PROPOSED EXPLORATION ACTIVITIES IN OFFSHORE LICENCE BLOCKS 3617 AND 3717 OFF THE SOUTH-WEST COAST OF SOUTH AFRICA

Fisheries Specialist Study

REV 01

27 November 2015

Prepared by:

Capricorn Marine Environmental (Pty) Ltd

Prepared for the Environmental Assessment Practitioner:

CCA Environmental (Pty) Ltd

On behalf of the Applicant:

Rhino Oil and Gas Exploration South Africa (Pty) Ltd

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EXECUTIVE SUMMARY

Rhino Oil and Gas Exploration South Africa (Pty) Ltd ("Rhino") is proposing to explore for oil and gas in an Exploration Licence area situated off the South-West Coast of South Africa (see **Figure 1**). This exploration licence area (Blocks 3617 & 3717) is located approximately 190 km off the coast in water depths greater than 3 500 m and is approximately 13 279 km^2 in extent. Rhino's proposed initial three-year exploration programme would include multi-beam bathymetry and 2D / 3D seismic surveys. Although survey commencement would ultimately depend on a permit award date, availability of seismic contractors and other factors, it is anticipated that initial surveying would be undertaken during the summer of 2016/2017 and would take on the order of 15 to 20 productive days to complete per area.

As part of the Scoping and Environmental Impact Assessment, this study provides an assessment of the potential impact on the fishing industry. When assessing the potential impacts of the proposed survey on commercial fisheries sectors, two different impacts were identified. The first is the impact of operational exclusion of fishing boats from the vicinity of the survey vessel (and towed gear array). The second is the potential loss of catch due to the potential behavioural responses of targeted fish stocks in response to the noise generated by the survey equipment.

The impact of the temporary exclusion of fisheries from operating within the vicinity of the survey vessel would be of short-term duration (The total duration of the survey would be 15 – 20 days and it is unlikely that any particular fishery would be disrupted continuously for this length of time). The exploration area overlaps with only the large pelagic longline and tuna pole sectors and the impact on these sectors is assessed to be of local extent. The impact of the survey on fishing operations of the large pelagic long-line sector is assessed to be of overall **very low** significance and the likelihood of the impact occurring is improbable. The impact on the tuna pole fishery is assessed to be of overall **insignificance** and it is unlikely that the impact would occur. The impact of the acoustic source on catch availability is unlikely to increase the significance of the impact on either of these fisheries and the implementation of appropriate mitigation measures is unlikely to reduce the overall significance of the impact. The impact is likely to be fully reversible and the loss of resource is considered to be low. There is **no impact** expected on the demersal trawl, demersal longline, traditional line-fish, small pelagic purse-seine and west coast rock lobster sectors. Similarly, there is **no impact** expected on the demersal or pelagic fisheries research surveys.

The implementation of a communication strategy with the South African fishing industry is considered essential.

a) Fishing industry bodies and other key affected parties should be informed of the proposed activities and requirements with regards to the safe operational limits around the vessel prior to the commencement of the project. The following industrial bodies and affected parties include:
   - Department of Agriculture, Forestry and Fisheries (DAFF);
   - South African Tuna Association (SATA);
   - South African Tuna Long-Line Association (SATLA);
   - Fresh Tuna Exporters Association (FTEA);
   - Transnet National Ports Authority (ports of Cape Town and Saldanha Bay);
   - South African Naval Hydrographic Office; and
   - South African Maritime Safety Authority (SAMSA).

b) The required safety zones around the survey vessel should be communicated via the issuing of Daily Navigational Warnings for the duration of operations through the South African Naval Hydrographic Office;

c) Any fishing vessel targets at a radar range of 12 nautical miles from the survey vessel should be called via radio and informed of the navigational safety requirements;

d) Affected parties should be notified through fishing industry bodies when the survey activities are complete;

e) The survey vessel should be accompanied by a chase vessel.

f) A Fisheries Liaison Officer (FLO) should be deployed on board either the survey or chase vessel to facilitate communication with fishing and maritime vessels; and

g) Notify stakeholders (see above) when the survey is complete and the survey vessel is off location.

CAPRICORN MARINE ENVIRONMENTAL PTY LTD

PROPOSED EXPLORATION IN 3617 AND 3717 OFF THE SOUTH-WEST COAST OF SOUTH AFRICA

Fisheries Specialist Study

27 November 2015

EXPERTISE AND DECLARATION OF INDEPENDENCE

This report was prepared by Dave Japp and Sarah Wilkinson of Capricorn Marine Environmental (Pty) Ltd (previously 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, specialising 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 on behalf of Rhino Oil and Gas Exploration South Africa (Pty) Ltd for their use in the Scoping and Environmental Impact Assessment process for the proposed offshore exploration activities in Blocks 3617 & 3717 located off the South-West Coast of South Africa. We do hereby declare that Capricorn Marine Environmental (Pty) Ltd is financially and otherwise independent of the Applicant and CCA Environmental.

Dave Japp (Chief Executive Officer)

Sarah Wilkinson (Project Director)

1. INTRODUCTION

1.1 Background

Rhino Oil and Gas Exploration South Africa (Pty) Ltd ("Rhino") is proposing to explore for oil and gas in an exploration licence area situated off the South-West Coast of South Africa (see Figure 1). This exploration licence area (Blocks 3617 & 3717) is located approximately 190 km off the coast in water depths greater than 3 500 m. The area is approximately 13 279 km[2] in extent. Rhino's proposed initial three-year exploration programme would include multi-beam bathymetry and 2D / 3D seismic surveys. These activities provide for the rapid collection of data and provide critical information regarding the exploration potential of these areas and would guide future exploration efforts.

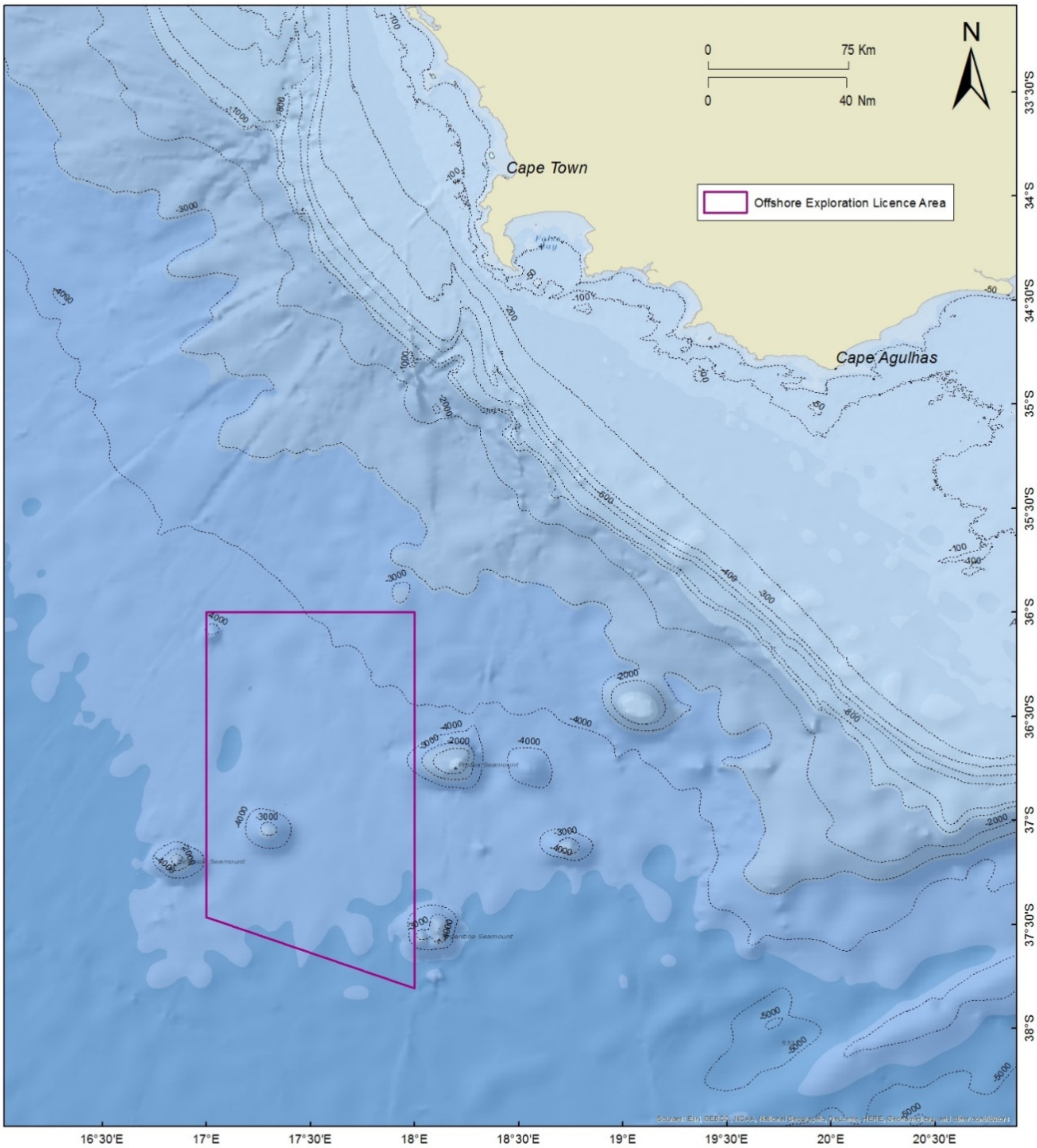

Figure 1: Location of Rhino's Exploration Right application licence area off the South-West Coast of South Africa.

In April 2015, Rhino lodged an application for an Exploration Right over the area with the Petroleum Agency of South Africa (PASA) in terms of Section 79 of the Mineral and Petroleum Resources Development Act, 2002 (No. 28 of 2002)

(MPRDA), as amended. PASA accepted the application on 22 May 2015. In terms of Section 79 of the MPRDA, a requirement for obtaining an Exploration Right is that the applicant must comply with Chapter 5 of the National Environmental Management Act, 1998 (No. 107 of 1998) (NEMA), as amended, with regards to consultation and reporting. In terms of NEMA, the proposed applications require Environmental Authorisation as they trigger Activity 18 in Listing Notice 2 (GN No. R984). As such a Scoping and Environmental Impact Assessment (hereafter termed "SEIA") process must be undertaken in terms of the Environmental Impact Assessment (EIA) Regulations 2014. CCA Environmental (Pty) Ltd (CCA) has been appointed by Rhino to undertake a SEIA process to meet the relevant requirements of both the MPRDA and NEMA. Capricorn Marine Environmental (Pty) Ltd has been contracted to undertake the Fisheries Specialist Study required for the SEIA process.

1.2 Project Description

1.2.1 Multi-beam Bathymetry Survey

The proposed multi-beam bathymetry survey would be conducted to provide an accurate measurement of seafloor depth and produce a digital terrain model of the seafloor (see Figure 2). The multi-beam bathymetry survey would be undertaken over the majority of the proposed exploration licence area.

The survey vessel would be equipped with a multi-beam echo sounder to obtain swath bathymetry and a sub-bottom profiler to image the seabed and the near surface geology in the immediate vicinity of each core and test location. The multi-beam system provides depth sounding information on either side of the vessel's track across a swath width of approximately two times the water depth. The multi-beam echo sounder emits a fan of acoustic beams from a transducer at frequencies ranging from 10 kHz to 200 kHz and typically produces sound levels in the order of 207 db re 1µPa at 1m. The sub-bottom profiler emits an acoustic pulse from a transducer at frequencies ranging from 3 kHz to 40 kHz and typically produces sound levels in the order of 206 db re 1µPa at 1m.

It is anticipated that data acquisition would take in the order of 15 to 20 productive days to complete at a vessel speed of 4 knots.

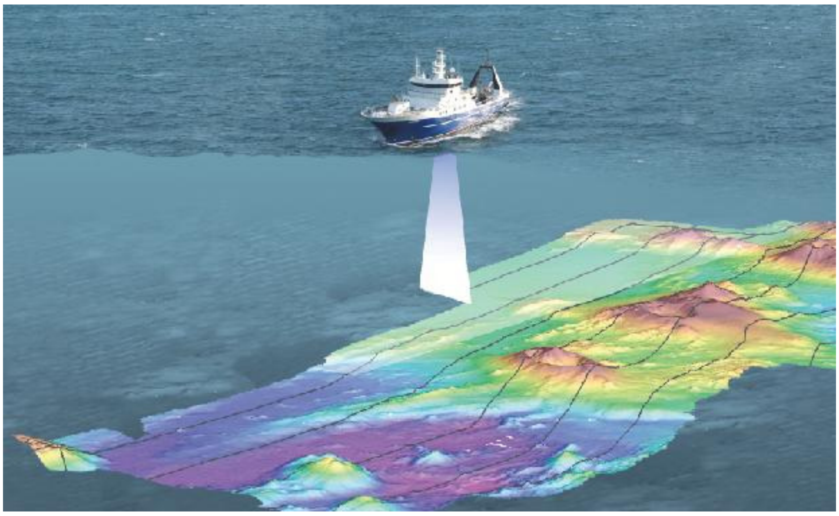

Figure 2: Illustration of a vessel using multi-beam depth/echo sounders (http://www.gns.cri.nz/).

1.2.2 Seismic Surveys

Seismic surveys are carried out during oil and gas exploration activities in order to investigate subsea geological formations. During seismic surveys, high-level, low frequency sounds are directed towards the seabed from near-surface sound sources towed by a seismic vessel. Signals reflected from geological interfaces below the seafloor are recorded by multiple receivers (or hydrophones) towed in a single or multiple streamer (see Figure 3). Analyses of the returned signals allow for interpretation of subsea geological formations.

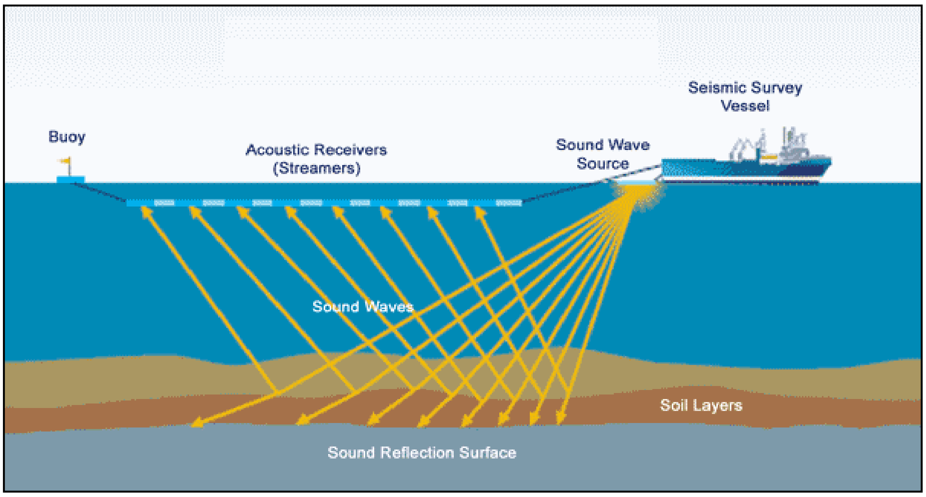

Figure 3: Principles of offshore seismic acquisition surveys (from fishsafe.eu).

Seismic surveys are undertaken to collect either 2D or 3D data. 2D surveys are typically applied to obtain regional data from widely spaced survey grids (tens of kilometres) and infill surveys on closer grids (down to a 1 km spacing) are applied to provide more detail over specific areas of interest. 3D surveys are typically applied to promising petroleum prospects to assist in fault interpretation, distribution of sand bodies, estimates of oil and gas in place and the location of exploration wells.

For this investigation Rhino is proposing to undertake acquisition of a 2D seismic survey within the proposed exploration licence area. However, if it is determined by subsequent analysis of existing data, that acquisition of a seismic dataset utilising 3D seismic techniques might be a more advantageous approach for data collection, then a 3D seismic survey might be substituted for the 2D survey or may be done in addition to the 2D seismic survey.

1.2.3 Extent, duration and timing

The proposed 2D seismic survey would comprise a number of low density spaced survey lines covering the majority of the exploration area (see Figure 4). The proposed 2D seismic survey would be minimum of 200 km in total length. Once the initial 2D survey has been undertaken the data would be analysed. After data analysis further possible target areas may be identified for 3D seismic surveying.

Although survey commencement would ultimately depend on a permit award date, availability of seismic contractors and other factors, it is anticipated that the survey would be undertaken during the summer of 2016/2017 and would take approximately 15 to 20 productive days to complete. The summer period has specifically been selected in order to avoid the main cetacean migration / breeding period from June to December, as well as ensuring optimal sea state and weather conditions.

1.2.4 Survey methodology and airgun array

The seismic vessel would travel along transects of a prescribed grid within the survey area that have been carefully chosen to cross any known or suspected geological structure. During surveying, the seismic vessel would travel at a speed of between four and six knots (i.e. 2 to 3 metres per second).

The seismic survey would involve a towed airgun array, which provides the seismic source energy for the profiling process, and a seismic wave detector system, usually known as a hydrophone streamer. The anticipated airgun and hydrophone array would be dependent on whether a 2D or 3D seismic survey is undertaken. The sound source or airgun array (one for 2D and two for 3D) would be situated some 80 m to 150 m behind the vessel at a depth of 5 m to 25 m below the surface. A 2D survey typically involves a single streamer, whereas 3D surveys use multiple streamers (up to 12 streamers spaced 100 m apart). The array can be up to 12 000 m long. The streamer/s would be towed at a depth of between 6 m and 30 m and would not be visible, except for the tail-buoy at the far end of the cable. A typical 3D seismic survey configuration and safe operational limits are illustrated in Figure 5.

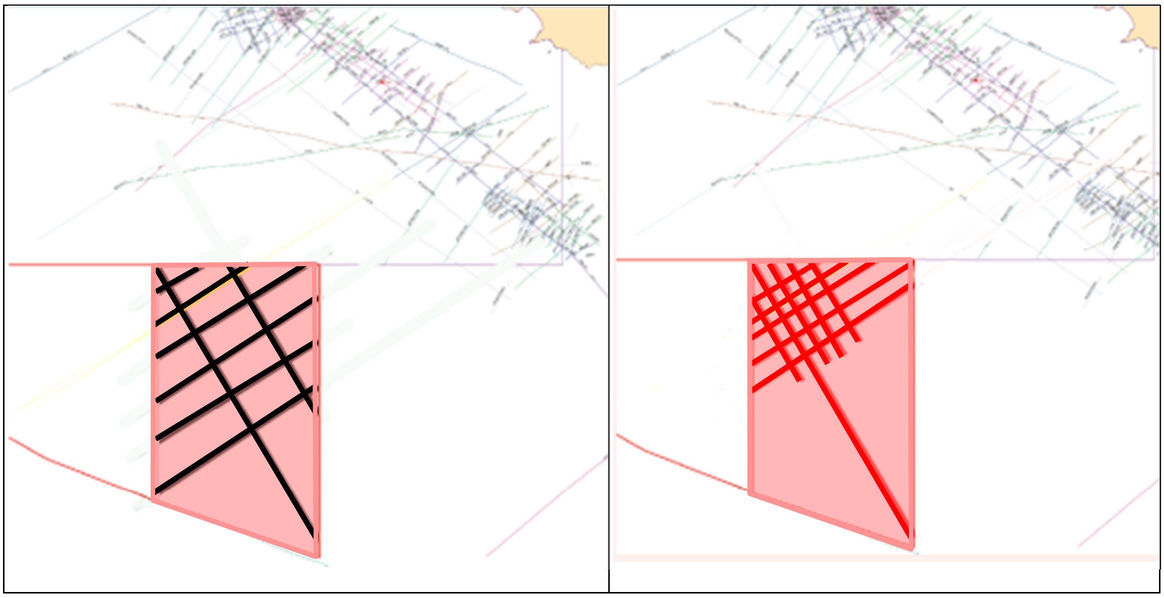

Figure 4: Indicative alternatives for the multi-beam bathymetry and seismic survey lines in the offshore exploration licence area.

1.3 Potential Impacts on Fisheries

1.3.1 Exclusion Zone

Under the Convention on the International Regulations for Preventing Collisions at Sea (COLREGS, 1972), a vessel that is engaged in surveying or towing operations is defined as a "vessel restricted in its ability to manoeuvre" which requires that power-driven and sailing vessels give way to a vessel restricted in its ability to manoeuvre. Vessels engaged in fishing shall, so far as possible, keep out of the way of the seismic survey operation. Furthermore, under the Marine Traffic Act, 1981 (No. 2 of 1981), a vessel (including array of airguns and hydrophones) used for the purpose of exploiting the seabed falls under the definition of an "offshore installation" and as such it is protected by a 500 m safety zone. It is an offence for an unauthorised vessel to enter the safety zone. In addition to a statutory 500 m safety zone a seismic contractor would typically request a safe operational limit (that is greater than the 500 m safety zone) that it would like other vessels to stay beyond. Typical safe operational limits for 2D and 3D surveys are illustrated in Figure 5. Support vessels are usually commissioned as 'chase' boats to ensure that other vessels adhere to the safe operational limits. A standby vessel would also be used to patrol the area to ensure that other vessels adhere to the 500 m safety zone around the survey vessel. The presence of a survey vessel could impact fisheries both through the physical exclusion or displacement of fishing effort as well as through the potential availability of fish resources in the vicinity of the survey.

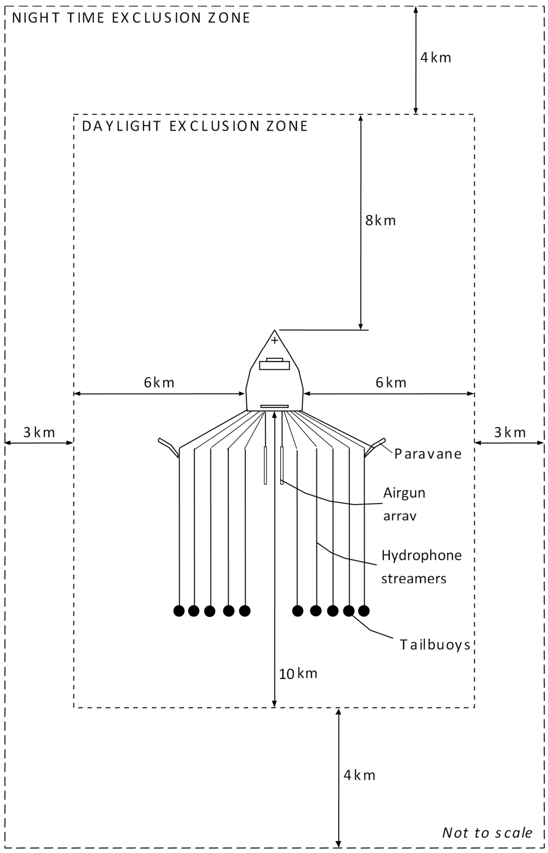

Figure 5: Typical configuration for a 3D seismic survey operation. Safe operational limits applicable to both 2D and 3D surveys are also shown.

1.3.2 **Acoustic Affects**

The acoustic effects of seismic surveys on fish has been reviewed and described in the marine fauna specialist assessment provided by Pisces Environmental Pty Ltd. In summary of this report, acoustic impacts on fish may result in either physiological damage or behavioural responses.

In addition to the potential impacts of exclusion to fishing areas, recent research has shown that seismic survey activity may affect the behaviour and physiology of fish and other marine fauna. Summarised below are some of the main impacts to be considered. Further details are outlined in Appendix 2.

- A range of damaging physical effects due to airgun noise have been described for fish, including swim-bladder damage, transient stunning, short-term stress responses, temporary hearing loss, haemorrhaging, eye damage and blindness . However, studies have shown that physical damage to fish caused from seismic sources occurs only in the immediate vicinity of the airguns, in distances of less than a few meters (Gausland 2003).
- Adult and juvenile fish have been shown to display several behavioural responses to seismic sound. These include leaving the area of the sound source by swimming away and changing depth distribution, changing schooling behaviour and startle responses to short range start up. These responses could affect spawning behaviour and migration patterns and Dalen et al. (1996) concluded that the use of seismic airguns be avoided within 50 km of important spawning or migration areas.
- While adult fish can flee from airgun noise, eggs and larvae area unable to do so and therefore may be affected by the signals. However, it was concluded that the impact of airguns on fish eggs and larvae will account for an insignificant amount of mortality compared to the natural mortality rate per day for most fish species at that life stage (Dalen and Mæsted 2008).

- Behavioural responses to seismic sound could lead to decreased catch rates if fish move out of important fishing grounds (Hirst and Rodhouse 2000). There is little information available on these potential impacts.

1.4 Terms of Reference

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

- Provide a general description of the fishing activities expected in the proposed exploration licence area and along the greater South-West Coast;
- Undertake a spatial and temporal assessment of expected fishing effort and catch in the proposed exploration licence area for each sector identified;
- Assess the risk of the proposed exploration activities on the different fishing sectors;
- Assess the impact of the proposed exclusion zones around the survey vessels and potential flight response of fish on the fishing activities based on the estimated percentage loss of catch and effort; and
- Make recommendations for mitigation measures that could be implemented to minimise or eliminate negative impacts on and enhance any benefits to the fishing industry.

2. DATA SOURCES

Data were sourced from the Department of Agriculture, Forestry and Fisheries (Branch: Fisheries) (DAFF) record of commercial catch and effort for the years 2000 to 2014. All data were referenced to a latitude and longitude position and were redisplayed on a 10x10 minute grid. There is an associated minimal amount of incorrectly-reported data associated with the commercial datasets. Additional information was obtained from the Marine Administration System from DAFF and from the *South Africa, Namibia and Mozambique Fishing Industry Handbook 2015*.

3. SOUTH AFRICAN COMMERCIAL FISHERIES

3.1 Overview

South Africa has a coastline that spans two ecosystems over a distance of 3 623 km, extending from the Orange River in the west on the border with Namibia, to Ponta do Ouro in the east on the Mozambique border. The western coastal shelf has highly productive commercial fisheries similar to other upwelling ecosystems around the world, while the East Coast is considerably less productive but has high species diversity, including both endemic and Indo-Pacific species. South Africa's commercial fisheries are regulated and monitored by DAFF (previously managed under the Department of Environmental Affairs: Directorate: Marine and Coastal Management). All fisheries in South Africa, as well as the processing, sale in and trade of almost all marine resources, are regulated under the Marine Living Resources Act, 1998 (No. 18 of 1998) (MLRA).

Approximately 14 different commercial fisheries sectors currently operate within South African waters (see **Error! Reference source not found.**). In addition to commercial sectors, recreational fishing occurs along the coastline comprising shore angling and small, open boats generally less than 10 m in length. The commercial and recreational fisheries are reported to catch over 250 marine species, although fewer than 5% of these are actively targeted by commercial fisheries, which comprise 90% of the landed catch.

Table 1. South African offshore commercial fishing sectors (TAC = total allowable catch; Source: DAFF)

Sector	Areas of Operation	Main Ports in Priority	Number of Vessels (2015)	Rights Holders (2015)	Landed Catch (2014)
Tuna pole	West Coast, South Coast	Cape Town, Saldanha	128	170	5 300 t
Pelagic long-line	West Coast, South Coast, East Coast	Cape Town, Durban, Richards Bay, Port Elizabeth	31	30	3 317 t
Mid-water trawl	South Coast	Cape Town, Port Elizabeth	6	19	6 317 t
Small pelagics	West Coast, South Coast	St Helena Bay, Saldanha, Hout Bay, Gansbaai, Mossel Bay	101	111	374 962 t
Hake long-line	West Coast, South Coast	Cape Town, Saldanha, Mossel Bay, Port Elizabeth, Gansbaai	64	146	9 798 t
Hake hand-line	West Coast, South Coast	All ports, harbours and beaches around the coast	100	86	non-operational
Traditional line fish	West Coast, South Coast, East Coast	All ports, harbours and beaches around the coast	450	422	6 445 t
Demersal shark long-line	South Coast	Cape Town, Hout Bay, Mossel Bay, Plettenberg Bay, Cape St Francis, Saldanha Bay, St Helena Bay, Gansbaai, Port Elizabeth	6	7	17 t
Hake deep sea trawl	West Coast, South Coast	Cape Town, Saldanha, Mossel Bay, Port Elizabeth	45	49	154 650 t
Hake/ sole inshore trawl	South Coast	Cape Town, Saldanha, Mossel Bay	31	18	6 281 t
West coast rock lobster	West Coast	Hout Bay, Kalk Bay, St. Helena	105	240	1 619 t
South coast rock lobster	South Coast	Cape Town, Port Elizabeth	12	15	774 t
Crustacean trawl	East Coast	Durban, Richards Bay	5	8	175 t
Squid jig	South Coast	Port Elizabeth, Port St Francis	138	121	3 494 t

The primary fisheries in terms of highest economic value and greatest landed tonnage are the demersal (bottom) trawl and long-line fisheries targeting the Cape hakes (*Merluccius paradoxus* and *M. capensis*) and the pelagic-directed purse-seine fishery targeting pilchard (*Sardinops ocellatus)*, anchovy (*Engraulis encrasicolus*) and red-eye round herring (*Etrumeus whiteadii*). Secondary species include a large assemblage of demersal fish of which monkfish (*Lophius vomerinus*), kingklip (*Genypterus capensis*) and snoek (*Thyrsites atun*) are the most commercially important.

Highly migratory tuna and tuna-like species are caught on the high seas and seasonally within the South African Exclusive Economic Zone (EEZ) by the pelagic long-line and pole fisheries. Targeted species include albacore (*Thunnus alalunga*), bigeye tuna (*T. obesus*), yellowfin tuna (*T. albacares*) and swordfish (*Xiphias gladius*).

The traditional line fishery refers to a long-standing fishery based on a large assemblage of primarily 35 different species. The fishery extends both into warm-temperate and cool-temperate biogeographical regions; but operates relatively close to shore. Within the Western Cape the predominant catch species is snoek (*Thyrsites atun*) while other species such as Cape bream (hottentot) (*Pachymetopon blochii)*, geelbek (*Atractoscion aequidens)*, kob (*Argyrosomus japonicus)* and yellowtail (*Seriola lalandi)* are also important. Towards the East Coast the number of catch species increases in number and includes resident reef fish (Sparidae and Serranidae), pelagic migrants (Carangidae and Scombridae) and demersal migrants (Sciaenidae and Sparidae).

Crustacean fisheries comprise a trap and hoop net fishery targeting West Coast rock lobster (*Jasus lalandii*), a line trap fishery targeting the South Coast rock lobster (*Palinurus gilchristi*) and a trawl fishery based solely on the East Coast targeting penaeid prawns, langoustines (*Metanephrops andamanicus* and *Nephropsis stewarti*), deep-water rock lobster (*Palinurus delagoae*) and red crab (*Chaceon macphersoni*).

Other fisheries include a mid-water trawl fishery targeting horse mackerel (*Trachurus trachurus capensis*) predominantly on the Agulhas Bank, South Coast and a hand-jig fishery targeting chokka squid (*Loligo vulgaris reynaudii*) exclusively on the South Coast.

Most commercial fish landings must take place at designated fishing harbours. For the larger industrial vessels targeting hake, only the major ports of Saldanha Bay, Cape Town, Mossel Bay and Port Elizabeth are used. On the West Coast, St. Helena Bay and Saldanha Bay are the main landing sites for the small pelagic fleets. These ports also have significant infrastructure for the processing of anchovy into fishmeal as well as canning of sardine. Smaller fishing harbours on the West / South-West Coast include Port Nolloth, Hondeklip and Laaiplek, Hout Bay and Gansbaai harbours. It has been estimated that there are up to 30 distinct small-scale fishing communities on the South African coastline, ranging in size from small villages to towns. Small-scale fisheries commonly use boats but occur mainly close to the shore. Those occurring along the West Coast of the country target West Coast rock lobster and line-fish species.

3.2 Spawning and Recruitment

The South African coastline is dominated by seasonally variable and sometimes strong currents and most species have evolved highly selective reproductive patterns to ensure that eggs and larvae can enter suitable nursery grounds situated along the coastline. The principle commercial fish species undergo a critical migration pattern in the Benguela and Agulhas ecosystems. The process is as follows (Refer to Figure 6):

- Adults spawn on the central Agulhas Bank in spring (September to November);
- Spawn drifts northwards in the Benguela current across the shelf;
- As eggs drift northwards, hatching takes place followed by larval development;
- Settlement of larvae occurs in the inshore areas, in particular the bays that are used as nurseries. This takes place from October through to Autumn (March onwards); and
- Juveniles shoal and begin a southward migration. This is the main period the anchovy and sardine are targeted by the small pelagic purse seine fishery. The demersal species such as hake migrate offshore into deeper water.

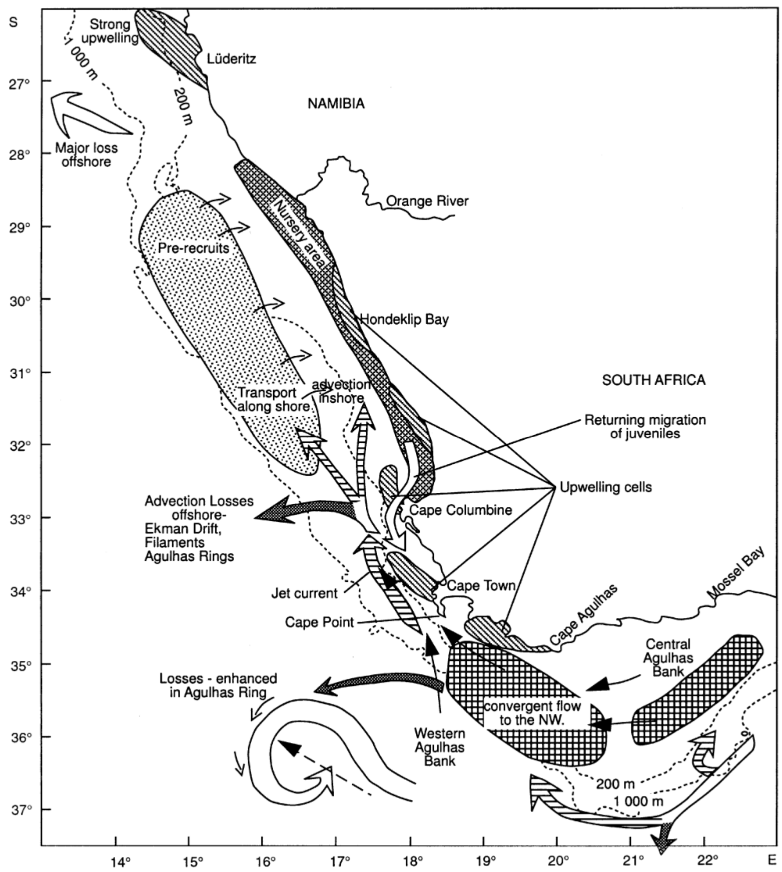

Figure 2. Generalised figure of the main fish recruiting process for species caught on the West Coast of South Africa (after Hutchings et al., 2002). Figure shows the West Coast nursery area and the western/central Agulhas Bank spawning grounds. Light stippled area on the West Coast marks the main recruiting area for the small pelagic fishery and dark stippled area on the Agulhas Bank marks the main spawning grounds for small pelagic fish.

Figures 7 and 8 show the abundance of hake eggs and larvae during September and October, coincident with a peak in spawning during the months of spring, in comparison to a typically lower abundance of hake eggs and larvae during Autumn (Figures 9 and 10).

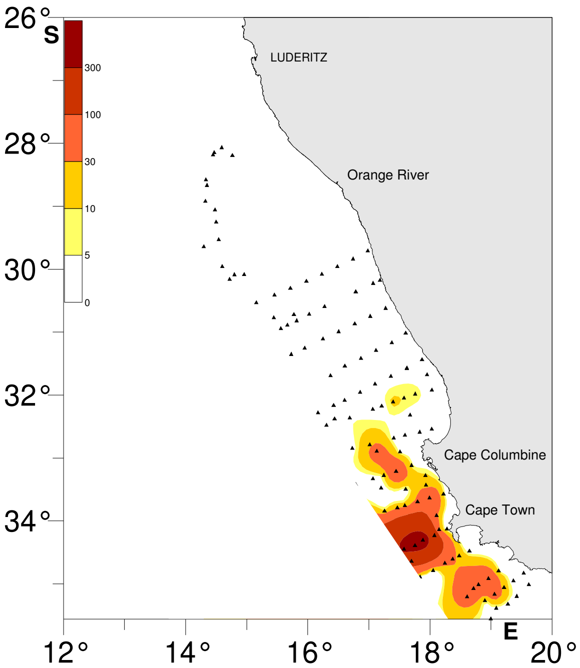

Figure 3. Typical distribution of hake eggs between September and October 2005 (source: Institute of Marine Research Bergen, Norway).

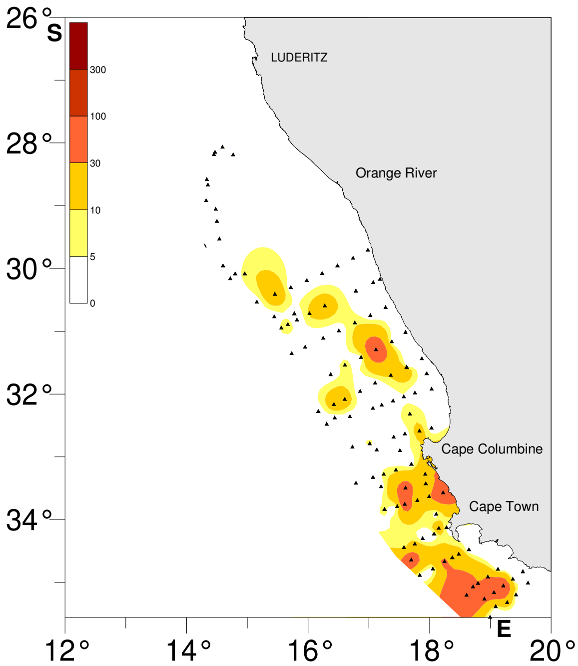

Figure 4. Typical distribution of hake larvae between September and October 2005 (source: Institute of Marine Research Bergen, Norway).

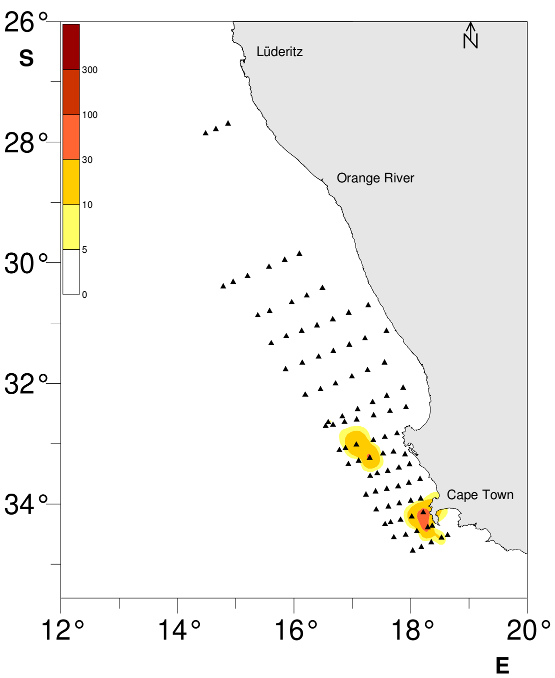

Figure 5. Typical distribution of hake eggs between March and April 2007 (source: Institute of Marine Research Bergen, Norway).

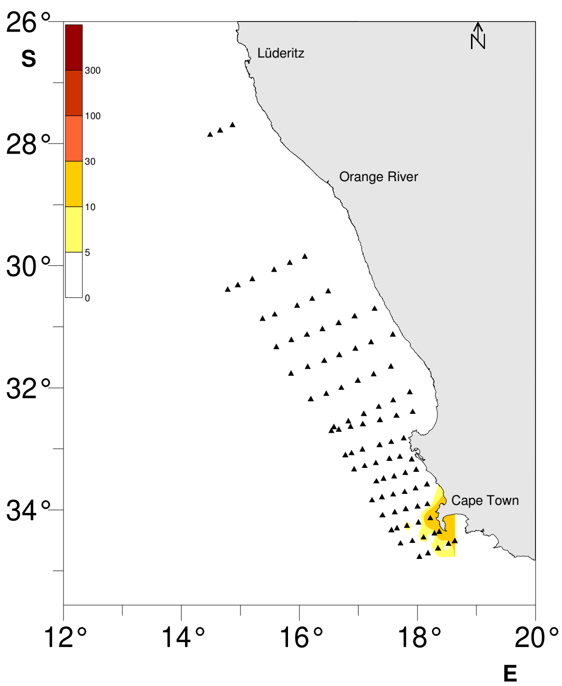

Figure 6. Typical distribution of hake larvae between March and April 2007 (source: Institute of Marine Research Bergen, Norway).

The fisheries sectors which are active in the vicinity and inshore of the proposed survey area are addressed further in the current report, *viz*;

1. Demersal trawl;
2. Demersal long-line;
3. Large pelagic long-line;
4. Tuna pole;
5. Traditional line-fish;
6. Small pelagic purse-seine; and
7. West Coast rock lobster sectors.

3.3 Demersal Trawl

The hake-directed trawl fishery is the most valuable sector of the South African fishing industry and is split into two sub-sectors: the offshore ("deep-sea") sector which is active off both the South and West Coasts, and the much smaller inshore trawl sector which is active off the South Coast. The fishery targets the Cape hakes (*Merluccius capensis* and *M. paradoxus*). Main by-catch species include monkfish (*Lophius vomerinus*), kingklip (*Genypterus capensis)* and snoek (*Thyrsites atun*). The current (2015) annual Total Allowable Catch (TAC) of hake across all South African fisheries sectors targeting hake is 147 500 tons, most of which is landed by the demersal trawl sector. The landings of hake by the demersal trawl offshore and inshore sectors over the period 1990 to 2013 is presented in Figure 11.

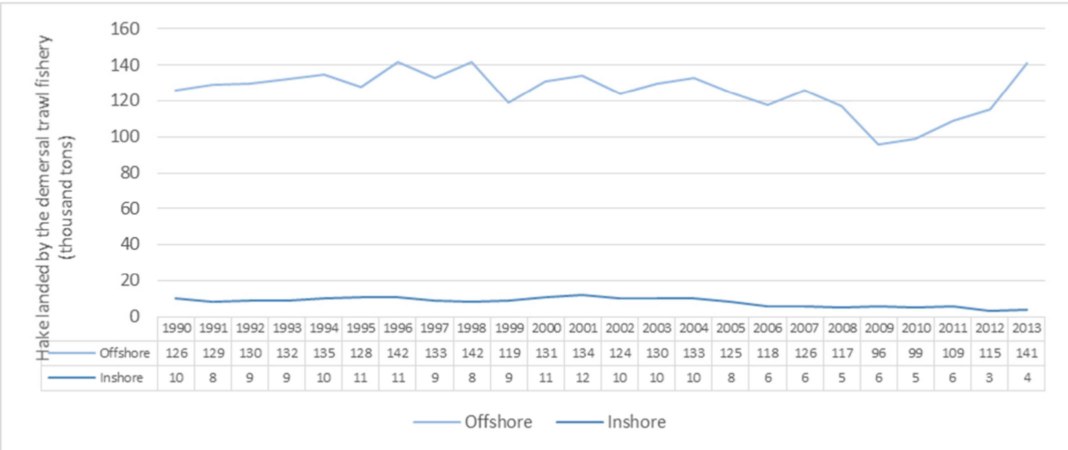

Figure 7. Landing of hake by the offshore and inshore demersal trawl fleets between 1990 and 2013.

Trawls are usually conducted along specific trawling lanes on "trawl friendly" substrate (flat, soft ground). The total trawl footprint within the South African EEZ is approximately 70 400 km^2 of which offshore grounds amount to 57 420 km^2 and inshore grounds 12 983 km^2 (SADSTIA, 2009). On the West / South-West Coast, these grounds extend in a continuous band along the shelf edge between the 300 m and 1 000 m bathymetric contours[1]. Trawl nets are generally towed along depth contours (thereby maintaining a relatively constant depth), running parallel to the depth contours in a north-westerly or south-easterly direction. Trawlers also target fish aggregations around bathymetric features, in particular seamounts and canyons (i.e. Cape Columbine and Cape Canyon), where there is an increase in seafloor slope. In these cases the direction of trawls also follows the depth contours. Trawlers are prohibited from operating within five nautical miles of the coastline.

[1] Trawling to these depths started in the mid 1990's for deep-water species such as orange roughy.

3.4 Demersal Long-Line

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 hake long-line fishery targeting the Cape hakes (*M. capensis* and *M. paradoxus*) and the shark long-line sector targeting only demersal species of shark. A demersal long-line vessel may deploy either a double or single line which is weighted along its length to keep it close to the seafloor (see Figure 12). Lines are typically between 10 km and 20 km in length, carrying between 6 900 and 15 600 hooks each. Long-line vessels vary in length from 18 m to 50 m and remain at sea for four to seven days at a time. Currently 64 hake-directed and six shark-directed vessels are operational within the fishery, most of which are based at Cape Town and Hout Bay harbours.

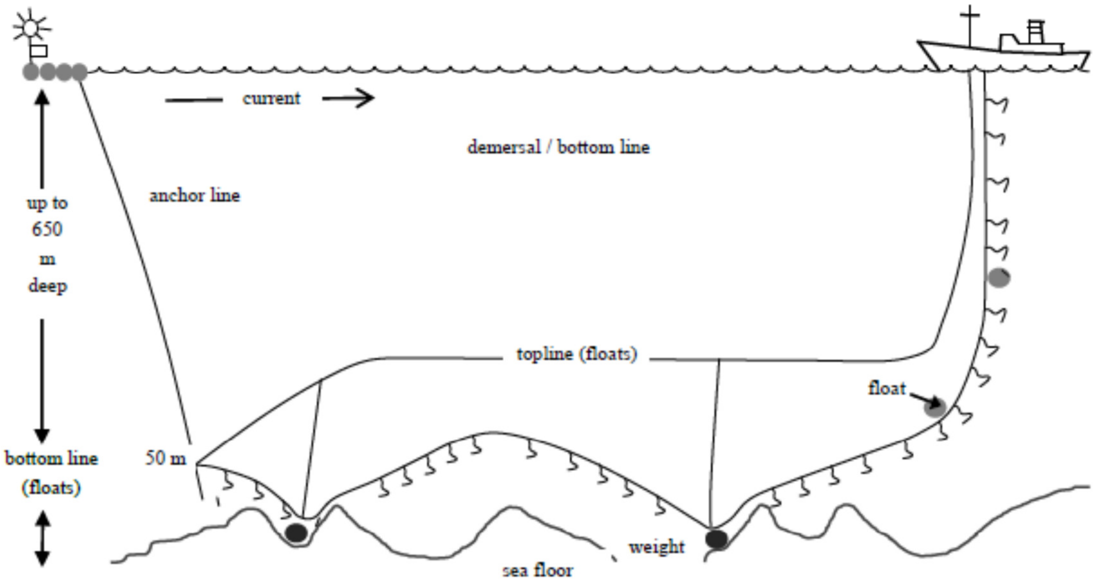

Figure 82. Typical configuration of demersal (bottom-set) hake long-line gear used in South African waters.

3.2.1 Demersal Hake-Directed Long-line Fishery

Like the demersal trawl fishery, the target species of the long-line fishery is the Cape hakes, with a small non-targeted commercial by-catch that includes kingklip. The catch landed is predominantly prime quality hake for export to Europe and is packed unfrozen on ice, which gives a value that is approximately 50% higher than that of trawled hake. Operations take place throughout the year with a slight increase in activity between August and December but tend to be *ad hoc* and intermittent, depending on market demand. The catch taken by the long-line fleet in 2014 amounted to 9 798 tons. Demersal long-line fishing grounds are similar to those targeted by the hake-directed trawl fleet. Lines are set parallel to bathymetric contours, along the shelf edge up to the 1 000 m isobath.

3.3.2 Demersal Shark-Directed Fishery

Capture of demersal shark species occurs primarily in the demersal shark long-line fishery whilst the large pelagic sector that targets tuna and swordfish catches pelagic shark species. Prior to 2006, both demersal and pelagic shark catches were managed as a single shark fishery but are now split in to the two sectors. The demersal shark fishery targets soupfin shark (*Galeorhinus galeus*), smooth-hound shark (*Mustelus spp*), spiny dogfish (*Squalus* spp), St Joseph shark (*Callorhinchus capensis*) and *Charcharhinus* spp., rays and skates. Other species that are not targeted but may be landed include cape gurnards (*Chelidonichthys capensis*), jacopever (*Sebastichthys capensis*) and smooth hammerhead shark (*Sphyrna zygaena*). The fishery operates within coastal waters and catches are landed at the harbours (from north to south) of St Helena Bay, Saldanha Bay, Cape Town, Hout Bay, Gansbaai, Mossel Bay, Plettenberg Bay, Cape St Francis, and Port Elizabeth.

There are currently six permit holders that have been issued with long-term rights to operate within the fishery. The fishery was first formerly introduced with the allocation of medium-term fishing rights in 2002. With only six rights allocated and vessels limited in size, fishing effort has remained relatively low. The fishery reported an annual average of 430 500 hooks set and 175 tons landed annually over the period 2007 to 2012. Effort is continuous throughout the year with an increase between May and October. The fishery operates in coastal waters, predominantly inshore of the 150 m isobath.

3.5 Large Pelagic Long-Line

The large pelagic long-line fishery operates extensively within the South African EEZ targeting primarily tuna and swordfish. The main target species is yellowfin tuna (Figure 13) with a high by-catch of blue shark (Figure 14). Catch composition, by weight, is presented in Figure 15.

Figure 13. Yellowfin tuna *Thunnus albacares* is the principle target species in the pelagic longline fishery.

Figure 14. Blue shark *Prionace glauca*

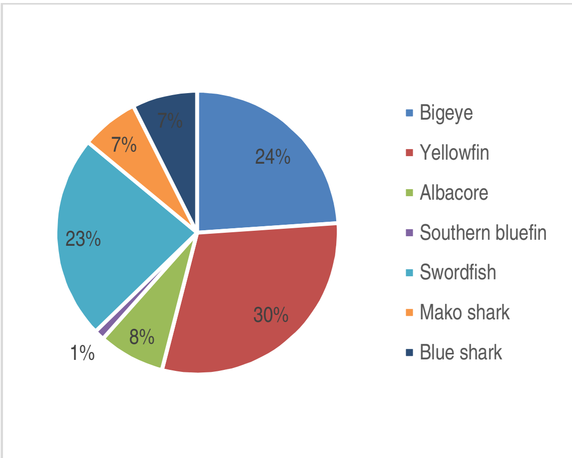

Figure 15: Species composition of catch landed by the large pelagic longline fishery (2000 - 2014).

Tuna, tuna-like species and billfishes are migratory stocks and are therefore managed as a "shared resource" amongst various countries under the auspices of the International Convention for Conservation of Atlantic Tunas[2] (ICCAT) for fishing in the Atlantic (west of Cape Agulhas). In the 1970s to mid-1990s the fishery was exclusively implemented by Asian fleets (up to 130 vessels) under bilateral agreements with South Africa. From the early 1990s those vessels were banned from South African waters and South Africa went through a period of low effort as fishing rights issues were resolved under the new arrangement. Thereafter a domestic fishery developed and 50 fishing rights were allocated to South Africans only. These rights holders now include a small fleet of local long-liners although the fishery is still undertaken primarily with Japanese vessels fishing in joint venture with South African companies. There are currently 30 commercial large pelagic fishing rights issued for South African waters and 31 vessels active in the fishery. During the

[2] https://www.iccat.int/en/

period 2000 to 2014, the national catch and effort recorded within the large pelagic fishery amounted to an average of 4 527 tons and 3.55 million hooks set per year. Annual landings fluctuate (Figure 16) according to environmental variables. The fishery operates year-round with an increase in effort during winter and spring (see Figure 17).

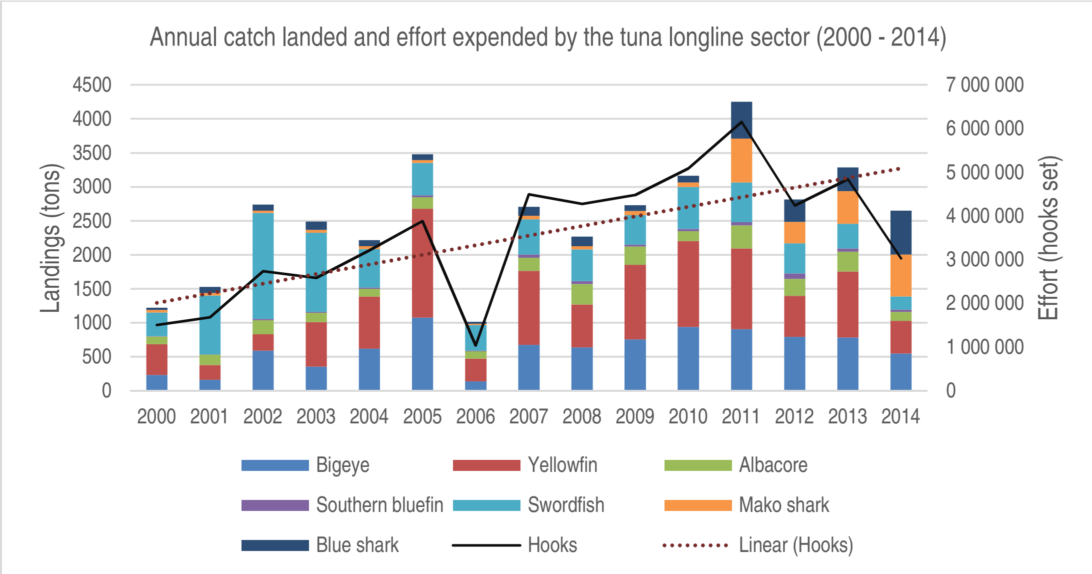

Figure 16: Annual catch landed and effort expended by the large pelagic longline sector (2000 - 2014).

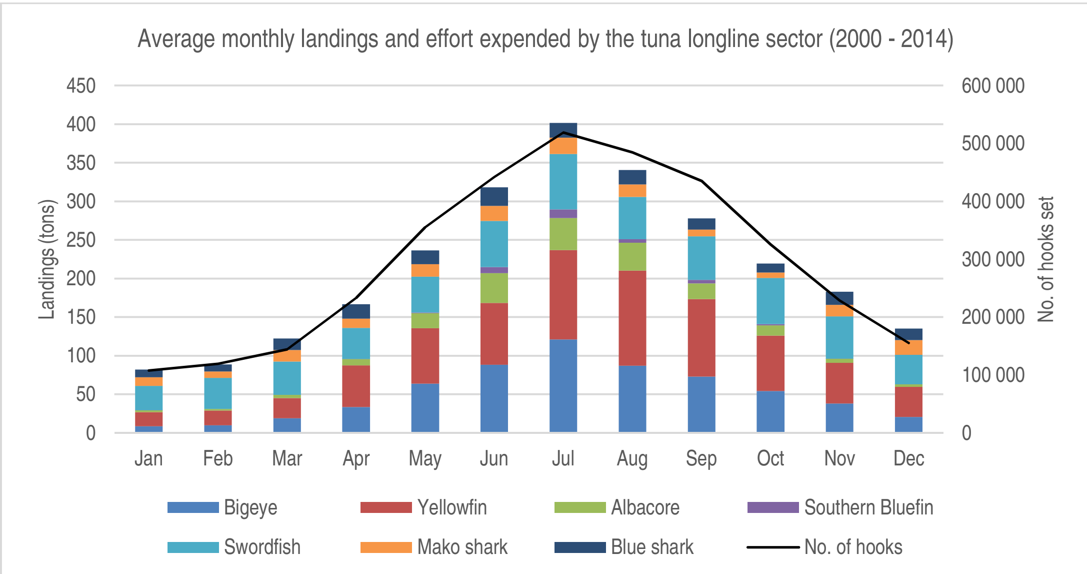

Figure 17. Average monthly landings and number of hooks set by the large pelagic longline fishery (2000 – 2014).

Historically, the fishery operates year-round from the continental shelf break into deeper waters. Catch per unit effort (CPUE) variations are driven by both the availability of fish (the spatial and temporal distribution of the target species) and the vulnerability of the target fish species to the gear used by the fishery (i.e. the catchability). The CPUE can also be influenced by changes in the behaviour of the target species. These changes in behaviour are driven by variability in environmental factors such as oceanic thermal structure and dissolved oxygen (Punsly and Nakano, 1992). Feeding behaviour may vary depending on light level, temperature, and abundance of natural prey **(**Engås and Løkkeborg, 1994; Sigler, 2000). The catchability of a target species also varies depending on the presence of conspecifics and the associated density and size distribution of competitors.

Vessels range from 30 m to 54 m in length. Gear consists of monofilament mainlines of between 25 km and 100 km in length which are suspended from surface buoys and marked at each end (see Figure 18 and Figure 19). The main fishing line is normally suspended 20 m below the water surface via droppers connecting it to surface buoys at regular intervals. Baited hooks are attached to the mainline via 20 m long trace lines, thereby targeting fish at a depth of 40 m below the surface. Up to 3 500 hooks may be set per line. Lines are usually set at night, with hauling commencing the next morning. Various types of buoys are used in combinations to keep the mainline near the surface and locate it should the line be cut or break for any reason. Each end of the line is marked by a Dahn Buoy and radar reflector, which marks the line position for later retrieval. A line may be left drifting during the night before retrieval by means of a powered hauler at a speed of approximately one knot. During hauling, vessel manoeuvrability is severely restricted and, in the event of an emergency, the line may be dropped and hauled in at a later stage. A photograph of a typical high seas long-line vessel is shown in Figure 20.

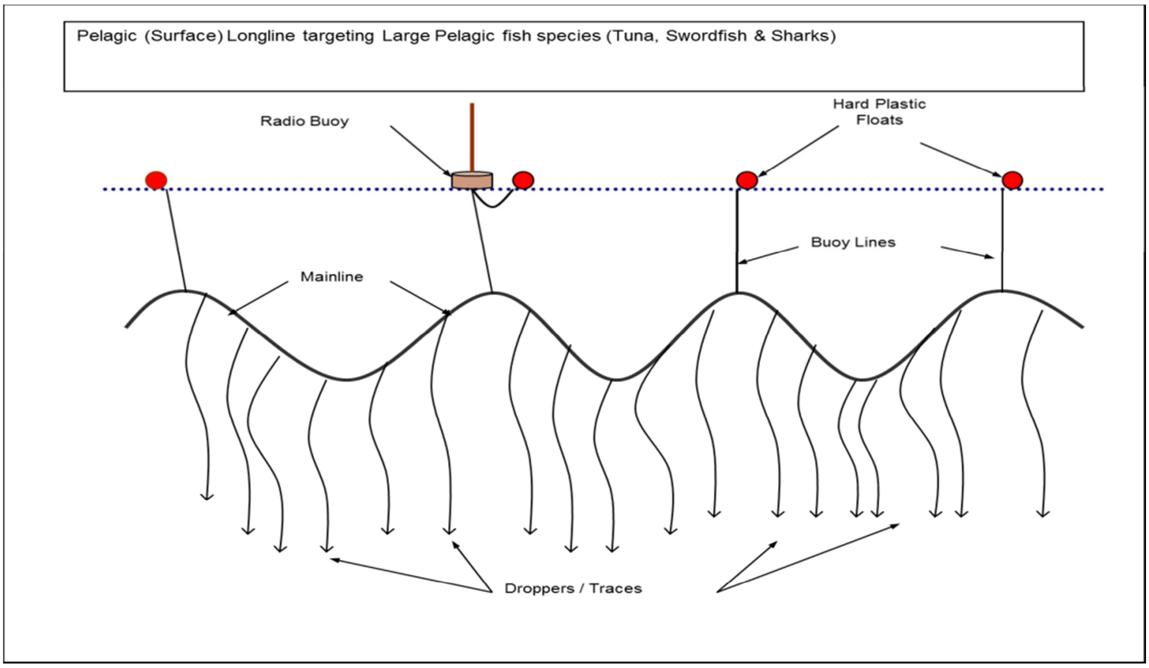

Figure 18. Typical pelagic long-line gear configuration targeting tuna, swordfish and shark species. Note: gear floats close to the surface of the sea and would present a potential obstruction to surface navigation.

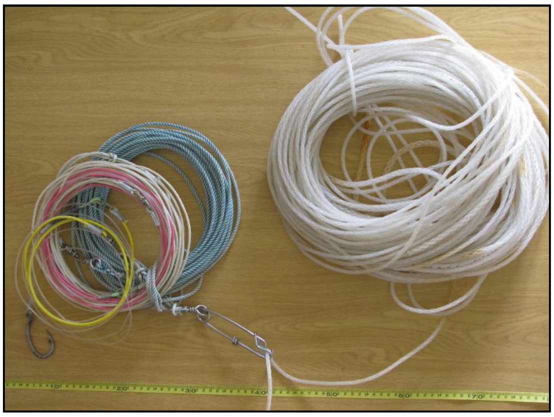

Figure 19. Photograph of a mainline (braided monofilament, right) with a dropper line and trace typically used by the pelagic long-line fishery (left).

Figure 20. A typical high seas longline vessel

3.6 Tuna Pole

Poling for tuna is predominantly based on the southern Atlantic longfin tuna stock also referred to as albacore (*T. alalunga* – Figure 21). Other catch species include yellowfin tuna, bigeye tuna, skipjack tuna (*Katsuwonus pelamis* – Figure 22), snoek and yellowtail.

The South African fleet consists of approximately 128 pole-and-line vessels which are based at the ports of Cape Town, Hout Bay and Saldanha Bay. 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 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 also 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 these 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 23).

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. 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 however they may deploy drogues at night in fair weather conditions in order to remain within a favoured area.

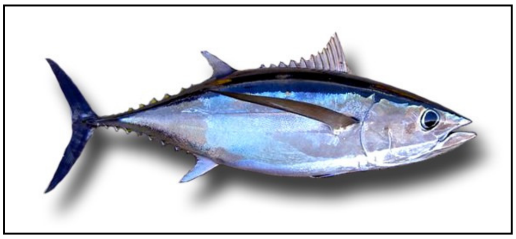

Figure 21: Longfin tuna *Thunnus alalunga* (Source: http://www.wwfsassi.co.za/)

Figure 22: Skipjack tuna *Katsuwonus pelamis*

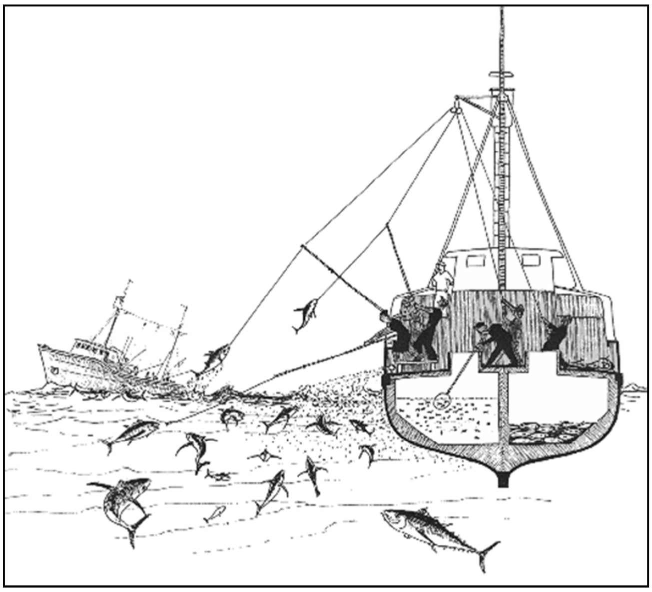

Figure 23: Schematic diagram (left) and photography (right) of pole and line operation (Source: www.fao.org/fishery).

Catch composition varies according to the time of year and area fished. Figure 24 shows the generalised species composition of catch by weight with 79% of total landings comprising albacore and 12% yellowfin tuna. Snoek comprises 7% and the remaining species make up 2% of the total catch. The 2014 TAC for the South African tuna pole fishery (albacore) was set at 4 400 tons of which 3 620 tons were landed. See Figure 25 for the tuna pole catches by year from 2003 to 2014. The average weight of albacore landed over this period was 3 371 tons per year with the proportion of albacore ranging from 72% to 91% of the total catch landed by the fishery. Effort is measured as the number of days during which fishing took place. This was reported as approximately 5500 days per year over the period 2003 to 2014. Note that there is a trend of gradually decreasing effort since 2003 although catches have been sustained. From month to month the expenditure of effort within the sector is highly variable (see Figure 26). The fishery is seasonal with vessels active predominantly between November and May and peak catches recorded from November to January. 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 which 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. Fishing activity occurs along the entire West Coast beyond the 200 m isobath. Activity would be expected to occur along the shelf break with favoured fishing grounds including areas north of Cape Columbine and between 60 km and 120 km offshore from Saldanha Bay.

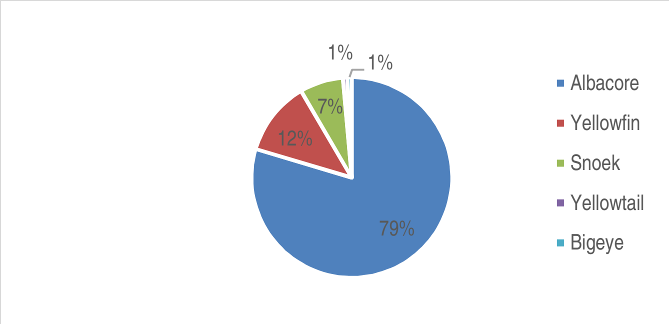

Figure 24: Pie chart showing species composition by weight of catch landed by the tuna pole sector (2003 - 2014).

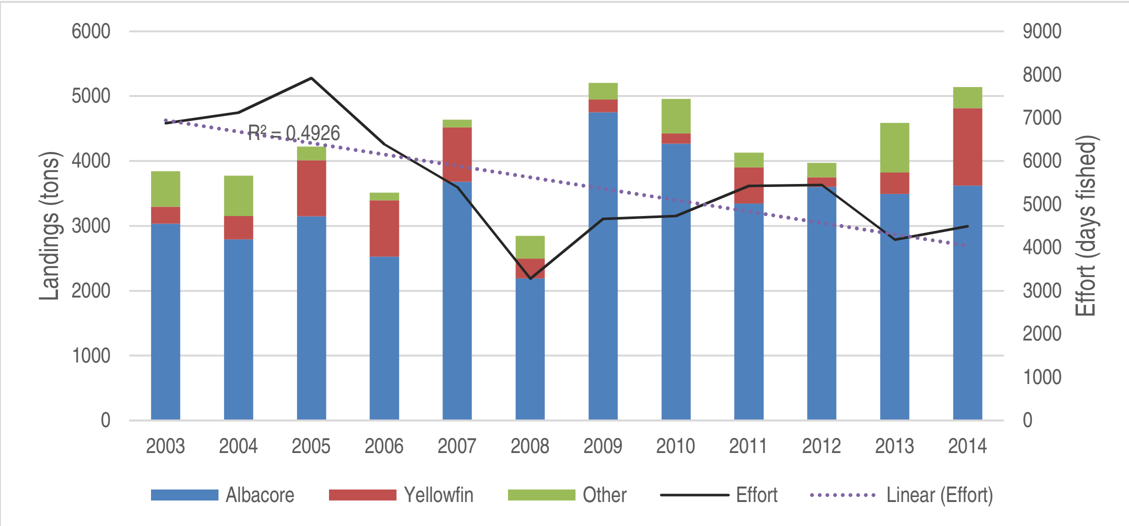

Figure 25: Annual landings (tons) recorded for the tuna pole fishery between 2003 and 2014. Effort over the same period is shown as total number of days fished.

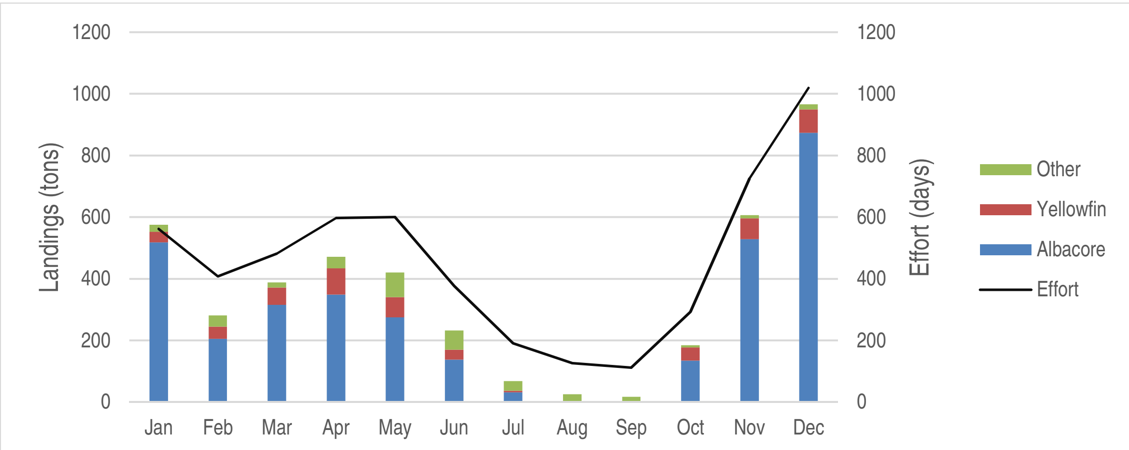

Figure 26: Average monthly catch landed (tons) by the tuna pole fishery between 2003 and 2014. Effort is shown as total number of days fished each month.

3.7 Traditional Line-Fish

The South African commercial line fishery is the country's third most important fishery in terms of landed volume and economic value. The majority of the fishery catch is made up of about 35 different species of reef fish as well as pelagic and demersal species which are mostly marketed locally as "fresh fish". The fishery is widespread across the country's shoreline from Port Nolloth on the West Coast to Cape Vidal on the East Coast and includes both cool temperate and warm-temperate biogeographic regions. Effort is managed geographically with the spatial effort of the fishery divided into three zones. The fishery includes commercial, subsistence and recreational sectors[3]. Up to 3 000 boats are involved in the fishery on the national level, 450 of which are involved in the commercial fishery and range in size from 3 m beach-launched dinghy's to 20 m harbour-based vessels that may remain at sea for up to 30 days (Mann, 2000). The fishery operates year-round and reported landings of 6 445 tons during 2014. Records of fishing activity off the West Coast of South Africa are predominantly coastal, up to the 200 m isobath. Fishing vessels generally range up to a maximum of 40 nm offshore, although fishing at the outer limit and beyond this range does occur but sporadically (C. Wilke, pers. comm[4]).

3.8 Small Pelagic Purse-Seine

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 variability in the upwelling ecosystem in which they exist. The two main targeted species are sardine and anchovy, with associated by-catch of round herring (red-eye) and juvenile horse mackerel. The fishery for sardine commenced off South Africa during the 1930s but only underwent major development following World War II (Beckley and van der Lingen 1999). Catches peaked at around 400 000 tons during the early-1960s and then declined rapidly to around 50 000 tons, with anchovy becoming the mainstay of the fishery. Sardine catches started to rise from the early-1990s following an increase in sardine biomass and cautious management and peaked again at 365 000 tons in 2004, before again showing a rapid decline. Annual landings have fluctuated between 300 000 and 600 000 tons over the last decade[5] (see Figure 27). Over the period 2000 to 2014, landings have averaged at 444 000 tons (all species). During 2014 the fishery landed 375 000 tons. The fishery operates throughout the year with a short break from mid-December to mid-January[6]. The geographical distribution and intensity of the fishery is largely dependent on the seasonal fluctuation and distribution of the targeted species.

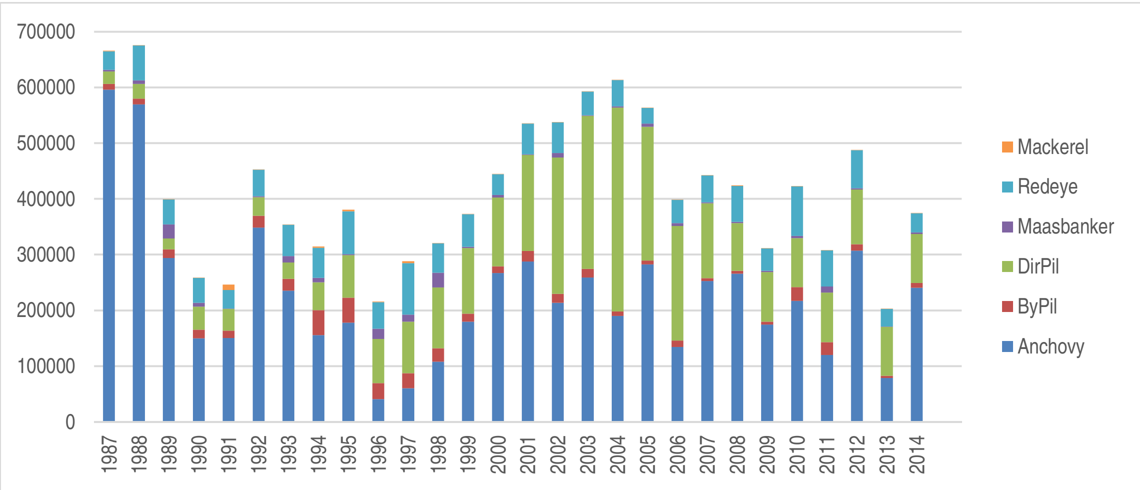

Figure 27: Total weight of catch landed by the small pelagic fishery from 1987 to 2014.

[3] Note: These fisheries are not artisanal in nature.
[4] Mr C. Wilke (christopherW@daff.gov.za) is the chief technician at DAFF for 35 years and is the principle contact for line-fish data collation.
[5] 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.
[6] The fishery has traditionally "rested" in December and early January primarily to reduce impact on juvenile sardine.

The fishery operates primarily along the west and south coasts of the Western Cape and the Eastern Cape coast up to a maximum distance of 100 km offshore, but usually closer inshore. Most of the effort in the sardine-directed fleet occurs from Lambert's Bay south past Saldanha and Cape Point and then eastwards along the coast to Mossel Bay and Port Elizabeth. The anchovy-directed fishery is active mainly between Lambert's Bay and Kleinbaai on the south-west coast of the country. Fishing for redeye takes place mainly from Lambert's Bay to south of Cape Point. A fleet of 101 vessels operate from St Helena Bay, Laaiplek, Saldanha Bay and Hout Bay 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.

3.9 West Coast Rock Lobster

The West Coast rock lobster (*J. lalandii*) is a slow-growing, long-lived species which occurs inside the 200 m depth contour along the entire West Coast from Walvis Bay in Namibia to East London on the East Coast. The fishery is divided into the offshore fishery and the near-shore fishery, both of which take place inshore of the 100 m isobath. Effort is seasonal with boats operating from the shore and coastal harbours. Catch is landed whole and is managed using a TAC, approximately 80% and 20% of which is allocated to the offshore and near-shore fisheries, respectively. The catch of West Coast rock lobster peaked at 18 000 tons in the early 1950s but has declined drastically since then, falling from nearly 6 000 tons in the late 1970s to the current levels of about 2 000 tons per year. The overall TAC for the 2015/16 fishing season has been set at 1924 tons, with 1243 tons and 376 tons apportioned to the commercial offshore and near-shore subsectors, respectively. The TAC apportioned for the subsistence (small-scale/interim relief) subsector, was set at 235 tons. The apportionment for the recreational fishing subsector is 69 tons or four west coast rock lobsters per person per day for the duration of the fishing season.

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 fishery operates seasonally, with closed seasons applicable to different zones.

3.10 Fisheries Research

Swept-area trawl surveys of demersal fish resources are carried out twice a year by DAFF in order to assess the stock abundance indices used to set the annual TACs for demersal fisheries. First started in 1985, the West Coast survey extends from Cape Agulhas (20°E) to the Namibian maritime boarder and takes place over the duration of approximately one month during January. The survey of the Southeast coast (20°E – 27°E longitude) takes place in April/May. 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. Trawl positions are randomly selected to cover specific depth strata that range from the coast to the 1 000 m isobath. Approximately 120 trawls are conducted during each survey and the location of these trawls is pre-determined usually a week before the cruise is scheduled to take place.

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. The timing of the demersal and acoustic surveys is not flexible, due to restrictions with availability of the research vessel as well as scientific requirements. During these surveys the survey vessels travels pre-determined transects (perpendicular to bathymetric contours) running offshore from the coastline to approximately the 200 m isobath. The survey is designed to cover an extensive area from the Orange River on the West Coast to Port Alfred on the East Coast and the DAFF survey vessel progresses systematically from the Northern border Southwards, around Cape Agulhas and on towards the East.

4. IMPACT ASSESSMENT

4.1 Methods

A number of international studies have reported reductions in catch rates of fish during and after seismic surveys (refer to Appendix 2 – Table 1). The observed declines in catch rates differed considerably from study to study and also according to species and gear type in the same areas and events. The method used here was as follows:

1) Studies demonstrate that seismic surveys are likely to lead to a reduction in catch rates not only in the immediate vicinity of the airgun but also in a wider area around it. Estimates of the distance from the airgun at which a decline in catch rates was observed, the duration of that impact and the magnitude of the impact (percentage reduction in catch rate) varied considerably between the examples reported. It was therefore decided to develop three scenarios of potential impact based on the information presented in Appendix 2 - Table 1. The details of each scenario are shown in Table 2.

Table 2: Details of three scenarios used to estimate potential impacts of the Rhino exploration on catches of fish by fisheries.

Factor	Scenario 1	Scenario 2	Scenario 3
Radius of impact (km)	0	9	33
Duration of impact (days)	0	5	10
Magnitude of impact (% decline in catch)	0	40	83 (pelagic fisheries) 50 (demersal fisheries)

2) The area that would be impacted under these different scenarios was estimated by adding the radius of impact to the proposed offshore exploration licence area.

3) The actual catches taken in the impact areas, under scenarios 1 and 2, were extracted from the DAFF data base (which includes the latitude and longitude for each fishing event) for a period of at least four years, the most recent for which a full year's data were available. The average catches for a full year were extracted and summed.

4) The potential reduction in catches was estimated as:

$$Ci = CT \times \left(\frac{Di}{Dt}\right) \times (\frac{Mi}{100})$$

where

Ci = catch potentially lost as a result of survey (tonnes)
CT = total catch recorded as taken in the impact area during fishing period (tonnes)
Di = duration of impact (5 or 10 days)
Dt = total days fished during fishing period (dependent on seasonality of fishery)
Mi = magnitude of impact (%)

4.2 Demersal Trawl

Impact on Operations (Exclusion Zone)

The demersal trawl fishery operates extensively around the South African coastline. On the west coast, vessels trawl along depth contours, predominantly along the 500 m isobaths but ranging between the 200 m and 1000 m isobaths (see Figure 28). The offshore exploration licence is situated at least 70 km from trawling grounds, thus there is no spatial overlap and **no impact** expected from the proposed survey operations on the demersal trawl sector. The degree of confidence in the assessment is high.

Impact on Catch Availability (Acoustic Impact)

A number of international studies have reported reductions in catch rates of fish during and after seismic surveys (refer to Appendix 2 – Table 1). The observed declines in catch rates differed considerably from study to study and also according to species and gear type in the same areas and events. A reduction in catch of a demersal species (cod in Norway) has been shown at varying distances of up to 33 km from the seismic source (Dalen et al. 2007). Trawl catches of cod and haddock and line catches of haddock reduced by 50% within an area of up to 33 km from the seismic source and effects lasted for at least five days (Engås *et al.*, 1996). Note that, to date, no studies have been carried out on the effects of seismic surveys on the behaviour of South African hake and the studies summarised above have been presented as indicative potential scenarios. Since the offshore exploration licence area is situated at least 70 km from trawling grounds, there is expected to be **no impact** of the proposed surveys on catch available to the demersal trawl sector.

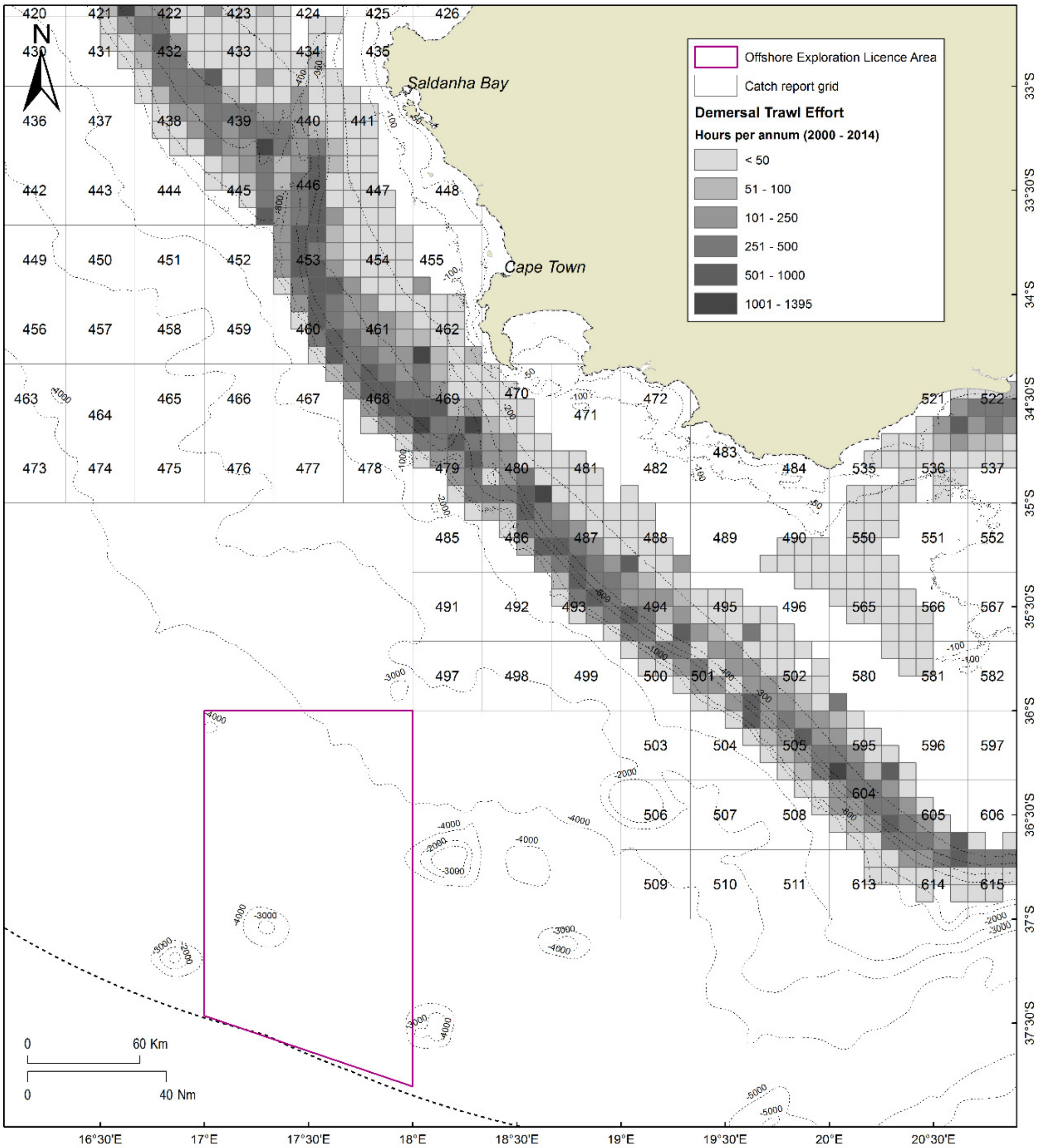

Figure 28. Spatial distribution of trawling effort expended by the South African hake-directed trawl sector in relation to the offshore exploration licence area (2000 – 2014). Annual effort is displayed as the number of hours fished on a 5' x 5' grid resolution. The demersal grid reference system (20' x 20') is also shown.

4.3 Demersal Long-Line

4.3.1 Hake-Directed

Impact on Operations (Exclusion Zone)

The demersal hake-directed long-line fishery operates in areas similar to those utilised by the demersal trawl sector. Demersal long-line grounds do not coincide with the proposed offshore exploration licence area (see Figure 29). Thus there is no spatial overlap and **no impact** expected from the proposed survey operations on the demersal long-line sector. The degree of confidence in the assessment is high.

Impact on Catch Availability (Acoustic Impact)

Since the offshore exploration licence area is situated at least 70 km from demersal long-line grounds, there is no expected impact of the proposed survey on catch available to the sector.

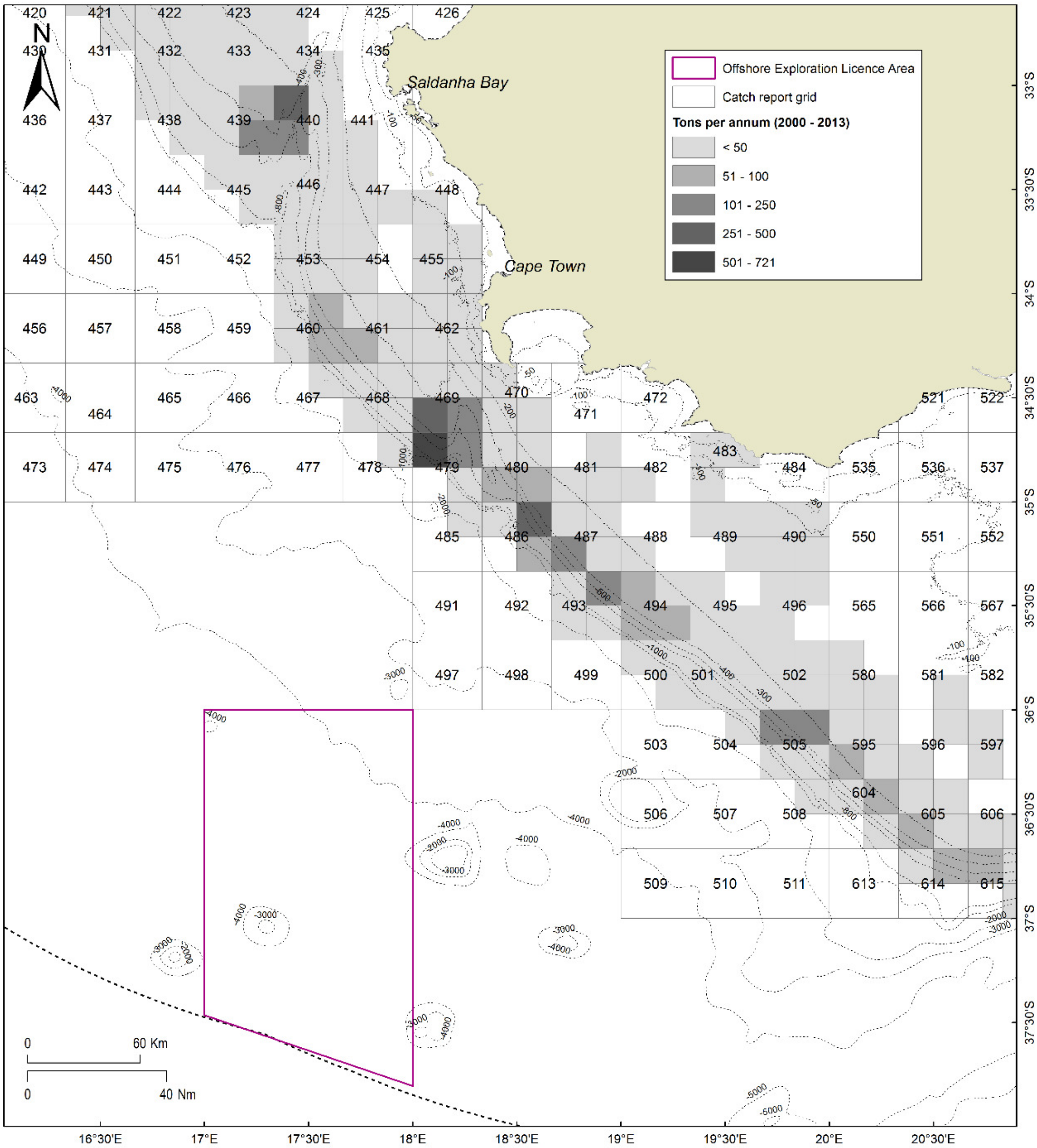

Figure 29. Spatial distribution of catch landed by the South African hake-directed demersal long-line fishery (2000 – 2013) in relation to the offshore exploration licence area. Annual catch is displayed in tons on a 10' x 10' grid resolution and the demersal grid reference system (20' x 20') is also shown.

4.3.2 Shark-Directed

Impact on Operations (Exclusion Zone)

The demersal shark-directed long-line fishery is a coastal fishery, operating predominantly in waters shallower than 150 m in depth. Demersal shark long-line grounds are situated at least 150 km inshore of the proposed offshore exploration licence area (see Figure 30). There is therefore no spatial overlap and **no impact** expected from the proposed survey operations on the shark-directed demersal long-line sector. The degree of confidence in the assessment is high.

Impact on Catch Availability (Acoustic Impact)

Due to the distance of the offshore exploration licence area from fishing grounds, there is expected to be **no impact** of the proposed surveys on catch available to the shark-directed demersal long-line sector.

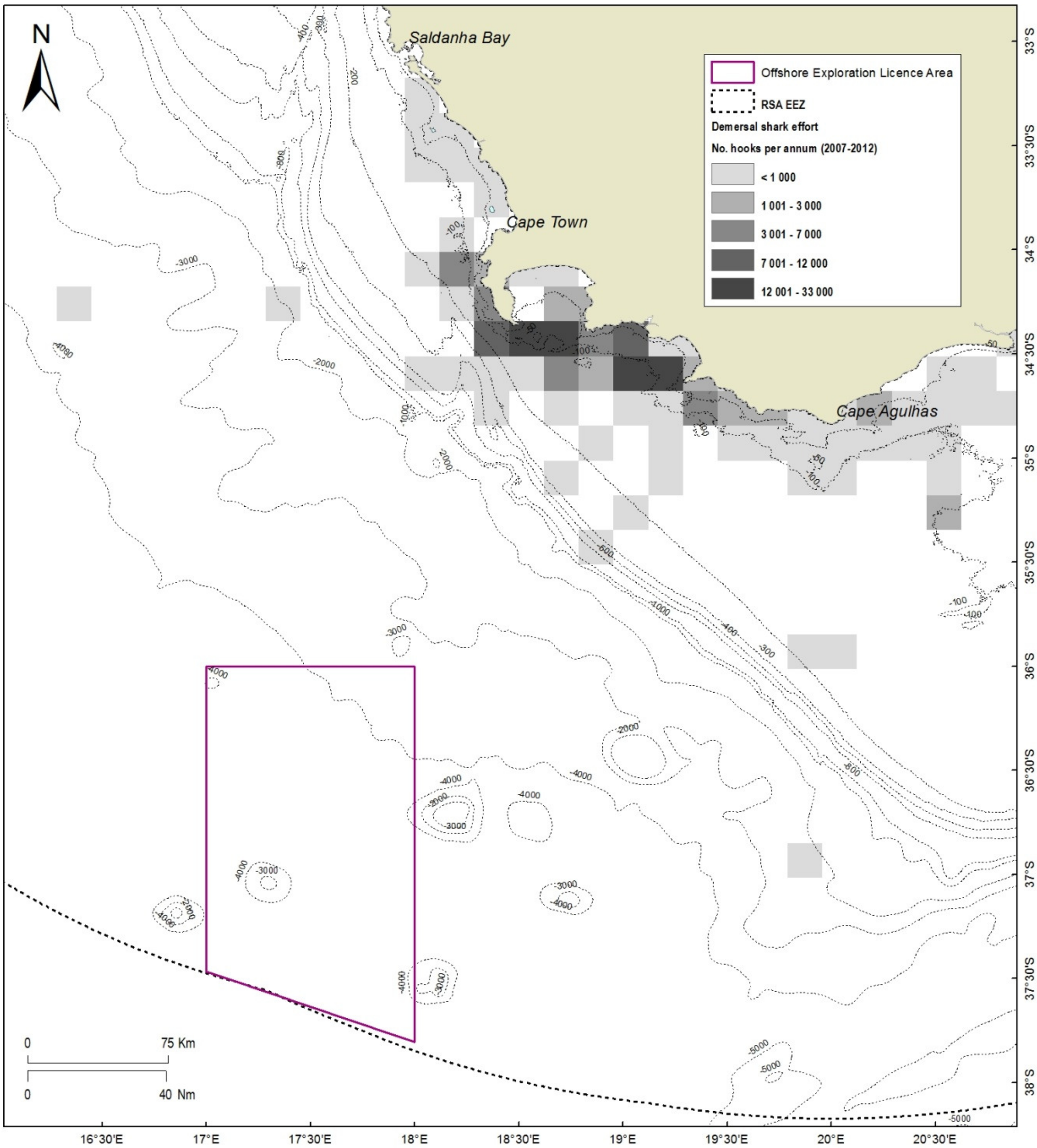

Figure 30. Spatial distribution of effort expended by the demersal long-line fishery targeting shark species (2007 – 2012). Effort is displayed on a 10' x 10' grid in relation to the offshore exploration licence area.

4.4 Large Pelagic Long-Line

Impact on Operations (Exclusion Zone)

The large pelagic long-line fishery operates across the entire extent of the South African EEZ, with activity centred along the shelf break. Pelagic long-line vessels can be expected to occur across the extent of the offshore exploration licence area (Figure 31); however, the main target areas are located inshore of the proposed exploration licence area and fishing effort within the licence area is very low. During the period 2000 to 2014, an average of 4 100 hooks were set and 2.6 tons of fish was caught per annum within the licence block. This amounts to approximately 0.1% of the national catch and 0.1% of the national effort. These figures comprise both the domestic and the foreign-flagged vessels fishing under joint ventures.

Impact on Catch Availability (Acoustic Impact)

Some behavioural impacts on target species can be expected and it is possible that fish will move some distance away from the survey vessel or sound during the survey. When assessing the potential loss of catch due to possible behavioural responses of targeted fish stocks, three scenarios were considered. This is based on the variability in research results on the distance from the acoustic source at which catch rates may be affected. Scenario 1 considers no effect of the seismic source on catch rates (e.g. when the survey takes place during a period of no fishing effort, which based on the 0.1% effort recorded for the area is a large percentage of the time). Scenario 2 assumes a 40% reduction in catch within a 9 km radius from the acoustic source over a 5 day period. Scenario 3 assumes an 83% reduction in catch within a 33 km radius from the source over a 10 day period. Based on records of catch taken from the areas between 2000 and 2014, the potential estimated loss could range from < 0.1 tons to 0.2 tons over the duration of the survey. This is equivalent to less than 0.01% of the average annual national landings recorded for the sector over this period. The total duration of the survey would be between 15 and 20 days and it is unlikely that any particular fishery would be disrupted continuously for this length of time. Due to the negligible amount of effort expended by the fishery within the offshore exploration licence area, the likelihood of the impact occurring is improbable and the fishery would likely be able to direct fishing effort elsewhere over the duration of the survey.

With regard to spawning and migration, tuna and other large pelagic species are not known to spawn in the survey area. Tuna are believed to spawn towards the tropics although some southward drifts of spawn (eggs and larvae) could be expected at low densities. The survey is therefore not expected to impact spawning and migratory behaviour.

Significance of Impact

Table 3 shows the impact rating of the proposed survey activities on the large pelagic long-line sector. The impact is assessed to be local in extent and of short-term duration. The intensity of the impact is assessed to be low and the overall significance of the impact is assessed to be **very low**. The impact is considered to be fully reversible and the degree of confidence in the assessment is high.

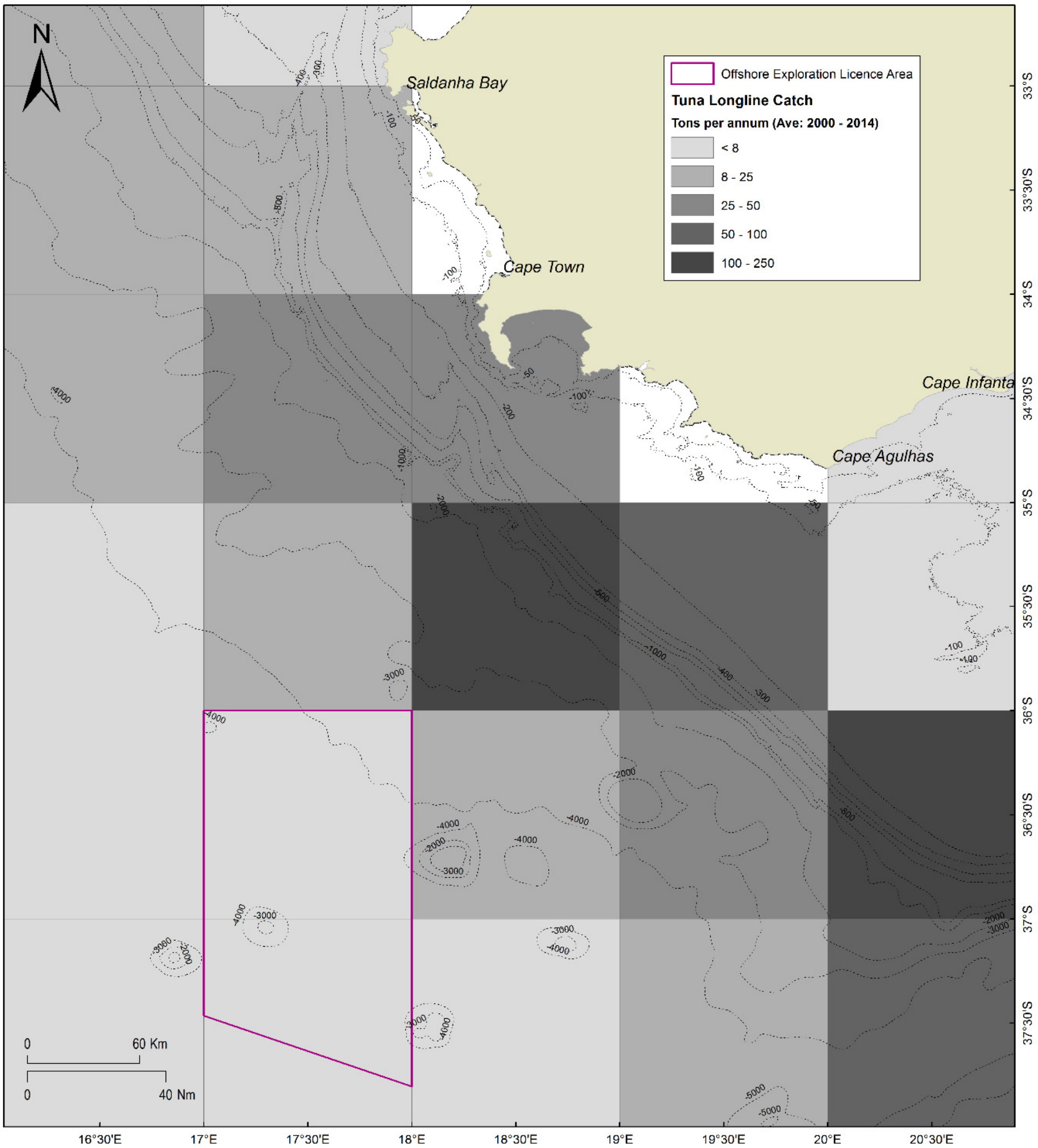

Figure 31. Spatial distribution of catch recorded by the domestic and foreign pelagic long-line sectors between 2000 and 2014. Catch is presented on a 60´ x 60´ grid basis. Note that a set line may range up to 100 km in length.

Table 3: Summary table showing impact ratings of the proposed survey activities on the large pelagic long-line sector both with and without mitigation measures in place.

	Impact on the Large Pelagic Long-Line Sector	
	Without Mitigation	With Mitigation
Extent	Local	Local
Duration	Short-Term	Short-Term
Intensity	Low	Low
Significance	Very Low	Very Low
Probability	Improbable	Improbable
Degree of Confidence	High	High
Degree to which impact can be mitigated	Very Low	Very Low
Reversibility	Fully Reversible	Fully Reversible
Loss of Resource	Low	Low

4.5 Tuna Pole

Impact on Operations (Exclusion Zone)

Fishing activity occurs along the entire West Coast beyond the 200 m isobath. Activity would be expected to occur along the shelf break with favoured fishing grounds including areas north of Cape Columbine and between 60 km and 120 km offshore from Saldanha Bay. Incidental fishing activity has been recorded in the vicinity of the offshore exploration licence area around a seamount situated adjacent to the boundary of the licence area (see Figure 32). Catch taken from the area amounts to 2.3 tons taken during a single year (2013) which is less than 0.01% of the overall catch reported by the sector.

Impact on Catch Availability (Acoustic Impact)

Some behavioural impacts on target species can be expected and it is possible that fish will move some distance away from the survey vessel or sound during the survey. When assessing the potential loss of catch due to possible behavioural responses of targeted fish stocks, three scenarios were considered. This is based on the variability in research results on the distance from the acoustic source at which catch rates may be affected. Scenario 1 considers no effect of the seismic source on catch rates (e.g. when the survey takes place during a period of no fishing effort, which is considered to be a large percentage of the time based on catch recorded for the area). Scenario 2 assumes a 40% reduction in catch within a 9 km radius from the acoustic source over a 5 day period. Scenario 3 assumes an 83% reduction in catch within a 33 km radius from the source over a 10 day period. Based on records of catch taken from the areas between 2000 and 2014, the potential estimated loss could range from 0.2 tons to 0.4 tons over the duration of the survey. This is equivalent to less than 0.001% of the average annual national landings recorded for the sector over this period. The total duration of the survey would be between 15 and 20 days and it is unlikely that any particular fishery would be disrupted continuously for this length of time. Due to the negligible amount of effort expended by the fishery within the offshore exploration licence area, the likelihood of the impact occurring is improbable and the fishery would likely be able to direct fishing effort elsewhere over the duration of the survey.

With regard to spawning and migration, tuna and other large pelagic species are not known to spawn in the survey area. Tuna are believed to spawn towards the tropics although some southward drifts of spawn (eggs and larvae) could be expected at low densities. The survey is therefore not expected to impact spawning and migratory behaviour.

Significance of Impact

Table 4 shows the impact rating of the proposed survey activities on the tuna pole sector. The impact is assessed to be local in extent and of short-term duration. The impact is assessed to be of very low intensity and of overall **insignificance**. The likelihood of the impact occurring is improbable. The impact is considered to be fully reversible and the degree of confidence in the assessment is high.

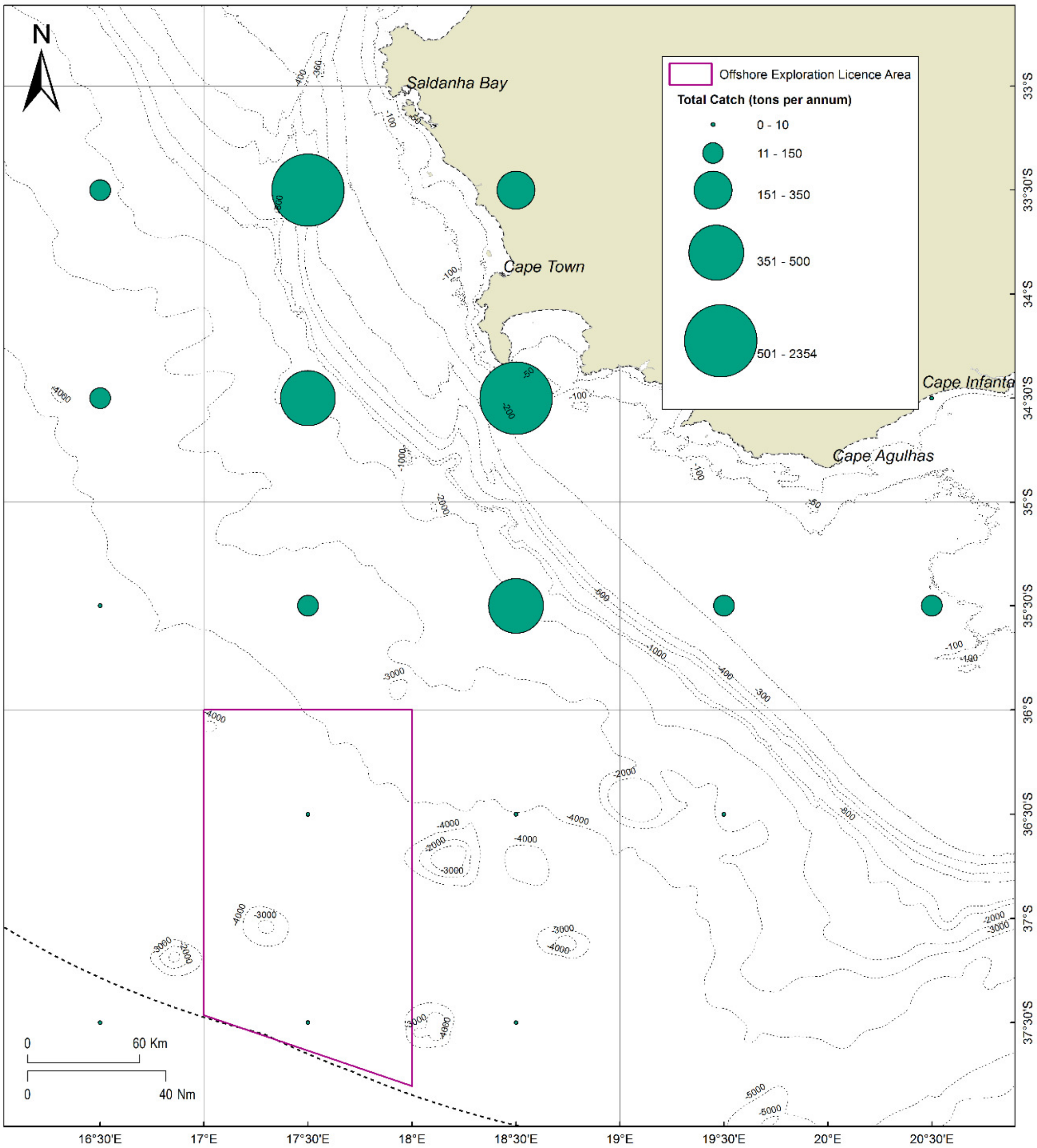

Figure 32. Spatial distribution of catch reported by the South African tuna pole fishery (2003 – 2014) in relation to the offshore exploration licence area.

Table 4: Summary table showing impact ratings of the proposed survey activities on the tuna pole sector both with and without mitigation measures in place.

	Impact on the Tuna Pole Sector	
	Without Mitigation	With Mitigation
Extent	Local	Local
Duration	Short-Term	Short-Term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Probability	Improbable	Improbable
Degree of Confidence	High	High
Degree to which impact can be mitigated	Very Low	Very Low
Reversibility	Fully Reversible	Fully Reversible
Loss of Resource	Low	Low

4.6 Traditional Line-Fish

Impact on Operations (Exclusion Zone)

The proposed offshore exploration licence area is situated at least 120 km from the range at which traditional line-fish vessels operate (see Figure 33). Thus there is no spatial overlap and **no impact** expected from the proposed survey operations on the traditional line-fish sector. The degree of confidence in the assessment is high.

Impact on Catch Availability (Acoustic Impact)

Due to the distance of the offshore exploration licence area from fishing grounds, there is expected to be **no impact** of the proposed surveys on catch available to the traditional line-fish sector.

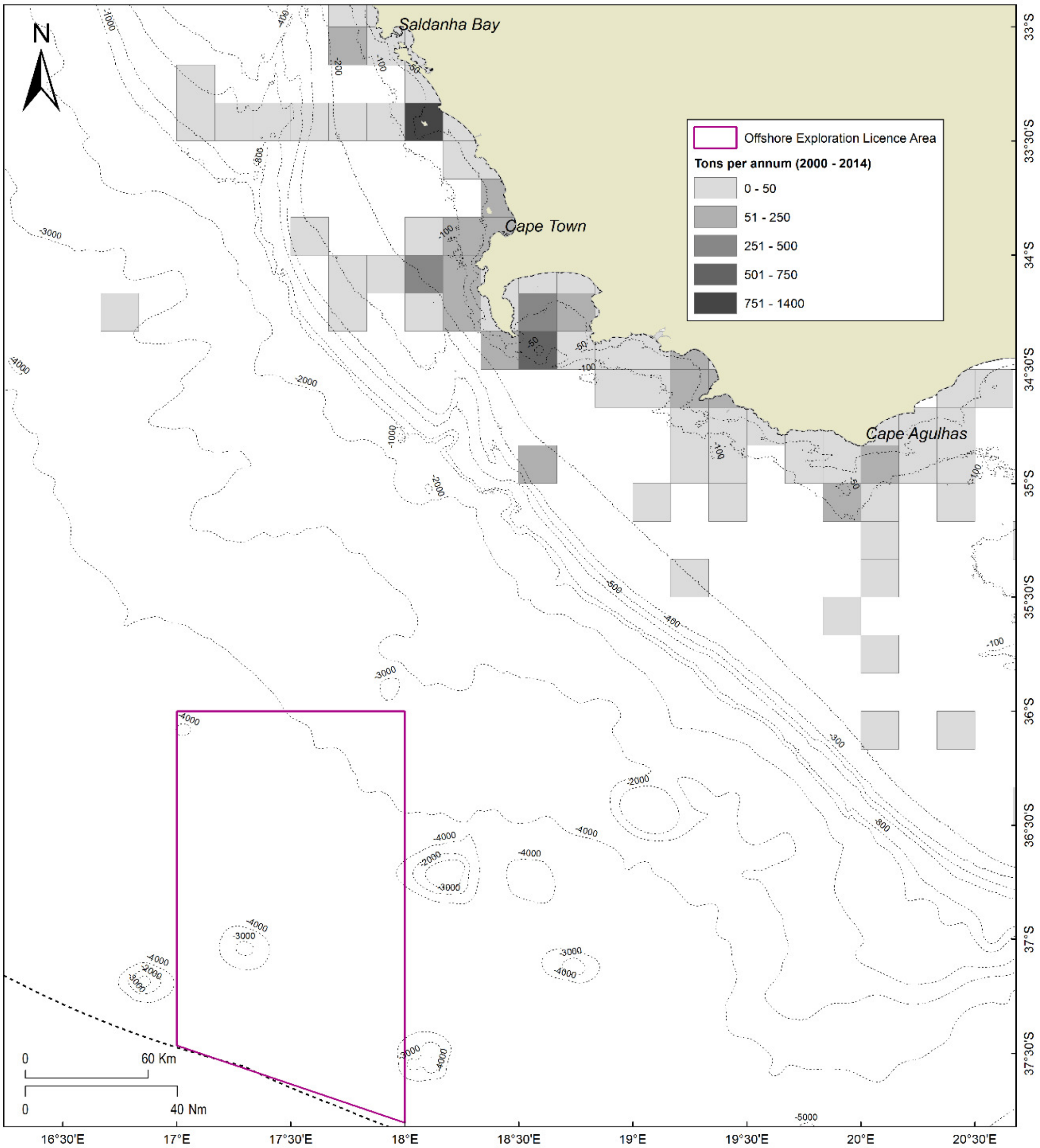

Figure 33: Spatial distribution of catch landed by the South African traditional line-fish sector (2000 – 2014) in relation to the offshore exploration licence area.

4.7 Small Pelagic Purse-Seine

Impact on Operations (Exclusion Zone)

The small pelagic purse-seine fishery operates primarily along the west and south coasts of the Western Cape and the Eastern Cape coast up to a maximum distance of 100 km offshore, but usually closer inshore. Figure 34 shows the catch reported by fishing grid (10 x 10 minute catch reporting grid) along the west and south coasts of the Western Cape for the period 2000 to 2014. Fishing grounds are situated at least 150 km inshore of the proposed offshore exploration licence area. There is no spatial overlap and **no impact** expected from the proposed survey operations on the small pelagic purse-seine sector. The degree of confidence in the assessment is high.

Impact on Catch Availability (Acoustic Impact)

Due to the distance of the offshore exploration licence area from fishing grounds, there is expected to be **no impact** of the proposed surveys on catch available to the small pelagic purse-seine sector.

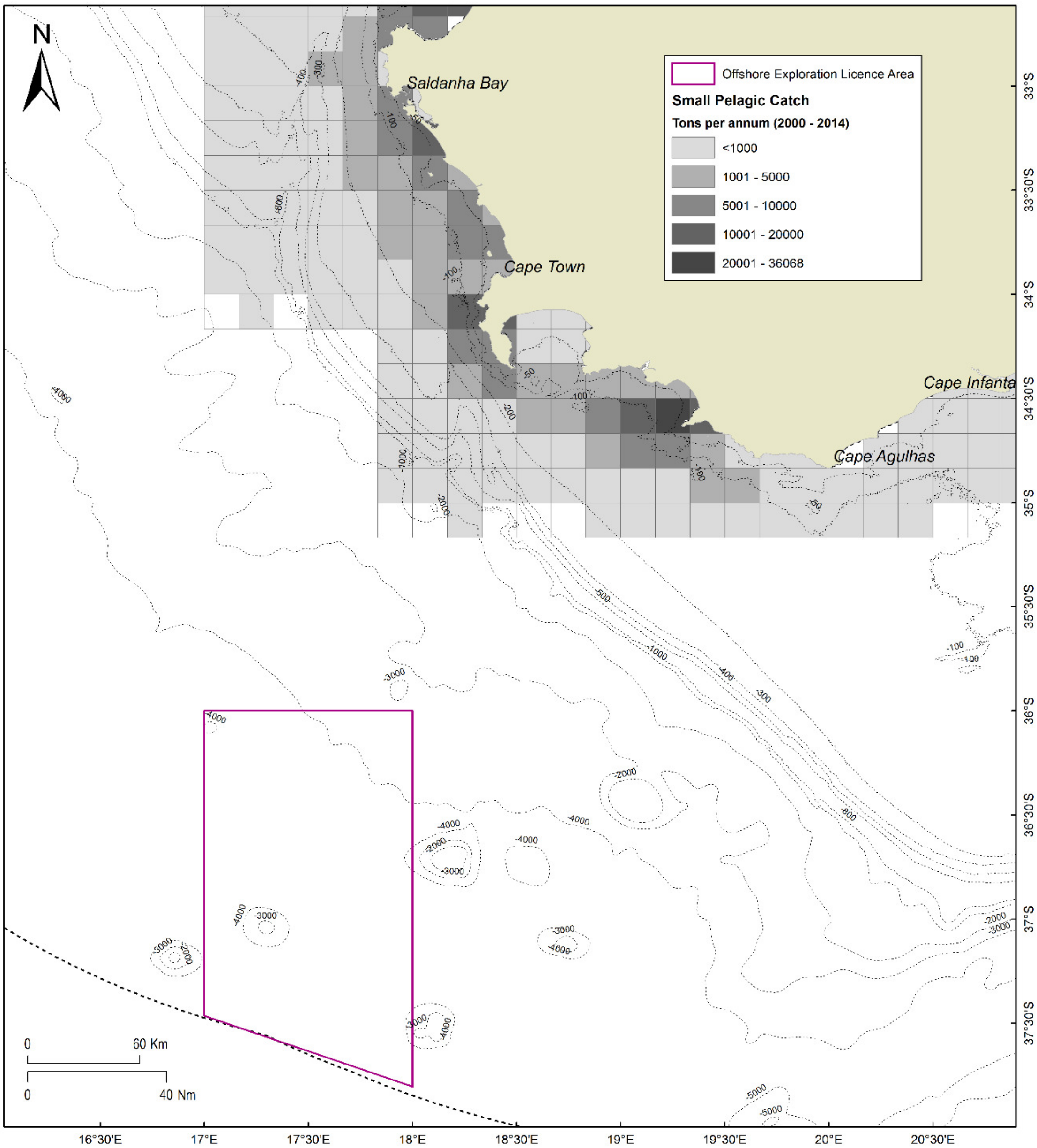

Figure 34. Spatial distribution of the average annual catch landed by the small pelagic purse-seine fishery (2000 – 2014) in relation to the offshore exploration licence area.

4.8 West Coast Rock Lobster

Impact on Operations (Exclusion Zone)

Figure 35 shows rock lobster catch reported by management area along the west and south coast. Since the fishery operates in waters shallower than 100 m, most fishing grounds are situated within 10 km of the coastline. The offshore exploration licence area is situated at least 170 km from rock lobster fishing grounds and would be expected to have **no impact** on fishing operations. The degree of confidence in the assessment is high.

Impact on Catch Availability (Acoustic Impact)

Due to the distance of the offshore exploration licence area from fishing grounds, there is expected to be **no impact** of the proposed surveys on catch available to the west coast rock lobster sector.

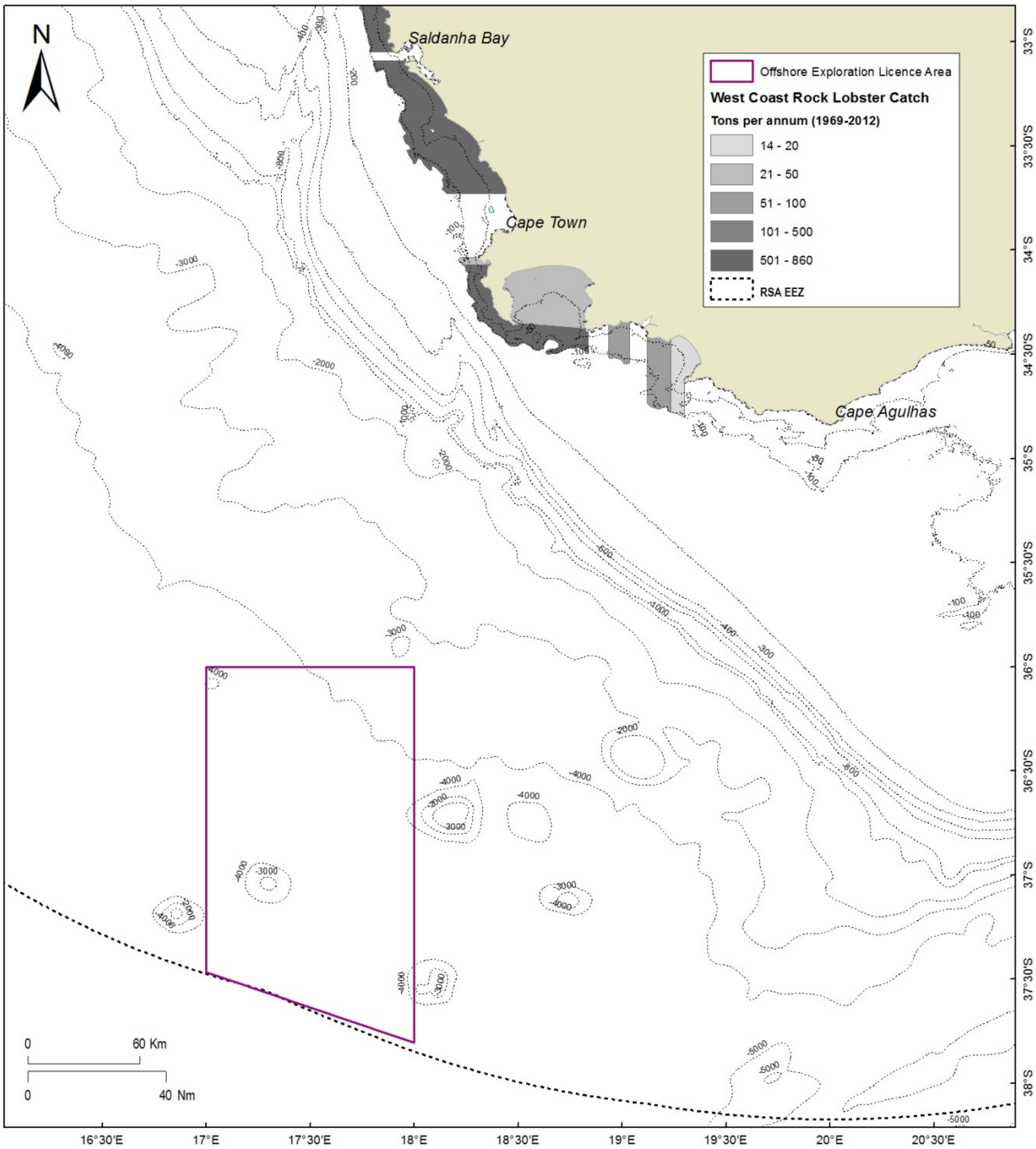

Figure 35: Spatial distribution of total catch (1969 – 2012) reported by the West Coast rock lobster fishery in relation to the offshore exploration licence area.

4.9 Fisheries Research

Impact on Operations (Exclusion Zone)

A swept-area trawl survey of demersal fish resources on the west coast is carried out each year during January and extends from Cape Agulhas (20° E) to the Namibian maritime border. Trawls are stratified by depth and, since research trawls do not exceed 1 000 m in depth, there is no overlap expected with the offshore licence area (see Figure 36). Acoustic pelagic biomass surveys follow pre-determined transects (perpendicular to bathymetric contours) running offshore from the coastline to approximately the 200 m isobath, approximately 140 km inshore of the proposed exploration licence area. Neither of the demersal nor pelagic surveys would be expected to coincide with the spatial extent of the offshore exploration licence area and there is **no impact** expected on either of these sectors. Due to the distance of the licence area from the areas of operation of both the pelagic and demersal surveys, **no impact** would be expected on the availability of fish for capture (or detection).

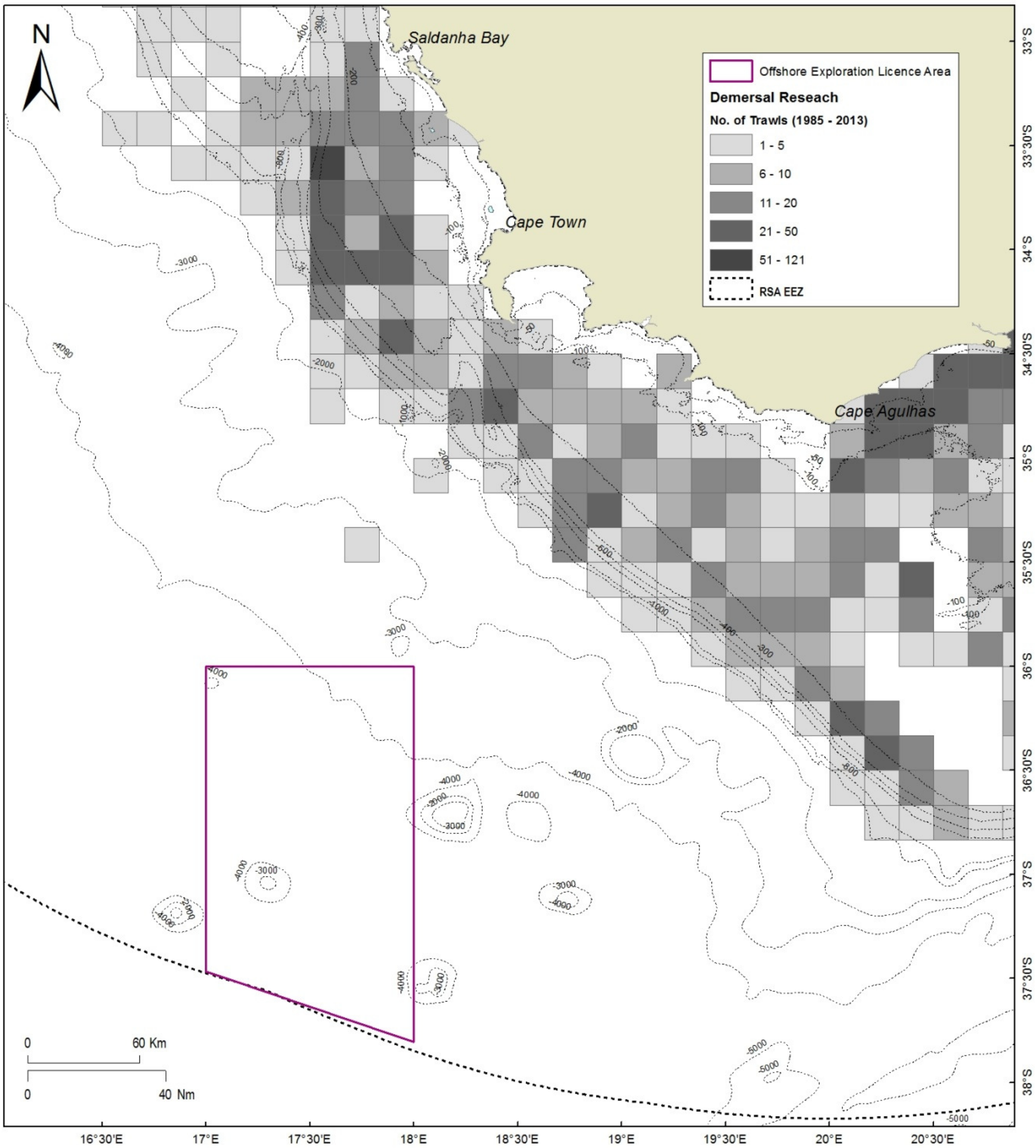

Figure 36: Spatial distribution of the number of demersal research trawls undertaken by DAFF in South African waters (1985 – 2013) in relation to the offshore exploration licence area.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The exploration area overlaps with only the large pelagic longline and tuna pole sectors. The impact on these sectors is assessed to be negative, of local extent and of short-term duration. The intensity of the impact on the large pelagic longline sector is considered to be low and of overall **very low** significance and the likelihood of the impact occurring is probable. The intensity of the impact on the tuna pole sector is assessed to be very low and of overall **insignificance**. It is improbable that the impact would occur. There is **no impact** expected on the demersal trawl, demersal longline, traditional line-fish, small pelagic purse-seine and west coast rock lobster sectors. Similarly, there is **no impact** expected on the demersal or pelagic fisheries research surveys. The implementation of appropriate mitigation measures is unlikely to reduce the overall significance of the impact of the proposed survey on the large pelagic and tune pole sectors. The impact is likely to be fully reversible and the loss of resource is considered to be low.

Table 5: Summary table of the impact ratings of the proposed survey programme on the South African fishing industry.

Demersal Trawl		
NO IMPACT		
Demersal Long-Line		
NO IMPACT		
Large Pelagic Long-Line	**Without Mitigation**	**With Mitigation**
Extent	Local	Local
Duration	Short-term	Short-term
Intensity	Low	Low
Significance	Very Low	Very Low
Probability	Improbable	Improbable
Degree of Confidence	High	High
Degree to which impact can be mitigated	Very Low	Very Low
Reversibility	Fully Reversible	Fully Reversible
Loss of Resource	Low	Low
Tuna Pole	**Without Mitigation**	**With Mitigation**
Extent	Local	Local
Duration	Short-term	Short-term
Intensity	Very Low	Very Low
Significance	Insignificant	Insignificant
Probability	Improbable	Improbable
Degree of Confidence	High	High
Degree to which impact can be mitigated	Very Low	Very Low
Reversibility	Fully Reversible	Fully Reversible
Loss of Resource	Low	Low
Traditional Line-fish		
NO IMPACT		
Small Pelagic Purse-Seine		
NO IMPACT		
West Coast Rock Lobster		
NO IMPACT		
Fisheries Research		
NO IMPACT		

5.2 Recommendations

The following measures are proposed with a view to reducing potential negative effects between the proposed survey activities and fishing operations. The implementation of a communication strategy with the fishing industry is considered essential but would not reduce the overall significance of the impact of the proposed survey programme on fisheries sectors:

- Fishing industry bodies and other key affected parties should be informed of the proposed activities and requirements with regards to the safe operational limits around the survey vessel prior to the commencement of the project. The following industrial bodies and affected parties include:
    - Department of Agriculture, Forestry and Fisheries (DAFF);
    - South African Tuna Association (SATA);
    - South African Tuna Long-Line Association (SATLA);
    - Fresh Tuna Exporters Association (FTEA);
    - Transnet National Ports Authority (ports of Cape Town and Saldanha Bay);
    - South African Navy Hydrographic office; and
    - South African Maritime Safety Authority (SAMSA).
- The required safety zones around survey vessels should be communicated via the issuing of Daily Navigational Warnings for the duration of the drilling operations through the South African Naval Hydrographic Office;
- Any fishing vessel targets at a radar range of 12 nautical miles from the survey vessel should be called via radio and informed of the navigational safety requirements;
- Affected parties should be notified through fishing industry bodies when the programme is complete;
- The survey vessel should be accompanied by a chase vessel.
- A Fisheries Liaison Officer (FLO) should be deployed on board either the survey or chase vessel to facilitate communication with fishing and maritime vessels; and
- Notify stakeholders (see above) when the survey is complete and the survey vessel is off location.

6. REFERENCES

Beckley LE. & van der Lingen CD. 1999. *Biology, fishery and management of sardines (*Sardinops *sagax) in southern African waters.* Marine and Freshwater Research **50**: 955-978.

Coetzee JC, vand der Lingen CD, Hutchings L & Fairweather TP. 2008. *Has the fishery contributed to a major shift in the distribution of South African sardine?* ICES Journal of Marine Science 65: 1676-1688.

Dalen J, Ona E, Sodal AV, Sǣtre R. 1996. Seismic investigations at sea; an evaluation of consequences for fish and fisheries. Institute of Marine Research. *Fisken og Havet* **9**: 26 pp. (In Norwegian with English summary).

Dalen J, Mǣsted K. 2008. The impact of seismic surveys. *Marine Research News* 5.

Engăs AS, Løkkerborge E, Ona E, Soldal AV. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Science* **53**: 2238 – 2249

Gausland I. 2003. Seismic surveys impact on fish and fisheries*. Report for Norwegian Oil Industry Association (OLF).* Stavanger. Norway.

Hirst AG, Rodhouse PG. 2000. Impacts of geophysical seismic surveying on fishing success. *Reviews in Fish Biology and Fisheries* **10**: 113-118.

Hutchings L, Jarre A, Lamont T, van den Berg M and Kirkman S.P. 2012. *St Helena Bay (southern Benguela) then and now: muted climate signals, large human impact.* African Journal of Marine Science 34(4): 559-583.

Mann BQ. 2000. Southern African Marine Linefish Status Reports. Oceanographic Research Institute Special Publication, Durban.

Strømme T, Lipinski M, Stenevik EK and Alvheim O. EAF-N2008/1 2008 BCC Survey No. 1: *Transboundary survey between Namibia and South Africa with focus on the shared stocks of deep water hake: Cruise report No 1/2008 (7 January – 26 February 2008)*. Institute of Marine Research Bergen, Norway & Marine and Coastal Management Cape Town, South Africa Bergen.

Punsly R and Nakano H. 1992. A review of the Japanese long-line fishery for tunas and billfishes in the eastern Pacific Ocean 1981- 1987. Bill. IATC 20(6), p 187 – 355.

Santulli A, Modica A, Messina C, Ceffa L, Curatolo A, Rivas G, Fabi G and D'Amelio V. 1999. Biochemical response of European Sea Bass (*Dicentratchus labrax L.*) to the stress induced offshore experimental seismic prospecting. Mar. Poll. Bull. 38(12): 1105 – 1114.

Hassel, A. Knutsen, T. Dalen, J. Skaar, K. Lfkkeborg, S. Misund, O. A. Ostensen, O. Fonn, M. & Haugland, E. K., 2004. Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*). ICES J. mar. Sci. 61: 1165–1173.

Sigler MF , 2000. Abundance estimate and capture of sablefish (*Anoplpoma fimbria*) by longline gear. Can. J. Fish. Aquat. Sci. 57 1270 – 1283.

van der Lingen, C.D. & van der Westhuizen, J.J., 2013. *Spatial distribution of directed sardine catches around South Africa, 1987-2012.* Scientific Working Group document, Department of Agriculture, Forestry and Fisheries, FISHERIES/2013/OCT/SWG-PEL/33, 9 pp.

Fishing Industry Handbook 2015: South Africa, Namibia & Mozambique 43rd Edition. George Warman Publications, Cape Town, South Africa.

APPENDIX 1: CONVENTION FOR ASSIGNING SIGNIFICANCE RATINGS TO IMPACTS

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

1 Extent;
2 Duration;
3 Intensity;
4 Significance;
5 Status of impact;
6 Probability; and
7 Degree of confidence.

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), “duration” (Section 2) and “intensity” (Section 3). The preliminary significance ratings for combinations of these three criteria are given in Section 4.

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

3. Describe the impact in terms of the probability of the impact occurring (Section 5) and the degree of confidence in the impact predictions, based on the availability of information and specialist knowledge (Section 6).

4. Additional criteria to be considered, which could “increase” the significance rating if deemed justified by the specialist, with motivation, are the following:

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

5. Additional criteria to be considered, which could “decrease” the significance rating if deemed justified by the specialist, with motivation, are the following:

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

6. 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 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.

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-West Coast
NATIONAL	South Africa
INTERNATIONAL	

DURATION

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

Rating	**Description**
SHORT TERM	0 - 5 years
MEDIUM TERM	6 - 15 years
LONG TERM	Where the impact would cease after the operational life of the activity, either because of natural 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

"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.

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***;

Rating	Description
	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.

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.

PROBABILITY
"Probability" describes the likelihood of the impact occurring.

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

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.

DEGREE TO WHICH THE 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.

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.

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.

APPENDIX 2: ACOUSTIC IMPACTS ON FISH

Seismic sound

For many years acoustic sources have been used to search for oil and gas in the marine environment (Hirst and Rodhouse 2000). Historically, sub-marine explosions were used; however this technique has been replaced with the use of airguns (Hirst and Rodhouse 2000). The equipment used during seismic surveys sends out energy pulses with very high peak pressures (Richardson et al. 1995). Pulse signals are directed downwards and then reflected upwards again by density discontinuities within sub-sea rock strata (McCauley et al. 2003). The travel time of the reflected signal drives the process of mapping geological profiles (McCauley et al. 2003). There is growing concern that human-generated noise in the marine environment could have damaging effects on both fish and fisheries (McCauley et al. 2003). Depending on the characteristics of the sound, airgun noise produced during seismic surveys may have no impact on marine organisms or it may cause disruptions to behaviour, physical or physiological damage (McCauley et al. 2003). The modern airguns used today result in lower peak pressures and longer rise times than the historically used chemical explosives. Nonetheless, these discharges may still be high enough to injure or disturb animals found in close proximity to the source vessel (Christian and Blocking 2010). Unfortunately there are only limited data and information currently available on the impacts of exposure to airgun sound on marine fish.

Mechanisms of hearing

All fish species gather information about their surroundings through mechanosensory systems located in the ear, the skin or both (Fay and Popper 2000). The swim bladder also plays an important role in some species, acting as a pressure receiver and vibrating in phase with sound waves. Sensory hair cells in the otolith organ of the inner ear are sensitive to sound pressure, and are stimulated by both particle velocity and the swim bladder. The lateral line organ in the skin is sensitive to particle motion. Fish species are differentially affected by sound according to the frequency with which the swim bladder is stimulated.

The majority of fish and elasmobranches can detect a wide range of sound frequencies, from less than 50 Hz (sometimes as low as 10-15 Hz) to between 500-1000 Hz (Popper 2003) and this overlaps with most noise produced through anthropogenic activities. They are, however, able to discriminate between sounds, differentiating between biological sounds and other 'noise'. They can also determine the direction of a sound. The sound waves produced during seismic surveys are low frequency, with most energy at 20-150 Hz (although significant contributions may extend up to 500 Hz) (Hirst and Rodhouse 2000), and overlap with the range at which fish hear well (Dalen and Mæsted 2008). Hearing thresholds differ greatly among species, and the impacts of seismic sounds are therefore species specific. Species that use a coupling of the ear and swim bladder to hear probably possess the best hearing (McCauley 1994) and are therefore suspected to experience greater impacts from seismic sounds than those without a swim bladder (Hirst and Rodhouse 2000).

Potential impacts on fish

Hearing allows fish to gather information about their physical, biological and social environment. It allows fish to communicate in terms of feeding, survival and reproduction (Dalen and Mæsted 2008). In some cases, introduced anthropogenic sounds can mask environmental sounds and signals, negatively impacting on an organism's ability to detect a risk of predation, prey items or mating opportunities (Christian and Blocking 2010). This can potentially affect survival and reproduction.

The potential impacts of seismic survey sound are not necessarily lethal for adult fish but can have a range of physiological effects, including swim-bladder damage (Falk and Lawrence 1973), transient stunning (Hastings 1990), short-term stress responses (Santulli et al. 1999; Smith et al. 2004), temporary hearing loss (Popper et al. 2005; Smith et al. 2006), haemorrhaging, eye damage and blindness (Hirst and Rodhouse 2000). Physical damage may lead to delayed mortality as reduced fitness is associated with higher vulnerability to predators and decreased ability to locate prey (Hirst and Rodhouse 2000; McCauley et al. 2003; Popper et al. 2005). Recent studies on the impact of seismic sounds on fish have, however, shown that physical damage is generally negligible and that direct physical damage from exposure to high level sound from airguns is not an issue that requires special mitigation (Gausland 2003). In most cases the majority of fish exposed to airgun noises will be some distance from the source and only a very few animals would therefore ever actually die or suffer great damage from the sound.

The potential physiological impacts of airgun noise will have a greater effect on younger life stages of fish: the eggs, larvae and fry. These organisms have limited movement and are therefore unable to avoid seismic sound by swimming away. Several studies measuring the effect of airgun noise on fish eggs and larvae have shown that mortalities and injuries were incurred at very close range to the airgun source (<5 m). Changes in buoyancy, ability to avoid predators, growth rate, ability to survive and general condition have also been recorded in larvae exposed to airgun noise and all of these effects are species specific. Yolk sac larvae located 2-3 m from the source incurred a 40-50% mortality rate (Booman et al. 1996) and in some species mortality rates 10-20% higher than normal were found in the later stages of organisms that had been within 1-2 m of the airgun discharge at a younger stage. However, seismic created morality is low in relation to natural mortality and is unlikely to have major impacts on recruitment to populations and therefore net production in fish populations (Dalen et al. 1996; Dalen and Mæsted 2008). In addition, because of the rate at which airguns are discharged and the fact that the vessel is continuously moving, it is highly unlikely that eggs and larvae will be repeatedly exposed to harmful sound waves (Dalen and Mæsted 2008).

The more significant impacts found are behavioural changes in adults and juveniles that occur within the vicinity of the sound source (Hirst and Rodhouse 2000; Gausland 2003). There are a number of different behavioural responses to airgun noise, such as leaving the area of the noise source (Dalen and Knutsen 1987; Løkkeborg 1991; Skalski et al. 1992; Løkkeborg and Soldal 1993; Engås et al. 1996; Wardle et al. 2001; Engås and Løkkeborg 2002; Hassel et al. 2004), changing depth distribution (Chapman and Hawkins 1969; Pearson et al. 1992; Slotte et al. 2004), changes in schooling behaviour (Slotte et al. 2004) and a startle response to short range start up or high level sounds (Pearson et al. 1992; Wardle et al. 2001). Habituation to seismic sound has also been seen, with normal behaviour recommencing several minutes after surveying has started. The behavioural responses described could affect spawning behaviour and migration patterns, although this has not yet been documented. It has been suggested that powerful external forces in the vicinity of a migration path or spawning grounds could cause disturbance to or even lead to cessation of spawning (Dalen and Mæsted 2008). This could affect subsequent recruitment to fish stocks if spawning is displaced geographically or temporally.

The area affected by airgun noise and the response of the fish is dependent on many different variables including local physical conditions of the sea, food supply for the fish and the behavioural patterns of the fish present (Gausland 2003). It will also depend on the character of the sound signal (McCauley et al. 2000) ambient noise levels and the hearing sensitivity and threshold of the species (Hirst and Rodhouse 2000). Hearing sensitivity in fish can vary with life-cycle stage, season, locality and duration of shooting (Hirst and Rodhouse 2000). It is therefore difficult to determine accurately the impact of seismic sound on the behaviour of fish (Gausland 2003). Some of the behavioural responses above have been observed up to 5 km away from the seismic vessel (Santulli et al. 1999; Hassel et al. 2004). While there is no doubt that seismic sound does affect the behaviour of fish in close proximity to the vessel, the magnitude of the noise may be within the level of natural stimuli for fish and may therefore not have long term impacts on affected populations (Gausland 2003). Behavioural changes resulting from airgun noise can, however, cause delayed mortality (Hirst and Rodhouse 2000). It has been recommended that the use of seismic airguns be avoided within 50 km of important spawning or spawning migration areas (Dalen et al. 1996; Gausland 2003).

Indirect effects on fisheries

It has been suggested that seismic survey sound could indirectly affect fisheries through changes in the distribution, abundance and catch rates of important fish species. These may be linked to changes in spawning, migration and feeding behaviour (Skalski et al. 1992). Adult and juvenile fish may swim away from the noise of airguns, either by moving out of the area or changing their vertical position in the water column, resulting in changes in distribution (Hirst and Rodhouse 2000). These changes could lead to decreased catch rates if fish move out of important fishing grounds (Hirst and Rodhouse 2000; Dalen and Mæsted 2008). For example, Engås et al. (1996) found a significant decline in catch rates of cod and haddock within the shooting area of a seismic survey carried out in the Barents Sea, near the Arctic Ocean. Vertical migration has also been shown to result in higher catches if fish are congregated at the bottom of the water column and then caught more easily in benthic trawl nets (Gausland 2003). Airgun noise related changes to prey and predator species of commercially important species could also play a role in affecting catch rates, as species are extremely dependent on their predator and prey species (Hirst and Rodhouse 2000). There is, however, very little information available on these potential impacts and information on changes in feeding behaviour is also lacking.

Table 1 presents a summary of the recorded impacts that could be directly relevant to this assessment of impacts on the small pelagic fishery. The table records impacts on eggs and other early life stages, on adults and on fishery catches. While the sounds from seismic surveys can have direct physiological impacts on adult fish, these are generally considered to be negligible in terms of overall impact on a population or stock and not to require any special mitigation (Wilkinson and Japp, 2015a, 2015b).

It is also generally recognized that the direct impacts from the airguns will have a greater impact on early life-stages but that injuries and mortality will usually only take place within 5 m of the source of the seismic sound. Any mortality of these early life stages resulting from seismic survey noise will be much lower than the natural mortality rates (Table 1, Wilkinson and Japp, 2015a, 2015b). In Norway, areas in which there are high densities of spawning fish can be closed to seismic spawning as a measure both to avoid scaring away the spawning adults and to avoid direct mortality of early life stages (Table 1 and Boertmann et al. 2009).

Table 1. A summary of impacts on fish and fish catches reported in the literature.

Nature of Impact	Range of Impact	Source
Propagation of Sound		
If airgun source is 227 dB re1 uPa atone meter, expect to receive 127 dB re 1 ~Pa signal level at 80-km from the source. Possibly true in the deeper water; but in shallow water the attenuation will reduce airgun pulses to below ambient levels.		IMT. 2000. Radiated noise levels from seismic airgun array. Doc. TV0010-200037-730.
On early life stages		
- 40-50% mortality of yolk sac larvae - Mortality rates 10-20% higher than normal in the later stages of organisms	2-3 m 1-2 m	Booman et al. 1996; Dalen et al. 2007.
- Increased mortality rates for fish eggs -Increase mortality for cod fry	Up to 5m 1-2 m	Dalen et al. 2007.
In summary - injuries and increased mortality at distances less than 5 m. Most frequent and serious injuries occur at distances out to approx. 1.5 m. Fish in early stages of life most vulnerable.		Dalen et al. 2007.
From results Holliday et al. (anchovy) and Booman et al. estimated that, as worst case, larvae mortality during typical seismic survey = 0.45% of larvae population. With "expected values" estimate during one run = 0.03% of larvae population	Total population.	Dalen et al. 2007.
Behavioural responses	Up to 5 km	Santulli et al. 1999; Hassel et al. 2004
Norway – areas closed to seismic surveys during periods when high densities of spawning fish. Measure to avoid scaring away spawning fish and prevent mortality of early life stages.	-	Boertmann et al. 2009.
Impacts on Adults		
Scare effect. Can have impact on spawning success.	[1] >30 km	Dalen et al. 2007.
Australia - scare effects, but do not necessarily lead to negative effects for the fish or the fish population.	1-2 km	Dalen et al. 2007.
Rapid responses (similar to C-start in fish) in European sea bass and sandeel, distances of up to 2.5 and 5.0 km	Distances of up to 2.5 and 5.0 km	Dalen et al. 2007.
Impacts on Catch Rates		
Significant decline in catch rates of cod and haddock within the shooting area of a seismic survey carried out in the Barents Sea, near the Arctic Ocean		Engås et al. (1996)
Reduced catches of cod in Norway	i) Approx 33 km (trawl) ii) Approx 8 km (line)	Dalen et al. 2007.
Barents Sea - catch rates during seismic shooting decreased over an area of 18 nautical miles out of the seismic area	An area of 18 nautical miles out of the seismic area	Dalen et al. 2007.
Trawl catches of cod and haddock and line catches of haddock reduced by 50% within an area of at least 18 nautical miles out from the shooting, 45-70% in seismic area. Effects lasted for at least 5 days.	Up to 18 nautical miles from shooting area. Highest reductions in shooting area. Not return to original levels after 5 days	Engås et al. (1996)
3D surveys. Within survey area (15x85km), gill net catches doubled during seismic shooting, haddock longline catch rates decreased (from between approx. 50 to approx. 30%).	Longline catches recovered within 10 days. Linear increase in catch rates with distance from array. Catch rates were within top quartile (3 out of 13	Løkkeborg et al. (2012).

	observations) after +/- 33 km	
Percentage cpue reductions from 'No apparent reduction' (3 cases) to 83% reduction. 8 cases observed reduction of at least 40%. 1 case observed increase in bycatch of 525%	Distances ranged from >9 to >33 km. Duration of impact ranged from approx. 12 hrs (1 case), +/- least 24 hrs (2 cases) at least 5 days (3 cases)	Table 1. Hirst and Rodhouse 2000
Average decline in cpue in hook and line fishery for *Sebastes* species of 52.4% (90% confidence intervals – 27.9 to 76.9% decline).	Fishing occurred at site of shooting and catch rates measured immediately after seismic shooting.	Skalski et al, 1992.

As shown on Table 1, a number of studies have reported reductions in catch rates of fish during and after seismic surveys. The observed declines in catch rates differed considerably from study to study and also according to species and gear type in the same areas and events. Estimated declines ranged from no apparent reduction to an 83% reduction in bycatch in a shrimp trawl (Løkkeborg and Soldal, 1993 reported in Hirst and Rodhouse, 2000).

The distance from the seismic sound source at which reductions in catch rates were measured also varied substantially from case to case ranging from (when reported) approximately 8 to 36 km. Hirst and Rodhouse (2000) compiled the results of a number of results from experiments, which indicated a range from greater than 1 km to greater than 33 km.

References

BOOMAN C, DALEN J, LEIVESTAD H, LEVSEN A, VAN DER MEEREN T, TOKLUM K. 1996. Effecter av luftkanonskyting på egg, larver og yngel. *Fisken Og Havet* 3: 1-83. (In Norwegian with English summary).

CHAPMAN CJ, HAWKINS AD. 1969. The importance of sound in fish behaviour in relation to capture by trawls. *FAO Fisheries Report* 62: 717-729.

CHRISTIAN JR, BLOCKING RC. 2010. Review of the effects of airgun sounds on fish. Marine Seismic Research, LGL Ltd, environmental research associates.

DALEN J, KNUTSEN GM. 1987. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. In: Merklinger. H.M.ed: *Progress in Underwater Acoustics*. Plenum Press, NY, pp 93 – 102.

DALEN J, ONA E, SODAL AV, SÆTRE R. 1996. Seismic investigations at sea; an evaluation of consequences for fish and fisheries. Institute of Marine Research. *Fisken og Havet* 9: 26 pp. (In Norwegian with English summary).

DALEN J, MÆSTED K. 2008. The impact of seismic surveys. *Marine Research News* 5.

ENGÅS AS, LØKKEBORG E, ONA E, SOLDAL AV. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Science* 53: 2238 – 2249.

ENGÅS AS, LØKKEBORG E. 2002. Effects of seismic shooting and vessel generated noise on fish behaviour and catch rates. Bioacoustics. *The international Journal of Animal Sound and its Recording* 12: 313-316.

FALK MR, LAWRENCE MJ. 1973. Seismic exploration: its nature and effects on fish. Canada Technical Report Series No. CEN/T-73-9. Department of Environment, Fisheries and Marine Service, Resource Management Branch, Fisheries Operations Directorate, Central Region (Environment), Winnipeg, MB.

FAY RR, POPPER AN. 2000. Evolution of hearing in vertebrates: The inner ear and processing. *Hearing Research* 149: 1-10.

GAUSLAND I. 2003. Seismic surveys impact on fish and fisheries. *Report for Norwegian Oil Industry Association (OLF)*. Stavanger. Norway.

HASTINGS MC. 1990. Effects of underwater sound on fish. Document No. 46254-900206-01IM, Project No. 401775-1600, AT&T Bell Laboratories.

HASSEL A, KNUTSEN T, DALEN J, SKAAR K, LØKKEBORG S, MISDUND OA, OSTENSEN O, FONN M, HAUGLAND EK. 2004. Influence on seismic shooting on the lesser sand eel (*Ammodytes marinus*). *ICES Journal of Marine Science* 61: 1165 – 1173.

HIRST AG, RODHOUSE PG. 2000. Impacts of geophysical seismic surveying on fishing success. *Reviews in Fish Biology and Fisheries* 10: 113-118.

HUTCHING L, BECKLEY LE, GRIFFITHS MH, ROBERTS MJ, SUNDBY S, VAN DER LINGEN C. 2002. Spawning on the edge: spawning grounds and nursery area around the southern African coastline. *Marine and Freshwater Research* 53: 307-318.

LØKKEBORG S. 1991. Effects of geophysical survey on catching success in long-line fishing. Paper presented at the International Council for Exploration of the Sea (ICES) Annual Science Conference. ICES CM B 40:1-9.

LØKKEBORG S, SOLDAL AV. 1993. The influence of seismic exploration with air guns on cod behaviour (*Gadus morhua*) and catch rates. *ICES Marine Science Symposium* 196:62-67.

MCCAULEY RD, FEWTRELL J, POPPER AN. 2003. High intensity anthropogenic sound damages fish ears. *Journal of the Acoustic Society of America* 113(1): 1-5.

MCCAULEY RD. 1994. "Seismic Surveys", In *Environmental Implications of Offshore Oil and Gas Developments in Australia – The Findings of an Independent Scientific Review*, edited by J. M. Swan, J. M. Neef and P.C. Young. Australian Petroleum Exploration Association, Sydney. Pp 19-122.

MCCAULEY RD, FEWTRELL J, DUNCAN AJ, JENNER C, JENNER M-N, PENROSE JD, PRINCE RIT, ADHITYA A, MURDOCH J, MCCABE K. 2000. Marine seismic surveys – a study of environmental implications. *APPEA Journal* 40: 692-706.

MCCAULEY RD, FEWTRELL J, POPPER AN. 2003. High intensity anthropogenic sound damages fish ears. *Journal of the Acoustic Society of America* 113(1): 1-5.

PEARSON WH, SKALSKI JR, MALME CI. 1992. Effects of sounds from a geophysical survey device on behaviour of captive rockfish (*Sebastes* spp). *Canadian Journal of Fisheries and Aquatic Science* 49: 1343 – 1365.

POPPER AN. 2003. Effects of anthropogenic sound on fishes. *Fisheries* 28: 24-31.

POPPER AN, SMITH ME, COTT PA, HANNA BW, MACGILLIVRAY AO, AUSTIN ME, MANN DA. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. *Journal of the Acoustic Society of America* 117(6): 3958-3971.

RICHARDSON WJ, GREENE JR CR, MALME CI, THOMSON DH. 1995. Marine mammals and noise. Academic Press, San Diego, CA.

SANTULLI AC, MESSINA C, CEFFA L, CURATOLO A, RIVAS G, FABI G, DAMELIO V. 1999. Biochemical responses of European sea bass (*Dicentrachus labraz*) to stress induced by offshore experimental seismic prospecting. *Marine Pollution Bulletin* 38: 1105 – 1114.

SKALSKI JR, PEARSON WH, MALME CI. 1992. Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Science* 49: 1357 – 1365.

SLOTTE A, HANSEN K, DALEN J, ONA E. 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. *Fisheries Research* 67: 143-150.

SMITH ME, KANE AS, POPPER AN. 2004. Noise-induced stress response and hearing loss in goldfish (*Carassius auratus*). *Journal of Experimental Biology* 207: 427-435.

SMITH ME, COFFIN AB, MILLER DL, POPPER AN. 2006. Anatomical and functional recovery of the goldfish (*Carassius auratus*). *Journal of Experimental Biology* 207: 427-435.

WARDLE CS, CARTER TJ, URQUHART GG, JOHNSTONE ADF, ZIOLKOWSKI AM, HAMPSON G, MACKIE D. 2001. Effect of seismic air guns on marine fish. *Continental Shelf research* 21:1005 – 1027.