

4. THE AFFECTED ENVIRONMENT

This chapter provides a description of the biophysical and socio-economic environment likely to be affected by the proposed project in the study area. The information provided here is based on previous information compiled for the area (CCA Environmental 2007a; CCA Environmental 2007b; CCA Environmental 2011; and Pisces Environmental Services, 2013), as well as the specialist marine fauna, fisheries and marine heritage studies undertaken as part of this study.

4.1 MARINE ENVIRONMENT

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

The study area lies within the southern zone of the Benguela Current region and is characterised by the cool Benguela upwelling system (Shillington 1998; Shannon 1985). A conceptual model of the Benguela system is shown in Figure 4.1.

4.1.1 METEOROLOGY

The meteorological processes of the South African 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 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).

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

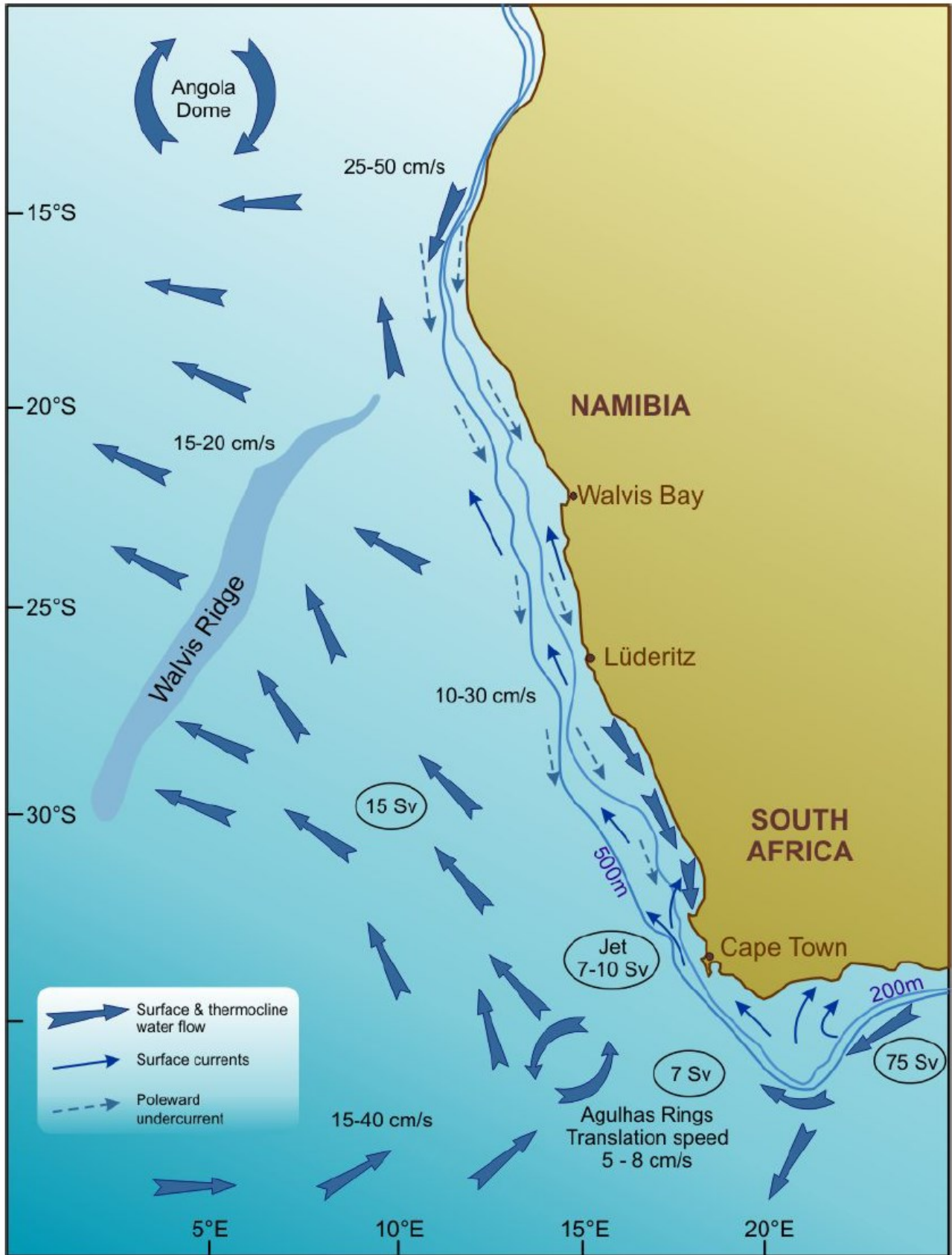


Figure 4-1: Circulation and volume flows of the Benguela current (after Shannon & Nelson, 1996)

4.1.2 PHYSICAL OCEANOGRAPHY

4.1.2.1 Waves

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

The wave regime along the southern African west coast shows only moderate seasonal variation in direction, with virtually all swells throughout the year coming from the south-west - south direction. Winter swells are strongly dominated by those from the south-west – south-south-west 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.

4.1.2.2 Tides

Tides along the West Coast are subject to a simple semi-diurnal tidal regime with a mean tidal range along the Namaqualand coast 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 Topography

The continental shelf along the West Coast is generally wide and deep, although large variations in both depth and width occur. The shelf maintains a general north-north-west trend, widening north of Cape Columbine and reaching its widest off the Orange River (180 km). Between Cape Columbine and the Orange River, there is usually a double shelf break, with the distinct inner and outer slopes, separated by a gently sloping ledge, the middle shelf. The immediate nearshore area consists mainly of a narrow (about 8 km wide) rugged rocky zone, sloping steeply seawards to a depth of around 80 m. The middle and outer shelf typically lacks relief, sloping gently seawards before reaching the shelf break at a depth of approximately 300 m.

Banks on the continental shelf include the Orange River pro-delta, a shallow (160 - 190 m) zone that reaches maximal widths (180 km) offshore of the Orange River, and Child's Bank, situated approximately 150 km offshore at about 31°S. Tripp Seamount is a geological feature to the west of the western extent of Concession 5C (Figure 4-2), which rises from approximately 1 000 m to a depth of 150 m.

4.1.2.4 Coastal and Continental Shelf Geology and Seabed Geomorphology

The inner shelf is underlain by Precambrian bedrock (also referred to as Pre-Mesozoic basement), whilst the middle and outer shelf areas are composed of Cretaceous and Tertiary sediments (Dingle 1973; Birch et al. 1976; Rogers 1977; Rogers & Bremner 1991). As a result of erosion on the continental shelf, the unconsolidated surface sediment cover is generally thin, often less than 1 m. Sediments are finer seawards, changing from sand on the inner and middle 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 (Figure 4-3).

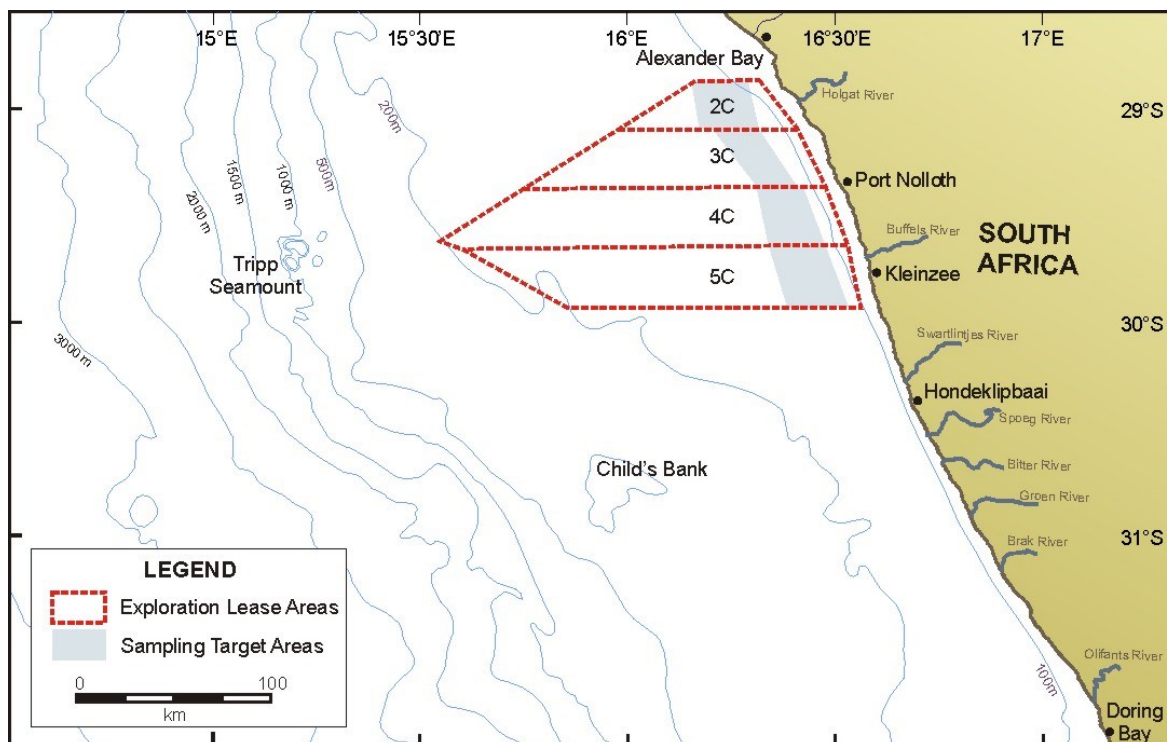


Figure 4-2: Sampling target area within the concession areas in relation to the regional bathymetry and showing proximity of prominent seabed features

An approximately 500 km long mud belt (up to 40 km wide, and of 15 m average thickness) is situated at water depths of between -30m and -100m over the innershelf slope between the Orange River and St Helena Bay (Birch et al. 1976). Further offshore, sediment is dominated by muddy sands, sandy muds, mud and some sand. The continental slope, seaward of the shelf break, has a smooth seafloor, underlain by calcareous ooze.

Present day sedimentation is limited to input mainly from the Orange River and minor contributions from other rivers like the Buffels and the Olifants Rivers. As the coarser sand and gravel sediment fractions are generally transported northward, most of the sediment containing the diamond mineralisation in the project area is considered to be relict deposits by now ephemeral rivers active during wetter climates in the past. The Orange River, when in flood, still contributes largely to the mud belt as suspended sediment is carried southward by poleward flow. In this context, the absence of large sediment bodies on the inner shelf reflects on the paucity of terrigenous sediment being introduced by the few rivers that presently drain the South African West Coast coastal plain and hinterland.

4.1.2.5 Upwelling and Plankton Production

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

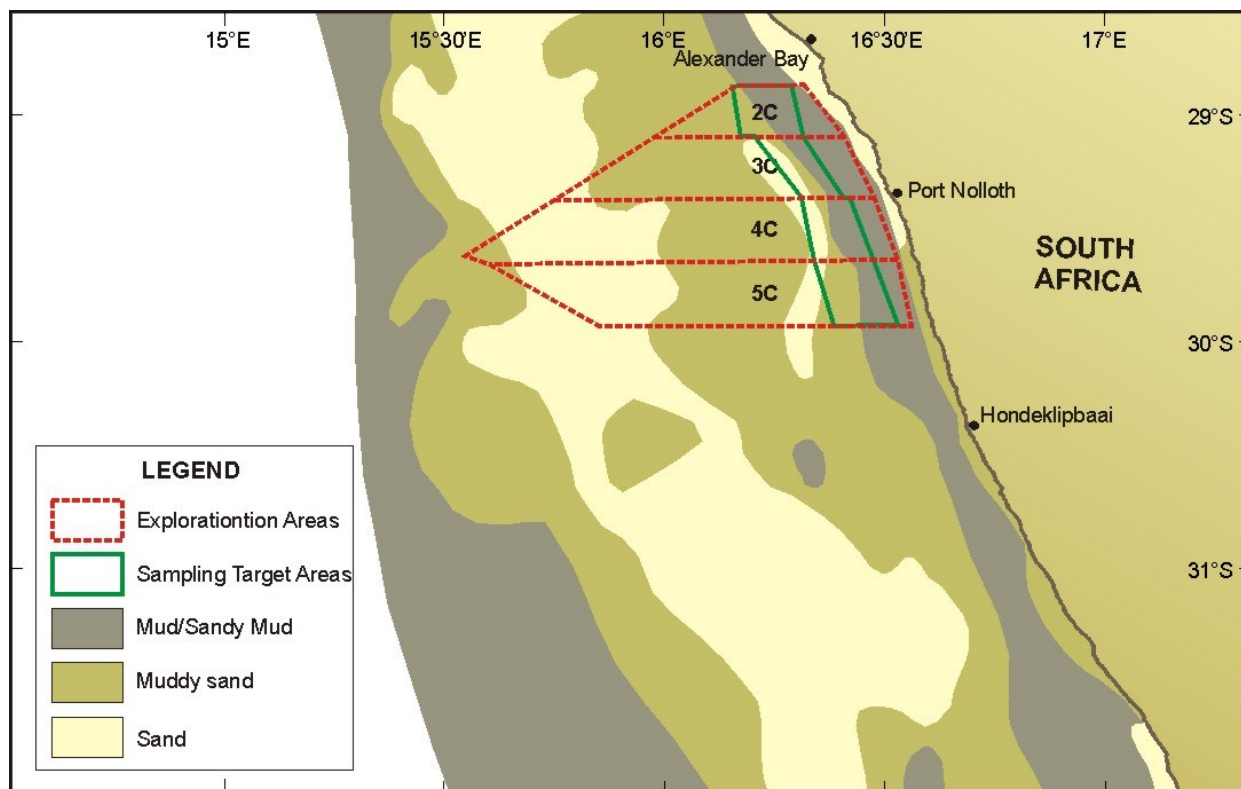


Figure 4-3: Concession areas and sediment sampling target areas in relation to sediment distribution on the continental shelf (Adapted from Rogers 1977).

4.1.2.6 Organic Inputs

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

Balanced multispecies ecosystem models have estimated that the Benguela region supported biomasses of 76.9 tons/km² of phytoplankton and 31.5 tons/km² of zooplankton alone (Shannon et al. 2003). Thirty-six percent of the phytoplankton and 5% of the zooplankton are estimated to be lost to the seabed annually. This natural annual input of millions of tons of organic material onto the seabed has a substantial effect on the ecosystems of the Benguela region. It provides most of the food requirements of the particulate and filter-feeding benthic communities that inhabit the sandy-muds of this area, and results in the high organic content of the muds in the region. As most of the organic detritus is not directly consumed, it enters the seabed decomposition cycle, resulting in subsequent depletion of oxygen in deeper waters.

An associated phenomenon ubiquitous to the Benguela system are red tides (dinoflagellate and/or ciliate blooms) (see Shannon & Pillar 1985; Pitcher 1998). Also referred to as Harmful Algal Blooms (HABs), these red tides can reach very large proportions, extending over several square kilometres of ocean. Toxic dinoflagellate species can cause extensive mortalities of fish and shellfish through direct poisoning, while degradation of organic-rich material derived from both toxic and non-toxic blooms results in oxygen depletion of subsurface water.

4.1.2.7 Low Oxygen Events

The continental shelf waters of the Benguela system are characterised by low oxygen concentrations with less than 40% saturation occurring frequently (e.g. Visser 1969; Bailey et al. 1985). The low oxygen concentrations are attributed to nutrient remineralisation in the bottom waters of the system (Chapman & Shannon 1985). The absolute rate of this is dependent upon the net organic material build-up in the sediments, with the carbon rich mud deposits playing an important role. As the mud on the shelf is distributed in discrete patches (see Figure 4-3), there are corresponding preferential areas for the formation of oxygen-poor water. The two main areas of low-oxygen water formation in the southern Benguela region are in the Orange River Bight and St Helena Bay (Chapman & Shannon 1985; Bailey 1991; Shannon & O'Toole 1998; Bailey 1999; Fossing et al. 2000).

The spatial distribution of oxygen-poor water in each of the areas is subject to short- and medium-term variability in the volume of hypoxic water that develops. De Decker (1970) showed that the occurrence of low oxygen water off Lambert's Bay is seasonal, with highest development in summer/autumn. Bailey & Chapman (1991), on the other hand, demonstrated that in the St Helena Bay area daily variability exists as a result of downward flux of oxygen through thermoclines and short-term variations in upwelling intensity. Subsequent upwelling processes can move this low-oxygen water up onto the inner shelf, and into nearshore waters, often with devastating effects on marine communities.

Periodic low oxygen events in the nearshore region can have catastrophic effects on the marine communities leading to large-scale stranding of rock lobsters, and mass mortalities of marine biota and fish (Newman & Pollock 1974; Matthews & Pitcher 1996; Pitcher 1998; Cockcroft et al. 2000) (see Figure 10, right). 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. The blooms develop over a period of unusually calm wind conditions when sea surface temperatures were high. 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.

4.1.2.8 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. Seasonal microphyte production associated with upwelling events will play an important role in determining the concentrations of POM in coastal waters. PIM, on the other hand, is primarily of geological origin consisting of fine sands, silts and clays. Off Namaqualand, the PIM loading in nearshore waters is strongly related to natural inputs from the Orange River or from 'berg' wind events. 'Berg' wind events can potentially contribute the same order of magnitude of sediment input as the annual estimated input of total sediment by the Orange River (Shannon & Anderson 1982; Zoutendyk 1992, 1995; 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. During storm events, concentrations near the seabed may even reach up to 10,000 mg/l (Miller & Sternberg 1988). In the vicinity of the Orange River mouth, where river outflow strongly influences the turbidity of coastal waters, measured concentrations ranged from 14.3 mg/l at Alexander Bay just south of the mouth (Zoutendyk 1995) to peak values of 7,400 mg/l immediately upstream of the river mouth during the 1988 Orange River flood (Bremner et al. 1990).

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

Superimposed on the suspended fine fraction, is the northward littoral drift of coarser bedload sediments, parallel to the coastline. This northward, nearshore transport is generated by the predominantly south-westerly swell and wind-induced waves. 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 typical of those depths, and re-suspension and shoreward movement of these by wave-induced currents occur primarily under storm conditions (see also Drake et al. 1985; Ward 1985; De Decker 1986). Data from a Waverider buoy at Port Nolloth have indicated that 2 m waves are capable of re-suspending medium sands (200 µm diameter) at approximately 10 m depth, whilst 6 m waves achieve this at approximately 42 m depth. Low-amplitude, long-period waves will, however, penetrate even deeper. Most of the sediment shallower than 90 m can therefore be subject to re-suspension and transport by heavy swells (Lane & Carter 1999).

Mean sediment deposition is naturally higher near the seafloor due to constant re-suspension of coarse and fine PIM by tides and wind-induced waves. Aggregation or flocculation of small particles into larger aggregates occurs as a result of cohesive properties of some fine sediments in saline waters. The combination of re-suspension of seabed sediments by heavy swells, and the faster settling rates of larger inorganic particles, typically causes higher sediment concentrations near the seabed. Significant re-suspension of sediments can also occur up into the water column under stronger wave conditions associated with high tides and storms. Re-suspension can result in dramatic increases in PIM concentrations within a few hours (Sheng et al. 1994). Wind speed and direction have also been found to influence the amount of material re-suspended (Ward 1985).

Although natural turbidity of seawater is a global phenomenon, there has been a worldwide increase of water turbidity and sediment load in coastal areas as a consequence of anthropogenic activities. These include dredging associated with the construction of harbours and coastal installations, beach replenishment, accelerated runoff of eroded soils as a result of deforestation or poor agricultural practices, discharges from terrestrial, coastal and marine mining operations (Airoldi 2003), and sediment plumes as a result of bottom trawling fishery activities. Such increase of sediment loads has been recognised as a major threat to marine biodiversity at a global scale (UNEP 1995).

4.1.3 BIOLOGICAL OCEANOGRAPHY

Biogeographically, concession areas 2C-5C fall into the cold temperate Namaqua Bioregion, which extend from Sylvia Hill, north of Lüderitz in Namibia to Cape Columbine (Emanuel et al. 1992; Lombard et al. 2004) (Figure 4-4). The coastal, wind-induced upwelling characterising the western Cape coastline, is the principle physical process which shapes the marine ecology of the southern Benguela region. The Benguela system is characterised by the presence of cold surface water, high biological productivity, and highly variable physical, chemical and biological conditions. The West Coast is, however, characterized by low marine species richness and low endemism (Awad et al. 2002).

Communities within marine habitats are largely ubiquitous throughout the southern African West Coast region, being particular only to substrate type or depth zone. These biological communities consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales). The majority of the proposed survey area is located beyond the 50 m depth contour. The near- and offshore marine ecosystems comprise a limited range of habitats, namely unconsolidated seabed sediments, deep water reefs and the water column. The biological communities 'typical' of these habitats are described briefly below, focussing both on dominant, commercially important and conspicuous species, as well as potentially threatened or sensitive species, which may be affected by the proposed prospecting activities.

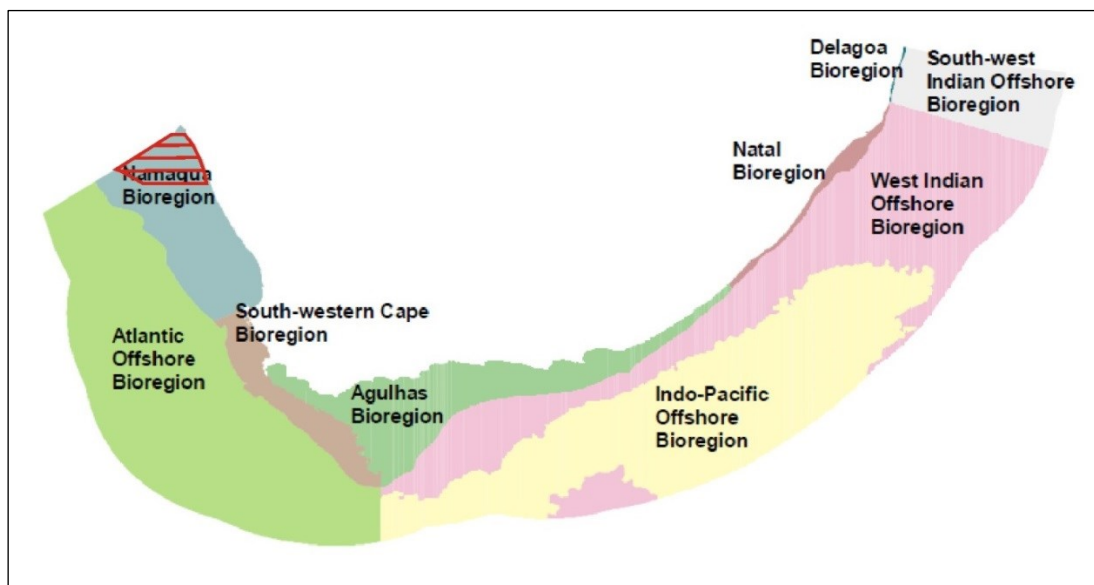


Figure 4-4: Concessions 2C-5C (red polygons) in relation to the South African inshore and offshore bioregions (adapted from Lombard et al. 2004).

4.1.3.1 Demersal Communities

4.1.3.1.1 Nearshore and Offshore unconsolidated habitats

The benthic biota of unconsolidated marine sediments constitute invertebrates that live on (epifauna) or burrow within (infauna) the sediments, and are generally divided into macrofauna (animals >1 mm) and meiofauna (<1 mm).

Concession areas 2C-5C include three macro-infauna communities on the inner- (i.e. 0-30 m depth) and midshelf (i.e. 30-150 m depth, Karenzi unpublished data). The inner-shelf community, which is affected by wave action, is characterised by various mobile predators (e.g. the gastropod *Bullia laevissima* and polychaete *Nereis* sp.), sedentary polychaetes and isopods. The mid-shelf community inhabits the

mudbelt and is characterised by the mud prawns *Callinassa* sp. and *Calocaris barnardi*. A second mid-shelf sandy community occurring in sandy sediments, is characterised by various polychaetes including deposit-feeding *Spiophanes soederstromi* and *Paraprionospio pinnata*.

Polychaetes, crustaceans and molluscs make up the largest proportion of individuals, biomass and species on the West Coast. The distribution of species within these communities are inherently patchy reflecting the high natural spatial and temporal variability associated with macro-infauna of unconsolidated sediments (e.g. Kenny et al. 1998; Kendall & Widdicombe 1999; van Dalssen et al. 2000; Zajac et al. 2000; Parry et al. 2003), with evidence of mass mortalities and substantial recruitments recorded on the South African West Coast (Steffani & Pulfrich 2004). Given the state of our current knowledge of South African macro-infauna it is not possible to determine the threat status or endemism of macro-infauna species on the West Coast, although such research is currently underway (pers. comm. Ms N. Karenyi, SANBI and NMMU). However, the marine component of the 2011 National Biodiversity Assessment (Sink et al. 2012), rated portions of the outer continental shelf on the West Coast as 'vulnerable' and 'critically endangered'. None of these, however, fall within concession areas 2C-5C.

Generally species richness increases from the inner shelf across the mid shelf and is influenced by sediment type (Karenyi unpublished data). The highest total abundance and species diversity was measured in sandy sediments of the mid-shelf. Biomass is highest in the inshore ($\pm 50 \text{ g/m}^2$ wet weight) and decreases across the mid-shelf averaging around 30 g/m^2 wet weight. This is contrary to Christie (1974) who found that biomass was greatest in the mudbelt at 80 m depth off Lamberts Bay, south of concession areas 2C-5C, where the sediment characteristics and the impact of environmental stressors (such as low oxygen events) are likely to differ from those in the concession areas.

Surveys conducted between 180 m and 480 m depth in the vicinity of concession areas 2C-5C revealed high proportions of hard ground rather than unconsolidated sediment on the outer shelf, although this requires further verification (Karenyi unpublished data). The benthic fauna of the outer shelf and continental slope (beyond approximately 450 m depth) are very poorly known largely due to limited opportunities for sampling as well as the lack of access to Remote Operated Vehicles (ROVs) for visual sampling of hard substrata. To date very few areas of the continental slope off the West Coast have been biologically surveyed.

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

The invertebrate macrofauna are important in the marine benthic environment as they influence major ecological processes (e.g. remineralisation and flux of organic matter deposited on the sea floor, pollutant metabolism, sediment stability) and serve as important food source for commercially valuable fish species

and other higher order consumers. As a result of their comparatively limited mobility and permanence over seasons, these animals provide an indication of historical environmental conditions and provide useful indices with which to measure environmental impacts (Gray 1974; Warwick 1993; Salas et al. 2006).

Also associated with soft-bottom substrates are demersal communities that comprise epifauna and bottom-dwelling vertebrate species, many of which are dependent on the invertebrate benthic macrofauna as a food source. According to Lange (2012) concession areas 2C-5C contained a single epifaunal community between the depths of 100 m and 250 m characterised by the hermit crabs *Sympagurus dimorphus* and *Parapaguris pilosimanus*, the prawn *Funchalia woodwardi* and the sea urchin *Brisaster capensis*. Atkinson (2009) also reported numerous species of urchins and burrowing anemones beyond 300 m depth off the West Coast.

4.1.3.1.2 Deep-water coral communities

There has been increasing interest in deep-water corals in recent years because of their likely sensitivity to disturbance and their long generation times. These benthic filter-feeders generally occur at depths below 150 m with some species being recorded from as deep as 3000 m. Some species form reefs while others are smaller and remain solitary. Corals add structural complexity to otherwise uniform seabed habitats thereby creating areas of high biological diversity (Breeze et al. 1997; MacIlsac et al. 2001). Deep water corals establish themselves below the thermocline where there is a continuous and regular supply of concentrated particulate organic matter, caused by the flow of a relatively strong current over special topographical formations which cause eddies to form. Nutrient seepage from the substratum might also promote a location for settlement (Hovland et al. 2002). In the productive Benguela region, substantial areas on the shelf should thus potentially be capable of supporting rich, cold water, benthic, filter-feeding communities.

Two geological features of note in the vicinity of concession areas 2C-5C are Child's Bank, situated 150 km offshore at 31°S and 75 km due south of the concession areas, and Tripp Seamount situated 250 km offshore at approximately 29°40'S and 70 km due west of the offshore boundaries of concessions 4C and 5C. Child's Bank was described by Dingle et al. (1987) to be a carbonate mound (bioherm). Composed of sediments and the calcareous deposits from an accumulation of carbonate skeletons of sessile organisms (e.g. cold-water coral, foraminifera or marl), such features typically have topographic relief, forming isolated seabed knolls in otherwise low profile homogenous seabed habitats (Kopaska-Merkel & Haywick 2001; Kenyon et al. 2003, Wheeler et al. 2005, Colman et al. 2005). Features such as banks, knolls and seamounts (referred to collectively here as "seamounts"), which protrude into the water column, are subject to, and interact with, the water currents surrounding them. The effects of such seabed features on the surrounding water masses can include the up-welling 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 influences 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. Seamounts provide an important habitat for commercial deepwater fish stocks such as orange roughy, oreos, alfonso and Patagonian toothfish, which aggregate around these features for either spawning or feeding (Koslow 1996).

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).

Enhanced currents, steep slopes and volcanic rocky substrata, in combination with locally generated detritus, favour the development of suspension feeders in the benthic communities characterising seamounts (Rogers 1994). 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 (reviewed in Rogers 2004). There is also associated mobile benthic fauna that includes echinoderms (sea urchins and sea cucumbers) and crustaceans (crabs and lobsters) (reviewed by Rogers 1994; Kenyon et al. 2003). Some of the smaller cnidarians species remain solitary while others form reefs thereby adding structural complexity to otherwise uniform seabed habitats. The coral frameworks offer refugia for a great variety of invertebrates and fish (including commercially important species) within, or in association with, the living and dead coral framework thereby creating spatially fragmented areas of high biological diversity.

Compared to the surrounding deep-sea environment, seamounts typically form biological hotspots with a distinct, abundant and diverse fauna, many species of which remain unidentified. Consequently, the fauna of seamounts is usually highly unique and may have a limited distribution restricted to a single geographic region, a seamount chain or even a single seamount location (Rogers et al. 2008). Levels of endemism on seamounts are also relatively high compared to the deep sea. As a result of conservative life histories (i.e. very slow growing, slow to mature, high longevity, low levels of recruitment) and sensitivity to changes in environmental conditions, such biological communities have been identified as Vulnerable Marine Ecosystems (VMEs). They are recognised as being particularly sensitive to anthropogenic disturbance (primarily deep-water trawl fisheries and mining), and once damaged are very slow to recover, or may never recover (FAO 2008).

It is not always the case that seamount habitats are VMEs, as some seamounts may not host communities of fragile animals or be associated with high levels of endemism. South Africa's seamounts and their associated benthic communities have not been extensively sampled by either geologists or biologists (Sink & Samaai 2009). Deep water corals are known from Child's Bank as well as the iBhubezi Reef to the south-east of Child's Bank. Furthermore, evidence from video footage taken on hard-substrate habitats in 100 - 120 m depth off southern Namibia (De Beers Marine, unpublished data) suggest that vulnerable communities including gorgonians, octocorals and reef-building sponges do occur on the continental shelf, and similar communities may thus be expected in concession areas 2C-5C.

Sediment samples collected at the base of Norwegian cold-water coral reefs revealed high interstitial concentrations of light hydrocarbons (methane, propane, ethane and higher hydrocarbons C4+) (Hovland & Thomsen 1997), which are typically considered indicative of localised light hydrocarbon micro-seepage through the seabed. Bacteria and other micro-organisms thrive on such hydrocarbon pore-water seepages, thereby providing suspension-feeders, including corals and gorgonians, with a substantial nutrient source. Some scientists believe there is a strong correlation between the occurrence of deep-water coral reefs and the relatively high values of light hydrocarbons (methane, ethane, propane and n-butane) in near-surface sediments (Hovland et al. 1998; Duncan & Roberts 2001; Hall-Spencer et al. 2002; Roberts & Gage 2003).

4.1.3.1.3 Demersal Fish Species

Demersal fish are those species that live and feed on or near the seabed. 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 & Gordoia 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 *M. capensis*, and includes jacobever *Helicolenus dactylopterus*, Izak catshark *Holohalaelurus regain*, soupfin shark *Galeorhinus galeus* and whitespotted houndshark *Mustelus palumbes*. The more diverse deeper water community is dominated by the deepwater hake *Merluccius paradoxus*, monkfish *Lophius vomerinus*, kingklip *Genypterus capensis*, bronze whiptail *Lucigadus ori* and hairy conger *Bassanago albescens* and various squalid shark species. There is some degree of species overlap between the depth zones.

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

The diversity and distribution of demersal cartilaginous fishes on the West Coast is discussed by Compagno et al. (1991). The species likely to occur in the licence area, and their approximate depth range, are listed in Table 1.

Table 4-1: Demersal cartilaginous species found on the continental shelf along the West Coast, with approximate depth range at which the species occurs (Compagno et al. 1991).

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

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

4.1.3.2 Pelagic Communities

In contrast to demersal and benthic biota that are associated with the seabed, pelagic species live and feed in the open water column. The pelagic communities are typically divided into plankton and fish, and their main predators, marine mammals (seals, dolphins and whales), seabirds and turtles.

4.1.3.2.1 Plankton

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

Phytoplankton are the principle primary producers with mean productivity ranging from 2.5 - 3.5 g C/m²/day for the midshelf region and decreasing to 1 g C/m²/day inshore of 130 m (Shannon & Field 1985; Mitchell-Innes & Walker 1991; Walker & Peterson 1991). The phytoplankton is dominated by large-celled organisms, which are adapted to the turbulent sea conditions. The most common diatom genera

are *Chaetoceros*, *Nitzschia*, *Thalassiosira*, *Skeletonema*, *Rhizosolenia*, *Coscinodiscus* and *Asterionella* (Shannon & Pillar 1985). Diatom blooms occur after upwelling events, whereas dinoflagellates (e.g. *Prorocentrum*, *Ceratium* and *Peridinium*) are more common in blooms that occur during quiescent periods, since they can grow rapidly at low nutrient concentrations. In the surf zone, diatoms and dinoflagellates are nearly equally important members of the phytoplankton, and some silicoflagellates are also present.

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

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

The macrozooplankton ($\geq 1600 \mu\text{m}$) are dominated by euphausiids of which 18 species occur in the area. The dominant species occurring in the nearshore are *Euphausia lucens* and *Nyctiphanes capensis*, although neither species appears to survive well in waters seaward of oceanic fronts over the continental shelf (Pillar et al. 1991). Standing stock estimates of mesozooplankton for the southern Benguela area range from 0.2 - 2.0 g C/m², with maximum values recorded during upwelling periods. Macrozooplankton biomass ranges from 0.1-1.0 g C/m², with production increasing north of Cape Columbine (Pillar 1986). Although it shows no appreciable onshore-offshore gradients, standing stock is highest over the shelf, with accumulation of some mobile zooplanktors (euphausiids) known to occur at oceanographic fronts. Beyond the continental slope biomass decreases markedly.

Zooplankton biomass varies with phytoplankton abundance and, accordingly, seasonal minima will exist during non-upwelling periods when primary production is lower (Brown 1984; Brown & Henry 1985), and during winter when predation by recruiting anchovy is high. More intense variation will occur in relation to the upwelling cycle; newly upwelled water supporting low zooplankton biomass due to paucity of food, whilst high biomasses develop in aged upwelled water subsequent to significant development of phytoplankton. Irregular pulsing of the upwelling system, combined with seasonal recruitment of pelagic fish species into West Coast shelf waters during winter, thus results in a highly variable and dynamic balance between plankton replenishment and food availability for pelagic fish species.

Concession areas 2C-5C lie within the influence of the Namaqua upwelling cell, and seasonally high phytoplankton abundance can be expected, providing favourable feeding conditions for micro-, meso- and macrozooplankton, and for ichthyoplankton. Immediately to the north of the upwelling cell, high turbulence and deep mixing in the water column result in diminished phytoplankton biomass and consequently the area is considered to be an environmental barrier to the transport of ichthyoplankton from the southern to the northern Benguela upwelling ecosystems. Important pelagic fish species, including anchovy, redeye round herring, horse mackerel and shallow-water hake, are reported as spawning on either side of the Orange River Banks area, but not within it (Figure 4-5). Phytoplankton, zooplankton and ichthyoplankton abundances in the licence area are thus expected to be comparatively high relative to the Orange River Banks area. In the offshore portions of the licence area plankton abundance is also expected to be low, with the major fish spawning and migration routes occurring further inshore on the shelf.

4.1.3.2.2 Cephalopods

The major cephalopod resource in the southern Benguela are sepoids/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 was generally higher in the summer than in winter. Cuttlefish are largely epi-benthic and occur on mud and fine sediments in association with their major prey item; mantis shrimps (Augustyn et al. 1995). They form an important food item for demersal fish.

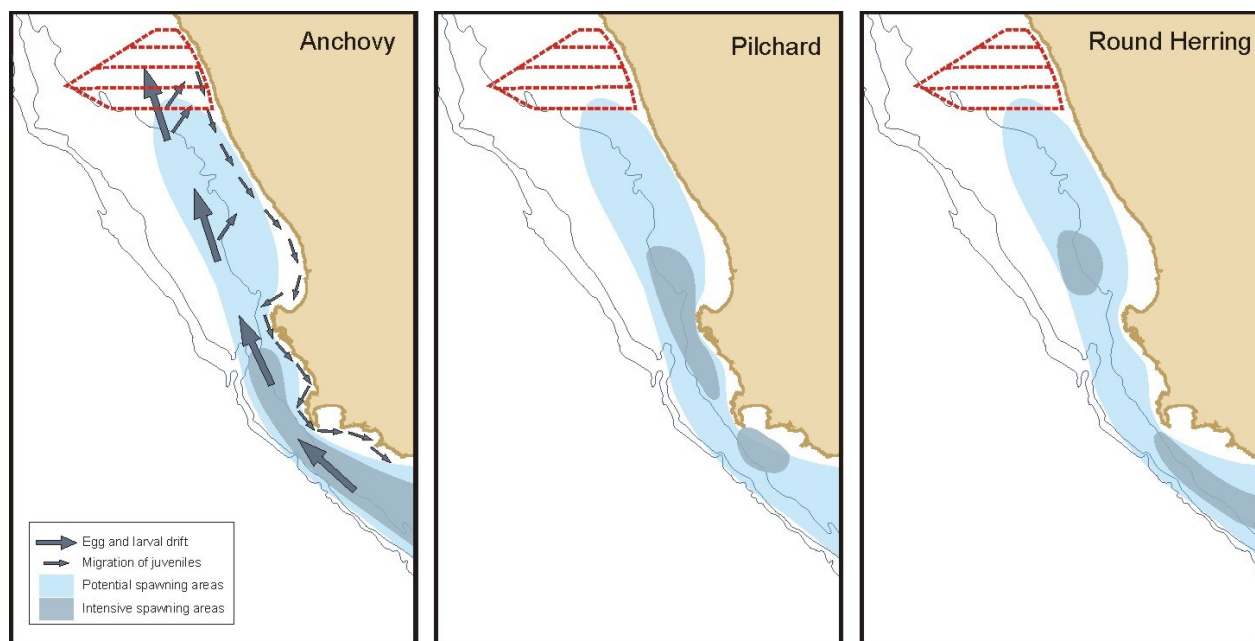


Figure 4-5: Concession areas 2C-5C (red polygons) in relation to major spawning areas in the southern Benguela region (adapted from Cruikshank 1990).

4.1.3.2.3 Pelagic Fish

Small pelagic species occurring beyond the surfzone and generally within the 200 m contour include the sardine/pilchard (*Sardinops 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 (Crawford et al. 1987), and exhibit similar life history patterns involving seasonal migrations between the west and south coasts. The spawning areas of the major pelagic species are distributed on the continental shelf and along the shelf edge 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.

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

juveniles of these small, short-lived (1 - 3 years) pelagic fish is highly variable both within and between species.

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

Large pelagic species include tunas, billfish and pelagic sharks, which migrate throughout the southern oceans, between surface and deep waters (>300 m) and have a highly seasonal abundance in the Benguela. Species occurring off western southern Africa include the albacore/longfin tuna *Thunnus alalunga*, 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 distributions of these species is dependent on food availability in the mixed boundary layer between the Benguela and warm central Atlantic waters. Concentrations of large pelagic species are also known to occur associated with underwater feature such as canyons and seamounts as well as meteorologically induced oceanic fronts (Penney *et al.* 1992).

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*. Occurring throughout the world in warm temperate waters, these species are usually found further offshore on the West Coast. Great whites *Carcharodon carcharias* may also be encountered in coastal and offshore areas. This species is a significant apex predator along the southern African coast, particularly in the vicinity of the seal colonies. Although not necessarily threatened with extinction, great whites are listed in Appendix II (species in which trade must be controlled in order to avoid utilization incompatible with their survival) of CITES (Convention on International Trade in Endangered Species) and is described as “vulnerable” in the International Union for Conservation of Nature (IUCN) Red listing. In response to global declines in abundance, white sharks were legislatively protected in South Africa in 1991.

Many of the large migratory pelagic species are considered threatened by the IUCN, primarily due to overfishing (Table 4-2). Tuna and swordfish are targeted by high seas fishing fleets and illegal overfishing has severely damaged the stocks of many of these species. Similarly, pelagic sharks, are either caught as bycatch in the pelagic tuna longline fisheries, or are specifically targeted for their fins, where the fins are removed and the remainder of the body discarded.

4.1.3.2.4 Turtles

Three species of turtle occur along the West Coast, namely the Leatherback (*Dermochelys coriacea*), and occasionally the Loggerhead (*Caretta caretta*) and the Green (*Chelonia mydas*) turtle. Loggerhead and Green turtles are expected to occur only as occasional visitors along the West Coast. The Leatherback is the only turtle likely to be encountered in the offshore waters of west South Africa.

The Benguela ecosystem, especially the northern Benguela where jelly fish numbers are high, is increasingly being recognized 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). Leatherback turtles from the east South Africa population have been satellite tracked swimming around the west coast of South Africa and remaining in the warmer waters west of the Benguela ecosystem (Lambardi et al. 2008) (Figure 4-6).

Table 4-2: Some of the more important large migratory pelagic fish likely to occur in the offshore regions of the South Coast.

Common Name	Species	IUCN Conservation Status
Tunas		
Southern Bluefin Tuna	<i>Thunnus maccoyii</i>	Critically Endangered
Bigeye Tuna	<i>Thunnus obesus</i>	Vulnerable
Longfin Tuna/Albacore	<i>Thunnus alalunga</i>	Near Threatened
Yellowfin Tuna	<i>Thunnus albacares</i>	Near Threatened
Frigate Tuna	<i>Auxis thazard</i>	Least concern
Skipjack Tuna	<i>Katsuwonus pelamis</i>	Least concern
Billfish		
Blue Marlin	<i>Makaira nigricans</i>	Vulnerable
Sailfish	<i>Istiophorus platypterus</i>	Least concern
Swordfish	<i>Xiphias gladius</i>	Least concern
Black Marlin	<i>Istiompax indica</i>	Data deficient
Pelagic Sharks		
Pelagic Thresher Shark	<i>Alopias pelagicus</i>	Vulnerable
Common Thresher Shark	<i>Alopias vulpinus</i>	Vulnerable
Great White Shark	<i>Carcharodon carcharias</i>	Vulnerable
Shortfin Mako	<i>Isurus oxyrinchus</i>	Vulnerable
Longfin Mako	<i>Isurus paucus</i>	Vulnerable
Blue Shark	<i>Prionace glauca</i>	Near Threatened
Oceanic Whitetip Shark	<i>Carcharhinus longimanus</i>	Vulnerable

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). Their abundance in the study area is unknown but expected to be low. Leatherbacks feed on jellyfish and are known to have mistaken plastic marine debris for their natural food. Ingesting this can obstruct the gut, lead to absorption of toxins and reduce the absorption of nutrients from their real food. 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 Convention on Migratory Species. Loggerhead and green turtles are listed as “Endangered”. As a signatory of the Convention on Migratory Species, South Africa has endorsed and signed an International Memorandum of Understanding specific to the conservation of marine turtles. South Africa is thus committed to conserve these species at an international level.

4.1.3.2.5 Seabirds

Large numbers of pelagic seabirds exploit the pelagic fish stocks of the Benguela system. Of the 49 species of seabirds that occur in the Benguela region, 14 are defined as resident, 10 are visitors from the northern hemisphere and 25 are migrants from the southern Ocean. The 18 species classified as being

common in the southern Benguela are listed in Table 4-3. The area between Cape Point and the Orange River supports 38% and 33% of the overall population of pelagic seabirds in winter and summer, respectively. Most of the species in the region reach highest densities offshore of the shelf break (200 – 500 m depth) with highest population levels during their non-breeding season (winter). Pintado petrels and Prion spp. show the most marked variation here.

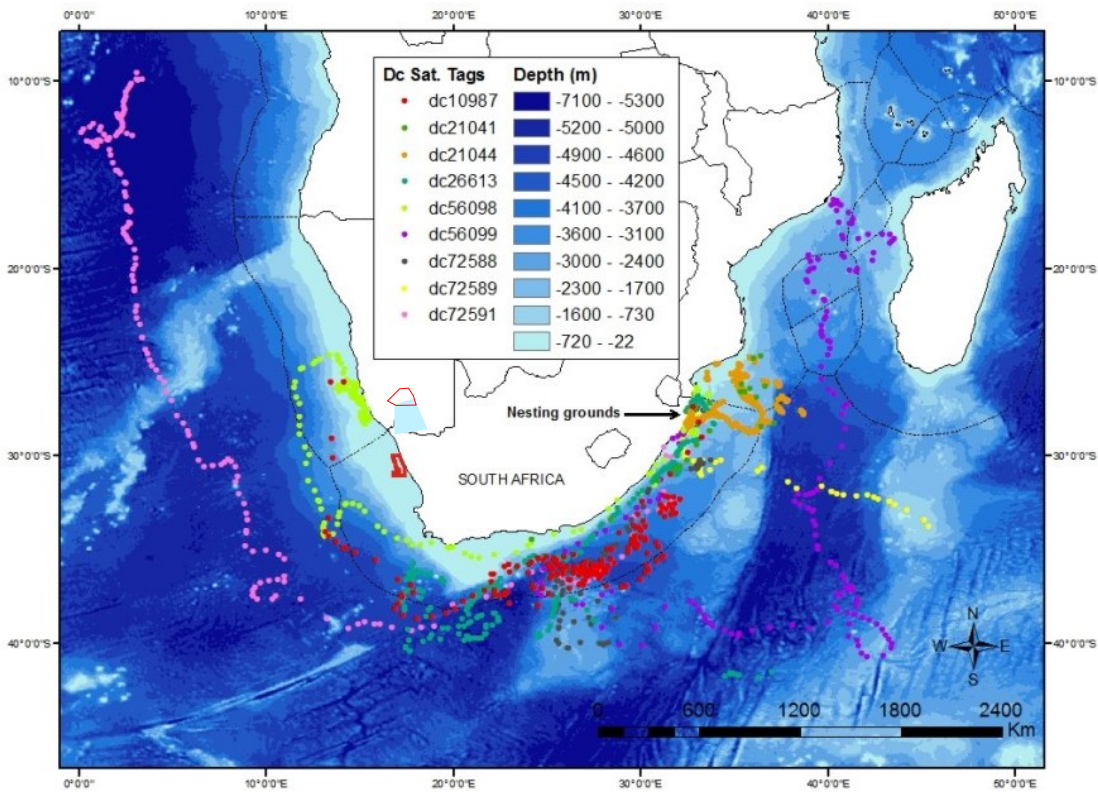


Figure 4-6: The post-nesting distribution of nine satellite tagged leatherback females (1996 – 2006; Oceans and Coast, unpublished data).

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

Table 4-3: Pelagic seabirds common in the southern Benguela region (Crawford et al. 1991).

Common Name	Species name	Global IUCN
Shy albatross	<i>Thalassarche cauta</i>	Near Threatened
Black browed albatross	<i>Thalassarche melanophrys</i>	Endangered ¹
Yellow nosed albatross	<i>Thalassarche chlororhynchos</i>	Endangered
Giant petrel sp.	<i>Macronectes halli/giganteus</i>	Near Threatened
Pintado petrel	<i>Daption capense</i>	Least concern

Common Name	Species name	Global IUCN
Greatwinged petrel	<i>Pterodroma macroptera</i>	Least concern
Soft plumaged petrel	<i>Pterodroma mollis</i>	Least concern
Prion spp	<i>Pachyptila</i> spp.	Least concern
White chinned petrel	<i>Procellaria aequinoctialis</i>	Vulnerable
Cory's shearwater	<i>Calonectris diomedea</i>	Least concern
Great shearwater	<i>Puffinus gravis</i>	Least concern
Sooty shearwater	<i>Puffinus griseus</i>	Near Threatened
European Storm petrel	<i>Hydrobates pelagicus</i>	Least concern
Leach's storm petrel	<i>Oceanodroma leucorhoa</i>	Least concern
Wilson's storm petrel	<i>Oceanites oceanicus</i>	Least concern
Blackbellied storm petrel	<i>Fregetta tropica</i>	Least concern
Skua spp.	<i>Catharacta/Stercorarius</i> spp.	Least concern
Sabine's gull	<i>Larus sabini</i>	Least concern

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

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

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

4.1.3.2.6 Marine Mammals

The marine mammal fauna occurring off the southern African coast includes several species of whales and dolphins and one resident seal species. Thirty three species of whales and dolphins are known (based on historic sightings or strandings records) or likely (based on habitat projections of known species parameters) to occur in these waters (Table 4-5). The offshore areas have been particularly poorly studied with almost all available information from deeper waters (>200 m) arising from historic whaling records prior to 1970. Current information on the distribution, population sizes and trends of most cetacean species occurring on the west coast of southern Africa is lacking. Information on smaller cetaceans in deeper waters is particularly poor and the precautionary principal must be used when considering possible encounters with cetaceans in this area.

Table 4-5: Cetaceans occurrence off the West Coast of South Africa, their seasonality, likely encounter frequency with proposed exploration drilling operations and IUCN conservation status.

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

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

Records from stranded specimens show that the area between St Helena Bay (~32° S, 18° E) and Cape Agulhas (~34° S, 20° E) is an area of transition between Atlantic and Indian Ocean species, as well as those more commonly associated with colder waters of the west coast (e.g. dusky dolphins and long finned pilot whales) and those of the warmer east coast (e.g. striped and Risso's dolphins) (Findlay *et al.* 1992). The project area lies north of this transition zone and can be considered to be truly on the 'west coast'. However, the warmer waters that occur offshore of the Benguela ecosystem (more than ~100 km offshore) provide an entirely different habitat, that despite the relatively high latitude may host some species associated with the more tropical and temperate parts of the Atlantic such as rough toothed dolphins, Pan-tropical spotted dolphins and short finned pilot whales. Owing to the uncertainty of species occurrence offshore, species that may occur there have been included here for the sake of completeness.

The distribution of cetaceans can largely be split into those associated with the continental shelf and those that occur in deep, oceanic water. Importantly, species from both environments may be found on the continental slope (200 – 2000 m) making this the most species rich area for cetaceans. Cetacean density on the continental shelf is usually higher than in pelagic waters as species associated with the pelagic environment tend to be wide ranging across thousands of kilometers. As the project target areas are located on the continental shelf, cetacean diversity in the area can be expected to be high. In the offshore portions of concession areas 2C-5C abundances will, however, be low compared to further inshore. The most common species within the project area (in terms of likely encounter rate not total population sizes) are likely to be the long-finned pilot whale and humpback whale.

Cetaceans are comprised of two taxonomic groups, the mysticetes (filter feeders with baleen) and the odontocetes (predatory whales and dolphins with teeth). The term 'whale' is used to describe species in both groups and is taxonomically meaningless (e.g. the killer whale and pilot whale are members of the Odontoceti, family Delphinidae and are thus dolphins). Due to differences in sociality, communication abilities, ranging behavior and acoustic behavior, these two groups are considered separately.

Table 4-5 lists the cetaceans likely to be found within the project area, based on data sourced from: Findlay *et al.* (1992), Best (2007), Weir (2011), Dr J-P. Roux, (MFMR pers. comm.) and unpublished records held by the Namibian Dolphin Project. Of the 33 species listed, three are endangered and one is considered vulnerable (IUCN Red Data list Categories). Altogether 17 species are listed as "data deficient" underlining how little is known about cetaceans, their distributions and population trends. The majority of data available on the seasonality and distribution of large whales in the project area is the result of commercial whaling activities mostly dating from the 1960s. Changes in the timing and distribution of migration may have occurred since these data were collected due to extirpation of populations or behaviours (e.g. migration routes may be learnt behaviours). The large whale species for which there are current data available are the humpback and southern right whale, although almost all data is limited to that collected on the continental shelf close to shore.

A review of the distribution and seasonality of the key cetacean species likely to be found within the project area is provided below.

(a) *Mysticete (Baleen) whales*

The majority of mysticetes whales fall into the family Balaenopeteridae. Those occurring in the 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. The majority of mysticete species occur in pelagic waters with only occasional visits to shelf waters. All of these species show some degree of migration either to or through the latitudes encompassed by the broader project area when en route between higher latitude (Antarctic or Subantarctic) feeding grounds and lower latitude breeding grounds.

Depending on the ultimate location of these feeding and breeding grounds, seasonality may be either unimodal, usually in winter months, or bimodal (e.g. May to July and October to November), reflecting a northward and southward migration through the area. Northward and southward migrations may take place at different distances from the coast due to whales following geographic or oceanographic features, thereby influencing the seasonality of occurrence at different locations. Because of the complexities of the migration patterns, each species is discussed separately below.

Two genetically and morphologically distinct populations of Bryde's whales live off the coast of southern Africa (Best 2001; Penry 2010). The "offshore population" lives beyond the shelf (>200 m depth) off west Africa and migrates between wintering grounds off equatorial west Africa (Gabon) and summering grounds off western South Africa. Its seasonality on the west coast is thus opposite to the majority of the balaenopterids with abundance likely to be highest in the broader project area in January - March. The "inshore population" of Bryde's, which lives on the continental shelf and Agulhas Bank, is unique amongst baleen whales in the region by being non-migratory. It may move further north into the Benguela current areas of the west of coast of South Africa and Namibia, especially in the winter months (Best 2007).

Sei whales migrate through South African waters, where they were historically hunted in relatively high numbers, to unknown breeding grounds further north. Their migration pattern thus shows a bimodal peak with numbers west of Cape Columbine highest in May and June, and again in August, September and October. All whales were caught in waters deeper than 200 m with most deeper than 1000 m (Best & Lockyer 2002). Almost all information is based on whaling records 1958-1963 and there is no current information on abundance or distribution patterns in the region.

Fin whales were historically caught off the West Coast of South Africa, with 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 abundance or distribution of fin whales off western South Africa.

Although blue whales were historically caught in high numbers off the South African West Coast, there have been only two confirmed sightings of the species in the area since 1973 (Branch et al. 2007), suggesting that the population using the area may have been extirpated by whaling. However, scientific search effort (and thus information) in pelagic waters is very low. The chance of encountering the species in the licence area is considered low.

Two forms of minke whale occur in the southern Hemisphere, the Antarctic minke whale (*Balaenoptera bonaerensis*) and the dwarf minke whale (*B. acutorostrata* subsp.); both species occur in the Benguela (Best 2007). Antarctic minke whales range from the pack ice of Antarctica to tropical waters and are usually seen more than approximately 50 km offshore. Although adults migrate from the Southern Ocean (summer) to tropical/temperate waters (winter) to breed, some animals, especially juveniles, are known to stay in tropical/temperate waters year round. The dwarf minke whale has a more temperate distribution than the Antarctic minke and they do not range further south than 60-65°S. Dwarf minkes have a similar migration pattern to Antarctic minkes with at least some animals migrating to the Southern Ocean during summer. Dwarf minke whales occur closer to shore than Antarctic minkes. Both species are generally solitary and densities are likely to be low in the project area.

The most abundant baleen whales in the Benguela are southern right whales and humpback whales. In the last decade, both species have been increasingly observed to remain on the west coast of South Africa well after the 'traditional' South African whale season (June – November) into spring and early summer (October – February) where they have been observed feeding in upwelling zones, especially off Saldanha and St Helena Bay (Barendse et al. 2011; Mate et al. 2011).

The majority of humpback whales passing through the Benguela are migrating to breeding grounds off tropical west Africa, between Angola and the Gulf of Guinea (Rosenbaum et al. 2009; Barendse et al. 2010). In coastal waters, the northward migration stream is larger than the southward peak (Best & Allison 2010; Elwen et al. 2013), suggesting that animals migrating north strike the coast at varying places north of St Helena Bay, resulting in increasing whale density on shelf waters and into deeper pelagic waters as one moves northwards, but no clear migration 'corridor'. On the southward migration, many humpbacks follow the Walvis Ridge offshore then head directly to high latitude feeding grounds, while others follow a more coastal route (including the majority of mother-calf pairs) possibly lingering in the feeding grounds off west South Africa in summer (Elwen et al. 2013, Rosenbaum et al. in press). 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 the most frequently encountered baleen whale in the project area, ranging from the coast out beyond the shelf, with year round presence but numbers peaking in July – February associated with the breeding migration and subsequent feeding in the Benguela.

The southern African population of southern right whales historically extended from southern Mozambique (Maputo Bay) to southern Angola (Baie dos Tigres) and is considered to be a single population within this range (Roux et al. 2011). The most recent abundance estimate for this population is available for 2008 which estimated the population at approximately 4600 individuals including all age and sex classes, which is thought to be at least 23% of the original population size (Brandaõ et al. 2011). Since the population is still continuing to grow at approximately 7% per year (Brandaõ et al. 2011), the population size in 2013 would number more than 6000 individuals. When the population numbers crashed, the range contracted down to just the south coast of South Africa, but as the population recovers, it is repopulating its historic grounds including Namibia (Roux et al. 2001) and Mozambique (Banks et al. 2011). Southern right whales are seen regularly in the nearshore waters of the West Coast (<3 km from shore), extending north into southern Namibia (Roux et al. 2001, 2011). Southern right whales have been recorded off the West Coast in all months of the year, but with numbers peaking in winter (June - September).

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

(b) *Odontocetes (toothed) whales*

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. Those in the region can range in size from 1.6-m long (Heaviside's dolphin) to 17 m (bull sperm whale).

All information about sperm whales in the southern African sub-region results from data collected during commercial whaling activities prior to 1985 (Best 2007). Sperm whales are the largest of the toothed whales and have a complex, structured social system with adult males behaving differently to younger males and female groups. They live in deep ocean waters, usually greater than 1000 m depth, although

they occasionally come onto the shelf in water 500 - 200 m deep (Best 2007). They are considered to be relatively abundant globally (Whitehead 2002), although no estimates are available for South African waters. Seasonality of catches suggests that medium and large sized males are more abundant in winter months while female groups are more abundant in autumn (March - April), although animals occur year round (Best 2007). Sperm whales are thus likely to be encountered in relatively high numbers in deeper waters (>500 m), predominantly in the winter months (April - October). Sperm whales feed at great depths during dives in excess of 30 minutes making them difficult to detect visually, however the regular echolocation clicks made by the species when diving make them relatively easy to detect acoustically using Passive Acoustic Monitoring (PAM).

There are almost no data available on the abundance, distribution or seasonality of the smaller odontocetes (including the beaked whales and dolphins) known to occur in oceanic waters (>200 m) off the shelf of the southern African West Coast. Beaked whales are all considered to be true deep water species usually being seen in waters in excess of 1000-2000 m deep (see various species accounts in Best 2007). Presence in the project area may fluctuate seasonally, but insufficient data exist to define this clearly.

The genus *Kogia* currently contains two recognised species, the pygmy (*K. breviceps*) and dwarf (*K. sima*) sperm whales, both of which most frequently occur in pelagic and shelf edge waters, although their seasonality is unknown. The majority of what is known about Kogiidae whales in the southern African subregion results from studies of stranded specimens (e.g. Ross 1979; Findlay et al. 1992; Plön 2004; Elwen et al. 2013).

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.

The false killer whale has a tropical to temperate distribution and most sightings off southern Africa have occurred in water deeper than 1000 m, but with a few recorded close to shore (Findlay et al. 1992). They usually occur in groups ranging in size from 1 - 100 animals (Best 2007). The strong bonds and matrilineal social structure of this species makes it vulnerable to mass stranding (8 instances of 4 or more animals stranding together have occurred in the Western Cape, all between St Helena Bay and Cape Agulhas). There is no information on population numbers or conservation status and no evidence of seasonality in the region (Best 2007).

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 (MMOs) and fisheries observers and researchers. 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.

The common dolphin is known to occur offshore in West Coast waters (Findlay et al. 1992; Best 2007), although 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 (\pm SD 287) for the South Africa region (Findlay et al. 1992). They are more frequently seen in the warmer waters offshore and to the north of the country, seasonality is not known.

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

Heaviside’s dolphins are relatively abundant in the Benguela ecosystem region with 10 000 animals estimated to live in the 400 km of coast between Cape Town and Lamberts Bay (Elwen et al. 2009). This species occupies waters from the coast to at least 200 m depth, (Elwen et al. 2006; Best 2007), and may show a diurnal onshore-offshore movement pattern (Elwen et al. 2010b), but this varies throughout the species range. Heaviside’s dolphins are resident year round.

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

Beaked whales were never targeted commercially and their pelagic distribution makes them the most poorly studied group of cetaceans. With recorded dives of well over an hour and in excess of 2 km deep, beaked whales are amongst the most extreme divers of any air breathing animals (Tyack et al. 2011). They also appear to be particularly vulnerable to certain types of anthropogenic noise, although reasons are not yet fully understood. All the beaked whales that may be encountered in the project area are pelagic species that tend to occur in small groups usually less than five, although larger aggregations of some species are known (MacLeod & D’Amico 2006; Best 2007).

In summary, the humpback and southern right whale are likely to be encountered year-round, with numbers in the Cape Columbine area highest between September and February, and not during winter as is common on the South Coast breeding grounds. Several other large whale species are also most abundant on the West Coast during winter: fin whales peak in May-July and October-November; sei whale numbers peak in May-June and again in August-October and offshore Bryde’s whale numbers are likely to be highest in January-February. Whale numbers on the shelf and in offshore waters are thus likely to be highest between October and February.

Of the migratory cetaceans, the Blue, Sei and Humpback whales are listed as “Endangered” and the Southern Right and Fin whale as “Vulnerable” in the IUCN Red Data book. All whales and dolphins are given protection under the South African Law. The Marine Living Resources Act, 1998 (No. 18 of 1998) states that no whales or dolphins may be harassed, killed or fished. No vessel or aircraft may, without a permit or exemption, approach closer than 300 m to any whale and a vessel should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m from a vessel or aircraft.

The Cape fur seal (*Arctocephalus pusillus pusillus*) is the only species of seal resident along the west coast of Africa, occurring at numerous breeding and non-breeding sites on the mainland and on nearshore islands and reefs (see Figure 4-7). Vagrant records from four other species of seal more usually associated with the subantarctic environment have also been recorded: southern elephant seal (*Mirounga leoninas*), subantarctic fur seal (*Arctocephalus tropicalis*), crabeater (*Lobodon carcinophagus*) and leopard seals (*Hydrurga leptonyx*) (David 1989).

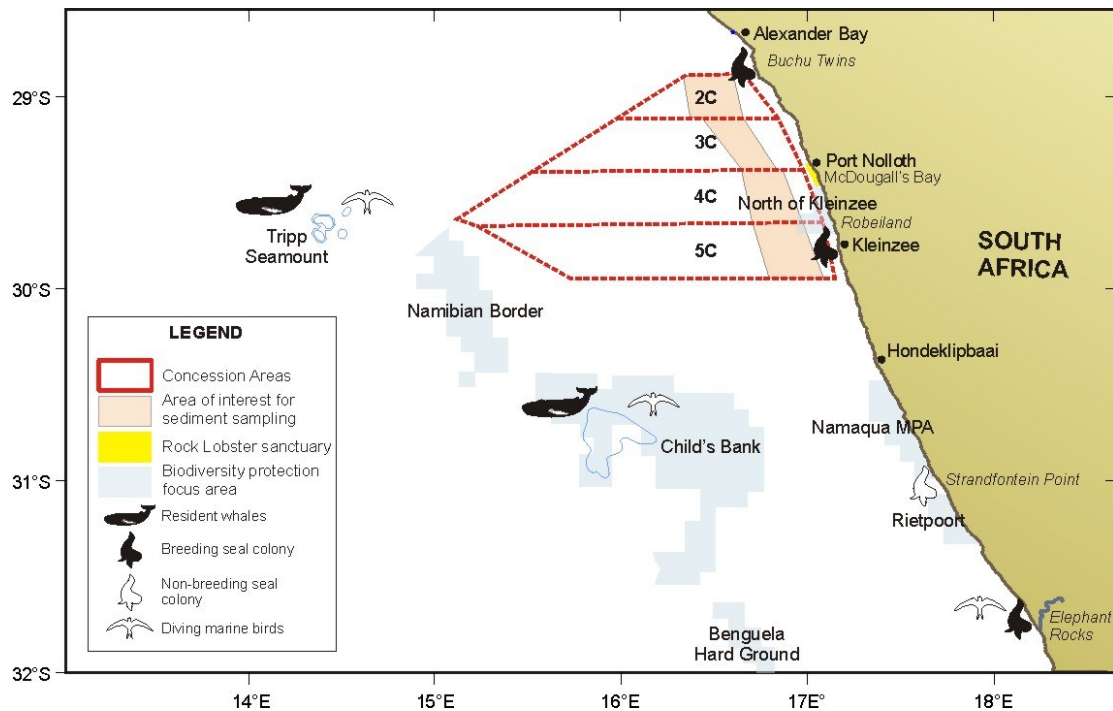


Figure 4-7: Project - environment interaction points on the West Coast, illustrating the location of seabird and seal colonies and resident whale populations in relation to Concession Areas 2C-5C (red polygons) and the proposed sampling target area (shaded orange).

There are a number of Cape fur seal colonies within the study area: at Kleinzee (incorporating Robeiland), at Buchu Twins near Alexander Bay, and Strandfontein Point (south of Hondeklipbaai). The colony at Kleinzee has the highest seal population and produces the highest seal pup numbers on the South African Coast (Wickens 1994). The colony at Buchu Twins, formerly a non-breeding colony, has also attained breeding status (M. Meyer, SFRI, pers. comm.). Non-breeding colonies occur south of Hondeklip Bay at Strandfontein Point and on Bird Island at Lamberts Bay, with the McDougall's Bay islands and Wedge Point being haul-out sites only and not permanently occupied by seals. All have important conservation value since they are largely undisturbed at present. Seals are highly mobile animals with a general foraging area covering the continental shelf up to 120 nautical miles 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 and other harvesting

The South African fishing industry consists of approximately 20 commercial sectors operating within the 200 nautical mile Exclusive Economic Zone (EEZ)¹. The western coastal shelf is a highly productive upwelling ecosystem (Benguela current) and supports a number of fisheries.

¹ The Exclusive Economic Zone is the zone extending from the coastline out to a distance of 200 nautical miles within which South Africa holds exclusive economic rights.

The largest and most economically valuable of these are the demersal trawl and long-line fisheries, targeting the cape hakes *Merluccius paradoxus* and *M. capensis*, and the pelagic purse-seine fishery targeting pilchard (*Sardinops sagax*), anchovy (*Engraulis encrasicolus*) and red-eye round herring (*Etrumeus whitheadii*). Secondary commercial species in the hake-directed fisheries include an assemblage of demersal (bottom-dwelling) fish of which monk fish (*Lophius vomerinus*) and snoek (*Thyrsites atun*) are the most important commercial species. Other fisheries active on the West Coast are the pelagic long-line fishery for tunas and swordfish and the tuna pole and traditional linefish sectors. West Coast rock lobster (*Jasus lalandi*) is an important trap fishery exploited close to the shoreline (waters shallower than 100 m) including the intertidal zone and kelp beds off the West Coast.

On the West Coast of South Africa, major fishing grounds tend to be centred along the shelf break which is located approximately along the 500 m isobath. Historically and currently the bulk of the main commercial fish stocks caught on the northern West Coast of South Africa have been landed and processed at the Western Cape ports of Cape Town and Saldanha (less than 1% of the South African commercial allowable catch is landed in the Northern Cape Province). The main reasons for this include lack of local infrastructure, distance to market and relatively low volumes of fish landings.

Concession areas 2C – 5C are situated close to the fishing harbour of Port Nolloth, a regional fishing node which operates at a low level of development. Historically, the harbour accommodated a West Coast rock lobster fishery, an experimental hake-long-line fishery and a small experimental trawl fishery during the 1980's (targeting gurnards and sole). Currently there is little fishing activity taking place from Port Nolloth (only inshore West Coast rock lobster and traditional line fishing). As the harbour is relatively shallow and does not have a breakwater, it becomes inaccessible to vessels during rough weather conditions and cannot accommodate larger vessels (length greater than 22 m). This has been a restrictive factor to the development of fisheries in the region.

The main commercial sectors operating in the vicinity of the study area are discussed below:

4.1.4.1.1 Demersal Trawl

The hake-directed trawl fishery is the most valuable sector of the South African fishing industry and is split into two sub-sectors: the offshore ("deep-sea") sector which is active off both the South and West Coasts, and the much smaller inshore trawl sector which is active off the South Coast. A fleet of 45 trawlers operate within the offshore sector targeting the Cape hakes (*Merluccius capensis* and *M. paradoxus*). Main by-catch species include monkfish (*Lophius vomerinus*), kingklip (*Genypterus capensis*) and snoek (*Thyrsites atun*).

The current annual 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. The relative landed proportions of by-catch species to targeted species approximates 20%. According to permit conditions for the sector, there is an Upper Precautionary Catch Limit (UPCL) of 8300 tons and 5264 tons for monkfish and kingklip, respectively. Catches of snoek may not exceed 20% of any landing and there is a "move on" clause that requires a vessel to change its fishing position where the catch of snoek in any one trawl exceeds 25% of the total catch. Should this occur, a vessel has to move to a new fishing position with a difference in water depth of at least 50 m.

Trawls are usually conducted along specific trawling lanes on "trawl friendly" substrate (flat, soft ground). On the West Coast, these grounds extend in a continuous band along the shelf edge between the 300 m and 1 000 m bathymetric contours. Monk-directed trawlers tend to fish shallower waters than hake-directed vessels on mostly muddy substrates. Trawl nets are generally towed along depth contours

(thereby maintaining a relatively constant depth) running parallel to the depth contours in a north-westerly or south-easterly direction. Trawlers also target fish aggregations around bathymetric features, in particular seamounts and canyons (i.e. Cape Columbine and Cape Canyon), where there is an increase in seafloor slope and in these cases the direction of trawls follow the depth contours. Trawlers are prohibited from operating within five nautical miles of the coastline.

The offshore fleet is segregated into wetfish and freezer vessels which differ in terms of the capacity for the processing of fish at sea and in terms of vessel size and capacity. While freezer vessels may work in an area for up to a month at a time, wetfish vessels may only remain in an area for about a week before returning to port. Wetfish vessels range between 24 m and 56 m in length while freezer vessels are usually larger, ranging up to 80 m in length. The gear configurations are similar for both freezer and wet fish vessels. Trawl gear is deployed astern of the vessel.

The towed gear typically consists of trawl warps, bridles and trawl doors, a footrope, headrope, net and codend (see Figure 4-8). The monk-directed trawlers use slightly heavier trawl gear, trawl at slower speeds and for longer periods (up to eight hours) compared to the hake-directed trawlers (60 minutes to four hours). Monk gear includes the use of “tickler” chains positioned ahead of the footrope to chase the monk off the substrate and into the net.

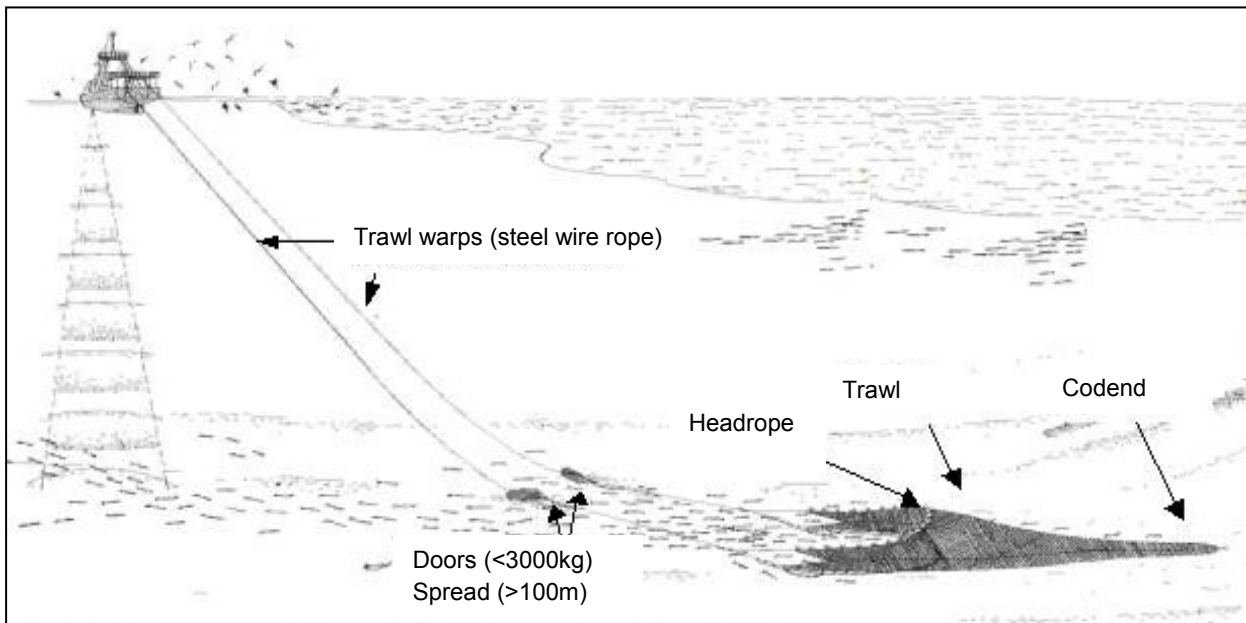


Figure 4-8: Typical gear configuration used by demersal trawlers (offshore) targeting hake.

Figure 4-9 shows the demersal trawl effort and catch between 2000 and 2012 in relation to the area of interest. Concession areas 2C – 5C do not coincide with hake or monk-directed trawling grounds, which are situated adjacent to the concession areas offshore of the 200 m isobath. Over the period 2000 to 2012, the demersal trawl fishery reported an average of 57 920 trawls per year with an associated catch of 127 743 tons of hake and 166 902 tons of all species landed. Recent years (2008 to 2012) have seen a decline in catch and effort with a reported 44 092 trawls per year and an associated catch of 113 607 tons of hake and 125 599 tons of all species landed. The fishery is active year-round, with a relatively constant amount of effort expended each month.

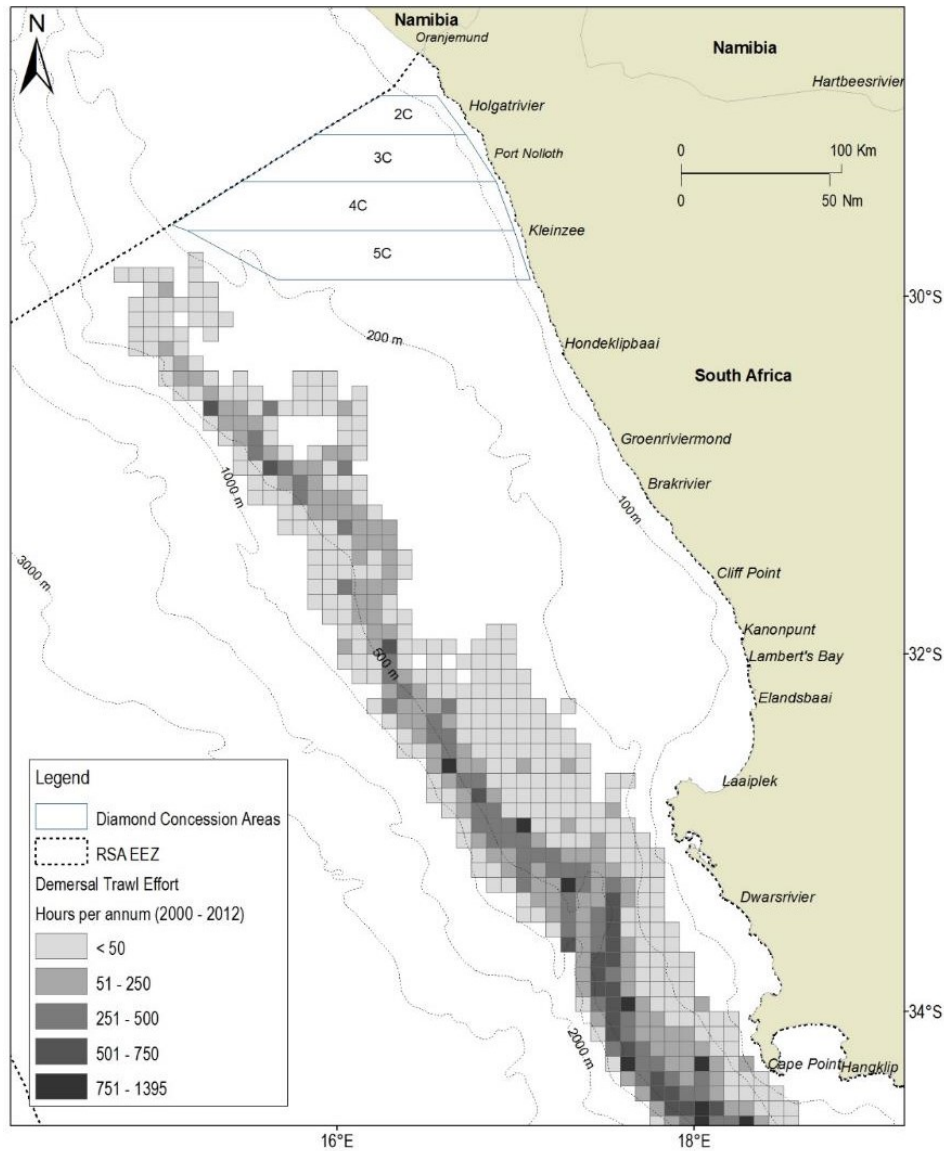


Figure 4-9: Spatial distribution of trawling effort expended by the South African hake-directed trawl sector in relation to Concession Areas 2C – 5C.

4.1.4.1.2 Demersal Long-Line (Hake-Directed)

The demersal long-line fishing technique is used to target bottom-dwelling species of fish. Two fishing sectors utilize this method of capture, namely the hake long-line fishery targeting the Cape hakes (*M. capensis* and *M. paradoxus*) and the shark long-line sector targeting only demersal species of shark.

A demersal long-line vessel may deploy either a double or single line which is weighted along its length to keep it close to the seafloor (see Figure 4-10). Steel anchors, of 40 kg to 60 kg, are placed at the ends of each line to anchor it, and are marked with an array of floats. If a double line system is used, top and bottom lines are connected by means of dropper lines. Lines are typically between 10 km and 20 km in length, carrying between 6 900 and 15 600 hooks each. Baited hooks are attached to the bottom line at regular intervals (1 to 1.5 m) by means of a snood. Gear is usually set at night at a speed of between five and nine knots. Once deployed the line is left to soak for up to eight hours before it is retrieved. A line hauler is used to retrieve gear (at a speed of approximately one knot) and can take six to ten hours to

complete. During hauling operations a demersal long-line vessel would be severely restricted in manoeuvrability.

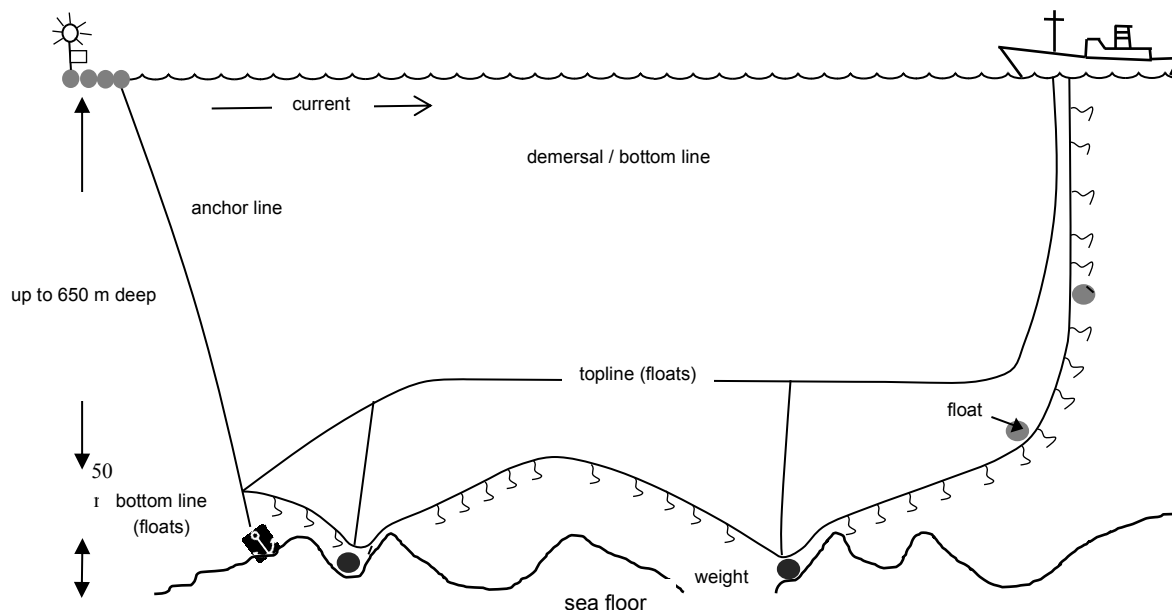


Figure 4-10: Typical configuration of demersal (bottom-set) hake long-line gear used in South African waters.

Of the total hake TAC of 144 671 tons set for 2012, the catch taken by the long-line fleet amounted to 8 399 tons (approximately 6% of the allowed hake catch, and 9 257 tons if all other bycatch species are included). Over the period 2000 to 2012, the fishery set an average of 30.7 million hooks and landed 8 791 tons of hake per year. This is slightly higher than the reported catch and effort over the last five years (2008 to 2012), during which time the fishery set an average of 28.9 million hooks and landed 8 368 tons of hake per year. The fishery operates year-round with a slight increase in activity between August and December.

Demersal long-line fishing grounds are similar to those targeted by the hake-directed trawl fleet. Lines are set parallel to bathymetric contours, along the shelf edge up to the 1 000 m isobath. Figure 4-11 shows the spatial distribution of hake-directed long-line catch recorded off the West Coast of South Africa between 2000 and 2012 and off the Namibian coast between 2000 and 2010.

4.1.4.1.3 Demersal Long-Line (Shark-Directed)

Capture of demersal shark species occurs primarily in the demersal shark long-line fishery whilst catches of pelagic shark species occurs primarily in the large pelagic sector that targets tuna and swordfish. Prior to 2006, both demersal and pelagic shark catches were managed as a single shark fishery. The demersal shark fishery targets soupfin shark (*Galeorhinus galeus*), smooth-hound shark (*Mustelus* spp), spiny dogfish (*Squalus* spp), St Joseph shark (*Callorhynchus capensis*), *Charcharhinus* spp., rays and skates. Other species which are not targeted but may be landed include cape gurnards (*Chelidonichthys capensis*), jacobever (*Sebastichthys capensis*) and smooth hammerhead shark (*Sphyrna zygaena*). Catches are landed at the harbours of Cape Town, Hout Bay, Mossel Bay, Plettenberg Bay, Cape St Francis, Saldanha Bay, St Helena Bay, Gansbaai and Port Elizabeth and currently six permit holders have been issued with long-term rights to operate within the fishery.

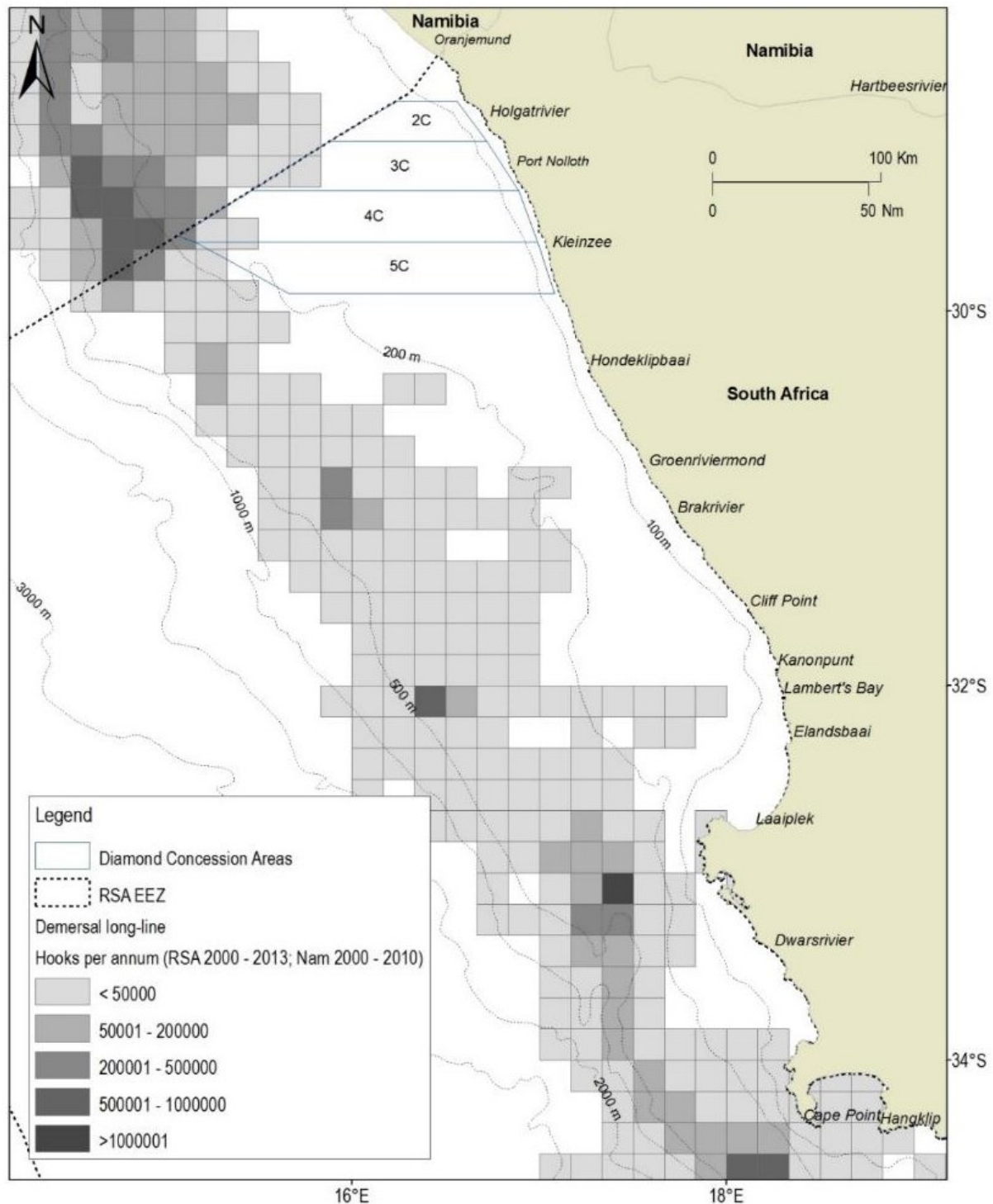


Figure 4-11: Spatial distribution of effort expended by the South African and Namibian hake-directed demersal long-line fisheries in relation to Concession Areas 2C – 5C (South Africa: 2000 – 2012; Namibia: 2000 – 2010).

The fishery was first formerly introduced with the allocation of medium-term fishing rights in 2002. With only six rights allocated and vessels limited in size, fishing effort has remained relatively low. Over the period 2007 to 2012, the fishery reported an annual average of 430 500 hooks set and 175 tons landed annually. Effort is continuous throughout the year with a relative increase between May and October. The fishery operates in coastal waters, predominantly inshore of the 150 m isobaths (Figure 4-12).

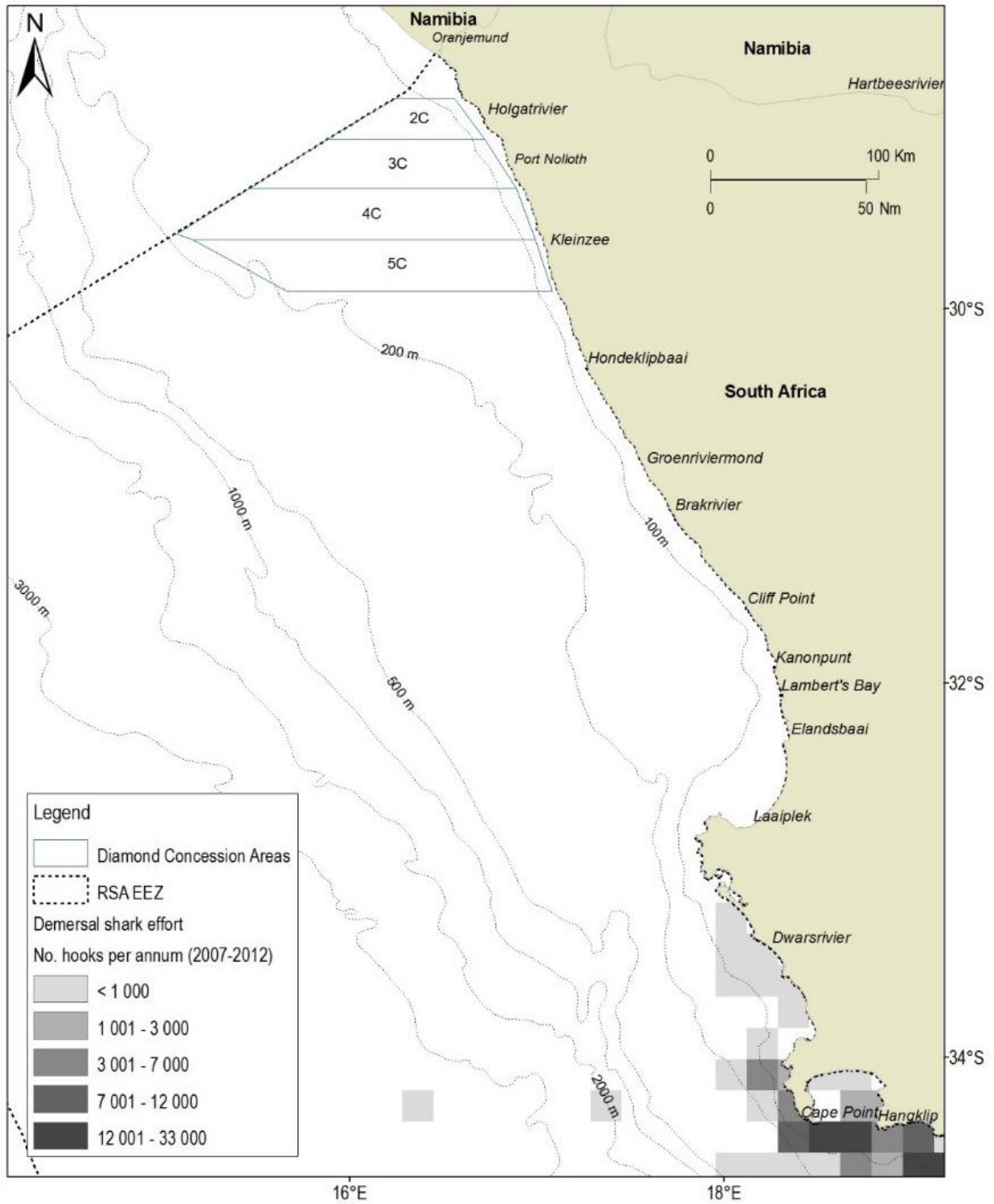


Figure 4-12: Spatial distribution of effort expended by the demersal long-line fishery targeting shark species (2007 – 2012) in relation to Concession Areas 2C – 5C.

4.1.4.1.4 Pelagic Long-line

The large pelagic long-line fishery operates year-round, extensively within the South African EEZ targeting primarily tuna and swordfish. Due to the highly migratory nature of these species, stocks straddle the EEZ of a number of countries and international waters. As such they are managed as a

“shared resource” amongst various countries. There are currently 30 commercial large pelagic fishing rights issued for South African waters and there are 31 vessels active in the fishery.

Pelagic long-line vessels set a drifting mainline, which can be up to 100 km in length. The mainline is kept near the surface or at a certain depth (20 m below) by means of buoys connected via “buoy-lines”, which are spaced approximately 500 m apart along the length of the mainline (see Figure 4-13). Hooks are attached to the mainline via 20 m long trace lines, which are clipped to the mainline at intervals of approximately 50 m. There can be up to 3 500 hooks per line. A single main line consists of twisted rope (6 to 8 mm diameter) or a thick nylon monofilament (5 to 7.5 mm diameter). Various types of buoys are used in combinations to keep the mainline near the surface and locate it should the line be cut or break for any reason. Each end of the line is marked by a Dahn Buoy and Radar reflector, which marks its position for later retrieval by the fishing vessel. A line may be left drifting for up to 18 hours before retrieval by means of a powered hauler at a speed of approximately 1 knot. During hauling a vessel’s manoeuvrability is severely restricted and, in the event of an emergency, the line may be dropped to be hauled in at a later stage.

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

Figure 4-14 shows the large pelagic long-line effort and catch between 2000 and 2012 in relation to the area of interest. During the period 2000 to 2012, the national catch and effort recorded within the large pelagic fishery amounted to an average of 3 018 tons and 3.49 million hooks set per year. The last five years (2008 to 2012) have seen an increase in effort, whilst landings have remained relatively constant within the fishery (3 047 tons and 4.84 million hooks set per year). The fishery operates year-round with a relative increase in effort during winter and spring.

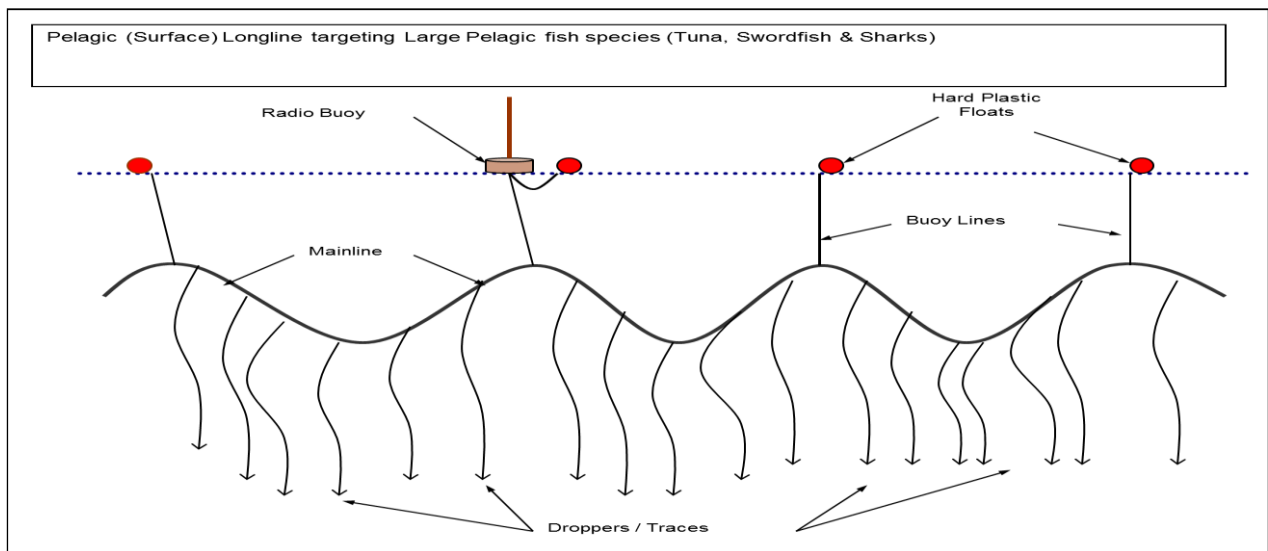


Figure 4-13: Typical pelagic long-line configuration targeting tuna, swordfish and shark species

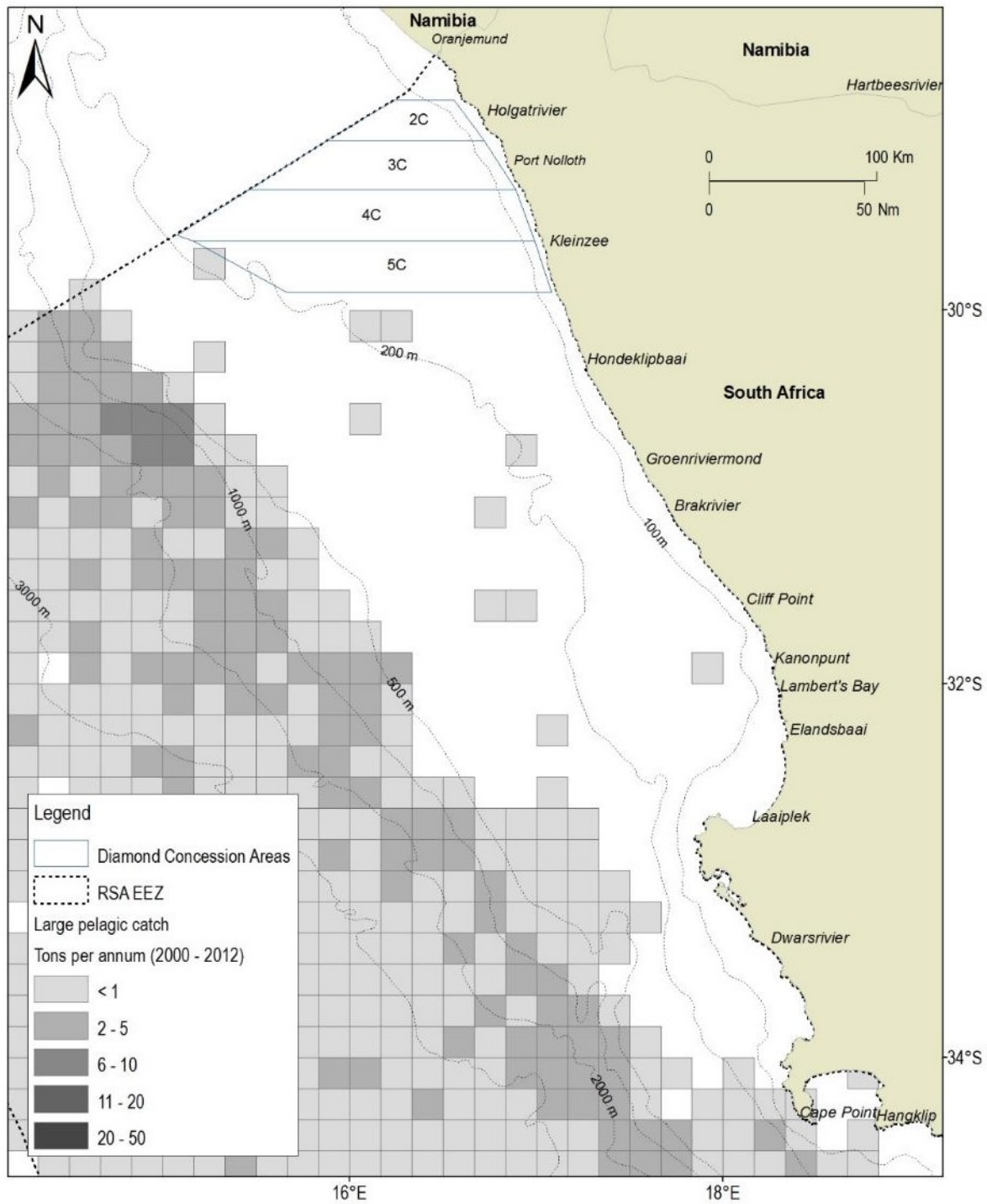


Figure 4-14: Spatial distribution of catch landed by the domestic and foreign pelagic long-line sectors between 2008 and 2012 in relation to Concession Areas 2C – 5C.

4.1.4.1.5 Tuna Pole

The tuna pole fishery is based on migratory species of tuna, predominantly Atlantic longfin tuna stock and a very small amount of skipjack tuna, yellowfin tuna and bigeye tuna. The South African fleet consists of approximately 128 pole-and-line vessels, which are based at the ports of Cape Town, Hout Bay and Saldanha Bay. The fishery is seasonal with vessel activity mostly between December and May and peak

catches in February and March. The 2014 TAC for the South African tuna pole fishery (albacore) will be set at 4 400 tons.

Vessels drift whilst attracting and catching shoals of pelagic tunas. Sonars and echo sounders are used to locate schools of tuna. Once a school is located, water is sprayed outwards from high-pressure nozzles to simulate small baitfish aggregating near the water surface. Live bait is then used to entice the tuna to the surface (chumming). Tuna swimming near the surface are caught with hand-held fishing poles. The ends of the 2 to 3 m poles are fitted with a short length of fishing line leading to a hook. In order to land heavier fish, lines may be strung from the ends of the poles to overhead blocks to increase lifting power (see Figure 4-15). Vessels are relatively small (less than 25 m in length) and store catch on ice, thus staying at sea for short periods (approximately five days).

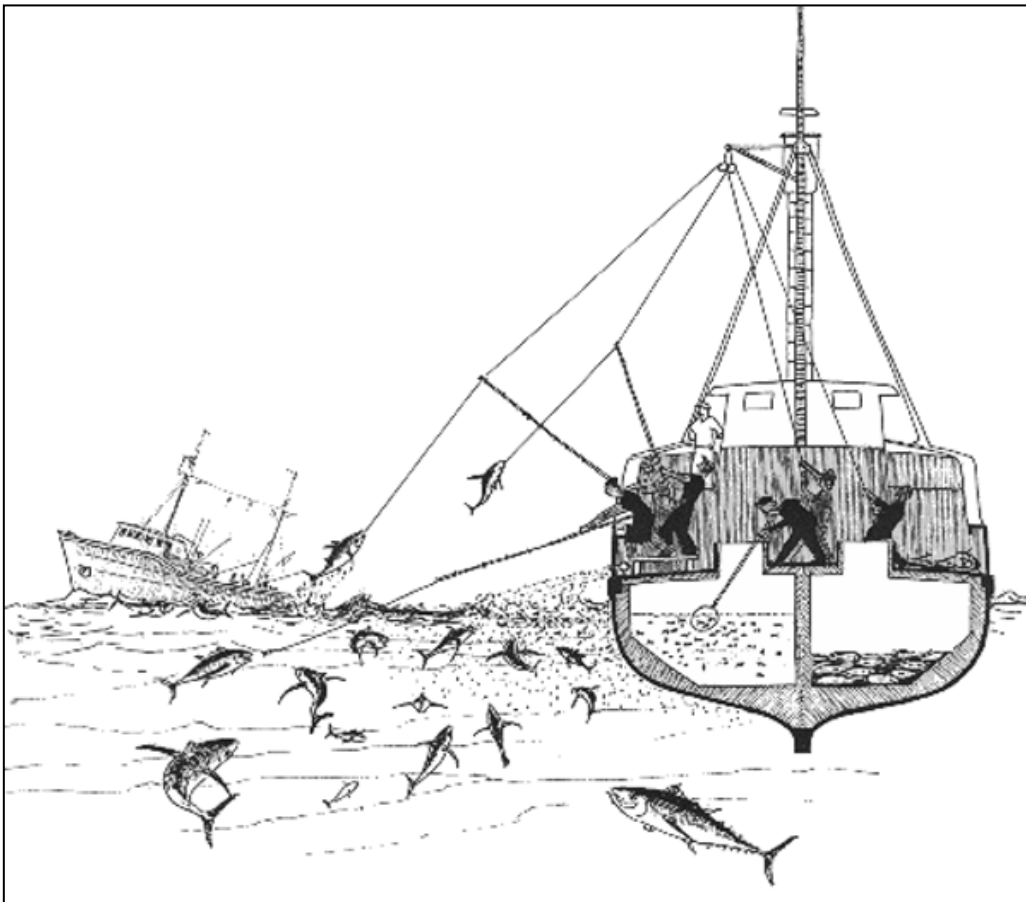


Figure 4-15: Schematic diagram of pole and line operation (www.fao.org/fishery)

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

Fishing activity occurs along the entire West Coast beyond the 200 m bathymetric contour. Activity would be expected to occur along the shelf break with favoured fishing grounds including areas north of Cape Columbine and between 60 km and 120 km offshore from Saldanha Bay. Figure 4-16 shows the tuna pole effort and catch between 2003 and 2012 in relation to the area of interest. The total catch landed and effort expended by the tuna pole sector over the period 2003 to 2012 was 4 110 tons (all species) and 5 723 fishing events per annum. The total catch landed and effort expended by the tuna pole sector over the period 2008 to 2012 was 4 221 tons (all species) and 4 707 fishing events per annum.

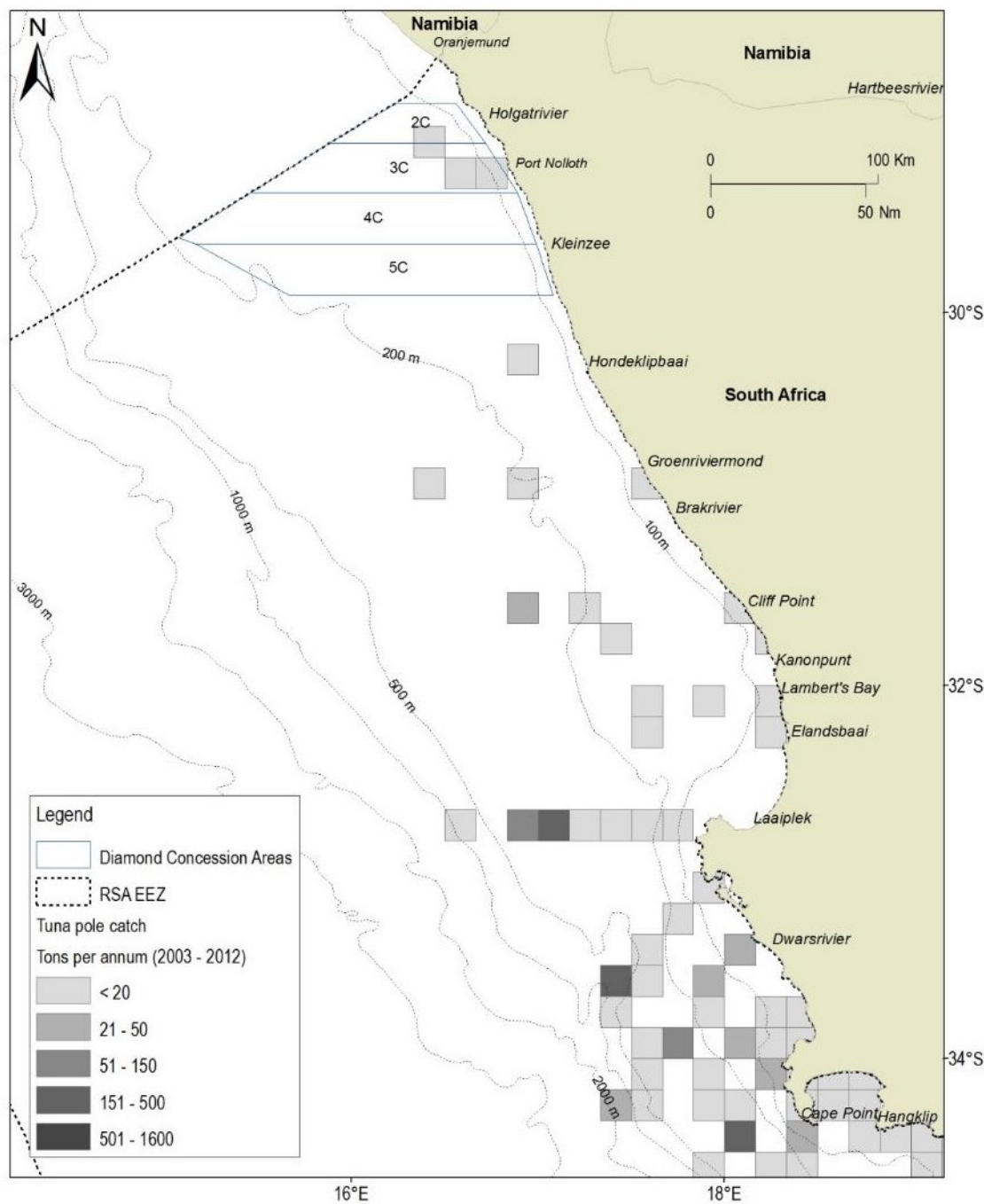


Figure 4-16: Spatial distribution of tuna pole catch from 2003 to 2012 in relation to Concession Areas 2C – 5C.

4.1.4.1.6 Traditional line-fish

This fishery includes commercial, subsistence and recreational sectors. The South African commercial line fishery is the country’s third most important fishery in terms of total tons landed and economic value. The bulk of the fishery catch is made up of about 35 different species of reef fish as well as pelagic and demersal species which are mostly marketed locally as “fresh fish”. In South Africa effort is managed geographically with the spatial effort of the fishery divided into three zones. The majority of the catch (up to 95%) is landed by the Cape commercial fishery, which operates on the continental shelf mostly up to a depth of 200 m from the Namibian border on the West Coast to the Kei River in the Eastern Cape. Up to

3 000 boats are involved in the fishery on the national level, 450 of which are involved in the commercial fishery.

Fishing vessels generally range up to a maximum of 40 nm offshore, although fishing at the outer limit of this range is sporadic. Figure 4-17 shows the traditional line-fish catch between 2000 and 2012 in relation to the area of interest. Over the period 2000 to 2012, the fishery reported an annual catch of 13 082 tons. Over the five-year period from 2008 to 2012, annual catches for the sector are lower at 8 551 tons.

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

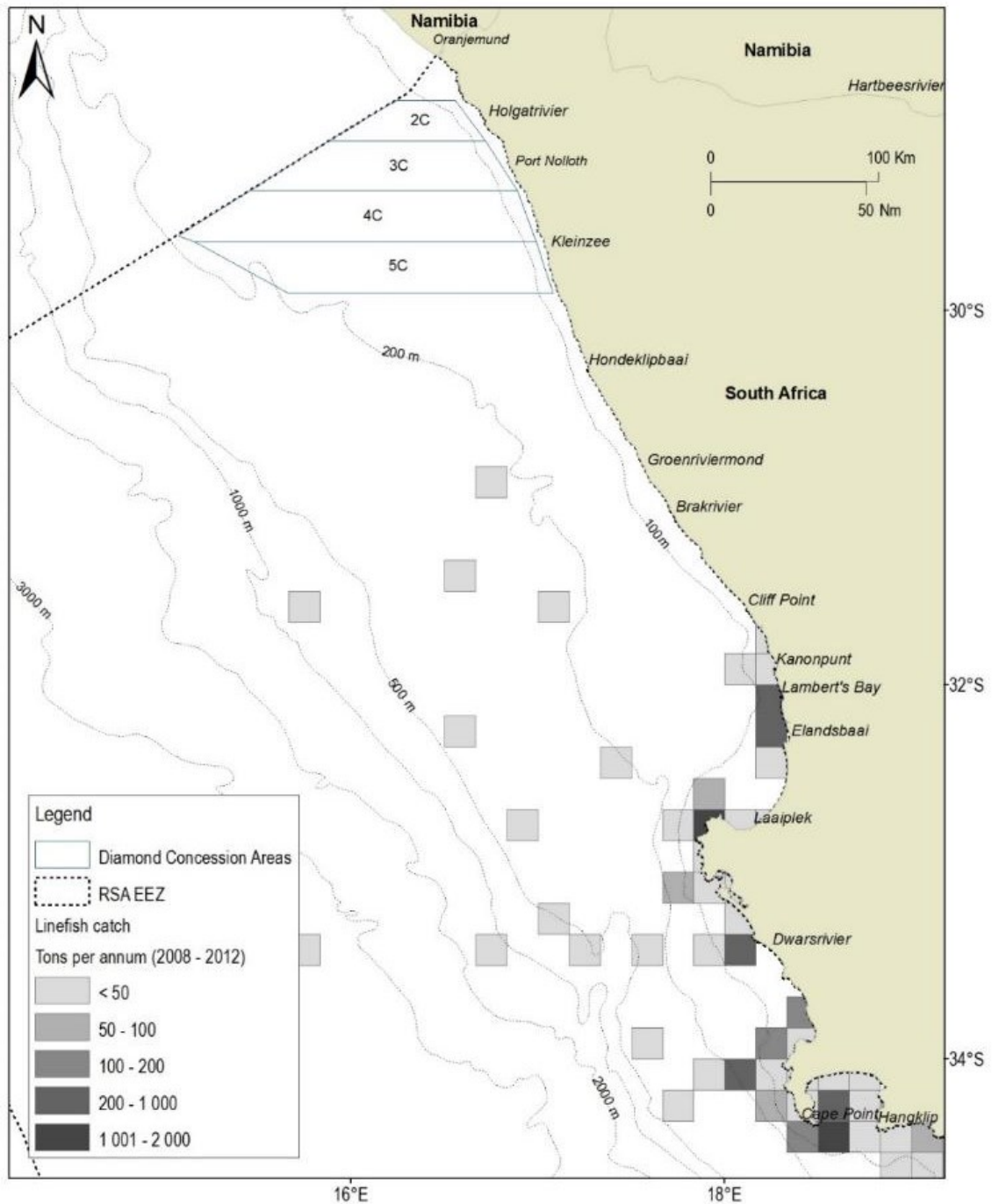


Figure 4-17: Spatial distribution of catch landed by the South African traditional linefish sector (2000 – 2012) in relation to Concession Areas 2C – 5C.

4.1.4.1.7 Small Pelagic Purse-Seine

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

Once a shoal has been located the vessel steams around it and encircle it with a large net. The depth of the net is usually between 60 m and 90 m. Netting walls surround aggregated fish both from the sides and from underneath, thus preventing them from escaping by diving downwards. These are surface nets framed by lines: a float line on top and lead line at the bottom (see Figure 4-18). Once the shoal has been encircled the net is pursed and hauled in and the fish are pumped onboard into the hold of the vessel. After the net is deployed the vessel has no ability to manoeuvre until the net has been fully recovered onboard, which may take up to 1.5 hours. Vessels usually operate overnight and return to offload their catch the following day.

The South African fishery, consisting of approximately 101 vessels, is active all year round with a short break from mid-December to mid-January (to reduce impact on juvenile sardine), with seasonal trends in the specific species targeted. The geographical distribution and intensity of the fishery is largely dependent on the seasonal fluctuation and geographical distribution of the targeted species. Fishing grounds occur primarily along the Western Cape and Eastern Cape coast up to a distance of 100 km offshore, but usually closer inshore. The sardine-directed fishery tends to concentrate effort in a broad area extending from St Helena Bay, southwards past Cape Town towards Cape Point and then eastwards along the coast to Mossel Bay and Port Elizabeth. The anchovy-directed fishery takes place predominantly on the South-West Coast from St Helena Bay to Cape Point and is most active in the period from March to September. Round herring (non-quota species) is targeted when available and specifically in the early part of the year (January to March) and is distributed South of Cape Point to St Helena Bay. There has been no reported effort within the concession areas between the years 2000 and 2012 (see Figure 4-19).

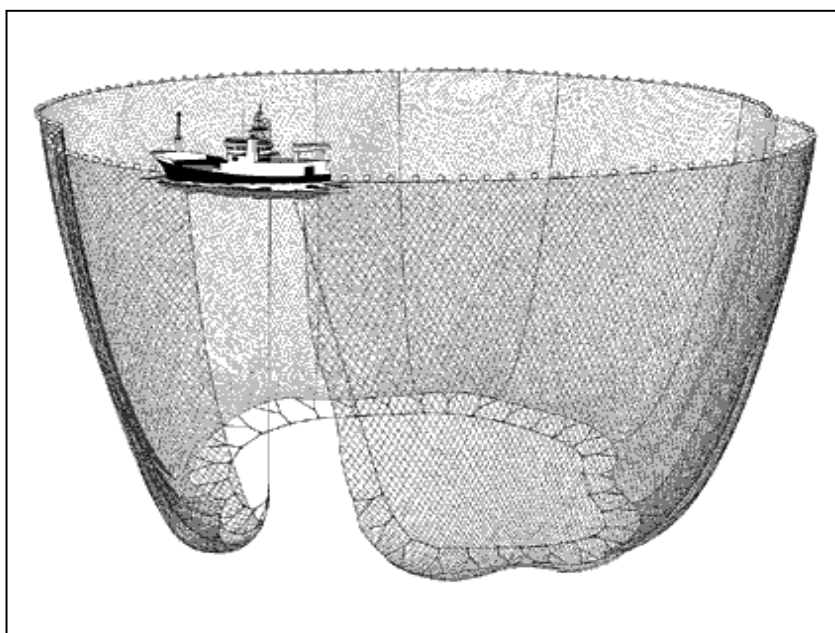


Figure 4-18: Pelagic purse-seine gear configuration.

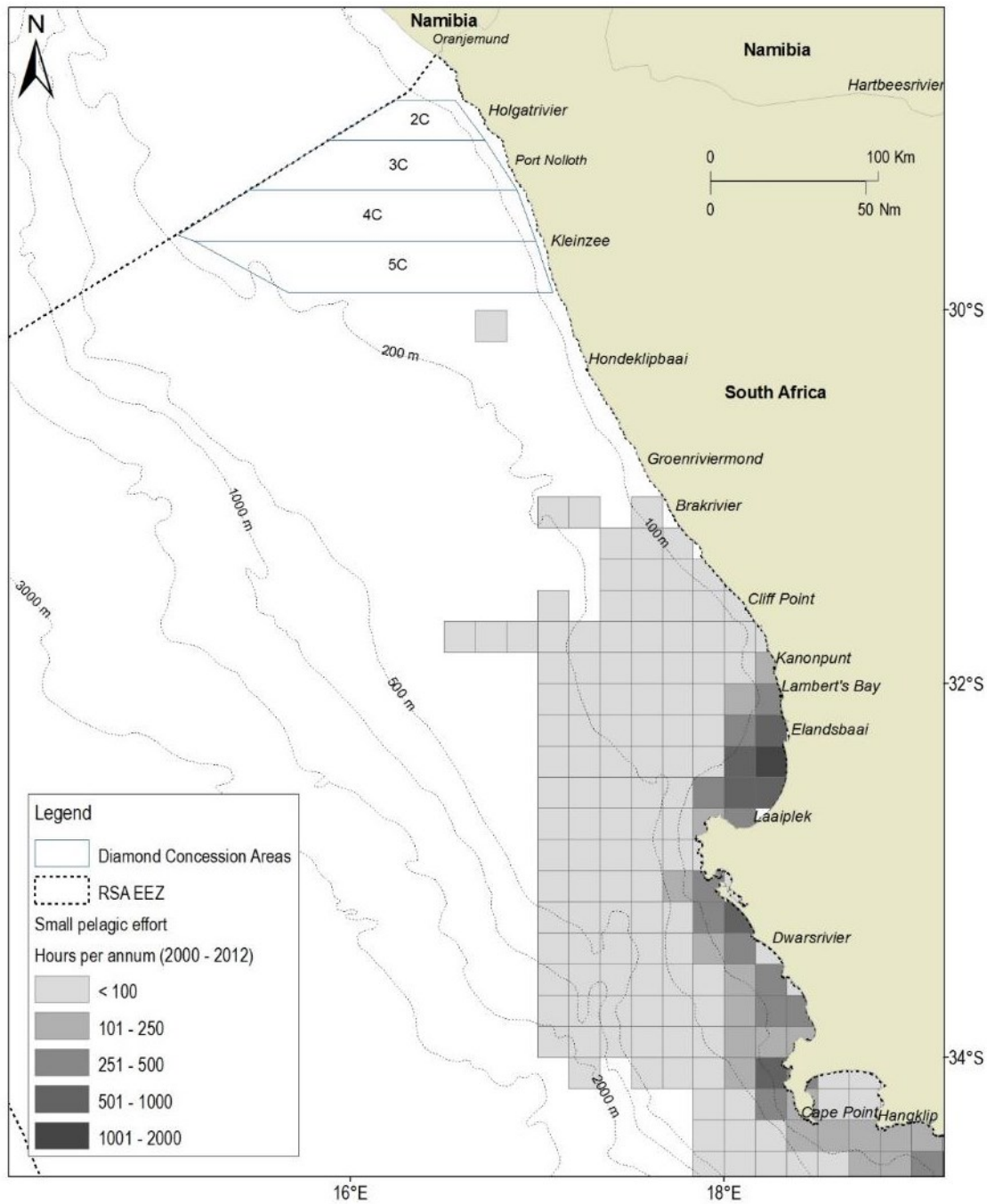


Figure 4-19: Spatial distribution of effort reported by the South African small pelagic purse-seine fishery (2000 – 2012) in relation to Concession Areas 2C – 5C.

4.1.4.1.8 West Coast Rock Lobster

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

Fishing grounds are divided into Zones stretching from the Orange River mouth to east of Cape Hangklip in the South-Eastern Cape. Effort is seasonal with boats operating from the shore and coastal harbours. Catch is managed using a TAC (80%), 20% of which is allocated to the offshore and inshore fisheries respectively. A total national landing of approximately 1 879 tons (whole weight) was recorded for 2012. Figure 4-20 shows the West Coast rock lobster catch between 1969 and 2012 in the various management zones in relation to the area of interest. Catches of rock lobster have declined systematically due to heavy fishing pressure and are currently estimated to be at only 3% of their pristine state.

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

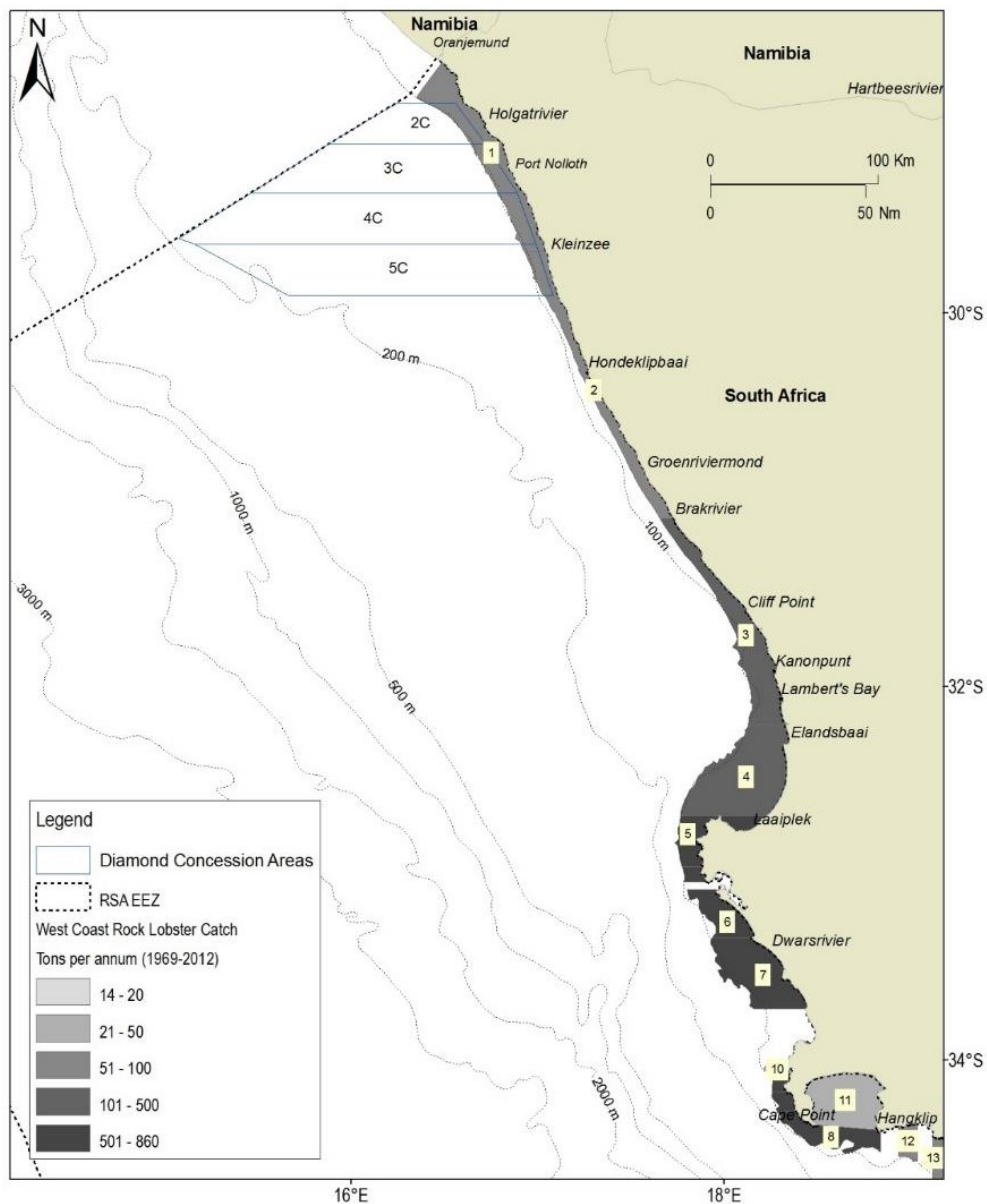


Figure 4-20: Spatial distribution of total catch (1969 – 2012) reported by the West Coast rock lobster fishery in relation to Concession Areas 2C – 5C. Management areas are labelled (1 – 13).

4.1.4.1.9 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 4-21). Approximately 120 trawls are conducted during each survey over a period of approximately one month.

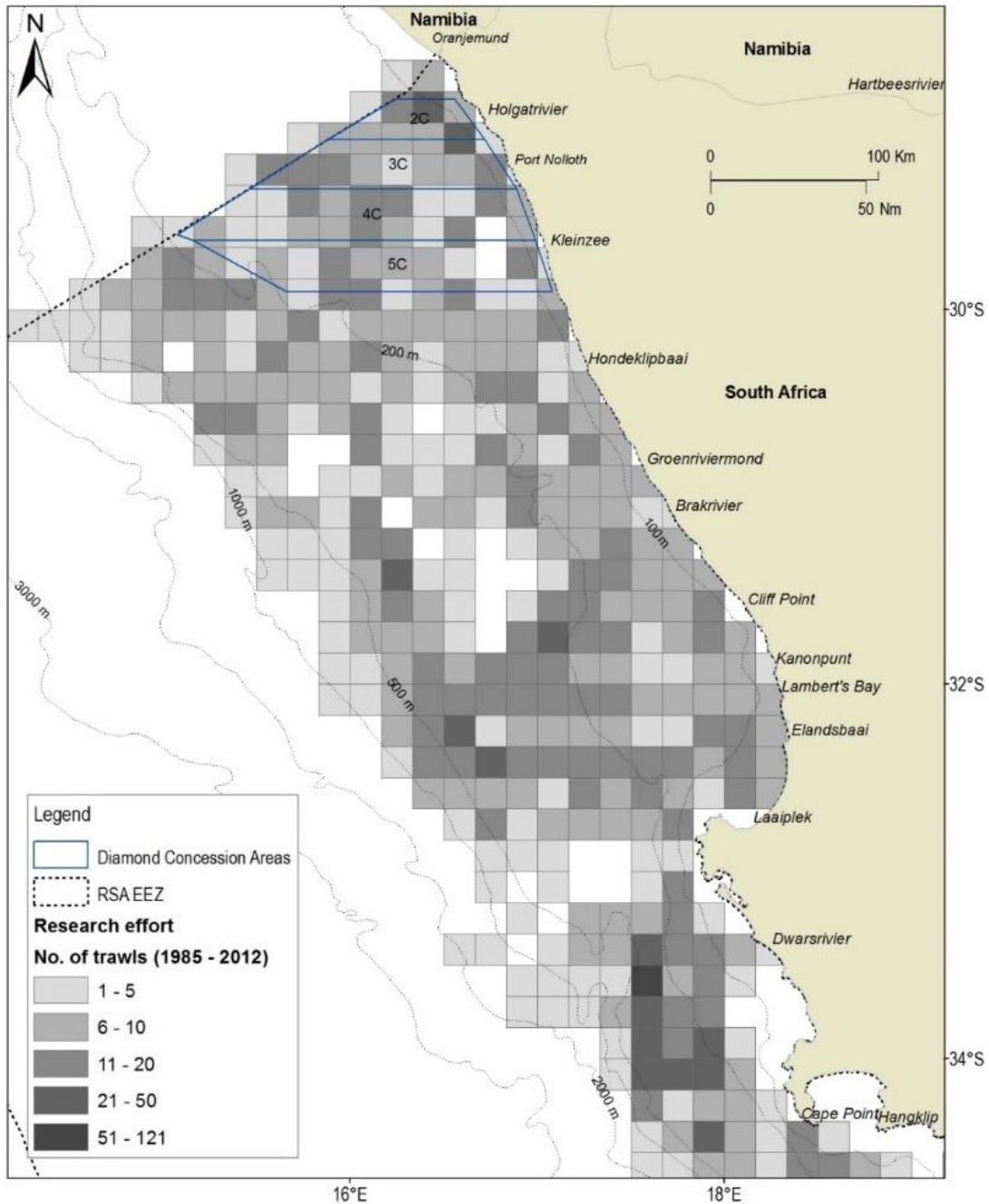


Figure 4-21: Spatial distribution of the number of demersal research trawls undertaken by DAFF in South African waters between 1985 and 2012 in relation to Concession Areas 2C – 5C.

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.

4.1.4.2 Shipping transport

The majority of shipping traffic is located on the outer edge of the continental shelf with traffic inshore of the continental shelf along the West Coast largely comprising fishing and mining vessels, especially between Kleinsee and Oranjemund (Figure 4-22). Chartered Traffic Separation Schemes, which are International Maritime Organisation (IMO) adapted, and other relevant information are listed in the South African Annual Notice to Mariners No 5. International shipping routes fall outside of the study area.

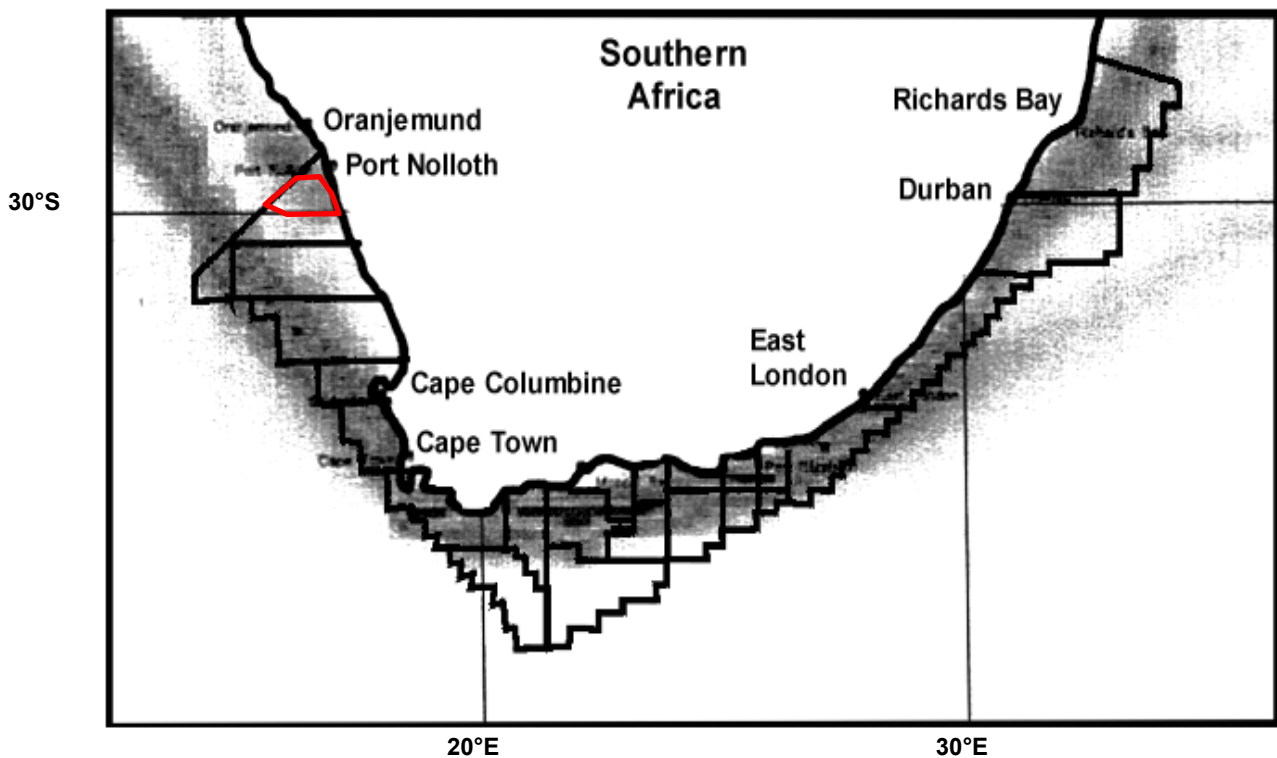


Figure 4-22: The major shipping routes along the west coast of South Africa showing petroleum license blocks (Data from the South African Centre for Oceanography). Approximate location of the concession areas is also shown.

4.1.4.3 Oil and Gas exploration and production

4.1.4.3.1 Exploration

The South African continental shelf and economic exclusion zone (EEZ) have similarly been partitioned into Licence blocks for petroleum exploration and production activities. Oil and gas exploration in the South African offshore commenced with seismic surveys in 1967. Since then numerous 2D and 3D seismic surveys have been undertaken on the west coast.

Approximately 40 exploration wells have been drilled since the 1960's. Prior to 1983, reliable technology was not available for removing wellheads from the seafloor. Since then, however, on completion of drilling operations, the well casing has been severed 3 m below the sea floor and removed from the seafloor together with the permanent and temporary guide bases. Of the approximately 40 wells drilled, 35 wellheads remain on the seafloor (Figure 4-23). Location and wellhead details are available from the Hydrographic office of the South African Navy (which issues the details to the public in a notice to mariners) or directly from PASA. Although no wells have recently been drilled in the area, further exploratory drilling is proposed for inshore and offshore portions of Block 1, with further target areas in Block 2B and the Orange Basin.

4.1.4.3.2 Development and 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 (which lies several hundred kilometres to the north-west off the coast of southern Namibia) have been identified for development. In this regard, a subsea pipeline to export gas from the iBhubesi field to a location either on the Cape Columbine peninsula or to Ankerlig approximately 25 km north of Cape Town is currently being proposed by Sunbird SA.

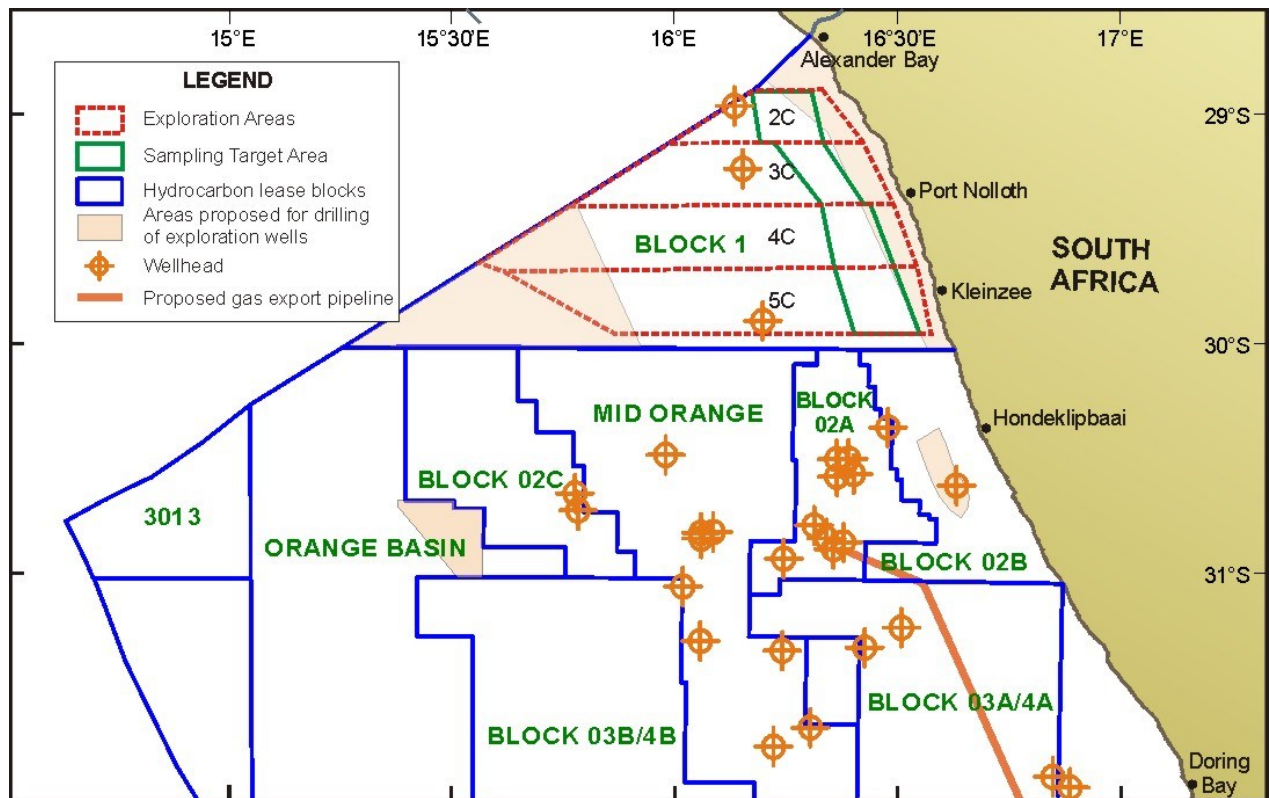


Figure 4-23: Location of hydrocarbon lease blocks, existing well heads, proposed areas for exploratory wells and the routing of the proposed iBhubesi gas export pipeline, in relation to Concession Areas 2C-5C.

4.1.4.4 Diamond prospecting and mining

The coastal area onshore of Concession Areas 2C-5C falls within the Alexkor, De Beers Namaqualand and TransHex coastal diamond mining areas and as public access is restricted, recreational activities along the coastline between Hondeklipbaai and Alexander Bay is limited to the area around Port Nolloth.

However, it is noted that there are camp sites open to the public north of Hondeklipbaai. De Beers previously undertook mining within the concession areas between 2007 – 2010 and currently undertake environmental monitoring surveys at various sites within the concession areas in order to assess benthic biodiversity recovery (refer to Figure 4-28).

The concessions lie adjacent to a number of marine diamond mining concession areas (see Figure 4-24). Neighbouring rights holders include Alexkor (1c and 4b) and Ocean Diamond Mining Holdings (2b, 3b, 5b, 6b and 6c). The marine diamond mining concession areas are split into four or five zones (Surf zone and (a) to (c) or (d)-concessions), which together extend from the high water mark out to approximately 500 m depth (Figure 4-25). The (b)-(c) boundary varies from 3 km to over 7 km from the high water mark.

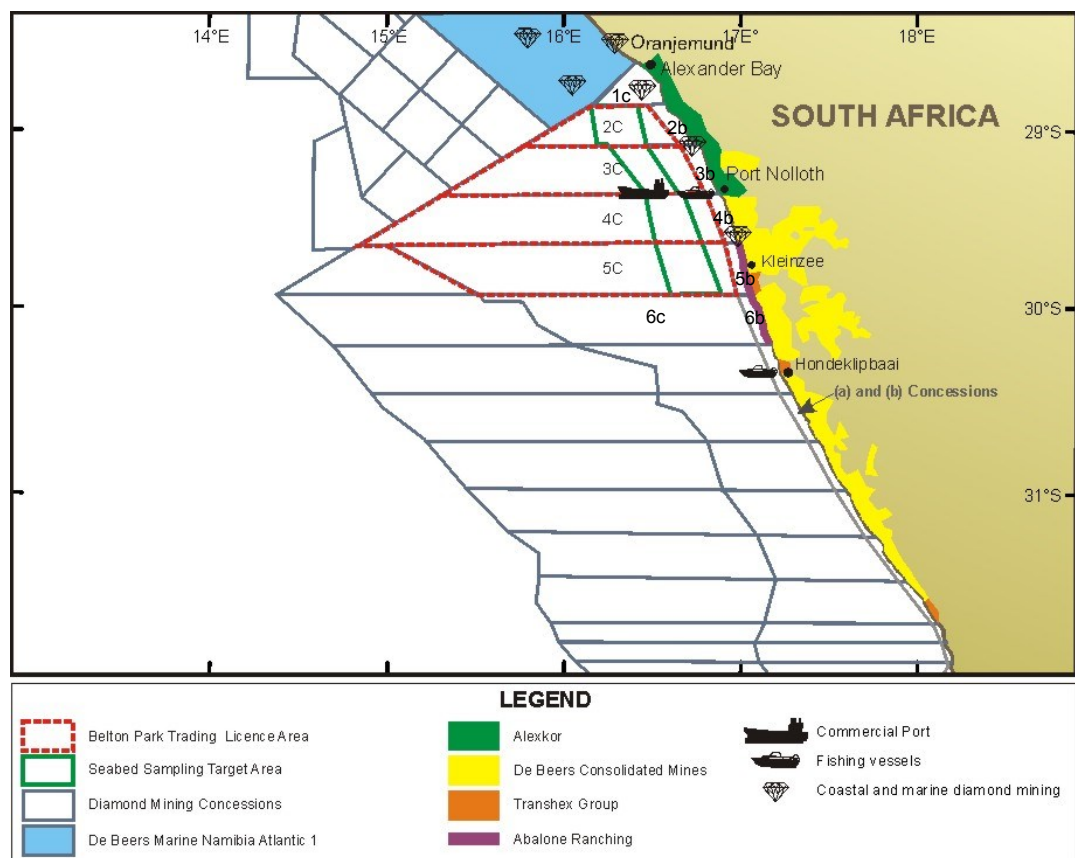


Figure 4-24: Location of Concession Areas 2C-5C in relation to marine diamond mining concessions and ports for commercial and fishing vessels and the proposed sampling target area.

On the Namaqualand coast marine diamond mining activity is primarily restricted to the surf-zone and (a)-concessions. Nearshore shallow-water mining is typically conducted by divers using small-scale suction hoses operating either directly from the shore or from converted fishing vessels out to approximately 20 m depth. Diver-assisted mining is largely exploratory and highly opportunistic in nature, being dependent on suitable, calm sea conditions. The typically exposed and wave-dominated nature of the Namaqualand coast effectively limits the periods in which mining can take place to a few days per month. As shore-based divers cannot excavate a gravel depth much more than 0.5 m, mining rates are low, approximately 35 m² worked by each contractor per year. Because of the tidal cycle and limitations imposed by sea conditions, such classifiers usually operate for less than 4 hours per day for an average of 5-6 days per month, although longer periods may be feasible in certain protected areas. However, with reference to the

Alexkor 2013 Annual Report, it is noted that the number of days had declined from 79 in 2003 to eight in 2012 and 23 in 2013.

Vessel-based diver-mining contractors usually work in the depth range immediately seaward of that exploited by shore-based divers, targeting gullies and potholes in the sub-tidal area just behind the surf-zone. A typical boat-based operation consists of a 10 - 15 m vessel, with the duration of their activities limited to daylight hours for 3 - 10 diving days per month. Estimated mining rates for vessel-based operations range from 300 m² – 1 000 m²/year. However, over the past few years there has been a substantial decline in small-scale diamond mining operations due to the global recession and depressed diamond prices, although some vessels do still operate out of Alexander Bay and Port Nolloth.

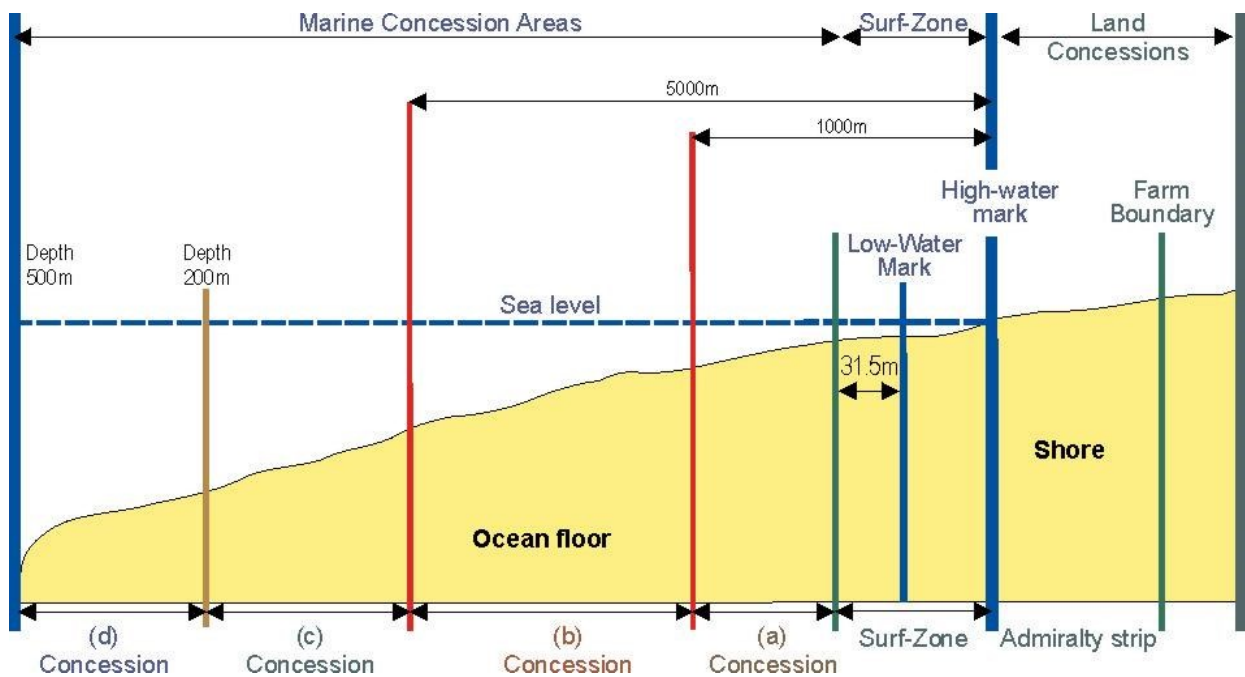


Figure 4-25: Diagram of the onshore and offshore boundaries of the South African (a) to (d) marine diamond mining concession areas.

No deep-water (exceeding 100m water depth) diamond mining is currently being undertaken in the South African offshore concession areas, since mining activities in De Beers Marine’s Mining Licence (SASA MPT 25/2011) ceased in 2010. In Namibian waters, to the north and adjacent to Concession 2C, deep-water diamond mining by De Beers Marine Namibia is currently operational in the Mining Licence Area ML47 (known as Atlantic I).

These mining operations are typically conducted to water depths of up to 150 m from fully self-contained mining vessels with on board processing facilities, using either large-diameter drill or seabed crawler technology. The vessels operate as semi-mobile mining platforms, anchored by a dynamic positioning system, commonly on a three to four anchor spread. Computer-controlled positioning winches enable the vessels to locate themselves precisely over a mining block of up to 400 m x 400 m. These mining vessels thus have limited manoeuvrability and other vessels should remain at a safe distance.

4.1.4.5 Prospecting and mining of other minerals

4.1.4.5.1 Heavy minerals

Heavy mineral sands containing, amongst other minerals, zircon, ilmenite, garnet and rutile may be found offshore of the West Coast. Although a literature search has not identified any published studies that detail the distribution of heavy minerals offshore, concentrations are known to exist onshore. Tronox's Namakwa Sands is currently exploiting heavy minerals from onshore deposits near Brand-se-Baai (approximately 385 km north of Cape Town).

De Beers Consolidated Mines (Pty) Ltd also holds overlapping Prospecting Rights for heavy minerals, gold platinum group elements and sapphire within concession areas 2c-5c.

4.1.4.5.2 Glauconite and phosphate

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

Prospecting permits for glauconite and phosphorite have been applied for three offshore areas between Cape Town and Saldanha. The co-ordinates of such prospecting is shown in Figure 4-26 and Table 4-6. On technical and economic grounds glauconite and phosphate are not being considered for mining at present.

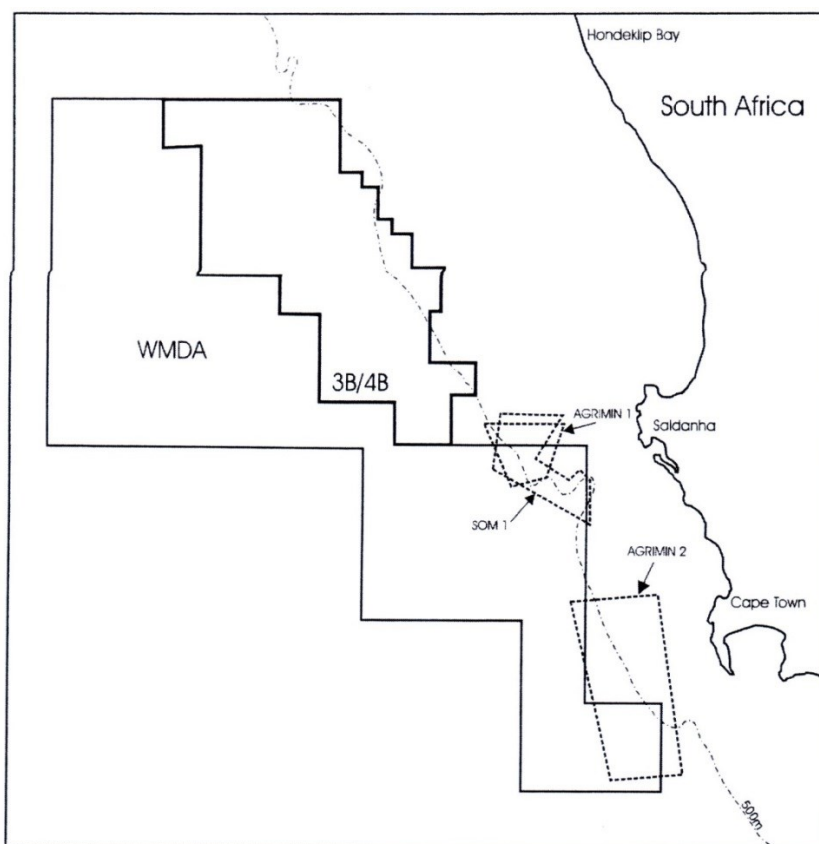


Figure 4-26: Location of glauconite and phosphorite prospecting areas (Agrimin1, Agrimin2 and SOM1).

Table 4-6: Limits of prospecting blocks for glauconite and phosphorite within the West Coast region. In each case the block is a polygon of points labelled A, B, C, D, etc.

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

4.1.4.5.3 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. 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.

4.1.4.6 Other

4.1.4.6.1 Anthropogenic marine hazards

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

4.1.4.6.2 Undersea cables

There are a number of submarine telecommunications cable systems across the Atlantic and the Indian Ocean (see Figure 4-27), 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.

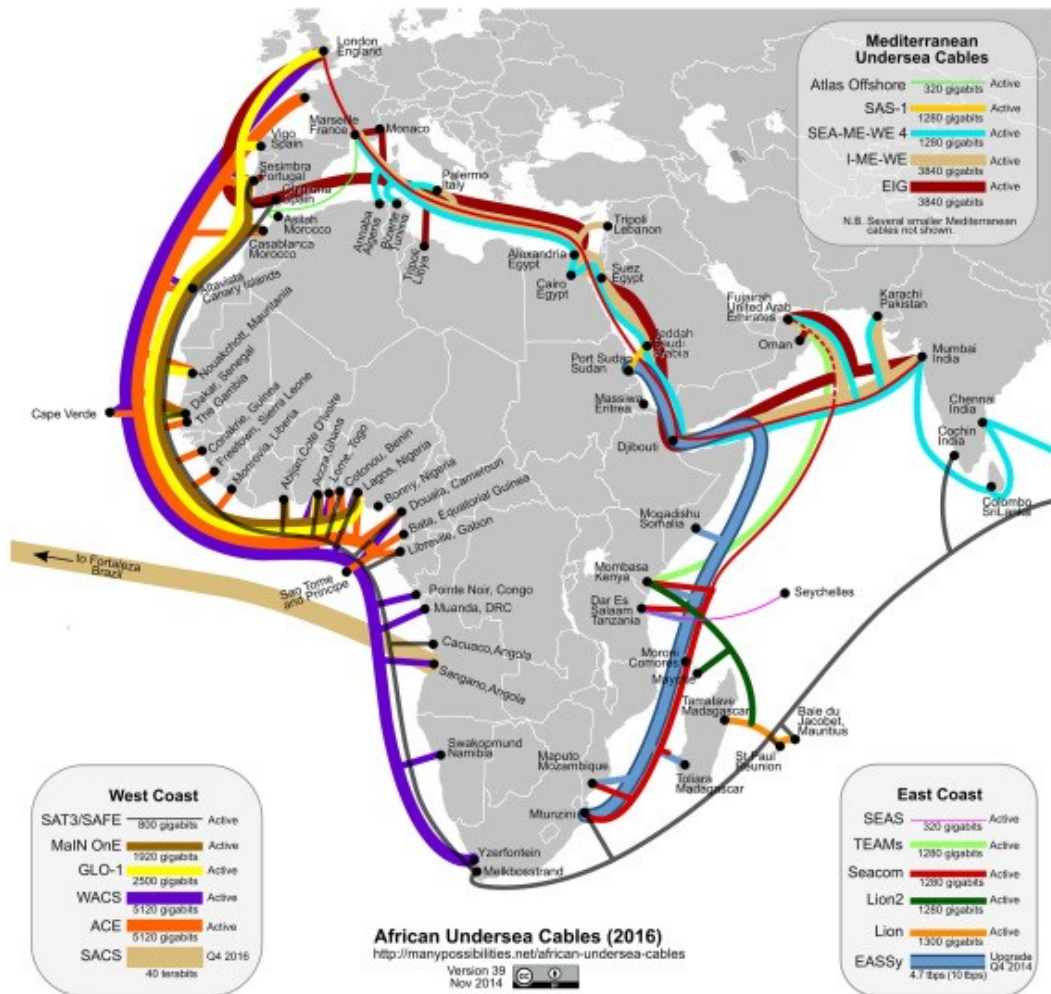


Figure 4-27: Configuration of the current African undersea cable systems, November 2014 (From <http://www.manypossibilities.net>).

4.1.4.6.3 Archaeological sites

As the West Coast contains a wealth of shell middens, cave deposits, historical artefacts, palaeontological sites and shipwrecks close to the shore, the occurrence of such sites further offshore cannot be excluded.

(a) Palaeontological sites

Stevenson & Bamford (2003) describe an abundance of in-situ fossilised yellowwood tree trunks in an approximate 2 km² area of seabed outcrop in 136-140 m depth, about 32 km offshore in concession area 4C. The fossilized wood and accompanying cold water coral colonies are considered vulnerable to any activities that could impact on the seabed (FAO 2006; Rogers et al. 2008; FAO 2009; Sink et al. 2012a,b). In addition there are other sites where fossilised yellowwood has been observed within concession area 5C (see Figure 4-28).

Following the application of the Conservation on Biological Diversity's (CBD) Ecologically or Biologically Significant Marine Areas (EBSA) criteria, the area (referred to as the Namaqua Fossil Forest) was identified as unique, and presented at the CBD Southeast Atlantic Ocean regional workshop for consideration as an EBSA warranting formal conservation (Sink & Kirkman 2013).

(b) Shipwrecks

Over 2 000 shipwrecks are present along the South African coastline. The majority of known wrecks along the West Coast are located in relatively shallow water close inshore (within the 100 m isobath) Wrecks older than 60 years old have National Monument status.

Possible wrecks most likely to be encountered during the proposed marine sediment sampling are those most likely to fall outside of known shallow water wreck events. The majority of the wrecks found within the concession areas sunk in the 19th century, a golden age for shipping around the South African coast. It is however noted that the precise location of all these wrecks is unknown as they have been documented only through survivor accounts, archival descriptions and eyewitness reports recorded in archives and databases. Six potential wreck sites have been identified as significant by the maritime and underwater cultural heritage specialist and are outlined in Table 4-7 below.

Table 4-7: Shipwrecks potentially located within Concession Areas 2C - 5C

Vessel Name	Date	Comment
St James	1586 or 1856	The shipwreck database of the South African Heritage Resources Agency lists the St James as a potential site within the concession areas. The ship is listed as being wrecked at an unknown location in 1586, making it potentially the oldest wreck in the search area. The date, however, may have been incorrectly entered into the database and the vessel may have been wrecked in 1856.
Edward Bonaventure	1591	The earliest known shipwreck that may lie within the concession areas is a Portuguese caravel, the Edward Bonaventure (1591). There are indications that it was captured by the Spanish prior to wrecking.
Nossa Senhora da Boa Viagem	1639	The Nossa Senhora da Boa Viagem (1639) was one of two small ships built from the timbers of the Nossa Senhora da Belem (1635), wrecked on the Transkei coast. Survivors of the wreck were attempting to reach the Portuguese outposts in Angola. After leaving the coast somewhere near the Umzimvubu River, the ship disappeared. The construction of this vessel by shipwreck survivors with little shipbuilding experience makes it unique.
Prins Wilhelm van Zeeland	1659	A Dutch vessel, Prins Wilhelm van Zeeland was wrecked off the South African coast in 1659.
Unknown American barque	1790	An unknown American barque wrecked in 1790 is one of the earlier examples of American vessels in South African waters.
Sea Bride	1863	Although a relatively late wreck, the Sea Bride has been deemed significant because of its association with the CSS Alabama. The Sea Bride was captured by the Confederate ship in 1863.

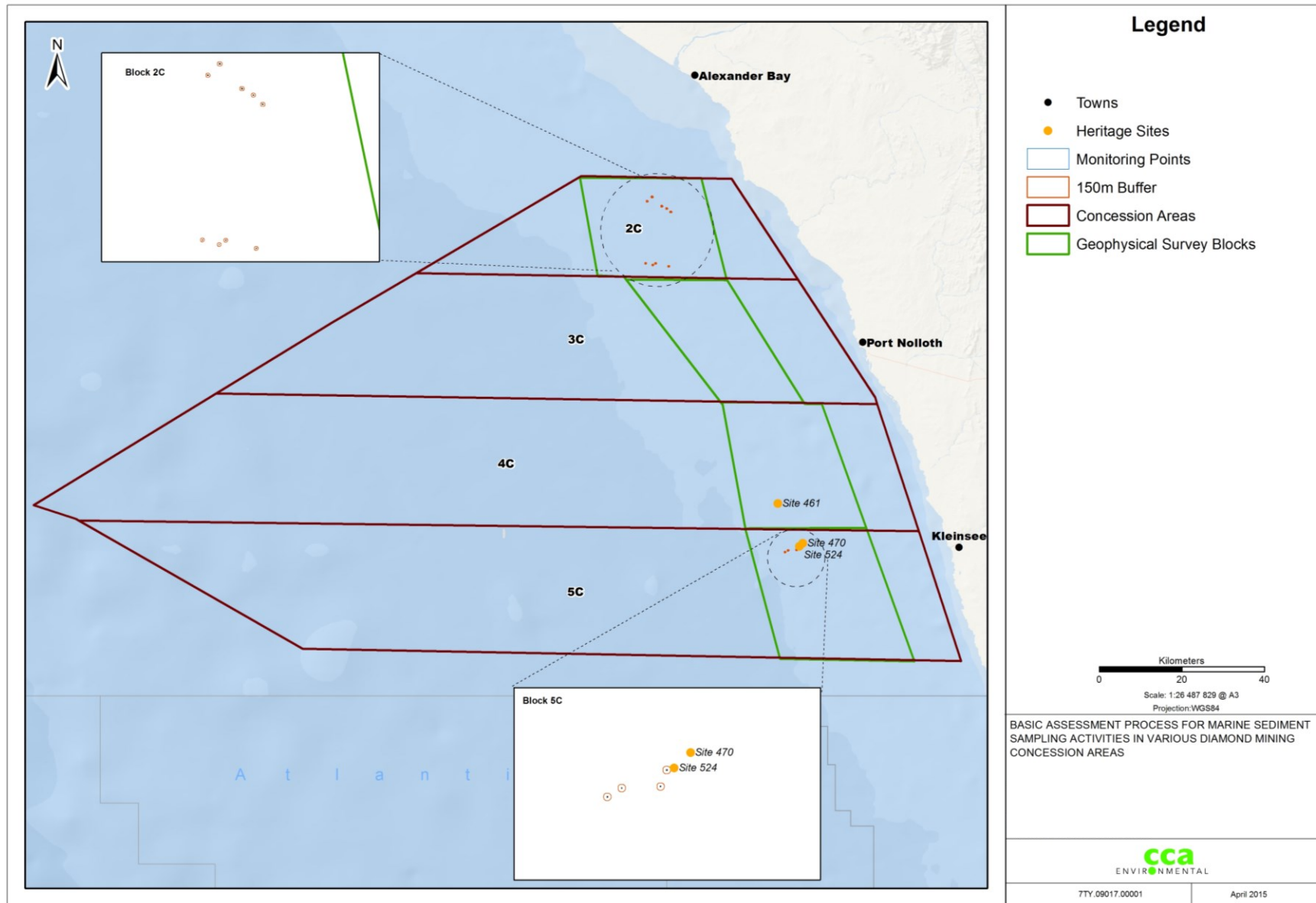


Figure 4-28: De Beers monitoring points and identified fossilised yellowwood sites within concession areas.

4.1.4.6.4 Ammunition dump sites

Details of ammunition dumped at the ammunition dumpsites on the West Coast are given on the respective SAN charts.

4.2 MARINE PROTECTED AREAS

4.2.1 CONSERVATION AREAS AND MARINE PROTECTED AREAS

Numerous conservation areas and a marine protected area (MPA) exist along the coastline of the Western Cape, although none fall directly within the proposed exploration drilling area. The only conservation area overlapping with Concession Areas 2C-5C in which restrictions apply is the McDougall's Bay rock lobster sanctuary near Port Nolloth, which is closed to commercial exploitation of rock lobsters (Figure 4-7).

Using biodiversity data mapped for the 2004 and 2011 National Biodiversity Assessments a systematic biodiversity plan has been developed for the West Coast with the objective of identifying coastal and offshore priority focus areas for MPA expansion (Sink *et al.* 2011; Majiedt *et al.* 2013). Potentially vulnerable marine ecosystems (VMEs) that were explicitly considered during the planning included the shelf break, seamounts, submarine canyons, hard grounds, submarine banks, deep reefs and cold water coral reefs. The biodiversity data were used to identify nine focus areas for protection on the West Coast between Cape Agulhas and the South African – Namibian border. Those within the broad project area are shown in Figure 4-7. The “North of Kleinzee” inshore priority area overlaps with the inshore portions of concession areas 4C and 5C, with the western extreme of the priority area extending into the area proposed for seabed sampling.

The Orange River Mouth wetland located in the north of concession area 2C provides an important habitat for large numbers of a great diversity of wetland birds and is listed as a Global Important Bird Area (IBA) (ZA023/NA 019) (BirdLife International 2005). The area was designated a Ramsar site in June 1991, and processes are underway to declare a jointly-managed transboundary Ramsar reserve. Further IBAs south of the project area include the Olifants River Estuary (ZA078), Verlorenvlei (ZA082), the Lower Berg River wetlands (ZA083) and the West Coast National Park and Saldanha Bay Islands (ZA 084). All of these are located well to the south of the area proposed for seabed sampling.

4.2.2 THREAT STATUS AND VULNERABLE MARINE ECOSYSTEMS

‘No-take’² MPAs offering protection of the Namaqua biozones (sub-photic, deep-photic, shallow-photic, intertidal and supratidal zones) are absent northwards from Cape Columbine (Emanuel *et al.* 1992, Lombard *et al.* 2004). Rocky shore and sandy beach habitats are generally not particularly sensitive to disturbance and natural recovery occurs within 2-5 years. However, much of the Namaqualand coastline has been subjected to decades of disturbance by shore-based diamond mining operations (Penney *et al.* 2007). These cumulative impacts and the lack of biodiversity protection has resulted in most of the coastal habitat types in Namaqualand being assigned a threat status of ‘critically endangered’ (Lombard *et al.* 2004; Sink *et al.* 2012) (Table 4-8). Using the SANBI benthic and coastal habitat type GIS database (Figure 4-29), the threat status of the benthic habitats within concession areas 2C-5C, and those potentially affected by proposed seabed sampling, were identified (Table 4-8).

² *no-take* means that extraction of any resources is prohibited.

Of the biodiversity focus areas, the “North of Kleinzee” area makes a major contribution to the potential protection of six habitat types, all of which are also present in the Proposed Namaqua MPA. Within the area the Namaqua Mixed Shore is ‘Endangered’, while the Namaqua Sandy Inshore and Namaqua Sheltered Rocky Coast are both considered ‘Critically Endangered’. These areas, however, all lie well inshore of the area proposed for seabed sampling.

The “Namibian Border” area, which lies offshore of the concession areas 2C-5C s, makes considerable contribution to targets for three habitat types including the ‘Critically Endangered’ Southern Benguela Hard Shelf habitat type. This area represents one of the few places along the shelf edge where threatened habitat types are in a good condition thus making habitat condition a major driver of selection (Majiedt et al. 2013).

Childs Bank is considered a potential VME, and the majority of the area still boasts comparatively good habitat condition. This biodiversity focus area makes significant contributions to five habitat targets, including the ‘Critically Endangered’ Southern Benguela Hard Shelf Edge and the ‘Vulnerable’ Southern Benguela Sandy Shelf Edge (Majiedt et al. 2013).

The Draft Basic Assessment Report identified the proposed Namaqualand MPA as an area of principal importance in the general project area. However, it is now understood that the Namaqualand MPA is no longer proposed. Instead the South African National Biodiversity Institute (SANBI) is in the process of developing an updated network of offshore MPAs as part of Operation Phakisa. The proposed Namaqua Fossil MPA forms part of this proposed offshore MPA network.

The area presently under consideration for the proposed Namaqua Fossil MPA is located around the identified Namaqua Fossil Forest ESBA (see Section 4.1.4.6.3). It is noted that the proposed MPA network has not yet been gazetted and is still subject to public consultation. Thus, the delineated boundaries for the proposed Namaqua Fossil MPA may still be subject to change prior to being formally proclaimed.

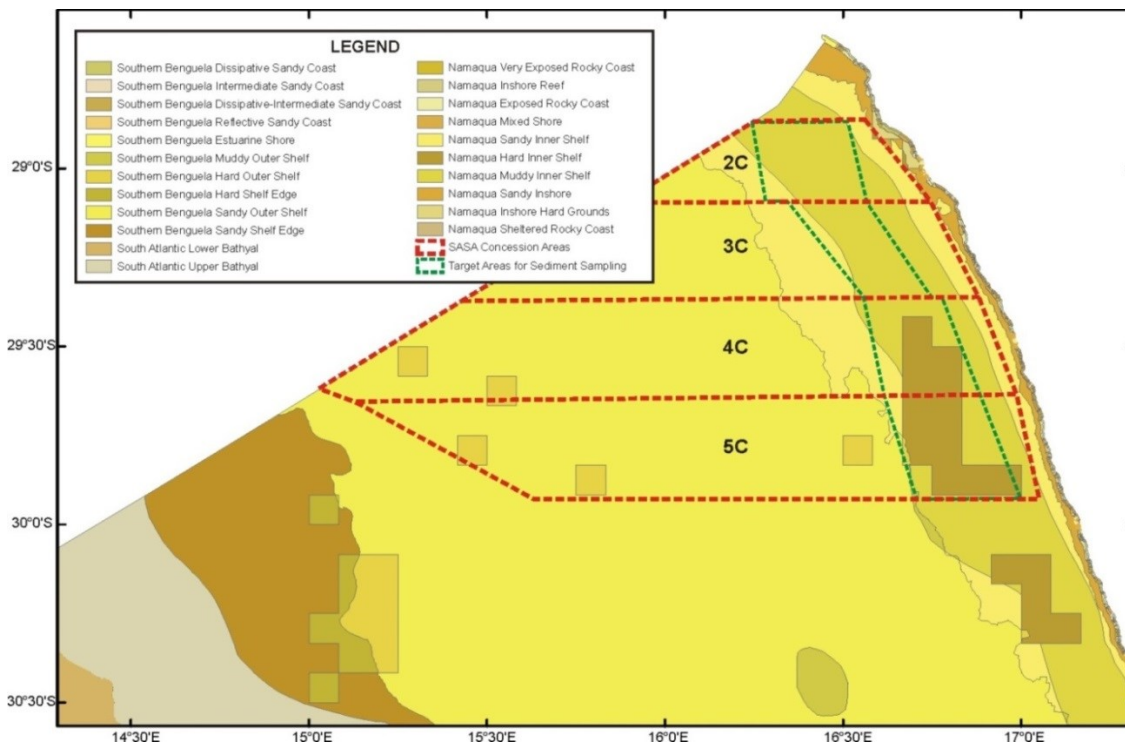


Figure 4-29: Benthic and coastal habitat types in Concession Areas 2C-5C.

Table 4-8: Ecosystem threat status for marine and coastal habitat types in Concessions 2C-5C (adapted from Sink *et al.* 2011). Those habitats potentially affected by the proposed seabed sampling are shaded.

Habitat Type	Threat Status
Namaqua Sandy Inshore	Critically Endangered
Namaqua Hard Inner Shelf	Least Threatened
Namaqua Muddy Inner Shelf	Least Threatened
Namaqua Sandy Inner Shelf	Least Threatened
Southern Benguela Hard Outer Shelf	Vulnerable
Southern Benguela Muddy Outer Shelf	Least Threatened
Southern Benguela Sandy Outer Shelf	Least Threatened

4.2.3 DEVELOPMENT POTENTIAL OF THE MARINE ENVIRONMENT IN THE PROJECT AREA

The economy of the Namaqualand region is dominated by mining. However, with the decline in the mining industry and the closure of many of the coastal mines, the economy of the region is declining and jobs are being lost with potential devastating socio-economic impacts on the region. The Northern Cape provincial government has recognized the need to investigate alternative economic activities to reduce the impact of minerals downscaling and has commissioned a series of baseline studies of the regional economy (Britz & Hecht 1997, Britz *et al.* 1999, 2000, Mather 1999). These assessments concluded that fishing and specifically mariculture offer a significant opportunity for long term (10+ years) sustainable economic development along the Namaqualand coast. The major opportunities cited in these studies include hake and lobster fishing (although the current trend in quota reduction is likely to limit development potentials), seaweed harvesting and aquaculture of abalone, seaweeds, oysters and finfish. The Northern Cape provincial government is facilitating the development of the fishing and mariculture sectors by means of a holistic sector planning approach and has in partnership with a representative community and industry based Fishing and Mariculture Development Association (FAMDA), developed the Northern Cape Province Fishing and Mariculture Sector Plan. This plan forms part of the 'Northern Cape - Fishing and Mariculture Sector Development Strategy' (www.northern-cape.gov.za, accessed December 2013) whereby implementation of the plan will be coordinated and driven by FAMDA.

Abalone ranching (i.e. the release of abalone seeds into the wild for harvesting purposes after a growth period) has been identified as one of the key opportunities to develop in the short- to medium-term and consequently the creation of abalone ranching enterprises around Hondeklip Bay and Port Nolloth forms part of the sector plan's development targets (www.northern-cape.gov.za). In the past, experimental abalone ranching concessions have been granted to Port Nolloth Sea Farms (PNSF) in sea mining areas 5 and 6, a 60-km strip of coastline, and to Ritztrade in the Port Nolloth area (www.northern-cape.co.za).

These experimental operations have shown that although abalone survival is highly variable depending on the site characteristics and sea conditions, abalone ranching on the Namaqualand coast has the potential for a lucrative commercial business venture (Sweijd *et al.* 1998, de Waal 2004). As a result, the government publication 'Guidelines and potential areas for marine ranching and stock enhancement of abalone *Haliotis midae* in South Africa' (GG No. 33470, Schedule 2, April 2010) identified broad areas along the South African coastline that might be suitable for abalone ranching. Along the Northern Cape coast, four specific zones were marked, separated by 6-13 km wide buffer zones. Currently, applications for abalone ranching projects have been submitted and permits for pilot projects for some of the zones have been granted. The proposed development site for the desalination plant and marine infrastructure is approximately 50-60 km south of the southern-most ranching zone in the Northern Cape.

Besides abalone sea-ranching, several other potential projects were identified in the sector plan. Most of these are land-based aquaculture projects (e.g. abalone and oyster hatcheries in Port Nolloth and abalone grow-out facility in Hondeklip Bay), but included was a pilot project to harvest natural populations of mussels and limpets in the intertidal coastal zone along the entire Northern Cape coast. The objective of the project was to determine the stock levels and to ascertain what percentage of the biomass of each species can be sustainably harvested, as well as the economic viability of harvesting the resource.