4. THE AFFECTED ENVIRONMENT

This chapter provides a description of the biophysical and socio-economic environment that is likely to be affected by the proposed exploration activities in Licence Blocks 3617 and 3717 off the South-West Coast of South Africa. This chapter has been divided into two sections, *viz.* marine environment and nearshore environment. In certain descriptions in this literature review, the South-West Coast is included in the West Coast (West of Cape Agulhas).

4.1 MARINE ENVIRONMENT (OFFSHORE)

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

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

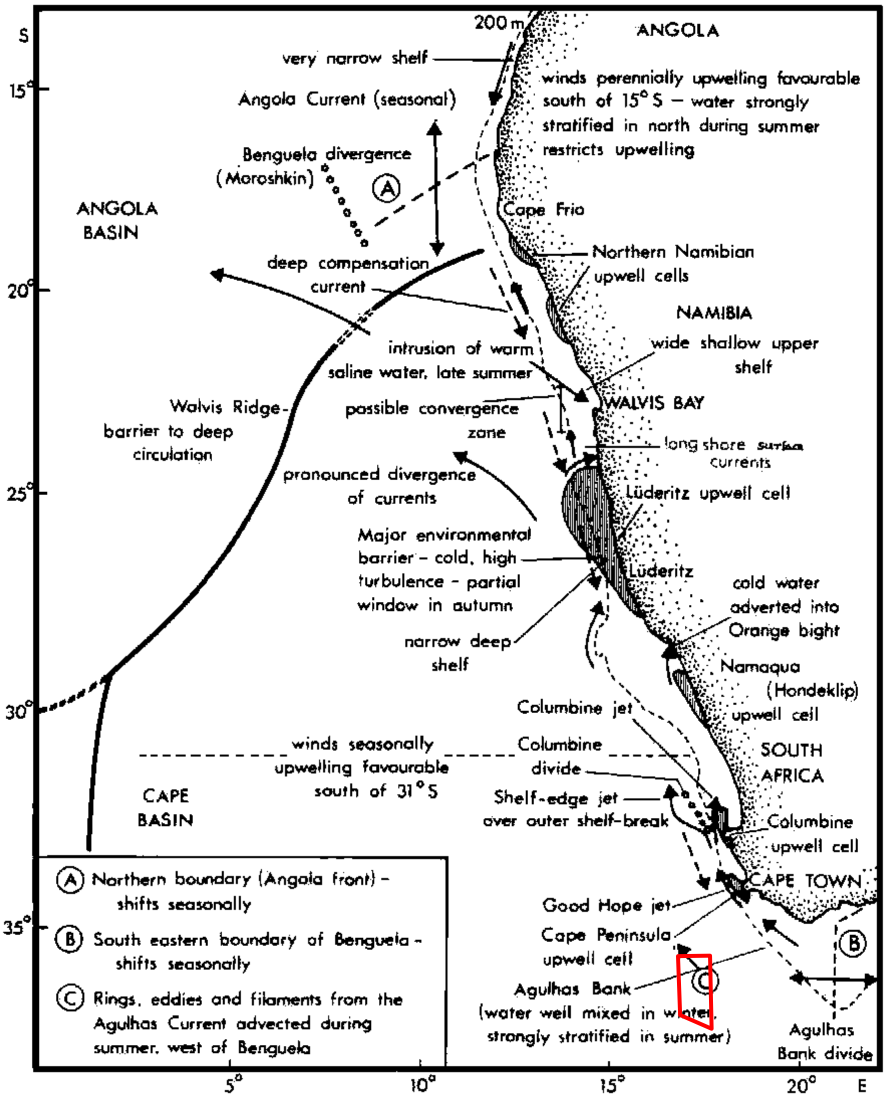

Figure 4.1: A conceptual model of the Benguela system (after Shannon 1985). Approximate location of Licence Blocks 3617 and 3717 is also indicated.

4.1.1 METEOROLOGY

The meteorological processes of the South African South-West Coast have been described by numerous authors, including Andrews and Hutchings (1980), Heydorn and Tinley (1980), Nelson and Hutchings (1983), Shannon (1985), Shannon and Nelson (1996), and Shillington (1998).

Wind and weather patterns along the South-West Coast are primarily due to the South Atlantic high-pressure cell and the eastward movement of mid-latitude cyclones (which originate within the westerly wind belt between 35° to 45°S), south of the subcontinent.

The South Atlantic high-pressure cell is perennial, but strongest during austral summer when it attains its southernmost extension to the south and south-west (approximately 30°S, 05°E) of the subcontinent. Linked to this high-pressure in summer is a low-pressure cell that forms over the subcontinent due to strong heating over land. The pressure differential of these two systems induces moderate to strong south-easterly (SE) winds near the shore during summer. Furthermore, the southern location of the South Atlantic high-pressure cell limits the impact that mid-latitude cyclones have on summer weather patterns so that, at best, the mid-latitude cyclones cause a slackening of the SE winds. During the austral winter both the weakening and north-ward migration of the South Atlantic high-pressure cell (to approximately 26°S, 10°E) and the increase in atmospheric pressure over the subcontinent result in the eastward moving mid-latitude cyclones advancing closer to the coast.

Strong north-westerly (NW) to south-westerly (SW) winds result from mid-latitude cyclones passing the southern Cape at a frequency of 3 to 6 days. Associated with the approach of mid-latitude cyclones is the appearance of low-pressure cells, which originate from near Lüderitz on the Namibian coast and quickly travel around the subcontinent (Reason and Jury 1990; Jury, Macarthur and Reason 1990). Mid-latitude cyclones can generate cut-off lows during winter. Cut-off lows are associated with extreme weather patterns, such as powerful convection updrafts and very strong atmospheric instability, resulting in a range of severe types of weather. Extreme weather conditions along the South-West Coast include very strong gale forces winds, rough seas (> 5 m) and torrential rain, leading to flooding and associated damages. No hurricanes are likely to occur off the South-West Coast.

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

4.1.2 PHYSICAL OCEANOGRAPHY

4.1.2.1 Waves

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

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

Typical seasonal swell-height rose-plots, compiled from Voluntary Observing Ship (VOS) data off Cape Columbine and Cape Point, are shown in Figure 4.2a and b.

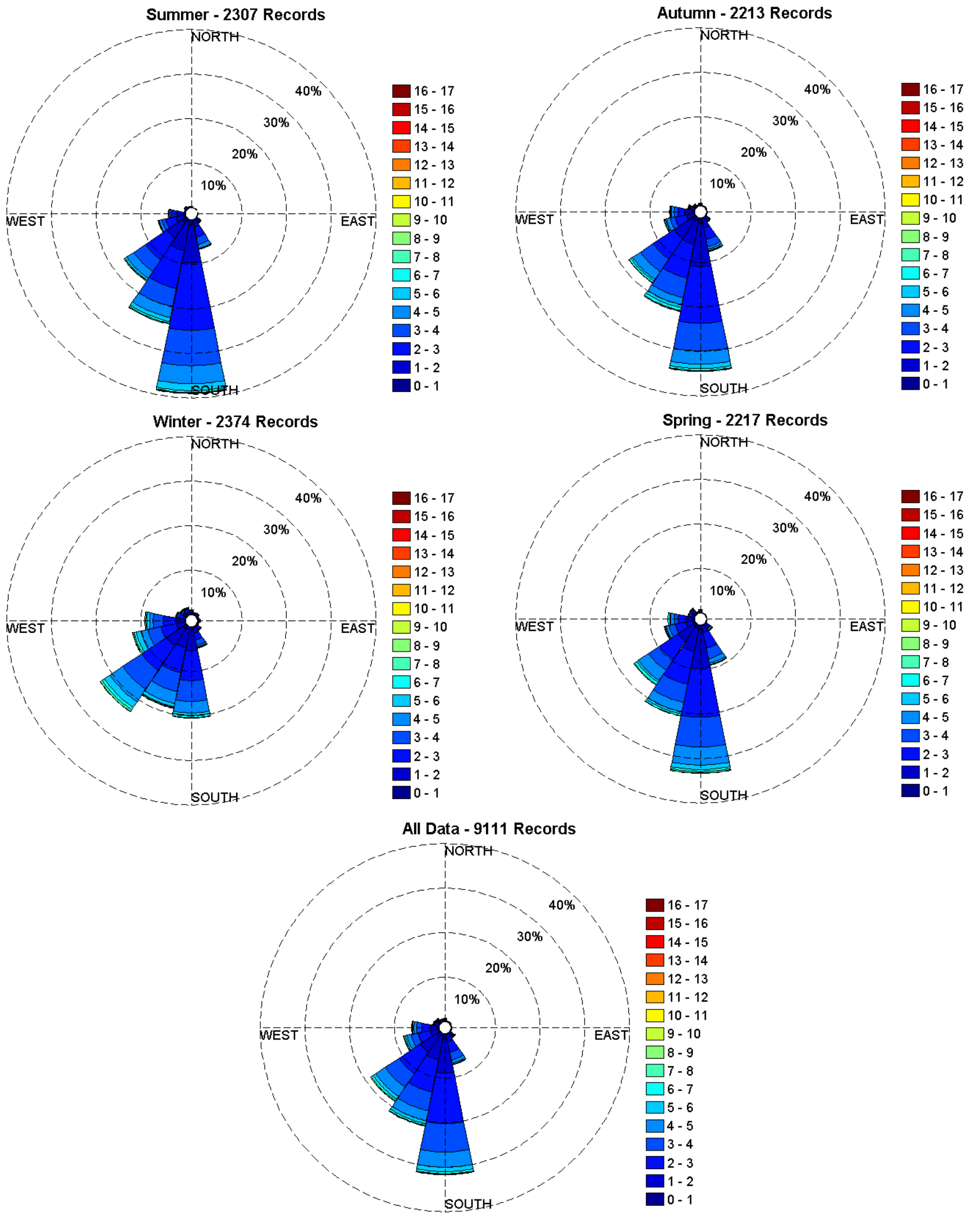

Figure 4.2a: Voluntary Observing Ship (VOS) Wave Height vs Wave Direction data for the Cape Columbine area 32.0° to 32.9° S and 17.0° to 17.9° E (1903/11/01 to 2011/05/24; 9 111 records) (from CSIR).

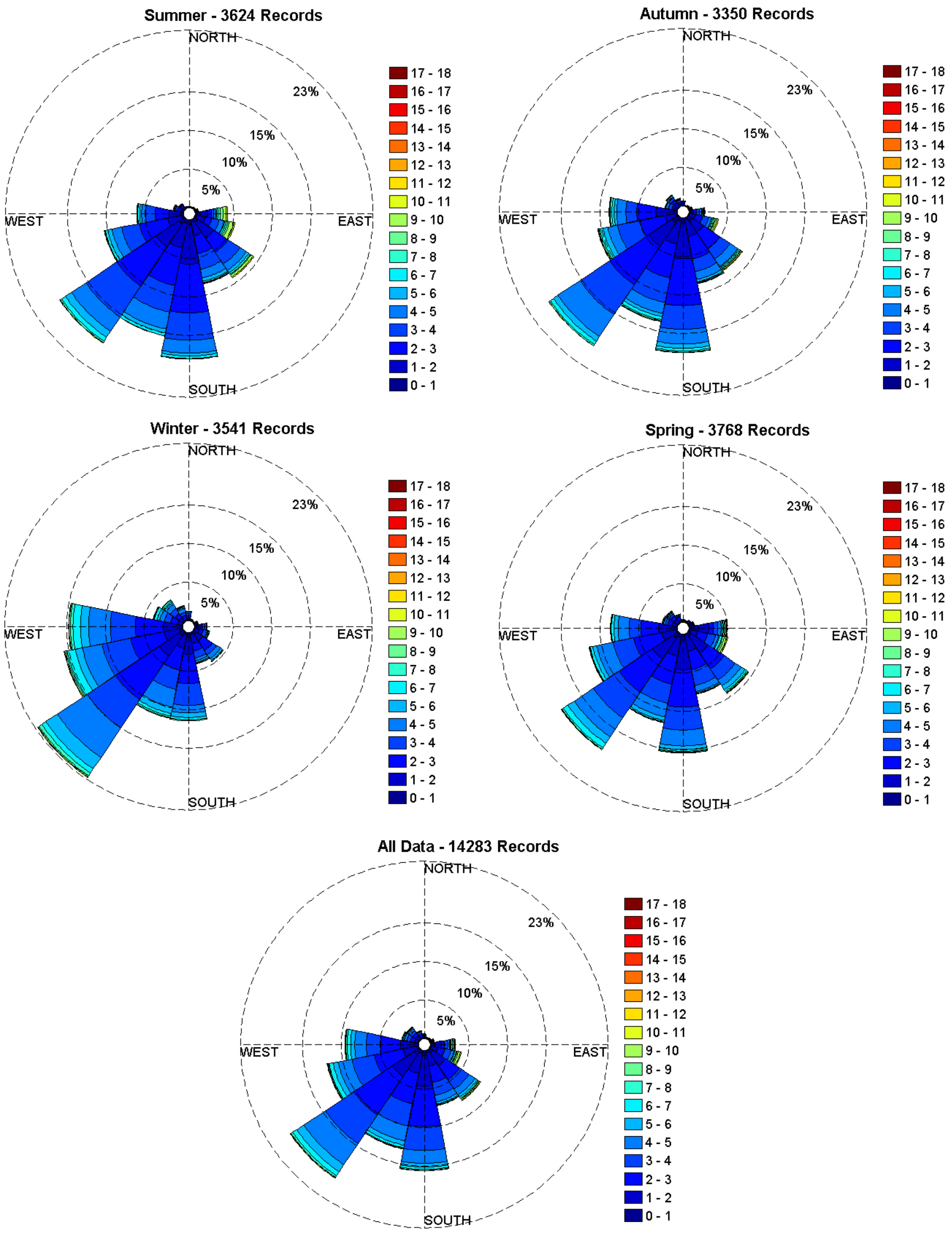

Figure 4.2b: VOS Wave Height vs Wave Direction data for the Cape Point area 34.0° to 34.9° S and 18.0° to 18.9° E (1900/01/01 to 2011/05/24; 14 283 records) (from CSIR).

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

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

4.1.2.2 Tides

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

4.1.2.3 Bathymetry and topography

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

The continental shelf along the West to South-West Coast is generally both wide and deep, although large variations in both depth and width occur (Figure 4.3). The shelf maintains a general north-north-west (NNW) trend north of Cape Point, being narrowest in the south between Cape Columbine and Cape Point (40 km) and widening to the north of Cape Columbine to its widest off the Orange River (180 km), and widening south of Cape Point due to the presence of the Agulhas Bank.

The immediate nearshore area consists mainly of a narrow (to about 8 km wide) rugged rocky zone which initially slopes steeply seawards to a depth of about 30 m and then gradually to about 80 m. The middle and outer shelf normally lacks relief and slope gently seawards reaching the shelf break (where the slope becomes significantly steeper) at a depth of approximately 300 m. A number of submarine canyons cut into the shelf between 31° and 35°S, the most prominent being the Cape Canyon and the Cape Point Valley.

Major bathymetric features in the region are the Protea Seamount (situated approximately between 36°S, 17°E) and the Cape Canyon (located approximately 33.5°S, 17.5°E). Outside the shelf break, depth increases rapidly to more than 1 000 m (Hutchings 1994). Licence Blocks 3617 and 3717 extend beyond the continental shelf with depths beyond 3 500 m.

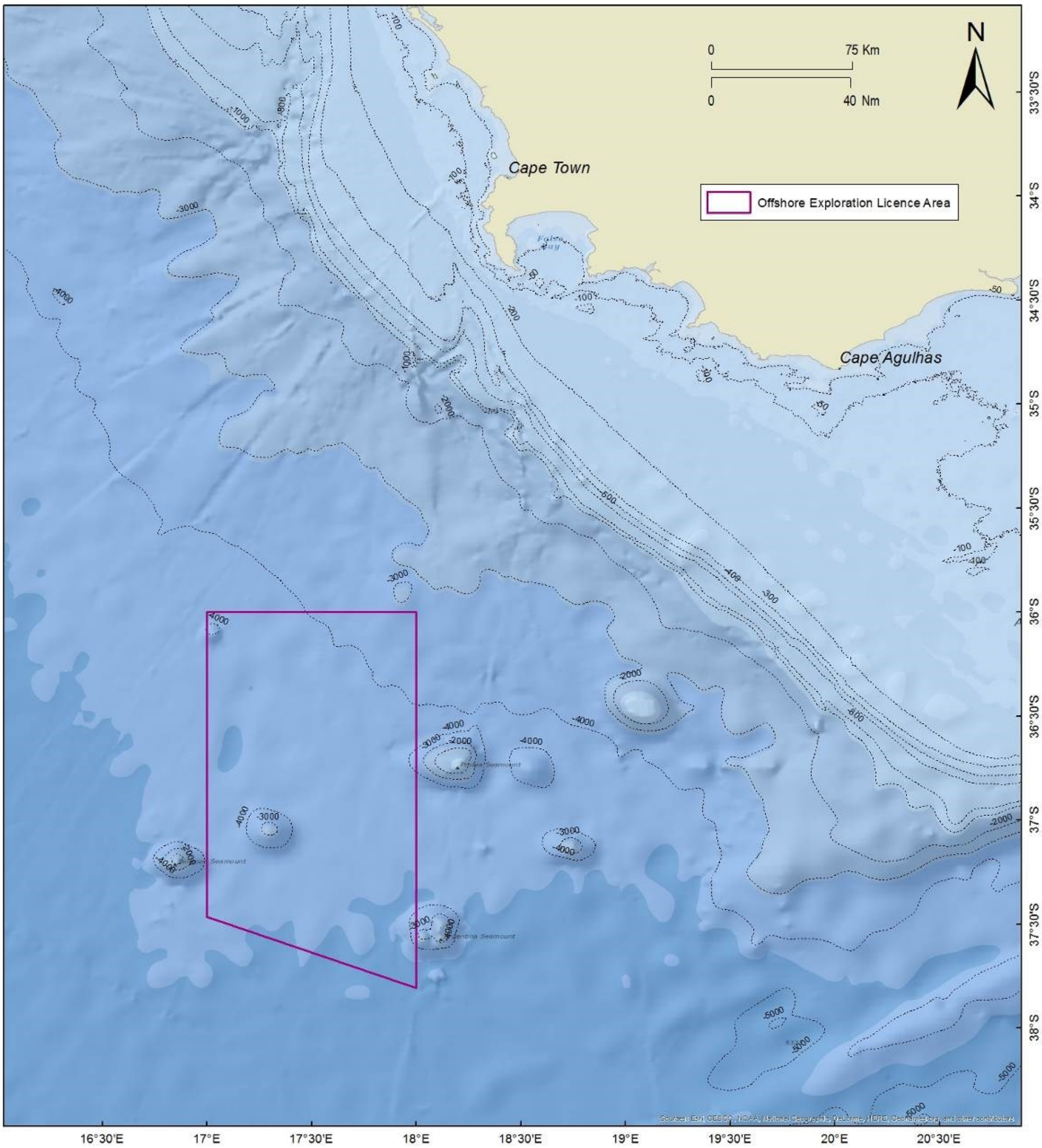

Figure 4.3: Bathymetry of the continental shelf off the West Coast of southern Africa. Approximate location of Licence Blocks 3617 & 3717 is also indicated.

4.1.2.4 Sediments

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

As a result of erosion on the continental shelf, the unconsolidated sediment cover is generally thin, often less than 1 m. Sediments are finer seawards, changing from sand on the inner and outer shelves to muddy sand and sandy mud in deeper water. However, this general pattern has been modified considerably by biological deposition (large areas of shelf sediments contain high levels of calcium carbonate) and localised river input. The continental slope, seaward of the shelf break, has a smooth seafloor, underlain by calcareous ooze. Isolated areas of seabed associated with the Cape Valley and Cape Canyon are characterised by hard outer shelf and shelf edge sediments (Sink et al. 2012).

4.1.2.5 Water masses and sea surface temperatures

Licence Blocks 3617 and 3717 comprises mostly of South Atlantic Central Water (SACW), either in its pure form in the deeper regions, or mixed with previously upwelled water of the same origin on the continental shelf (Nelson and Hutchings 1983). Salinities range between 34.5% and 35.5% (Shannon 1985).

The deeper waters (thermocline water) comprise of South Indian and tropical Atlantic Central Water, Antarctic Intermediate Water (AAIW), North Atlantic Deep Water (NADW) and Antarctic Bottom Water (AABW). The thermocline water mass (6°C, 34.5 Practical Salinity Units (psu) – 16°C, 35.5 psu) is that which upwells along the coast and which constitutes the shelf waters of the Benguela, although in highly modified forms. Thermocline water overlies AAIW (34.2-34.5 psu with potential temperature 4-5°C). NADW has a potential temperature less than 3°C and salinity greater than 34.8 psu, and lies below the AAIW stratum. In the Cape Basin, it lies above the AABW, which is located deeper than about 3 800 m. AABW is cooler than 1.4°C and has a salinity of 34.82 psu. South and east of Cape Agulhas, the Agulhas retroflection area is a global “hot spot” in terms of temperature variability and water movements.

Off the south-western Cape the upwelling of cool water occurs during the summer months stabilising the seawater temperature along this coastline to some extent so that the average sea surface temperature changes little throughout the year (13 to 15 °C). Over the continental margin, progressively colder waters encroach onto the continental shelf between the Orange River and the Cape Peninsula (Shannon and Nelson 1996).

4.1.2.6 Water Circulation

Water circulation off the West Coast is dominated by upwelling (see Section 4.1.2.7).

The ocean currents occurring off the West Coast are complex and are summarised in Figure 4.4. Data suggests that currents north of Cape Columbine are weaker and more variable than the currents to the south (Boyd *et al*. 1992). The most important is the Benguela current, which constitutes a broad, shallow and slow NW flow along the West Coast between the cool coastal upwelled waters and warmer Central Atlantic surface waters further offshore. The current is driven by the moderate to strong S to SE winds which are characteristic of the region and is most prevalent at the surface, although it does follow the major seafloor topographic features (Nelson and Hutchings 1983). Current velocities in continental shelf areas generally range between 10–30 cm/s (Boyd & Oberholster 1994). Shelf edge jet currents exist off both Cape Columbine (Nelson and Hutchings 1983) and the Cape Peninsula (Bang 1970; Shillington 1998), where flow is locally more intense (up to 50 cm/s off Cape Columbine and 70 cm/s off the Cape Peninsula). In the south the Benguela current has a width of 200 km, widening rapidly northwards to 750 km.

The flows are predominantly wind-forced, barotropic and fluctuate between poleward and equatorward flow (Shillington *et al.* 1990; Nelson & Hutchings 1983). Near bottom shelf flow is mainly poleward with low velocities of typically 5 cm/s. The poleward flow becomes more consistent in the southern Benguela (Pulfrich, 2011). A southward flow of surface water occurs close inshore during periods of barotropic reversals and during winter when upwelling is not taking place.

Agulhas Current water does occasionally enter the south-east Atlantic in summer as warm water filaments (<50 m deep) or eddies (several 100 m wide and deep). These warm water tongues are usually at least 180 km offshore and seldom move further north than 33°S and do not appear to impact the Benguela shelf region.

4.1.2.7 Upwelling

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

Upwelling occurs along the South-West and West Coasts from Cape Agulhas to northern Namibia (Figure 4.4). The principle upwelling centre on the West Coast lies off Lüderitz and the Lüderitz upwelling cell effectively divides the Benguela Upwelling system into a northern and southern region, which are meteorologically distinct (Pitcher *et al.* 1992). In the south upwelling-favourable SE winds are most prevalent during spring and summer, and upwelling occurs mostly between September and March. Upwelling in the southern Benguela area is highly variable on macro, meso and micro scales. Both continental shelf bathymetry and upwelling winds drive upwelling in the southern Benguela which is further influenced by local topography and meteorology (Shannon 1985), resulting in centres of enhanced upwelling off Namaqualand (30°S), Cape Columbine (33°S) and Cape Peninsula (34°S) (Figure 4.5).

Both bathymetry and orography control upwelling at Cape Columbine. Two fronts separate a divergence zone off the Columbine Peninsula, an oceanic front at the shelf edge and a shallower inshore front. Upwelling off the Cape Peninsula is among the most marked in the world with upwelling rates estimated to average 21 m/day (maximum of 32 m/day). A well-defined front exists over the shelf break off the Cape Peninsula, outside of which is a well-developed equatorward jet reaching speeds of 60 cm/s on the surface and 120 cm/s at 150 m (Andrews and Hutchings 1980).

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

4.1.2.8 Nutrient distribution

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

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

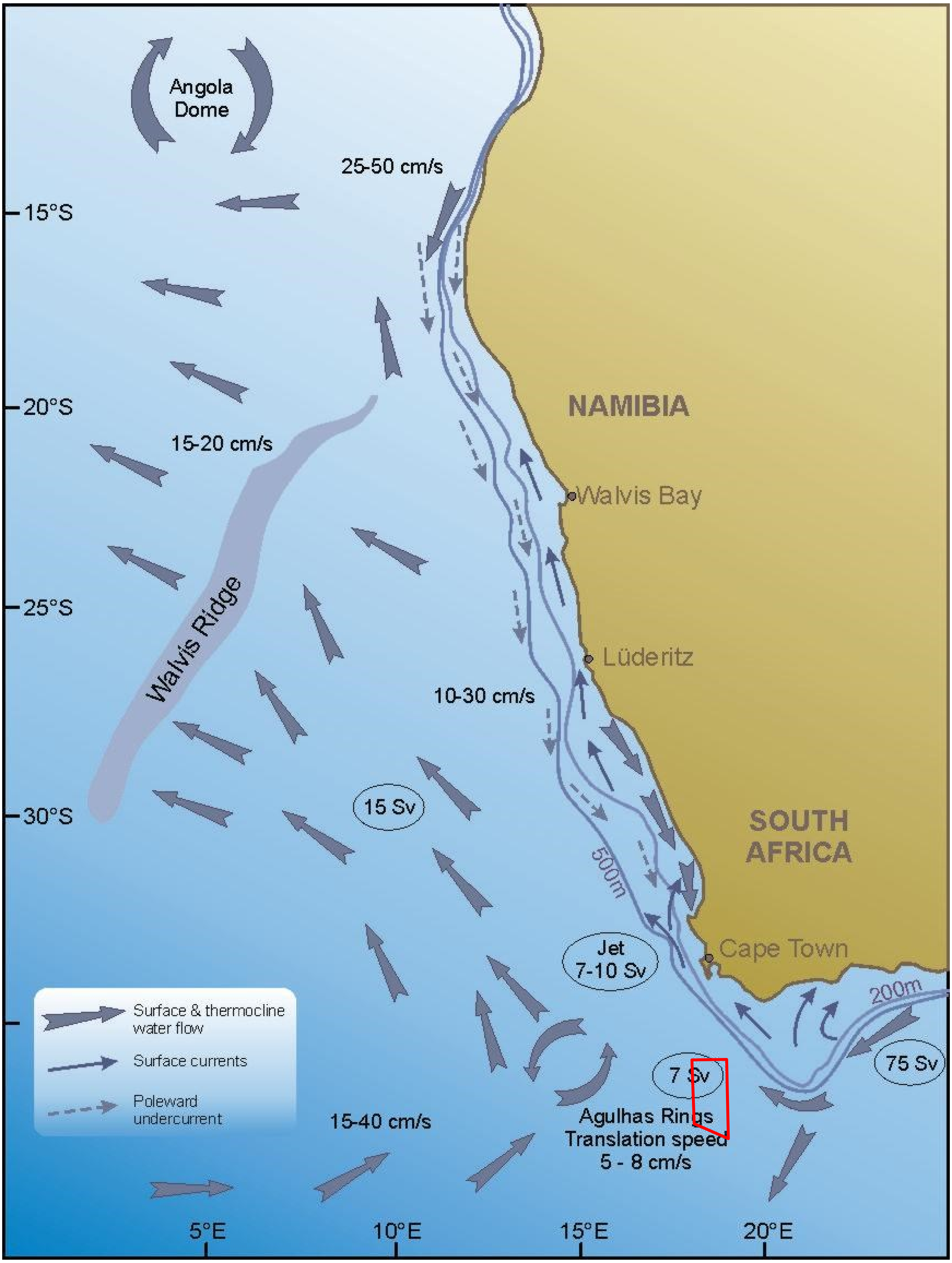

Figure 4.4: Major features of the predominant circulation patterns and volume flows in the Benguela System, along the southern Namibian and South African west coasts (re-drawn from Shannon & Nelson 1996). Approximate location of Licence Blocks 3616 & 3717 is also indicated.

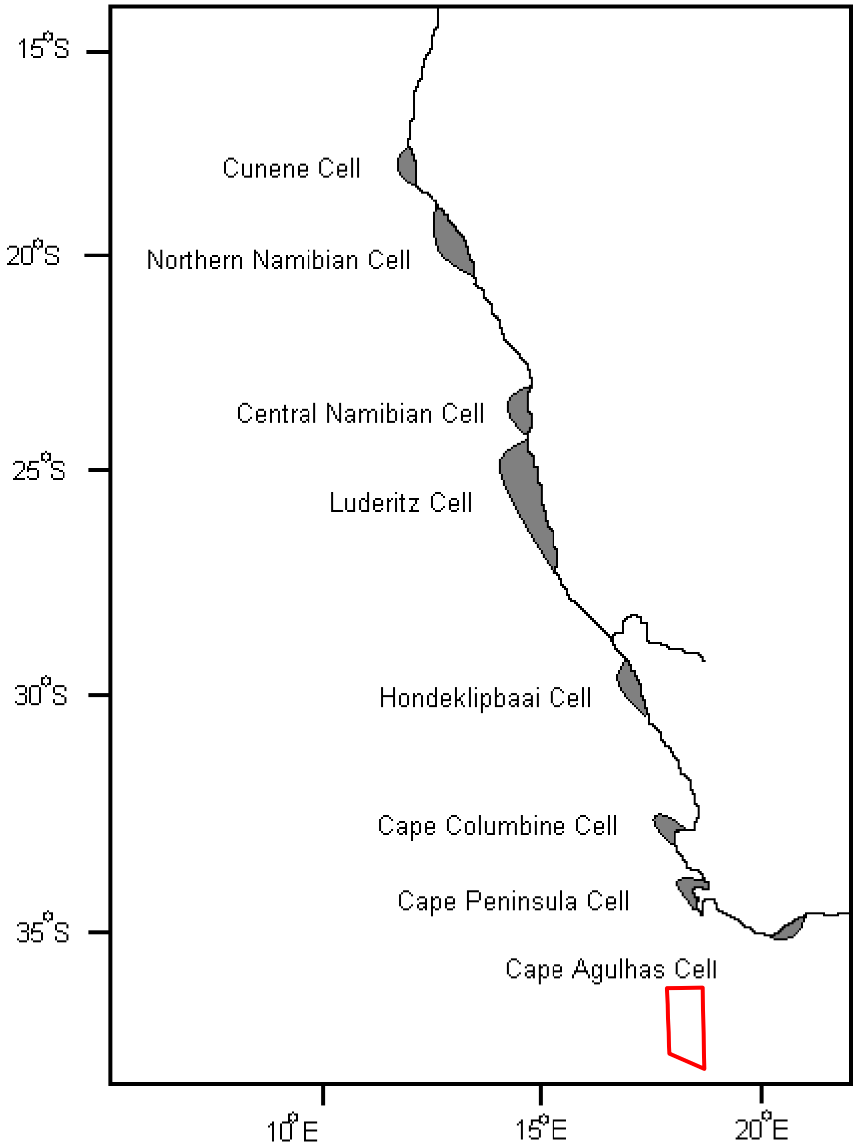

Figure 4.5: The location of three major upwelling cells along the West Coast (Shannon and Nelson, 1996). Approximate location of Licence Blocks 3616 & 3717 is also indicated.

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

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

4.1.2.9 Oxygen concentration

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

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

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

4.1.2.10 Turbidity

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

Concentrations of suspended particulate matter in shallow coastal waters can vary both spatially and temporally, typically ranging from a few mg/l to several tens of mg/l (Bricelj & Malouf 1984; Berg & Newell 1986; Fegley *et al*. 1992). Field measurements of TSPM and PIM concentrations in the Benguela current system have indicated that outside of major flood events, background concentrations of coastal and continental shelf suspended sediments are generally <12 mg/l, showing significant long-shore variation (Zoutendyk 1995). Considerably higher concentrations of PIM have, however, been reported from southern African West Coast waters under stronger wave conditions associated with high tides and storms, or under flood conditions. Field measurements of TSPM and PIM concentrations in the southern Benguela are summarised in Table 4.1.

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

On the inner and middle continental shelf, the ambient currents are insufficient to transport coarse sediments, and resuspension and shoreward movement of these by wave-induced currents occur primarily under storm conditions (see also Drake *et al*. 1985; Ward 1985).

Table 4.1: Mean concentrations of total suspended particulate matter (TSPM) and particulate inorganic matter (PIM) expresses as mg/ℓ from coastal waters in the Benguela.

Region	TSPM	PIM	Source
Dalebrook (RSA)	1.5		Cliff (1982)
Olifantsbos (RSA)		1	Zoutendyk (1995)
Oudekraal (RSA)	1.6		Stuart (1982), Stuart *et al.* (1982)
Melkbosstrand (RSA)		~4.5	Zoutendyk (1995)
Saldanha Bay (RSA)		<4	Carter & Coles (1998)
Groenrivier (RSA)		8.8	Bustamante (1994)
		2	Zoutendyk (1995)
Port Nolloth (RSA)		~2.75	Zoutendyk (1995)
Alexander Bay (RSA)		14.3	Zoutendyk (1995)
Orange River	9		Emery *et al.* (1973)
Orange River 1988 flood		7,400	Bremner *et al.* (1990)

4.1.3 BIOLOGICAL OCEANOGRAPHY

South Africa is divided into nine bioregions (see Figure 4.6). Licence Blocks 3616 and 3717 are located in one of these bioregions, namely the Atlantic Offshore bioregion (Emanuel *et al.* 1992; Lombard et al. 2004).

The South African National Biodiversity Institute (SANBI) has initiated a process to identify potential priority areas for spatial management in the offshore environment that require protection (Sink, *et. al.,* 2012). Areas which have been identified as priority areas for protection are presented in Section 4.1.4.6e. Licence Blocks 3616 and 3717 overlap with the proposed Southeast Atlantic Seamount protection area (see Figure 4.13). Sink, *et. al.* (2012) also mapped the ecosystem threat status of offshore benthic and pelagic habitats. Licence Blocks 3616 and 3717 coincide with areas mapped as least threatened (see Figure 4.7 and 4.8).

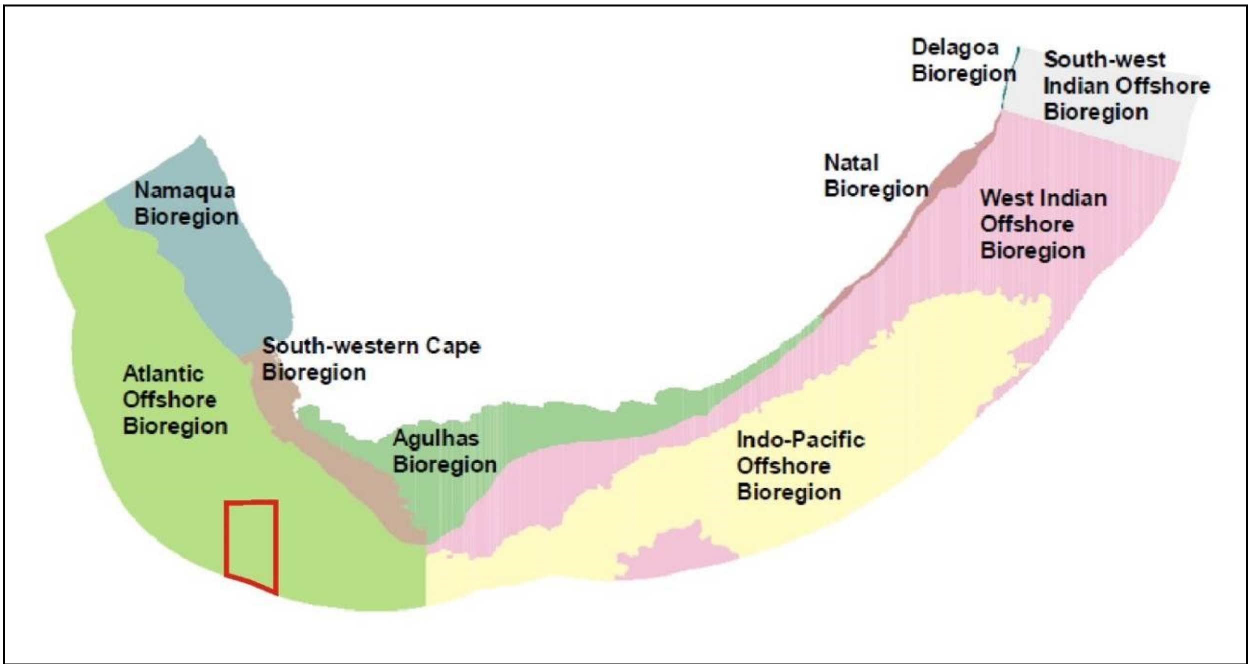

Figure 4.6: The nine bioregions defined by the NBSA study (Lombard and Strauss 2004). The approximate location of Licence Blocks 3616 & 3717 is also shown.

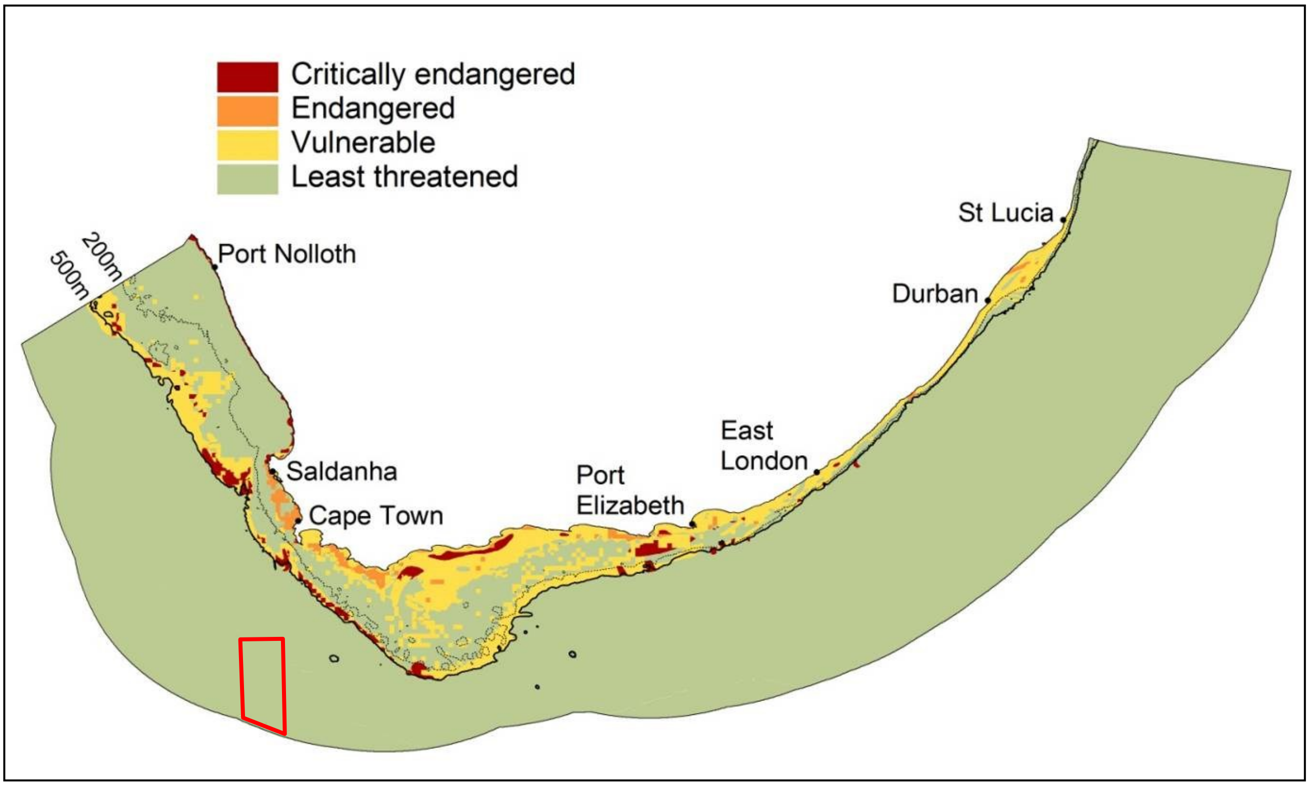

Figure 4.7: **Ecosystem threat status for coastal and offshore benthic habitat types in South Africa (Sink, et. al., 2012). The approximate location of Licence Blocks 3616 & 3717 is also shown.**

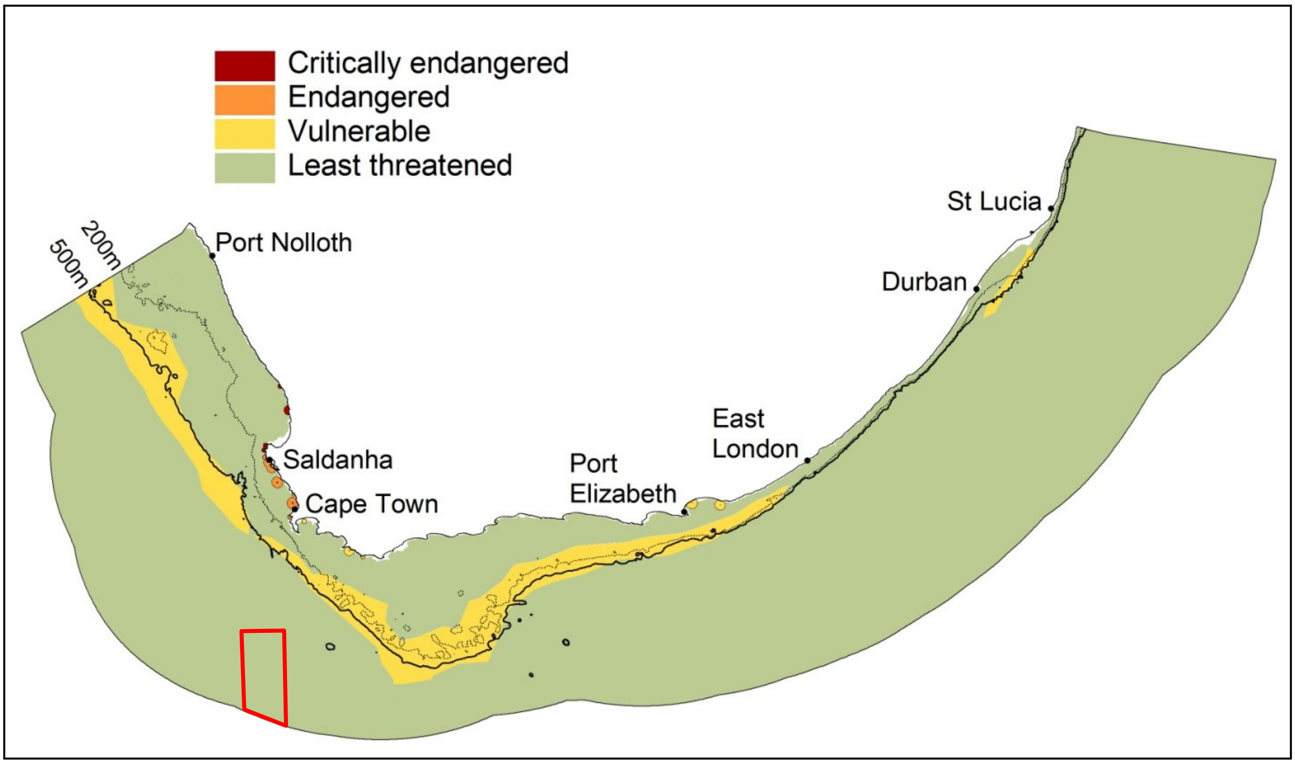

Figure 4.8: **Ecosystem threat status for offshore pelagic habitat types in South Africa (Sink, et. al., 2012). The approximate location of Licence Blocks 3616 & 3717 is also shown.**

Communities within marine habitats are largely ubiquitous throughout the southern African South-West Coast region, being particular only to substrate type or depth zone. These biological communities consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales). Licence Blocks 3616 and 3717 are located well beyond the 3 000 m depth contour, the closest point to shore being approximately 190 km offshore of Cape Point. The deep-water marine ecosystems comprise a limited range of habitats, namely unconsolidated seabed sediments and the water column. The biological communities 'typical' of these habitats are described briefly below, focussing both on dominant, commercially important and conspicuous species, as well as potentially threatened species.

4.1.3.1 Plankton

Plankton comprises of three components:

(a) Phytoplankton

Features of phytoplankton distribution in the Benguela system are summarised in Figure 4.9. Phytoplankton and "*chlorophyll a*" concentrations vary seasonally along the West Coast, being minimal in winter and summer (<1-2 mg/m³) and maximal (2-4 mg/m³) in spring and autumn. Brown (1992) divided the shelf areas of the West and South Coasts into three regions; West Coast (north of Cape Columbine), the Cape Coast from Cape Columbine to Cape Agulhas and the South Coast (to the east of Cape Agulhas). Mean "*chlorophyll a"* concentrations measured in the surface 30 m of the water column in each of inshore (< 200 m depth) and offshore (200 m – 500 m depth) areas in the West Coast region are shown in Table 4.2.

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

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

Red tides (dinoflagellate and/or ciliate blooms or harmful algal blooms) may occur inshore along the coast north of Cape Point (especially in the Lamberts Bay to St Helena Bay region), usually during relaxation of upwelling cells in late summer to autumn. Such red tides (which can range in colour) may be toxic and animals, particularly filter feeding species, may accumulate toxins in their tissues. Furthermore, decomposition of red tides may strip the remaining oxygen from the water and turn it anoxic (known as a "black tide"), having catastrophic consequences on the inshore fauna of the affected area. The massive mortality of fish, lobsters and other inter- and subtidal invertebrates between Cape Columbine and the Berg River mouth during 1994 serves as an example of a black tide.

There is considerable variation in phytoplankton abundance off the West Coast (Pitcher *et al.* 1992), in terms of both the longshore and offshore scales (productivity levels between Cape Point and the Orange River mouth range from 0.3 to 11 $gC.m^{-2}.day^{-1}$).

(b) Zooplankton

Features of the zooplankton distribution in the Benguela system are summarised in Figure 4.10. Zooplankton biomass is related to that of phytoplankton, and is thus seasonal, being minimal during winter when the rate of upwelling is lower (Andrews and Hutchings 1980). Zooplankton biomass is low in newly upwelled waters, but increases as these waters age and develops substantial phytoplankton. However, zooplankton blooms lag phytoplankton blooms and thus are found even further offshore, with zooplankton biomass being maximal 40 to 100 km offshore in summer. During winter (when no upwelling occurs in the southern Benguela region) maximal zooplankton biomass is observed close inshore, values being low offshore. An estimated 5 % of the zooplankton is lost to the seabed annually.

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

Euphausiids (18 species) dominate the macrozooplankton (Pillar 1986), of which *Euphausia lucens* and *Nyctiphanes capensis* are the most abundant in the shelf region with *E. lucens* dominating the region between Lüderitz and Cape Agulhas (Pillar *et al.* 1992). Other important groups contributing to the southern Benguela macrozooplankton community are chaetognaths (24 species), hyperiid amphipods (over 70 species within the southern and northern Benguela) and tunicates (42 species) (see Gibbons *et al.* 1992). Macrozooplankton standing stocks are greatest north of Cape Columbine (0.5 $gC.m^{-2}$) and decline southwards and eastwards to 0.1 $gC.m^{-2}$ at the eastern boundary of the West Coast.

Table 4.2: Mean concentrations of chlorophyll a in the southern Benguela system over the period 1971 to 1989 (after Brown 1992).

Season	Coast	Mean *"chlorophyll a"* concentrations ($mg.m^{-3}$)		
		Total shelf	Inshore shelf	Offshore shelf
All year	Whole area	1.82	2.28	1.00
	West Coast	2.11	3.32	0.78
	Cape Coast	2.50	3.58	1.43
	South Coast	1.35	1.46	1.00
Spring	Whole area	2.28	2.50	1.61
	West Coast	4.98	5.41	
	Cape Coast	2.93	3.61	2.03
	South Coast	1.43	1.50	1.16
Summer	Whole area	2.09	2.83	0.93
	West Coast	2.28	3.62	0.79
	Cape Coast	3.30	4.96	1.44
	South Coast	1.06	1.19	0.57
Autumn	Whole area	2.14	2.50	1.12
	West Coast	2.68	3.94	0.52
	Cape Coast	2.84	3.98	1.56
	South Coast	1.63	1.70	1.16
Winter	Whole area	1.54	1.84	0.96
	West Coast	1.88	2.75	0.88
	Cape Coast	1.55	1.96	1.14
	South Coast	1.25	1.32	0.92

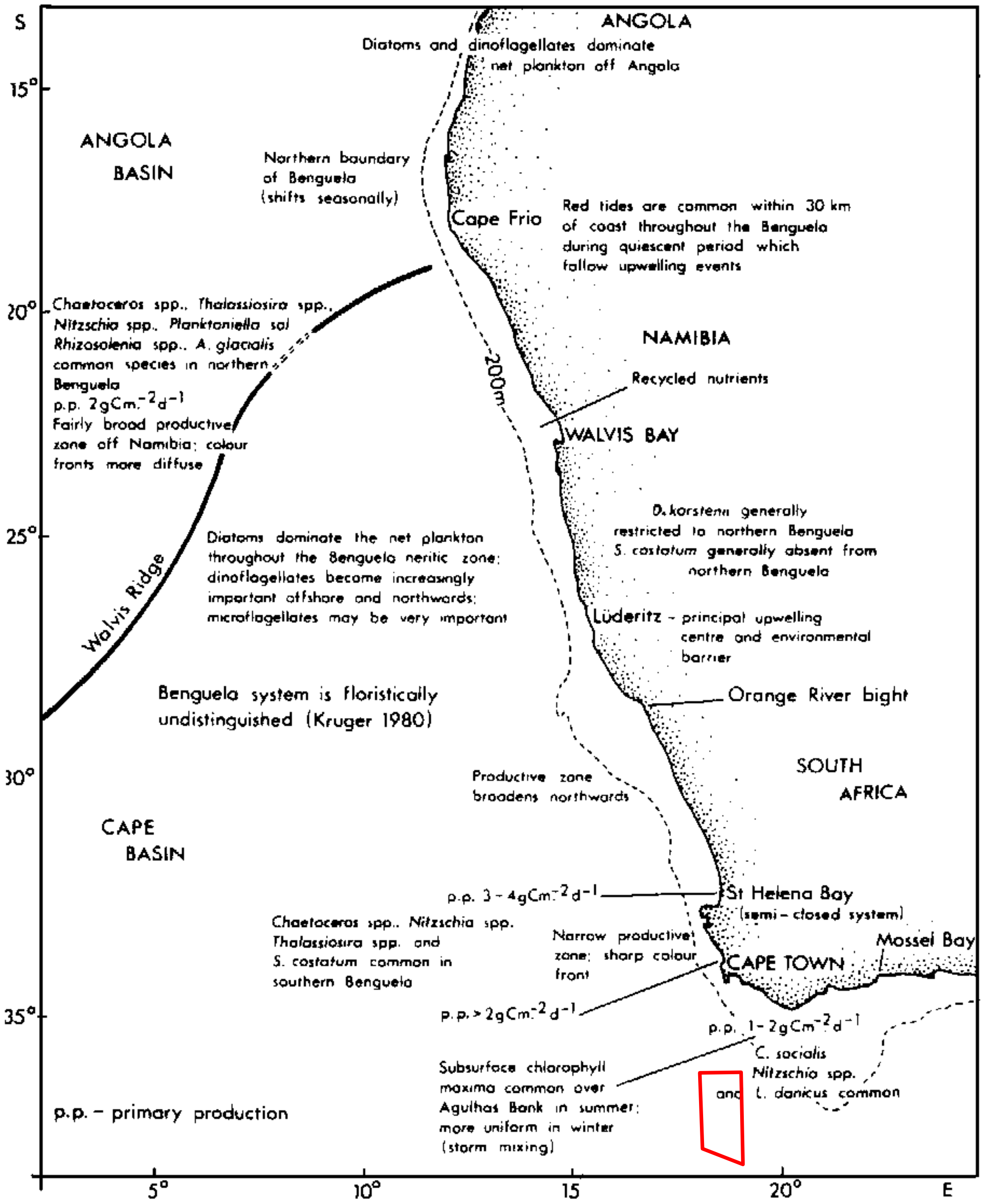

Figure 4.9: Features of phytoplankton distribution in the Benguela System (after Shannon and Pillar 1986). Approximate location of Licence Blocks 3616 & 3717 is also indicated.

(c) Ichthyoplankton

Ichthyoplankton comprises both fish eggs and larvae, and despite comprising a small component of the overall plankton, is important due to commercial fisheries. Various pelagic and demersal fish species are known to spawn in the southern Benguela, including pilchard, round herring, chub mackerel and hakes (Crawford et al. 1987) (see Figure 4.11), and their eggs and larvae form an important contribution to the ichthyoplankton in the region.

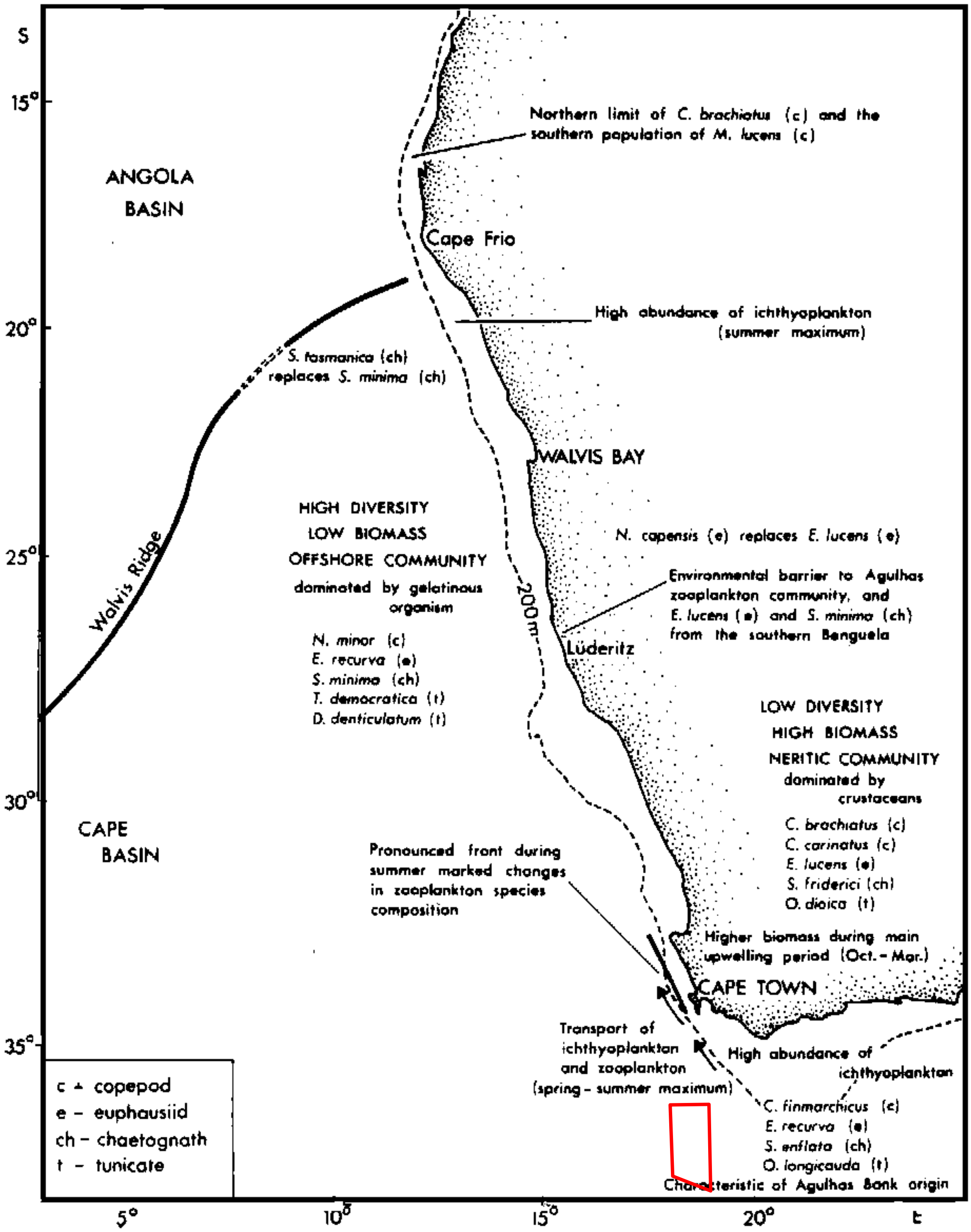

Figure 4.10: Features of zooplankton and ichtyoplankton distribution in the Benguela system (after Shannon and Pillar 1986). Approximate location of Licence Blocks 3616 & 3717 is also indicated.

The spawning areas of the major pelagic species are distributed on the continental shelf and along the shelf edge extending from south of St Helena Bay to Mossel Bay on the South Coast (Shannon & Pillar 1986) (see Figure 4.11. They spawn inshore of the shelf edge and downstream of major upwelling centres (particularly on the Agulhas Bank), in spring and summer and their eggs and larvae are subsequently carried around Cape Point and up the coast in northward flowing surface waters. The spawning areas and northward egg and larval drift thus occurs well inshore of the Exploration Area.

Of the demersal species, the two hake species (*Merluccius capensis* and *M. paradoxus*) spawn on the continental shelf off St Helena Bay and the western Agulhas Bank (see Figure 4.11). Hake spawning occurs in spring and early summer, with a secondary spawning peak in autumn. Kingklip (*Genypterus capensis*) spawning occurs along the southern African West Coast from Cape Point northwards (Payne 1977). Eggs and/or larvae of snoek (*Thyrsites atun*), jacopever (*Helicolenus dactylopterus*), dragonet (*Paracallionymus costatus*) and saury (*Scomberesox saurus scomberoides*) have also been reported in the southern Benguela.

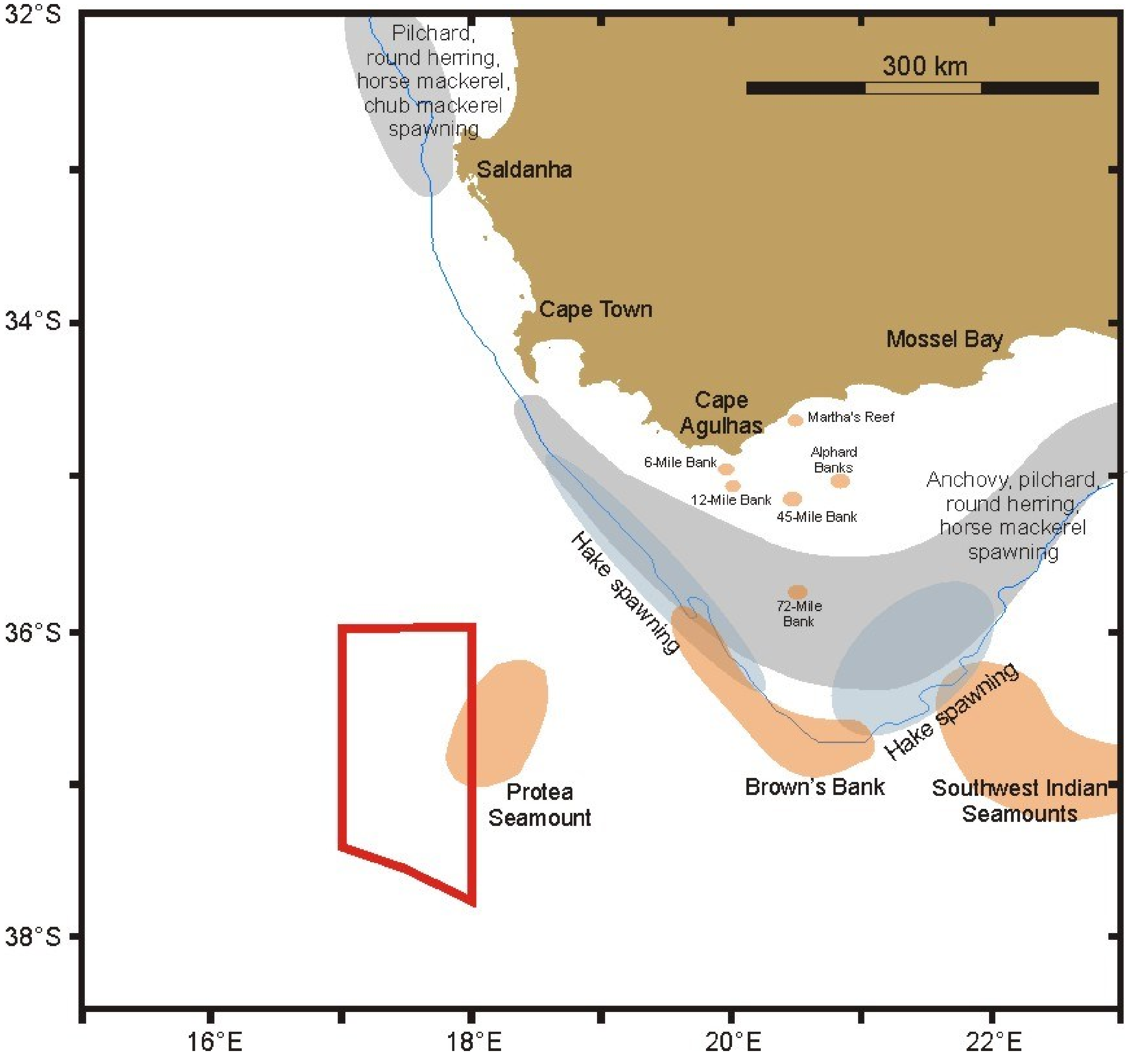

Figure 4.11: Major spawning areas in the southern Benguela region in relation to Licence Blocks 3616 & 3717 for different pelagic species. Adapted from Anders (1975), Crawford et al. (1987) and Hutchings (1994).

4.1.3.2 Benthic invertebrate macrofauna

The benthic biota of soft-bottom substrates constitutes invertebrates that live on (epifauna) or burrow within (infauna) the sediments and are generally divided into macrofauna (animals >1 mm) and meiofauna (<1 mm). The structure and composition of benthic soft bottom communities is primarily a function of water depth and sediment composition (Steffani & Pulfrich 2004a, 2004b; 2007; Steffani 2007a; 2007b), but other factors such as current velocity, organic content and food abundance also play a role (Flach & Thomsen 1998; Ellingsen 2002).

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

Typical species occurring at depths of up to 60 m included the snail *Nassarius* spp., the polychaetes *Orbinia angrapequensis, Nepthys sphaerocirrata*, several members of the spionid genera *Prionospio*, and the amphipods *Urothoe grimaldi* and *Ampelisca brevicornis*. The bivalves *Tellina gilchristi* and *Dosinia lupinus orbignyi* are also common in certain areas (Pulfrich, 2011). Offshore communities are dominated by polychaetes (e.g. *Diopatra dubia, D. monroi, D. cuprea cuprea*, *Lumbrineris albidentata, Laonice cirrata*), echinoderms (e.g. *Amphiura* sp., *Ophiura* sp.) and crustaceans (e.g. *Ampelisca brevicornis, Hippomedon onconotus, Tanais philetaerus*) (Atkinson 2009). The benthic fauna of the continental shelf and continental slope beyond approximately 450 m depth are poorly known. With little sea floor topography and hard substrate, such areas are likely to offer minimal habitat diversity or niches for animals to occupy. Detritus-feeding crustaceans, holothurians and echinoderms tend to be the dominant epi-benthic organisms of such habitats.

Soft-bottom substrates are also associated with demersal communities that comprise bottom-dwelling invertebrate and vertebrate species, many of which are dependent on the invertebrate benthic macrofauna as a food source. Atkinson (2009) reported numerous species of urchins and burrowing anemones beyond 300 m water depth off the West Coast.

4.1.3.3 Invertebrates

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

Studies have shown that the majority of seabed species recorded from similar areas have short life spans (a few years or less) and relatively high reproductive rates, indicating the potential for rapid recovery after natural or anthropogenic disturbance of the soft sediment environment. The only species associated with these environments that are slow growing, slow to mature, long-lived and therefore slow to recover and consequently are regarded as vulnerable are the seapens - a list of species recorded by Lopez-Gonzales *et al.* (2001) is given in Table 4.3.

Table 4.3: List of seapen species sampled by Lopez-Gonzales *et al.* (2001) during cruises in the Benguela Region.

Species	Zoogeographic Region	Depth Range (m)*
Anthoptillum grandiflorum	Widespread	238-2 500
Amphibelemnon namibiensis	Benguela	91-304
Crassophyllum cristatum	Benguela	40-650
Distichoptilum gracile	Widespread	650-4 300
Funiculina quadriangularis	Widespread	60-2 600
Halipteris africana	Benguela	459-659
Kopholobelemnon stelliferum	Widespread	400-1 180
Pennatula inflata	Widespread	457-741
Scleroptilum grandiflorum	Widespread	500-4 200
Stylatula macpheersoni	Benguela	245-318
Umbellula thomsoni	Widespread	1300-6 200
Virgularia mirabilis	Widespread	9-400
Virgularia tuberculata	Benguela	75-1 050

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

4.1.3.4 Deep water coral communities

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

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

4.1.3.5 Cephalopods

On the basis of abundance and trophic links with other species, eight species of cephalopod are important and a further five species have potential importance within the Benguela system (Table 4.4). The main cephalopod species that occurs within the southern Benguela system are the sepiods / cuttlefish (Lipinski 1992; Augustyn *et al.* 1995). Most of the cephalopod resource is distributed on the mid-shelf with *Sepia australis* being most abundant at depths between 60-190 m, whereas *S. hieronis* densities were higher at depths between 110-250 m. *Rossia enigmatica* occurs more commonly on the edge of the shelf to depths of 500 m. Biomass of these species is generally higher in the summer than in winter.

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

Table 4.4: Cephalopod species of importance or potential importance within the Benguela System (after Lipinski 1992).

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

4.1.3.6 Seamount Communities

One important geological feature is located within the vicinity of Licence Blocks 3616 and 3717, namely the Protea Seamount (see Figure 4.11). Features such as banks, knolls and seamounts (referred to collectively here as “seamounts”), which protrude into the water column, are subject to, and interact with, the water currents surrounding them. The effects of such seabed features on the surrounding water masses can include the upwelling of relatively cool, nutrient-rich water into nutrient-poor surface water thereby resulting in higher productivity (Clark *et al.* 1999), which can in turn strongly influence the distribution of organisms on and around seamounts. Evidence of enrichment of bottom-associated communities and high abundances of demersal fishes has been regularly reported over such seabed features.

The enhanced fluxes of detritus and plankton that develop in response to the complex current regimes lead to the development of detritivore-based food-webs, which in turn lead to the presence of seamount scavengers and predators. Deep- and cold-water corals (including stony corals, black corals and soft corals) are a prominent component of the suspension-feeding fauna of many seamounts, accompanied by barnacles, bryozoans, polychaetes, molluscs, sponges, sea squirts, basket stars, brittle stars and crinoids (Rogers 2004). There is also associated mobile benthic fauna that includes echinoderms (sea urchins and sea cucumbers) and crustaceans (crabs and lobsters) (Rogers 1994). Seamounts also provide an important habitat for commercial deepwater fish stocks, such as orange roughy, oreos, alfonsino and Patogonian toothfish, which aggregate around these features for either spawning or feeding (Koslow 1996).

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

4.1.3.7 Fishes

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

(a) Demersal species

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

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

(b) Pelagic species

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

Most of the pelagic species exhibit similar life history patterns involving seasonal migrations between the west and south coasts. Apart from round herring which spawn offshore of the shelf break on the West Coast, the spawning areas of the major pelagic species are distributed on the continental shelf extending from south of St Helena Bay to Mossel Bay on the South Coast (Shannon & Pillar 1986). They spawn downstream of major upwelling centres in spring and summer, and their eggs and larvae are subsequently carried around Cape Point and up the coast in northward flowing surface waters (see Figure 4.11).

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

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

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

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

4.1.3.8 Turtles

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

The leatherback turtle is likely to be encountered in the offshore waters west of South Africa. The Benguela ecosystem, especially the northern Benguela where jelly fish numbers are high, is increasingly being recognised as a potentially important feeding area for leatherback turtles from several globally significant nesting populations in the south Atlantic (Gabon, Brazil) and south east Indian Ocean (South Africa) (Lambardi *et al*. 2008, Elwen & Leeney 2011, SASTN 2011[1]).

Leatherback turtles inhabit deeper waters and are considered a pelagic species, travelling the ocean currents in search of their prey (primarily jellyfish). While hunting they may dive to over 600 m and remain submerged for up to 54 minutes (Hays *et al*. 2004), thus making them difficult to observe from the surface and potentially susceptible to seismic operations. Leatherback turtles breed on the northern KwaZulu-Natal coastline of the East Coast and in the Republic of Congo and Gabon on the West Coast.

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

4.1.3.9 Birds

There are a total of 49 species of seabirds occurring within the southern Benguela area, of which 14 are resident species, 25 are migrants from the southern ocean and 10 are visitors from the northern hemisphere. Table 4.5 provides a list of the common species occurring within the study area.

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

The availability of breeding sites is an extremely important determinant in the distribution of resident seabirds. Although breeding areas are distributed along the whole coast, islands are especially important. The number of successfully breeding birds at the particular breeding sites varies with food abundance. Fourteen resident species breed along the West Coast, including Cape Gannet, African Penguin, four species of Cormorant, White Pelican, three Gull and four Tern species (Table 4.6).

Table 4.5: Pelagic seabirds common in the southern Benguela region (Crawford *et al*. 1991).

Common Name	Species name	Global IUCN
Shy albatross	*Thalassarche cauta*	Near Threatened
Black browed albatross	*Thalassarche melanophrys*	Endangered[1]
Yellow nosed albatross	*Thalassarche chlororhynchos*	Endangered
Giant petrel sp.	*Macronectes halli/giganteus*	Near Threatened
Pintado petrel	*Daption capense*	Least concern
Greatwinged petrel	*Pterodroma macroptera*	Least concern
Soft plumaged petrel	*Pterodroma mollis*	Least concern
Prion spp	*Pachyptila* spp.	Least concern
White chinned petrel	*Procellaria aequinoctialis*	Vulnerable
Cory’s shearwater	*Calonectris diomedea*	Least concern
Great shearwater	*Puffinus gravis*	Least concern

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

Common Name	Species name	Global IUCN
Sooty shearwater	*Puffinus griseus*	Near Threatened
European Storm petrel	*Hydrobates pelagicus*	Least concern
Leach's storm petrel	*Oceanodroma leucorhoa*	Least concern
Wilson's storm petrel	*Oceanites oceanicus*	Least concern
Blackbellied storm petrel	*Fregetta tropica*	Least concern
Skua spp.	*Catharacta*/*Stercorarius* spp.	Least concern
Sabine's gull	*Larus sabini*	Least concern

Table 4.6: Breeding resident seabirds present along the West Coast (CCA & CMS 2001).

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

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

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

African penguin colonies (*Spheniscus demersus*) occur at 27 localities around the coast of South Africa and Namibia (see Figure 4.12). The species forages at sea with most birds being found within 20 km of their colonies. African penguin distribution at sea is consistent with that of the pelagic shoaling fish, which generally occur within the 200 m isobath.

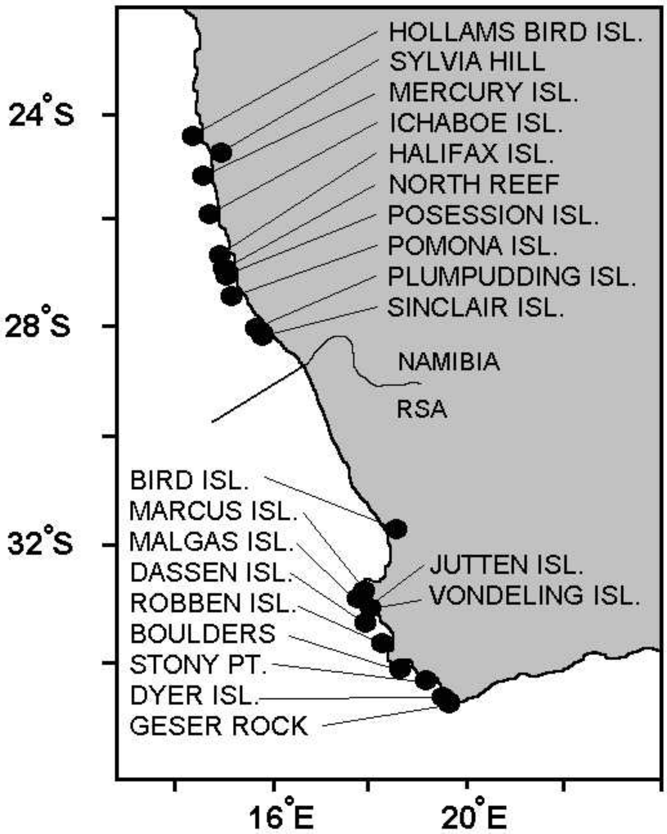

Figure 4.12: The distribution of breeding colonies of African penguins on the South African West Coast.

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

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

4.1.3.10 Marine mammals

The marine mammal fauna of the West Coast comprises between 28 and 31 species of cetaceans (whales and dolphins) and four seal species, of which the Cape fur seal (*Arctocephalus pusillus*) is the most common. The range of cetacean species reflects largely taxonomic uncertainty at species and sub-species level, rather than uncertainty of occurrence or distribution patterns (Findlay *et al.* 1992).

(a) Cetaceans

Cetaceans comprised two basic taxonomic groups: the mysticetes (filter-feeding baleen whales), which are largely migratory, and the odontocetes (toothed predatory whales and dolphins), which may be resident or migratory. More than 20 species of whales and dolphins are known or likely to occur in the offshore environment (>200 m depth) off the South-West coast of South Africa (see Table 4.7). The offshore areas have been particularly poorly studied with almost all available information from deeper waters (>200 m) arising from historic whaling records. Information on smaller cetaceans in deeper waters is particularly poor.

Mysticete cetaceans occurring in the study area include the blue, fin, sei, Antarctic minke, dwarf minke, humpback and Bryde's whales. The southern right whale (Family *Balaenidae*) and pygmy right whale (Family *Neobalaenidae*) are from taxonomically separate groups. Most of these species occur in pelagic waters, with only occasional visits into shelf waters. All of these species show some degree of migration either to, or through, the latitudes encompassed by the broader study area when en route between higher-latitude feeding grounds (Antarctic or Subantarctic) and lower-latitude breeding grounds. Depending on the ultimate location of these feeding and breeding grounds, seasonality off South Africa can be either unimodal (usually in June-August, e.g. minke and blue whales) or bimodal (usually May-July and October-November, e.g. fin whales), reflecting a northward and southward migration through the area. As whales follow geographic or oceanographic features, the northward and southward migrations may take place at difference distances from the coast, thereby influencing the seasonality of occurrence at different locations. Due to the complexities of the migration patterns, each species is discussed in further detail below.

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

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

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

- <u>Blue whales:</u> Antarctic blue whales were historically caught in high numbers during commercial whaling activities, with a single peak in catch rates during July in Walvis Bay, Namibia and at Namibe, Angola suggesting that in the eastern South Atlantic these latitudes are close to the northern migration limit for the species (Best 2007). Very few confirmed sightings of blue whales have occurred off the west coast of South Africa since 1973 (Branch *et al.* 2007), although new reports from pelagic waters have confirmed their current presence in the area, although at very low densities.

Table 4.7: Cetaceans occurrence offshore of the South-West Coast, their seasonality and likely encounter frequency.

Common Name	Scientific Name	Occurrence on Shelf	Occurrence offshore	IUCN Conservation Status (2008)	Seasonality in impact zone	Likely encounter frequency
Delphinids						
Dusky dolphin	*Lagenorhynchus obscurus*	Yes 0-800m	No	Data Deficient	Year round	Unlikely
Common bottlenose dolphin (Offshore)	*Tursiops truncatus*	Yes	Yes	Least Concern	Year round	Weekly
Common dolphin - Short beaked	*Delphinus delphis*	Occasional	Yes	Least Concern	Year round	Weekly
Common dolphin - Long beaked	*Delphinis capensis*	Yes	No	Data Deficient		Weekly
Southern right whale dolphin	*Lissodelphis peronii*	Yes	Yes	Data Deficient	Year round	Rare
Long-finned pilot whale	*Globicephala melas*	Edge	Yes	Data Deficient	Year round	Weekly
Short-finned pilot whale	*Globicephala macrorhynchus*	?	?	Data Deficient	Year round	Unlikely
Killer whale	*Orcinus orca*	Occasional	Yes	Data Deficient	Year round	Weekly
False killer whale	*Pseudorca crassidens*	Occasional	Yes	Data Deficient	Year round	Weekly
Pygmy killer whale	*Feresa attenuata*	?	Yes	Data Deficient	Year round	Unlikely
Risso's dolphin	*Grampus griseus*	Edge	Yes	Least Concern	Year round	Monthly
Sperm whales						
Pygmy sperm whale	*Kogia breviceps*	Edge	Yes	Data Deficient	Year round	Weekly
Dwarf sperm whale	*Kogia sima*	Edge	?	Data Deficient	Year round	Weekly
Sperm whale	*Physeter macrocephalus*	Edge	Yes	Vulnerable A1d	Year round	Weekly
Beaked whales						
Cuvier's	*Ziphius cavirostris*	No	Yes	Least Concern	Year round	Rare
Arnoux's	*Beradius arnuxii*	No	Yes	Data Deficient	Year round	Rare
Southern bottlenose	*Hyperoodon planifrons*	No	Yes	Least Concern	Year round	Rare
Layard's	*Mesoplodon layardii*	No	Yes	Data Deficient	Year round	Rare
True's	*M. mirus*	No	Yes	Data Deficient	Year round	Rare
Gray's	*M. grayi*	No	Yes	Data Deficient	Year round	Rare
Blainville's	*M. densirostris*	No	Yes	Data Deficient	Year round	Rare

Common Name	Scientific Name	Occurrence on Shelf	Occurrence offshore	IUCN Conservation Status (2008)	Seasonality in impact zone	Likely encounter frequency
Baleen whales						
Antarctic minke	*Balaenoptera bonaerensis*	Yes	Yes	Data Deficient	Higher in winter	Weekly
Dwarf minke	*B. acutorostrata*	Yes	Yes	Not assessed	Year round	Weekly
Fin whale	*B. physalus*	Yes	Yes	Endangered	May-Jul, Oct-Nov	Occasional
Blue	*B. musculus*	No	Yes	Endangered	May-Aug	Unlikely
Sei	*B. borealis*	Edge	Yes	Endangered	May-Jun, Aug-Oct	Weekly
Bryde's (both forms)	*B. brydei*	Yes	Yes	Data Deficient	Higher in summer	Monthly
Humpback	*Megaptera novaeangliae*	Yes	Yes	Least Concern	Year round, higher in Jun-Nov	Weekly
Pygmy right	*Caperea marginata*	Yes	?	Data Deficient	Year round	Unlikely
Southern right	*Eubalaena australis*	Yes	No	Least Concern	Year round, higher in Jul-Nov	Monthly

- <u>Minke whales:</u> Two forms of minke whale occur in the southern Hemisphere, the Antarctic minke whale and the dwarf minke whale, both of which are likely to occur in the exploration licence area (Best 2007, NDP unpublished data). Antarctic minke whales range from Antarctica to tropical waters and are usually seen more than approximately 50 km offshore. Although adults of the species do migrate from the Southern Ocean (summer) to tropical/temperate waters (winter) where they are thought to breed, some animals, especially juveniles, are known to stay in tropical/temperate waters year round. The dwarf minke whale has a more temperate distribution than the Antarctic minke and they do not range further south than 60-65°S. Dwarf minkes have a similar migration pattern to Antarctic minkes with at least some animals migrating to the Southern Ocean during summer. Dwarf minke whales occur closer to shore than Antarctic minkes.

- <u>Southern right whales:</u> Southern right whales migrate from Southern Ocean feeding grounds at approximately 60°S to the coastline of southern Africa where they were historically found from southern Mozambique (Maputo Bay) to southern Angola (Baie dos Tigres). Southern right whales also feed during spring and summer months on the west coast of South Africa between St Helena and Saldanha Bays, and possibly further north and now have an almost year round presence along the South African coast (Mate et al. 2011; Peters et al. 2011; Barendse & Best 2014). Right whales tend to remain within a few kilometres of shore except when migrating to and from sub-Antarctic feeding grounds when it is possible they will pass through the exploration licence area.

- <u>Humpback whales:</u> The majority of humpback whales on the West Coast are migrating past the southern African continent to breeding grounds off Angola and the Gulf of Guinea (Rosenbaum *et al.* 2009, Barendse *et al*. 2010), while those migrating up the east coast of heading to breeding grounds of Mozambique and Madagascar (Findlay et al. 2011). The exploration licence area is located outside the known migration corridors of either population, but given that it is situated to the west of Cape Agulhas, it is considered likely that 'west coast' whales are more likely to be encountered.

  A large number of humpback whales can be found feeding within the Benguela ecosystem (especially between Saldanha Bay and St Helena Bay) in the spring and summer months (Barendse et al. 2011). Individuals using this west-coast feeding ground may migrate through the exploration licence area *en route* to or from the Antarctic. The exact relationship between whales using this feeding ground and those breeding further north is not fully understood at the moment, but there is some overlap of individuals (Carvalho et al. 2009; Barendse et al. 2011). Recent abundance estimates put the number of animals in the west African breeding population to be in excess of 9,000 individuals in 2005 (IWC 2012) and it is likely to have increased since this time at about 5% per annum (IWC 2012). Humpback whales are thus likely to be one of the most frequently encountered baleen whales in in the exploration licence area.

The Odontoceti are a varied group of animals including the dolphins, porpoises, beaked whales and sperm whales. Species occurring within the broader project area display a diversity of features, for example their ranging patterns vary from extremely coastal and highly site specific to oceanic and wide ranging.

- <u>Sperm whales:</u> Sperm whales are the largest of the toothed whales and have a complex, well-structured social system with adult males behaving differently from younger males and female groups. They live in deep ocean waters, usually greater than 1 000 m depth, occasionally coming into depths of 500-200 m on the shelf (Best 2007). Seasonality of catches off the west South Africa suggest that medium- and large-sized males are more abundant during winter, while female groups are more abundant in autumn (March-April), although animals occur year round (Best 2007). Sperm whales feed at great depth, during dives in excess of 30 minutes, making them difficult to detect visually. Very little data is available on the abundance, distribution or seasonality of the smaller odontocetes known to occur in oceanic waters (greater than 200 m) off the shelf of southern Africa. Beaked whales are all considered to be true deep-water species usually being seen in waters in excess of 1 000 - 2 000 m deep. The presence of Sperm whales in the exploration licence area may fluctuate seasonally, but insufficient data exist to define this clearly.

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

- Killer whales: Killer whales have a circum-global distribution being found in all oceans from the equator to the ice edge (Best 2007). Killer whales occur year round in low densities off western South Africa (Best *et al.* 2010), Namibia (Elwen & Leeney 2011) and in the Eastern Tropical Atlantic (Weir *et al.* 2010). Killer whales are found in all depths from the coast to deep open ocean environments and may thus be encountered in the project area at low levels.

- False killer whales: The species has a tropical to temperate distribution and most sightings off southern Africa have occurred in water deeper than 1 000 m but with a few close to shore as well (Findlay *et al*. 1992). False killer whales usually occur in groups ranging in size from 1 - 100 animals (mean 20.2) (Best 2007), and are thus likely to be fairly easily seen in most weather conditions. There is no information on population numbers of conservation status and no evidence of seasonality in the region (Best 2007) but they are likely to be encountered in the project area regularly.

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

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

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

- Risso's dolphin: Risso's dolphins are distributed worldwide in tropical and temperate seas and show a general preference for shelf edge waters less than 1 500 m deep (Best 2007). Although sightings have occurred beyond this, encounters are likely to be rare in the project area.

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

- Beaked Whales (Various Species): Beaked whales were never targeted commercially and their pelagic distribution makes them largely inaccessible to most researchers making them the most poorly studied group of cetaceans. Beaked whales appear to be particularly vulnerable to certain types of man-made noise. All the beaked whales that may be encountered in the exploration licence area are pelagic species that tend to occur in small groups usually less than five, although larger aggregations of some species are known (MacLeod & D'Amico 2006; Best 2007).

(b) Seals

The Cape fur seal (*Arctocephalus pusillus pusillus*) is common along the South-West Coast, congregating at numerous breeding and non-breeding sites on the mainland and on nearshore islands and reefs (Figure 4.13). Three other seal species may occasionally be found as vagrants along the West Coast.

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

4.1.4 HUMAN UTILISATION

4.1.4.1 Fisheries

The South African fishing industry consists of approximately 20 commercial sectors operating within the country's 200 nautical mile Exclusive Economic Zone (EEZ)[3]. Due to the upwelling that characterises the West Coast, the region sustains very productive fisheries. Seven commercial fisheries are active on the West Coast and are described further below.

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

(*a*) *Demersal trawl fisheries*

Demersal trawl is South Africa's most valuable fishery accounting for approximately half of the income generated from commercial fisheries. Demersal trawlers operate extensively around the coast primarily targeting the bottom-dwelling (demersal) species of hake (*Merluccius paradoxus* and *M. capensis*). Other commercially valuable trawl catch species are kingklip, monk, mackerel, panga, ribbonfish, chokka, gurnards, jacopever, octopus, pilchards and skates. The current annual hake Total Allowable Catch (TAC) of hake across all sectors targeting hake is 156 075 tons (2013), of which the majority is landed by the demersal trawl sector.

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

[3] The Exclusive Economic Zone is the 200 nm zone from the South African coastline out to sea over which it holds exclusive economic rights.

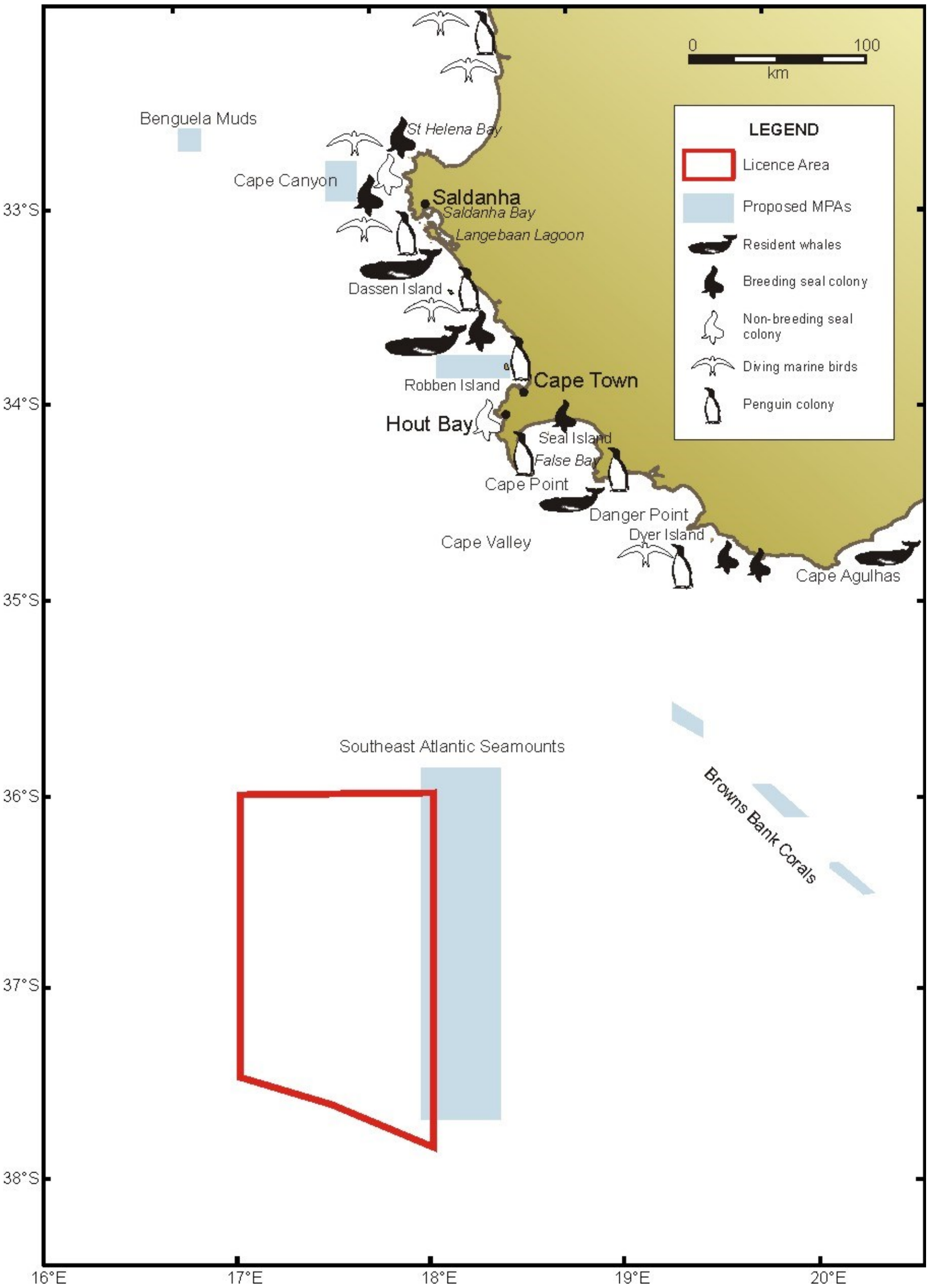

Figure 4.13: Location of seabird and seal colonies and resident whale populations in relation to Licence Blocks 3616 and 3717. The location of areas identified potential offshore Marine Protected Areas by Operation Phakisa (shaded blue) are also shown.

The hake-directed trawl fishery is split into two sub-sectors: a small inshore trawling sector and a large deep-sea trawl sector operating on both the South and West Coasts. The inshore trawling sector is based on the South / East Coast between Cape Agulhas and the Great Kei River and is most intense along the 100 m depth contour. The deep-sea trawl sector on the West Coast operates mainly in water depths of 200 m to 1 000 m and extends from Hondeklipbaai in a southwards direction to the southern point of the Agulhas Bank. On the South Coast, offshore trawlers may not fish shallower than 110 m depth or within 20 nm of the coast. There are currently 98 licenced vessels operating within the deep-sea trawl sector and most operate out of Cape Town and Saldanha Bay. Both inshore and offshore vessels have a similar gear configuration. The towed gear typically consists of trawl warps, bridles and trawl doors, a footrope, headrope, net and codend (see Figure 4.14).

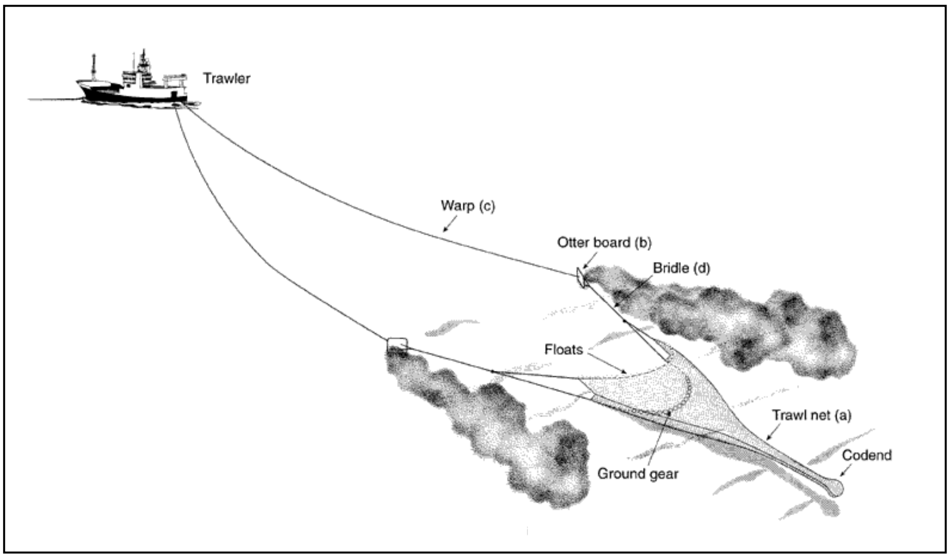

Figure 4.14: Schematic diagram of trawl gear typically used by demersal trawlers.

(b) Demersal long-line fishery

Two fishing sectors use this method of capture, namely the hake long-line sector (*M. capensis* and *M. paradoxus*) and the shark long-line sector targeting only the demersal species of shark.

The hake-directed fishery targets the Cape hakes with a small non-targeted commercial bycatch species that includes kingklip. A total nominal catch weight of approximately 9 494 tons has been set for this fishery in 2012. The hake-directed long-liners operate in well-defined areas extending along the shelf break from Port Nolloth to Cape Agulhas. There are currently 64 vessels licenced within the sector, operating from all major harbours, including Cape Town, Hout Bay, Mossel Bay and Port Elizabeth. Secondary points of deployment include St Helena Bay, Saldanha Bay, Hermanus, Gansbaai, Plettenberg Bay and Cape St Francis.

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

Bottom-set long-line gear is robust and comprises two lines as well as dropper lines with subsurface floats attached (see Figure 4.16). Lines are typically 20 – 30 nm in length and contain about 10 000 to 20 000 hooks. Demersal long-lines are anchored at either end and marked by an array of large buoys. Vessels set from 2 000 to 15 000 hooks per day generally shooting at night or early morning and recovering gear throughout the day. Once deployed the line is left to soak for up to eight hours before it is retrieved. During hauling operations manoeuvrability is severely restricted and direct communications from the survey vessels would be required in order to keep fishing vessels and gear clear of the survey vessel. Hake-directed fishing activity would be expected to occur along and inshore of the 500 m depth contour (see Figure 4.17).

The shark-directed fishery operates relatively close to shore, generally inshore of the 200 m isobath. Demersal shark longline fishing is also not permitted in tidal lagoons, estuaries, closed areas and marine protected areas (see Figures 4.18).

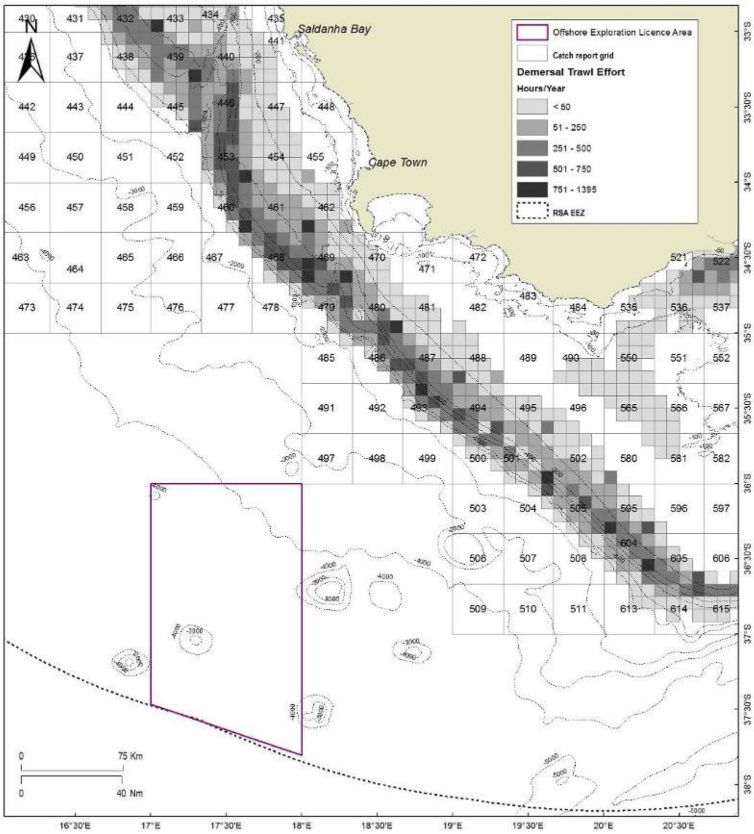

Figure 4.15: Distribution of fishing effort by the demersal trawl fishery in relation to Licence Blocks 3616 & 3717 from 2000 to 2012.

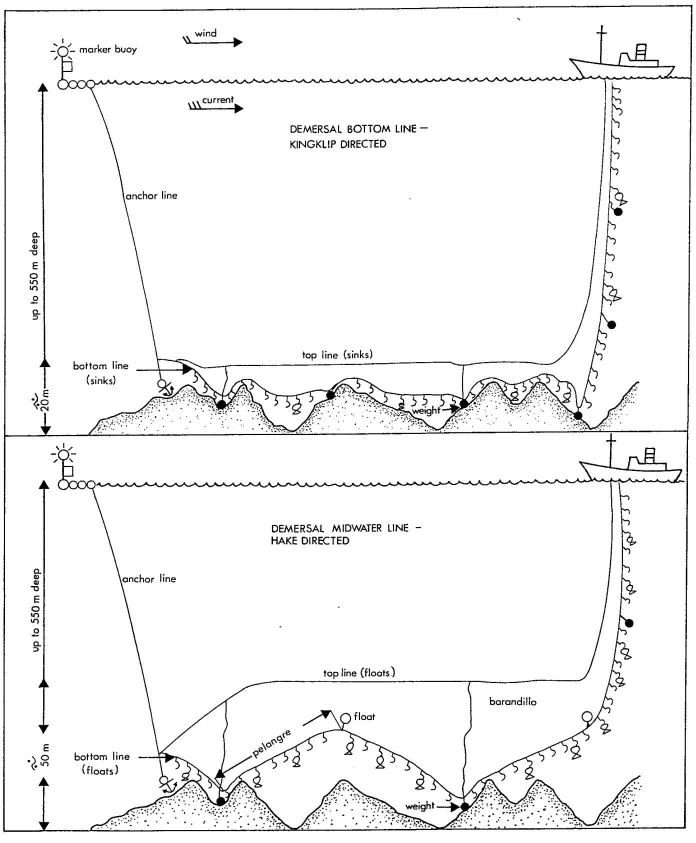

Figure 4.16: Diagram illustrating typical fishing gear deployed when fishing for demersal (bottom dwelling) species. Note the variation in depth of gear deployed for two different species (hake and kingklip).

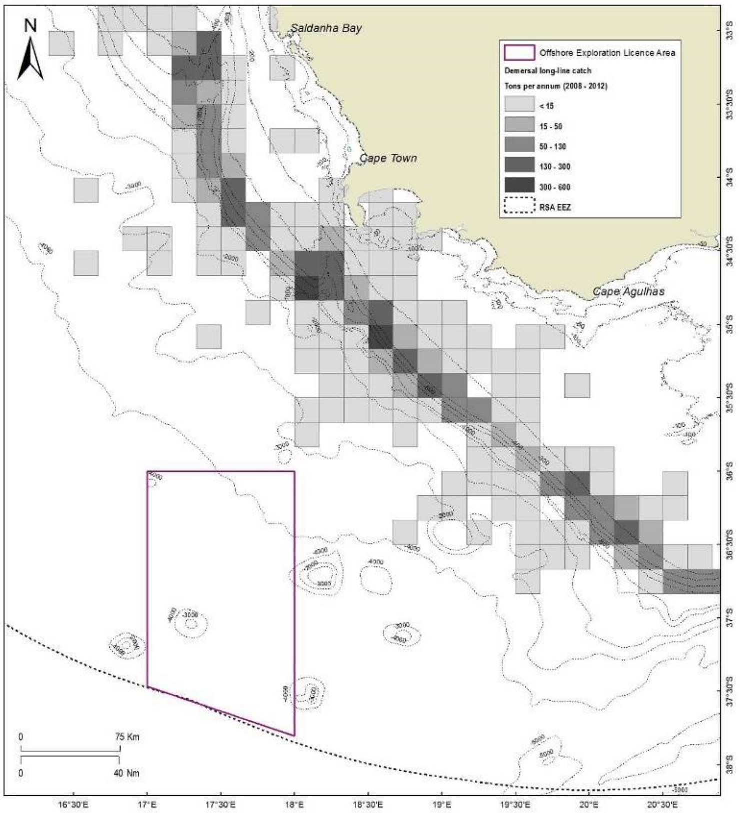

Figure 4.17: Distribution of fishing effort by the hake demersal long-line sector in relation to Licence Blocks 3616 & 3717.

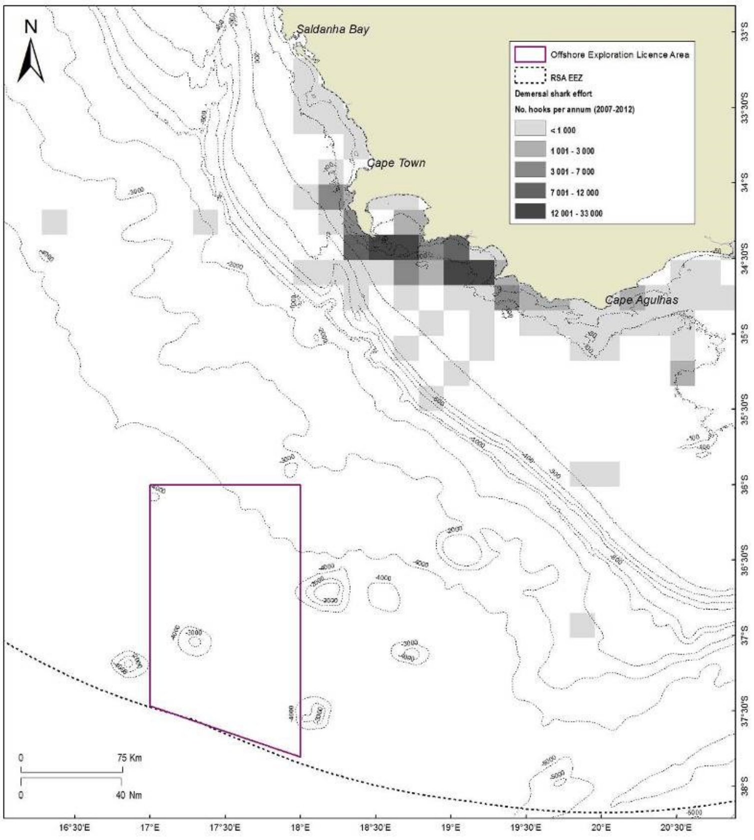

Figure 4.18: Distribution of fishing effort by the shark demersal long-line sector in relation to Licence Blocks 3616 & 3717.

(c) Large p*elagic long-line fishery*

The pelagic long-line fishery operates extensively off the South-West Coast. This fishery targets yellowfin tuna, bigeye tuna, swordfish and shark species (primarily mako shark). Due to the highly migratory nature of these species, stocks straddle the EEZ of a number of countries and international waters. As such they are managed at an international level through country allocations and global effort control. The TAC for 2013 is set at 10 000 t for tuna (40t for bluefin), 1 001 tons for swordfish and 2 000 tons for sharks.

Fifty foreign and South-African-flagged vessels operate within South African waters. This type of long-line gear targets pelagic species and therefore extends downwards from the sea surface. A drifting long-line consists of a mainline kept near the surface or at a certain depth by means of regularly spaced floats and with relatively long snoods (short sections of monofilament line) with baited hooks, evenly spaced on the mainline (see Figure 4.19). Drifting long-lines are set vertically, each line hanging from a float at the surface. A single main line consists of twisted rope (6 to 8 mm diameter) or a thick nylon monofilament (5 to 7.5 mm diameter). The mainline of a pelagic long-line can be over 100 km long. Droppers with the hook and bait on one end are attached to the main line by clips at intervals of 20 to 30 m. A dropper can be made up of several parts and be up to 45 m long. Buoys are attached to the main line by buoy-lines at intervals to keep the mainline near the surface. Various types of buoys are used in combinations to keep the mainline near the surface and locate it should the line be cut or break for any reason. Each end of the line is marked by a Dahn Buoy and Radar reflector, which marks its position for later retrieval by the fishing vessel. A line may be left drifting for a considerable length of time and is retrieved by means of a powered hauler at a speed of approximately 1 knot. During hauling a vessel's manoeuvrability will be severely restricted and, in the event of an emergency, the line may be dropped to be hauled in at a later stage.

Pelagic long-line effort extend along and offshore of the 500 m bathycontour, whilst pelagic shark species are targeted primarily along the 200 m isobath.

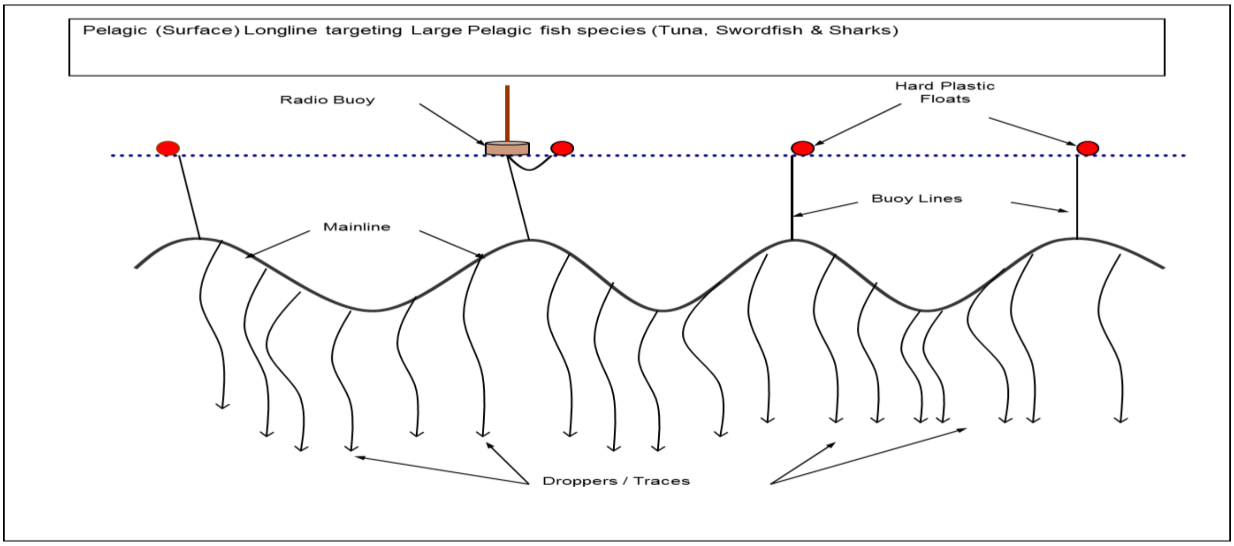

Figure 4.19: Typical Pelagic long-line configuration targeting tuna, swordfish and shark species.

(d) Small pelagic purse seine fishery

The small pelagic purse seine fishery is the largest South African fishery by volume and the second most important in terms of value. The pelagic purse-seine fishery targets small mid-water and surface-shoaling species such as sardine, anchovy, juvenile horse mackerel and round herring.

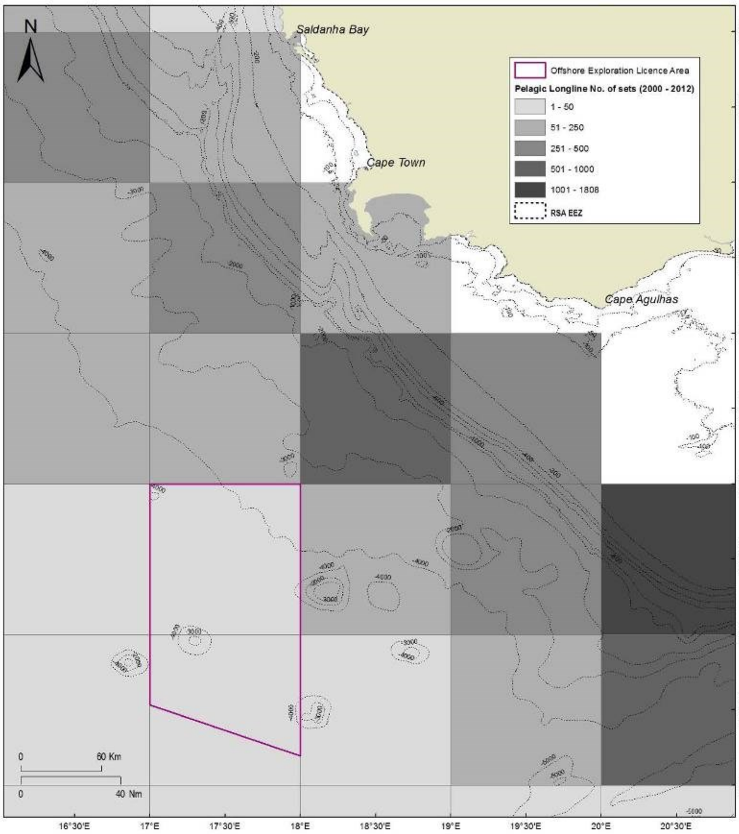

Figure 4.20: Distribution of actual lines set by the large pelagic long-line fishery in relation to Licence Blocks 3616 & 3717.

Once a shoal has been located the vessel steams around it and encircle it with a large net. The depth of the net is usually between 60 m and 90 m. Netting walls surround aggregated fish both from the sides and from underneath, thus preventing them from escaping by diving downwards. These are surface nets framed by lines: a float line on top and lead line at the bottom (see Figure 4.21). Once the shoal has been encircled the net is pursed and hauled in and the fish are pumped onboard into the hold of the vessel. After the net is deployed the vessel has no ability to manoeuvre until the net has been fully recovered onboard and this may take up to 1.5 hours. Therefore, direct communication from the survey vessel would be required to ensure purse-seine vessels stay clear of the survey vessel.

The fishery operates throughout the year with a short break over the Christmas and New Year period. The geographical distribution and intensity of the fishery is largely dependent on the seasonal fluctuation and geographical distribution of the targeted species. Fishing grounds occur primarily along the West and South Coasts up to a distance of 50 nautical miles offshore. There are currently 101 vessels operating within the sector, the majority operating from St Helena Bay, Saldanha Bay and Hout Bay with fewer vessels operating on the South Coast from the harbours of Gansbaai, Mossel Bay and Port Elizabeth.

(e) Tuna pole fishing

The tuna pole fishery is based on migratory species of tuna, predominantly longfin tuna (*Thunnus alalunga*) and yellowfin tuna (*T. albacares*). Tuna pole fishing is conducted by a large fleet of 128 vessels operating mostly from Cape Town, Hout Bay and Saldanha Bay. The fishery lands approximately 3 500 to 5 000 tons of longfin tuna and 400 to 800 tons of yellowfin tuna annually.

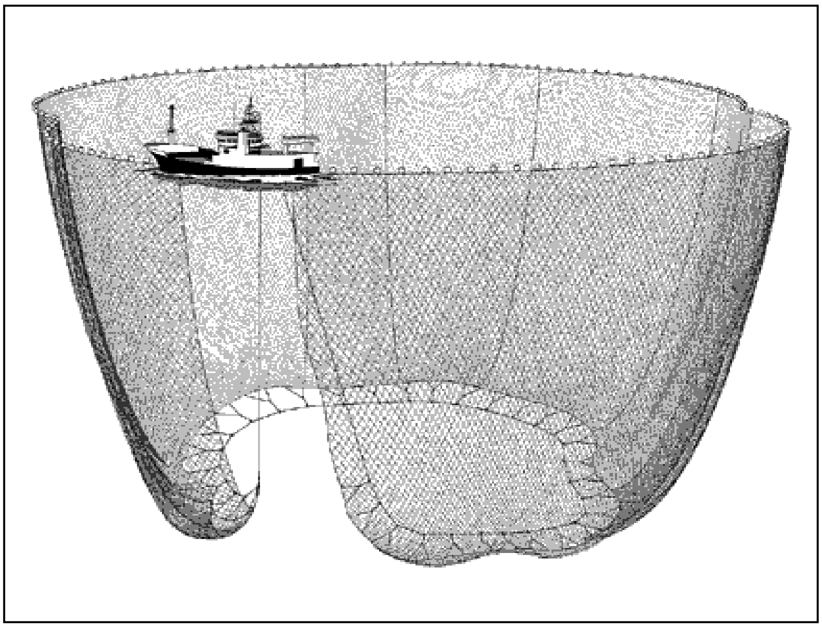

Figure 4.21: Typical gear configuration of a pelagic purse-seine vessel targeting small pelagic species.

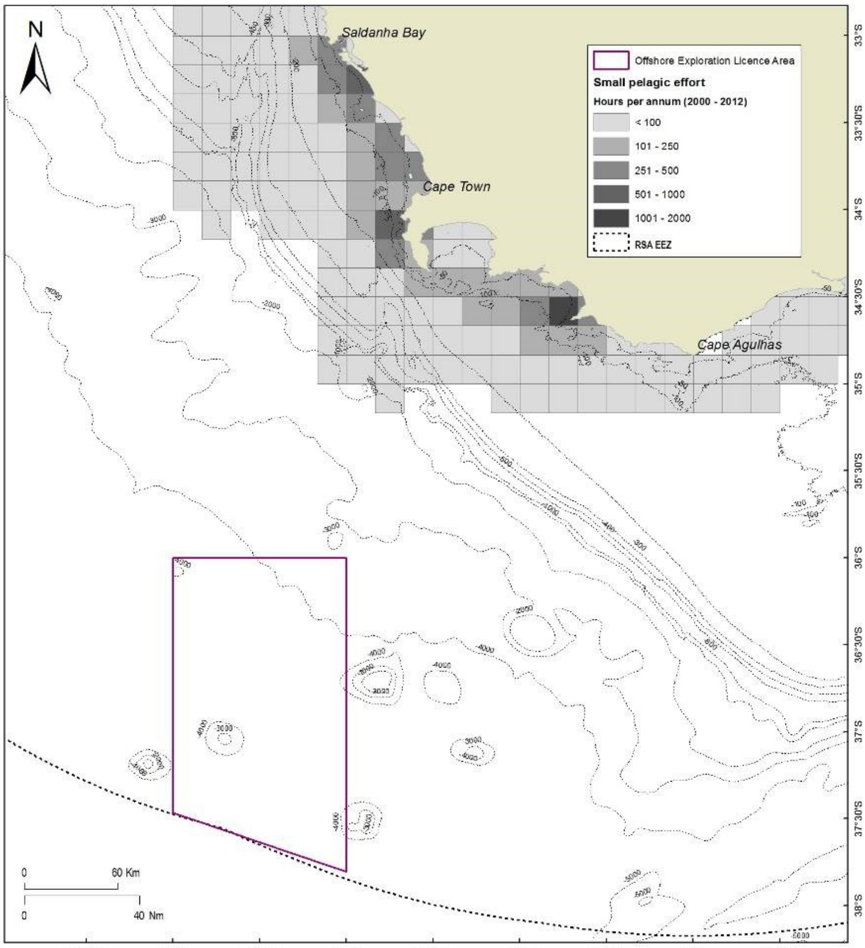

Figure 4.22: Distribution of fishing effort by the small pelagic purse-seine fishery in relation to Licence Blocks 3616 & 3717.

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

Effort on the South-West Coast is directed mainly inshore of the 500 m bathycontour, particularly around Cape Columbine and the Cape Canyon (see Figure 4.23).

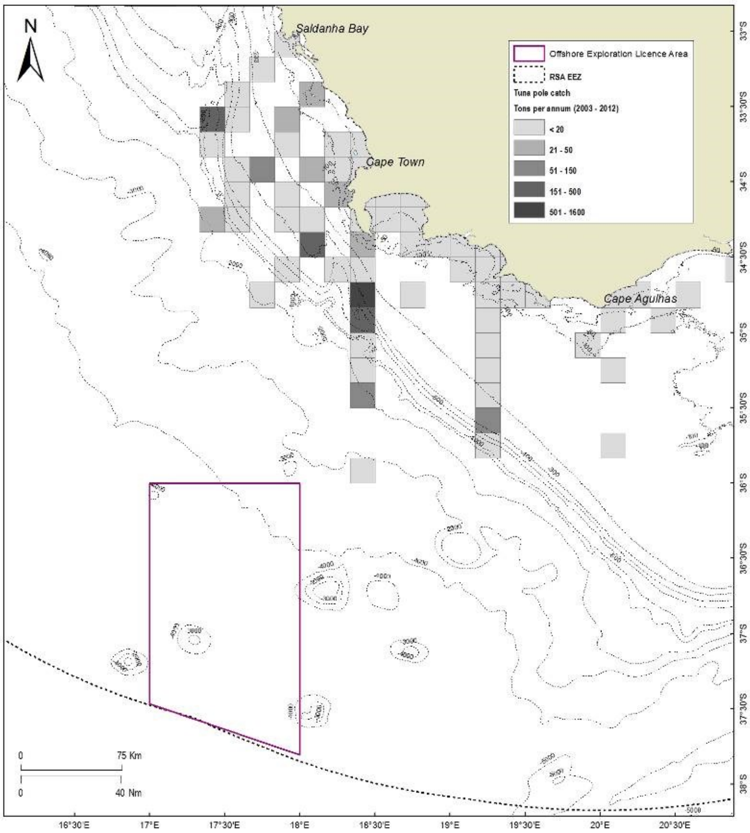

Figure 4.23: Main area of fishing effort in the tuna pole fishery in relation to Licence Blocks 3616 & 3717.

(f) Traditional line fishery

The bulk of the traditional line fishery is based on approximately 35 species of reef fish as well as pelagic and demersal species. Different assemblages of species are targeted according to the region in which they are being fished and include tuna species, sparidae, serranidae, caragidae, scombridae and sciaenidae. On the West Coast the dominant species targeted is snoek (*Thyrsites atun*). This fishery comprises recreational, commercial and subsistence sectors, jointly landing approximately 13 000 tons per annum (over the period 2000 to 2012). Historically, the sector incorporated the tuna pole fishery and was ranked third according to volume of landings and overall economic value. Currently, the volume of fish caught by the traditional line fishery is much lower than many other commercial sectors, but is one of the most important in terms of the number of active participants.

Vessels targeting snoek and other line fish species operate relatively close to the coastline out to a maximum depth of 120 m. Skiboats (recreational permit-holders) and deckboats (commercially operated) targeting tuna species operate in much deeper waters, similar to those frequented by tuna pole vessels, in particular in the area around Cape Columbine to Cape Point (see Figure 4.24).

Gear consists of hand line or rod-and-reel. Line fishers are restricted to a maximum of ten hooks per line but a single fisherman may operate several lines at a time. There are currently about 455 vessels operating extensively around the coast.

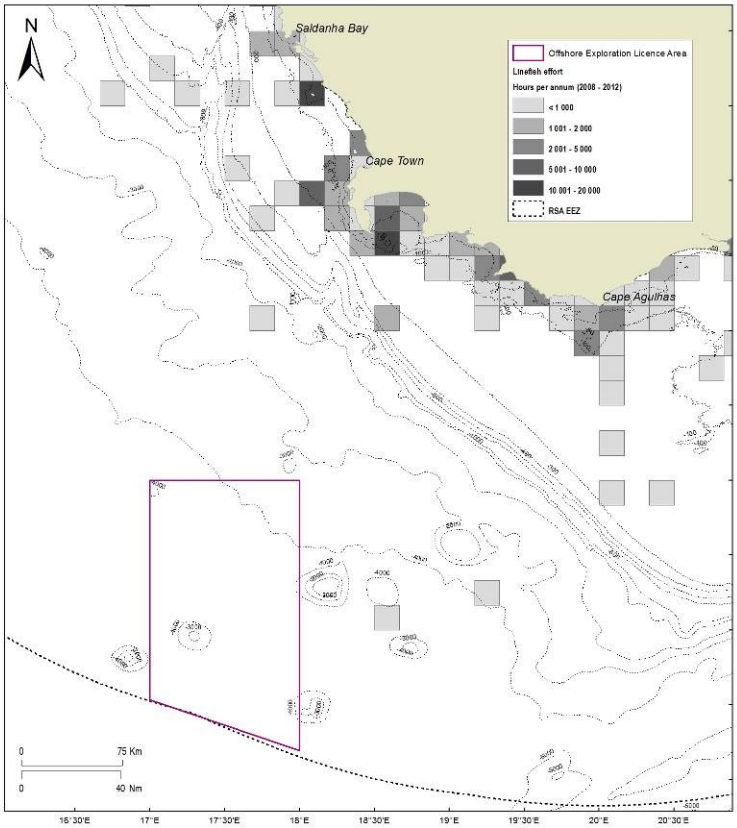

Figure 4.24: Main area of fishing effort in the traditional line fishery in relation to Licence Blocks 3616 & 3717.

(g) West Coast rock lobster fishery

The West Coast rock lobster fishery is considered to be the third most valuable fishery in South Africa. The West Coast Rock Lobster occurs inside the 200 m depth contour along the entire West Coast to East London on the East Coast. The fishery is divided into the offshore fishery and the near-shore fishery, both of which are directed inshore of the 100 m bathycontour (see Figure 4.25). Fishing grounds are divided into zones for management purposes, stretching from the Orange River mouth to east of Cape Hangklip on the East Coast.

The offshore sector operates in a water depth range of 30 m to 100 m whilst the inshore fishery is restricted to depths shallower than 30 m, due to the type of gear used. The offshore sector makes use of traps consisting of rectangular metal frames covered by netting, which are deployed from trap boats (otherwise known as “deck boats”) whilst the inshore fishery makes use of hoopnets deployed from small dingys. The offshore sector set traps at dusk and each vessel can leave up to 30 traps in the fishing grounds overnight during the week.

Effort is seasonal with boats operating from the shore and coastal harbours. Catch is managed using a TAC, which has been set at 2 167 tons for the 2013/14 season. Since effort is directed inshore of the 100 m bathycontour no interaction is expected with the West Coast rock lobster fishery (see Figure 4.25).

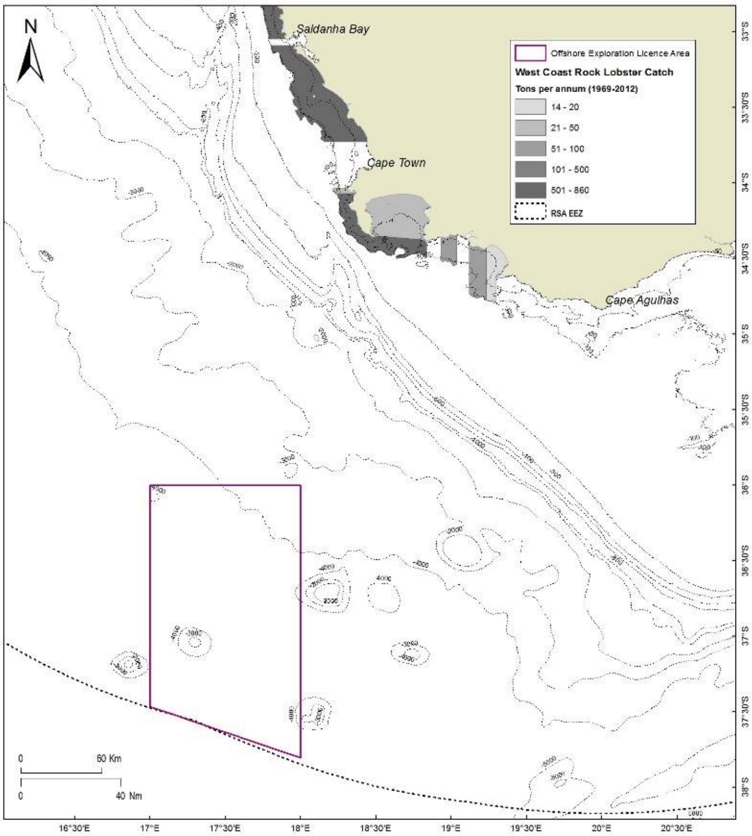

Figure 4.25: Location of Licence Blocks 3616 & 3717 in relation to the West Coast Rock Lobster fishery.

(h) Fisheries research

Surveys of demersal fish resources are carried out in January (West Coast survey) and May (South Coast survey) each year by DAFF in order to set the annual TACs for demersal fisheries. Stratified, bottom trawls are conducted to assess the biomass, abundance and distribution of hake, horse mackerel, squid and other demersal trawl species on the shelf and upper slope of the South African coast. The gear configuration is similar to that of commercial demersal trawlers, however, nets are towed for a shorter duration of generally 30 minutes per tow. Trawl positions are randomly selected to cover specific depth strata that range from the coast to the 1 000 m bathymetric contour (see Figure 4.26), thus inshore of the proposed area of interest. Approximately 120 trawls are conducted during each survey over a period of approximately one month.

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

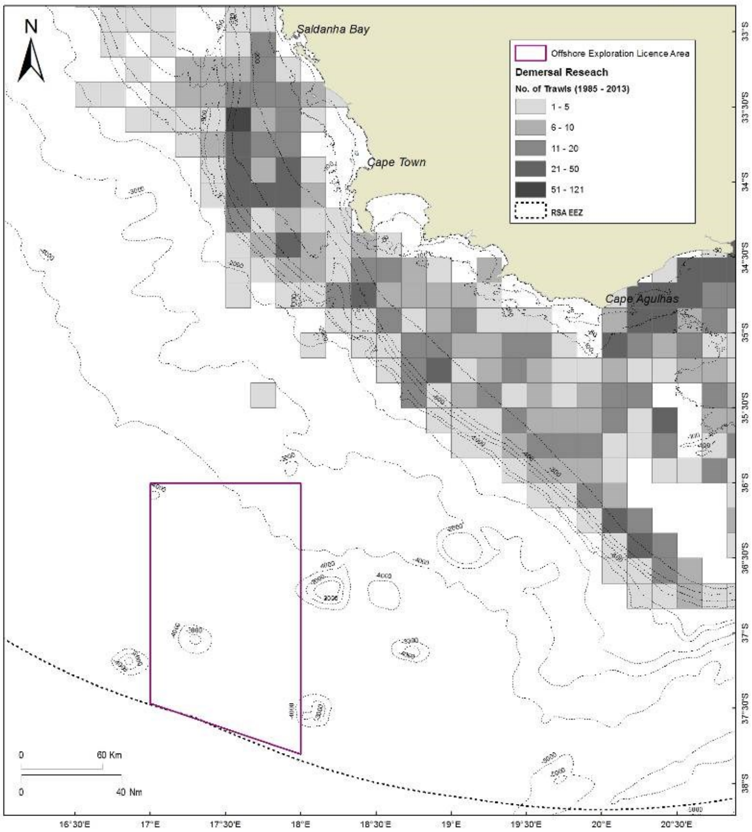

Figure 4.26: The spatial distribution of research trawls conducted between 1985 and 2013 in relation to Licence Blocks 3616 & 3717.

4.1.4.2 Shipping transport

A large number of vessels navigate along the West, South and East coasts on their way around the southern African subcontinent. The majority of shipping traffic is located on the outer edge of the continental shelf (between 12 and 24 nm offshore) (Figure 4.27) with traffic inshore of the continental shelf along the South-West Coast largely comprising fishing vessels.

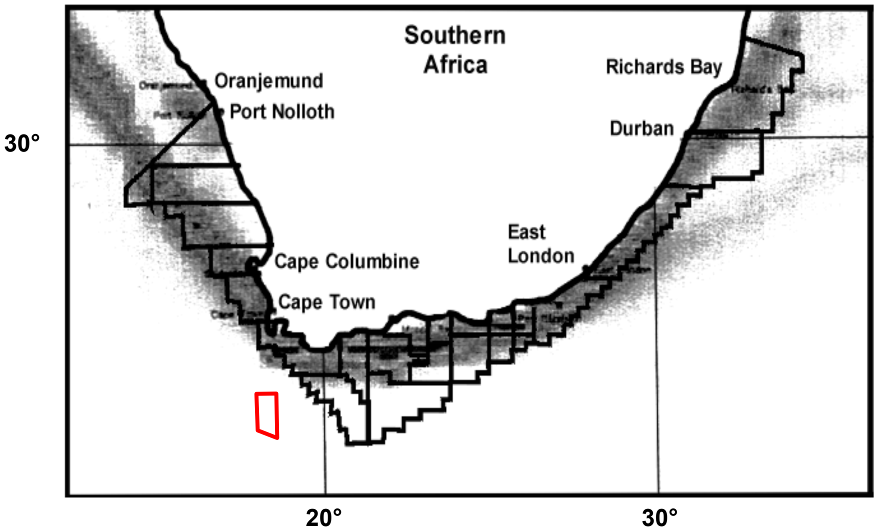

Figure 4.27: The major shipping routes along the west coast of South Africa showing petroleum licence blocks (Data from the South African Centre for Oceanography). Approximate location of Licence Blocks 3616 & 3717 is also shown.

Important harbours along the South-West Coast include Cape Town, Hout Bay, St Helena Bay, Saldanha Bay, Hermanus, Gansbaai, Struis Bay, Arniston and Still Bay.

4.1.4.3 Oil and gas exploration

(a) Exploration

Exploration for oil and gas is currently undertaken in a number of licence blocks off the West, South and East coasts of South Africa (see Figure 4.28).

(b) Production

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

Off the South Coast PetroSA operates the F-A production platform, which was brought into production in 1992. The F-A platform is located 85 kilometres south of Mossel Bay in a water depth of 102 m.

Gas and associated condensate from the associated gas fields (F-A, E-M and South Coast Gas) are processed through the platform. The produced gas and condensate are exported through two separate 93 km pipelines to the PetroSA Gas-to-Liquid (GTL) plant in Mossel Bay.

PetroSA is currently producing oil from the Oryx/Oribi oil fields (E-AR and E-BT fields). These fields are tied back to the ORCA floating production platform. The ORCA lies approximately 130 km south-west of Mossel Bay. The gas and oil are separated on the ORCA and the gas is flared (burned off). The stabilised (degassed) oil is exported through a calm buoy to a shuttle tanker.

PetroSA brought the Sable Oil Field into production in 2003. The Sable Field consists of the E-BD and E-CE reservoirs, which lie 17 km to the west of the Oryx/Oribi Oil Field and 85 km south-west of the F-A Platform. Sable is currently not producing.

A 500 m statutory exclusion zone around any floating production storage and offloading unit and sea structures prohibits entry of all unauthorized vessels and aircraft. Larger safety zones around the E-M, F-A, South Coast Gas and Oryx/Oribi developments, established by the SA Navy Hydrographic Office, prohibit any activities that impact on the seafloor, i.e. anchoring, deploying of trawling gear, etc. to take place in these areas.

4.1.4.4 Prospecting and mining of other minerals

(a) Glauconite and phosphate

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

A number of prospecting areas for glauconite and phosphorite / phosphate are located off the West Coast (see Figure 4.29). Green Flash Trading received their prospecting rights for Areas 251 and 257 in 2012/2013. The prospecting rights for Agrimin1, Agrimin2 and SOM1 have expired (Jan Briers, DMR *pers. comm.*, December 2013).

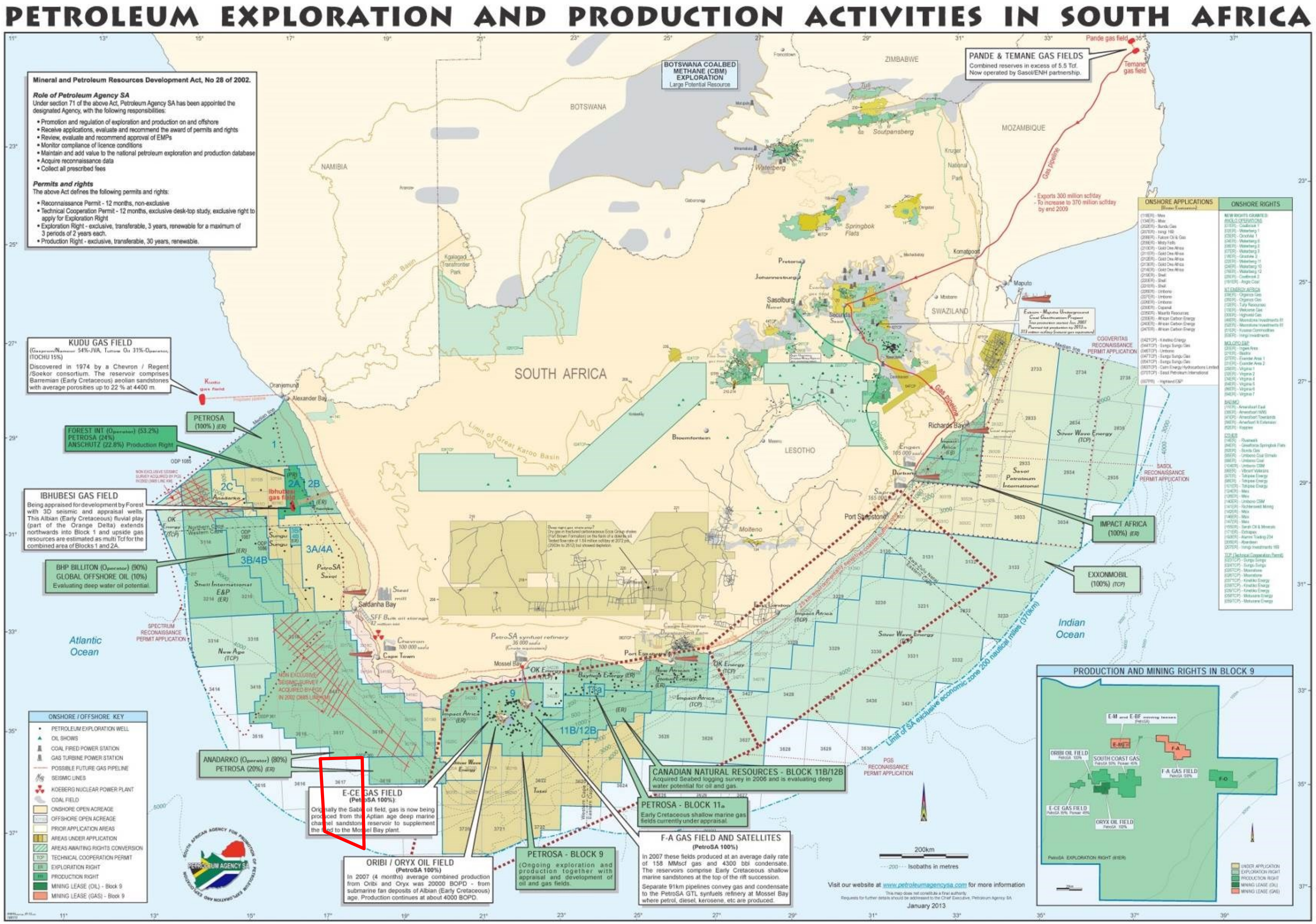

Figure 4.28: Petroleum licence blocks off the West, South and East coasts of South Africa (after PASA, 2015). Licence Blocks 3616 & 3717 are highlighted in red.

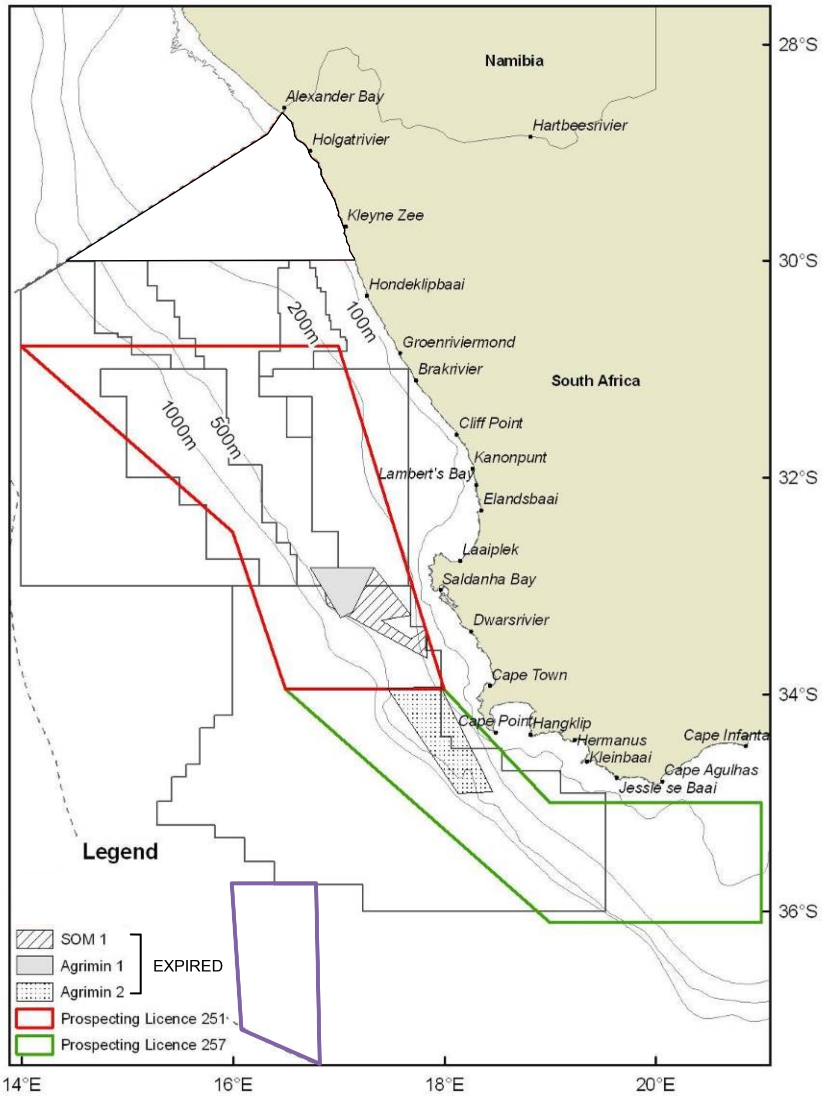

Figure 4.29: Location of glauconite and phosphorite / phosphate prospecting areas in relation to Licence Blocks 3616 & 3717.

(b) Manganese nodules in ultra-deep water

Rogers (1995) and Rogers and Bremner (1991) report that manganese nodules enriched in valuable metals occur in deep water areas (>3 000 m) off the West Coast (see Figure 4.30). 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.

4.1.4.5 Other

(a) Anthropogenic marine hazards

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

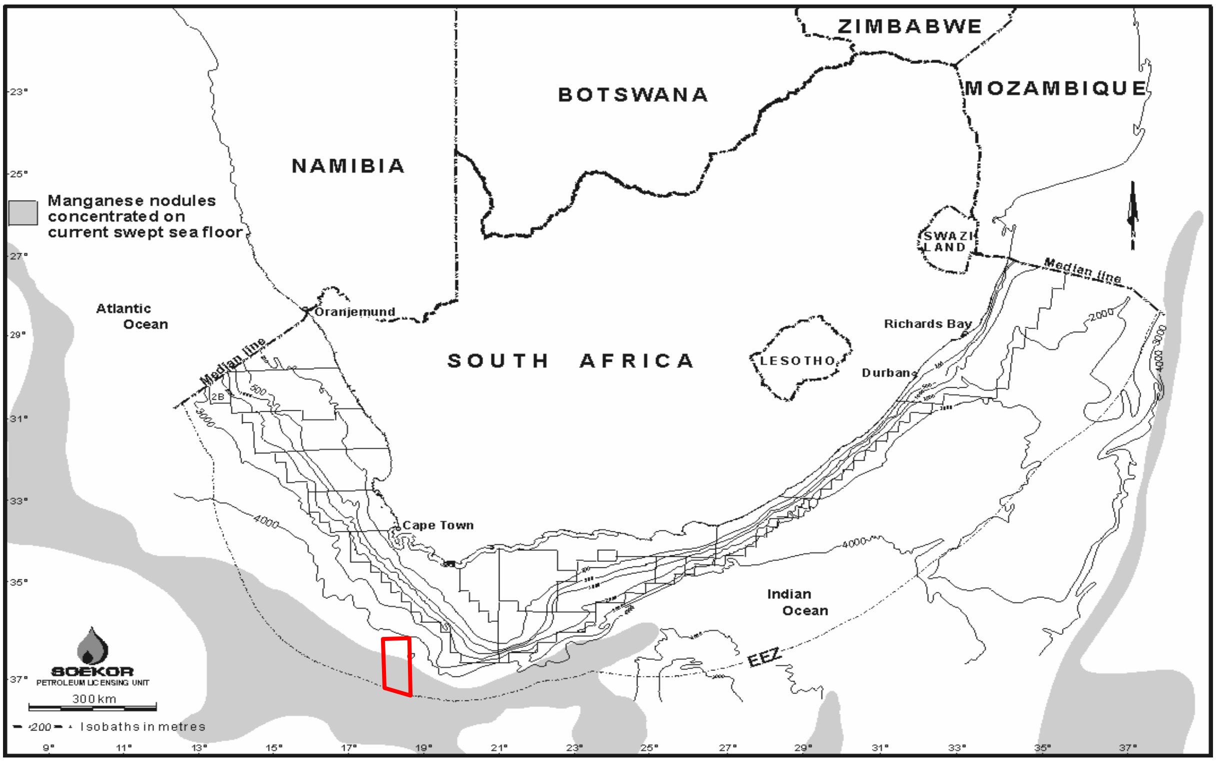

Figure 4.30: Schematic of location of manganese nodules off Southern Africa, showing petroleum licence blocks (Modified from Rogers 1995). Approximate location of Licence Blocks 3616 & 3717 is also indicated.

(b) Undersea cables

There are a number of submarine telecommunications cable systems across the Atlantic and the Indian Ocean (see Figure 4.31), including *inter alia*:

- South Atlantic Telecommunications cable No.3 / West African Submarine Cable / South Africa Far East (SAT3/WASC/SAFE): This cable system is divided into two sub-systems, SAT3/WASC in the Atlantic Ocean and SAFE in the Indian Ocean. The SAT3/WASC sub-system connects Portugal (Sesimbra) with South Africa (Melkbosstrand). From Melkbosstrand the SAT-3/WASC sub-system is extended via the SAFE sub-system to Malaysia (Penang) and has intermediate landing points at Mtunzini South Africa, Saint Paul Reunion, Bale Jacot Mauritius and Cochin India (www.safe-sat3.co.za).
- Eastern Africa Submarine Cable System (EASSy): This is a high bandwidth fibre optic cable system, which connects countries of eastern Africa to the rest of the world. EASSy runs from Mtunzini (off the East Coast) in South Africa to Port Sudan in Sudan, with landing points in nine countries, and connected to at least ten landlocked countries.
- West Africa Cable System (WACS): WACS is 14 530 km in length, linking South Africa (Yzerfontein) and the United Kingdom (London). It has 14 landing points, 12 along the western coast of Africa (including Cape Verde and Canary Islands) and 2 in Europe (Portugal and England) completed on land by a cable termination station in London.
- African Coast to Europe (ACE): The ACE submarine communications cable is a 17 000 km cable system along the West Coast of Africa between France and South Africa (Yzerfontein).

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

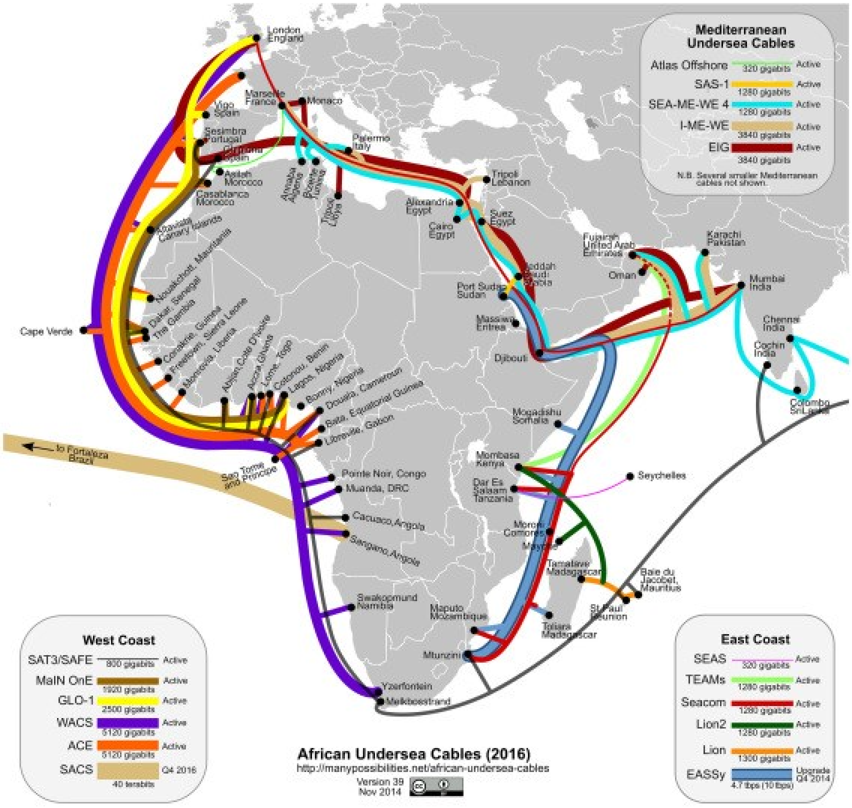

Figure 4.31: Configuration of the current African undersea cable systems, November 2014 (From http://www.manypossibilities.net).

(c) Marine archaeological sites

Over 2 000 shipwrecks are present along the South African coastline. The majority of known wrecks along the South-West Coast are located in relatively shallow water close inshore (within the 100 m isobath). Wrecks older than 50 years old have National Monument status. According to the South African Heritage Resources Agency (SAHRA) there are between 45 and 50 shipwrecks located around Robben Island, approximately 20 shipwrecks between Cape Town and Milnerton and approximately 20 shipwrecks between Milnerton and Saldanha Bay.

(d) Ammunition dump sites

Ammunition and explosive dumpsites off the South-West Coast are presented on SAN Chart 56. There are four disused explosives dumping grounds, none of which occur within Licence Blocks 3616 & 3717 (see Figure 4.32), and one active ammunition dumping ground.

(e) Conservation areas and Marine Protected Areas

Numerous conservation areas and a Marine Protected Area (MPA) exist along the coastline of the South-Western Cape, however Licence Blocks 3616 & 3717 do not overlap with any of these (see Figure 4.33). A systematic biodiversity plan has been developed for the West Coast (Majiedt et al. 2013) with the objective of identifying both coastal and offshore priority areas for MPA expansion. To this end, nine focus areas have been identified for protection on the West Coast between Cape Agulhas and the South African – Namibian border. These focus areas have been carried forward through Operation Phakisa for the proposed development of offshore MPAs. Those within the broad project area are shown in Figure 4.33. The eastern border of the exploration licence area falls within the proposed Southeast Atlantic Seamounts MPA.

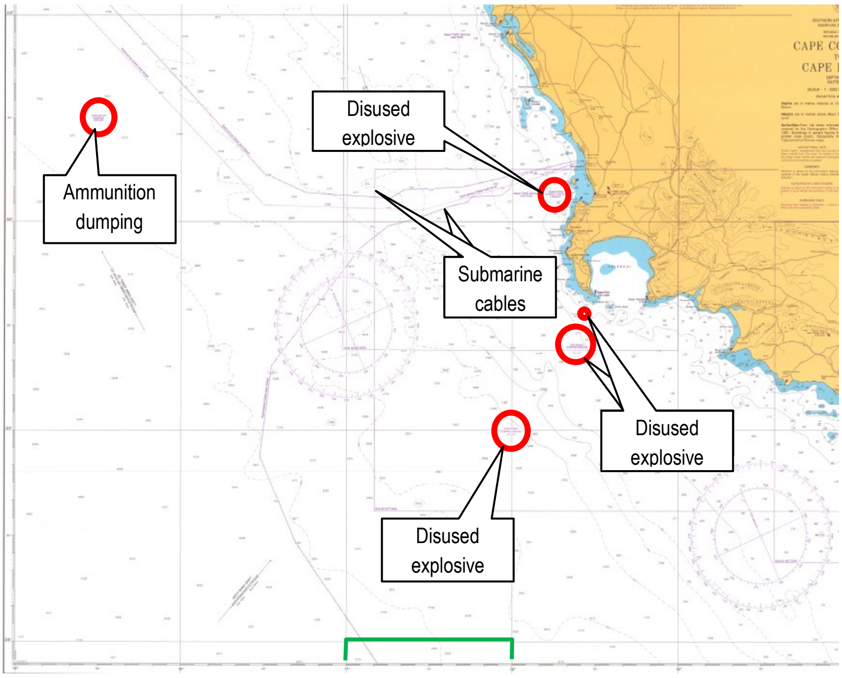

Figure 4.32: The location of Licence Blocks 3617 and 3717 (shown in green) in relation to ammunition and explosive dumping grounds and subsea cable off the West Coast (from SAN Chart 56).

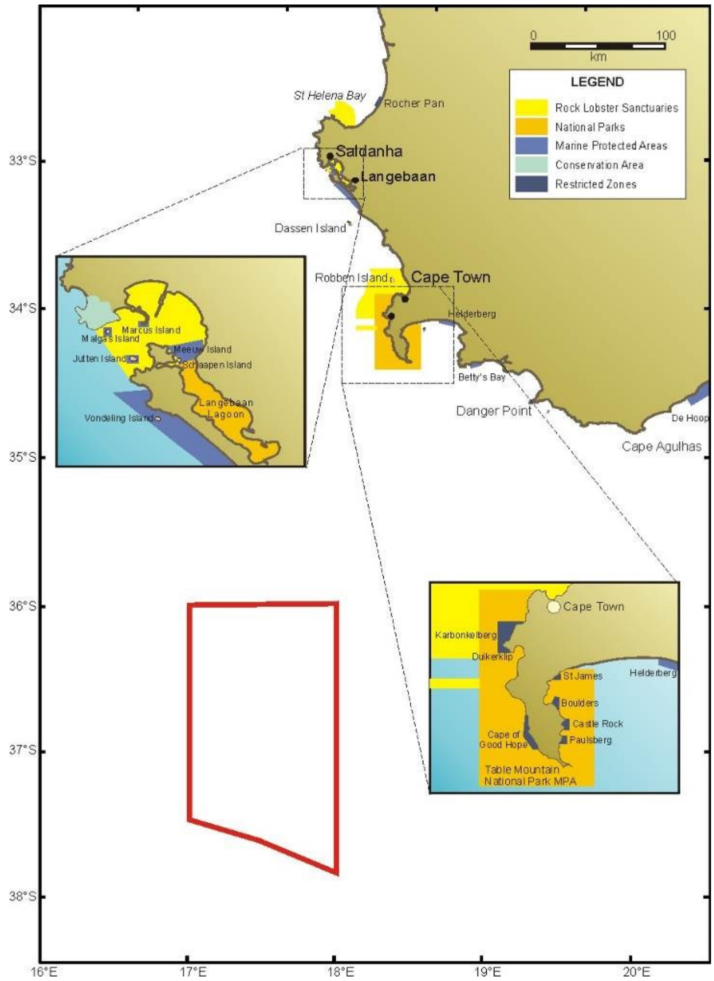

Figure 4.33: Reserves and Marine Protected Areas on the South-West Coast in relation to Licence Blocks 3616 and 3717.