seal (*Arctocephalus pusillus*). The range of cetacean species reflects largely taxonomic uncertainty at species and sub- species level, rather than uncertainty of occurrence or distribution patterns (which are summarised in *Table 4.4*).

Cetaceans

The majority of migratory cetaceans in South African waters are large baleen whales. Populations of large baleen whales in South African waters were decimated by historical whaling and are presently a fraction of their pre-exploitation densities. Blue (*Balaenoptera musculus)*, fin (*B. physalus*), sei (*B. borealis*), minke (*B. acutorostrata / B. bonaerensis*) and humpback whales (Megaptera novaeangliae) make winter migrations through the West Coast region en route from Antarctic summer feeding grounds to winter breeding grounds. While blue, fin and sei whales migrate off or along the continental shelf edge (and are thus distributed in deeper waters), humpback whales migrate over the continental shelf and along the coast.

Two types of Bryde's whales are recorded from South African waters (Best, 1977) - a smaller neritic form (of which the taxonomic status is uncertain) and a larger pelagic form described as *Balaenoptera brydei*. While the smaller neritic form is resident (particularly over the Agulhas Bank) the larger offshore form is migratory along the African west coast, being found off Saldanha Bay in winter.

Southern right whales (*Eubalaena australis*) migrate into the near-shore region of the West Coast (Mainly south of Lamberts Bay) between June and November each year (although animals may be sighted as early as April and as late as January), although historical catches of southern right whales were relatively high off Walvis Bay, Namibia (Richards and du Pasquier, 1989). This population is increasing at approximately 7 % per annum, yet is still probably around 10 % of the initial abundance. Killer whales are found year round in the waters of the South Coast, although the seasonality of sightings in the whaling grounds (in September and October) suggests that some killer whales are highly migratory (Findlay, 1989).

The pygmy right whale (*Caperea marginata*) shows a strong summer seasonality in water depths of less than 50 m along the coast between Algoa Bay in the east and Walvis Bay, Namibia. Arnoux's beaked whale (*Berardius arnuxii*) has been recorded along the West Coasts to the east of 18° E during summer. Layard's beaked whale (*Mesoplodon layardii*) is distributed throughout the West Coast pelagic waters in summer and early autumn.

Seven faunal provinces define the distribution of resident cetaceans within the West Coast region (after Findlay et al., 1992) north of Cape Point. These include:

- *Agulhas Bank to Lamberts Bay (inshore)* - Two species, the longbeaked common dolphin (*Delphinus delphis*) and the resident smaller inshore

Bryde's whale appear to be strongly associated with the Agulhas Bank region and the West Coast inshore region as far north as Lambert's Bay. Although these species will be found elsewhere in southern African waters (a common dolphin species is recorded from strandings on the Namibian coast) the majority of records are from the Agulhas Bank region.

- *West Coast Inshore* – Two species, the Heaviside's dolphin (*Cephalorhynchus heavisidii*) and the dusky dolphin (*Lagenorhynchus obscurus*) are resident over the shelf with Heaviside's dolphin found inshore to the north of Cape Point and dusky dolphin found inshore west of False Bay.

- *West Coast Offshore* - Two pelagic species of cetacean, True's beaked whale (*Mesoplodon mirus*) and the dwarf sperm whale (*Kogia sima*) appear to be limited to offshore region between Cape Columbine and the Eastern Cape. A further two species, Gray's beaked whale (*Mesoplodon grayii*) and the long finned pilot whale (*Globicephala melas*) appear to be limited to the offshore region between Namibia and the Eastern Cape. These species are found in deep waters elsewhere in the world and apart from the pilot whale are recorded only as strandings on the South African coast. A localised distribution of southern right-whale dolphins is recorded off the coast of southern Namibia and may range into the northern waters of the West Coast region.

- *Agulhas Current Species* - The movement of warm Agulhas Current water into the South Coast region results in warm water species being stranded in the region. Southern bottlenose whales (*Hyperoodon planifrons*), Blainville's beaked whale (*Mesoplodon densirostris*), and striped dolphin (*Stenella coeruleoalba*) have been recorded as strandings between Cape Columbine and Cape Agulhas. The latter two species have warm water pelagic distributions elsewhere in the world.

- *Cosmopolitan* - Killer whales (*Orcinus orca*) and minke whales (possibly *Balaenoptera acutorostrata*) are found in both continental shelf and offshore waters of the West Coast. Cuvier's beaked whale (*Ziphius cavirostris*), pygmy sperm whales (*Kogia breviceps*), False killer whales (*Pseudorca crassidens*), pygmy killer whales (*Feresa attenuata*), Risso's dolphins (*Grampus griseus*), and sperm whales (*Physeter macrocephalus*) are found throughout the offshore waters of the West Coast.

Table 4.4 *Whale and Dolphin Species Found Along the West Coast*

Common Name	Scientific Name	Distribution
Migratory cetaceans		
Southern right whale	*Eubalaena australis*	Extreme inshore
Humpback whale	*Megaptera novaeangliae*	Transit inshore
Minke whale	*Balaenoptera acutorostrata*	Cosmopolitan
Blue whale	*Balaenoptera musculus*	Transit offshore
Sei whale	*Balaenoptera borealis*	Transit offshore
Fin whale	*Balaenoptera physalus*	Transit offshore
Bryde's whale	*Balaenoptera brydei*	Seasonal offshore
Possibly migratory cetaceans		

Common Name	Scientific Name	Distribution
Pygmy right whale	*Caperea marginata*	Possible extreme inshore
Strap-toothed whale	*Mesoplodon layardii*	Offshore
Arnoux's beaked whale	*Berardius arnuxii*	Recorded from Cape Columbine eastwards
Cetaceans resident over the shelf		
Bottlenose dolphin	*Tursiops aduncus*	Extreme Inshore east of False Bay
Indo-Pacific humpback dolphin	*Sousa chinensis*	Extreme Inshore east of Walker Bay
Heaviside's dolphin	*Cephalorhynchus heavisidii*	Extreme Inshore north of Cape Point
Dusky dolphin	*Lagenorhynchus obscurus*	Extreme Inshore west of False Bay
Longbeaked common dolphin	*Delphinus delphis*	Continental shelf south of Lamberts Bay
Southern right-whale dolphin	*Lissodelphis peronii*	Localised distribution (see text)
Killer whale	*Orcinus orca*	Cosmopolitan
Bryde's whale	*Balaenoptera brydei?*	Continental shelf south of Lamberts Bay
Cetaceans resident in pelagic waters offshore of the continental shelf		
Killer whale	*Orcinus orca*	Cosmopolitan
Southern right-whale dolphin	*Lissodelphis peronii*	Localised distribution (see text)
Risso's dolphin	*Grampus griseus*	Offshore and shelf edge
False killer whale	*Pseudorca crassidens*	Offshore
Pygmy killer whale	*Feresa attenuata*	Offshore
Long-finned pilot whale	*Globicephala melas*	Offshore
Sperm whale	*Physeter macrocephalus*	Offshore
Pygmy sperm whale	*Kogia breviceps*	Offshore
Dwarf sperm whale	*Kogia sima*	Offshore east of Cape Columbine
Cuvier's beaked whale	*Ziphius cavirostris*	Offshore
Gray's beaked whale	*Mesoplodon grayi*	Offshore
Blainville's beaked whale	*Mesoplodon densirostris*	Offshore east of Cape Columbine
True's beaked whale	*Mesoplodon mirus*	Offshore east of Cape Columbine
Common dolphin	*Delphinus species*	Offshore
Bottlenose dolphin	*Tursiops truncatus*	Offshore

Seals

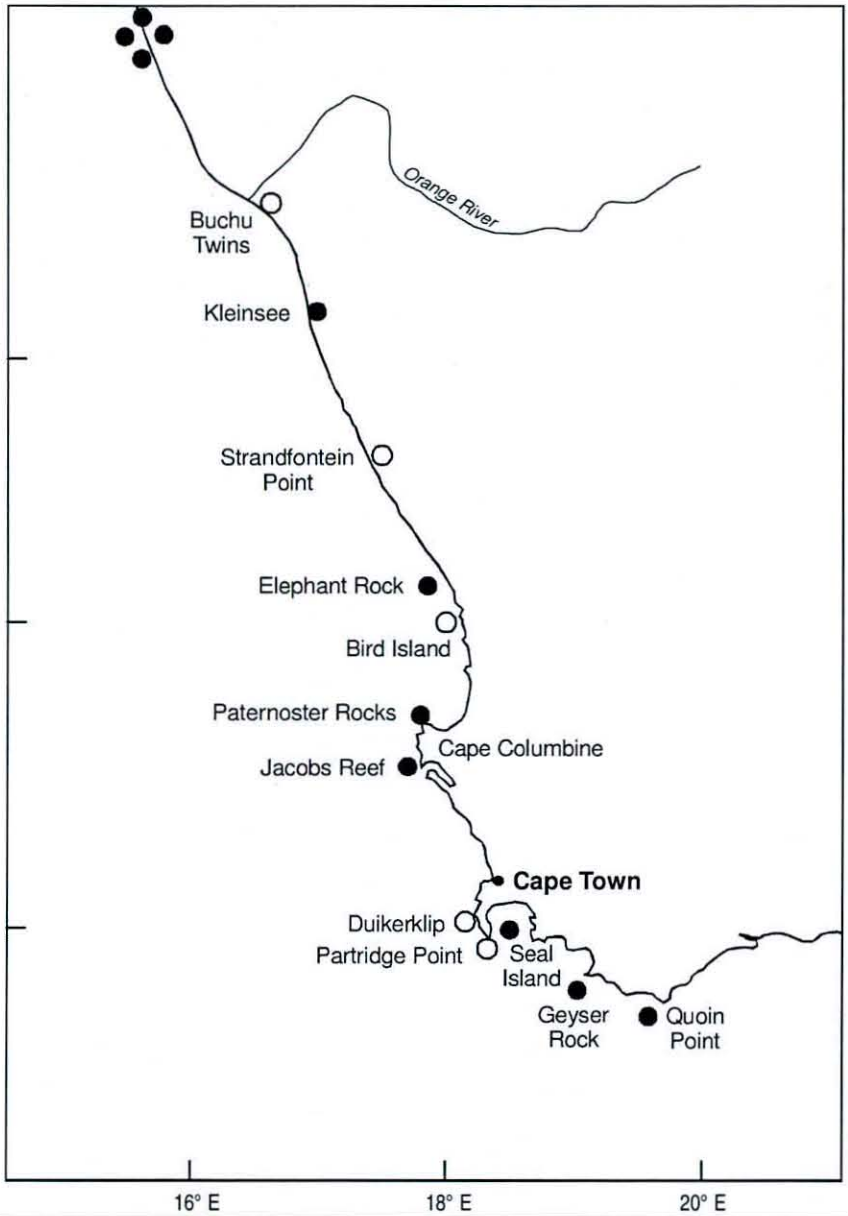
The Cape fur seal (*Arctocephalus pusillus pusillus*) congregates in seven breeding and five non-breeding colonies along the West Coast (*Figure 4.15*). Five other seal species may occasionally be found as vagrants along the West Coast.

Cape fur seals were heavily exploited up until the late nineteenth century in South African waters. After 1900 seals were harvested from certain colonies almost every year up until 1983, during which an estimated 2.5 million pups and bulls were harvested. The population has shown a rapid increase since the 1940's and in 1984 the population was thought to be some 1.1 million animals and increasing at about 3.7 % per annum (1971 to 1984). In 1990, an estimated 2,000,000 seals were distributed around the southern African coast (Butterworth and Wickens, 1990), although numbers fluctuate. The increase is presumed to reflect the population's natural response to past overexploitation.

Kleinsee is the largest of the breeding colonies (population estimates ranging from 35,450 in 1972 to 74,620 in 1989) in South Africa, and produces the largest number of pups in the country.

Cape fur seals appear to forage over the continental shelf to a maximum depth of approximately 200 m, although a male seal was video recorded by Forest Exploration at the A-K2 wellhead 84 km offshore from Hondeklip Bay at a water depth of 250 m. Two females from the Kleinsee colony tagged with depth recorders showed over 70% of dives to depths of less than 50 m (Kooyman and Gentry, 1986).

Figure 4.15 *The Location of Breeding (●) and Non-breeding (O) Colonies of Cape Fur Seals Along the West Coast*



Source: Wickens et al 1992

4.5 *NEARSHORE BIOLOGICAL OCEANOGRAPHY*

4.5.1 *Rocky Shores*

The West Coast's shoreline comprises approximately 980km, of which some 54% is rocky shore. Over 80% of this rocky shore comprises exposed rocky headlands, the balance being wave cut platforms (Jackson and Lipschitz, 1984). Rocky shore faunal diversity is low although biomass may be high (Branch and Griffiths, 1988), while floral diversity and biomass are high

(Bolton, 1986). Important intertidal species include limpets (*Patella granatina, P. argenvillei* and *P. granularis*), the two indigenous mussels (the black rock mussel *Choromytilus meridionalis* and brown mussel *Perna perna* (both of which have been partially replaced by the alien Mediterranean mussel *Mytilus galloprovincialis*)), and the reef worm *Gunnarea capensis* (Branch, Griffiths, Branch and Beckley, 1994). The alien Mediterranean mussel has become the dominant intertidal mussel species along the whole of the West Coast, except where the rocky shore is inundated with sand regularly, where the black rock mussel remains dominant.

4.5.2 *Sandy Shores*

Approximately 46% of the West Coast comprises fine grain sandy beaches (Jackson and Lipschitz, 1984). The sandy beach fauna is very uniform from Cape Point north. Important taxa include the beach hopper *Talorchestia* (at the top of the shore), sand mussel *Donax serra* (intertidal to shallow subtidal), and gastropod *Bullia digitalis* in the swash zone (Branch et al., 1994).

The giant beach isopod *Tylos granulatus* should be considered a threatened species, being extremely sensitive to human activity and coastal mining.

4.5.3 *Shallow Subtidal*

Off sandy beaches, important mollusc species include white mussels *Donax serra*, finger plough snail *Bullia digitalis* and *B. laevissima*, although crustaceans (e.g. three spot swimming crab *Ovalipes trimaculatus*) may be more important (Branch et al., 1994). The surf zones off sandy beaches are also important nursery areas for a variety of fish species.

On shallow subtidal reefs, the community is dominated by three species of kelp (*Ecklonia maxima, Laminaria palida, Macrocystis angustifolia*) which form extensive beds to depths around 12m and up to 3 km offshore; light levels limiting the depth to which beds extend. The community below kelp bed canopies comprises many invertebrate species, including ribbed mussel (*Aulacomya ater*), the commercially important perlemoen (*Haliotis midae*) and numerous crustaceans, including red crab *Plagusia chabrus* and west coast rock lobster *Jasus lalandii* (Branch et al., 1994).

4.5.4 *Estuaries*

Jackson and Lipschitz (1984) describe 34 estuarine systems along the West Coast, of which Langebaan Lagoon is not a true estuary as it is totally marine. Of the 33 remaining systems, only six are open to the sea throughout the year. Nineteen estuarine systems are located south of Bokpunt, highlighting the low rainfall and lack of perennial rivers to the north. The larger estuarine systems are important habitats for birds and nursery areas for fish species, while the majority of the smaller ephemeral systems do not support classic estuarine fauna or important bird populations (Jackson and Lipschitz, 1984). Of these, the Orange River mouth and Verlorenvlei area are proclaimed Ramsar sites along with the West Coast National Park (including the offshore islands) at Langebaan (Cowan, 1995), while the Berg River estuary has been proposed as a Ramsar site. The Berg and Olifants River are the only available recruitment areas for estuarine dependent fish species between Cape Town and the Orange River.

4.6 *HUMAN USE*

4.6.1 *Fisheries and Other Harvesting*

Due to the upwelling that characterises the West Coast (particularly the area north of Cape Point), the region sustains very productive fisheries, with up to 600 000 tonnes of fish (including invertebrates but excluding seaweeds) at a value of around R4 billion having been landed in 2009. The discussion below relates only to commercial fisheries, with recreational fisheries being discussed in the following section. Crawford *et al.*, (1987) provide a substantial review of the commercial fisheries of the West Coast.

Fisheries can be categorised by the different types of fishing gear they deploy. The different fisheries are discussed below, along with their catch composition and their target areas.

Purse-seine Fisheries

Purse-seining is practised along most of the West Coast, from its eastern boundary around to Port Nolloth. This fishery is directed at pilchard (*Sardinops sagax*) and anchovy (*Engraulis encrasicolus*). The round herring (*Etrumeus whiteheadi*) is an important (non-quota controlled) bycatch and is targeted from January to April. Cape horse mackerel (*Trachurus capensis*) chub mackerel (*Scomber japonicus*) and lanternfish are also important bycatch species.

Table 4.6 lists the annual catch composition (by species and mass) of the West Coast purse-seine fishery during different years. In the early to mid 1980s, the overall catch averaged some 380 000 tonnes (Crawford *et al.*, 1987), between 1995 and 1998 catches declined to below 300 000 tonnes due to a significant decline in anchovy abundance, but currently (2009) catches within the pelagic purse-seine fishery are ~ 500 000 tonnes[1]. Catch rates of all pelagic species are generally maximal in St Helena Bay, off Saldanha Bay and between Walker Bay and Danger Point (Crawford, 1981). *Figure 4.16* shows the most productive purse-seine fishing areas off the West coast.

(1) [1] Catches in this fishery vary widely between years and include both Anchovy and Sardine. In 2009 the sardine allowable catch was low at 95 000 t and the anchovy catch high at > 400 000 t.

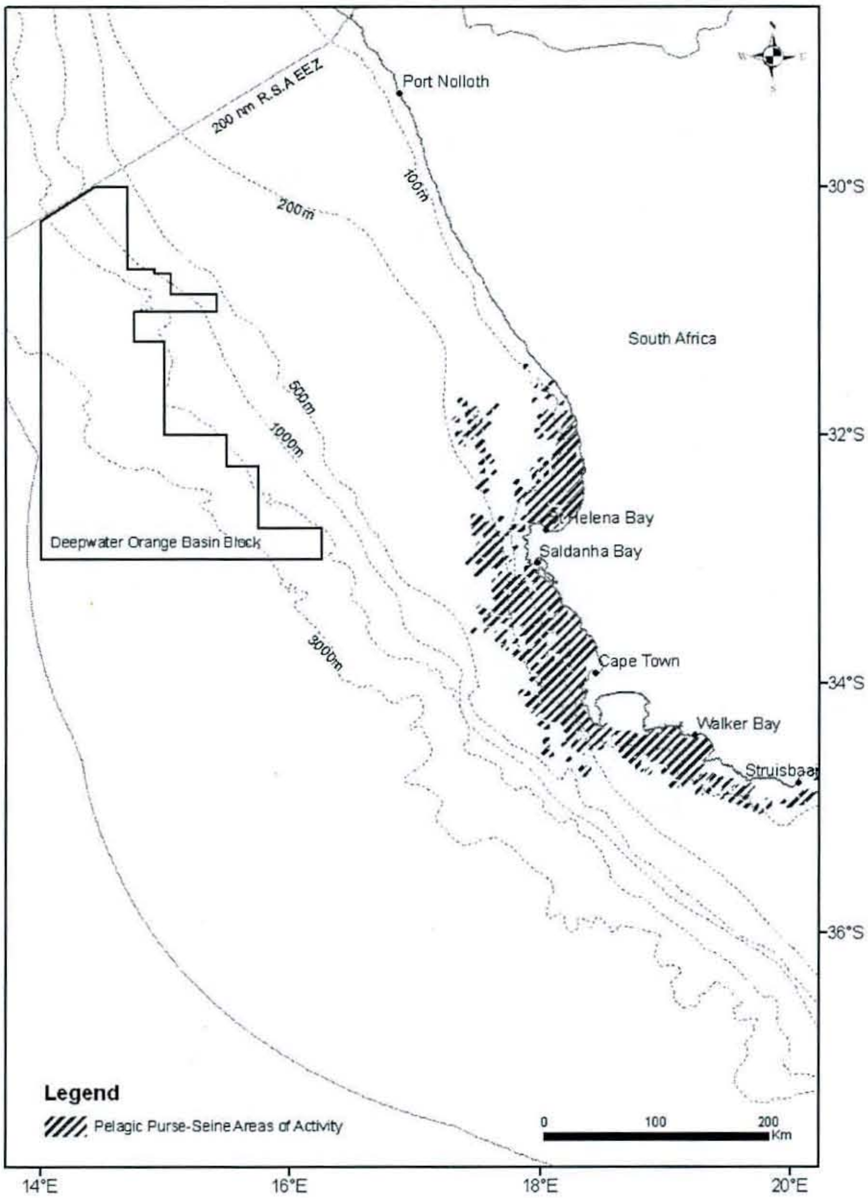
Table 4.5 *The Species Composition of the South African Purse-seine Fleet's Landings (Thousands of Metric Tonnes) from 1980 to 2008[1].*

Year	Pilchard	Horse mackerel	Anchovy	Chub mackerel	Round herring	Lanternfish	Total
1980	50.4	0.4	315.5	0.2	14.1	0.1	380.7
1981	46.2	6.1	292.0	0.3	24.3	10.3	379.2
1982	33.5	1.1	306.9	2.7	31.0	0.7	375.9
1983	60.5	1.4	240.2	3.8	69.0	1.6	376.5
1984	27.2	2.5	272.5	0.7	28.6	13.4	344.9
1985	30.7	0.8	272.6	0.1	39.8	31.0	375.0
1986	30.5	0.5	303.8	0.1	52.3	0.6	388.4
1987	33.0	2.8	596.0	0.8	33.3	0.0	667.9
1988	32.2	6.3	569.8	0.3	62.6	0.1	672.1
1989	34.6	25.5	294.2	0.3	44.5	4.7	404.3
1990	56.7	7.2	150.1	0.0	44.3	0.6	259.3
1991	51.9	0.5	150.6	9.9	33.5	0.7	248.5
1992	53.4	2.0	347.5	0.3	47.4	0.7	452.0
1993	50.7	11.6	235.8	0.4	56.3	1.2	357.0
1994	92.8	8.2	155.6	2.0	54.1	0.9	314.5
1995	111.7	1.7	178.3	1.3	76.8	1.0	364.6
1996	99.7	20.8	40.8	0.3	47.2	0.0	213.1
1997	117.0	12.7	60.1	3.7	92.2	0.2	286.0
1998	128.0	26.6	107.5	0.1	52.5	6.6	321.4
1999	132.2	2.0	180.5	0.4	58.9	0.2	375.4
2000	136.1	4.6	267.8	0.3	37.8	0.3	447.2
2001	191.5	0.9	287.5	0.1	55.3	0.1	535.5
2002	260.9	8.1	213.4	0.1	54.8	0.0	537.4
2003	290.0	1.0	258.9	0.3	42.5	0.1	592.7
2004	373.8	2.0	190.1	0.0	47.2	0.0	614.2
2005	246.7	5.6	282.7	0.3	28.4	0.0	563.8
2006	205.9	2.0	134.2	0.2	41.9	0.0	384.2
2007	139.4	1.9	252.8	0.4	47.9	0.0	442.4
2008	126.0	2.0	265.8	1.0	64.2	0.0	459.0

Note: The figures above only represent the purse-seine catches – the catches of horse and chub mackerels are much higher in the trawl-directed fisheries.

(1) [1] Data for 1980 to 2007 were taken from the Fishing Industry Handbooks (Marine & Coastal Management, DEAT)

Figure 4.16 ***Pelagic Purse-Seine Fishing Grounds***



Mid-water-trawl Fisheries

Horse mackerel (*Trachurus spp*) is the main target species for this fishery, although chub mackerel and snoek (*Thyrsites atun*) are also targeted. The status of horse mackerel stocks is uncertain although a single stock is believed to exist off the South African coast. The catch of horse mackerel on the West Coast comprises predominantly of juveniles in the purse-seine fishery (with an annual precautionary catch limit of 5 000 t). The midwater trawl fishery, however, is directed at the adult stock on the South and East Coasts (annual precautionary limit of 48 000 t).

The gear (mid-water) deployed comprises very large mid-water nets that are fished both close to the substrate and in mid-water (depending on the location of the shoals and on the diurnal vertical migration of the species). Presently, there is only one dedicated mid-water trawl vessel which operates on the South Coast, targeting mostly adult fish in the Port Elizabeth area. Several demersal trawl vessels also have quotas to fish horse mackerel, which allows them to switch target species when conditions are favourable, but these vessels are predominantly bottom-trawl directed. Mid-water trawlers tow very large nets and are severely restricted in their ability to manoeuvre and can be expected to interact with other restricted surface navigation (such as seismic survey vessels and gear).

Demersal-trawl Fisheries

Figure 4.17 depicts the important West Coast demersal trawling grounds. Hake (*Merluccius capensis* and *M. paradoxus*) is the most targeted species with annual landings of hake catches approximating 121 000 t. Demersal catches between the West and South/East Coast grounds are in the approximate ratio of 2:1. The West Coast sole (*Austroglossus microlepis*) is also targeted on trawling grounds off the Orange River although this fishery is now permanently closed. *M. capensis* is found shallower than *M. paradoxus* although the two co-occur at intermediate depths and both species are caught by demersal trawlers. Other species such as kingklip (*Genypterus capensis*), monkfish (*Lophius spp*) and snoek are caught as a bycatch, but are at times also targeted.

Figure 4.17 *Schematic of Areas Where Demersal Trawling is Undertaken Along the West Coast*

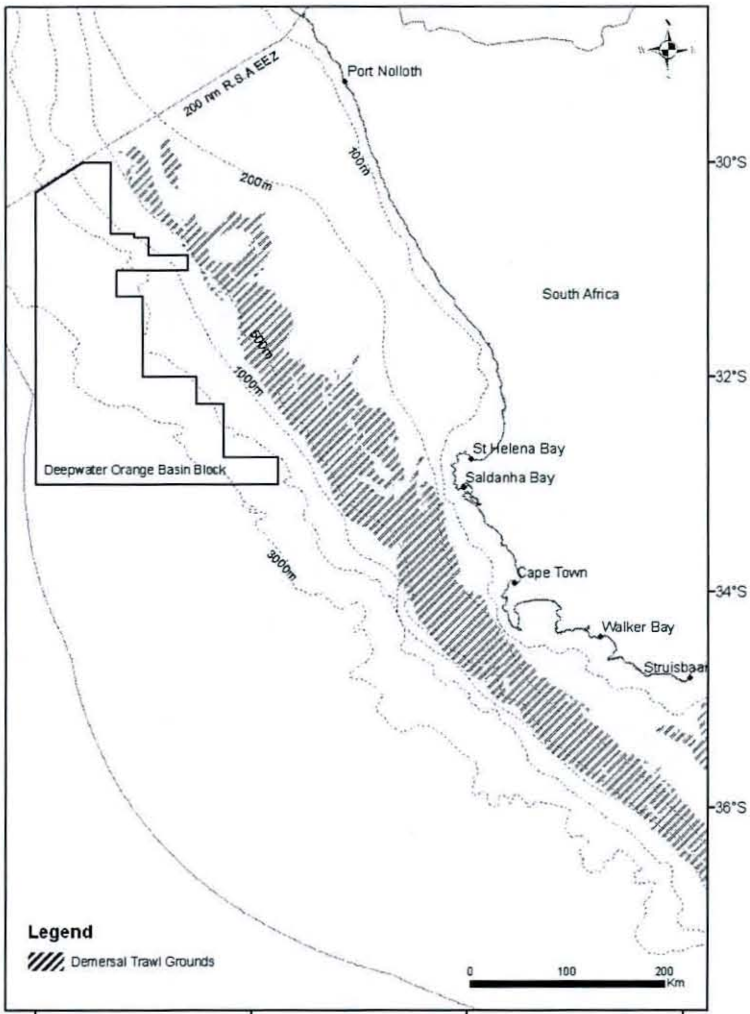


Table 4.6 *South African Deep Sea and Inshore Trawl Catch (Thousand Tonnes)*

Year	Hake	Horse mackerel	Kingklip	Monk	Snoek	Total
1996	153.7	12.9	3.1	6.1	5.5	195.8
1997	142.4	11.3	3.6	7.6	5.2	182.1
1998	146.1	9.9	3.2	7.9	6.7	186.9
1999	131.8	14.6	3.9	7.0	3.4	171.5
2000	142.9	24.6	3.6	8.6	4.0	194.9
2001	145.4	28.0	4.9	10.5	3.8	204.3
2002	132.8	16.0	5.0	8.4	7.3	182.6
2003	140.0	28.8	4.4	7.4	5.6	201.0
2004	142.8	32.1	4.3	8.6	8.0	213.0
2005	132.1	34.6	3.6	8.6	6.1	208.6
2006	123.6	22.2	2.8	7.4	3.2	177.9
2007	132.7	29.8	2.5	7.7	3.9	192.3

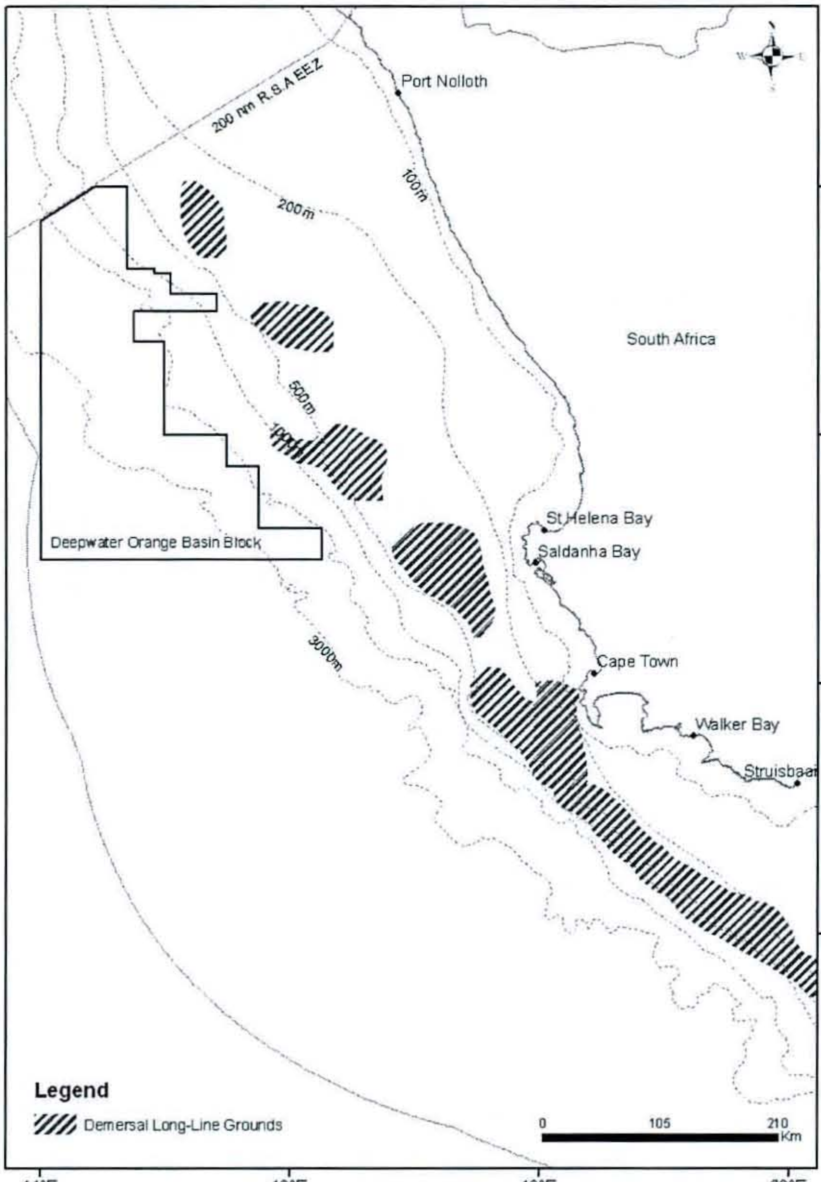
Year	Hake	Horse mackerel	Kingklip	Monk	Snoek	Total
2008	-	-	-	-	-	-

Hook and Line Fisheries

These fisheries can be divided into longlining and traditional linefishing.

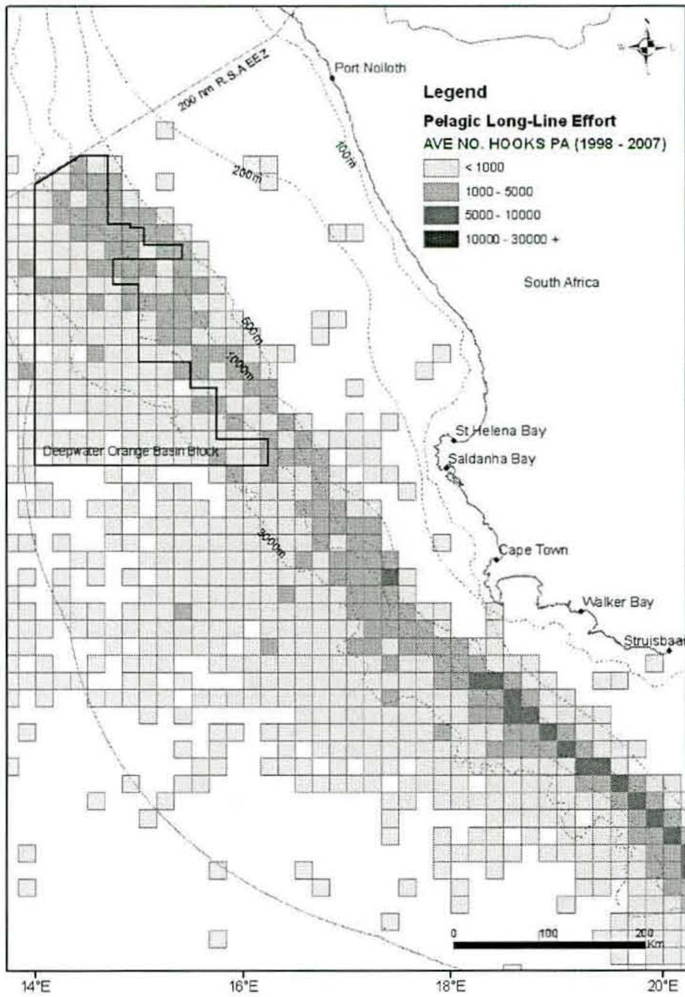
Demersal longline. The demersal longline fishery targets both hake and kingklip, and operates along the West and Southeast coast. On the West Coast the fished areas extend from Hondeklip Bay to the eastern boundary of the West Coast (*Figure 4.18*). Lines containing up to 20,000 baited hooks are set over rocky bottoms adjacent to, and within, trawling grounds. Lines are anchored at either end by an array of large buoys and the gear lies deep and just off the substrate. Bottom-set longline gear is robust and comprises two lines as well as dropper lines with subsurface floats attached. Vessels set from 2 000 to 20,000 hooks per day, generally shooting at night or early morning and recovering gear throughout the day. Boats standby their gear and are also restricted in their movements when hauling and shooting. Hooks are spaced about one fathom apart and lines can extend up to 20 km in length. Presently there are 132 rights holders and 64 vessels active within the fishery. Vessels can be small with poor communication infrastructure and therefore may disrupt survey activities.

Figure 4.18 ***Demersal Longline Fishing Grounds***



Pelagic longline. (*Figure 4.19*) The pelagic (tuna) longline fishery operates widely on the West Coast and Agulhas Bank targeting yellowfin tuna (*Thunnus albacares*), bigeye tuna (*T. obesus*), longfin tuna *(T. alalunga)*, broadbill swordfish (*Xiphias gladius*) and shark. The number of long-term right's holders for the period 2005 – 2015 is currently 43 with 31 active vessels (2009) operating within the fishery. A major difficulty with this fishery is that most permit holders are foreign flag (Japanese and Republic of China) through joint ventures with South African rights holders and are therefore difficult to communicate with.

Figure 4.19   Pelagic Longline Fishing Effort



Tuna pole. Tuna species are also targeted by pole fishers working along the West Coast particularly between 29 and 32 °S. This fishing method involves locating a shoal of tuna, and then spraying water alongside the vessel to attract the fish to the surface, at which point they are caught with baited hooks and gaffed aboard. The tuna pole fishery fleet consists of approximately 200 vessels. *Table 4.1* lists the tuna species landed from the West Coast and their percentage contribution to their total catch from the south-eastern Atlantic.

Traditional boat-based linefishery. Closer inshore, the traditional boat-based linefishery operating from the Cape Peninsula northwards is reliant on snoek. Between 1969 and 1984, the annual average catch of snoek was around 3,600 tonnes and over 4,200 tonnes during the 1992 and 1993 season (Boonstra, 1993). During the 1996 and 1997 seasons, over 6,000 tonnes was landed from the West Coast (Stuttaford, 1998) and catches for 2007 are estimated at 2,742 tonnes (R.S.A all areas). Snoek contributes around 80% of the value of this sector's catch. Cape Hottentot (*Pachymetopon blochii*) is also targeted north of

Cape Point (126 tonnes during 2007). Between Cape Point and the eastern boundary, numerous other linefish species are targeted in inshore waters by commercial and recreational boat-based anglers. Furthermore, recreational shore anglers target a number of other species which are not usually landed by boat-based anglers.

Set-net, Drift-net and Beach-seine Fisheries

These are multispecies fisheries, together landing some 25 linefish species off the Western Cape. The most important of these is harder (*Liza richardsonii*), of which 95% of the catch is landed between Elands Bay and Cape Agulhas, with the highest catches being landed in St Helena Bay and False Bay. Other important species to these fisheries are St Joseph shark (*Callorhincus capensis*), landed mostly north of Cape Town, white steenbras (*Lithognathus lithognathus*) and yellowtail (*Seriola lalandi*), both of which are landed mostly within False Bay, and kob (*Argyrosomus inodorus*), which is landed mostly east of the Berg River.

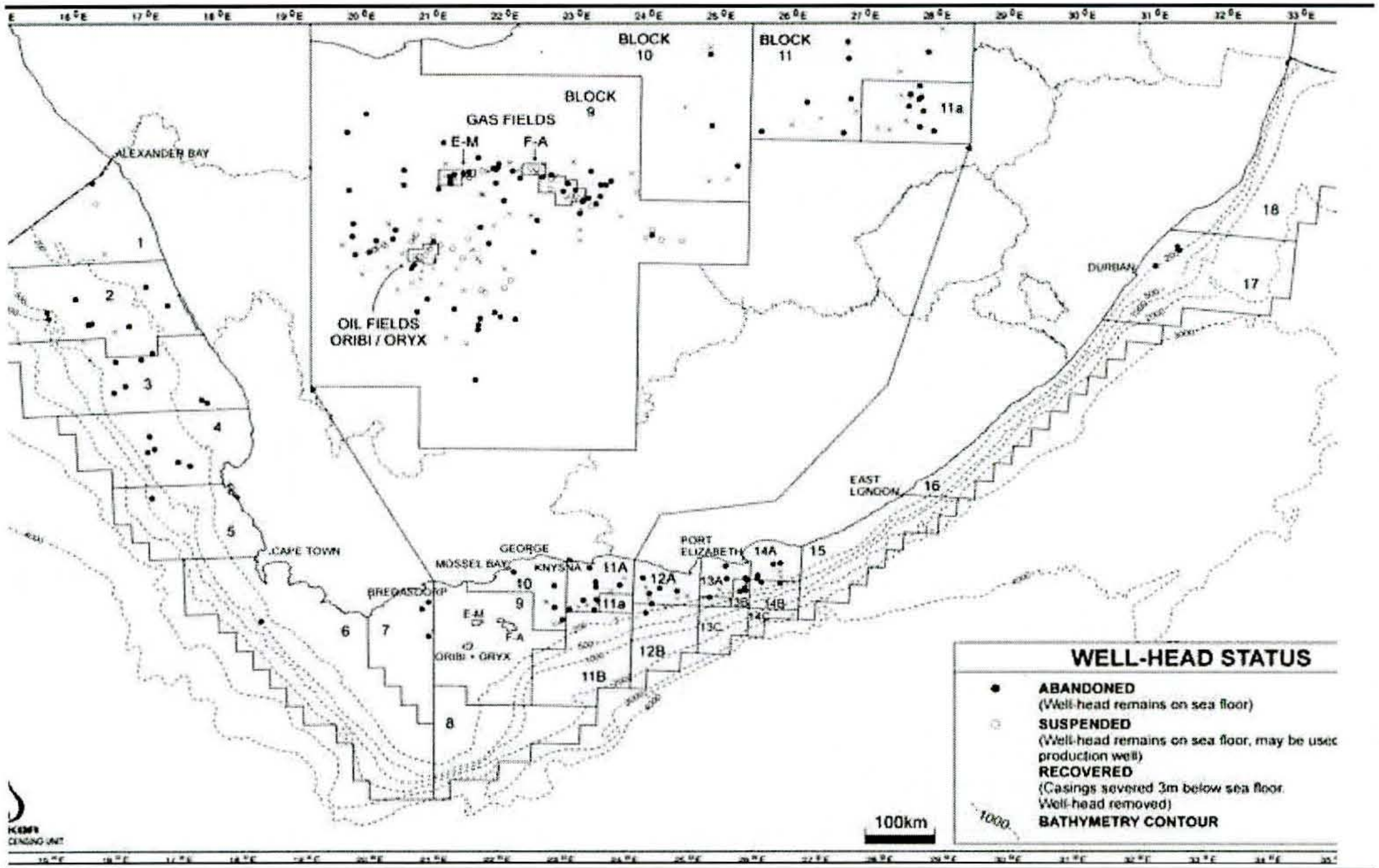
Crustacean Fisheries

These trap-fisheries target mainly the west coast rock lobster (*Jasus lalandii*) to a depth of 100m along the West Coast. This species is found in commercially exploitable densities between the Orange River mouth and Cape Point, with the area around Dassen Island being the most productive rock lobster grounds. Some 2,875 tonnes of west coast rock lobsters were landed by this fishery in the 2008 fishing season.

4.7 SHIPPING TRANSPORT

The majority of shipping traffic is located on the outer edge of the continental shelf (*Figure 4.20*). Traffic encountered inshore of the continental shelf along the West Coast north of Cape Point comprises fishing and mining vessels. East of Cape Point, inshore boat traffic is heavier.

Figure 4.22 Wellhead Status for Offshore Petroleum Exploration



There are a number of companies currently involved in oil or gas appraisal in deep and shallow areas off the West Coast. These include Forest Exploration International; Anschutz Corporation; Q Venture Development Ltd.; Sasol Petroleum International, PetroSA and BHP Billiton Petroleum Great Britain Ltd.

There is no current development or production from the South African West Coast offshore. However, Forest Oil is currently appraising the Ibhubesi Gas discovery within Block 2A for development. The Kudu gas structure, which is being considered for development lies in Namibia north of the South African border.

4.8.2 Gas Hydrates

Gas hydrates are naturally occurring crystalline substances composed of water and gas, in which a solid water lattice accommodates gas molecules in a cage-like structure. While methane, propane and other gases can be included in the structure, methane hydrates are the most common. Gas hydrates form under conditions of cold temperature (<11°C) and high pressure. In the marine environment, they are typically found in water depths of 1,000 m or more, although they have been reported in water as shallow as 200 m. Gas hydrates are known to exist on the sea floor and also in the pore space of sediments for hundreds of meters below the sediment surface. Their presence can be inferred from reflection seismic data, by so called 'Bottom Simulating Reflectors'. These result at the bottom of the gas hydrate stability zone from the contact between a low velocity interval containing free gas and an overlaying high velocity interval containing gas hydrate.

Gas hydrates are significant for a number of reasons, the most important of which are:

- They represent a significant accumulation of methane and associated carbon that is only now being factored into an understanding of the global carbon and climate cycles.
- They represent a major new potential energy source. The global volume of gas hydrate may be greater than the known volume of conventional gas deposits. The technology does not yet exist to economically recover the gas hydrates, but research is being applied to the issue.
- Gas hydrate accumulations around the thermogenic gas seeps at the seafloor are known to support communities of bacterial and associated benthic organisms and as such represent a previously unknown part of the marine energy and food chains.
- Taken together with other factors, the presence of Bottom Simulating Reflectors (BSR's) may be used to infer the presence of an active hydrocarbon system which is generating thermogenic methane, and thus potentially commercial accumulations of conventional gas or possibly oil at depth.

Petroleum Agency SA's seismic data from the West Coast reveals the presence of such Bottom Simulating Reflections, these being associated with interpreted escape chimneys of thermogenic gas which are linked to major faults.

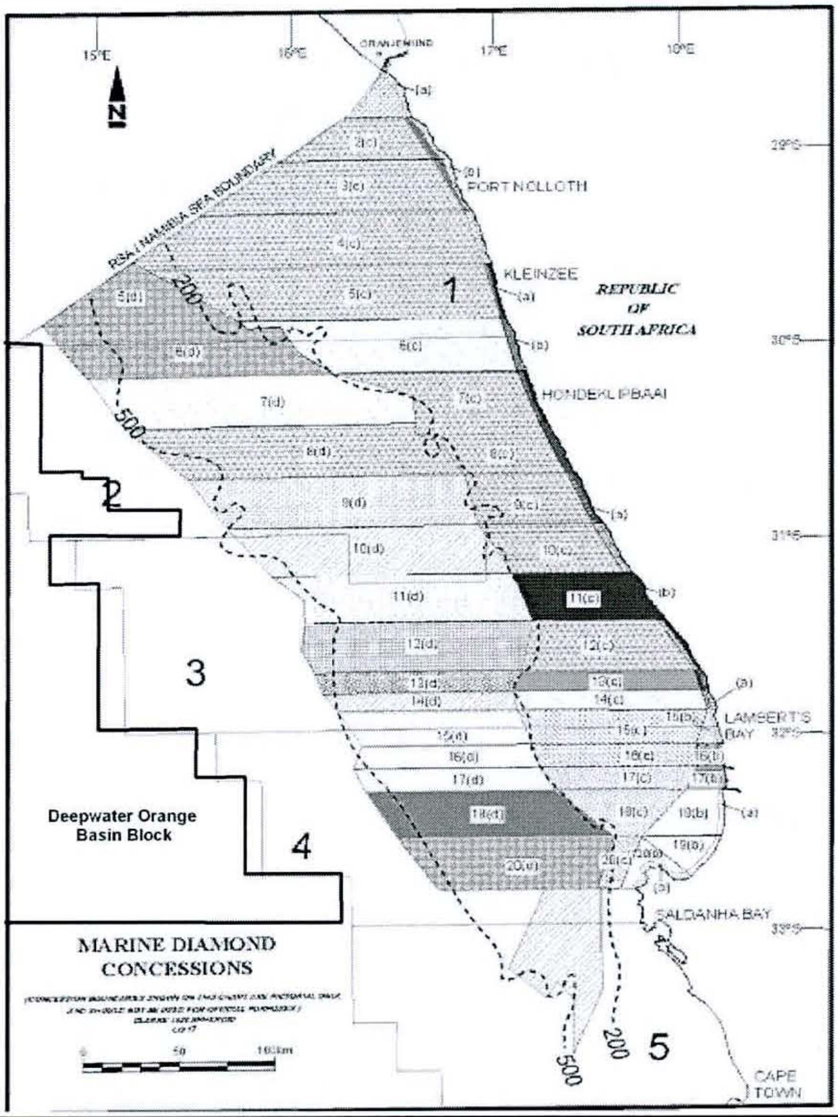
Gas hydrates are being investigated in the South African offshore as part of the on-going research into all potential hydrocarbon resources. The above section is based on information obtained from Bailey and Rogers (1997), Freeman (1997), Hovland et al., (1997), Collett and Kuuskra (1998), Henriet and Mienert (1998), and Avraham et al., (2000).

4.8.3 Diamond Prospecting and Mining

The offshore diamond mining area off the West Coast of South Africa extends from Cape Columbine in the south to the maritime boundary between South Africa and Namibia in the north, and from the shoreline to the continental slope (approximately 500 m water depth). The area is divided into several concession blocks. Current offshore diamond mining and exploration is currently limited to the nearshore strip on the West Coast of South Africa (water depths are mostly less than 150 m). Exploration and mining may extend deeper in future as diamond mining technology improves. It should be noted that the OBDWLA is located in water depths of between 500 m and 3,500 m.

The majority of concessions being worked at present are close inshore, where diamonds are mined either underwater by shore-based divers, or by land based mining equipment that extracts the gravel from areas where the sea has been pushed back by temporary dykes. Two different processes can mine diamonds further offshore: the underwater crawler and the large rotating drill. Both methods employ air–lift suction to deliver the gravel to anchored mining vessels where it is sorted before being returned to the seafloor.

Figure 4.23 *Map of Diamond Mining Concessions on West Coast of South Africa*



Source: Department of Minerals and Energy

4.8.4 *Prospecting and Mining of Other Minerals*

Heavy Minerals

Heavy minerals are currently exploited from onshore deposits near Velddrift, to the north of Saldanha. No permits have been issued for offshore prospecting or mining of heavy minerals on the West Coast.

Glauconite and Phosphorite

Glauconite pellets (an iron and magnesium rich clay mineral) and bedded and peletal phosphorite occur on the seafloor over large areas of the continental shelf on the West Coast. These represent potentially commercial resources that could be considered for mining at some time in the future to provide a source of agricultural phosphate and potassium. Two separate companies have been granted prospecting permits for glauconite and phosphorite. The location of such prospecting Blocks are shown in *Table 4.7*.

Table 4.7 ***Limits of Prospecting Blocks for Glauconite and Phosphorite Within the West Coast Region. In Each Case the Block is a Polygon of Points Labelled***

Block Title	Latitude (S):	Longitude (E):
Agrimin1		
A	32° 49′ 40.11′	17° 19′ 57.12″
B	32° 49′ 39.93″	16° 44′ 23.13″
C	33° 17′ 40.92″	17° 01′ 11.70″
D	33° 13′ 59.88″	17° 07′ 59.99″
Agrimin2		
A	33° 56′ 23.4654″	17° 27′ 23.9975″
B	34° 54′ 31.9601″	18° 07′ 40.2233″
C	34° 53′ 59.5830″	18° 27′ 34.4074″
D	33° 55′ 43.0337″	17° 57′ 58.6973″
SOM1		
A	32° 49′ 39.00″	16° 50′ 9.66″
B	33° 10′ 24.74″	16° 53′ 29.30″
C	33° 40′ 00.00″	17° 50′ 00.00″
D	33° 23′ 30.00″	17° 50′ 00.00″
E	33° 19′ 00.00″	17° 24′ 00.00″
F	33° 29′ 00.00″	17° 41′ 00.00″
G	33° 16′ 00.00″	17° 41′ 00.00″
H	32° 49′ 00.00″	17° 20′ 08.08″

Manganese Nodules in Ultra-deep Water

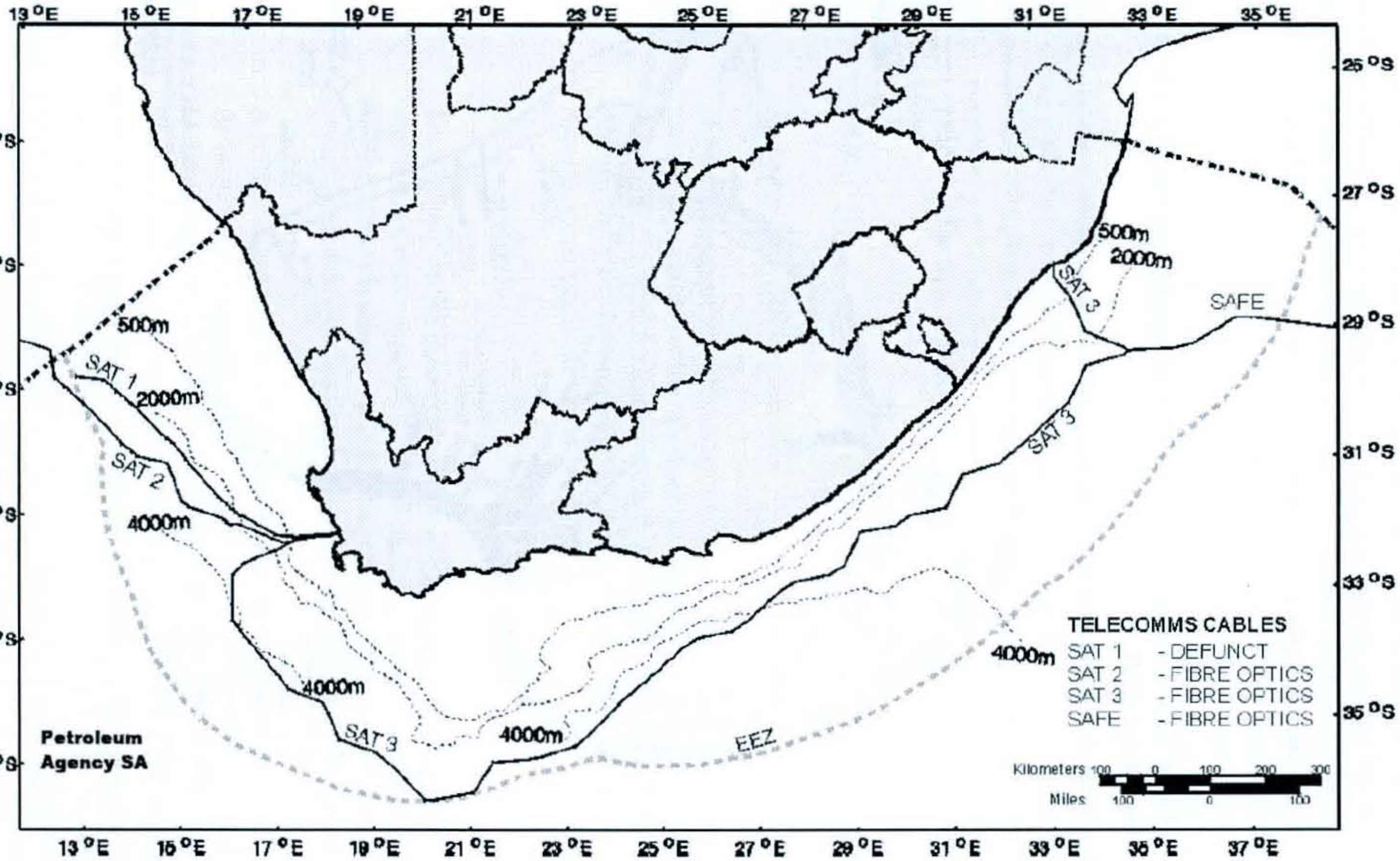
Rogers (1987, 1995) and Rogers and Bremner (1991) report that manganese nodules enriched in valuable metals occur in deep water areas (>3,000 m) on the West Coast. The nickel, copper and cobalt contents of the nodules fall below the current mining economic cut-off grade of 2% over most of the area, but the possibility exists for mineral grade nodules in the areas north of 33°S in the Cape Basin and off northern Namaqualand.

4.9 RECREATIONAL UTILISATION

Recreational activities along the West Coast extend as far as Port Nolloth, although activity is focused in the Cape Town to Saldanha Bay areas. In this area there are also numerous Marine Protected Areas (MPAs) that control both consumptive and non-consumptive activities (see discussion on MPAs below).

Consumptive recreational users are primarily people collecting marine organisms from the sea for their own consumption. Recreational anglers (Brouwer *et al.*, 1997) and divers (Mann *et al.*, 1997) target linefish from either a boat or the shore, while shore-based divers also target west coast rock

Figure 4.25 Schematic diagram of the location of undersea cables



Source: Telkom SA

4.10.3 *Existing Undersea Pipelines*

Bulk oil loading facilities are present inshore off Saldanha and Cape Town harbours while there is also the possibility of a future gas pipeline (either underwater or land-based) being established, linking the Ibhubesi Gas discovery to Saldanha Bay and Cape Town.

4.10.4 *Archaeological Sites*

Over 2,000 shipwrecks are present along the South African coastline (Gribble, 1997). The majority of known wrecks lost along the West Coast are located in relatively shallow water close inshore (Turner, 1988). Wrecks older than 50 years old are declared national monuments (Gribble, 1997).

4.10.5 *Marine Protected Areas (MPAs)*

The major functions of MPAs include:

- exclusion of threats and provision of refuge areas for marine life;
- preservation of representative communities in their natural state;
- provision of undisturbed sites for research and monitoring;
- contribution to sustainability of fisheries.

See *Figure 4.26* for the MPAs in South African waters. The Cape Peninsula Marine Protected Area (MPA) includes all of the coastal waters around the Cape Peninsula from Mouille Point in the west to Muizenberg in the east. This is one of the most diverse and productive stretches of coastline in South Africa. The Cape Peninsula MPA was declared in June 2004.

Langebaan Lagoon Marine Protected Area (MPA) and Sixteen Mile Beach MPA are part of the West Coast National Park. The length of the combined shorelines of Langebaan Lagoon MPA and Sixteen Mile Beach is 66 km. Langebaan is an important MPA because of its unique characteristics – a warm oligotrophic lagoon, along the west coast which is cold, nutrient-rich and wave exposed. It supports very rich bird life and is a Ramsar site. Sixteen Mile Beach lies on the exposed side of the peninsula, and is representative of west coast high energy sandy beaches. The MPA is managed by South African National Parks (WWF Marine Parks Programme Website, accessed 08/01/2010).

The proposed Namaqualand MPA would be South Africa's largest MPA at 9,700 km^2. It would extend from the inter-tidal area between the Spoeg and Groen River, out to sea to include Child's Bank and the 1,000 m isobath and. The proposed MPA would not overlap with the OBDWLA, but would lie adjacent to the OBDWLA. Important species protected by the Namaqualand MPA would include hake, kingklip, monkfish, rock lobster and tuna. The proposed Namaqualand MPA would have been the first MPA in the Namaqua bioregion but was contested due to diamond, oil, gas and commercial fishing interests in the area.

4.11 *SUMMARY*

- West Coast winds and weather patterns are primarily due to the South Atlantic High-pressure cell and eastward movement of mid-latitude cyclones south of the subcontinent. SE winds dominate during summer, NW to SW winds during winter.
- Swells come from the SW, most being generated by mid-latitude cyclones to the south of the country. They reach 7m in height, with peak energy periods from 9.7-15.5 seconds.
- Surface currents flow NW and are primarily wind driven. Deep currents flow poleward.
- Oxygen concentrations near the bottom are generally lower than 2ml/l.
- Upwelling, driven by S-SE winds, is a dominant oceanographic feature. It is more seasonal to the south. Major upwelling centres are located at Namaqualand, Cape Columbine (33□S) and the Cape Peninsula (34°S).
- Upwelling results in the movement of high nutrient concentrations to the surface, where biological processes modify them.
- The resulting high productivity of West Coast waters sustains high biomass, although faunal diversity is low compared to the east and south coast.
- The major spawning grounds of pelagic fish species are located south of Cape Columbine. Recruitment of both pelagic and demersal species occurs along the whole coast.
- A major continental shelf fishery targets both pelagic/epipelagic (e.g. anchovy, sardine) and demersal fish species (e.g. hake). Linefishing is also undertaken, targeting mostly snoek with some cape hottentot also being landed.
- Rock lobsters are an important resource landed by commercial and recreational fishers in relatively shallow waters (< 80 m).
- Most fishing permit holders are foreign (Japanese and Republic of China) through joint ventures with South African rights holders and communication is therefore difficult.
- Twenty-three cetacean species are present off the West Coast, of which Heaviside's dolphin is endemic to the south-western African coast between Cape Point and Cape Cross.
- Islands located along the coast are important breeding and roosting sites for seabirds.
- Cape fur seals are abundant, with seven breeding and six non-breeding colonies along the coast. Cape fur seals appear to forage over the continental shelf to a maximum depth of approximately 200 m.
- The northern areas of the West Coast are important diamond mining areas.
- The Cape Peninsula Marine Protected Area was declared in July 2004.

Table 4.8 *Regulations Enforced Within the Different Marine Protected Areas Located Along the West Coast*

Marine Protected Areas and Closed Areas	Regulations
St Helena Bay	
Shell Bay Point to Stompneus Point	3 nautical miles (nm) seaward from high water mark, no rock lobster may be caught
Stompneus Point to beacon SHBE/DR (Wilde Varkens Valley A)	6nm seawards from high water mark, no rock lobster may be caught
Saldanha Bay	
Between North and South Head	No rock lobster may be caught
South of the line from beacon LB3 and LB4	No angling or bait collecting
Jutten, Malgas and Marcus Island	No fishing allowed along the shores of these islands
Plankies and Rooipan se Klippe	No fishing from the shore allowed
Rocherpan Marine Reserve	Only shore angling allowed
Melkbos Point to Die Josie	12nm (~22.2km) seaward from the high water mark, no rock lobster may be caught
Karbonkelberg	
The Sentinel and Hout Bay and Oudekraal	3.3nm offshore at the widest point, no fishing allowed
Cape of Good Hope	
Hoek van die Bobbejaan and Scarborough	1nm seawards, no fishing allowed
False Bay	
St James to Kalk Bay tidal pool	500m seawards from high water mark, no fishing allowed
Lourens River mouth to Gordon's Bay harbour	500m seawards, only shore angling allowed
Simonstown harbour and Oatlands	no fishing allowed
Millers Point and Partridge Point	1nm seawards, no fishing allowed
Smitswinkel Point and Venus Pool	1nm seawards, no fishing allowed
Eerste River mouth and Lourens River mouth	500m seawards from high water mark, no fishing allowed
Betty's Bay Marine Reserve Mudge Point Hawston harbour (western limit) to Frans Senekal Reserve (eastern limit)	Between beacon B1 & B4, for 2nm seawards from the high water mark, only shore angling allowed
	100m seawards from the high water mark, only collection of rock lobster and shore angling allowed
Onrus River	
Between beacons at Van der Riet Hoek and Marine Drive Point	

Marine Protected Areas and Closed Areas	Regulations
Hermanus From Kraal Rock to Rietfontein	Only shore angling allowed
Gans Bay	500m seawards, only shore angling allowed
Dyer Island	2nm from the high water mark around the island, only shore angling allowed

Table 4.9 Coastal Sensitivity for Each Petroleum Licence Block on the West Coast of South Africa

Region	Settlements	Coastal Formation	Estuaries And Wetlands	Sensitive Areas	Human Utilisation	Oil Spill Contingency Plan
Block 1	Port Nolloth, Kleinsee	Exposed Rocky Headlands, Fine Grain Sandy Beaches, Wave Cut Rocky Platforms	Orange River	Kleinsee Seal Colony	Diamond Concessions On Coastline, Rock Lobster Fishing, Abalone Ranching Harbours : Port Nolloth	Zone 1 (Orange River To Elandsbaai)
Block 2	Hondeklipbaai	Exposed Rocky Headlands, Fine Grain Sandy Beaches	Spoeg River, Groen River	Proposed Groen Spoeg Namaqualand MPA	Diamond Concessions On Coastline, Rock Lobster Fishing.	Zone 1 (Orange River To Elandsbaai)
Block 3a	Strandfontein, Doringbaai	Exposed Rocky Headlands, Fine Grain Sandy Beaches	Olifants River	Elephant Rock Seal And Seabird Colony	Diamond Concessions On Coastline, Rock Lobster Fishing.	Zone 1 (Orange River To Elandsbaai)
Block 4a	Lamberts Bay, Elandsbaai, Dwarskersbos, St Helena Bay, Brittania Bay, Paternoster	Exposed Rocky Headlands, Fine Grain Sandy Beaches	Berg River, Verlorenvlei	Lamberts Bay Seabird Colony, Jacobs Reef Seal Colony, Dwarskersbos / Rocherpan Marine Reserve, St Helena Bay Marine Protected Areas.	Rock Lobster Fishing, Pelagic And Demersal Fishing, Recreation / Tourism Harbours : Lamberts Bay, Velddrif, Stoney Point	Zone 1 (Orange River To Elandsbaai) Zone 2 (Elandsbaai To Bokpunt)

Region	Settlements	Coastal Formation	Estuaries And Wetlands	Sensitive Areas	Human Utilisation	Oil Spill Contingency Plan
Block 5	Saldanha Bay, Langebaan, Kreefbaai, Yserfontein, Melkbos, Greater Cape Town Metropolitan Area	Exposed Rocky Headlands, Fine Grain Sandy Beaches	Langebaan Lagoon	West Coast National Park Including Langebaan Lagoon, Seabird Colonies On Malgas, Marcus, Vondeling, Jutten And Dassen Islands, Robbesteen Seal Colony, Robben Island, Seasonal (Jun - Nov) Right Whale Breeding Ground	Rock Lobster Fishing, Pelagic And Demersal Fishing, Recreation / Tourism, Mariculture (Saldanha Bay) Harbours : Saldanha Bay, Table Bay	Zone 2 (Elandsbaai To Bokpunt) Zone 3 (Bokpunt To Steenbras River)
Block 6a (Bounded On The Inshore Border By Op8)	Greater Cape Town Metropolitan Area, Rooiels, Betty's Bay, Kleinmond, Greater Hermanus, De Kelders, Gansbaai, Kleinbaai, Franskraal, Pearly Beach	Exposed Rocky Headlands, Fine Grain Sandy Beaches	Zand River, Eerste River, Steenbras River, Bot River, Klein River, Uilkraals River	Cape Peninsula MPA, Betty's Bay Marine Reserve, Mudge Point Conservation Area, Hermanus Marine Reserve, Dyer Island, Geyser Rock, Quoin Rock, Ratel River Rocks, Seasonal (Jun – Nov) Right Whale Breeding Ground.	Rock Lobster Fishing, Pelagic And Demersal Fishing, Abalone Fishing, Abalone Mariculture, Recreation / Tourism Harbours : Hout Bay, Simonstown, Kalk Bay, Gordon's Bay, Hermanus, Gansbaai	Zone 3 (Bokpunt To Steenbras River) Zone 4 (Steenbras River To Uilkraals River) Zone 5 (Uilkraals River To Breede River)
Ultra Deep Orange Basin Block	None (>150km offshore)	None (>150km offshore)	None (>150km offshore)	Proximity to proposed Namaqualand MPA	Pelagic Long-line fishing mainly in North Eastern part of block. Main fishing grounds to east of block. Harbours : Port Nolloth, Saldanha Bay	Zone 1 (Orange River To Elandsbaai) Zone 2 (Elandsbaai To Bokpunt)

5 *IMPACT ASSESSMENT*

5.1 *INTRODUCTION*

This *Chapter* focuses on the potential impacts related to 2D and/or 3D seismic surveys and provides a high-level assessment of the impacts associated with prospect well drilling activities. For each activity, the impacts are discussed and assessed for the following three phases:

- Establishment Phase;
- Operation Phase; and
- Decommissioning and Post Closure Phase.

The Initial Period of the work programme will be a desk study and regional 2D seismic surveys and gravity magnetic acquisition will take place. Further 2D and 3D seismic acquisition and/ or CSEM methods will take place if the decision is taken to enter the 1st Renewal Period. Each seismic acquisition programme will take between four and eight weeks to complete. If decisions are taken to extend into the 2nd and 3rd Renewal Periods, additional detailed Impact Assessments integrating environmental, social and health aspects will be carried out to inform the planning process and specific EMPs will be developed prior to any field activity.

Table 5.1 summarises the potential impacts associated with seismic survey and prospect well drilling activities. This *Chapter* further identifies the impacts associated with these activities and provides an assessment of their associated impact. The potential impacts as a result of the seismic activities are provided in detail, an overview is provided of the potential impacts of prospect well drilling activities. This section will be updated should Shell decide to enter the 2nd Renewal Period.

A matrix of the potential environmental impacts at the various stages of seismic survey activities is provided in *Table 5.1*. Impact assessment appropriate to seismic activities for the various phases is provided below. With the proper application of management techniques and best environmental practice, many if not all, potential impacts should eliminated.

Table 5.1 *Summary of Potential Environmental Impacts*

Phase	Activity	Potential Impact	Environmental Resource Affected	Description
Offshore seismic activities	Seismic equipment	Noise	Biosphere	Acoustic sources have the potential to cause disturbance to marine organisms and there may be a may need to avoid sensitive areas and consider seasonality. Impacts would be short-term and transient.
	Vessel operations	Emissions and discharges	Atmosphere, Aquatic and Terrestrial	Vessel operations may be associated with in atmospheric emissions from vessel engines; discharges to ocean: bilges, sewage; spilages; waste and garbage disposal to shore. Impacts would be low-level, short-term, transient
		Interference	Human, socio-economic and cultural	Interaction of the seismic vessel with other resource users (e.g. fishing, shipping lanes). has the potential to cause short-term, transient impacts to people and the socio-cultural environment
Off shore prospect well drilling activities	Operations	Discharges Emissions Wastes	Human, socio-economic and cultural, Atmosphere, Biosphere, Aquatic and Terrestrial	The discharges, emissions and wastes generated by the prospect well drilling activities include drilling muds, cuttings, wash water, drainage, sewage, sanitary and kitchen wastes, spillages and leakages, emissions from plant equipment; noise and light and solid waste disposal onshore. These discharges, emissions and wastes have the potential to cause a disturbance to benthic and pelagic organisms, marine birds and result in negative changes in sediment, water and quality as well as a loss of access and disturbance to other marine resource users. Impacts would be short-term and transient.
	Decommissioning	Footprint	Biosphere and Aquatic	The footprint of the drilling activities could result in sedimentation and water contamination, damage to benthic and pelagic habitats, organisms and biodiversity. There may also be implications for onshore solid waste disposal, infrastructure and resource conflicts. Proper controls during operations and careful decommissioning should effectively remove risk and long-term impact.

Source: UNEP IE

5.2 *ENVIRONMENTAL IMPACTS OF SEISMIC SURVEYS: ESTABLISHMENT PHASE*

This phase includes the finalisation of the seismic contractors, the hiring and training of staff, mobilisation of the seismic vessel and chase vessel, travel to the seismic acquisition area, testing of equipment, deployment of the geophone array (just before the vessel reaches the seismic acquisition area and planned seismic lines) and preparation for beginning firing of the airguns.

5.2.1 *Geology and Sediment*

No impact will occur as staff and vessel mobilisation do not have physical impacts on the geology and sediments of the seabed or coastline. The seismic activities, including the deployment of the geophone streamers occur no deeper than 20 m from the surface of the sea.

5.2.2 *Physical Oceanography*

Staff and vessel mobilisation do not impact the physical oceanography. The seismic activities, including the deployment of the geophone streamers occur no deeper than 20 m from the surface and has no impact on physical oceanography processes in the survey block.

5.2.3 *Physical Nature of Surrounding Areas*

No impact is envisaged, as the staff and vessel mobilisation and preparation for the seismic surveys do not have any effect on the physical nature of the receiving environment.

5.2.4 *Air Quality*

Emissions to the environment during the establishment phase will result mainly from movement of the seismic vessel onto site. The impact on air quality would be negligible and no greater than that from another vessel of similar size.

5.2.5 *Water Quality*

All survey vessels will comply fully with international agreed standards regulated under MARPOL 73/78 and relevant South African legislation for the disposal of waste, specifically:

- Drainage from machinery spaces will be treated to ensure that it does not contain more than 15 mg/l of oil.
- All other discharges will be treated such that their average monthly oil content is no greater than 40 mg/l. The instantaneous oil content of all discharges will not exceed 100 mg/l.
- No plastics or garbage will be discharged to sea. These will segregated, quantified and accounted for prior to disposal at dedicated facilities.

- Food wastes will be macerated and discharged offshore, more than 12 nautical miles (21.6 km) from the nearest land or island, or brought to shore for disposal.
- Sewage discharges will either be treated and disinfected in an approved treatment plant and discharged more than 12 nautical miles from shore (mainland and islands), or contained and discharged at dedicated facilities.
- Hazardous waste (used lubricating oil, filters, batteries etc) will be disposed at dedicated onshore hazardous waste disposal facilities.

The impacts on water quality after mitigation are deemed to be negligible.

5.2.6 *Fauna and Flora*

No impact on flora or fauna is envisaged as the vessel would be steered as an ordinary vessel to the survey block area.

5.2.7 *Marine Transport Routes*

Movement of the seismic vessel onto site is expected to have a negligible impact on transport routes after mitigation. Any impacts on marine traffic would be related to interference with the streamers. The seismic equipment and geophone array will not be deployed until the vessel is close to the operational area, just before operation (firing of the airgun).

Shell will provide details of the seismic survey plan to mariners and fishing operators in advance of the initiation of seismic activities.

5.2.8 *Mariculture Activities*

There will be no impact on mariculture activities. The mobilisation of the vessel would result in no particular increase in marine traffic levels in the area, no significant changes to the physical nature of the area which may impact mariculture activities.

5.2.9 *Commercial and Recreational Fishing*

Movement of the seismic vessel onto site may have an impact on fishing activities, particularly pelagic longline fishing since this is widely carried out in the OBDWLA. This short-term impact is anticipated to be minimal as the seismic equipment is not deployed until the vessel is close to the operational area. In order to minimise disruption to the seismic vessel and other users of the sea Shell will notify fishers and employ a Fisheries Liaison Officer (FLO).

5.2.10 *Mining Activities*

There will be no impact on mining activities as no mining activities are being undertaken within the survey block.

5.2.11 *Communication Infrastructure*

No effects of seismic sounds on submarine fibre optic cables, linkage boxes or repeaters are expected, as the SAT1 and SAT2 cables are located on the seabed and there is no likely interference. The proposed route for the new WACS cable passes through the OBDWLA, but mobilisation of the seismic vessel is unlikely to interfere with the laying of the cable.

5.3 *Environmental Impacts of Seismic Surveys: Operational Phase*

During the operational phase, the survey vessel travels along the planned seismic lines at a speed of between 4 to 6 knots towing one (2D) or more (3D) streamers approximately 5 – 8 km in length with attached geophones. The airgun sound source (single source for 2D surveys) or array of airguns (3D surveys), is attached approximately 300 m behind the vessel at a depth of 5-10 m below the surface and produces sound of 220-230 dB re 1 mPa @ 1m (single airgun) or 250 dB re 1 mPa @ 1m (airgun array) mainly within the 0 - 120 Hz bandwidth.

The seismic vessel will need to turn at the end of the seismic line and will discontinue shooting, turn in an arc, and then resume shooting once on the next seismic line.

5.3.1 *Geology and Sediment*

There will be no impact on the seafloor or underlying rocks during the operational phase. The seismic survey activities occur offshore and within the highest 10 m of the water column. The seismic pulses generated are not of sufficient energy to have an impact on the geology or sediment of the seabed.

5.3.2 *Physical Oceanography*

There will be no effects on physical oceanography other than that for any vessel at sea. The movement of the seismic vessel, the towing of the geophones and the seismic noise do not have any effect on the physical oceanography of the area.

5.3.3 *Physical Nature of Surrounding Areas*

The normal controlled operations of the seismic vessel will not alter the physical characteristics of the coastline or seabed. There are no impacts on the physical nature of the surrounding areas.

5.3.4 *Air Quality*

During normal operating conditions controlled emission of sulphur dioxide and oxides of nitrogen will be ensured through conventional design features provided with the equipment. Manufacturer's instructions for the operation and maintenance of the equipment will be followed to ensure that equipment operation is carried out at the highest possible level of efficiency. This will also help in maintaining emissions such as carbon dioxide and carbon monoxide to minimum possible levels. Due to the limited duration of the survey the impact of air emissions is assessed to be of negligible significance.

In order to support various operations, fuel oil will be used in turbines, generators, compressors and other equipment. Use of fuel in combustion processes will produce combustion gases such as oxides of nitrogen and sulphur. These gases will be emitted to the atmosphere and emissions have the potential of causing short-term changes in the air quality of the area, but due to the small amounts and easy dispersion, this would be of negligible significance.

Mitigation of Impacts on Air Quality

- Regular maintenance of motors and generators to ensure that equipment is operated and maintained to manufacturer's specification.

Residual Impacts on Air Quality

- Air quality impacts are regarded as negligible given the short duration of the seismic survey.

5.3.5 *Water Quality*

Wastes, discharges and emissions that will be generated during the proposed seismic survey will include liquid effluents including deck drainage, drainage from machinery spaces and sewage, kitchen and other solid waste and hazardous wastes. Untreated drainage will be limited to rainwater and sea spray run-off from uncontaminated areas and this will have a negligible impact on the water quality and on the ecology of the receiving waters. Nonetheless, mitigation measures are proposed to ensure that pollution is minimised.

Mitigation of Impacts on Water Quality

- All survey vessels will comply fully with international agreed standards regulated under MARPOL 73/78 and relevant South African legislation for the disposal of waste, specifically:
- Drainage from machinery spaces will be treated according to MARPOL 73/78 limits (to ensure that it does not contain more than 15 $mg.l^{-1}$ of oil)
- Oily drainage from all other areas will be treated and stored on the vessel prior to discharge at an appropriate facility for the shallow water area and discharged to sea for the deep water areas
- All other discharges will be treated according to MARPOL 73/78 limits (average monthly oil content is does not exceed 40 $mg.l^{-1}$). The instantaneous oil content of all discharges will not exceed 100 $mg.l^{-1}$.
- No plastics or garbage will be discharged to sea. These will either be burnt in trash baskets onboard the vessel or be segregated, quantified and accounted for prior to disposal at dedicated facilities.
- Food wastes will be macerated and discharged offshore, more than 12 nautical miles (21.6 km) from the nearest land or island, or brought to shore for disposal.
- Sewage discharges will either be treated and disinfected in an approved treatment plant and discharged more than 12 nautical miles (21.6 km) from shore (mainland and islands), or contained and discharged at dedicated facilities.

- Hazardous waste (used lubricating oil, filters, batteries etc) will be disposed at dedicated onshore hazardous waste disposal facilities.

Residual Impacts on Water Quality
The overall residual impacts of emissions and waste generated on air and water quality are considered to be negligible.

5.3.6 *Fauna and Flora*

Characteristics of Seismic Noise

The most frequently used sound sources for seismic surveys are arrays of airguns that have dominant energy in the 10-300 Hz frequencies. Sound pressure levels of airgun arrays at the source (1 m) are in the region of 230-258 dB re 1 µPa-m (McCauley, 1994; Richardson et al, 1995). Despite the fact that most of the energy of the pulses is of relatively low frequency (50 – 100 Hz), airgun array pulses contain some energy up to 500 - 1000 Hz (Richardson et al, 1995). Analysis of broadband spectra of seismic survey airgun emissions has shown considerable energy at around 22 kHz (90 dB re 1 µPa2 Hz-1 at 750 m).

For an organism to respond to sound, the sound has to exceed that of the ambient noise, which has either non-biological or biological origins. McCauley (1994) noted that non-biological underwater noise has three principal sources, namely wind (including waves and the surf zone), rain and anthropogenic causes. Noise increases with increasing wind speed, with most of the noise being generated by bubble oscillations within waves (Cato, 1978, Banner and Cato, 1988). Rain produces broad-frequency spectra sounds, increasing with the intensity of the downpour.

Shipping sounds cover a wide range of spectra, and include extremely loud noises when the source is in close proximity. *Table 5.2* summarises the non-biological sources of marine noise and provides some expected ranges in relation to drilling activities.

Table 5.2 Comparison of Underwater Noise Types

Source	Frequency and Strength
Wind	1Hz - 25 kHz; 95 dB at 100-200 Hz (Force 12)
Rain	Broad spectrum; 80 dB-m (heavy rain)
Ships (depending on vessel size)	1 Hz - 1 kHz; 150 - 200 dB-m
Invertebrates	2-10 kHz; <140 dB-m
Fish	100 Hz - 5 kHz; <140 dB-m
Mammals	12 Hz – 160 kHz
Drilling (from fixed platform)	5 Hz – 1.2 kHz; 119-127 dB
Drilling (from semi-submersible)	29-70 Hz; 125 dB
Seismic survey	0-120 Hz, 220-230 dB-m

Source: ERM, 2005

Underwater biological noises are produced by a wide variety of marine organisms, particularly during reproduction, displays of territoriality and echo-location. Marine invertebrates, for example rock lobster *Panulirus spp* (McCauley, 1994) and snapper shrimp *Alpheus spp* (Cato and Bell, 1992), generally utilise frequency spectra greater than 2 kHz. Sounds produced by fish have a wider frequency range, from 100 Hz to about 5 kHz. Marine mammals demonstrate the greatest range of frequencies during sound production, ranging from 12 Hz in large baleen whales such as blue whale *Balaenoptera musculus* (Watkins et al, 1987) to 160 kHz in harbour porpoises *Phocoena phocoena* (Mohl and Andersen, 1973).

For a sound signal to be detected, it must contain sufficient energy to exceed any ambient noise present at frequencies near the signal frequency. The signal to noise ratio (at the receiver) is determined by the source level, the transmission through air or water, the ambient noise level and the sensitivity of the receiver.

The impact of noise on marine fauna is largely dependent on the received levels of noise against the background or ambient noise that is present, and the hearing sensitivity of the receiver. The received level is dependent on a number of parameters including the source characteristics (level and frequency), the transmission or propagation loss and the receptive capabilities of the animal. The transmission or propagation loss of sound through water obviously results in sound levels decreasing with distance from the source. Consequently the distance of the receiver from the source probably has the greatest influence on the sound levels that are perceived.

Generic Impacts of Noise on Marine Biota

Three distance zones can be defined around a sound source in terms of the influence of the sound on marine fauna. These are:

(i) the zone of pathological injury;
(ii) the zone of behavioural response; and
(iii) the zone of audibility (where the sound is audible but has no effect on the animal or its behaviour).

A fourth zone, the zone of masking, exists but is difficult to quantify (Richardson etc al, 1995). The potential effects of noise on marine organisms can be categorised as follows:

- Behavioural changes are often hard to detect, but generally involve a cessation of normal activities and the commencement of avoidance or 'startle' behaviour as a result of the detection of sound from marine construction activity. Continued exposure often results in habituation to the sound, followed by a recommencement of normal behaviour.

- Interference with and masking of sounds produced by animals for communication purposes is also difficult to assess, but is likely to result in the temporary cessation of sound production, or a muffling of sounds.

- Physical damage or injury can arise from the differential rate of transmission of sound pressure waves through tissues of varying densities. The effect is particularly marked at interfaces between tissues and gas-filled cavities, for example, the swim-bladders of fishes or the lungs of mammals. The sound-receiving apparatus of most organisms is generally comprised of sensory hair cells, which are extremely sensitive to vibrations. Over-stimulation of these can potentially lead to pathological injury (including disorientation, stunning and any associated predation).

- Shifts of hearing threshold – Repeated or continual exposure to high level sound results in a gradual deterioration of hearing through permanent (PTS) or temporary threshold shifts (TTS).

- Acoustically induced decompression sickness - Crum and Mao (1996) suggested that significant acoustically induced bubble formation could be expected at received levels of over 210 dB.

The significance (if applicable) of these effects for the different groups of marine fauna encountered on the South Coast are discussed below.

5.3.7 *Phytoplankton and Zooplankton*

High level seismic sounds such as seismic firing could result in pathological injury or mortality of plankton. The documented effects of impulsive seismic type sounds on plankton are however limited to the immediate vicinity (within 10 m) of the source.

The mortality or injury impacts of seismic noise on plankton are deemed to be negligible due to the rapid regeneration of plankton. Regeneration time of phytoplankton is rapid (although subject to nutrient availability) so that a region vacated by mortality would be rapidly re-colonised by phytoplankton. Re-colonisation times of a water column by zooplankton would depend on a number of variables, including seasonality of spawning, water movement, and vertical migration of plankton species and proximity of breeding adult populations.

Consequently, the effects of seismic noise on plankton are deemed to be of negligible significance. The effects are probably similar to that of the wake of a vessel.

Invertebrates

Potential direct impacts of seismic surveys on invertebrate species include mortality and behavioural avoidance impacts. Potential secondary impacts include impacts:

- on fishing of commercially important species; or
- increased predation of invertebrates as a result of injury because they may be impacted or disorientated.

Marine invertebrates, and particularly crustaceans, do not have elaborate organs for the detection of sound, but rather rely on mechanoreceptors to detect waterborne vibrations. Additionally, most invertebrates do not possess air-filled spaces within their body cavities, so their sensitivity to sounds is much reduced. While limited published information about the effects of seismic surveys on invertebrate fauna is available, some of the literature is summarised below:

- Kosheleva (1992, in Turnpenny and Nedwell, 1994) and Matishov (1992, in Turnpenny and Nedwell, 1994) carried out experiments on the exposure of invertebrate species to airgun noise. No detectable effects were found on mussels (*Mytilus edulis*), periwinkles (*Littorina sp.*) or the crustacean crayfish (*Gammarus locusta*) at sound pressure levels of 229 dB (at 0.5 m from a source level of 223 dB re 1 µPa at 1 m). However, a source level of 217 dB (2 m from this source level) resulted in splitting of 33 percent of the shells of Iceland scallops and a 15 percent spine loss in sea urchins.

- McCauley (1994) reviewed the measured behavioural responses of invertebrates to particle motion of low frequency stimulation and suggested there may well be some limited behavioural response to seismic sounds in the near field.

- Wardle et al (2001) undertook underwater observations of free ranging invertebrates (crustaceans, echinoderms and molluscs) exposed to three synchronised 150 cui pneumatic airguns fired every 60 seconds at distances between 109 and 5.3 m from a video camera. No avoidance of the reef area by invertebrate species was recorded.

- Webb and Kempf (1998) found that a seismic array with a total volume of 480 in^3 and a source level of 190 dB re 1µPa at 1m and 2m water depth did not result in any mortality of brown shrimp in the Wadden Sea and found no reduction in catch rates. Also, Steffe and Murphy (1992), as cited in McCauley (1994), were unable to show any significant effects on prawn catch rates before, during or after seismic survey of the coast of New South Wales, Australia. Likewise, La Belle et al (1996) showed that sampling before and after seismic shooting showed no evidence of clam mortality.

The effects of seismic noise on benthic invertebrate fauna are therefore considered to be negligible from seismic surveys where noise will largely be within the far-field range. Because of the large distance to the seabed (95 percent of the OBDWLA area is deeper than 1000 m), effects to benthic invertebrates and associated behavioural avoidance are improbable, and the consequent impacts of behavioural avoidance are considered to be of negligible significance.

The impacts of seismic noise on mobile invertebrates (for example rock lobster) are generally deemed to be of negligible significance. There is likely to be some behavioural avoidance of seismic surveys by water column invertebrates. This is deemed to be of negligible significance due to availability of high mobility, alternate habitat and post-survey return of animals.

Mitigation of Impacts on Invertebrates

- The survey will utilise "soft starts" to ensure that invertebrates can move away from and avoid the seismic noise sources. "Soft starts" refer to the practice of increasing the source level of a sound source array gradually rather than to commence firing all sound sources at full volume, after a period when seismic sources have been silent or about to start. This procedure intends to allow any marine fauna that is are close to the array to move away before they are exposed to emissions at full power. Prior to the start of seismic shooting, sound levels are increased gradually by 6 dB per minute over a period of at least 20 minutes.

Residual Impacts on Invertebrates

Overall impacts on invertebrates are considered to be negligible.

5.3.8 *Fish*

Potential impacts on fish species include mortality and behavioural avoidance of seismic sound sources. Secondary socioeconomic impacts on fishing of commercially important species may occur temporarily and is further discussed in *Section 5.3.16*.

Pathological Trauma or Mortality

Seismic noise is most likely to affect fish with swim bladders. Evidence of the potential impact of underwater explosion shock waves on fish is given by circumstantial evidence when underwater explosions are used to seal wellheads and kingklip (*Genypterus capensis*) are frequently seen floating on the sea surface after such blasts. However, it should be noted that the rise time for a seismic shot is much slower than that of an underwater explosion and that seismic surveys using airguns do not produce a shockwave (large amplitude compression wave), as is the case with explosions, but a pulse (a series of intermittent waves, of lower amplitude that are regular in form and frequency of occurrence (Encarta, 2009).

Assessment of the pathological effects of impulsive airgun type sounds on fish species have usually involved the exposure of captive or caged fish to nearby sound sources (see McCauley, 1994 and Turnpenny and Nedwell, 1994). The following experimental case studies provide some evidence of injury or mortality to fish species.

- Weinhold and Weaver (1972, in Turnpenny and Nedwell, 1994) found no lethal effects of 330 and 660 cm^3 airguns (the estimated received level of which Turnpenny and Nedwell (1994) suggested to be approximately 214-

216 dB re 1 µPa) to exposed caged Coho salmon (*Oncorhynchus kisutch*) smolts.

- Falk and Lawrence (1973) exposed caged, juvenile coregonid fish to an operating airgun (which Turnpenny and Nedwell (1994) estimate resulted in a received level of 226-234 dB re 1 µPa) and found certain of the fish suffered swimbladder damage.

- Kosheleva (1992) investigated the effects of single and arrayed airguns of between 1000 and 20,000 cm^3 (which Turnpenny and Nedwell (1994) suggested had peak sound pressure levels of between 220 and 240 dB re 1 µPa) on benthos, phytoplankton and fish and found that exposure at distance of greater than 1 m or more resulted in no pathological damage to the fish.

- Hastings (1990, in Turnpenny and Nedwell, 1994) found that lethal thresholds for fish began at 229 dB and transient stunning was reported at 192-198 dB received, but that captive fish usually recovered after 30 minutes. Turnpenny and Nedwell (1994) noted that such transient stunning could be lethal in the wild due to an increase in predation.

- McCauley (1994) reviewed experiments in which fish were exposed to black powder detonations and stated that the signal from detonation of black powder has similar characteristics to that of airguns. He noted that Hubbs and Reichner (1952, in McCauley, 1994) found that peak pressures as high as 240 dB re 1 µPa peak did not result in fish mortalities. However, no received levels are given in this text.

- McCauley et al (2000) reported preliminary results of pathological examinations of pink snapper (*Chrysophrys aurata*) exposed to airguns in experimental trials. Fish were exposed to a maximum level of sound which corresponds to an approximate rms level of 193 dB re 1 µPa. Examinations of maculae showed ablated or damaged hair cells on the saggital otoliths ([1]). Although the extent of such temporary damage was low, the authors note that it may be indicative of greater damage and reduced fitness after exposure. The authors noted however that the results are preliminary and that the duration of injury is at present unknown. McCauley et al (2003) found injury to fish hearing organs remained for 58 days after being subject to airgun pulses and that full hearing recovery may have taken four months.

Although the above studies provide evidence of the possibility that pathological trauma or mortality will occur if the fish is in close proximity to airguns, given the general high mobility of fish, it is generally assumed that the majority of fish species would avoid seismic noise at lower levels than

(1) The hearing system of fish is made up of sets of organs containing calcareous stones termed the saggital, utricle and lagena otoliths. In most boney fish the saggital otoliths are the primary hearing transducers. Each otolith has a surrounding sensory epithelium termed the macula, which is lined with hair cells. Movement of the otolith results in pressure on the macula hair cells and the nervous response.

where pathological injury or mortality would occur. The pathological injury / mortality impacts are deemed to be of low significance.

Behavioural Avoidance of Seismic Survey Areas

Behavioural responses of fish species to seismic surveys have been investigated using caged trials (eg Pearson et al, 1992; McCauley et al, 2000) and at sea measurements (using both sonar and net and line catch rates) of avoidance and distribution changes in association with seismic surveys or operating airguns (eg Skalski et al, 1992; Dalen and Rakness, 1985; Løkkeborg, 1991) and underwater video observation of free ranging fish and acoustically tagged fish (Wardle et al, 2001). McCauley et al, 2000 reported on results of experimental trials carried out to evaluate the response of 14 caged fish species to a nearby operating airgun (20 cui Bolt 600B). Apart from the pathological injury described above, the following responses to airgun sounds were noted:

- A startle response to short range start up or high level sounds; these included the C-turn type response (an involuntary muscular spasm on one side of the fish and the fish darting in that direction) described by Pearson et al (1982). Startle responses were greater from smaller fishes and a lessening of startle responses through time (habituation) was noted.

- Spatial changes in schooling behaviour such that fish tended to use the lower portion of the cage during trials, as found by Pearson et al (1982). In particular fish tended to use the centre portion of the bottom of the cage during high noise exposure.

- In some trials, a tendency to faster swimming and the formation of tighter grouping during airgun exposure in some trials.

- A return to normal behaviour patterns some 14 – 30 minutes after airgun operation ceased.

Changes in fish behaviour and in situ distribution as a result of seismic surveys have been reported by a number of authors, and these are summarised below.

- Dalen and Rakness (1985, in Turnpenny and Nedwell, 1994) and Dalen and Knutsen (1987) reported on a study in which an airgun array (of total volume of 77, 932 cm^3) and source level 249.9 dB was used to investigate the effects of seismic surveys on distribution of fish in the northern North Sea. Prior to the seismic operation, the distribution of fish species was determined from echo-sounding and sample trawling to confirm species and size classes of fish within the area. Over 100 acoustic surveys were made along each seismic survey track, prior to shooting and again immediately afterwards. No surveys were carried out with time after the seismic shooting, so that the longer term effects of the seismic shooting were not determined. Fish abundance in the area declined after shooting;

small pelagic and demersal species showed reductions in abundance of 54 percent, 13 percent and 36 percent respectively. As echo-surveys cannot detect fish close to the sea floor, bottom trawl sampling was carried out to investigate changes of fish distribution. Significant increases in trawl catch (34 percent and 290 percent) were recorded in two samples collected after shooting compared to trawl catches prior to shooting which suggested that certain fish species descended to the sea floor during shooting.

- Løkkeborg (1991) reported on investigations undertaken off the coast of northern Norway in which the effects of an airgun array (a peak source level of 239 dB re 1 µPa at 1 m) on commercial fishing for cod (*Gadus morhua*) were assessed through catches of four long-liner operators monitored in the survey area. Catches were reduced by 55-80 percent within the survey area during seismic shooting, although they returned to pre-seismic levels 24 hours after shooting. Reduction of catch was recorded at up to five km from the array, which the author suggested corresponds to a received sound level of 161 dB. Turnpenny and Nedwell (1994) noted that this catch reduction could have resulted from either reduced feeding activity or through the cod moving out of the study area.

- Løkkeborg and Soldal (1993) described investigations of the effects of seismic surveying on cod catches by long-lining operations and by-catches of other species in shrimp trawls off the coast of Norway and in the Barents Sea. They reported that analyses of catch records showed seismic survey operations significantly affected the catch rates of cod in both long line and trawl fisheries. Catches from long lines set within the seismic survey area were reduced by between 55 and 80 percent, while by-catches of cod in shrimp trawls were reduced by about 80 - 85 percent. The authors noted that their data was collected from commercial fishing vessels operating near seismic surveys and despite the fact that they do not provide an ideal basis for quantifying all impacts; the trends strongly suggested the tendency for reduced catches for up to 24 hours and at least 9 km in extent.

- A further study carried out off the Norwegian coast was reported by Engås et al (1993, in Turnpenny and Nedwell, 1994) and Engås et al (1995). This comprehensive and dedicated study was designed specifically to determine the effects of seismic surveys on catch and catch-availability of cod and haddock (*Melanogrammus aeglefinus*) and the temporal and spatial effects of seismic surveys on catches. An 18 airgun array (total volume of 82,132 cm^3 and source level of 248.7dB re 1 µPa at 1 m) was fired over an area of 5.5km by 18.5km and investigations of fish distributions were carried out over a 74km^2 area. Acoustic surveys of fish were carried out in a concentric pattern to a distance of 37 km from the centre of the seismic surveys (in conjunction with verification bottom sampling trawling) prior to, during and after seismic shooting. Commercial trawl sampling was designed on a similar protocol, with 60 - 67 trawls of a standard 145 m sweep being carried out before, during and after seismic shooting. Longline fishing was also carried out at different ranges before, during and after shooting. Three major findings of this study were:

- The distributions and catch rates of both cod and haddock were affected by seismic shooting, both over the seismic survey area and beyond. Catches in trawls of both species were halved over the 74 km^2 area with reductions of up to 70 percent near the centre of the shooting operation. Long-line catches showed a reduction of 50 percent and 44 percent of haddock and cod respectively. However catches of cod increased away from the centre of seismic operations, so that at 30 km no effect was measured. The authors suggested that the difference between the catches of cod recorded in the long-line and trawl effort might result from the long-line fishing not being a quantitative measure of fishing effort.
- A greater proportion of larger fish (> 60 cm) were driven out of the survey area than smaller fish.
- The fish distribution did not return to the pre-shooting patterns within the five days after shooting terminated.

- Wardle et al (2001) undertook underwater observations of free ranging marine reef fishes (small, medium and large gadoids, gobies flatfishes and wrasse) exposed to three synchronised 150 cui pneumatic airguns fired every 60 seconds at distances between 109 and 5.3 m from a video camera. No avoidance of the area by fish was recorded. Fish however exhibited the classic C-turn response. During trials when the guns were visible to the video camera (and fish), fish reacted directionally from the gun. Wardle et al (2001) suggest that fish remained undamaged at received sound levels of over 218 dB re 1 µPa. Similarly, cod and saithe tagged with acoustic pingers showed no directional avoidance of firing airguns. Wardle et al also suggest that the lack of response noted in their trials compared to other reported trials might arise from the fact that the populations studied were resident.

- The effects of airgun noise on spawning behaviour of fish are unknown

Behavioural responses of some fish to seismic sounds were elicited at relatively low levels of about 160 dB re 1 µPa, with evidence of avoidance of seismic survey areas by schooling fish (of up to 30 km and for up to five days after shooting terminated) and changes in feeding behaviours associated with seismic noise.

In contrast to the recorded changes in schooling behaviour and distribution of some fish species, some large pelagic fish show little avoidance behaviour and may actually investigate hydrophone streamers. On the basis of studies carried out elsewhere, the impact of seismic surveys on local fish behaviour is deemed to be of low-medium significance.

The socioeconomic impact that may occur as a result of a decrease in fish catch is discussed briefly in *Section 5* and is considered to be negligible.

Masking of Environmental Sounds and Communication

The effect of masking of the relatively low source levels produced in fish communication by seismic surveys may be variable and is consequently unknown. The degree of masking of a call for example, will depend on a number of factors including:

- the source level of the seismic noise;
- the distance of the receiver (listener) from the source;
- the source level of the call; and
- the distance of the caller from the listener and the current ambient noise.

The importance of communication to the survival of local fish species is unknown, but it may be important in breeding behaviour. Many different fish species are known to use swim bladders for the production of sound (eg kingklip and kob) and this plays an important role in species identification and spawning behaviour. Given the large distribution range of most fish species (relative to seismic survey areas), the effects of seismic noise in masking communication sounds of fish and environmental sound stimuli are assumed to be negligible.

The effect of masking (of the relatively low source levels produced in fish communication) by seismic surveys is unknown.

Indirect Impacts

The indirect effects of seismic surveys on South African fish species are difficult to determine, and would depend on the diet make-up of the fish species concerned and the effect of seismic surveys on the diet species. While no effect is assumed for herbivorous, planktivorous or invertebrate eating species, there may be some indirect effect on piscivorous species. There is little information on feeding success of fish (or larger predators, for that matter) in association with seismic survey noise. Reduced line-fish catches in association with seismic surveys have been suggested to result from changes in feeding behaviour.

Given that the OBDWLA area lies outside of the main spawning and recruitment areas of fish species in the Southern Benguela area and the large distribution range of most fish species (relative to seismic survey areas), the indirect effect of seismic noise on feeding or predation of fish is assumed to be of negligible significance.

Mitigation of Impacts on Fish

- Implement "soft starts" at the initiation of all shooting activity to reduce noise impacts on fish by allowing time for the fish to move from the area before pathological seismic noise levels are reached.

Residual Impacts on Fish
The overall impacts of the seismic survey on fish before mitigation are judged to be of low-medium significance. The residual impacts on fish is deemed to be of low significance after the implementation of "soft starts" and given the temporary nature of seismic surveys, the ability of the fish to move away from high sound levels and the large distribution range of fish species negating any possible feeding or predation impacts.

5.3.9 *Seabirds*

The coast between Cape Point and the Orange River mouth is estimated to support 38 and 33% of the overall winter and summer populations of migrant seabirds found between Cape Point and the northern Namibian border respectively (Crawford et al., 1991). All these species feed relatively close inshore, although gannets and kelp gulls may feed further offshore. Most African penguins (*Spheniscus demersus*) occur within 20 km of the coast, with distribution consistent with areas of shoaling fish. The block is at least 150km off-shore and land based birds will be rarely found in the area.

Pathological Trauma or Mortality

Among the marine avifauna of South African waters, it is only the diving birds or birds which rest on the water surface, which may be affected by the underwater noise of seismic surveys. Of these, it is only the African penguin (*Spheniscus demersus*) (SA Red Data species listed as Vulnerable) which is flightless (and consequently more susceptible to underwater seismic noise) and Cape gannet (*Morus capensis*) (SA Red Data species listed as Concerned) are considered. Although underwater blasts have been reported to result in deaths to seabirds, the rise times of seismic survey pulses are considerably lower than those of underwater blasting and bird mortalities from seismic survey pulses are unlikely.

The continuous nature of the intermittent seismic survey pulses suggest that birds would hear the seismic sound sources at distances where the levels would not induce mortality or injury, and consequently be able to flee an approaching sound source. The potential for injury to seabirds from seismic surveys in the open ocean is consequently deemed to be low.

Behavioural Avoidance of Seismic Survey Areas

Although speculative, the low hearing thresholds of African penguins at frequencies which coincide with seismic surveys suggest that they could hear seismic surveys from considerable distances (over 100 km). No behavioural underwater audiograms or critical ratios have, however, been established. Behaviourally penguins may be able to avoid some seismic survey noise by surface swimming with the head above water, although the avoidance response of the species usually involves diving or rapid swimming underwater.

The impact of seismic noise on the behaviour of seabirds is generally deemed to be negligible, given the transitory nature of seismic surveys and the large feeding range of the seabird species.

Masking of Environmental Sounds and Communication

The impact of seismic noise in masking communication and environmental sound stimuli of seabirds is assumed to be of negligible significance.

Indirect Impacts

African penguins forage at sea, and most birds are found within 20 km of the coast. African penguins mainly consume pelagic shoaling fish species such as anchovy (*Engraulis japonicus*), round herring (*Eutrumeuscapensis* and E. *teres*), horse mackerel (*Trachurus trachurus*) and pilchard (*Sardinops sagax*) and their distribution is consistent with that of the pelagic shoaling fish, which occur within the 200 m isobath and therefore within the survey block. Given the large distribution range of penguins and their prey species (relative to seismic survey areas), the indirect effect of seismic noise on feeding is assumed to be negligible.

The overall impacts of the seismic surveys on seabirds is deemed to be of negligible significance due to their high mobility and large feeding ranges, and due to the offshore location (at least 150 km) of the survey block.

Mitigation of Impacts on Seabirds

- A radius of 500 m should be scanned for the presence of diving seabirds
- Implement at least 20 minute "soft starts" at the initiation of all shooting activity to reduce noise impacts on diving seabirds and fish and allow time for the birds to move from the area before pathological seismic noise levels are reached. Initiation of firing should only begin after observations have confirmed that the visual area around the vessel to a distance of 500 m (safety zone) is clear of all diving seabird species.
- Seabird incidence and behaviour will be recorded by the onboard IO/ MMO, including incidence of predatory seabird attraction due to mass disoreintaion of fish. Incidence of seabird feeding near the streamers will be recorded.

Residual Impact on Seabirds

The overall impact on seabirds is likely to be negligible, given the transitory nature and short duration of the seismic surveys, their large feeding range of the seabird species that they are able to hear the seismic noise and move away from the source.

5.3.10 *Impacts on Seals*

Pathological Trauma or Mortality

The pathological effect of loud low frequency sounds on pinnipeds (including the Cape fur seal (*Arctocephalus pusillus*) (IUCN Least Concern) found within the West Coast region) has not been well documented. A speculative model of the pain threshold for seals and sea lions has been developed using measured discomfort and injury thresholds for humans (of 120 and 160 dB above the minimum hearing threshold, though this may be as low as 80 dB for prolonged continuous exposure) (CCA, 2001). Taking a seal and sea lion minimum hearing thresholds of 65 and 80 dB re 1 µPa respectively, the model suggests that this pain threshold is in the region of 185 dB re 1 µPa for seals and 200 dB for sea lions. No audiograms have been measured for Cape fur seals. However, it would appear from audiograms and call frequencies of other species that the majority of seismic sound energy lies at frequencies where seal hearing is relatively poor. Higher frequency components (where energies are relatively low) of seismic surveys would, however, overlap the optimal hearing frequencies of seal species. The potential of injury to seals from seismic noise is deemed to be low as it is assumed that highly mobile creatures such as fur seals would avoid severe sound sources at levels below those at which discomfort occurs.

Behavioural Avoidance of Seismic Survey Areas

No detailed information on the reactions of fur seals to seismic exploration noise could be sourced. An airgun has been reported to cause an initial startle reaction of Cape fur seals, but it was ineffective in scaring them away from fishing gear. Generally, seals appear to be relatively tolerant to noise pulses from explosives, especially if there is an attraction to prey in the area. Such rapid rise time underwater explosions are more invasive than the slower rise-time seismic sound pulses. Cape fur seals often approach seismic survey operations and may bite hydrophone treamers, and it is assumed that this attraction is a learned response to towed fishing gear being an available food supply. The impact of seismic surveys on Cape fur seal behaviour is deemed to be low and of negligible significance.

Masking of Environmental Sounds and Communication

There are no known impacts of the seismic noise on seal communication.

Indirect Impacts

The impact of seismic survey noise on fur seal feeding is unknown. The diet of Cape fur seals comprises anchovy, hakes, pilchard, horse mackerel and cephalopods. Evidence of continued feeding in association with 'seal bombs' (used to scare seals from fishing gear) suggests that any effect will be low to negligible. Kleinsee seal breeding colony (population estimates ranging from 35,450 in 1972 to 74,620 in 1989) produces the largest number of pups in the country and is the largest in South Africa. Cape fur seals, however, appear to forage mainly over the continental shelf to a maximum depth of approximately 200 m, although a male seal was video recorded at the A-K2 wellhead 84 km offshore from Hondeklip Bay at a water depth of 250 m and depth recorders on two females from the Kleinsee colony showed over 70% of dives to depths of less than 50 m (Kooyman and Gentry, 1986). Since the OBDWLA is located at least 150 km from the coast it is not anticipated that there will be an interaction with Cape fur seals during seismic activities and the large distribution range of most seal prey species, the indirect effect of seismic noise on feeding of seals is assumed to be negligible. However, the implementation of "soft starts" at the initiation of all seismic shooting will mitigate the impact of seismic surveys on seals.

Mitigation of Impacts on Seals

- In the event that it is observed that the group is clearly stressed by the seismic (airgun) activity suggesting signs of injury or mortality, then the airguns are to be stopped immediately and action taken by the vessel to avoid further contact with the animals.
- Large groups of small mammals such as dolphins and seals, which frequently investigate vessels and their activity and are highly mobile, are not likely a concern and no evasive action is required from the survey vessel.

Residual Impact on Seals

The overall impact on seals is deemed to be negligible due to their high mobility and minimal behavioural impacts.

Given this behaviour and the large distribution range of most seal prey species (relative to seismic survey areas), the indirect effect of seismic noise on feeding of seals is anticipated to be negligible.

5.3.11 *Cetaceans (Whales and Dolphins) Overview*

Whale and dolphin species common to the project area can be divided into baleen whale and toothed whale and dolphin species. Available research (McCauley (1994), Richardson et al (1995), Gordon and Moscrop (1996) and Perry (1998)) suggests that there is considerable difference in the hearing sensitivities of baleen and toothed whales and dolphins, with baleen whale hearing centered at below 1 kHz, while toothed whale and dolphin hearing is centered at frequencies of between 10 and 100 kHz.

A number of migratory cetaceans are found within the South Coast regions and therefore may occur within the survey block. These include Blue (*Balaenoptera musculus*), fin (*B. physalus*), sei (*B. borealis*), minke (*B. acutorostrata / B. bonaerensis*), Bryde's whale (*Balaenoptera brydei*), Arnoux's beaked whale (*Berardius arnuxii*) and humpback whales (*Megaptera novaeangliae*) make winter migrations through the West Coast region en route from Antarctic summer feeding grounds to winter breeding grounds. While blue [IUCN Endangered], fin [IUCN Endangered]), sei [IUCN Endangered], Bryde's [IUCN Data Deficient] and Arnoux's beaked [IUCN Data Deficient] whales migrate offshore or along the continental shelf edge (and are thus distributed in deeper waters), humpback whales [IUCN Least Concern], migrate over the continental shelf and along the coast. The pygmy right whale (*Caperea marginata*) shows a strong summer seasonality in water depths of less than 50 m along the coast between Algoa Bay in the east and Walvis Bay, Namibia. Arnoux's beaked whale (*Berardius arnuxii*) has been recorded along the West Coasts to the east of 18° E during summer. Layard's beaked whale (*Mesoplodon layardii*) is distributed throughout the West Coast pelagic waters in summer and early autumn.

Resident cetaceans in the West Coast area and may occur in the seismic area include the Gray's beaked whale (Mesoplodon grayii) [IUCN Data Deficient] and the long finned pilot whale (*Globicephala melas*) [IUCN Data Deficient], Killer whales (*Orcinus orca*) [IUCN Data Deficient], Cuvier's beaked whale (*Ziphius cavirostris*) [IUCN Least Concern], pygmy sperm whales (*Kogia breviceps*) [IUCN Data Deficient],, False killer whales (*Pseudorca crassidens*) [IUCN Data Deficient], pygmy killer whales (*Feresa attenuata*) [IUCN Data Deficient], Risso's dolphins (*Grampus griseus*) [IUCN Least Concern], Common dolphin (*Delphinus spp.*), Bottlenose dolphin (*Tursiops truncates*) [IUCN Least Concern] and sperm whales (*Physeter macrocephalus*) [IUCN Vulnerable] are found throughout the offshore waters of the West Coast. In addition, a localised distribution of southern right-whale dolphins (*Lissodelphis peronii*) [IUCN Data Deficient] is recorded off the coast of southern Namibia and may range into the northern waters of the West Coast region.

A summary of the interactions and timing of various cetacean migrations is provided in
Table 5.3 Summary of scheduling interactions based relevant cetacean migration (ie excluding species only occurring inshore)
below.

Table 5.3 ***Summary of scheduling interactions based relevant cetacean migration (ie excluding species only occurring inshore)***

Species/ Activity	J	F	M	A	M	J	J	A	S	O	N	D
Blue whale						■	■	■				
Fin whale						■	■	■				
Sei whale						■	■	■				
Minke whale						■	■	■				
Bryde's whale						■	■	■				
Arnoux's beaked whale	■										■	■
Layard's beaked whale	■	■	■									
Various resident cetaceans**	■	■	■	■	■	■	■	■	■	■	■	■
Unconducive weather conditions					■	■	■	■	■	■		

* winter migration of various species including the blue whale, fin whale and sei whale (offshore) and humpback whale (inshore)

** These include Gray's beaked, long finned pilot, Killer whale, Cuvier's beaked , pygmy sperm, False killer whales, pygmy killer whale, Risso's dolphins (Grampus griseus), Common dolphin, Bottlenose dolphin, sperm whales and southern right-whale dolphins.

Shell should take note of these timing interactions in planning of the seismic surveys. The seismic surveys would preferably be undertaken during April/ May or September/ October.

5.3.12 *Toothed Whales (Whales and Dolphins)*

Pathological Trauma or Mortality

Although there is no evidence of whales or dolphins being killed or injured by seismic emissions, pathological injury to cetaceans can result from exposure to high sound levels through a number of avenues, including trauma to both auditory and non-auditory tissues. Richardson et al (1995) speculate (on the basis that prolonged exposure to noises of ~80 dB above the hearing threshold induces Permanent Threshold Shifts (PTS) in humans) that very prolonged exposure to noise levels of about 120 dB re 1µPa may induce PTS in beluga whales, although other marine mammals would require much higher levels than these. The 'above threshold' criteria for inducing PTS in humans are based on continuous exposure for 8hr/day over 10 years, so that gradual PTS in marine mammals is highly unlikely to occur from seismic surveys. Such permanent hearing damage does, however, not always develop gradually, but may result from brief exposure to high sound levels.

No literature is available on the distances at which seismic sounds produce injury to marine mammals. McCauley (1994) suggested that damage to most marine mammal hearing could occur at around 220 dB re 1 µPa. Assuming spherical spreading, McCauley (1994) has suggested that pathological injury to baleen whale and dolphin hearing would occur within 32 m and 100 m of the downward focussed beam of a large seismic array (of source level of 250 dB re 1 µPa at 1 m), respectively.

The impact of pathological injury to toothed whales and dolphins from seismic noise is deemed to be low as it is assumed that highly mobile creatures such as cetaceans would avoid severe sound sources at levels well below those at which injury would occur.

Behavioural avoidance of seismic areas

Behavioural audiograms have been measured for several species of toothed whales. The minimum thresholds were in the region of 39-55 dB with best frequencies of between 8 and 90 kHz (CCA, 2001). Generally, toothed whale hearing is centred at frequencies of between 10 and 100 kHz. A low frequency response of bottlenose dolphin (50-150 Hz) has been suggested to be a tactile response of the animal to movement of water particles at low frequencies.

Such a response would only be found close to a sound source within the near field.

Behavioural responses of sperm whales (*Physeter macrocephalus*) to seismic noise may occur at considerable distances from the noise source. Sighting surveys showed that sperm whales were displaced by 50-60 km from an area in the Gulf of Mexico where seismic surveys were taking place and sperm whales in the southern Indian Ocean ceased calling in some instances when seismic pulses were received at 10-15 dB above ambient noise from a source some 300 km distant. Distribution of common dolphins (*Delphinus delphis*) monitored acoustically in the southern Irish Sea prior to, during and after a seismic survey showed that acoustic contact time was lower during the period of seismic activity than before or after the activity. However trials may have been compromised by late autumn southward movement of dolphins, which coincided with the survey period. Reports of dolphins swimming in the vicinity of operating seismic vessels suggest that there is little effect of seismic surveys on these species.

The impact on behaviour of toothed whales is deemed to be of low to medium significance depending on the species concerned and whether the seismic survey is undertaken during breeding and calving seasons. Impacts during migration times would be medium and would be low at other times of the year (before mitigation).

Masking of Environmental Sounds and Communication

Toothed whales vocalise at frequencies higher than those used in seismic surveys. Echolocation clicks produced by odontocete cetaceans are generally of frequencies of well above those produced in seismic surveys and it is probable that such clicks are not masked by seismic survey noise. The effect of masking of environmental noise stimuli by seismic survey noise is unknown. The diets of toothed whales and dolphins in South African waters largely comprise fish, cephalopod and crustacean species.

Indirect Impacts

Given the large distribution range of most prey species (relative to seismic survey areas), the indirect effect of seismic noise on feeding of cetaceans is assumed to be negligible.

5.3.13 *Baleen Whales*

Baleen whales are well adapted to hear low frequency sounds and therefore will be most receptive to the noise produced during the proposed seismic operation.

Pathological Trauma or Mortality

Lien et al (1993) and Ketten et al (1993) estimate damage to hearing of humpback whales caused by explosives in the North - Western Atlantic

Ocean. McCauley (1994), however, notes that airguns used in seismic surveys do not produce the near-instantaneous pressure increase produced by shock waves of explosives and that the information reported by Lien et al (1993) and Ketten et al (1993) are not applicable to non-explosive seismic sources. However, as noted by Evans and Nice (1996) such accounts suggest that humpback whales might tolerate sounds at levels which cause pathological trauma, as neither avoidance of the blast area, nor behavioural responses were noted (Lien et al, 1993, and Ketten et al, 1993).

Although no full audiograms have been measured for baleen whales, the inferences suggest baleen whale hearing is centred at below 1 kHz. There is considerable evidence for the low frequency auditory sensitivity of baleen whales, based on the following:

- a partial behavioural response audiogram for gray whales;
- the assumption that best hearing is centred on frequencies at which the animals vocalise; and
- anatomical evidence of the structure of the ears of baleen whales.

The impact of pathological injury to baleen whales from seismic noise is deemed to be medium as it is assumed that highly mobile creatures such as cetaceans would avoid severe sound sources at levels well below those at which injury would occur. The impact is reduced by implementation of the mitigation measures outlined below but remains of medium significance.

Behavioural Avoidance of Seismic Survey Areas

There are a number of published responses of baleen whales to seismic operations (by a number of authors (Malme et al (1985), McCauley et al (1996, 2000), Thompson et al (1986)) including evidence of avoidance of seismic surveys by some baleen whale species such as humpback *(Megaptera novaeangliae)*, gray (*Eschrichtius robustus*) and bowhead (*Balaena mysticetus*) whales. Such avoidance generally occurred at received levels of between 120 and 180 dB. McCauley et al (2000), on the basis of humpback whale movement in Western Australia, summarised the results of these studies into two findings:

- Displacements of migratory animals are localised and brief (initiated at a distance of about 4 to 5 km to a closest distance of about 3 km), and the little chance of physiological effects suggest seismic surveys to be a low risk for migratory whales.

- Whales, which are not migrating but using the area as a calving or nursery ground, may be more seriously affected through disturbance of suckling or resting. McCauley et al (2000) suggest potential avoidance ranges of 7-12 km by nursing animals (based on results of single airgun trials scaled to 2D array measurements), but note that these might differ in different sound propagation conditions.

In addition, McCauley (2000) noted that in terms of management purposes, the impacts on migrating humpback whales and nursing humpback whales need to be assessed differently. While the risk of seismic surveys and activities to migrating whales appeared to be low, the risk to nursing whales or whales occupying a critical habitat would be far higher.

The risk of seismic surveys and activities to migrating whales is anticipated to be low with the implementation of mitigation measures. As the OBDWLA is a long distance off the coast, the risk to nursing whales or whales occupying a critical habitat is anticipated to be low.

Masking of Environmental Sounds and Communication

Baleen whales appear to vocalise exclusively within the frequency range of the maximum energy of seismic survey noise. Humpback whales utilise vocalisations as breeding behaviour (males sing complex songs on the breeding grounds) and calls may be utilised by southern right whales in attracting males to oestrus females. The effect of seismic survey noise masking the communication of baleen whale noise is, however, extremely difficult to quantify. For example, the degree of masking of a call will depend on a number of factors including:

- the source level and frequency of the seismic noise;
- the distance of the receiver (listener) from the source;
- the source level and frequency of the call;
- the distance of the caller from the listener; and
- the current ambient noise.

The impact of seismic survey noise in masking the communication of baleen whales will therefore ranges from low to high significance depending on the time of year of the survey, with lower significance between the months of December and May. As far as practicable, seismic surveys will be planned to coincide with the movement of migratory cetaceans out of South African waters. Should seismic surveys be required during the winter breeding migrations of baleen whales, then every attempt should be made to direct the survey in such a way as to minimise coverage of breeding areas or migration paths. In particular, it is recommended that seismic survey activity that could affect breeding success of southern right whales should not be carried out in the coastal waters of the southern Cape region (between Lambert's Bay and Algoa Bay) between July and November.

Indirect Impacts

All of the baleen whales, apart from the inshore stock of Bryde's whale are highly migratory with summer feeding migrations outside of South African waters and feeding occurs outside of the region of interest. However, there is increasing evidence that few humpback whales are remaining within the Benguela Current region in summer months, possibly feeding on clupeid like fish in local waters. Given the large distribution range of most prey species of

Bryde's whales (relative to seismic survey areas), the indirect effect of seismic noise on feeding of whales is anticipated to be of negligible significance.

The initiation of all seismic airgun firing will be carried out as "soft-starts" in order to limit the impacts of seismic noise on mobile marine mammal fauna.

Mitigation of Impacts on Baleen Whales

- The initiation of all seismic airgun firing will be carried out as soft-starts in order to limit the impacts of seismic noise on mobile marine mammal fauna.
- Establishment of a 500 m marine mammal exclusion zone. Initiation of firing should only begin after observations have confirmed that the visual area around the vessel to a distance of 500 m (safety zone) is clear of all cetacean species, thirty minutes prior to firing, so that deep or long diving species can be detected.
- Low-level warning airgun discharges should be fired at regular intervals durign night-time line changes, in order to keep animals away from the survey activities.
- The use of Passive Acoustic Modelling (PAM) should be used during times of low visibility and at night-time when observations are not possible.
- Where possible, seismic surveys will be planned to coincide with the movement of migratory cetaceans out of South African waters in accordance with
- *Table* 5.3 Summary of scheduling interactions based relevant cetacean migration (ie excluding species only occurring inshore)
- , preferably April/ May or September/ October.
- The use of the lowest practicable airgun volume should be defined and enforced.
- A marine mammal observation programme will be established for the survey and undertaken. The MMOs will carry out daylight observations (where possible) of the survey region and record responses of all marine mammals to seismic shooting, including distance from the vessel, swimming speed and direction and obvious changes in behaviour and displacement or attraction.
- MMOs must keep accurate records of all "soft starts" and pre-firing observations, any feeding behaviour within the streamers, sightings (location, time) of injured or dead protected species (irrespective of if caused by the seismic vessel).
- Seismic shooting will be terminated when obvious changes to cetacean behaviours are observed from the survey vessel, or animals are observed within 500 m of operating airguns. Conservative safety distances are defined by received sound pressure levels of 180dB re 1 µPa (rms) for baleen and sperm whales and 210 dB re 1 µPa (rms) for toothed whales, (OGP/IAGC, 2003).

Residual Impact on Cetaceans (Whales and Dolphins)

The overall impact on cetaceans is deemed to be medium before mitigation and low after the implementation of mitigation measures due to the high levels of mobility, the short duration of the seismic surveys and the avoidance of the winter migration times.

The diets of toothed whales and dolphins in South African waters largely comprise fish, cephalopod and crustacean species. Given the large distribution range of most prey species (relative to seismic survey areas), the indirect effect of seismic noise on feeding of cetaceans is anticipated to be negligible.

The impact of seismic surveys on toothed whales will be mitigated by the implementation of "soft-starts" at the initiation of all seismic shooting.

5.3.14 *Marine Transport Routes*

Seismic surveys require accurate navigation of the sound source and receiver streamers over pre-determined survey transects. This and the fact that the array and the hydrophone streamers need to be towed in a set configuration and at a set speed behind the seismic vessel, means that the survey operation has little manoeuvrability while operating. Consequently, other vessels may be required to alter course to avoid the towed array and hydrophone streamers and to keep clear of the exclusion zone.

The displacement of transport shipping will be limited to within the extreme near vicinity of the seismic vessel and array and will be of very temporary extent (hours). The impact of such displacement is not significantly greater than displacement associated with any other vessel restricted in her ability to manoeuvre and is deemed to be of negligible significance after mitigation.

Mitigation of Impacts on Marine Transport Routes

- A notice of the seismic operations will be provided to mariners of through the SA Navy Hydrographic Office and port captains of the Port of Cape Town and Port of Walvis Bay.

Residual Impacts on Marine Transport Routes

The impact on marine transport routes is considered to be negligible due to the short duration of the survey.

5.3.15 *Mariculture Activities*

No impact on mariculture is expected as a result of the proposed seismic survey. The mobilisation of the vessel would result in no particular increase in marine traffic levels in the area, no significant changes to the physical nature of the area which may impact mariculture activities.

5.3.16 *Commercial and Recreational Fishing*

Seismic surveys could potentially impact the fishing industries by:

(i) temporary cessation or displacement of fishing activities in the seismic survey area;
(ii) alteration in fish catches and catch distribution; or
(iii) interaction with fishing gear.

Temporary Cessation or Displacement of Fishing Activities

Trawling and Longlining

The OBDWLA falls outside of the pelagic purse-seine fishing, demersal trawling and demersal longline grounds. Pelagic longline fishing however occurs within the OBDWLA at various levels of effort (*Figure 4.19*) by at least 31 active vessels (2009) operating within the area. Tuna pole fishing by a fleet of approximately 200 vessels is also known to occur within the OBDWLA

The displacement of fishing effort or activities will be limited to within the near vicinity of the seismic vessel and is likely to affect the different sectors in different way. Longlines because of their length and potential drift patterns would need to remove the lines a period of several days until such time as the survey gear is well clear of the longline grounds. Trawlers on the other hand may only be affected over a period of hours as they have greater control of their gear, can manoeuvre more easily and can shift to adjacent grounds.

The displacement of these fishing activities is considered to be of medium significance, prior to, and of low significance after mitigation.

West Coast Rock Lobster

West Coast Rock Lobster fisheries target this species to a depth of 100 m and will not interact with the seismic surveys which will occur far offshore.

Recreational Fishing

Coastal recreation along the West Coast may involve either consumptive or non-consumptive use of the marine environment. ecreational anglers (Brouwer et al., 1997) and divers (Mann et al., 1997) target linefish from either a boat or the shore, while shore-based divers also target west coast rock lobsters[1]. The majority of recreational exploitation of marine resources on the West Coast occurs in near-shore areas, such as from protected beaches, lagoons and small boat harbours. The West Coast is however cold and frequently rough – recreational activity is limited to when good sea conditions prevail and also to seasonal restrictions.

Given that the seismic surveys are planned at least 150 km offshore, there are unlikely to be any impacts on the recreational users.

(4) [1] Note. Recreational and commercial exploitation of abalone was stopped in 2007 due to the poor state of the resource and poaching,

Alteration of Fishing Catch Rates and Catch Distribution

A further effect of seismic surveys on the fishing industry (pelagic longlining and tuna poling) would be temporary avoidance of seismic survey areas by some fish species. Such avoidance may lead to reduced catches over the extreme short term in the seismic survey area, although increased catches could theoretically be experienced outside of the survey area. Recreational practices are mostly undertaken near coastal settlements, and are largely practiced for their aesthetic value.

The significance of the impact is expected to be negligible.

Interaction with Fishing Gear

In the event that longlines are found in the path of a towed seismic array it is highly likely that steps would have to be taken to avoid the fishing gear and seismic equipment becoming entangled with associated cost implications of damage to both the fishing and the oil and gas industries. Loss of gear and reduced catches are both costly to the fishing industry. In the same way, entanglement of seismic gear with a longline, or by fishing vessels or trawlers passing through the gear, would have significant financial implications for the seismic survey operator.

The impact of seismic surveys on fishing gear could be of medium significance and of low significance after mitigation.

Mitigation of Impacts on Fishing

- Appointment of a FLO to communicate with the various fisheries stakeholders and to inform all fishery stakeholders of the seismic plan and associated timeframes. The FLO should liaise with the lobster fishing vessels to plan the placing of fishing gear, if possible, or provide additional notice of the areas of exclusion.
- Avoidance of any conflict between the fishing and the oil and gas industries can only be achieved through effective communication and ensuring that the survey area is free of fishing gear prior to the seismic vessel undertaking its operation in that area. This should be done through an FLO. The FLO should ensure effective communication with foreign vessels (namely Republic of China and Japanese vessels) and smaller vessels through the choice of language and mode of communication to be used.
- A chase boat will be used at the beginning of the survey to help set up the communications with the fishers in the area and to clear the area of fishing gear prior to the seismic vessel entering the specific survey area. The boat will also be used to maintain the exclusion zone and ensure that no vessels or fishing gear remain in the path of the seismic vessel.

- A notice of the seismic operations will be provided to mariners of through the SA Navy Hydrographic Office and port captains at the Ports of Cape Town and Walvis Bay.

Residual Impacts on Fishing
The overall impacts on fishing activities are moderate before implementation of mitigation measures and low significance after mitigation due to the mobility of the fishing vessels, the short duration of the seismic survey, providing timeous information on the survey plan and schedule.

5.3.17 Marine Mining Industries

As seismic operations require that the tow-vessel holds a fixed course on predetermined transects, other vessels may be required to alter course to avoid the operation and the towed array and hydrophone streamers. Although possible conflicts of interests exist where mining and seismic surveys are planned in co-incident areas, there are no mining activities within the survey block and therefore no impacts on marine mining activities.

Diamond Mining

As previously discussed, marine diamond mining is currently carried out in the near shore region (less than 150 m water depths) with human divers using suction pipes to lift gravel to small vessels or the shore. Exploration and mining may extend deeper in future as diamond mining technology improves.

Offshore marine diamond prospecting utilises drill ships or seabed crawlers with airlifts. This activity is presently limited to the northern area of the West Coast region (Blocks 1A and 2A), but could be increased to larger areas of the West Coast in the future (See *Figure 4.24*).

Due to its distance offshore and water depths of between 500 m and 3500 m, it is anticipated that there will be no impact on diamond mining and prospecting in the OBDWLA.

Other Minerals

Potential mining operations include minerals such as manganese nodules, agricultural minerals such as glauconite and phosphorite, and heavy minerals such as ilmenite and rutile. There is presently no extraction of heavy metals from sand mining within the marine environment in South Africa. Manganese nodules enriched with valuable metals occur in water depths of over 3,000 m on the West, South and East Coasts of South Africa. Generally, the nickel, copper and cobalt contents of the nodules fall below the current mining economic grade over most of this area, although mineable grade nodules possibly occur in areas north of 33° S in the Cape Basin and off northern Namaqualand. No prospecting permits have yet been applied for. The potential for conflict is therefore anticipated to be very low.

5.3.18 *Communication Infrastructure*

No effects of seismic sounds on submarine fibre optic cables, linkage boxes or repeaters are expected, as the SAT1, SAT2 and proposed WACS cables are located far offshore and from the survey block.

The potential future proposed West Africa Cable System (WACS) route would pass through the OBDWLA, with a planned landing at the town of Yzerfontein on the West Coast. There is the potential for an exclusion zone of one nautical mile to each side of the cable, where no anchoring will be permitted.

If the timing of the cable laying and seismic surveys are likely to overlap, impacts of the seismic survey on laying of the WACS cable could be of high significance prior to mitigation, and of low significance after mitigation.

Mitigation of Impacts on Communication Infrastructure

- Shell to obtain confirmation of the WACS cable-laying schedule. Shell should initiate negotiations with the relevant parties if the seismic surveys and cable-laying activities are planned for the same time within the same area.
- A notice of the seismic operations will be provided to mariners of through the SA Navy Hydrographic Office and port captains at the Ports of Cape Town and Walvis Bay.

Residual Impacts on Communication Infrastructure

The overall impacts on communication infrastructure are negligible significance after mitigation.

5.4 *Environmental Impacts of Seismic Surveys: Decommissioning and Post-Closure Phases*

This phase includes the gathering, dismantling and loading of the seismic lines and geophones, demobilisation of the seismic vessel and any chase vessels, travel from the seismic acquisition area back to the port and disposal of any generated waste during the seismic activities.

5.4.1 *Geology and Sediment*

No impact will occur as staff and vessel mobilisation do not have physical impacts on the geology and sediments of the seabed or coastline. The seismic activities, including the deployment of the geophone streamers occur no deeper than 20 m from the surface of the sea.

5.4.2 *Physical Oceanography*

Staff and vessel demobilisation do not impact the physical oceanography. The seismic activities, including the dismantling of the geophone streamers occur no deeper than 20 m from the surface and has no impact on physical oceanography processes in the survey block.

5.4.3 *Physical Nature of Surrounding Areas*

No impact is envisaged, as the staff, vessel and streamer demobilisation do not have any effect on the physical nature of the receiving environment.

5.4.4 *Air Quality*

Emissions to the atmosphere during the establishment phase will result mainly from movement of the seismic vessel onto site. This negligible impact on air quality would be minimal and no greater than that from another vessel of similar size.

5.4.5 *Water Quality*

All survey vessels will comply fully with international agreed standards regulated under MARPOL 73/78 and relevant South African legislation for the disposal of waste, specifically:

- Drainage from machinery spaces will be treated to ensure that it does not contain more than 15 mg/l of oil.
- All other discharges will be treated such that their average monthly oil content is no greater than 40 mg/l. The instantaneous oil content of all discharges will not exceed 100 mg/l.
- No plastics or garbage will be discharged to sea. These will either be burnt in trash baskets onboard the vessel or be segregated, quantified and accounted for prior to disposal at dedicated facilities.

- Shifts of hearing threshold – Repeated or continual exposure to high level sound results in a gradual deterioration of hearing through permanent threshold shifts (1) (PTS) or temporary threshold shifts (TTS).

- Tissue damage – Tissue damage usually arises from the near instantaneous increase in pressure, which forms shock waves of explosive pulses. As rise times are not rapid in non-explosive seismic sources, tissue damage from such sources is likely to be negligible.

- Acoustically induced decompression sickness (Crum and Mao (1996)) suggested that significant acoustically induced bubble formation could be expected at received levels of over 210 dB.

Much of the limited information available on the impact of underwater noise on humans is from military sources. The U.S. Navy has conducted two studies of relevance (see www/surtass-lfa-eis.com):

- The Applied Research laboratory of the University of Texas carried out 437 tests on 87 divers over the period 1993 to 1995. Divers were subject to a nine 100 second 50% duty cycle 160 dB pulses of varying frequency above 160 Hz. The study did not induce any long term effects on major organ systems and concluded that sound pressure levels of below 160 dB would "not be expected" to cause physiological damage to a diver.

- Studies conducted by the U.S. Office of Naval Research (ONR) and the U.S. Naval Submarine Medical Research Laboratory (NSMRL) in conjunction with a consortium of university and military laboratories developed guidance for safe exposure limits for recreational and commercial divers to low frequency sound, particularly SURTASS Low Frequency Active Sonar (LFAS). The studies concluded that the maximum intensity used during tests (received level of 157 dB) did not produce physiological evidence of damage in human subjects. A two percent "very severe" aversion reaction was recorded in divers at a level of 148 dB. The NSMRL therefore determined (by scaling back the intensity by 3 dB (a 50 percent reduction in signal strength) that a received level of 145 dB would provide a suitable margin of safety for divers. Consequently, in June 1999, NSMRL set interim guidance for the operation of low frequency underwater sound sources in the presence of recreational divers at 145 dB. This guidance has been endorsed by both the Navy's Bureau of Medicine and Surgery and the Naval Sea System Command (British Ministry of Defence, 2004).

Richardson et al (1995) also noted a number of vertigo and discomfort effects to human divers from underwater sounds. The underwater seismic array emissions are expected to be in the order of 220 - 250 dB re 1µPa at 1 m at

(1) Permanent Threshold Shift (PTS) refers to an increase in the threshold of hearing that is permanent, not temporary. It is an unrecoverable deafening due to physiological damage to the hearing organs that does not diminish with time. PTS may occur as a result of long-term exposures and/or extremely loud noises. Repeated exposures that cause to temporary threshold shift (TTS) can induce PTS as well.

source. Richardson et al (1995) noted that in water depths of 25 to 50 m deep, airgun arrays are often audible to ranges of 50-75 km and that detection ranges can exceed 100 km with efficient propagation or in deep water. Application of such attenuation rates suggest that seismic sounds could be heard by divers for considerable distances from source. In shallow water (20 to 110m deep) basic cylindrical spreading modelling suggests that the limit for humans would be met at around 56 km from the source. However, this does not include the effect of bottom attenuation, which could affect the result by a factor of five.

As the seismic area is at least 150 km offshore and in water of depths of over 250 m, there are unlikely to be impacts on divers as a result of the seismic survey.

5.5.5 *Impacts on Sites of Historic, Archaeological and Cultural Interest including Shipwrecks*

No impact on archaeological or culturally sensitive sites is envisaged. The seismic activities, including the deployment of the geophone streamers occur no deeper than 20 m from the surface of the sea and these activities will therefore not encounter any sensitive receptors, primarily located on the seabed.

5.5.6 *Impacts on Recreation*

No impact on recreational activities is envisaged. The mobilisation of the vessel would result in no particular increase in marine traffic levels in the area, and therefore no impact on recreational activities. There are no known recreational uses of the seismic area and therefore no impact is expected.

5.6 *ENVIRONMENTAL IMPACTS OF PROSPECT WELL DRILLING ACTIVITIES: ESTABLISHMENT PHASE*

This EMPr focuses on assessing the impacts and identifying mitigation related to the 2D and 3D seismic surveys and provides only an overview of these for the prospect well drilling. If Shell decides to extend the exploration into the 2nd and 3rd Renewal Periods, additional detailed impact assessments of prospect well drilling will be carried out to inform the planning process and specific EMPs will be developed prior to any field activity.

This phase includes the finalisation of the drilling contractors, the hiring and training of staff, mobilisation of the vessel, travel to the drilling sites, testing of equipment, deployment of the drilling unit. In addition, a site survey of new drilling areas and locations is typically undertaken to ensure the location is suitable and safe to establish the drilling vessel prior to drilling.

A matrix of the environmental impacts at the various stages of prospect well drilling activities is provided in *Table 5.1* and *Table 5.6*.

5.6.1 *Geology and Sediment*

A semi submersible drilling unit is held in position by an array of six to eight anchors. During installation of the anchors there will be some local disturbance to the seabed sediments. A drilling ship is held in place by dynamic positioning and is not anchored. The impact on geology and sediments is anticipated to be negligible.

5.6.2 *Physical Oceanography*

It is anticipated that there will be no impact on physical oceanography.

5.6.3 *Physical Nature of Surrounding Areas*

It is anticipated that there will be no impact on the physical nature of the surrounding areas.

5.6.4 *Fauna and Flora*

Disturbance of the seafloor by the anchor chain and anchors will have some minor disturbance on benthic communities. The impact will be low as the area disturbed by them is small and would be rapidly re-colonised by benthic communities. The significance of the impact on benthic populations is anticipated to be negligible.

5.6.5 *Sites of Historic, Archaeological and Cultural Interest including Shipwrecks*

Each individual prospect well location will be investigated (with reference to Admiralty Charts) to ensure that no sites would be impacted and for operational reasons. The likelihood of disturbing a shipwreck is expected to be small considering the vast size of the South African offshore area. The significance of this impact is anticipated to be negligible.

5.6.6 *Marine Recreational Facilities and Transport Routes*

Movement of a drilling rig onto site is not expected to have any impact on transport routes or marine recreational facilities as the rig at tow would be similar to any other vessel. The significance of this impact is anticipated to be negligible.

5.6.7 *Mariculture Activities*

It is anticipated that there will be no impact on mariculture activities.

5.6.8 *Commercial and Recreational Fishing*

It is anticipated that there will be very little impact on commercial and no impact on recreational fishing during establishment.

5.6.9 *Air Quality*

Emissions to the atmosphere during the establishment phase will result mainly from the tow vessel and from the support vessels. This short-term impact on air quality is anticipated to be minimal and no greater than that from another vessel of similar size. The impact on a wider atmospheric scale is anticipated to be negligible.

5.7 *ENVIRONMENTAL IMPACTS OF PROSPECT WELL DRILLING ACTIVITIES: OPERATIONAL PHASE*

The operational phase includes the actual prospect well drilling, which is conducted from a semi-submersible drilling vessel or a drill-ship to reach depths of 5,000 m and more below the seabed. A typical rig will drill a well using equipment such as a derrick, drawworks, drilling mud handling equipment, power generators, cementing and testing equipment and a blow-out prevention (BOP) unit. The drill cuttings are removed from the well using drilling fluid or "mud" to balance underground hydrostatic pressure, cool the drill bit and flush out rock cuttings.

5.7.1 *Geology and Sediment*

Anchors will only occupy a small area on the seabed for the six to eight week period during which each well will be drilled and tested. It is anticipated that there will be no impact on geology and sediment.

5.7.2 *Physical Oceanography*

Disposal of Drilling Mud and Cuttings

It is anticipated that most wells will be drilled to a depth of between 2,000 and 4,000 m. For wells at these depths the total amount of cuttings disposed into the marine environment per well will vary from about 375 m^3 up to 450 m^3. Mud will be recycled but some drilling mud is always lost with the cuttings. Mud will also be discharged at intermediate stages of the drilling programme and on completion of each well.

On contact with seawater, the majority of cuttings and drilling mud are dispersed by the current and settle to the bottom over a wide area bearing in mind that water depths in the block are typically 500 to 3,500 m or more. Much of the mud adhering to the cuttings together with finer particles will wash out during this sinking process and form a turbid plume. A typical plume extends some 30-40 m vertically, is 40-60 m wide and extends 100 – 4,000 m from the discharge point. Dilution of a plume will be greater where there is a fast current.

Deposition of both the cuttings themselves and the fines in the plume, may exert a smothering effect on benthic organisms within approximately 800 m of the discharge point, depending on current flows. The primary impact, therefore, particularly from smaller particles, is physical, such as clogging of fish gills and smothering of filter feeding animals. At a depth of at least 500 m there will be very significant dispersion of the cuttings and smothering is very unlikely to occur. Any residual effects will be of short duration and, in the absence of toxic components, recolonisation will be rapid. Furthermore, in the overall context of sediment input from rivers, the volume of mud and drill cuttings to be discharged is extremely small. The significance of this impact is anticipated to be negligible.

Flare during a Possible Production Test

Migratory land birds can be attracted to light sources at night, especially under conditions of low visibility caused by fog or mist. Where the light source is a gas or oil flare from a well test, mortalities to land and/or seabirds can occur. Flow testing and hence, flaring may only take place towards the end of the exploratory drilling period and will be of a short duration (18-24 hours per test). Consequently the period during which the flare potentially poses a hazard to birds will be limited. In addition, well testing (and associated flaring of gas/and or oil) will only take place if potentially commercial accumulations of hydrocarbons are found. Historically only one in three wells has been tested in the case of the South African offshore. The significance of the impact on migratory land birds and seabirds is anticipated to be negligible.

5.7.4 *Disturbance by Helicopter Operations*

Helicopters are used to affect crew changes between the drilling unit and the nearest airport. Such flights could disturb bird colonies and breeding whales.

Flying over bird colonies at low altitude can cause disturbances leading to mortalities of the young of these animals. Birds may abandon their nests temporarily thereby exposing the eggs and chicks to predation. The impact is anticipated to be of low to medium significance.

Flying over seal colonies at low altitude can cause stampedes of seals to the sea resulting in deaths of juveniles or of nesting birds within the seal colony. It is an offence in terms of the Seabirds and Seals Act of 1973 to wilfully disturb seals on the coast or on offshore islands. The impact of flights over such colonies is anticipated to be of low to medium significance depending on aircraft height.

The disturbance of whales by helicopters will largely depend on the altitude and distance of the aircraft from the animals and the prevailing sea conditions. In terms of the Marine Living Resources Act (Act 18 of 1998) it is illegal for an aircraft to approach to within 300 m of whales in South African waters.

Carefully planned helicopter flight paths will ensure that any impact can be avoided and as such it is anticipated to have a low significance.

Effects of Well Drilling Noise on Marine Animals

The noise generated by prospect well drilling could impact on the behaviour or distribution of marine animals. Generally noise from drilling activities is at a similar level to noise from shipping activities, though obviously differs in its stationary nature.

Little information on the responses of animals to drilling can be found in the literature. Marine mammals (whales, dolphins and seals) are often sighted from drilling facilities. The response of whales to drill ship noise is variable and probably reflects the variable noise arising from the facility. In general whales appear most responsive when the noise alters or increases which suggests some degree of habituation to stationary noise sources. Richardson et al (1995) suggested that responses to continuous noise from a stationery source are less than that from a moving source.

The impact of drilling noise on marine fauna is expected to be localised and anticipated to be of negligible significance.

5.7.5 *Sites of Historic, Archaeological and Cultural Interest Including Shipwrecks*

This is addressed during the establishment phase, please see *Section 5.6.5.*

5.7.6 *Marine Recreational Facilities and Transport Routes*

The presence of a drilling rig and its supply vessel in waters used by shipping and fishing vessels could result in:

- Damage to vessels and to fishing gear caused by collisions with the drilling unit and/or the tenders;
- Damage to the fishing gear caused by interference with anchors and anchor chain; and
- Damage to the drill rig and/or the tenders caused by vessels and fishing gear.

As exploration activities could take place anywhere off the South African coast, there could well be instances where rig positions coincide with both shipping transport routes and fishing activities. The main shipping lanes around the coast, as defined by the Department of Transport, are illustrated in the Baseline Environmental Report. Provided normal rules of the sea are observed the likelihood of a rig damaging a vessel or fishing gear is small. It is normal practice to issue notice to mariners and consult with harbour authorities and fishery organisations and communities prior to field activities. The significance of this impact is anticipated to be negligible to low.

5.7.7 *Mariculture Activities*

It is anticipated that no impact will occur to mariculture activities.

5.7.8 *Commercial and Recreational Fishing*

Loss-of-access to Fishing Grounds Due to Exclusion Zone around Drilling Unit

While the drilling unit is operational, a temporary 500 m statutory activity exclusion (safety) zone around the rig will be in force. The total area of this exclusion zone is 0.8 km^2. The anchors, however, extend out far beyond this limit. For a rig in 100 m water depth anchors extend some 1,500 m from the rig. This effectively excludes fishing over an area of about 4.7 km^2. This area increases with increased water depth.

The exclusion zones around a drilling rig together with the hazard posed by the anchors will temporarily exclude trawling from the proximity of a rig. The effect of this exclusion zone on the fishing industry is judged to cause only minor (if any) nuisance to the fishing industry and is not likely to affect catches.

It is recognized that the true impact of drilling on fishing operations within defined fishing areas will depend on the precise locations of prospect wells in relation to present trawling lanes. In at least some cases, there may be sufficient latitude in either the drilling position or the trawling lane to allow the two activities to coexist without the occurrence of any significant negative impact upon the fishing industry. This is clearly the ideal that should be sought through consultation between the petroleum exploration operator and the fishing industry and consultation between Shell and the fishing industry in this regard is essential. Special attention should be given to planning the engagement with international (Japanese and Republic of China) fishing operators in the appropriate language. The significance of this impact is anticipated to be low.

Impact of Abandoned and Suspended Wellheads and Lost Equipment on the Fishing Industry

Concern has been raised by the fishing industry about the impact that abandoned and suspended wellheads and lost equipment (such as anchors) could have on fishing activities. Specifically this relates to bottom trawling where nets could be entangled by such obstructions and the vessel and crew can be placed at risk. Although trawling activities do not appear to occur within the OBDWLA, demersal trawling is undertaken in very close proximity to the Eastern part of the OBDWLA (see *Figure 4.18*).

Petroleum exploration sub-lease contracts negotiated by Petroleum Agency under OP26 exploration lease specify that the wellheads of all newly drilled wells are removed after the well has been completed. In this situation, there will be no long term negative impact on the trawling industry.

The exception to this rule is where a well is suspended pending further work such as additional drilling or flow testing at a later stage, or completion and use as a production or injection well in the longer term. In this case, the wellhead is left in position and a corrosion cap is fitted. When the decision is taken to use it as a production well, a set of production valves must be fitted. The life of a production well is very variable but it is typically in use for years.

It is anticipated that all wells will be abandoned; however, the impact of abandoned and suspended wellheads in one specific well-defined fishing area could vary between low to high significance if there is a notable effect on trawling activities and catches.

Where the density of exploration wells is low, as is presently the case for the East and West coasts, the interference with any fishing activities is expected to be small provided that due caution is exercised when trawling in proximity to known wellhead locations. Similarly the effect of lost equipment on fishing activities will be small. The significance of this impact is anticipated to be negligible to low.

The PASA has carefully checked the location details of all wellheads that remain on the seafloor as well as lost equipment for the whole offshore area. This information has been forwarded to the South African Navy Hydrographic Office and to representatives of affected offshore industries, notably the trawling associations and the marine diamond mining industry. With modern navigation aids, fishing vessels will be able to avoid any such sea floor hazards. Consultation with the fishing industry through the appropriate mode of communication and choice of language is important in this regard.

5.7.9 *Impacts on Marine Mining Industries*

While the drilling unit is operational, a temporary 500 m radius statutory activity exclusion zone around the rig will be in force. The total area of the exclusion zone is 0.8 km^2. For safety reasons, mining should not take place within the radius of the rig anchors that extend out some 1,500 m (approximately 4.7 km^2) from the rig. Localised temporary cessation of mining in an exclusion zone created by prospect well drilling would cause only minor nuisance to mining as the area affected is small in terms of the total area available for diamond and other mining activities. The significance of this impact is anticipated to be negligible to low.

Diamond Mining

The offshore diamond mining area off the West Coast of South Africa extends from Cape Columbine in the south to the maritime boundary between South Africa and Namibia in the north, and from the shoreline to the continental slope (approximately 500 m water depth). The area is divided into several concession blocks. Current offshore diamond mining and exploration is currently limited to the nearshore strip on the West Coast of South Africa (water depths are mostly less than 150 m). Exploration and mining may extend deeper in future as diamond mining technology improves. The OBDWLA is located in water depths of between 500 m and 3,500 m and activities will therefore not impact diamond mining or exploration.

Potential conflicts relating to the development stage of gas prospects where a pipeline would need to be laid to shore are possible but these issues can only be dealt with if a potentially commercial discovery is made and a production right is applied for. In this case a separate EMPr will be needed that addresses the specific details of the proposed development.

Other Minerals

Potential mining operations include minerals such as manganese nodules, agricultural minerals such as glauconite and phosphorite, and heavy minerals such as ilmenite and rutile. There is presently no extraction of heavy metals from sand mining within the marine environment in South Africa. Manganese nodules enriched with valuable metals occur in water depths of over 3000 m on the West, South and East Coasts of South Africa. Generally, the nickel, copper and cobalt contents of the nodules fall below the current mining economic grade over most of this area, although mineable grade nodules possibly occur in areas north of 33° S in the Cape Basin and off northern Namaqualand. No prospecting permits have yet been applied for. The potential for conflict is therefore very low. Concentrations of glauconite and phosphorite have been identified in both the southern West Coast region and off the South Coast. Prospecting permits have been applied for three areas to the west of the coast between Cape Town and Saldanha, and further interest in the South Coast deposits has been identified. It is presently unknown as to what method will be used to mine these areas, if prospecting is successful. It is consequently impossible to critically assess the impacts of prospect well drilling on such mining operations, but they are anticipated to be minimal.

If drilling takes place it will be at least 150 km offshore. There is currently no mining occurring in the area.

5.7.10 *Air Quality*

Diesel is used aboard a drilling unit and the supply vessels as fuel for generators and motors. Diesel exhaust gases comprise SO_2, CO and CO_2 and NO_x, plus "carbon-black" (soot) which contain some polyaromatic hydrocarbon particulates. There is some concern that soot is carcinogenic.

Well testing and associated flaring of oil and gas will release CO_2, CO, NO_x and (unburned) hydrocarbons. These compounds are known to contribute to atmospheric problems such as the greenhouse effect and ozone depletion. The hydrocarbon is not expected to contain any sulphur.

Burning of waste, e.g. domestic packaging materials, aboard can release soot as well as CO, CO_2 and possibly dioxins depending upon the composition of the materials to be burned.

It is not expected that such emissions will have a direct effect on any other activity. The impact of such emissions on a wider atmospheric scale is therefore anticipated to be insignificant.

5.8 *ENVIRONMENTAL IMPACTS OF PROSPECT WELL DRILLING ACTIVITIES: DECOMMISSIONING AND POST-CLOSURE PHASES*

This phase includes the dismantling and loading of the drilling equipment and travel from the prospect well location back to the port and disposal of the waste generated during the drilling activities. PASA requires that all wellheads of all new wells drilled must be removed unless they are suspended pending further work or for use as production wells.

5.8.1 *Geology and Sediment*

There will be localised disturbance of the seabed due to anchor pulling, wellhead removal and well capping. The effects are anticipated to be localised.

5.8.2 *Physical Oceanography*

Any discharge to the sea during decommissioning and removal activities are likely to be considered routine and therefore are not anticipated to cause any significant impact on the environment.

5.8.3 *Physical Nature of Surrounding Areas*

It is anticipated that no surrounding areas will be affected.

5.8.4 *Fauna and Flora*

It is anticipated that there will be some local disturbance of benthic communities during rig decommissioning and removal activities. Benthic communities are anticipated to rapidly recover after this phase.

5.8.5 *Sites of Historic, Archaeological and Cultural Interest Including Shipwrecks*

It is anticipated that there will be no impact during decommissioning.

5.8.6 *Marine Recreational Facilities and Transport Routes*

On completion of prospect well drilling, the contracted vessel will leave the area and move to its next project. The Prospecting Permit Holder will then notify affected parties that these activities have ceased in the area.

5.8.7 *Mariculture Activities*

It is anticipated that there will be no impacts to mariculture activities.

5.8.8 *Commercial and Recreational Fishing*

On completion of prospect well drilling, the contracted vessel will leave the area and move to its next project. Any effect on commercial or recreational fishing while the drilling unit leaves the area is expected to be small.

5.8.9 *Impacts on Marine Mining Industries*

It is anticipated that there will be no impact on marine mining industries.

5.8.10 *Air Quality*

The effect on air quality is anticipated to be negligible.

5.8.11 *Oil Spill Impacts and Other Accidental Releases*

This scenario assumes that accidental spillage of oil will occur. Although the probability of an uncontrolled release of hydrocarbons (blowout), either by oil or gas, is extremely low, it nonetheless provides the greatest environmental concern in exploratory drilling. Oil spill modelling has not been done specifically for this EMPr, but previous studies (CSIR, 1995a; CSIR 1995b; CCA and CSIR, 1998; and CSIR, 1998) have assessed the impact of oil spills under two spill volume scenarios as indicated below. However, it must be noted that these scenarios are based on the spill occurring at 50-70 km from the coastline, while the OBDWLA is at least 150 km from the coast.

Small spill (150 to 700 barrels of oil or diesel): This scenario was chosen to assess the effect of an accident involving the supply vessels or during the transfer of diesel fuel to the drilling unit. For the ORIBI production facility an oil spill was assumed to have occurred from the production riser and export pipeline failing.

Large spill (5,000 to 30,000 barrels of crude oil): This spill scenario was selected to investigate the consequences of a major spill arising from a well blowout or loss of well control. In the case of the ORIBI study the spill was assumed to have taken place from a collision between a tanker or vessel and the production platform. The simulations were performed with OILMAP, a numerical oil spill trajectory model. The main input data for the simulation studies consisted of known wind and current data. The spill trajectories are governed by the current velocity field and to a lesser extent by the wind field. A summary of the simulations for the work undertaken in License Area 2814A (Namibia), Block 9 and Blocks 17/18, representing scenarios for the West, South and East coasts respectively, is shown in *Table 5.4*. The results shown here are for the worst case scenario at the offshore distances indicated. No account is taken of any intervention in the transport and fate of the spilled oil.

The minimum time in which a spill could potentially reach the shore is 21 hours for Block 9 (50 km from shore) and 15 hours for Block 17/18 (40km from shore) under a constant onshore wind of 72 km/hr. For the Namibian example, a spill could reach the shore within 24 hours under a constant onshore wind of 90 km/hr. However, it was indicated that the probability of such conditions occurring is extremely remote. These worst case scenarios were investigated as input to the oil spill contingency planning for the drilling operation. For future exploration activities off the South African coast response plans must be designed to ensure that a spill under such hypothetical conditions can be handled effectively.

Table 5.4 *Results of Previous Oil Spill Simulation Studies*

Simulation Type	Spill size	2814A Namibia 70 km offshore	Block 9 50 km offshore	Block 17/18 40 km offshore
Minimum time to shore wind speed of 72 km/hr	Small	Would not reach shore	Would not reach shore	12 hrs with a continual south-east wind blowing
	Large	24 hrs with a continual south-west wind of 90 km/hr	21 hrs with a continual southerly wind blowing	15 hrs with a continual south-east wind blowing
Probability of shoreline oiling and travel time	Small	As for large spill but will disappear in 2 to 3 days	40 % Less than 5 days	50 % Less than 2 to 3 days
	Large	70 to 90% probability of spill moving away from shore	50 % Less than 3 days	70 % Less than 3 days
Volume of oil reaching the shore	Small	Would disappear before reaching the shore	Would disappear before reaching the shore	Less than 30 %
	Large	Would disappear before reaching the shore	Less than 30 % during spring	Less than 30 % during summer

Note: Small spill - 150 to 700 barrels of oil or diesel; large spill - 5,000 to 30,000 barrels of crude oil

It must be emphasised that the probability of an oil spill actually occurring is very small. In 30 years of operation and drilling in South Africa, in which 287 wells have been drilled, no blowout has yet occurred. In addition the scenarios presented are for release points much closer to the shore than the OBDWLA which is a minimum of 150km form the shore.

The sections below identify the impact of the oil spill scenarios on various components of the environment. As a small spill disperses rapidly and would never reach the shore, the impact of such a spill is anticipated to be negligible. A possible exception to this is, however, its effect on pelagic seabirds. Hence the potential impact of 700 barrels of diesel fuel spill is only discussed in *Section 5.8.11* (below).

Geology and Sediment

It is anticipated that either crude oil or gas could be found during prospect well drilling. As the gas would be evaporate and the progress of any spill is likely to be dominated by evaporative processes and water action, it is unlikely that any of the heavier hydrocarbon fractions will coagulate and sink to the sediments in any significant quantity.

Oceanography

A large spill could result in the oiling of a large area of surface water in the area. The main effects of this are covered in the sections below that deal with individual categories of habitats and their inhabitants. These findings are based on untreated oil spills.

Physical Nature of Surrounding Area

The main effects of this are covered in the sections below, which deal with individual categories of habitats and their habitats.

Fauna and Flora

<u>Fish Eggs and Larvae</u>
Heavy loss of pelagic eggs and fish larvae may occur if they were present in the area of oil spill.

The time of year during which a large spill takes place will greatly affect the degree of impact that will result. Should it coincide with a major spawning peak, it could result in severe mortalities and hence a reduction in recruitment. However, it should be pointed out that spawning and recruitment success is subject to variability in environmental conditions that have a far greater impact than would be posed by a single large spill. Consequently the impact of such a large spill could be locally severe but of short duration. Ultimately the significance of the impact on fish populations is anticipated to be negligible.

<u>Seabirds: Coastal and Pelagic</u>
Birds, both at sea and along the coast, are vulnerable to oil spills. Individual pelagic seabirds, which become oiled, almost certainly will die as a result of even moderate oiling which damages plumage and eyes. Even if oiled seabirds are collected for cleaning and rehabilitation the success rate is low.

Oil spills will have a variety of effects on birds including (CSIR, 1998):

- fouling of plumage;
- ingestion of oil;
- effects on reproduction; and
- physical disturbance.

The likely impact from the two scenarios are described below:

(i) small diesel spill

Two-thirds of a small spill (700 barrels) of diesel fuel would disappear in 2 - 3 days as a result of evaporation and entrainment in the water column, consequently only birds occurring in the immediate vicinity of the source of such a spill would be at serious risk. Where future drilling takes place some distance offshore the sites would mainly be frequented by pelagic birds. These birds spend much of the time on the wing so relatively few should be oiled. In addition, since these birds are widely dispersed when foraging, the impact of a relatively small diesel fuel spill on their populations is likely to be insignificant. Where drilling takes place close to the shore, the impact on coastal birds could be of high significance. This is discussed further in the section below.

(ii) large diesel spill

A large spill could have a high impact on coastal birds should the oil reach the coast and enter any estuary. In particular, those species that actively swim and dive in the sea and estuaries, e.g. white pelican (*Pelecanus onocrotalus*), Cape gannet (*Morus capensis*) and whitebreasted cormorant (*Phalacrocorax carbo*) would be at the greatest risk from an oil spill. Gulls, terns and waders will be less affected although food availability maybe reduced by the oil covering tidal mudflats and foreshore areas. Without mitigation the impacts could be of high significance, even in the long term.

The potential impact of a spill on pelagic seabirds from the Southern Ocean is likely to be limited since these birds spend much of the time on the wing and are widely dispersed when foraging.

A major oil spill, however, could affect large numbers of pelagic seabirds should the spill coincide with a calm period when these birds often alight on the water. The effect on their overall populations is difficult to assess but could be severe. Since various breeding populations of migrant species have clearly defined wintering grounds it is conceivable that a spill could have severe local effect on a given species. Albatrosses and the larger petrels are long-lived and usually raise only one or two chicks each breeding season; thus the population will take a long time to recover from major losses.

<u>Dolphins and Whales (Cetacea)</u>

Thirty seven species of whales and dolphins are known to occur off the coast of South Africa. The impact of oil pollution on local cetacean populations would obviously depend on the timing and extent of the spill. In particular, oil pollution in areas of cetacean critical habitat (areas important to the survival of the population), such as the extreme near-shore calving grounds of southern right whales, would be the most likely to impact populations.

In extreme circumstances a large spill could impact a whale or dolphin population where the spill impacts critical habitat of that population. It is assumed that the majority of cetaceans would be able to avoid oil pollution, though effects on the population could occur where the region of avoidance is critical to population survival. The area of most concern is the calving and nursery ground of southern right whales in sheltered bays of the south coast between June and November each year. Although adult whales have been noted to swim, and even have a far higher surfacing rate than adults and could possibly be affected by inhalation of volatile hydrocarbons.

Depending on timing and extent, the effects of an oil spill on cetaceans could range from low to high significance

Seals

The Cape fur seal (*Arctocephalus pusillus*) mainly occurs between Algoa Bay (South Africa) and northern Namibia although occasional vagrants occur in Kwazulu-Natal waters. Fur seals belong to the family Otariidae ('eared" seals) which rely on their very dense fur for thermoreguletion, whereas "true" seals of the family Phocidae rely on thick fat deposits. Little work has been done on the effect of an oil spill on fur seals, but they are expected to be particularly vulnerable as oil would clog their fur and they would die of hypothermia (or starvation, if they had taken refuge on land). Worldwide public interest in marine mammals would require that the response to any threat to the seals is extremely rapid and effective.

The impact will depend very much on the locality of the spill and geographical distribution of the relevant species. A spill event in close proximity to Cape fur seals could have an impact of high significance. Sea colonies off the coast are particularly vulnerable.

The Coastal Environment

The coastal environment has been divided into the following categories for this assessment:

- Terrestrial environment;
- Wetlands, including coastal lagoons and estuaries; and
- Intertidal zone, including beaches and rocky shores.

Sandy beaches on exposed coasts with high wave and solar energy will be the least impacted and recover most rapidly. Similarly exposed rocky shores after initial mortalities will recover relatively rapidly. The most sensitive coastal areas are the coastal lagoons and estuaries. Should oil enter these systems in any quantity the impact will be severe and of long-term duration.

Secondary impacts on lagoon- and estuary-dependent biota will be equally severe. Strenuous efforts must be made to prevent oil from entering the coastal lagoons and the estuaries. Whenever possible the spilled oil should be recovered at sea as close to the source as possible. Should the sea state prevent mechanical recovery the spill should be treated with dispersants.

Marine Recreational Facilities and Transport Routes

Routes may be affected by the location of an oil slick, especially with emergency vessels in the area. As this is only expected to create minor detours for vessels the significance of this impact is anticipated to be low.

Mariculture Activities

Mariculture activities could be severely affected if oil reaches the coast.

Commercial and Recreational Fishing

In the event of an oil spill, fishing may be temporarily suspended through having to avoid fishing in oiled waters, and may suffer gear damage due to oil contamination. For a large spill fishing activities and revenues could be affected over a wide area until such time as the oil either has been dispersed or broken up naturally. The impacts if any could be large spatially but have short duration and will constitute a nuisance rather than a problem to the fishing industry. In certain fishery sectors (especially coastal and intertidal fisheries) the impact could be as long as one season. The significance of such an impact is anticipated to be medium to high.

Air Quality

Locally evaporative gasses released by the spill will affect air quality. On a larger atmospheric level the impact is anticipated to be negligible.

5.9 *SOCIO-ECONOMIC IMPACTS OF PROSPECT WELL DRILLING ACTIVITIES*

5.9.1 *Benefits*

Revenue

Indirect revenues are anticipated to be generated as a result of prospect well drilling. Revenue generating activities include re-fueling, ship / gear repair, port dues, helicopter services, sweeper boat hire, limited employment opportunities for contract staff, and supply of local engineering materials, chemicals, food and environmental consulting work.

Effects on Economy

It is anticipated that prospect well drilling will have very little effect on the economy. However, should such exploration identify viable hydrocarbon reserves, this could result in an oil and/or gas production project with associated demand for local materials and possibly labour as well as the generation of tax revenues.

Social Benefits

A significant benefit of prospecting activities will be the payment by Shell towards the Upstream Training Trust. The funds are directed to up-grading teaching and to providing support to previously disadvantaged students at tertiary education institutions. Job opportunities associated with prospect well drilling operations are limited, as such surveys are typically of short duration (the duration of a typical drilling operation in deep water is four to eight weeks) and the crew are usually foreign specialists who are specially trained. Limited work opportunities may become available for local specialists, artisans, catering staff and labourers with prior experience of an oil rig. Prospect well drilling activities are not anticipated to require the creation of new functions, the reallocation of existing functions, nor the creation of new institutions in the DME, PASA or any other government department.

5.9.2 *No Project Option*

Prospect well drilling forms an essential part of the process of finding and proving the presence of commercial oil and gas deposits.

The no project option should only be considered after a careful assessment of the likely drilling impact related to a specific area and the implications of enforcing a no project option.

5.9.3 *Detrimental Impacts*

The impact of prospect well drilling is anticipated to be negligible to low. Only minor nuisance is likely to be caused to other users of the sea and as indicated by international literature the effect on marine life is expected to be minimal. As such there is unlikely to be any negative socio-economic impact as a result of the prospect well drilling activities.

The major potential detrimental impact during prospect well drilling is an uncontrolled oil blow-out. The planning and management of each drilling operation is focussed on preventing such an occurrence. No blow-out has occurred in 30 years of drilling in South Africa, in which some 287 wells have been drilled.

5.10 *SUMMARY*

A summary of the environmental impacts discussed within this chapter are included in *Table 5.5* below for seismic surveys and well-drilling.

Table 5.5 ***Summary of the significance of identified impacts of the proposed 2D seismic survey within the OBDWLA***

PHASE	**Establishment Phase**		**Operational Phase**		**Decommissioning Phase**	
SIGNIFICANCE	**Without mitigation**	**With mitigation**	**Without mitigation**	**With mitigation**	**Without mitigation**	**With mitigation**
Geology and Sediment	N	N	N	N	N	N
Oceanography	N	N	N	N	N	N
Physical Surroundings	N	N	N	N	N	N
Air Quality	N	N	N	N	N	N
Water Quality	N	N	N	N	N	N
Phytoplankton and Zooplankton	N	N	N	N	N	N
Invertebrates	N	N	N	N	N	N
Fish	N	N	L-M	L	N	N
Seabirds	N	N	N	N	N	N
Seals	N	N	N	N	N	N
Cetaceans	N	N	M	L	N	
Cultural/ Historical Sites	N	N	N	N	N	N
Transport Routes	N	N	N	N	N	N
Mariculture Activities	N	N	N	N	N	N
Commercial and Recreational Fishing	N	N	M	L	N	N
Marine Mining	-	-	-	-	-	-
Communication Infrastructure	-	-	-	-	-	-

- = No Impact N=Negligible, L=Low Impact, M=Medium Impact, H=High Impact, Those receptors where
Normal font text = without mitigation
Definition of impact significance:
Low: Will not have an influence on a decision regarding whether or not the activity should go ahead
Medium: Will have an influence on the decision unless it is mitigated
High: Will influence the decision regardless of any possible mitigation