4. DESCRIPTION OF THE OFFSHORE MARINE ENVIRONMENT

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

4.1 METEOROLOGY

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

The prevailing winds in the Benguela region are controlled by the South Atlantic subtropical anticyclone, the eastward moving mid-latitude cyclones south of southern Africa and the seasonal atmospheric pressure field over the subcontinent.

The strongest winds occur during the summer (October to March) (CSIR 2006). Virtually all winds in summer come from the south to south-southeast (see Figure 4.1), strongly dominated by southerlies which occur over 40% of the time, averaging 20 - 30 knots (kts) and reaching speeds in excess of 60 kts (100 km/h). South-easterlies are almost as common, blowing about one-third of the time and also averaging 20 - 30 kts. The combination of these southerly and south-easterly winds drive the massive offshore movement of surface water, resulting in strong upwelling of nutrient-rich bottom waters, which characterise this region in summer.

Winter remains dominated by southerly to south-easterly winds, but the closer proximity of the winter cold-front systems results in a significant south-westerly to north-westerly component (see Figure 4.1). This ‘reversal’ from the summer condition results in cessation of upwelling, movement of warmer mid-Atlantic water shorewards and breakdown of the strong thermoclines which typically develop in summer. There are also more calms in winter, occurring about 3% of the time, and wind speeds generally do not reach the maximum speeds of summer. However, the westerly winds blow in synchrony with the prevailing south-westerly swell direction, resulting in heavier swell conditions in winter.

Another 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 29 knots). At times, such winds may blow along a large proportion of the West Coast north of Cape Point and can be intensified by local topography. Aeolian transport of fine sand and dust may occur up to 150 km offshore.

4.2 PHYSICAL OCEANOGRAPHY

4.2.1 BATHYMETRY AND 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-northwest trend, widening north of Cape Columbine and reaching its widest (180 km) off the Orange River. The nature of the shelf break varies off the West Coast of South Africa. 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 immediate nearshore area consists mainly of a narrow (about 8 km wide) rugged rocky zone and slopes steeply seawards to a depth of around 80 m. The middle and outer shelf normally lacks relief and slopes gently seawards reaching the shelf break at a depth of approximately 300 m.

Banks on the continental shelf include the Orange Bank (Shelf or Cone), 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, and approximately 75 km due west of the Ibhubesi Gas Field (see Figure 4.2). Child's Bank is the only known submarine bank within South Africa's Exclusive Economic Zone (EEZ), rising from a depth of 350 - 400 m water to less than 200 m at its shallowest point. The bank area has been estimated to cover some 1 450 km^2 (Sink *et al*. 2012).

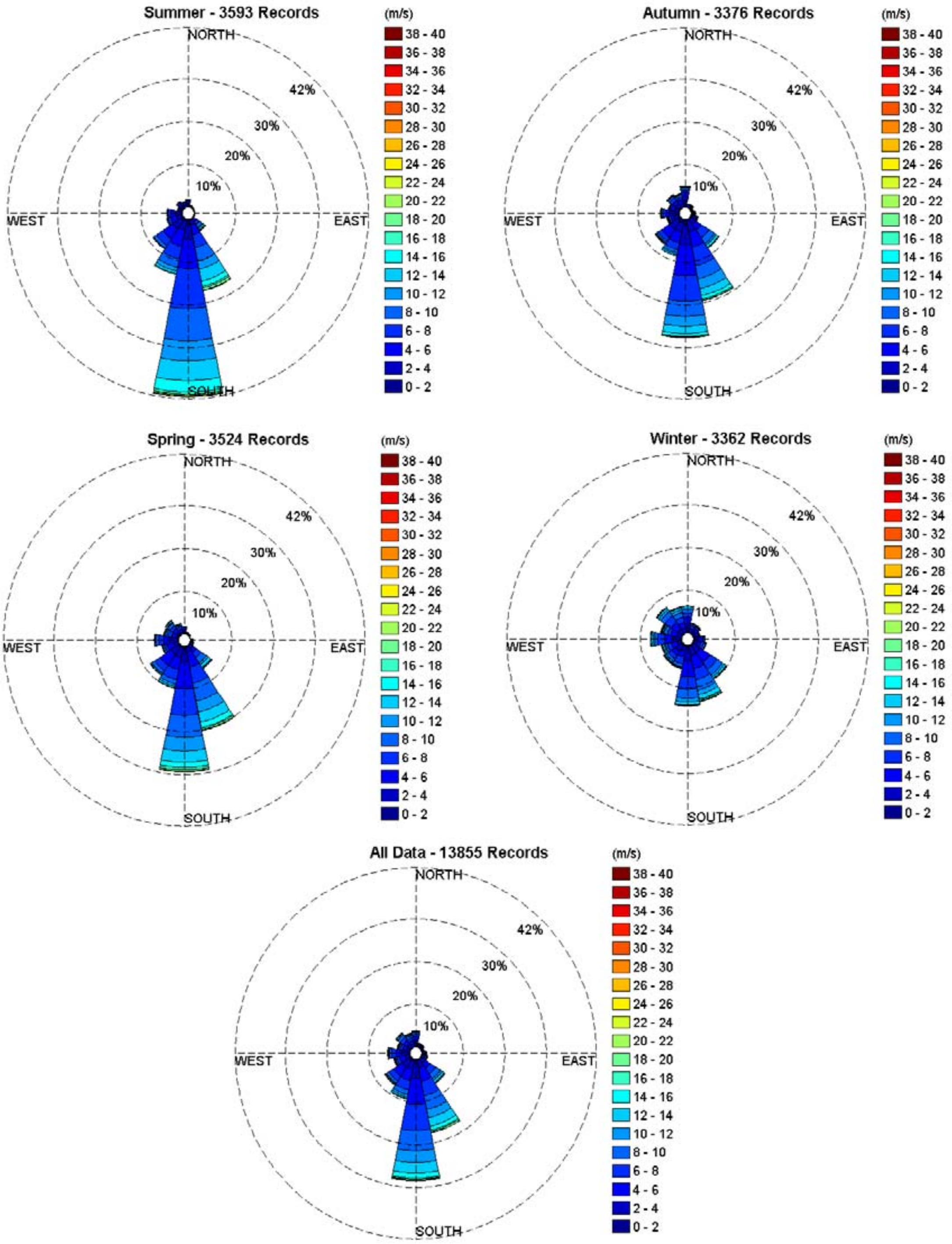


Figure 4.1: VOS Wind Speed vs Wind Direction data for the Cape Columbine area 32.0 to 32.9 S and 17.0 to 17.9 E (1903-11-01 to 2011-05-24; 13 855 records) (from CSIR).

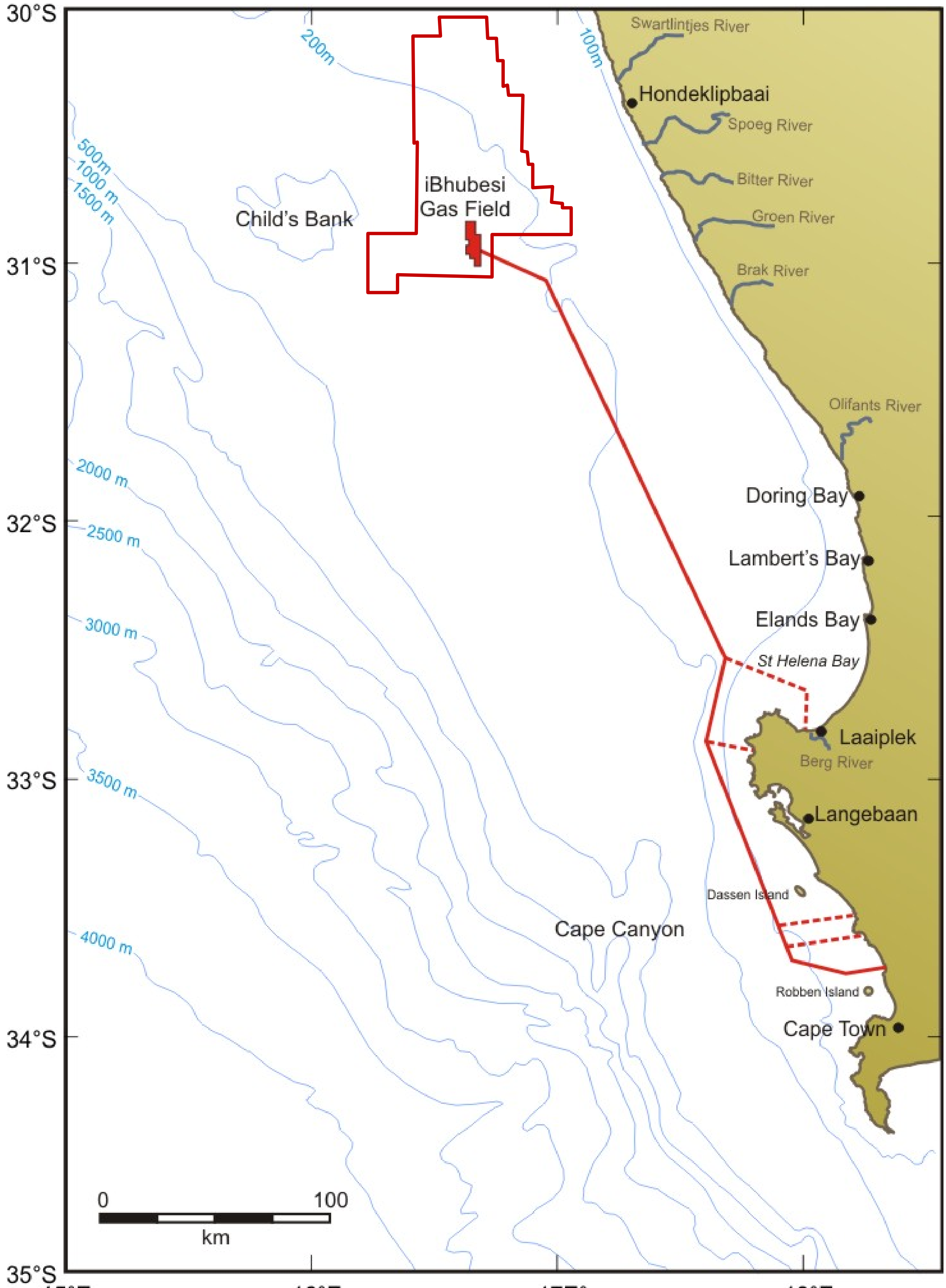


Figure 4.2: **Ibhubesi Gas Field and proposed production pipeline route alternatives in relation to bathymetry and seabed features off the West Coast.**

4.2.2 WAVES AND TIDES

Most of the West Coast of southern Africa is exposed and experiences strong wave action, rated 13 to 17 on the 20 point exposure scale (McLachlan 1980). It is impacted by heavy south-westerly swells generated in the roaring forties, as well as significant sea waves generated locally by the prevailing moderate to strong southerly winds. 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 and south-southwest direction. Winter swells are strongly dominated by those from south and south-southwest, which occur almost 80% of the time, and typically exceed 2 m in height, averaging about 3 m, and often attaining over 5 m. With wind speeds capable of reaching 100 km/h during heavy winter south-westerly storms, winter swell heights can exceed 10 m.

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

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

4.2.3 WATER CIRCULATION AND COASTAL CURRENTS

Water circulation off the West Coast is dominated by upwelling (see Section 4.2.4).

The ocean currents occurring off the West Coast are complex and are summarised in Figure 4.3. Data suggests that currents north of Cape Columbine are weaker and more variable than the currents to the south (Boyd *et al*. 1992). The most important is the Benguela current, which constitutes a broad, shallow and slow NW flow along the West Coast between the cool coastal upwelled waters and warmer Central Atlantic surface waters further offshore. The current is driven by the moderate to strong south to south-east winds which are characteristic of the region and is most prevalent at the surface, although it does follow the major seafloor topographic features (Nelson and Hutchings 1983). Current velocities in continental shelf areas generally range between 10–30 cm/s (Boyd & Oberholster 1994). Shelf edge jet currents exist off both Cape Columbine (Nelson and Hutchings 1983) and the Cape Peninsula (Shillington 1998), where flow is locally more intense (up to 50 cm/s off Cape Columbine and 70 cm/s off the Cape Peninsula). In the south the Benguela current has a width of 200 km, widening rapidly northwards to 750 km.

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

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

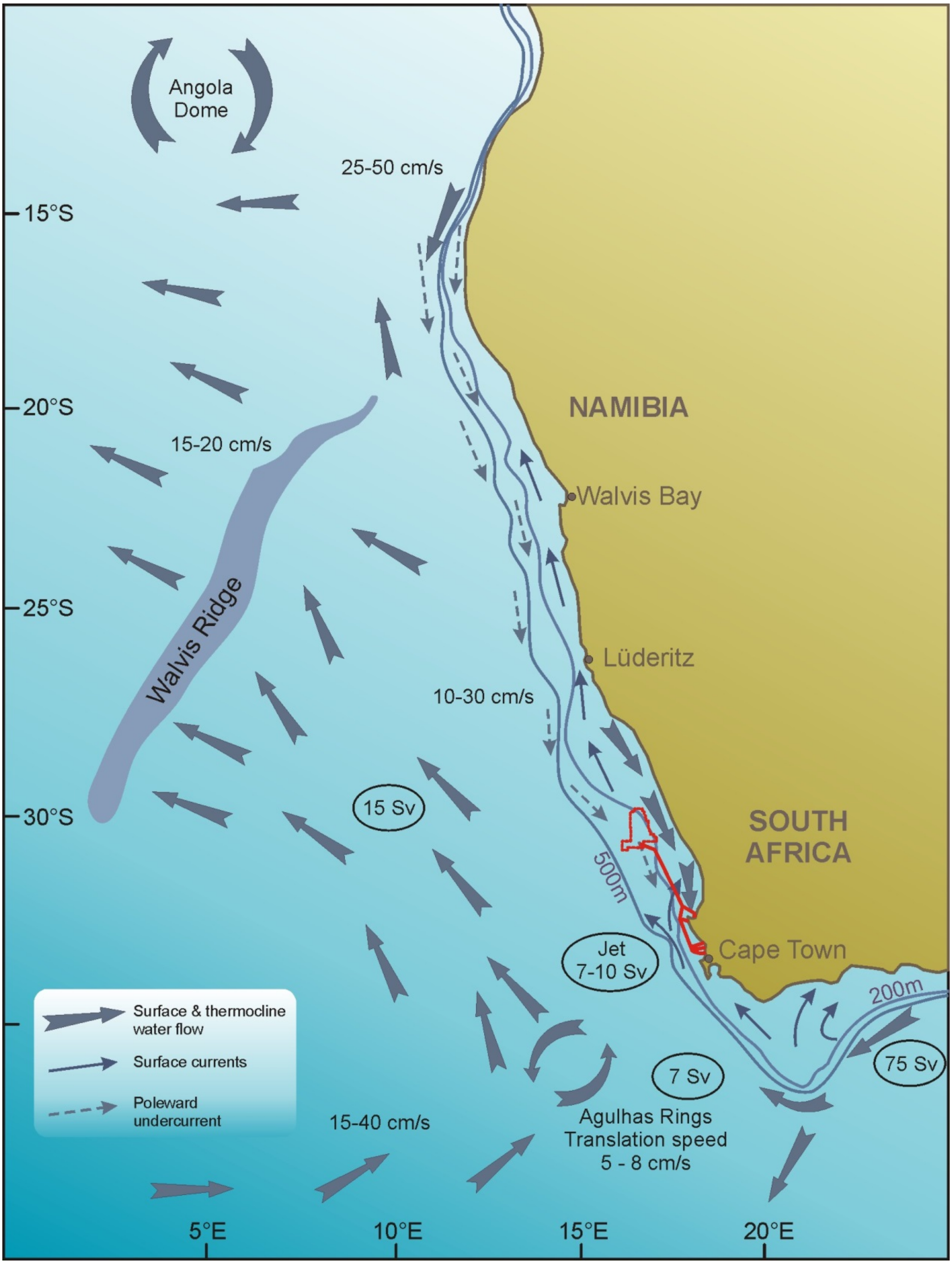


Figure 4.3: **Major features of the predominant circulation patterns and volume flows in the Benguela System, along the southern Namibian and South African west coasts (re-drawn from Shannon & Nelson 1996). The licence area and the proposed pipeline route alternatives are also shown.**

4.2.4 UPWELLING

Upwelling occurs along the West Coast from Cape Agulhas to northern Namibia. During upwelling the comparatively nutrient-poor surface waters are displaced by enriched deep water, supporting substantial seasonal primary phytoplankton production. The cold, upwelled water is rich in inorganic nutrients, the major contributors being various forms of nitrates, phosphates and silicates (Chapman & Shannon 1985). This is mediated by nutrient regeneration from biogenic material in the sediments (Bailey *et al*. 1985). The range of nutrient concentrations can thus be large but, in general, concentrations are high

There are three upwelling centres in the southern Benguela, namely the Cape Point (34°S), Cape Columbine (33°S) and Namaqua (30°S) upwelling cells (Taunton-Clark 1985) (Figure 4.4). Upwelling in these cells is seasonal, with maximum upwelling occurring between September and March.

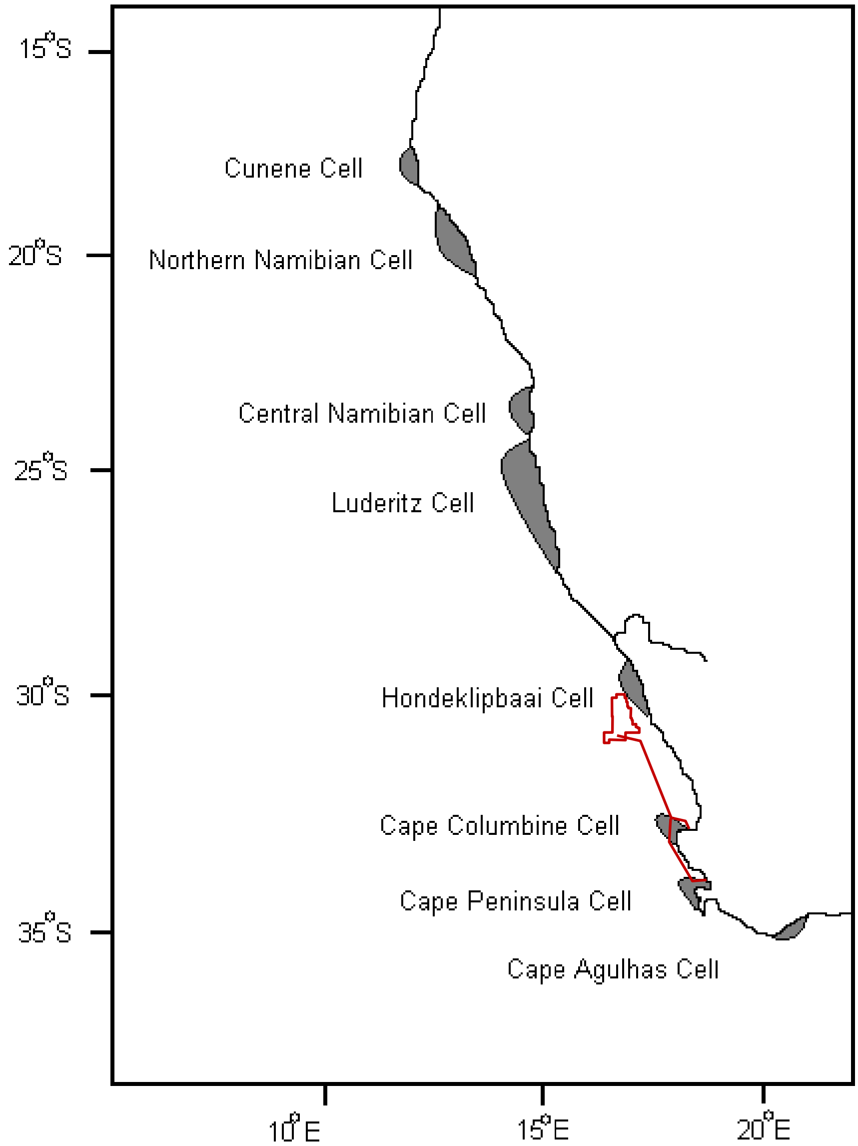


Figure 4.4: The location of three major upwelling cells along the West Coast (Shannon and Nelson, 1996). Approximate location of Block 2A and the proposed production pipeline area also indicated.

Once upwelled, the water warms and stabilises, and moves offshore where a thermocline usually develops. Nutrient-rich upwelled water enhances primary production, and the West Coast region consequently supports substantial pelagic fisheries (Heydorn and Tinley 1980; Shillington 1998). Although the rate and intensity of upwelling fluctuates with seasonal variations in wind patterns, the most intense upwelling tends to occur where the shelf is narrowest and the wind strongest.

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. Biological decay of plankton blooms can in turn lead to “black tide” events, as the available dissolved oxygen is stripped from the water during the decomposition process. Subsequent anoxic decomposition by sulphur reducing bacteria can result in the formation and release of hydrogen sulphide (Pitcher and Calder 2000).

4.2.5 NUTRIENT DISTRIBUTION

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

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

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

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

4.2.6 OXYGEN CONCENTRATION

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

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 (Matthews & Pitcher 1996; Pitcher 1998; Cockcroft *et al*. 2000). The development of anoxic conditions as a result of the decomposition of huge amounts of organic matter generated by phytoplankton 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 where 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.

4.2.7 SEDIMENTS

Figure 4.5 illustrates the distribution of seabed surface sediment types off the West Coast of South Africa. The inner shelf is underlain by Precambrian bedrock (Pre-Mesozoic basement), whilst the middle and outer shelf areas are composed of Cretaceous and Tertiary sediments (Dingle *et al*. 1987; Rogers & Bremner 1991).

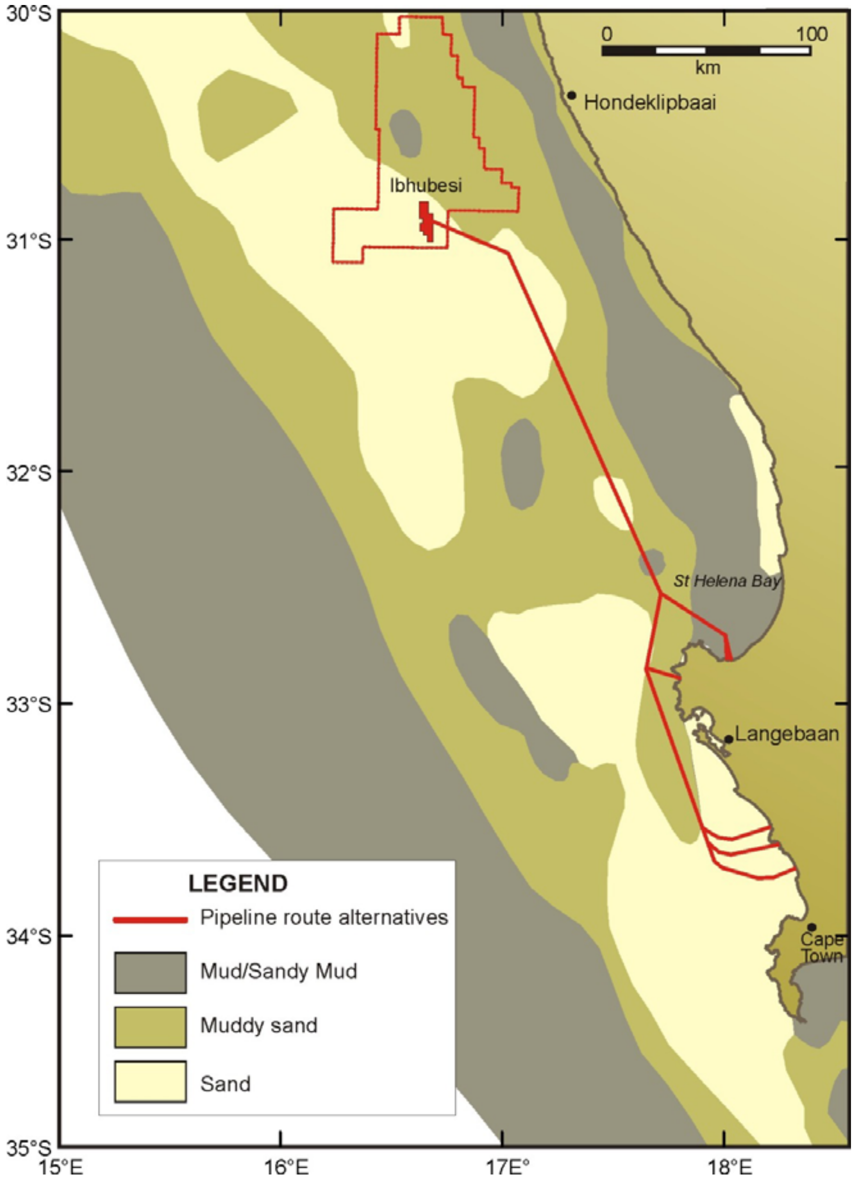


Figure 4.5: Ibhubesi Gas Field and proposed production pipeline route alternatives in relation to sediment distribution on the continental shelf of the West Coast.

As a result of erosion on the continental shelf, the unconsolidated sediment cover is generally thin, often less than 1 m. Sediments are finer seawards, changing from sand on the inner and outer shelves to muddy sand and sandy mud in deeper water. However, this general pattern has been modified considerably by biological deposition (large areas of shelf sediments contain high levels of calcium carbonate) and localised river input.

An approximately 500 km long mud belt (up to 40 km wide and of 15 m average thickness) is situated over the innershelf between the Orange River and St Helena Bay. Further offshore, sediment is dominated by muds and sandy muds. The continental slope, seaward of the shelf break, has a smooth seafloor, underlain by calcareous ooze.

Present day sedimentation is limited to input from the Orange River. This sediment is generally transported northward. 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 West Coast coastal plain.

4.2.8 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 plays 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. Although highly variable, annual discharge rates of sediments by the Orange River is estimated to vary from 8 - 26 million tons/yr (Rogers 1979). ‘Berg’ wind events can potentially contribute the same order of magnitude of sediment input as the annual estimated input of sediment by the Orange River (Shannon and Anderson 1982; Zoutendyk 1992, 1995; Shannon and O’Toole 1998; Lane and 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 and Malouf 1984; Berg and 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 and 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 and 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). 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. 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).

4.3 BIOLOGICAL OCEANOGRAPHY

South Africa is divided into nine bioregions (see Figure 4.6). The proposed pipeline falls within the cold temperate Namaqua and the South-western Cape Bioregions (Emanuel *et al*. 1992; Lombard *et al.* 2004). 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, characterised by low marine species richness and low endemicity (Awad *et al.* 2002).

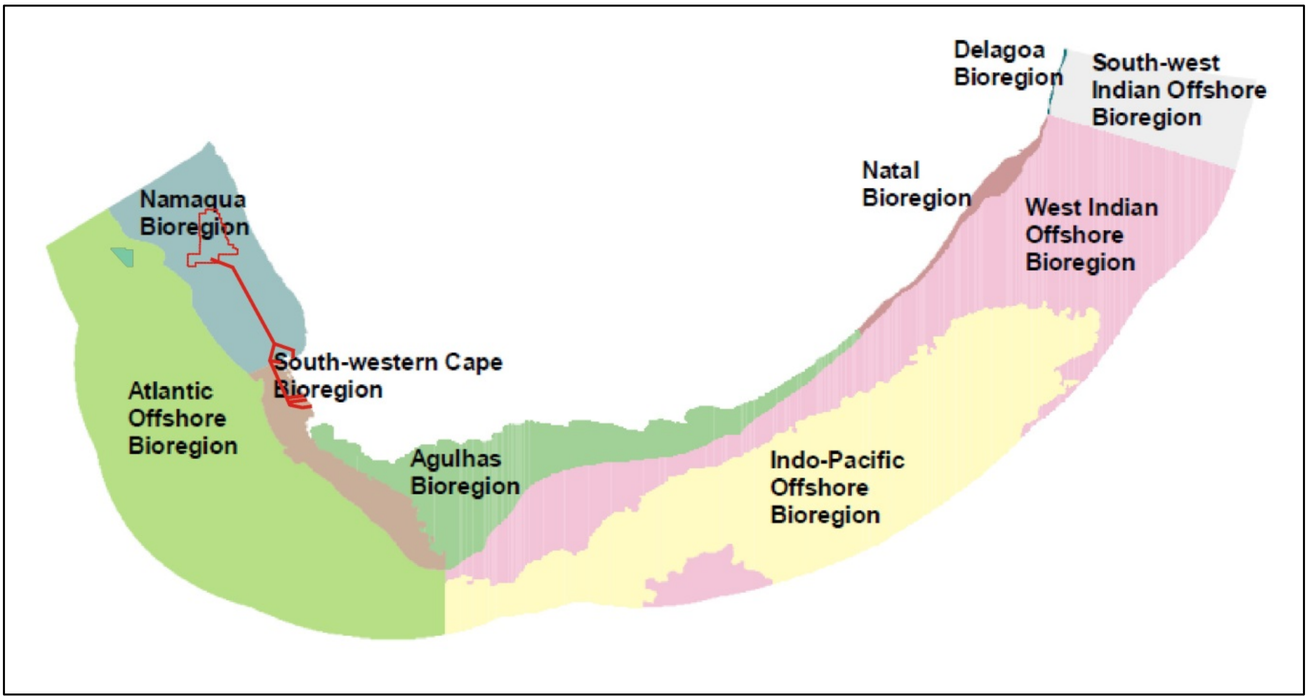


Figure 4.6: Proposed production pipeline route alternatives in relation to the South African inshore and offshore bioregions (red line) (adapted from Lombard *et al*. 2004).

The biotas of the nearshore marine habitats off the West Coast are relatively robust, being naturally adapted to an extremely dynamic environment where biophysical disturbances are commonplace. Communities within this region are largely ubiquitous, particular to substrate type (i.e. hard vs. soft bottom), exposure to wave action, or water depth. Habitats specific to the study area include:

- Sandy intertidal and subtidal substrates;
- Intertidal rocky shores and subtidal reefs; and
- The water column / body.

The biological communities consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales). No rare or endangered benthic invertebrate species have been recorded (Awad *et al.* 2002). 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 pipeline routing.

4.3.1 THREAT STATUS

Sink et. al. (2012) mapped the ecosystem threat status of offshore benthic and pelagic habitats. The proposed offshore production pipeline route coincides with benthic habitats mapped largely as 'least threatened' (see Figure 4.7). The proposed pipeline would traverse an area of 'vulnerable' habitat to the south-east of Child's Bank and 'endangered' habitat in the nearshore areas on the innershelf south of Cape Columbine. The majority of the offshore pelagic habitat types is rated as 'least threatened' with only a narrow band along the shelf break of the West Coast being rated as 'vulnerable' (see Figure 4.7), primarily due to its importance as a migration pathway for various resource species (e.g. whales, tuna, billfish, turtles).

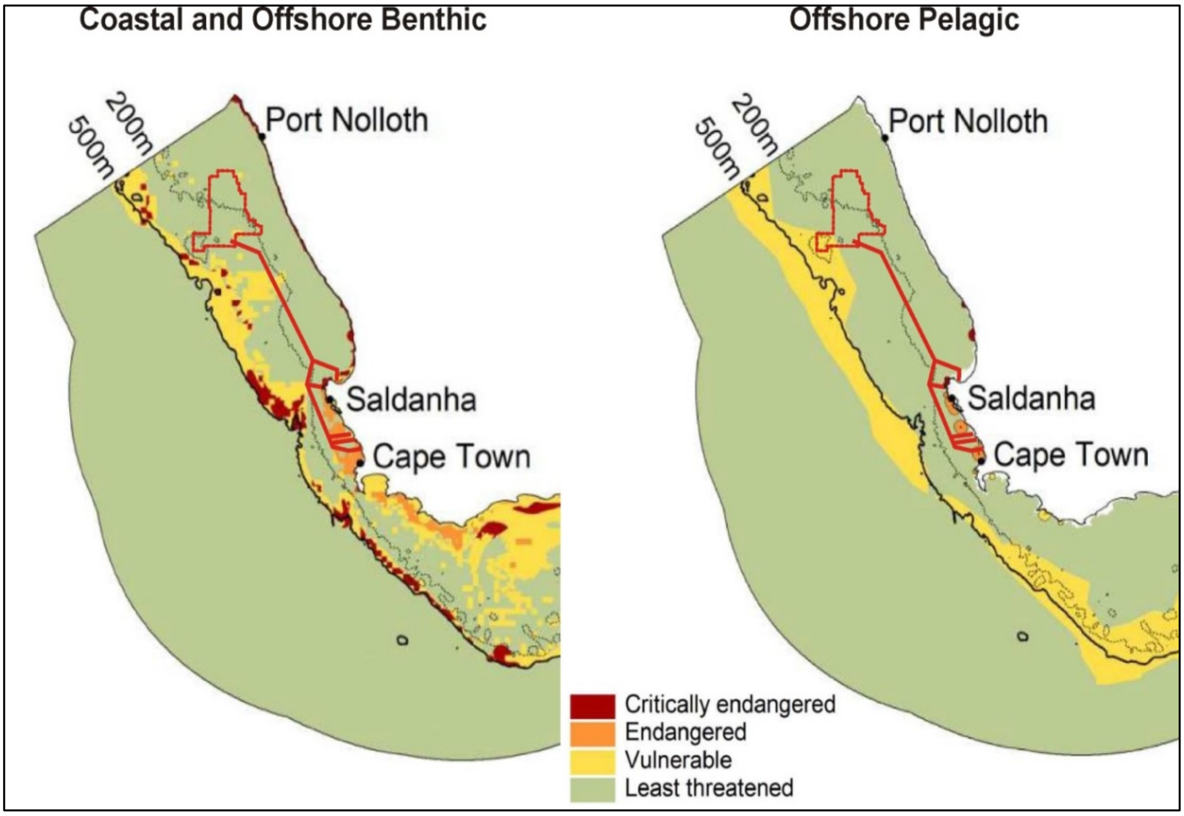


Figure 4.7: Proposed production pipeline route alternatives in relation to the ecosystem threat status for coastal and offshore benthic habitat types (left), and offshore pelagic habitat types on the South African West Coast (adapted from Sink *et al*. 2012).

Majiedt *et al*. 2013 also mapped benthic and coastal habitat types and their associated threat status. The benthic habitats potentially affected by the proposed production pipeline are shown in Figure 4.8 and Table 4.1. Of the southern shore-crossing alternatives, the Duynefontein and Silwerstroom Strand alternatives pass through areas considered to be "critically endangered" marine habitats, whereas the Grotto Bay alternative passes through "vulnerable" and "endangered" marine habitats (see Figure 4.9). The northern shore-crossing alternatives at Noordwesbaai and St Helena (West and East) all pass through areas considered to be "critically endangered" marine habitats near the coast (see Figure 4.10).

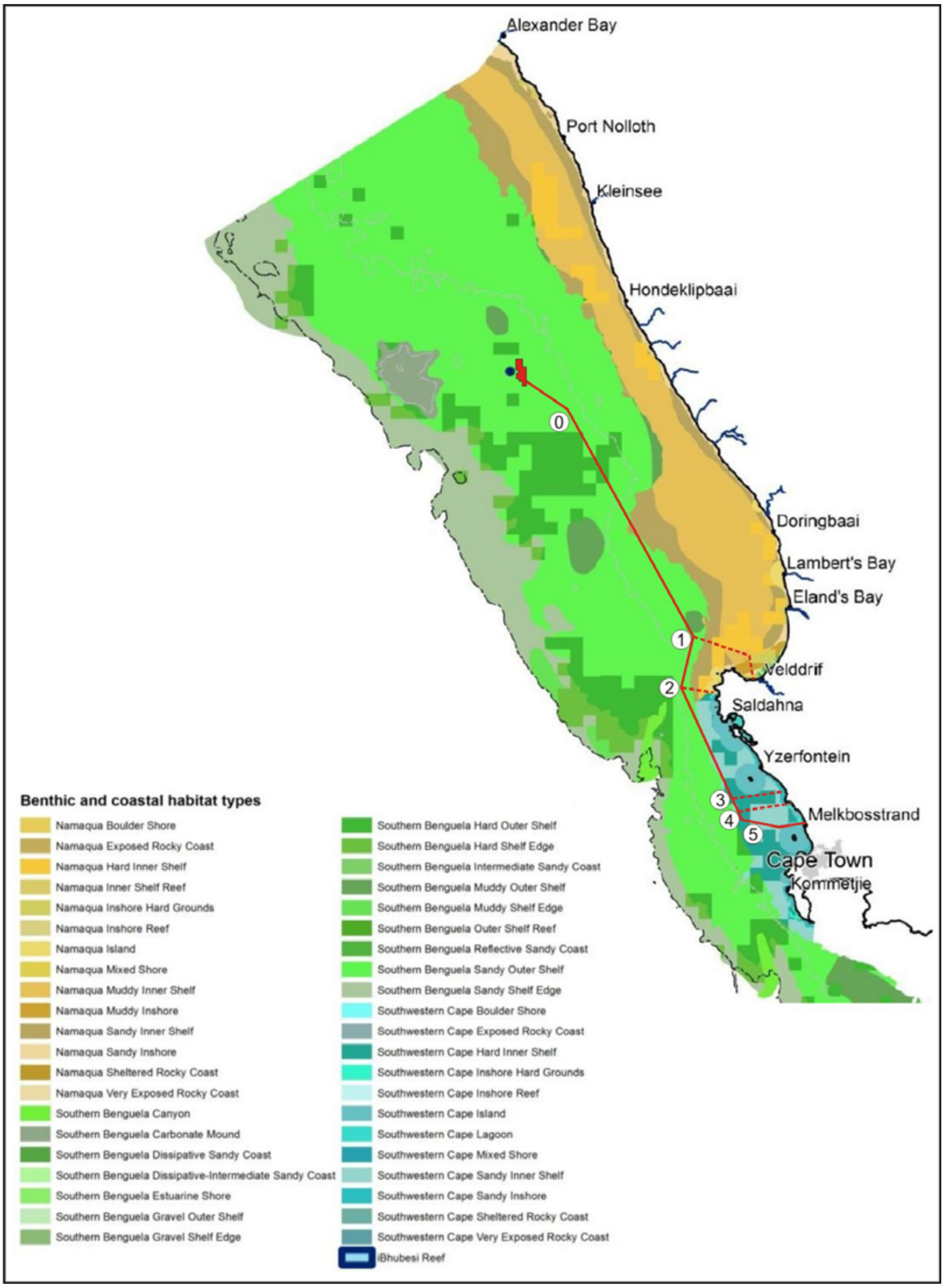


Figure 4.8: Ibhubesi Gas Field and proposed production pipeline route alternatives in relation to benthic and coastal habitat types on the West Coast (adapted from Majiedt *et al*. 2013).

Table 4.1: Ecosystem threat status for marine and coastal habitat types on the West Coast (adapted from Sink *et al*. 2011). Only those habitats affected by the proposed gas pipeline routes are shown.

Habitat Type (numbers relate to route alternative in Figure 4.8)	Threat Status
Namaqua Inshore Hard Grounds (1)	Critically Endangered
Namaqua Mixed Shore (1)	Endangered
Namaqua Muddy Inshore (1)	Vulnerable
Namaqua Sandy Inshore (1)	Critically Endangered
Namaqua Hard Inner Shelf (1, 2)	Least Threatened
Namaqua Muddy Inner Shelf (1)	Least Threatened
Namaqua Sandy Inner Shelf (0, 1, 2)	Least Threatened
Southern Benguela Dissipative sandy coast (4, 5)	Least Threatened
Southern Benguela Hard Outer Shelf (0)	Vulnerable
Southern Benguela Intermediate Sandy Coast (1, 2)	Least Threatened
Southern Benguela Muddy Outer Shelf (0)	Least Threatened
Southern Benguela Sandy Outer Shelf (0, 1, 2)	Least Threatened
Southwestern Cape Hard Inner Shelf (2, 3, 4, 5)	Endangered
Southwestern Cape Inshore Hard Grounds (4, 5)	Critically Endangered
Southwestern Cape Mixed Shore (2)	Vulnerable
Southwestern Cape Sandy Inner Shelf (2, 3, 4, 5)	Least Threatened
Southwestern Cape Sandy Inshore (2, 3, 4, 5)	Vulnerable

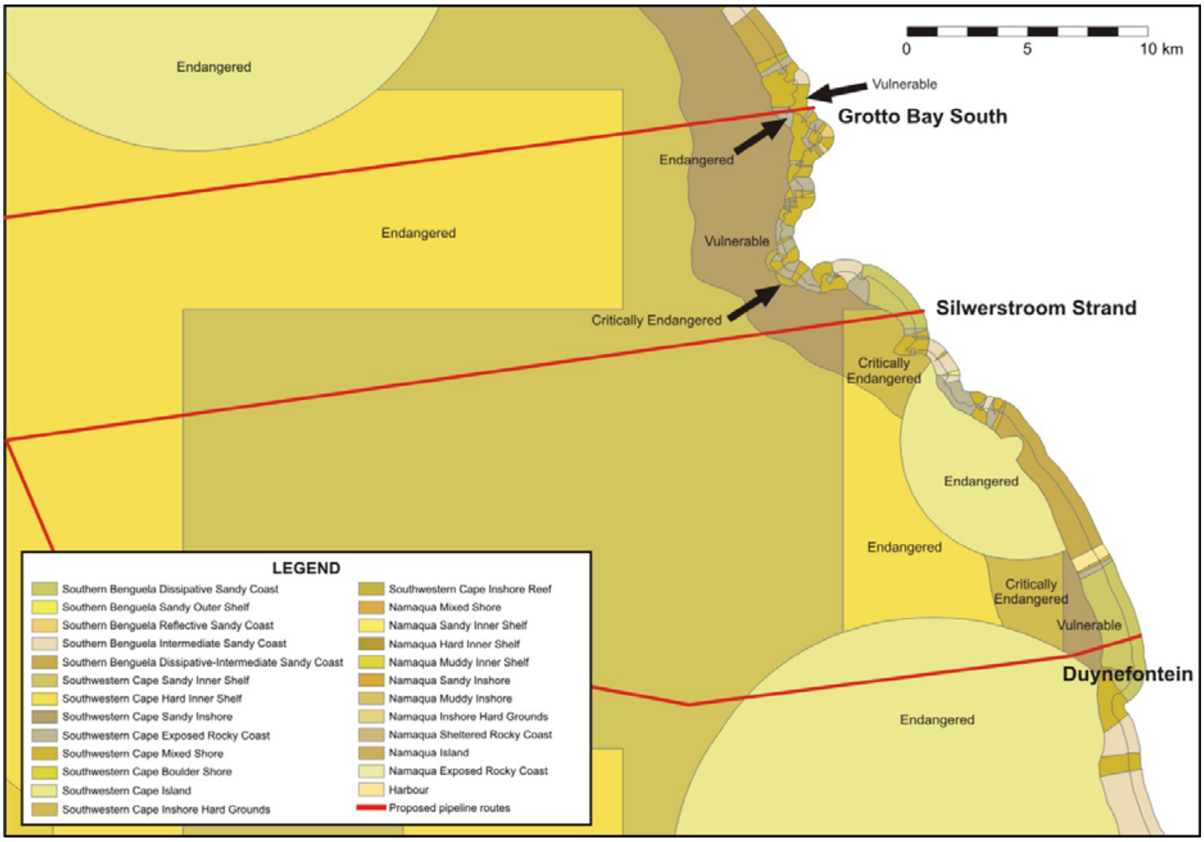


Figure 4.9: Offshore benthic and coastal habitat types affected by the southern shore-crossing alternatives between Grotto Bay and Duynefontein.

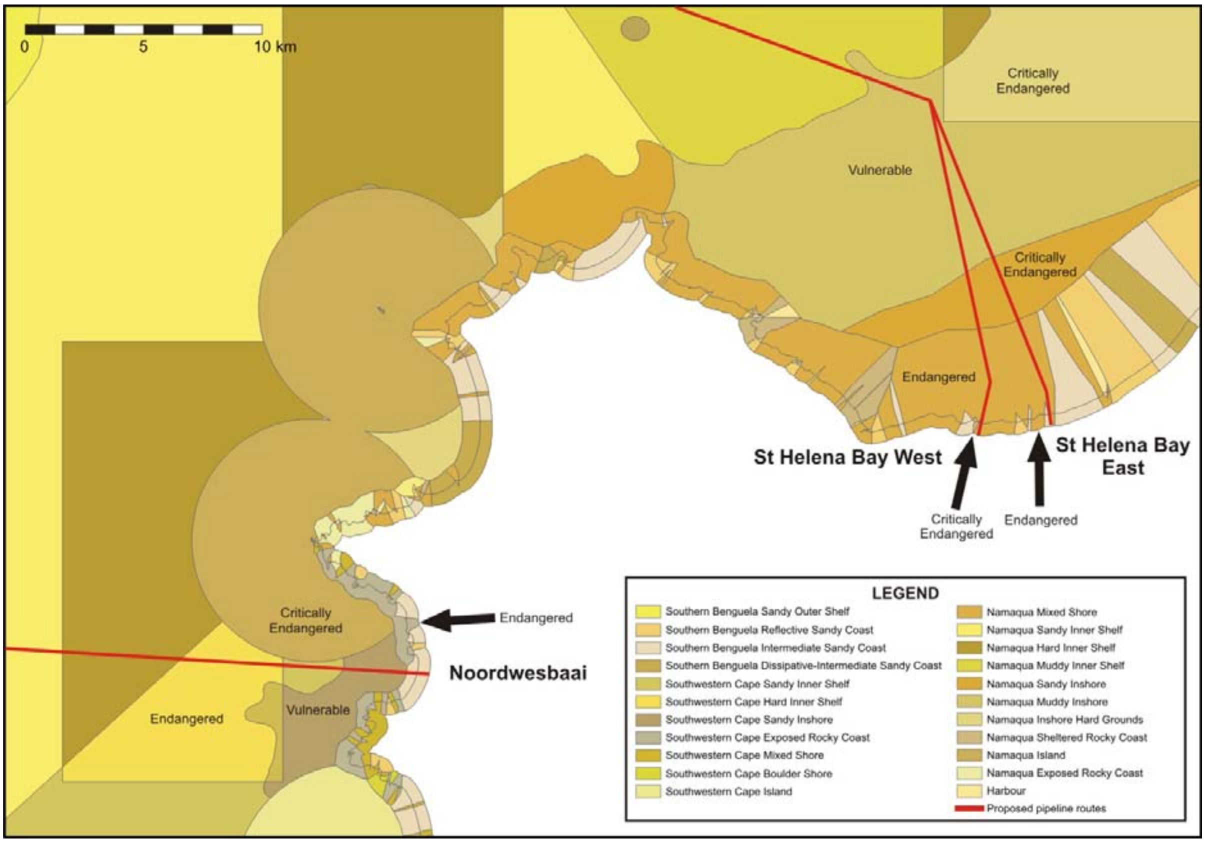


Figure 4.10: Offshore benthic and coastal habitat types affected by the northern shore-crossing alternatives on the Saldanha Peninsula.

4.3.2 SANDY SUBSTRATE HABITATS AND BIOTA

The benthic biota of soft bottom substrates constitutes invertebrates that live on, or burrow within, the sediments, and are generally divided into megafauna (>10 cm), macrofauna (animals >1 mm) and meiofauna (<1 mm).

4.3.2.1 Intertidal sandy beaches

The coastlines from Hondeklipbaai to the Olifants River mouth is dominated by rocky shores, but south of the river mouth to Table Bay, sandy shores are found to dominate.

Sandy beaches are one of the most dynamic coastal environments. With the exception of a few beaches in large bay systems (such as St Helena Bay, Saldanha Bay, Table Bay), the beaches along the West Coast of South Africa are typically highly exposed. Exposed sandy shores consist of coupled surf-zone, beach and dune systems, which together form the active littoral sand transport zone (Short & Hesp 1985).

The composition of their faunal communities is largely dependent on the interaction of wave energy, beach slope and sand particle size, which is termed beach morphodynamics. Three morphodynamic beach types are described: dissipative, reflective and intermediate beaches (McLachlan *et al.* 1993):

- *Dissipative beaches* are relatively wide and flat with fine sands and low wave energy. Waves start to break far from the shore in a series of spilling breakers that 'dissipate' their energy along a broad surf zone. This generates slow swashes with long periods, resulting in less turbulent conditions on the gently sloping beach face. These beaches usually harbour the richest intertidal faunal communities.

- *Reflective beaches* in contrast, have high wave energy, and are coarse grained (>500 µm sand) with narrow and steep intertidal beach faces. The relative absence of a surf-zone causes the waves to break directly on the shore causing a high turnover of sand. The result is depauperate faunal communities.
- *Intermediate beaches* exist between these extremes and have a very variable species composition (McLachlan *et al.* 1993; Jaramillo *et al.* 1995, Soares 2003). This variability is mainly attributable to the amount and quality of food available. Beaches with a high input of e.g. kelp wrack have a rich and diverse drift-line fauna, which is sparse or absent on beaches lacking a drift-line (Branch & Griffiths 1988). As a result of the combination of typical beach characteristics, and the special adaptations of beach fauna to these, beaches act as filters and energy recyclers in the nearshore environment (Brown & McLachlan 1990).

Numerous methods of classifying beach zonation have been proposed, based either on physical or biological criteria. The general scheme proposed by Branch & Griffiths (1988) is used below (Figure 4.11), supplemented by data from various publications on West Coast sandy beach biota (e.g. Bally 1987; Brown *et al.* 1989; Soares *et al.* 1996, 1997; Nel 2001; Nel *et al*. 2003; Soares 2003; Branch *et al.* 2010; Harris 2012).

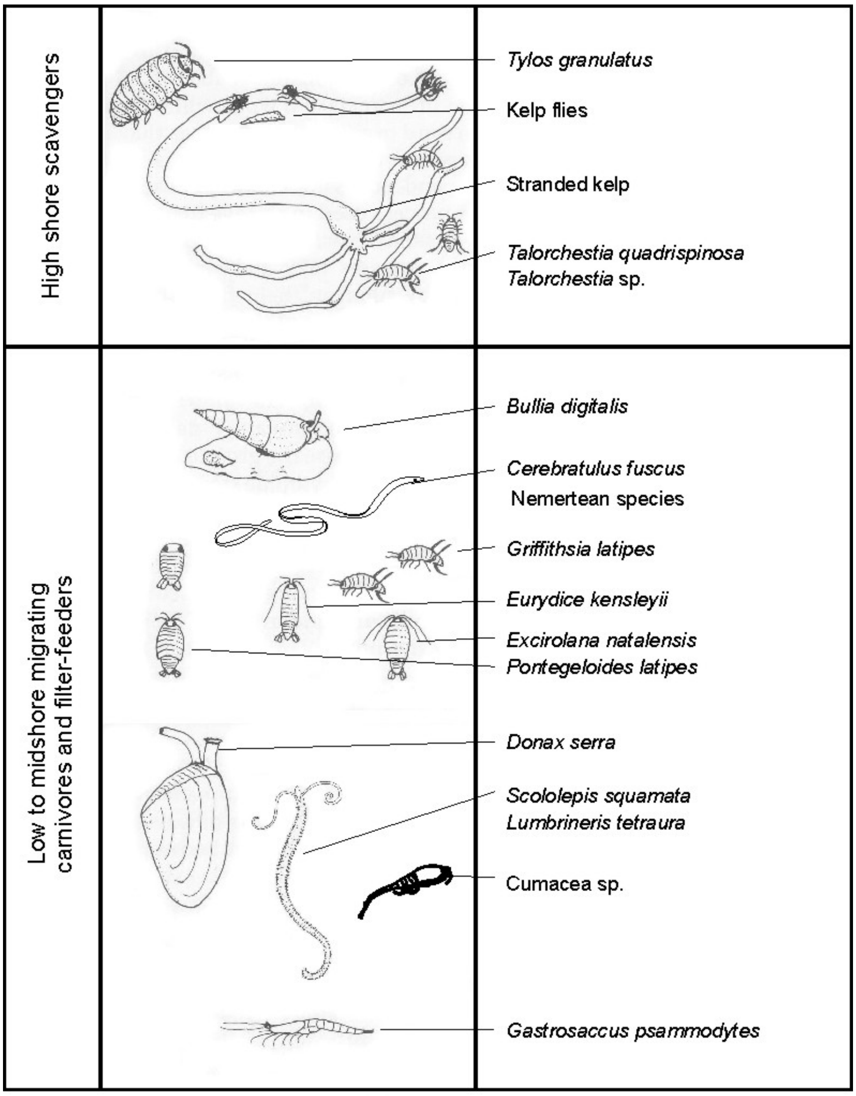


Figure 4.11: Schematic representation of the West Coast intertidal beach zonation (adapted from Branch & Branch 1981). Species commonly occurring on the beaches are listed.

The macrofaunal communities of sandy beaches are generally ubiquitous throughout the southern African West Coast region, being particular only to substratum type, wave exposure and/or depth zone. Due to the exposed nature of the coastline in the study area, most beaches are of the intermediate to reflective type.

The macrofauna occurring in the different zones off the beach (Figure 4.12) consist of:

- The *supralittoral zone* is situated above the high water spring (HWS) tide level, and receives water input only from large waves at spring high tides or through sea spray. This zone is characterised by a mixture of air breathing terrestrial and semi-terrestrial fauna, often associated with and feeding on kelp deposited near or on the driftline. Terrestrial species include a diverse array of beetles and arachnids and some oligochaetes, while semi-terrestrial fauna include the oniscid isopod *Tylos granulatus*, and amphipods of the genus *Talorchestia*.
- The *intertidal zone or mid-littoral zone* has a vertical range of about 2 m. This mid-shore region is characterised by the cirolanid isopods *Pontogeloides latipes*, *Eurydice* (*longicornis*=) *kensleyi* and *Excirolana natalensis*, the polychaetes *Scolelepis squamata*, *Orbinia angrapequensis*, *Nepthys hombergii* and *Lumbrineris tetraura*, and amphipods of the families Haustoridae and Phoxocephalidae. In some areas, juvenile and adult sand mussels *Donax serra* may also be present in considerable numbers.
- The *inner turbulent zone* extends from the Low Water Spring mark to about approximately 2 m depth. The mysid *Gastrosaccus psammodytes* (Mysidacea, Crustacea), the ribbon worm *Cerebratulus fuscus* (Nemertea), the cumacean *Cumopsis robusta* (Cumacea) and a variety of polychaetes including *Scolelepis squamata* and *Lumbrineris tetraura*, are typical of this zone, although they generally extend partially into the midlittoral above. In areas where a suitable swash climate exists, the gastropod *Bullia digitalis* (Gastropoda, Mollusca) may also be present in considerable numbers, surfing up and down the beach in search of carrion.
- The *transition zone* spans approximately 2 - 5 m depth beyond the inner turbulent zone. Extreme turbulence is experienced in this zone, and as a consequence this zone typically harbours the lowest diversity on sandy beaches. Typical fauna include amphipods such as *Cunicus profundus* and burrowing polychaetes such as *Cirriformia tentaculata* and *Lumbrineris tetraura.*
- The *zone below 5 m depth* shows increase in species diversity due to reduced turbulence. In addition to the polychaetes found in the transition zone, other polychaetes in this zone include *Pectinaria capensis*, and *Sabellides ludertizii*. The sea pen V*irgularia schultzi* (Pennatulacea, Cnidaria) is also common as is a host of amphipod species and the three spot swimming crab *Ovalipes punctatus* (Brachyura, Crustacea).

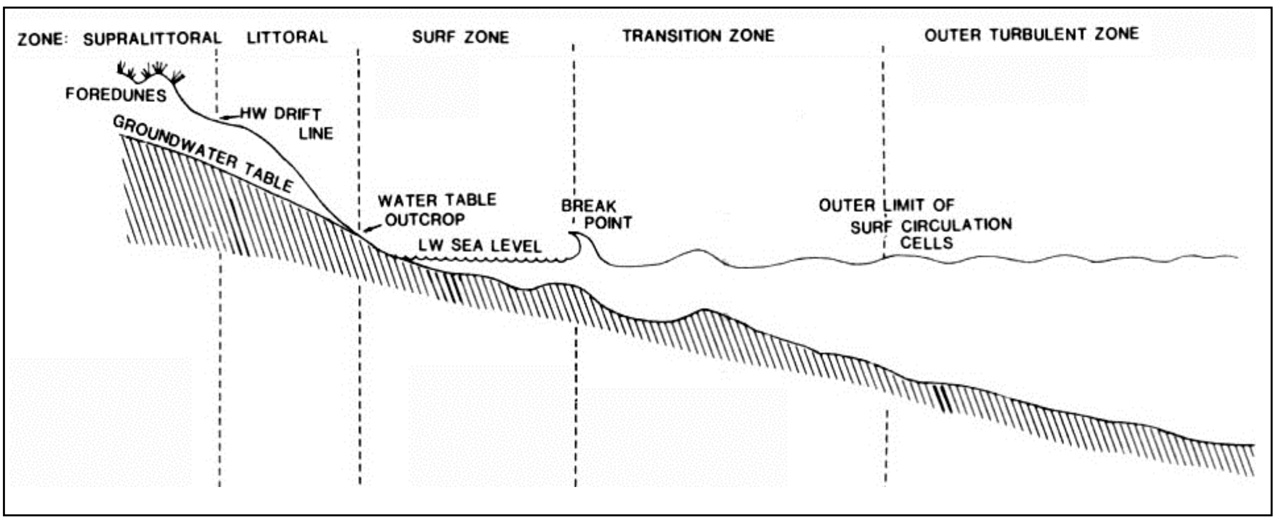


Figure 4.12: Generalised scheme of zonation on sandy shores (Modified from Brown & MacLachlan 1990).

4.3.2.2 Nearshore and offshore unconsolidated habitats

Three macro-infauna communities have been identified on the inner- (0-30 m depth) and mid-shelf (30-150 m depth) off the West Coast (Karenyi unpublished data). These are described below.

- 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 *Callianassa* 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 is inherently patchy reflecting the high natural spatial and temporal variability associated with macro-infauna of unconsolidated sediments. 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 (± 50 g/m^2 wet weight) and decreases across the mid-shelf averaging around 30 g/m^2 wet weight.

Benthic communities are known to be structured by the complex interplay of a large array of environmental factors, including water depth, sediment grain size, shear bed stress (a measure of the impact of current velocity on sediment), oxygen concentration, productivity, organic carbon and seafloor temperature.

Other natural processes operating in the deep water shelf areas of the West Coast can over-ride 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 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 and sediment stability) and serve as important food source for commercially valuable fish species and other higher order consumers.

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) the continental shelf on the West Coast between depths of 100 m and 250 m, contained a single epifaunal community 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.

A review of video footage from previous drilling operations in Block 2A has confirmed that the seabed at 200-250 m water depth is comprised of unconsolidated sediments, with some evidence of patches of shelly grit. Epifauna comprised primarily sea pens, brittle stars, burrowing anemones and hermit crabs, with gorgonians and sponges being observed in isolated areas only.

4.3.3 ROCKY SUBSTRATE HABITATS AND BIOTA

The biological communities of rocky intertidal and subtidal reefs are generally ubiquitous throughout the southern African West Coast region, being particular only to wave exposure, turbulence and/or depth zone.

4.3.3.1 Intertidal rocky shores

West Coast rocky intertidal shores can be divided into five zones on the basis of their characteristic biological communities: The Littorina, Upper Balanoid, Lower Balanoid, Cochlear/Argenvillei and the Infratidal Zones (see Figure 4.13 and Plate 4.1). These biological zones correspond roughly to zones based on tidal heights.

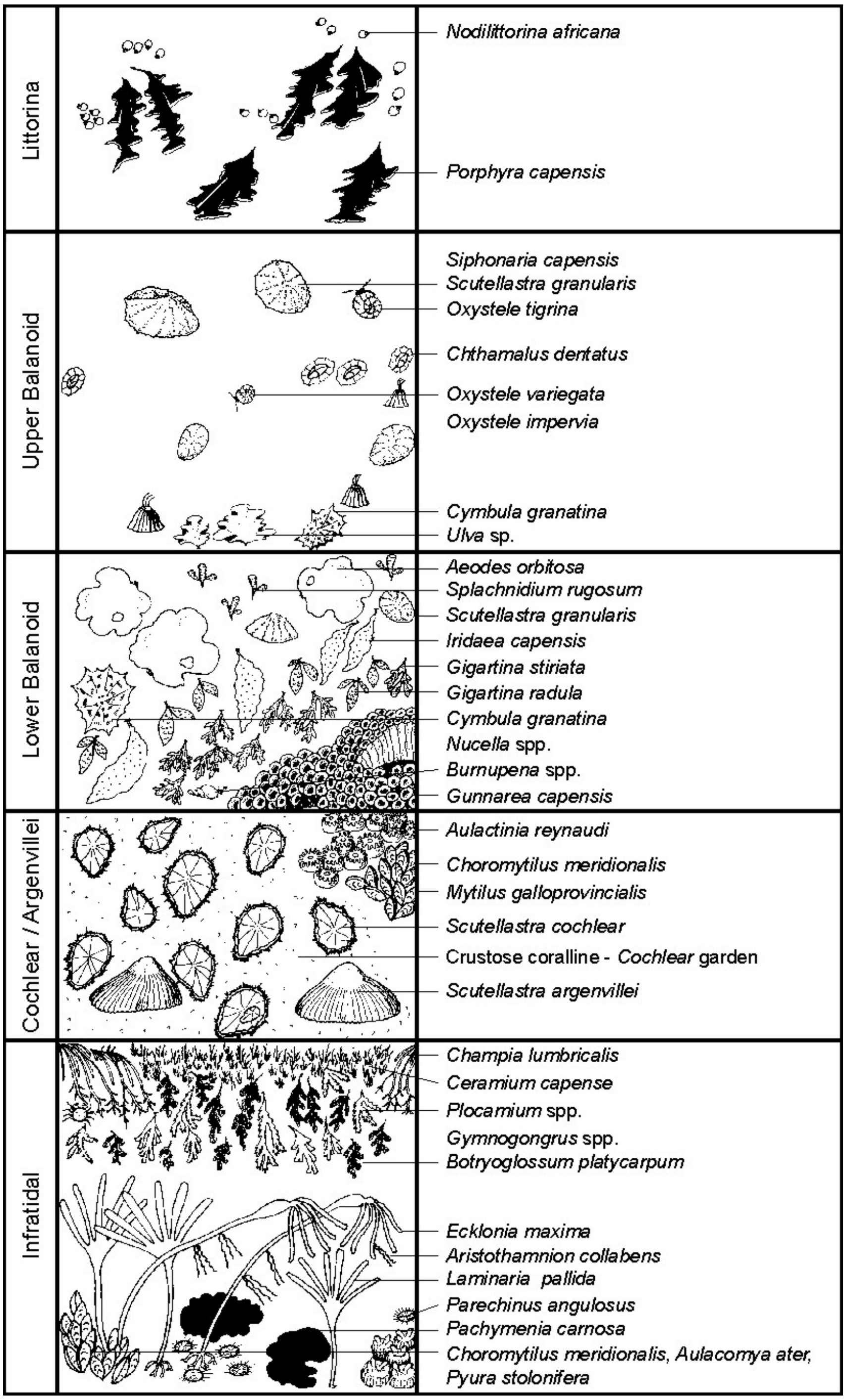


Figure 4.13: Schematic representation of the West Coast intertidal zonation (adapted from Branch & Branch 1981).

Plate 4.1: Typical rocky intertidal zonation on the southern African West Coast.

Several studies on the West Coast of southern Africa have documented the important effects of wave action on the intertidal rocky-shore community. Wave action enhances filter-feeders by increasing the concentration and turnover of particulate food, leading to an elevation of overall biomass despite a low species diversity (McQuaid & Branch 1985, Bustamante & Branch 1995a, 1996a, henninnte *et al.* 1997). Conversely, sheltered shores are diverse with a relatively low biomass, and only in relatively sheltered embayments does drift kelp accumulate and provide a vital support for kelp trapping limpets. In the subtidal, these differences diminish as wave exposure is moderated with depth.

Biota found in these different habitats is described below.

- The uppermost part of the shore is the *supralittoral fringe*, which is the part of the shore that is most exposed to air, perhaps having more in common with the terrestrial environment. The supralittoral is characterised by low species diversity, with the tiny periwinkle *Afrolittorina knysnaensis*, and the red alga *Porphyra capensis* constituting the most common macroscopic life.
- The *upper mid-littoral or upper balanoid zone* is characterised by the limpet *Scutellastra granularis*, which is present on all shores. The gastropods *Oxystele variegata*, *Nucella dubia*, and *Helcion pectunculus* are variably present, as are low densities of the barnacles *Tetraclita serrata*, *Octomeris angulosa* and *Chthalamus dentatus*. Flora is best represented by the green algae *Ulva* spp.
- Toward the *lower mid-littoral or lower balanoid zone*, biological communities are determined by exposure to wave action. On sheltered and moderately exposed shores, a diversity of algae abounds, namely green algae; brown algae – *Splachnidium rugosum*; and red algae – *Aeodes orbitosa*, *Mazzaella (=Iridaea) capensis*, *Gigartina polycarpa* (=*radula*), *Sarcothalia* (=*Gigartina*) *stiriata*, and with increasing wave exposure *Plocamium rigidum* and *P. cornutum*, and *Champia lumbricalis*. The gastropods *Cymbula granatina* and *Burnupena* spp. are also common, as is the reef building polychaete *Gunnarea capensis*, and the small cushion starfish *Patiriella exigua*. On more exposed shores, the alien mussel *Mytilus galloprovinciali* is found. It is now the most abundant and widespread invasive marine species along the entire West Coast and parts of the South Coast (Robinson *et al.* 2005). Recently, another alien invasive has been recorded, the acorn barnacle *Balanus glandul.*
- Along the *sublittoral fringe or cochlear zone*, the large kelp-trapping limpet *Scutellastra argenvillei* dominates forming dense, almost monospecific stands. Similarly, *C. granatina* is the dominant grazer on more sheltered shores. On more exposed shores *M. galloprovincialis* dominates and as the cover

of *M. galloprovincialis* increases, the abundance and size of *S. argenvillei* declines. Semi-exposed shores do, however, offer a refuge preventing global extinction of the limpet. The anemone *Aulactinia reynaudi*, numerous whelk species and the sea urchin *Parechinus angulosus* are also found. Very recently, the invasion of west coast rocky shores by another mytilid, the small *Semimytilus algosus*, was noted (de Greef *et al.* 2013).

4.3.3.2 Rocky habitats and kelp beds

Biological communities of the rocky sublittoral can be broadly grouped into an inshore zone from the sublittoral fringe to a depth of about 10 m dominated by flora and an offshore zone below 10 m depth dominated by fauna.

From the sublittoral fringe to a depth of between 5 and 10 m, the benthos is largely dominated by algae, in particular two species of kelp, namely the canopy forming kelp *Ecklonia maxima* (see Plate 4.2) and the smaller *Laminaria pallida*, which forms a sub-canopy to a height of about 2 m. *Ecklonia maxima* is the dominant species from west of Cape Agulhas to north of Cape Columbine, whereas *Laminaria pallida* becomes the dominant kelp north of Cape Columbine and thus in the project area, extending from Danger Point east of Cape Agulhas to Rocky Point in northern Namibia (Stegenga *et al.* 1997; Rand 2006).

Plate 4.2: The canopy-forming kelp *Ecklonia maxima* provides an important habitat for a diversity of marine biota (Photo: Geoff Spiby).

Kelp beds absorb and dissipate much of the typically high wave energy reaching the shore, thereby providing important partially-sheltered habitats for a high diversity of marine flora and fauna, resulting in diverse and typical kelp-forest communities being established. There is substantial spatial and temporal variability in the density and biomass of kelp beds, depending on the action of storms, seabed topography, and the presence or absence of sand and grazers.

Growing beneath the kelp canopy, and epiphytically on the kelps themselves, are a diversity of understorey algae. Representative algae include *Botryocarpa prolifera*, *Neuroglossum binderianum*, *Botryoglossum platycarpum*, *Hymenena venosa* and *Rhodymenia* (=*Epymenia*) *obtusa*, various coralline algae, as well as subtidal extensions of some algae occurring primarily in the intertidal zones (Bolton 1986). Epiphytic species include *Polysiphonia virgata*, *Gelidium vittatum (=Suhria vittata)* and *Carpoblepharis flaccida*. In particular, the presence of coralline crusts is thought to be a key factor in supporting a rich shallow-water community by providing substrate, refuge and food to a wide variety of infaunal and epifaunal invertebrates (Chenelot *et al.* 2008).

The sublittoral invertebrate fauna is dominated by suspension and filter-feeders, such as the mussels *Aulacomya ater* and *Choromytilus meriodonalis*, and the Cape reef worm *Gunnarea capensis*, and a variety of sponges and sea cucumbers. Grazers are less common, with most herbivors being restricted to grazing of juvenile algae or debris-feeding on detached macrophytes. The dominant herbivore is the sea urchin *Parechinus angulosus*, with lesser grazing pressure from limpets, the isopod *Paridotea reticulata* and the amphipod *Ampithoe humeralis*. The abalone *Haliotis midae*, an important commercial species present in kelp beds south of Cape Columbine, but is naturally absent north thereof.

Key predators in the sub-littoral include the commercially important West Coast rock lobster *Jasus lalandii* and the octopus *Octopus vulgaris*. The rock lobster acts as a keystone species as it influences community structure *via* predation on a wide range of benthic organisms (Mayfield *et al.* 2000) including the reduction in density, or even elimination, of black mussel *Choromytilus meriodonalis*, and ribbed mussels *Aulacomya ater*.

Of lesser importance as predators, although numerically significant, are various starfish, feather and brittle stars, and gastropods, including the whelks *Nucella* spp. and *Burnupena* spp. Fish species commonly found in kelp beds off the West Coast include hottentot *Pachymetopon blochii*, two tone finger fin *Chirodactylus brachydactylus*, red fingers *Cheilodactylus fasciatus*, galjoen *Dichistius capensis*, rock suckers *Chorisochismus dentex* and the catshark *Haploblepharus pictus* (Branch *et al.* 2010).

4.3.3.3 Deep water coral and seamount communities

Deep water corals are benthic filter-feeders and generally occur at depths below 150 m with some species being recorded from as deep as 3 000 m. Some species form reefs while others are smaller and remain solitary. Corals add structural complexity to otherwise uniform seabed habitats thereby creating areas of high biological diversity (Breeze *et al*. 1997; MacIssac *et al*. 2001). Deep water corals establish themselves below the thermocline where there is a continuous and regular supply of concentrated particulate organic matter, caused by the flow of a relatively strong current over special topographical formations which cause eddies to form.

The effects of such seabed features on the surrounding water masses can include the upwelling of relatively cool, nutrient-rich water into nutrient-poor surface water thereby resulting in higher productivity (Clark *et al.* 1999), which can in turn strongly 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. It provides an important habitat for commercial deepwater fish stocks such as orange roughy, oreos, alfonsino 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). 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) (see Plate 4.3) are a prominent component 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).

Plate 4.3: Gorgonians and bryozoans communities recorded on deep-water reefs (100-120 m) off the southern African West Coast (Photos: De Beers Marine).

A geological feature of note in the vicinity of Block 2A is the carbonate mound (bioherm), Child's Bank (Dingle *et al.* 1987). It is composed of sediments and the calcareous deposits from an accumulation of carbonate skeletons of sessile organisms (e.g. cold-water coral, foraminifera or marl). Deep water corals are known from the Ibhubesi Reef to the east of the Ibhubesi Gas Field. Furthermore, evidence from video footage taken on hard-substrate habitats in 100 - 120 m depth off southern Namibia and to the south-east of Child's Bank (De Beers Marine, unpublished data) suggest that vulnerable communities including gorgonians, octocorals and reef-building sponges do occur on the continental shelf.

Levels of endemism on seamounts are relatively high and have been identified as Vulnerable Marine Ecosystems (VMEs). They are known to 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).

In the productive Benguela region, substantial areas on and off the edge of the shelf should potentially be capable of supporting rich, cold water, benthic, filter-feeding communities. Potential VMEs, including the shelf break, seamounts, submarine canyons, hard grounds, submarine banks, deep reefs and cold water coral reefs, within the general study area are illustrated in Figure 4.14. Deep water corals are known to occur on the Ibhubesi Reef, which occurs in Block 2A (see Figures 4.14 and 4.18). Furthermore, evidence from video footage taken on hard-substrate habitats in 100 - 120 m depth off southern Namibia and to the south-east of Child's Bank (De Beers Marine, unpublished data) suggest that vulnerable communities including gorgonians, octocorals and reef-building sponges do occur on the continental shelf.

Sediment samples collected at the base of Norwegian cold-water coral reefs revealed high interstitial concentrations of light hydrocarbons (e.g. methane, propane, ethane). 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).

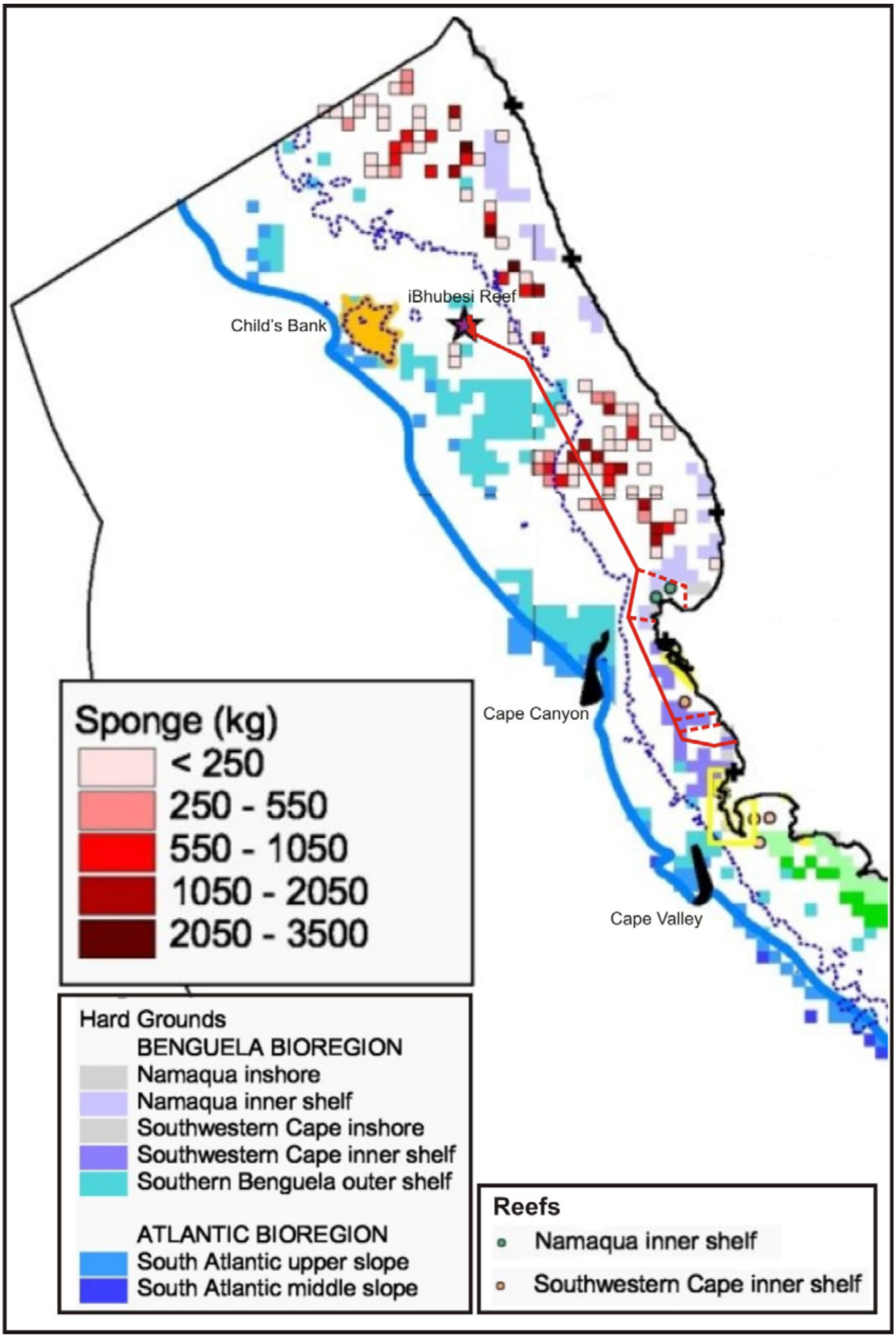


Figure 4.14: Proposed production pipeline route alternatives in relation to potential Vulnerable Marine Ecosystems on the West Coast (adapted from Sink *et al*. 2011).

4.3.4 THE WATER COLUMN / BODY

4.3.4.1 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/m^2/day for the midshelf region and decreasing to 1 g C/m^2/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*, *Nitschia*, *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 *mesozooplankton* (≥200 µm) is dominated by copepods, which are overall the most dominant and diverse group in southern African zooplankton. Important species are *Centropages brachiatus*, *Calanoides carinatus*, *Metridia lucens*, *Nannocalanus minor*, *Clausocalanus arcuicornis*, *Paracalanus parvus*, *P. crassirostris* and *Ctenocalanus vanus*. All of the above species typically occur in the phytoplankton rich upper mixed layer of the water column, with the exception of *M. lucens* which undertakes considerable vertical migration.
- The *macrozooplankton* (≥1 600 µm) 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*. Standing stock estimates of mesozooplankton for the southern Benguela area range from 0.2 - 2.0 g C/m^2, with maximum values recorded during upwelling periods, with production increasing north of Cape Columbine (Pillar 1986). Beyond the continental slope biomass decreases markedly. Localised peaks in biomass may, however, occur in the vicinity of Child's Bank in response to topographically steered upwelling around such seabed features.
- Although *ichthyoplankton* (fish eggs and larvae) comprise a minor component of the overall plankton, it remains significant due to the commercial importance of the overall fishery in the region. Various pelagic and demersal fish species are known to spawn in the inshore regions of the southern Benguela, (including pilchard, round herring, chub mackerel lanternfish and hakes (Crawford *et al.* 1987) and their eggs and larvae form an important contribution to the ichthyoplankton in the region (see Figure 4.15). Ichthyoplankton abundance along the proposed pipeline route is thus expected to be high.

4.3.4.2 Cephalopods

On the basis of abundance and trophic links with other species, eight species of cephalopod are important and a further five species have potential importance within the Benguela system (Table 4.2). The major cephalopod resource in the southern Benguela are sepiods/cuttlefish (Lipinski 1992; Augustyn *et al.* 1995). Most of the cephalopod resource is distributed on the mid-shelf with *Sepia australis* being most abundant at depths between 60-190 m, whereas *S. hieronis* densities were higher at depths between 110-250 m. *Rossia enigmatica* occurs more commonly on the edge of the shelf to depths of 500 m. Biomass of these species is generally higher in the summer than in winter.

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

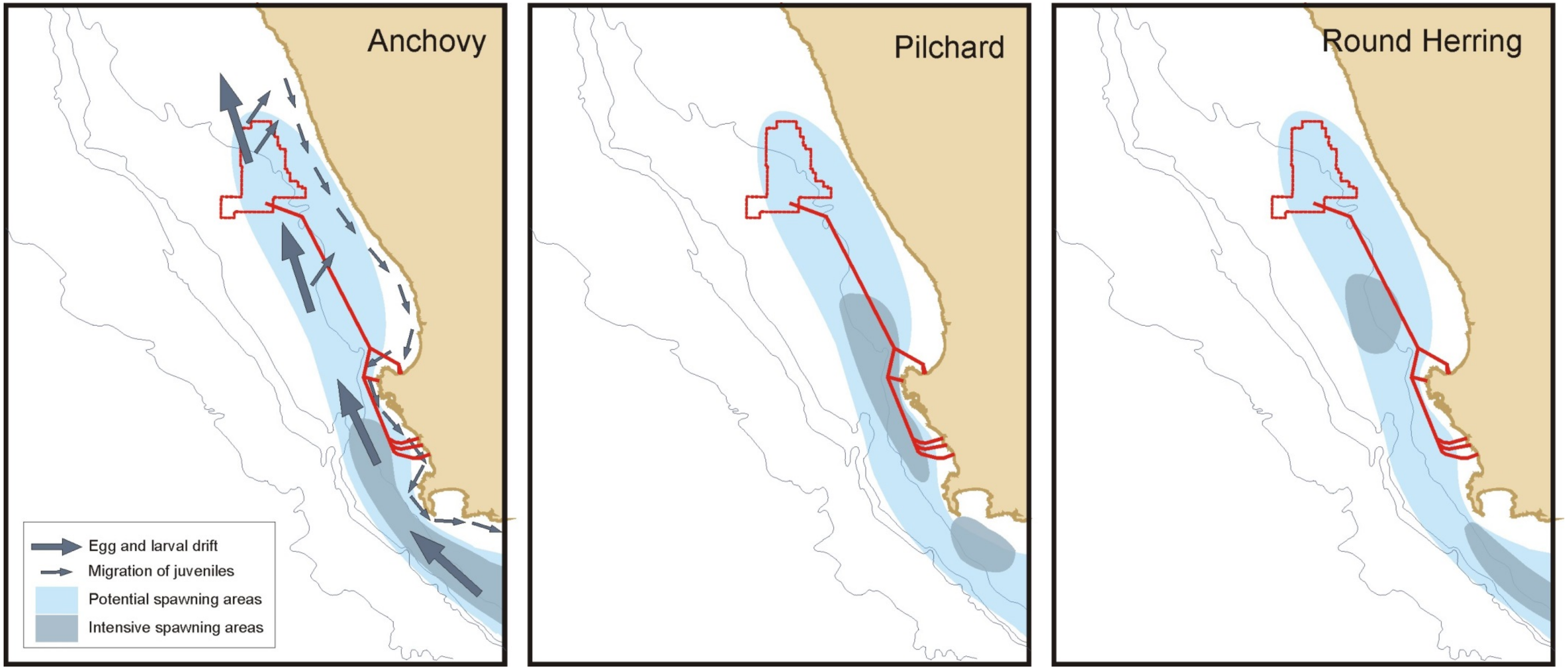


Figure 4.15: Proposed production pipeline route alternatives in relation to major spawning areas in the southern Benguela region (adapted from Cruikshank 1990).

Table 4.2: Cephalopod species of importance or potential importance within the Benguela System (after Lipinski 1992).

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

4.3.4.3 Fishes

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

(a) Demersal fish species

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

Roel (1987) showed seasonal variations in the distribution ranges shelf communities, with species such as the pelagic goby *Sufflogobius bibarbatus*, and West Coast sole *Austroglossus microlepis* only occurring in shallow water north of Cape Point during summer. The deep-sea community was found to be homogenous both spatially and temporally. However, two long-term community shifts in demersal fish communities have been noted; 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.

The diversity and distribution of demersal cartilagenous fishes on the West Coast is discussed by Compagno *et al*. (1991). The species that may occur on the continental shelf in the general project area, and their approximate depth range, are listed in Table 4.3.

Table 4.3: 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 (m)
Frilled shark	*Chlamydoselachus anguineus*	200-1 000
Six gill cowshark	*Hexanchus griseus*	150-600
Bramble shark	*Echinorhinus brucus*	55-285
Arrowhead dogfish	*Deania profundorum*	200-500
Longsnout dogfish	*Deania quadrispinosum*	200-650
Spotted spiny dogfish	*Squalus acanthias*	100-400
Shortnose spiny dogfish	*Squalus megalops*	75-460
Shortspine spiny dogfish	*Squalus mitsukurii*	150-600
Sixgill sawshark	*Pliotrema warreni*	60-500
Tigar catshark	*Halaelurus natalensis*	50-100
Izak catshark	*Holohalaelurus regani*	100-500
Yellowspotted catshark	*Scyliorhinus capensis*	150-500
Soupfin shark/Vaalhaai	*Galeorhinus galeus*	<10-300
Houndshark	*Mustelus mustelus*	<100
Whitespotted houndshark	*Mustelus palumbes*	>350
Little guitarfish	*Rhinobatos annulatus*	>100
Atlantic electric ray	*Torpedo nobiliana*	120-450
Roughnose legskate	*Crurirajaparcomaculata*	150-620
Thorny skate	*Raja radiata*	50-600
Slime skate	*Raja pullopunctatus*	15-460
Rough-belly skate	*Raja springeri*	85-500
Yellowspot skate	*Raja wallacei*	70-500
Biscuit skate	*Raja clavata*	25-500
Bigthorn skate	*Raja confundens*	100-800
Spearnose skate	*Raja alba*	75-260
St Joseph	*Callorhinchus capensis*	30-380

(b) Pelagic fish species

The structure of the nearshore and surf zone fish community varies greatly with the degree of wave exposure. Species richness and abundance is generally high in sheltered and semi-exposed areas but typically very low off the more exposed beaches (Clark 1997a, 1997b).

The surf-zone and outer turbulent zone habitats of sandy beaches are considered to be important nursery habitats for marine fishes (Modde 1980; Lasiak 1981; Kinoshita & Fujita 1988; Clark *et al.* 1994). Surf-zone fish communities off the South African West Coast have relatively high biomass, but low species diversity. Typical surf-zone fish include harders (*Liza richardsonii*), white stumpnose (*Rhabdosargus globiceps*), Cape sole (*Heteromycteris capensis*), Cape gurnard (*Chelidonichthys capensis*), False Bay klipfish (*Clinus latipennis*), sandsharks (*Rhinobatos annulatus*), eagle ray (*Myliobatis aquila*), and smooth-hound (*Mustelus mustelus*) (Clark 1997b).

Fish species commonly found in kelp beds off the West Coast include hottentot *Pachymetopon blochii*, twotone fingerfin *Chirodactylus brachydactylus*, red fingers *Cheilodactylus fasciatus*, galjoen *Dichistius capensis*, rock suckers *Chorisochismus dentex,* maned blennies *Scartella emarginata* and the catshark *Haploblepharus pictus* (Sauer *et al.* 1997; Brouwer *et al*. 1997; Branch *et al*. 2010).

Small pelagic species occurring beyond the surfzone and generally within the 200 m contour include the sardine/pilchard (*Sadinops ocellatus*), anchovy (*Engraulis capensis*), chub mackerel (*Scomber japonicus*), horse mackerel (*Trachurus capensis*) and round herring (*Etrumeus whiteheadi*). These species typically occur in mixed shoals of various sizes (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 fish species (see Figure 4.15) are distributed on the continental shelf and along the shelf edge extending from south of St Helena Bay to Mossel Bay on the South Coast (Shannon & Pillar 1986). 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 gradually move southwards in the inshore flowing surface current, towards the major spawning grounds east of Cape Point.

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 (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. Many of the large migratory pelagic species are considered threatened by the IUCN, primarily due to overfishing (see Table 4.4).

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 by the pelagic long-line fishery or are specifically targeted for their fins.

Table 4.4: 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	*Thunnus maccoyii*	Critically Endangered
Bigeye Tuna	*Thunnus obesus*	Vulnerable
Longfin Tuna/Albacore	*Thunnus alalunga*	Near Threatened
Yellowfin Tuna	*Thunnus albacares*	Near Threatened
Frigate Tuna	*Auxis thazard*	Least concern
Skipjack Tuna	*Katsuwonus pelamis*	Least concern
Billfish		
Blue Marlin	*Makaira nigricans*	Vulnerable
Sailfish	*Istiophorus platypterus*	Least concern
Swordfish	*Xiphias gladius*	Least concern
Black Marlin	*Istiompax indica*	Data deficient
Pelagic Sharks		
Pelagic Thresher Shark	*Alopias pelagicus*	Vulnerable
Common Thresher Shark	*Alopias vulpinus*	Vulnerable
Great White Shark	*Carcharodon carcharias*	Vulnerable
Shortfin Mako	*Isurus oxyrinchus*	Vulnerable
Longfin Mako	*Isurus paucus*	Vulnerable
Blue Shark	*Prionace glauca*	Near Threatened
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Vulnerable

4.3.4.4 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. The Leatherback is the only turtle likely to be encountered in the offshore waters of west South Africa. Loggerhead and green turtles are expected to occur only as occasional visitors along the West Coast.

Leatherback turtles inhabit deeper waters and are considered a pelagic species. The Benguela ecosystem, especially the northern Benguela where jelly fish numbers are high, is increasingly being recognised as a potentially important feeding area for leatherback turtles. 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 and CMS (Convention on Migratory Species). 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 4.16). 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.

Loggerhead and green turtles are listed as “Endangered”. As a signatory of CMS, South Africa has endorsed and signed a CMS International Memorandum of Understanding specific to the conservation of marine turtles. South Africa is thus committed to conserve these species at an international level.

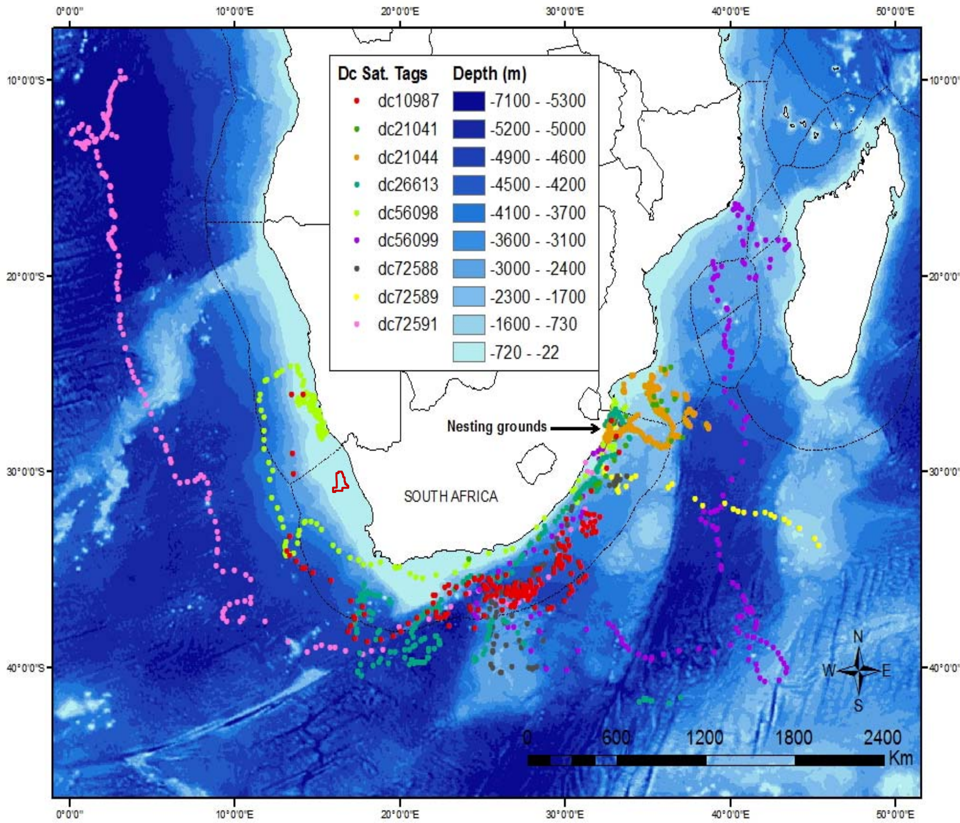


Figure 4.16: The post-nesting distribution of nine satellite tagged leatherback females (1996 – 2006; Oceans and Coast, unpublished data). The approximate location of Block 2A is also shown.

4.3.4.5 Seabirds

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

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

The availability of breeding sites is an extremely important determinant in the distribution of resident seabirds. Although breeding areas are distributed along the whole coast, islands are especially important, particularly those between Dyer Island and Lamberts Bay. Fourteen resident species breed along the West Coast, including Cape gannet, African penguin, four species of cormorant, white pelican, three gull and four tern species (Table 4.6).

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

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

African penguin colonies (*Spheniscus demersus*) occur at 27 localities around the coast of South Africa and Namibia (see Figure 4.17). The species forages at sea with most birds being found within 20 km of their colonies. African penguin distribution at sea is consistent with that of the pelagic shoaling fish, which generally occur within the 200 m isobath. The decline in the African penguin population is ascribed primarily to the removal of the accumulated guano from the islands during the nineteenth century. Penguins used to breed in burrows in the guano and are now forced to nest in the open, thereby being exposed to much greater predation and thermal stress.

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

Shore birds likely to be encountered in the area of the proposed pipeline shore crossings include the African black oystercatcher *Haematopus moquini* (Listed as “Near-threatened” on the IUCN red data list).

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

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

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

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

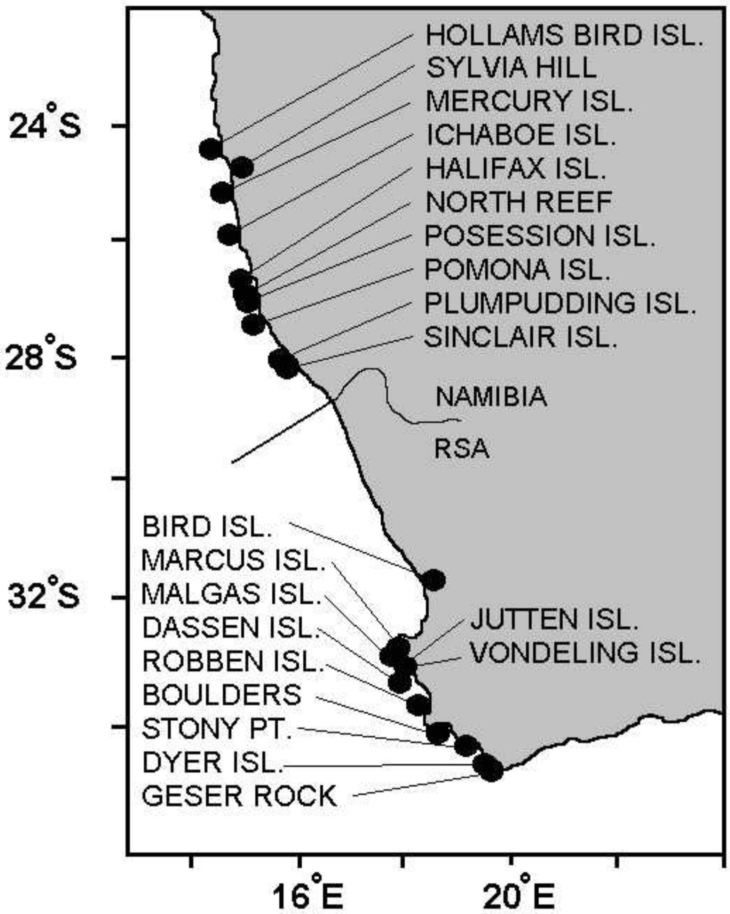


Figure 4.17: The distribution of breeding colonies of African penguins on the South African West Coast.

4.3.4.6 Cetaceans

The cetacean fauna of the West Coast comprises 33 species of whales and dolphins known or to occur here (see Table 4.7). The offshore areas have been particularly poorly studied with almost all available information from deeper waters (>200 m) arising from historic whaling records. Information on smaller cetaceans in deeper waters is particularly poor. The distribution of whales and dolphins on the West Coast can largely be split into those associated with the continental shelf and those that occur in deep, oceanic waters. Species from both environments may, however, be found associated with the shelf (200 - 1 000 m), making this the most species-rich area for cetaceans.

Cetaceans comprised two basic taxonomic groups: the mysticetes (filter-feeding baleen whales) and the odontocetes (toothed predatory whales and dolphins).

(a) Mysticetes (baleen) whales

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

- Southern right and humpback whales: The most abundant baleen whales off the coast of South Africa are southern right (listed as Least Concern) and humpback whales (listed as Least Concern). Southern right whales migrate to the southern Africa subcontinent to breed and calve, where they tend to have an extremely coastal distribution mainly in sheltered bays (90% <2 km from shore; Best 1990, Elwen & Best 2004). They typically arrive in coastal waters off the West Coast in June, increasing to a maximum number in September/October, with most departing in December (although animals may be sighted as early as April and as late as February). On the West Coast they are most common south of Lambert's Bay (CCA & CMS 2001), although a number of the bays between Chameis Bay (27°56'S) and Conception Bay (23°55'S) in Namibia have in recent years become popular calving sites (Currie *et al*. 2009), with sightings reported as far north as the Kunene and Möwe Bay (Roux *et al*. 2001). The Southern Right calving season extends from late June to late October, peaking in August (Best 1994; Roux *et al*. 2001), with cow-calf pairs remaining in sheltered bays for up to two months before starting their southern migration.

  The majority of humpback whales on the West Coast are migrating past the southern African continent to breeding grounds off Angola, Republic of Congo and Gabon (Rosenbaum *et al.* 2009, Barendse *et al*. 2010). On the West Coast it is thought that only a small proportion of the main migration comes close inshore, the majority choosing the shortest route to the central West African breeding grounds by following the edge of the continental shelf (Best 2007; Best & Allison 2010). Humpback whales migrate at various distances from the coast including pelagic waters (Barendse et al. 2002), and as they are likely to regularly cross the study area, will probably be the most abundant large whale encountered. Most humpbacks reach southern African waters around April, continuing through to September/October when the southern migration begins and continues through to December. The calving season for humpbacks extends from July to October, peaking in early August (Best 2007). Cow-calf pairs are typically the last to leave southern African waters on the return southward migration, although considerable variation in the departure time from breeding areas has been recorded (Barendse *et al*. 2010).

Table 4.7: Cetaceans occurrence off the West Coast of South Africa, their seasonality, likely encounter frequency with proposed pipeline construction and IUCN conservation status.

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

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

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. The offshore location of the proposed area of interest makes encounters with whales undergoing summer migrations highly unlikely.

Since the southern right population is still continuing to grow at approximately 7% per year (Brandaõ *et al.* 2011), the population size in 2013 would number more than 6 000 individuals. Recent abundance estimates put the number of humpback whales in the west African breeding population to be in excess of 9 000 individuals in 2005 and it is likely to have increased since this time at about 5% per annum (IWC 2012).

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

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

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

- Blue whales: Antarctic blue whales were historically caught in high numbers during commercial whaling activities, with a single peak in catch rates during July in Walvis Bay, Namibia and at Namibe, Angola suggesting that in the eastern South Atlantic these latitudes are close to the northern migration limit for the species (Best 2007). Only two confirmed sightings of blue whales have occurred off the entire West Coast of Africa since 1973 (Branch *et al.* 2007), although search effort (and thus information), especially in pelagic waters is very low. This suggests that the population using the area may have been extirpated by whaling and there is a low chance of encountering the species in the study area.

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

- Pygmy right whale: The smallest of the baleen whales, the pygmy right whale occurs in the Benguela region (Leeney *et al.* 2013). The species is more commonly associated with cool temperate waters between 30°S and 55°S. There are no data on the abundance or conservation status of this species. As it was not subjected to commercial whaling, the population is expected to be near to original numbers. Sightings of this species at sea are rare (Best 2007) due in part to their small size and inconspicuous blows. Density in the study area is likely to be low.

(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 study area display a diversity of features, for example their ranging patterns vary from extremely coastal and highly site specific to oceanic and wide ranging. There is 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 off the shelf of the West Coast. Beaked whales are all considered to be true deep water species usually being seen in waters in excess of 1 000 – 2 000 m depth (Best 2007). Their presence in the area may fluctuate seasonally, but insufficient data exist to define this clearly.

- Sperm whales: Sperm whales are the largest of the toothed whales and have a complex, well-structured social system with adult males behaving differently from younger males and female groups. They live in deep ocean waters, usually greater than 1 000 m depth, occasionally coming into depths of 500-200 m on the shelf (Best 2007). Seasonality of catches off the West Coast suggest that medium- and large-sized males are more abundant during winter, while female groups are more abundant in autumn (March-April), although animals occur year round (Best 2007). Sperm whales feed at great depth, during dives in excess of 30 minutes, making them difficult to detect visually. Sperm whales in the project area are likely to be encountered in relatively high numbers in deeper waters (>500 m) beyond the proposed pipeline depth, predominantly in the winter months (April - October).

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

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

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

- Long-finned pilot whales: Long finned pilot whales display a preference for temperate waters and are usually associated with the continental shelf or deep water adjacent to it (Mate *et al.* 2005; Findlay *et al.* 1992; Weir 2011). They are regularly seen associated with the shelf edge by marine mammal observers and fisheries observers and researchers. 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 study area will be long-finned.

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

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

- Southern right whale dolphins: The cold waters of the Benguela provide a northwards extension of the normally subantarctic habitat of this species (Best 2007). Most records in the region originate in a relatively restricted region between 26˚S and 28˚S off Lüderitz (Rose & Payne 1991) in water 100 – 2 000 m deep (Best, 2007), where they are seen several times per year (Findlay *et al*. 1992; JP Roux[1] pers comm.). It is possible that the Namibian sightings represent a resident population (Findlay *et al.* 1992). Encounters in the study area are unlikely.

- Dusky dolphins: 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.

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

- Heaviside's dolphins: This species is relatively abundant in the Benguela ecosystem within the region of 10 000 animals estimated to live in the 400 km of coast between Cape Town and Lamberts Bay (Elwen *et al.* 2009). Individuals show high site fidelity to small home ranges, 50 - 80 km along shore (Elwen *et al*. 2006) and may thus be more vulnerable to threats within their home range. 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.

- Beaked whales (various species): Beaked whales were never targeted commercially and their pelagic distribution makes them largely inaccessible to most researchers making them the most poorly studied group of cetaceans. All the beaked whales that may be encountered in the study 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). The long, deep dives of beaked whales make them both difficult to detect visually.

- Other delphinids: 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 it is likely that encounters would be rare.

4.3.4.7 Seals

The Cape fur seal (*Arctocephalus pusillus pusillus*), listed as "Least Concern" on the IUCN Red List of Threatened Species, 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. 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).

There are a number of Cape fur seal colonies within the broader study area: Elephant Rocks (north of the Olifants River mouth), Bird Island (Lambert's Bay) Paternoster Rocks and Jacobs Reef at Cape Columbine, Cape Columbine, Vondeling Island (Saldanha Bay), Robbesteen (near Koeberg) and Duikerklip (Hout Bay). Non-breeding colonies occur at Strandfontein Point (south of Hondeklipbaai), on Jutten Island (Kirkman *et al.* 2013), at Paternoster Point at Cape Columbine and Duikerklip in Hout Bay (see Figure 4.18). 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 nm offshore, 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).

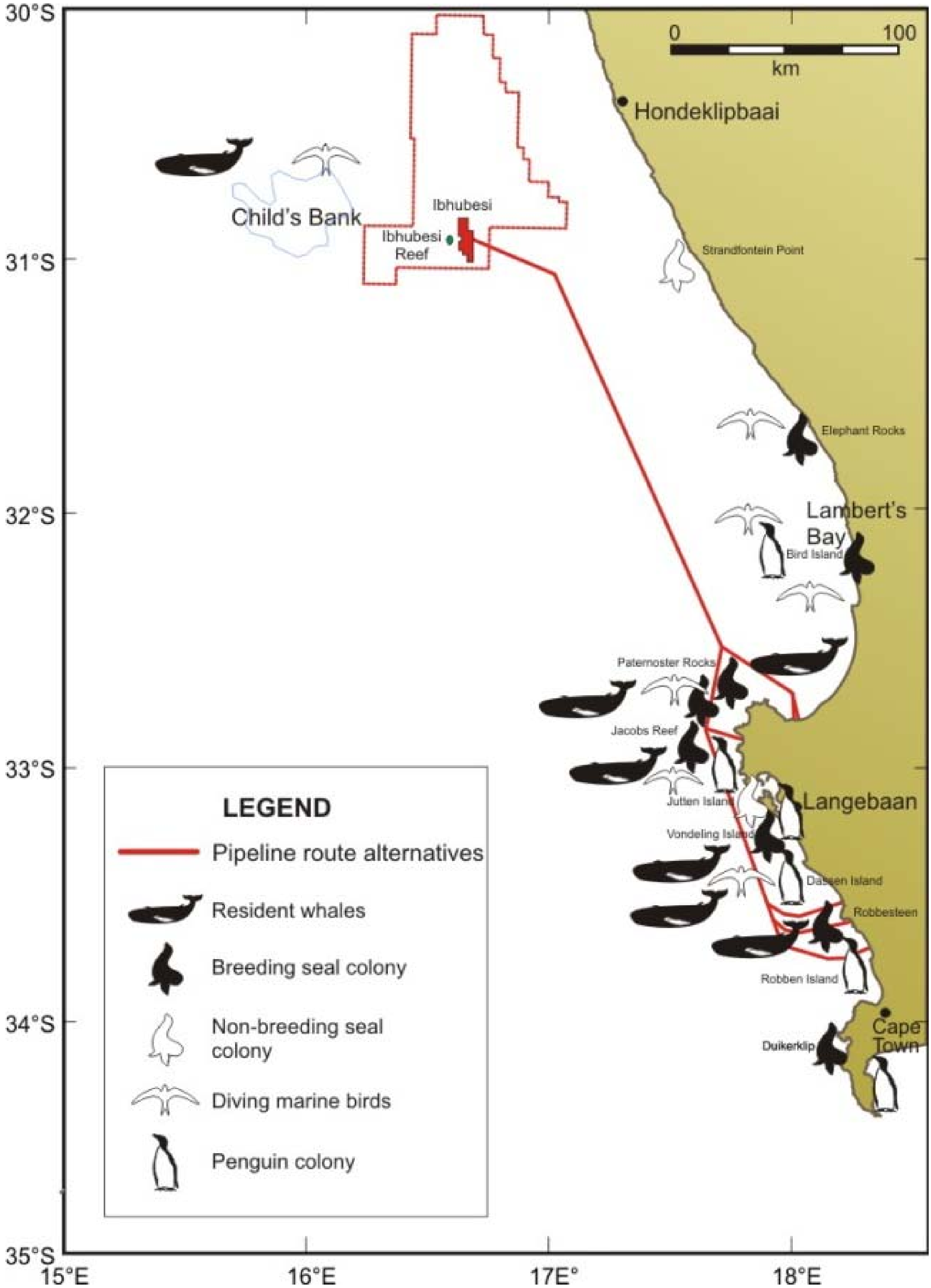


Figure 4.18: Ibhubesi Gas Field and proposed production pipeline route alternatives in relation to seabird and seal colonies and resident whale populations.

4.4 OTHER USES OF MARINE ENVIRONMENT

4.4.1 FISHERIES

The South African fishing industry consists of 14 commercial sectors operating within the country's 200 nm EEZ. The following fisheries are active off the West Coast:

- Demersal trawl;
- Small pelagic purse-seine;
- Demersal long-line (hake and shark);
- Large pelagic long-line;
- Tuna pole;
- Traditional line fish; and
- West Coast rock lobster.

4.4.1.1 *Demersal trawl*

Demersal trawl is South Africa's most valuable fishery accounting for approximately half of the income generated from commercial fisheries. Demersal trawlers operate extensively around the coast primarily targeting the bottom-dwelling (demersal) species of hake (*Merluccius paradoxus* and *M. capensis*). Main by-catch species include monkfish (*Lophius vomerinus*), kingklip (*Genypterus capensis*) and snoek (*Thyrsites atun*). The hake-directed trawl fishery is split into two sub-sectors: a small inshore trawling sector active off the South Coast and a large deep-sea trawl sector operating on both the South and West coasts. There are currently 45 trawlers operating within the offshore sector. The current annual hake Total Allowable Catch (TAC) of hake across all sectors is 156 075 tons (2013), of which the majority is landed by the demersal trawl sector.

The towed gear typically consists of trawl warps, bridles and trawl doors, a footrope, headrope, net and codend (see Figure 4.19). 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.

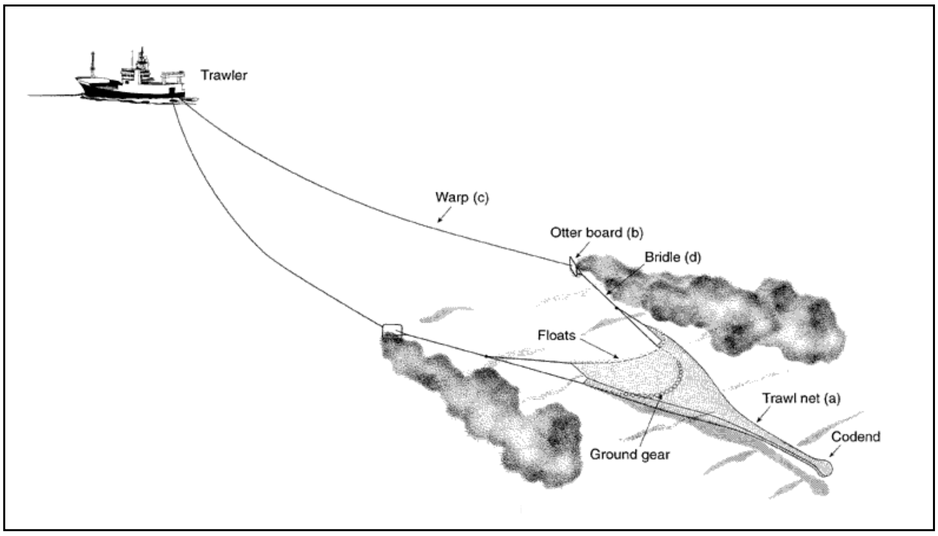
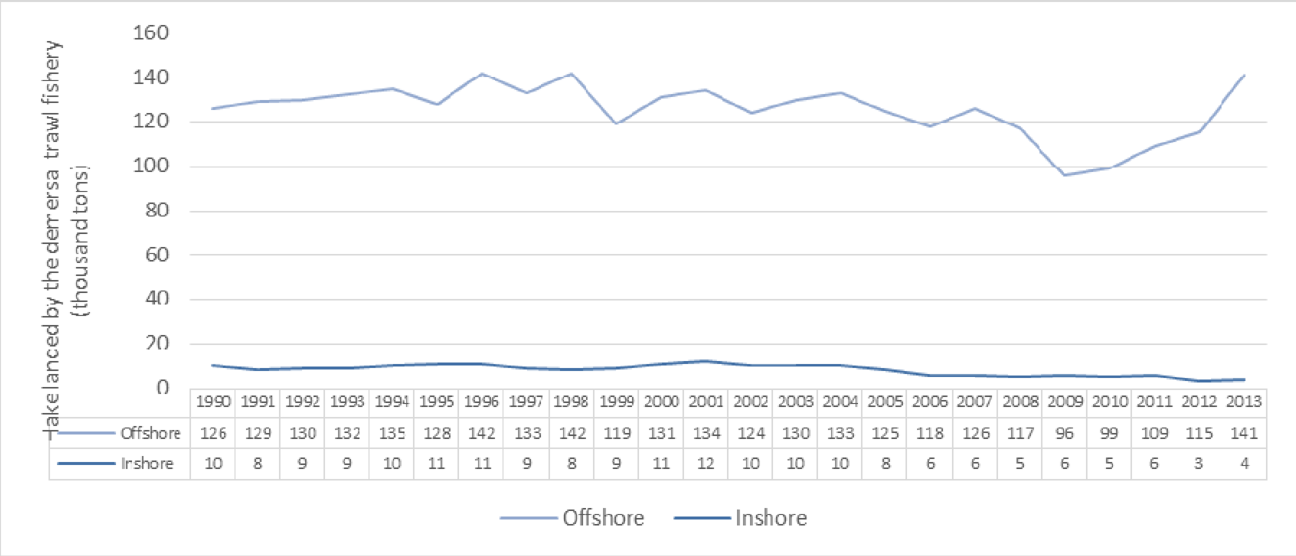


Figure 4.19: Typical gear configuration used by demersal trawlers (offshore) targeting hake.

The landings of hake by the demersal trawl sector (offshore and inshore) over the period 1990 to 2013 are presented in Figure 4.20. 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.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Offshore	126	129	130	132	135	128	142	133	142	119	131	134	124	130	133	125	118	126	117	96	99	109	115	141
Inshore	10	8	9	9	10	11	11	9	8	9	11	12	10	10	10	8	6	6	5	6	5	6	3	4

Figure 4.20: Landing of hake by the offshore and inshore demersal trawl fleets between 1990 and 2013.

The deep sea trawl sector on the West Coast operates mainly in a continuous band along the shelf edge between the 300 m and 1 000 m bathymetric contours. Monk-directed trawlers tend to fish in shallower waters compared to the 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. Child's Bank, 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 5 nm of the coastline.

The spatial distribution of demersal trawl fishing effort (2000 to 2012) along the West Coast in relation to Block 2A and the proposed offshore pipeline route alternatives is shown in Figure 4.21. Fishing grounds do not coincide with Block 2A. The proposed offshore pipeline only passes through one commercial fisheries grid block along its length (i.e. Grid Block 441 offshore of Saldanha Bay). Records show that approximately 0.02% and 0.07% of the national catch and effort, respectively, has been recorded in Grid Block 441.

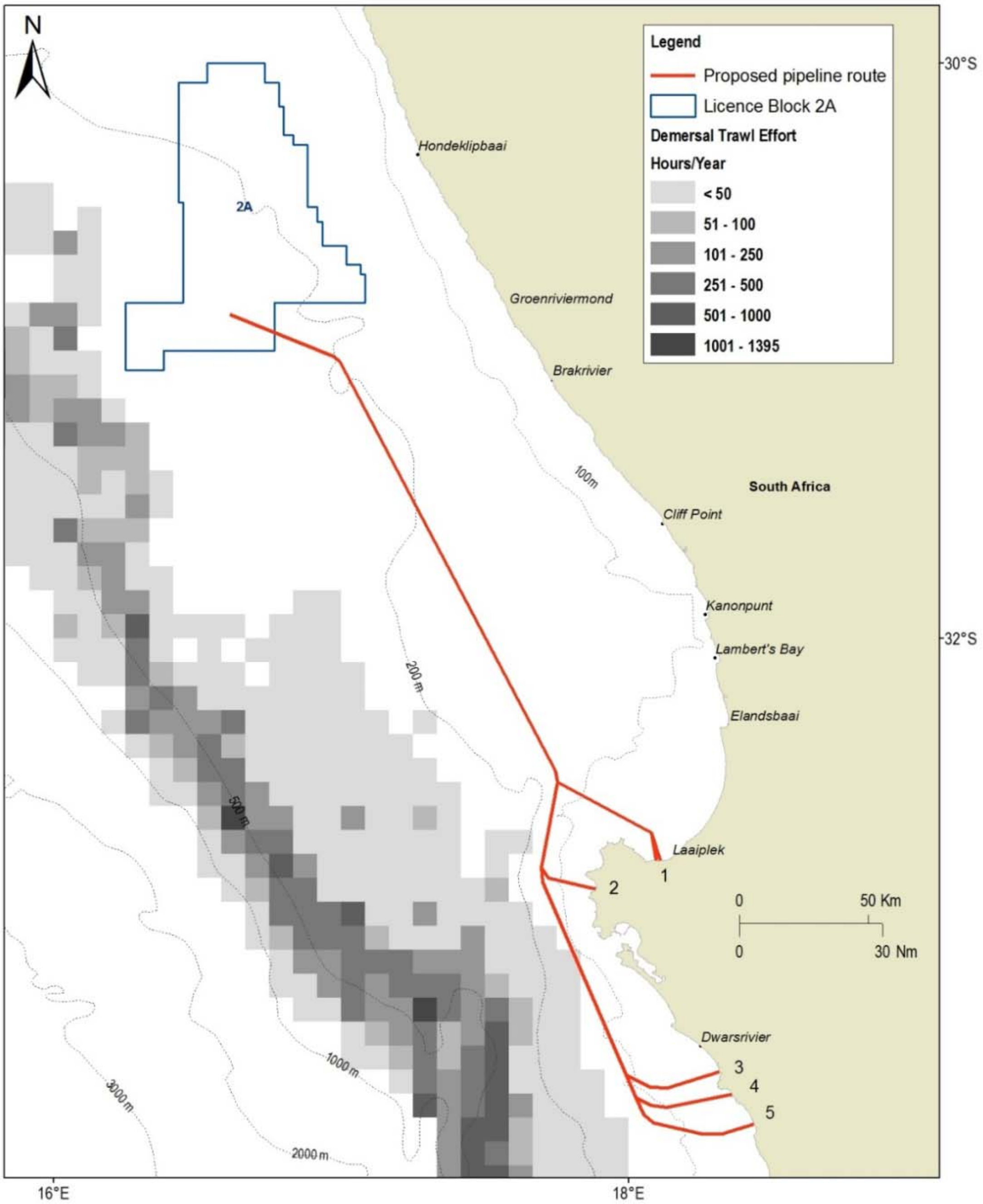


Figure 4.21: The location of Block 2A and proposed pipeline alternatives in relation to hake-directed demersal trawl effort along West Coast between 2000 and 2012.

4.4.1.2 Small pelagic purse-seine fishing

The South African small pelagic purse-seine fishery is the largest fishery by volume and the second most important in terms of value. The two main targeted species are sardine and anchovy, with associated by-catch of round herring (red-eye) and juvenile horse mackerel. Annual landings have fluctuated between 300 000 and 600 000 tons over the last decade, with landings of 468 000 tons recorded per annum between 2000 and 2012, compared to 391 000 tons per annum recorded between 2008 and 2012.

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 Lamberts Bay to Kleinbaai (19.5°E) on the South Coast 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 from Lambert's Bay to south of Cape Point.

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 4.22). 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.

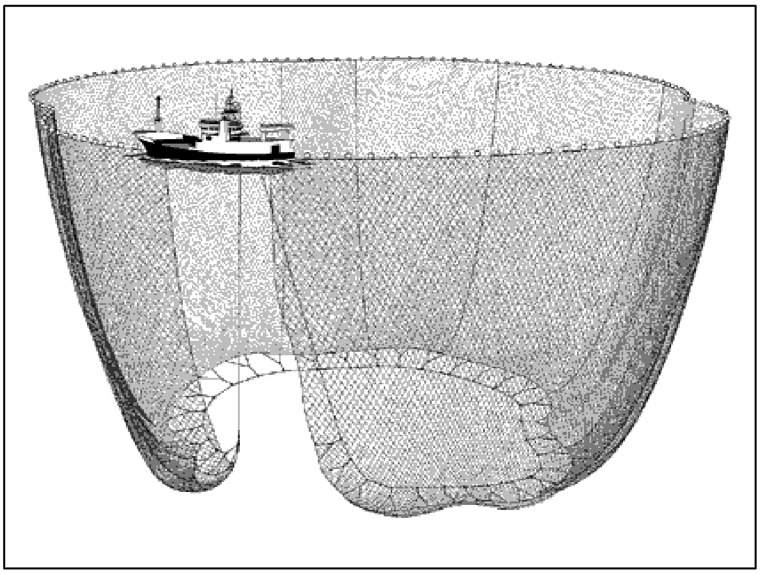


Figure 4.22: Pelagic purse-seine gear configuration.

The reported annual effort expended by the small pelagic purse-seine sector for the period 2000 to 2012 in relation to the proposed offshore pipeline alternatives are shown in Figures 4.23 and 4.24. Although there is no effort recorded in Block 2A, fishing activity is evident along the majority of the length of the proposed offshore pipeline. Since the fishery is pelagic in nature, fishing operations would not be affected by the presence of a pipeline on the seafloor. The fishery could, however, be affected during pipeline installation due to the 500 m safety zone around the pipe-laying vessel. Effort recorded by this fishery over the period 2000 to 2012 indicates that the safety zone would coincide with between 0.06% and 0.48% of the total number of fishing events recorded by the fishery, depending on the landing site selected (see Table 4.8).

Table 4.8: Percentage of total fishing events undertaken by the small pelagic purse-seine fishery from 2000 to 2012 within the 500 m safety zone around six alternative offshore pipeline alternatives.

Landing Points	Percentage of total throws
St Helena East	0.15
St Helena West	0.14
Noordwesbaai	0.06
Grotto Bay	0.44
Silwerstroom Strand	0.42
Duynefontein	0.48

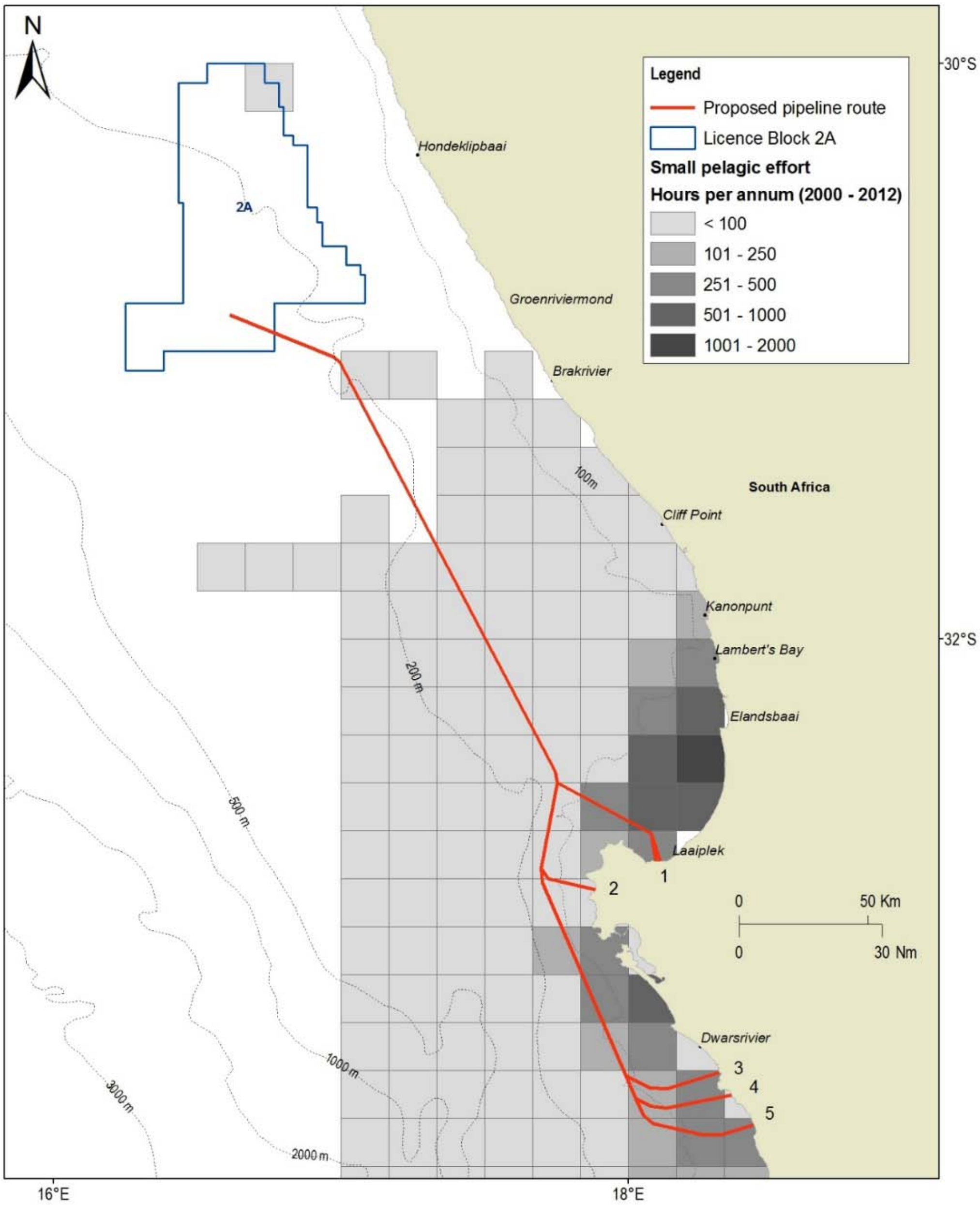


Figure 4.23: The location of Block 2A and the proposed pipeline alternatives in relation to pelagic purse-seine effort between 2000 and 2012.

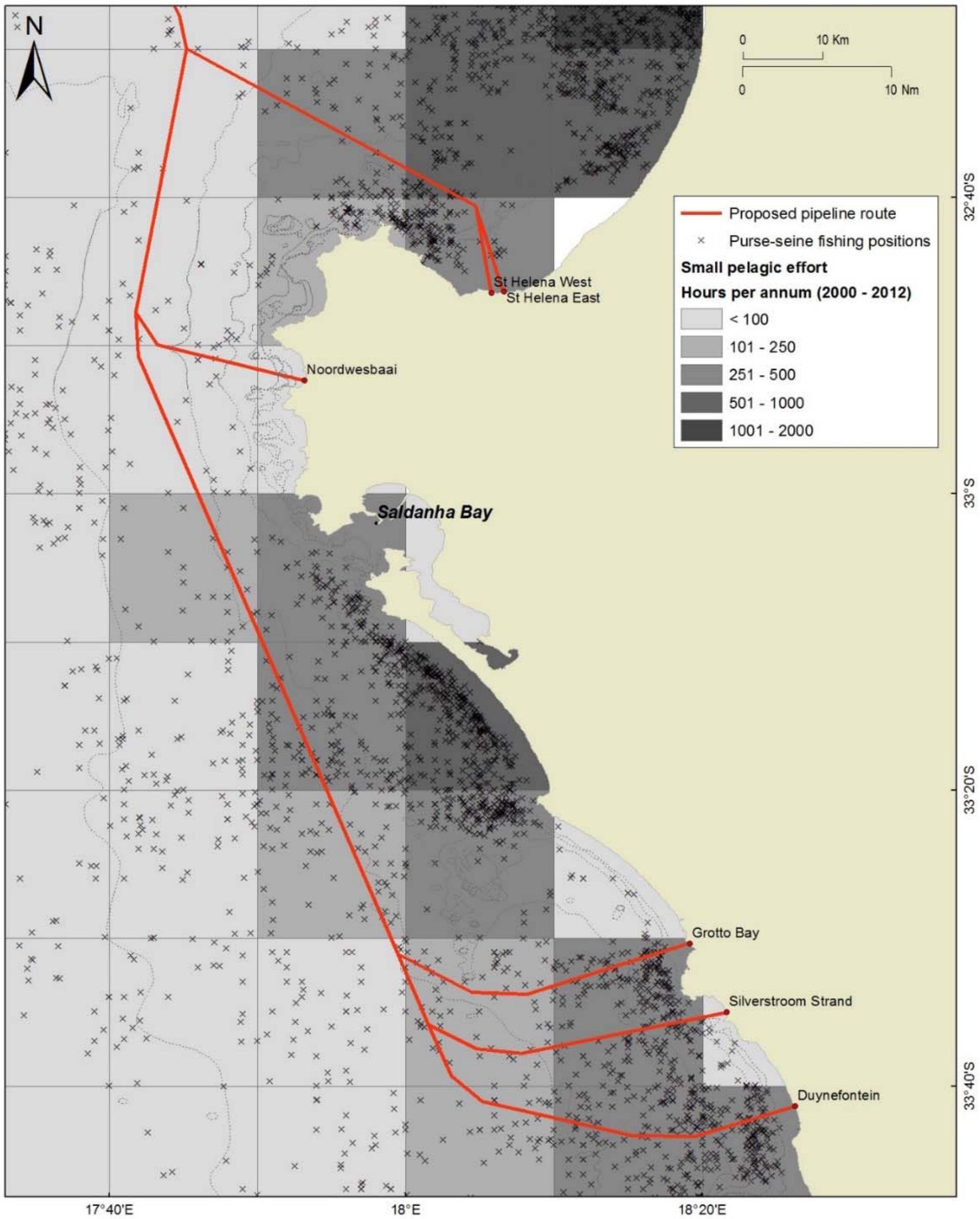


Figure 4.24: The location of the proposed pipeline shore-crossing alternatives in relation to pelagic purse-seine effort between 2000 and 2012.

4.4.1.3 Demersal long-line

In South Africa the demersal long-line fishery operates in well-defined areas extending along the shelf break from Port Nolloth to Cape Agulhas and is comprised of the hake-directed, with a small non-targeted commercial by-catch that includes kingklip, and shark-directed demersal long-line sectors.

Bottom-set long-line gear is robust and comprises two lines as well as dropper lines with subsurface floats attached (see Figure 4.25). 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 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.

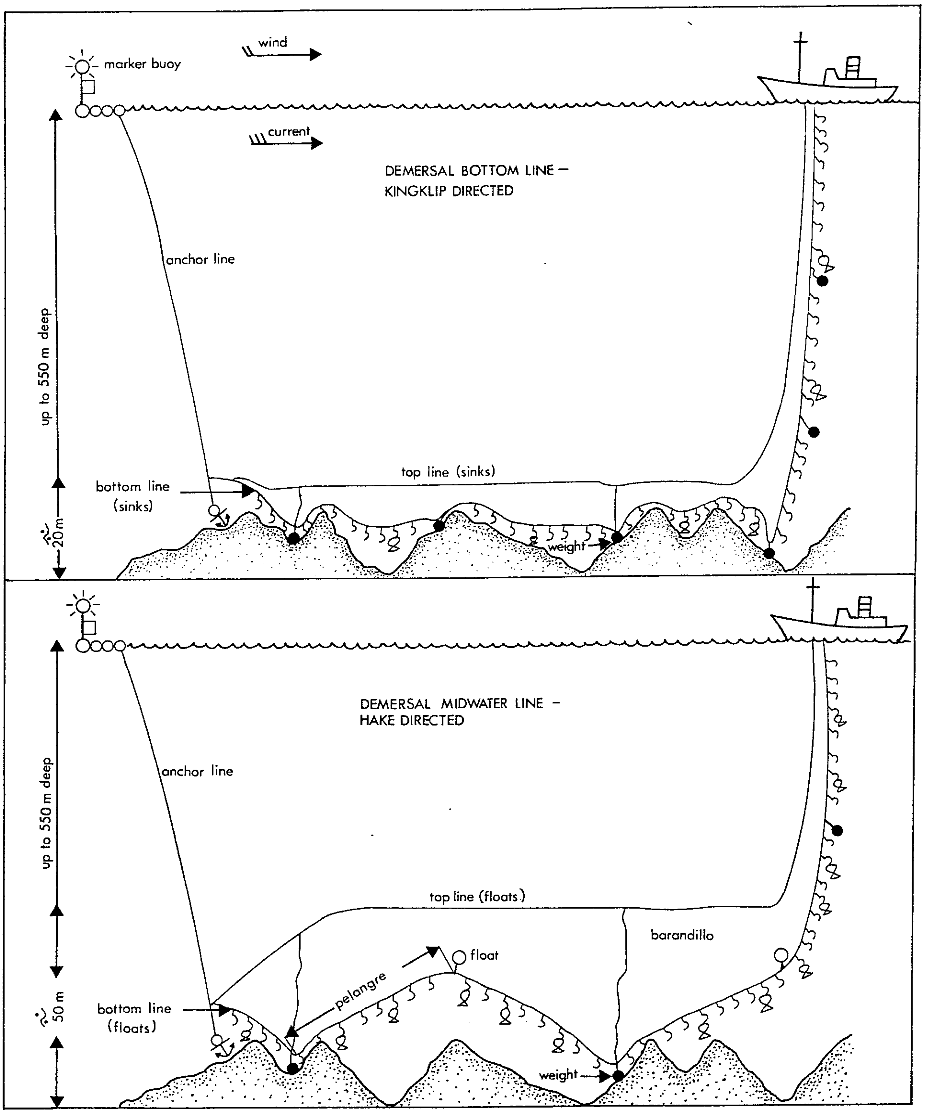


Figure 4.25: Typical configuration of Demersal (bottom-set) hake long-line gear used in South African waters.

(a) Hake-directed demersal long-line sector

Most of the 64 hake-directed vessels are based at the harbours of Cape Town and Hout Bay. Operations are *ad hoc* and intermittent, subject to market demand. The fishery operates year-round with a slight increase in activity between August and December.

Annual landings of hake by the demersal long-line fishery over the period 1990 to 2002 are shown in Figure 4.26. 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 period between 2008 and 2012, during which time the fishery set an average of 28.9 million hooks and landed 8 368 tons of hake per year.

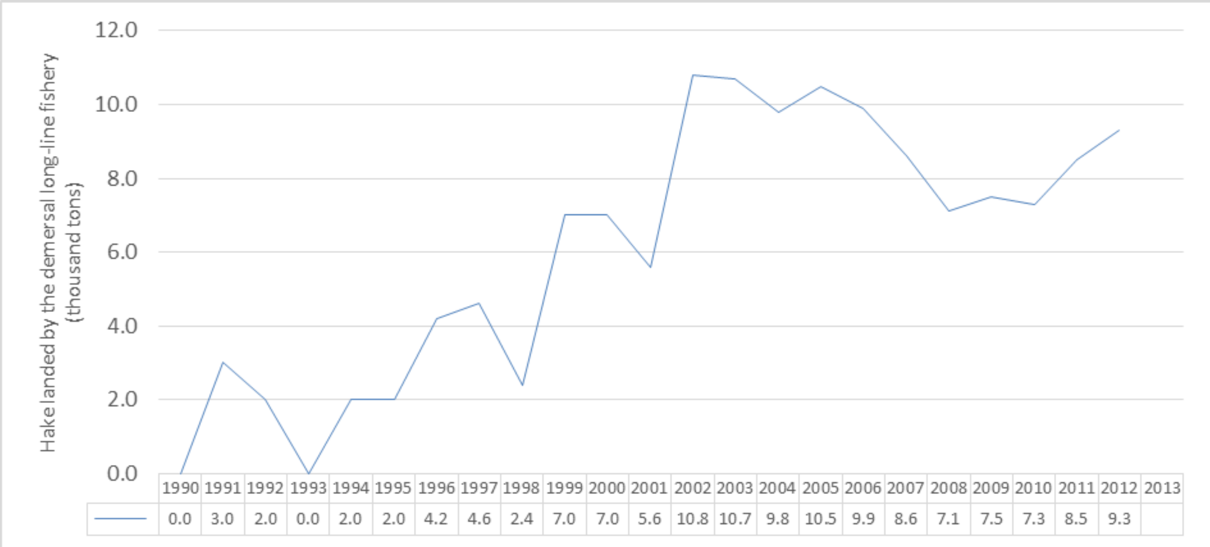


Figure 4.26: Hake landings recorded by the demersal long-line fishery over the period 1990 to 2012.

Figure 4.27 shows the spatial distribution of hake-directed long-line effort recorded off the West Coast between 2000 and 2012. Demersal long-line fishing grounds are similar to those targeted by the hake-directed trawl fleet. Lines are set parallel to bathymetric contours, predominantly along the shelf edge. On the West Coast (i.e. West of 20°E), effort is expended predominantly between the 250 m and 500 m isobaths in an almost continuous band extending from south of the Agulhas Bank to in line with St Helena Bay. Northwards of St Helena Bay, effort is more fragmented but runs predominantly between the 350 m and 450 m isobaths.

During the period 2000 to 2013, while some effort was recorded within grid blocks through which the pipeline passes, there is only one recorded fishing event that coincides with the proposed pipeline (see Grid Block 414 in Figure 4.28). Although fishing effort in the vicinity of the proposed pipeline is low, fishing is likely to occur. It is anticipated that, in terms of the Marine Traffic Act, 1981, demersal long-line vessels would not be permitted to set lines within 500 m of the proposed pipeline as the gear includes anchoring, which could damage to the pipeline.

(b) Shark-directed demersal long-line sector

The demersal shark fishery targets soupfin shark, smooth-hound shark, spiny dogfish, St Joseph shark, *Charcharhinus* spp., rays and skates. Other species which are not targeted but may be landed include Cape gurnards, jacopever and smooth hammerhead shark. Effort is continuous throughout the year with a relative increase between May and October. 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. Over the period 2007 to 2012, the fishery reported an annual average of 430 500 hooks set and 175 tons landed annually.

The spatial distribution of effort expended by the shark-directed demersal long-line fishery in the vicinity of the proposed production pipeline is shown in Figure 4.29. On the West Coast (West of 20°E), fishing grounds are centred predominantly in coastal waters inshore of the 200 m isobaths around the South-Western Cape coastline and extending up to Saldanha Bay.

The fishing grounds do not coincide with Block 2A or the northern pipeline route alternatives. There have, however, been several fishing events in close proximity to the proposed pipeline route alternatives associated with the southern shore-crossing and the fishery could be expected to operate within these areas. The level of fishing effort in the vicinity of the southern shore-crossings is relatively low compared with that expended by the fishery on a national level.

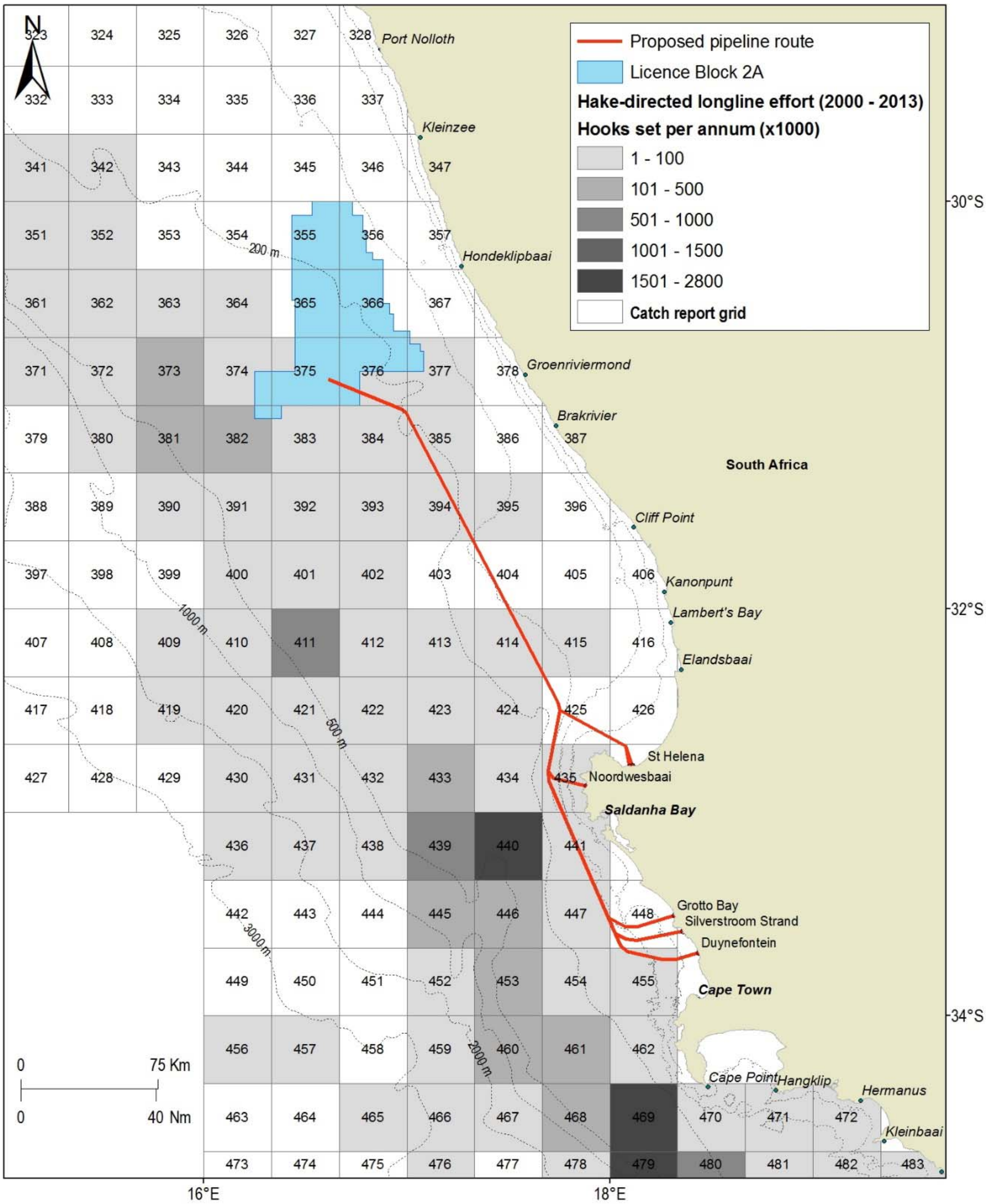


Figure 4.27: The location of Block 2A and the proposed production pipeline in relation to hake-directed demersal long-line effort along the West Coast between 2000 and 2013.

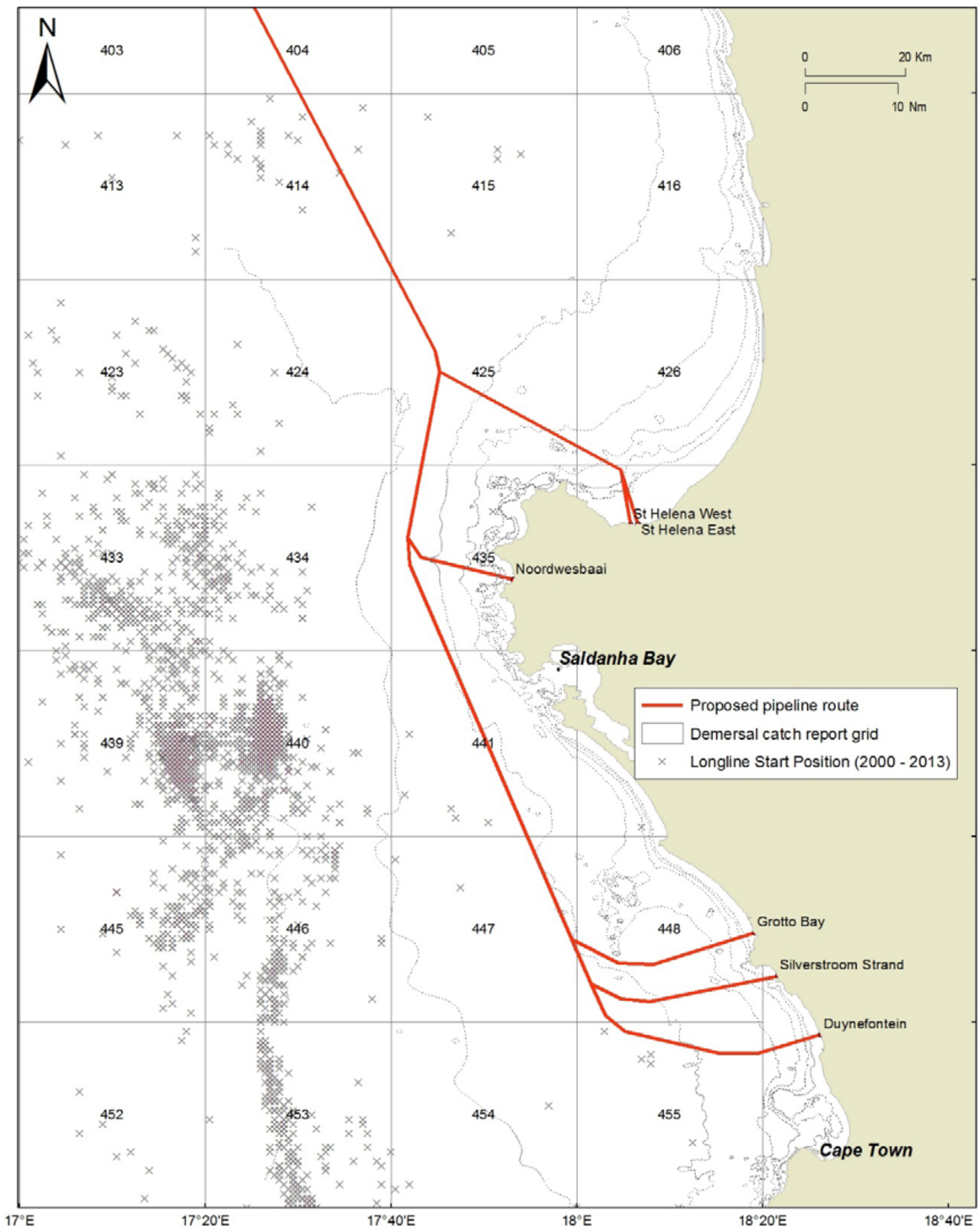


Figure 4.28: The location of the proposed pipeline shore-crossing alternatives in relation to hake-directed demersal long-line effort. Effort is indicated as the recorded position of the start of lines set between 2000 and 2013.

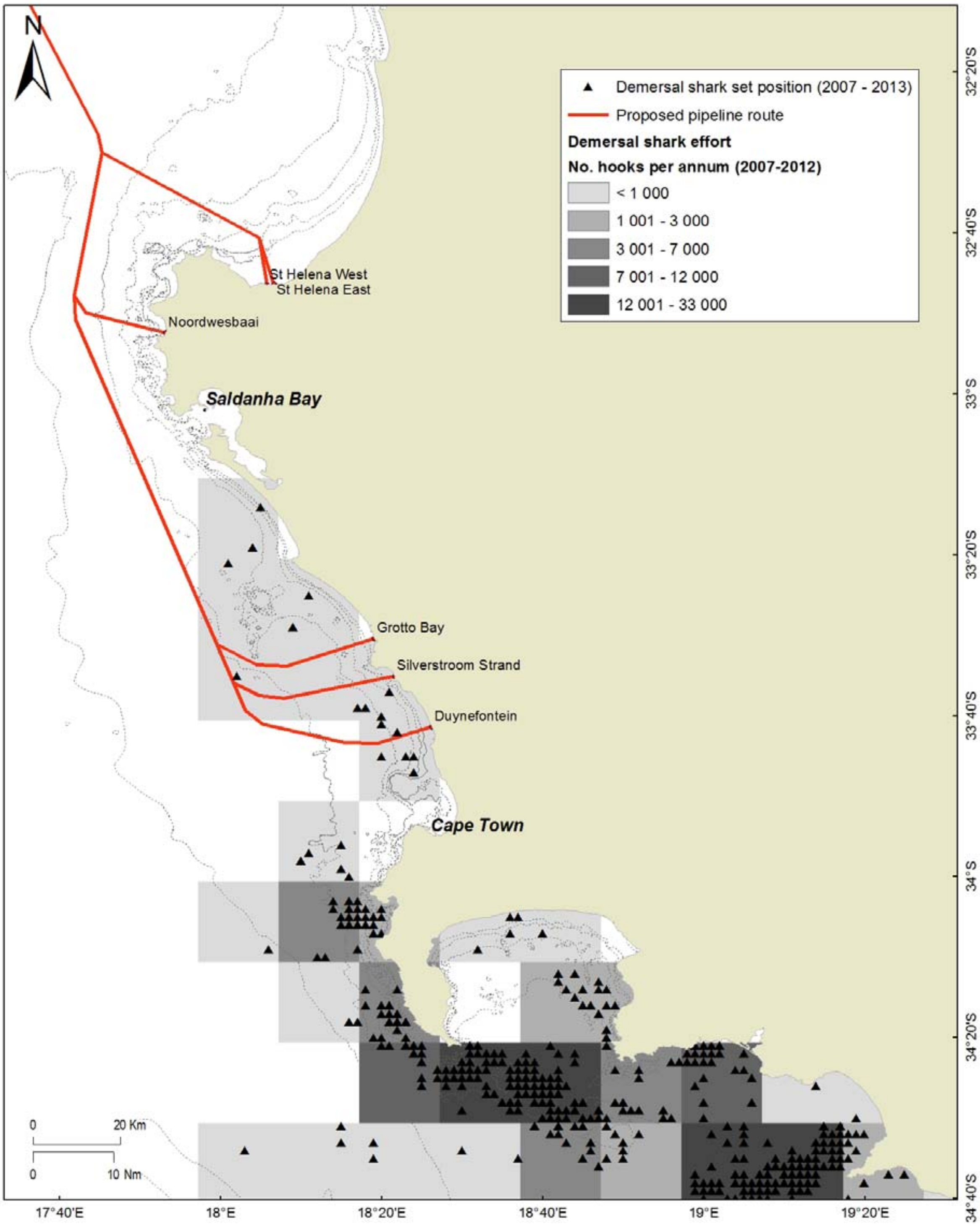


Figure 4.29: The location of the proposed pipeline shore-crossing alternatives in relation to shark-directed demersal long-line effort between 2007 and 2012.

4.4.1.4 Pelagic long-line

The large pelagic long-line fishery operates year-round with a relative increase in effort during winter and spring, 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 mainly through the International Convention for the Conservation of Atlantic Tunas (ICCAT). 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 4.30). 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 it’s 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.

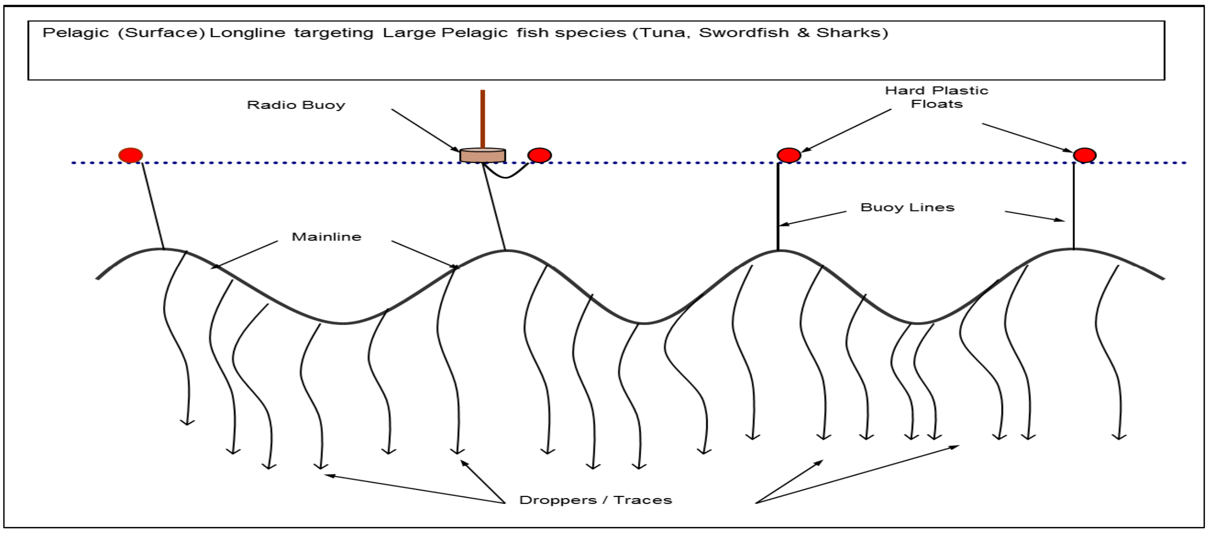


Figure 4.30: Typical Pelagic long-line configuration targeting tuna, swordfish and shark species.

The fishery operates extensively from the continental shelf break into deeper waters. 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. However, during the period 2008 to 2012 there has been an increase in effort, whilst landings have remained relatively constant within the fishery (3 047 tons and 4.84 million hooks set per year).

Figure 4.31 shows the spatial distribution of catch reported by the large pelagic long-line sector in the vicinity of Block 2A and the proposed production pipeline. Fishing activity is concentrated at the shelf break, predominantly seawards of the 500 m isobath but with incidental records closer inshore. There is very limited catch record from Block 2A and it is unlikely that the 500 m safety zone around the proposed production facility would impact this sector. There is no evidence of fishing activity having taken place within 500 m of the proposed offshore pipeline route over the period 2000 to 2012 and it is, therefore, unlikely that the sector would be affected by the installation of the proposed pipeline.

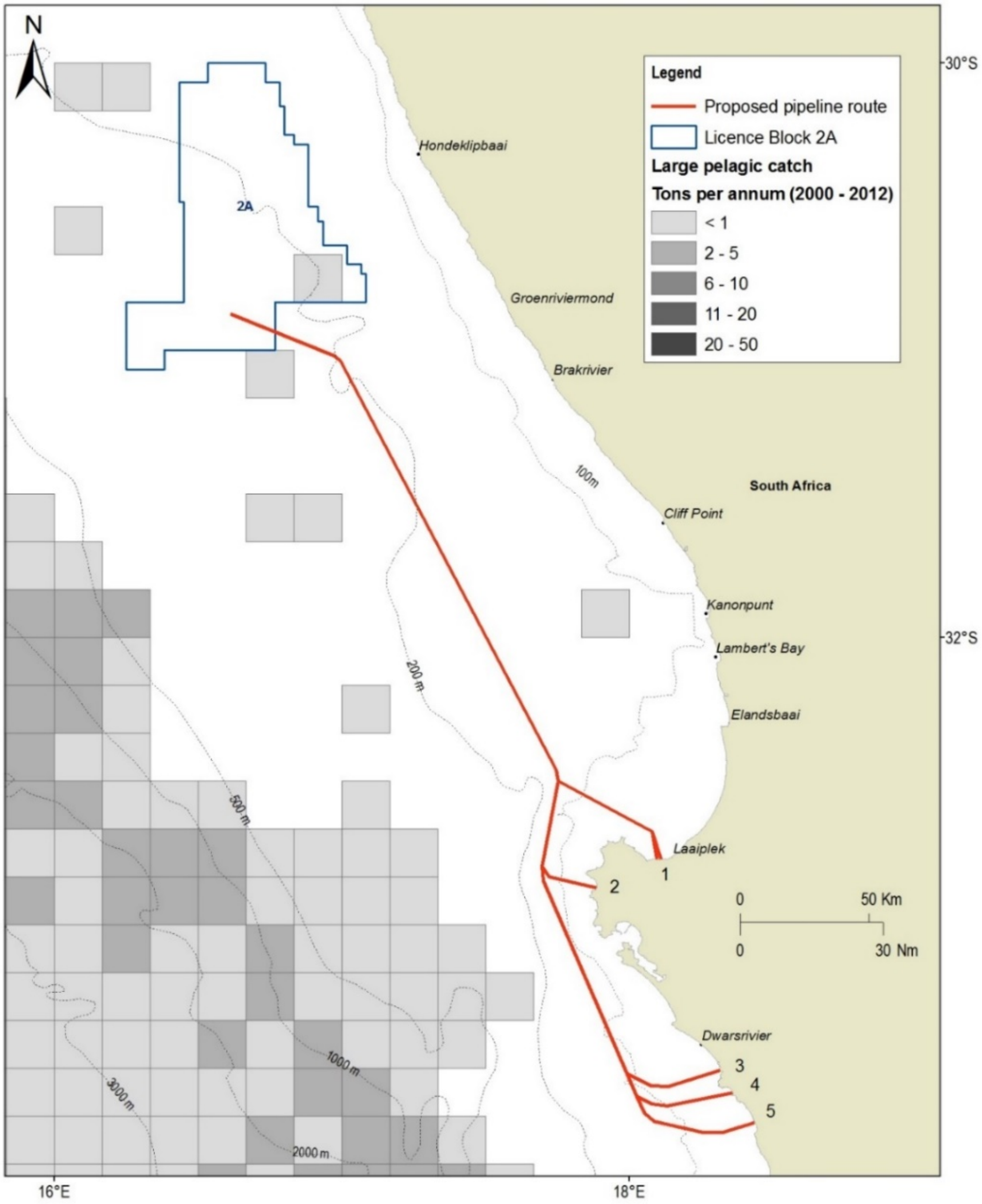


Figure 4.31: The location of Block 2A and the proposed production pipeline in relation to pelagic long-line catch along West Coast between 2000 and 2012.

4.4.1.5 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) was 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 4.32). 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). 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.

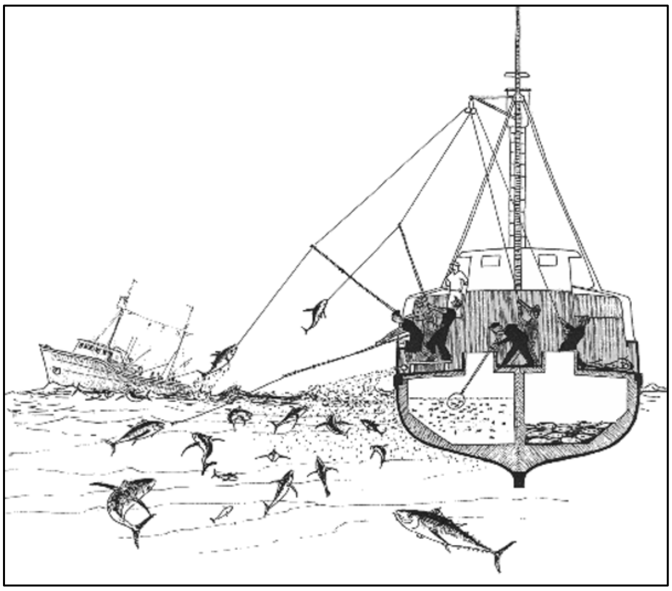


Figure 4.32: Schematic diagram of pole and line operation (www.fao.org/fishery).

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 4.33 shows the spatial distribution of catch in the vicinity of Block 2A and the proposed production pipeline. While some catches have been recorded within grids through which the proposed pipeline passes, over the period 2003 to 2012, there have been no recorded fishing events that have occurred within 500 m of the proposed pipeline and only a few fishing events have been in close proximity to the pipeline corridor (see Figure 4.34).

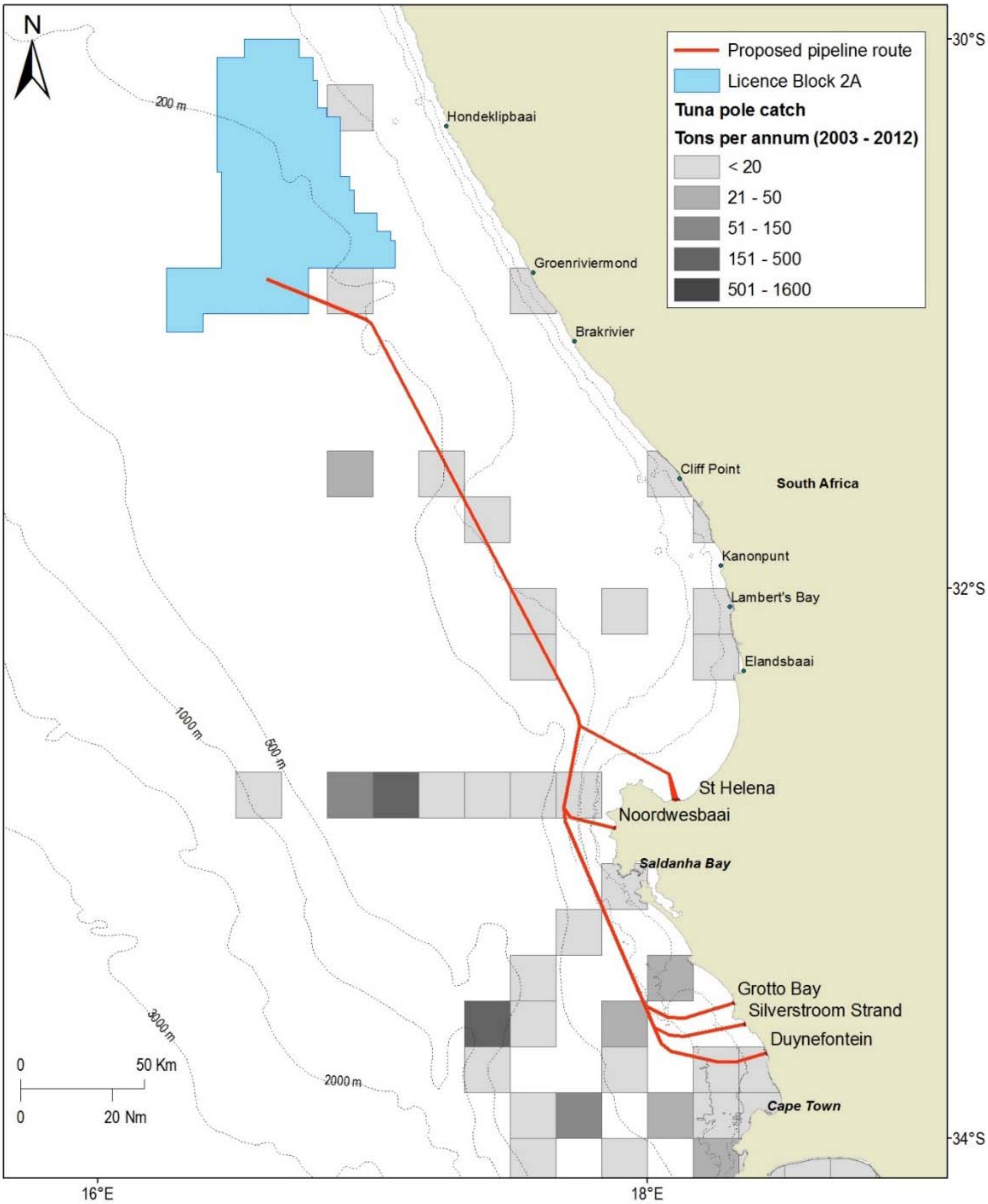


Figure 4.33: The location of Block 2A and the proposed production pipeline in relation to tuna pole catch along West Coast between 2003 and 2012.

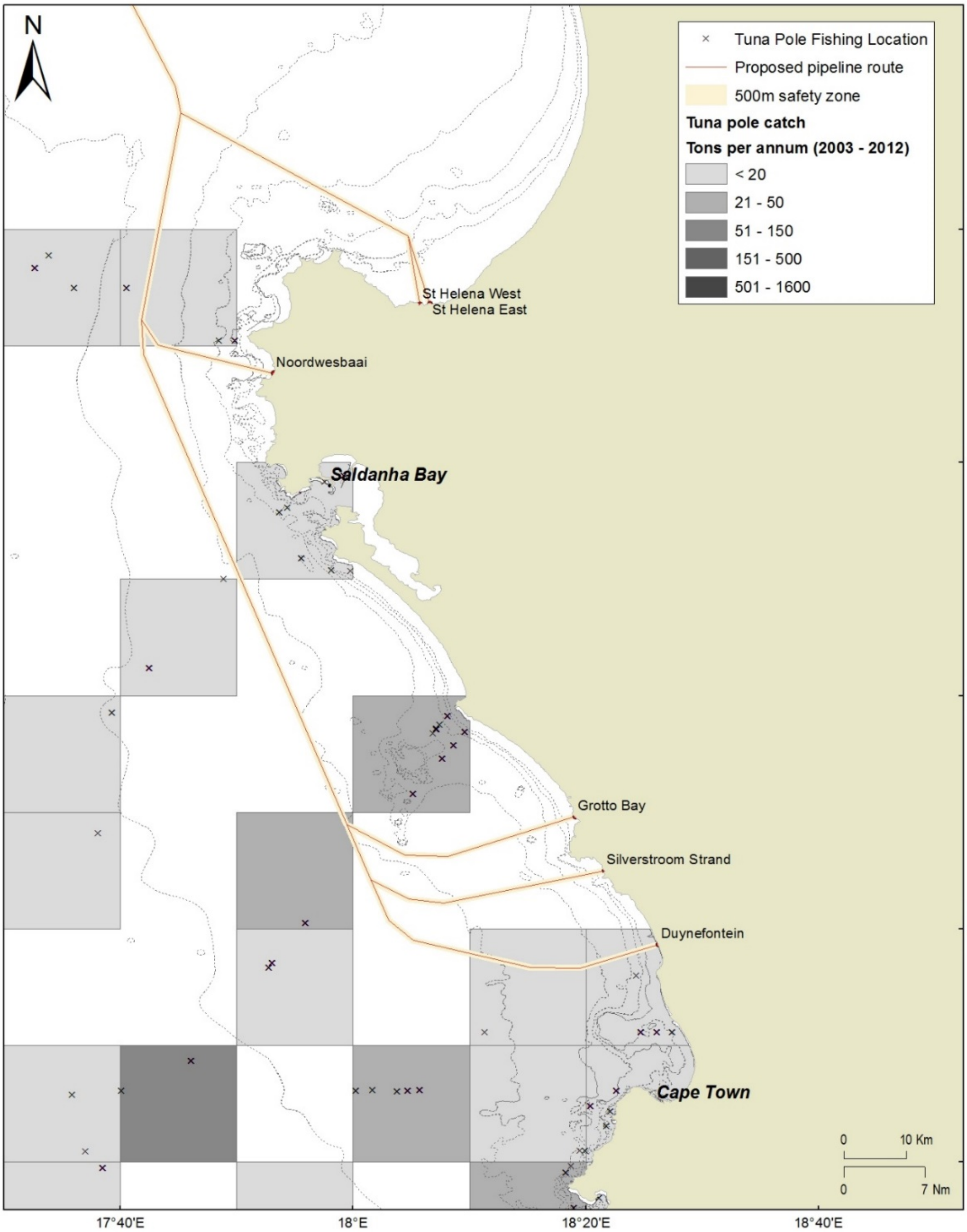


Figure 4.34: The location of the proposed pipeline shore-crossing alternatives in relation to tuna pole catch between 2003 and 2012.

4.4.1.6 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 approximately 35 species of reef fish, as well as pelagic and demersal species. The fishery is widespread across the country's shoreline from Port Nolloth on the West Coast to Cape Vidal on the East Coast. 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 between from the Namibian border on the West Coast to the Kei River in the Eastern Cape. Fishing vessels generally range up to a maximum of 40 nm offshore, although fishing at the outer limit and beyond this range would be sporadic (C. Wilke, *pers. comm*.). Up to 3 000 boats are involved in the fishery on the national level, 450 of which are involved in the commercial fishery.

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.

The fishery operates year-round and records of fishing activity off the West Coast of South Africa are predominantly coastal up to the 200 m isobath. During the period 2000 to 2012, while some effort is recorded within grid blocks through which the pipeline passes (Figure 4.35), there is only one recorded fishing event that coincides with the proposed pipeline at the Grotto Bay pipeline landing site (Figure 4.36). Although fishing effort in the vicinity of the proposed production platform and pipeline is low, it can be expected to occur. There are several small-scale fishing communities in the St Helena Bay area, at Saldanha Bay, Langebaan and Mamre/Atlantis, close to Silwerstroom Strand. Since the fishery is pelagic in nature, fishing operations would not be affected by the presence of a pipeline on the seafloor. The fishery could, however, be affected during pipeline installation due to the 500 m safety zone around the pipe-laying vessel.

4.4.1.7 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 two sectors, namely the offshore sector which operates in a water depth range of 30 m to 100 m and the inshore fishery which is restricted by the type of gear used to waters shallower than 30 m in depth. Fishing grounds are divided for management purposes into zones (and further subdivided into areas) stretching from the Orange River mouth to east of Cape Hangklip in the South-Eastern Cape. The fishery operates seasonally operating from the shore and coastal harbours, with closed seasons applicable to different zones:

- Zone A (Management Area 1 and 2) operates from 1 October to 30 April; and
- Zone B – F (Management Area 3 to 14) operates between 15 November and 30 June. Management Area 8, located within the deep-water area off Cape Point, operates between 15 November and 30 September (D. van Zyl, *pers. comm*.).

The landing sites for this fishery are distributed along the West Coast and include Port Nolloth, St Helena Bay, Laaiplek, Doringbaai, Lambert Bay, Saldanha Bay and Yzerfontein. 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.

Catch is managed using a TAC, 80% and 20% of which is allocated to the offshore and inshore fisheries respectively. 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. A total national landing of approximately 1 879 tons (whole weight) was recorded for 2012 and a TAC of 2 167 tons has been set for the 2013/14 season.

Figure 4.37 shows the spatial distribution of catch taken by the inshore and offshore West Coast rock lobster fisheries over the period 1969 to 2012. Although there is no effort recorded in Block 2A and the majority of the proposed pipeline, fishing activity can be expected for all pipeline alternatives inshore of the 100 m isobath, in particular around shallow-water bathymetric features within Rock Lobster Management Areas 4, 5, 6 and 7 indicated in Figure 4.38 and Figure 4.39. It is anticipated that, in terms of the Marine Traffic Act, 1981, vessels could potentially set traps within 500 m of the pipeline. However, due to possible risk of pipeline damage traps may not be allowed to be set over or in very close proximity to the pipeline.

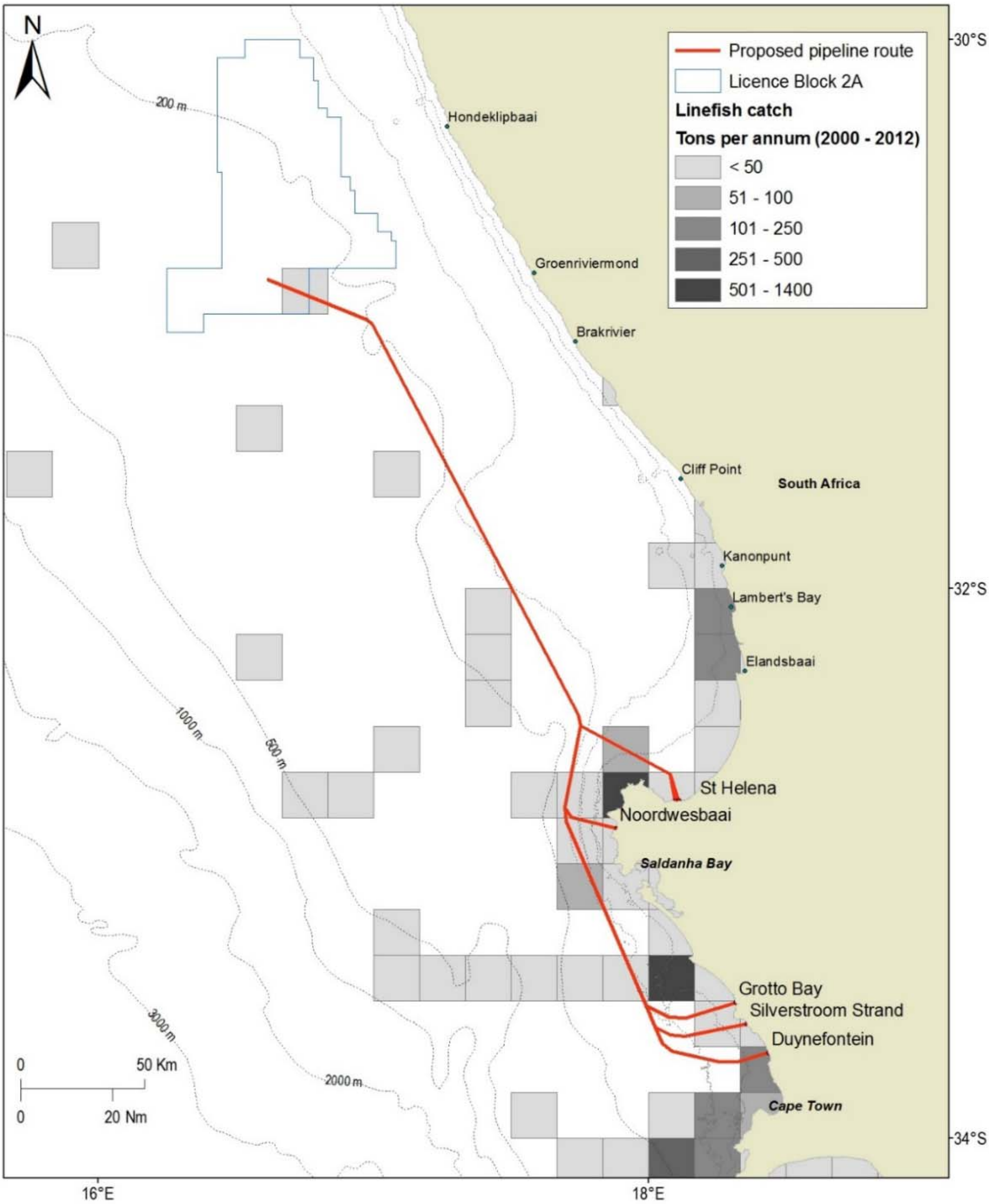


Figure 4.35: The location of Block 2A and the proposed production pipeline in relation to traditional line fishing catch along the West Coast between 2000 and 2102.

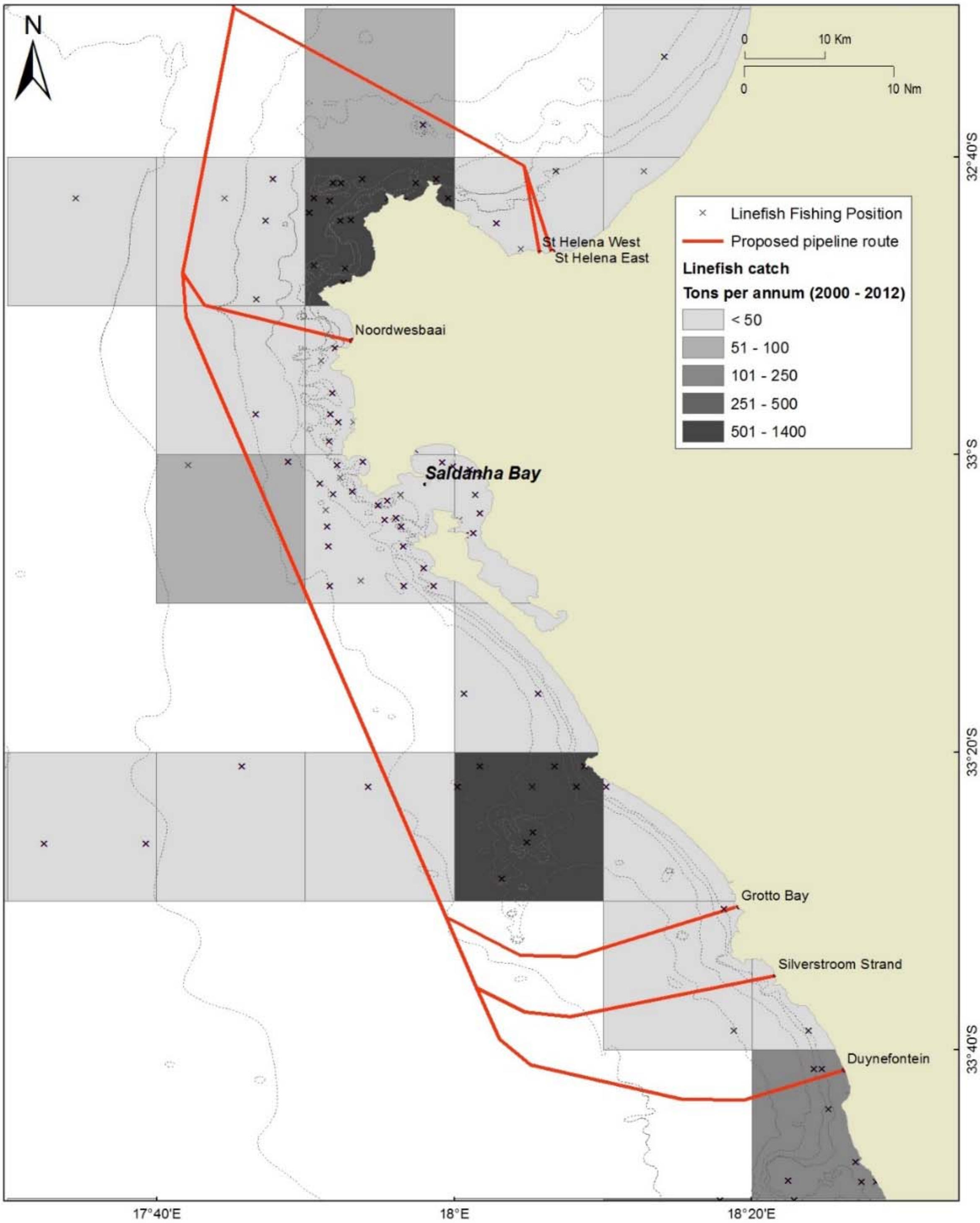


Figure 4.36: The location of the proposed pipeline shore-crossing alternatives in relation to traditional line fishing catch between 2000 and 2102.

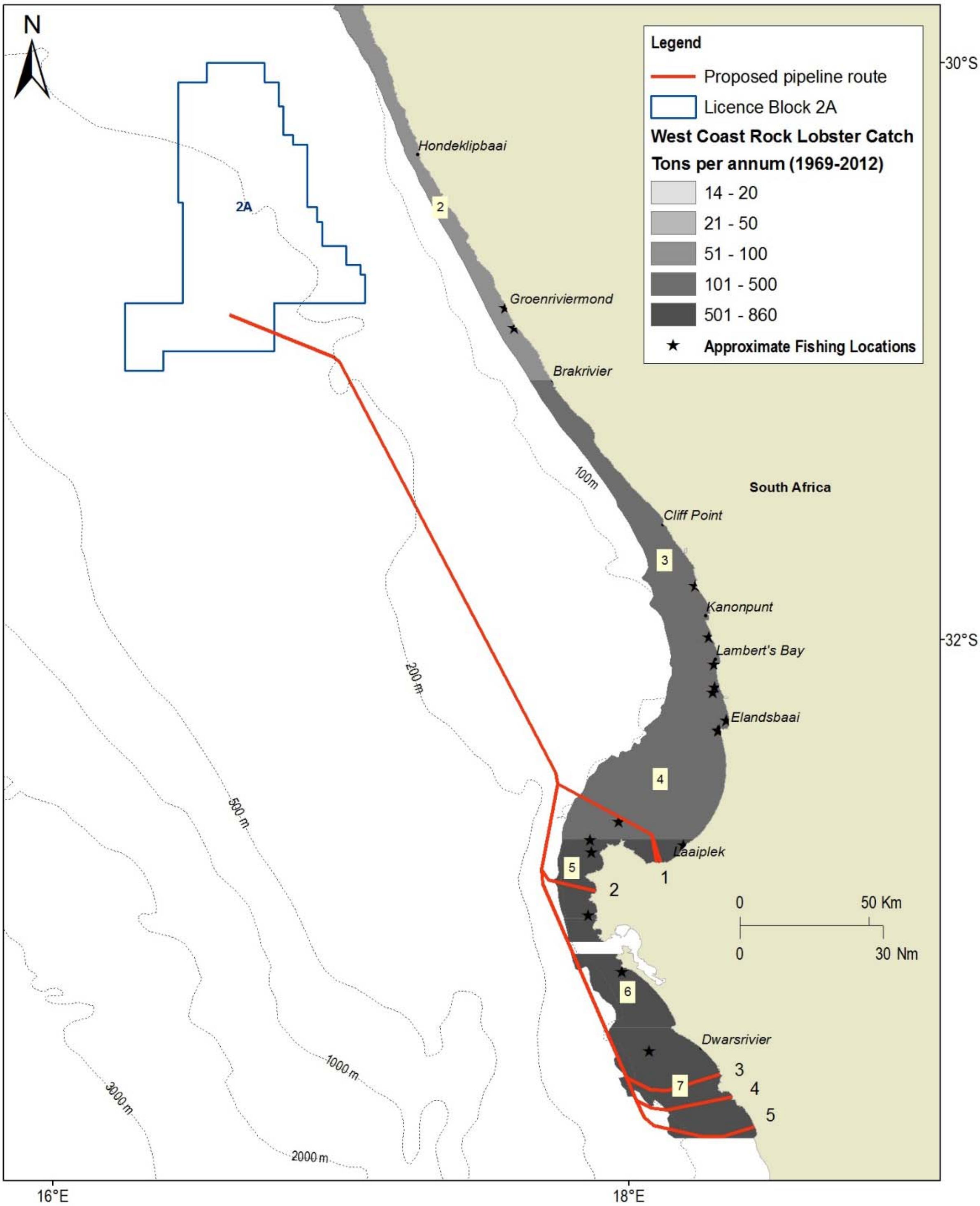


Figure 4.37: The location of Block 2A and the proposed production pipeline in relation to West Coast Rock Lobster Management Areas and catch along West Coast between 1969 and 2012.

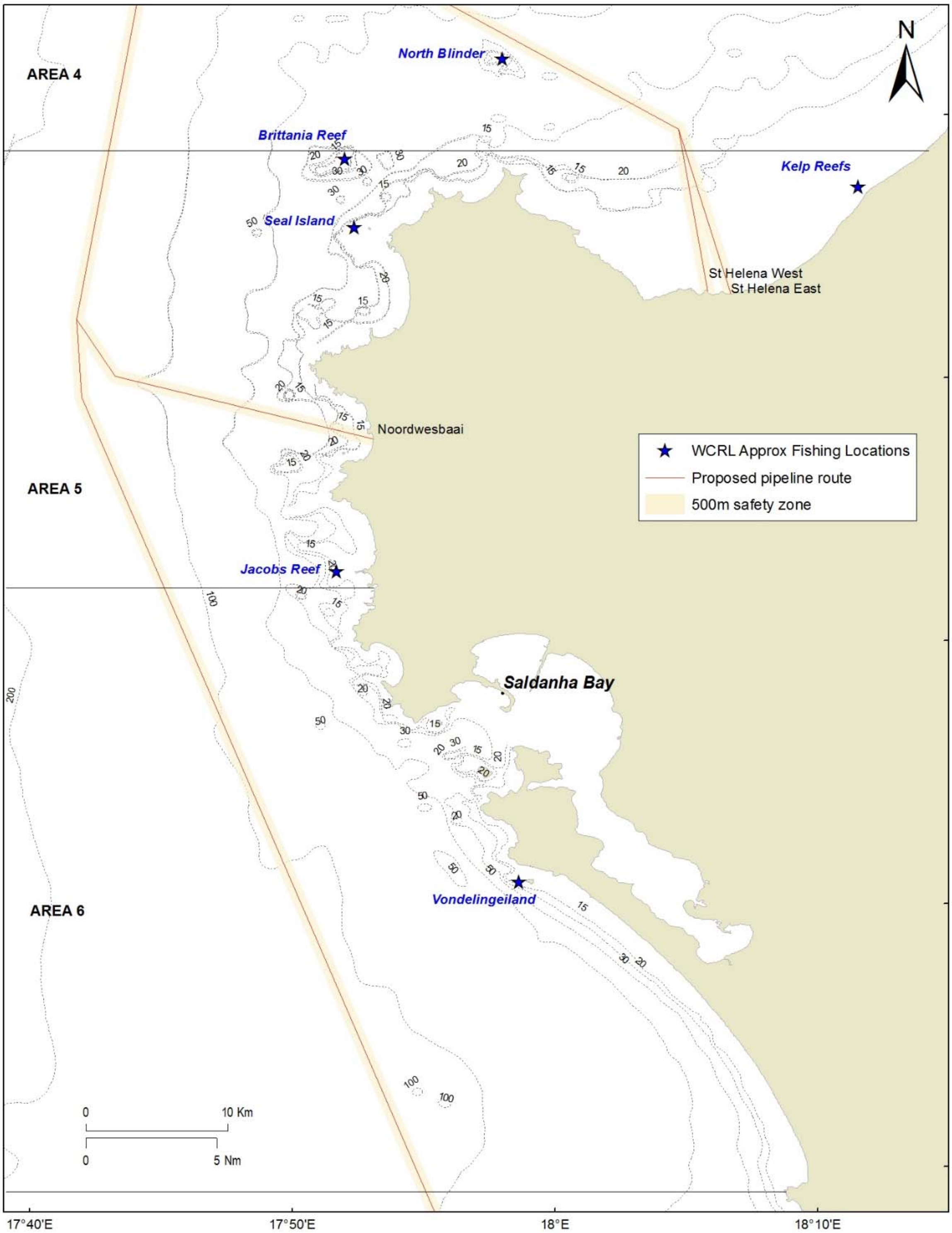


Figure 4.38: The location of the proposed northern shore-crossing alternatives in relation to the approximate location of fishing grounds utilised by the West Coast rock lobster fishery

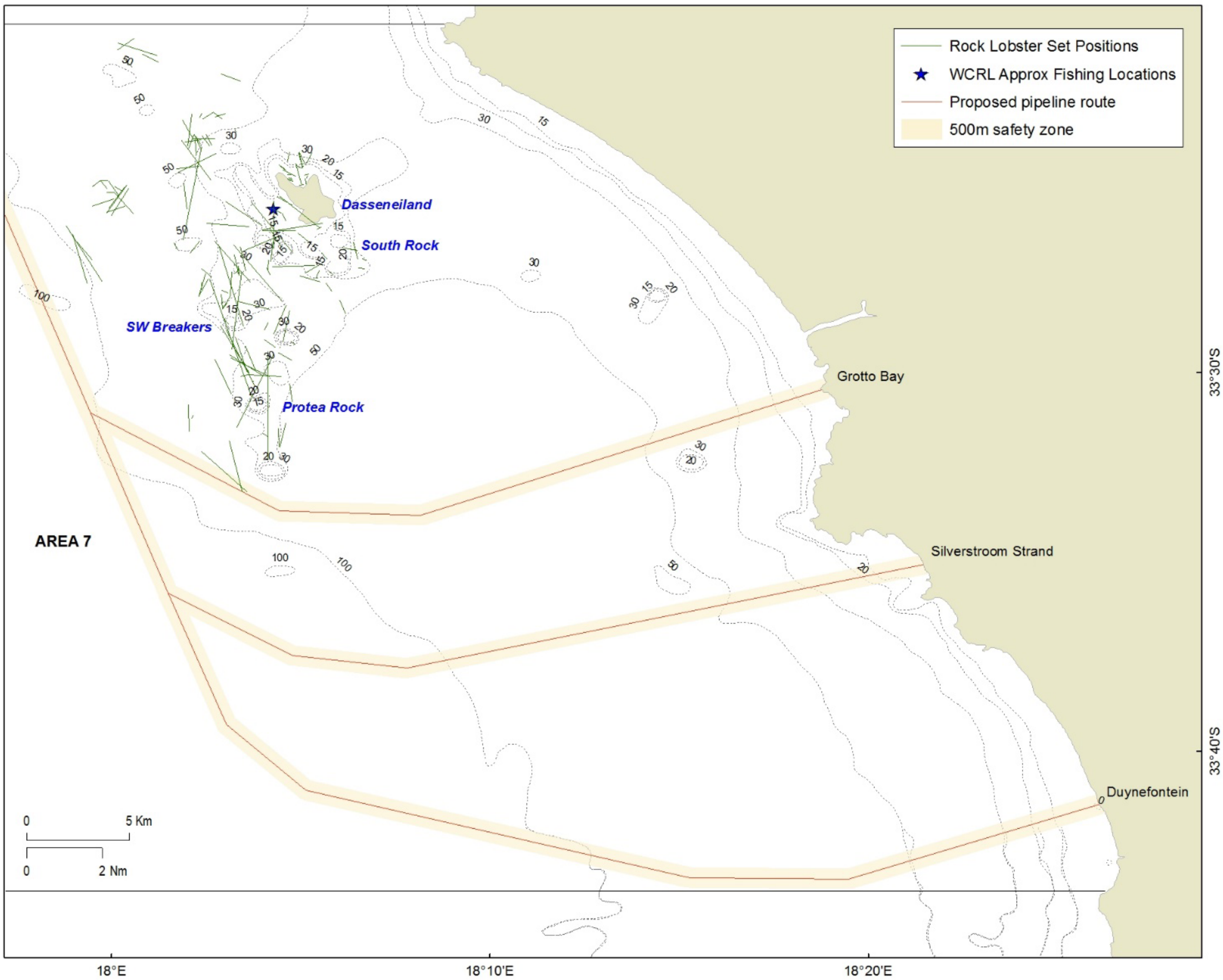


Figure 4.39: The location of the proposed southern shore-crossing alternatives in relation to the approximate location of fishing grounds utilised by the West Coast rock lobster fishery

4.4.1.8 Fisheries research

Surveys of demersal fish resources are carried out in January (West Coast survey) and May (South Coast survey) each year by the Department of Agriculture, Forestry and Fisheries (DAFF) in order to set the annual TACs for demersal fisheries. Stratified, bottom trawls are conducted to assess the biomass, abundance and distribution of hake, horse mackerel, squid and other demersal trawl species on the shelf and upper slope of the South African coast. The 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. Approximately 120 trawls are conducted during each survey over a period of approximately one month. The spatial distribution of research trawls undertaken in relation to the proposed project development area is shown below in Figure 4.40.

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 (see Figure 4.41). The survey is designed to cover an extensive area from the Orange River on the West Coast to Port Alfred on the East Coast.

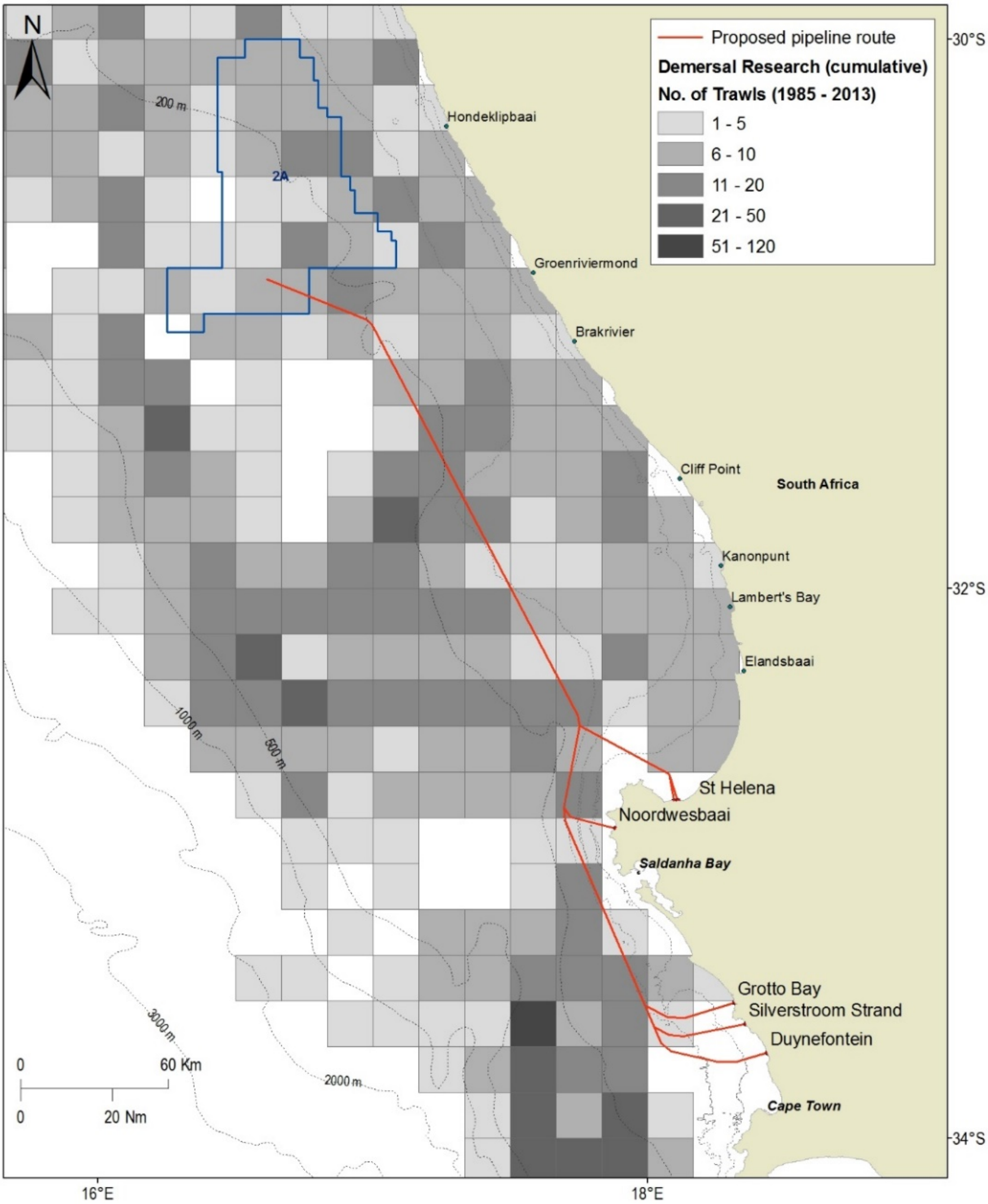


Figure 4.40: The location of Block 2A and the proposed production pipeline in relation to demersal research trawling effort along West Coast between 1985 and 2013.

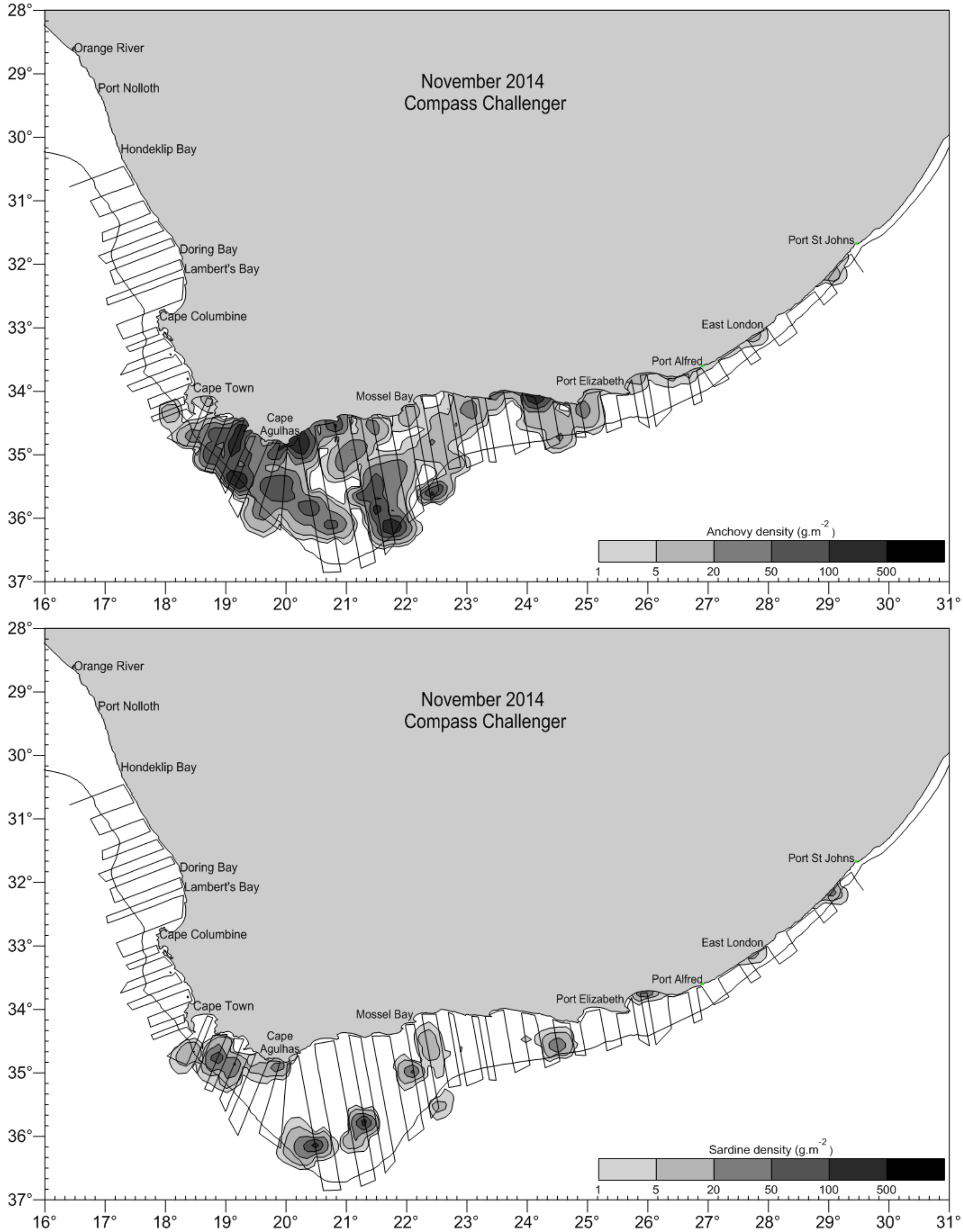


Figure 4.41: Spatial distribution of survey tracks undertaken during the acoustic biomass survey by DAFF during November 2014. Density of anchovy (above) and sardine (below) is also shown.

4.4.2 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 4.42 shows that the majority of the shipping traffic *en route* to Cape Town would pass offshore of the proposed production pipeline route.

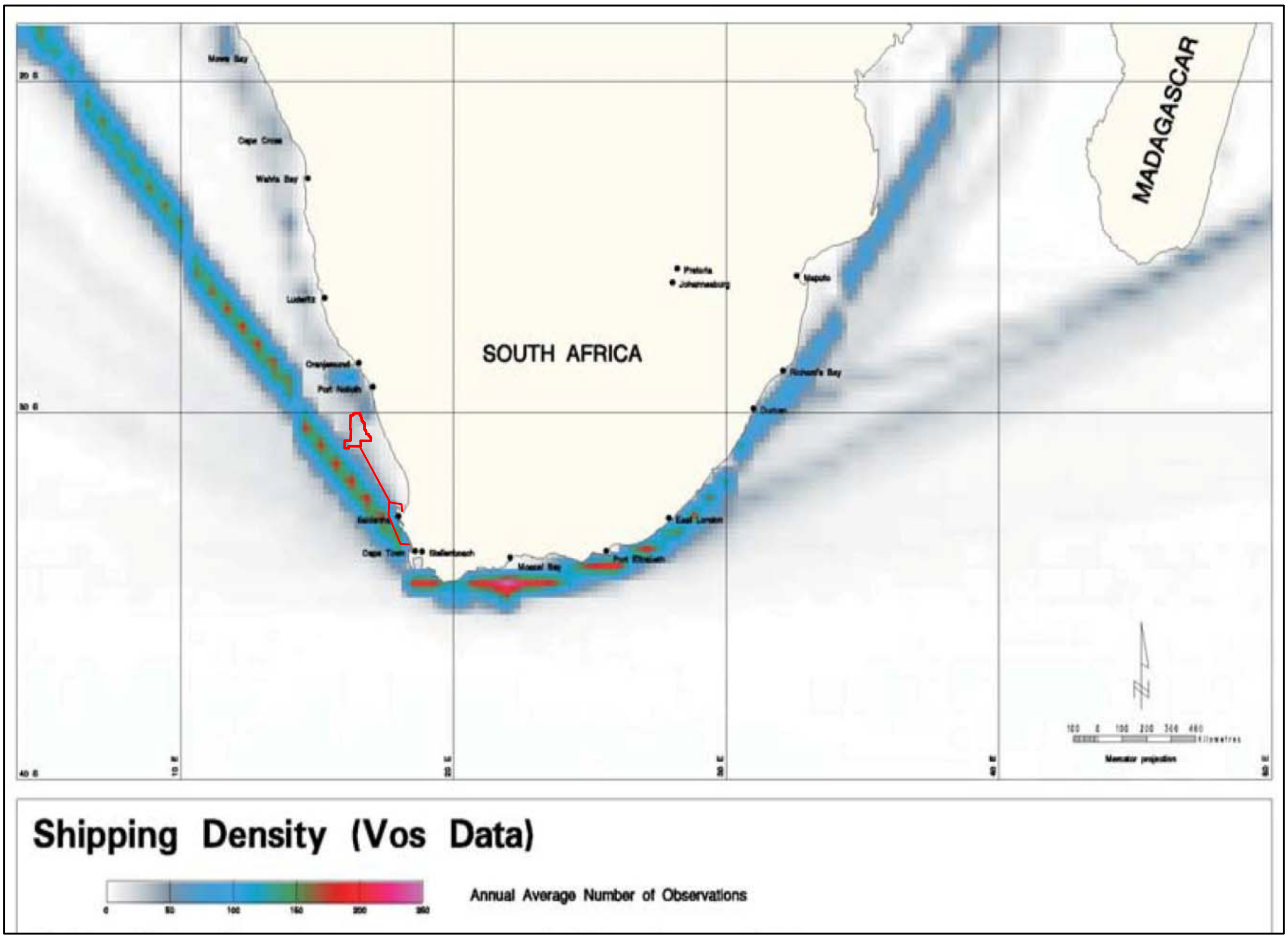


Figure 4.42: Major shipping routes around southern Africa. The approximate location of Licence Block 2A and proposed production pipeline are also shown. Data from the South African Data Centre for Oceanography (image source: CSIR).

4.4.3 OIL AND GAS EXPLORATION AND PRODUCTION

Exploration for oil and gas is currently undertaken in a number of licence blocks off the West, South and East coasts of South Africa (see Figure 4.43).

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

4.4.4 DIAMOND PROSPECTING AND MINING

Marine diamonds are mined along the West Coast of South Africa from just south of Lamberts Bay to the Orange River mouth. Twenty diamond mining concessions have been established along the West Coast with each concession divided into four zones from the coast seaward (a, b, c & d). Figure 4.43 shows Block 2A and proposed pipeline in relation to the diamond mining concessions. The majority of concessions worked at present are those closer inshore (water depths are mostly less than 150 m). No deep water diamond mining is currently being undertaken in the South African offshore concession areas, since mining activities ceased in Mining Licence 3 (ML3) (currently referred to as MPT25/2011) in 2010. De Beers Marine has applied to the Department of Mineral Resources for closure of this mining licence.

International Mining and Dredging SA (Pty) Ltd (as part of a mining agreement with Alexkor) is currently undertaking sampling activities in concessions 1B and 1C. Belton Park Trading 127 (Pty) Ltd, a company of the International Mining and Dredging Holding Limited group, has a prospecting right (diamonds) for concessions 2C, 3C, 4C and 5C, which overlap with ML3.

4.4.5 PROSPECTING AND MINING OF OTHER MINERALS

4.4.5.1 Heavy minerals

Heavy mineral sands containing, amongst other minerals, zircon, ilmenite, garnet and rutile may be found offshore of the West Coast. Tronox's Namakwa Sands is currently exploiting heavy minerals from onshore deposits near Brand-se-Baai (approximately 385 km north of Cape Town). In October 2009, De Beers Marine secured a Prospecting Right for platinum group metals, gold and sapphires in the DMBC licence area (see Figure 4.44).

In addition, De Beers Consolidated Mines secured a prospecting right (including heavy minerals, platinum group metals, gold and sapphire) for three areas inshore of the 200 m bathymetric contour (see Figure 4.45). De Beers Marine is the operator of this prospecting right.

4.4.5.2 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).

A number of prospecting areas for glauconite and phosphorite / phosphate are located off the West Coast (see Figure 4.46), one of which is partially located within Licence Block 2A and the proposed production pipeline route (i.e. Prospecting area 251). Green Flash Trading received their prospecting rights for Areas 251 and 257 in 2012/2013. The prospecting rights for Agrimin1, Agrimin2 and SOM1 have expired (Jan Briers, *pers. comm* - previously at DMR).

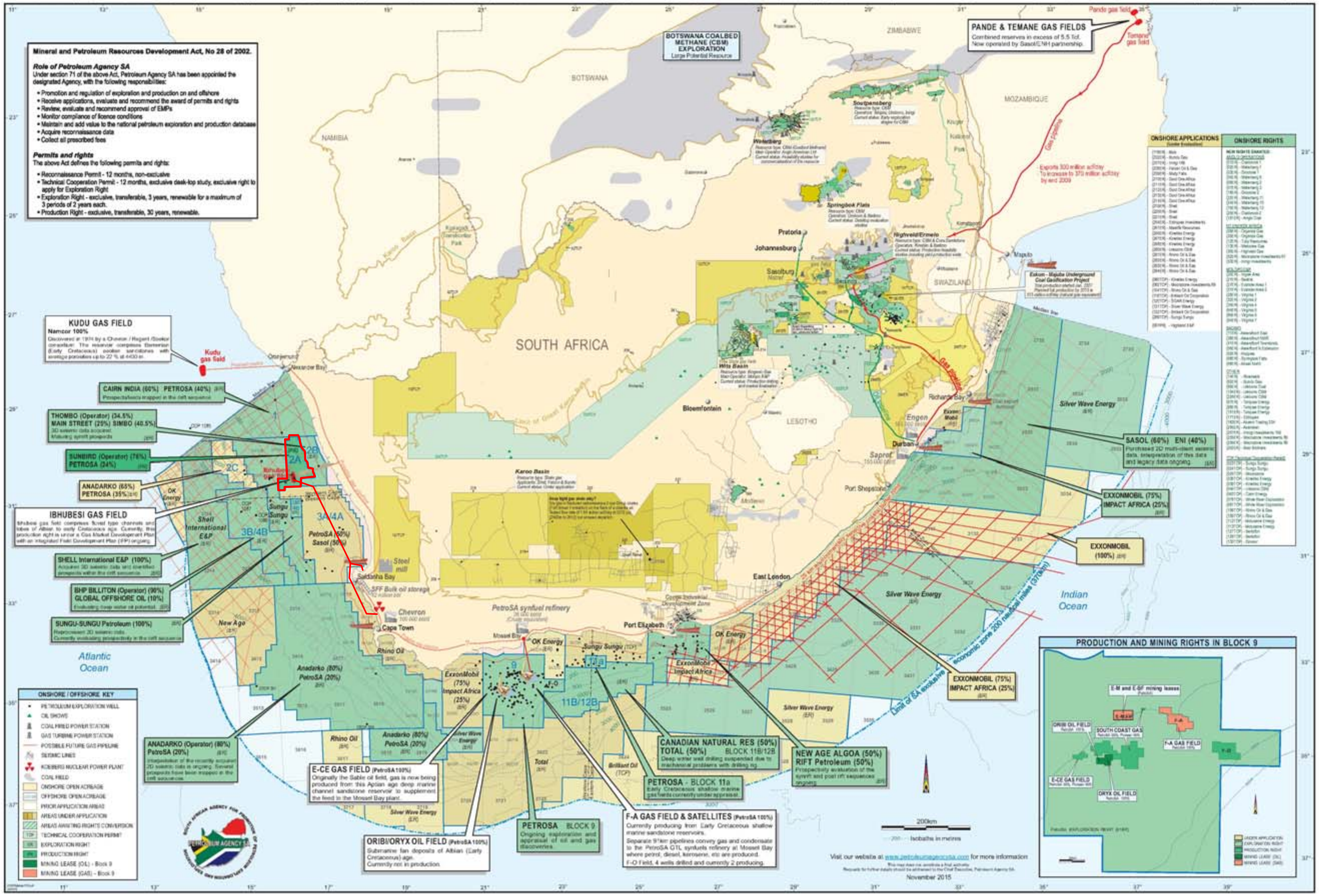


Figure 4.43: **Petroleum licence blocks off the West, South and East coasts of South Africa (PASA, November 2015). Licence Block 2A and the proposed production pipeline are highlighted in red.**

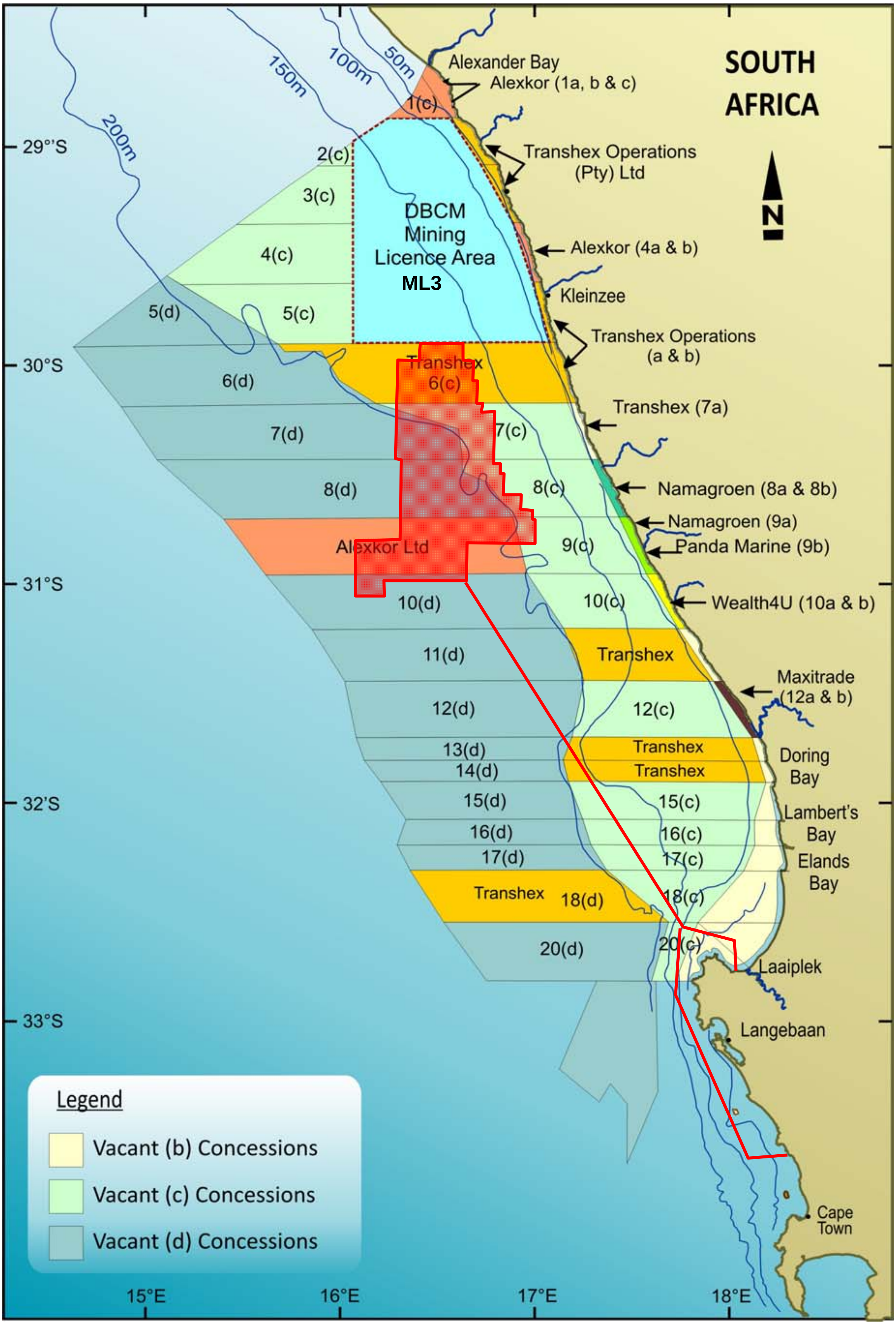


Figure 4.44: The approximately location of Licence Block 2A and the proposed production pipeline in relation to the South African Diamond Rights Holders off the West Coast (compiled by De Beers, 2011).

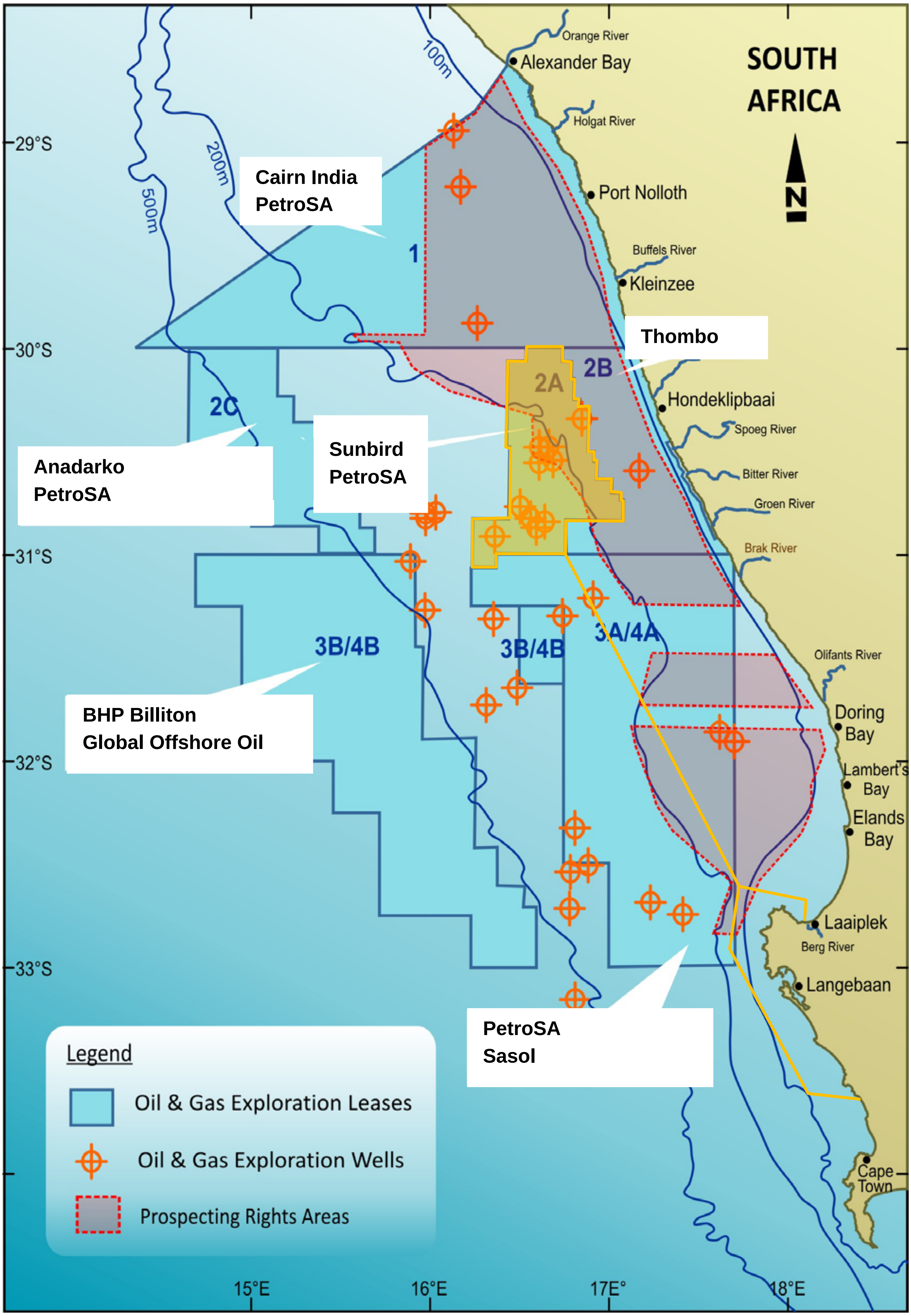


Figure 4.45: The location of Licence Block 2A and the proposed production pipeline in relation to De Beers Consolidated Mines' prospecting right area off the West Coast of South Africa (adapted from De Beers, 2012).

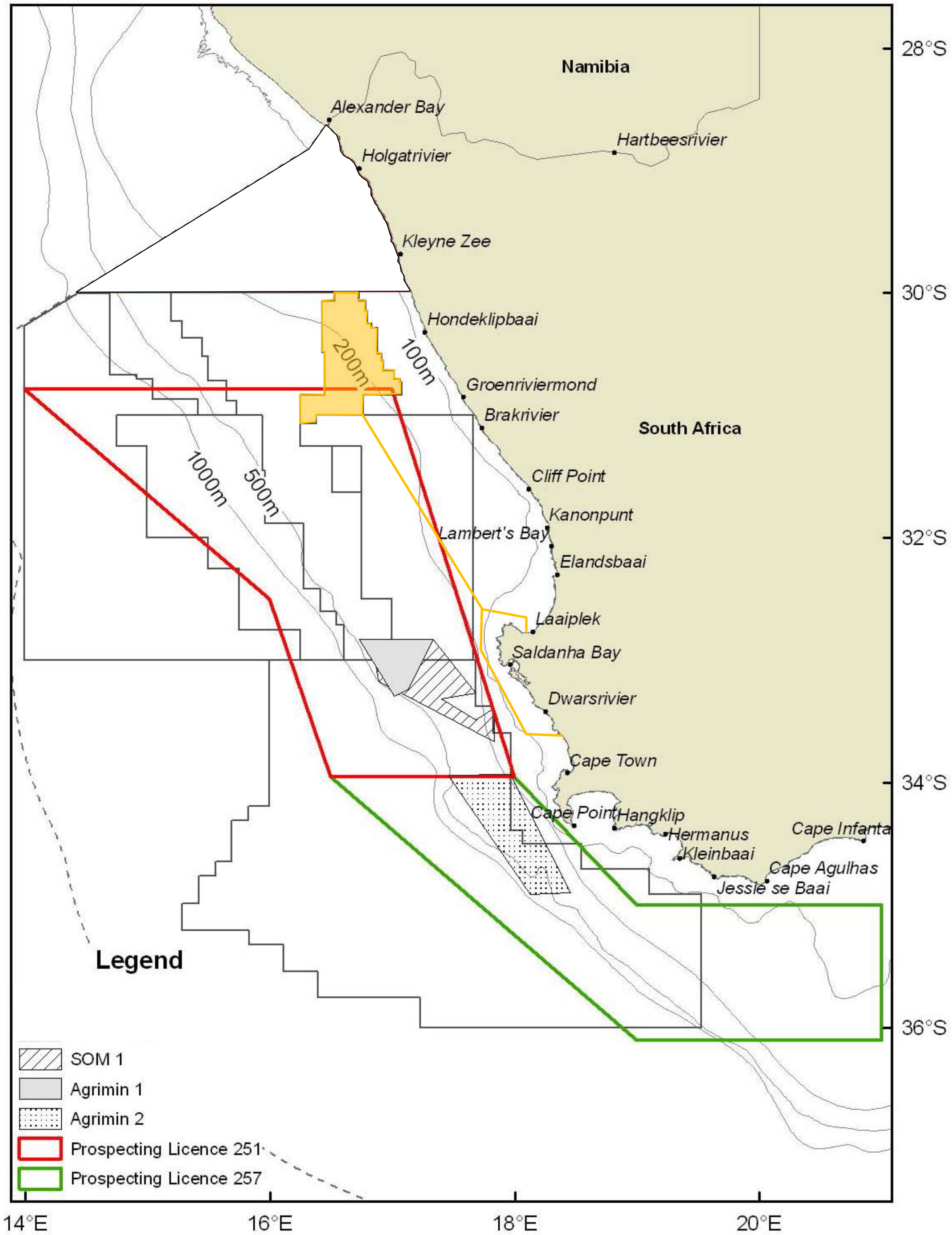


Figure 4.46: The location of Block 2A and the proposed production pipeline in relation to glauconite and phosphorite / phosphate prospecting areas of the West Coast.

4.4.5.3 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, well offshore of Block 2A and the proposed pipeline (see Figure 4.47). 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.

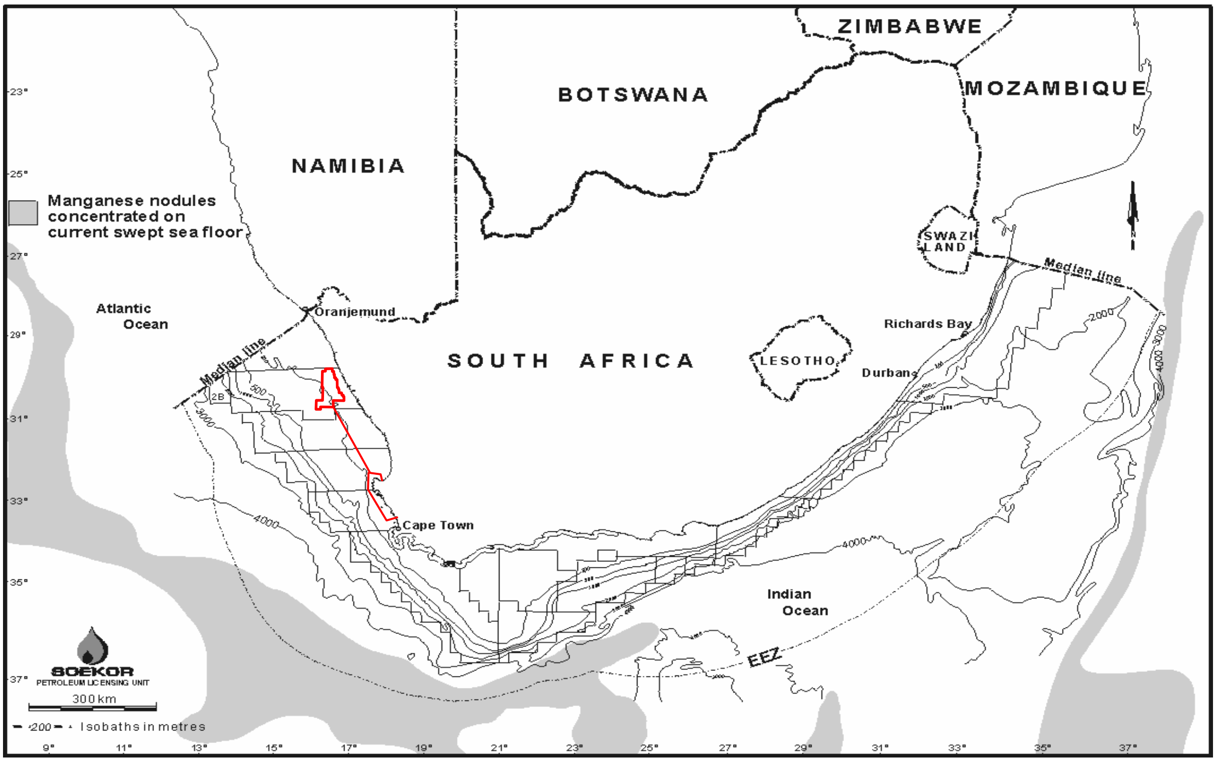


Figure 4.47: Schematic of location of manganese nodules off Southern Africa, showing petroleum licence blocks (Modified from Rogers 1995). The approximate location of Block 2A and the proposed production pipeline are also shown.

4.4.6 OTHER

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

4.4.6.1 Undersea cables

There are a number of submarine telecommunications cable systems across the Atlantic and the Indian Ocean (see Figure 4.48), including:

- 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. The proposed production pipeline passes over the cable landing at Yzerfontein (see Figure 4.49).

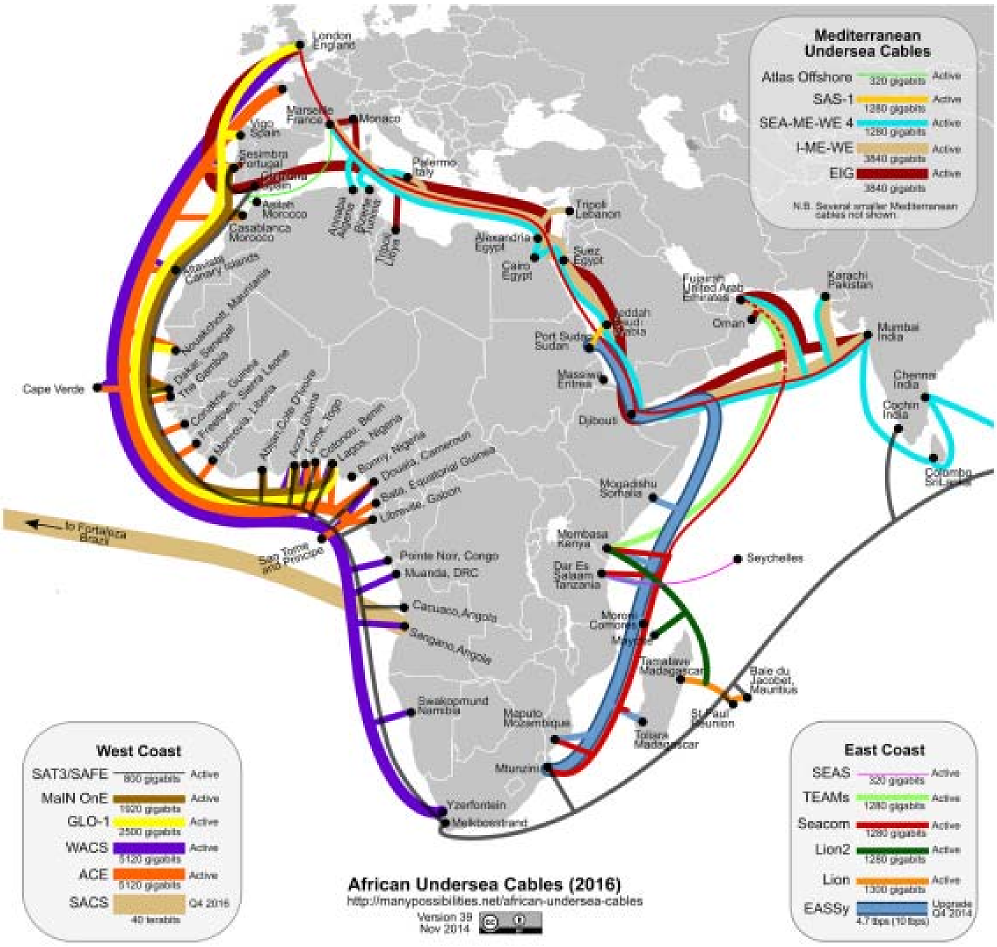


Figure 4.48: Configuration of the current African undersea cable systems, November 2014 (From http://www.manypossibilities.net).

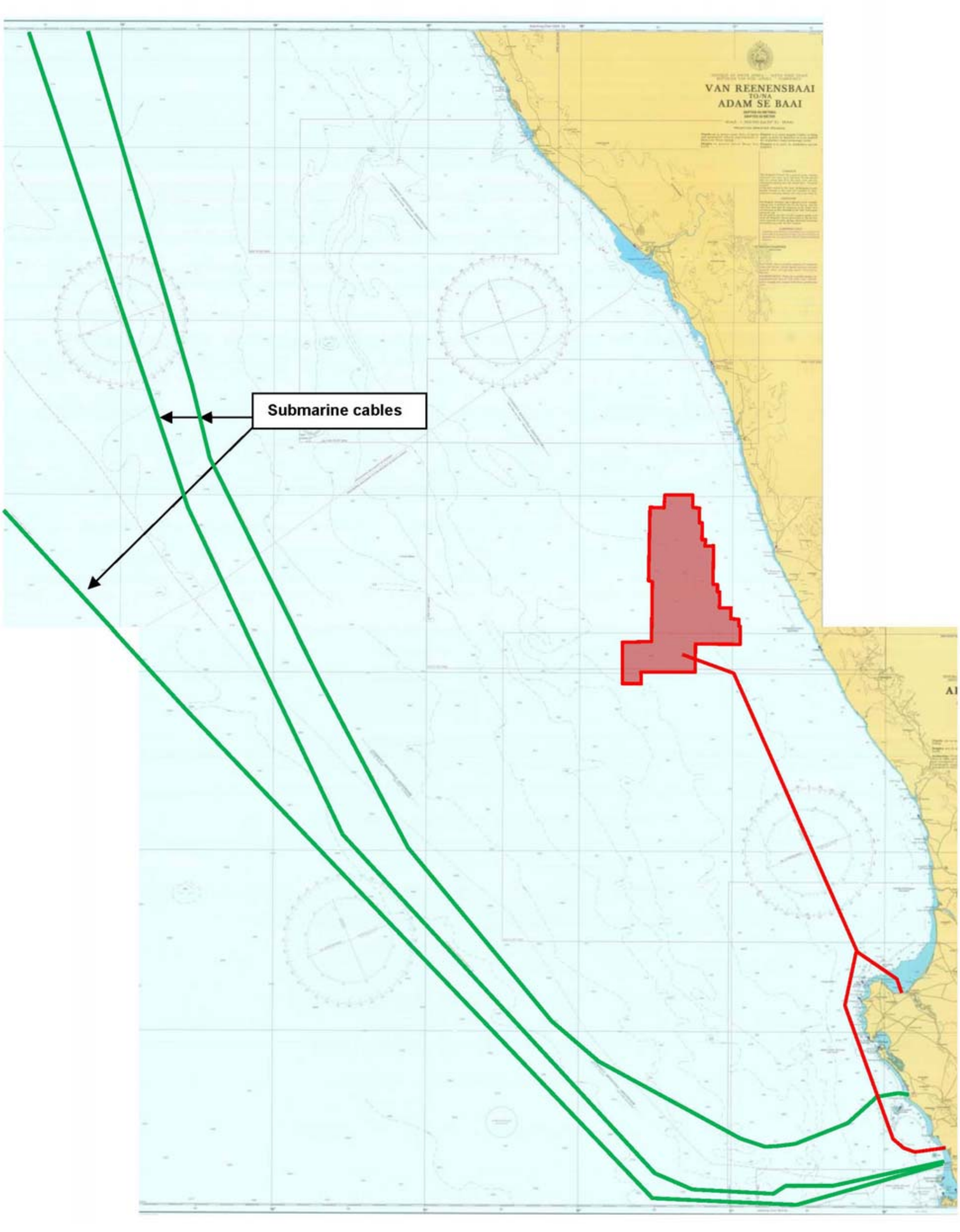


Figure 4.49: Location of Block 2A and the proposed production pipeline in relation to submarine cables (Adapted from SAN Charts SAN54 and SAN55).

4.4.6.2 Marine archaeological sites

In terms of the National Heritage Resources Act (No. 25 of 1999), any wreck, being any vessel, aircraft or any part thereof, older than 60 years lying in South Africa's territorial waters or maritime cultural zone is protected.

Shipwrecks occurring, or possibly occurring, in the study area are listed in Table 4.9 and illustrated in Figures 4.50 to 4.53. It should, however, be noted that shipwreck locations are estimates only as in most instances the actual locations were not recorded.

Table 4.9: Shipwreck database for the study area (refer to Appendix 12 in Volume 3 for additional information on each of these wrecks).

No.	Date	Vessel Name	General Area	Status	Possible alternative impacted
1	31 May 1668	*Schollevaar*	Between Blouberg and Grotto Bay	Wrecked	All southern alternatives.
2	1672	*Zeelt*	West Coast Area	Disappeared	All southern and northern alternatives
3	3 Oct 1717	*Geen Rust*	Cape Area	Burnt	All southern and northern alternatives
4	1806	*Skelton Castle*	West Coast	Disappeared	All southern and northern alternatives
5	14 Mar 1838	*St Clair*	Saldanha Area	Wrecked	All southern alternatives.
6	1839	*Jeune Edward*	Cape Area	Diappeared (Unverified!)	All southern and northern alternatives
7	4 Jan 1839	*Pescadora*	Saldanha Area	Wrecked	Impact unlikely
8	13 Mar1839	*Shylock*	Dassen Island Area	Wrecked	Impact unlikely
9	Dec 1840	*Australia*	West Coast Area	Burnt; Sank	All northern alternatives
10	4 Oct 1848	*Mary*	Cape Area	Burnt; Scuttled	All southern and northern alternatives
11	18 Sep 1850	*Saxon*	Cape Area	Abandoned	All southern and northern alternatives
12	17Apr 1851	*Reflector*	St Helena Area	Wrecked	St Helena alternatives
13	4 May 1855	Unknown vessel	Melkbosstrand Area	Wrecked	All southern alternatives
14	19 Jul 1857	*Susan*	Saldanha Bay Area	Sank	All southern alternatives
15	Jan 1858	*Admiral Collingwood*	Saldanha Bay Area	Sank	All southern and northern alternatives
16	25 Jun 1859	*Rosebud*	Lambert's Bay Area	Sank	Impact unlikely
17	20 Sep 1859	*Unity*	Saldanha Bay Area	Sank	All northern and southern alternatives
18	1862	*Asia*	West Coast Area?	Abandoned	All northern and southern alternatives
19	Feb 1864	*Luban*	West Coast Area	Sank	All southern and northern alternatives
20	Aug 1866	*Livily*	Saldanha Bay Area	Wrecked	Noordwesbaai alternative
21	Aug 1866	*Samelia*	Saldanha Bay Area	Wrecked	Noordwesbaai alternative
22	10 Oct 1868	*Joachim*	Cape Coast	Burnt; Sank	All southern and northern alternatives

No.	Date	Vessel Name	General Area	Status	Possible alternative impacted
23	1869	*Mistress of the Seas*	Cape Coast	Burnt; Sank	All southern and northern alternatives
24	24 Jul 1870	*Mary*	West Coast Area	Disappeared	All southern and northern alternatives
25	30 Aug 1874	*Oliver Cromwell*	Cape Coast?	Burnt; Sank	All southern and northern alternatives
26	27 Aug 1878	*Stranger*	West Coast Area	Burnt; Abandoned	All southern and northern alternatives
27	1882	*Maria Frederika*	West Coast Area	Disappeared	All southern and northern alternatives
28	9 Apr 1885	*Juno*	Cape Coast	Burnt; Abandoned	All southern and northern alternatives
29	10 Dec 1896	*British Peer*	Near Grotto Bay	Wrecked	Grotto Bay alternative
30	18 Dec 1897	*Resolu*	Saldanha Area	Wrecked	Noordwesbaai alternative
31	5 Apr 1900	*Mexican*	Saldanha Bay Area	Sank	All southern and northern alternatives
32	1909	*Canton*	Cape Area	Wrecked	All southern and northern alternatives
33	13 Jan 1910	*Cerne*	Dassen Island Area	Sank	All southern and northern alternatives
34	26 Jan 1917	*Matheran*	Dassen Island Area	Mined; Sank	All southern alternatives
35	12 Feb 1917	*Cilicia*	Cape Area	Mined; Sank	All southern alternatives
36	10 Aug 1917	*City of Athens*	Dassen Island Area	Mined; Sank	All southern alternatives
37	Jun/Jul 1918	*Eros*	West Coast Area	Sank	Impact unlikely
38	Jan 1945	*Luna*	Hondeklip Bay Area	Disappeared	Impact unlikely
39	Nov 1968	*Wuta*	Saldanha Bay Area	Sank	All southern alternatives (not protected under NHRA)
40	8 Jun 1969	*Ocean Meteor*	Dassen Island Area	Sank	All southern alternatives (not protected by NHRA)
41	7 Jul 1971	*Zulu II*	Saldanha Bay Area	Sank	All southern alternatives and Noordwesbaai alternative (not protected under NHRA)
42	16 Jan 1972	*Shin Fung Yang*	Saldanha Bay Area	Sank	All northern and southern alternatives (not protected under NHRA)
43	16 May 1973	*Gilia*	Saldanha Bay Area	Sank	All northern and southern alternatives (not protected under NHRA)
44	May 1976	*Lorraine*	Saldanha Bay Area	Sank	All southern alternatives
45	20 Jan 1977	*Harvest Neptune*	Saldanha Bay Area	Burnt; Sank	Impact unlikely (not protected under NHRA)

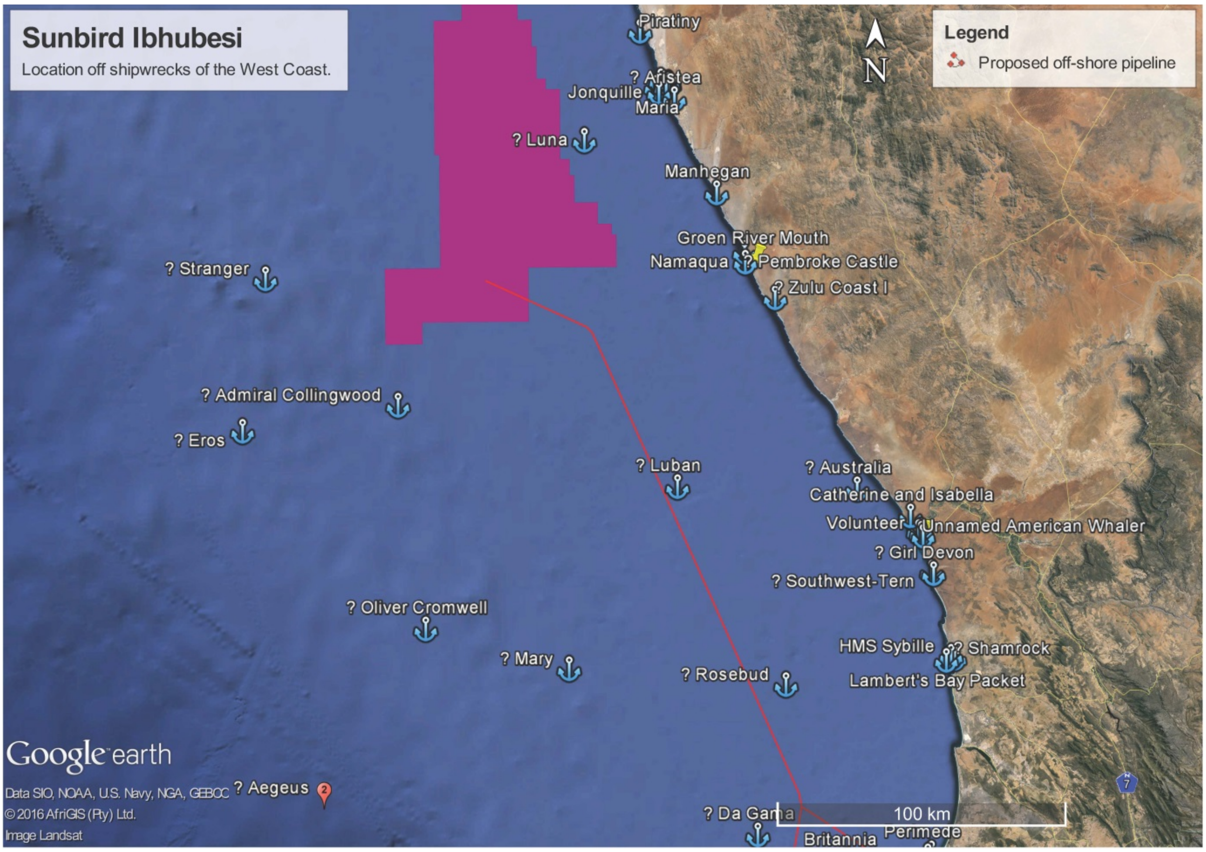


Figure 4.50: Location of Block 2A and the proposed production pipeline in relation to possible shipwrecks between Hondeklipbaai and Elands Bay.

Figure 4.51: Location of the proposed northern pipeline alternatives in relation to possible shipwrecks.

Figure 4.52: Location of the proposed production pipeline off Saldanha Bay (*en route* southern alternatives) in relation to possible shipwreck

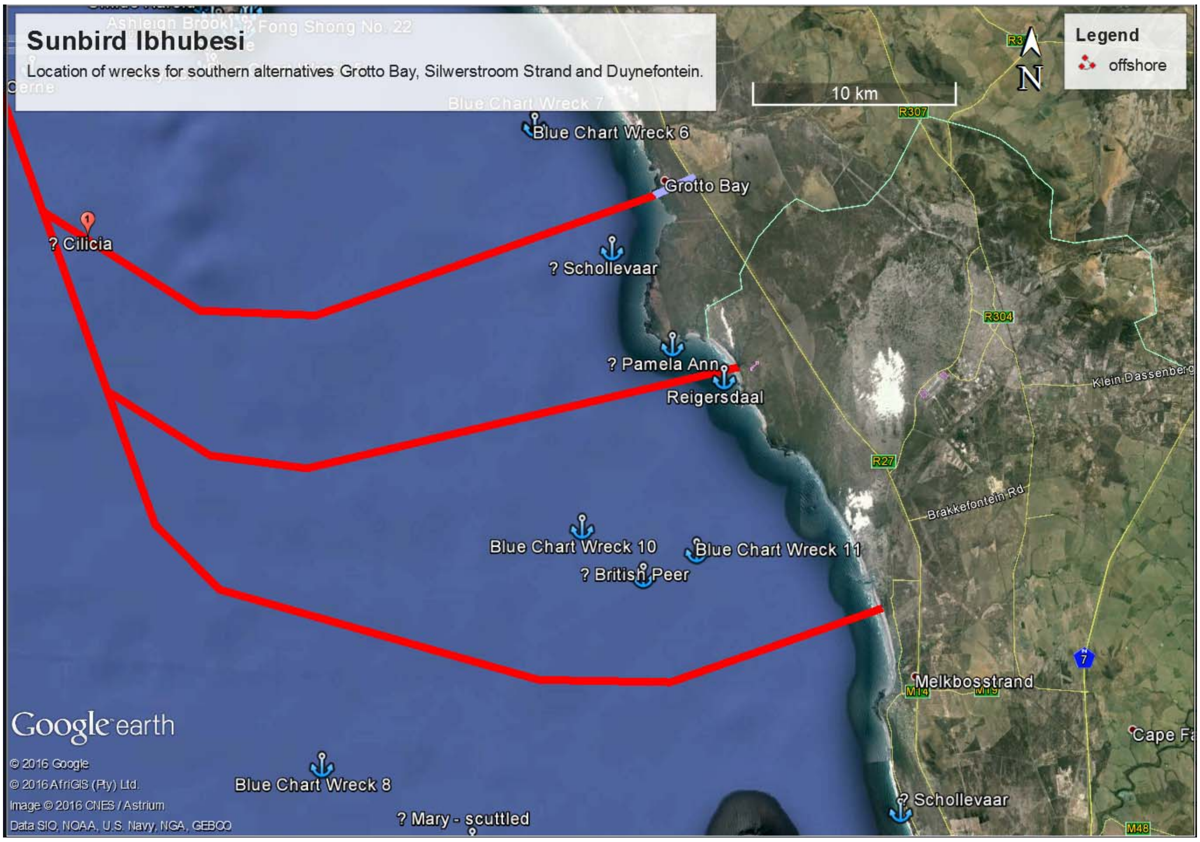


Figure 4.53: Location of the proposed southern pipeline alternatives in relation to possible shipwreck.

4.4.6.3 Ammunition dump sites

Ammunition and explosive dumpsites off the South-West Coast are presented on SAN Chart 56. Such sites are located offshore and to the south of the proposed production pipeline (see Figure 4.54).

4.4.6.4 Mariculture industries

The following mariculture facilities can be found along the West Coast of South Africa (O'Sullivan 1998; DAFF 2011):

- Alexkor Diamond Mines has an oyster (*Crassostrea gigax*) growout system in the seawater reservoirs employed by diamond processing plants south of Alexander Bay, while a similar facility for oysters, perlemoen (*Haliotis midae*) and the red seaweed *Gracilaria gracilis* can be found at Kleinsee;
- A permit has been granted for perlemoen ranching within a 100 km long 0 to 20 m deep zone north and south of Port Nolloth. Oysters are also grown at Port Nolloth;
- A perlemoen aquaculture operation at Hondeklip Bay;
- Abalone, oysters and finfish are grown in Jacobs Bay;
- Abalone, mussels, seaweed, oysters, clams and scallops are grown in Paternoster;
- Oysters and seaweed are grown in St Helena Bay; and
- Mussels and oysters are grown within Saldanha Bay.

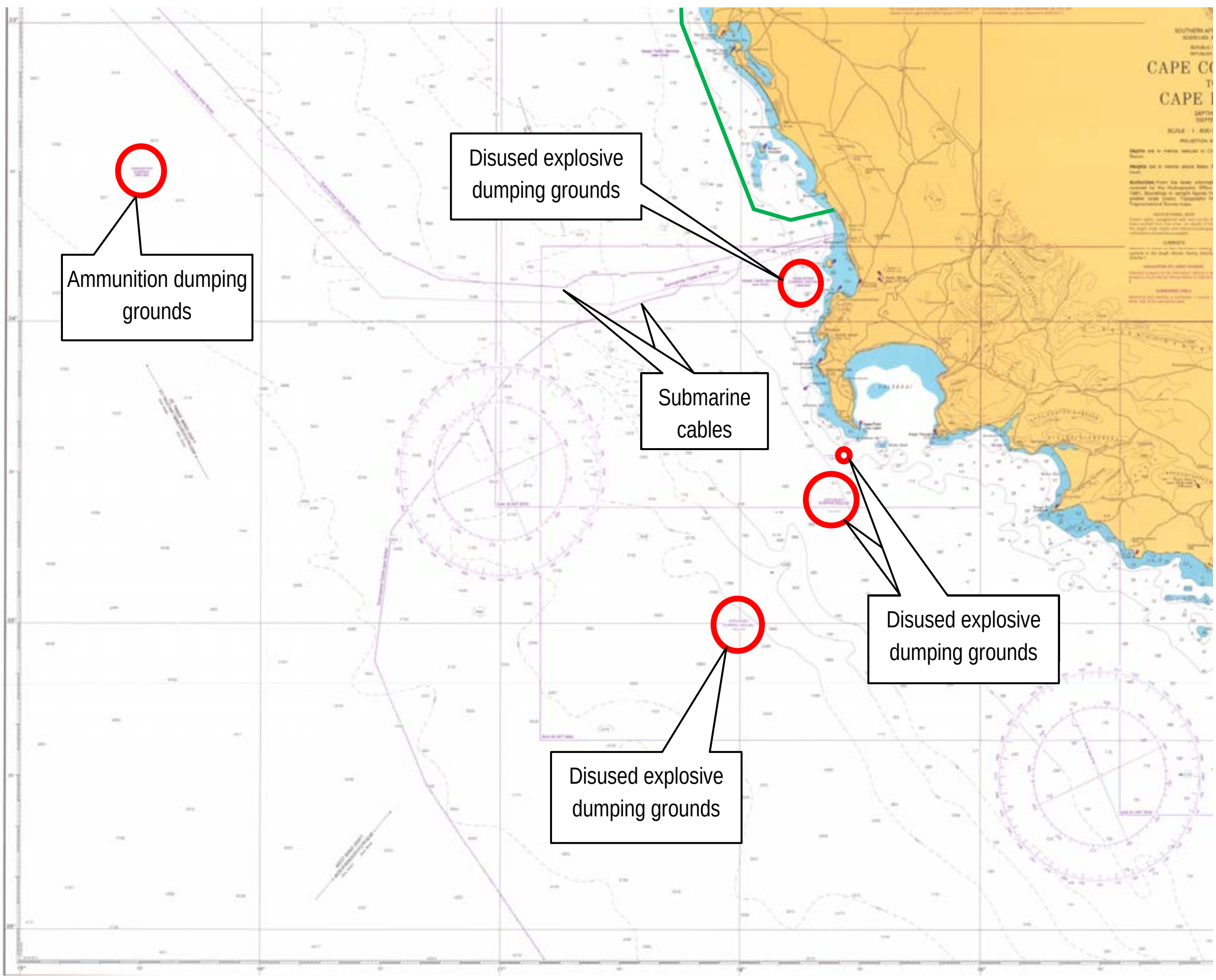


Figure 4.54: The location of the proposed production pipeline (green line) in relation to ammunition and explosive dumping grounds and subsea cable off the West Coast (from SAN Chart 56).

4.4.6.5 Recreational utilisation

Recreational use of the offshore areas is negligible. However, coastal recreation along the West Coast may be either consumptive or non-consumptive.

Consumptive recreational uses involve people collecting material from the sea for their own use. Recreational anglers (Brouwer, Mann, Lamberth, Sauer and Erasmus 1997) and divers (Mann, Scott, Mann-Lang, Brouwer, Lamberth, Sauer and Erasmus 1997) target linefish from either a boat or the shore, while shore-based divers also target perlemoen and West Coast rock lobsters. Rock lobsters are also exploited recreationally from boats with the use of hoop nets. The majority of recreational exploitation of marine resources occurs from inshore waters, and is not substantial compared to activities along the South and East Coasts.

Non-consumptive recreational uses of the marine environment include watersports, nature watching and beach recreation. Recreational practices are mostly undertaken near coastal settlements, and are largely practised for their aesthetic value. Recreational sites are listed by Jackson and Lipshitz (1984).

Although few resource economic studies exist for South African marine recreational use, the value of recreational coastal use and tourism should not be underestimated.

4.4.6.6 Marine outfall/intake pipes

Thirty-four outfalls, of which the majority are sewerage outfalls, and 17 intakes are located along the West Coast of South Africa. An important pipeline intake/outfall is the Koeberg Nuclear Power Station; a thermal outfall, discharging warmed cooling water into the cooler coastal waters rather than a chemical effluent. A 2 nm marine exclusion zone exists offshore of the nuclear power station.

4.4.6.7 Conservation Areas, Marine Protected Areas and World Heritage Sites

Numerous conservation areas and MPAs exist along the coastline of the Western Cape, none of which would be traversed by the proposed pipeline route (Figure 4.55). For the sake of completeness, they are briefly summarised in Table 4.10.

As noted in Sections 2.1.4 and 2.1.8, Robben Island is both a South African National Heritage Site as well as a UNESCO World Heritage Site. The island is located in Table Bay, approximately 7 km west of the coast of Bloubergstrand and approximately 8.2 km south of the Duynefontein pipeline route alternative.

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). As a result of this work and as part of the Operation Phakisa Initiative, 22 new MPAs have been identified and proposed for declaration in terms of NEM:PAA, nine of which are located off the West / South-West Coast. The declaration of these new MPAs aims to create approximately 70 000 km^2 of marine protected areas, increasing the protection within the South African EEZ to more than 5%. The proposed offshore infrastructure does not overlap with any of these proposed MPAs (see Figure 4.55).

Table 4.10: List of marine conservation areas along the West Coast of South African.

Bioregion	Marine Protected Area / Conservation Area	Protection	Location
Namaqualand	McDougall's Bay Rock Lobster Sanctuary: 2.5 km of coastline, 3 km south of Port Nolloth	No rock lobsters may be caught.	29°14' S 16°52' E
	Robeiland / Kleinzee Seal Colony Robeiland: 15 km north of Kleinzee	Island reserve for seabirds and seals, no access	29°33' S 16°59' E
	Elephant Rocks (Olifant's River Mouth)	Island reserve for seabirds and seals, no access	31°38' S 18°07' E
	Penguin / Bird Island (Lambert's Bay)	Island reserve for seabirds and seals, no access	32°05' S 18°18' E
	St Helena Bay Rock Lobster Sanctuary From Shelly Bay Point to Stompneus Point, extending three nautical miles seaward of the high-water mark; From Stompneus Point to SHBE/DR beacon, extending six nautical miles seaward of the high-water mark	No rock lobster may be caught	32°43' S 18°00'-07' E
South-Western Cape	Paternoster Rocks – Egg and Seal Island: Between Great Paternoster Point & Cape Columbine	Island reserve for seabirds and seals, no access.	32°44' S 17°51' E
	Jacob's Reef: Jacob's Baai	Island reserve for seabirds and seals, no access	32°57' S 17°51' E
	Malgas Island, Jutten Island and Marcus Island Marine Protected Areas: Saldanha Bay	No person permitted on the islands and no fishing allowed along the shores. Marcus Island is a 'no-take' MPA	33°02' S to 33°05' S
	West Coast National Park: Langebaan Lagoon north of a line drawn from beacon LB3 at Oesterwal to beacon LB4 at Preekstoel, south of Kraal Bay. Jutten, Malgas, Marcus and Schaapen. Langebaan Lagoon MPA Saldanha Bay	Only angling and bait collection are permitted Ramsar Site since 1988 and zoned MPA. Zone A: harvesting allowed; Zone B: no extractive removal; Zone C: no entry. No rock lobster fishing between North Head and South Head, No net, netting or long-line may be used.	33°02' S to 33°12' S
	Sixteen Mile Beach (including Vondeling Island): Plankies to Rooipan se Klippe (near Yzerfontein).	No fishing from the shore	33°08' S to 33°19' S
	Within 12 nautical miles seaward of the high water mark between Melkbos Punt and "Die Josie" at Chapmans Peak	No fishing, collecting or disturbing of rock lobsters	33°44'S to 34°05'S
	Within 12 nautical miles seaward of the high water mark between Klein Slangkop Point and Slangkop Point Lighthouse	No fishing, collecting or disturbing of rock lobsters by commercial permit holder	34°07'36S to 34°09'S
	Table Mountain National Park MPA	Fishing allowed in the majority of the MPA, subject Department of Agriculture, Fisheries and Forestry permits, regulations and seasons. Six "no-take" zones where no fishing or extractive activities are allowed.	33°54'S to 34°23'S

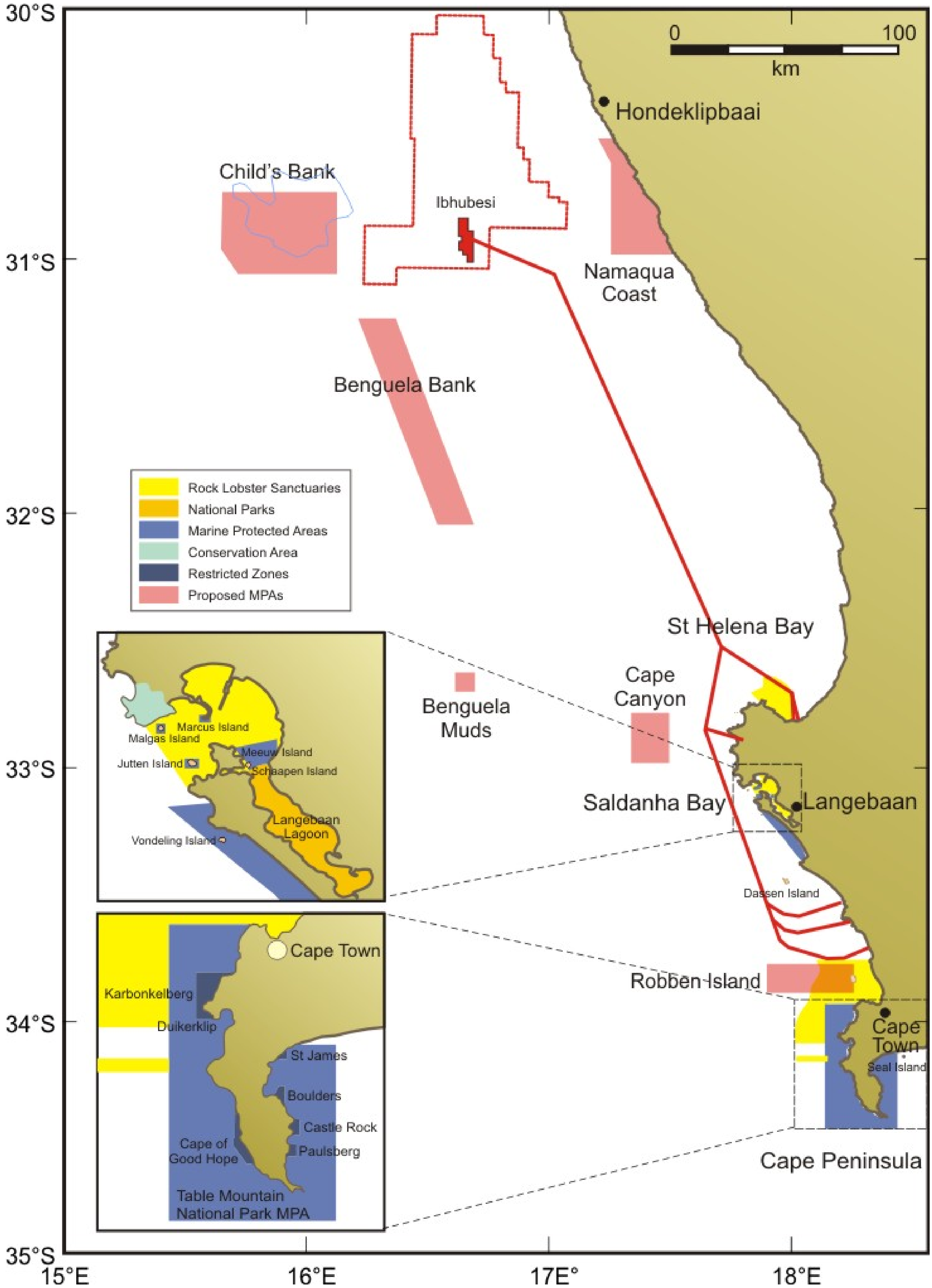


Figure 4.55: Ibhubesi Gas Field and proposed production pipeline route alternatives in relation to conservation areas and Marine Protected Areas (declared and proposed) on the West Coast.