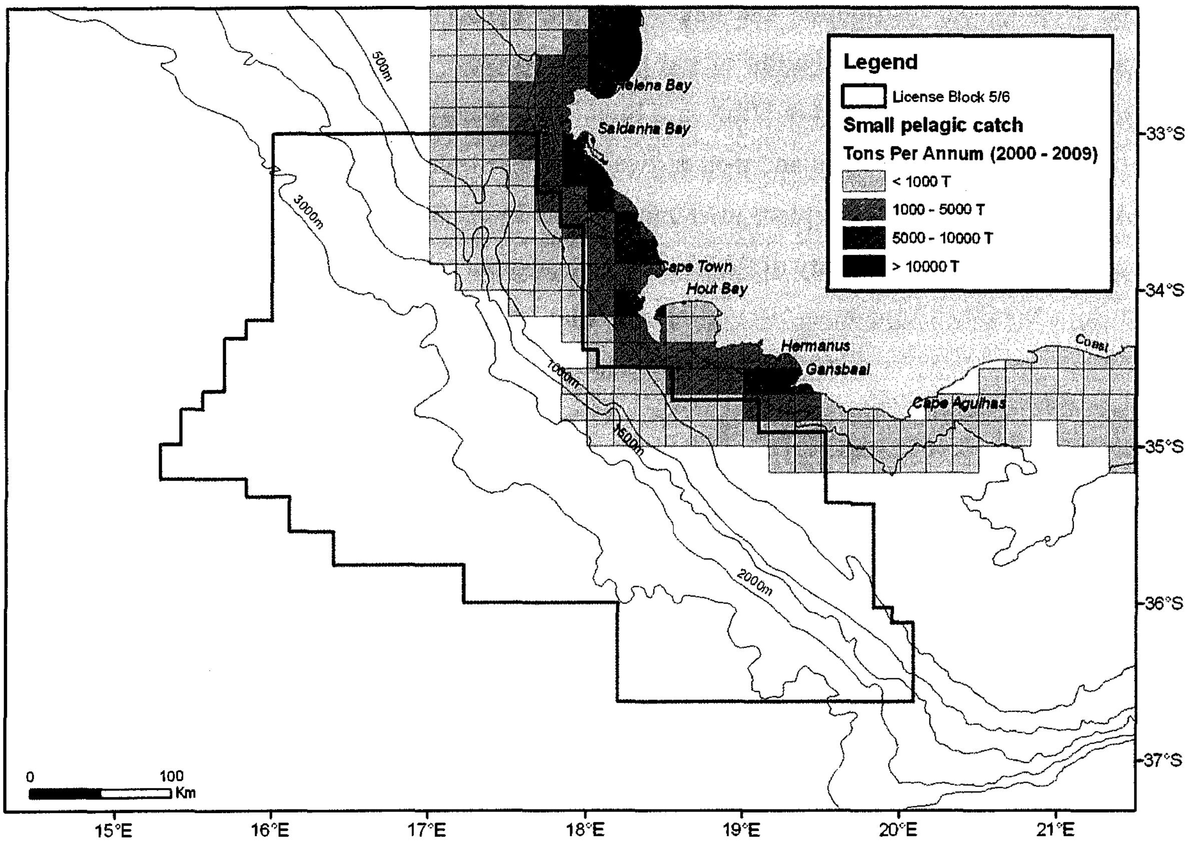


Figure 3a. Distribution of fishing activity within the small pelagic purse-seine fishery in respect to License Block 5/6. Data are presented on a 10 x 10 minute spatial grid as the average annual catch of small pelagic species for the period 2000 to 2009. Note that it is unlikely that fishing activity extends offshore of the 500 m bathycontour, and catch reports beyond this depth are possibly due to either isolated or incorrectly-reported fishing positions.

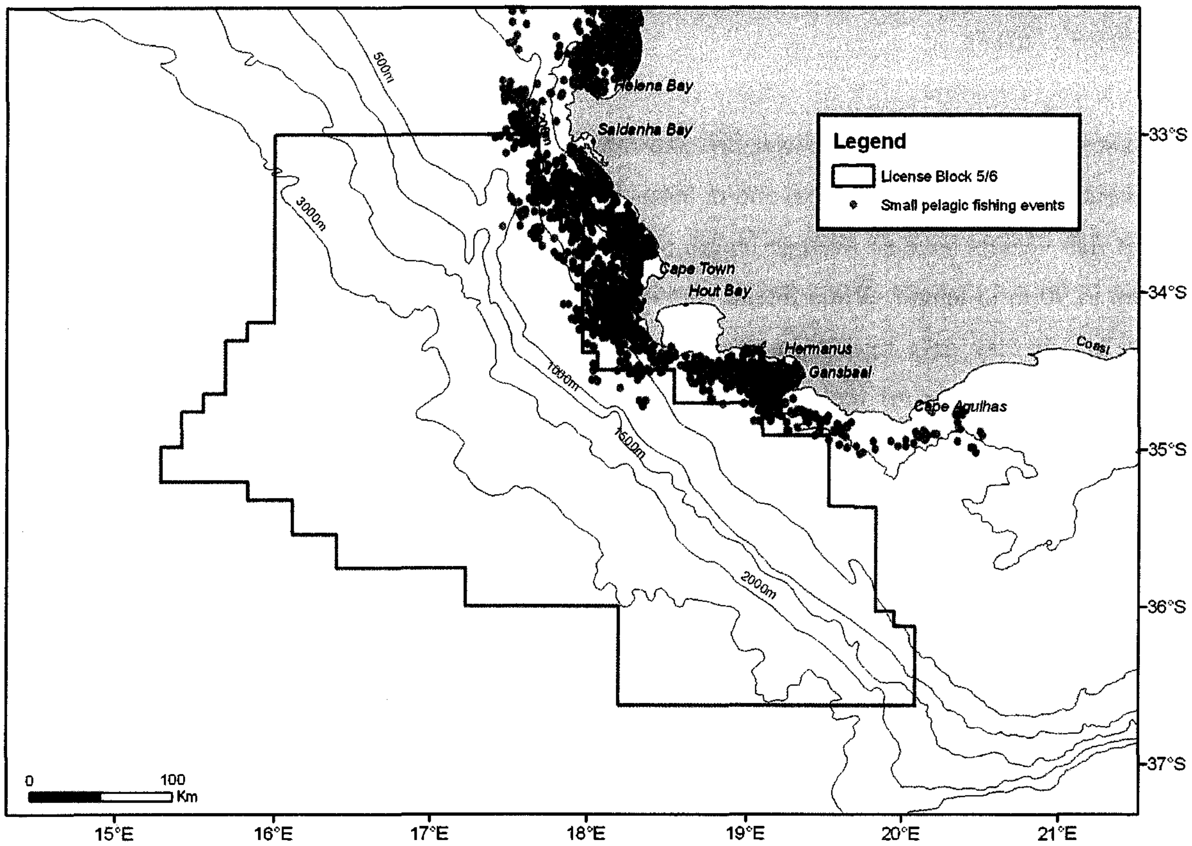


Figure 3b. Distribution of fishing activity within the small pelagic purse-seine fishery in respect to License Block 5/6. The positions of recorded net deployments is shown for the period 2000 to 2009.

4.2 Demersal Trawl Fishery

The demersal trawl fishery is South Africa's most important fishery and, for the last decade, it has accounted for more than half of the income generated from commercial fisheries. Prior to 1978 a single demersal trawl fishery targeted the two Cape hake species off southern Africa. After this date, the fishery was formally separated into an offshore sector targeting deep-water hake (*M. paradoxus)* and an inshore sector targeting shallow-water hake (*M. capensis*) and Agulhas sole (*Austroglossus pectoralis*). These sectors are divided at the 110 m depth contour on the South Coast (the inshore fishery does not occur West of the 20° E line of longitude. Offshore fishing grounds along the West Coast are centred at depths of between 200 m and 900 m and extend from Hondeklipbaai in a southward direction to the southern point of the Agulhas Bank. On the South Coast, deep-sea trawlers may not fish shallower than 110 m depth or within 20 nautical miles of the coast. In this southern region, rocky terrain largely forces trawlers to concentrate on the offshore edge of the Agulhas Bank. Inshore trawl grounds are located between Cape Agulhas and the Great Kei River. In this region hake directed trawling is most intense along the 100 m depth contour, although in the vicinity of Mossel Bay trawling occurs close inshore. Sole directed fishing takes place primarily between Mossel Bay and Struisbaai and there is no sole-directed activity West of the

20° E line of longitude. The Total Allowable Catch of hake for the demersal trawl fishery is currently set at 131,780 tons (2011).

The deep-sea fleet is segregated into wet fish and freezer vessels which differ in terms of the capacity for the processing of fish offshore (at sea) and in terms of vessel size and capacity (shaft power of 750 – 3000 kW). Wet fish vessels have an average length of 45 m, are generally smaller than freezer vessels which may be up to 90 m in length. While freezer vessels may work in an area for up to a month at a time, wet fish vessels fish may only remain in an area for about a week before returning to port. Trawl gear configurations are similar for both freezer and wet fish vessels, the main elements of which are trawl warps, bridles and doors, a footrope, headrope, net and codend (see Figure 4). Generally, trawlers tow their gear at 3.5 knots for up to four hours per drag. When towing gear, the distance of the trawl net from the vessel is usually between two and three times the depth of the water. The horizontal net opening may be up to 50 m in width and 10 m in height. The swept area on the seabed between the doors may be up to 150 m.

Typical demersal trawl gear configuration consists of (see Figure 4):

i. Steel warps up to 32 mm diameter - in pairs up to 3 km long when towed
ii. A pair of trawl doors (500 kg to 3 tons each)
iii. Net footropes which may have heavy steel bobbins attached (up to 24" diameter) as well as large rubber rollers ("rock-hoppers")
iv. Net mesh (diamond or square shape) is normally wide at the net opening whereas the bottom end of the net (or cod-end) has a 130 mm stretched mesh

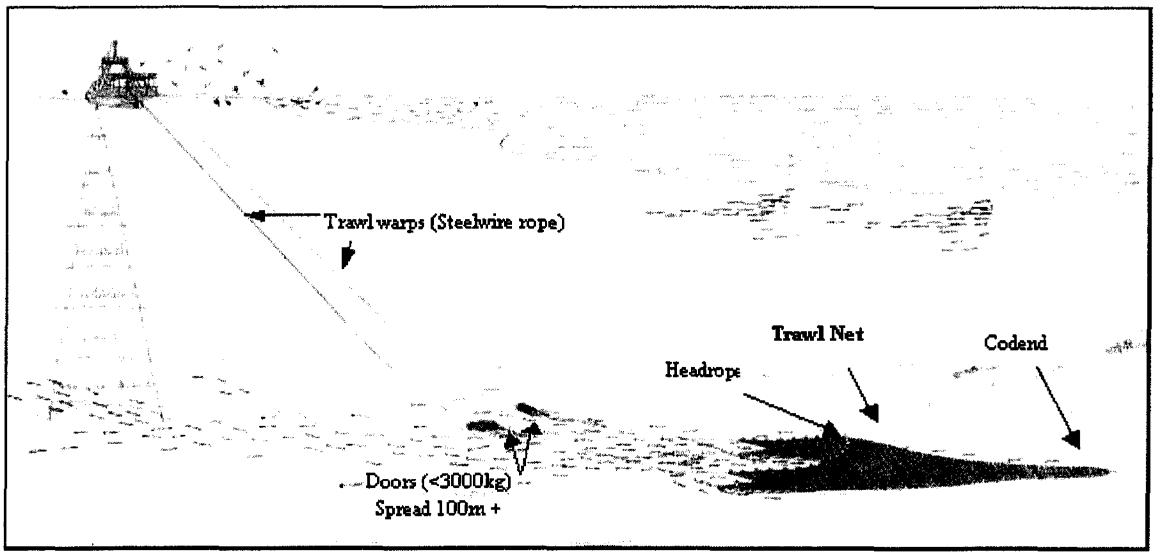
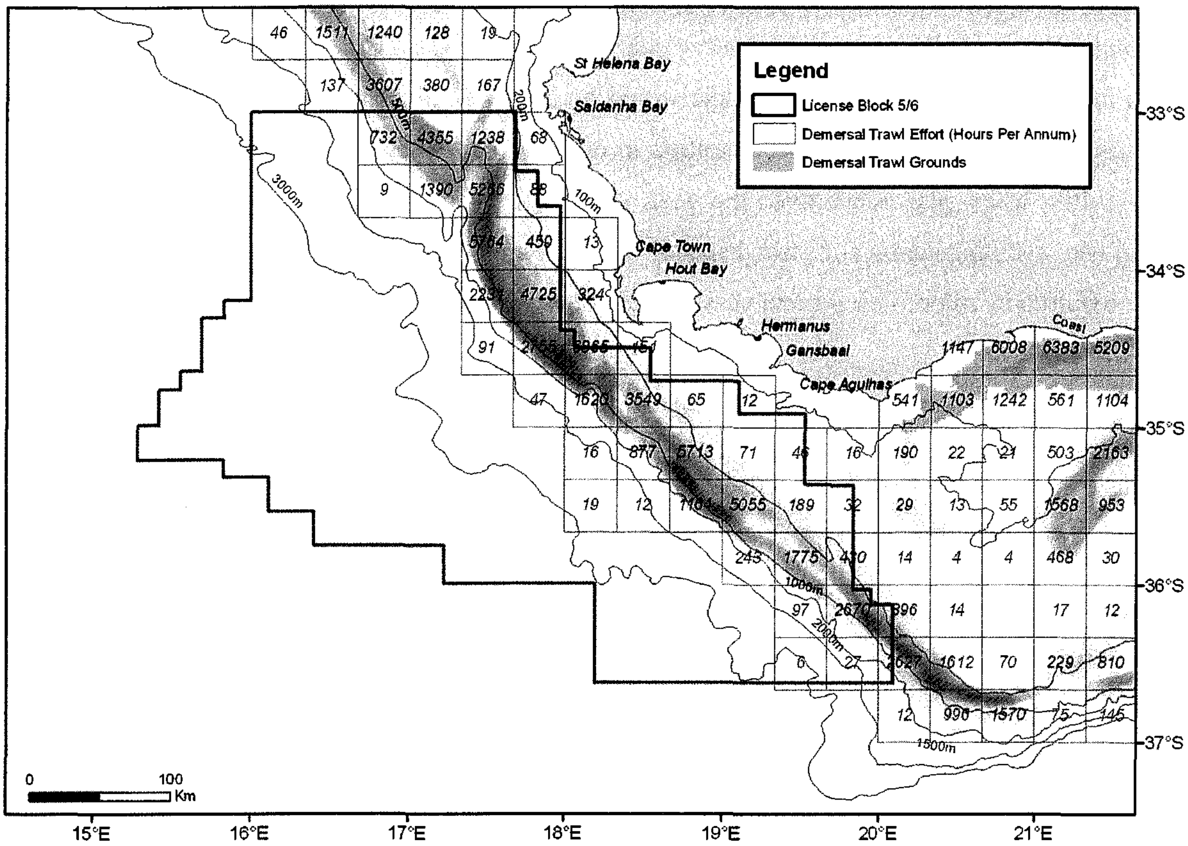


Figure 4. Schematic diagram of trawl gear typically used by deep-sea demersal trawl vessels.

The majority of vessels licensed to conduct hake deep-sea trawl are registered at the ports of Cape Town and Saldanha Bay, with 83 of a total of 98 vessels registered at West Coast harbours. It is highly likely that both freezer and wet fish trawler vessels would be encountered within the survey area in Block 5/6 and there is generally no seasonal differentiation in effort levels. Although these vessels are restricted in manoeuvrability when gear is deployed the gear can be recovered within a period of 30-minutes or the vessel can take avoiding action at its trawl speed. Therefore, direct communication from the survey vessel would be required in order to keep trawl vessels clear of the survey vessel.

Trawl grounds cover approximately 19,631 km^2 within License Block 5/6 – an estimated 27.8 % of the total available trawl ground. Over the period 2000 to 2008, 41.0 % of the total effort of the demersal trawl fishery was conducted within the area at an average of 63,381 hours of trawling per year. Although overall national effort has declined over this period due to reductions in the Total Allowable Catch (TAC), the relative amount of trawling activity within this area has increased. An annual average of 78,329 tons of catch (nominal weight of all species landed) has been recorded in Block 5/6. This is at least 50.0 % of the average total catch landed nationally during this period. Trawling within the License Block is distributed from depths of 200 m to a maximum of 900 m (see Figure 5).

The intensity of the likely impact of the proposed surveys on the demersal trawl fishery is assessed to be **high**, whereas the overall significance of the impact is assessed to be **LOW** due to the short-term duration of the impact and since surveying in the majority of the block would have no impact on the fishery. In order to minimize the impact on the fishery, it is suggested that survey design be communicated to the trawling industry in order to co-ordinate areas that would remain open to trawling and that regular updates on the whereabouts of planned survey transects be relayed to the fleet. The placement of concrete anchors along CSEM transects is deemed to pose no risk to trawlers that make use of "rock-hopper" gear; however, any trawlers operating without such gear would be at risk of picking up these anchors. It is advised that the location of any anchors be made available to the trawling industry so that they can be avoided until such time as they disintegrate (six to eight months after deployment).



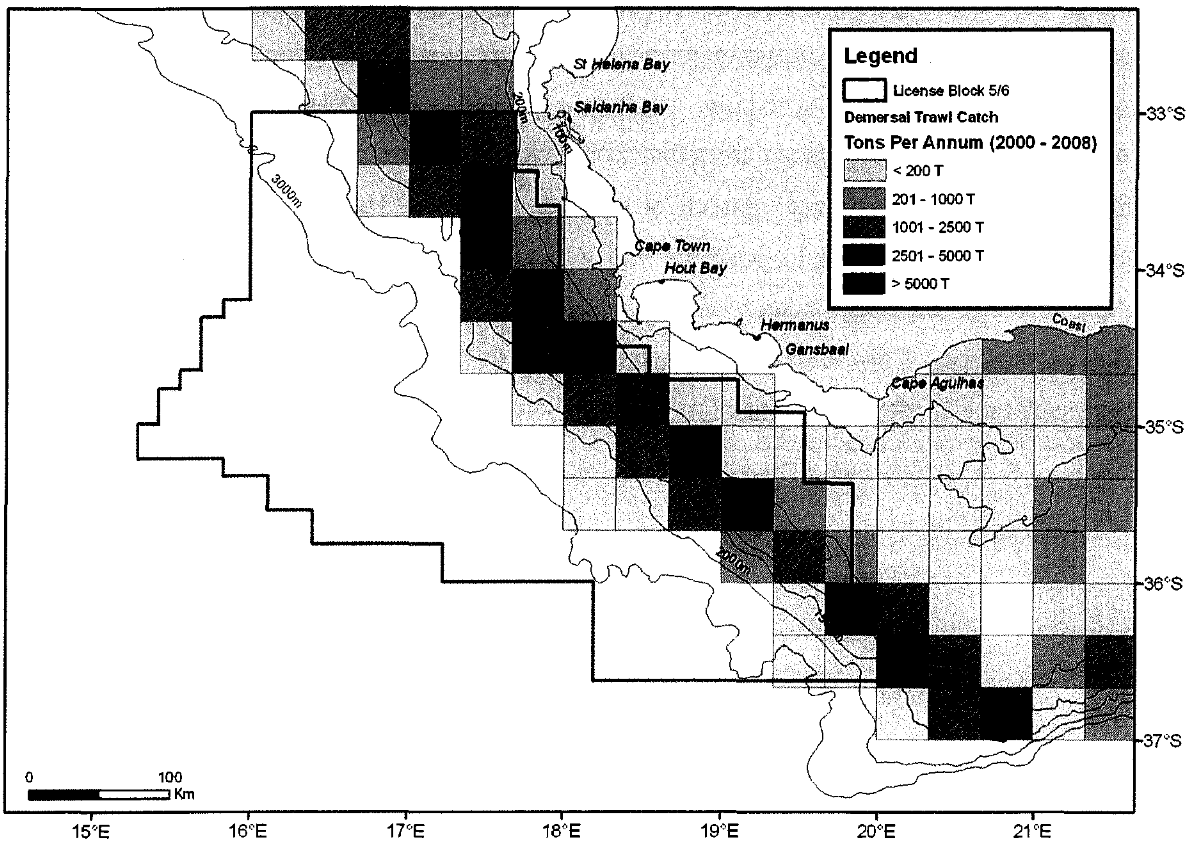


Figure 5a and b. Distribution of fishing effort and catch landed by the demersal trawl fishery in respect to License Block 5/6 for the years 2000 to 2008.

4.3 Demersal Long-Line Fisheries

The demersal long-line fishing technique is used to target bottom-dwelling species of fish. Two fishing sectors utilize this method of capture, namely the long-line fishery for Cape hakes and the shark long-line sector targeting only the demersal species of shark. A demersal long-line vessel may deploy either a double or single line which is weighted along it's length to keep it close to the seafloor (see Figure 6). Steel anchors, of 40 to 60 kg are placed at the ends of each line to anchor it. These anchor positions are marked with an array of floats. If a double line system is used, top and bottom lines are connected by means of dropper lines. Since the top-line (polyethylene, 10 – 16 mm diameter) is more buoyant than the bottom line, it is raised off the seafloor and minimizes the risk of snagging or fouling. The purpose of the top-line is to aid in gear retrieval if the bottom line breaks at any point along the length of the line. Lines are typically 20 – 30 nautical miles in length. 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 5 – 9 knots. Once deployed the line is left to soak for up to eight hours before it is retrieved. A line hauler is used to retrieve gear (at a speed of approximately 1 knot) and can take six to ten hours to complete. During hauling operations manoeuvrability would be severely restricted and direct communications from the survey vessel would be required in order to keep vessels and gear clear of the survey vessel.

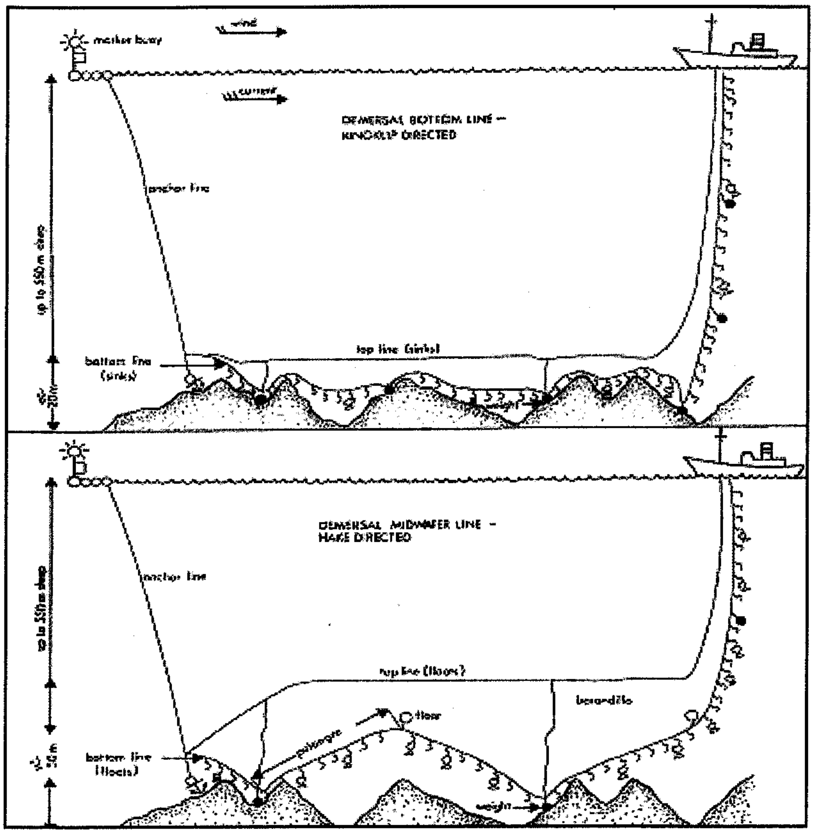


Figure 6. Schematic diagram showing a typical configuration of long-line gear used to target demersal fish species.

4.3.1 Hake-Directed Fishery

Like the demersal trawl fishery the target species of this fishery is the Cape hakes, with a small non-targeted commercial by-catch that includes kingklip. A total nominal catch weight of 7,713 tons was recorded within the fishery for 2009. The hake long-line fishery is a relatively new fishery in South Africa, having started in 1994 as an experimental fishery, with long-term commercial rights being allocated in 2004. Fishing takes place along the West and South East coasts, in areas similar to those targeted by the demersal trawl fleet. The catch is landed predominantly prime quality hake for export to Europe. The catch is packed unfrozen on ice and the value is approximately 50% higher than that of trawled hake. There are currently 64 vessels licensed within the sector, operating from all major harbours, including Cape Town, Hout Bay, Mossel Bay and Port Elizabeth. Secondary points of deployment include St Helena Bay, Saldanha Bay, Hermanus, Gansbaai, Plettenberg Bay and Cape St Francis; however there is far less activity from these areas than from the main harbours. Vessels based in Cape Town and Hout Bay operate almost exclusively on the West Coast (west of 20° E). Vessels vary from 18 m to 50 m in length and remain at sea for four to seven days at a time. The fishery is directed in both inshore and offshore areas. Inshore long-line operations are restricted by the number of hooks that may be set per line while offshore operations may only take place in waters deeper than 110 m and is restricted to the use of no more than 20,000 hooks per line.

Demersal long-line vessels operate in well-defined areas extending along the shelf break from Port Nolloth to Cape Agulhas (Figures 7a and b). Fishing activity would be expected to occur within the survey area along and inshore of the 500 m depth contour. Long-line grounds coincide with approximately 17,852 km^2 of Block 5/6 which is estimated to be 30.6 % of the total grounds fished by the demersal long-line fishery. An annual average of 19.1 million hooks were set and 4,126 tons of hake were caught in the area over the period 2002 to 2008, corresponding to 44.8 % of the overall national effort and 48.4 % of the total landings respectively. The intensity of the impact of the proposed surveys on the demersal long-line fishery is assessed to be **high**, whereas the overall significance of the impact is assessed to be **LOW** due to the short-term duration of the impact.

4.3.2 Shark-Directed Fishery

Capture of demersal shark species occurs primarily in the demersal shark long-line fishery whilst catches of pelagic shark species occurs primarily in the large pelagic sector that targets tuna and swordfish. Prior to 2006, both demersal and pelagic shark catches were managed as a single shark fishery. The demersal shark fishery targets soupfin shark (*Galeorhinus galeus*), smooth-hound shark (*Mustelus spp.*), spiny dogfish (*Squalus* spp), St Joseph shark (*Callorhinchus capensis*), *Charcharhinus* spp., rays and skates. Other species which are not targeted but may be landed include cape gurnards (*Chelidonichthys capensis*), jacopever (*Sebastichthys capensis*) and smooth hammerhead shark (*Sphyrna zygaena*). 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 relatively close to shore, generally inshore of the 200 m isobath. Demersal shark longline fishing is also not permitted in False Bay between Cape Hangklip and Cape Point, or in tidal lagoons, estuaries, closed areas and marine protected areas. Demersal shark longline fishing grounds are found only inshore of the proposed survey area (see Figures 7a and b) and, as such, the specific impact of the demersal longline shark-directed fishing operations is unlikely to increase the significance of the overall impact on the demersal long-line fishing method.

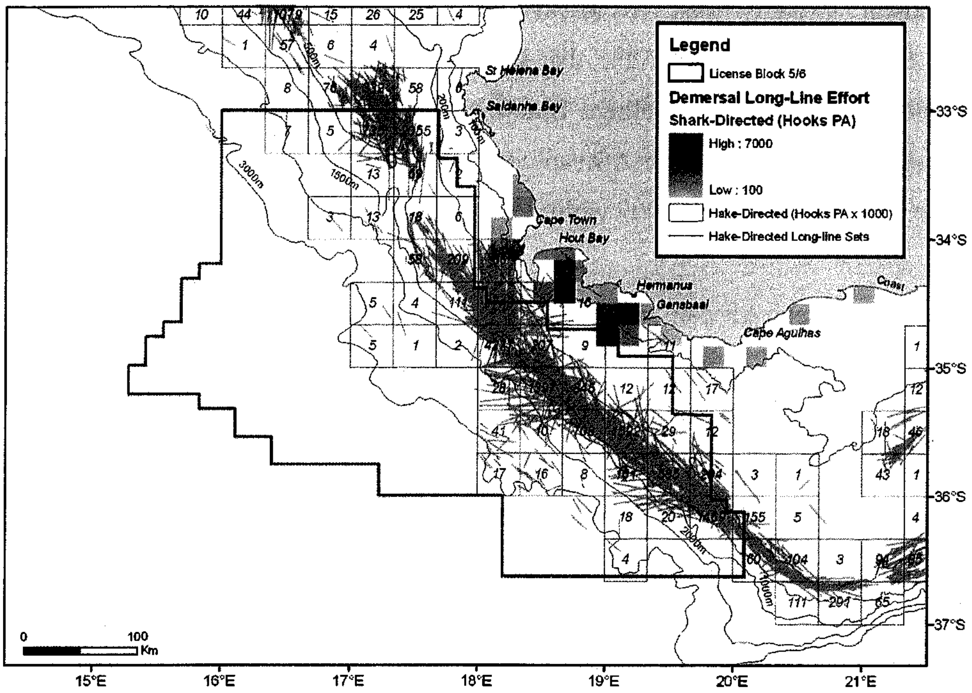


Figure 7a. Distribution of fishing effort of the demersal long-line fisheries for hake (2002 – 2008) and shark (2003 – 2008) in the vicinity of License Block 5/6. Data are displayed as the average annual number of hooks set per 20 x 20 minute (hake) and 10 x 10 minute grid (shark).

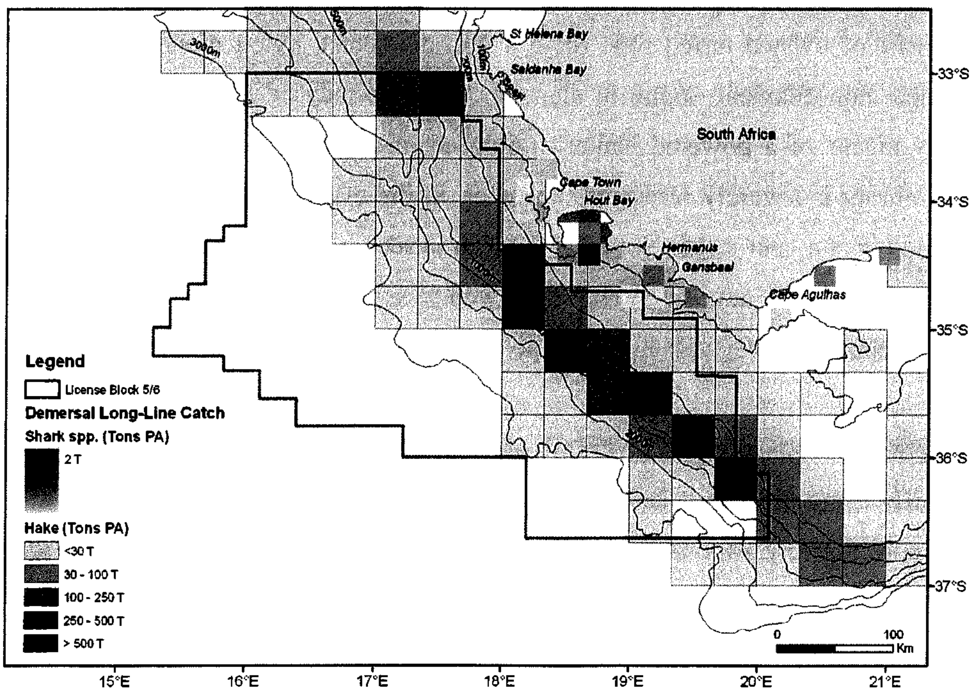


Figure 7b. Distribution of catch landed by the demersal long-line fisheries for hake (2002 – 2008) and shark (2003 – 2008) in respect to License Block 5/6.

4.4 Large Pelagic Long-Line Fishery

The target species within the South African pelagic long-line sector are yellowfin tuna, bigeye tuna, swordfish and shark species (primarily mako shark). Due to the highly migratory nature of these species, stocks straddle the EEZs of a number of countries and international waters. As such they are managed at an international level through country allocations and global effort control. It is at this level that Regional Fisheries Management Organisations (RFMOs) such as the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCBT) are instrumental in managing the pelagic long-line sector around the South African coast. Nominal reported landings of 2,136 tons were recorded within the fishery for the year 2009 within the South African EEZ and on the high seas.

Twenty-nine foreign and South-African-flagged vessels operate within South African waters. Trip lengths range from three weeks to three months in duration. Although most vessels operate from the Cape Town harbour, the areas of operation are extensive within the entire South African EEZ. Tuna are targeted at thermocline fronts, predominantly along and offshore of the shelf break. Pelagic long-line vessels set a drifting mainline, up to 50-100 km in length, and are marked at intervals along its length with radio buoys (Dahn) and floats to facilitate later retrieval. 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. Between radio buoys the mainline is kept near the surface or at a certain depth by means of ridged hard-plastic buoys, (connected via a "buoy-lines" of approximately 20 to 30 m). The buoys are spaced approximately 500 m apart along the length of the mainline. Hooks are attached to the mainline on branch lines, (droppers), which are clipped to the mainline at intervals of 20 to 30 m between the ridged buoys, (see Figure 8). The main line can consist of twisted tarred rope (6 to 8 mm diameter), nylon monofilament (5 to 7.5 mm diameter) or braided monofilament ~6mm in diameter. 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, however, in the event of an emergency, the line may be dropped to be hauled in at a later stage. Note that the gear is set close to the sea surface and will present a potential obstruction to surface navigation and the towed seismic array if encountered. Therefore, direct communication between the survey vessel and the pelagic long-line vessels is important.

Pelagic long-line effort extends along and offshore of the 500 m bathycontour whilst pelagic shark species are targeted primarily along the 200 m isobath. Grounds cover an estimated 76,032 km^2 of Block 5/6 (see Figures 9a,b,c). Approximately 14.8 % of the total national effort is conducted within this area each year (180 sets and 315,000 hooks) and 15.7 % of the total landings of targeted species are derived from this area (~252 tons). Within the pelagic shark-directed fishery, approximately 22.7 % of the total national effort and 19.8 % of the total catch is taken within Block 5/6. The intensity of the impact of the proposed surveys on the pelagic long-line fishery is assessed to be **high**, whereas the overall significance of the impact is assessed to be **LOW** due to the short-term duration of the impact.

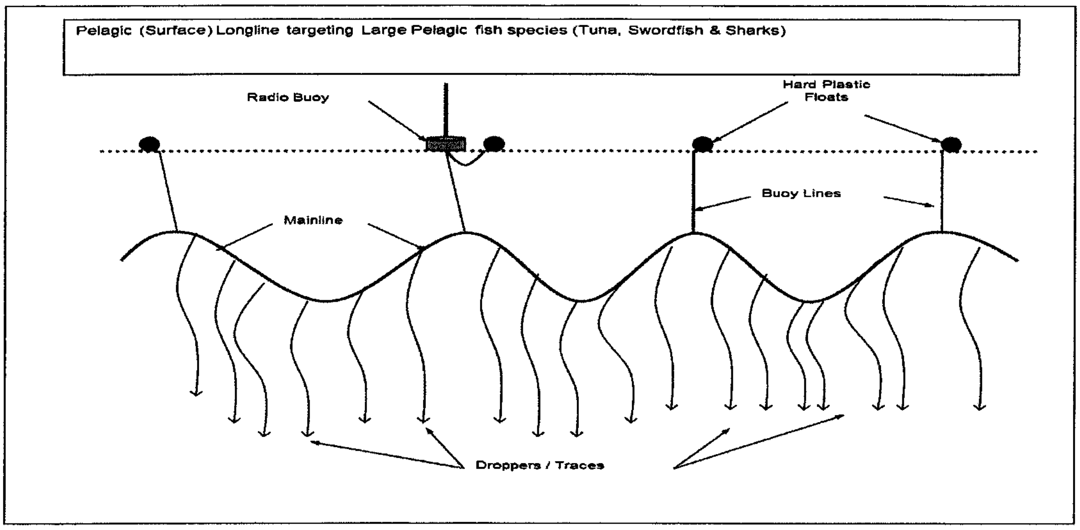


Figure 8. Typical pelagic long-line gear configuration targeting tuna, swordfish and shark species. Note the gear floats close to the surface of the sea and would present a potential obstruction to surface navigation.

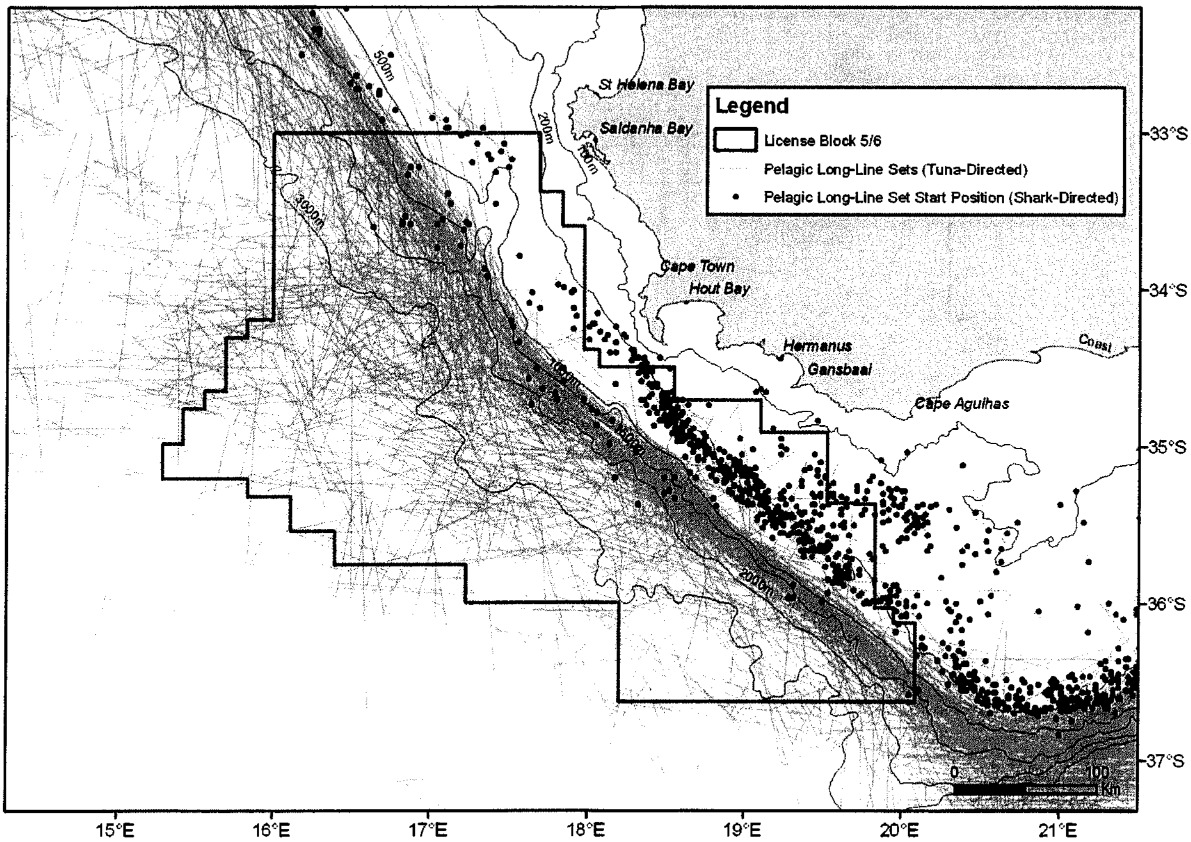
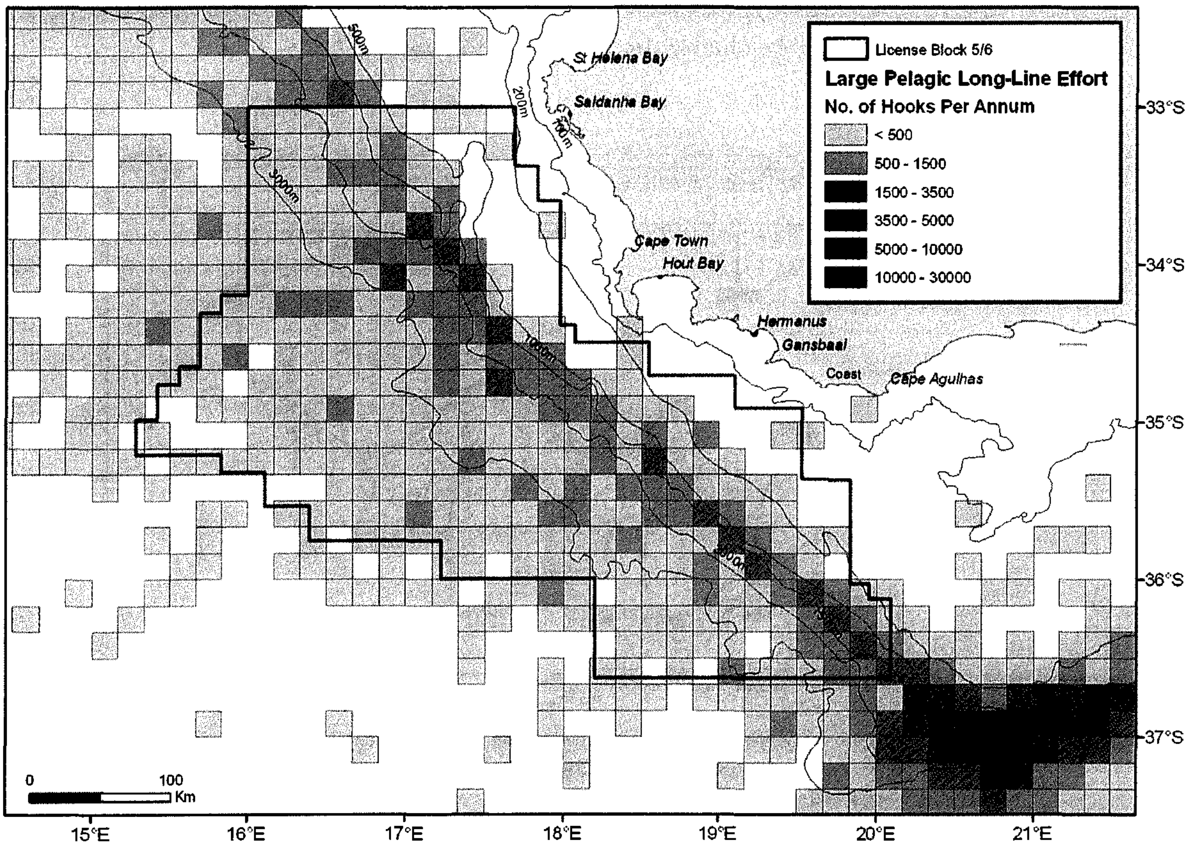


Figure 9a. Distribution of fishing positions of the large pelagic long-line (tuna and shark-directed) fishery from 1998 to 2007 in respect to License Block 5/6.



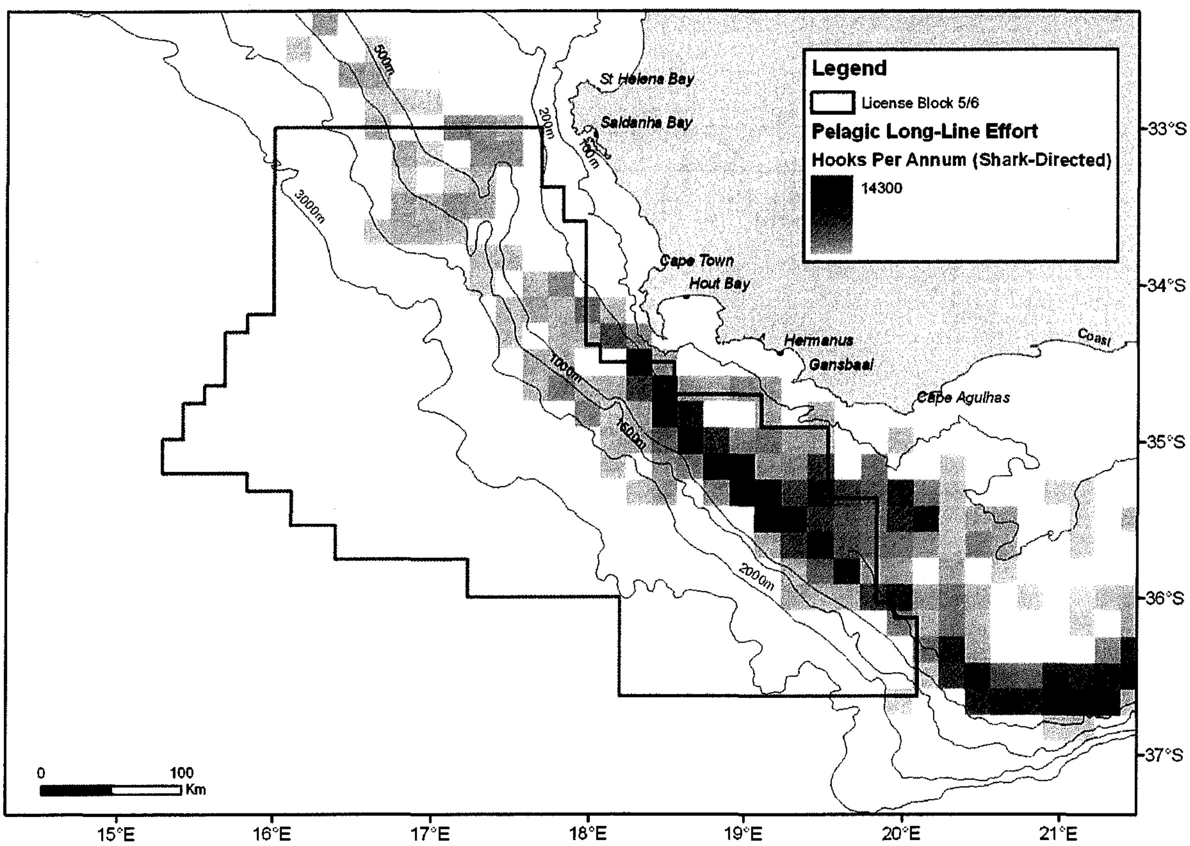


Figure 9b and 9c. Distribution of fishing effort (no. of hooks set per annum) within the large pelagic long-line fishery targeting (a) tuna species (1998 to 2007) and (b) pelagic shark species (2003 – 2008) in respect to License Block 5/6.

4.5 Tuna Pole Fishery

The tuna pole fishery is based on migratory species of tuna – predominantly longfin tuna (*T. alalunga*) and yellowfin tuna (*T. albacares*). Tuna pole fishing is conducted by a fleet of 130 vessels, 119 of which are registered at the ports of Cape Town and Hout Bay. Depending on the availability of fish, the fishing season varies between years, starting between October and December and ending between April and June. The fishery lands approximately 3,500 – 5,000 tons of longfin tuna and 400 – 800 tons of yellowfin tuna annually off the entire South African coastline (DAFF: Craig Smith, pers comm.).

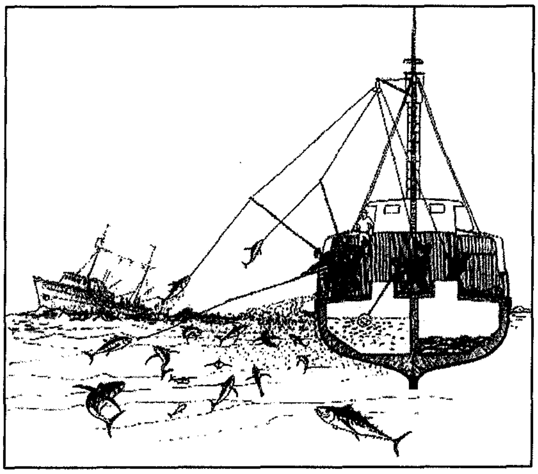


Figure 10. Schematic diagram of pole and line operation (www.fao.org/fishery).

Vessels operating within the fishery are typically small (< 25 m in length). Catch is stored on ice, chilled sea water or frozen and the storage method often determines the range of the vessel. Trip durations average between four and five days, depending on the distance of the fishing grounds from port. Vessels operating on ground in the Cape Canyon may be between two and seven days, whilst those working North of Cape Columbine spend 10 – 12 days at sea per trip. Vessels drift whilst attracting and catching pelagic tuna species. Whilst at sea, the majority of time is spent searching for fish with actual fishing events taking place over a relatively short period of time. Sonars and echo sounders are used to locate schools of tuna. At the start of fishing, water is sprayed outwards from high-pressure nozzles to simulate small baitfish aggregating near the water surface, thereby attracting tuna to the surface. Live bait is flung out 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. Hooked fish are pulled from the water and many tons can be landed in a short period of time. 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 10).

Within License Block 5/6 activity would be expected between the 200 m and 500 m bathycontours, particularly around Cape Columbine and the Cape Canyon (see Figure 11). Over the period 2000 to 2010 the tuna pole fishery has caught an average of 3,289 tons of albacore and yellowfin tuna within Block 5/6 each year. Effort fluctuates according to the availability of fish in the area, but once a shoal of tuna is located a number of vessels will move into the area and target a single shoal and may remain in the area for days at a time. As such the fishery is dependent on window periods of favourable conditions relating to catch availability.

The nature of the fishery and communication between vessels often results in a large number of these vessels operating in close proximity to each other at a time. The vessels fish predominantly during daylight hours and as they do not anchor or have any fixed gear in the water, these vessels remain highly manoeuvrable and could take avoiding action at any time. 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. The fishery is seasonal with vessel activity mostly between October and May. This period coincides with the normal seismic survey period in South Africa between Dec to June. It is recommended that sufficient notice be given to the tuna pole fishery of the proposed location of survey transects. A possible mitigation measure for the impact of survey operations on the fishery would be for the tuna pole fishers to request that the survey vessel avoid any particular fishing area if a shoal of fish were to be located within the License Block during survey operations. It is suggested that a consultation process be established between the tuna pole fishing industry members and survey operators to discuss the possibility of altering the survey programme at short notice.

The intensity of the impact of the proposed surveys on the tuna pole fishery is assessed to be **high**, whereas the overall significance of the impact is assessed to be **LOW** due to the short-term duration of the impact.

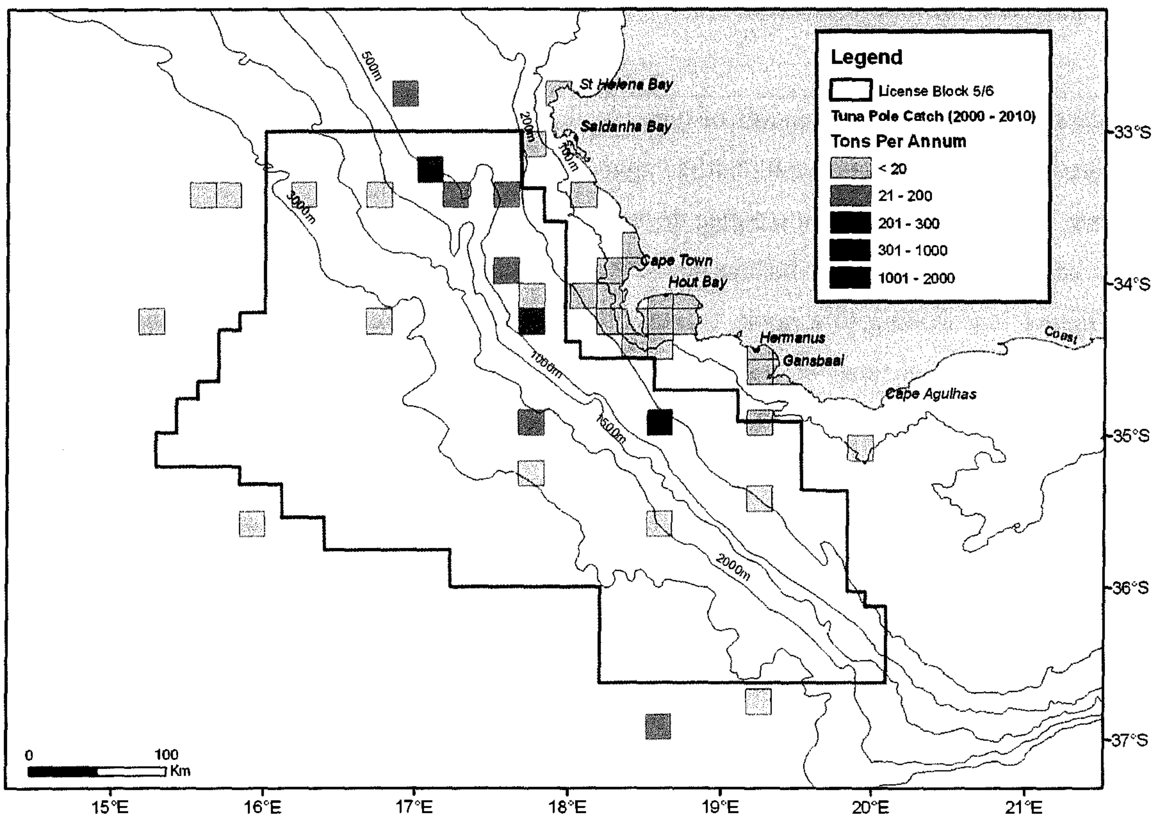


Figure 11. Main area of fishing effort in the tuna pole fishery in respect to License Block 5/6.

4.6 Traditional Line Fishery

The traditional line fishery is based on 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. On the West Coast the dominant species targeted is snoek (*Thyrsites atun*). This fishery comprises recreational, commercial and subsistence sectors, jointly landing approximately 14,100 tons per annum (2009). Historically, the sector incorporated the tuna pole fishery and was ranked third according to volume of landings and overall economic value. Currently, the volume of fish caught by the traditional line fishery is much lower than many other commercial sectors, but is one of the most important in terms of the number of active participants. Almost all of the traditional line fish catch is consumed locally.

The commercial fishery operates between Port Nolloth on the West Coast to Cape Vidal on the East Coast from the coast out to the 120 m depth contour. Gear consists of hand line or rod-and-reel. Recreational permit-holders fish via skiboat (fast motor boats) or from the shore (anglers) whereas the commercial sector is purely boat-based. Subsistence permit-holders are shore-based and estuarine (purely based on the East Coast). Line fishers are restricted to a maximum of ten hooks per line but a single fisherman may operate several lines at a time. Vessels targeting snoek and other line fish species operate relatively close to the coastline out to a maximum depth of 120 m and as such would expected to be impacted by seismic operations only if the survey vessel were to move into waters shallower than 120 m. Skiboats (recreational permit-holders) and deckboats (commercially operated) targeting tuna species operate in much deeper waters, similar to those frequented by tuna pole vessels, in particular in the area south of Cape Point (see Figure 12). Over the period 2006 to 2010, these vessels were active within Block 5/6 for an average of 83 days per year, landing an average of 87.0 tons (0.6% of the total national landings). Catch rates may fluctuate from year to year depending on the seasonal availability of tuna, with reported annual landings ranging from 39.1 tons to 180.8 tons during the period 2006 to 2010.

Due to the large number of users, launch sites, species targeted, and the wide operational range, the line fishery is managed on an effort basis, rather than on a catch basis. There are currently about 450 vessels operating extensively around the coast and skiboats used in the recreational sector may be launched from a number of slipways and harbours around the South-Western Cape. Of particular importance would be to relay information of the proposed survey operations and timing to all right's holders within the fishery. Due to the large number of vessels and launch sites it is suggested that advertisements be placed in local newspapers and that posters be distributed at skiboat clubs and around jetties.

The impact of the proposed surveys on the traditional line fishery is assessed to be of **low** intensity and of **VERY LOW** overall significance due to the short-term duration of the impact.

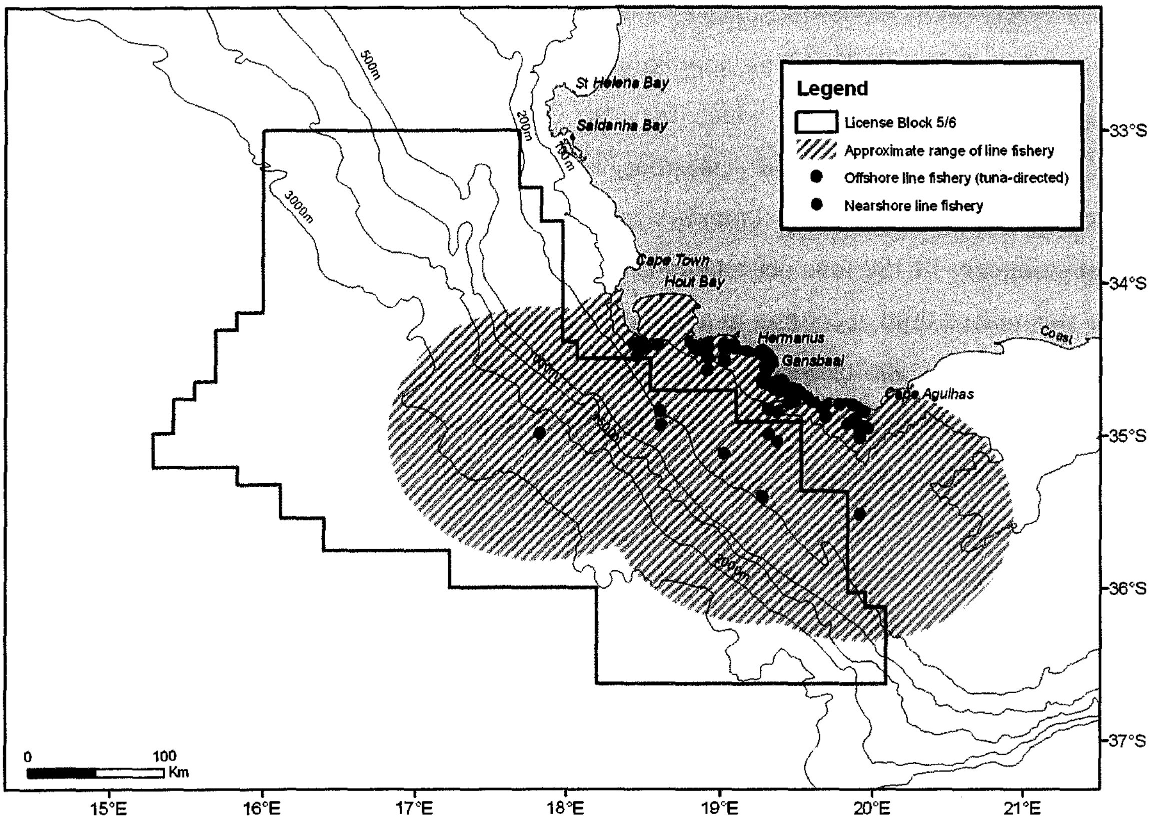


Figure 12. Main area of fishing effort in the line fishery in respect to License Block 5/6. *Note that fishing data east of 20°E and north of 33°S has been excluded from this map.*

4.7 West Coast Rock Lobster Fishery

The West Coast rock lobster fishery is considered to be the third most valuable fishery in South Africa with an approximate catch value of R200 million per annum (www.feike.co.za, 2007). The West Coast rock lobster is a slow-growing, long-lived species which occur inside the 200 m depth contour along the entire West Coast to East London on the East Coast. The fishery is divided into the offshore fishery and the near-shore fishery, both directed inshore of the 100 m bathycontour.

Fishing grounds are divided for management purposes into Zones (and further subdivided into Areas) stretching from the Orange River mouth to east of Cape Hangklip in the South-Eastern Cape. 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. The offshore sector makes use of traps consisting of rectangular metal frames covered by netting, which are deployed from trap boats (otherwise known as "deck boats") whilst the inshore fishery makes use of hoopnets deployed from small dingys. The West Coast rock lobster offshore fishing fleet consists of vessels that range in length from 6 m to 14 m. Traps are set at dusk and retrieved during the early morning using a powerful winch for hauling. Vessels using traps will leave up to 30 traps per vessel in the fishing grounds overnight during the week, Monday to Friday. As a requirement of permit conditions for this sector, all traps must be removed over the weekend.

Effort is seasonal with boats operating from the shore and coastal harbours. Catch is landed whole and is managed using a TAC, 80% and 20% of which is allocated to the offshore and inshore fisheries respectively. The majority of effort (97 %) is directed in designated rock lobster Areas extending from Abrahamskraal to Gansbaai. A total national landing of 2,100 tons (whole weight) was recorded for 2009.

Since Block 5/6 lies offshore of the 100 m bathycontour there is no interaction expected between the proposed surveys and the West Coast rock lobster fishery (see Figure 13); however if the survey vessel moves out of the License Block into shallower waters e.g. during line changes, fishing operations may be affected. This potential impact is considered to be **INSIGNIFICANT**.

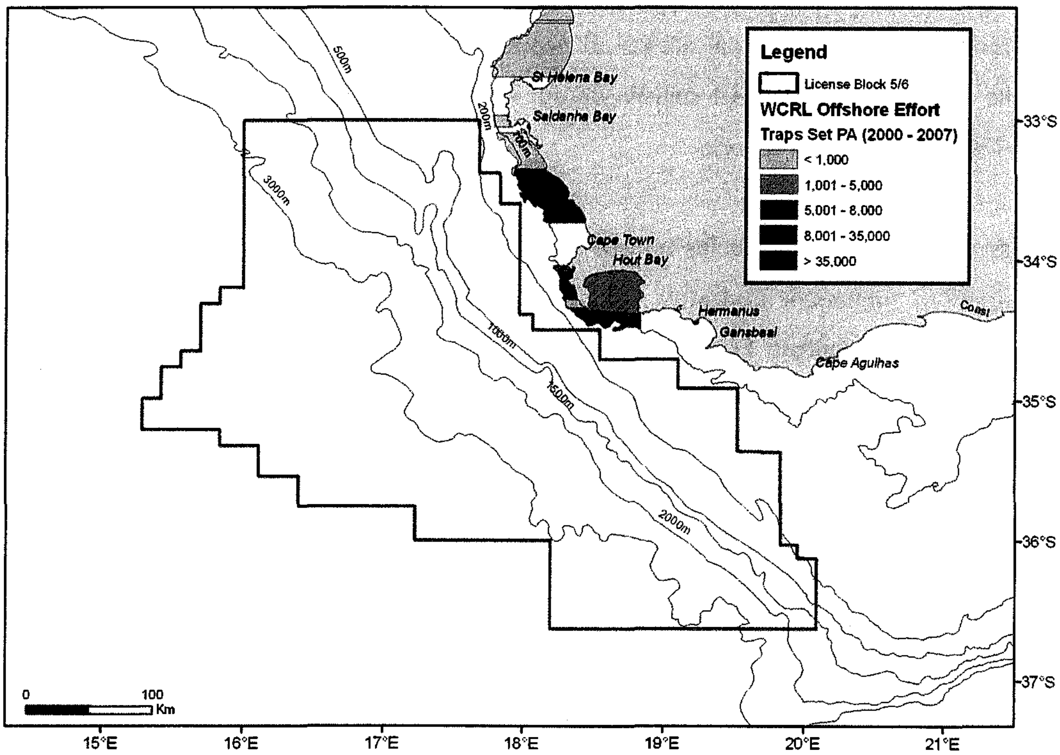


Figure 13. Distribution of fishing effort within the West Coast rock lobster offshore sector in respect to License Block 5/6.

5.0 FISHERIES RESEARCH

A survey of demersal fish resources is carried out twice a year by the Department of Agriculture, Forestry and Fisheries (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 survey vessel *FRS Africana* is the dedicated research vessel used to conduct both surveys. A similar gear configuration is used to that of commercial demersal trawlers, however nets are towed for a shorter duration of generally 30 minutes per tow. First started in 1985, the first survey covers the West Coast offshore region, working from South to North from Cape Agulhas (20° E) to the Orange River. Trawl positions are randomly selected to cover specific depth strata that range from coast to the 1000 m bathycontour (see Figure 14). Approximately 120 trawls are conducted during each cruise and the location of these trawls is pre-determined usually a week before the cruise is scheduled to take place. The surveys usually last one month each, and take place in January (West Coast survey) and May (South Coast survey). From 2013 it is possible that the surveys of the West and South Coasts will not be distinct in time, but will be carried out as a single survey. If this is approved, it is likely that the single survey would commence in January at the Orange River, and that the survey vessel would move southwards and progress on to the South Coast and east of 20° E. The overall survey duration would be approximately two months. It is expected that the demersal survey of the West Coast would coincide with the proposed survey activities within Block 5/6 since research trawls are carried out across all depth strata within the area from the coast to a depth of 1000 m. The South Coast demersal survey would not be affected by the proposed seismic survey as it takes place East of the License Block.

The biomass of small pelagic species is 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 the surveys the survey vessel travels pre-determined transects (perpendicular to bathycontours) running from the coast out to approximately the 200 m bathycontour. The survey is designed to cover an area extensive area from the Orange River on the West Coast to Port Alfred on the South Coast and the survey vessel *FRS Africana* progresses systematically from the Northern border Southwards, around Cape Agulhas and on towards the East. The timings of the demersal and acoustic surveys are not flexible, due to restrictions with availability of the research vessel as well as scientific requirements.

The potential impact of the seismic survey operations on the demersal and acoustic research surveys is considered to be **high (LOW** significance) if the research survey areas of operation coincide with seismic survey areas. The intensity of the impact could be lowered through effective mitigation measures and the most effective means of mitigation would be the timing of seismic survey operations to avoid periods during which research survey activity would be conducted within Block 5/6. It is recommended that the managers of the research survey programmes be involved during the planning stages of the seismic survey in order to negotiate the timing of transects or trawls to avoid conflict between the seismic and research survey operations. The relevant contacts at DAFF currently responsible for the planning of the demersal and acoustic cruises are Deon Durholtz and Janet Coetzee respectively.

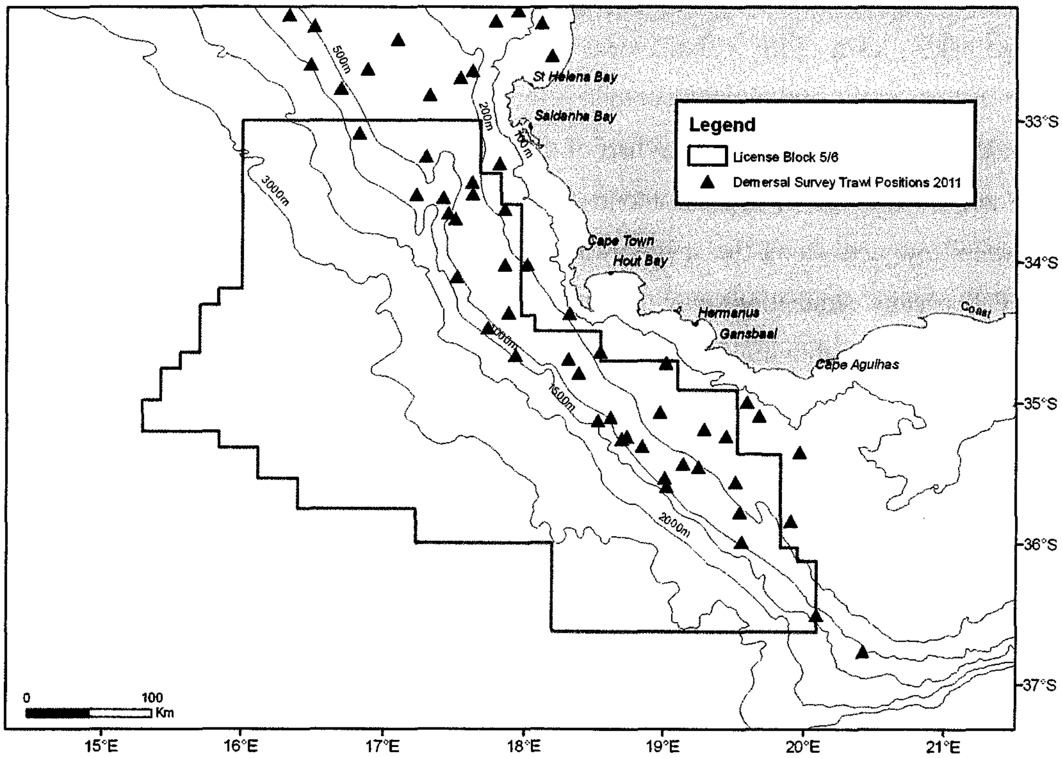


Figure 14. Distribution of research trawls conducted during the January/February 2011 West Coast demersal survey in respect to License Block 5/6.

6.0 SUMMARY AND RECOMMENDATIONS

Six commercial fisheries have been identified as being active within License Block 5/6 and could potentially be impacted by seismic and CSEM survey operations (Table 2). With the exception of the large pelagic long-line fishery, all other fishing effort is directed inshore of the 1000 m bathycontour and, as such, survey activities offshore of this would have a minimal impact on fisheries. Disruption to fishing activities could be minimized depending on the final location and timing of the survey transects as well as the type of survey acquisition used (2D/3D/CSEM). At this point, however, the details of survey lines are indicative only. The following fisheries have been identified as being active in or around License Block 5/6:

- The small pelagic fishery is a boat-based fishery using purse-seine gear to capture surface-shoaling fish species (predominantly sardine). The fishery operates predominantly from the harbours of St Helena Bay, Saldanha Bay and Hout Bay on fishing grounds extending along the West and South coasts of the Western Cape to a distance of 50 nautical miles offshore. The fishery is active all year round, with seasonal trends in the specific species targeted. Activity within the fishery would be expected across the inshore region of Block 5/6.

- A significant amount of activity within the demersal long-line and trawl fisheries (both targeting Cape hakes) takes place within License Block 5/6. Long-line fishing grounds are situated along and inshore of the 500 m bathycontour in the northern half of the License Block and extending to a depth of 900 m in the Southern half of the block. Trawlers would be expected to occur between the 200 m and 900 m depth contours. Both fisheries are active all year round. Since demersal trawlers tow nets along the seafloor, the presence of receivers anchored on the seabed (used in CSEM seismic acquisition) may increase the duration and intensity of the impact on the fishery if they are placed within trawled grounds.

- Long-line vessels targeting pelagic tuna species, swordfish and shark operate extensively around the entire coast along the shelf-break and into deeper waters. As such vessel activity would be expected to be encountered within Block 5/6 offshore of the 200 m bathycontour. Since the gear used by this fishery consists of surface-set drifting lines of up to 100 km in length, this fishery would be highlighted as posing a potential hazard to the seismic operation in terms of gear entanglements. Note that the datasets for the tuna-directed and historical shark-directed fisheries have been combined in this assessment as similar gear types are used in both sectors. Shark-directed pelagic long-line vessels fish shallower than tuna-directed long-line vessels.

- Tuna pole activity would be expected within a depth range of 200 m to 500 m across the entire block and particularly around Cape Columbine and the Cape Canyon. The fishery is seasonal with vessel activity between October and May.

- With respect to the research cruises undertaken by DAFF, demersal surveys and acoustic surveys are undertaken within the License Block area four times per year. The potential impact of the seismic survey operations on the demersal and acoustic research is considered to be high (LOW significance) if the research survey areas of operation coincide with seismic survey areas.

No.	Sector	% of total fishing ground overlapped by Block 5/6	% national effort conducted within Block 5/6	% national catch taken within Block 5/6
1	Small pelagic	15.6	Unavailable	4.2
2	Demersal trawl	27.8	41	50
3	Demersal long-line	30.6	44.8	48.4
4	Large pelagic	Unknown	14.8	15.7
5	Tuna pole	Unavailable	Unavailable	Unavailable
6	Traditional line fish	Unavailable	Unavailable	Unavailable
7	West Coast rock lobster	0	0	0
8	Fisheries research	Unknown	Unknown	N/A

The following recommendations are proposed in order to minimize disruptions to both the survey and fishing operations:

1. Prior to the commencement of the survey, PetroSA and Fishing Industry should meet to discuss programme and the possibility of streamlining the survey and fishing programmes (i.e. try to accommodate industry where possible), etc.
2. Prior to the commencement of the survey, the fishing industry, DAFF (Branch: Fisheries) and other interested and affected parties should be consulted and informed of the pending activity and the likely implications for the various fishing sectors in the area as well as research surveys planned to coincide with the proposed seismic operations. It is recommended that harbour masters and key identified fishing operators be notified via email, and that advertisements be placed in local newspapers and posters be delivered by hand to skiboat and yacht clubs as well as directly on board vessels where possible;
3. It is advised that the location of any concrete anchors (used along CSEM transects) be made available to the trawling industry so that they can be avoided by vessels that do not use "rock-hopper" gear until such time as they disintegrate (six to eight months after deployment).
4. An experienced on-board Observer should be deployed on the survey vessel to facilitate communication with maritime vessels. The on-board Observer should be familiar with fisheries operational in the area, as well as with environmental monitoring protocols relating specifically to marine mammals, birds and other fauna. In this regard it is recommended that the Joint Nature Conservation Committee (JNCC) guidelines be followed.
5. The Observer should report daily on vessel activity and respond and advise on action to be taken in the event of encountering fishing gear and the survey vessel's potential impacts on marine fauna.
6. A daily electronic reporting routine should be set up to keep interested and affected parties informed of survey activity, fisheries interactions and environmental issues.
7. Due the high level of interaction with fishers and fishing gear it is strongly recommended that the survey vessel be accompanied by a chase vessel with staff familiar with the fisheries expected in the area.

In terms of fishing sector-specific communications, the following mitigation measures are recommended:

1. **Pelagic Long-line**: Establish communications with the known operators if drifting buoys (with radar responders) are sighted.
2. **Demersal Long-line**: Identify gear (marked at each end by a surface buoy) - demersal long-liners generally stay close to their lines when gear is deployed and communication with skippers on the position of set gear is essential.
3. **Demersal Trawl**: Identify vessels – due to proximity to trawl grounds, notification of survey areas of operation is essential. With good communication and reduced time in the area disruption of fishing activity can be minimised.

4. **Tuna Pole** : Notification to the local operators and ongoing communications throughout the duration of the survey.
5. **Small Pelagic Purse-Seine**: Identify active vessels and set up ongoing communications with operators for the duration of the survey.

Table 2. Fishing industry impact ratings due to the proposed surveys by PetroSA (Pty) Ltd.

NATURE OF IMPACT	*SMALL PELAGIC PURSE-SEINE*	*DEMERSAL TRAWL*	*DEMERSAL LONG-LINE*	*LARGE PELAGIC LONG-LINE*	*TUNA POLE*	*TRADITIONAL LINE FISH*	*WEST COAST ROCK LOBSTER*	*FISHERIES RESEARCH*
EXTENT	LOCAL	LOCAL	LOCAL	LOCAL	LOCAL	LOCAL	LOCAL	LOCAL
DURATION	SHORT TERM	SHORT TERM	SHORT TERM	SHORT TERM	SHORT TERM	SHORT TERM	SHORT TERM	SHORT TERM
INTENSITY	LOW	HIGH	HIGH	HIGH	HIGH	LOW	ZERO	HIGH
STATUS	NEGATIVE	NEGATIVE	NEGATIVE	NEGATIVE	NEGATIVE	NEGATIVE	NEGATIVE	NEGATIVE
PROBABLILITY	PROBABLE	DEFINITE	DEFINITE	PROBABLE	PROBABLE	PROBABLE	IMPROBABLE	PROBABLE
SIGNIFICANCE	VERY LOW	LOW	LOW	LOW	LOW	VERY LOW	INSIGNIFICANT	LOW
DEGREE OF CONFIDENCE	HIGH	HIGH	HIGH	HIGH	MEDIUM	MEDIUM	HIGH	HIGH

APPENDIX 1
CONVENTION FOR ASSIGNING SIGNIFICANCE RATINGS TO IMPACTS

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

Rating	Definition of Rating
Extent – defines the physical extent or spatial scale of the impact	
LOCAL	Extending only as far as the activity, limited to the site and its immediate surroundings. Specialist studies to specify extent.
REGIONAL	e.g. South-West Coast
NATIONAL	South Africa
INTERNATIONAL	Extending beyond the borders of South Africa
Duration – the time frame over which the impact will be experienced	
SHORT TERM	0 - 5 years
MEDIUM TERM	6 - 15 years
LONG TERM	Where the impact would cease after the operational life of the activity, either because of natural processes or by human intervention.
PERMANENT	Where mitigation either by natural processes or by human intervention would not occur in such a way or in such time span that the impact can be considered transient.
Intensity – establishes whether the magnitude of the impact is destructive or benign in relation to the sensitivity of the receiving environment	
Zero to Very Low	Where fishing operations are not affected.
LOW	Where fishing operations continue, albeit in a slightly modified way.
MEDIUM	Where fishing operations continue, albeit in a modified way.
HIGH	Where fishing operations are altered to the extent that they temporarily or permanently cease.
Status – describes whether the impact would have a negative, positive or zero effect on the affected environment	
POSITIVE	The impact benefits fishing operations
NEGATIVE	The impact results in a cost to the fishing industry
NEUTRAL	The impact has no effect
Probability – the likelihood of the impact occurring	
IMPROBABLE	Where the possibility of the impact to materialise is very low either because of design or historic experience.
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 preventive measures.
Degree of confidence in impact predictions – based on available information and specialist knowledge	
LOW	Less than 35% sure of impact prediction.
MEDIUM	Between 35% and 70% sure of impact prediction.
HIGH	Greater than 70% sure of impact prediction.

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

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

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

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

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

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

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 significance ratings are based on largely objective criteria and inform decision-making at a project level as opposed to a local community level. In some instances, therefore, whilst the significance rating of potential impacts might be "low" or "very low", the importance of these impacts to local communities or individuals might be extremely high. The importance which I&APs attach to impacts must be taken into consideration, and recommendations should be made as to ways of avoiding or minimising these negative impacts through project design, selection of appropriate alternatives and / or management.

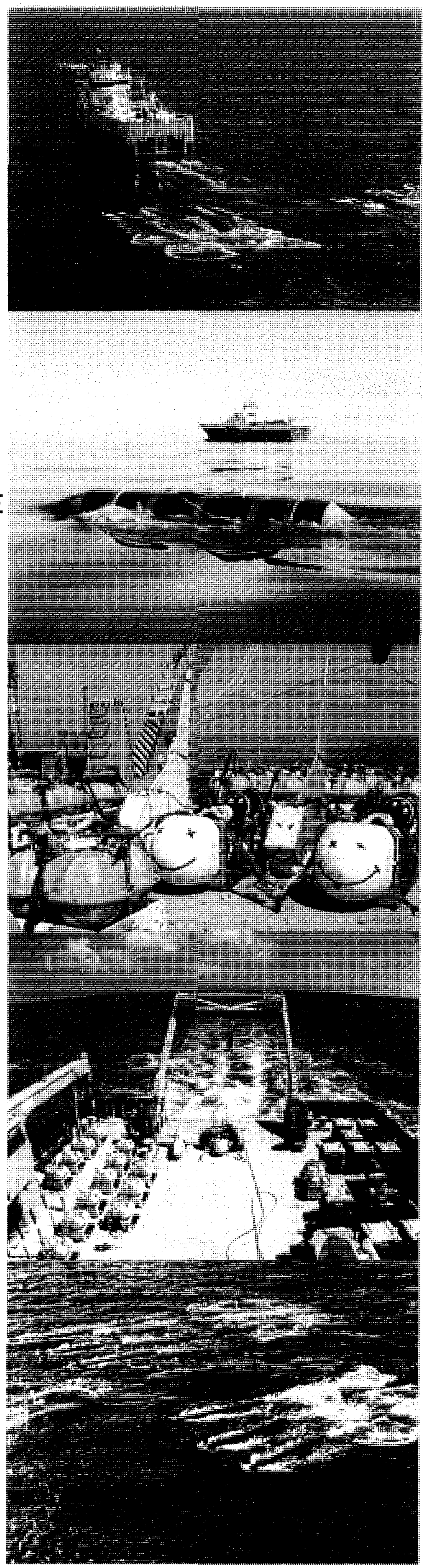
The relationship between the significance ratings after mitigation and decision-making can be broadly defined as follows:

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

APPENDIX 5.2:

MARINE FAUNAL ASSESSMENT

PISCES
Environmental
Services (Pty) Ltd



ENVIRONMENTAL MANAGEMENT PROGRAMME FOR PROPOSED SEISMIC AND CONTROLLED SOURCE ELECTROMAGNETIC SURVEYS IN LICENCE BLOCK 5/6, SOUTH-WEST COAST, SOUTH AFRICA

Marine Faunal Assessment

Prepared for:

CCA ENVIRONMENTAL

On behalf of:

PetroSA

June 2011

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CCA Environmental (Pty) Ltd

On behalf of:

PetroSA (Pty) Ltd

Prepared by

Andrea Pulfrich
Pisces Environmental Services (Pty) Ltd

June 2011

PISCES Environmental Services (Pty) Ltd

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EXPERTISE AND DECLARATION OF INDEPENDENCE

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

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

This specialist report was compiled as a desktop study on behalf of CCA Environmental (Pty) Ltd, 35 Roeland Square, 30 Drury Lane, Cape Town, 8001. The compilation followed a review process of published (peer reviewed) and unpublished literature and the assessment of potential impacts based on proposed activities and identification of impacts (and their mitigation) within the available literature.

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

Andrea Pulfrich

Dr Andrea Pulfrich

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EXECUTIVE SUMMARY

The Petroleum Oil and Gas Corporation of South Africa (Pty) Ltd (PetroSA) has applied for exploration rights for Block 5/6 off the South-West Coast of South Africa. PetroSA's proposed work programme for the first exploration period of three years may include the undertaking of seismic and Controlled Source Electromagnetic (CSEM) surveys. This document comprises the specialist report on potential impacts of the proposed operations on marine fauna in the area, submitted as part of the Environmental Management Programme (EMP) for the proposed surveys compiled by CCA Environmental (Pty) Ltd.

Marine seismic and CSEM surveys are carried out during hydrocarbon exploration activities to identify potential reservoirs of oil or gas within sub-sea geological formations. The nature of the sound impulses utilised during hydro-acoustic surveys have resulted in concern over their potential impact on marine fauna, particularly marine mammals, fish, and diving birds.

Seismic Surveys

Modern seismic surveys are most commonly carried out using an array of airguns, towed behind a survey vessel, just below the sea surface. The airguns produce some of the most intense non-explosive sound source used by humans in the marine environment. Broadband source levels produced by airgun arrays may be in the region of 220 to 250 dB re 1 µPa at 1 m. Although most of the energy produced by airgun arrays is in the 0 to 120 Hz bandwidth, received energy at some distance from the source may be found at much higher frequencies due to the transmission and attenuation of seismic sound. In assessing the impacts of seismic surveys on marine fauna it is thus important to quantify the airgun pulses as they are *received* by the animals using measures that relate to sensation levels of a biological receiver. Exposure to high level seismic sounds could result in pathological injury or mortality, behavioural avoidance impacts, impacts of masking on communication and the use of environmental sound by species, and indirect impacts through impacts on predators or prey.

Acoustic impacts to plankton

Impacts of seismic pulses on plankton would include only pathological injury or mortality. Mortality or injury to plankton would occur within metres of the firing airgun sound sources and would be similar in volume to mortality and injury arising from the turbulence of a ship's propellers. The intensity of impact would be low across the survey area and duration, and the significance of pathological injury to plankton is consequently deemed **very low**.

Acoustic impacts to invertebrates

Potential impacts of seismic pulses on invertebrates could include pathological injury; behavioural avoidance of seismic survey areas; masking of environmental sounds and communication; and indirect impacts due to effects on predators or prey. Information on the effects of seismic surveys on invertebrate fauna or the response of invertebrates to seismic impulses is sparse. The received noise at water depths of over 100 m is likely to be within the far-field range, and outside of distances at which pathological injury or avoidance of benthic invertebrates would occur. Limited avoidance of sounds may occur in mobile neritic and pelagic invertebrates and is deemed to be of low intensity. However, cephalopods have been shown to alter their behaviour in response to received sounds of approximately 160 dB re 1 µPa

and it is assumed that they would evade noise levels higher than this (at estimated distances of 2-5 km) and consequently at greater ranges than where pathological injury would occur. Impacts arising from both masking of biological or environmental sounds and arising from indirect effects on invertebrate predators or prey are unknown. The potential impact of seismic noise on invertebrates is consequently deemed of negligible to low intensity across the survey area and duration and is considered to be of **very low** significance, with and without mitigation.

Acoustic impacts to fish

Potential impacts of seismic pulses to fish species could include pathological injury and mortality; behavioural avoidance of seismic survey areas; masking of environmental sounds and communication; and indirect impacts due to effects on predators or prey. Given the general high mobility of fish it is assumed that the majority of fish species would avoid seismic noise at lower levels than where pathological injury or mortality would occur. Possible injury or mortality could, however, occur on initiation of a sound source at full pressure in the vicinity of fish (at received levels of over about 180 dB re 1 μPa), or where reproductive, territorial or feeding behaviour override a flight response to seismic survey sounds. The potential pathological impact on fish species could be of high intensity across the local survey area. The duration of impact would depend on the extent or duration of injury or restocking of the area, and may extend beyond the survey duration, although limited to the short term. The impact is therefore considered to be of **low** significance, without the implementation of mitigation measures, and of **very low** significance with the implementation of soft start mitigation. Behavioural responses of fish to seismic sounds include avoidance of seismic survey areas by shoaling species, and changes in feeding behaviour and vertical distribution. The potential impact on local fish behaviour could therefore be of high intensity, but limited to the survey area and short term, and is consequently considered to be of **low** significance (with and without mitigation).

Fish deliberately produces sounds, although communication and the use of environmental sounds by fish in the offshore environment off the west coast of South Africa are unknown. Impacts arising from masking of sounds are expected to be of low intensity due to the duty cycle of seismic surveys in relation to the more continuous biological noise. Such impacts would occur across the survey area and survey duration (local and short term), and are consequently considered of **very low** significance.

The assessment of indirect effects of seismic surveys on fish is limited by the complexity of trophic pathways in the marine environment, although reduced line-fish catches in association with seismic surveys have been suggested to have resulted from changes in feeding behaviour.

Acoustic impacts to seabirds

Among the marine avifauna of South African waters, it is only the diving birds or birds which rest on the sea surface which may be affected by the underwater noise of seismic surveys. Of the diving seabirds, the African penguin and Cape gannet occur within the proposed seismic survey area. Potential impacts of seismic pulses to diving birds could include pathological injury; behavioural avoidance of seismic survey areas; the masking of environmental sounds and communication; and indirect impacts due to effects on predators or prey.

Diving seabirds are highly mobile and would be expected to flee from approaching sound sources at greater ranges than where pathological injury would occur, although initiation of a sound source at full power in the vicinity of diving seabirds could result in injury. The potential for pathological impact of seismic noise on diving bird species is considered to be of high intensity and would be limited to the survey area, although could extend beyond the survey period. The potential pathological impact on diving species is considered to be of **low** significance without mitigation, and **very low** significance with mitigation.

African penguins would be expected to hear seismic survey at considerable distances as they have good hearing at low frequencies (which coincide with seismic survey sounds). Response distances are speculative, however, as no empirical evidence is available. The potential impact of behavioural avoidance is considered to be of medium to high intensity, but would be limited to the vicinity of the operating airgun within the survey area over the duration of the survey. The significance of the impact is therefore deemed to be **low**, but with a low confidence level because of the lack of information.

As with other vertebrates, the assessment of indirect effects of seismic surveys on diving seabirds is limited by the complexity of trophic pathways in the marine environment. No information is available on the feeding success of seabirds in association with seismic survey noise. However, the broad ranges of mainly clupeid fish prey species (in relation to avoidance patterns of seismic surveys of such prey species) and the extensive ranges over which most seabirds feed suggest that indirect impacts would be **very low.**

Acoustic impacts to turtles

Potential impacts of seismic pulses to turtles could include pathological injury, behavioural avoidance of seismic survey areas, masking of environmental sounds and underwater communication, and indirect impacts due to effects on predators or prey.

The overlap of the hearing sensitivity of turtles with the higher frequencies produced by airguns, suggest that turtles may be considerably affected by seismic noise, but may only detect airguns at close range (<10 m) or are not sufficiently mobile to move away from approaching airgun arrays (particularly if basking). Initiation of a sound source at full power in the immediate vicinity of a swimming or basking turtle would be expected to result in pathological injury. The impact could therefore be of high intensity, but remain within the short-term. However, as the abundance of adult turtles in the survey area is low, the likelihood of encountering turtles is expected to be low. The potential pathological impact on turtles from acoustic noise, or through collision or entanglement in the towed seismic equipment is considered to be of **low** significance without mitigation, and **very low** significance with mitigation.

Behavioural changes by turtles in response to seismic sounds range from apparent lack of movement away from active airgun arrays through to startle response and avoidance by fleeing an operating sound source. The impact of seismic sounds on turtle behaviour would be of high intensity, localised, and would persist only for the duration of the survey. Given the extent of turtle distributions and migrations relative to the seismic survey are, the impact of seismic noise is deemed to be of **low** significance without mitigation and **very low** with mitigation.

The Leatherback turtles that are likely to be encountered during the survey feed on pelagic jellyfish, which have a naturally temporally and spatially variable distribution. Adverse modification of such food sources would thus be insignificant, and the effects of seismic surveys on the feeding behaviour of turtles is thus expected to be **VERY LOW** both with and without mitigation.

Although it is speculated that turtles may use acoustic cues for navigation during migrations, information on turtle communication, or the effect of seismic noise in masking environmental cues and communication, is lacking. Their low abundance in the survey area would suggest that the potential significance of this impact (should it occur) would be **INSIGNIFICANT**.

Acoustic impacts to seals

Potential impacts of seismic pulses to Cape fur seals could include pathological injury, behavioural avoidance of seismic survey areas, masking of environmental sounds and underwater communication, and indirect impacts due to effects on predators or prey.

The pathological effects of loud low frequency sounds on seals have not been well documented, but it is assumed that being highly mobile creatures fur seals would avoid severe sound sources at levels below those at which discomfort occurs. Although Cape fur seals are recorded as approaching operational seismic survey gear (learned associated feeding stimuli may override the flight response), noise of moderate intensity and duration is sufficient to induce temporary threshold shift (TTS) in pinniped species. The potential impact of pathological injury to seals as a result of seismic noise is therefore deemed to be of medium intensity and would be limited to the survey area, although injury could extend beyond the survey duration. The significance of impact without mitigation is **very low** with and without mitigation.

Partial avoidance of operating airguns has been recorded for some seals species, Cape fur seals appear to be relatively tolerant to loud noise pulses and, despite an initial startle reaction, individuals quickly reverted back to normal behaviour. The potential impact of seal behaviour in response to seismic surveys is thus considered to be of low to medium intensity and limited to the survey area and duration. The significance behavioural avoidance impacts are consequently deemed **very low** with and without mitigation.

The use of underwater sounds for environmental interpretation and communication by Cape fur seals is unknown, although masking is likely to be limited by the low duty cycle of seismic pulses (one firing every 10 to 15 seconds). The impacts of masking are considered **very low** with and without mitigation.

The assessment of indirect effects of seismic surveys on Cape fur seals is limited by the complexity of trophic pathways in the marine environment. However, the broad ranges of fish prey species (in relation to the avoidance patterns of seismic surveys of such prey species and the extended foraging ranges of Cape fur seals) suggest that indirect impacts due to effects on predators or prey would be **very low** with and without mitigation.

Acoustic impacts to Whales and Dolphins

A wide diversity of cetaceans (whales and dolphins) occur off the coast of the South-Western Cape. The majority of migratory cetaceans in southern African waters are baleen whales (mysticetes), while toothed whales (odontocetes) may be resident or migratory. Potential impacts of seismic pulses to whales and dolphins could include pathological injury, behavioural avoidance of seismic survey areas, masking of environmental sounds and communication, and indirect impacts due to effects on prey.

There is little information available on the levels of noise that would potentially result in pathological injury to whales and dolphins. Information suggests that cetaceans would need to be in close vicinity to operating airguns to receive injury, and being highly mobile it is assumed that they would avoid sound sources at distances well outside those where injury would occur. Deep-diving cetacean species may, however, be more susceptible to acoustic injury, particularly in the case of seafloor-focussed seismic surveys, where the downward focussed impulses could trap deep diving cetaceans within the survey pulse, as escaping towards the surface would result in exposure to higher sound level pulses. The majority of baleen whales migrate to the southern African subcontinent to breed during winter months and the location of the licence block overlaps with the migration paths. The impact of potential pathological injury to cetaceans as a result of high-amplitude seismic sounds is deemed to be of high intensity, but would be limited to the vicinity of operating airguns within the survey area. The significance of this impact is therefore considered to be low (toothed whales) to **medium** (Southern Rights and Humpbacks), without the implementation of mitigation measures and of **very low** (toothed whales) to **low** (Southern Rights and Humpbacks) significance with mitigation.

Avoidance of seismic survey activity by cetaceans, particularly mysticete species, begins at distances where levels of approximately 150 to 180 dB are received. More subtle alterations in behaviour may occur at received levels of 120 dB. Although behavioural avoidance of seismic noise in the proposed survey area by baleen whales is highly likely, such avoidance is generally considered of minimal impact in relation to the distances of migrations of the majority of baleen whale species. The impact on breeding species within mating, calving and nursing areas or seasons (or on species within feeding grounds) would be higher than on non-breeding/non-feeding or migratory species. The potential impact of behavioural avoidance of seismic survey areas by mysticete cetaceans is considered to be of high intensity, across the survey area and duration. The significance of impact is deemed **medium** without mitigation and **low** with mitigation. There is less evidence of avoidance of seismic surveys by toothed whales (including dolphins), and the impact of seismic survey noise on the behaviour of toothed whales is deemed to be of medium intensity over the survey area and duration. The overall significance will vary between species, and ranges between **low** and **very low** before mitigation and **very low** with mitigation.

Masking impacts to cetaceans are likely to be limited by the low duty cycle of seismic pulses, and consequently the intensity of impact is likely to be low over the survey area and duration. In the migratory baleen whale species, however,vocalisation increases once they reach the breeding grounds and on the return journey when accompanied by calves. Whereas for odontocetes the significance is rated as **very low**, both with and without mitigation, for mysticetes it is rated as **low** without mitigation and **very low** with mitigation.

The majority of baleen whales would undertake little feeding within breeding ground waters, although there is recent evidence that certain upwelling centres may be utilised as a low latitude feeding ground by both Southern Right and Humpback whales during summer. The assessment of indirect effects of seismic surveys on resident odontocete cetaceans is limited by the complexity of trophic pathways in the marine environment. However, the broad ranges of prey species (in relation to the avoidance patterns of seismic surveys of such prey species) suggest that indirect impacts due to effects on predators or prey would be **very low**, both with and without mitigation.

The following mitigation measures are recommended for all seismic surveys:

- Seismic surveys should as far as possible be planned to avoid cetatean migration periods or winter breeding concentrations (June to November), and ensure that migration paths are not blocked.
- The use of the lowest practicable airgun volume should be defined and enforced, and airgun use should be prohibited outside of the licence area.
- Prior to the commencement of "soft starts" an area of 500-m radius around the survey vessel (exclusion zone) should be scanned for the presence of diving seabirds, turtles, seals and cetaceans. There should be a dedicated pre-shoot watch of at least 30 minutes for deep-diving species. "Soft starts" should be delayed until such time as this area is clear of individuals of diving seabirds, turtles and cetaceans. Soft-start should not begin until 30 minutes after the animals depart the exclusion zone or 30 minutes after they are last seen. In the case of fur seals and small odontocetes, which may occur commonly around the vessel, the presence of seals and small odontocetes (including number and position / distance from the vessel) and their behaviour should be recorded prior to "soft start" procedures. If possible, "soft starts" should only commence once it has been confirmed that there is no seal and small odontocetes activity within 500 m of the airguns. However, if after a period of 30 minutes they are still within 500 m of the airguns, the normal "soft start" procedure should be allowed to commence for at least a 20-minutes duration. Their activity should be carefully monitored during "soft starts" to determine if they display any obvious negative responses to the airguns and gear or if there are any signs of injury or mortality as a direct result of the seismic activities.
- The implementation of "soft-start" procedures of a minimum of 20 minutes' duration on initiation of seismic surveying would mitigate any extent of pathological injury in most mobile vertebrate species as a result of seismic noise and is consequently considered a mandatory management measure for the implementation of the proposed seismic survey. "Soft start" procedures should not be initiated during times of poor visibility or darkness without the use of existing PAM technology to confirm that no cetaceans are present.
- An onboard independent MMO must be appointed for the duration of the seismic survey. The MMO should have experience in seabird, turtle and marine mammal identification and observation techniques. The duties of the MMO would be to:
  - Record initiation of seismic firing activity and associated "soft starts", airgun activities and seismic noise levels;
  - Observe and record responses of marine fauna to seismic shooting, including seabird, turtle and cetacean incidence and behaviour and any mortality or injuries of marine fauna as a result of the seismic survey. Data captured should include species identification, position (latitude/longitude), distance from the vessel, swimming speed and direction (if applicable) and any obvious changes in behaviour (e.g. startle responses or changes in surfacing/diving frequencies, breathing patterns) as a result of the seismic activities. Both the identification

and the behaviour of the animals must be recorded accurately along with current seismic sound levels. Any attraction of predatory seabirds, large pelagic fish or cetaceans (by mass disorientation or stunning of fish as a result of seismic survey activities) and incidents of feeding behaviour among the hydrophone streamers should also be recorded;

  - Sightings of any injured or dead protected species (marine mammals and sea turtles) should be recorded, regardless of whether the injury or death was caused by the seismic vessel itself. If the injury or death was caused by a collision with the seismic vessel, the date and location (latitude/longitude) of the strike, and the species identification or a description of the animal should be recorded.
  - Record meteorological conditions;
  - Request the temporarily termination of the seismic survey or adjusting of seismic shooting, as appropriate. It is important that MMOs have a full understanding of the financial implications of terminating firing, and that such decisions are made confidently and expediently. A log of all termination decisions must be kept (for inclusion in both daily and "close-out" reports);
  - Prepare daily reports of all observations, to be forwarded to the necessary authorities on a daily or weekly basis to ensure compliance with the mitigation measures.

- Seismic shooting should be terminated on observation of any obvious mortality or injuries to cetaceans, turtles, seals or large mortalities of invertebrate and fish species as a direct result of the survey. Such mortalities would be of particular concern where a) commercially important species are involved, or b) mortality events attract higher order predator and scavenger species into the seismic area during the survey, thus subjecting them to acoustic impulses. Seismic shooting should also be terminated when obvious negative changes to turtle, seal or cetacean behaviours are observed from the survey vessel, or turtles and cetaceans (not seals and small odontocetes) are observed within the immediate vicinity (within 500 m) of operating airguns and appear to be approaching firing airgun. The rationale for this is that animals at close distances (*i.e.* where pathological injury may occur) may be suffering from reduced hearing as a result of seismic sounds, that frequencies of seismic sound energy lies below best hearing frequencies (certain toothed cetaceans and seals), or that animals have become trapped within the ensonified area through diving behaviour.
- All breaks in airgun firing of longer than 20 minutes must be followed by a "soft-start" procedure of at least 20 minutes prior to the survey operation continuing. Breaks of shorter than 20 minutes should be followed by a "soft-start" of similar duration.
- Ideally, airgun use should be prohibited at night, and restricted during adverse weather conditions and thick fog. However, to ensure that the seismic survey has minimal overall duration within the study area, airgun use should only be permitted at night on condition that visual watches are maintained using night-vision/infra-red binoculars, or PAM technology is implemented to confirm that no cetaceans are present.
- Ensure that 'turtle-friendly' tail buoys are used by the survey contractor or that existing tail buoys are fitted with either exclusion or deflector 'turtle guards'.
- Reduce lighting on board the survey vessels to minimum safety levels to minimise stranding of pelagic seabirds on the survey vessels at night. All stranded seabirds must be retrieved and released according to appropriate guidelines.

- Marine mammal incidence data and seismic source output data arising from surveys should be made available on request to the Marine Mammal Institute, Department of Agriculture, Fisheries and Forestry, and the Petroleum Agency of South Africa for analyses of survey impacts in local waters.for analyses of survey impacts in local waters.
- Should the survey schedules overlap with the start of the sensitive period in terms of large mammals migrating through the area, airgun use should ideally be prohibited at night, and restricted during adverse weather conditions and thick fog. However, to ensure that the seismic survey has minimal overall duration within the study area, airgun use should only be permitted at night on condition that visual watches are maintained using night-vision/infra-red binoculars, or PAM technology is implemented to confirm that no cetaceans are present.
- The use of Passive Acoustic Monitoring (PAM) is encouraged by most international guidelines as a mitigation tool to detect marine mammals through their vocalisations, ***particularly if species of particular conservation importance are likely to be encountered in the proposed survey area***, or where a given species or group is difficult to detect by visual observation alone. Such monitoring can provide distance and bearing of the animals from the survey vessel. Although PAM would only identify animals that are calling or vocal, it has the advantage of 24 hour per day availability as opposed to visual monitoring, which can only be confidently carried out during daylight hours, or under adequate visibility conditions. Considering that most of the offshore migrating baleen whale species likely to be encountered are listed as "Endangered", and a proportion of the population is present off Saldanha Bay year-round, every effort should be made to ensure that the vessel is fitted with PAM technology.
- No seismic survey-related activities are to take place within Marine Protected Areas.

Controlled Source Electomagnetic Surveys

During CSEM surveys a horizontal electric dipole transmitter is towed with a neutrally buoyant streamer containing two electrodes, at 30 - 50 m above the sea floor. In shallow-water applications, a negatively buoyant horizontal electric dipole is suspended at constant depth (typically 10 m) below two GPS-positioned buoys. An alternating current, where the direction is changed every 1-2 seconds, is set up to flow between the two electrodes thereby injecting a current of up to 1,000 amps into the sea water and generating both an electric and magnetic field. The repetitive electromagnetic signal is transmited at a frequency of 0.05 - 10 Hz, upwards into the overlying water column and downwards into the underlying sediments. The electric field strength decreases rapidly from 60 volts per metre (V/m) at the electrode surface to 0.001 V/m at a distance of 500 m. The magnetic field generated by the electrodes similarly decreases rapidly with distance from the source, reducing from 200,000 nanno tesla (nT) at 1 m to and 2,000 nT at 100 m distance from the source. At 4 m from the source the magnetic field is comparable to the Earth's magnetic field (40,000 - 60,000 nT).

The electromagnetic receivers are autonomous sea floor units that are deployed at 1-km spacing at pre-defined locations on a grid and free-fall to the seabed. Each receiver has a concrete anchor of soluble cement and records data continuously while the electromagnetic source transmits a continuous waveform. On completion of the survey, the receivers are released and float back to the surface for recovery, while the anchors are left on the seafloor to dissolve over a six to eight month period.

Knowledge on the potential biological effects of CSEM on marine fauna is limited as threshold and safety limits have typically only been published for human exposure. At the present stage of knowledge, however, the use of electromagnetic seabed logging techniques does not appear to involve substantial deleterious effects on marine life as they are considerably quieter than the typical seismic applications. In assessing the potential impacts of CSEM surveys on marine fauna the effects of electric and magnetic fields on some relevant biological systems and the use of electric and magnetic fields by marine organisms (for navigation and prey detection) are presented. Exposure to electromagnetic fields could result in pathological injury or mortality, behavioural avoidance impacts, or disruption of migration through interference with navigational clues. Other potential impacts of CSEM surveys on marine life include crushing of biota by the concrete anchors of the receiver units.

Electromagnetic impacts to invertebrates

A small area of benthic habitat (about 1 m^2 per concrete base) will be altered as the concrete receiver-base settles onto the seafloor potentially crushing or smothering any infauna in the footprint. In the event of the base landing on relatively hard bottom, it will temporarily increase hard substrate habitat for colonisation by sessile organisms. In relation to the overall available seabed area in the licence block, and the fact that the anchors would dissolve in 6 - 8 months, the impact on benthic macrofauna or their habitat is considered **insignificant** both with and without mitigation.

The very low frequency, very short duration energy used in CSEM applications should not effect benthic invertebrate health. As the maximum duration of potential effect for any one point will be very short (in the order of an hour), and any effects should be quickly reversible. Because the source is an alternating current, the magnitude of any effects on benthic invertebrates will be negligible, and impacts on marine benthic invertebrates are thus predicted to be **insignificant** both with and without mitigation.

Those species containing magnetic material that may be present at the survey depths may detect the CSEM source and even react to it. However, the geographic extent of exposure is expected to be small, and the maximum duration of potential effect for any one point will be very short. Any effect on orientation or navigation will be negligible, and consequently impacts are deemed to be **insignificant** both with and without mitigation.

Electromagnetic impacts to bony fishes

There are no known reports of the effects of electromagnetics on fish ichthyoplankton. Adult bony fish do not appear to be particularly sensitive to low frequency electromagnetic alternating current, and would need to come in very close contact of the electrodes in order to show behavioural response or suffer injury. Most species are likely to have rapid escape mechanisms and will be capable of escaping any field from the towed CSEM source before it comes close enough to cause injury. The very low frequency, very short duration radiation from the CSEM source should therefore have negligible effects on the health of bony fish, and the impacts of the CSEM surveys are thus predicted to be **insignificant** both with and without mitigation.

Any migrating species occurring in the survey area are likely to use a variety of navigational clues, all of which are likely to over-ride any geomagnetic information. Any potential effects on the behaviour or migration of bony fishes will thus be of small geographic extent, short duration (no more than a few hours), and low magnitude, and is consequently deemed to be **insignificant** both with and without mitigation.

Electromagnetic impacts to cartilagenous fishes

Elasmobranchs and chimaerids are most likely to detect the electrical fields produced by CSEM as their electroreceptive organs are sensitive to stimuli in the very low frequency range, which overlaps with that used in CSEM. Their sensitivity to electric fields, however, suggests that they will be repelled as the source approaches them, thereby avoiding any negative effects by leaving the area. Pathological injury as a result of CSEM surveys is thus highly unlikely, and any effects on cartilagenous fishes are tdeemed to be **insignificant** both with and without mitigation.

As with migratory bony fish, geomagnetics are not their only navigational clue used by migratory pelagic sharks occurring in the survey area. Given the near-surface and/or seasonal distribution of migratory species, electromagnetic fields from the CSEM source would be absent or very weak, and the duration of any exposure will be short. The interaction of the proposed survey with migrating sharks can thus be considered negligible. The surveys may, however, temporarily disrupt prey detection by some demersal eleasmobranchs. The use of electroreception as an aid to prey detection appears to vary with species but is known to be short range (within a few metres) in those that have been studied. Any potential effects on cartilagenous fish behaviour or navigation will be of small geographic extent, short duration and low magnitude, and consequently the impacts of CSEM on elasmobranch fishes are predicted to be of **very low** significance both with and without mitigation.

Electromagnetic impacts to turtles

Abundance of turtles in the survey area is expected to be low, and as adult sea turtles do not appear to be sensitive to or to utilize electromagnetic fields, effects of the CSEM surveys on health or navigation will be negligible. Leatherback turtle hatchlings can detect and use geomagnetic information to assist in navigation, but are likely to only occur as occasional strays in the southern portion of the survey area. Any effects of the CSEM surveys are thus predicted to be **insignificant** both with and without mitigation.

Electromagnetic impacts to seabirds

Birds known to exhibit magnetic orientation that are expected to occur in thesurvey area, feed near the surface by plunging (shearwaters) or surface skimming (petrels) and will therefore not be exposed to the geomagnetic field from the source. Any effects on diving seabirds of the CSEM surveys are thus predicted to be **insignificant** both with and without mitigation.

Two other potential adverse interactions between seabirds and CSEM surveys are (1) stranding of birds on the survey vessel due to being attracted to the vessel lights at night, and (2) oiling through accidental loss of buoyancy liquid or hydraulic fluid from the towed gear. However, effects on seabird populations from any of the activities associated with CSEM surveys, are predicted to be **insignificant** both with and without mitigation, as the number of animals potentially affected will be small.

Electromagnetic impacts to seals and cetaceans

Direct health effects on marine mammals from the CSEM surveys are unlikely given what is known on the effects of electromagnetic radiation on mammals. Any effects on cetaceans and seals of the ultra low frequency, alternating current and short duration of exposure associated with CSEM can thus be expected to be **insignificant.**

Cetaceans are thought to use geomagnetics for long distance navigation and could thus potentially be temporarily disturbed by the field emanating from the source. Significant effects are, however, unlikely given that the source current is alternating, the duration of exposure is likely to be short, and the fact that animals use more than one clue to navigate. Effects of the CSEM survey on behaviour patterns and navigation of cetaceans and seals can thus be considered **insignificant** both with and without mitigation.

The following mitigation measures are recommended for all CSEM surveys:

- Use standard operational procedure to warm up the source transmitter (*i.e.* equivalent to ramp-up of current in electric source). It is recommended that the electromagnetic source should be ramped up over a 20 - 40 minute period.
- No operation of the electromagnetic source during turns in between survey lines.
- Concrete moorings used for signal receiver units must be of biodegradable cement.
- All autonomous signal receiver units must be recovered on the completion of the CSEM survey.
- The location of signal receiver units, and the timing and location of planned survey activities must be registered and distributed via "Notice to Mariners" and "Notice to Fishers".
- Standard maritime safety/navigation and equipment handling and acquisition procedures must be adhered to during surveys.
- A register must be maintained of equipment lost overboard, and every effort should be made to recover lost equipment.
- Reduce lighting on board the survey ship to minimum safety levels to minimise stranding of pelagic seabirds on the survey vessel at night. All stranded seabirds must be retrieved and released according to appropriate guidelines.
- Ensure that Marine Mammal Observers/Fisheries Liaison Officers are on board to identify and monitor marine mammals and communicate with fishing vessels if required.
- All data recorded by MMOs should at minimum form part of a survey close-out report. Furthermore, daily or weekly reports should be forwarded to the necessary authorities to ensure compliance with the mitigation measures.
- Marine mammal incidence data and seismic source output data arising from surveys should be made available to the Marine Mammal Institute, Department of

Environmental Affairs, the Petroleum Agency of South Africa and appropriate research institutes for analyses of survey impacts in local waters.

- No survey-related activities are to take place within Marine Protected Areas.

1. GENERAL INTRODUCTION

Hydrocarbon deposits occur in reservoirs in sedimentary rock layers. Being lighter than water they accumulate in traps where the sedimentary layers are arched or tilted by folding or faulting of the geological layers. Marine seismic surveys and controlled-source electromagnetic (CSEM) acquisition are the primary methods for locating such deposits and are thus an indispensable component of offshore oil or gas exploration.

For this investigation the Petroleum Oil and Gas Corporation of South Africa (Pty) Ltd (PetroSA), as South Africa's National Oil Company, has applied to the Petroleum Agency SA (PASA) for exploration rights for Block 5/6 off the South-West Coast of South Africa. PetroSA's proposed work programme for the first exploration period of three years may include the undertaking of seismic and CSEM surveys. CCA Environmental (Pty) Ltd (CCA) has been appointed to compile the Environmental Management Programme (EMP) for the proposed surveys. CCA in turn has approached Pisces Environmental Services (Pty) Ltd for a specialist report on potential impacts of the proposed operations on marine fauna in the area.

Seismic survey programmes comprise data acquisition in either two-dimensional (2D) and/or three dimensional (3D) scales, depending on information requirements. 2D surveys are typically applied to obtain regional data from widely spaced survey grids and provide a vertical slice through the seafloor geology along the survey track-line. Infill surveys on closer grids subsequently provide more detail over specific areas of interest. In contrast, 3D seismic surveys are conducted on a very tight survey grid in specific target areas identified during 2D applications, and provide a cube image of the seafloor geology along each survey track-line. Although seismic data can define the geometry of a possible reservoir, they cannot identify the fluid fills (*i.e.* it cannot distinguish between a hydrocarbon-filled reservoir and a salt water-saturated reservoir) or the rock types. Therefore, once potential targets in deep water (usually beyond 500 m depth) have been located, CSEM methods, which determine the resistivity of the sub-surface rock to depths of up to a few kilometres below the seafloor, are used to identify the nature of the reservoir contents. CSEM and 3D surveys in combination are typically applied to promising petroleum prospects to assist in fault line interpretation, bulk measurements of oil and gas in place and the location of boreholes, thereby greatly reducing the risk of drilling a dry well.

During seismic surveys high-level, low frequency sound impulses are generated by an array of acoustic instrumentation towed behind a survey vessel, just below the sea surface. The sounds are directed towards the seabed and the seismic signal is reflected by the geological interfaces below the seafloor. The reflected signals are received by receivers or sets of hydrophones towed behind the vessel in a single streamer (2D) or in multiple streamers (3D) and are fed back to the recording instruments onboard. The spacing between the hydrophone groups is commonly 25 m or shorter, depending on the purpose of the seismic survey. Each group contains many hydrophones, spaced less than 1 m apart. The hydrophone streamers must be towed at constant depth (6 - 10 m), with flotation usually achieved by filling the cables with kerosene, so that they are neutrally buoyant. To compensate for minor adjustments, Automatic Cable Levellers, or "birds" are used. The ends of the hydrophone streamers are marked with tail buoys, to warn shipping about the presence of the cable in the water. The tail buoys also act as a platform for surface positioning systems so that the cable locations can be accurately monitored.

Marine CSEM techniques (also known as seabed logging or remote reservoir resistivity mapping) use a high-powered horizontal electric dipole source to transmit a low frequency signal through the earth to an array of seafloor deployed receivers, which detect and record the electric and magnetic field. CSEM applications have the capability to differentiate between low resistivity water-saturated reservoirs, and high resistivity hydrocarbon-containing reservoirs, providing resolution at a scale of typically a few tens of metres. During CSEM surveys, the same level of geophysically useable energy is generally put into the water as impulsive sources like airguns, but over a longer period of time, and at lower peak sound level. Peak sound levels are therefore considerably lower than those typically used during seismic applications.

The nature of the sound impulses utilised during hydro-acoustic surveys have resulted in concern over their potential impact on marine fauna, particularly marine mammals, fish, and turtles (McCauley *et al.* 2000). Consequently, it has been proposed that environmental management be applied at the exploration stage of the a life cycle of a hydrocarbon field project (Duff *et al.* 1997, in Salter & Ford 2001).

1.1. Scope of Work

This specialist report was compiled as a desktop study on behalf of CCA, for their use in compiling an EMP as part of an application by PetroSA for an Exploration Right in Block 5/6, offshore of the South African south-west coast. The terms of reference for this study, as specified by CCA, are:

- Provide a general description of the local marine fauna in and around the proposed seismic area;
- Identify, describe and assess the significance of potential impacts of the proposed seismic surveys on the local marine fauna, focussing particularly on marine mammals, but including generic effects on turtles, fish and pelagic and benthic invertebrates; and
- Identify practicable mitigation measures to reduce any negative impacts and indicate how these could be implemented in the implementation and management of the proposed project.

1.2. Approach to the Study

As determined by the terms of reference, this study has adopted a 'desktop' approach. Consequently, the description of the natural baseline environment in the study area is based on a review and collation of existing information and data from the scientific literature, internal reports and the Generic Environmental Management Programme Report (EMPR) compiled for oil and gas exploration in South Africa (CCA & CMS 2001). The information for the identification of potential impacts was drawn from various scientific publications and the Generic EMPR as well as information sourced from the Internet. The sources consulted are listed in the Reference chapter.

All identified marine and coastal impacts are summarised, categorised and ranked in appropriate impact assessment tables, to be incorporated in the overall EMP for the proposed project.

2. DESCRIPTION OF THE PROPOSED PROJECTS

PetroSA is proposing to explore for oil and gas in Block 5/6 off the South-West Coast of South Africa (Figure 1). The proposed work programme for the first exploration period of three years may include seismic surveys in a two-dimensional (2D) and three-dimensional (3D) scale, and CSEM acquisition. The total area of the licence Block is 94,118 km^2.

Although the full extent and exact target area of this survey is not known at present, the proposed survey is envisaged to be in the order of 6,700 km in length (see Figure 1). The survey programme is scheduled to commence in February 2012.

The entire seismic operation from the tow-ship to the end of hydrophone streamers may be up to 10,000 m in length, and up to 1,000 m in width, depending on the number of and separation configuration of the streamers (Figure 2). The survey vessel would steam a series of predefined transects describing the survey grid, the headings of which would be fixed and reciprocal. Consequently the survey vessel would be restricted in manoeuvrability (a turn radius of 3 km is expected), and other vessels should remain clear of it. A supply vessel and a chase vessel usually assist in the operation of keeping other vessels at a safe distance.

During the seismic survey process, the towing vessel would steam at 4 -6 knots along the prescribed transects and the sound sources would be "fired" by an array of airguns commonly towed some 100 m behind the vessel at a depth of 5 to 6 m. The streamers would therefore not be visible, except for the tail-buoys at the terminal ends of the cables. Each triggering of a sound pulse is termed a seismic shot, and these are fired at intervals of 6-20 seconds (depending on water depth and other environmental characteristics) (Barger & Hamblen 1980). Each seismic shot is typically only a few milliseconds in duration, and despite peak levels within each shot being high, the total energy delivered into the water is low.

Airguns have most of their energy in the 5-300 Hz frequency range, with the optimal frequency required for deep penetration seismic work being 50-80 Hz. The maximum sound pressure levels at the source of airgun arrays in use today in the seismic industry are in the range 230-255dB re 1μPa at 1 m, with the majority of their produced energy being low frequency of 10-100 Hz (McCauley 1994; NRC 2003). The location where this level of sound is attained is directly beneath the airgun array, generally near its centre, but the exact location and depth beneath the array are dependent on the detailed makeup of the array, the water depth, and the physical properties of the seafloor (Dragoset 2000).

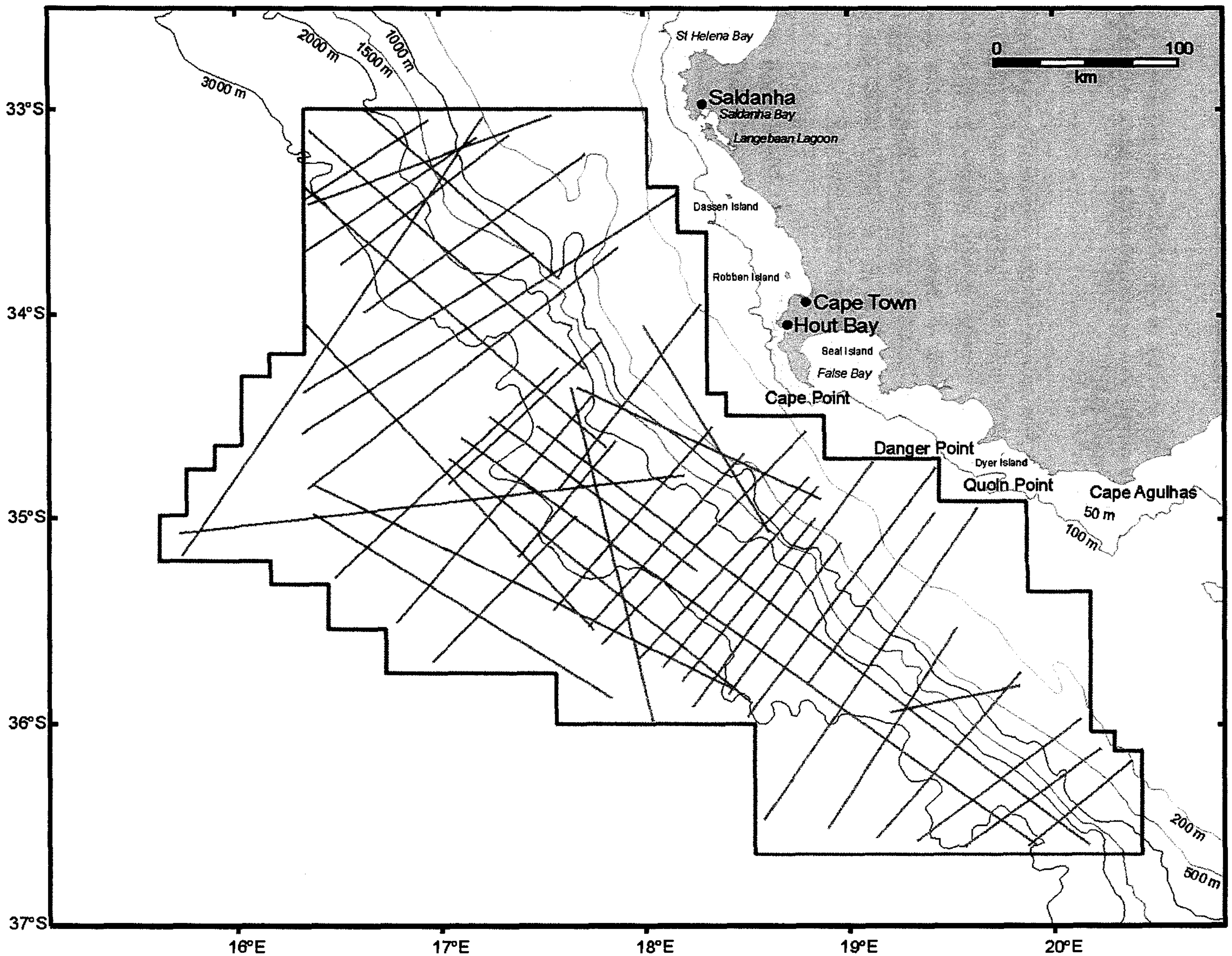

Figure 1: Map showing location of Block 5/6 (red polygon), and proposed seismic survey lines (grey). Places mentioned in the text are also indicated.

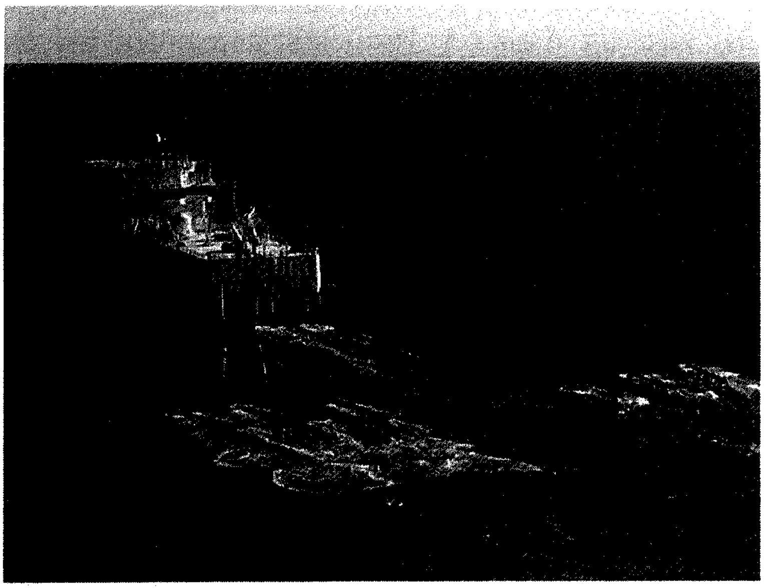

Figure 2: Typical seismic survey vessel towing an airgun array (Photo: www.flickr.com/photos/Pennycook).

During CSEM surveys a horizontal electric dipole transmitter (Figure 3, left) is towed with a neutrally buoyant streamer (up to 300 m long) containing two electrodes, at 30 - 50 m above the sea floor and at a speed of 2 - 3 knots. An alternating current, where the direction is changed every 1-2 seconds, is set up to flow between the two electrodes thereby injecting a current of up to 1,000 amps into the sea water and generating both an electric and magnetic field. The repetitive electromagnetic signal is transmited at a frequency of 0.05 - 10 Hz, upwards into the overlying water column and downwards into the underlying sediments. Typically only a few, closely-spaced frequencies are used, tuned to detect the target reservoir. The electric field strength decreases rapidly from 60 volts per metre (V/m) at the electrode surface to 0.001 V/m at a distance of 500 m. The magnetic field generated by the electrodes similarly decreases rapidly with distance from the source, reducing from 200,000 nanno tesla (nT) at 1 m to and 2,000 nT at 100 m distance from the source. At 4 m from the source the magnetic field is comparable to the Earth's magnetic field (40,000 - 60,000 nT).

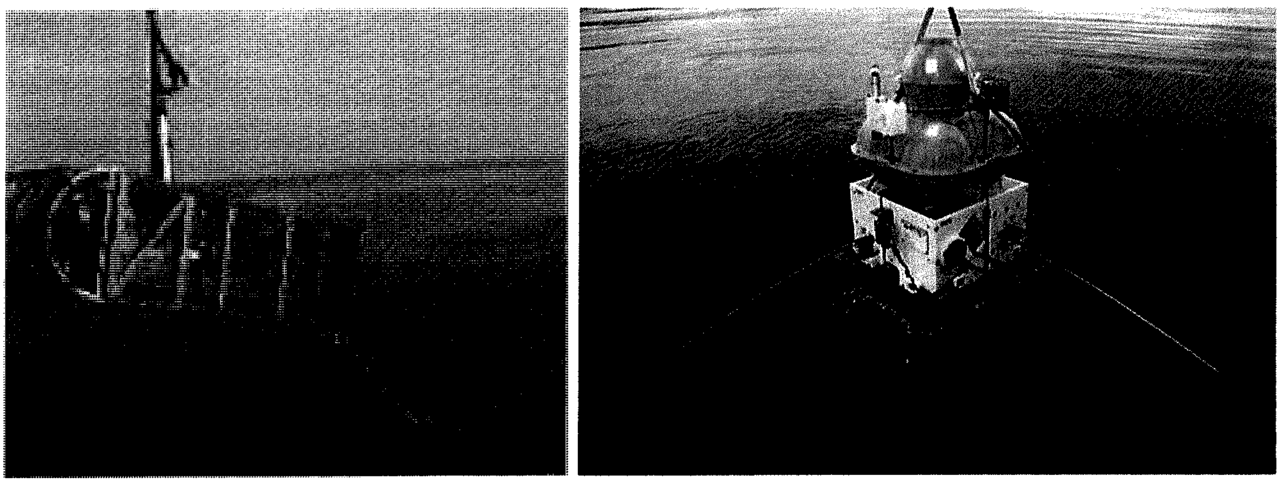

Figure 3: Typical CSEM towed electric diapole transmitter (left) and autonomous seabed receiver (right) (Photo: Left: www.ohmsurveys.com; Right: www.emgs.com).

The electromagnetic receivers (Figure 3, right) are autonomous sea floor units that are deployed at 1-km spacing at pre-defined locations on a grid and free-fall to the seabed. Receivers are usually set in one or two lines over the prospecting area, with lines being from 20-30 km long. Each receiver has a concrete anchor of patented soluble cement and records data continuously while the electromagnetic source transmits a continuous waveform. On completion of the survey, underwater acoustics are used to release the anchor and allow the receiver to float back to the surface for recovery. The anchors are left on the seafloor to dissolve over a six to eight month period, with the concrete being reduced to disaggregated sand thereby ensuring no seabed hazards remain.

In more recent shallow-water applications (<100 m depth), the deployment setup comprises surface towing of the horizontal electric dipole which is suspended from two GPS-positioned buoys. The electrodes have negative buoyancy, ensuring constant depth (typically 10 m) below the buoys. A third float provides additional support for the towfish containing the current generator and for the umbilical. The benefits of such shallow water applications include faster towing speeds (up to 4 knots), improved source manoeuvrability resulting in shorter tow line change times and no risk of impact with seabed features or subsea installations (Shantsev *et al.* 2010).

3. DESCRIPTION OF THE BASELINE MARINE ENVIRONMENT

The descriptions of the physical and biological environments along the South-Western Cape coast focus primarily on the study area between Cape Columbine and Cape Agulhas. The purpose of this environmental description is to provide the marine baseline environmental context within which the proposed exploration programme will take place. The summaries presented below are based on information gleaned from various sources, including the Generic EMPRs for Marine Diamond Mining off the West Coast of South Africa (Lane & Carter 1999), and Oil and Gas Exploration off the Coast of South Africa (CCA & CMS 2001), Penney *et al.* (2007), and Marine Faunal Impact studies compiled for EIAs and EMPRs for seismic surveys on the South African coastline (Pulfrich 2010a, 2010b).

3.1. Geophysical Characteristics

3.1.1 Bathymetry

The continental shelf along the South-West Coast maintains a general NNW trend. It is narrowest between Cape Columbine and Cape Point (40 km), widening to the north of Cape Columbine reaching its widest off the Orange River (180 km), and widening south of Cape Point due to the presence of the Agulhas Bank (Figure 1). The immediate nearshore area consists mainly of a narrow (about 8 km wide) rugged rocky zone and slopes steeply seawards to a depth of around 80 m. The middle and outer shelf normally lacks relief and slopes gently seawards reaching the shelf break at a depth of ~300 m.

3.1.2 Coastal and Inner-shelf Geology and Seabed Geomorphology

The inner shelf is underlain by Precambrian bedrock (also referred to as Pre-Mesozoic basement), whilst the middle and outer shelf areas are composed of Cretaceous and Tertiary sediments (Dingle 1973; Birch *et al.* 1976; Rogers 1977; Rogers & Bremner 1991). As a result of erosion, the middle shelf has a minimum cover of sandy sediment, thinning out markedly over the underlying rocky features of the outer shelf. The cover of unconsolidated sediment on the shelf is thus 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 (Figure 4). The continental slope, seaward of the shelf break, has a smooth seafloor, underlain by calcareous ooze.

3.2. Biophysical Characteristics

3.2.1 Wind Patterns

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

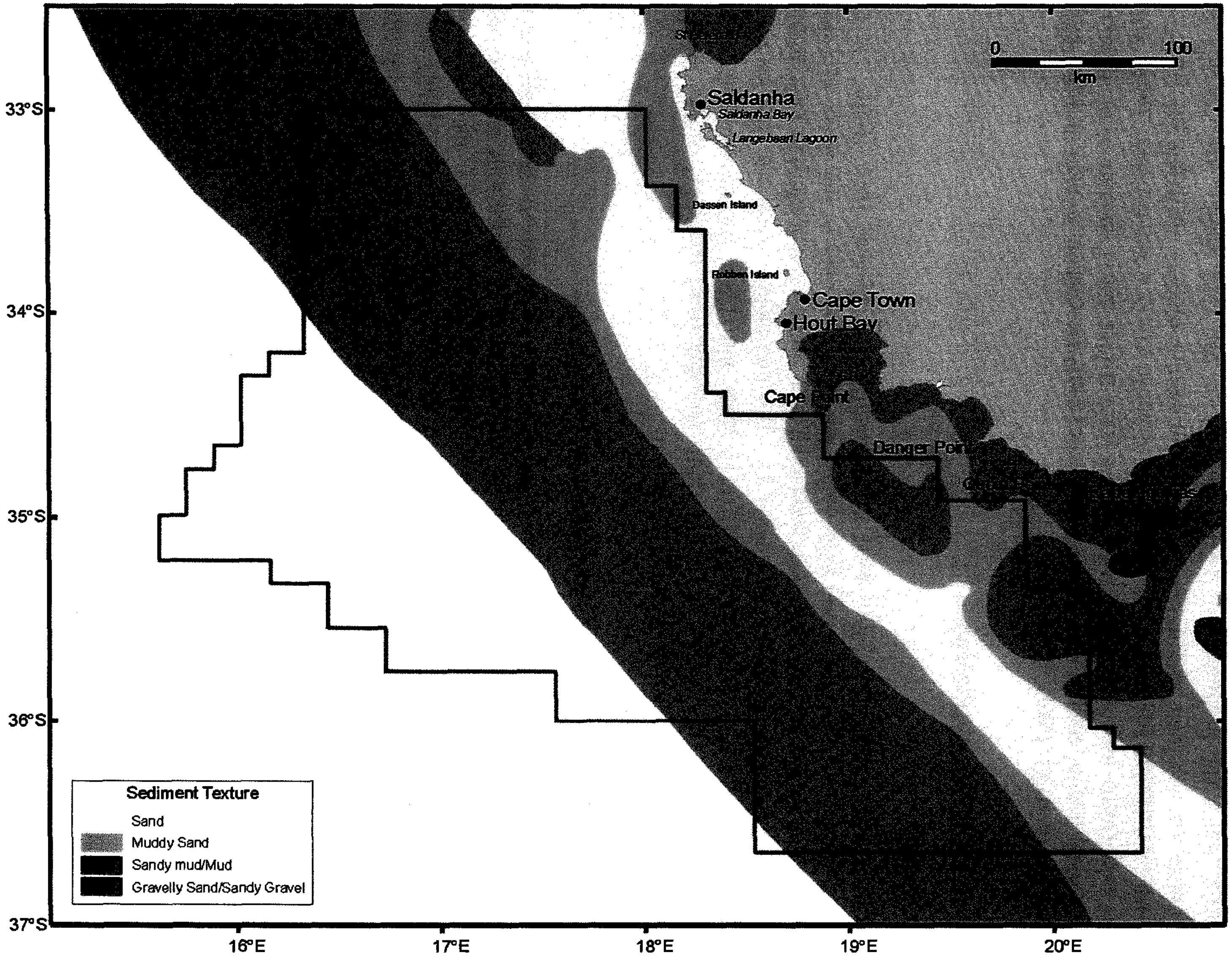

Figure 4: Sediment distribution on the continental shelf off the South-Western Cape Coast (Adapted from Rogers 1977).

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, during which winds blow 99% of the time, with a total of 226 gales (winds exceeding 18 m/s or 35 kts) being recorded over the period (Figures 5a and 5b; supplied by CSIR). Virtually all winds in summer come from the southeast to south-west, strongly dominated by southerlies which occur over 40% of the time, averaging 20 - 30 kts and reaching speeds in excess of 100 km/h (60 kts). South-easterlies are almost as common, blowing about one-third of the time, and also averaging 20 - 30 kts. The combination of these southerly/south-easterly winds drives the massive offshore movements of surface water, and the resultant strong upwelling of nutrient-rich bottom waters, which characterise this region in summer.

Winter remains dominated by southerly to south-easterly winds, but the closer proximity of the winter cold-front systems results in a significant south-westerly to north-westerly component (Figures 5a and 5b). 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.

3.2.2 Large-Scale Circulation and Coastal Currents

The southern African West Coast is strongly influenced by the Benguela Current. Current velocities in continental shelf areas generally range between 10-30 cm/s (Boyd & Oberholster 1994). On its western side, flow is more transient and characterised by large eddies shed from the retroflection of the Agulhas Current. In the south the Benguela current has a width of 200 km, widening rapidly northwards to 750 km. The flows are predominantly wind-forced, barotropic and fluctuate between poleward and equatorward flow (Shillington *et al.* 1990; Nelson & Hutchings 1983) (Figure 6). Fluctuation periods of these flows are 3 - 10 days, although the long-term mean current residual is in an approximate northwest (alongshore) direction. Near bottom shelf flow is mainly poleward (Nelson 1989) with low velocities of typically 5 cm/s. The poleward flow becomes more consistent in the southern Benguela.

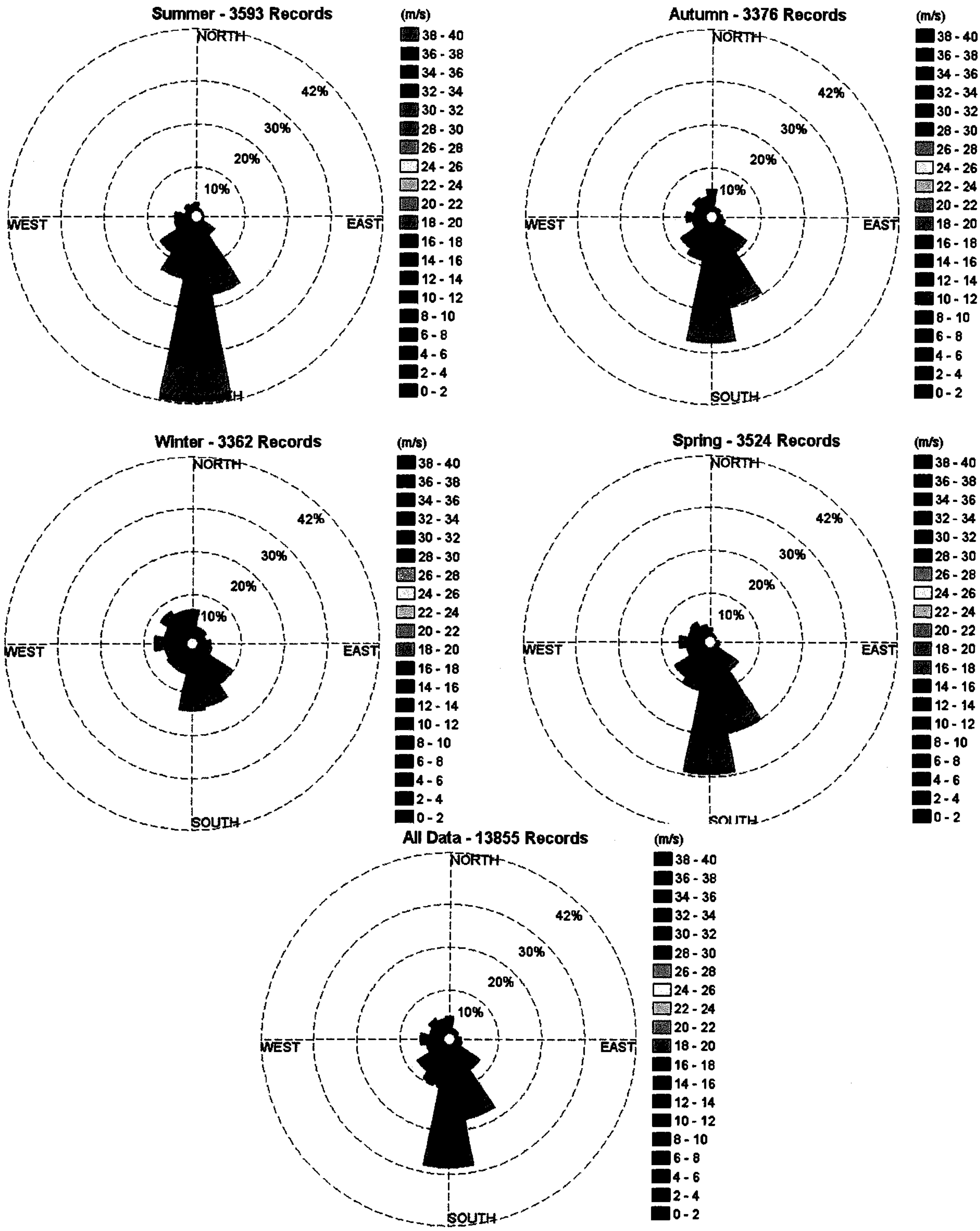

Figure 5a: VOS Wind Speed vs Wind Direction data for the Cape Columbine area 32.0 to 32.9 S and 17.0 to 17.9 E (1903-11-01 to 2011-05-24; 13,855 records) (from CSIR).

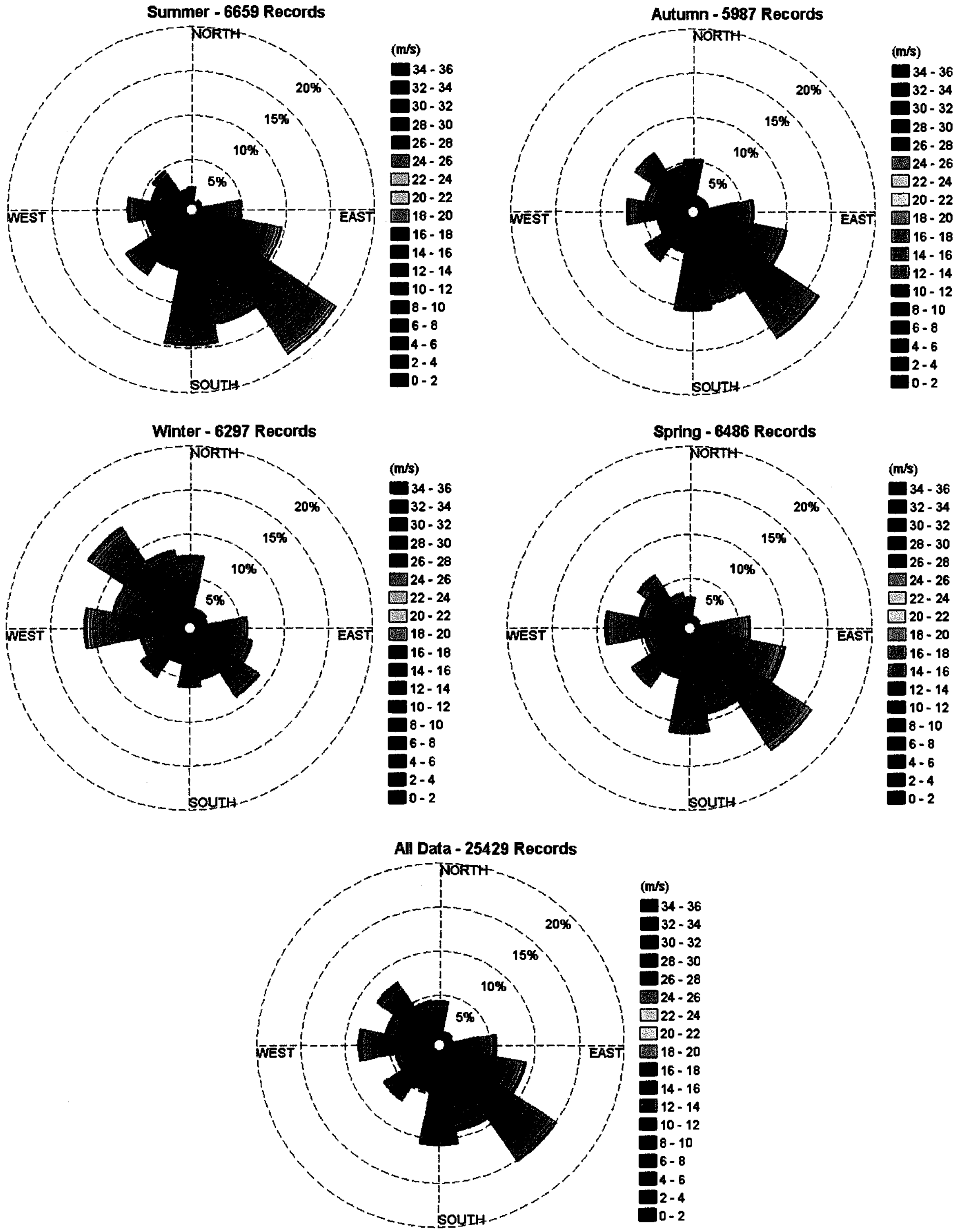

Figure 5b: VOS Wind Speed vs Wind Direction data for the Cape Point area 34.0 to 34.9 S and 18.0 to 18.9 E (1900-01-01 to 2011-05-24; 25,429 records) (from CSIR).

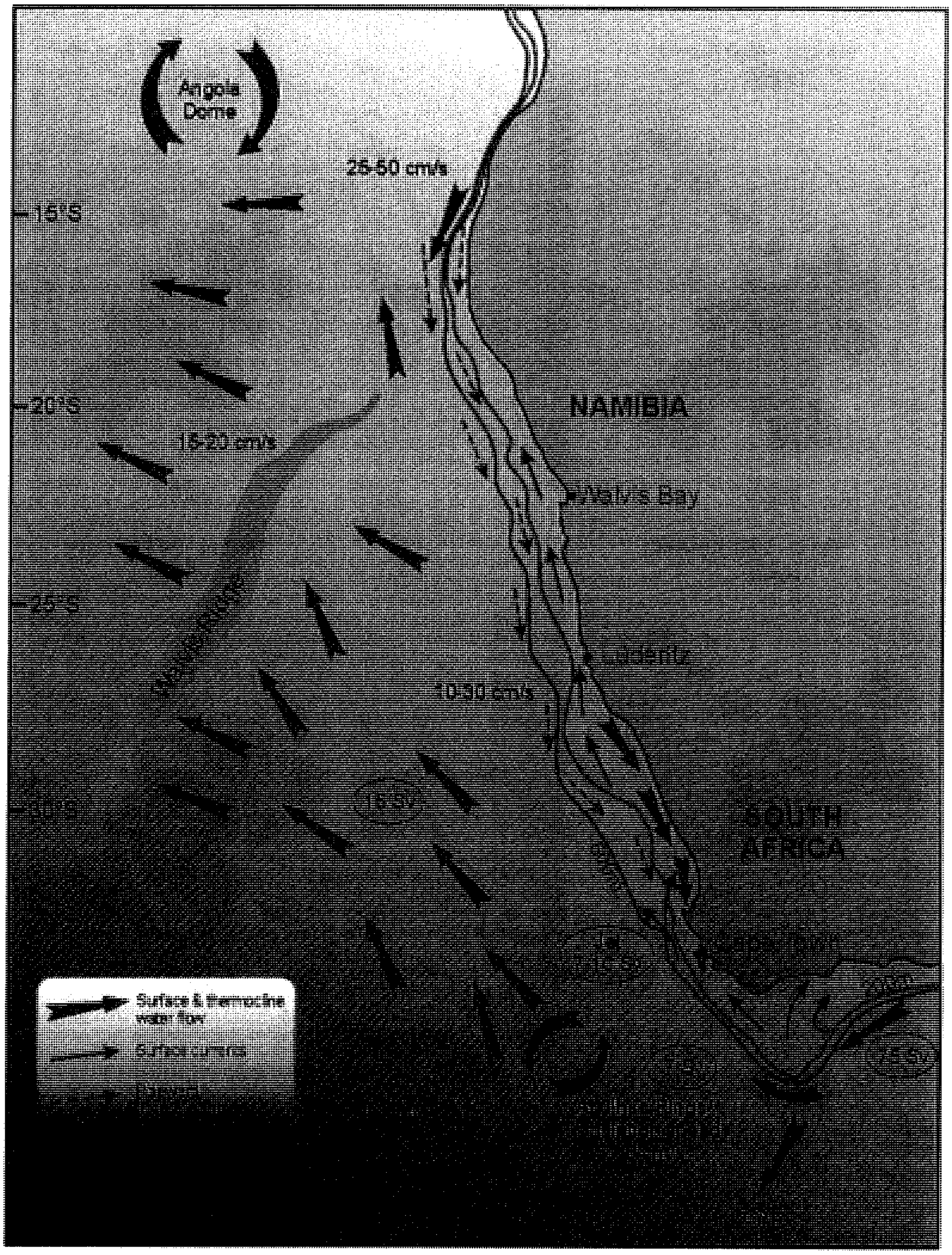

Figure 6: Major features of the predominant circulation patterns and volume flows in the Benguela System, along the southern Namibian and South African west coasts (re-drawn from Shannon & Nelson 1996).

The major feature of the Benguela Current Coastal is upwelling and the consequent high nutrient supply to surface waters leads to high biological production and large fish stocks. The prevailing longshore, equatorward winds move nearshore surface water northwards and offshore. To balance the displaced water, cold, deeper water wells up inshore. Although the rate and intensity of upwelling fluctuates with seasonal variations in wind patterns, the most intense upwelling tends to occur where the shelf is narrowest and the wind strongest. There are three upwelling centres in the southern Benguela, namely the Namaqua (30°S), Cape Columbine (33°S) and Cape Point (34°S) upwelling cells (Taunton-Clark 1985) (Figure 7; bottom left). Upwelling in these cells is seasonal, with maximum upwelling occurring between September and March. An example of one such strong upwelling event in December 1996, followed by relaxation of upwelling and intrusion of warm Agulhas waters from the south, is shown in the satellite images in Figure 7.

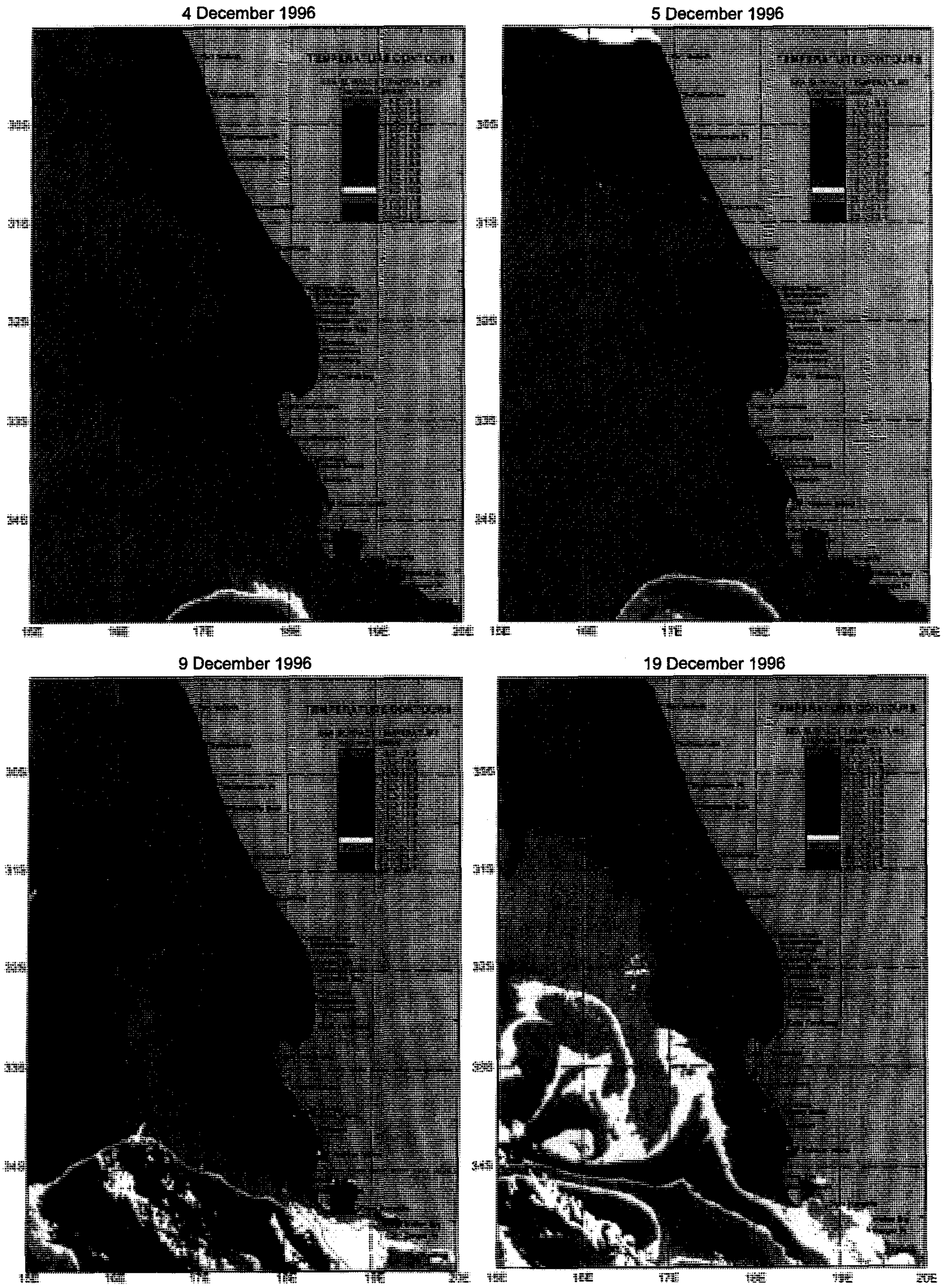

Figure 7: Satellite sea-surface temperature images showing upwelling intensity along the South African west coast on four days in December 1996 (from Lane & Carter 1999).

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

3.2.3 Waves and Tides

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

Typical seasonal swell-height rose-plots, compiled from data collected off Cape Columbine and Cape Point, are shown in Figures 8a and 8b, respectively (supplied by CSIR). The wave regime along the southern African west coast shows only moderate seasonal variation in direction, with virtually all swells throughout the year coming from the SW - S direction. Winter swells, however, are strongly dominated by those from the SW - SSW, which occur almost 80% of the time, and typically exceed 2 m in height, averaging about 3 m, and often attaining over 5 m. With wind speeds capable of reaching 100 km/h during heavy winter south-westerly storms, winter swell heights can exceed 10 m, and have been reported to reach in excess of 20 m height at the internationally renowned "Dungeons'" surf spot on the Cape Peninsula west coast.

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 more pronounced southerly swell component in summer. These southerly swells tend to be wind-induced, with shorter wave periods (~8 seconds), and are generally steeper than swell waves (CSIR 1996). These wind-induced southerly waves are relatively local and, although less powerful, tend to work together with the strong southerly winds of summer to cause the northward-flowing nearshore surface currents, and result in substantial nearshore sediment mobilisation, and northwards transport, by the combined action of currents, wind and waves.

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

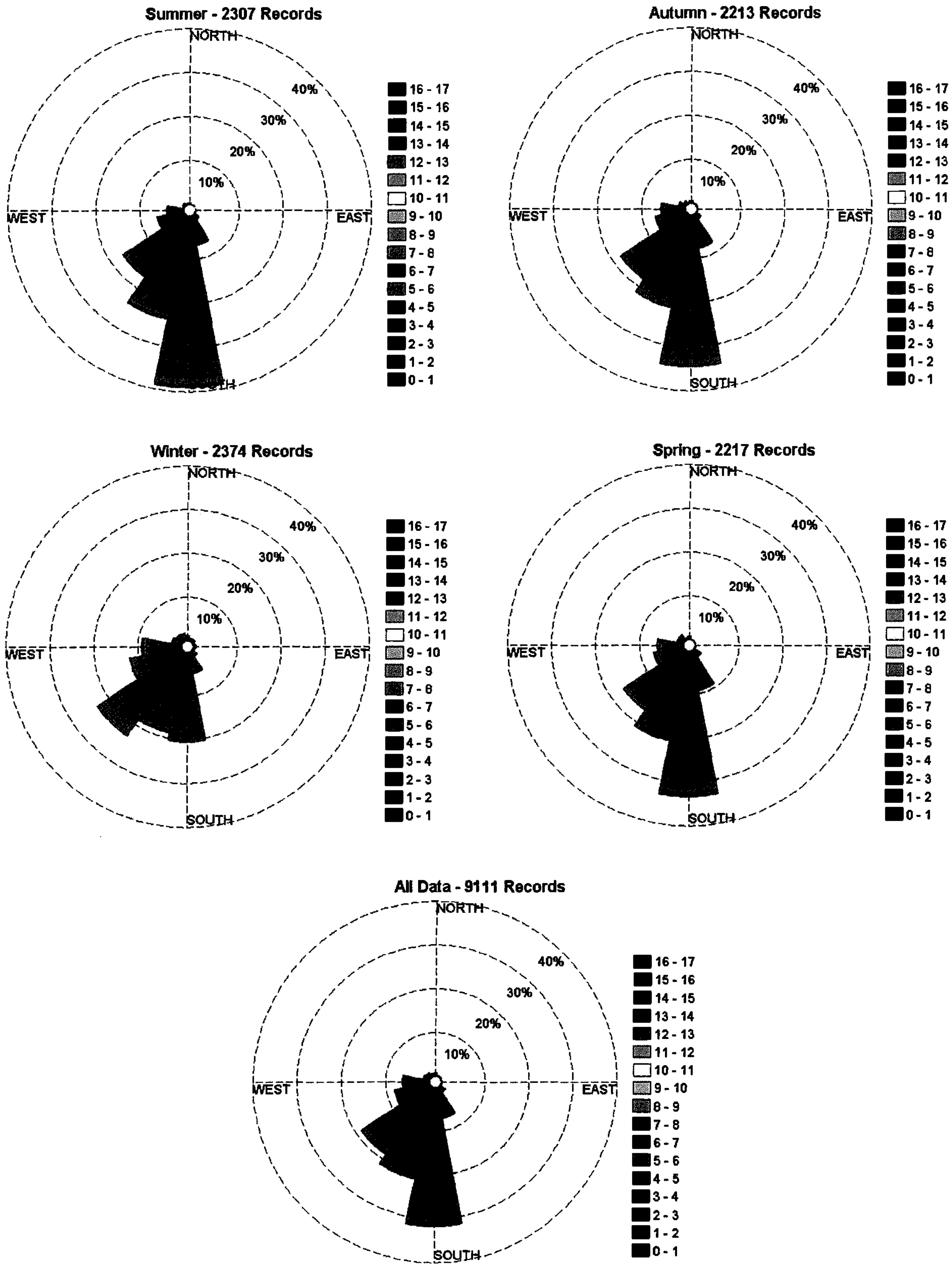

Figure 8a: VOS Wave Height vs Wave Direction data for the Cape Columbine area 32.0 to 32.9 S and 17.0 to 17.9 E (1903-11-01 to 2011-05-24; 9,111 records) (from CSIR).

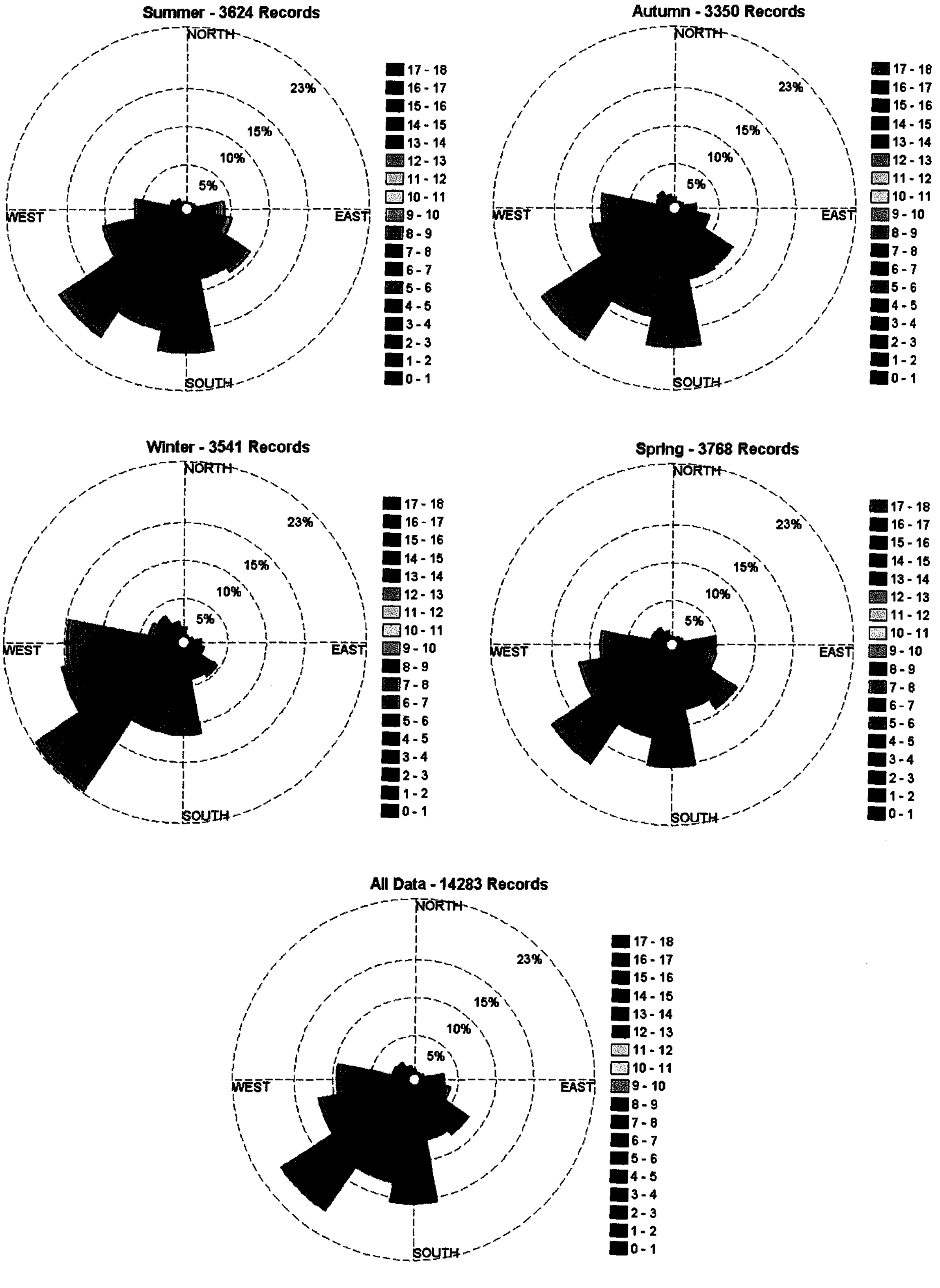

Figure 8b: VOS Wave Height vs Wave Direction data for the Cape Point area 34.0 to 34.9 S and 18.0 to 18.9 E (1900-01-01 to 2011-05-24; 14,283 records) (from CSIR).

3.2.4 Water

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

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

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

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

3.2.5 Upwelling & Plankton Production

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

3.2.6 Organic Inputs

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

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

An associated phenomenon ubiquitous to the Benguela system are red tides (dinoflagellate and/or ciliate blooms) (see Shannon & Pillar 1985; Pitcher 1998). Also referred to as Harmful Algal Blooms (HABs), these red tides can reach very large proportions, with sometimes spectacular effects. Toxic dinoflagellate species can cause extensive mortalities of fish and shellfish through direct poisoning, while degradation of organic-rich material derived from both toxic and non-toxic blooms results in oxygen depletion of subsurface water. Periodic low oxygen events associated with massive algal blooms in the nearshore can have catastrophic effects on the biota (see below).

3.3. The Biological Environment

Biogeographically, the coastline of the study area falls into the South-western Cape and Agulhas Bioregions, which extend from Cape Columbine to Cape Point, and from Cape Point eastwards to to the Mbashe River, respectively (Emanuel *et al.* 1992; Lombard *et al.* 2004). The portion of Block 5/6 that extends beyong the shelf break onto the continental slope and into abyssal depths fall into the Atlantic Offshore Bioregion (Lombard *et al.* 2004). The coastal, wind-induced upwelling characterising the south-western Cape coastline, is the principle physical process which shapes the marine ecology of the southern Benguela region. The Benguela system is characterised by the presence of cold surface water, high biological productivity, and highly variable physical, chemical and biological conditions (Barnard 1998).

Communities within marine habitats are largely ubiquitous throughout the southern African South-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). Block 5/6 are located beyond the 100 m depth contour, the closest points to shore being ~21 km due west of Jacobsbaai and 17 km due south of Cape Point. The deep-water 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 or sensitive species, which may be affected by the proposed seismic and CSEM surveys.

3.3.1 Demersal Communities

3.3.1.1 Benthic Invertebrate Macrofauna

The benthic biota of soft-bottom substrates constitutes invertebrates that live on (epifauna), or burrow within (infauna), the sediments, and are generally divided into macrofauna (animals >1 mm) and meiofauna (<1 mm). The structure and composition of benthic soft bottom communities is primarily a function of water depth and sediment grain size, but other factors such as current velocity, organic content, and food abundance also play a role (Snelgrove & Butman 1994; Flach & Thomsen 1998; Ellingsen 2002).

Numerous studies have been conducted on southern African West Coast continental shelf benthos, mostly focused on mining, pollution or demersal trawling impacts (Christie & Moldan 1977; Moldan 1978; Jackson & McGibbon 1991; Environmental Evaluation Unit 1996; Parkins & Field 1997; 1998; Pulfrich & Penney 1999; Goosen *et al.* 2000; Savage *et al.* 2001; Steffani & Pulfrich 2004a, 2004b; 2007; Steffani 2007a; 2007b; Atkinson 2009). The description below is drawn from the various baseline and monitoring surveys conducted by diamond mining companies (Bickerton & Carter 1995; Steffani & Pulfrich 2007; Steffani 2007a; 2007b), supplemented by the work of Christie (1974), who undertook a systematic study investigating macrobenthic community distributions across the continental shelf off Lamberts Bay.

In general, species diversity, abundance and biomass increase from the shore to 80 m depth, with communities being characterised equally by polychaetes, crustaceans and molluscs. Further offshore to 120 m depth, the midshelf is a particularly rich benthic habitat where biomass can attain 60 g/m^2 dry weight (Christie 1974; see also Steffani 2007b). The comparatively high benthic biomass in this midshelf region represents an important food source to carnivores such as the mantis shrimp, cephalopods and demersal fish species (Lane & Carter 1999). Outside of this rich zone biomass declines to 4.9 g/m^2 at 200 m depth and then is consistently low (<3 g/m^2) on the outer shelf (Christie 1974).

Typical species occurring at depths of up to 60 m included the snail *Nassarius* spp., the polychaetes *Orbinia angrapequensis*, *Nepthys sphaerocirrata*, several members of the spionid genera *Prionospio*, and the amphipods *Urothoe grimaldi* and *Ampelisca brevicornis*. The bivalves *Tellina gilchristi* and *Dosinia lupinus orbignyi* are also common in certain areas. All these species are typical of the southern African West Coast (Christie 1974; 1976; McLachlan 1986; Parkins & Field 1998; Pulfrich & Penney 1999; Goosen *et al.* 2000; Steffani & Pulfrich 2004a; 2007; Steffani, unpublished data). Further offshore communities are dominated by polychaetes (e.g. *Diopatra dubia, D. monroi, D. cuprea cuprea, Lumbrineris albidentata, Laonice cirrata*), echinoderms (e.g. *Amphiura* sp., *Ophiura* sp.) and crustaceans (e.g. *Ampelisca brevicornis, Hippomedon onconotus, Tanais philetaerus*) (Atkinson 2009).

Whilst many empirical studies related community structure to sediment composition (e.g. Christie 1974; Warwick *et al.* 1991; Yates *et al.* 1993; Desprez 2000; van Dalfsen *et al.* 2000), other studies have illustrated the high natural variability of soft-bottom communities, both in space and time, on scales of hundreds of metres to metres (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 (Steffani & Pulfrich 2004). It is likely that the distribution of marine communities in the mixed deposits of the coastal zone is controlled by complex interactions between physical and biological factors at the sediment-water interface, rather than by the granulometric properties of the sediments alone (Snelgrove & Butman 1994; Seiderer & Newell 1999). Local hydrodynamic conditions, and patchy settlement of larvae, will also contribute to small-scale variability of benthic community structure.

It is evident that an array of environmental factors and their complex interplay is ultimately responsible for the structure of benthic communities. Yet the relative importance of each of these factors is difficult to determine as these factors interact and combine to define a distinct habitat in which the animals occur. However, it is clear that water depth and sediment composition are two of the major components of the physical environment determining the macrofauna community structure (Steffani & Pulfrich 2004a, 2004b; 2007; Steffani 2007a; 2007b).

Also associated with soft-bottom substrates are demersal communities that comprise bottom-dwelling invertebrate and vertebrate species, many of which are dependent on the invertebrate benthic macrofauna as a food source. Atkinson (2009) reported numerous species of urchins and burrowing anemones beyond 300 m depth off the West Coast. Common commercial demersal species found mostly on the continental shelf but also extending beyond 500 m water depth include both the shallow-water hake, *Merluccuis capensis* and the deep-water hake (*Merluccius paradoxus*), monkfish (*Lophius vomerinus*), and kingklip (*Genypterus capensis*). There are also many other demersal "bycatch" species that include jacopever (*Helicolenus dactylopterus*), angelfish/pomfret (*Brama brama*), kingklip (*Genypterus capensis*) and gurnard (*Chelidonichtyes* sp).

3.3.1.2 Deep-water coral communities

There has been increasing interest in deep-water corals in recent years because of their likely sensitivity to disturbance and their long generation times. These benthic filter-feeders generally occur at depths exceeding 150 m. Some species form reefs while others are smaller and remain solitary. Corals add structural complexity to otherwise uniform seabed habitats thereby creating areas of high biological diversity (Breeze *et al.* 1997; MacIssac *et al.* 2001). Deep water corals establish themselves below the thermocline where there is a continuous and regular supply of concentrated particulate organic matter, caused by the flow of a relatively strong current over special topographical formations which cause eddies to form. Nutrient seepage from the substratum might also promote a location for settlement (Hovland *et al.* 2002). Substantial shelf areas in the productive Benguela region should thus potentially be capable of supporting rich, cold water, benthic, filter-feeding communities.

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

Roel (1987) showed seasonal variations in the distribution ranges shelf communities, with species such as the pelagic goby *Sufflogobius bibarbatus*, and West Coast sole *Austroglossus microlepis* occurring in shallow water north of Cape Point during summer only. The deep-sea community was found to be homogenous both spatially and temporally. In a more recent stdy, however, Atkinson (2009) identified two long-term community shifts in demersal fish communities; the first (early to mid-1990s) being associated with an overall increase in density of many species, whilst many species decreased in density during the second shift (mid-2000s). These community shifts correspond temporally with regime shifts detected in environmental forcing variables (Sea Surface Temperatures and upwelling anomalies) (Howard *et al.* 2007) and with the eastward shifts observed in small pelagic fish species and rock lobster populations (Coetzee *et al.* 2008, Cockcroft *et al.* 2008).

The diversity and distribution of demersal cartilagenous fishes on the West Coast is discussed by Compagno *et al.* (1991). The species likely to occur in Block 5/6, and their approximate depth range, are listed in Table 1.

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

Common Name	Scientific name	Depth Range
Frilled shark	*Chlamydoselachus anguineus*	200-1,000
Six gill cowshark	*Hexanchus griseus*	150-600
Gulper shark	*Centrophorus granulosus*	480
Leafscale gulper shark	*Centrophorus squamosus*	370-800
Bramble shark	*Echinorhinus brucus*	55-285
Black dogfish	*Centroscyllium fabricii*	>700
Portuguese shark	*Centroscymnus coelolepis*	>700
Longnose velvet dogfish	*Centroscymnus crepidater*	400-700
Birdbeak dogfish	*Deania calcea*	400-800
Arrowhead dogfish	*Deania profundorum*	200-500
Longsnout dogfish	*Deania quadrispinosum*	200-650
Sculpted lanternshark	*Etmopterus brachyurus*	450-900
Brown lanternshark	*Etmopterus compagnoi*	450-925
Giant lanternshark	*Etmopterus granulosus*	>700
Smooth lanternshark	*Etmopterus pusillus*	400-500
Spotted spiny dogfish	*Squalus acanthias*	100-400
Shortnose spiny dogfish	*Squalus megalops*	75-460

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

3.3.2 Pelagic Communities

The pelagic communities are typically divided into plankton and fish, and their main predators, marine mammals (seals, dolphins and whales), seabirds and turtles.

3.3.2.1 Plankton

Plankton is particularly abundant in the shelf waters off the South-West Coast, being associated with the upwelling characteristic of the area. Plankton range from single-celled bacteria to jellyfish of 2-m diameter, and include bacterio-plankton, phytoplankton, zooplankton, and ichthyoplankton (Figure 9).

Phytoplankton are the principle primary producers with mean productivity ranging from 2.5 - 3.5 g $C.m^{-2}.day^{-1}$ for the midshelf region and decreasing to 1 g $C.m^{-2}.day^{-1}$ inshore of 130 m (Shannon & Field 1985; Mitchell-Innes & Walker 1991; Walker & Peterson 1991). The phytoplankton is dominated by large-celled organisms, which are adapted to the turbulent sea conditions. The most common diatom genera are *Chaetoceros*, *Nitschia*, *Thalassiosira*, *Skeletonema*, *Rhizosolenia*, *Coscinodiscus* and *Asterionella* (Shannon & Pillar 1986). Diatom blooms occur after upwelling events, whereas dinoflagellates (e.g. *Prorocentrum*, *Ceratium* and *Peridinium*) are more common in blooms that occur during quiescent periods, since they can grow rapidly at low nutrient concentrations. In the surf zone, diatoms and dinoflagellates are nearly equally important members of the phytoplankton, and some silicoflagellates are also present.

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

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

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

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

Zooplankton biomass varies with phytoplankton abundance and, accordingly, seasonal minima will exist during non-upwelling periods when primary production is lower (Brown 1984; Brown &

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

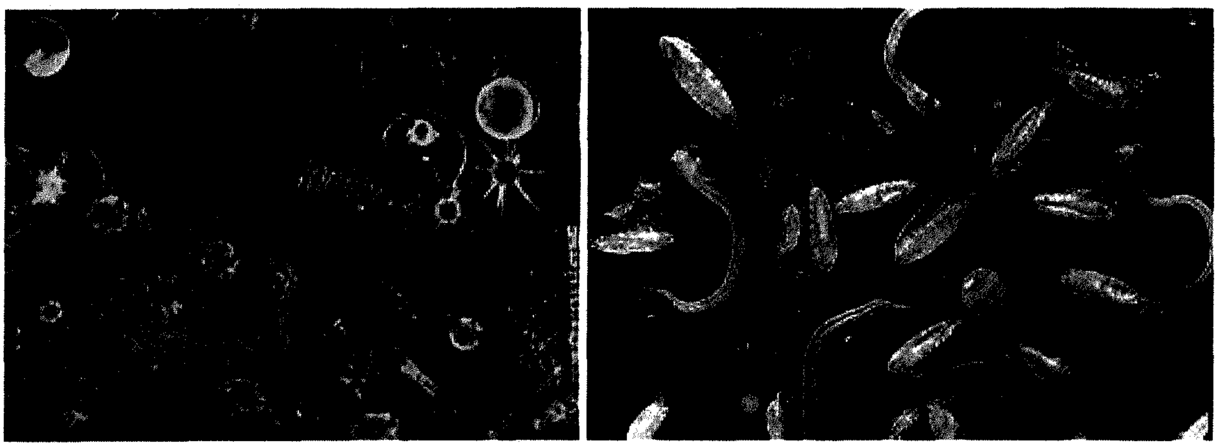

Figure 9: Phytoplankton (left, photo: hymagazine.com) and zooplankton (right, photo: mysciencebox.org) is associated with upwelling cells.

Although ichthyoplankton (fish eggs and larvae) comprise a minor component of the overall plankton, it remains significant due to the commercial importance of the overall fishery in the region. Various pelagic and demersal fish species are known to spawn in the southern Benguela, (including pilchard, round herring, chub mackerel lanternfish and hakes (Crawford *et al.* 1987) (see Figure 10), and their eggs and larvae form an important contribution to the ichthyoplankton in the region.

3.3.2.2 Cephalopods

The major cephalopod resource in the southern Benguela are sepiods/cuttlefish (Lipinski 1992; Augustyn *et al.* 1995) (Table 2). Most of the cephalopod resource is distributed on the mid-shelf with *Sepia australis* being most abundant at depths between 60-190 m, whereas *S. hieronis* densities were higher at depths between 110-250 m. *Rossia enigmatica* occurs more commonly on the edge of the shelf to depths of 500 m. Biomass of these species was generally higher in the summer than in winter.

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

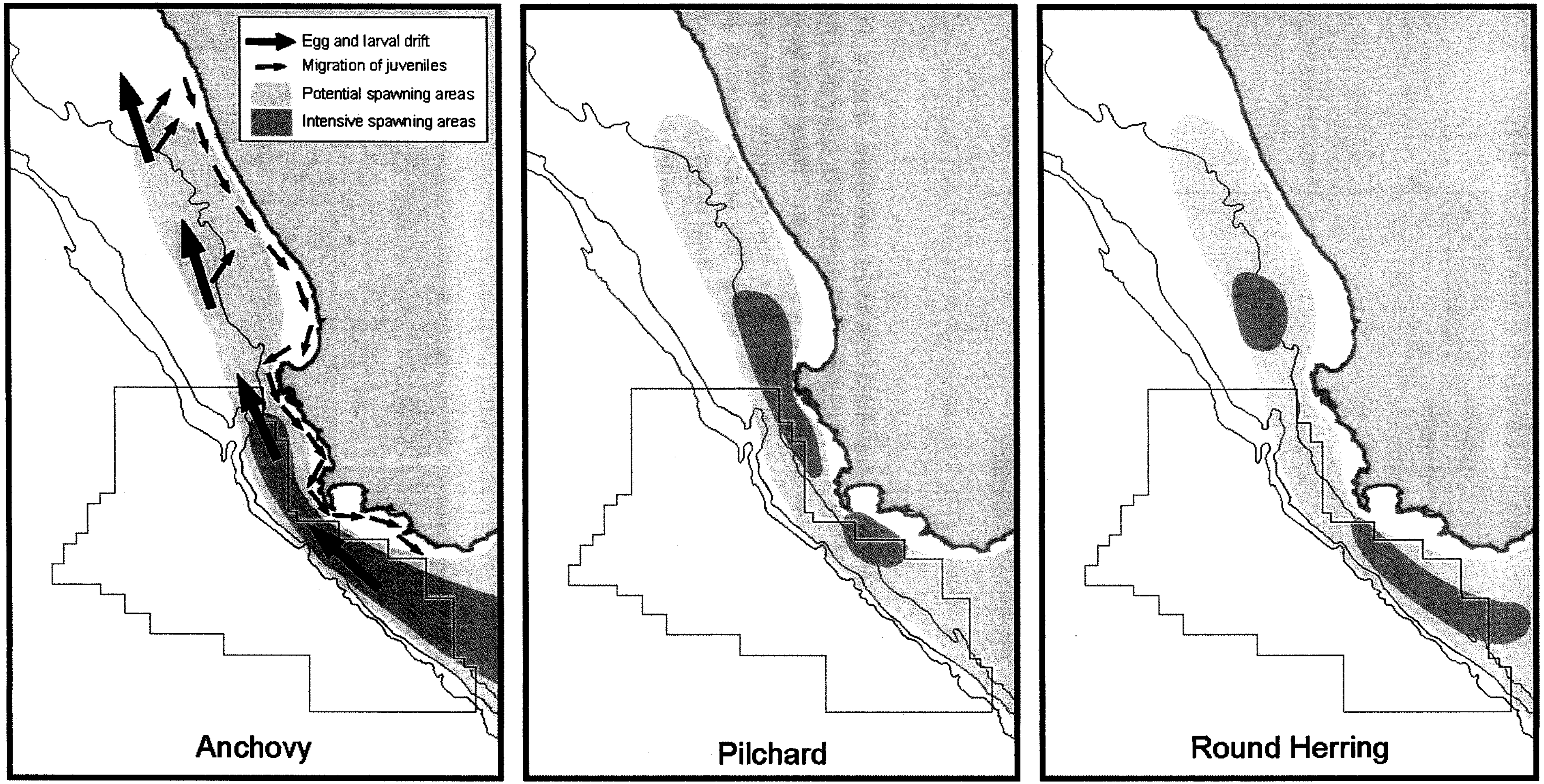

Figure 10: Major spawning areas in the southern Benguela region (adapted from Cruikshank 1990).

Table 2: The cephalopod species occurring in the Benguela system (Lipinski 1992).

Species
Loligo vulgaris reynaudii
Todarodes angolensis
Todarodes filippovae
Todaropsis eblanae
Lycoteuthis ?diadema
Sepia australis
Sepia hieronis
Octopus spp.
Argonauta spp.
Rossia enigmatica
Ommastrephes bartramii
Abraliopsis gilchristi
Lolliguncula mercatoris
Histioteuthis miranda

3.3.2.3 Fish

Small pelagic species include the sardine/pilchard (*Sadinops ocellatus*) (Figure 11, left), anchovy (*Engraulis capensis*), chub mackerel (*Scomber japonicus*), horse mackerel (*Trachurus capensis*) (Figure 11, right) and round herring (*Etrumeus whiteheadi*). These species typically occur in mixed shoals of various sizes (Crawford *et al.* 1987), and generally occur within the 200 m contour. Most of the pelagic species exhibit similar life history patterns involving seasonal migrations between the west and south coasts. Apart from round herring which spawn offshore of the shelf break on the West Coast (see Figure 10), 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.

Figure 11: Cape fur seal preying on a shoal of pilchards (left). School of horse mackerel (right) (photos: www.underwatervideo.co.za; www.delivery.superstock.com).

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

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

Large pelagic species include tunas, billfish and pelagic sharks, which migrate throughout the southern oceans, between surface and deep waters (>300 m) and have a highly seasonal abundance in the Benguela. Species occurring off western southern Africa include the albacore/longfin tuna *Thunnus alalunga* (Figure 12, right), yellowfin *T. albacares*, bigeye *T. obesus*, and skipjack *Katsuwonus pelamis tunas*, as well as the Atlantic blue marlin *Makaira nigricans* (Figure 12, left), the white marlin *Tetrapturus albidus* and the broadbill swordfish *Xiphias gladius* (Payne & Crawford 1989). The distributions of these species is dependent on food availability in the mixed boundary layer between the Benguela and warm central Atlantic waters. Concentrations of large pelagic species are also known to occur associated with underwater feature such as canyons and seamounts as well as meteorologically induced oceanic fronts (Penney *et al.* 1992).

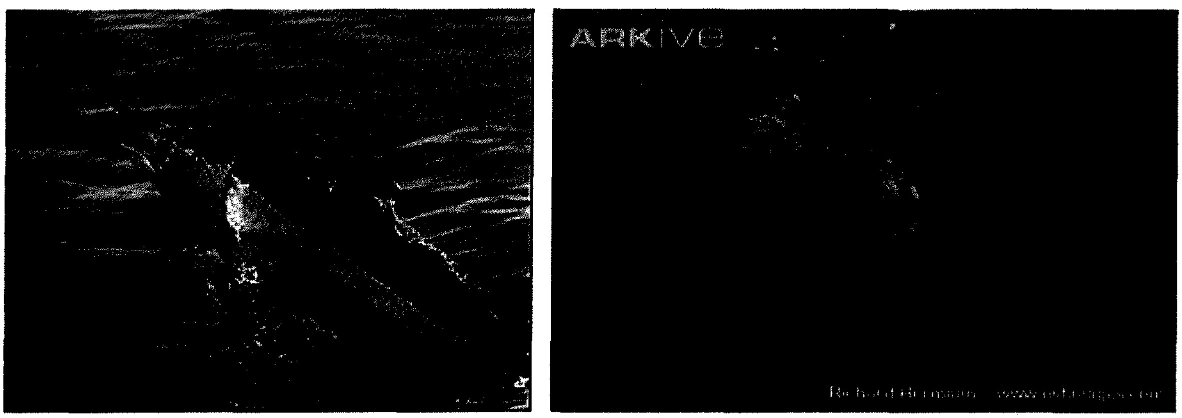

Figure 12: Large migratory pelagic fish such as blue marlin (left) and longfin tuna (right) occur in offshore waters (photos: www.samathatours.com; www.osfimages.com).

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

3.3.2.4 Turtles

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

The Leatherback is the only turtle likely to be encountered in the offshore waters of Block 5/6. Leatherback Turtles, the largest living marine reptile, nest on the beaches of the northern KwaZulu-Natal coastline between October and February, extending into March. The southern extremity of the nesting area is thus located well over 1,000 km to the north-east of the proposed survey areas. Hatchlings are born from late January through to March when the Agulhas Current is warmest. Once hatchlings enter the sea, they move southward in the Agulhas Current and are thought to remain in the southern Indian Ocean gyre for the first five years of their lives. Beach strandings of juveniles along the South coast suggest juvenile turtles in the Agulhas Current as far south as Mossel Bay (Hughes 1974). On the African West Coast the nearest nesting sites are approximately 3,000 km north-west of survey area in Republic of Congo and Gabon.

Adult Leatherbacks are known to frequent the cold southern ocean and are often recorded off the southern African West Coast. They inhabit deeper waters and are considered a pelagic species, travelling the ocean currents in search of their prey (primarily jellyfish). While hunting they may dive to over 100 m and remain submerged for up to 35 minutes. Their large size allows them to maintain a constant core body temperature and consequently they can penetrate colder temperate waters. Their abundance in the study areas is expected to be low. Leatherbacks feed on jellyfish and are known to have mistaken plastic marine debris for their natural food. Ingesting this can obstruct the gut, lead to absorption of toxins and reduce the absorption of nutrients from their real food. The turtles also get entangled in fishing gear and drown. 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. South Africa is thus committed to conserve these species at an international level.

3.3.2.5 Seabirds

Large numbers of pelagic seabirds exploit the pelagic fish stocks of the Benguela system. Of the 49 species of seabirds that occur in the Benguela region, 14 are defined as resident, 10 are visitors from the northern hemisphere and 25 are migrants from the southern Ocean. The 16 species classified as being common in the southern Benguela are listed in Table 3. The area between Cape Point and the Orange River supports 38% and 33% of the overall population of pelagic seabirds in winter and summer, respectively. Most of the species in the region reach highest densities offshore of the shelf break (200 - 500 m depth) with highest population levels during their non-breeding season (winter). Pintado petrels and Prion spp. show the most marked variation here.

14 species of seabirds breed in southern Africa; Cape Gannet, African Penguin, four species of Cormorant, White Pelican, three Gull and four Tern species (Table 4). The breeding areas are distributed around the coast with islands being especially important. The number of successfully breeding birds at the particular breeding sites varies with food abundance.

Figure 13: Cape Gannets *Morus capensis* (left) (Photo: NACOMA) and African Penguins *Spheniscus demersus* (right) (Photo: Klaus Jost) breed primarily on the offshore Islands.

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 2003; Ludynia 2007), and African Penguins have also been recorded as far as 60 km offshore.

3.3.2.6 Marine Mammals

Marine mammals occurring off the Southwest Coast include cetaceans (whales and dolphins) and seals.

The marine mammal fauna of the West Coast comprises between 28 and 31 species of cetaceans (whales and dolphins) and four species of seals of which the Cape fur seal (*Arctocephalus pusillus*) is the most common. The range in cetacean species number is due to taxonomic uncertainty at species and sub-species level, rather than uncertainty of occurrence or distribution patterns (Findlay *et al.* 1992). Nonetheless, the diversity is comparatively high, reflecting the cool inshore waters of the Benguela Upwelling system and the occurrence of

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

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

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

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

Common name	Species name	Global IUCN Status
African Penguin	*Spheniscus demersus*	Vulnerable
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

warmer oceanic water offshore of this. Cetaceans can be divided into two major groups, the mysticetes or baleen whales which are largely migratory, and the toothed whales or odontocetes which may be resident or migratory.

Six faunal provinces define the distribution of resident cetaceans within the South-West Coast region (Findlay *et al.* 1992; Peddemors 1999) (Figure 14). These include:

- *West Coast Offshore* - Two pelagic species of cetacean, True's beaked whale (*Mesoplodon mirus*) and the dwarf sperm whale (*Kogia sima*) appear to be limited to offshore region between Cape Columbine and the Eastern Cape. A further two species, Gray's beaked whale (*Mesoplodon grayii*) and the long finned pilot whale (*Globicephala melas*) appear to be limited to the offshore region between Namibia and the Eastern Cape. These species are found in deep waters elsewhere in the world and apart from the pilot whale are recorded only as strandings on the South African coast. A localised distribution of southern right-whale dolphins (*Lissodelphis peronii*) is associated with the continental shelf and the shelf-edge in the region between 24° and 28° S.
- *West Coast Inshore* - Two species, the Benguela dolphin (*Cephalorhynchus heavisidii)* and the dusky dolphin (*Lagenorhynchus obscurus*) (Figure 15, right) are resident over the shelf with the Benguela (Heaviside's) dolphin (*Cephalorhynchus heavisidii*) (Figure 15, left) found inshore to the north of Cape Point and dusky dolphin found inshore west of False Bay.
- *Agulhas Bank to Lamberts Bay* - Two species, the long-beaked common dolphin (*Delphinus delphis*) and the resident smaller inshore Bryde's whale (*Balaenoptera edeni*) appear to be strongly associated with the Agulhas Bank region and the West Coast inshore region as far north as Lambert's Bay. Although these species will be found elsewhere in southern African waters the majority of records are from the Agulhas Bank region.
- *South Coast Extreme Inshore* - Both Indo Pacific humpbacked dolphins (*Sousa chinensis*) and the smaller bottlenose dolphin (*Tursiops truncatus aduncus*) occur in extreme inshore waters to the east of False Bay.
- *Agulhas Current Species* - The movement of warm Agulhas Current water into the South Coast region results in warm water species being stranded in the region. Southern bottlenose whales (*Hyperoodon planifrons*), Blainville's beaked whale (*Mesoplodon densirostris*), and striped dolphin (*Stenella coeruleoalba*) have been recorded as strandings between Cape Columbine and Cape Agulhas. The latter two species have warm water pelagic distributions elsewhere in the world.
- *Cosmopolitan* - Killer whales (*Orcinus orca*) and minke whales (possibly *Balaenoptera acutorostrata*) are found in both continental shelf and offshore waters of the West Coast. Cuvier's beaked whale (*Ziphius cavirostris*), pygmy sperm whales (*Kogia breviceps*), False killer whales (*Pseudorca crassidens*), pygmy killer whales (*Feresa attenuata*), Risso's dolphins (*Grampus griseus*), and sperm whales (*Physeter macrocephalus*) are found throughout the offshore waters of the West Coast. A second common dolphin species occurs in the offshore region of the West Coast.

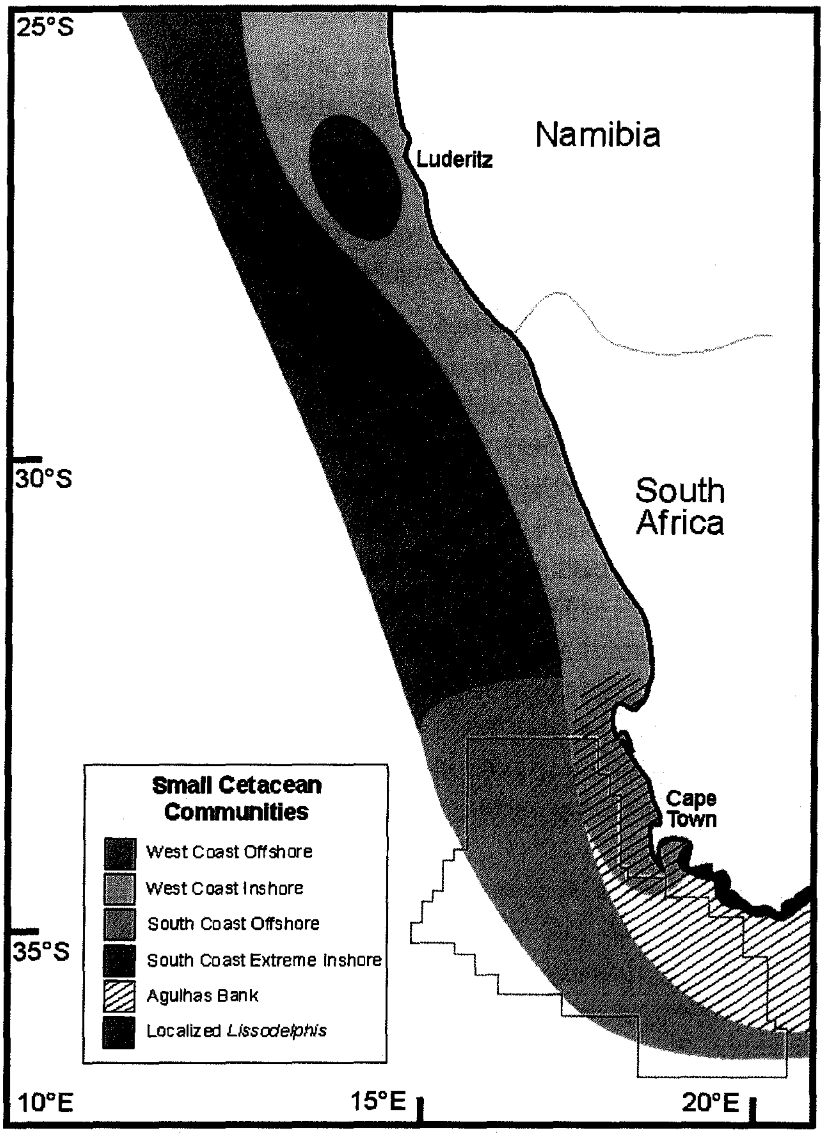

Figure 14: Diagramatic representation of the distribution patterns of small cetaceans in southern African West Coast waters in relation to Block 5/6 (red polygon) (Modified from Findlay *et al.* 1992).

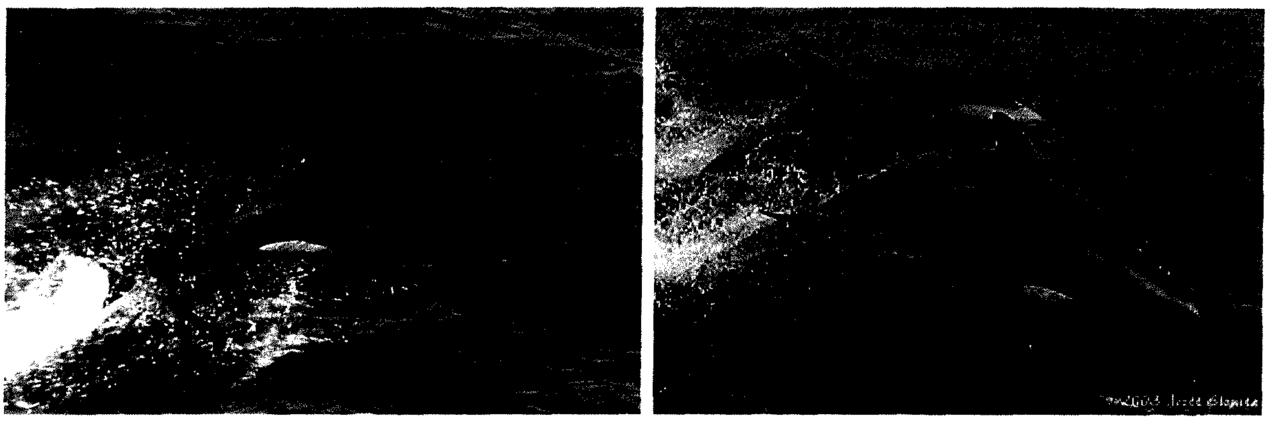

Figure 15: The endemic Benguela Dolphin *Cephalorhynchus heavisidii* (left) (Photo: De Beers Marine Namibia), and Dusky dolphin *Lagenorhynchus obscurus* (right) (Photo: scottelowitzphotography.com).

The majority of baleen whales (Blue *Balaenoptera musculus*, Fin *B. physalus*, Sei *B. borealis*, Minke *B acutorostrata / B. bonaerensis*, Southern Right *Eubalaena australis* and Humpback whales *Megaptera novaeangliae*) migrate from Antarctic summer feeding grounds to the southern African subcontinent to breed during winter months. While Blue, Fin and Sei whales migrate off or along the West Coast continental shelf edge (and are thus distributed in deeper waters), Humpback and Southern Right whales migrate over the continental shelf and along the coast.

Two types of Bryde's whales are recorded from South African waters - a smaller neritic form (of which the taxonomic status is uncertain) and a larger pelagic form described as *Balaenoptera brydei*. The smaller neritic form is resident (particularly over the Agulhas Bank) but does show some movement up the west coast in winter. The larger offshore form is migratory along the West Coast, migrating northwards in autumn and south again in Spring. They occur off Saldanha Bay in winter (Best 2001).

Southern Right whales (Figure 16, right) arrive in coastal waters off the southern African West Coast in June, building up to a maximum in September/October and departing again 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 for Southern Right whales (Currie *et al.* 2009), with sightings reported as far north as the Kunene and Möwe Bay (Roux *et al.* 2001) indicating that the distribution does extend northwards. On the African east coast, the winter distribution extends as far as Maputo Bay, Mozambique, although sightings have been reported off Madagascar. Currently the most significant winter concentration of Southern Rights is on the South Coast, between Cape Town and Port Elizabeth (Best 2007). 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 Southern Right population is increasing at approximately 7% per annum, yet is still probably around 10% of the pre-exploitation abundance (Best 2000).

The main winter concentration areas for Humpback whales (Figure 16, left) include Angola, Republic of Congo and Gabon on the west coast of Africa, and Mozambique, Madagascar, Kenya and Tanzania on the east coast. Three principal migration routes for Humpbacks in the south-west Indian Ocean have been proposed. On the first route up the East Coast, the northern migration reaches the coast in the vicinity of Knysna. On the West Coast it is thought that only a small proportion of the main migration comes close inshore (*i.e.* second route), the majority choosing the shortest route to the central West African breeding grounds by following the edge of the continental shelf (*i.e.* third route) (Best 2007; Best & Allison 2010). 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).

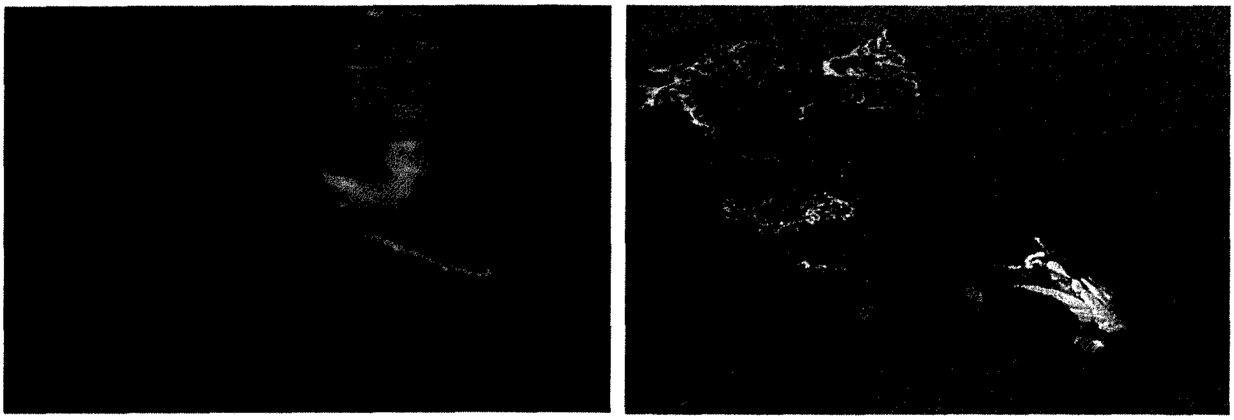

Figure 16: The Humpback whale *Megaptera novaeangliae* (left) and the Southern Right whale *Eubalaena australis* (right) migrate along the southern African and West Coast during winter (Photos: www.divephotoguide.com; www.aad.gov.au).

Deviations from the predictable and seasonal migration patterns of these two species have, however, recently been reported from the Cape Columbine - Yzerfontein area (Best 2007; Barendse *et al.* 2010) (see Figure 19). High abundances of both Southern Right and Humpback whales in this area during spring and summer, and their occurrence further offshore, indicates that the region may serve as an important summer feeding area. 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.

Killer whales are found year round in the waters of the West Coast, although the seasonality of sightings within the whaling grounds (in September and October) suggests that some killer whales are highly migratory. The pygmy right whale (*Caperea marginata*) shows a strong summer seasonality in water depths of less than 50 m along the coast between Algoa Bay in the east and Walvis Bay, Namibia. Arnoux's beaked whale (*Berardius arnuxii*) has been recorded along the West Coasts to the east of 18° E during summer. Layard's beaked whale (*Mesoplodon layardii*) is distributed throughout the West Coast pelagic waters in summer and early autumn.

Of the migratory cetaceans, the Blue, Sei and Humpback whales are listed as "Endangered" and the Southern Right and Fin whale as "Vulnerable" in the IUCN Red Data book. All whales and dolphins are given protection under the South African Law. The Marine Living Resources Act, 1998 (No. 18 of 1998) states that no whales or dolphins may be harassed, killed or fished. No vessel or aircraft may approach closer than 300 m to any whale and a vessel should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m from a vessel or aircraft.

The Cape fur seal (*Arctocephalus pusillus pusillus*) (Figure 17) is common along the Southern African West Coast, occurring at numerous breeding and non-breeding sites on the mainland and on nearshore islands and reefs (see Figure 19). Far less common on the waters of the West Coast are the subantarctic fur seal (*Arctocephalus tropicalisa)*, the leopard seal (*Hydrurga* *leptonyx)*, and the southern elephant seal (*Mirounga leonia)*. These species are represented by vagrant individuals.

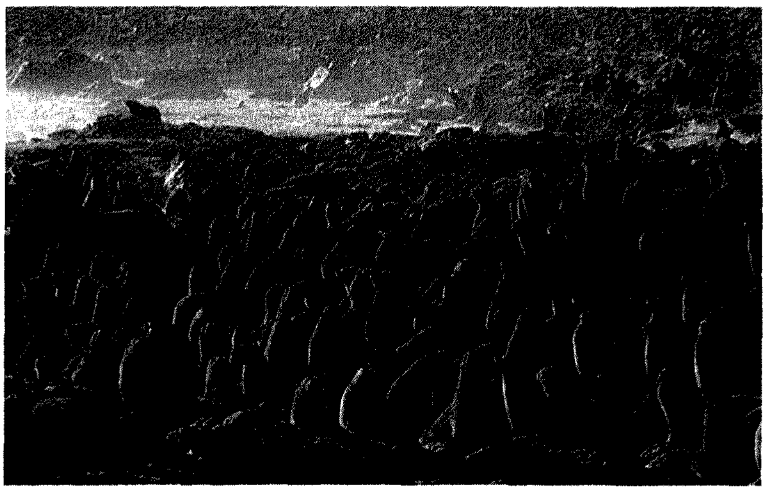

Figure 17: Colony of Cape fur seals *Arctocephalus pusillus pusillus* (Photo: Dirk Heinrich).

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

3.3.2 Conservation Areas and Marine Protected Areas

In South Africa there are several types of protected areas in the marine and coastal environment where special regulations apply for conservation, fishery management and the promotion of tourism. These include:

- **Marine Protected Areas**, which are declared under Section 43 of the Marine Living Resources Act, No. 18 of 1998. In general no fishing, construction work, pollution, or any form of disturbance is allowed here unless written permission has been granted by the Minister;
- **Closed Areas**, which are declared under Section 77 of the Marine Living Resources Act. Fishing is restricted or prohibited entirely in these areas; and
- **National Parks**, which are declared under the National Parks Act, No. 57 of 1976, and subsequent amendments.

Numerous conservation areas and a marine protected area (MPA) exist along the coastline of the South-Western Cape, although none fall within Blocks 5/6 (Figure 18). However, for the sake of completeness, they are briefly summarised below.

South of Cape Columbine, there are various MPAs associated with Langebaan Lagoon (a RAMSAR site), the Saldanha Bay Islands and the Cape Peninsula (Figure 18). These include 'no-take' areas, as well as areas where restrictions on fishing gears (Tables 5 and 6) and/or species apply.

Under the Sea Birds and Seals Protection Act (Act 46 of 1973), access was also restricted to South African islands and offshore reefs, especially if these supported colonies of seals or seabirds. The Act is currently under revision and a Policy for Seals, Seabirds and Shorebirds in South Africa has been drafted. Under the revised Act, any seabird and seal colony, whether on the mainland or on islands, will be protected. In addition to the MPAs listed in Table 6, areas on the South-West Coast which will be protected and to which access will be restricted include:

- Cape Columbine, Jutten Island and Vondeling Island colonies.
- Robbesteen near Koeberg.
- Duikerklip at Hout Bay.

Table 5: List of marine conservation areas coincident with South African marine diamond mining concessions.

Bioregion	Marine Protected Area	Protection	Location
Namaqualand	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-base 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

Bioregion	Marine Protected Area	Protection	Location
	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
	Within 12 nautical miles 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 nautical miles 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
Agulhas	Helderberg MPA : adjacent to the Helderberg Coastal Reserve between the mouth of the Eerste River and the mouth of the Lourens River in False Bay, extending 500 m seawards from the high-water mark.	No fishing is allowed	34°04'52"S to 34°05'59"S
	Betty's Bay MPA: from the western boundary at Stony Point, to eastern boundary, marked east of "Jock-se-baai", and as southern boundary the latitude 34 °24'.45S, extending two nautical miles seawards from the high water mark	Stony Point African Penguin colony, abalone, west coast rock lobsters, and various linefish. Only shore angling is allowed.	34°22'S to 34°21'S

Table 6: List of South African West Coast restricted fishing areas.

Area	Restricted Gear
Cape Point to Orange River - within 5 miles seaward of high water mark	Trawl Net
Cape Point to South head, Saldanha - within 3 miles seaward of high water mark	Drift- or set-net
Stompneus Point to Doctor's Reef - within 500 m seaward of high water mark	Drift- or set-net
Stompneus Point to mouth of Bokram River	Purse-seine
Strand Closed Area: mouth of the Lourens River, and the eastern breakwater of the harbour at Gordon's Bay, extending 500 m seawards.	Only shore angling is allowed
Mudge Point Closed Area: western limit of the Hawston harbour and the eastern limit of the Frans Senekal Reserve, extending 100 m seawards from the high-water mark.	Only shore angling and the catching of rock lobster is allowed
Onrus River Closed Area: inside Harderbaai north of a line between the beacons at Van der Riet Hoek and Marine Drive Point.	Only shore angling is allowed
Hermanus Closed Area: between the beacons at Kraal Rock, Walker Bay, and Rietfontein, extending 500 m seawards from the high-water mark.	Only shore angling (and no other type of fishing) is allowed

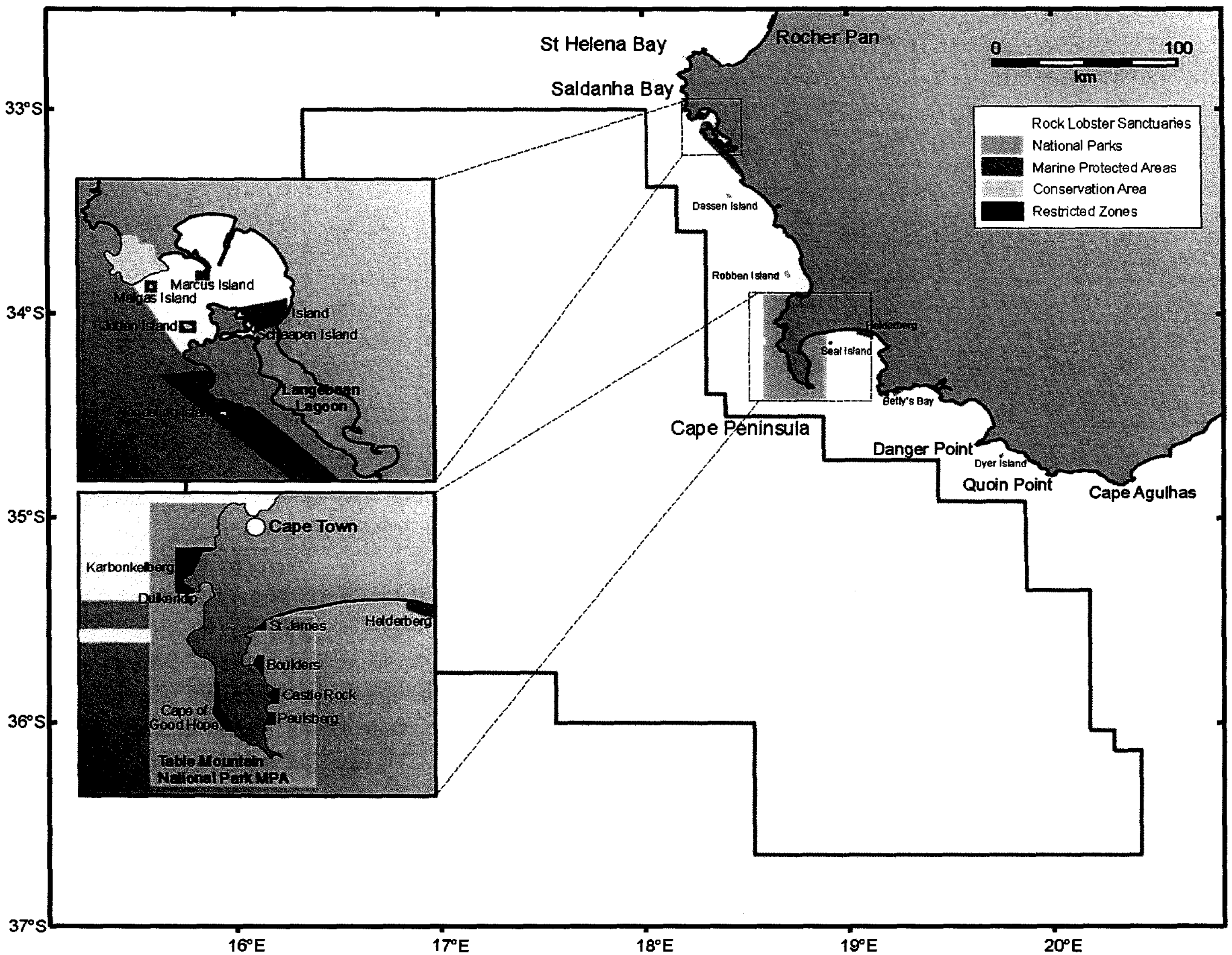

Figure 18: Reserves and Marine Protected Areas on the South-West Coast in relation to Block 5/6 (red polygon).

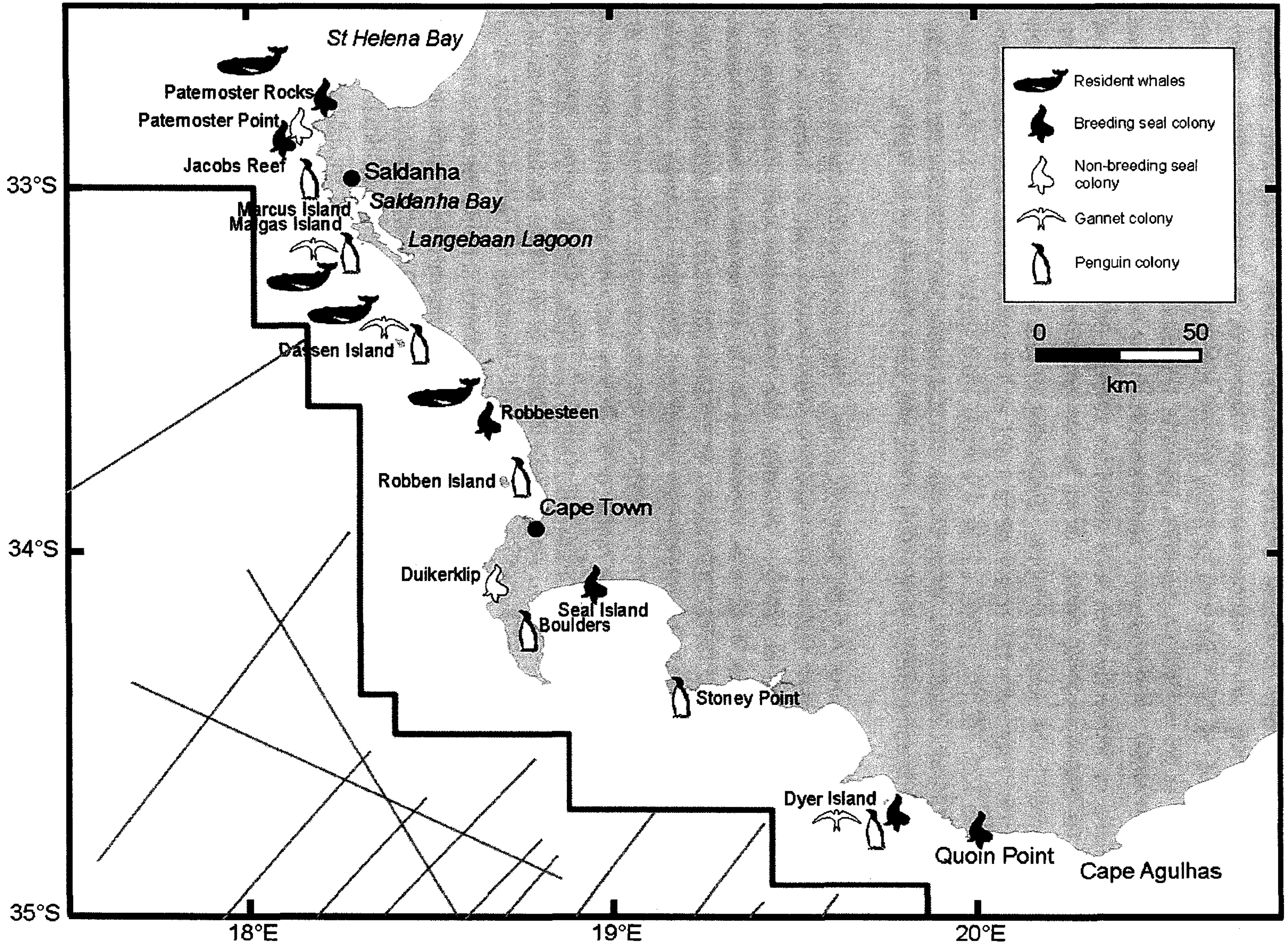

Figure 19: Project - environment interaction points on the South-West Coast, illustrating the location of seabird and seal colonies and resident whale populations in relation to the eastern boundary of Block 5/6 (red polygon) and proposed survey lines (grey).

4. ACOUSTIC IMPACTS OF SEISMIC SURVEYS ON MARINE FAUNA

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

Seismic surveys are another source of anthropogenic noise. The airguns used in modern seismic surveys produce some of the most intense non-explosive sound sources used by humans in the marine environment (Gordon *et al.* 2004). However, the transmission and attenuation of seismic sound is probably of equal or greater importance in the assessment of environmental impacts than the produced source levels themselves, as transmission losses and attenuation are very site specific, and are affected by propagation conditions, distance or range, water and receiver depth and bathymetrical aspect with respect to the source array. In water depths of 25 - 50 m airgun arrays are often audible to ranges of 50 -75 km, and with efficient propagation conditions such as experienced on the continental shelf or in deep oceanic water, detection ranges can exceed 100 km and 1,000 km, respectively (Bowles *et al.* 1991; Richardson *et al.* 1995; see also references in McCauley 1994). The signal character of seismic shots also changes considerably with propagation effects. Reflective boundaries include the sea surface, the seafloor and boundaries between water masses of different temperatures or salinities, with each of these preferentially scattering or absorbing different frequencies of the source signal. This results in the received signal having a different spectral makeup from the initial source signal. In shallow water (<50 m) at ranges exceeding 4 km from the source, signals tend to increase in length from <30 milliseconds, with a frequency peak between 10-100 Hz and a short rise time, to a longer signal of 0.25-0.75 seconds, with a downward frequency sweep of between 200 - 500 Hz and a longer rise time (McCauley 1994; McCauley *et al.* 2000).

In contrast, in deep water received levels vary widely with range and depth of the exposed animals, and exposure levels cannot be adequately estimated using simple geometric spreading laws (Madsen *et al.* 2006). These authors found that the received levels fell to a minimum between 5 - 9 km from the source and then started increasing again at ranges between 9 - 13 km, so that absolute received levels were as high at 12 km as they were at 2 km, with the complex sound reception fields arising from multi-path sound transmission.

Acoustic pressure variation is usually considered the major physical stimulus in animal hearing, but certain taxa are capable of detecting either or both the pressure and particle velocity components of a sound (Turl 1993). An important component of hearing is the ability to detect sounds over and above the ambient background noise. Auditory masking of a sound occurs when its' received level is at a similar level to background noise within the same frequencies. The signal to noise ratio required to detect a pure tone signal in the presence of background noise is referred to as the critical ratio.

The auditory thresholds of many species are affected by the ratio of the sound stimulus duration to the total time (duty cycle) of impulsive sounds of <200 millisecond duration. The lower the duty cycle the higher the hearing threshold usually is. Although seismic sound impulses are extremely short and have a low duty cycle at the source, received levels may be longer due to the transmission and attenuation of the sound (as discussed above).

Below follows a brief review of the impacts of seismic surveys on marine faunal communities. This information is largely drawn from McCauley (1994), McCauley *et al.* (2000), the Generic EMPR for Oil and Gas Prospecting off the Coast of South Africa (CCA & CMS 2001) and the very comprehensive reviews by Cetus Projects (2007, 2008), compiled as part of the Environmental Impact Assessment for the Ibhubesi Gas Field and the CGG Veritas surveys on the Namibian shelf, respectively. While the effects on pelagic and benthic invertebrates, turtles and seabirds is covered briefly, the discussion and assessments focus primarily on fish and marine mammals.

4.1. Impacts on Plankton

As the movement of phytoplankton and zooplankton is largely limited by currents, they are not able to actively avoid the seismic vessel and thus are likely to come into close contact with the sound sources. Phytoplankton are not known to be affected by seismic surveys and are unlikely to show any significant effects of exposure to airgun impulses outside of a 1 m distance (Kosheleva 1992; McCauley 1994).

Zooplankton comprises meroplankton (organisms which spend a portion of their life cycle as plankton, such as fish and invertebrate larvae and eggs) and holoplankton (organisms that remain planktonic for their entire life cycle, such as siphonophores, nudibranchs and barnacles). The abundance and spatial distribution of zooplankton is highly variable and dependent on factors such as fecundity, seasonality in production, tolerances to temperature, length of time spent in the water column, hydrodynamic processes and natural mortality. Zooplankton densities are generally low and patchily distributed. The amount of exposure to the influence of seismic airgun arrays is thus dependent on a wide range of variables. Invertebrate members of the plankton that have a gas-filled flotation aid, may be more receptive to the sounds produced by seismic airgun arrays, and the range of effects may extend further for these species than for other plankton. However, for a large seismic array, a pathological effect out to 10 m from the array is considered a generous value with known effects demonstrated to 5 m only (Kostyuchenko 1971).

McCauley (1994) concludes that when compared with total population sizes or natural mortality rates of planktonic organisms, the relative influence of seismic sound sources on these populations can be considered insignificant. The wash from ships propellers and bow waves can be expected to have a similar, if not greater, volumetric effect on plankton than the sounds generated by airgun arrays.

Due to their importance in commercial fisheries, numerous studies have been undertaken experimentally exposing the eggs and larvae of various ichthyoplankton species to airgun sources (reviewed in McCauley 1994). These are discussed further in Section 4.3.

4.2. Impacts on Marine Invertebrates

Many marine invertebrates have tactile organs or hairs (termed mechanoreceptors), which are sensitive to hydro-acoustic near-field disturbances, and some have highly sophisticated statocysts, which have some resemblance to the ears of fishes (Offutt 1970; Hawkins & Myrberg 1983; Budelmann 1988, 1992; Packard *et al.* 1990; Popper *et al.* 2001) and are thought to be sensitive to the particle acceleration component of a sound wave in the far-field. However, information on hearing by invertebrates, and noise impacts on them is sparse. Although many invertebrates cannot sense the pressure of a sound wave or the lower amplitude component of high frequency sounds, low frequency high amplitude sounds may be detected *via* the mechanoreceptors, particularly in the near-field (<< 20 m) of such sound sources (McCauley 1994). Sensitivity to near-field low-frequency sounds or hydroacoustic disturbances has been recorded for the lobster *Homarus americanus* (Offut 1970), and various other invertebrate species (Horridge 1965, 1966; Horridge & Boulton 1967; Moore & Cobb 1986; Packard *et al.* 1990; Turnpenney & Nedwell 1994).

Despite no quantitative records of invertebrate mortality from seismic sound exposure under field operating conditions, lethal and sub-lethal effects have been observed under experimental conditions where invertebrates were exposed to airguns up to five metres away. These include reduced growth and reproduction rates and behavioural changes in crustaceans (McCauley 1994; McCauley *et al.* 2000; DFO 2004). The effects of seismic survey energy on snow crab (*Chionoecetes opilo*) on the Atlantic coast of Canada, for example ranged from no physiological damage but effects on developing fertilized eggs at 2 m range (Christian *et al.* 2003) to possible bruising of the heptopancreas and ovaries, delayed embryo development, smaller larvae, and indications of greater leg loss but no acute or longer term mortality and no changes in embryo survival or post hatch larval mobility (DFO 2004). The ecological significance of sub-lethal or physiological effects could thus range from trivial to important depending on their nature.

Giant squid strandings coincident with seismic surveys have been reported (Guerra *et al.* 2004). Although animals showed no external damage, all had severe internal injuries (including disintegrated muscles and unrecognisable organs) indicative of having ascended from depth too quickly. The causative link to seismic surveys has, however, not been established with certainty.

Behavioural responses of invertebrates to particle motion of low frequency stimulation has been measured by numerous researchers (reviewed in McCauley 1994). Again a wide range of responses are reported ranging from no avoidance by free ranging invertebrates (crustaceans, echinoderms and molluscs) of reef areas subjected to pneumatic airgun fire (Wardle *et al.*

2001), and no reduction in catch rates of brown shrimp (Webb & Kempf 1998), prawns (Steffe & Murphy 1992, in McCauley, 1994) or rock lobsters (Parry & Gasson 2006) in the near-field during or after seismic surveys.

Cephalopods, in contrast, may be receptive to the far-field sounds of seismic airguns, although responses are unknown. Behavioural response range from attraction at 600 Hz pure tone (Maniwa 1976), through startle responses at received levels of 174 dB re 1 μPa, to increase levels of alarm responses once levels had reached 156 - 161 dB re 1 μPa (McCauley *et al.* 2000). Based on the results of caged experiments, McCauley *et al.* (2000) therefore suggest that squid would significantly alter their behaviour at an estimated 2 - 5 km from an approaching large seismic source.

4.3. Impacts on Fish

Fish hearing has been reviewed by numerous authors including Popper and Fay (1973), Hawkins (1973), Tavolga *et al.* (1981), Lewis (1983), Atema *et al.* (1988), and Fay (1988). Fish have two different systems to detect sounds namely 1) the ear (and the otolith organ of their inner ear) that is sensitive to sound pressure and 2) the lateral line organ that is sensitive to particle motion. Certain species utilise separate inner ear and lateral line mechanisms for detecting sound; each system having its own hearing threshold (Tavolga & Wodinsky 1963), and it has been suggested that fish can shift from particle velocity sensitivity to pressure sensitivity as frequency increases (Cahn *et al.* 1970, in Turl 1993).

In fish, the proximity of the swim-bladder to the inner ear is an important component in the hearing as it acts as the pressure receiver and vibrates in phase with the sound wave. Vibrations of the otoliths, however, result from both the particle velocity component of the sound as well as stimulus from the swim-bladder. The resonant frequency of the swim-bladder is important in the assessment of impacts of sounds as species with swim-bladders of a resonant frequency similar to the sound frequency would be expected to be most susceptible to injury. Although the higher frequency energy of received seismic impulses needs to be taken into consideration, the low frequency sounds of seismic surveys would be most damaging to swim-bladders of larger fish. The lateral line is sensitive to low frequency (between 20 and 500 Hz) stimuli through the particle velocity component of sound.

Most species of fish and elasmobranchs are able to detect sounds from well below 50 Hz (some as low as 10 or 15 Hz) to upward of 500 - 1,000 Hz (Popper & Fay 1999; Popper 2003; Popper *et al.* 2003), and consequently can detect sounds within the frequency range of most widely occurring anthropogenic noises. Within the frequency range of 100 - 1,000 Hz at which most fish hear best, hearing thresholds vary considerably (50 and 110 dB re 1 μPa). They are able to discriminate between sounds, determine the direction of a sound, and detect biologically relevant sounds in the presence of noise. In addition, some clupeid fish can detect ultrasonic sounds to over 200 kHz (Popper & Fay 1999; Mann *et al.* 2001; Popper *et al.* 2004). Fish that possess a coupling between the ear and swim-bladder have probably the best hearing of fish species (McCauley 1994). Consequently, there is a wide range of susceptibility among fish to seismic sounds, with those with a swim-bladder will be more susceptible to anthropogenic sounds than those without this organ.

Studies have shown that fish can be exposed directly to the sound of seismic survey without lethal effects, outside of a very localised range of pathological effects. Pathological effects of impulsive airgun sounds on fish species include swim-bladder damage (Falk & Lawrence 1973), transient stunning (Hastings 1990, in Turnpenney & Nedwell 1994), short-term biochemical variations in different tissues typical of primary and secondary stress response (Santulli *et al.* 1999; Smith *et al.* 2004), and temporary hearing loss due to destruction of the hair cells in the hearing maculae (Enger 1981; Lombarte *et al.* 1993; Hastings *et al.* 1996; McCauley *et al.* 2000; Scholik & Yan 2001, 2002; McCauley *et al.* 2003; Popper *et al.* 2005; Smith *et al.* 2006). Popper (2008) concludes that as the vast majority of fish exposed to seismic sounds will in all likelihood be some distance from the source, where the sound level has attenuated considerably, only a very small number of animals in a large population will ever be directly killed or damaged by sounds from seismic airgun arrays.

Behavioural responses to impulsive sounds are varied and include leaving the area of the noise source (Suzuki *et al.* 1980; Dalen & Rakness 1985; Dalen & Knutsen 1987; Løkkeborg 1991; Skalski *et al.* 1992; Løkkeborg & Soldal 1993; Engås *et al.* 1996; Wardle *et al.* 2001; Engås & Løkkeborg 2002; Hassel *et al.* 2004), changes in depth distribution (Chapman & Hawkins 1969; Dalen 1973; Pearson *et al.* 1992; Slotte *et al.* 2004), spatial changes in schooling behaviour (Slotte *et al.* 2004), and startle response to short range start up or high level sounds (Pearson *et al.* 1992; Wardle *et al.* 2001). In some cases behavioural responses were observed at up to 5 km distance from the firing airgun array (Santulli *et al.* 1999; Hassel *et al.* 2004). Behavioural effects are generally short-term, however, with duration of the effect being less than or equal to the duration of exposure, although these vary between species and individuals, and are dependent on the properties of the received sound. In some cases behaviour patterns returned to normal within minutes of commencement of surveying indicating habituation to the noise. Disturbance of fish is believed to cease at noise levels below 160 dB re 1µPa. The ecological significance of such effects is therefore expected to be low, except in cases where they influence reproductive activity.

Although the effects of airgun noise on spawning behaviour of fish have not been quantified to date, it is predicted that if fish are exposed to powerful external forces on their migration paths or spawning grounds, they may be disturbed or even cease spawning altogether. The deflection from migration paths may be sufficient to disperse spawning aggregations and displace spawning geographically and temporally, thereby affecting recruitment to fish stocks. The magnitude of effect in these cases will depend on the biology of the species and the extent of the dispersion or deflection. Dalen *et al.* (1996), however, recommended that in areas with concentrated spawning or spawning migration seismic shooting be avoided at a distance of ~50 km from these areas.

Indirect effects of seismic shooting on fish include reports of reduced catches resulting from changes in feeding behaviour or vertical distribution, but information on feeding success of fish (or larger predators) in association with seismic survey noise is lacking. For example, Skalski *et al.* (1992) showed a decrease in rockfish (*Sebastes* sp.) catch in areas exposed to an airgun emission at 186-191 dB re 1 µPa, but reported that sounds as low as 160 dB did not elicit declines in catches despite inducing a startle response in the fish.

More recent studies measuring the catch rates of haddock (*Melanogrammus aeglefinus*) and Atlantic cod (*Gadus morhua*) as an indicator of fish behaviour in response to seismic noise, reported that catch rates declined significantly within 30 km of seismic operations, with the effect lasting for up to 5 days after termination of airgun use (Engås *et al.* 1996; Engås & Løkkeborg 2002). Catch rates, however, subsequently returned to normal leading the investigators to conclude that the decline in catch rate resulted from the fish moving away from the fishing site as a result of the airgun sounds. Slotte *et al.* (2004) used fishing sonar to observe the behavior of pelagic shoaling species (blue whiting and Norwegian spring spawning herring), and found that fishes in the vicinity of airguns moved to greater depths (rather than out of the area) after the airgun exposure compared to their vertical position prior to airgun usage. The abundance of fish 30-50 km away from the ensonification increased, suggesting that migrating fish would not enter the zone of seismic activity. Gausland (2003), however, refutes the results of these studies, stating that catch decline was from factors other than exposure to airguns and that the data were not statistically different from normal variation in catch rates over several seasons. McCauley *et al.* (2000), similarly notes that for many fish species behavioural changes or avoidance effects involve little if any risk factor and potential seismic effects on fishes may thus not necessarily translate to population scale effects or disruptions to fisheries. Popper (2008) points out that catch rate studies tell nothing about how fish really react to sound, and concludes that data on behavioural effects of seismic noise on fish polulations is lacking.

The physiological effects of seismic sounds from airgun arrays will mainly affect the younger life stages of fish such as eggs, larvae and fry, many of which form a component of the meroplankton and thus have limited ability to escape from their original areas in the event of various influences. Numerous studies have been undertaken experimentally exposing the eggs and larvae of various fish species to airgun sources (Kostyuchenko 1971; Dalen & Knutsen 1987; Holliday *et al.* 1987; Booman *et al.* 1992; Kosheleva 1992; Popper *et al.* 2005, amongst others). These studies generally identified mortalities and pathological injuries at very close range (<5 m) only. For example, increased mortality rates for fish eggs were proven out to ~5 m distance from the air guns. A mortality rate of 40-50% was recorded for yolk sac larvae (particularly for turbot) at a distance of 2-3 m (Booman *et al.* 1996), although mortality figures for yolk sac larvae of anchovies at the same distances were lower (Holliday *et al.* 1987). Yolk sac larvae of cod experienced significant eye injuries (retinal stratification) at a distance of 1 m from an air gun array (Matishov 1992), and Booman *et al.* (1996) report damage to brain cells and lateral line organs at <2 m distance from an airgun array. Increased mortality rates (10-20%) at later stages (larvae, post-larvae and fry) were proven for several species at distances of 1-2 m. Changes have also been observed in the buoyancy of the organisms, in their ability to avoid predators and effects that affect the general condition of larvae, their growth rate and thus their ability to survive. Temporary disorientation juvenile fry was recorded for some species (McCauley 1994). Fish larvae with swim-bladders may be more receptive to the sounds produced by seismic airgun arrays, and the range of effects may extend further for these species than for others.

From a fish resource perspective, these effects may potentially contribute to a certain diminished net production in fish populations. However, Sætre & Ona (1996) calculated that under the "worst case" scenario, the number of larvae killed during a typical seismic survey was 0.45% of the total larvae population. When more realistic "expected values" were applied to each parameter of the calculation model, the estimated value for killed larvae during one run was equal to 0.03% of the larvae population. If the same larval population was exposed to multiple seismic runs, the effect would add up for each run. For species such as cod, herring and capelin, the natural mortality is estimated at 5-15% per day of the total population for eggs and larvae. This declines to 1-3% per day once the species reach the 0 group stage *i.e.* at approximately 6 months (Sætre & Ona 1996). Consequently, Dalen *et al.* (1996) concluded that seismic-created mortality is so low that it can be considered to have an inconsequential impact on recruitment to the populations.

4.4. Impacts on Seabirds

Among the marine avifauna of South African waters, it is only the diving birds, or birds which rest on the water surface, that may be affected by the underwater noise of seismic surveys. The African penguin (*Spheniscus demersus*), which is flightless and occurs along the South Coast, would be particularly susceptible to impacts from underwater seismic noise. In African penguins the best hearing is in the 600 Hz to 4 kHz range with the upper limit of hearing at 15 kHz and the lower limit at 100 Hz (Wever *et al.* 1969). No critical ratios have, however, been measured. Principal energy of vocalisation of African penguins was found at <2 kHz, although some energy was measured at up to 6 kHz (Wever *et al.* 1969).

The continuous nature of the intermittent seismic survey pulses, however, suggest that birds would hear the sound sources at distances where levels would not induce mortality or injury, and consequently be able to flee an approaching sound source. Consequently, the potential for injury to seabirds from seismic surveys in the open ocean is deemed to be low (see also Stemp 1985, in Turnpenny & Nedwell 1994), particularly given the extensive feeding range of the plunge-diving seabird species.

4.5. Impacts on Turtles

The potential effects of seismic surveys on turtles include:

- Pathological injury (including disorientation) or mortality from seismic noise;
- Behavioural avoidance of seismic survey areas;
- Collision with or entanglement in towed seismic apparatus;
- Masking of environmental sounds and communication;
- Indirect effects due to effects on prey.

Available data on marine turtle hearing is limited, but suggest highest auditory sensitivity at frequencies of 250 - 700 Hz, and some sensitivity to frequencies at least as low as 60 Hz (Ridgway *et al.* 1969; Wever *et al.* 1978, in McCauley 1994; O'Hara & Wilcox, 1990; Moein-Bartol *et al.* 1999). The overlap of this hearing sensitivity with the higher frequencies produced by airguns, suggest that turtles may be considerably affected by seismic noise.

No information on pathological injury to turtle hearing could be sourced in the literature. If subjected to seismic sounds at close range, temporary or permanent hearing impairment may result, but it is unlikely to cause death or life-threatening injury. As with other large mobile marine vertebrates, it is assumed that sea turtles will avoid seismic noise at levels/distances where the noise is a discomfort. Juvenile turtles may be unable to avoid seismic sounds in the open ocean, and consequently may be more susceptible to seismic noise.

Behavioural changes in response to anthropogenic sounds have been reported for some sea turtles. Controlled exposure experiments on captive turtles found an increase in swim speed and erratic behaviour indicative of avoidance, at received airgun sound levels of 166 - 176 dB re 1 µPa (O'Hara & Wilcox 1990; McCauley *et al.* 2000). Sounds of frequency of 250 and 500 Hz resulted in a startle response from a loggerhead turtle (Lenhardt *et al.* 1983, in McCauley 1994), and avoidance by 30 m of operating airguns where the received level would have been in the order of 175 - 176 dB re 1 µPa (O'Hara 1990). McCauley (1994), however, pointed out that these results may have been influenced by echo associated with the shallow environment in which the test was undertaken.

Further trials carried out on caged loggerhead and green turtles include those of Moein *et al.* (1994) and McCauley *et al.* (2000), who investigated responses to airgun impulses by measuring avoidance behaviour, physiological response and electroencephalogram measurements of hearing capability. Results indicated that significant avoidance response occurred at received levels ranging between 172 and 176 dB re 1 µPa at 24 m, and repeated trails several days later suggest either temporary reduction in hearing capability or habituation with repeated exposure. Hearing however returned after two weeks (Moein *et al.* 1994; McCauley *et al.* 2000). McCauley *et al.* (2000) reported that above levels of 166 dB re 1 µPa turtles increased their swimming activity compared to periods when airguns were inactive. Above 175 dB re 1 µPa turtle behaviour became more erratic possibly reflecting an agitated behavioural state at which unrestrained turtles would show avoidance response by fleeing an operating sound source. These would correspond to distances of 2 km and 1 km from a seismic vessel operating in 100 - 120 m of water, respectively.

Observations of marine turtles during a ten-month seismic survey in deep water (1,000-3,000 m) off Angola found that turtle sighting rate during guns-off (0.43 turtles/h) was double that of full-array seismic activity (0.20/h) (Weir 2007). In contrast, Parente *et al.* (2006), working off Brazil found no significant differences in turtle sightings with airgun state. Weir (2007) notes that while her results are suggestive of avoidance of airguns by turtles, they should be treated with caution since a large proportion of the sightings occurred during unusually calm conditions and during peak diurnal abundance of turtles when the airguns were inactive. While there was indication that turtles occurred closer to the source during guns-off than full-array, there was no significant difference in the median distance of turtle sightings from the airguns during full-array or guns-off, suggesting a lack of movement away from active airguns. It is thus possible that during deep water surveys turtles only detect airguns at close range or are not sufficiently mobile to move away from approaching airgun arrays (particularly if basking for metabolic purposes when they may be slow to react) (Weir 2007). This is in marked contrast to previous assessments that assumed that the impact of seismic noise on behaviour of adult turtles in the open ocean environment is of low significance given the mobility of the animals (CSIR 1998; CCA & CMS 2001). In the study by Weir (2007) a confident assessment of turtle behaviour in relation to seismic status was hindered, however, by the apparent reaction of individual animals to the survey vessel and towed equipment rather than specifically to airgun sound. As these reactions occurred at close range (usually <10 m) to approaching objects, they appeared to be based principally on visual detection (Weir 2007).

Although collisions between turtles and vessels are not limited to seismic ships, the large amount of equipment towed astern of survey vessels does increase the potential for collision, or entrapped within seismic equipment and towed surface floats. Basking turtles are particularly slow to react to approaching objects may not be able to move rapidly away from approaching airguns even if motivated to do so (Figure 20). Almost all reported turtle entrapments have been associated with the tail buoy; the large float attached to the end of each seismic cable, which is used to monitor the location of the cable. The tail buoys have a subsurface structure ('undercarriage') consisting of a 'twin-fin' design, which is primarily used for counter-balancing the upper structure to ensure stability in the water. Towing points are located on the leading edge of each side of the undercarriage, and these are attached by chains to a swivel leading to the end of the seismic cable (Ketos Ecology 2009). It is thought that entrapment occurs either as a result of 'startle diving' in front of towed equipment or following foraging on barnacles and other organisms growing along seismic cables and surfacing to breathe immediately in front of the tail buoy (primarily loggerhead and Olive Ridley turtles). In the first case the turtle becomes stuck within the angled gap between the chains and the underside of the buoy, lying on their sides across the top of the chains and underneath the float with their ventral surface facing the oncoming water thereby causing the turtle to be held firmly in position (Figure 21, left). Depending on the size of the turtle, they can also become stuck within the gap below a tail buoy, which extends to 0.8 m below water level and is ~0.6 m wide. The animal would need to be small enough to enter the gap, but too big to pass all the way through the undercarriage. Furthermore, the presence of the propeller in the undercarriage of some buoy-designs prohibits turtles that have entered the undercarriage from travelling out of the trailing end of the buoy (Figure 21, right). Once stuck inside or in front of a tail buoy, the water pressure generated by the 4-5 knot towing speed, would hold the animal against/inside the buoy with little chance of escape due to the angle of its body in relation to the forward movement of the buoy. For a trapped turtle this situation will be fatal, as it will be unable to reach the surface to breathe (Ketos Ecology 2009).

Breeding adults of sea turtles undertake large migrations between their nesting sites and distant foraging areas. Although Lenhardt *et al.* (1983) speculated that turtles may use acoustic cues for navigation during migrations, information on turtle communication is lacking. The effect of seismic noise in masking environmental cues such as surf noise (150-500 Hz), which overlaps the frequencies of optimal hearing in turtles (McCauley 1994), is unknown and speculative.

Figure 20: Basking turtle on a collision path with a seismic buoy off Angola (Ketos Ecology 2009).

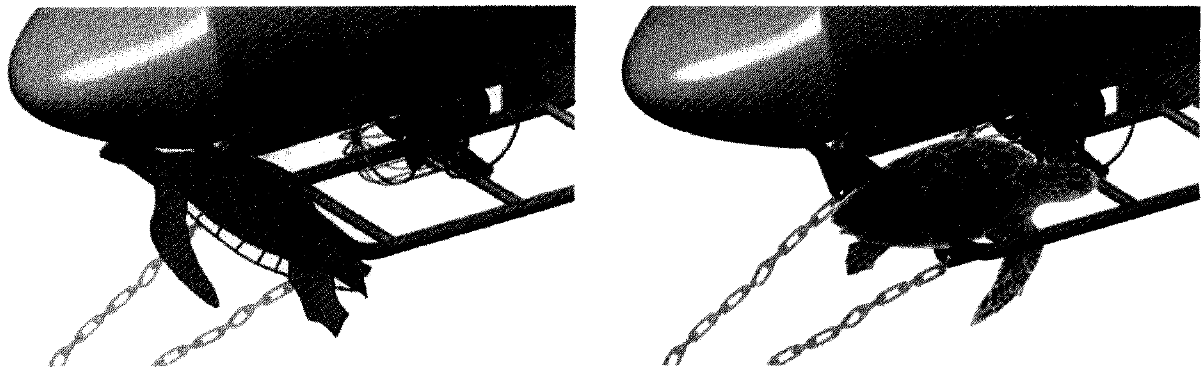

Figure 21: Turtles commonly become trapped in front of the undercarriage of the tail buoy in the area between the buoy and the towing chains (left), and inside the 'twin-fin' undercarriage structure (right) (Ketos Ecology 2009).

4.6. Impacts on Seals

The Cape fur seal forages over the continental shelf to depths of over 200 m and would consequently be expected to occur within the proposed seismic survey area.

Underwater behavioural audiograms have been obtained for two species of Otariidae (sea lions and fur seals), but no audiograms have been measured for Cape fur seals. Extrapolation of these audiograms to below 100 Hz would result in hearing thresholds of approximately 140-150 dB re 1 µPa for the California sea lion and well above 150 dB re 1 µPa for the Northern fur seal. The range of greatest sensitivity in fur seals lies between the frequencies of 2-32 kHz (McCauley 1994). Underwater critical ratios have been measured for two northern fur seals and averaged ranged from 19 dB at 4 kHz to 27 dB at 32 kHz. The audiograms available for otariid pinnipeds suggest they are less sensitive to low frequency sounds (<1 kHz) than to higher frequency sounds (>1 kHz). The range of low frequency sounds (30-100 Hz) typical of seismic airgun arrays thus falls below the range of greatest hearing sensitivity in fur seals. This generalisation should, however, be treated with caution as no critical ratios have been measured for Cape fur seals.

Seals produce underwater sounds over a wide frequency range, including low frequency components. Although no measurement of the underwater sounds have been made for the Cape fur seal, such measurements have been made for a con-generic species *Arctocephalus philippii*, which produced narrow-band underwater calls at 150 Hz. Aerial calls of seals range up to 6 Hz, with the dominant energy in the 2-4 kHz band. However, these calls have strong tonal components below 1 kHz, suggesting some low frequency hearing capability and therefore some susceptibility to disturbance from the higher frequency components of seismic airgun sources (Goold & Fish 1998; Madsen *et al.* 2006).

The potential impact of seismic survey noise on seals could include pathological injury to individuals, behavioural avoidance of individuals (and subsequent displacement from key habitat), masking of important environmental or biological sounds and indirect effects due to effects on predators or prey.

The pathological effects of loud low frequency sounds on seals are not well documented, but include cochlear lesions following rapid rise time explosive blasts (Bohne *et al.* 1985; 1986, in McCauley 1994), temporary threshold shifts (TTS) following exposure to octave-band noise (frequencies ranged from 100 Hz to 2000 Hz, octave-band exposure levels were approximately 60-75 dB, while noise-exposure periods lasted a total of 20-22 min) (Kastak *et al.* 1999), with recovery to baseline threshold levels within 24 h of noise exposure.

Using measured discomfort and injury thresholds for humans, Greenlaw (1987) modelled the pain threshold for seals and sea lions and speculated that this pain threshold was in the region of 185 - 200 dB re 1 μPa. The impact of pathological injury to seals from seismic noise is deemed to be low as it is assumed that highly mobile creatures such as fur seals would avoid severe sound sources at levels below those at which discomfort occurs. However, noise of moderate intensity and duration may be sufficient to induce TTS under water in pinniped species (Kastak *et al.* 1999). Reports of seals swimming within close proximity of firing airguns should thus be interpreted with caution in terms of the impacts on individuals as such individuals may well be experiencing hearing threshold shifts.

Information on the behavioural response of fur seals to seismic exploration noise is lacking (Richardson *et al.* 1995; Gordon *et al.* 2004). Reports of studies conducted with Harbour and Grey seals include initial startle reaction to airgun arrays, and range from partial avoidance of the area close to the vessel (within 150 m) (Harris *et al.* 2001) to fright response (dramatic reduction in heart rate), followed by a clear change in behaviour, with shorter erratic dives, rapid movement away from the noise source and a complete disruption of foraging behaviour (Gordon *et al.* 2004). In most cases, however, individuals quickly reverted back to normal behaviour once the seismic shooting ceased and did not appear to avoid the survey area. Seals seem to show adaptive responses by moving away from airguns and reducing the risk of sustaining hearing damage. Potential for long-term habitat exclusion and foraging disruption over longer periods of exposure (*i.e.* during full-scale surveys conducted over extended periods) is however a concern.

Cape fur seals generally appear to be relatively tolerant to noise pulses from underwater explosives, which are probably more invasive than the slower rise-time seismic sound pulses. There are also reports of Cape fur seals approaching seismic survey operations and individuals biting hydrophone streamers (CSIR 1998). This may be related to their relative insensitivity to sound below 1 kHz and their tendency to swim at or near the surface, exposing them to reduced sound levels. It has also been suggested that this attraction is a learned response to towed fishing gear being an available food supply.

4.7. Impacts on Whales and Dolphins

The cetaceans comprise baleen whales (mysticetes) and toothed whales and dolphins (odontocetes). Whilst the majority of baleen whales are migratory, the majority of dolphins and small toothed whales are resident.

Cetacean hearing has received considerable attention in the international literature, and available information has been reviewed by several authors including Popper (1980), Fobes & Smock (1981), Schusterman (1981), Ridgway (1983), Watkins & Wartzok (1985), Johnson (1986), Moore & Schusterman (1987) and Au (1993). Reactions of cetaceans to anthropogenic sounds have been reviewed by McCauley (1994), Richardson *et al.* (1995), Gordon & Moscrop (1996) and Perry (1998). More recently reviews have focussed specifically on the effects of sounds from seismic surveys on marine mammals (DFO 2004; NRC 2005; Nowacek *et al.* 2007; Southall *et al.* 2007; Abgrall *et al.* 2008, amongst others).

Available information shows that marine mammals as a group have wide variations in ear anatomy, frequency range and amplitude sensitivity. Considerable differences also exist between the hearing sensitivities of baleen and toothed whales and dolphins. For most species the best frequency sensitivity corresponds closely to the frequencies at which they vocalise. Baleen whales appear to vocalise at low frequencies producing a rich and complex range of underwater sounds ranging from about 12 Hz to 8 kHz. In contrast, small odontocetes vocalise at far higher frequencies producing a wide range of whistles, clicks, pulsed sounds and echolocation clicks. The frequency range of toothed whale sounds excluding echo location clicks are mostly <20 kHz with most of the energy typically around 10 kHz, although some calls may be as low as 100 to 900 Hz. Consequently, baleen whale hearing is centred at below 1 kHz (Fleischer 1976, 1978; Norris & Leatherwood 1981), while toothed whale and dolphin hearing is centred at frequencies of between 10 and 100 kHz (Richardson *et al.*1995).

The factors that affect the response of marine mammals to sounds in their environment include the sound level and other properties of the sound, the physical and behavioural state of the animal and its prevailing acoustic characteristics, and the ecological features of the environment in which the animal encounters the sound. The responses of cetaceans to noise sources are often also dependent on the perceived motion of the sound source, as well as the nature of the sound itself. For example, many whales are more likely to tolerate a stationary source than they are one that is approaching them (Watkins 1986; Leung-Ng & Leung 2003), or are more likely to respond to a stimulus with a sudden onset than to one that is continuously present (Malme *et al.* 1985).

Behavioural and electrophysical audiograms are available for several species of toothed whales (killer whale: Hall & Johnson 1972; Bain *et al.* 1993, false killer whale: Thomas *et al.* 1988, bottlenose dolphins: Johnson 1967, beluga: White *et al.* 1978; Awbrey *et al.* 1988, Harbour porpoise: Andersen 1970, Chinese river dolphin and Amazon river dolphin: Jacobs & Hall 1972; Risso's dolphin: Nachtigall *et al.* 1995, 1996, a sperm whale calf: Carder & Ridgway 1990). The high hearing thresholds at low frequency for those species tested implies that the low frequency component of seismic shots (10 - 300 Hz) will not be audible to the whales at any great distance. However, the higher frequency of an airgun array shot may be audible from tens of kilometres away, due to the very low sensitivity thresholds of many toothed whales at frequencies exceeding 1 kHz. Although the match is poor, overlap nonetheless exists between the frequency spectra of seismic shots and the hearing threshold curve with frequency for some toothed whale species, suggesting that these may react to seismic shots at long ranges, but that hearing damage from seismic shots is only likely to occur at close range. They will thus not be affected as severely as many fish, and possibly sea turtles and baleen whales that have their greatest hearing sensitivity at low frequencies (McCauley 1994).

Behavioural or electrophysical audiograms have not been measured for the larger toothed whales or for baleen whales. A partial response "audiogram" exists for the gray whale based on the avoidance of migrating whales to a pure tone source (Dahlheim & Ljungblad 1990). Frankel *et al.* (1995, in Perry 1998) found humpback whales in the wild to detect sounds ranging from 10 Hz to 10 kHz at levels of 102 to 106 dB re 1 μPa. Based on the low frequency calls produced by larger toothed whales, and anatomical and paleaontological evidence for baleen whales, it is predicted that these whales hear best in the low frequencies (Fleischer 1976, 1978; McCauley 1994). The larger toothed whales and baleen whales will thus be very receptive to the sound produced by seismic airgun arrays.

The potential impact of seismic survey noise on cetaceans could include pathological injury to individuals, behavioural avoidance (and subsequent displacement from key habitat), masking of important environmental or biological sounds or effects due to indirect effects on prey.

Exposure to high sound levels can result in pathological injury to cetaceans through a number of avenues, including shifts of hearing thresholds (as either permanent (PTS) or temporary threshold shifts (TTS)) (Richardson *et al.* 1995; Au *et al.* 1999; Schlundt *et al.* 2000; Finneran *et al.* 2000), tissue damage (Lien *et al.* 1993; Ketten *et al.* 1993), acoustically induced decompression sickness particularly in beaked whales (Crum & Mao 1996; Cox *et al.* 2006), and non-auditory physiological effects including elevated blood pressures, increased heart and respiration rates, and temporary increases in blood catecholamines and glucocorticoids (Bowles & Thompson 1996), which may have secondary impacts on reproduction. Most studies conducted on pathological injuries in cetaceans, however, investigated the effects of explosive pulses (Bohne *et al.* 1985, 1986; Lien *et al.* 1993; Ketten *et al.* 1993) and mid-frequency sonar pulses (Simmonds & Lopez-Jurado 1991; Crum & Mao 1996; Frantzis 1998; Balcomb & Claridge 2001; Evans & England 2001; Jepson *et al.* 2003; Cox *et al.* 2006), and the results are thus not applicable to non-explosive seismic sources such as those from airgun arrays.

There are no data on received levels that would induce permanent threshold shifts (PTS) in cetaceans, although Richardson *et al.* (1995) speculated that very prolonged exposure to noise levels of about 120 dB re 1µPa may induce PTS in beluga whales, but that other marine mammals would require much higher levels than these. Gradual PTS in marine mammals is highly unlikely to occur from seismic surveys. However, permanent hearing damage does not always develop gradually, but may result from brief exposure to high sound levels.

Experiments to induce threshold shifts have only recently been conducted on captive marine mammals (Au *et al.* 1999; Schlundt *et al.* 2000, Finneran *et al.* 2000). Temporary threshold shifts (TTS) became evident at received levels of 194 - 201 dB re 1 µPa at 3 kHz, 193-196 dB at 20 kHz and 192-194 dB at 75 kHz in a bottlenose dolphin exposed to 1-second pulses underwater. However, the relatively long 1-second pulse that elicited the TTS response supplies considerably more energy to the water column than a very much shorter seismic pulse. Finneran *et al.* (2003) found a 226 dB re 1 µPa (peak) was required to create TTS in a beluga, and no TTS was observed in a dolphin at up to 230 dB (peak) using a water gun.

Richardson *et al.* (1995) speculated that the Damage Risk Criteria (DRC) (*i.e.* the tolerable limits for noise exposure) for a marine mammal exposed to 100 seismic pulses might be in the order of 178 - 208 dB re 1µPa. They note, however, that as the duration of peak pressure is less than 200 ms, hearing damage is unlikely unless peak to peak pressure is several dB above these.

Typical behavioural response in cetaceans to seismic airgun noise include initial startle responses (Malme *et al.* 1985; Ljungblad *et al.* 1988; McCauley *et al.* 2000), changes in surfacing behaviour (Ljungblad *et al.* 1988; Richardson *et al.* 1985a; McCauley *et al.* 1996, 2000), shorter dives (Ljungblad *et al.* 1988), changes in respiration rate (Ljungblad *et al.* 1988; Richardson *et al.* 1985, 1986; Malme *et al.* 1983, 1985,1986), slowing of travel (Malme *et al.* 1983, 1984), and changes in vocalisations (McDonald *et al.* 1993, 1995). These subtle changes in behavioural measures are often the only observable reaction of whales to reception of anthropogenic stimuli, and there is no evidence that these changes are biologically significant for the animals (see for example McCauley 1994). Possible exceptions are impacts at individual (through reproductive success) and population level through disruption of feeding within preferred areas (as reported by Weller *et al.* (2002) for Western gray whales). For continuous noise, whales begin to avoid sounds at exposure levels of 110 dB, and more than 80% of species observed show avoidance to sounds of 130 dB. For seismic noise, most whales show avoidance behaviour above 160 dB (Malme *et al.* 1983, 1984; Ljungblad *et al.* 1988; Pidcock *et al.* 2003). Behavioural responses are often evident beyond 5 km from the sound source (Ljungblad *et al.* 1988; Richardson *et al.* 1986, 1995), with the most marked avoidance response recorded by Kolski and Johnson (1987) who reported bowhead whales swimming rapidly away from an approaching seismic vessel at a 24 km distance.

In an analysis of marine mammals sightings recorded from seismic survey vessels in United Kingdom waters Stone (2003) reported that responses to large gun seismic activity varied between species, with small odontocetes showing the strongest avoidance response. Responses of large odontocetes (killer whales, pilot whales and sperm whales) were less marked, with sperm whales showing no observable avoidance effects (see also Rankin & Evans 1998; Davis *et al.* 2000; Madsen *et al.* 2006). Baleen whales showed fewer responses to seismic survey activity than small odontocetes, and although there were no effects observed for individual baleen whale species, fin and sei whales were less likely to remain submerged during firing activity. All baleen whales combined showed changes in behavioural responses further from the survey vessel (see also Ljungblad *et al.* 1988; McCauley 2000; Abgrall *et al.* 2008), and both orientated away from the vessel and altered course more often during shooting activity. The author suggests that different species adopt different strategies in response to seismic survey disturbance, with faster smaller odontocetes fleeing the survey area (e.g. Weir 2008), while larger slower moving baleen whales orientate away from and move slowly from the firing guns, possibly remaining on the surface as they do so (see also Richardson *et al.* 1985a, 1985b, 1986, 1995). Responses to small airguns were less, and although no difference in distance to firing and non-firing small airguns were recorded, there were fewer sightings of small odontocetes in association with firing airguns. Other reports suggest that there is little effect of seismic surveys on small odontocetes such as dolphins, as these have been reported swimming near operating seismic vessels (Duncan 1985; Evans & Nice 1996; Abgrall *et al.* 2008; but see also Schlundt *et al.* 2000).

McCauley *et al.* (1996, 2000) found no obvious evidence that humpback whales were displaced by 2D and 3D seismic surveys and no apparent gross changes in the whale's migratory path could be linked to the seismic survey. Localised avoidance of the survey vessel during airgun operation was however noted. Whales which are not migrating but using the area as a calving or nursery ground may be more seriously affected through disturbance of suckling or resting. Potential avoidance ranges of 7-12 km by nursing animals have been suggested, although these might differ in different sound propagation conditions (McCauley *et al.* 2000). Disturbance of mating behaviour (which could involve a high degree of acoustic selection) by seismic noise could be of consequence to breeding animals.

Potential interference of seismic emissions with acoustic communication in cetaceans includes direct masking of the communication signal, temporary or permanent reduction in the hearing capability of the animal through exposure to high sound levels or limited communication due to behavioural changes in response to the seismic sound source.

Baleen whales generally appear to vocalise almost exclusively within the frequency range of the maximum energy of seismic sounds, while toothed whales vocalise at much higher frequencies, and it is likely that clicks are not masked by seismic survey noise (Goold & Fish 1998). Goold & Fish (1998) indicate that the largest impacts of seismic noise on common dolphins would include masking of communication sounds produced at 10 m or less within 1 km of the sound.

The majority of baleen whales will undertake little feeding within breeding ground waters and rely on blubber reserves during their migrations. Although the fish and cephalopod prey of toothed whales and dolphins may be affected by seismic surveys, impacts will be highly localised and small in relation to the feeding ranges of cetacean species.

5. IMPACTS OF CONTROLLED SOURCE ELECTROMAGNETIC SURVEYS ON MARINE FAUNA

The descriptions below on electromagnetism and its potential effects on marine organisms are largely gleaned and summarised from the comprehensive reviews by Johnsson & Ramstad (2004) and Buchanan *et al.* (2006).

5.1. Electromagnetism and Electrical Induction

Anything that carries or produces electricity generates an electromagnetic field (EMF). EMFs comprise an electric field component that arises from differences in potential among electric charges (*i.e.* electromotive force) and a magnetic field component that arises from the motion of electric charges (*i.e.* current). The coexisting electric and magnetic fields each consist of waves that travel together in space at the speed of light. The electromagnetic wave is characterized by a frequency (measured in hertz Hz; 1 Hz = 1 cycle per second) and a wavelength (distance traveled in one cycle).

Electric fields (E) are measured in volts per metre (E = V/m). Magnetic fields (H) are measured as amperes per metre (H = A/m) but are typically expressed in terms of magnetic flux or field density as tesla (T). All of the magnetic information provided in this report is in units of nanno teslas (nT).

Electromagnetic waves consist of energy particles (quanta) and quanta of higher frequency waves carry more energy than lower frequency waves. At the high-frequency end of the electromagnetic spectrum, gamma rays contain so much energy per quantum that they are classified as *ionizing radiation* as they can break down molecular bonds. At the low end of the spectrum, the long wavelength radio and microwave frequencies carry insufficient energy to break molecular bonds and are classified as *non-ionizing radiation*. Frequency fields less than 300 Hz (e.g. most household appliances) are defined as *extremely low frequency*. **CSEM is classified as *ultra low frequency*** (1 Hz), with low electric field strengths (<30 mV/m) and low magnetic field strengths (<2 A/m or 2,500 nT).

The marine environment is by no means devoid of electric and magnetic fields. The Earth's geomagnetic field is ever-present, with typical magnetic flux densities from 30,000 nT at the equator to 60,000 nT at the magnetic poles. An electrical current is generated (induced) in any conductor moving through a magnetic field (as per Faraday's Law). The geomagnetic field may thus also produce weak electric fields when, for example, an ocean current moves at right angles to it. Furthermore, all marine animals are electrical conductors as they continually generate internal voltage gradients and electrical currents as part of normal functions, sensory and motor mechanisms, reproductive processes, and membrane integrity. In fact, many marine animals have evolved the capacity to perceive and utilise EMFs to detect prey or navigate during migrations. EMFs of sufficient strength, however, have the ability to induce micro-currents within an organism, possibly disrupting their normal electrical functions. It must be noted though that an induced biological effect does not necessarily imply a detrimental effect on the organism.

During CSEM acquisition the horizontal electric dipole source, which is towed slowly 30 - 50 m above the seabed, transmits a repetitive electromagnetic signal at a frequency of 0.05 to 10 Hz upwards into the overlying water column and downwards into the underlying sediments. Induction of micro-currents in marine organisms could thus be associated with either the electrical or magnetic component of the CSEM wave. The electromagnetic energy in the CSEM wave is, however, rapidly attenuated in seawater and seafloor sediments, so that within a few metres of the source the Earth's magnetic field is already stronger than the CSEM generated field. Animals with the capacity to detect and use constant geomagnetic fields are thus likely to only detect the signal within close proximity to the source (within 100 m). Nonetheless, potential behavioural or physiological impacts on them as a result of CSEM surveys need to be considered.

There is a large volume of existing literature (more than 25,000 publications over the last thirty years—WHO 2005) concerning the potential biological effects of non-ionizing radiation. Studies, however, have focused almost exclusively on human health issues, concluding that exposure to low frequency, low intensity electrical or magnetic fields has minimal health risk. The human health guidelines for the general public (100,000 nT at 50 Hz for magnetic fields and 5,000 V/m for electrical fields) (WHO 2005) are well above the levels generated during CSEM surveys. Low frequency CSEM covering a small area over a short period of time is thus unlikely to have any discernible health effects on marine biota. Direct health effects are therefore not considered further here. Potential concerns do, however, exist as regards animals that may use geomagnetism to assist navigation or electro-reception to assist in finding food. These aspects are discussed in the following sections.

5.2. Magnetoreception in Marine Animals

There are three potential mechanisms for magnetoreception (*i.e.* ability to detect a magnetic field to perceive direction, altitude or locaton) by animals: (1) magnetized particles, (2) electroreception, and (3) photopigments (Wiltschko & Wiltschko 1995a; Ritz *et al.* 2000; Walker *et al.* 2003). The latter is known only from passerine birds and a species of swimming newt and will not be dealt with further here. Navigation through the use of geomagnetism is also discussed.

5.2.1 Magnetic Particles

The classical example of marine organisms that use the geomagnetic field for orientation is magnetotactic bacteria (Blackmore 1975). Magnetotactic bacteria contain linear arrays of single-domain magnetite (Fe_3O_4) crystals that function as miniature compass needles, thereby forcing them to align with the ambient magnetic field when moving freely. The magnetic inclination in the northern and southern hemispheres enables these organisms to rely on the Earth's magnetic field in returning to the seabed sediments where the environment is more favourable for them. Magnetized magnetite crystals have also been found in some species of insects, chitons, crustaceans, amphibians, reptiles, fish, birds and mammals, including humans; many have the ability to precipitate ferromagnetic magnetite (Kirschvink & Gould 1981; Frankel *et al.* 1979; Walcott *et al.* 1979; Kirschvink *et al.* 1985, 1992; Mann *et al.* 1988). It is unknown how the presence of magnetite influences the behaviour of large animals but presumably the mechanism acts at the neural cell level. Buchanan *et al.* (2006) list the species found to contain magnetic material, of which the Green Turtle, Yellowfin Tuna, and Humpback whale potentially occur in the Block 5/6 area. Other marine species listed include a chiton, various crustaceans (barnacle, shrimp and spiny lobster), numerous bony and cartilaginous fish species and a dolphin. None of these occur off the South-West Coast but related species that may similarly contain ferromagnetic magnetite do, and these may therefore potentially be affected by the CSEM surveys.

5.2.2 Electroreception

Electroreception occurs primarily in cartilaginous (Chondrichthyes) and bony (Osteichthyes) fishes, and refers to species that can detect weak electric fields for use in prey location, communication, and possibly navigation. The bony fishes in which electroreception is present include a number of freshwater species (Collin & Whitehead 2004), and will thus not be discussed further here. The principal group of electroreceptive marine fishes of interest for this report are the Chondrichthyes: sharks, skates, rays, and chimaeras (see review in von der Emde 1998).

Electroreceptive organs (Ampullae of Lorenzini) are present in all elasmobranch (sharks, skates and rays) and holocephalid (chimaera) species. Ampullae are found scattered over the head in sharks and chimaeras, and the head and pectoral fins in skates and rays. The ampullae are capable of detecting weak electric currents in seawater (Murray 1960, 1962), being most sensitive in the very low frequency range between 0.125 to 8 Hz (von der Emde 1998; Bleckman & Hofmann 1999; Kalmijn 2000; Bodznick *et al.* 2003). The clustering of ampullae over the surface of the body results in unequal simulation relative to weak electric fields proximal to the fish and enables it to determine the intensity, spatial configuration and direction of the low-frequency electrical source (von der Emde 1998; Tricus 2001).

Swimming sharks and rays exhibited avoidance responses when subjected to voltage gradients of 1-10 μV/cm (Kalmijn 1966). Sedate sharks and rays visibly responded to a wave field of 5 Hz with a voltage gradient of 0.1 μV/cm. Changes in the heart rate of a ray were detected down to a voltage gradient of 0.01 μV/cm. The dogfish (*Mustelus canis*) and stingray (*Urolophus halleri*) showed behavioral responses to gradients as low as 5 nV/cm (Kalmijn 1982). It has also been demonstrated that the electrosensory organs are used to detect prey, even when this is buried in the seabed sediments. In laboratory experiments bottom cruising sharks (*Scyliorhinus canicula*) and rays (*Raja clavata*) elicited sharp and sudden attack behavior when they came within 15 cm of a prey item buried in the sand (Kalmijn 1971, 1978, 2000; see also Meyer *et al.* 2004). Similarly, *in situ* experiments using dipole DC electric fields designed to mimic those given off by prey, elicited feeding responses in dogfish (*M. canis*) at distances of between 15 and 30 cm, at voltage gradients of ≤0.033 μV/cm to ≤1.9 nV/cm, respectively (Kalmijn 1982). In open-water (40 m depth) studies of the blue shark (*Prionace glauca*), the sharks repeatedly struck at DC dipole electric fields similar in strength to those used in the dogfish trials. There are also isolated reports of electroreceptive capabilities in Chimaera (Fields *et al.* 1993).

Skates are thought to be particularly sensitive to voltage gradients. Electric organs are universally present in all 234 species of the Rajidae (Jacob *et al.* 1994), and in several species are used for communication (Bratton & Ayers 1987). Electrocyte morphology and size of electric organ, as well as discharge varies among different species and genera of skates and may be species specific (Brock *et al.* 1953; Bratton & Ayers 1987; Jacob *et al.* 1994).

Despite the sensitivity of ampullae of Lorenzini, the electro-detection capability of elasmobranchs is limited in effective range, with detection decreasing rapidly with distance out to maximum ranges of 30 to 50 cm (Kalmijn 1971, 1982). In general, elasmobranchs need to be within one metre of their prey to detect it (Montgomery & Penkhurst 1997). Just as the electromagnetic signal from a CSEM source is rapidly attenuated, so the voltage gradients of the bioelectric fields generated by marine animals fall off rapidly with distance (Kalmijn 1971).

It has been postulated that electrosensitivity may be a function of the depth at which the species live. Raschi (1986) found that the number and size of ampullae in a species of skate occurring at a depth range of between 63 and 2,058 m, increased significantly with depth, suggesting increasing reliance on electroreception in species inhabiting deep regions of the ocean (Raschi & Adams 1988).

5.2.3 Navigation

To use geomagnetism to navigate, an animal must have the ability to detect some parameter of the Earth's magnetic field (e.g. total field intensity, polarity, inclination angle). The presence of both an inclination compass and a polarity compass has been identified in birds (Wiltschko & Wiltschko 1995). The inclination compass detects and interprets the inclination angle of the earth's magnetic field to determine "toward the pole" versus "toward the equator" and the polarity compass distinguishes between north and south by the polarity vector. Detection of changes in field intensity has been shown in juvenile Loggerhead turtles can distinguish (Lohmann & Lohmann 1996b).

Two navigational models been internationally researched:

- The main hypothesis in long distance sea turtle navigation is the use of a **bi-coordinate geomagnetic navigation system**, in which the animal can detect at least two distinct parameters of the Earth's geomagnetic field; these parameters vary relative to each other across the Earth's surface allowing a grid to be formed.
- Some cetaceans and sharks are thought to use the **topotaxis system**, through the ability to navigate the highs and lows of the local geomagnetic landscape.

Buchanan *et al.* (2006) list the species shown to use magnetic compass orientation, of which Leatherback and Loggerhead turtle hatchlings and Yellowfin tuna potentially occur in the Block 5/6 area. Other marine species listed include a nudibranch, various crustaceans (talitrid amphipods, isopods and spiny lobster), and numerous bony fish species. None of these occur off the South-West Coast but related species that may similarly have the ability to use either an inclination, polarity, or field intensity magnetic compass do occur there, and these may therefore potentially be affected by the CSEM surveys.

5.3. Magnetic Orientation in Marine Animals

5.3.1 Marine Invertebrates

The western Atlantic spiny lobster (*Panulirus argus*), which undertakes mass migrations in which thousands of lobsters walk across the seafloor in head-to-tail procession, has been the subject of several magnetic orientation studies. In both laboratory and field studies, lobsters were found to orientate to the polarity of the Earth's field or to an induced magnetic field (Lohmann 1985; Lohmann *et al.* 1995). In various capture and release experiments with juvenile lobsters in Florida Bay, Boyles and Lohmann (2003) found that displaced and released animals significantly orientated in the direction of their capture site using geomagnetic cues.

The only other marine invertebrate that has been investigated is the marine nudibranch *Tritonia diomedea*. Lohmann and Willows (1987) observed the body angle alignment of *Tritonia* under two geomagnetic fields: the Earth's normal field, and a field in which the horizontal component of the Earth's field was neutralized. In the Earth's field, the orientation of the animals was approximately east, being mediated by magnetic field detection, whereas animals in the canceled field orientated randomly. Preferred magnetic direction also shifted with the day of the lunar month.

5.3.2 Fishes

Most species of salmon travel great distances from their natal streams to oceanic feeding grounds. Biological magnetite has been found in numerous salmon species (Chinook, Sockeye, Chum and Atlantic), and some (Pacific, Atlantic, Chinook, Sockeye) have been reported to orientate magnetically (Kirschvink *et al.* 1985; Walker *et al.* 1988; Moore *et al.* 1990), although magnetic information can be over-ridden by other clues such as light, currents and olfactory ones (Quinn 1980; Brannon *et al.* 1981; Quinn *et al.* 1981; Quinn & Brannon 1982; Quinn & Groot 1983; Taylor 1987). In their review, Doving and Stabell (2003), however, question the ability of fish to form and "memorise" a geomagnetic map of the Earth's field that is "noisy" with short- and long-term variability, geological anomalies, and magnetic storms (±200 nT).

Magnetite and hematite deposition has also been reported in the skulls, vertebral columns, and pelvic girdles of the European eel (Hanson *et al.* 1984a,b), and elvers were reported to show directional preferences that disappeared when the magnetic field was neutralized (Branover 1970; Ovchinnikov *et al.* 1973). Studies on America eels, however, have failed to show any particular sensitivity to magnetic fields or any magnetic compass abilities, although magnetosensitivity has been shown in the "glass eel" stage of the related Pacific species, with a similar migratory lifestyle (Nishi & Kawamura 2005).

The electroreceptive system of elasmobranchs is thought to either allow them to sense voltage gradients generated by currents flowing through the Earth's magnetic field ("passive" model), or to sense the voltage gradients produced within their bodies when swimming through the magnetic field ("active" model). The elasmobranch electrosensory system could therefore theoretically provide it with a 360° navigational ability (Paulin 1995; Kalmijn 2000, 2003; Montgomery & Walker 2001). Some species have been shown to detect magnetic fields and to use that information to locate prey (Kamijin 1978; Meyer *et al.* 2004).

In an acoustic telemetry study Carey and Scharold (1990) tracked 22 blue sharks over the shelf and slope between George's Bank and Cape Hatteras. The sharks maintained constant headings in deep water day and night thus ruling out celestial clues, and complex mixing of different water masses in the study area also ruled out chemical clues. The sharks' tracks were not altered by geomagnetic anomalies which ruled out topotaxis. It was therefore concluded that the sharks were navigating using a polarity or inclination compass. Klimley (1993) in contrast suggested evidence of topotaxis in hammerhead sharks in the Gulf of California.

While the electroreceptive sensitivity of sharks, skates, and rays is well established, and some studies have shown that these fishes can detect the Earth's geomagnetic field, empirical evidence that elasmobranchs use geotaxis to navigate is still lacking.

5.3.3 Sea Turtles

There is strong evidence that turtle hatchings (at least loggerhead and leatherback sea turtles) (Lohmann & Lohmann 1994; 1996a, b) and loggerhead juveniles (Avins & Lohmann 2003) use geomagnetic orientation to navigate long distances. Experimental results suggest that young turtles can respond to three parameters of the earth's magnetic field: angle, polarity and intensity. This enables them to use a bi-coordinate system, which either acts alone or in synergy with other clues such as light, temperature, current, or chemical gradients (Lohmann & Lohmann 1994; Avins & Lohmann 2003, 2004).

In contrast, there is little evidence that adult sea turtles use geomagnetic navigation. Adult Loggerheads and Green turtles are known to travel large trans-oceanic distances. Satellite tracking has revealed relatively straight-line travel in these species (Papi *et al.* 1995, 2000; Nichols *et al.* 2000) but their navigation mechanism is unknown. Celestial navigation appears unlikely because their in-air eyesight is poor. Green turtles have been observed *via* satellite tagging to exhibit behaviour characteristic of a search pattern for chemical clues (Luschi *et al.* 2001; Akesson *et al.* 2003).

5.3.4 Cetaceans (Whales and Dolphins)

It has been theorized that cetaceans use geomagnetic information for orientation. Magnetized material has been found in Pacific dolphins (Zoegler *et al.* 1981) and Humpback whales (Fuller *et al.* 1985). Information from stranding studies in the UK and USA suggest that live strandings typically involved oceanic species that stranded in areas where geomagnetic contour lines ran perpendicular to shore (Klinowska 1985), and generally occurred 1-2 days after major geomagnetic storms (Klinowska 1986; Cornwell-Husten 1986; Kirschvink *et al.* 1986; Kirschvink 1990; Walker *et al.* 1992). In contrast, studies on New Zealand cetacean strandings showed no relationship to regions where geomagnetic contours were perpendicular to the coastline or to geomagnetic maxima or minima (Brabyn & Frew 1994). The authors note that New Zealand does not have a geomagnetic field of sufficient pattern or intensity to support a cetacean navigation system, whereas the seafloor off the east coast of the US and the UK where the previous studies were undertaken is characterized by strong magnetic lineation. Other potential factors such as the presence of a sick animal in the group, shallow water, sandy bottoms and gradual sloping beaches (Rogan *et al.* 1997; Mazzuca *et al.* 1999), have also been suggested. Hui (1994) reported no associations with magnetic intensity gradients or directional orientation with magnetic patterns in free-ranging common dolphin in the Southern California Bight, but did find an association between dolphin sightings and bottom topography.

5.4. Potential Impacts of CSEM on Marine Animals

Using examples from electric fishing, fish conditioning by electric barrier and high-voltage direct current (HVDC) sea cables, Johnsson & Ramstad (2004) put the potential impacts of CSEM on marine organisms into context. Their review is summarised below. The primary variable for determining the severity of an electric shock is the electric current that passes through the body. This depends not only on the voltage and the resistance of the path it follows through the body, but also on the frequency and waveform of the electric field. As larger fish have a greater head-to-tail voltage drop, they are more likely to sustain injury as a result of the electric shock than smaller individuals of the same species.

A direct current produces the most predictable and consistent behavioural responses in fish, namely either escape from or attraction to the source when it first comes in contact with the electric field gradient (2-8 V/m). Attraction to an electrode (galvanotaxis) is facilitated by stimulation of the sensory nerve body cells that produce the swimming reflex (12-34 V/m). This is followed by immobility due to the relaxation of muscles induced partly by a brain reflex (galvanonarcosis)(34-80 V/m), and subsequently inhibited swimming during which the normal swimming is retarded resulting in the fish swimming weakly on its side towards the anode (80-100 V/m). Immobility and muscular rigidity (tetany) occurs only when the fish is quite close to the electrode (>100 V/m) and results in increased likelihood of stress, injury or instant mortality. Pulsed direct current (typically 30 - 60 Hz pulse repetition) produces similar reactions in fish as those reported for direct current exposure, although responses will depend on the strength of the electric field gradient, as well as the pulse shape, pulse frequency and pulse duration.

The effects on fish of an alternating current (typically 30 - 60 Hz) are similar to those for a direct current, except that the forced swimming stage induces the fish to take up a transverse position to the field (transverse oscillotaxis). Closer to the electrode, the muscles contract further inducing oscillonarcosis. The strong muscular contractions in both oscillotaxis and oscillonarcosis cause irreversible damage and a high mortality rate in fish.

Injuries to fish as a result of electrical shock include skeletal injuries and external burns, although muscle, nerve and tissue damage, physiological and behavioural disturbances, such as stress reactions, reduced swim stamina and reduced fertility can also occur with no visible external signs. This implies that the fish will require a substantial time to regain normal physiological status.

The maximum electric field strength close to the electrodes in CSEM is typically below 100 V/m. The electric field gradients of 2 V/m and 8 V/m known to induce a behavioural response in fish would be found at between ~3.25 m and 1.50 m from the horizontal dipole electrodes, respectively. Galvanotaxis would occur at 1.25 to <1 m, and immobility with relaxed muscels only very close to the electrode.

In long term storage of live fish and fish farming in closed off bays and fjords type of electric barrier has been developed comprising electrodes hanging down into the water about 5 m apart. A high voltage electronic switch discharges current pulses to the neighbour electrode creating an electric field in the sea around and between the electrodes. The current is thus pulsed with a current density of ~2,500 A/m^2, a level certainly associated with responses by fish. Exposure of fish to the electric fields and currents, however, showed that fish reacted without deleterious effects. The magnitude of the currents and current densities used for electric barriers are higher than typically used by CSEM technology.

Monopolar high-voltage direct current sea cables are commonly used for electric power-transfer across sea barriers. The monopolar configuration uses a cathode at one side of the sea barrier and an anode at the other side, with a fixed direction electric current between them. The return-current passes through the seawater and seabed, being rapidly attenuated with increasing distance from the sea electrodes. There are therefore many similarities between such cables and CSEM technology. Measurements taken at the cathode of the Baltic Cable between Sweden and Finland revealed that with an applied current of 1,275 A, the electric field was 1.1 V/m at a distance of 10 cm from the cathode and only 0.07 V/m 1 m from the cathode. The static magnetic flux density measured at a distance of 1 m from a monopolar cable with a current of 1,500 A will be ~300 μT, and at a distance of 5 and 20 m away the magnetic field will only be ~50 and 5 μT, respectively. This implies that in the direct proximity of the cable the magnetic field vector will add to the local geomagnetic field vector, thereby altering the magnetic field gradient. Studies conducted on the orientation of eels in relation to the locally disturbed geomagnetic field produced by these seacables, found that the cable did not obstruct the migration in any significant way.

6. ASSESSMENT OF ACOUSTIC AND ELECTROMAGNETIC IMPACTS ON MARINE FAUNA

6.1. Assessment Procedure

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

Rating	Definition of Rating
***Extent** - defines the physical extent or spatial scale of the impact*	
Local	Extending only as far as the activity, limited to the site and its immediate surroundings
Regional	Limited to the South-Western Cape coast
National	Limited to the coastline of South Africa
International	Extending beyond the borders of South Africa
***Duration** - the time frame over which the impact will be experienced*	
Short-term	0 - 5 years
Medium-term	6 - 15 years
Long-term	Where the impact would cease after the operational life of the activity, either because of natural processes or by human intervention
Permanent	Where mitigation either by natural processes or by human intervention would not occur in such a way or in such time span that the impact can be considered transient
***Intensity** - establishes whether the magnitude of the impact is destructive or benign in relation to the sensitivity of the receiving environment*	
Zero to Very Low	Where the impact affects the environment in such a way that natural functions and processes are not affected.
Low	Where the impact affects the environment in such a way that natural functions and processes continue, albeit in a slightly modified way.
Medium	Where the affected environment is altered, but natural functions and processes continue, albeit in a modified way
High	Where environmental functions and processes are altered to the extent that they temporarily or permanently cease
***Status of the Impact** - describes whether the impact would have a negative, positive or zero effect on the affected environment*	
Positive	The impact benefits the environment
Negative	The impact results in a cost to the environment
Neutral	The impact has no effect
***Probability** - the likelihood of the impact occurring*	
Improbable	Possibility very low either because of design or historic experience
Probable	Distinct possibility
Highly Probable	Most likely
Definite	Impact will occur regardless of preventive measures

Rating	Definition of Rating
***Degree of confidence in predictions** - in terms of basing the assessment on available information and specialist knowledge*	
Low	Less than 35% sure of impact prediction
Medium	Between 35% and 70% sure of impact prediction
High	Greater than 70% sure of impact prediction

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

***Significance** - attempts to evaluate the importance of a particular impact, and in doing so incorporates extent, duration and intensity*	
VERY HIGH	Impacts could be EITHER: 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 enduring in the medium term; OR of high intensity at a national level in the short term; OR of medium intensity at a national level in the medium term; OR of low intensity at a national level in the long term; OR of high intensity at a local level in the long term; OR of medium intensity at a regional level in the long term.
MEDIUM	Impacts could be EITHER: of high intensity at a local level and endure in the medium term; OR of medium intensity at a regional level in the medium term; OR of high intensity at a regional level in the short term; OR of medium intensity at a national level in the short term; OR of medium intensity at a local level in the long term; OR of low intensity at a national level in the medium term; OR of low intensity at a regional level in the long term.
LOW	Impacts could be EITHER of low intensity at a regional level, enduring in the medium term; OR of low intensity at a national level in the short term; OR of high intensity at a local level and endure in the short term; OR of medium intensity at a regional level in the short term; OR of low intensity at a local level in the long term; OR of medium intensity at a local level, enduring in the medium term.
VERY LOW	Impacts could be EITHER of low intensity at a local level and endure in the medium term; OR of low intensity at a regional level and endure in the short term; OR of low to medium intensity at a local level, enduring in the short term.
INSIGNIFICANT	Impacts with: Zero to Very Low intensity with any combination of extent and duration.
UNKNOWN	Where it is not possible to determine the significance of an impact.

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

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

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

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

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

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

Furthermore, the degree to which an impact can be mitigated or enhanced, and reversed is defined as follows:

***Degree to which impact can be mitigated** - indicates the degree to which an impact can be reduced or enhanced*	
None	No change in impact after mitigation.
Very low	Where the significance rating stays the same, but where mitigation will reduce the intensity of the impact.
Low	Where the significance rating drops by one level, after mitigation.
Medium	Where the significance rating drops by two to three levels, after mitigation.
High	Where the significance rating drops by more than three levels, after mitigation.

***Reversibility of an Impact** - refers to the degree to which an impact can be reversed*	
Irreversible	Where the impact is permanent.
Partially reversible	Where the impact can be partially reversed.
Fully reversible	Where the impact can be completely reversed.

6.2. Assessment of Acoustics Impacts

Although indicative lines for the 2D survey are available, PetroSA has not provided details for the array source volume or the target areas for the 3D and CSEM surveys. Similarly, the survey timing and duration have not been finalised. The assessment below is therefore by necessity fairly generic.

6.2.1 Impacts to Plankton

Potential impacts of seismic pulses on plankton and fish eggs and larvae would include mortality or pathological injury in the immediate vicinity of the airgun sound source. Impacts would thus be of high intensity at very close range (<5 m from the airguns) only, and no more significant than the effect of the wash from ships propellers and bow waves. As plankton distribution is naturally temporally and spatially variable and natural mortality rates are high, any impacts would thus be of low to negligible intensity across the survey area and for the duration of the survey (short-term).

The proposed survey area lies within the Cape Columbine and Peninsula upwelling cells, between approximately 32.5°S - 34.5°S. Areas of intense upwelling are characterised by diminished phytoplankton biomass due to high turbulence and deep mixing in the water column. A deficiency of phytoplankton results in poor feeding conditions for micro-, meso- and macrozooplankton and for ichthyoplankton. Phytoplankton, zooplankton and ichthyoplankton abundances in the inshore portions of the survey area are thus expected to be comparatively low. Specific target areas for the proposed seismic survey programme have not been finalised, but the Licence Area overlaps with the spring to early summer spawning areas for a number of commercially important species (see Figure 10), including anchovy, pilchard, round herring and chub mackerel, with spawning of all except chub mackerel extending southeastward onto the Agulhas Bank. The survey area also overlaps within the northward egg and larval drift for anchovy. Ichthyoplankton abundance in the offshore areas of Block 5/6 are thus expected to be seasonally comparatively high.

Dalen *et al.* (1996) recommended that seismic survey activities should avoid areas of concentrated spawning or spawning migration paths by 50 km, particularly areas subjected to repeated, high intensity surveys. Considering the spatial extent of the spawning areas, and the low frequency and short duration of seismic surveys in the area, mitigation through avoidance of concentrated spawning areas is not deemed necessary.

The overall potential impact of seismic noise on plankton and ichthyoplankton is, however, deemed to be of **VERY LOW** significance both with and without mitigation.

Mitigation
No direct mitigation measures for potential impacts on plankton and fish egg and larval stages are feasible or deemed necessary.

Impacts of seismic noise to plankton and ichthyoplankton		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	Medium	Medium

6.2.2 Impacts to Marine Invertebrates

Although some marine invertebrates have mechanoreceptors or statocyst organs that are sensitive to hydroacoustic disturbances, most do not possess hearing organs that perceive sound pressure. Potential impacts of seismic pulses on invertebrates include pathological injury and behavioural avoidance of seismic survey areas. Masking of environmental sounds and indirect impacts due to effects on predators or prey have not been documented and are highly unlikely.

Pathological injury and mortality

There is little published information on the effects of seismic surveys on invertebrate fauna. It has been postulated, however, that shellfish, crustaceans and most other invertebrates can only hear seismic survey sounds at very close range, such as less than 20 m away (McCauley 1994). This implies that only surveys conducted in very shallow water will have any detrimental effects. The eastern boundary of the licence areas lies beyond the 100 m depth contour and therefore well offshore of rock-lobster fishing grounds. The West Coast rock lobster *Jasus lalandii* generally exhibits strong associations with, and a preference for, nearshore creviced reef habitats and kelp beds, and avoids gravel and sand areas (Pulfrich & Penney 2001). Their depth distribution and availability is, however, strongly influenced by environmental conditions (Newman & Pollock 1971; Pollock 1978; Beyers 1979; Pollock & Beyers 1981; Bailey *et al.* 1985; Pollock & Shannon 1987; Tomalin 1993; Pulfrich *et al.* 2006, amongst others). During the summer lobsters typically occur inshore in response to declining bottom oxygen levels in deeper water (Pollock & Shannon 1987). In contrast, in the winter months (or when the water column is well mixed) lobsters migrate offshore and can occur to depths of 130 m when conditions are favourable.

As the survey would be conducted in excess of 100 m depth the received noise at the seabed would be within the far-field range, and outside of distances at which pathological injury of rock lobsters or other benthic invertebrates would be expected. The potential impact of seismic noise on pathological injury or mortality of invertebrates is consequently deemed of low to negligible intensity across the survey area and for the survey duration and is considered to be of **VERY LOW** significance both with and without mitigation. No mitigation measures for potential impacts on marine invertebrates and their larvae are feasible or deemed necessary.

Behavioural avoidance

Similarly, there is little published information on the effects of seismic surveys on the response of invertebrate fauna to seismic impulses. Limited avoidance of airgun sounds may occur in mobile neritic and pelagic invertebrates and is deemed to be of low intensity. Of the marine invertebrates only cephalopods are receptive to the far-field sounds of seismic airgun arrays. Although consistent avoidance has not been reported, behavioural changes have been observed at 2 - 5 km from an approaching large seismic source (McCauley *et al.* 2000). The received noise at the seabed would be within the far-field range, and thus outside of distances at which avoidance of benthic invertebrates would be expected, but potentially within the response range of cephalopods. The potential impact of seismic noise on invertebrate behaviour is consequently deemed of low to negligible intensity across the survey area and for the survey duration and is considered to be of **VERY LOW** significance both with and without mitigation, and no mitigation measures are deemed necessary.

Impacts of seismic noise to marine invertebrates resulting in pathological injury		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	Medium	Medium

Impacts of seismic noise to marine invertebrates resulting in behavioural avoidance		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	Medium	Medium

6.2.3 Impacts to Fish

A review of the available literature suggests that potential impacts of seismic pulses to fish (including sharks) species could include pathological injury and mortality, behavioural avoidance of the seismic survey area, masking of environmental sounds and communication, and indirect impacts due to effects on predators or prey.

Pathological injury and mortality

The greatest risk of pathological injury from seismic sound sources is for species that establish home ranges on shallow-water reefs or congregate in inshore waters to spawn or feed, and those displaying an instinctive alarm response to hide on the seabed or in the reef rather than flee. Large demersal or reef-fish species with swim-bladders are also more susceptible than those without this organ. Such species may suffer pathological injury or severe hearing damage and adverse effects may intensify and last for a considerable time after the termination of the sound source. However, as the proposed survey area will be located well offshore in water depths of beyond 100 m, the received noise by demersal species at the seabed would be within the far-field range, and outside of distances at which pathological injury or avoidance would be expected. Given the high mobility of most pelagic fish that occur offshore of the 100 m isobath, particularly the highly migratory tuna and billfish species likely to be encountered in deeper water, it is assumed that the majority of pelagic species would avoid seismic noise at levels below those where pathological injury or mortality would result. Furthermore, in many of the large pelagic species, the swim-bladders are either underdeveloped or absent, and the risk of pathological injury through damage of this organ is therefore lower. Possible injury or mortality in pelagic species could occur on initiation of a sound source at full pressure in the immediate vicinity of fish, or where reproductive or feeding behaviour override a flight response to seismic survey sounds. The potential pathological impact on pelagic species, would be of high intensity. The potential pathological impact on demersal and nearshore reef species would, however, be insignificant as they would only be affected in the far-field range, if at all. The duration of the impact on the population would be limited to the short-term. The impact is therefore considered to be of **LOW** significance without the implementation of mitigation measures, and of **VERY LOW** significance with mitigation measures.

Behavioural avoidance

Behavioural responses such as avoidance of seismic survey areas and changes in feeding behaviours of some fish to seismic sounds have been documented at received levels of about 160 dB re 1 μPa. The potential impact on fish behaviour could therefore be of high intensity (particularly in the near-field of the airgun array), over the short term, but limited to the survey area. Any observed effects are unlikely to persist for more than a few days after termination of airgun use. Consequently it is considered to be of **LOW** significance both with and without mitigation.

Reproductive success / spawning

Fish populations can be further impacted if behavioural responses result in deflection from migration paths or disturbance of spawning. If fish on their migration paths or spawning grounds are exposed to powerful external forces, they may be disturbed or even cease spawning altogether thereby affecting recruitment to fish stocks. The magnitude of effect in these cases will depend on the biology of the species and the extent of the dispersion or deflection. Studies undertaken experimentally exposing the eggs and larvae of various fish species to airgun sources, however, identified mortalities and pathological injuries at very close range (<5 m) only. Considering the wide range over which the potentially affected species occur, the relatively short duration of the seismic surveys and that the migration routes do not constitute narrow restricted paths, the impact is considered to be of **VERY LOW** significance both with and without mitigation.

Considering the spatial extent of the spawning areas, and the low frequency and short duration of seismic surveys in the area, any indirect effects of mortality to ichthyoplankton (assessed in Section 6.2.1) on recruitment to adult fish populations is also considered to be of **VERY LOW** significance both with and without mitigation.

Masking of environmental sounds and communication

Communication and the use of environmental sounds by fish in the offshore environment off the South-West coast are unknown. Impacts arising from masking of sounds are expected to be of low intensity due to the duty cycle of seismic surveys in relation to the more continuous biological noise. Such impacts would occur across the survey area and for the duration of the survey and are consequently considered of **VERY LOW** significance both with and without mitigation.

Indirect impacts due to effects on predators or prey

The assessment of indirect effects of seismic surveys on fish is limited by the complexity of trophic pathways in the marine environment. The impacts are difficult to determine, and would depend on the diet make-up of the fish species concerned and the effect of seismic surveys on the diet species. Indirect impacts of seismic surveying could include attraction of predatory species such as sharks and tunas to pelagic fish stunned by seismic noise. In such cases where feeding behaviour overrides a flight response to seismic survey sounds, injury or mortality could result if the seismic sound source is initiated at full power in the immediate vicinity of the feeding predators. Little information is available on the feeding success of large migratory species in association with seismic survey noise. Considering the extensive range over which large pelagic fish species feed in relation to the survey area the impact is likely to be of **VERY LOW** significance both with and without mitigation.

Mitigation

Recommendations for mitigation include:

- All initiation of airgun firing be carried out as "soft-starts" of at least 20 minutes duration, allowing fish to move out of the survey area and thus avoid potential pathological injury as a result of seismic noise.
- No survey-related activities are to take place within Marine Protected Areas.

Impacts of seismic noise on fish resulting in pathological injury		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	High	Low to Medium
Significance	Low	Very Low
Status	Negative	Negative
Probability	Probable	Improbable
Confidence	Medium	Medium

Impacts of seismic noise on fish resulting in behavioural avoidance		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	High	Medium
Significance	Low	Low
Status	Negative	Negative
Probability	Probable	Improbable
Confidence	Medium	Medium

Impacts of seismic noise on reproductive success and spawning		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Medium	Low to Medium
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Improbable
Confidence	Medium	Medium

Impacts of seismic noise on fish resulting in masking of sounds		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey.	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Low	Low

Impacts of seismic noise on fish resulting in indirect impacts on food sources		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey.	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Low	Low

6.2.4 Impacts to Seabirds

Among the marine avifauna occurring along the South-West coast, it is only the species that feed by plunge-diving or that rest on the sea surface, which may be affected by underwater seismic noise. Potential impacts of seismic pulses to diving birds could include pathological injury, behavioural avoidance of seismic survey areas and indirect impacts due to effects on prey. The seabird species are all highly mobile and would be expected to flee from approaching seismic noise sources at distances well beyond those that could cause pathological injury, but initiation of a sound source at full power in the immediate vicinity of diving seabirds could result in injury or mortality where feeding behaviour override a flight response to seismic survey sounds. The potential for pathological injury or behavioural avoidance in non-diving seabird species is considered **INSIGNIFICANT** and will not be discussed further here.

Pathological injury

The continuous nature of the intermittent seismic survey pulses suggest that diving birds would hear the sound sources at distances where levels would not induce mortality or injury, and consequently be able to flee an approaching sound source. The potential for pathological impact of seismic noise on diving birds could be of high intensity but would be limited to the survey area and survey duration (short term). Of the plunge diving species that occur along the South-Western Cape coastline, only the Cape Gannet regularly feeds as far offshore as 100 km, the rest foraging in nearshore areas up to 40 km from the coast. The nearest nesting grounds are at Bird Island in Lambert's Bay, Malgas and Marcus Island at Saldanha Bay and Dyer Island at Danger Point (see Figure 19). There is therefore a high probability of encountering gannets in the survey area, particularly during spring and summer when pelagic shoaling species frequent the area during their spawning migrations. African Penguins are known to forage as far as 60 km offshore and juveniles have been reported to travel up the coast regularly. The nearest African Penguin nesting sites are at the Saldanha Bay Islands, Dassen and Robben Islands, Boulders Beach in False Bay, Betty's Bay and Dyer Island (see Figure 19). Should surveys be conducted in the inshore portions of the Licence areas, there is therefore a high probability of survey operation encountering penguins. Depending on the survey location, the potential pathological impact on diving species could thus be of **MEDIUM** (inshore) to **LOW** (offshore) significance without mitigation, and of **LOW** (inshore) to **VERY LOW** (offshore) significance with mitigation.

Behavioural avoidance

African penguins would be expected to hear seismic sounds at considerable distances as they have good hearing at low frequencies (which coincide with seismic shots). Response distances are speculative, however, as no empirical evidence is available. Behavioural avoidance by diving seabirds would be limited to within the long range of the operating airgun over the duration of the survey period. The impact is likely to be of medium to high intensity. Due to the likelihood of encountering gannets and penguins in the survey area, the potential impact on the behaviour of diving seabirds is considered to be of **MEDIUM** (inshore) to **LOW** (offshore) significance without mitigation, and of **LOW** (inshore) to **VERY LOW** (offshore) significance with mitigation.

Indirect impacts due to effects on prey

As with other vertebrates, the assessment of indirect effects of seismic surveys on diving seabirds is limited by the complexity of trophic pathways in the marine environment. The impacts are difficult to determine, and would depend on the diet make-up of the bird species concerned and the effect of seismic surveys on the diet species. No information is available on the feeding success of seabirds in association with seismic survey noise. With few exceptions, most plunge-diving birds forage on small shoaling fish prey species relatively close to the shore and are unlikely to feed extensively in offshore waters that would be targeted during the seismic survey. The broad ranges of potential fish prey species (in relation to potential avoidance patterns of seismic surveys of such prey) and extensive ranges over which most seabirds feed suggest that indirect impacts would be **VERY LOW** with and without mitigation.

Other Potential Impacts

Other potential adverse interactions between seabirds and seismic surveys are (1) stranding of birds on the survey vessel due to being attracted to the vessel lights at night, and (2) oiling through accidental loss of buoyancy liquid or hydraulic fluid from the towed gear. However, while there is some potential for effects on individual seabirds through strandings or oiling, no significant effects on seabird populations are predicted, as the number of animals potentially affected will be small. The impacts are thus assessed as being **INSIGNIFICANT.**

Mitigation

Recommendations for mitigation include:

- All initiation of airgun firing to be carried out as “soft-starts” of at least 20 minutes duration.
- An area of radius of 500 m to be scanned by an independent observer for the presence of diving seabirds prior to the commencement of “soft starts” and that these be delayed until such time as this area is clear of diving seabirds.
- Seabird incidence and behaviour should be recorded by an onboard Independent Observer. Any obvious mortality or injuries to seabirds as a direct result of the survey should result in temporary termination of operations.
- Any attraction of predatory seabirds (by mass disorientation or stunning of fish as a result of seismic survey activities) and incidents of feeding behaviour among the hydrophone streamers should be recorded by an onboard Independent Observer.
- Reduce lighting on board the survey ship to minimum safety levels to minimise stranding of pelagic seabirds on the survey vessel at night. All stranded seabirds must be retrieved and released according to appropriate guidelines.
- No survey-related activities are to take place within Marine Protected Areas.

Impacts of seismic noise on diving seabirds resulting in pathological injury		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	High	Medium
Significance	Medium (Inshore) to Low (Offshore)	Low (Inshore) to Very Low (Offshore)
Status	Negative	Negative
Probability	Highly Probable	Improbable
Confidence	Medium	Medium

Impacts of seismic noise on diving seabirds resulting in behavioural avoidance		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Medium to High	Low
Significance	Medium (Inshore) to Low (Offshore)	Low (Inshore) to Very Low (Offshore)
Status	Negative	Negative
Probability	Probable	Improbable
Confidence	Medium	Medium

Impact: Impacts of seismic noise on seabirds resulting in indirect impacts on food sources		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey.	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Low	Low

Impacts of seismic surveys to seabirds through stranding or oiling		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Medium	Medium

6.2.5 Impacts to Turtles

Although three species of turtles occur along the West and South-West Coasts, it is only the Leatherback turtle which is likely to be encountered in deeper waters. However, abundances are likely to be extremely low comprising occasional visitors. The most likely impacts to turtles from seismic survey operations include pathological injury (including disorientation) or mortality from seismic noise or collision with or entanglement in towed seismic apparatus, behavioural avoidance of seismic survey areas, and indirect effects due to the effects of seismic sounds on prey species.

Pathological injury (including disorientation) or mortality

Although no information could be sourced on pathological injury to turtle hearing as a result of seismic sounds, the overlap of their hearing sensitivity with the higher frequencies produced by airguns, suggest that turtles may be considerably affected by seismic noise. Recent evidence, however, suggests that turtles only detect airguns at close range (<10 m) or are not sufficiently mobile to move away from approaching airgun arrays (particularly if basking). Initiation of a sound source at full power in the immediate vicinity of a swimming or basking turtle would be expected to result in pathological injury. The potential impact could therefore be of high intensity, but remain within the short-term. However, as the abundance of adult turtles along the South-West coast is low, the likelihood of encountering turtles during the proposed survey is thus also expected to be low. The potential pathological impact on turtles is considered to be of **LOW** significance without mitigation, and **VERY LOW** significance with mitigation.

The potential for collision between adult turtles and the seismic vessel, or entanglement of turtles in the towed seismic equipment and surface floats, is highly dependent on the abundance and behaviour of turtles in the survey area at the time of the survey. As the breeding areas for Leatherback turtles occur over 2,000 km to north-west and over 1,000 km to the north-east of the survey area (in Republic of Congo and Gabon, and KwaZulu-Natal, respectively), turtles encountered during the survey are likely to be migrating vagrants and impacts through collision or entanglement would be of low intensity and short-term. The impacts on turtles through collision or entanglement of seismic equipment is thus considered to be of **LOW** significance without mitigation and **VERY LOW** significance with mitigation.

Behavioural avoidance

Behavioural changes by turtles in response to seismic sounds range from apparent lack of movement away from active airgun arrays through to startle response and avoidance by fleeing an operating sound source. The impact of seismic sounds on turtle behaviour is of high intensity, but would persist only for the duration of the survey, and be restricted to the survey area. Given the general extent of turtle migrations relative to the seismic survey target grid, the impact of seismic noise on turtle migrations is deemed to be of **LOW** significance without mitigation and **VERY LOW** with mitigation.

Indirect effects due to the effects of seismic sounds on prey species

Leatherback turtles feed on jellyfish, which are pelagic and therefore have a naturally temporally and spatially variable distribution. Adverse modification of such pelagic food sources would thus be insignificant, and the effects of seismic surveys on the feeding behaviour of turtles is thus expected to be **VERY LOW** both with and without mitigation.

Masking of environmental sounds and communication

Breeding adults of sea turtles undertake large migrations between distant foraging areas and their nesting sites (which on the African West Coast are ~3,000 km north-west of survey area in Republic of Congo and Gabon, and on the East Coast are over 1,000 km to the north-east of the survey area in KwaZulu-Natal). Although it is speculated that turtles may use acoustic cues for navigation during migrations, information on turtle communication is lacking. There is no information available in the literature on the effect of seismic noise in masking environmental cues and communication in turtles, but their low abundance in the survey area would suggest that the potential significance of this impact (should it occur) would be **INSIGNIFICANT**.

Mitigation

A number of mitigation measures are recommended for potential impacts of seismic surveys on turtles:

- All initiation of airgun firing be carried out as "soft-starts" of at least 20 minutes duration.
- An area of radius of 500 m be scanned by an independent observer for the presence of turtles prior to the commencement of "soft starts" and that these be delayed until such time as this area is clear of turtles.
- Daylight observations of the survey region should be carried out by onboard Independent Observers and incidence of turtles and their responses to seismic shooting should be recorded.
- Seismic shooting should be terminated when obvious changes to turtle behaviour is observed from the survey vessel, or animals are observed within the immediate vicinity (within 500 m) of operating airguns and appear to be approaching firing airgun.
- Any obvious mortality or injuries to turtles as a direct result of the survey should result in temporary termination of operations.
- Ensure that 'turtle-friendly' tail buoys are used by the survey contractor or that existing tail buoys are fitted with either exclusion or deflector 'turtle guards'.

Impacts of seismic noise on turtles resulting in pathological injury, or collision and entanglement with towed equipment		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	High	Low
Significance	Low	Very Low
Status	Negative	Negative
Probability	Probable to Highly Probably	Probable
Confidence	Medium	Medium

Impacts of seismic noise on turtles resulting in behavioural avoidance		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey.	Short-term
Intensity	High	Low
Significance	Low	Very Low
Status	Negative	Negative
Probability	Highly Probable	Probable
Confidence	High	High

Impacts of seismic noise on turtles resulting in indirect impacts on food sources		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey.	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Low	Low

Impacts of seismic noise on turtles resulting in masking of sounds		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey.	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Low	Low

6.2.6 Impacts to Seals

Pathological injury or mortality

The pathological effects of loud low frequency sounds on seals have not been well documented. The potential for pathological injury to seals from seismic noise is expected to be low as being highly mobile, fur seals would avoid severe sound sources at levels well below those at which discomfort occurs. Past studies suggest that noise of moderate intensity and duration is sufficient to induce temporary threshold shifts in seals, as individuals did not appear to avoid the survey area. Their tendency to swim at or near the surface will also expose them to reduced sound levels when in close proximity to an operating airgun array. Breeding colonies are located at Paternoster Rocks and Jacobs Reef at Cape Columbine, Robbesteen, Seal Island in False Bay, Geyser Rocks at Dyer Island and at Quoin Point, with non-breeding colonies at Great Paternoster Point at Cape Columbine and Duikerklip at Hout Bay (see Figure 19). The proposed survey area therefore potentially falls within the foraging range of seals from the nearby colonies. The potential impact of pathological injury to seals as a result of seismic noise is therefore deemed to be of medium intensity and would be limited to the survey area, although injury could extend beyond the survey duration. The significance of the impact is **VERY LOW** with and without mitigation.

Behavioural avoidance

Although partial avoidance of operating airguns has been recorded for some seals species, Cape fur seals appear to be relatively tolerant to loud noise pulses and, despite an initial startle reaction, individuals quickly reverted back to normal behaviour. The potential impact of seal behaviour in response to seismic surveys is thus considered to be of low to medium intensity and limited to the survey area and duration. The significance of behavioural avoidance impacts are consequently deemed **VERY LOW**, both with and without mitigation.

Masking of environmental sounds and communication

The use of underwater sounds for environmental interpretation and communication by Cape fur seals is unknown, although masking is likely to be limited by the low duty cycle of seismic pulses (one firing every 10 to 15 seconds). The impacts of masking are considered **VERY LOW**, both with and without mitigation.

Indirect effects due to the effects of seismic sounds on prey species

As with other vertebrates, the assessment of indirect effects of seismic surveys on Cape fur seals is limited by the complexity of trophic pathways in the marine environment. The impacts are difficult to determine, and would depend on the diet make-up of the species (and the flexibility of the diet), and the effect of seismic surveys on the diet species. The broad ranges of fish prey species (in relation to the avoidance patterns of seismic surveys of such prey species) and the extended foraging ranges of Cape fur seals suggest that indirect impacts due to effects on predators or prey would be **VERY LOW**, both with and without mitigation.

Mitigation

Mitigation measures recommended for potential impacts of seismic surveys on seals are:

- Daylight observations of the survey region should be carried out by onboard Marine Mammal Observers (MMOs) and the presence of seals (including number and position / distance from the vessel) and their behaviour should be recorded prior to "soft start" procedures.
- "Soft start" procedures should, if possible, only commence once it has been confirmed that there is no seal activity within 500 m of the airguns. If after a period of 30 minutes seals are still within 500 m of the airguns, the normal "soft start" procedure should be allowed to commence for at least a 20-minutes duration.
- The MMO should monitor seal behaviour during "soft starts" to determine if the seals display any obvious negative responses to the airguns and gear or if there are any signs of injury or mortality to seals as a direct result of seismic shooting operations.

- Seismic shooting should be terminated when obvious negative changes to seal behaviour are observed or there is any obvious mortality or injuries to seals as a direct result of the survey.
- The MMO's daily report should record general seal activity, numbers and any noticeable change in behaviour.

Impacts of seismic noise on seals resulting in pathological injury		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Medium	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	Medium	Medium

Impacts of seismic noise on seals resulting in behavioural avoidance		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey.	Short-term
Intensity	Low to medium	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	High	High

Impacts of seismic surveys on seals resulting in masking of sounds and communication		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	Medium	Medium

Impacts of seismic surveys on seals resulting from indirect effects on their prey		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	High	High

6.2.7 Impacts to Whales and Dolphins

A wide diversity of cetaceans (whales and dolphins) occur off the coast of the South-Western Cape. The majority of migratory cetaceans in southern African waters are baleen whales (mysticetes), while toothed whales (odontocetes) may be resident or migratory. Potential impacts of seismic pulses to whales and dolphins could include pathological injury, behavioural avoidance of seismic survey areas, masking of environmental sounds and communication, and indirect impacts due to effects on prey.

Marked differences occur in the hearing of baleen whales (mysticete cetaceans) and toothed whales and dolphins (odontocete cetaceans). The hearing of baleen whale is centred at below 1 kHz and they are therefore very receptive to the sound produced by seismic airgun arrays. In contrast, the hearing of toothed whale and dolphin is centred at frequencies of between 10 and 100 kHz, suggesting that these may react to seismic shots at long ranges, but that hearing damage from seismic shots is only likely to occur at close range. Mysticete and odontocete cetaceans are thus assessed separately below.

Pathological injury

There is little information available on the levels of noise that would potentially result in pathological injury to cetaceans, and no permanent threshold shifts have been recorded. Available information suggests that the animal would need to be in close proximity to operating airguns to suffer pathological injury, and being highly mobile it is assumed that they would avoid sound sources at distances well beyond those at which injury is likely to occur. Deep-diving cetacean species may, however, be more susceptible to acoustic injury, particularly in the case of seafloor-focussed seismic surveys, where the downward focussed impulses could trap deep diving cetaceans within the survey pulse, as escaping towards the surface would result in exposure to higher sound level pulses.

The majority of baleen whales migrate to the southern African subcontinent to breed during winter months. The main winter concentration areas for Humpback whales include Angola, Republic of Congo and Gabon on the west coast of Africa, and Mozambique, Madagascar, Kenya and Tanzania on the east coast. On the West Coast the migration route for humpback whales follows the edge of the continental shelf with a small proportion of the migration coming close inshore. On the East Coast, the northern migration reaches the coast in the vicinity of Knysna (Best 2007). Most reach southern African waters around April, continuing through to September/October when the southern migration begins and continues through to December. Southern right whales arrive in coastal waters off the southern African West Coast in June, building up to a maximum in September/October and departing again in December. High abundances of both Southern Right and Humpback whales along the southern portions of the West Coast during spring and summer, however, suggest localised resident populations year round. The proposed survey area thus lies within the migration path of Humpback whales, but offshore of areas frequented by Southern Right whales for breeding / calving. If the seismic survey is undertaken between June and December when whales are present in peak abundance, more animals are likely to be impacted.

The majority of the toothed whales that occur in inshore and offshore waters are resident, and interaction with the proposed survey will thus occur throughout the year.

The impact of potential pathological injury to both mysticete and odontocete cetaceans as a result of high-amplitude seismic sounds is deemed to be of high intensity, but would be limited to the immediate vicinity of operating airguns within the survey area. The impact is therefore considered to be of **LOW** (toothed whales) to **MEDIUM** (Humpbacks and Southern Rights) significance before mitigation and **VERY LOW** (toothed whales) to **LOW** (Humpbacks and Southern Rights) significance with mitigation.

Behavioural avoidance

Avoidance of seismic survey activity by cetaceans, particularly mysticete species, begins at distances where levels of approximately 150 to 180 dB are received. More subtle alterations in behaviour may occur at received levels of 120 dB. Although behavioural avoidance of seismic noise in the proposed survey area by baleen whales is highly likely, such avoidance is generally considered of minimal impact in relation to the distances of migrations of the majority of baleen whale species.

Of greater concern than general avoidance of migrating whales is avoidance of critical breeding habitat or area where mating, calving or nursing occurs. Southern right whales mostly remain in the coastal area south of Lambert's Bay. Females are constrained to give birth and nurse their calves in sheltered inshore areas protected from swell and wind. The proposed survey area, which is located offshore beyond the 100 m isobath, therefore does not overlap with nearshore regions potentially utilised by Southern Right whales as a mating, calving, or nursery grounds. There is, however, potential overlap with migration routes of both Humpback whales (to their winter breeding concentrations on the West and East Coasts) and Souther Right whales (to their breeding areas on the coast). There is also potential overlap with local abundances of resident whales in the Cape Columbine - Saldanha Bay area during summer months.

The potential impact of behavioural avoidance of seismic survey areas by mysticete cetaceans is considered to be of high intensity, across the survey area and for the duration of the survey. Considering the distribution ranges of most species of cetaceans, the impact of seismic surveying is considered of **MEDIUM** significance before mitigation. Limiting seismic surveys to outside of the winter/spring (June to November) baleen whale migration would reduce the intensity of potential impacts to low resulting in **LOW** significance with mitigation.

Information available on behavioural responses of toothed whales and dolphins to seismic surveys is more limited than that for baleen whales. There is less evidence of avoidance of seismic surveys by toothed whales (including dolphins), and consequently the impact of seismic survey noise on the behaviour of toothed whales is considered to be of medium intensity over the survey area and duration. The endemic Benguela dolphin has a restricted distribution in inshore waters and mostly occurs within five nautical miles of the shore and therefore inshore of the proposed survey area. Encounters are only likely when the survey vessel is making turns to survey those lines perpendicular to the coast. A number of other toothed whale species, however, have a more pelagic distribution thus occurring further offshore. The overall significance will therefore vary between species, and consequently ranges between **LOW** and **VERY LOW** before mitigation and **VERY LOW** with mitigation.

Masking of environmental sounds and communication

Baleen whales appear to vocalise almost exclusively within the frequency range of the maximum energy of seismic survey noise, while toothed whales vocalise at frequencies higher than these. Masking of communication signals is thus likely to be limited by the low duty cycle of seismic pulses, and consequently the intensity of impact on both baleen and toothed whales is likely to be low over the survey area and duration. However, in the migratory baleen whale species, vocalisation increases once they reach the breeding grounds and on the return journey in December - January when accompanied by calves. Whereas for odontocetes the significance is rated as **VERY LOW**, both with and without mitigation, for mysticetes it is rated as **LOW** without mitigation and **VERY LOW** with mitigation.

Indirect impacts due to effects on prey

As with other vertebrates, the assessment of indirect effects of seismic surveys on resident odontocetes and/or local abundances of mysticetes is limited by the complexity of trophic pathways in the marine environment. However, it is likely that both fish and cephalopod prey of toothed whales and dolphins and the preferred crustacean prey of mysticetes may be affected over limited areas, although the impacts are difficult to determine. The broad distribution ranges of the prey species (in relation to the avoidance patterns of seismic surveys of such prey species) suggest that indirect impacts due to effects on prey would be of **VERY LOW** significance with and without mitigation.

Other potential impacts

Given the slow speed (about 1.5 - 2 kts) of the vessel while towing the seismic array, ship strikes are also unlikely.

Mitigation

Mitigation measures to reduce the impact of seismic survey impulses on cetaceans include:

- As far as possible, avoid planning seismic surveys during the movement of migratory cetaceans (particularly baleen whales) from their southern feeding grounds into low latitude waters (June to November).

- Survey vessels should accommodate dedicated independent MMOs with experience in seabird, turtle and marine mammal identification and observation techniques, to carry out daylight observations of the survey region and record incidence of marine mammals, and their responses to seismic shooting. Data collected should include position, distance from the vessel, swimming speed and direction, and obvious changes in behaviour (e.g. startle responses or changes in surfacing/diving frequencies, breathing patterns). The identification and the behaviour of the animals must be recorded accurately along with current seismic noise levels.
- All initiations of seismic surveys must be carried out as "soft-starts" for a minimum of 20 minutes. This requires that the sound source be ramped from low to full power, thus allowing a flight response to outside the zone of injury or avoidance. The rational for the 20 minute "soft-start" period is based on the flight speeds of cetacean species.
- Initiation of firing is only to begin after observations by MMOs have deemed the visual area around the vessel to a distance of 500 m to be clear of all large cetacean species for at least 30 minutes prior to firing, so that deep- or long-diving species can be detected. In the case of small cetacean (particularly dolphins), which are common in inshore waters and often attracted to survey vessels, "soft start" procedures should, if possible, only commence once it has been confirmed that there is no small cetacean activity within 500 m of the airguns. If after a period of 30 minutes small cetaceans are still within 500 m of the airguns, the normal "soft start" procedure should be allowed to commence for at least a 20-minutes duration. The MMO should monitor small cetacean behaviour during "soft starts" to determine if the animals display any obvious negative responses to the airguns and gear or if there are any signs of injury or mortality as a direct result of seismic shooting operations.
- All breaks in airgun firing of longer than 20 minutes must be followed by a "soft-start" procedure of at least 20 minutes prior to the survey operation continuing. Breaks shorter than 20 minutes should be followed by a "soft-start" of similar duration.
- Seismic shooting should be terminated when obvious changes to cetacean behaviour is observed from the survey vessel, or animals are observed within the immediate vicinity (within 500 m) of operating airguns and appear to be approaching firing airgun.
- All data recorded by MMOs should at minimum form part of a survey close-out report. Furthermore, daily or weekly reports should be forwarded to the necessary authorities to ensure compliance with the mitigation measures.
- Marine mammal incidence data and seismic source output data arising from surveys should be made available on request to the Marine Mammal Institute, Department of Agriculture, Fisheries and Forestry, and the Petroleum Agency of South Africa for analyses of survey impacts in local waters.for analyses of survey impacts in local waters.
- Should the survey schedules overlap with the start of the sensitive period in terms of large mammals migrating through the area, airgun use should ideally be prohibited at night, and restricted during adverse weather conditions and thick fog. However, to ensure that the seismic survey has minimal overall duration within the study area, airgun use should only be permitted at night on condition that visual watches are maintained using night-vision/infra-red binoculars, or PAM technology is implemented to confirm that no cetaceans are present.

- The use of Passive Acoustic Monitoring (PAM) is encouraged by most international guidelines as a mitigation tool to detect marine mammals through their vocalisations, ***particularly if species of particular conservation importance are likely to be encountered in the proposed survey area***, or where a given species or group is difficult to detect by visual observation alone. Such monitoring can provide distance and bearing of the animals from the survey vessel. Although PAM would only identify animals that are calling or vocal, it has the advantage of 24 hour per day availability as opposed to visual monitoring, which can only be confidently carried out during daylight hours, or under adequate visibility conditions. Considering that most of the offshore migrating baleen whale species likely to be encountered are listed as "Endangered", and a proportion of the population is present off Saldanha Bay year-round, every effort should be made to ensure that the vessel is fitted with PAM technology.
- No survey-related activities are to take place within Marine Protected Areas.

Potential impact of seismic noise to mysticete cetaceans.

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

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

Impacts of seismic surveys on baleen whales resulting in masking of sounds and communication		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Medium	Low
Significance	Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	Medium	Medium

Impacts of seismic surveys on baleen whales resulting from indirect effects on their prey		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	Medium	Medium

Potential impact of seismic noise to odontocete cetaceans.

Impacts of seismic noise on toothed whales and dolphins resulting in pathological injury		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	High	Low to Medium
Significance	Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	Medium	Medium

Impacts of seismic noise on toothed whales and dolphins resulting in behavioural avoidance		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey.	Short-term
Intensity	Medium	Low to Medium
Significance	Very Low - Low (species specific)	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	High	High

Impacts of seismic surveys on toothed whales and dolphins resulting in masking of sounds and communication		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	Medium	Medium

Impacts of seismic surveys on toothed whales and dolphins resulting from indirect effects on their prey		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area.	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	Medium	Medium

6.3. Assessment of Electromagnetic Impacts

Organisms use internal electric potentials and signals for a wide variety of biological functions (e.g orientation or prey detection), and in some cases can perceive very small electric and magnetic fields. Perturbations from external electric and magnetic fields on such physiological systems need not necessarily have detrimental biological effects, as the magnitude of the effect will depend on the field intensities and exposure times to them, their frequency content, modulation, etc. As threshold and safety limits are typically only published for human exposure, and not for animals, knowledge on the potential biological effects of CSEM is limited. At the present stage of knowledge, however, the use of electromagnetic seabed logging techniques does not appear to involve substantial deleterious effects on marine life as they are considerably quieter than the typical seismic applications used in hydrocarbon exploration. The magnetic field generated during CSEM applications decreases rapidly with distance from the source, so that within 4 m of the source it is already comparable to the Earth's magnetic field (40,000 - 60,000 nT), and within 100 m distance has reduced to only 2,000 nT.

The basic effects of electric and magnetic fields on some relevant biological systems and the use of electric and magnetic fields by marine organisms (for navigation and prey detection) are discussed below. Based on this information the potential effects of CSEM surveys on marine biota are assessed.

Besides electromagnetic effects, other potential impacts of CSEM surveys on marine life include crushing of biota by the concrete anchors of the autonomous receiver units, stranding of seabirds attracted by vessel lights, collisions with marine mammals or turtles during operations, and accidental loss of buoyancy liquid or hydraulic fluid from the towed gear.

PetroSA has not provided details for the CSEM receiver locations, the number deployed or the target areas for the CSEM surveys. Similalrly, the survey timing and duration have not been finalised. The assessment below is therefore by necessity fairly generic.

6.3.1 Impacts to Benthic Invertebrates

Pathological injury or mortality

A small area of benthic habitat (about 1 m^2 per concrete base) will be altered as the concrete receiver-base settles onto the seafloor. The base will sink into the soft unconsolidated seabed sediments potentially crushing or smothering any infauna in the footprint. In the event of the base landing on relatively hard bottom, it will temporarily increase hard substrate habitat for colonisation by sessile organisms. In relation to the overall available seabed area in Block 5/6, and the fact that the anchors would dissolve in 6 - 8 months, the impact on benthic macrofauna or their habitat can be considered **INSIGNIFICANT** both with and without mitigation. Use of biodegradable cement must be implemented though to ensure that the cement anchors do not constitute a seabed hazard to demersal trawling in the area.

The very low frequency, very short duration energy used in CSEM applications should not effect benthic invertebrate health. As the maximum duration of potential effect for any one point will be very short (in the order of an hour), and any effects should be quickly reversible. Because the source is an alternating current, the magnitude of any effects on benthic invertebrates will be negligible. Impacts on marine benthic invertebrates from the CSEM survey are thus predicted to be **INSIGNIFICANT** both with and without mitigation.

Behavioural avoidance and disruption of migration

Those species containing magnetic material that may be present at the survey depths may detect the CSEM source and even react to it. However, the geographic extent of exposure is expected to be small in relation to similar available habitat, and the maximum duration of potential effect for any one point will be very short (in the order of an hour). Because the source is an alternating current, any effect on orientation or navigation will be negligible.

The West Coast rock lobster *Jasus lalandii* typically occurs in inshore waters to ~50 m depth where it supports and important commercial fishery. Adults are known to undergo a well defined seasonal inshore-offshore migration in response to changes in near-bottom dissolved oxygen concentrations (Newman & Pollock 1971; Pollock 1982; Tomalin 1993; Booth 1997; Noli & Grobler 1998) and may seasonally occur out to depths of ~150 m. As the licence block is located at depths beyond 100 m, interaction with rock lobsters is highly unlikely.

Impacts from the CSEM survey on rock lobsters or any other invertebrates containing magnetic material for orientation or navigation is thus predicted to be **INSIGNIFICANT** both with and without mitigation.

Mitigation
Mitigation measures to reduce the impact of CSEM surveys are presented in Section 6.3.7.

Impacts of receiver bases to benthic invertebrates		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Definite	Definite
Confidence	High	High

Impacts of electromagnetic fields on behaviour and migration of invertebrates		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Medium	Medium

6.3.2 Impacts to Fishes

6.3.2.1 Ichthyoplankton

There are no known reports of the effects of electromagnetics on fish ichthyoplankton. Fish eggs do not contain magnetite and there are no reported significant effects on animal or human eggs from low level, short duration electromagnetic energy. The following discussion is thus limited to the juvenile and adult stages of bony and cartilaginous fishes.

6.3.2.2 Bony Fishes

Pathological injury
Bony fish in general do not appear to be particularly sensitive to low frequency electromagnetic alternating current, and would need to come in very close contact (within ~3 m) of the electrodes in order to show behavioural response. In the case of deep-water applications, demersal species would be exposed to the source and induced fields the longest, due to their association with the seabed. In shallow-water applications pelagic and shoaling species are the most likely to encounter the towed source. At short distances from the electrode the fish may respond with an attraction towards the electrode, which may potentially lead to some degree of immobilization due to inhibited swimming. Only very close

to the electrodes would there be an elevated risk of injury, although the field strengths involved appear to be too weak to induce lethal injuries. Most species, however, are likely to have rapid escape mechanisms and will thus be capable of escaping any field from the towed CSEM source before it comes close enough to cause injury. The probability of injury is thus very low, but should interaction occur the intensity is likely to be very low. The very low frequency, very short duration radiation from the CSEM source should therefore have negligible effects on bony fish, and the impacts of the CSEM surveys are thus predicted to be **INSIGNIFICANT** both with and without mitigation.

Behavioural avoidance and disruption of migration

Some species occurring in the survey area undertake migrations (small shoaling pelagic species, large pelagic tunas and billfish, chub mackerel, snoek), and of these, yellowfin tuna are known to use magnetic compass orientation. However, migrating species are likely to use a variety of navigational clues, all of which probably over-ride any geomagnetic information. Given the fixed and transient magnetic anomalies that migrating fish would encounter, the ability to form a fully memorised geomagnetic map seems unlikely.

Migrating shoals or individuals tend to occur near the surface in proximity to their food sources. Any field from the deep-towed CSEM transmitter would thus be absent or very weak. In shallow-water applications, however, the source may be encountered in the near-field, but given the seasonal distribution of most of the pelagic shoaling species, interaction of the proposed survey with migrating fish can be considered negligible. Any reaction of migrating species to the source in their immediate proximity would be of short duration and variable (because of the alternating current). The geomagnetic field is also only as one of several cues for navigation, and other navigational signals would not be affected. If the CSEM source is perceived as an irritant, the fish have good mobility and can leave the immediate area.

Any potential effects on the behaviour of bony fishes will thus be of small geographic extent, short duration (no more than a few hours), and low magnitude. Any effects of the CSEM surveys on the behaviour or migration of bony fishes are thus predicted to be **INSIGNIFICANT** both with and without mitigation.

Mitigation

Mitigation measures to reduce the impact of CSEM surveys are presented in Section 6.3.7.

Pathological injury to bony fishes due to electromagnetic fields		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Medium	Medium

Impacts of electromagnetic fields on behaviour and migration of bony fishes		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Medium	Medium

6.3.2.2 Cartilaginous Fishes

Pathological injury

Elasmobranchs and chimaerids are most likely to detect the electrical fields produced by CSEM because their electroreceptive organs are sensitive to stimuli in the very low frequency range from 0.125 Hz to 8.0 Hz, which overlaps with the frequency range used in CSEM. Due to their association with the seabed, demersal elasmobranch and chimaerid species would be exposed to the source and induced fields the longest in the case of deep-water surveys. However, their sensitivity to electric fields suggests that elasmobranches will be repelled as the source approaches them and the field gets stronger, in which case they will avoid any potential effects by leaving the area. While they have rapid escape mechanisms, not all species may be capable of sustained swimming to flee to a suitable distance from the source. Nonetheless, any pathological injury as a result of CSEM surveys is highly unlikely, and any effects on cartilagenous fishes are thus predicted to be **INSIGNIFICANT** both with and without mitigation.

Behavioural avoidance and disruption of migration

Of the pelagic sharks that potentially occur in the Block 5/6 area, the blue, short-fin mako, great white, oceanic whitetip and whale sharks are known to migrate long distances. The proposed CSEM survey is, however, unlikely to disrupt any navigation abilities of these pelagic species as the source current is alternating and thus any potential effect on orientation or navigation will be "self-cancelling". As with migratory bony fish, geomagnetics are not their only navigational clue. Given their near-surface and/or seasonal distribution, any field from the deep-towed CSEM transmitter would thus be absent or very weak, and only in shallow-water applications, would the source may be encountered in the near-field. As the duration of any exposure will be short, the interaction of the proposed survey with migrating sharks can thus be considered negligible.

The sensitivity of elasmobranches to electromagnetic fields further suggests that there is a distinct possibility that the fields produced by CSEM may perturb the behaviour of these types of species. Deep-water surveys may temporarily disrupt prey detection by some demersal species. The use of electroreception as an aid to prey detection appears to vary with species but is known to be short range (within a few metres) in those that have been studied.

Any potential effects on cartilaginous fish behaviour or navigation will be of small geographic extent, short duration (no more than a few hours unless pelagic species are travelling with the vessel and at the same speed in which case any effect could last longer), and low magnitude. There will be no or negligible effect on their behaviour or navigational ability, and consequently the impacts of CSEM on elasmobranch fishes are predicted to be of **VERY LOW** significance both with and without mitigation.

Mitigation

Mitigation measures to reduce the impact of CSEM surveys are presented in Section 6.3.7.

Pathological injury to cartilaginous fishes due to electromagnetic fields		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Medium	Medium

Impacts of electromagnetic fields on behaviour and migration of cartilaginous fishes		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Status	Negative	Negative
Probability	Probable	Probable
Confidence	Medium	Medium

6.3.3 Impacts to Turtles

Pathological injury

Turtles spend most of their time near the surface where any field from a deep-towed CSEM source would be absent or very weak. Leatherbacks, however, have been recorded diving to depths greater than 1,000 m (Eckert *et at.*1989) and could thus encounter the electromagnetic fields during a dive. In shallow-water applications, the source may be briefly encountered in the near-field but is unlikely to have any significant effect on the animal. Furthermore, adult sea turtles do not appear to be sensitive to electromagnetic fields, so effects on health will be negligible (due to alternating nature of current and the very brief exposure period). Abundance of turtles in the survey area is expected to be low, and consequently any effects of the CSEM surveys are predicted to be **INSIGNIFICANT** both with and without mitigation.

Behavioural avoidance and disruption of migration

Adult sea turtles do not appear to utilize electromagnetic fields, so effects on navigation will be negligible. Leatherback turtle hatchlings can detect and use geomagnetic information to assist in navigation, but will occur only in surface waters as occasional strays in the southern portion of the survey area. Any field from the deep-towed CSEM transmitter thus would be absent or very weak, but in the event of shallow-water surveys the source may be encountered in the near-field. However, given their seasonal distribution and low abundance in the survey area, interaction will be negligible. Any effects on migrating turtle adults and hatchlings of the CSEM surveys are predicted to be **INSIGNIFICANT** both with and without mitigation.

Mitigation
Mitigation measures to reduce the impact of CSEM surveys are presented in Section 6.3.7.

Pathological injury to turtles due to electromagnetic fields		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Medium	Medium

Impacts of electromagnetic fields behaviour and migration of adult turtles and hatchlings		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Medium	Medium

6.3.4 Impacts to Seabirds

Pathological injury and navigation
Birds of the Order Procellariformes (shearwaters and petrels) have been shown to exhibit magnetic orientation (Wiltschko & Wiltschko 1995). While these are expected to occur in the Block 5/6 survey area, they feed near the surface by plunging (shearwaters) or surface skimming (petrels). They will therefore not be exposed to the geomagnetic field from the source towed near the seabed, but may encounter the electromagnetic fields during surface-towed surveys. Cape gannets feed near the surface to depths of ~10 m (Adams & Walker 1993), and Cape cormorants and African Penguins, can dive to depths of 92 m and 130 m (Burger 1991), respectively. These species may therefore be at risk from exposure to some level of electromagnetic (depending on survey depth). Any exposure would, however, be of short duration and variable (because of the alternating current) and effects on diving seabirds are thus predicted to be **INSIGNIFICANT** both with and without mitigation.

Other impacts
The only two other potential adverse interactions between seabirds and CSEM surveys are (1) stranding of birds on the survey vessel due to being attracted to the vessel lights at night, and (2) oiling through accidental loss of buoyancy liquid or hydraulic fluid from the towed gear. However, if the oil leaked at depth, little or no oil would likely reach the surface. Thus, while there is some potential for effects on individual seabirds, effects on seabird populations from any of the activities associated with CSEM surveys, are predicted to be **INSIGNIFICANT** both with and without mitigation, as the number of animals potentially affected will be small.

Mitigation
Mitigation measures to reduce the impact of CSEM surveys are presented in Section 6.3.7.

Pathological injury to and disruption of navigation in diving seabirds		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Medium	Medium

Impacts of CSEM surveys to seabirds through stranding or oiling		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Improbable	improbable
Confidence	Medium	Medium

6.3.5 Impacts to Cetaceans and Seals

Pathological injury
Direct health effects on marine mammals are unlikely given what is known on the effects of electromagnetic radiation on mammals. Of the whales that are likely to be frequently encountered in the survey area, the Humpback can dive to a maximum depth of about 210 m, whereas Southern Rights can dive to 300 m. Cape fur seals can reach maximum depths of 200 m, although 70% of dives are shallower than 50 m. Cetaceans and seals may therefore be exposed to the geomagnetic field from the source when surveying in the inshore portions of the licence block using either deep-water or shallow-water applications. Any effects on cetaceans and seals of the ultra low frequency, alternating current and short duration of exposure

associated with CSEM can, however, be expected to be negligible. Any impacts of the CSEM surveys on the health of cetaceans and seals are thus predicted to be **INSIGNIFICANT** both with and without mitigation.

Behavioural avoidance and disruption of migration

Cetaceans are thought to use geomagnetics for long distance navigation and could thus potentially be temporarily disturbed by the field emanating from the source. Migrating animals, however, frequent surface waters where the signal from the deep-towed source will be very weak or non-existent. Only in the event of shallow-water surveys may the source be encountered in the near-field. Any encounter with a moving field will be limited and their exposure times will therefore be very short. Significant effects are thus unlikely given that the source current is alternating, the duration of exposure is likely to be short, and the fact that animals use more than one clue to navigate. Furthermore, the electromagnetic fields produced by the CSEM source are rapidly attenuated with distance from the electrodes, so local magnetic field anomalies are highly unlikely to play any role. Any effects on navigation will be "self-cancelling" and of small geographic extent, low magnitude, and short duration (less than a few hours). Effects of the CSEM survey on behaviour patterns and navigation of cetaceans and seals can thus be considered **INSIGNIFICANT** both with and without mitigation.

Other potential impacts

Given the slow speed (about 2 - 4 knots) of the vessel while towing the electromagnetic transmitter, ship strikes are also unlikely.

Impacts of electromagnetic fields to cetaceans and seals		
	Without Mitigation	Assuming Mitigation
Extent	Local: limited to survey area	Local
Duration	Short-term: for duration of survey	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Status	Negative	Negative
Probability	Improbable	Improbable
Confidence	Medium	Medium

6.3.6 Cumulative Effects of CSEM surveys

Cumulative effects of CSEM survey within Block 5/6 will be negligible as there are no other licence holders planning exploration/prospecting projects that would generate underwater electromagnetic fields in the area. Some cumulative effects are possible around the Telkom cables from western Europe that are laid on the seafloor approximately following the 3,000 m isobath. They run up the Cape Canyon to Melkbosstrand, a few kilometres north of Cape Town. The SAT-1 cable is abandoned and the SAT-2 cable, which is a fibre-optics cable, is functional. The SAT-3 fibre-optics cable follows the same route from Melkbosstrand to a depth of around 3,000 m but then veers eastwards up the South and East Coasts. Where seafloor conditions permitted, the SAT-3 cable was buried 0.7 m below the seafloor from the coast landing points to 1,000 m water depth. In April 2011, a newly laid subsea telecommunications cable, the

West African Cable System (WACS), landed at Yzerfontein in the Western Cape. This cable extends along the western coastline of Africa.

6.3.7 Mitigation

CSEM surveys are not analogous to seismic surveys and thus the same type of mitigation measures are not warranted. For example, during seismic surveys monitoring of marine mammals and seabirds is conducted as a mitigation strategy in conjunction with a 500 m safety zone. In the case of CSEM, the electromagnetic source is towed just above the seafloor and therefore risk to animals at/near the surface is considered negligible. In shallow-water CSEM applications, however, the source is typically towed at a constant depth of 10 m below the sea surface.

Mitigation measures implemented internationally (Buchanan *et al.* 2006; LGL Limited 2009; Woodside 2010) to reduce the impact of CSEM surveys on marine fauna include:

- Use standard operational procedure to warm up the source transmitter (*i.e.* equivalent to ramp-up of current in electric source). It is recommended that the electromagnetic source should be ramped up over a 20 - 40 minute period.
- No operation of the electromagnetic source during turns in between survey lines.
- Concrete moorings used for signal receiver units must be of biodegradable cement.
- All autonomous signal receiver units must be recovered on the completion of the CSEM survey.
- The location of signal receiver units, and the timing and location of planned survey activities must be registered and distributed via "Notice to Mariners" and "Notice to Fishers".
- Standard maritime safety/navigation and equipment handling and acquisition procedures must be adhered to during surveys.
- A register must be maintained of equipment lost overboard, and every effort should be made to recover lost equipment.
- Reduce lighting on board the survey ship to minimum safety levels to minimise stranding of pelagic seabirds on the survey vessel at night. All stranded seabirds must be retrieved and released according to appropriate guidelines.
- Ensure that Marine Mammal Observers/Fisheries Liaison Officers are on board to identify and monitor marine mammals and communicate with fishing vessels if required.
- All data recorded by MMOs should at minimum form part of a survey close-out report. Furthermore, daily or weekly reports should be forwarded to the necessary authorities to ensure compliance with the mitigation measures.
- Marine mammal incidence data and seismic source output data arising from surveys should be made available to the Marine Mammal Institute, Department of Environmental Affairs, the Petroleum Agency of South Africa and appropriate research institutes for analyses of survey impacts in local waters.
- No survey-related activities are to take place within Marine Protected Areas.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. Conclusions

If all environmental guidelines, and appropriate mitigation measures advanced in this report, and the EMP for the proposed survey programmes as a whole, are implemented, there is no reason why the proposed seismic and CSEM surveys should not proceed. As far as possible, seismic surveys should be planned to avoid cetacean migration (June to November) periods, and data collected by independent onboard observers should form part of a survey close-out report to be forwarded to the necessary authorities, and any incidence data and seismic source output data arising from surveys should be made available on request for analyses of survey impacts in Southern African waters.

The assessments of impacts of seismic sounds provided in the scientific literature usually consider short-term responses at the level of individual animals only, as our understanding of how such short-term effects relate to adverse residual effects at the population level are limited. Data on behavioural reactions acquired over the short-term could, however, easily be misinterpreted as being less significant than the cumulative effects over the long-term, *i.e.* what is initially interpreted as an impact not having a detrimental effect and thus being of low significance, may turn out to result in a long-term decline in the population. A significant adverse residual environmental effect is considered one that affects marine biota by causing a decline in abundance or change in distribution of a population(s) over more than one generation within an area. Natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent.

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

Given the depth at which the CSEM source is operating (30 - 50 m above the seabed in >500 m water depth) during seabed logging surveys, and the comparatively low densities of marine fauna at those depths, the likelihood of encounters within 100 m of the moving source is very low. Furthermore, any exposure to the source would be of short duration, and any effects on marine fauna of the ultra-low frequency, alternating current associated with CSEM is generally expected to be negligible.

Although seismic and CSEM technologies are currently complementary in the exploration phase, the application of CSEM technology as a potential alternative to seismics has recently received some attention (Weilgard 2010). Controlled source electromagnetics generally put the same level of geophysically useable energy into the water as impulsive sources like airguns, but over a longer period of time, and at lower peak sound level. By using a sweep rather than an impulse, thereby spreading out the energy over time, controlled sources can reduce peak sound levels by 30 dB. Consequently they are quieter than the typical seismic applications used in hydrocarbon prospecting. Furthermore, controlled sources can produce sound over the frequency range desired, generating signals that can be specifically designed to maximise geological interpretability and minimise the impact on marine mammals. It has been suggested that the exploration work-flow should be front-loaded with the use of silent technologies from the planning stages of a project, thereby optimising the exploration process and requiring less sound from the start. For example, if 2D airgun surveys followed by quieter technologies (e.g. 3D CSEM) do not show promising targets, proceeding with 3D seismic surveys may not be worthwhile. Conversely, one may optimize 3D seismic activities based on the results from 2D seismic and 3D CSEM (Weilgart 2010).

The significance of the impacts both before and after mitigation are summarised below for the proposed seismic and CSEM survey programmes.

Seismic Impact	Significance (before mitigation)	Significance (after mitigation)
Plankton		
Pathological injury and mortality	Very Low	Very Low
Marine Invertebrates		
Pathological injury and mortality	Very Low	Very Low
Behavioural avoidance	Very Low	Very Low
Fish		
Mortality and/or pathological injury	Low	Very Low
Avoidance behaviour	Low	Low
Reproductive success / spawning	Very Low	Very Low
Masking of sounds	Very Low	Very Low
Indirect impacts on food sources	Very Low	Very Low
Seabirds		
Pathological injury	Medium to Low	Low to Very Low
Avoidance behaviour	Medium to Low	Low to Very Low
Indirect impacts on food sources	Very Low	Very Low
Stranding and oiling	Insignificant	Insignificant
Turtles		
Pathological injury, collision and entanglement	Low	Very Low
Avoidance behaviour	Low	Very Low
Indirect impacts on food sources	Very Low	Very Low
Masking of sounds	Insignificant	Insignificant
Seals		
Pathological injury or mortality	Very Low	Very Low
Avoidance behaviour	Very Low	Very Low
Masking of sounds	Very Low	Very Low
Indirect impacts on food sources	Very Low	Very Low

Seismic Impact	Significance (before mitigation)	Significance (after mitigation)
Whales and dolphins		
Baleen whales		
Pathological injury	Medium	Low
Avoidance behaviour	Medium	Low
Masking of sounds and indirect impacts on food sources	Low	Very Low
Indirect impacts on food sources	Very Low	Very Low
Toothed whales and dolphins		
Pathological injury	Low	Very Low
Avoidance behaviour	Low to Very Low	Very Low
Masking of sounds and indirect impacts on food sources	Very Low	Very Low
Indirect impacts on food sources	Very Low	Very Low
Other Potential Impacts		
Interaction with vessel traffic	Insignificant	Insignificant

Electromagnetic Impact	Significance (before mitigation)	Significance (after mitigation)
Marine Invertebrates		
Pathological injury or mortality	Insignificant	Insignificant
Behavioural avoidance and disruption of migration	Insignificant	Insignificant
Bony Fish		
Pathological injury	Insignificant	Insignificant
Avoidance behaviour and disruption of migration	Insignificant	Insignificant
Cartilagenous Fish		
Pathological injury	Insignificant	Insignificant
Avoidance behaviour and disruption of migration	Very Low	Very Low
Turtles		
Pathological injury	Insignificant	Insignificant
Avoidance behaviour and disruption of migration	Insignificant	Insignificant
Seabirds		
Pathological injury and navigation	Insignificant	Insignificant
Stranding and oiling	Insignificant	Insignificant
Cetaceans and Seals		
Pathological injury	Insignificant	Insignificant
Avoidance behaviour and disruption of migration	Insignificant	Insignificant
Other Potential Impacts		
Interaction with vessel traffic	Insignificant	Insignificant

7.2. Recommended Mitigation Measures

Detailed mitigation measures for seismic surveys in other parts of the world are provided by Weir *et al.* (2006), Compton *et al.* (2007) and US Department of Interior (2007). Many of the international guidelines presented in these documents are extremely conservative as they are designed for areas experiencing repeated, high intensity surveys and harbouring particularly sensitive species, or species with high conservation status. The guidelines currently applied for seismic surveying in South African waters are those proposed in the Generic EMPR (CCA & CMS 2001), and to date these have not resulted in any known or recorded mortalities of marine mammals, turtles or seabirds. The mitigation measures proposed below are based largely on the guidelines currently accepted for seismic surveys in South Africa, but have been revised to include salient points from international guidelines discussed in the documents cited above.

- Seismic surveys should as far as possible be planned to avoid cetatean migration periods or winter breeding concentrations (June to November), and ensure that migration paths are not blocked.
- The use of the lowest practicable airgun volume should be defined and enforced, and airgun use should be prohibited outside of the licence area.
- Prior to the commencement of "soft starts" an area of 500-m radius around the survey vessel (exclusion zone) should be scanned for the presence of diving seabirds, turtles, seals and cetaceans. There should be a dedicated pre-shoot watch of at least 30 minutes for deep-diving species. "Soft starts" should be delayed until such time as this area is clear of individuals of diving seabirds, turtles and cetaceans. Soft-start should not begin until 30 minutes after the animals depart the exclusion zone or 30 minutes after they are last seen. In the case of fur seals and small odontocetes, which may occur commonly around the vessel, the presence of seals and small odontocetes (including number and position / distance from the vessel) and their behaviour should be recorded prior to "soft start" procedures. If possible, "soft starts" should only commence once it has been confirmed that there is no seal and small odontocetes activity within 500 m of the airguns. However, if after a period of 30 minutes they are still within 500 m of the airguns, the normal "soft start" procedure should be allowed to commence for at least a 20-minutes duration. Their activity should be carefully monitored during "soft starts" to determine if they display any obvious negative responses to the airguns and gear or if there are any signs of injury or mortality as a direct result of the seismic activities.
- The implementation of "soft-start" procedures of a minimum of 20 minutes' duration on initiation of seismic surveying would mitigate any extent of pathological injury in most mobile vertebrate species as a result of seismic noise and is consequently considered a mandatory management measure for the implementation of the proposed seismic survey. "Soft start" procedures should not be initiated during times of poor visibility or darkness without the use of existing PAM technology to confirm that no cetaceans are present.

- An onboard independent MMO must be appointed for the duration of the seismic survey[1]. The MMO should have experience in seabird, turtle and marine mammal identification and observation techniques. The duties of the MMO would be to:
  - Record initiation of seismic firing activity and associated "soft starts", airgun activities and seismic noise levels;
  - Observe and record responses of marine fauna to seismic shooting, including seabird, turtle and cetacean incidence and behaviour and any mortality or injuries of marine fauna as a result of the seismic survey. Data captured should include species identification, position (latitude/longitude), distance from the vessel, swimming speed and direction (if applicable) and any obvious changes in behaviour (e.g. startle responses or changes in surfacing/diving frequencies, breathing patterns) as a result of the seismic activities. Both the identification and the behaviour of the animals must be recorded accurately along with current seismic sound levels. Any attraction of predatory seabirds, large pelagic fish or cetaceans (by mass disorientation or stunning of fish as a result of seismic survey activities) and incidents of feeding behaviour among the hydrophone streamers should also be recorded;
  - Sightings of any injured or dead protected species (marine mammals and sea turtles) should be recorded, regardless of whether the injury or death was caused by the seismic vessel itself. If the injury or death was caused by a collision with the seismic vessel, the date and location (latitude/longitude) of the strike, and the species identification or a description of the animal should be recorded.
  - Record meteorological conditions;
  - Request the temporarily termination of the seismic survey or adjusting of seismic shooting, as appropriate. It is important that MMOs have a full understanding of the financial implications of terminating firing, and that such decisions are made confidently and expediently. A log of all termination decisions must be kept (for inclusion in both daily and "close-out" reports);
  - Prepare daily reports of all observations, to be forwarded to the necessary authorities on a daily or weekly basis to ensure compliance with the mitigation measures.
- Seismic shooting should be terminated on observation of any obvious mortality or injuries to cetaceans, turtles, seals or large mortalities of invertebrate and fish species as a direct result of the survey. Such mortalities would be of particular concern where a) commercially important species are involved, or b) mortality events attract higher order predator and scavenger species into the seismic area during the survey, thus subjecting them to acoustic impulses. Seismic shooting should also be terminated when obvious negative changes to turtle, seal or cetacean behaviours are observed from the survey vessel, or turtles and cetaceans (not seals and small odontocetes) are observed within the immediate vicinity (within 500 m) of operating airguns and appear to be

[1] One observer is the norm, but in high latitudes two are required during summer months due to the longer daylight hours. Brazilian guidelines in contrast require at least three observers to be aboard, in order to allow efficient rotation of duties and maintain full coverage.

approaching firing airgun[2]. The rationale for this is that animals at close distances *(i.e.* where pathological injury may occur) may be suffering from reduced hearing as a result of seismic sounds, that frequencies of seismic sound energy lies below best hearing frequencies (certain toothed cetaceans and seals), or that animals have become trapped within the ensonified area through diving behaviour.

- All breaks in airgun firing of longer than 20 minutes must be followed by a "soft-start" procedure of at least 20 minutes prior to the survey operation continuing. Breaks of shorter than 20 minutes should be followed by a "soft-start" of similar duration.
- Ideally, airgun use should be prohibited at night, and restricted during adverse weather conditions and thick fog. However, to ensure that the seismic survey has minimal overall duration within the study area, airgun use should only be permitted at night on condition that visual watches are maintained using night-vision/infra-red binoculars, or PAM technology is implemented to confirm that no cetaceans are present.
- Ensure that 'turtle-friendly' tail buoys are used by the survey contractor or that existing tail buoys are fitted with either exclusion or deflector 'turtle guards'.
- Reduce lighting on board the survey vessels to minimum safety levels to minimise stranding of pelagic seabirds on the survey vessels at night. All stranded seabirds must be retrieved and released according to appropriate guidelines.
- Marine mammal incidence data and seismic source output data arising from surveys should be made available on request to the Marine Mammal Institute, Department of Agriculture, Fisheries and Forestry, and the Petroleum Agency of South Africa for analyses of survey impacts in local waters.for analyses of survey impacts in local waters.
- Should the survey schedules overlap with the start of the sensitive period in terms of large mammals migrating through the area, airgun use should ideally be prohibited at night, and restricted during adverse weather conditions and thick fog. However, to ensure that the seismic survey has minimal overall duration within the study area, airgun use should only be permitted at night on condition that visual watches are maintained using night-vision/infra-red binoculars, or PAM technology is implemented to confirm that no cetaceans are present.
- The use of Passive Acoustic Monitoring (PAM) is encouraged by most international guidelines as a mitigation tool to detect marine mammals through their vocalisations, ***particularly if species of particular conservation importance are likely to be encountered in the proposed survey area***, or where a given species or group is difficult to detect by visual observation alone. Such monitoring can provide distance and bearing of the animals from the survey vessel. Although PAM would only identify animals that are calling or vocal, it has the advantage of 24 hour per day availability as opposed to visual monitoring, which can only be confidently carried out during daylight hours, or under adequate visibility conditions. Considering that most of the offshore

[2] Recommended safety zones in some of the international guidelines include implementation of an observation zone of 3 km radius, low-power zone of 1.5 - 2 km radius (to cater for cow-calf pairs), and safety shut-down zone of 500 m radius around the survey vessel. Alternatively, a safety zone of 160 dB root mean squared (rms) can be calculated based on site-specific sound speed profiles and airgun parameters. The application of propagation loss models to calculate safety radii based on sound pressure levels represents a more scientific approach than the arbitrary designation of a 500 m radius (see Compton *et al.* (2007) for details).

migrating baleen whale species likely to be encountered are listed as "Endangered", and a proportion of the population is present off Saldanha Bay year-round, every effort should be made to ensure that the vessel is fitted with PAM technology.

- No seismic survey-related activities are to take place within Marine Protected Areas.

Mitigation measures implemented internationally to reduce the impact of CSEM surveys on marine fauna are listed below. It is recommended these be implemented during the proposed surveys in Block 5/6.

- Use standard operational procedure to warm up the source transmitter (*i.e.* equivalent to ramp-up of current in electric source). It is recommended that the electromagnetic source should be ramped up over a 20 - 40 minute period.
- No operation of the electromagnetic source during turns in between survey lines.
- Concrete moorings used for signal receiver units must be of biodegradable cement.
- All autonomous signal receiver units must be recovered on the completion of the CSEM survey.
- The location of signal receiver units, and the timing and location of planned survey activities must be registered and distributed via "Notice to Mariners" and "Notice to Fishers".
- Standard maritime safety/navigation and equipment handling and acquisition procedures must be adhered to during surveys.
- A register must be maintained of equipment lost overboard, and every effort should be made to recover lost equipment.
- Reduce lighting on board the survey ship to minimum safety levels to minimise stranding of pelagic seabirds on the survey vessel at night. All stranded seabirds must be retrieved and released according to appropriate guidelines.
- Ensure that Marine Mammal Observers/Fisheries Liaison Officers are on board to identify and monitor marine mammals and communicate with fishing vessels if required.
- All data recorded by MMOs should at minimum form part of a survey close-out report. Furthermore, daily or weekly reports should be forwarded to the necessary authorities to ensure compliance with the mitigation measures.
- Marine mammal incidence data and seismic source output data arising from surveys should be made available on request to the Marine Mammal Institute, Department of Environmental Affairs, the Petroleum Agency of South Africa and appropriate research institutes for analyses of survey impacts in local waters.
- No CSEM survey-related activities are to take place within Marine Protected Areas.

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